Transport Roads & Maritime Services

NSW GOVERNMENT

Windsor Bridge replacement project

Environmental impact statement
Volume 1 - main report

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Roads and Maritime Services

Windsor Bridge replacement project

Environmental impact statement

November 2012

Prepared by Sinclair Knight Merz
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Working paper 7 - Soil, sediments, water and waste

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Working paper 9 - Land use, property and socio-economic

Working paper 10 - Flora and fauna

Working paper 11 - Air quality

Certification

Submission of environmental impact statement prepared under Part 5.1 of the *Environmental Planning and Assessment Act 1979*.

Environmental impact statement prepared by:

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Roads and Maritime Services NSW

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North Sydney NSW 2059

Address of the land on which the infrastructure to which the statement relates:

Parts of Old Bridge Street, Bridge Street, George Street Wilberforce Road, Freemans Reach Road, The Terrace, Thompson Square, Hawkesbury River and other adjacent areas in Windsor. Hawkesbury LGA.

Description of the infrastructure to which the statement relates:

Windsor bridge replacement:

- Construction and operation of a replacement bridge, approach roads, intersections and associated infrastructure for a new river crossing at Windsor.
- Demolition of the existing Windsor bridge and approach roads.
- Rehabilitation and landscaping of Thompson Square and other areas.

Environmental impact statement:

An environmental impact statement is attached addressing all matters in accordance with Part 5.1 of the *Environmental Planning and Assessment Act 1979*.

Declaration: I certify that I have prepared the contents of this environmental impact statement in response to the Director-General's environmental assessment requirements dated 24 November 2011 and the relevant provisions of Schedule 2 of the Environmental Planning and Assessment Regulation 2000. To the best of my knowledge the information contained in the environmental impact statement is not false or misleading.

Signature:

Name: Jonas Ball
Date: 1.11.2012

Glossary of terms and abbreviations

Term	Meaning
Abutment	The end support of a bridge or similar structure
Access	The driveway by which vehicles and/or pedestrians enter and/or leave property adjacent to a road.
Alignment	The geometric layout (eg of a road) in plan (horizontal) and elevation (vertical).
AM peak period	6 – 10 am weekdays
Annual average daily traffic (AADT)	The total volume of traffic passing a roadside observation point over the period of a calendar year, divided by the number of days in that year (365 or 366 days).
Annual average weekday traffic (AAWT)	The average 24 hour traffic volume on weekdays (Monday to Thursday or Friday) throughout a 12 month period, at a specific observation point.
Arterial	The main or trunk roads of the State road network.
Acid Sulfate Soils (ASS)	Naturally acidic clays, mud and other sediments usually found in swamps and estuaries. They may become extremely acidic when drained and exposed to oxygen and may produce acidic leachate run-off that can pollute waters and liberate toxins.
Backed artefacts	An Aboriginal artefact generally produced before 1500BC that is characterised by a flat back.
Backfill	Fill replaced in an excavation
Base case / 'do nothing case'	Used in evaluating projects to compare the cost and benefit of the existing road (the base case) with another or a number of other projects or options.
Beams seating area	The area on headstocks on which the bridge beams sit upon
Benefit cost ratio (BCR)	The ratio of the monetary benefits to the costs of a project as a measure of worth to the community. The higher the number the greater the benefits compared to the costs.
Bored piling	A method of piling using drilling or boring.
Bridge approach road	A relatively short length of carriageway leading up to a bridge, including embankment, pavement and safety barriers.
Bridge deck	The surface of the bridge, including road and pedestrian/cyclist pathway.
Carbonation of concrete	Carbon dioxide in the air diffuses into concrete and reacts with alkalis within the concrete. This leads to corrosion of embedded reinforcing steel in the concrete which expand, causing the concrete to bulge and crack.
Carriageway	The portion of roadway used by vehicles including shoulders and ancillary lanes.
Casting bed	A temporary work area where concrete is placed to construct the bridge prior to launching the bridge into its final position.
Collector road	A local road that moves traffic to arterial roads.
Concrete	A mixture of fine and coarse aggregate, water, cement and admixtures.
Crossfall	The slope, measured at right angles to the alignment, of the surface of any part of a carriageway.

Term	Meaning
Cross-section	A vertical section, generally at right angles to the centreline showing the ground. On drawings it commonly shows the road to be constructed, or as constructed.
Cut	The depth from the natural surface of the ground to the subgrade level.
Cutting	Formation resulting from the construction of the road below existing ground level – the material is cut out or excavated.
dB(A)	Decibels using the A-weighted scale measured according to the frequency to the human ear.
Design speed	A speed fixed for the design and correlation of those geometric features of a carriageway that influence vehicle operation. Design speed should not be less than the intended 85th percentile speed
Design standard	Identified particular standards used in the design eg standard lane width.
Earthworks	All operations involved in loosening, excavating, placing, shaping and compacting soil or rock.
EIS	Environmental impact statement.
Embankment	An earthen structure where the road subgrade level is above the natural surface.
EP&A Act	NSW *Environmental Planning and Assessment Act 1979.*
Fill	The material placed in an embankment
Foreshore	The area of land adjacent to the bank of a river.
Foundation	The soil or rock upon which a structure rests.
Girders	A type of support beam.
Graphitisation	Leaching of cast iron in slightly acidic water which leads to corrosion and weakening.
Grade	A length of carriageway sloping longitudinally.
Greenhouse gases (GHG)	Include carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, hydrofluocarbons and perfluorocarbons.
Gutter	A drain which is lined or paved (along the side of a road).
Headstocks	A structure that sits on top of bridge piers that supports the superstructure and deck of a bridge.
Incrementally launched	A type of bridge that is constructed by setting up a casting bed on one side of the river, casting segments of the bridge and then launching each new segment across the alignment on to the piers.
In situ	An operation carried out on a material in its final position.
Kerb	An edge stone or concrete shape used for bordering a road and defining the footway.
LA_{eq}	The equivalent continuous sound level. This is the energy average of the varying noise over the sample period and is equivalent to the level of constant noise which contains the same energy as the varying noise environment. This measure is a common measure of environmental noise and road traffic noise.

Term	Meaning
LA_{90}	The noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below LA90 level for 10% of the time. This measure is commonly referred to as background noise level.
Landscape character	The aggregate of built, natural and cultural aspects that make up an area and provide a sense of place. Includes all aspects of a tract of land – built, planted and natural topographical and ecological features.
Launching yard	A temporary work area (adjacent to the casting bed) where completed sections of the bridge are pushed (launched) into their final position.
LEP	Local Environmental Plan.
Level of service (LoS)	A qualitative measure describing operational conditions within a traffic stream and their perception by motorists and/or passengers.
LGA	Local government area.
Matters of national environmental significance	Matters listed under the *Environment Protection and Biodiveristy Conservation Act 1999*.
Median	The central reservation which separates carriageways from traffic travelling in the opposite direction.
Milling	Removing the surface of a pavement (typically 25 to 75 mm in depth) with a machine equipped with a transverse rotating cutter drum.
PAMP	Pedestrian Access Management Plan
Pavement	The portion of carriageway placed above the subgrade for the support of, and to form a running surface for vehicular traffic.
Pier	An intermediate support in a bridge having more than one span. Part of the substructure supporting the superstructure and transferring the loads to the foundations.
Pier caps / pile caps	A structural member designed to connect and distribute loads from the above structure to a group of piers or piles.
Pile	A slender member driven, screwed or formed in the ground to resist loads or thrust.
PM_{10}	Particulate matter less than 10 microns in diameter.
PM peak period	3-7pm weekdays.
Post tensioning	A method of prestressing in which tendons are tensioned after the concrete has hardened.
Project footprint	The extent of impact that the project makes on the land.
Office of the Hawkesbury Nepean	A NSW Government initiative to improve the health of the Hawkesbury-Nepean river system (now closed).
Open space	Space available to recreational uses.
Overshadowing	The shadow cast by a structure.
Rat run	Avoiding traffic on main roads by using secondary and local roads.
Reinforced concrete	Concrete strengthened within its mass by steel bars, mesh or steel fibres.

Term	Meaning
Reinforcement	Bars, or mesh, usually steel, embedded in concrete, masonry or brickwork for the purpose of resisting particular stresses eg tensile, temperature related etc.
Receiver	An environmental modelling term used to describe a map reference point where the impact is predicted. A sensitive receiver is a home, work place, school or other place where people spend some time.
Retaining wall	A wall constructed to resist lateral pressure from the adjoining ground or to maintain in position a mass of earth.
Riparian	Relating to the banks of a natural waterway.
RMS	Roads and Maritime Services NSW (formerly Roads and Traffic Authority).
Roadworks	A general term for any work on a road for construction, repair or maintenance.
Rock rip rap protection	Medium to large size rock protection, against scour, applied (usually by dumping) to the face of an embankment.
Roundabout	An intersection where all traffic travels in one direction around a central island.
RTA	(former) Roads and Traffic Authority (now RMS).
Safety barrier	A physical barrier separating roadside hazards or opposing traffic and the travelled way, designed to resist penetration by an out-of-control vehicle and as far as practicable, to stop or redirect colliding vehicles.
Scour	The erosion of material by the action of flowing water.
Section 170 register	A register established in accordance with section 170 of the *Heritage Act 1977* to record all heritage items in the ownership or under control of RMS (or other state government agencies).
Shared path	A pathway used for both cyclists and pedestrians, usually located on the side of the road.
Shoulder	The portion of the carriageway beyond the traffic lanes adjacent to and flush with the surface of the pavement.
Sight distance	The distance measured along the carriageway over which objects of defined height are visible to a driver whose eyes are at a specified height above the pavement surface level.
Site compound	Area enclosing construction machinery, stockpiles, site offices and other ancillary facilities.
Soffit	The underside of a building or bridge.
Spalling	Natural deterioration of concrete due to carbonation.
Span	The distance between centres of adjacent supports of a bridge.
Spoil	Surplus excavated material
Stockpile	Temporarily stored materials such as soil, sand, gravel and spoil/waste.
Sub-arterial	A road that supports and links state roads.
Subgrade	The trimmed or prepared portion of the formation on which the pavement is constructed.
Substructure	In a bridge, the piers and abutments (including wing walls) which support the superstructure.

Term	Meaning
Superstructure	That part of a bridge structure which is supported by the piers and abutments.
Thompson Square	The area defined by George Street, the building lines on the east and west of Thompson Square parkland and The Terrace.
Thompson Square Conservation Area	Also known as the Thompson Square Precinct, this is the area of Thompson Square listed on the State Heritage Register of NSW. One of the oldest public squares in Australia, constructed in 1811. Surrounding buildings were constructed between 1815 and 1880 in the colonial Georgian style. The Square consists of George Street, Bridge Street, Thompson Square and The Terrace.
Thompson Square open space area	Including all public lands (roads, footpaths, car parks, parkland areas, verges and medians) within Thompson Square.
Thompson Square lower parkland	Includes the parkland area below / north of Bridge Street bounded by Bridge Street, Old Bridge Street and The Terrace.
Thompson Square parkland	The parkland area bounded by George Street, Old Bridge Street, The Terrace and Thompson Square road. It includes both the Thompson Square upper and lower parkland areas.
Thompson Square road	The road on the western side of Thompson Square parkland.
Thompson Square upper parkland	Includes the parkland area above / south of Bridge Street bounded by Bridge Street, George Street and Thompson Square road.
Underpass	A tunnel constructed for the use of pedestrians and cyclists under a carriageway.
Urban design	The process and product of designing human settlements and their supporting infrastructure, in urban and rural environments.
Vertical alignment	The longitudinal profile along the design line of a road.
Vertical curve	A curve (generally parabolic) in the longitudinal profile of a carriageway to provide for a change of grade at a specified vertical acceleration.
View point	A point in the landscape chosen to measure impacts to visual amenity.
Water quality basin	An area where stormwater is ponded to be treated before entering a waterway.

Executive Summary

What is proposed?

Roads and Maritime Services NSW (RMS) is proposing to replace the existing bridge over the Hawkesbury River at Windsor. The proposal for bridge replacement includes the following key features:

- Construction of a new bridge over the Hawkesbury River at Windsor, around 35 metres downstream of the existing Windsor bridge.
- Construction of new approach roads and intersections to connect the new bridge to existing road network.
- Modifications to local roads and access arrangements, including changes to the Macquarie Park access and connection of The Terrace.
- Construction of pedestrian and cycling facilities, including a shared pedestrian/cycle pathway for access to and across the new bridge.
- Removal and backfilling of the existing bridge approach roads.
- Demolition and removal of the existing road bridge, known as Windsor bridge.
- Urban design and landscaping works, including within the parkland area of Thompson Square and adjacent to the northern intersection of Wilberforce Road, Freemans Reach Road and the Macquarie Park access road.
- Ancillary works such as public utility adjustments, water management measures and scour protection works, as required.

What are the project objectives?

The primary aim of the project is to provide a safe and reliable crossing of the Hawkesbury River at Windsor. Specific objectives for the project are:

- To improve safety for motorists, pedestrians and cyclists.
- To improve traffic and transport efficiency.
- To improve the level of flood immunity.
- To meet long term community needs.
- To minimise the impact on heritage and the character of the local area.
- To be a cost effective and an affordable outcome.

Why is it needed?

Windsor bridge provides an important link for communities on each side of the Hawkesbury River in the Windsor locality, as well as an important regional link between western Sydney, the Blue Mountains and the Hunter region. Around 19,000 vehicles use the bridge each day, with around seven per cent of these being heavy vehicles. The nearest alternative bridge crossing of the Hawkesbury is located around 10 kilometres away at Richmond, requiring a road detour of around 20 kilometres to drive between the southern and northern sides of the river at Windsor.

There are a number of reasons why the project is needed. Critically, the structural piers and other parts of the existing Windsor bridge are over 130 years old and are substantially deteriorated due to age and heavy use. The bridge requires extensive rehabilitation work if it is to be used and maintained into the future.

Speed restrictions are currently imposed due to the structural weakness of the bridge and it is inspected regularly to ensure public safety. A load limit may also need to be applied in the short term and ultimately closure of the bridge is expected in the longer term when ongoing maintenance can no longer provide a structurally adequate bridge.

The remaining safe life of the bridge cannot be accurately predicted due to deterioration, heavy use and risk of flooding, however RMS could need to close it anytime without notice to protect public safety if regular inspections identify considerable further structural weakness.

In addition to deteriorating with age, the existing bridge does not meet current engineering and road safety standards. The approach roads and intersections also have a number of safety issues, such as lack of safe crossing locations for pedestrians and poor vehicle sight distances.

A further limitation of the existing bridge is that it is below the 1-in-2 year flood event level while the surrounding approach roads have a higher level of flood immunity. Finally, the existing bridge and intersections cause traffic delays and congestion especially in the peak period. The predicted growth in traffic numbers using this river crossing would result in even greater delays and congestion at the existing bridge and intersections in the future. RMS has identified that the most effective solution to these deficiencies is to replace the existing bridge.

How would the project satisfy this need?

The project would provide a new bridge, approach roads and intersections to current road design standards. The project design would improve the level of flood immunity to that of the surrounding approach roads, and provide safer crossings for pedestrians. The existing bridge would be removed thereby removing the risk of deterioration and failure.

The improved intersections and higher capacity bridge would provide acceptable traffic performance immediately and into the future when the bridge would be reconfigured to provide three lanes (two lanes southbound and one lane northbound).

What alternatives were considered?

The project development process involved an integrated design approach with engineers, urban designers and architects working collaboratively with environmental and heritage specialists. This approach complemented the process of participation and input from community and stakeholders.

A range of options were considered during the options selection process, including a number of options identified by the community. The options assessment process took into account transport needs, heritage impacts, environmental impacts and engineering and cost constraints.

Early phases of the options assessment process identified opportunities to retain the existing bridge, bypass Windsor or replace the existing bridge at Windsor. The ten options considered would have provided river crossings at a variety of different locations. Three of these options were short-listed and further assessment identified a preferred option for the location of a replacement bridge at Windsor.

Various bridge types and bridge and road alignments were then considered for this preferred option. The different bridges and alignments presented different impacts and opportunities.

An outcome of the integrated design approach was adjusting project design speed, allowing the southern approach road to the new bridge through Thompson Square to be lowered. This lower alignment option reduced potential visual and heritage impacts. Different intersection types and configurations were considered on the northern and southern sides of the bridge, as were locations for the pedestrian and cyclist shared path. A number of options were considered for the design of Thompson Square.

How did the community participate in selecting the preferred project?

RMS used a range of consultation tools and activities to ensure the community was actively involved in the project development and options selection process. Consultation for the project began in July 2009 with input sought on the ten options to rehabilitate or replace the existing bridge. Consultation continued on the preferred option to allow community issues to be considered in the design of the bridge, Thompson Square and surrounding project elements.

Consultation tools and activities used to facilitate community participation throughout the options assessment process included community information sessions, public displays, on-line discussion forums, a series of community focus group meetings and a deliberative forum. A range of more traditional activities were also adopted, including door knocking, newsletters, advertisements and community updates seeking feedback and input on the project. Local council, government agencies the Heritage Council of NSW and Aboriginal stakeholders were also consulted during project development.

RMS will continue to provide opportunities for the community to participate in the detailed design of Thompson Square and in further minimising project impacts.

What are the main beneficial outcomes expected?

The main beneficial outcome of the project would be maintaining an essential local and regional road link across the Hawkesbury River at Windsor for commercial, residential and tourist traffic. The project would also improve safety and flood immunity for this river crossing.

The removal of the approach road to the existing bridge which currently diagonally bisects Thompson Square and the consolidation of the two parkland areas would increase the usable open space area within Thompson Square. It would also improve access to the waterfront from the Windsor commercial area. Transport through and from Windsor, and access to the waterfront, are important historical aspects of this area dating back to its establishment.

The project would also improve pedestrian and cyclist access, safety and connectivity through the provision of shared use pathways and a signalised intersection at Bridge and George streets to enable safe crossing of this busy intersection for pedestrians.

What are the main adverse outcomes expected?

The project would result in a number of adverse impacts particularly on heritage and visual impacts. The main adverse outcomes identified include:

- Impacts to the heritage values of Thompson Square, as well as potential impacts to archaeology within Thompson Square and foreshore areas.
- Impacts to Aboriginal archaeology.
- Visual impacts and impacts to the landscape character of the area.
- Additional traffic noise and changes to access arrangements for some residents.
- Construction related impacts such as noise, vibration, traffic and air and water quality issues.

How will the likely impacts be managed?

RMS has identified a number of mitigation and management measures to avoid, manage, mitigate, offset and/or monitor impacts during pre-construction, construction and operation of the project.

If the project is approved, the design, construction and operation of the project would be undertaken in accordance with these measures, as well as any additional measures identified in conditions of approval for the project.

How can I comment on the proposal and/or the environmental impact statement?

The NSW Department of Planning and Infrastructure will make the environmental impact statement publicly available for a minimum period of 30 days. During this period, it will be available for inspection at the Department of Planning and Infrastructure website: http://majorprojects.planning.nsw.gov.au/, on the RMS project website www.rms.nsw.gov.au, at selected RMS offices, and at various displays in the region. Display locations include:

- Hawkesbury Council Chambers.
- RMS Motor Registry, Richmond.
- Deerubbin Centre (Windsor Central Library).
- Windsor Post Office.
- RMS Office, Blacktown.
- RMS Head Office, North Sydney.
- NSW Department of Planning and Infrastructure, Bridge Street, Sydney.
- Nature Conservation Council of NSW, Newtown.

RMS will also be conducting community information sessions. A project information line will be available throughout the exhibition period – 1800 822 486 (toll free).

A person may make written submissions to the Director-General of the Department of Planning and Infrastructure during the exhibition period. All submissions received will be placed on the Department of Planning and Infrastructure website.

Submissions can be made using the online form at the Department's website at http://majorprojects.planning.nsw.gov.au

People unable to lodge submissions online can send it via email to **plan_comments@planning.nsw.gov.au** or via mail to:

Director Infrastructure Projects
Department of Planning and Infrastructure
GPO Box 39
Sydney NSW 2001

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1 Introduction

This chapter provides a broad overview of the project and why it is required. It also identifies the purpose and structure of this Environmental Impact Statement (EIS).

1.1 The proposed project

Roads and Maritime Services NSW (RMS) is seeking approval under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to replace the existing bridge over the Hawkesbury River at Windsor (known as Windsor bridge). The existing bridge needs to be replaced as its structural integrity is deteriorating with age and it is no longer cost-effective to maintain.

RMS proposes to replace the existing Windsor bridge over the Hawkesbury River. The Windsor bridge replacement project would involve:

- Construction of a new bridge over the Hawkesbury River at Windsor, around 35 metres downstream of the existing Windsor bridge.
- Construction of new approach roads and intersections to connect the new bridge to existing road network.
- Modifications to local roads and access arrangements, including changes to the Macquarie Park access and connection of The Terrace.
- Construction of pedestrian and cycling facilities, including a shared pedestrian/cycle pathway for access to and across the new bridge.
- Removal and backfilling of the existing bridge approach roads.
- Demolition of the existing Windsor bridge.
- Urban design and landscaping works, including within the parkland area of Thompson Square and adjacent to the northern intersection of Wilberforce Road, Freemans Reach Road and the Macquarie Park access road.
- Ancillary works such as public utility adjustments, water management measures and scour protection works.

This EIS seeks approval for the project elements described above. The EIS has been prepared based on a concept design. If approved, a further detailed design process will follow which may include variations to the concept design.

Figure 1-1 provides a photo montage of the replacement bridge while key elements of the project are shown in **Figure 1-2**. A detailed description of the project is provided in Chapter 5.

1.2 Project location and context

The project is located at Windsor in the Hawkesbury local government area about 57 kilometres north west of Sydney. The township of Windsor is located on the south bank of the Hawkesbury River at the foot of the Blue Mountains. The proposed bridge works and associated road works that make up the project extend from the intersection of Freemans Reach Road and Wilberforce Road in the north to the intersection of Macquarie Street and Bridge Street in the south. The location and regional context of the project are shown in **Figure 1-3**.

The area surrounding Windsor is predominantly rural, although there is extensive and expanding urban development to the south and west of the town. Windsor is a major historic town, with European settlement dating back to the late 1700s. The town contains numerous buildings and sites of historic heritage significance, which are a key feature of its character. The existing Windsor bridge was opened in 1874 and is the oldest existing bridge across the Hawkesbury River. It provides an important local link for communities on each side of the river, as well as an important regional link between western Sydney, the Blue Mountains and the Hunter region. Around 19,000 vehicles use the bridge each day, with around seven per cent of these being heavy vehicles.

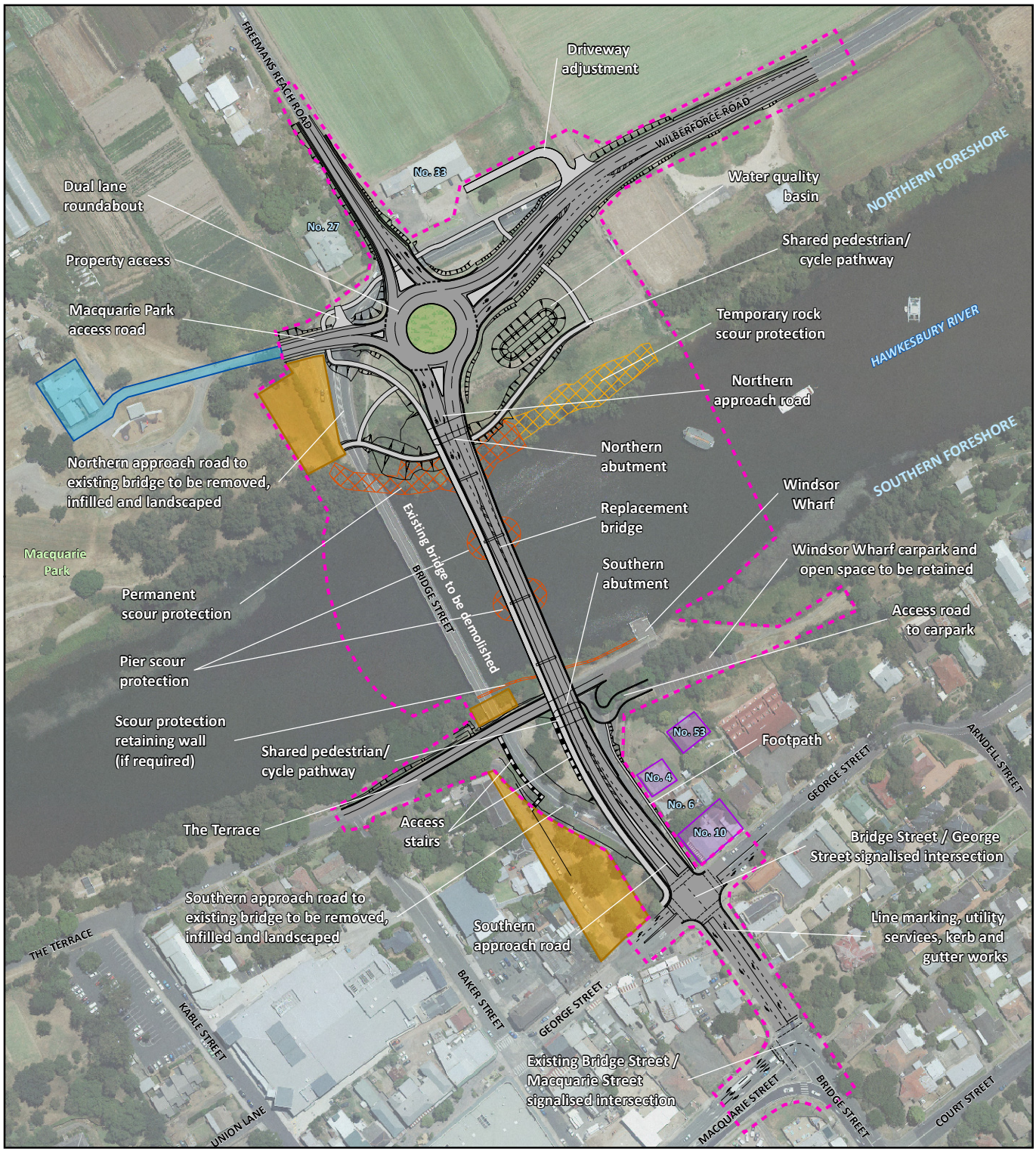
Parts of the existing bridge are 138 years old and are deteriorating as a result of age and heavy use. Elements of the bridge have deteriorated substantially and RMS has assessed that it is not practical to replace or repair these elements. The existing bridge and adjacent intersections no longer meet the demands of current peak hour traffic volumes or current road standards. The level of maintenance required to maintain adequate road safety is no longer cost effective and it is therefore regarded that the bridge has reached the end of its economic life.

In June 2008, in recognition of the condition of the existing bridge, the NSW Government announced funding for a bridge replacement project. Following this announcement, RMS began preliminary investigations to assess potential bridge replacement options in consultation with the local community and stakeholders. The options considered and the results of the options assessment process are presented in Chapter 4.

RMS recognises that the project has the potential to have a range of adverse effects on the environment and community of Windsor, including but not limited to impacts on heritage, traffic and transport, landscape character, and the socio-economic environment. Furthermore, it is considered that the impacts of the project on historic heritage are likely to be significant, with direct impacts on State Heritage Register listed Thompson Square Conservation Area and other State and local heritage items.

Figure 1-1 Photomontage of the project from the southern bank

Figure 1-2 | Key project elements



Indicative only – subject to detailed design

LEGEND

- Concept design
- Construction work zone
- Permanent rock scour protection (if required)
- Temporary rock scour protection (if required)
- Properties requiring flood mitigation works. Works subject to further consultation with and agreement from affected property owners.
- Properties requiring noise mitigation works. Works that are feasible and reasonable would be subject to further consultation with and agreement from affected property owners.
- Works subject to further council and stakeholder consultation

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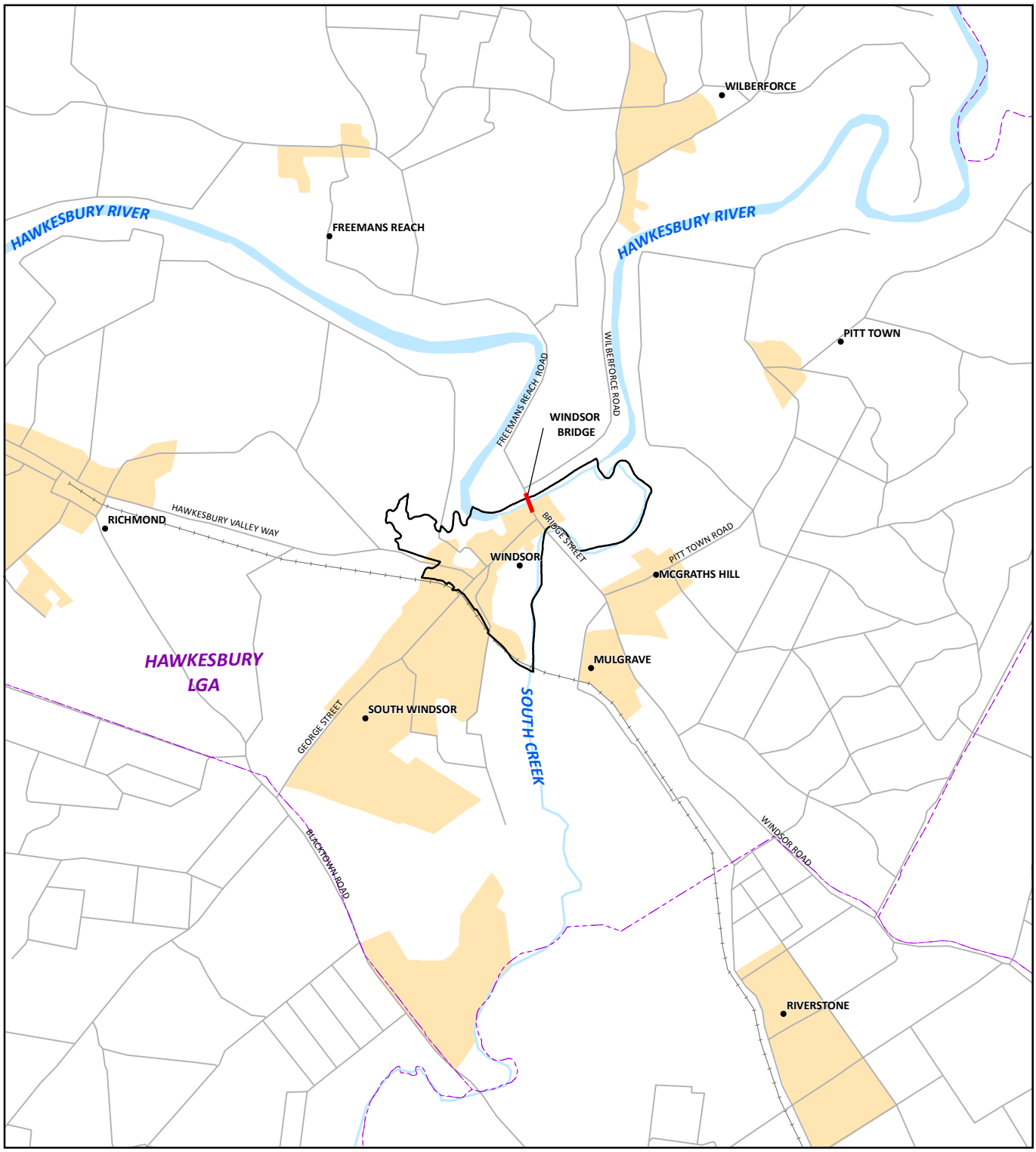
Figure 1-3 | Location and regional context of the project



LEGEND

- Windsor State Suburb Boundary
- Urban area
- LGA boundary
- River
- Major road
- Railway

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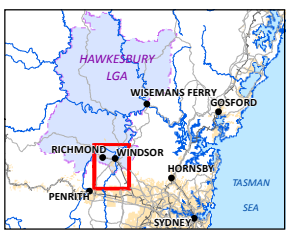

1.3 Structure of this Environmental Impact Statement

This EIS has been prepared to support RMS' application for approval of the project under Part 5.1 of the EP&A Act. It has been prepared in accordance with Part 3, Schedule 2 of the *Environmental Planning and Assessment Regulation 2000* and the Environmental Assessment Requirements issued by the Director General of the Department of Planning and Infrastructure. The Director General's requirements and other requirements under the regulation including where they are addressed in the EIS are presented in Appendix A and Appendix B, respectively.

This EIS is divided into four volumes:

- Volume 1 – this report.
- Volume 2 – Historic and Aboriginal heritage working papers.
- Volume 3 – Visual Amenity, Urban Design and Landscape working paper.
- Volume 4 – all other working papers.

The working papers in Volumes 2, 3 and 4 document the methods and results of the specialist environmental studies that have been undertaken for the EIS. The key findings from the working papers are incorporated into the relevant chapters of this volume. Further detail on the contents of each volume is provided below.

1.3.1 Volume 1

This volume of the EIS is structured as follows:

- Introduction (this chapter).
- Assessment process (Chapter 2) – outlines the statutory requirements for the project and explains the steps in the assessment and approval process.
- Strategic justification and project need (Chapter 3) – provides the strategic context and outlines the need for and objectives of the project.
- Project development and alternatives (Chapter 4) – reviews the alternatives considered in developing the project.
- Description of the project (Chapter 5) – describes the scope of the project, the project elements, the design standards and criteria, the proposed construction process, and the likely staging of project delivery.
- Consultation (Chapter 6) – describes the community and stakeholder consultation undertaken and identifies the corresponding issues raised.
- Assessment of key issues (Chapter 7) – identifies the key environmental issues for the project, the potential environmental impacts in relation to these issues, and the proposed impact mitigation and management measures.
- Assessment of other issues (Chapter 8) – identifies the other environmental issues associated with the project, the associated potential environmental impacts, and the proposed impact mitigation and management measures.
- Environmental risk analysis (Chapter 9) – describes the environmental risk assessment applied to the project to identify and confirm the key issues.
- Summary of impact mitigation and management measures (Chapter 10) – collates the impact mitigation and management measures identified in Chapters 7 and 8.

- Justification and conclusion (Chapter 11) – provides a justification to the carrying out of the project and a summary of the main findings with respect to the potential environmental impacts and benefits.
- References (Chapter 12) – provides details of all documents and other information sources cited within the document.
- Appendix A - Director General's Requirements and checklist.
- Appendix B - Regulation checklist.
- Appendix C - Existing bridge technical investigation reports.

1.3.2 Appendices - Volume 2 to 4

The appendices containing the working papers have been divided into three separate volumes:

Volume 2

- Working paper 1 - State and local historic (terrestrial) heritage.
- Working paper 2 - Maritime heritage.
- Working paper 3 - Aboriginal heritage.

Volume 3

- Working paper 5 - Urban design and landscape concept.

Volume 4

- Working paper 4 - Traffic and transport.
- Working paper 6 - Noise and vibration.
- Working paper 7 - Soil, sediment, water and waste.
- Working paper 8 - Hydrology.
- Working paper 9 - Landuse, property and socio-economic.
- Working paper 10 - Flora and fauna.
- Working paper 11 - Air quality.

2 Assessment process

This chapter describes the planning approval process for the project as well as other relevant environmental planning and statutory approval requirements.

2.1 Approval framework

2.1.1 Environmental Planning and Assessment Act 1979

RMS is seeking approval for the proposed Windsor Bridge replacement project under Part 5.1 of the EP&A Act.

Clause 94 of the *State Environmental Planning Policy (Infrastructure) 2007* (the Infrastructure SEPP) applies to development for the purpose of a road or road infrastructure facilities and provides that these types of works are development which is permissible without consent. The project is appropriately classified as "road works" under the Infrastructure SEPP.

Clause 14 of the *State Environmental Planning Policy (State and Regional Development) 2011* declares development as State significant infrastructure if it is permissible without consent and specified in Schedule 3.

Clause 1 of Schedule 3 of the *State Environmental Planning Policy (State and Regional Development) 2011* specifies infrastructure or other development that would be an activity for which the proponent is also the determining authority and would, in the opinion of the proponent, require an environmental impact statement to be obtained under Part 5 of the Planning Act.

RMS formed the opinion that the project is likely to significantly affect the environment and would require an environmental impact statement to be obtained and consequently the project is State significant infrastructure under Part 5.1.

The approval process under Part 5.1 of the EP&A Act is illustrated in **Figure 2-1**. Further information on the assessment process is available on the Department of Planning and Infrastructure website (www.planning.nsw.gov.au).

2.1.2 Environmental planning instruments

Environmental planning instruments do not apply to or in respect of State significant infrastructure, except where they apply to the declaration of infrastructure as State significant infrastructure (EP&A Act s.115ZF(2)). The project is declared to be State significant infrastructure through Clause 14 and Schedule 3 (Part 1(1)) of the State Environmental Planning Policy (State and Regional Development) 2011. Therefore the following state environmental planning policies (SEPPs) and local environmental plans (LEPs) which may have otherwise applied, do not apply to the project:

- Sydney Regional Environmental Plan No 20—Hawkesbury-Nepean River (No 2—1997) (a deemed SEPP).
- SEPP No. 55 – Remediation of Land.
- SEPP (Infrastructure) 2007.
- Hawkesbury LEP 2012.

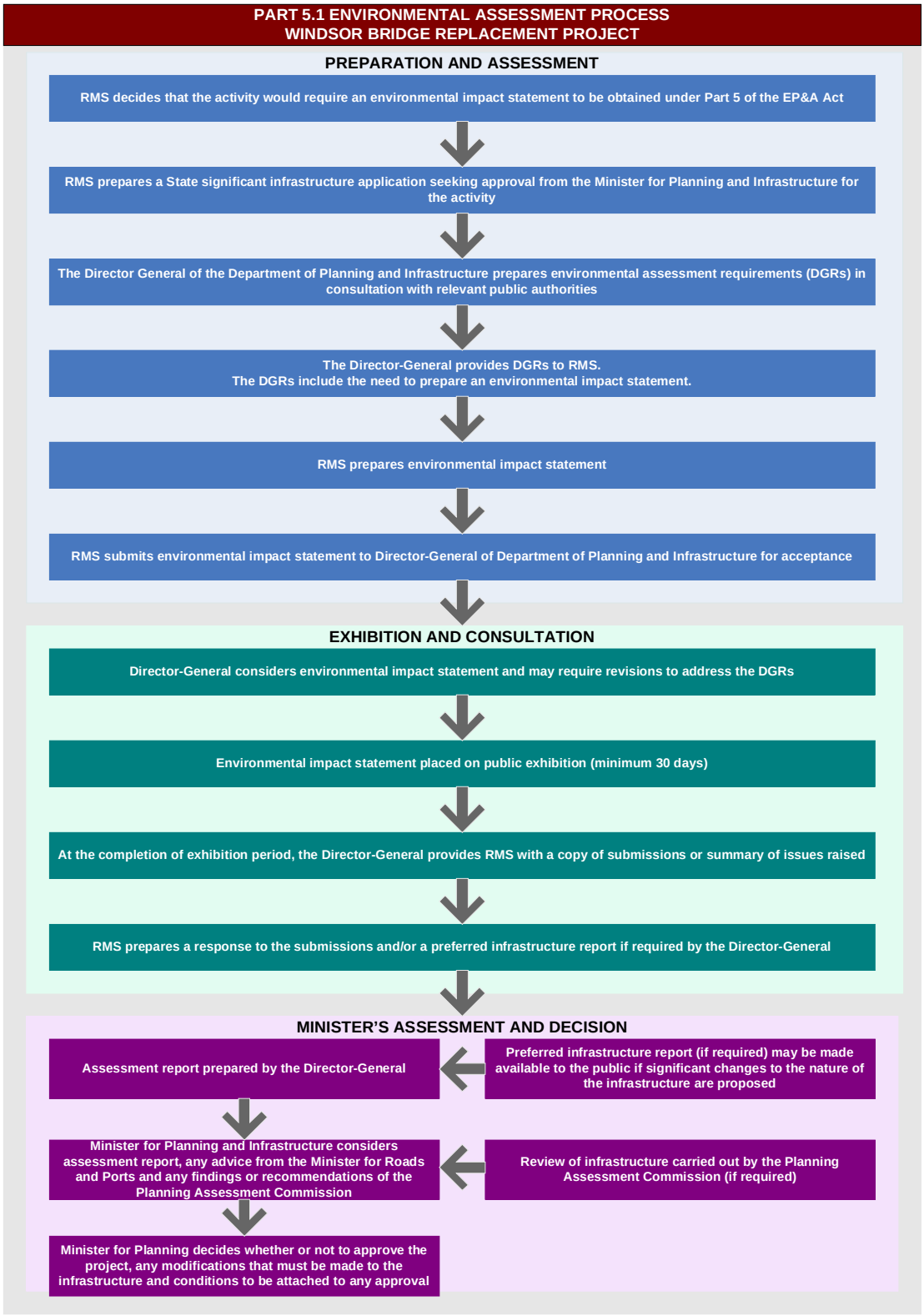

Figure 2-1 State significant infrastructure assessment and approval process

2.2 Other legislation

2.2.1 NSW legislation

A number of approvals that generally apply under other NSW legislation are not required for a project approved under Part 5.1 of the EP&A Act (EP&A Act s.115ZG). Exemptions potentially relevant to the project include:

- Permits under sections 201, 205 and 219 of the *Fisheries Management Act 1994*.
- Approvals under Part 4 and excavation permits under section 139 of the *Heritage Act 1977*.
- Aboriginal heritage impact permits under section 90 of the *National Parks and Wildlife Act 1974*.
- Authorisations under the *Native Vegetation Act 2003* to clear native vegetation or State protected land.
- Various approvals under the *Water Management Act 2000*, including water use approvals under section 89, water management work approvals under section 90, and activity approvals (other than aquifer interference approvals) under section 91.

Approvals under other NSW legislation that may apply to the project include:

- An aquifer interference approval under the *Water Management Act 2000* if construction requires intersection of a groundwater source. This is further discussed in **Section 7.6**.

Other legislation that may apply to the project includes:

- *Land Acquisition (Just Terms Compensation) Act 1991* – applies to the compulsory acquisition of any land required for the project. Acquisition is further discussed in **Section 7.8**.
- *Crown Lands Act 1989* - applies to the acquisition of land reserved under this Act. A land status search undertaken in June 2012 confirmed there will be Crown land where at least partial acquisition would be required for the project. Crown land impacted by the project is further discussed in **Section 7.8**.
- *Aboriginal Land Rights Act 1983* – there is an area of Crown land on the southern side of the project that is the subject of an Aboriginal Land Claim made under this Act. This claim is currently being investigated by the Crown Lands Division of the Department of Primary Industries. Crown land impacted by the project is further discussed in **Section 7.8**.
- *Protection of the Environment Operations Act 1997* – applies to the prevention of pollution, appropriate disposal of waste and the need to notify the Environment Protection Authority (EPA) in the event of any incidents that cause or have the potential to cause environmental harm. This is further discussed in **Section 7.6**.
- *Contaminated Land Management Act 1997* – requires notification to the EPA in the event of discovering or causing contamination. Contamination is further discussed in **Section 7.6**.

Under clause 115ZH of the EP&A Act, certain approvals cannot be refused if they are necessary for carrying out approved State significant infrastructure and are required to be substantially consistent with the approval under Part 5.1. Such an approval that may apply to the project would be an environment protection licence under Chapter 3 of the *Protection of the Environment Operations Act 1997*.

2.2.2 Commonwealth legislation

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) proposed 'actions' that have the potential to significantly impact on matters of national environmental significance, the environment of Commonwealth land or that are being carried out by a Commonwealth agency must be referred to the Commonwealth Government. If the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities determines that a referred project is a 'controlled action' under the EPBC Act, the approval of that minister would be required for the project in addition to the NSW Minister for Planning and Infrastructure's approval.

Based on the results of the environmental investigations carried out for this EIS, it is considered that no matters of national environmental significance or areas of Commonwealth land are likely to be impacted by the project. Accordingly RMS has decided that no referral is required at this stage. RMS notes that the project would impact on the Thompson Square Precinct (hereafter referred to as the Thompson Square Conservation Area), which includes parts of the project area. The Thompson Square Conservation Area has been nominated for inclusion on the National Heritage List. The listing is currently under consideration by the Minister. Further information on the Thompson Square Conservation Area, including the impacts of the project, is provided in **Section 7.1**.

3 Strategic justification and project need

This chapter describes the strategic landuse and transport policies which underpin the need and justification for the project. It also identifies objectives and actions from these policies which need to be considered in the assessment of options and the preferred option in subsequent chapters. The Director General's requirements relating to this chapter are presented below.

Director General's requirements	Where addressed
A statement of the objectives of the project, including a description of the strategic need, justification, objectives and outcomes for the project, the aims and objectives of relevant strategic planning and transport policies, including NSW 2021, the Metropolitan Plan for Sydney 2036 and the draft North West Subregional Strategy.	This chapter and Chapter 11.
Identification of how relevant planning, land use and development matters (including relevant strategic and statutory matters) have been considered in the impact assessment (direct, indirect and cumulative impacts) and/or in developing management / mitigation measures.	This chapter and Chapters 5, 7, 8 and 10.

3.1 Strategic planning and policy framework

The following sections describe the compatibility of the project with key strategic planning and policy documents.

3.1.1 NSW 2021

NSW 2021 A Plan to Make NSW No 1 (Department of Premier and Cabinet, 2011) is the NSW Government's 10-year strategic plan setting priorities for action and guiding resource allocation within the NSW budget. The plan includes strategies for returning quality services and renovating infrastructure, with goals and targets for improving transport and road safety. Presented in **Table 3-1** is an assessment of the project objectives against relevant NSW 2021 goals, targets and actions.

The project is consistent with the NSW 2021 plan as it aims to replace an existing road crossing of the Hawkesbury River that is deteriorating with age and cannot be maintained effectively through standard maintenance programs. The project is needed to improve the safety and efficiency of the bridge and maintain the road linkage between the southern and northern sides of the Hawkesbury River at Windsor. The bridge is important for both the local community and regional road networks, including traffic routes between Sydney, the Blue Mountains and the Hunter region.

Table 3-1 Assessment of the project against the relevant goals, targets and plans of NSW 2021 A Plan to Make NSW No 1

Goals and targets	Actions	Relevance to the project
Improve the efficiency of the road network during peak times on Sydney's road corridors		
Improve AM and PM peak hour travel speeds on 100 major road corridors	Deliver road infrastructure to: • Relieve congestion. • Improve safety. • Enhance and expand capacity on road corridors.	Key project objectives of the project are to improve traffic and transport efficiency and to improve safety for motorists, pedestrians and cyclists – which assists in meeting this goal and target. The delivery of a replacement bridge (ie road infrastructure) would be a complying action with the plan that assists the target and goal to be achieved.
Improve road safety		
Reduce fatalities to 4.3 per 100,000 population by 2016	• Improve the safety of roads by carrying out road development, upgrading, maintenance and safety works, such as safety barriers and works on local roads to address crash risks • Cut congestion and introduce safe, simpler speed zones to save lives.	One of the key project objectives is to improve safety for motorists, pedestrians and cyclists – which assist in meeting this goal and target. The replacement bridge would be designed to meet current safety standards – whereas the existing bridge does not. The project would also reduce congestion. These would be complying actions with the plan that enables the target and goal to be achieved.
Increase expenditure on critical NSW infrastructure		
Increase investment in regional infrastructure	Prepare a 20 year State Infrastructure Strategy, detailed five year Infrastructure Plans and Sectoral State Infrastructure Strategy Statements	The project has been allocated funding as part of the most recent five year Infrastructure Plan. Freemans Reach Road and Wilberforce Road provide connections from regional areas to Windsor and the Sydney metropolitan area.
Improve the quality of urban and rural State roads		
93% of state roads meet national road smoothness standards by 2016	Conduct road resurfacing and reconstruction programs to improve road quality in areas not currently meeting the national road smoothness standards	The project would meet national road smoothness standards and consequently a complying action that enables the target and goal to be achieved.

3.1.2 Metropolitan Plan for Sydney 2036

The *Metropolitan Plan for Sydney 2036* (NSW Government, 2010a) is a strategic policy document to guide Sydney's growth and development over the next 25 years with the aim of improving sustainability, affordability and lifestyles. It builds on the *Metropolitan Strategy: A City of Cities* (Department of Planning, 2005), identifying a range of strategic directions and policy settings to meet Sydney's future needs in transport, housing and employment while protecting the environment and community. The plan integrates land use and transport planning, addressing the need to be able to move around the city efficiently for work, recreation and other activities.

One of the aims of the plan is to ensure that infrastructure development is guided by the need to reduce car travel and traffic congestion, improve air quality and reduce greenhouse gas emissions. This means focusing on both developing new infrastructure and improving existing infrastructure to support established urban centres.

The project is compatible with the *Metropolitan Plan for Sydney 2036* as it aims to maintain an existing, long established road crossing of the Hawkesbury River at Windsor, which is important to both the local community and wider regional transport network. Without this road crossing of the Hawkesbury River, a 20 kilometre road detour via the Richmond Bridge would be required to gain access between the southern and northern sides of the Hawkesbury River in the Windsor locality. A river crossing at this location assists in reducing car travel and traffic congestion, improving air quality and reducing greenhouse gas emissions (which are aims of the *Metropolitan Plan for Sydney 2036*). The project is compatible with maintaining existing transport networks that support an established urban centre, as well as protecting the environment and lifestyle of the Windsor community.

3.1.3 Draft NSW Long Term Transport Master Plan

The draft *NSW Long Term Transport Master Plan* (Transport for NSW, 2012) sets the direction for transport planning for the next 20 years, providing a framework for transport policy and investment decisions. The draft Master Plan integrates transport with wider economic, infrastructure, social, housing and land use planning including the *Metropolitan Strategy for Sydney 2036*, and the *State Infrastructure Strategy* to provide a coherent overall approach.

The plan does not specifically mention a replacement bridge at Windsor, however the overall objectives of the plan are important to consider in relation to the project (see **Table 3-2**).

Table 3-2 Assessment of the project against the relevant objectives of the Draft NSW Long Term Transport Master Plan

Objective from plan	Relevance to the project
Improve quality of service – by putting the customer at the centre of transport planning and service delivery, improving the quality of travel experiences, offering more travel choices and providing integrated services that directly meet our travel requirements.	The project would result in an improved quality of travel experiences by reducing congestion and providing a safer less stressful driving experience in comparison to the existing situation.
Improve liveability – by shaping our cities and major centres, improving connectivity and customer service, and facilitating ease of movement in our major cities and activity centres.	The project would increase the ease of movement and connectivity between the southern and northern sides of the Hawkesbury River for vehicles, cyclists and pedestrians..
Support economic growth and productivity – by providing a transport system that responds directly to customer needs, is more efficient, increases freight efficiency and improves the connectivity and accessibility of people to other people, opportunities, goods and services.	The project would provide a more efficient and safer link between the agricultural and horticultural businesses north of the Hawkesbury River and the markets, employees and suppliers on the southern side of the Hawkesbury River.
Support regional development – by improving accessibility to jobs, services and people, improving freight connections to markets and providing better links between clusters of business activity.	As the project is located in the Greater Sydney region, there would no direct benefits from the project to regional communities.
Improve safety and security – by placing a high priority on addressing the causes and risks of transport accidents and security incidents.	The project would result in improved safety for pedestrians, cyclists and motorists as the project would be designed to meet modern safety standards and would provide additional facilities to enable pedestrians to safety cross the alignment of the project.
Reduce social disadvantage – by improving access to goods, services and employment and education opportunities for people across all parts of the State.	The project would increase the ease of movement and access to the goods, services and employment for residents north of the Hawkesbury River.
Improve sustainability – by maintaining and optimising the use of the transport network, easing congestion, growing the proportion of travel by sustainable modes such as public transport, walking and cycling, and becoming more energy efficient.	The project would use existing roads and other infrastructure where possible. It would ease traffic congestion during peak periods. The project would also include new pedestrian and cyclist facilities.
Strengthen transport planning processes – by improving integrated transport planning processes, including with land use planning, identifying areas where evidence should be collected for future decision making and continually improving governance and administration of the transport system.	A high growth rate of traffic using the project has been used to account for potential urban development north of the Hawkesbury River.

3.1.4 First things first – A 20 year State Infrastructure Strategy

In October 2012, Infrastructure NSW released *First things first – A 20 year State Infrastructure Strategy* (the Strategy) (Infrastructure NSW, 2012). The Strategy assesses the current state of infrastructure in NSW and the need and strategic priorities for infrastructure for the next 20 years. The Strategy does not specifically mention a replacement bridge at Windsor, however, the Strategy is not required to produce a detailed capital works budget for NSW.

Three guidance principles were defined in the Strategy and the project is assessed against these principles in the table below. Overall the project would meet the guidance principles of the Strategy.

Table 3-3 Assessment of the project against the guidance principles of the State Infrastructure Strategy

Guidance principles	Relevance to project
Incremental improvement Incremental improvement can address infrastructure problems more quickly and cost effectively than one-off major and mega projects, and should be thoroughly considered first to resolve problems. Major projects, if shown to be necessary and cost effective, should be the second option considered. Incremental improvements include operational and economic reforms that increase the utilisation of existing assets.	The project comprises the replacement of an existing asset due to deterioration. The project fits within the existing road network and requires minimal changes, however it is not considered to be an incremental improvement or a major project.
Investing in NSW's strengths The priority is those regions of NSW and sectors of the economy with the highest growth potential, which are constrained by inadequate infrastructure capacity. Speculative infrastructure investment on the promise of creating growth has often led to waste, not regeneration, and should be avoided.	The project is an investment in an important river crossing which is currently constrained by poor capacity. The region north of the Hawkesbury River provides important agricultural and horticultural products to Sydney metropolitan area.
Affordability and fiscal sustainability To be capable of being delivered the Strategy must be affordable and realistic. Rigorous prioritisation of infrastructure investment ensures that the projects and reforms recommended deliver strong positive economic returns to NSW.	The project has a high benefit to cost ratio and is affordable especially in comparison to other river crossing options.

3.1.5 Draft North West Subregional Strategy

The *draft North West Subregional Strategy* (Department of Planning, 2007) is being developed by the NSW Government in consultation with local councils to guide land use planning until 2031 in the Baulkham Hills, Blacktown, Blue Mountains, Hawkesbury and Penrith local government areas. The aims of the strategy include strengthening existing areas with improved accessibility and services, and creation of vibrant and liveable centres where people can live, work and access services.

A draft document has been prepared and was placed on public exhibition for comment from 24 December 2007 to 28 March 2008. Submissions on the draft document have been made by the community, government agencies, the development industry and local councils, and are currently being reviewed. When finalised, the North West Subregional Strategy will be a key planning tool for local councils.

The draft *North West Subregional Strategy* classifies Windsor as a town centre, with a rural outlook and rich colonial heritage. It identifies that the potential for further growth of Windsor is limited due to flooding constraints, however, there remains the opportunity to renew and improve the physical, economic and cultural environment of the centre. It also identifies that there are limited public transport services and links, and the town relies heavily on car and pedestrian activity. There are no specific actions or goals relating to Windsor or to the project, however the goal D1.1.1 - The Roads and Traffic Authority to continue to coordinate road upgrades in existing and growth areas – would be applicable.

The project supports the draft *North West Subregional Strategy* as it aims to maintain an existing, long established road crossing of the Hawkesbury River at Windsor, which is important to both the local Windsor community and wider regional transport network. The township of Windsor is one of the main urban centres in the Hawkesbury local government area (LGA) and supports valuable rural industries in the region. Maintaining the existing road network at Windsor, including providing a safe and efficient road crossing of the Hawkesbury River, is essential to maintaining established transport routes that are important to community lifestyle and the local and regional economy.

3.1.6 The Hawkesbury Residential Land Strategy

The *Hawkesbury Residential Land Strategy* (Hassell, 2011) was developed to guide future residential development within the Hawkesbury LGA over the next 30 years and ensure future residential development is sustainable and meets the needs of the Hawkesbury population. The *Hawkesbury Residential Land Strategy* seeks to:

- Accommodate between 5000 and 6000 additional dwellings by 2031, mainly within the existing urban areas as prescribed in the draft *North West Subregional Strategy* (Department of Planning, 2007).
- Preserve the unique and high quality natural environment of the LGA.
- Accommodate the changing population, which presents new demands in terms of housing, services and access.
- Identify on-going development pressures to expand into natural and rural areas, as well as new development both in and around existing centres.
- Identify physical constraints of flood, native vegetation and bushfire risk.

The *Hawkesbury Residential Land Strategy* nominated areas within the LGA that were suitable for future urban development based on a number of environmental, economic, land use and other criteria.

While the specific development targets of the *Hawkesbury Residential Land Strategy* were not expressly included in traffic growth estimates, the traffic growth due to changes in land use and residential development have been considered on a regional scale using growth rates derived from the Sydney Strategic Transport Model (SSTM). This is the accepted model used for such projections and is supplied by the Bureau of Transport Statistics. The traffic impact assessment for the project indicates that with a 25 per cent growth in traffic using the river crossing at Windsor (see **Section 7.3**), the project would operate at an acceptable level of service.

Also the key directions established in the *Hawkesbury Community Strategic Plan 2010-2030* (Hawkesbury City Council, 2010) guided the development of the Residential Land Strategy including:

- **Looking after people and place** - A community in which the area's character is preserved and lifestyle choices are provided with sustainable, planned, well serviced development, within strongly connected, safe and friendly neighbourhoods.
- **Caring for our environment** - A community dedicated to minimising its environmental footprint, enjoying a clean river and an environment that is nurtured, healthy, protected and provides opportunities for its sustainable use.
- **Linking the Hawkesbury** - A community which is provided with facilities and services efficiently linked by well maintained roads and accessible and integrated transport and communication systems which also connect surrounding regions.
- **Supporting Business and Local Jobs** - New and existing industries, which provide opportunities for a range of local employment and training options, complemented by thriving town centres.
- **Shaping our future together** - An independent, strong and engaged community, with a respected leadership, which provides for the future needs of its people in a sustainable and financially responsible manner.

The project would directly achieve at least two of the key directions, namely Linking the Hawkesbury and Supporting Business and Local Jobs. The design, construction and operation of the project would be undertaken in a manner to achieve the other key directions.

3.1.7 Jacaranda Ponds development – Glossodia

Hawkesbury City Council has given support in July 2012 for the submission of a detailed planning proposal for the rezoning of about 186 hectares of rural land for up to 580 large lot residential and low density residential allotments adjacent to the village of Glossodia. Glossodia is Hawkesbury's second largest urban settlement north of the Hawkesbury River, behind North Richmond and currently has a total of 840 dwellings.

Final planning approval and rezoning of the land is subject to a number of additional studies being undertaken by the proponent and approval from the Department of Planning and Infrastructure. Hawkesbury City Council have also identified a number of conditions relating to traffic that would need to be satisfied before it gave its final support for rezoning. One of these conditions is that there has been satisfactory progress to the replacement of the existing Windsor bridge.

The approval and construction of the project would satisfy one of the conditions that need to be met to allow the Jacaranda Ponds development to proceed with support from the Hawkesbury City Council. The increase in traffic generated by Jacaranda Ponds development while not explicitly included in traffic growth estimates for the project could easily be accommodated by the increased capacity of the replacement bridge.

3.1.8 Plan of Management for the Windsor Foreshore Parks Incorporating the Great River Walk

Plan of Management for the Windsor Foreshore Parks Incorporating the Great River Walk (Hawkesbury City Council, 2009) applies to a series of foreshore open spaces including: Governor Phillip Reserve, Deerubbin Park, Macquarie Park, Howe Park, Holland's Paddock, Thompson Square reserve and Windsor Wharf Reserve located in Windsor within the Hawkesbury City LGA. The parks and reserves covered in this Plan of Management are currently classified as community and operational land under the *Local Government Act 1993* or are Crown Lands under the care, control and management of council for the purpose of public recreation and wharfage.

The lands covered by this plan form part of the route of the Great River Walk. The Great River Walk project is an undertaking to expand the network of regional recreational trails serving the Sydney basin. Ultimately the walk would extend for 570 kilometres along the length of the Hawkesbury Nepean River, from the estuary at Broken Bay to its source in the Southern Highlands and beyond to Canberra.

The incorporation and enhancement of foreshore open spaces within Windsor to provide a linked river trail is the main focus of this plan. The process of linking public open spaces will provide further opportunities for the enhancement of recreation in Windsor both in terms of the overall open space system and of specific parks. The project would directly support this main focus of the plan through the revitalisation of Thompson Square, thereby enhancing this foreshore open space.

The plan identifies key issues which impact the future development of the Great River Walk. A number of these key issues are directly relevant to the project including:

- Bridge Street/George Street intersection – This is a difficult and potentially dangerous road crossing currently preventing safe and fluid pedestrian movements from the Windsor town centre along George Street to Governor Phillip Reserve.
- Access to Macquarie Park from Howe Park path requires two difficult and potentially dangerous road crossings (ie crossing the southern approach road and northern approach road of the existing bridge). The existing timber stair underpass (of existing bridge) is often not used as it is a longer alternative route adding more time to the trip as pedestrians must go down the stairs and then climb another set of stairs.
- Macquarie Park – The foreshore path terminates abruptly here and there is a lack of pedestrian crossing to Windsor bridge.

The project would directly address all of these key issues including:

- Providing traffic signals at the Bridge Street/George Street intersection which would provide safe pedestrian movements from the Windsor town centre along George Street to Governor Phillip Reserve.
- New pedestrian paths and stairs would eliminate the two difficult and potentially dangerous road crossings (southern and northern bridge approach roads) between Macquarie Park and Howe Park.
- A provision would be made to connect the foreshore path from Macquarie Park to the new shared path on the replacement bridge.

The plan also contains management objectives and actions to facilitate the further development of the Great River Walk. There are a number of specific objectives and actions relating to the project and these are presented and assessed in **Table 3-4**.

The plan also presents concept designs for the Thompson Square parkland and other foreshore parks adjacent to the project. Where possible these concept designs would inform any urban and landscape design measures that would be developed as part of the project. Achieving all the objectives and outcomes of these concept designs is beyond the scope of the project, however RMS would continue to work with Hawkesbury City Council, the community and heritage agencies to develop and implement urban design and landscaping outcomes that consider the heritage values and long term uses of Thompson Square.

3.1.9 Hawkesbury Mobility Plan 2010

The Hawkesbury Mobility Plan 2010 consists of a Pedestrian Access Management Plan (PAMP) and a Bike Plan which have a combined objective to "*identify a cohesive strategy for linking residents, particularly residents living in localities with high proportions of vulnerable road users, to the major commercial centres of the city by means of safe and accessible pathways and cycleways"* (GTA Consultants, 2010).

The Bike Plan identifies regional and subregional cycle routes in the LGA and includes a subregional cycleway route from Windsor to Wilberforce which crosses the existing Windsor bridge. The existing Windsor bridge was identified in the plan as a section of on-road cycleway as having inadequate lane and shoulder width for cyclists. It was also identified as a major constraint in improving the safety and continuity of the cycleways to the north of the Hawkesbury River.

The PAMP specifically identified Bridge Street and its intersection with George Street as a major barrier to east-west pedestrian movements and an area with poor pedestrian facilities. One the PAMP's recommendations is to "*investigate redesign of the intersection of Bridge Street and Georges Street (eg. traffic signals) to accommodate greater pedestrian movement. Note the potential future realignment of Windsor Bridge would open up Thompson Square and allow opportunities for improved east-west connection"* (GTA Consultants, 2010).

The project through its improved pedestrian and cyclist facilities around Thompson Square, at the George Street and Bridge Street intersection and across the river would enable a number of the recommendations of the Mobility Plan to be achieved.

Table 3-4 Assessment of the project against directly relevant management objectives and actions from Plan of Management for the Windsor Foreshore Parks Incorporating the Great River Walk

Management objective	Action from Plan of Management	Relevance to the project
The proposed RMS (formerly RTA) Windsor Bridge Replacement project allows for a reinstatement of historic connection between the Hawkesbury water front and Thompson Square	Reinstatement of connection between the Hawkesbury water front and Thompson Square is pursued through Landscape design and sensitivity to the historical role of Thompson Square is carried through any landscape modifications to the area	The project would allow for a reinstatement of the historic connection between the Hawkesbury water front and Thompson Square. Hawkesbury City Council (HCC), heritage agencies and specialists, the community and other stakeholder groups would continue to be consulted on the landscape design for Thompson Square. Refer to **Section 7.4** for details about visual amenity, urban design and landscaping.
Planning and management strategies promote both cohesion and diversity through the overall open space entity	Prepare landscape / improvement plan for Windsor Wharf Reserve to consider: • Improved pedestrian access to The Terrace facilitated through RMS (formerly RTA) bridge replacement project. • Activating use of foreshore spaces for fishing and other activities through reduction of spatial impacts of parking and access. • Integration of RMS (formerly RTA) bridge replacement to Windsor Road. • Optimisation of slope as design feature - eg viewing areas.	HCC and the community would continue to be consulted on landscape and urban design measures for The Terrace, foreshore areas and any areas of Windsor Wharf Reserve impacted by the project to ensure that HCC objectives/actions can be accommodated.
	Prepare landscape / improvement plan for Macquarie Park to consider: • Improved pedestrian access to the town centre facilitated through RMS (formerly RTA) bridge replacement project. • Improved linkage from park to bridge for pedestrians and cyclist. • Extension of park area to east.	HCC and the community would continue to be consulted on landscaping and urban design measures for northern foreshore areas and the pedestrian/cyclist paths to ensure that HCC objectives/actions can be accommodated. With the removal and rehabilitation of the northern approach road to the existing bridge, Macquarie Park would be able to be extended east.
Safe connection of foreshore open spaces for pedestrians/ cyclists	Liaise with RMS (formerly RTA) to establish a signalled crossing at the intersection of Bridge Street and George Street	A signalled crossing at the intersection of Bridge Street and George Street is part of the project.

3.1.10 NSW BikePlan

The *NSW BikePlan* (NSW Government, 2010b) aims to make NSW one of the world's best places to ride a bike. Following the *Metropolitan Transport Plan's* $158 million commitment to improve urban cycle networks, the *NSW BikePlan* details the State's largest cycle program to date. The *NSW BikePlan* outlines how the NSW Government will work in partnership with local councils, communities and businesses to grow bike-riding over ten years.

Through the *NSW BikePlan*, the NSW Government will encourage more and safer cycling, to:

- Increase the share of short trips by bike in Greater Sydney for all travel purposes to five per cent by 2016.
- Double the use of cycling to get to work, across all of NSW, between 2006 and 2016.

While there is no mention specifically of Windsor in the *NSW BikePlan*, the project would meet the objectives of encouraging cycling by:

- Providing an appropriately designed and safe shared three metre wide cyclist/pedestrian path across the Hawkesbury River, at Windsor. The cyclist/pedestrian path across the existing bridge is only one metre wide and is not suitable for cyclists.
- Providing an appropriately designed and safe shared three metre wide cyclist/pedestrian path linking the bridge to Macquarie Park – and provision would be made for Hawkesbury City Council to connect to a future possible northern river bank path.
- Providing cyclist and pedestrian access underneath the replacement bridge along The Terrace – and provision would be made for Hawkesbury City Council to connect to a future possible southern river bank path.

3.1.11 NSW Greenhouse Plan

The *NSW Greenhouse Plan* (The NSW Greenhouse Office, The Cabinet Office of the Government of New South Wales, 2005) was developed to set out actions for the NSW Government to reduce the emissions of its own activities and to work with other stakeholders to reduce the emissions from their activities. The main objectives of this plan are to:

- Increase awareness among those expected to be most affected by the impacts of climate change.
- Begin to develop adaptation strategies to those climate change impacts we cannot avoid.
- Put NSW on track to meeting its targets of limiting 2025 emissions to 2000 levels; and reducing emissions by 60 per cent by 2050.

During the design and construction of the project, opportunities to minimise greenhouse gas emissions would be identified and implemented where practical and cost effective. These are discussed in **Section 8.2**.

The design of the project and this EIS would identify potential climate change impacts and include mitigation strategies to minimise any impacts on the operation and life span of the bridge.

3.1.12 Action for Air

Action for Air 2009 (DECCW, 2010) is an air quality management plan for the Greater Metropolitan Region covering Sydney, the Lower Hunter and the Illawarra. Action for Air focuses on regional air pollution. The strategies address the two pollutants of primary concern: photochemical smog (ground-level ozone); and fine particle pollution. The main sources of air pollution from human activities in the region are emissions from motor vehicles, industry, and commercial and domestic sources.

The project does not directly address any of the actions proposed to improve air quality in the Greater Metropolitan Region. However the project would indirectly meet some of the actions by:

- Providing improved cycling paths in the local area.
- Increasing the efficiency of traffic movements in comparison to the existing bridge. This would result in lower fuel usage and lower vehicle emissions.

3.2 Need for the project

Windsor bridge provides an important link for communities on each side of the Hawkesbury River in the Windsor locality, as well as an important regional link between western Sydney, the Blue Mountains and the Hunter region. Around 19,000 vehicles use the bridge each day, with around seven per cent of these being heavy vehicles. The nearest alternative bridge crossing of the Hawkesbury is located around 10 kilometres away at Richmond, requiring a road detour of around 20 kilometres to drive between the southern and northern sides of the river at Windsor.

There are a number of reasons why a replacement river crossing at Windsor is required including:

- Deterioration in the condition of the existing bridge.
- The existing bridge and approach roads do not meet current engineering and safety standards.
- The existing bridge has a lower flood immunity than the surrounding roads.
- The poor current traffic performance and capacity of the existing bridge and intersections – and the predicted growth in traffic numbers using this river crossing in the future.

These are further discussed below.

3.2.1 Condition of existing bridge

Parts of the existing Windsor bridge are over 130 years old and are deteriorating due to age and heavy use. The bridge is regularly inspected to identify maintenance requirements and ensure safety for use, revealing ongoing and escalating maintenance issues. Technical inspection reports about the condition of the existing bridge are provided in **Appendix C.** Inspections have shown that while the bridge is suitable for current vehicle and pedestrian use:

- Sections of the bridge below the water line are heavily corroded and substantial graphitisation of the cast iron has occurred on some piers. This has resulted in variable pier wall thickness but in places the piers have corroded so much that the wall thickness is very low (less than five millimetres). The average wall thickness from the underwater cores taken to date is about 15 millimetres (CTI, 2011). The original wall thickness was estimated to be about 30 millimetres.
- Horizontal cracking is present in the pier columns, including both columns of the fifth pier from the southern bank. There is also a short vertical crack on the upstream column of the fifth pier from the southern bank, and there are vertical cracks in the brackets securing the upper end of the diagonal bracing to most piers. Such cracks would be expected to have a serious impact on the overall serviceability of the bridge (CDS, May 2011).
- There has been a 16 per cent deterioration in the stiffness of at least one of the bridge spans since 2003. The stiffness of a span determines the load it is able to support – and with deteriorating stiffness – load limits on the bridge may need to be implemented (Access: UTS, 2007).
- Bracing between the older cast iron column sections on three piers are undergoing considerable corrosion at the water-line and may require replacement or repair.
- The bridge deck has a number of issues including:
    - Extensive spalling, leaching, wide cracks and exposed and corroded steel reinforcement at the ends of the deck slab.
    - External beams – have severe spalling and carbonation of concrete, suspect quality of concrete, exposed and corroded steel reinforcement and loss of 50 per cent of beams seating area at the headstocks.
    - Internal beams – have minor spalling and carbonation of concrete, suspect quality of concrete, and loss of 20 per cent of beams seating area at the headstocks.
    - Deck joints – are old and do not allow expansion, have no compression seals and the sealed surfaces at the joints are cracked and bulged.
    - Headstocks - have severe spalling and carbonation of concrete, suspect quality of concrete and cracking.

Overall the condition of the existing bridge is rated as poor and, while the bridge is suitable for current use, would need extensive rehabilitation works if it was to be used and maintained into the future (RTA, 2003 and 2005). Subsequent inspections (including underwater inspections) in 2012 that followed the March 2012 floods have not identified any further significant deterioration of the structure. Also if a new bridge was to be constructed downstream of the existing bridge, retaining the existing bridge would not be possible due to the risks of its failure during a flood event. Debris from the failed bridge may cause physical damage to the piers of a new downstream bridge or may become caught in the new bridge, damming floodwaters and putting unacceptable stresses on the structure of the new bridge.

3.2.2 Engineering and safety standards

In addition to the deterioration of the existing bridge with age, the existing bridge does not meet current engineering and road safety standards including:

- The bridge deck at 6.1 metres wide is less than the recommended width for a two lane bridge. This restricts the movement of heavy vehicles with some drivers electing to wait on one side of the bridge while an oncoming heavy vehicle passes, resulting in traffic delays.
- The standard and condition of the existing bridge also necessitates that heavy vehicle speeds are limited to 40 kilometres per hour. With ongoing deterioration of the bridge, a vehicle load limit would ultimately need to be introduced, which would further restrict commercial traffic and impact travel times and the local economy.
- The pedestrian path on the existing bridge is only one metre wide and is unsuitable for cyclists.
- The traffic and pedestrian safety barriers on the existing bridge do not meet current design standards.

There are also a number of safety issues with the approach roads and intersections including:

- There are no safe crossing locations for pedestrians at the George Street/ Bridge Street intersection and across the northern approach road from the existing bridge pedestrian path to Macquarie Park.
- The sight distances for vehicles at the George Street/ Bridge Street intersection and the Freemans Reach Road and Wilberforce Road intersection do not comply with current safety standards.

3.2.3 Flood immunity

A further limitation of the existing bridge is that it is below the 1 in 2 year flood event level while the surrounding approach roads have a higher level of flood immunity. Over the past 100 years, the existing bridge is thought to have been flooded on 59 occasions, while the approach roads have still been accessible in many of these events.

A new bridge with a flood immunity similar to surrounding roads would provide improved flood evacuation opportunities for floodplain areas north of Windsor and would provide access across the Hawkesbury River for a wider range of flood events.

3.2.4 Traffic capacity

The traffic and transport assessment undertaken for this EIS (see **Section 7.3**) found that:

- The existing intersection of Freemans Reach Road and Wilberforce Road has an unacceptable level of service in the morning peak resulting in substantial queues along both roads.
- While the level of service of the existing roundabout at the George Street/Bridge Street intersection currently has an acceptable level of service, by 2016 the level of service is predicted to be unacceptable due to growth in traffic.

- Traffic numbers are estimated to grow by 25 per cent by 2026, and this would result in even poorer traffic performance of the existing bridge and intersections.

Based upon these outcomes, improved intersections and a higher capacity bridge would be required to provide acceptable traffic performance now and into the future. The traffic and transport assessment also found that a new two lane bridge and improved intersections would initially be able to convey traffic with an acceptable level of service. However, in the future when traffic numbers have increased, a three lane bridge (two lanes southbound and one lane northbound) would be required to convey traffic with an acceptable level of service.

3.3 Economic analysis

Economic analysis assists decision-makers to understand the economic worth of a project in monetary terms. It helps determine what is 'value for money' and allows the economic worth of a particular initiative to be considered in the context of other potential benefits and impacts. A favourable economic analysis often forms a key element of the project justification.

An economic analysis was undertaken for the project (SKM, 2012d). The analysis quantified the costs and benefits of the project in dollar terms and provided a benefit-cost ratio (BCR) as an indicator of its economic performance. The following economic costs and benefits were considered:

- Capital expenditure.
- Incremental operating costs.
- Travel time savings.
- Vehicle operating costs.
- Safety impacts.
- Externalities.

The economic analysis returned a high BCR of 14.6 and concluded that the project would create benefits that would be realised by the general community and would outweigh the initial upfront construction and ongoing operational costs. Key findings included:

- Travel time benefits accrued from improved travel speeds due to the removal of speed restrictions and proposed improvements to the existing curvature, grade.
- Reduced vehicle operating costs due to improved road conditions and the increase in average vehicle speed compared the base case.
- Annual crash savings due to proposed safety measures and the change in vehicle kilometres travelled.
- Decreases in externality costs compared to the base case.

Economic analysis undertaken as part of the options evaluation for the project (RMS, 2011) yielded a BCR lower than the current value (SKM, 2012d). This difference is due to the adoption of different base case assumptions around traffic flow and the inclusion of a number of additional economic factors in the recent analysis, such as vehicle operating costs, externalities and safety impacts.

This resulted in BCR values for different options increasing proportionally (approximately) but still providing a consistent comparison between those options. The BCR values calculated in 2012 for options 1 and 6 are outlined in Section 4.2.2.

A summary of the economic analysis for the project is provided in **Table 3-5** below.

Table 3-5 Economic analysis results

Attribute	Present Value [#]
Costs	
Capital costs	$ 46.36 million[##]
Maintenance costs	-$ 0.26 million
Total costs	$ 46.10 million
Benefits	
Travel time savings	$ 548.80 million
Vehicle operating cost savings	$ 118.95 million
External savings	$ 0.58 million
Safety savings	$ 3.70 million
Total benefits	$ 672.03 million
Benefit cost ratio (BCR)	**14.6**
Net present value (NPV)	**$ 625.93 million**

Using seven per cent real discount rate
Based on a total nominal capital cost of $50.4 million

3.4 Project objectives

The primary aim of the project is to provide a safe and reliable crossing of the Hawkesbury River at Windsor. Specific objectives for the project are:

- To improve safety for motorists, pedestrians and cyclists.
- To improve traffic and transport efficiency.
- To improve the level of flood immunity.
- To meet long term community needs.
- To minimise the impact on heritage and the character of the local area.
- To be a cost effective and an affordable outcome.

These project objectives have been expanded to include specific criteria for each objective. Options considered and the preferred option are assessed against the project objectives and criteria in **Chapter 4**.

3.5 Statement of strategic need and justification

If the existing bridge is not replaced, its structural condition would continue to deteriorate with age. This would lead to increasing maintenance costs and imposing a load limit in the short term and ultimately closure of the bridge in the long term when ongoing maintenance can no longer provide an adequate level of traffic safety. This would result in the loss of an important bridge crossing of the Hawkesbury River, with impacts on local and regional connectivity. Existing bridge users would need to use alternative river crossing points, resulting in increased travel times and adverse effects on the local economy of Windsor.

Also the existing bridge and intersections would not be able the cope with the predicted growth in traffic numbers using this river crossing. Currently the intersection of Freemans Reach Road and Wilberforce Road has an unacceptable level of service in the morning peak and the intersection at George Street and Bridge Street is predicted to operate at an unacceptable level of service by 2016.

In addition to its poor and deteriorating condition, the existing bridge has a number of other issues that support the need for a new bridge including:

- The bridge design and approach roads do not meet current road design and safety standards.
- The condition and design of the existing bridge places limits on heavy vehicle use, with a 40 kilometre per hour speed limit and restrictions in use due to the narrow lane widths.
- The existing bridge has a lower flood immunity than the surrounding approach roads.

A new bridge across the Hawkesbury River at Windsor is an important and essential project for the local and regional community. This option would comply with the strategic development plans and policies for the State, region and LGA as it would:

- Maintain important infrastructure while improving transport and safety.
- Provide a continuing essential regional and local road link across the Hawkesbury River at Windsor for commercial, tourist and residential traffic.
- Support predicted growth in traffic numbers using the river crossing.
- Address many of the key constraints to the development of the Great River Walk in Windsor and meet recommendation of the Hawkesbury Mobility Plan 2010 (GTA Consultants, 2010).

In providing a new bridge, the deficiencies of the existing bridge crossing of the Hawkesbury River at Windsor would be addressed and additional strategic objectives such as those detailed in **Section 3.4** would be achieved. The options for providing a new bridge at Windsor are discussed in the following chapter.

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4 Project development and alternatives

This chapter describes the various alternatives and options for the project that were considered during the project development process. It explains how and why the preferred option was selected and describes the different route, bridge, approach road, intersection and Thompson Square urban design options considered.

Director General's requirements	Where addressed
An analysis of feasible alternatives to the carrying out of the project and project justification, including: An analysis of alternatives/options considered having regard to the project objectives (including an assessment of the environmental costs and benefits of the project relative to alternatives and the consequences of not carrying out the project), and the provision of a clear discussion of the route development and selection process, the suitability of the chosen alignment and whether or not the project is in the public interest.	Chapter 4 – Describes the alternatives considered. Chapters 3 and 11 – Provide the justification for the project.

4.1 Options development and selection process

This section presents a summary of the process followed to develop, assess and select options for various components of the project including:

- The route (or alignment) of the replacement bridge.
- The approach roads and intersections.
- The bridge type.
- The design of Thompson Square.

It also provides information on when input on the options was sought from community, stakeholder groups and government agencies during the process. An integrated design approach was taken for the development of the project, involving engineers, urban designers and architects working collaboratively with environmental and heritage specialists. This approach complemented the input process from external stakeholder groups. The environmental sensitivities and constraints of Windsor and its surrounding areas have been taken into account in the design development process, with adverse impacts avoided or minimised in design to the greatest extent practicable.

Detailed information on the specific options for each of the project components is presented in **Section 4.2** to **Section 4.6**.

Project development and options assessment was staged and is summarised in **Section 4.1.1** to **Section 4.1.5**) provide more detail on each of the stages.

The stages of project development were:

- *Stage 1* - Identification of alternatives for a river crossing at Windsor and development of route options and project objectives.
- *Stage 2* - Short-listing of route options and further investigation and assessment against project objectives and criteria.
- *Stage 3* - Selection of a preferred route option.
- *Stage 4* - Development, assessment and selection of options for the existing Windsor bridge.
- *Stage 5* - Development, assessment and selection of options for the approach roads and intersection types.
- *Stage 6* - Development, assessment and selection of options for the bridge type.
- *Stage 7* - Development, assessment and selection of options for the urban design of Thompson Square and the shared pathway.

4.1.1 Development of alternatives and options for a river crossing at Windsor

In recognition of the need to address the deteriorating condition of the existing Windsor bridge, the NSW Government announced in June 2008 that it would provide funding to rehabilitate or replace this important river crossing. Four alternatives were identified 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.

The do nothing alternative was not investigated further as it was not considered feasible because of the high costs associated with maintaining the existing bridge, the high vehicle usage and its inherent safety and flood immunity design issues. In the short to medium term, the existing bridge would further deteriorate resulting in load limits for heavy vehicles to be imposed – and eventually either total closure of the bridge to all vehicles or failure of the bridge in a flood event. Also any growth in traffic would result in further congestion and capacity issues.

The ten options considered are listed in **Table 4-1** and shown in **Figure 4-1**. Further information on each of the options is provided in **Section 4.3**.

A detailed options assessment report was prepared by RMS (RTA, 2011), 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 option 9 – Refurbishment of the existing bridge as its preferred option. Their second preferences were the bypass options of Windsor (options 6 and 8). 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.

4.1.2 Assessment of short-listed route options against project objectives

From the original six project objectives, additional criteria (as identified in Chapter 3, **Section 3.4**) were developed by RMS to provide a more comprehensive assessment of short-listed options. A comparison of each of the short-listed options against the original project objectives and criteria is provided in **Table 4-2**. The 'base case' or 'do-nothing' alternative was also assessed for comparative purposes only. The base case would include the current schedule of maintenance works required to address on-going structural deterioration of the existing bridge. Further detail on the consequences of the base case is provided in **Section 3.2**.

As shown in **Table 4-2,** option 1 performed well in terms of safety, flood immunity and long term community needs. It would increase the area of consolidated open space within Thompson Square, provide an opportunity to reinstate the typical Macquarie era grid street layout and improve the relationship between open space and the river. Option 1 also offered the best value for money. However option 1 would have a significant impact on historic heritage as it would directly impact the Thompson Square Conservation Area and remnants of the 19th century Windsor wharf. It would also have considerable visual impact from within and outside Thompson Square.

Option 2 had similar benefits to option 1, however, it would not provide an improvement in flood immunity. It would also have a significant impact on historic heritage as it would directly impact the Thompson Square Conservation Area and remnants of the 19th century Windsor wharf and have considerable visual impact from within and outside Thompson Square.

Option 6 performed well in terms of safety, traffic and transport efficiency. Option 6 would not affect the Thompson Square Conservation Area, however would have visual impacts upon other heritage items such as the Tebbutt's Peninsula House group and the Observatory. Option 6 performed poorly, however, in terms of amenity impacts on previously unaffected residential areas, increased flooding risks, and would have amenity and recreational impacts on Governor Phillip Park. The cost of option 6 was substantially higher than the other options as two bridges and a longer length of approach roads would be required.

4.1.3 Selection of the preferred route option

The selection of the preferred option by RMS was based on consideration of transport needs, heritage impacts, environmental impacts and engineering and cost constraints. The decision on the preferred option was made by considering:

- The performance of each option against the project objectives.
- The relative advantages and disadvantages of each option.
- Information on the potential impact of each option, including biophysical, heritage, community and socio-economic impacts.
- Community and government agency issues, as identified in community and agency consultation.

Option 1 (new high-level downstream bridge) was identified by RMS as the preferred option for the project. This option was found to perform best in terms of value for money and would perform well in relation to most of the project objectives (refer to **Table 4-2**).

While RMS selected option 1 as the preferred option for the replacement bridge it was recognised that there is significant opposition to this option within parts of the community (eg. Community Action for Windsor Bridge) and the Heritage Council of NSW. This opposition was due to its potential impacts on the heritage values of the Thompson Square Conservation Area and the heritage character of Windsor. While the Heritage Council of NSW and parts of the community support a bypass such as option 6, other sections of the community and the Hawkesbury City Council support option 1.

To minimise the potential heritage impacts of option 1 and to develop urban design and landuse outcomes that minimise amenity impacts and provide opportunities for use of this historic precinct, RMS undertook further refinement of the preferred option including:

- Identifying a bridge type that can be designed to minimise visual impacts and is sympathetic to the historic vistas.
- Reducing the bulk and height of the bridge and approach roads as much as possible while still retaining its functionality.
- Reducing the amount of land required in Thompson Square for the bridge and approach roads.
- Developing urban design and landuse principles and plans to minimise amenity impacts and provide opportunities for future uses of Thompson Square in conjunction with key stakeholders.

Further consultation was undertaken with the Heritage Council of NSW in 2010 on option 1. While the Heritage Council of NSW reinforced its preference for a bypass option, it identified design and mitigation measures which would need to be considered in further development of option 1. These measures were further reiterated in consultation undertaken in 2011 and included (Heritage Council of NSW letters dated 9 September 2011 and 28 October 2011):

- Urban design input, detailed design review and further heritage advice must be obtained which will allow modifications to be explored that would lower the intervention and impacts on Thompson Square'.
- Consideration should be given to reduction of the overall bulk and scale of the road embankments and increasing the permeability of the structure to prevent the imposition of a solid barrier across Thompson Square.'
- Comprehensive archaeological investigations' to identify the potential archaeological resource to identify impacts and inform detailed design'.
- Specific heritage impacts arising from construction and operation of option 1 as a result of vibration, demolition, archaeological disturbance, altered historical arrangements and access, changes to the landscape and vistas and architectural noise treatment of buildings on the State Heritage Register require assessment.

The Heritage Council of NSW concerns and requirements have been used to guide the further development of design and environmental impact assessment of the project. The design requirements are further discussed in the following sections, which included urban designers, architects and heritage specialists working collaboratively to assist the design process.

The NSW Office of Environment and Heritage (OEH) were also consulted in 2011 on potential impacts of option 1 on Aboriginal heritage and they noted that:

- The project is located "within a highly sensitive archaeological landscape feature with the potential to contain some of the oldest surviving evidence of Aboriginal life along the Hawkesbury River and in NSW" (OEH letter dated 31/10/11).
- "The alluvial terrace in the location of the proposed bridge is therefore of potentially very high [Aboriginal cultural heritage] significance" (OEH letter dated 31/10/11).

These OEH comments were reflected in the Director General's requirements for the project and have been addressed in the Aboriginal heritage impact assessment for this EIS (see **Section 7.2**).

4.1.4 Development, assessment and selection of options for the existing Windsor bridge

The existing Windsor bridge is listed on the RMS Heritage and Conservation Register as an item of State significance and has been in use for over 130 years since opening in 1874. Both community and other stakeholders such as the Heritage Council of NSW have sought for the existing bridge to be retained for pedestrians and cyclists if the refurbishment option was not the preferred option. The alternative option to retaining the existing bridge would be to demolish it. The advantages of retaining the existing bridge would include:

- Retaining a Section 170 RMS Heritage and Conservation Register listed heritage item which forms part of the heritage vistas and values of Windsor.
- Proving an additional pedestrian and cyclist link between Windsor township and Macquarie Park.

The disadvantages of retaining the existing bridge would include:

- Substantial ongoing and escalating maintenance costs as the bridge further deteriorates. While the removal of vehicles from the bridge may reduce maintenance costs in the short term, in the longer term these would be substantial as the piers and steel reinforcing in the concrete corrodes further.
- Risk to the replacement bridge if the existing bridge fails in a flood event. A failure may result in sections of the existing bridge being washed downstream causing direct physical damage to the replacement bridge. Debris from the failed bridge may also lodge underneath the replacement bridge, impeding floodwaters and causing stresses that the replacement bridge may not be designed to handle. Both scenarios could result in substantial damage to or failure of the replacement bridge.
- Increased flooding upstream of the bridges. Preliminary modelling indicates that two bridges would result in increased flooding upstream especially for floods up to the 1 in 5 year flood event. This would result in increased property damage and costs for flood mitigation works.

Hawkesbury City Council were also consulted on retaining the existing bridge and indicated that they do not want to own or maintain the existing bridge.

Based on the advantages and disadvantages of retaining the bridge, RMS decided that it was not feasible to retain the existing bridge especially due to the risk of damage to the replacement bridge and upstream flooding impacts. Therefore the preferred option for the existing bridge would be to demolish it once the new bridge is complete.

4.1.5 Development, assessment and selection of options for the approach roads and intersection types

A series of design workshops were held to further refine the design of approach roads and intersections. Attendees at these workshops included bridge and road engineers, environmental planners, heritage architects, heritage advisers, urban designers and RMS personnel. One of the key outcomes in relation to the approach roads was a reduction in the design speed from 60 kilometres per hour to 50 kilometres per hour which allowed the bridge height to be decreased, reducing its visual impact.

A number of different intersection types and lane configurations were assessed for existing and future traffic scenarios including:

- For the northern intersection:
  - Traffic lights.
  - Single lane roundabout.
  - Dual lane roundabout.
- For the southern intersection:
  - Maintain the existing roundabout.
  - Traffic lights.

The conclusions of the additional traffic modelling were that for the northern intersection a dual lane roundabout was the preferred intersection type and for the southern intersection, traffic lights were identified as the preferred option.

4.1.6 Options development, assessment and selection of a bridge type

Potential options for the bridge form were examined through a series of project team workshops and design reviews. A “Bridge Form Alternatives” report (SKM, 2012a) was produced, detailing the types of bridges considered and their advantages and disadvantages relative to key design criteria. Apart from the standard bridge design criteria relating to functionality, capacity and durability, there were a number of additional key criteria considered in comparing and assessing the bridge form options. These criteria included the ability to withstand immersion by flood waters, visual appearance, cost, construction impacts on Thompson Square, number of piers and other environmental risks and design issues.

The eight bridge form options that were considered for the replacement bridge included:

- Precast concrete plank with composite cast in situ concrete deck bridge.
- Incrementally launched bridge.
- Cast in situ balanced cantilever bridge.
- Arch bridge (with arch under the deck).
- Arch bridge (with arch above the deck).
- Truss bridge.
- Cable stayed bridge.
- Concrete cast in situ bridge.

To assist with the selection of the preferred bridge form, a Bridge Options Review Workshop was held in January 2012. The workshop involved assessing and scoring the alternative bridge form options in terms of environmental and technical criteria (See **Table 4-3**). Workshop participants included bridge and road engineers, environmental planners, heritage architects, heritage advisers, urban designers and RMS personnel. Input from the community focus group established for the project and the NSW Government Architect and an independent third party architect was also sought before making a decision on the preferred bridge option.

Based on the combined outcomes of the Bridge Options Review Workshop and input from the community focus group, the incrementally launched bridge was found to be the preferred bridge form. Key factors in the selection of this bridge form included its:

- Lower visual impact and ability to be architecturally enhanced.
- Relatively small number of piers in comparison to some of the other options.
- Ability to be constructed and launched from the northern bank, which would minimise construction impacts on Thompson Square.

4.1.7 Development, assessment and selection of options for the urban design of Thompson Square

Urban design principles were developed to guide the design process for the bridge replacement project, including Thompson Square. A series of options for the Thompson Square parkland were developed based on these principles. The options were primarily based upon around the location of paths and stairways to provide access to and around the Thompson Square parkland as well as the shared pathway across the replacement bridge.

The project team met with Hawkesbury City Council officers in March 2012 to present and discuss the possible options for the Thompson Square parkland. Feedback from Hawkesbury City Council on 3 April 2012 was incorporated into the Thompson Square options assessment. Input was also sought from the community focus group on the different options.

Based upon the community group and Hawkesbury City Council feedback, a preferred option was selected. This consisted of a shared path along the western side of the replacement bridge and two sets of stairways on either side of the Thompson Square parkland to link new and existing paths to The Terrace.

4.2 Route options development

4.2.1 Overview of route options

In July 2009 RMS identified ten potential options for a river crossing at Windsor: two options involving the refurbishment of the existing bridge, two options involving a bypass of Windsor and six for a new replacement bridge. The ten options are listed in **Table 4-1** and shown in **Figure 4-1**. Further information on each of the alternatives is provided in **Section 4.2.2**. The other option would be the ‘do nothing’ or ‘base case’ option, however as discussed in Chapter 3 this was not considered a feasible option due to the poor and deteriorating condition of the existing bridge and its critical function in providing a crossing of the Hawkesbury River at Windsor.

Table 4-1 Route options considered

Option	Route option type	Name
Option 1	New bridge	New downstream high-level bridge via Old Bridge Street, Windsor
Option 2	New bridge	New downstream low-level bridge via Old Bridge Street, Windsor
Option 3	New bridge	New bridge immediately upstream of existing bridge
Option 4	New bridge	New bridge at Baker Street, Windsor
Option 5	New bridge	New bridge at Kable Street, Windsor
Option 6	Bypass	New bridge parallel to Palmer Street, Windsor and new bridge over South Creek
Option 7	New bridge	New bridge at Palmer Street, Windsor via Court Street and North Street
Option 8	Bypass	New bridge at Pitt Town Bottoms
Option 9A	Refurbishment	Refurbishment of existing bridge to provide a 2 lane crossing
Option 9B	Refurbishment	Refurbishment of existing bridge to provide a 3 lane crossing

Apart from the refurbishment options, all other options included removing the existing bridge as the costs to repair and maintain the existing bridge would be substantial even if its use was limited to pedestrians and cyclists only. Even if repaired, the existing bridge would still have a limited lifespan due to the considerable corrosion of the iron piers below the water line and the spalling of the bridge girders. Additionally if the existing bridge failed during a flood event it may cause physical damage to a new downstream bridge or to other downstream structures such as Windsor wharf. Debris from the failed existing bridge might also be captured by a new downstream bridge, impeding floodwaters and causing stresses that result in the failure of the new bridge.

4.2.2 Description of the route options and performance against objectives

This section describes each of the ten options considered for the river crossing at Windsor, including a broad assessment against the project objectives and criteria (as defined in **Section 3.4**). The route options considered are shown in **Figure 4-1**.

Option 1 – New downstream high-level bridge via Old Bridge Street

Option 1 involves replacing the existing bridge with a new high-level bridge along the alignment of Old Bridge Street, around 35 metres downstream of the existing bridge. The southern approach to the new bridge would be via the existing alignment of Old Bridge Street on the eastern side of the Thompson Square parkland, with the existing roundabout at George Street retained in the short-term and converted to traffic lights in the future. On the northern bank of the river, a new approach road would be constructed to connect the new bridge with the existing intersection of Freemans Reach Road and Wilberforce Road. A new intersection would be constructed to manage traffic at this busy location.

Option 1 meets many of the project objectives and criteria including:

- Flood immunity – This option would provide an improved and appropriate level of flood immunity in consideration of the surrounding road network.
- Pedestrian and cyclist connections – Better and safer connections to Macquarie Park and The Terrace for pedestrian and cyclist access would be provided with this option.
- Efficient connection for local traffic - The option would provide the most direct route from Windsor Road to Freemans Reach Road via the existing road corridor and maintain direct access into the Windsor township.
- Land acquisition – The amount of land acquired for option 1 would be low in comparison to other options.
- Cost and return on investment – This option would have a low cost in comparison to other replacement options and a higher benefit cost ratio (BCR greater than 14) in comparison to option 6 (BCR about eight).

The project objectives and criteria that option 1 performs poorly against would be minimising impacts on heritage and the character of the local area. Option 1 would have a significant impact on historic heritage as it would directly impact the Thompson Square Conservation Area and remnants of the 19th century Windsor wharf. It would also have substantial visual impacts within Thompson Square and for views to and from Windsor along the Hawkesbury River.

While some heritage impacts would be unavoidable, this option would also provide an opportunity to increase the area of Thompson Square parkland and connections to surrounding areas. Specifically, by removing the existing bridge approach road that runs through the Thompson Square parkland, it would consolidate the currently divided open space and improve pedestrian connections to the river. This increase and reconfiguration of the open space, in conjunction with the urban design and landscaping treatments and heritage management measures described in this EIS, would provide an opportunity to increase the area for public use and address the heritage values of the area.

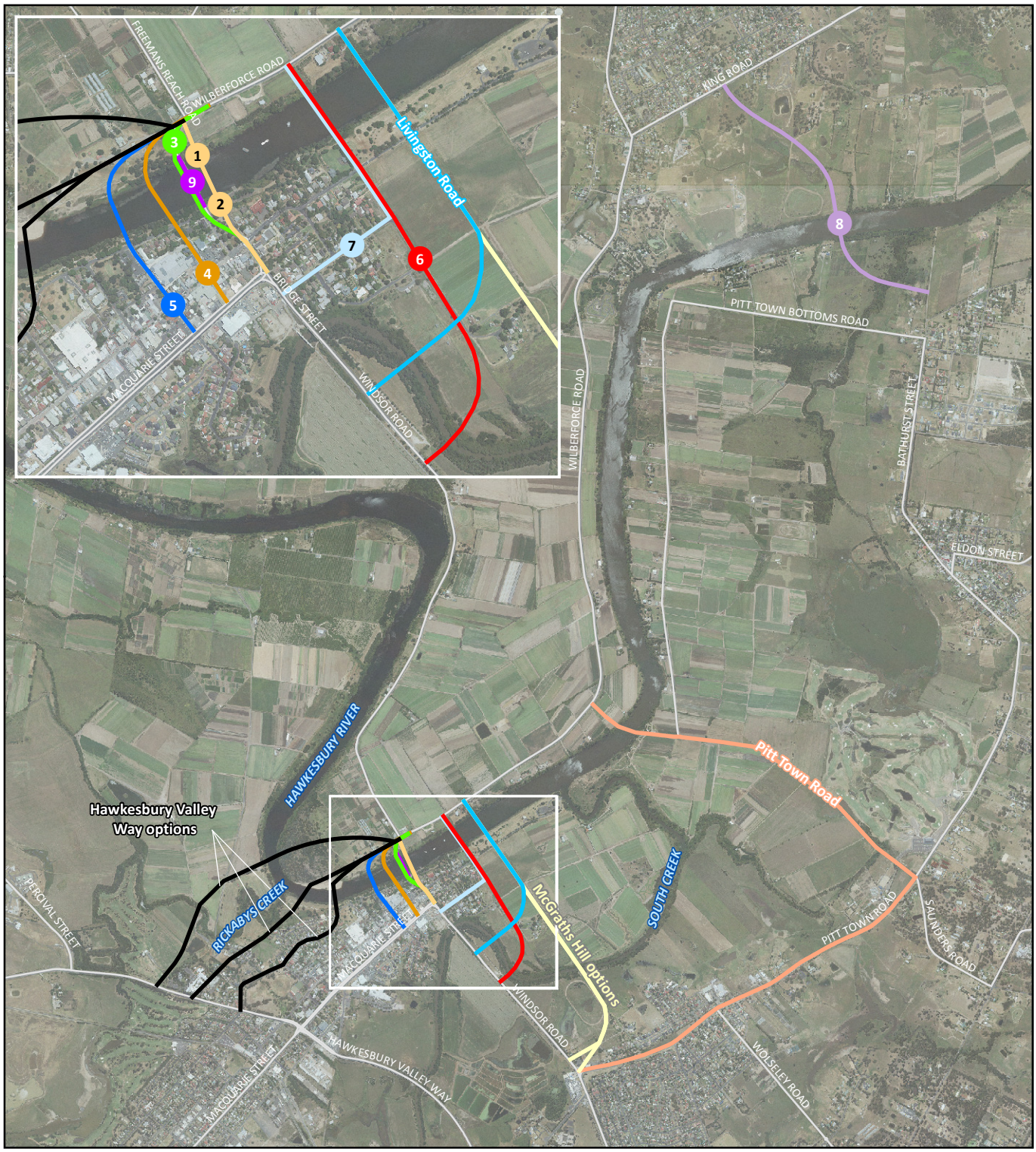
Option 2 – New downstream low-level bridge via Old Bridge Street

As for option 1, option 2 would involve providing a replacement bridge along the alignment of Old Bridge Street, around 35 metres downstream of the existing bridge. The primary difference between option 1 and 2 would be in the height of the replacement bridge, with option 2 involving a low-level bridge in contrast to the high-level bridge of option 1.

This option would be similar to option 1 in terms of meeting project objectives and criteria, with a couple of notable differences. Direct impacts on heritage would be similar to option 1, although the low-level bridge would have a lesser visual impact on the overall heritage character of the Windsor township. However the low-level of the bridge would not have flood immunity to match the flood immunity of the approach roads and hence would not provide any improvement in access during minor flood events. Additionally, this option prevents an extension of The Terrace under the new bridge to allow access of vehicles to Windsor Wharf.

The need to provide a crossing that matches the flood immunity of the surrounding roads is one of the project objectives and the failure of option 2 to meet this objective is a disadvantage.

Figure 4-1 | Windsor Bridge replacement options



Indicative only – subject to detailed design

LEGEND

Bridge replacement options

RMS options

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9

Community options

- Hawkesbury Valley Way options
- Livingston Road
- McGraths Hill options
- Pitt Town Road

Major road

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Option 3 – New bridge immediately upstream of existing bridge

Option 3 would replace the existing bridge with a new bridge that primarily follows the existing alignment of Bridge Street through Thompson Square, around 10 metres upstream of the existing bridge. This option would maintain the existing roundabout at George Street and the current alignment of Bridge Street. It would create a curved bridge that meets the existing alignment of Wilberforce Road. Advantages of option 3 with respect to the project objectives include:

- Pedestrian and cyclist connections – Better and safer connections to Macquarie Park and The Terrace for pedestrian and cyclist access would be provided with this option.
- Efficient connection for local traffic - The option would provide a direct route from Windsor Road to Freemans Reach Road via the existing road corridor and maintain direct access into the Windsor township.
- Land acquisition – The amount of land acquired for option 3 would be low in comparison to other options.
- Cost and return on investment – This option would have one of the lowest costs, and higher return on investment, although it would cost more than option 1 and would have a lower benefit cost ratio.

While option 3 meets many of the project objectives and criteria, it would create significant disruptions to traffic and the community during construction due to the proximity of the replacement bridge to the existing bridge. These disruptions would potentially include closing the existing bridge for up to three months during construction of the new bridge, which would require traffic to be diverted to the Richmond Bridge (about a 20 kilometre road detour). Option 3 would have higher impacts on the heritage values of the Thompson Square Conservation Area compared to options 1 and 2 as it would encroach on the Doctors House as well as having similar visual impacts on historic vistas. Unlike option 1 and 2, option 3 would not provide the opportunity to improve Thompson Square parkland by uniting the currently bisected parkland.

Option 4 – New bridge at Baker Street

Option 4 involves replacing the existing bridge with a new bridge along the alignment of Baker Street, Windsor. The new bridge would be around 70 metres upstream of the existing bridge and would connect Baker Street to existing roads in Macquarie Park on the northern bank of the Hawkesbury River. Advantages of this option with respect to the project objectives include:

- Providing improved bridge flood immunity.
- Improving pedestrian and cyclist access and safety across the bridge to Macquarie Park.

However it would not meet many of the other project objectives and criteria such as:

- Traffic and transport efficiency – The high volumes of traffic using the bridge would need to use Baker Street and cross George Street to access Macquarie Road. This would cause local congestion and poor traffic performance.
- Meeting long-term community needs - The high volumes of traffic using Baker Street would have negative impacts on the business and shopping environment, background noise levels and pedestrian safety. There would also be the loss of recreational space in Macquarie Park and additional land may need to be acquired along Baker Street.
- Impact on the heritage and character of the local area – Baker Street contains heritage listed buildings and the heritage vista of this relatively quiet street would be negatively impacted.
- Cost effectiveness and affordable – This option would be more expensive than some other options due to land acquisition and longer approach roads.

This option would split the town centre in half resulting in a high severance impact.

Option 5 – New bridge at Kable Street

Option 5 is similar to option 4 and involves replacing the existing bridge with a new bridge along the alignment of Kable Street, Windsor. The new bridge would be around 170 metres upstream of the existing bridge and would connect to existing roads in Macquarie Park on the northern bank.

As for option 4, option 5 would meet some of the project objectives (including providing improved bridge flood immunity and improved pedestrian access and safety across the bridge) but it would score poorly against many of the other project objectives and criteria such as:

- Traffic and transport efficiency – The high volumes of traffic using the bridge would need to use Kable Street and cross George Street to access Macquarie Road. This would cause local congestion and poor traffic performance.
- Meeting long-term community needs - The high volumes of traffic using Kable Street would have negative impacts on the business and shopping environment, background noise levels and pedestrian safety. There would also be the loss of recreational space in Macquarie Park.
- Impact on the heritage and character of the local area – Kable Street contains heritage listed buildings and the heritage vista of this relatively quiet street would be negatively impacted.
- Cost effectiveness and affordable – This option would be more expensive than some other options due to land acquisition and longer approach roads.

This option would split the town centre in half resulting in a high severance impact.

Option 6 – New bridge parallel to Palmer Street and new bridge over South Creek

Option 6 would involve replacing the existing bridge with a new bridge around 400 metres downstream of the existing bridge. Option 6 would include a new signalised T-intersection on Windsor Road north of Pitt Town Road, a bridge over South Creek, a 1.2 kilometre road parallel to Palmer Street and through Governor Phillip Park, a new bridge over the Hawkesbury River and a new T-intersection on Wilberforce Road. This option would meet many of the project objectives and criteria including:

- Providing improved bridge flood immunity.
- Improved traffic and transport efficiency – It would provide an efficient regional traffic connection with minimal delays and queues.
- Protecting the built heritage of the town and its setting – through avoiding heritage impacts on Thompson Square Conservation Area and surrounding heritage buildings.
- Minimising property access impacts – There would be no properties which would experience a deterioration in permanent access.

While this option meets many project objectives, it would not achieve other project objectives and criteria such as:

- Cost effective and affordable outcomes – This would be one of the most expensive options with a capital cost of about double that of options 1 and 2. It would far exceed the budget allocated to the project and the cost of the option does not provide value for money in comparison to other options despite the positive aspects associated with this option.
- Noise impacts – While there would be a reduction in noise impacts on the already exposed sensitive receivers around Thompson Square, there would be new noise and amenity impacts on residents living near Palmer Street, who are not currently exposed to noise from busy roads.
- Local traffic access – The efficiency of local traffic connections to the township of Windsor would be reduced.
- Impacts on recreational areas – The recreational amenity of Governor Philip Park would be impacted and there may be impacts on boating activities that are held regularly in the waters directly adjacent to Governor Philip Park. Access to Windsor Wharf by larger boats would be affected due to the height restrictions of the downstream bridge.
- Impacts on Aboriginal and historic heritage - This option was not preferred by Aboriginal stakeholders due to its potential impact on cultural and archaeological sites. However it should be noted that no detailed studies on potentially impacted sites have been undertaken. There would also be a number of heritage listed buildings potentially impacted such as the Tebbutt's Peninsula House group and the Observatory.

Option 6 would have a negative impact on residents who live along the route of the new bridge approach road and have chosen their location of residence on the basis that it is not on a busy road. The lifestyles of these residents have the potential to be impacted by the construction and operation of the new road.

Option 7 – New bridge at Palmer Street via Court Street and North Street

Option 7 would involve replacing the existing bridge with a new bridge at the end of Palmer Street. Traffic would access Palmer Street and the new bridge via Court and North Streets. A new signalised intersection would be installed at the corner of Windsor Road and North/Court Street, establishing the southern approach route to the bridge and a new T-intersection would be installed where the bridge connects to Wilberforce Road. This option would meet some of the project objectives and criteria including:

- Providing improved bridge flood immunity.
- Protecting the built heritage of the town and its setting – through avoiding heritage impacts on Thompson Square and surrounding heritage buildings.

While this option meets a number of the project objectives, it would not achieve other project objectives and criteria such as:

- Increased noise impacts – While there would be a reduction in noise impacts on the already exposed sensitive receivers around Thompson Square, there would be new noise and amenity impacts on residents living along Palmer, Court and North Streets, who are not currently exposed to busy roads.
- Reduction in local traffic access – The efficiency of local traffic connections to the township of Windsor would be reduced.
- Impacts on recreational areas – Recreational amenity of Governor Philip Park would be impacted and there may be impacts on boating activities that are held regularly in the waters directly adjacent to Governor Philip Park. Access to Windsor Wharf by larger boats would be affected due to the height restrictions of the downstream bridge.
- Impacts on Aboriginal and historic heritage - This option was not preferred by Aboriginal stakeholders due to its potential impact on cultural and archaeological sites. However it should be noted that no detailed studies on potentially impacted sites have been undertaken. There would also be heritage impacts, in particular on the North Street Conservation Area and Court House. These may include direct impacts from construction activities (eg. vibration, road widening) and amenity impacts from the operation and visual appearance of the road.

Option 8 – New bridge at Pitt Town Bottoms

Option 8 would involve replacing the existing bridge with a new bridge located at Pitt Town Bottoms and connecting to Wilberforce, around six kilometres downstream of the existing bridge. There would be no bridge crossing of the Hawkesbury River at Windsor if this option was implemented.

From the southern approach, traffic would be diverted down Pitt Town Road at the intersection with Windsor Road and would travel along Pitt Town Road onto Bathurst Street and Punt Road. A new viaduct or low embankment would be provided to extend Punt Road across Bardenarang Creek and the adjacent Hawkesbury River floodplain. On the northern bank of the Hawkesbury River, the bridge would intersect with King Road at a T-intersection. Traffic would turn left (westbound) into King Road and intersect with Wilberforce/Singleton Road at the existing T-intersection at Wilberforce. The new bridge would not provide pedestrian access given the isolation of the crossing from populated areas.

Option 8 meets some of the project objectives and criteria, including providing improved bridge flood immunity and minimising impacts on historic heritage in Windsor. This option does not meet some key project objectives and criteria including:

- Providing an efficient connection for local traffic – This option would remove the historical direct link between the southern and northern sides of the river at Windsor and result in a nine kilometre detour of the Windsor township. This would have adverse effects on local residents and businesses, as well as significantly changing the character of Windsor.
- Impacts on recreational areas - Establishment of new in-water structures (bridge pylons) in a part of the river used extensively by recreational boaters for high-speed water skiing activities.
- Impact on heritage – heritage vistas and historic heritage items in the Pitt Town area would be impacted. The location also has significance as a place of contact between the Aboriginal community and European explorers.
- Cost effective and affordable outcomes – This would be the most expensive option with a capital cost of about three times that of options 1 and 2. It would far exceed the budget allocated to the project and would not provide value for money.

Option 9A & 9B – Refurbishment of existing bridge

Refurbishing the existing bridge would require extensive works to achieve current road design standards and stabilise the structural deterioration. The refurbishment option comprises two sub-options (option 9A and option 9B) corresponding to different refurbishment methods.

Option 9A – Refurbishment of existing bridge to provide a two lane crossing

Option 9A would:

- Not require the removal or the replacement of the existing bridge deck.
- Retain the existing narrow lane widths on the current bridge.
- Replace the bridge joints, concrete the bridge deck, install deck drainage and beams and add additional steel girders between the existing concrete beams. The cast iron piers would require strengthening by concrete encasement.
- Close the existing bridge for three months during the refurbishment.

Option 9B – Refurbishment of existing bridge to provide a three lane crossing

Option 9B would:

- Remove and replace the existing bridge deck and existing superstructure. The rubble in the existing cast iron casings would be drilled out and replaced with a reinforced concrete infill to create permanently cased bored piles.
- Refurbish the bridge superstructure to include a head stock, beams and decking that would accommodate a wider road platform.
- Require closing the bridge for twelve months during the refurbishment.

Both options would have only minor heritage impacts on Thompson Square. However, these options are not preferred as they do not meet key project objectives and criteria. In particular, it is not considered to be cost-effective, with the cost of refurbishing the existing bridge for a 25 year life span likely to exceed $18 million (for option 9A), not including the community costs that would be incurred during the refurbishment period as a result of closure of the bridge and the need for road detours. Furthermore, refurbishing the existing structure would not improve its flood immunity. Traffic access during flood events would remain unchanged from existing conditions and the bridge would continue to be exposed to the same level of flood damage.

Community options

As a result of the display of the initial ten options developed by RMS and through the community focus group, a number of additional options were suggested by community stakeholders.

Livingston Road options

These options are a variation of option 6. One alternative suggested begins with a new signalised T-intersection on Windsor Road, north of Pitt Town Road, to then travel east by a new bridge across South Creek. It then runs parallel and to the east of Palmer Street along intended Livingston Road, proceeding to a new bridge over the Hawkesbury River, intersecting with Wilberforce Road at a T-intersection. Another variation on this option (McGraths Hill option) had a road starting at the Pitt Town Road and Windsor Road intersection or near to it, a bridge crossing South Creek and then a similar route to the route described above.

These options would have similar performance in meeting the project objectives and criteria as option 6 but would have the benefit of reducing impact on properties closer to Palmer Street. However, these options would not meet the project criterion to minimise the impacts on recreational areas as they would have greater impact on the boating activities which are regularly held in the waters directly adjacent to Governor Philip Park and would also split Governor Philip Park in half. A single span bridge across the Hawkesbury River was also suggested by the community to mitigate impacts on boating activities (the Sustainable Bypass option). While this would mitigate some of the impacts on recreational boating, the cost of a single span bridge would be substantial and would not be justified.

In response to this suggestion, RMS made a concerted effort to address some of the concerns by slightly modifying option 6 during the detailed options assessment in 2011. Accordingly, the option 6 route was marginally shifted to the eastern side of Palmer Street and direct access to Palmer Street was removed. A small landscape mound was proposed between the new alignment and Palmer Street to minimise traffic noise. This would to some extent meet the intention of the Livingston Road proposal as raised in the community response. However, the other issues such impacts on Governor Phillip Park, impacts on boat users and the overall cost of this option would still not be addressed.

Pitt Town Bottom Road option

This option begins at the intersection of Pitt Town Road and Windsor Road, then travels east along the existing alignment of Pitt Town Road/Pitt Town Bottom Road and then across the Hawkesbury River to intersect with Wilberforce Road. However, while this option would meet the project objectives and criteria for traffic and transport efficiency and historic heritage impacts, it would not meet other project objectives and criteria relating to Aboriginal heritage, flood immunity, property acquisition and local pedestrian and traffic access. This option would also substantially exceed the project budget.

Hawkesbury Way option

Three potential options were identified with bridges proposed upstream of the existing bridge and access provided from Hawkesbury Valley Way. Two of the options would begin at the intersection of Freemans Reach Road and Wilberforce Road with a road through Macquarie Park, a bridge across the Hawkesbury River from Macquarie Park to Howe Park and then a connection to The Hawkesbury Way via either The Terrace and Moses Street or across Primrose Place, Greenway Crescent and Rum Corps Lane. While these two options would meet project objectives for heritage by maintaining heritage values of Thompson Square, neither would meet other project objectives and criteria with respect to impacts on recreational areas and from noise.

A third option would similarly begin at the intersection of Freemans Reach Road and Wilberforce Road, but would follow a different alignment through the centre of Macquarie Park instead of spanning the beach areas as proposed in the former two variants. The alignment would then cross the Hawkesbury River from Macquarie Park to Deerubbun Park. While the river is narrow at this location the bridge structure would be need to begin from within Macquarie Park due to the topography and geology of the eastern bank. The alignment would continue almost parallel with the access road for the playing field car park, cross Rickabys Creek on a second bridge crossing and extend between a resort and a golf club to connect with Hawkesbury Valley Way at a new intersection.

While this third Hawkesbury Valley Way option would meet project objectives for heritage and safety, it is anticipated to only partially meet the traffic objective unless a number of additional significant improvements were made to the surrounding traffic network.

The community stakeholders who suggested the Hawkesbury Valley Way options also proposed an alternative option for refurbishment of the existing Windsor bridge. The scope of refurbishment proposed under this option differed from that proposed under options 9A and 9B above. It would employ different strengthening methods that would allow the bridge to be retained for light vehicles only. Refurbishment under this option would be less expensive than options 9A and 9B, however like those options it would necessitate temporary closures of the bridge.

Benefits to traffic efficiency and pedestrian safety within Windsor would be expected due to a reduction in the number of vehicles travelling through the area and impacts on Thompson Square and the existing Windsor bridge would be reduced. However, the option would impact on the local character of the area along the proposed route, including a number of recreational areas and businesses. Further, it would not meet the cost objective, with high costs associated with two bridge structures and considerable property acquisition. Significant adjustments to the surrounding road network would also be required and these could included new traffic signals, road widening with associated property acquisitions, bridge rehabilitation/replacement, utility adjustments and adjustments to drainage.

Bridge Road tunnel option

This option would involve a tunnel under George Street, connecting Bridge Street between the area south of Macquarie Street and the southern approach road to the new bridge. "Cut and cover" construction would be likely to be required, involving extensive widening of Bridge Street. This would necessitate the acquisition and demolition of most properties on Bridge Street between Macquarie Street and the Hawkesbury River.

While this option would meet the project objective to improve safety for motorists, pedestrians and cyclists by creating a grade separated crossing of George Street, it would not improve traffic efficiency. Substantial traffic impacts are anticipated as a result of changes in the operation of Macquarie Street intersection. An alternative option involving removing vehicle access between George Street and Bridge Street may reduce the amount of acquisition and demolition required but would result in an unacceptable reduction in traffic efficiency at this intersection and on surrounding roads. Further, construction activities would require extensive road closures in the area, including the Windsor bridge over the Hawkesbury River for around two years. This would impact local and regional traffic, placing additional traffic loads on the North Richmond crossing of the Hawkesbury River.

The option would also not meet heritage, flood and cost objectives. Direct impacts on numerous heritage items along Bridge Street would be anticipated as well as subsurface archaeological impacts. It is estimated that the cost of a tunnel would be significantly more than the cost of the project.

4.2.3 Consultation, assessment and selection of the preferred route option

Information on details, impacts and costs of each of the options were presented to the community, stakeholder groups and government agencies to obtain feedback. Further details of the issues raised during the consultation process can be found in Chapter 6 of this document the "Windsor Bridge Options Report" (RTA, 2011) and the "Community Consultation Report" (RTA, 2009a), which are available on the RMS website (www.rms.nsw.gov.au/roadprojects).

While RMS did not request that the community nominate a preferred option, many of the submissions identified one or more preferred options for the replacement bridge. The three most preferred options were options 1, 2 and 6. However, many submissions were opposed to options 1 and 2 because of their potential impact on Thompson Square and the heritage values and vistas of Windsor. Many submissions were opposed to option 6 due to new amenity impacts on previously unaffected residential areas and the potential economic impacts of a bypass of the town centre.

Following the community information sessions, a government agency workshop was held to consider the issues and concerns relating to each option. The workshop was held on 18 September 2009 and was attended by Hawkesbury City Council, the then NSW Maritime (now RMS), the Heritage Branch of the NSW Office of Environment and Heritage, and the Government Architects Office. The workshop participants identified project objectives, considered the positive and negative aspects of each option and identified opportunities to improve project outcomes, particularly in terms of visual amenity and urban design, heritage, traffic and impacts on the Windsor community. The workshop participants recommended that options 3, 4, 5, 7, 8 and 9 not be considered further as they did not meet one or more of the project objectives. They also recommended that further work on short-listed option 1, 2 and 6 were required before a preferred option could be recommended.

Given that there is little or no support for the other options (ie options 3, 4, 5, 7, 8 and 9), they were not further developed and are not further discussed in the EIS.

A comparison of each of the short-listed options against the project objectives and criteria is provided in **Table 4-2**).

While option 1 was selected as the preferred option for the replacement bridge by RMS, it is recognised that there is significant opposition to this option within parts of the community and from the Heritage Council of NSW due to its potential impacts on the heritage values of Thompson Square and the heritage character of Windsor. To minimise these potential impacts and to develop urban design and landuse outcomes that enhance the amenity and use of this historic precinct, RMS has undertaken further development of the preferred option which is discussed in the following sections.

4.3 Road and approach road alignment and intersection options

A series of design workshops were held to further refine the preferred option, including the design of approach roads and intersections. Attendees at these workshops included bridge and road engineers, environmental planners, heritage architects, heritage advisers, urban designers and RMS personnel. One of the major focuses of the design workshops was to minimise the impact of the preferred option for the replacement bridge on the:

- Heritage values of Thompson Square and its surrounds.
- Heritage vistas from the Windsor township and from the northern bank of the Hawkesbury River.

It was agreed at the workshops that the two main methods for achieving these outcomes were to:

- Lower the bridge and approach road relative to the surrounding landforms to minimise the visual intrusiveness of the replacement bridge (see **Section 4.3.1)**.
- Select a bridge type that was designed to be sympathetic to its surrounding heritage environment (refer to **Section 4.4** for discussion of bridge options considered).

The second focus of the workshops was to identify the preferred options for the intersections where the new bridge and approach roads connect to the existing road network. The preliminary concept design developed by RMS identified that:

- The southern approach road intersection (at the corner of Old Bridge Street and George Street) would remain a roundabout until growth in traffic numbers required the installation of traffic lights to maintain an acceptable level of service.
- The northern approach road intersection (at the intersection of the northern bridge approach road, Macquarie Park access road, Freemans Reach Road and Wilberforce Road) would have traffic lights controlling movements.

These intersection types were reviewed and changed as part of developing a more detailed concept design (see **Section 4.3.2**).

Table 4-2 Performance of the options against the project objectives

Objectives (in bold) and component criteria	Performance against the project objectives			
	1	2	6	Do nothing
To improve safety for motorists, pedestrians and cyclists				
Meets the various design codes	★★	★★	★★	
Meets a road speed of 60 km/h*	★★	★★	★★	
Ensures pedestrian safety	★★	★★	★★	★
To improve traffic and transport efficiency				
Minimises queue length/delays	★★	★★	★★★★	
Improves performance of road network	★★	★★	★★	
Enables two heavy vehicles to pass on the bridge without waiting	★★	★★	★★	
Improves load capacity of the crossing to meet current load standards	★★	★★	★★	
To improve the level of flood immunity				
Provides a crossing that has a higher level of flood immunity than the existing bridge	★★★	★★	★★	
Provides a crossing with a flood immunity that is compatible with the surrounding approach roads	★★★★	★★	★★	
To meet long term community needs				
Provides an efficient connection for local traffic	★★★	★★★	★★	★★
Provides an efficient connection for regional traffic	★★	★★	★★★★	★
Provides a pedestrian and cyclist connection to surrounding locations	★★★	★★★	★★	★★★
Minimises impacts on recreational spaces	★★	★★	★★	★★
Minimises impacts of noise	★★★	★★★	★	★★★
Minimises impacts to businesses and the shopping environment	★★	★★	★★	★★
Minimises impacts on property access	★★	★★	★★★★	★★★★
Minimises need for acquisition	★★★	★★★	★★	★★★★
Provides a 100 year life span for the bridge	★★	★★	★★	
To minimise the impact on heritage and the character of the local area				
Minimises impact on Aboriginal and non-Aboriginal heritage and conservation areas			★★	★★
Protects the town built heritage and its setting	★	★	★★★	★★★
Minimises visual impact and impacts on the character of local area	★	★	★★	★★★
To be a cost effective and an affordable outcome				
Provides a cost effective solution - capital cost	★★★	★★★	★	★★★★
Provides a cost effective solution - maintenance	★★★	★★★	★★★	
Provides a cost effective solution - investment on return	★★★	★★★	★★★	
Minimises the impact of construction in regards to length and timing	★★★	★★★	★★★	★★

Worse performance — Better performance

	★	★★	★★★	★★★★

*Note: The design speed limit was changed to 50 kilometres per hour to allow a reduction in the height of the bridge (see **Section 4.3.1**).

4.3.1 Bridge and road alignment options

To lower the bridge and approaches relative to surrounding landforms (while still improving its flood immunity) required a modification to one of the primary design criteria for the project, namely the design speed for the replacement bridge. Reducing the design speed from 60 kilometres per hour to 50 kilometres per hour would allow the southern approach road through Thompson Square to be lowered closer to the existing ground levels. This would still meet road safety requirements and improve flood immunity. Workshop participants agreed this modification should be considered to minimise the impacts of the project on the heritage values and vistas of Thompson Square and Windsor.

Based upon this recommendation from the design workshop participants, RMS revised the design speed for the replacement bridge to 50 kilometres per hour. It was also considered that a lower design speed limit would be more appropriate given that the speed limit along many of Windsor's streets is 50 kilometres per hour. The reduction of the design speed to 50 kilometres per hour allowed the southern approach road through Thompson Square to be lowered compared to a design based upon 60 kilometres per hour. The change in the height of the replacement bridge as a result of lowering design speed limit is shown in **Figure 4-2**.

Further reductions in the height of the new bridge and approach road were investigated but were not considered to be feasible, as there needs to about 3.6 metres of under bridge clearance on the southern side to allow small coaches, service vehicles and emergency vehicles to access Windsor Wharf. While The Terrace could be lowered to achieve the required clearance under the replacement bridge this was considered undesirable due to the potential disturbance of terrestrial and maritime archaeological sites and a steeper access road the wharf car park.

4.3.2 Intersection options

The RMS preliminary concept design proposed a signalised intersection at the northern end of the replacement bridge and retaining the existing roundabout at the southern end of the replacement bridge (ie the corner of Bridge and George Streets). This roundabout would eventually be replaced by traffic lights when growth in traffic numbers resulted in an unacceptable level of service at the intersection.

These intersection types were reviewed during the design development process to:

- Ensure that they provided an acceptable level of service both when the replacement bridge was initially opened and into the future.
- Assess new traffic information collected in early 2012.
- Identify the optimal intersection type in terms of traffic and pedestrian safety.

A number of different intersection types and lane configurations were assessed for existing and future traffic scenarios including:

- For the northern intersection:
  - Traffic lights.
  - Single lane roundabout.
  - Dual lane roundabout.
- For the southern intersection:
  - Maintain the existing roundabout.
  - Traffic lights.

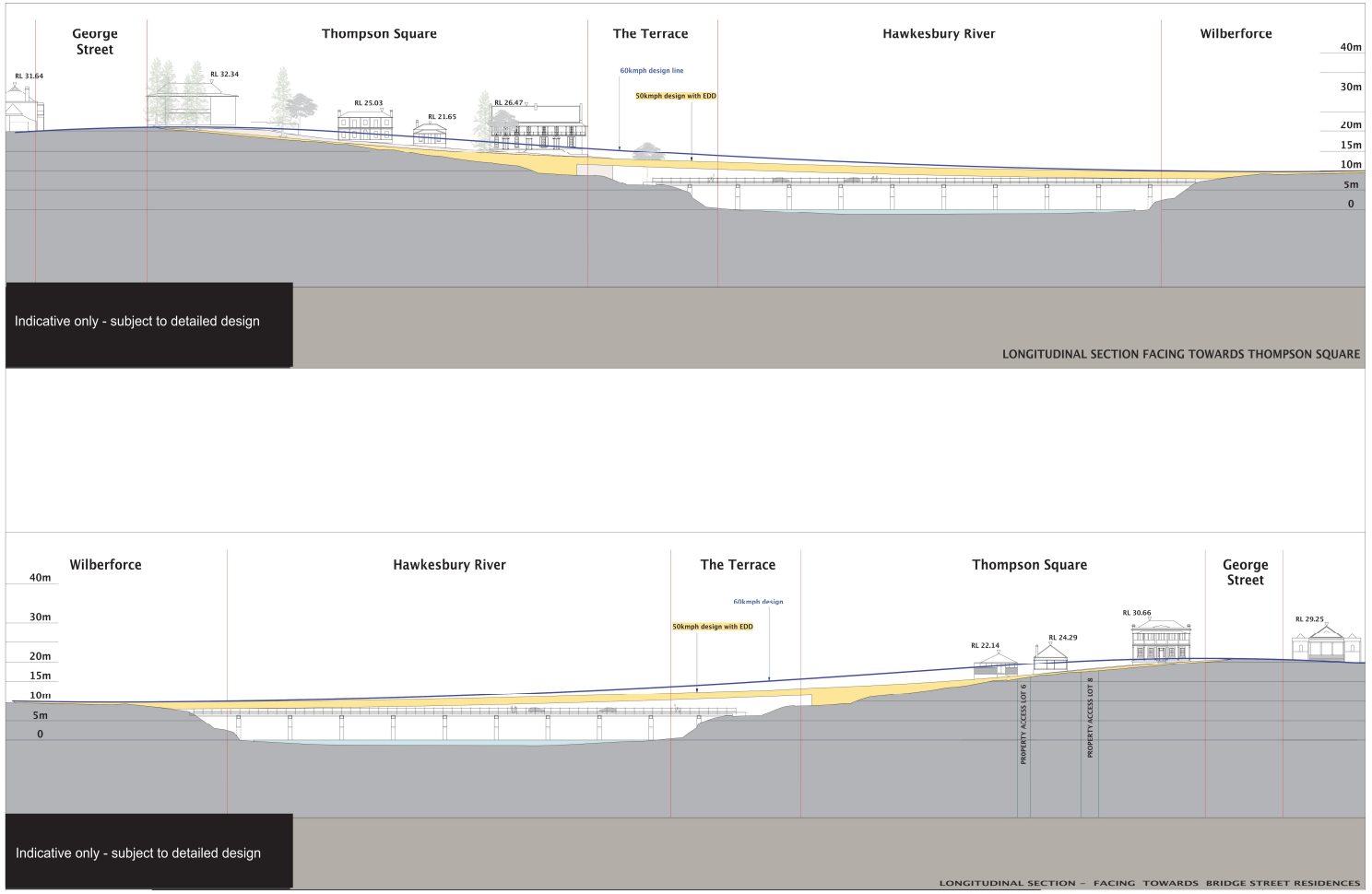


Figure 4-2 Replacement bridge elevations for 60 and 50 kilometre per hour design speed limits

The conclusions of the additional traffic modelling were that for the northern intersection a dual lane roundabout was the preferred intersection type. While traffic lights would provide similar traffic outcomes to a dual lane roundabout, operating and maintaining traffic lights in the floodplain adjacent to the bridge was undesirable and costly as they would be subject to frequent immersion by floodwaters. While a dual lane roundabout would require more land than traffic lights it would be cheaper both to construct and maintain in the longer term. A single lane roundabout would not provide an acceptable level of service especially for morning peak traffic from Wilberforce Road.

The roundabout would also act as a traffic calming device as motorists enter the 50 kilometres per hour zone. It also provides a visual entry point into the township of Windsor.

For the southern intersection, traffic lights were identified as the preferred option, rather than maintaining the existing roundabout in the short term. Traffic lights would result in improved levels of service for traffic from all directions in all peak periods. The provision of a signalised intersection at the corner of Bridge and George streets also addresses the concern of pedestrian safety raised during community consultation. The existing roundabout has no designated pedestrian crossings of Bridge/Old Bridge Street at the intersection, making access across this intersection difficult and dangerous. With a signalised intersection, pedestrian crossing of the intersection would be catered for and made safer. This was considered an important outcome as most of the local hotel accommodation and Governor Phillip Park is located on the eastern side of Windsor and pedestrian traffic from this area is required to cross Bridge/Old Bridge Street for direct access to the Windsor town centre.

4.4 Bridge options

A series of preliminary concept designs for the replacement bridge were developed to determine a preferred bridge type for the replacement bridge. Based on advice from the heritage architect and urban designers, it was considered desirable to have a straight (rather than curved) bridge option as perpendicular to the river banks as possible. This allowed consideration of a wide range of bridge types. Eight bridge options were considered:

- Bridge option 1 - Precast concrete plank with cast in situ concrete deck bridge.
- Bridge option 2 - Incrementally launched bridge.
- Bridge option 3 - Cast in situ balanced cantilever bridge.
- Bridge option 4 - Arch bridge (with arch under the deck).
- Bridge option 5 - Arch bridge (with arch above the deck).
- Bridge option 6 - Truss bridge.
- Bridge option 7 - Cable stayed bridge.
- Bridge option 8 – Concrete cast in situ bridge.

4.4.1 Assessment criteria for bridge options

Apart from the standard bridge design criteria relating to functionality, capacity and durability, there were a number of additional key criteria considered in comparing and assessing the bridge options. These criteria were as follows:

- The suitability of the bridge type to undergo regular immersion by flood waters - some bridge types were found to be unsuitable for regular immersion by flood waters for the following reasons:
  - Some bridge types (eg cantilever bridges) would be buoyant (ie have a tendency to float) because of the presence of voids in the superstructure. This would result in unacceptable stresses on other elements of the bridge and increase the risk of failure.
  - Some bridge types (eg arch bridges) would potentially capture significant quantities of flood debris, resulting in increased stress on other elements of the bridge and greater maintenance requirements.
  - Some bridge types (eg truss bridges) would need to be constructed predominately of materials that are not suitable for regular immersion, such as steel (which would undergo increased corrosion with regular immersion).
- The visual appearance of the bridge, including:
  - The ability of the bridge type to reflect the heritage values of Windsor.
  - The bulk and direct visual impact of the bridge type on heritage vistas.
- Number of piers in the river – minimising the number of piers in the river was considered beneficial for boating and other water-based recreational activities as well as minimising visual impact.
- Construction impacts on Thompson Square – some bridge types would require greater disturbance or use of Thompson Square during construction.
- Other environmental risks – some bridge types would take longer to build or pose greater environmental risks during construction. This is specifically of concern for the project due to the higher possibility of the bridge undergoing immersion by flood waters during the construction period.
- Other issues – such as the complexity of design and construction, ability to accommodate services, maintainability and flexibility in road geometry.
- Cost – some bridge types were considerably more expensive than other options.

4.4.2 Assessment of bridge options

Each of the eight bridge options and their relative performance against the assessment criteria are described in greater detail in the following sections and summarised in **Table 4-3**.

Table 4-3 Relative performance of bridge structure options against key criteria

Criteria	Bridge structure options							
	Precast concrete plank bridge	Incrementally launched bridge	Balanced cantilever bridge	Arch bridge (under the deck)	Arch bridge (above the deck)	Truss bridge	Cable stayed bridge	Concrete cast in situ bridge
Flood performance operation	★★★★	★★★		★		★		★★★
Impact on flood levels	★★	★★						★
Bridge aesthetics	★	★★★	★	★★★★	★★	★	★	★★★★
Compatibility to Windsor		★★	★	★★★	★			★★★★
Impact on vistas/views		★★★	★	★★★	★★			★★★★
Abutment built form	★★	★	★	★★	★★	★★	★★★	★★★
Enhances water-based activities	★	★★	★★★	★★★	★★★	★★	★★	★★
Design/construct complexity	★★★★	★★★	★	★	★	★		★
Construction impact Thompson Square	★★	★★★		★★	★★	★★★	★	
Construction period	★★★★	★★★	★★	★★	★★	★★★	★	★★
Flood performance construction	★★★	★★		★	★	★★		
Maintainability	★★★★	★★	★★★	★	★★	★		★★
Flexibility in road geometry	★★★	★	★★	★★	★★	★	★	★★★★
Ability to include services		★★★	★★★★	★★	★	★★	★★	★★
Flexibility for future changes	★★★	★	★★	★		★		★★
Cost	★★★★	★★★	★	★★	★★	★★★		★★

Worse performance — Better performance

	★	★★	★★★	★★★★

Bridge option 1 - Precast concrete plank with composite cast in situ concrete deck

This form of bridge is the most common bridge type in NSW – and could be constructed either using the standard RMS 18 metre spans or the Queensland style 26 metre spans. The bridge superstructure consists of precast concrete planks which are placed from pier to pier. The bridge deck and other elements of the superstructure are then cast in situ once the planks have been placed. An example of this type of bridge is shown in **Figure 4-3**.

Figure 4-3 Example of a precast concrete plank bridge (Adelong Bridge, NSW)

The main advantages of this bridge option would be:

- Excellent flood performance.
- Cost – the lowest cost bridge type to construct and maintain in comparison to other options.
- Flexibility – able to vary the horizontal and vertical alignment.
- Minimal design and construction risks.

The main disadvantages of this bridge options would be:

- Higher number of piers – because the length of the planks are limited, a higher number of piers (five) would be required in comparison to other options. However the number of piers would be lower than the existing bridge.
- Limited opportunities to ensure that the visual appearance of the bridge would be sympathetic to heritage vistas and values of Windsor in comparison to other bridge types. While the parapets (ie the sides of the bridge deck) would be able to be architecturally treated, the underside of the bridge cannot be modified.

Bridge option 2 - Incrementally launched bridge

This type of bridge is constructed by setting up a casting bed on one side of the river, casting segments of the bridge and then 'pushing' (ie launching) each new segment across the alignment on to the piers. A typical span would be about 30 metres and the superstructure and other elements of the bridge are incorporated into each segment. An example of this type of bridge is shown in **Figure 4-4**.

Figure 4-4 Example of an incrementally launched bridge (Corowa, NSW)

The main advantages of this bridge option would be:

- Good flood performance.
- Lower visual impact – There would be opportunities to include architectural features within the bridge superstructure - and the underside of the bridge is uncluttered and uncomplicated resulting in reduced visual impact on the heritage vista and values of Windsor.
- Reduced construction impacts in Thompson Square – the casting bed and most other equipment associated with the construction would be located on the northern bank, minimising construction impacts on Thompson Square.
- Only four piers in the river would be required because 30 metre spans are achievable.

The main disadvantages of this bridge option would be:

- Flexibility – the ability to vary the horizontal and vertical alignments would be limited.
- The abutments of this type of bridge would be more visually prominent than some other types of bridges.
- Cost – this type of bridge would cost about 50 per cent more than a plank bridge.

Bridge option 3 – Cast in situ balanced cantilever bridge

This type of bridge can have large spans (up to 65 metres) and consequently would require only two piers in the river (see **Figure 4-5**). The bridge is constructed from one or more piers with the deck and superstructure cast in situ in equal lengths either side of the pier. Generally the superstructure depth at the piers is significant, tapering to a smaller depth in the middle of the span.

Figure 4-5 Example of an in situ balanced cantilever bridge (Brunswick, NSW)

The main advantage of this bridge option would be:

- Lower number of piers – because 60 metre spans are achievable, only two piers would be required in comparison to other options.

The main disadvantages of this bridge option would be:

- Poor flood performance – the bridge superstructure would be typically buoyant – though measures could be incorporated into the design and construction to minimise buoyancy. Also the relatively deep superstructure at the piers would result in substantial horizontal forces on the bridge during immersion in flood events and may cause increased flood levels upstream.
- Visual appearance – the superstructure would be visually prominent and would not be sympathetic to the historic vistas and values of Windsor.
- Construction risk – this type of bridge would be slow to construct and the main construction areas would be located directly over the river. The combination of these factors increase environmental risks such as water pollution if flood events were to occur during construction.
- Cost – this bridge would be expensive to construct.

Bridge option 4 - Arch bridge (with arch under the deck)

Typically this type of bridge would be constructed by attaching steel or precast concrete arches to the piers and then adding additional structural support. The deck and other bridge elements would then be cast in situ. Two piers in the river would be required for support. An example of bridge type is shown in **Figure 4-6**.

Figure 4-6 Example of an Arch Bridge with arch under deck (Yelgun, NSW)

The main advantages of this bridge option would be:

- Lower number of piers – only two piers would be required for this bridge type.
- Visual appearance - there would be substantial opportunities to include architectural features within the bridge superstructure which would be sympathetic to the heritage vista and values of Windsor.

The main disadvantages of this bridge option would be:

- Poor flood performance – the relatively deep superstructure would result in substantial horizontal forces on the bridge during immersion in flood events and the bridge would be prone to collect flood debris.
- Cost – this would be one of the highest cost bridge types to construct in comparison to other options. As this type of bridge is relatively uncommon, there are substantial risks in design and construction costs.
- Construction risk – this type of bridge would be slow to construct and the main construction areas would be located directly over the river. The combination of these factors increase environmental risks such as water pollution if flood events were to occur during construction.

Bridge option 5 - Arch bridges (with arch above the deck)

The features and construction of this type of bridge are very similar to Option 4, except the arches extend above the bridge deck and the bridge deck is suspended from the arches. An example of this type of bridge is shown in **Figure 4-7**.

Figure 4-7 Example of an arch bridge with arch above deck (Coffs Harbour, NSW)

The main advantage of this bridge type would be the lower number of piers. Because 100 metre spans would be achievable, only one pier would be required in the river for this bridge type.

The main disadvantages of this bridge option would be:

- Poor flood performance – the relatively large cross-sectional area would result in substantial horizontal forces on the bridge during immersion in flood events and the bridge would be prone to collect flood debris.
- Visual appearance – the arches over the deck would be visually prominent and would not be sympathetic to the heritage vistas of the area.
- Cost – one of the highest cost bridge types to construct in comparison to other options. As this type of bridge is relatively uncommon, there would be substantial risks in design and construction costs.

Bridge option 6 - Truss bridges

An example of this type of bridge is the Iron Cove Bridge in Sydney (see **Figure 4-8**). Steel trusses would be assembled on the bank and then floated and lifted into place between piers. A concrete deck would be then cast in situ. Two piers in the river would be required.

Figure 4-8 Example of a truss bridge (Iron Cove Bridge, Sydney)

The main advantages of this bridge option would be:

- Lower number of piers – because 47 metre spans would be achievable, only two piers would be required in comparison to other options.
- Lower construction impact on Thompson Square – the trusses would be assembled on the northern bank, avoiding impacts on Thompson Square.

The main disadvantages of this bridge option would be:

- Poor flood performance – the trusses on the bridge would be prone to collect flood debris. Also as the trusses would be steel, the maintenance costs would be higher in comparison to other types of bridges.
- Visual appearance – the trusses over the deck would be visually prominent and would not be sympathetic to the heritage vistas of the area.

Bridge option 7 - Cable stayed bridge

A cable stayed bridge would consist of two towers with cables from the top of towers supporting a concrete deck. Two piers in the river would be required. An example of a cable stayed bridge is presented in **Figure 4-9**.

Figure 4-9 Example of a cable stayed bridge (ANZAC Bridge, Sydney)

The main advantage of this bridge type would be the lower numbers of piers. Because large spans are achievable, only two piers would be required.

The main disadvantages of this bridge options would be:

- Poor flood performance – the cables would be prone to collect flood debris and the deck would become unstable during immersion.
- Visual appearance – the towers over the deck would be visually prominent and would not be sympathetic to the heritage vistas of the area.
- Cost – one of the highest cost bridge types to construct in comparison to other options.

Bridge option 8 – Cast in situ concrete bridge

This type of bridge can take many forms and would be only limited by the ability to place formwork to allow the casting to take place. It is likely that only two piers would be required.

Figure 4-10 Example of a cast in-situ bridge (Emigrant Creek, Sydney)

The main advantages of this bridge option would be:

- Lower number piers – because large spans are achievable, only two piers would be required.
- Visual appearance – there would be opportunities to include architectural features within the bridge superstructure to make the bridge form sympathetic to the heritage vistas and values of Windsor.

The main disadvantages of this bridge type would be:

- Cost – one of the highest cost bridge types to construct in comparison to other options.
- Environmental risk – due to the need to provide extensive formwork (and potentially temporary piles in the river), there is a risk of damage to or loss of the formwork and resulting water pollution if the bridge construction site was to experience immersion during a flood event.
- Construction impacts on Thompson Square – there would be considerable disturbance and loss of use of Thompson Square during construction.

4.4.3 Selection of the preferred bridge structure type

To assist with the selection of the preferred bridge structure type, a Bridge Options Review Workshop was held in January 2012. The workshop involved assessing and scoring the alternative bridge structure options in terms of environmental and technical criteria (See **Table 4-3**). Workshop participants included bridge and road engineers, environmental planners, heritage architects, heritage advisers, urban designers and RMS personnel. Input from the community focus group established for the project was also sought before making a decision on the preferred bridge option.

Bridge structure types with bulky or prominent superstructures were found to perform poorly in terms of their ability to withstand flood events and their adverse visual impacts. These bridge structure types included the balanced cantilever (bridge option 3), arch (bridge option 4 and 5), truss (bridge option 6) and cable stayed bridges (bridge option 7). Workshop participants agreed that these bridge structure types were not suitable for the replacement bridge at Windsor.

Three bridge structure types were found to be potentially suitable for the Windsor bridge replacement, namely the cast in situ concrete bridge (bridge option 8), the Queensland style plank bridge (bridge option 1) and the incrementally launched bridge (bridge option 2). Of these three structural types, the cast in situ concrete bridge (bridge option 8) was found to have the greatest flexibility in visual appearance but significant disadvantages that ruled it out as the preferred option (namely high cost, construction risk and construction impacts on Thompson Square). The Queensland style plank bridge (bridge option 1), while considered to have significant benefits (namely cost and ease of construction) was also ruled out because of the limited scope for architecturally improving the visual appearance of this structure type, combined with the relatively high visual prominence of the structure and large number of piers.

Based on the combined outcomes of the Bridge Options Review Workshop and input from the community focus group, the incrementally launched bridge (bridge option 2) was found to be the preferred bridge structure option. Key factors in the selection of this bridge option included its:

- Lower visual impact and ability to be architecturally enhanced.
- Relatively small number of piers in comparison to some of the other options.
- Ability to be constructed and launched from the northern bank, which would minimise construction impacts on Thompson Square.

4.5 Thompson Square options

In selecting option 1 as the preferred option for the bridge alignment, it was recognised that it would adversely impact the significance of the State Heritage Register-listed Thompson Square heritage conservation area and the overall historic vistas and values of Windsor. To minimise these potential impacts substantial effort has been invested in developing appropriate design and environmental management measures to minimise the visual impact of the project. A preliminary concept plan for the future consolidation and reinvigoration of Thompson Square and adjacent areas as a community space that reflects the important historical values of the area has been developed with feedback from Hawkesbury City Council and the community focus group. It is recognised that further work and input from stakeholder groups would be required before a plan for the area can be finalised.

4.5.1 Thompson Square options

Historical context

The heritage values and uses of Thompson Square are an important context to the development and assessment of any modifications to the area. These are summarised below:

- Thompson Square has been and is the primary location for accessing the Hawkesbury River within the Windsor township since its development as the Green Hills settlement. The physical access and vistas from Thompson Square to the river are essential to maintain.
- Thompson Square has been and is the primary location for crossing the Hawkesbury River. In the past it has also been a location for wharves to ship and receive goods when river transport was the principal means of moving large quantities of heavy goods. Crossing of the river pre-1874 was via a ferry or punt crossing and post 1874 via the bridge. Consequently a road from George Street to either the wharves or the bridge has been a constant feature of Thompson Square, although the alignment, size and layout of roads in Thompson Square has varied considerably over 200 years. The current alignment bisecting the square into two triangular segments was established in 1934.
- The Government Precinct, from which Thompson Square evolved was the focus of much of the early development of the township of Windsor, with many important buildings surrounding the square, such as the barracks, Governor's cottage and granary. Many of the original buildings predating or built in the Macquarie period were demolished and the land was redeveloped between 1840 and 1880. However, many of these replacement buildings still exist and are included in the Thompson Square Conservation Area State heritage listing. As the town grew the focus of development moved westward and more important buildings were located away from Thompson Square. However, as noted above, Thompson Square still remained the most important local link to the river, the wharves and to northern side of the river either via a punt or bridge.

A full description of the historic heritage of the study area is provided in **Section 7.1**.

Existing condition

Open space in Thompson Square is currently diagonally bisected by the southern approach road to the existing Windsor bridge. The approach road is located in a cut (up to five metres deep) and safe pedestrian access across the approach road is only possible via two sets of substandard stairs under the first span of the bridge. There are also a number of other local roads in the Thompson Square heritage conservation area including Old Bridge Street, The Terrace, Thompson Square road and carparks.

The Thompson Square upper parkland is about 500 square metres in size. It is predominately grassed parkland with about 14 medium to large trees, some picnic benches and seats, and civic memorials. The park is used by tourists and locals generally to eat lunch or for short rest periods. Events are also held in the park regularly, such as bands playing on the weekend or public holidays and as part of the annual Windsor Jazz and Blues Festival. However the amenity of the park is impacted by noise and exhaust emissions from vehicles using the existing Windsor bridge approach road and George Street.

The Thompson Square lower parkland contains a small sloping grassed area, about 10 medium to large trees and a car park. This area is not extensively used as it is on the eastern side of the existing Windsor bridge approach road and is difficult to access on foot from the town centre. It is also impacted by vehicles using the existing Windsor bridge approach road.

Buildings on the western side of the square are accessed along Thompson Square road, while the two on the eastern side and the recently upgraded wharf use the Old Bridge Street alignment.

Opportunities with preferred bridge alignment option

Locating the bridge and approach roads on the eastern side of the Thompson Square parkland provides opportunities to improve the size, amenity, appearance and use of the green space with Thompson Square. The approach road to the existing Windsor bridge would be removed, the cutting backfilled and landscaped to provide additional green space and connect the two existing sections of the Thompson Square parkland. Uninterrupted pedestrian and cyclist access would be able to be provided along The Terrace to the wharf. Access from the new pedestrian/cyclist path across the replacement bridge to the town centre would also need to be provided.

Hawkesbury City Council has also developed a concept landscape masterplan for the southern river bank (including Thompson Square parkland) and have identified potential uses for a redeveloped Thompson Square parkland. Hawkesbury City Council would be responsible for maintaining the Thompson Square parkland in the future.

Urban design principles and development of concept alternatives

In response to the significant heritage and social values of Thompson Square, urban design principles were developed to guide the design process for the bridge replacement project, including Thompson Square. These are:

- Protect and interpret the heritage values of Thompson Square and Windsor in general.
- Maximise the available open space in Thompson Square by minimising the road corridor footprint.
- Define a preferred form and character for Thompson Square based on a range of appropriate uses.
- Enhance access around and through Thompson Square.
- Improve the amenity of Thompson Square and the surrounding areas.

A series of options for the Thompson Square parkland were developed based on these principles and are presented in **Table 4-4**. To achieve the objectives stated above, the focus in considering the best outcome for Thompson Square was on access both into and around the square. The options generated focussed on the location and alignment of the shared path associated with the replacement bridge and access to the river foreshore via The Terrace.

The shared path along Thompson Square and across the new bridge is an integral component of the project as it provides a safe and improved pedestrian and cyclist link between the recreational areas on both sides of the Hawkesbury River. While components of the shared path extend outside of Thompson Square, the design of the square considered a number of potential path crossings. As such, the shared path consideration process has been described as part of the Thompson Square considerations.

The minimum recommended width for a shared path is 2.4 metres and apart from the bridge, the minimum width of all paths would be 2.4 metres. A three metre wide shared path has been proposed for the bridge to cater for the higher speeds travelled by cyclists due to the slope of the bridge deck. The width of the shared path along the bridge will be reviewed during detailed design, with narrower widths further considered. Alternative locations for the shared path were investigated to minimise the width and visual impact of the bridge. Options included:

- Constructing a separate pedestrian and cyclist bridge and path.
- Suspending the pedestrian and cyclist path under the bridge.
- Retaining the existing bridge to provide pedestrian and cyclist access.
- Constructing a shared path on the eastern side of the project (option E).
- Constructing a shared path on the western side of the project (option B).

The first option was not considered viable because of cost, potential upstream flooding impacts and the visual impacts of a second bridge. The second option was not viable due to the visual impact of a suspended walkway and potential flooding damage to the path during immersion. The option to retain the existing bridge was considered in **Section 4.1.4**.

While option E (shared path on eastern side of the project, refer to **Table 4-4**) locates the shared path outside of Thompson Square parkland and provides a greater area of green space, the additional area of green space in the parkland would be unusable as it would be directly adjacent to the southern approach road and subject to high noise levels from passing traffic. A path along the eastern side of the southern approach road would be steep in places (eight per cent grade) and would not provide a direct linkage from the bridge to The Terrace and to the lower parts of Thompson Square parkland. Also two crossings of the project alignment, one at the George Street/Bridge Street intersection and the other under northern bridge abutment, would be required with a path along the eastern side of the project.

Option B was considered the preferred option for Thompson Square, recognising that further consultation and design development would be required. Option B was preferred over other alternatives as it would maximise the amount of green space within Thompson Square, efficiently accommodate pedestrian and cyclist movements and would provide the most flexibility for future uses of Thompson Square.

Secondary footpaths through the square and other parts of the square have not been fully explored as the detailed design of the final form of Thompson Square would require further input from Hawkesbury City Council and other stakeholders. Access for people who are mobility impaired between George Street, The Terrace and the river foreshore would be by using Thompson Square road, past the Doctor's House to The Terrace. For the purposes of the EIS and for further consultation the design of option B was further developed and is presented in **Figure 4-11**.

All options for Thompson Square provide opportunities to incorporate interpretation of the human history of Windsor into their fabric, along with the bridge approaches by selection of finishes for built structures, visual and other sensory devices and more traditional signage and naming.

4.5.2 Other urban design options

Other urban design aspects of the project for which options were developed and considered included:

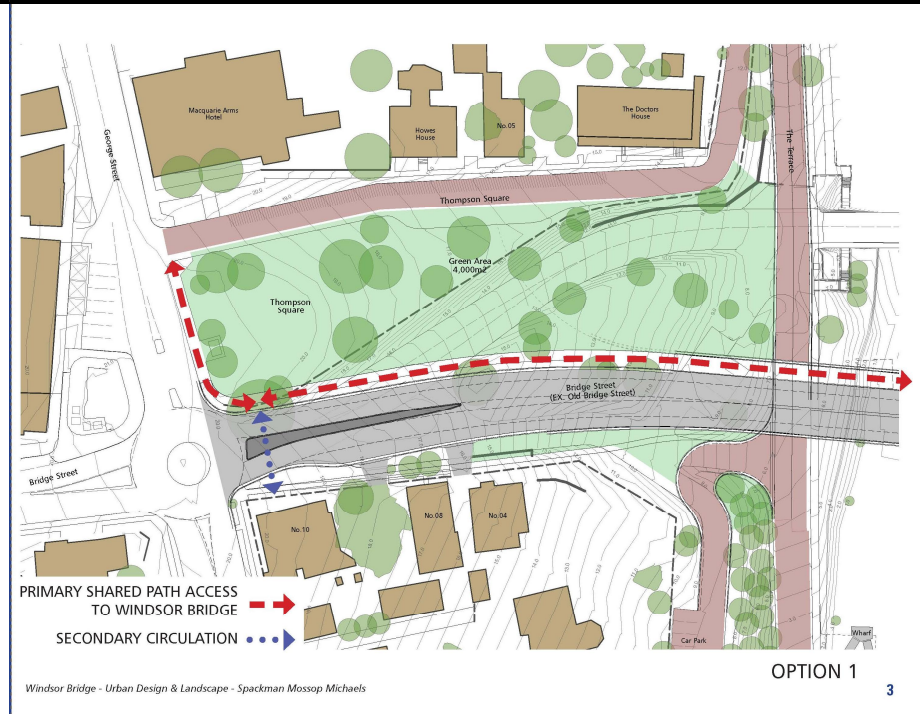
- The landscaping and pedestrian/cyclist pathways on the northern bank.
- Pier design of the replacement bridge.
- Other elements of the bridge including soffits, barriers etc.

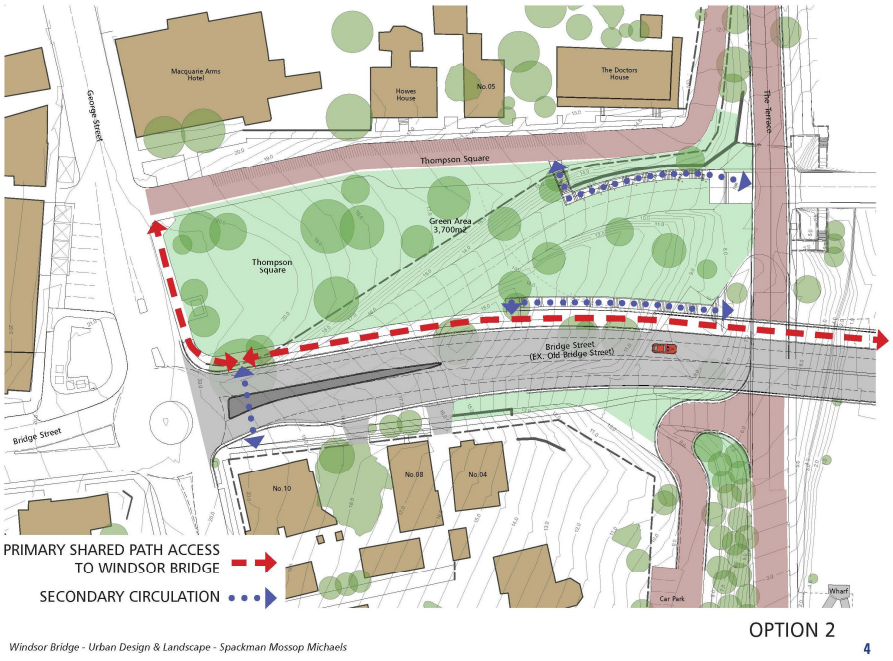
Additional information on these options can be found in the Visual Amenity, Urban Design and Landscaping working paper (Working paper 5 – Volume 3). These would be further refined during the detailed design process.

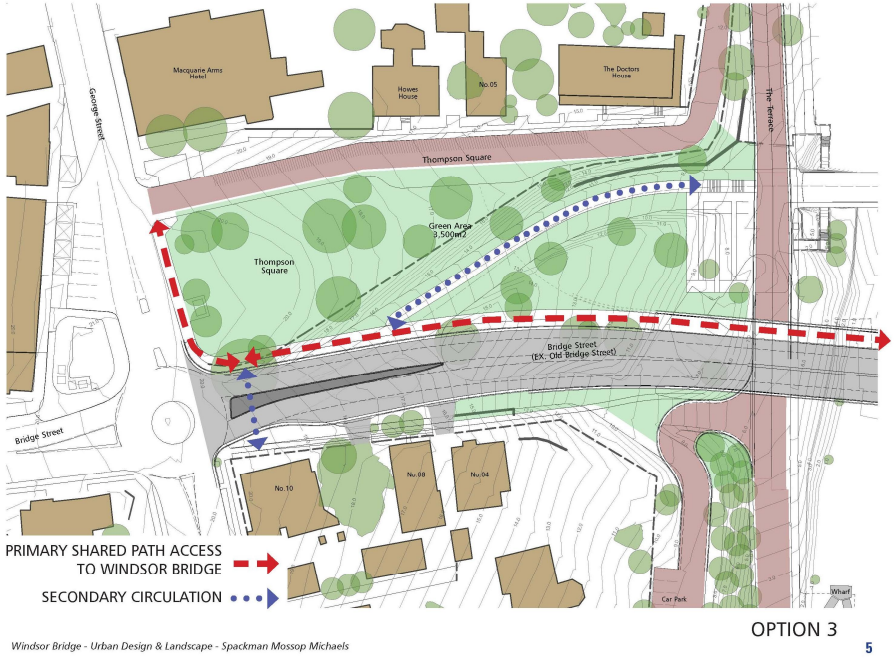
4.6 Consideration of the principles of Ecologically Sustainable Development

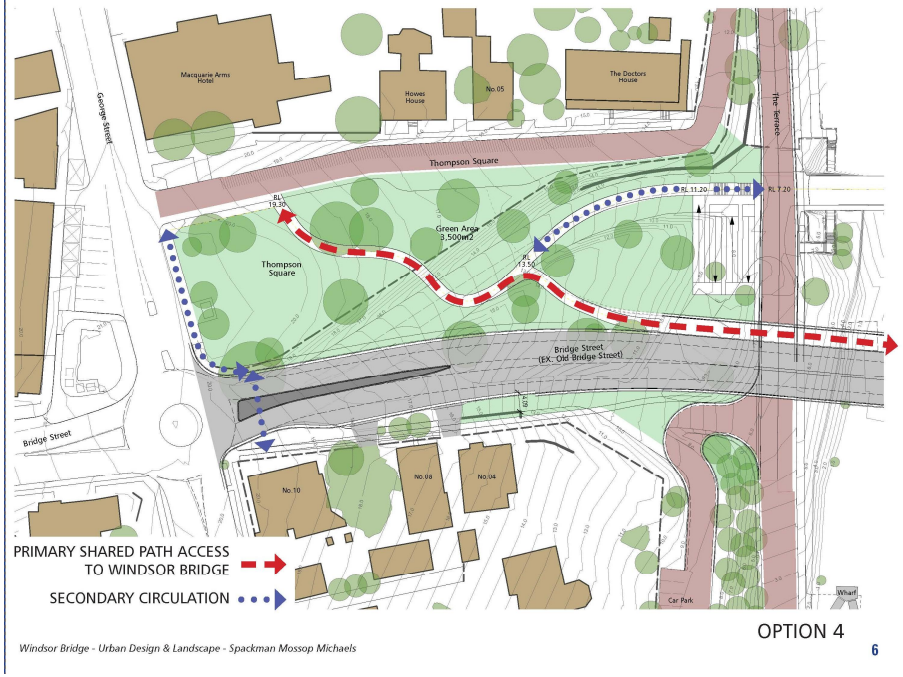
The environmental, social, engineering and cost factors considered in the options selection process and project development, as summarised in this chapter of the EIS, are consistent with consideration of the principles of Ecologically Sustainable Development (ESD). Consideration of ESD would continue during the detailed design process, including further refining the design of the bridge and Thompson Square to further minimise potential impacts. The principles of ESD would also be incorporated in construction through the development and implementation of environmental management measures, should the project be approved. ESD is considered in further detail as part of the justification for the project in Chapter 11.

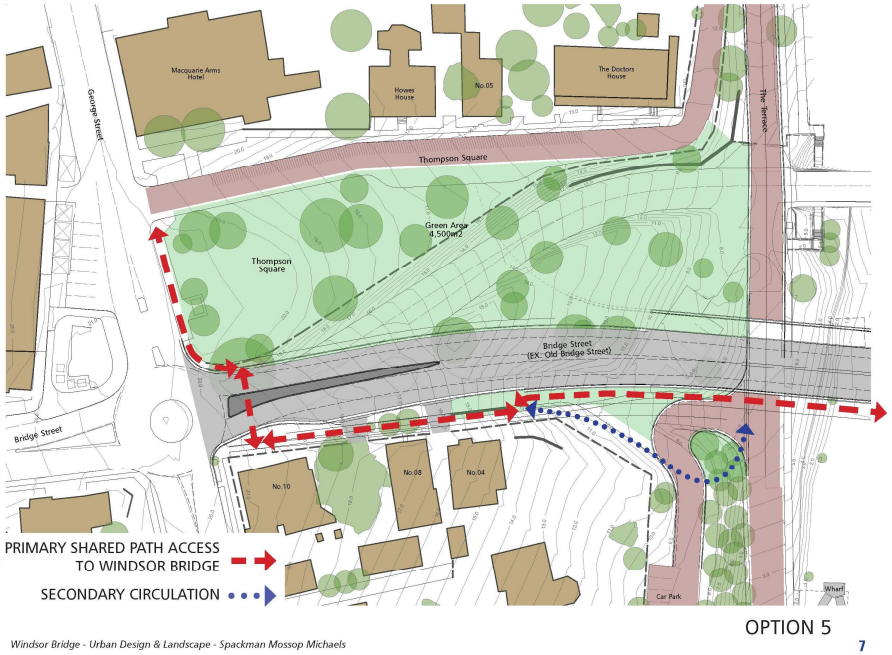
Table 4-4 Urban design options for Thompson Square open space

Option	Design	Description and Assessment
A		**Description** This option would consist of a single shared path along the new alignment of Bridge Street – which would join with the existing path along George Street. No additional paths or stairways would be provided in the Thompson Square parkland. **Advantages** 1) The shared path provides a logical and direct connection to the bridge from the George Street and Bridge Street intersection. 2) Uninterrupted green open space in Thompson Square is provided. This is helped by aligning the path with the edge of the square. 3) The shared path alignment is easily constructed adjacent to the roadway reducing the construction footprint in Thompson Square. 4) The shared path provides a suitable alignment for both pedestrians and cyclists. **Disadvantages** 1) This creates a relatively steep grade (up to eight per cent) down to the bridge, which is not desirable for mobility impaired access. 2) The access from the area around the intersection on George Street, near the Macquarie Arms Hotel, to the bridge, is not direct. 3) The footpath on the eastern side of the square between Bridge Street and the adjoining properties would not be suitable for mobility impaired access.

Option	Design	Description and Assessment
B		**Description** This option would consist of a single shared path along the new alignment of Bridge Street – which would join with the existing path along George Street. Landscaped stairways from the Bridge Street shared path to The Terrace and from Thompson Square road to The Terrace would also be provided. **Advantages** 1) The stairs adjacent to the bridge abutment provide direct access to The Terrace and the river foreshore and assist in integrating the bridge abutment into the Square. 2) Stairs adjacent to the retaining wall next to the Doctor's House would provide access for pedestrians from the road in the square down to The Terrace and river foreshore. 3) The shared path provides a logical and direct connection to the bridge from the George Street and Bridge Street intersection. 4) Contiguous green open space in Thompson Square would be provided. This is helped by aligning the path with the edge of the square. 5) The shared path alignment is easily constructed adjacent to the roadway reducing the construction footprint in Thompson Square. 6) The shared path provides a suitable alignment for both pedestrians and cyclists. **Disadvantages** 1) This option does not improve access for mobility impaired people to The Terrace and the river, over that described in option 1 or the current situation. 2) This creates a relatively steep grade (up to eight per cent) down to the bridge, which is not desirable for mobility impaired access. 3) The access from the area around the intersection on George Street, near the Macquarie Arms Hotel, to the bridge, is not direct. 4) The footpath on the eastern side of the square between Bridge Street and the adjoining properties would not be suitable for mobility impaired access.

Option	Design	Description and Assessment
C		**Description** This option would consist of a single shared path along the new alignment of Bridge Street – which would join with the existing path along George Street. A secondary path would be provided basically along the alignment of the existing approach road to a series of ramps to provide mobility impaired access to The Terrace. **Advantages** 1) The secondary path provides direct access through the Square to The Terrace and to the river foreshore. 2) The secondary path provides opportunity to interpret the heritage alignment of the existing Bridge Street approach to the bridge through Thompson Square. 3) The shared path provides a logical and direct connection to the bridge from the George Street and Bridge Street intersection. 4) The shared path alignment is easily constructed adjacent to the roadway reducing the construction footprint in Thompson Square. 5) The shared path provides a suitable alignment for both pedestrians and cyclists. **Disadvantages** 1) A secondary path cuts across the Square disrupting the contiguous green open space between George Street and The Terrace. 2) A secondary path would require complex grading in order to meet mobility impaired access guidelines. 3) The ramp access on the secondary path adjacent to The Terrace both physically and visually separates The Terrace from the square. 4) This creates a relatively steep grade (up to eight per cent) down to the bridge and this is not desirable for mobility impaired access. 5) The access from the area around the intersection on George Street, near the Macquarie Arms Hotel, to the bridge, is not direct. 6) The footpath on the eastern side of Bridge Street and the adjoining properties will not be suitable for mobility impaired access.

Option	Design	Description and Assessment
D		**Description** This option would consist of a curved shared path through the middle of the Thompson Square parkland. A secondary path would be provided from the shared path along the alignment of the existing approach road to a series of ramps to provide mobility impaired access to The Terrace. **Advantages** 1. A shared path provides more direct access to the George Street intersection near the Macquarie Arms Hotel. 2. Pedestrian and cyclist amenity is improved as it is partially located within the square and away from traffic on Bridge Street. 3. Both paths provide some opportunity to interpret the earlier/historic alignments of roads through the square. 4. The secondary path provides more direct access through the square to The Terrace and the river foreshore. **Disadvantages** 1. Direct shared path access is not provided to the George and Bridge Street intersection to avoid duplicating the shared path in Thompson Square. 2. The shared path alignment is not in a typical location being away from the roadside and therefore may be disorienting for new path users. 3. The shared and secondary paths cut across the square disrupting the green open space between George Street and The Terrace. 4. The shared path alignment is less easily constructed away from the roadway increasing the construction footprint into the Square. 5. Both paths would require complex grading to meet mobility impaired access guidelines. 6. The ramp access on the secondary path adjacent to The Terrace physically and visually separates The Terrace from the square and takes up substantial space.

Option	Design	Description and Assessment
E		**Description** The shared path along Bridge Street and the replacement bridge would be on the eastern side. There would be no paths or ramps in Thompson Square green space. **Advantages** 1. The shared path maximises the use of an area of the road corridor which would be underutilised due to the need for a curved road alignment on the approach to the bridge. 2. The shared path provides a logical and direct connection to the bridge from the George Street and Bridge Street intersection. 3. The uninterrupted green open space in the square is maximised by aligning the path with the eastern edge of the square. 4. The shared path alignment is easily constructed adjacent to the roadway minimising the construction footprint. 5. Access to and from the properties on the eastern side of the square across Bridge Street is helped by this alignment of the shared path. 6. The shared path provides a suitable alignment for both pedestrians and cyclists. **Disadvantages** 1. The relatively steep grade (up to eight per cent) down to the bridge is not desirable for providing mobility impaired access. 2. Access from the area around the intersection on George Street, near the Macquarie Arms Hotel, to the bridge, is not direct and requires people to cross the George and Bridge Streets intersection. 3. Access to Macquarie Park on the northern foreshore requires crossing under the bridge at the abutment. 4. Access for mobility impaired people down to The Terrace and River foreshore is restricted to the road on the western edge of the square (past the Doctor's House).

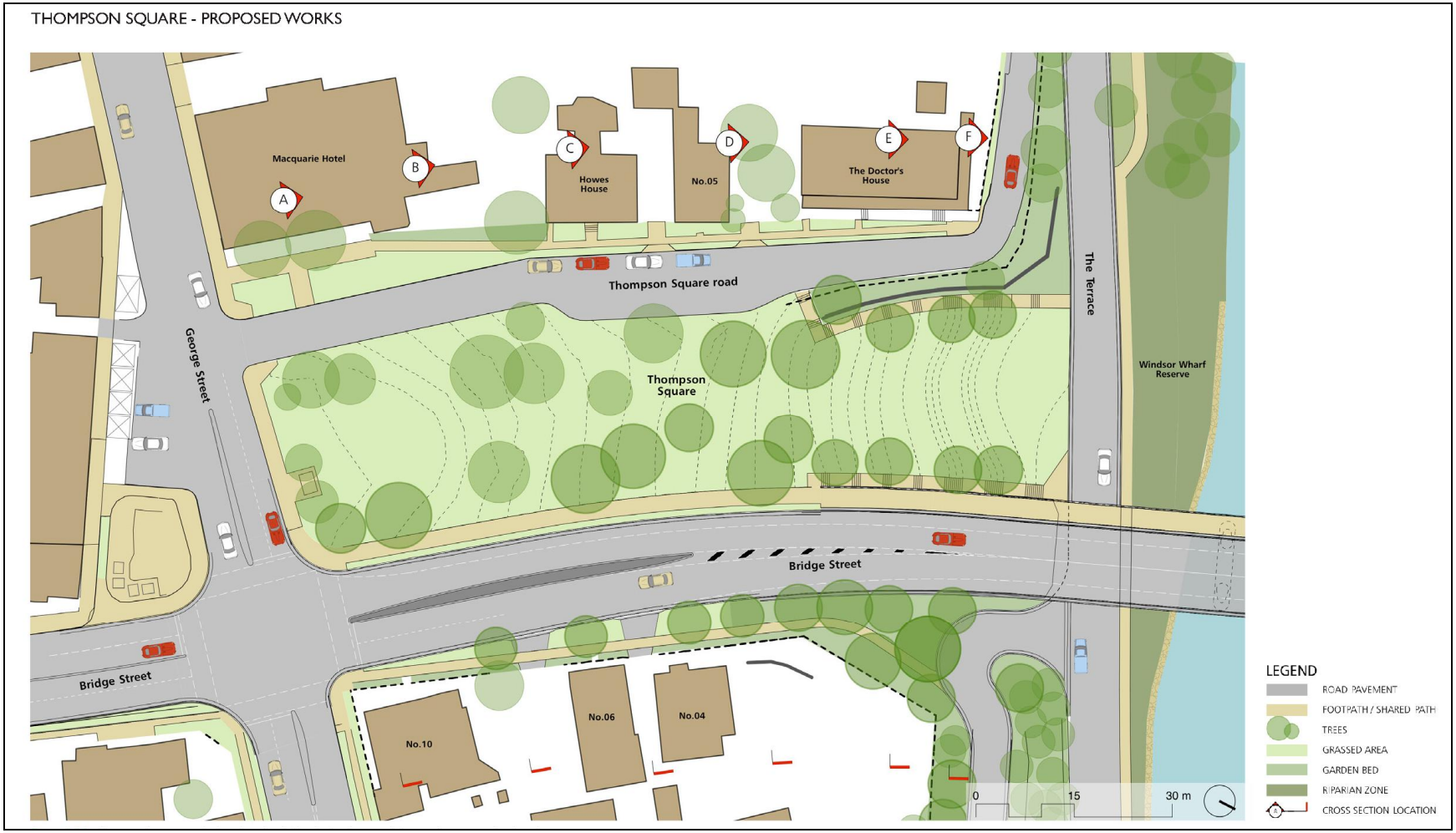


Figure 4-11 Further development of option B

4.7 Confirmation of the preferred option for the project

The preferred option for the project comprises the following:

- Replace the existing Windsor bridge with a new downstream high-level bridge via the alignment of Old Bridge Street (option 1).
- Provide an incrementally launched bridge structure (bridge option 2).
- Minimise bridge height and vertical elevation of the bridge access road in Thompson Square to reduce visual impacts on Thompson Square while still providing sufficient under-bridge clearance for service vehicles to access Windsor Wharf along The Terrace.
- Replace the roundabout at the intersection of George Street and Bridge Street with traffic signals and construct a new dual lane roundabout at the intersection of Freemans Reach Road, Wilberforce Road, Macquarie Park access road and the northern bridge approach road.
- Rehabilitate Thompson Square based on option B – recognising that further consultation is required.
- Rehabilitate and landscape other areas of the project impacted by construction.
- Demolish the existing Windsor bridge.

In comparison to other options, the preferred option for the project performs best in terms of value for money and satisfies the majority of project objectives (refer to **Table 4-2**). The selected bridge option and southern approach road alignment would also minimise the option's potential visual and construction impacts on the Thompson Square parkland. The replacement bridge would have improved flood immunity, would allow access along The Terrace for buses, emergency and service vehicles, and would provide improved pedestrian access both across the river and along the southern bank.

In comparison to the other options, adverse impacts on community amenity and traffic flows during the construction period would be relatively minor and there would be no significant long-term changes in access to Windsor for local residents or through traffic. The new bridge would maintain the existing, historic linkage between the northern and southern sides of the Hawkesbury River at Windsor and the continuity of Thompson Square as a link to the river and a civic park.

The main adverse effects of the preferred option would be impacts on historic heritage, including direct and visual impacts on Thompson Square Conservation Area, the character of its open space and surrounding heritage buildings, and buried archaeological evidence, with potential for flow-on effects on the character and amenity of the Windsor township. Additional issues include the potential for traffic noise and vibration impacts associated with the change in location and height of the bridge, as well as changed access arrangements for two properties on Old Bridge Street. These impacts have been considered in design and options development - and would be further mitigated and/or managed using the measures identified in this EIS. These measures include:

- Detailed management and conservation measures to avoid, minimise and mitigate impacts on historic heritage.
- Urban design and landscaping treatments to integrate the new bridge with the existing environment and maximise the potential benefits to public open space, community amenity and the character of Windsor.

It should be recognised that Thompson Square has been and is the primary location for crossing the Hawkesbury River and also in the past, a location for wharves to ship and receive goods when river transport was the principal means of moving large quantities or heavy goods. Crossing of the river pre-1874 was via a ferry or punt crossing and post 1874 via the bridge. Consequently a road from George Street to either the wharves or the bridge has been a constant feature of Thompson Square, although the alignment, size and layout of roads in Thompson Square has varied considerably over 200 years. The current alignment was established in 1934.

One of the benefits of the preferred option is that it removes the existing bridge approach road through the Thompson Square parkland, creating a larger area of consolidated open space in this location. This increase in consolidated parkland, in conjunction with the proposed urban design and landscaping treatments and the proposed heritage management and conservation measures, provides an opportunity to improve some of the amenity aspects of the area for public use consolidating the currently divided open space and improve pedestrian connections to the river. This increase and reconfiguration of the open space, in conjunction with the urban design and landscaping treatments and heritage management measures described in this EIS, would provide an opportunity to increase the area for public use and address the heritage values of area.

The adverse impacts of the preferred option are considered justified in view of the need for the project and the alternative options available. If the bridge is not refurbished or replaced, its structural condition will continue to deteriorate with age. This will lead to increasing maintenance costs in the short term and ultimate closure of the bridge in the long term when ongoing maintenance can no longer provide an adequate level of traffic safety. This would result in the loss of an important bridge crossing of the Hawkesbury River, with impacts on local and regional connectivity. Existing bridge users would need to use alternative river crossing points, resulting in increased travel times and adverse effects on the local economy of Windsor.

The preferred option, including the chosen alignment for the replacement bridge, minimises the substantial changes to traffic conditions and access arrangements that would be associated with other options. In particular, it avoids:

- The need to close the existing bridge during the construction period, which would be required intermittently during construction for option 3 (new bridge immediately upstream of existing bridge) and for the duration of the construction period for option 9A and B (refurbishment of the existing bridge).
- Impacts on residential areas that currently do not experience high levels of traffic and associated amenity impacts (options 4, 5, 6, 7 and 8 and community options – Livingston Road, Pitt Town Bottom Road and Hawkesbury Way).
- Loss of parking and major changes in road access within the Windsor township (which would occur in the cases of options 4 and 5 and community option – Bridge Street tunnel).
- Impacts on existing boating activities (which are likely to occur in the cases of options 6, 7 and 8 and community options – Livingston Road and Pitt Town Bottom Road).
- Closures of the bridge during low level flood events (which would occur in the cases of option 2 and 9).

The proposed flood immunity level of the new bridge and the proposed number of traffic lanes would be compatible with the approach roads and surrounding traffic routes. Higher levels of flood immunity would not be justified given that access would still be limited by the flood immunity of the approach roads that traverse the Hawkesbury floodplain. Similarly, the width of the bridge and corresponding traffic lane numbers would be limited by the capacity of the intersections and access roads within the township.

The replacement of the existing bridge at Windsor would clearly be in the public interest as the existing bridge does not meet safety and traffic requirements. With high future traffic growth predicted due to increased urban development in the townships on the northern bank of the Hawkesbury River, traffic and safety issues would increase. The existing Windsor bridge has reached the end of its design life and the only long-term cost effective option would be to build a new replacement bridge.

The preferred option for the replacement bridge and other elements of the project are described in detail in **Chapter 5**.

5 Project description

This chapter provides a detailed description of the construction and operation of the project. It defines the project scope and describes each of the project elements, the design standards and criteria used in the development of the concept design, and the proposed construction process.

5.1 Project scope

RMS proposes to replace the existing Windsor bridge over the Hawkesbury River. The Windsor bridge replacement project would involve:

- Construction of a new bridge over the Hawkesbury River at Windsor, around 35 metres downstream of the existing Windsor bridge.
- Construction of new approach roads and intersections to connect the new bridge to existing road network.
- Modifications to local roads and access arrangements, including changes to the Macquarie Park access and connection of The Terrace.
- Construction of pedestrian and cycling facilities, including a shared pedestrian/cycle pathway for access to and across the new bridge.
- Removal and backfilling of the existing bridge approach roads.
- Demolition of the existing Windsor bridge.
- Urban design and landscaping works, including within the parkland area of Thompson Square and adjacent to the northern intersection of Wilberforce Road, Freemans Reach Road and the Macquarie Park access road.
- Ancillary works such as public utility adjustments, water management measures and scour protection works.

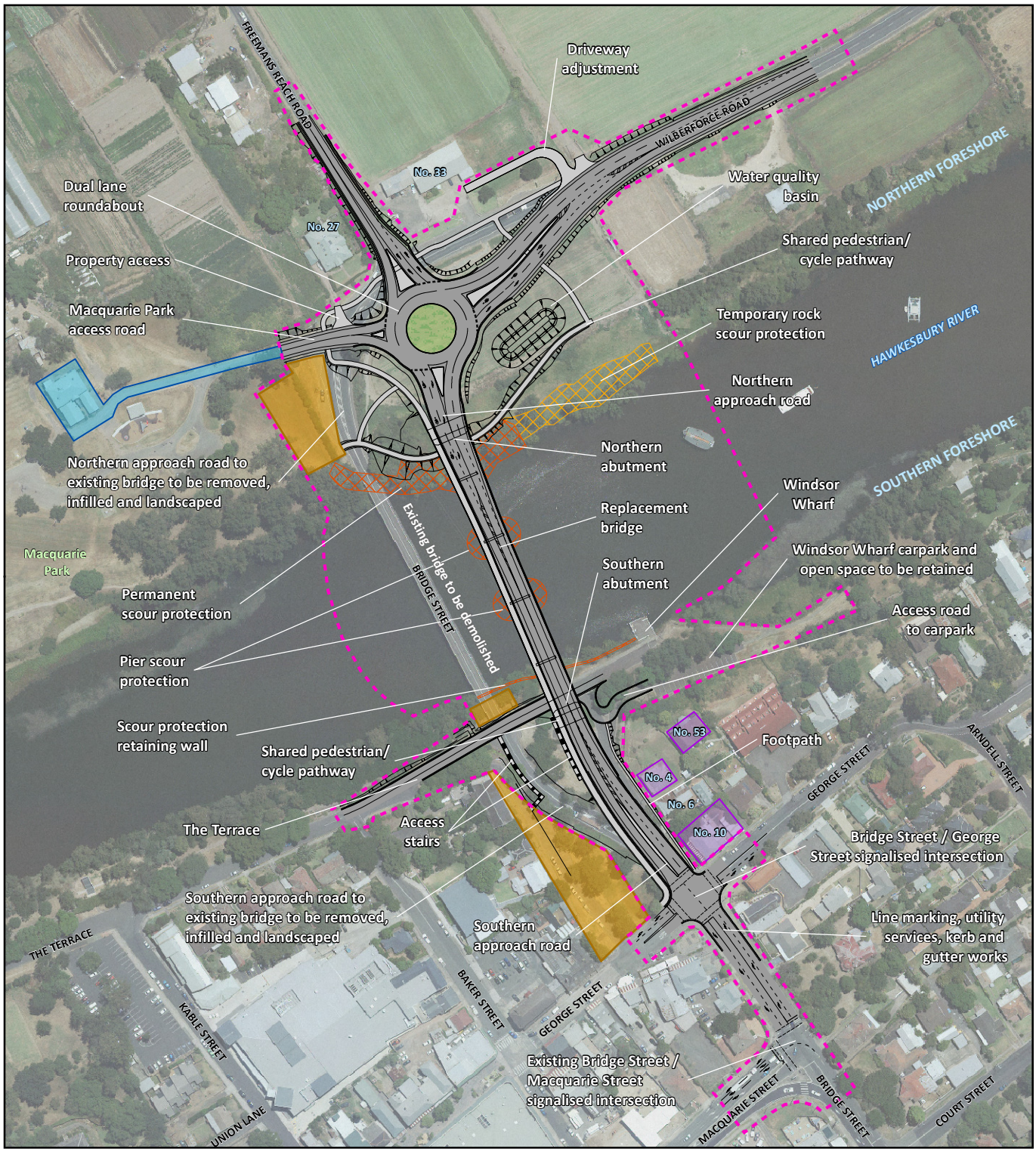
This EIS seeks approval for the project elements described above. The EIS has been prepared based on a concept design. If approved, a further detailed design process will follow which may include variations to the concept design. This approach is consistent with the approach taken in other environmental assessments of major infrastructure projects. In this EIS, however, the level of project detail described in the subsequent sections is substantially greater than would normally be provided. The reason for this detail is to assist with understanding and conveying the potential impacts of the project on heritage views and vistas.

The detailed design process will seek to further minimise impacts and optimise traffic efficiency. In doing so it is likely to necessitate changes to a number of project elements but will not affect the key project elements described. These design changes would consider the principles of ESD.

Figure 5-1 and **Figures 5-1a to Figure 5-1c** shows the key elements of the project concept design as well as the total indicative project boundary anticipated for construction and operation of the works. The design of the project presented in the figures is indicative and would be subject to further refinement during detailed design. **Figure 5-2** shows indicative locations of the temporary construction and compound sites.

Further details of the various work elements are provided in **Section 5.2**. Refinements to design features may be made during the detailed design phase (if the project is approved) to further reduce environmental impacts.

Figure 5-1 | Key project elements



Indicative only – subject to detailed design

LEGEND

- Concept design
- Construction work zone
- Permanent rock scour protection (if required)
- Temporary rock scour protection (if required)
- Properties requiring flood mitigation works. Works subject to further consultation with and agreement from affected property owners.
- Properties requiring noise mitigation works. Works that are feasible and reasonable would be subject to further consultation with and agreement from affected property owners.
- Works subject to further council and stakeholder consultation

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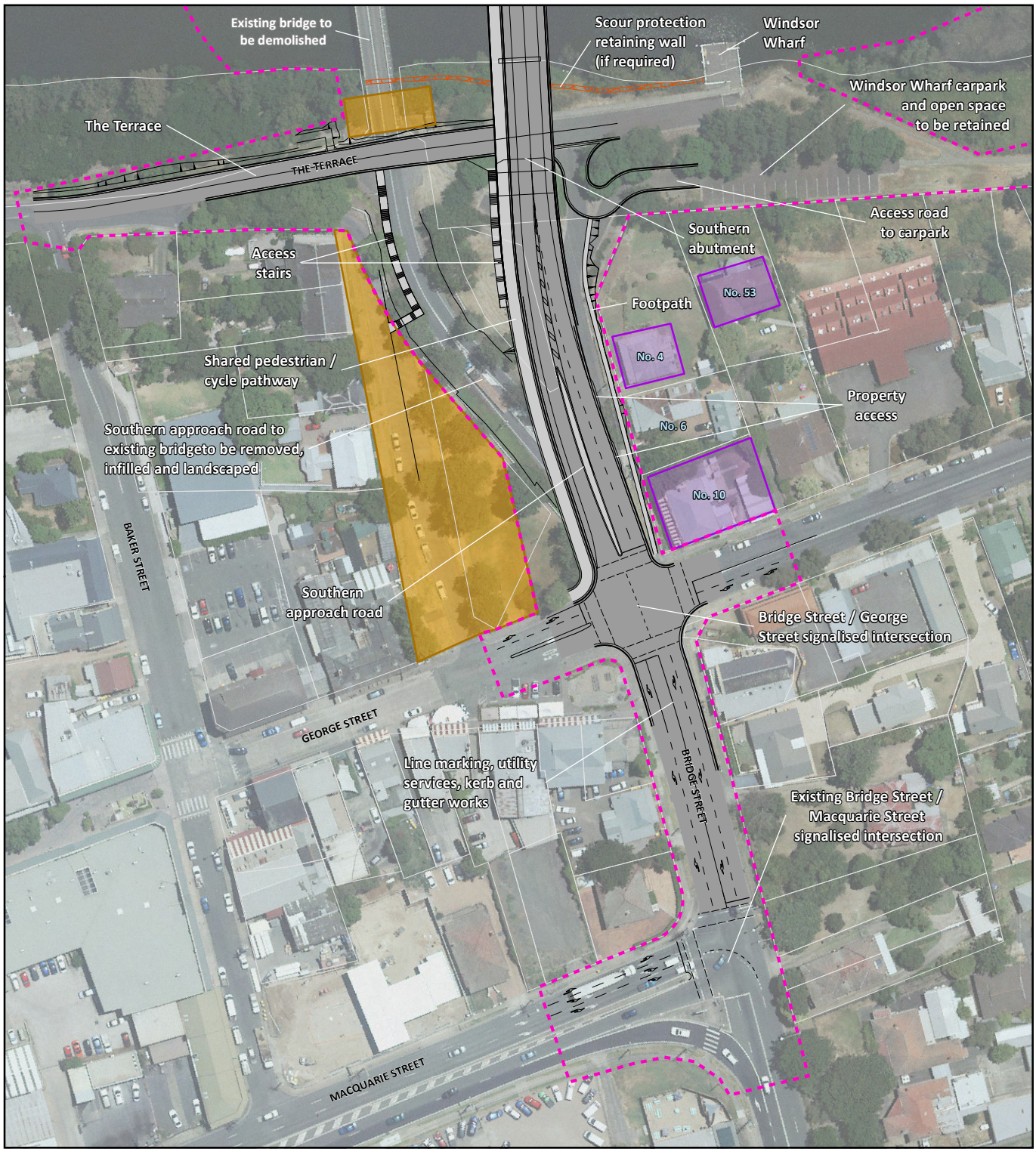
AUSIMAGE SKM

Figure 5-1a | Key project elements - Southern Approach



Indicative only – subject to detailed design

LEGEND

- Concept design
- Construction work zone
- Permanent rock scour protection (if required)
- Temporary rock scour protection (if required)
- Cadastral boundary
- Properties requiring flood mitigation works. Works subject to further consultation with and agreement from affected property owners.
- Properties requiring noise mitigation works. Works that are feasible and reasonable would be subject to further consultation with and agreement from affected property owners.
- Works subject to further council and stakeholder consultation

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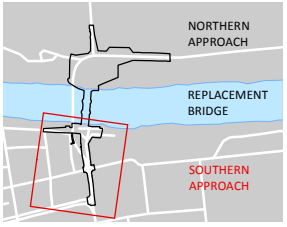
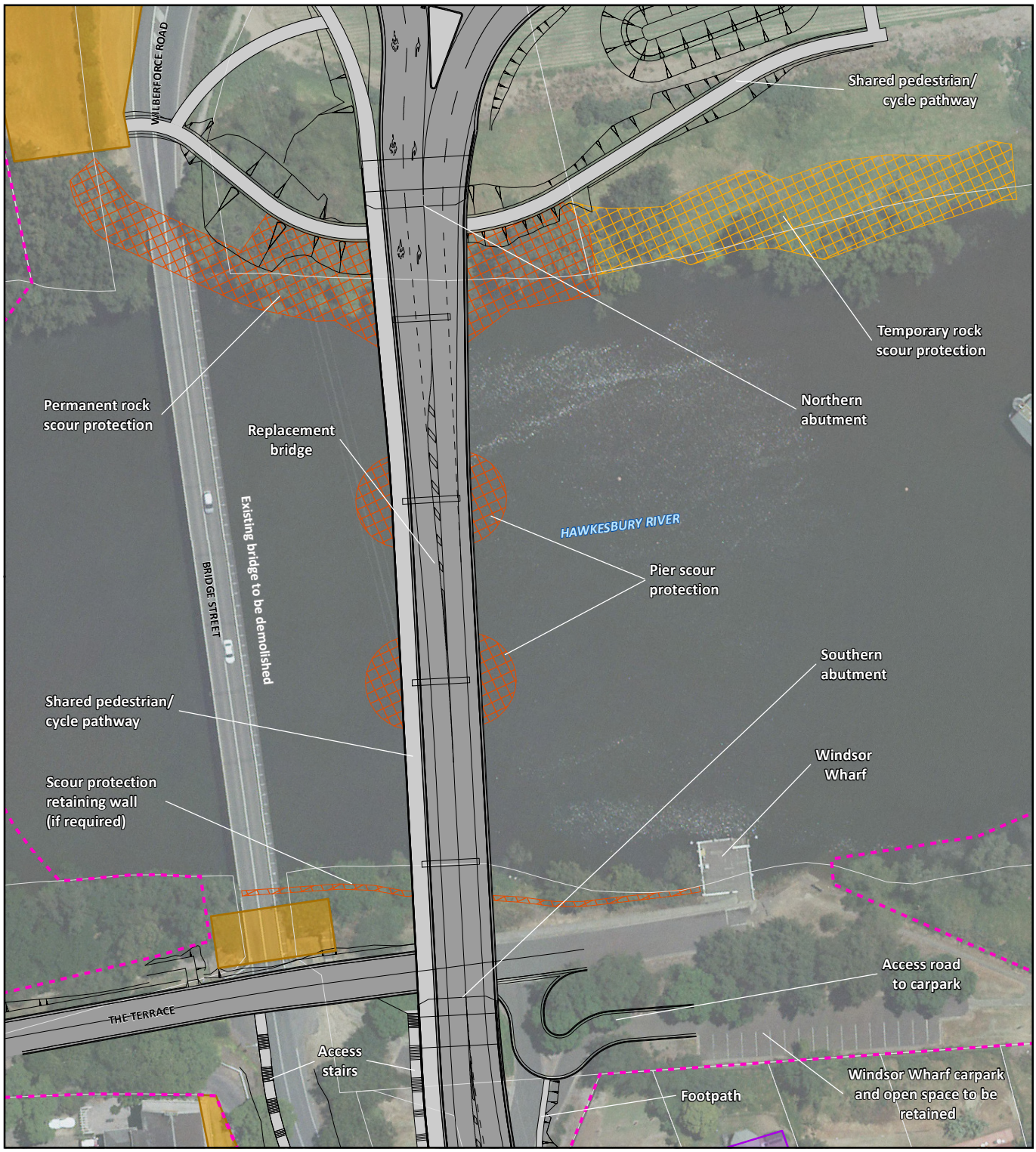


AUSIMAGE SKM

Figure 5-1b | Key project elements - Replacement Bridge



Indicative only – subject to detailed design

LEGEND

- Concept design
- Construction work zone
- Permanent rock scour protection (if required)
- Temporary rock scour protection (if required)
- Cadastral boundary
- Properties requiring flood mitigation works. Works subject to further consultation with and agreement from affected property owners.
- Properties requiring noise mitigation works. Works that are feasible and reasonable would be subject to further consultation with and agreement from affected property owners.
- Works subject to further council and stakeholder consultation

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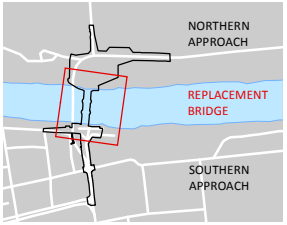
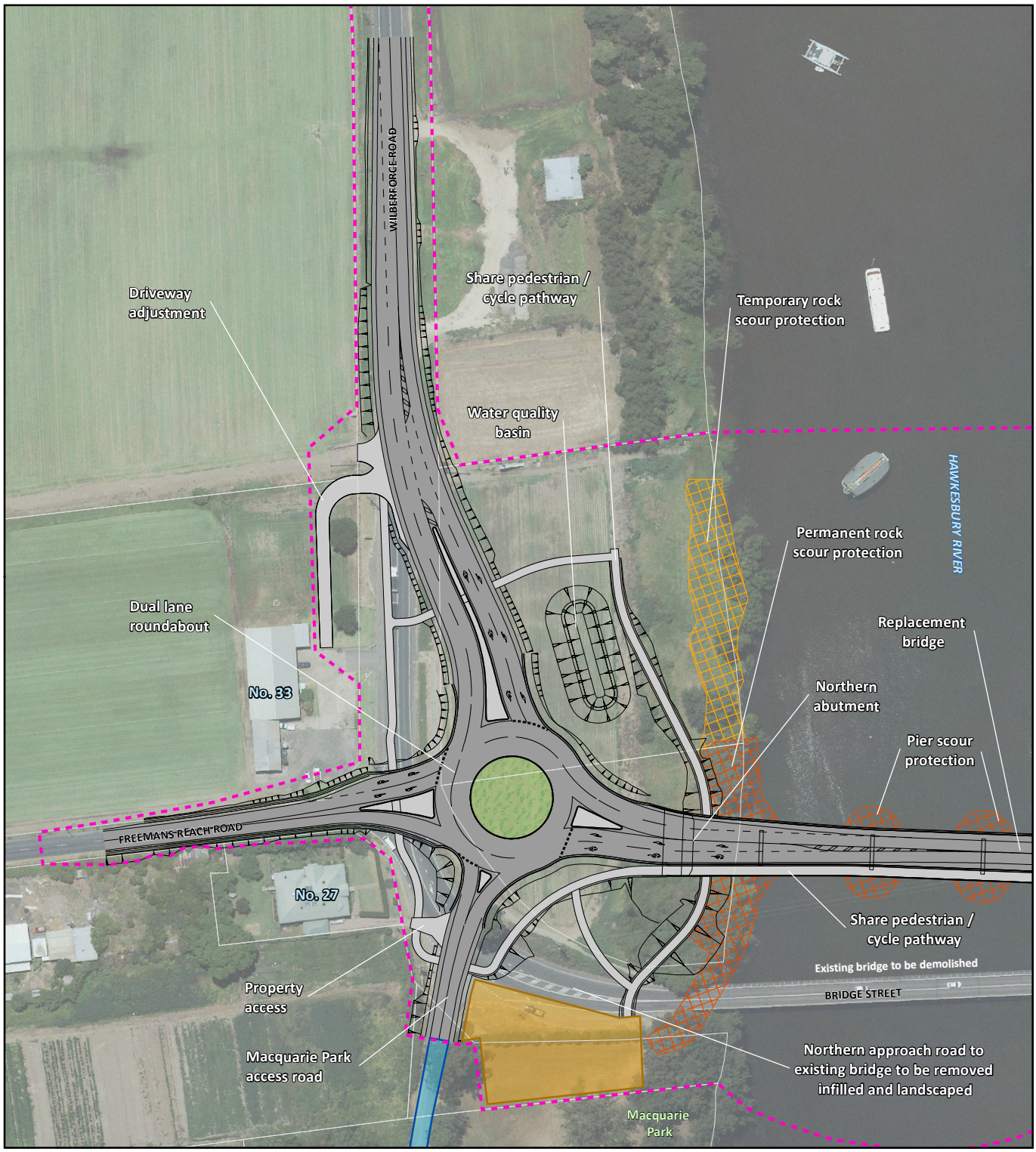


AUSIMAGE SKM

Figure 5-1c | Key project elements - Northern Approach



Indicative only – subject to detailed design

LEGEND

- Concept design
- Construction work zone
- Permanent rock scour protection (if required)
- Temporary rock scour protection (if required)
- Cadastral boundary
- Properties requiring flood mitigation works. Works subject to further consultation with and agreement from affected property owners.
- Properties requiring noise mitigation works. Works that are feasible and reasonable would be subject to further consultation with and agreement from affected property owners.
- Works subject to further council and stakeholder consultation

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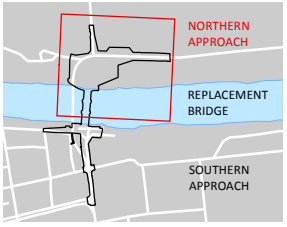
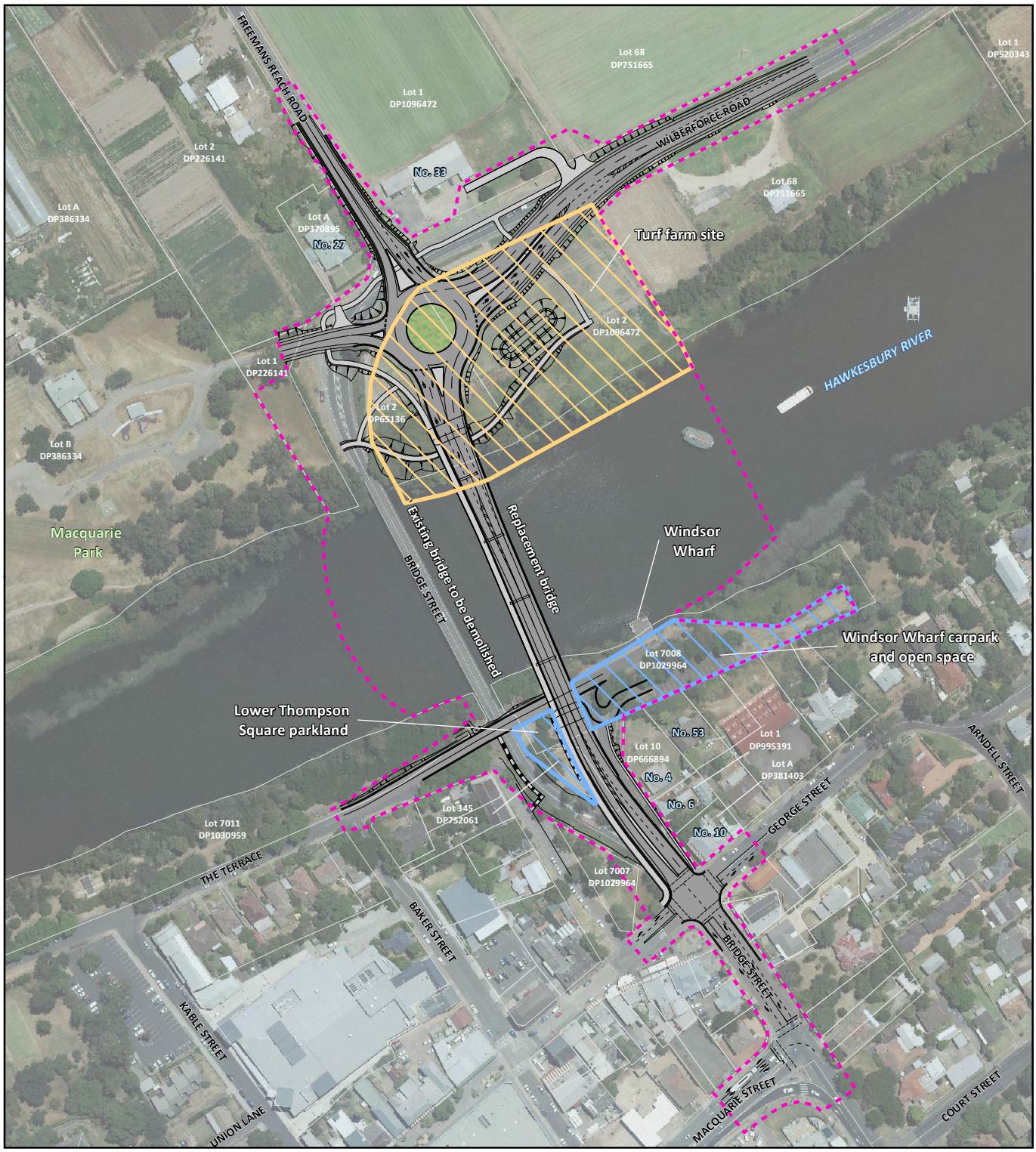


AUSIMAGE SKM

Figure 5-2 | Indicative areas for temporary construction compounds



Indicative only – subject to detailed design

LEGEND

- Concept design
- Construction work zone
- Areas for temporary construction and secondary compound sites
- Main construction compound site
- Cadastral boundary

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AUSIMAGE SKM

5.2 Project elements

5.2.1 The replacement bridge

The replacement bridge would be located around 35 metres downstream of the existing Windsor bridge. The southern approach to the replacement bridge would be via a new realigned section of Bridge Street, which would start at the existing intersection of George Street and Bridge Street and head generally north-westwards along the alignment of Old Bridge Street on the eastern side of the Thompson Square parkland. On the northern side of the river, the replacement bridge would connect with the junction of Wilberforce Road, Freemans Reach Road and the Macquarie Park access road at a new roundabout intersection (to be constructed as part of the project). Bridge approach roads and intersection modifications are described in **Section 5.2.2**.

The replacement bridge would be constructed using the incrementally launched method. The bridge would comprise of five spans and would be constructed of reinforced concrete. The bridge deck would be about 15.2 metres wide and supported on up to four piers within the river. It would have an overall length of about 159 metres, spanning both the river and The Terrace. The clearance under the bridge where it spans The Terrace would be about 3.6 metres, which would allow a range of service and emergency vehicles to pass under the bridge and access Windsor Wharf. The minimum clearance under the bridge where it spans the river would be about 7.5 metres at the average high tide level. An illustration of the proposed replacement bridge is provided in **Figure 5-3** and a cross section is presented in **Figure 5-4a** and **Figure 5-4b**.

The replacement bridge would initially comprise two traffic lanes (one in each direction), each 3.5 metres wide and with an adjacent two metre wide shoulder. There would also be a three metre wide shared pedestrian/cycle path on the western side of the bridge.

The wide road shoulders of the replacement bridge would allow the bridge to be re-configured to a three lane bridge in the future, when required. This would be achieved by reducing the road shoulder width to 0.5 metres and changing the lane markings, without the need for additional construction. The change in lane configuration would not affect the width of the pedestrian/cycle path. The introduction of the three lane configuration would occur when growth in traffic results in unacceptable levels of service. The three traffic lanes would consist of two southbound lanes and one northbound lane. All three lanes would be about 3.3 metres wide.

The low point of the replacement bridge at deck level would be around 9.8 metres Australian Height Datum (AHD), making it around 2.8 metres higher than the lowest point of the existing bridge. This would give the replacement bridge a slightly higher level of flood immunity than the existing bridge. Specifically, while the existing bridge is overtopped in a one in two year flood, the replacement bridge is predicted to remain above water for the one in two year flood but be overtopped in an event just smaller than the one in three year flood.

FIGURE 5-3 | Western Elevation of replacement bridge

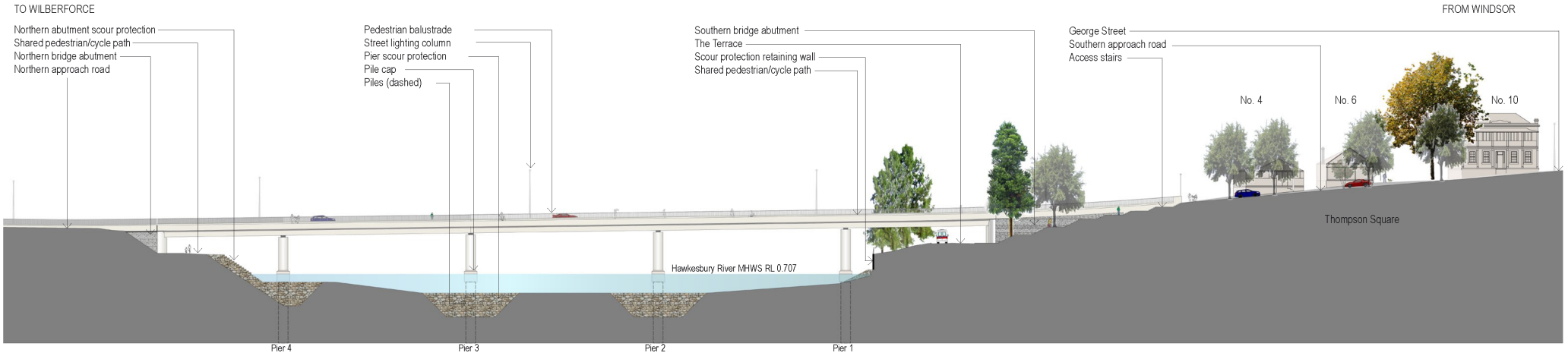

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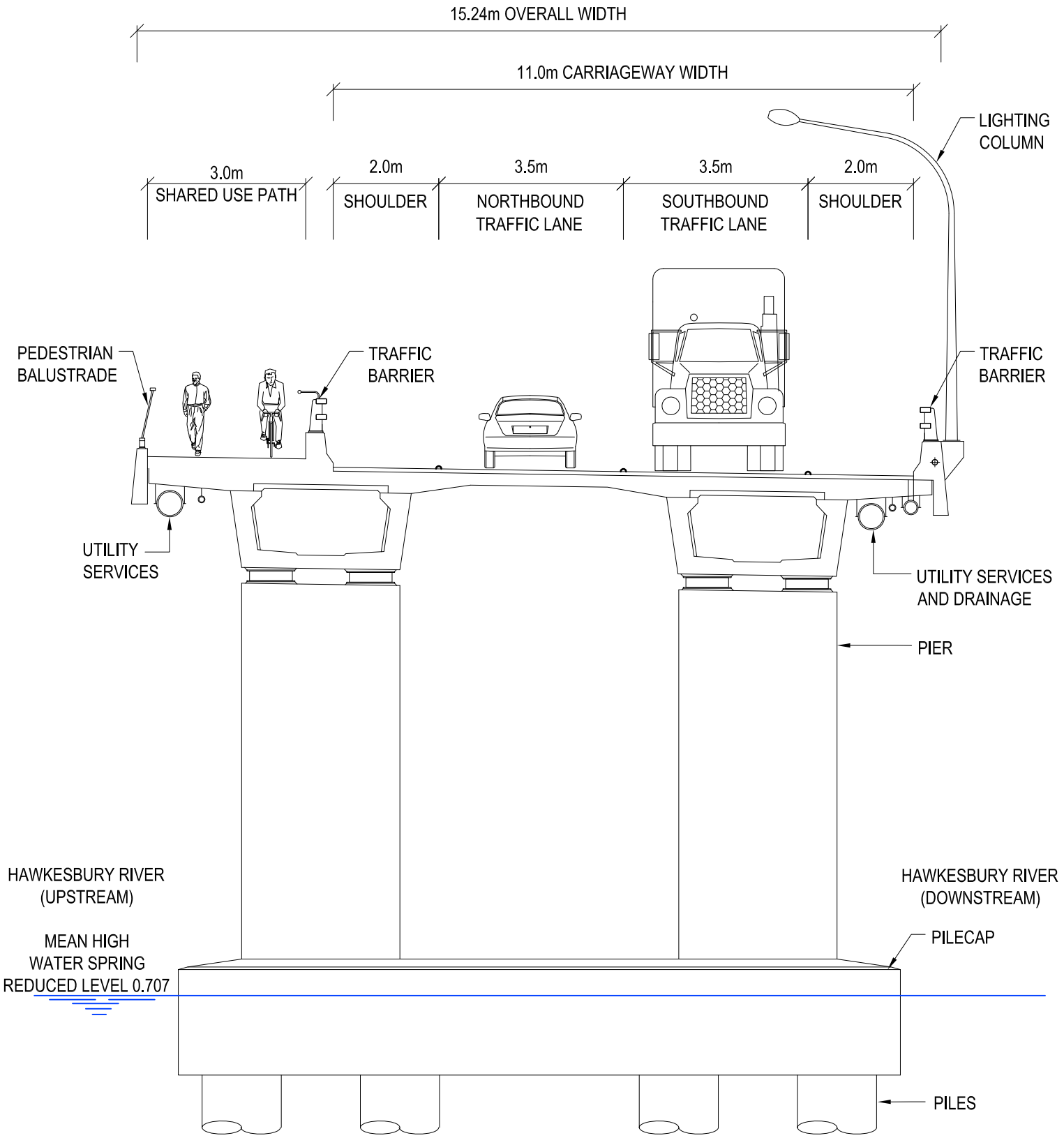
FIGURE 5-4a | Typical cross section of bridge - two lane configuration (at time of opening)



0 1 2 3 4 5m

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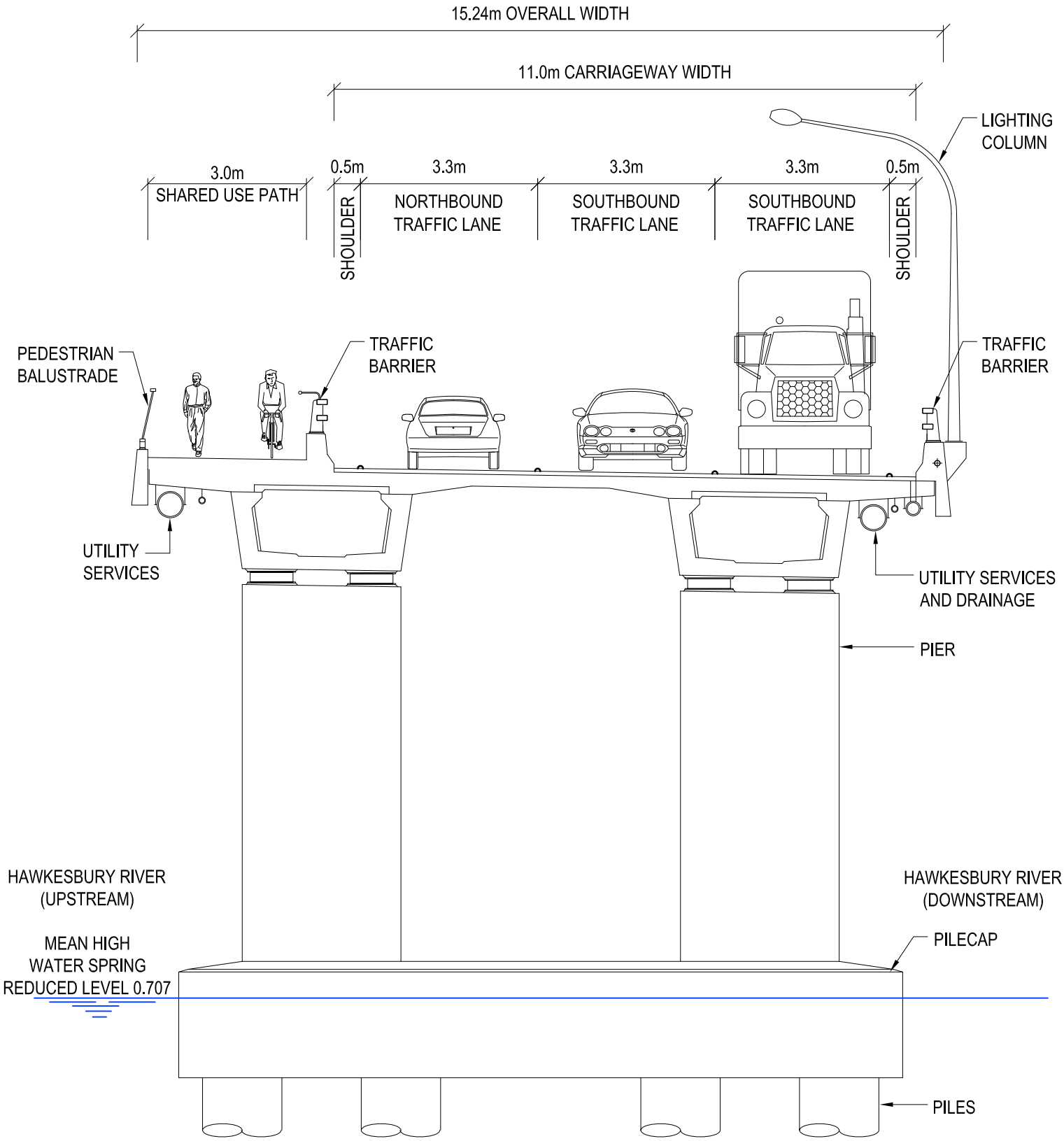
INDICATIVE ONLY - SUBJECT TO DETAILED DESIGN

FIGURE 5-4b | Typical cross section of bridge - three lane configuration (future option)



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SCALE 1:100

This level of flood immunity is consistent with that of the immunity of the roads on the northern side of the Hawkesbury River i.e. Wilberforce Road and Freemans Reach Road, which have a flood immunity that lies about midway between the one in two year and one in three year flood levels. The replacement bridge would be marginally above minimum road levels along Wilberforce Road and Freemans Reach Road, and thus may improve flood access into Windsor from the north. It is important to note that the frequency and depth of flooding in the Windsor area is expected to increase under climate change scenarios (refer to Chapter 7, **Section 7.7**).

5.2.2 Reconstruction of existing bridge approach roads and intersections

Modifications would be made to existing bridge approach roads and intersections to accommodate the change in bridge location and provide improvements in traffic safety and flow. The locations of these works are shown on **Figure 5-1** and **Figures 5-1a to c** and would include:

- Construction of a new southern approach road, involving realignment of Bridge Street north of its intersection with George Street so that it follows the existing alignment of Old Bridge Street and connects to the replacement bridge.
- Removal of the existing section of Bridge Street that runs diagonally through Thompson Square, backfilling the cutting and reinstatement of this area as open space.
- Replacement of the existing roundabout at the intersection of George Street and Bridge Street with a new signalised intersection.
- Construction of a new northern bridge approach road.
- Construction of a new dual lane roundabout at the junction of Freemans Reach Road, Wilberforce Road, Macquarie Park access road and the new northern bridge approach road.
- Upgrade of the Freemans Reach Road, Wilberforce Road and Macquarie Park access road approaches to the new dual lane roundabout.

5.2.3 Additional modifications to local roads and access arrangements

Changes to property access

Under the new bridge approach arrangements, vehicles would no longer be able to turn right into (or out of) two existing properties on the eastern side of Old Bridge Street (Number 4 and Number 6 Old Bridge Street). Vehicle access to these properties would be available via the southbound carriageway of the southern approach road through ‘left-in’ / ‘left-out’ turning movements. Drivers travelling from the south would need to cross the bridge, circle the roundabout and re-cross the bridge from the northern side to gain access to these properties. Drivers exiting these two properties and wanting to travel north would first need to turn left and make a right turn into George Street and make their way to Macquarie Street before turning left into Bridge Street and travelling north.

Access to Number 33 Wilberforce Road would also be altered under the new traffic arrangements. For safety, the existing driveway would be removed and a new driveway constructed further to the east (away from the proposed dual lane roundabout) to a point where all turning movements onto and off Wilberforce Road could be maintained.

Connection of The Terrace

The Terrace is a minor local road on the southern side of the river and is currently split into two sections by the existing Windsor bridge and approach road through Thompson Square. The removal of the existing bridge and approach road through Thompson Square and the raised height of the replacement bridge would allow the two sections of The Terrace to be connected to provide continuous access along the southern bank of the river and access to Windsor Wharf for pedestrians, cyclists and vehicles.

Vehicle access along The Terrace to Windsor Wharf would be limited by the clearance under the new bridge, which would provide for a clearance of about 3.6 metres. This would allow for light vehicles, buses, a range of service vehicles and emergency vehicles. The clearance would prevent large trucks and coaches (which are about 4.3 metres high) from accessing Windsor Wharf.

Additional road modifications

A number of additional minor modifications would be made to existing roads and footpaths as part of the project. These would include:

- Construction of new road pavement on Bridge Street between Macquarie Street and George Street to allow the required road pavement levels at the new signalised intersection of Bridge Street and George Street to be achieved.
- Alteration of linemarking on Bridge Street between Macquarie Street and George Street to safely direct traffic through the new signalised intersection that would replace the roundabout at George Street and Bridge Street.
- Shortening the length of the central concrete median in Macquarie Street (at the intersection with Bridge Street) to allow the width of the existing pedestrian crossing to be increased from three metres to 3.5 metres in order to meet current design standards.
- Providing additional conduits below the existing footpath along the eastern side of Bridge Street (between Macquarie Street and George Street) via trenching methods to connect the two signalised intersections together such that both sets of traffic signals can be coordinated.
- The existing 33kV (overhead) electricity cable may also be buried underground within the Bridge Street alignment between the Macquarie Street and George Street intersections.

The need for other additional minor modifications may be identified during detailed design.

5.2.4 Pedestrian and cycling facilities

The project would incorporate facilities for pedestrians and cyclists as shown in **Figure 5-5**. The facilities would include a shared pedestrian/cycle pathway constructed from the corner of George and Bridge Streets to Wilberforce Road. It would go along the western side of the southern bridge approach road, across the western side of the replacement bridge to the new dual lane roundabout where Freemans Reach Road and Macquarie Park access road intersect. Pedestrian and cyclist access along the southern bank of the river would also be improved with the connection and redevelopment of The Terrace. The following pedestrian and cyclist facilities would be constructed:

- A 2.4 metre wide shared pedestrian and cyclist path from the intersection of Bridge Street and George Street, to the southern abutment of the replacement bridge.
- A three metre wide shared pedestrian and cyclist path across the western side of the replacement bridge.
- A 2.4 metre wide shared pedestrian path north of the replacement bridge to a point near the entrance to Macquarie Park as shown in **Figure 5-5** and **Figure 5-5a–c**.
- Construction of a new 1.2 metre wide footpath adjacent to properties fronting the realigned Bridge Street. The footpath would extend from the intersection of Bridge Street and George Street and connect to The Terrace on the eastern side of the realigned Bridge Street.
- Construction of a new signalised pedestrian crossing on all four approaches to the intersection of Bridge Street and George Street.
- Construction of new pedestrian footpaths for safe access around and across the proposed dual lane roundabout at the junction of Freemans Reach Road, Wilberforce Road and the Macquarie Park access road, connecting to the path across the replacement bridge.
- Other paths and stairs in Thompson Square parkland (see **Section 5.2.8**).

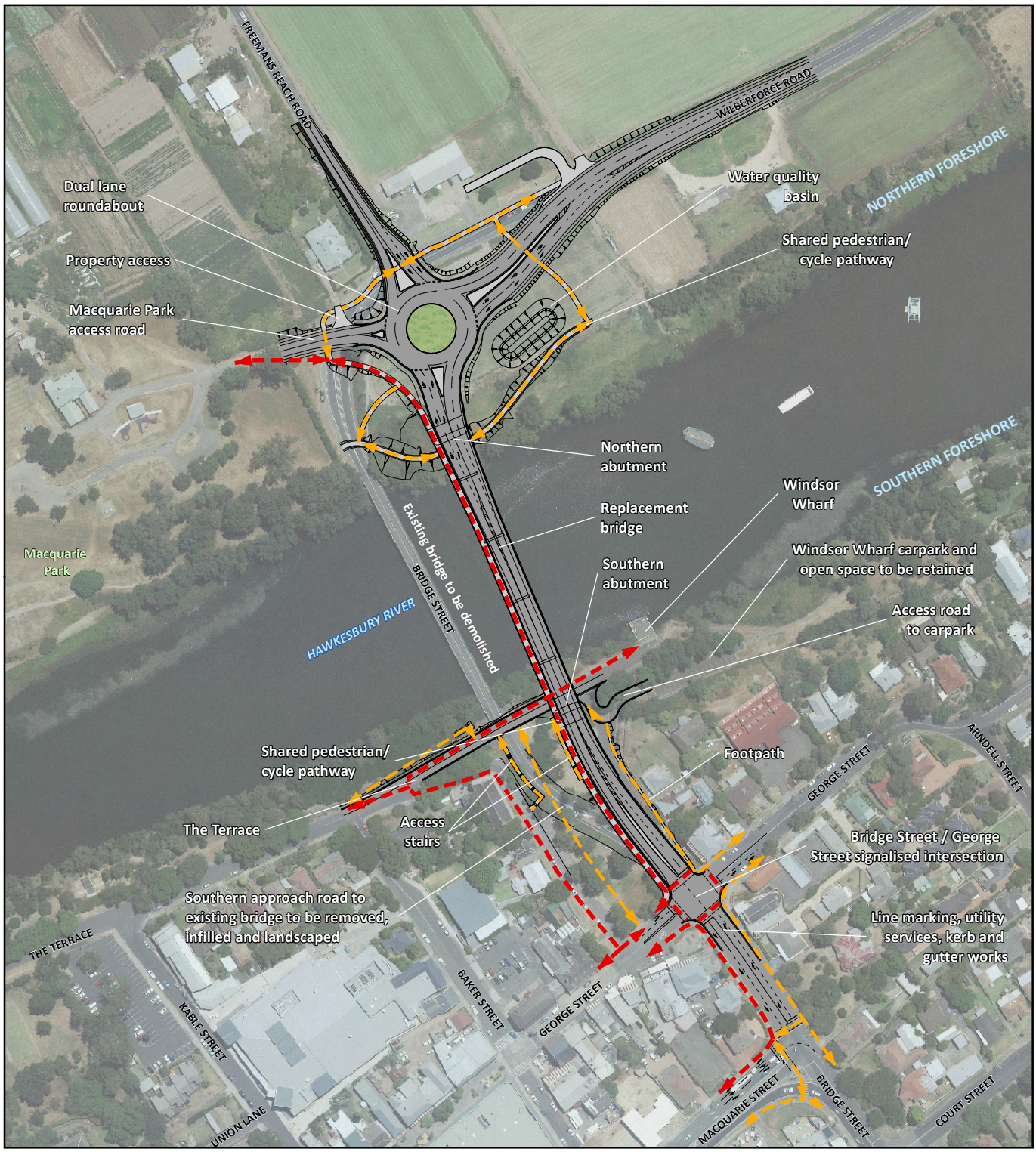
5.2.5 Removal and backfill of the existing bridge approach roads

Removal and backfill of the existing bridge approach roads would occur following commissioning of the new bridge and would include:

- Removal of the existing section of Bridge Street that runs through the Thompson Square open space area, including the road pavement, kerb and guttering, traffic barriers, signage, street lighting, redundant services and road drainage infrastructure.
- Infilling, regrading and landscaping of the road cutting through Thompson Square and reinstatement of the area as part of the Thompson Square parkland.
- Infilling, regrading and landscaping the northern approach road to the existing bridge.

Landscaping would be a key element of this component of the works and is discussed further in **Section 5.2.8**.

Figure 5-5 | Access and circulation



LEGEND

- Concept design
- Primary pedestrian and cyclist circulation
- Secondary pedestrian and cyclist access

Indicative only – subject to detailed design

Sinclair Knight Merz does not warrant that this document is definitive nor free of error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

GDA 1994 | MGA Zone 56
A4 1:3,000

0 100
Metres

AUSIMAGE SKM

Figure 5-5a | Access and circulation - Southern Approach

LEGEND

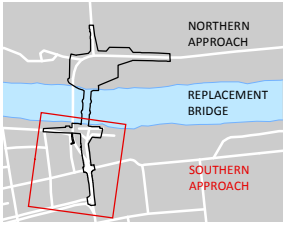
- Concept design
- Cadastral boundary
- Primary pedestrian and cyclist circulation
- Secondary pedestrian and cyclist access

Indicative only – subject to detailed design

Sinclair Knight Merz does not warrant that this document is definitive nor free of error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

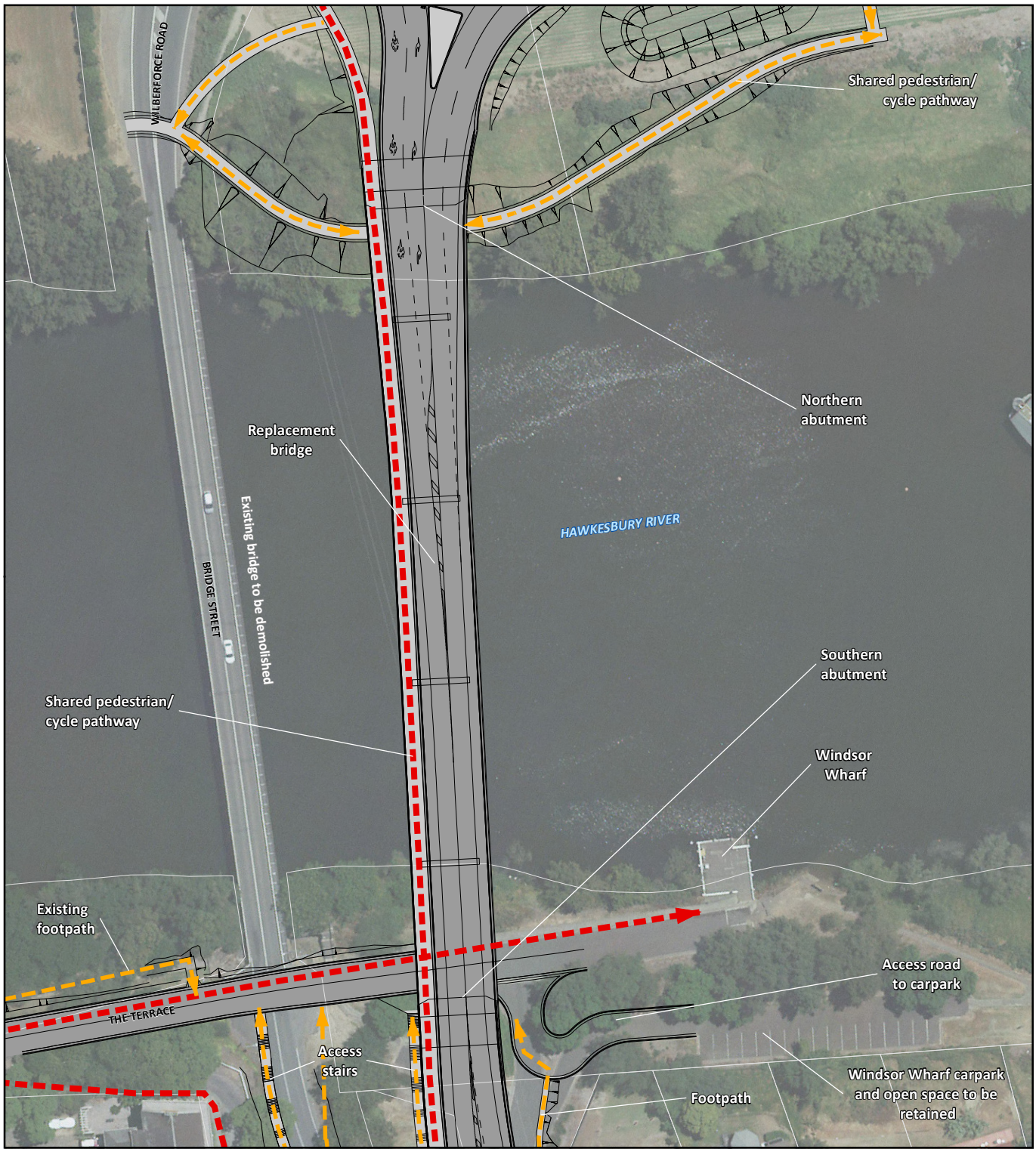
GDA 1994 | MGA Zone 56
A4 1:1,500

0 50
Metres



AUSIMAGE SKM

Figure 5-5b | Access and circulation - Replacement Bridge



LEGEND

- Concept design
- Cadastral boundary
- Primary pedestrian and cyclist circulation
- Secondary pedestrian and cyclist access

Indicative only – subject to detailed design

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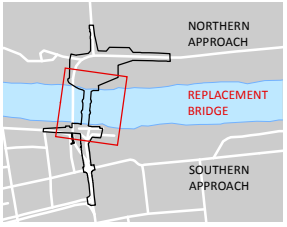
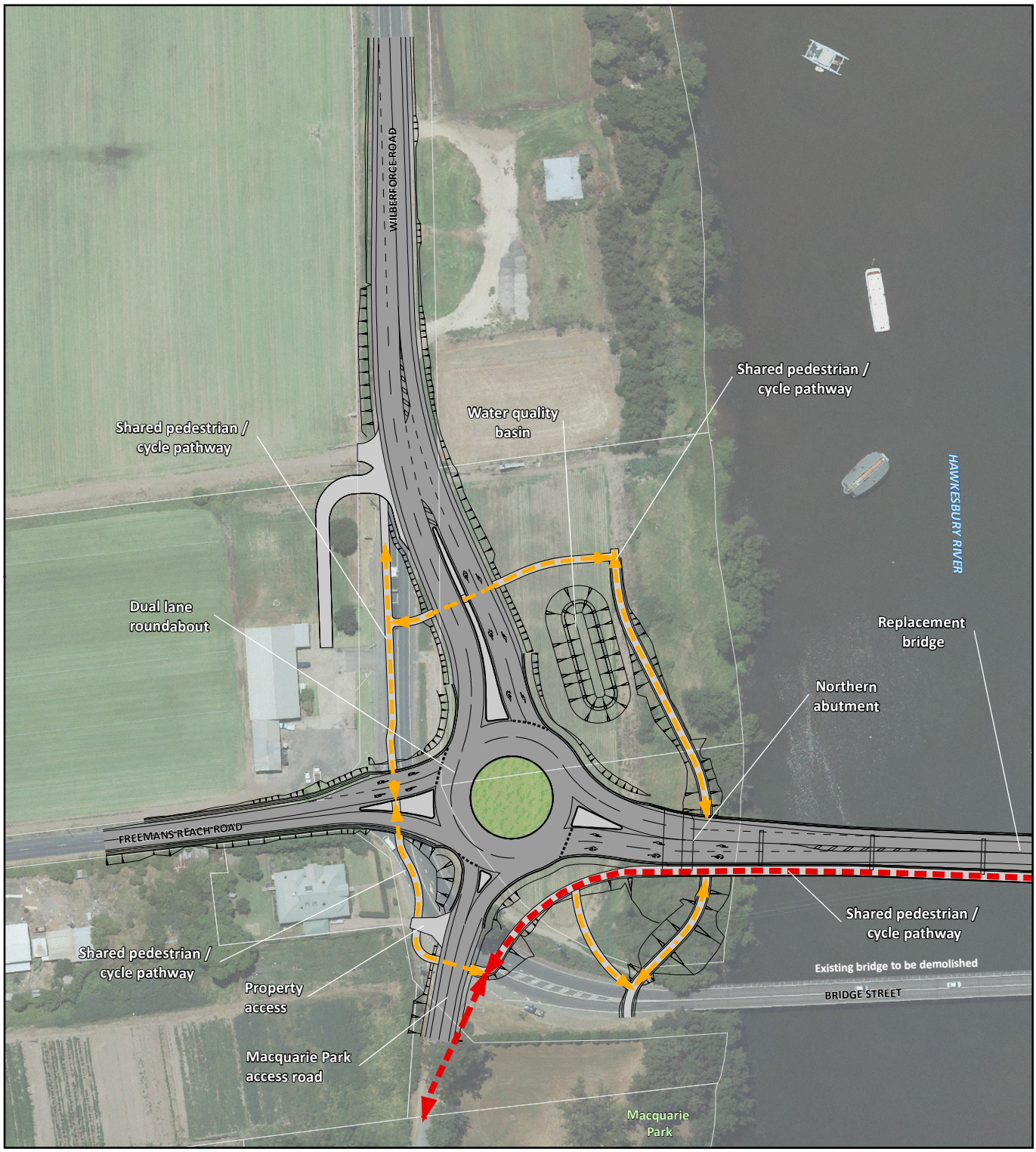
GDA 1994 | MGA Zone 56
A4 1:1,100

0 40
Metres



AUSIMAGE SKM

Figure 5-5c | Access and circulation - Northern Approach



LEGEND

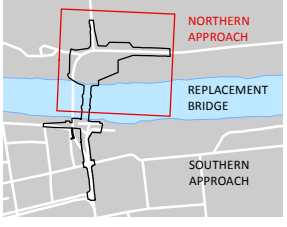
- Concept design
- Cadastral boundary
- Primary pedestrian and cyclist circulation
- Secondary pedestrian and cyclist access

Indicative only – subject to detailed design

Sinclair Knight Merz does not warrant that this document is definitive nor free of error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

GDA 1994 | MGA Zone 56
A4 1:1,800

0 50
Metres



AUSIMAGE SKM

5.2.6 Demolition of the existing bridge

The existing Windsor bridge would be removed following commissioning of the replacement bridge and associated bridge approach roads. Works associated with the demolition would include:

- Disconnection and relocation of existing public utility services on the bridge (see **Section 5.2.7**).
- Management of bridge elements painted with lead based paints.
- Rehabilitation of the bridge site, including treating and/or removing any contaminated soils or materials identified.

A detailed methodology for the demolition of the existing bridge has yet to be developed and would be subject to further investigations and studies. The poor condition of the bridge and the relatively low load bearing capacity of the bridge spans would be considered in the development of the demolition methodology.

While a final methodology has not been developed it is likely that the existing bridge superstructure and substructure would be removed in sections, with temporary bracing installed, as required, to maintain the stability of remaining sections during the demolition process. Where possible, the process of demolition would involve cutting the superstructure and substructure into sections, with each section transported off-site for demolition at a licensed facility. This approach would minimise potential environmental impacts, such as noise, dust, disturbance of roads and contamination of the river. Disruption of waterway traffic would be limited to the greatest extent practicable, with alternative navigation channels provided while the existing navigation span is closed for the demolition works.

Bridge materials resulting from the demolition would be recycled where possible. Materials that have the potential to be re-used include the iron piers, railing, metal components of the bridge abutment and the service conduits. Lead-based paint has been identified on some elements of the existing bridge and would need to be removed before recycling or reuse of materials. Recycling facilities and reuse options would be identified prior to the preparation of the demolition contract and written into the demolition contract. Further details of the demolition process are provided in **Section 5.5**.

5.2.7 Ancillary works

Public utility works

The project would require adjustment, relocation and protection of existing public utilities and services, including water mains, sewer mains and electrical and telecommunications cables. The main public utility works would be associated with the services that are supported by the existing bridge superstructure. The existing bridge supports:

- A 450 millimetre water main (cement lined steel pipe).
- A 50 millimetre sewer rising main (galvanised iron pipe).
- A 100 millimetre electrical conduit.
- Three 80 millimetre galvanised iron telecommunications conduits.

These services would need to be removed and replaced with new services on the replacement bridge. The replacement bridge would also need to be able to accommodate additional future services which may include a recycled water main and high voltage power.

Other public utilities that may need to be adjusted as part of the project include:

- High voltage (33 kV) overhead power lines. If technically feasible, the 33 kV overhead power lines would be relocated within the replacement bridge. This would involve placing the cables underground along Bridge Street between Macquarie Street and the replacement bridge and locating the high voltage power lines within conduits within the replacement bridge. If the 33 kV power lines are unable to be relocated in the replacement bridge they would remain as overhead lines but would be relocated to be clear of replacement bridge. The 33kV power lines may need to be temporarily relocated to allow construction of the the bridge – before they are installed on their final alignment.
- Power lines near the corner of Wilberforce Road and Freemans Reach Road.
- Local stormwater drainage infrastructure.
- A sewer rising main from Windsor Wharf to the local sewer system, which is used to pump out boat sewage holding tanks.
- A gravity sewer main, which runs beneath Old Bridge and Bridge Streets.
- A number of water mains on both the northern and southern river banks.
- Street lighting would be provided throughout the project.
- Telstra assets located near the proposed southern bridge abutment, which would need to be relocated prior to construction of the bridge abutment.
- Additional telecommunications assets located on the northern side of the river.

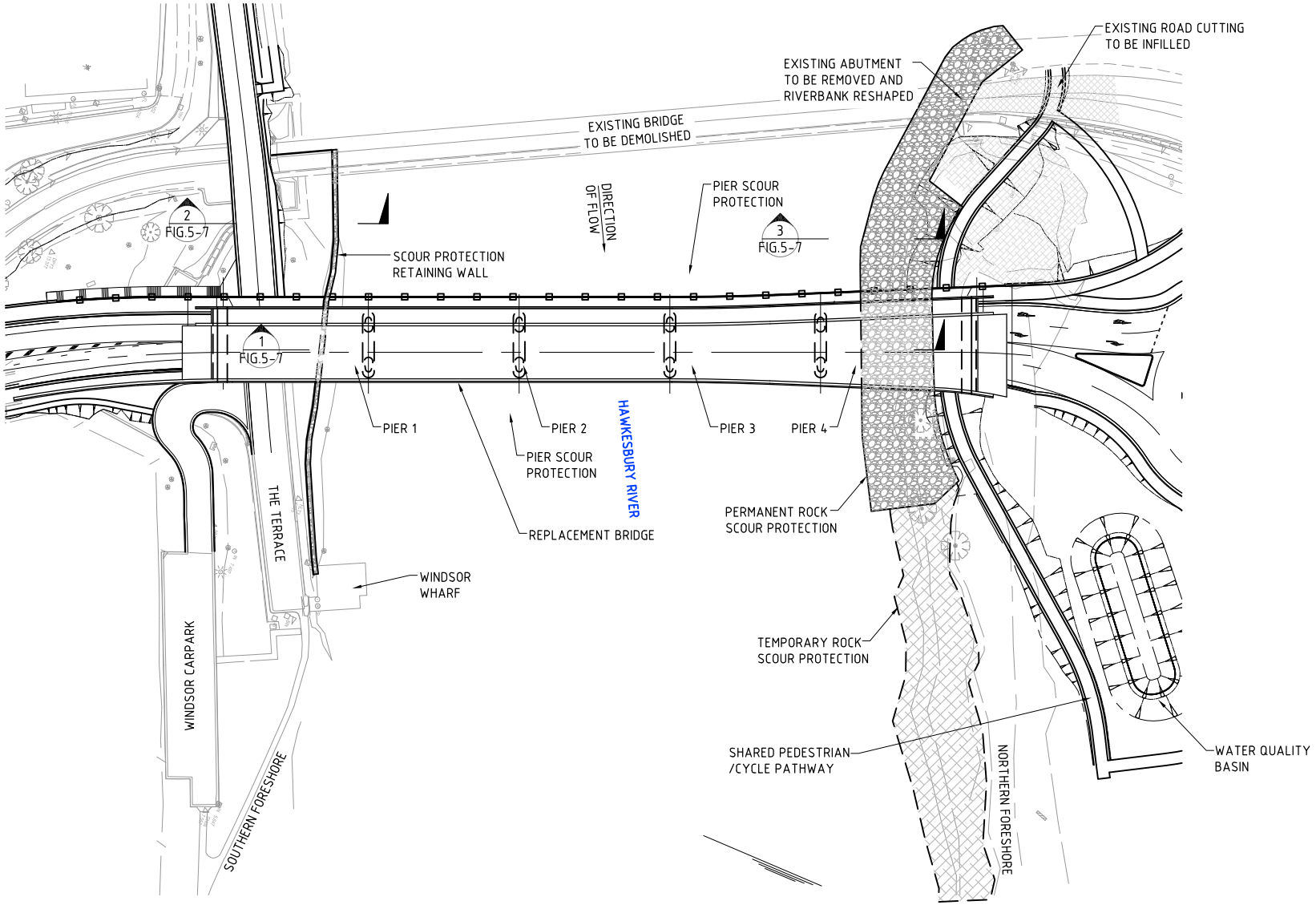
Scour protection works

Scour protection may need to be installed around the bridge abutments and the bridge piers to protect these structures from bank and/or river bed erosion during flood or high flow events. **Figure 5-6** and **Figure 5-7** show the extent and design of potential scour protection. The requirements for the scour protection would be reviewed during the detailed design and it may be possible to reduce the amount of scour protection in some locations.

If required, scour protection would extend about eight metres around each of the two piers in the centre of the river to a depth of about 4.5 metres. The scour protection would consist of rocks about 900 millimetres in diameter – with the top of the rock scour protection level with the existing bed of the river.

Scour protection for the pier adjacent to the northern bank would be incorporated with the scour protection for the northern abutment, if required. The scour protection for the northern bank would consist of rocks about 900 millimetres in diameter to a depth of about 1.6 metres and would extend to a height of about five metres above the mean water level to the new pedestrian/cyclist path. For scour protection above the water level, options to soften the appearance of rock scour protection would be investigated and assessed during detailed design. Options to be considered include overlaying the rock scour protection with sandstone facing blocks and/or including vegetation and landscaping within the scour protections works. The selection of a preferred treatment would also consider maintenance, durability and safety to install and maintain.

FIGURE 5-6 | Scour Protection to Bridge



PLAN

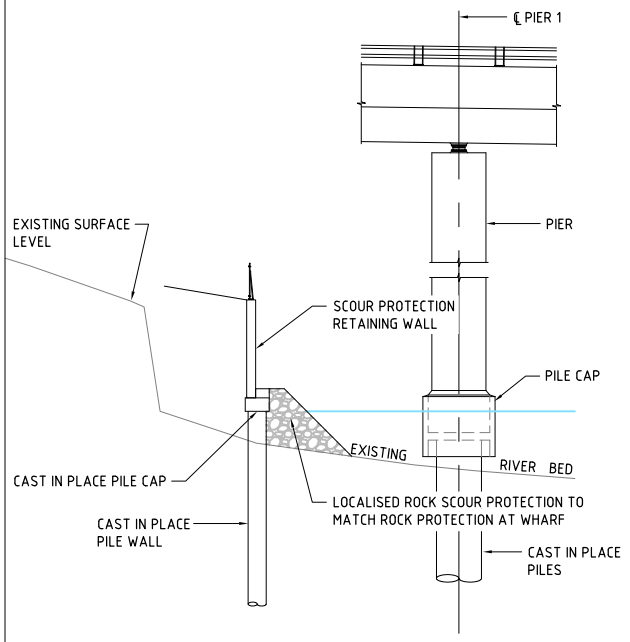
0 12.5 25 37.5 50 62.5m

SCALE 1:1250 (A4)

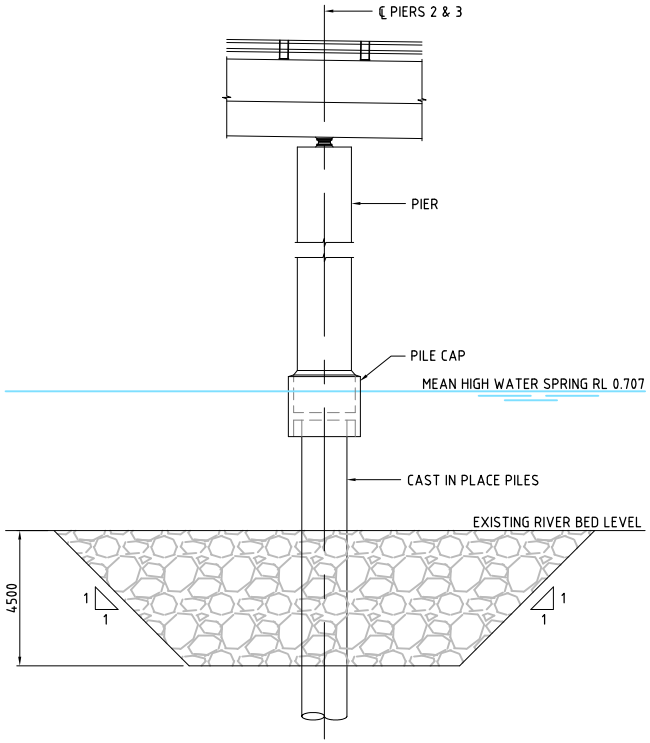
INDICATIVE ONLY - SUBJECT TO DETAILED DESIGN

SKM

FIGURE 5-7 | Scour Protection to Bridge

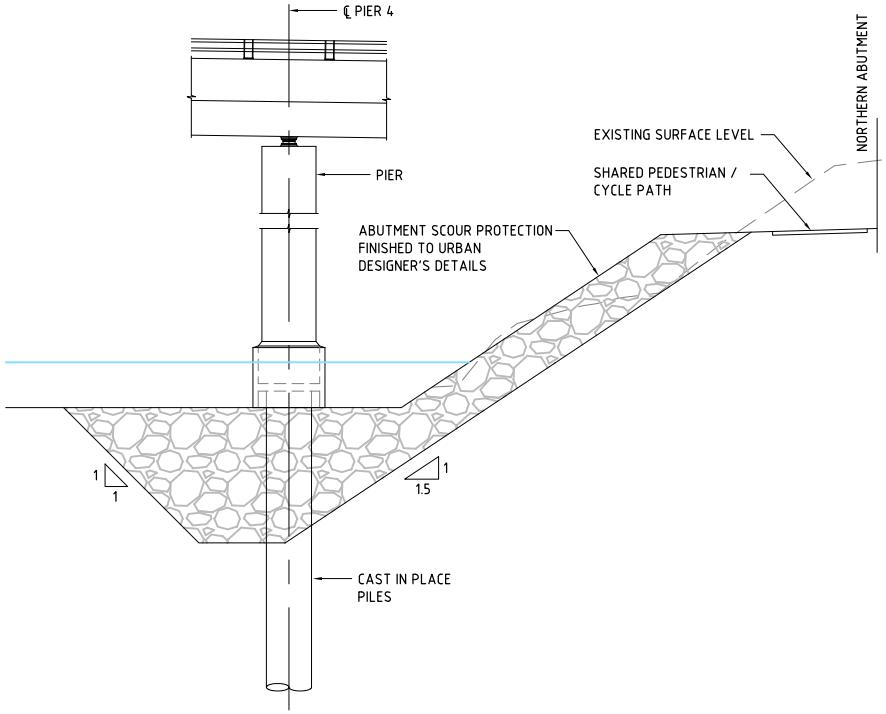


AT PIER 1

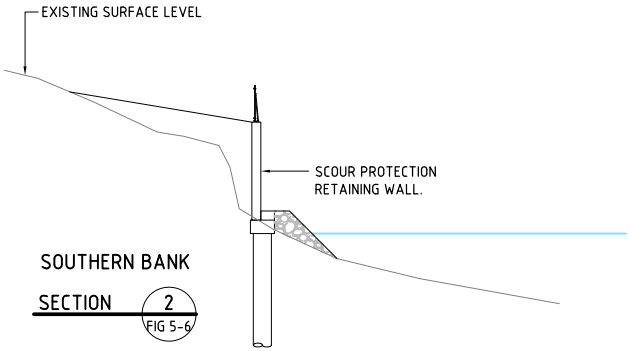


AT PIERS 2 AND 3

SECTION 1 FIG 5-6

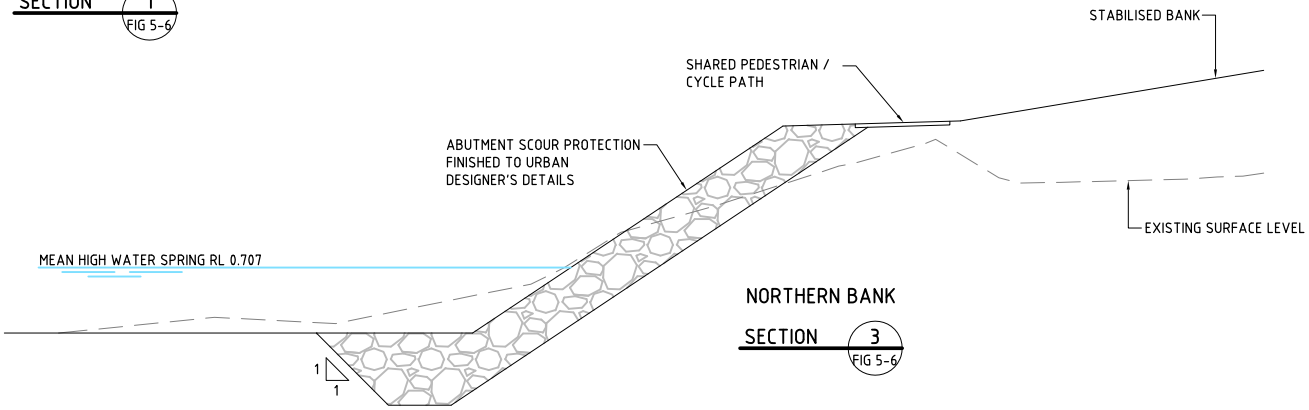


AT PIER 4



SOUTHERN BANK

SECTION 2 FIG 5-6



NORTHERN BANK

SECTION 3 FIG 5-6

0 2.5 5 7.5 10 12.5m

SCALE 1:250 (A4)

INDICATIVE ONLY - SUBJECT TO DETAILED DESIGN

SKM

Additional scour protection would be provided north of the new path adjacent to the northern bridge abutment and this would be reinforced grass. Temporary scour protection may be required further downstream of the northern abutment during construction to stabilise the existing river bank and allow a construction access road to the river to be safely constructed, however all temporary scour protection would be removed after construction.

Rock scour protection for the southern pier would be less extensive than the northern side of the river as bedrock is closer to the surface. Rock scour protection around the southernmost bridge pier and along the river bank below the water line would be as required but likely consist of a single layer of 900 millimetre diameter rocks. The primary scour protection for the southern abutment would be a new retaining wall about three to four metres high, which would extend from the existing bridge to Windsor Wharf.

Additional scour protection would be provided around the demolished abutments of the existing bridge, once the existing bridge has been demolished and removed.

Water quality management

The project would include construction of a permanent water quality basin to intercept and treat stormwater runoff from the bridge and northern approach roads before it enters the Hawkesbury River. The basin would be located on the eastern side of the proposed roundabout at the junction of Freemans Reach Road, Wilberforce Road and the Macquarie Park access road.

On the southern bank, a net to capture litter would be installed at the end of the stormwater drainage system for the southern approach road. A hand operated shut-off valve would also be installed near the end of the stormwater drainage system to capture any spills within the stormwater system resulting from a road accident.

Noise mitigation works

Some residential properties along Old Bridge Street would likely require works to reduce the impact of increased traffic noise generated during operation of the project. These works could include:

- Ventilation systems and air conditioning to allow windows and outside doors to be closed.
- Double glazing or similar measures to reduce the transmission of noise through windows.
- Sealing of other gaps in facades, doors and windows.
- Roof, wall and/or floor insulation.

An inspection of the upper floor residential premises at the heritage listed 10 Bridge Street property was undertaken by a heritage architect to identify potential noise mitigation options that would be appropriate to the heritage item (CityPlan, 2012). The precise noise mitigation works would be in keeping with the recommendations of CityPlan (2012) and would be implemented in consultation and with the agreement of the affected property owner.

Works may also be required at Number 4 Old Bridge Street and 53 George Street; however as these buildings are not heritage listed these works would be determined during detailed design.

Other buildings would not qualify for noise mitigation works as they either are commercial premises or noise levels would comply with the criteria in the Road Noise Policy (DECCW, 2011).

All noise mitigation works would be undertaken in consultation and with agreement of the property owners. Where possible the noise mitigation works would be installed before construction of the project commences to provide mitigation during the construction period as well as operation.

Flood mitigation works

Based upon the flood modelling undertaken on the concept design, potential flood mitigation works would be required for a number of properties upstream of the replacement bridge. Detailed design may identify further properties that require flood mitigation works.

Flood mitigation works may include but would not necessarily be limited to:

- Improvement to property access for minor flood events.
- Property protection measures such as sealing doors and windows or bunding.
- Developing or revising a flood emergency plan.

All flood mitigation works would be undertaken in consultation and with agreement of the affected property owners.

5.2.8 Urban design and landscape works

This section provides an outline of the proposed urban design and landscape component of the project. Further details of the proposed urban design and landscape concept are provided in Chapter 7, **Section 7.4**.

Urban design and landscape works

The urban design and landscape concept design for the project would involve:

- Application of bridge architecture design principles as part of the integrated engineering and urban design of the bridge superstructure and approach roads, including the area adjacent to the northern approach intersection of Wilberforce Road, Freemans Reach Road and the Macquarie Park access road.
- Redevelopment of The Terrace for pedestrian and vehicle access along the southern bank of the river to Windsor Wharf.
- Removal of the existing bridge approach road that runs through Thompson Square and reinstatement of this land as part of the Thompson Square parkland.
- Improvement of existing areas of open space by linking the Thompson Square open space area with the river foreshore, including new access steps, pathways and landscape treatments.
- Revegetation of areas of the river bank disturbed by construction, including the southern and northern banks of the river adjacent to the replacement bridge and the former site of the existing bridge (once demolished).
- Application of urban design principles to the scour protection works.

Urban design and landscape works on the southern side of the river and within Thompson Square parkland would include:

- Removal of some trees that would be impacted by the project.
- Minor earthworks in the upper Thompson Square parkland to provide a gentle slope and improve the physical and visual connection from the park to the river.
- Planting of trees and other vegetation in Thompson Square parkland.
- Construction of stairs from the bridge pedestrian/cyclist shared path to The Terrace and from Thompson Square road to The Terrace to provide pedestrian access.
- Construction of other paths within Thompson Square parkland as agreed with Council.
- Reinstatement of the section of The Terrace and river bank currently impacted by the existing bridge and approach roads.
- Hard and soft landscape works in the road reserve between the three properties on Old Bridge Street and the new southern bridge approach road.
- Architectural treatment of the southern bridge abutment to minimise visual impacts.
- Application of urban design treatments to scour protection works.

Urban design and landscape works on the northern side of the river would include:

- Minor earthworks to improve the visual appearance of the bank.
- Planting of trees and other vegetation.
- Architectural treatment of the northern bridge abutment to minimise visual impacts.
- Application of urban design treatments to scour protection works.

Figure 5-8 shows the extent and type of works proposed for Thompson Square, the southern bank, the northern bank and adjacent areas. In developing this scope of works, Council and other relevant stakeholders have been consulted, however, further consultation and public comment on the proposed design is planned to be sought and incorporated into the detailed design of the project. This may result in changes to some of the components and / or locations of urban design works.

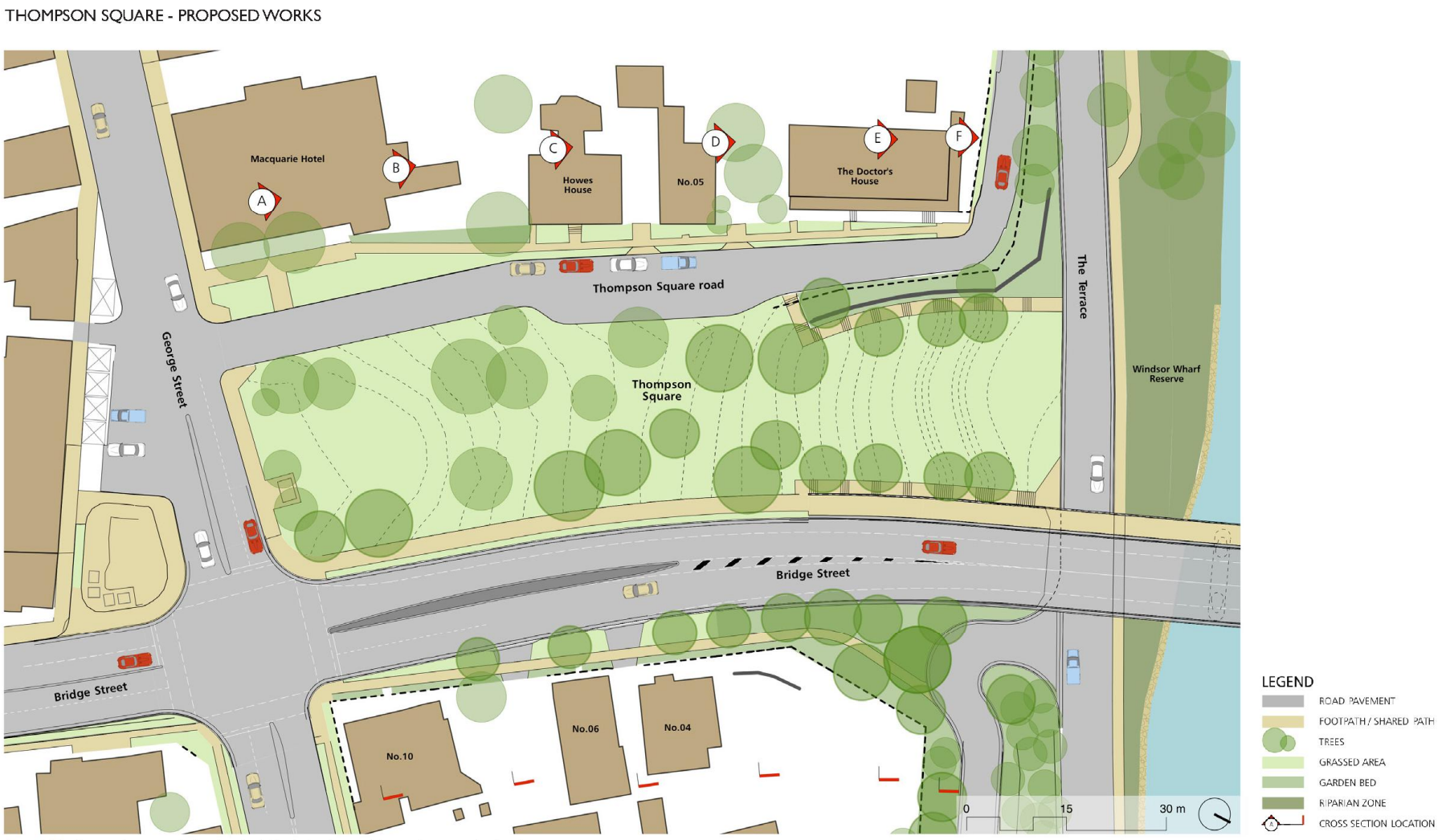


Figure 5-8 Concept design of Thompson Square

5.2.9 Property acquisition and transfer of ownership

Some land would be acquired to enable the construction of the replacement bridge and approach roads. Excess land that is no longer required for the existing bridge and approach roads would be rehabilitated and transferred (returned) to the control of Council. Details of the land that would be acquired and the land that would be transferred to the control of Council are shown in **Table 5-1 and Table 5-2**.

On the northern side of the river, two lots would be acquired and there would be partial acquisition of two other lots. Land that would be acquired on the northern side is currently used for turf farming. The lot containing the northern approach road to the existing bridge would be rehabilitated and returned to the control of Council. Overall there would be an increase in the land for public open space on the northern bank of the river.

On the southern bank, acquisition of two parcels of Crown land would be required. Small areas of these parcels of Crown Land would be incorporated into the project footprint. Old Bridge Street, which is currently owned by Council and zoned road reserve, would be transferred to RMS and incorporated in the project footprint. The southern approach road to the existing bridge would be rehabilitated and incorporated into the Thompson Square parkland in consultation with Council. Overall there would be an increase in the land for public open space in Thompson Square. The impact of these proposed changes in land use is addressed in **Section 7.8**.

Table 5-1 Land acquisition - directly affected properties

Property	Tenure	Existing land use	Impact
Northern bank			
Lot 2 DP1096472	Private	Commercial – turf farm	Total acquisition of 8960 m^2 of which about 40% would be used for the project and 60% would be public open space.
Lot 2 DP65136	Private	Commercial – turf farm	Total acquisition of 4650 m^2 of which about 70% would be used for the project and 30% would be public open space.
Lot 1 DP1096472	Private	Residential/ commercial – turf farm	Partial acquisition (422 m^2 of 4770 m^2).
Lot 68 DP751665	Private	Commercial – turf farm	Partial acquisition (135m^2 of 139,600 m^2).
Lot 1 DP226141	Public	Road and reserve for existing bridge approach	About 1400m^2 of extra open public space would be generated resulting from removal of the northern approach road.
Southern bank			
Lot 345 DP752061	Crown land	Thompson Square	Total acquisition – 338 m^2 of the 524 m^2 lot area would be used for the project and the rest would be retained as open space.
Lot 7008 DP1029964	Crown land	Park, car parking and Windsor Wharf	Total acquisition – 334 m^2 of the 7089 m^2 lot area would be used for the project and the rest would be retained as open space.

Table 5-2 Land to be transferred (returned) to Council

Property	Tenure	Existing land use	Impact
Existing road reserve	Crown land	Road reserve for existing bridge approach through Thompson Square	About 1400m^2 of extra open space would be generated resulting from removal of the southern approach road. Land would be incorporated into Thompson Square parkland.

5.2.10 Temporary construction facilities

Construction of the project would require establishment and operation of temporary construction and compound sites for the duration of the construction period (about 20 months). These facilities would be removed at the completion of construction and the sites would be restored and landscaped.

The main construction compound would be located on the north side of the river within the existing turf farm between the Hawkesbury River and Wilberforce Road (Lot 2 DP 1096472 and Lot 2 DP65136). This main construction compound is identified as the Turf Farm Site on **Figure 5-2** and is discussed in further detail below.

Additional areas would be used for construction purposes and as secondary compound sites. These include:

- Windsor Wharf carpark and open space (Lot 7008 DP1029964) – On the south side of the river immediately to the south of Windsor Wharf between Old Bridge Street and Windsor Wharf. Construction compounds and facilities would be limited to the existing paved areas and grassed areas.
- The lower Thompson Square parkland (Lot 345 DP752061) – this area would be required to allow construction of the southern bridge abutment and approach road.
- Office space in a building near the project – this location has not yet been identified.

Temporary construction facilities would be the main focus of construction activity and would also be used for temporary storage of construction materials and equipment and the placement of temporary facilities for construction workers. The key factors considered in selecting the proposed construction compound sites were as follows:

- Access to the main road network.
- Access to services such as electricity and water.
- Proximity to key construction areas.
- Minimising local traffic disruptions.
- Distance to residences and other land uses that would be particularly sensitive to the impacts of construction activities.
- Minimising heritage, visual and vegetation impacts.

The main construction compound site, secondary compound site and additional areas would be used for construction purposes are described below

Turf farm site

The main construction and compound site would be located within the area of land designated as Lot 2 DP 1096472 and Lot 2 DP65136 between Wilberforce Road and the northern side of the Hawkesbury River. This land is currently used for turf farming and would be acquired by RMS for the project. The site would support bridge construction activities and would include the main compound facilities and site office for the project. The casting yard, large cranes, laydown areas and other facilities supporting the incrementally launched bridge would be located on this site. Piling and excavation of up to about 4000 cubic metres of soil for establishment of the casting yard and supporting facilities would be required.

The site is generally level and would only require very minor grading and contour works to provide for safe vehicle turning areas and access to/from Wilberforce Road. Access to the main construction and compound site would be from Wilberforce Road. Minor modifications to Wilberforce Road such as the construction of temporary road pavements, a roundabout or slip lanes would be required to provide safe access to the site.

Temporary jetties or pontoons would also be established on the foreshore to allow water access to and from the bridge piers for workers and materials. A temporary access road from the construction compound to the temporary jetties or pontoons would also be constructed.

Establishment of the construction compound would require removal of irrigation water pipes and sprinklers that currently provide water for turf farming. The site includes an area of land at the foreshore that would need to be cleared of vegetation to allow for the construction of scour protection works associated with protecting the northern abutment and a temporary access road.

Construction activities at the site would be predominantly confined to standard daytime working hours, with some intermittent deliveries by heavy vehicles and unloading of bridge components and equipment taking place at night. Inaudible works may be undertaken in the casting yard outside standard construction work hours.

Part of the site would also form the permanent northern abutment for the replacement bridge as well as the new intersection of Wilberforce Road, Freemans Reach Road and the Macquarie Park access road.

Windsor Wharf carpark and open space

This secondary construction and compound site would be established on council-owned car parks and open space near Windsor Wharf (Lot 7008 DP1029964). Construction facilities would be limited to the existing paved areas and grassed areas. Clearing of the existing vegetation would be limited to a number of small planted trees that may require removal or trimming to allow access.

The car park immediately to the west of Old Bridge Street is about 180 square metres and would support road and bridge construction activities. It would also form part of the new bridge approach road between George Street and the replacement bridge. The car park adjacent to Windsor Wharf is about 500 square metres and would be used for a secondary project office, compound facilities and storage area. The grassed areas would be used as a storage area or portable offices may be located in these areas. Construction activities on the sites would be predominantly confined to standard day time working hours, with some intermittent deliveries by heavy vehicles and unloading of construction components and equipment taking place at night.

Vehicle access to the construction site would be via Old Bridge Street or via The Terrace. Public vehicle access to Windsor Wharf would need to be temporarily closed until road works between George Street and the replacement bridge are completed. Pedestrian access (via The Terrace) would generally be maintained to Windsor Wharf during construction. Pedestrian access would be temporarily restricted during critical activities, such as landing the final bridge span into position, reconstructing The Terrace and constructing the southern bridge abutment.

Lower Thompson Square parkland

The lower Thompson Square parkland has been identified as a secondary compound for the project. While it would be required for construction, the types of activities undertaken in the parkland would be limited and would include:

- Part of the southern approach road and abutment would be located in the lower parkland area and these areas would be directly disturbed by construction activities.
- An area directly adjacent to the southern approach road and abutment would be required to provide access to enable construction of these project elements.
- A small demountable may be located near The Terrace for security and traffic control for access to the southern bank construction area.
- Temporary fencing would be installed for security and safety reasons.

In recognition of the heritage values of the lower Thompson Square parkland, the area would not be used for parking, storage of materials, office demountables or any other typical construction compound activity.

It should be recognised that heritage excavations in the lower parkland area may be substantial and extend outside the directly impacted construction area as this area contains both Aboriginal and historic areas of interest.

While not all of the lower Thompson Square parkland would be required for construction, the lower parkland would be closed to public access during construction for safety reasons.

Office space

Office space may be leased in a building near the project. The location of potential office space has yet to be identified. The office space would be used to accommodate administration and construction personnel to avoid the need to locate temporary office space in flood prone areas on the northern and southern bank of the river. As the location and need for off-site office space has yet to be determined, RMS are not seeking approval for this activity.

Table 5-3 Proposed construction site compound facilities

Site location	Proposed uses/ facilities	Potential site establishment works
Turf farm site	Storage facility Stockpile area Site offices Lunch rooms Toilet and shower facilities First aid shed Fuel and hazardous goods storage Concrete washout Parking Concrete casting bed and launching yard Temporary jetties or pontoons	• Erect temporary fencing • Install environmental controls • Survey area • Minor modifications to Wilberforce Road • Construction of casting yard and associated facilities • Construct temporary driveway (and carpark if required) • Establish crane • Construct hardstand areas • Erect sheds using cranes and trucks • Connect services to the compound • Install office equipment • Install temporary jetties or pontoons and provide access
Windsor Wharf car park and open space	Storage facility Stockpile area Lunch rooms Toilet facilities First aid shed Parking Site offices	• Erect temporary fencing • Install environmental controls • Gain service approvals and carry out works as per the approvals • Erect sheds using cranes and trucks • Connect services to the compound
Lower Thompson Square parkland	Access to southern abutment and approach road Storage facility	• Erect temporary fencing • Install environmental controls

Water-based construction facilities

As well as temporary piers/pontoons, the construction of the piers closest to both river banks could require temporary land reclamation works to provide a suitable working platform as the locations may be too restricted to move barges into position in the shallow water. The area of land reclamation would be about 500 square metres. Reclamation would be carried out by placing large rocks into position followed by increasingly smaller sized aggregates until a level work platform is achieved. The materials used would be removed once the works are complete. Appropriate environmental management measures such as silt curtains would be used to minimise any impacts on water quality during construction and removal of these temporary facilities.

Alternatively temporary steel jetties may be installed to access the construction locations for the bridge piers. Temporary steel piers would be installed followed by a steel deck to support a variety of construction activities and plant. The steel jetties would be removed once construction of the bridge piers is completed.

5.2.11 Heritage investigations

Early works involving additional field investigations for Aboriginal and historic heritage (including maritime heritage) would be carried out as part of the project environmental management measures. Further detailed design and consultation with regulatory authorities would be undertaken to determine the location, type and scope of heritage investigations required. The early works would also involve establishment of site compounds and ancillary facilities (including several portable buildings and toilets) for the heritage investigations, as well as protection and/or relocation of services and utilities.

Aboriginal heritage investigations (salvage)

The early works for Aboriginal heritage investigations would include:

- Salvage excavation at identified Aboriginal heritage sites on the southern bank of the river in accordance with the procedures identified in the Aboriginal heritage chapter (refer to **Section 7.2**).
- Recording and protection of Aboriginal heritage in accordance with the procedures identified in the Aboriginal heritage chapter (refer to **Section 7.2**).

The salvage excavation works on the southern bank of the river would involve two areas of open excavation as follows:

- An area of about 100 square metres at the corner of George and Bridge Streets, extending along the length of the proposed approach road formation to The Terrace.
- An area of about 25-50 square metres between Bridge Street, Old Bridge Street and the wharf carpark.

These areas have been identified as locations where there is a high probability of finding Aboriginal archaeological material and as being of sufficient size to obtain the necessary archaeological coverage of the impacted area.

Removal of archaeological material from the excavation area would be carried out by hand and machinery until sufficient material has been recovered and recorded. The depth of excavation is expected to extend until the maximum depth of construction impact is reached, although excavation beyond the base of impact depth may be required to optimise information retrieval. The works would be accompanied by signage for public information and interpretation, including signage providing Aboriginal heritage information and signage providing information on the scope of the investigations.

Terrestrial historic heritage investigations (salvage)

The early works for terrestrial historic heritage investigations would include:

- Salvage excavation at identified historic heritage sites on the southern bank of the river in accordance with the procedures identified in the non- Aboriginal heritage chapter (refer to **Section 7.1**).
- Recording and protection of historic heritage in accordance with the procedures identified in the historic heritage chapter (refer to **Section 7.1**).

The salvage excavation works on the southern bank of the river would involve all areas that would be disturbed as part of construction of the replacement bridge.

Removal of archaeological material from the excavation area would be carried out by hand and machinery until sufficient material has been recovered and recorded. The works would be accompanied by signage for public information and interpretation, including signage providing historic heritage information and signage providing information on the scope of the investigations.

Early works – maritime historic heritage investigations (salvage)

The early works for maritime historic heritage investigations would include:

- Salvage excavation at identified historic heritage sites on the southern bank of the river and within the river in accordance with the procedures identified in the non- Aboriginal heritage chapter (refer to **Section 7.1**).
- Recording and protection of historic heritage in accordance with the procedures identified in the historic heritage chapter (refer to **Section 7.1**).

The salvage excavation works on the southern side of the river would involve the area of the old Windsor wharf including the river banks – and the water immediately around the old wharf.

Removal of archaeological material from the excavation area would be carried out by hand and machinery until sufficient material has been recovered and recorded. Divers would be required to salvage the areas within the river. The depth of excavation is expected to extend until the maximum depth of construction impact is reached, although excavation beyond the base of impact depth may be required to optimise information retrieval. The works would be accompanied by signage for public information and interpretation, including signage providing non- Aboriginal heritage information and signage providing information on the scope of the investigations.

5.3 Design criteria

5.3.1 Urban design objectives

Urban design objectives and principles were identified for the project to achieve a concept design outcome that is physically, visually and operationally integrated with the surrounding environment. The urban design objectives are as follows:

- Develop an integrated concept design that fits sensitively with the existing qualities and characteristics of Windsor and its Hawkesbury River setting.
- Enhance the existing amenity, visual character and cultural landscapes of Thompson Square and Windsor.
- Maintain the integrity of cultural and historic buildings, structures, elements and spaces of Windsor.
- Improve connectivity for vehicles, pedestrians and cyclists.

A landscape character and visual assessment is contained in **Section 7.3** and working paper 4 in Volume 3. These contain further detail on the objectives, including the design principles that apply to each. The design responses to these objectives are also provided.

5.3.2 Design standards and criteria for the replacement bridge

The proposed replacement bridge has been designed in accordance with the Australian Standard for Bridge Design (AS 5100). It meets the design criteria for Bridge Classification Type II, earthquake design category BEDC-1, and the additional engineering criteria presented in **Table 5-4** (refer to the glossary for clarification of terms).

One of the key criteria for the design of the replacement bridge was to improve the flood immunity of the river crossing. The proposed replacement bridge has a flood immunity that is just below the 1 in 3 year flood level. This provides an improved level of flood immunity relative to existing conditions and matches the flood immunity of the northern approach roads.

The replacement bridge would be above the river water level for floods approaching the 1 in 3 year flood event but would be inundated during larger floods. The bridge design has therefore been selected based on the need to withstand regular immersion. The proposed replacement bridge has also been designed to withstand floods up to the 1 in 2000 year event without collapse or loss of structural integrity.

The piers of the replacement bridge have been designed to withstand the impact of vessels on the river. A 60 tonne vessel travelling at 2.1 metres per second (four knots), which equates to a 1950kN collision loading, has been selected as the criteria for determining the impact resistance requirements of the bridge piers.

The road across the replacement bridge (and the bridge approach roads) would meet the design criteria for a 50 kilometre per hour speed limit – which has been reduced from the original project objective of 60 kilometres per hour design speed limit. This lower design speed allows the height of the southern approach road to decrease as it approaches the river and thereby reduces the potential visual impact of the bridge on Thompson Square. Further reductions in the height of the replacement bridge and southern approach road through Thompson Square parkland were not considered to be feasible as there needs to be at least 3.6 metres of under bridge clearance to The Terrace to allow service vehicles and emergency service vehicles to access Windsor Wharf.

5.3.3 Design standards and criteria for the approach roads

The road works component of the project has been designed in accordance with Austroads - Guide to Road Design. The engineering design parameters for the road works component are summarised in **Table 5-5**.

Additional factors that were taken into account in the design of the approach roads and intersections were associated with the need to maintain and improve traffic flow and the need to minimise impacts on heritage and properties. These factors are summarised in **Table 5-6**. Urban design considerations, including the need to minimise impacts on heritage items and the overall heritage character of the Windsor township, are discussed in **Section 5.4.**

Table 5-4 Engineering design parameters for the bridge structure

Item/ parameter	Value
Horizontal alignment	Design speed - 50 km/h
	Curve radius – not applicable as the bridge is straight
Vertical alignment	Design speed - 50 km/h
	Crest "K" min value – not applicable
	Southern bridge abutment Sag "K" minimum value - 7.1
	Grade – Maximum 1.35 %
Traffic loading	SM1600
Earthquake loading acceleration coefficient	0.08
Site factor	1.0
Crossfall	Maximum 1.5%
Overall bridge width	Maximum 15.24 metres
Road carriageway width	Maximum 11 metres
Number of lanes on bridge	Northbound – 1
	Southbound – 1 initially, with provision in the width of the proposed road shoulders to provide two southbound lanes in the future, if required, by changing the lane markings.
Lane width (on bridge) at time of opening	3.5 metres with 2.0 metres wide shoulders
Lane width (on bridge) when re-line marked to three lanes	3.3 metres approximately with 0.5 metres wide shoulders
Road clearance at The Terrace	Minimum 3.6 metres
Proposed navigational clearance	Minimum 7.5 metres at MHWS
Shared use path width	3.0 metres

Table 5-5 Engineering design parameters for the road works

Item / parameter	Criteria
Horizontal alignment	Design speed - 50 km/h
	Curve radius and location - 150 metres minimum on northern approach road, 300 metres minimum on southern approach road, 118.5 metres minimum on Wilberforce Road, 200 metres minimum on Macquarie Park access road, straight on Freemans Reach Road
Vertical alignment	Design speed - 50 km/h
	Crest "K" min value - 3.5 on southern approach road
	Sag "K" min value - 10.3 on northern approach road, 7.1 on southern approach road, 5.4 on Wilberforce Road, 9.4 on Macquarie Park access road, 4.9 on Freemans Reach Road
	Grade – Maximum 8.4 %
Stopping sight distance	Reaction time 1.5 sec
	Horizontal - 45 metres
	Vertical - 39 metres
Traffic lane width	Two lanes 3.5 metres wide
Road shoulder width	2 metres (both carriageways on the northern and southern approach roads)
Crossfall/superelevation	Maximum 3.0 %

Table 5-6 Additional design objectives for the approach roads

Component	Design criteria
Southern approach road	Minimise disturbance of Thompson Square by minimising the width of the southern approach road and aligning the southern approach road to maximise open space in Thompson Square. Lower the road level as much as possible through Thompson Square
	Provide left in/left out access for the two properties at 4 and 6 Old Bridge Street.
Northern approach road	Maintain access to Macquarie Park.
	Avoid impacts on the local heritage listed building "Bridgeview".
	Improve traffic flow and safety at the Freemans Reach Road, Wilberforce Road and northern bridge approach road intersection.

5.3.4 Design standards and specifications for pedestrian and cyclist facilities

The following design standards and specifications would be applied to the design and construction pedestrian and cyclist facilities:

- Austroads – Guide to Road Design part 6A – Pedestrian and Cyclist Paths.
- Austroads – Cycling Aspects of Austroads Guides.
- AS/NZS1158 (Set): 2007, Lighting for roads and public spaces set.
- AS/NZS 1158.1.1: 2005, Lighting for roads and public spaces, vehicular traffic (category V) lighting – performance and design requirements.
- AS/NZS 1158.1.3: 1997, Road lighting part 1.3: vehicular traffic lighting (category V) – guide to design, installation, operation and maintenance.
- AS/NZS 1158.3.1:2005, Lighting for roads and public spaces, pedestrian area (Category P) lighting – performance and design requirements.
- AS 1428.1-2001, Design for access and mobility part 1: general requirements for access: new building work.

5.3.5 Design standards and specifications for the demolition works

The following design standards and specifications would be applied to the demolition of the existing bridge:

- RMS Specification B341 – Demolition of Existing Structures.
- AS2601-2001 – The Demolition of Structures.

5.3.6 Other design standards and specifications

Standards and specifications for the design of other project elements include:

Drainage and scour infrastructure including water quality basins

- Austroads – Guide to Road Design Part 5 – Drainage Design.
- Austroads – Guide to Bridge Technology Part 4: Design Procurement and Concept Design.

Utility relocation design and / or protection

- Relevant Australian Standards.
- NSW Streets Opening Conference - Guide to Codes and Practices for Streets Opening (2009).

Traffic signals

- Specification SI/TCS/8 - Installation and Reconstruction of Traffic Light Signals (RTA).
- Traffic Signals Practice, Design (RTA).
- Traffic Signal Design Standards - RTA-TC-189 (RTA).
- Traffic Signal Design (RTA).
- AS/NZS 3000:2000 – Electrical Installations (Standards Australia).

5.4 Construction works

Construction would be staged to minimise environmental and traffic impacts. The likely staging of construction activities would be as follows:

- Pre-construction activities.
- Early works activities.
- Construction of temporary pavement at Wilberforce Road and near the corner of George and Bridge streets to provide additional road width to enable construction of next stages.
- Bridge construction activities.
- Construction of the northern roundabout and approach road and most of the southern approach road.
- Construction of the remainder of the southern approach road and the new sections of Freemans Reach Road, Wilberforce Road and Macquarie Park access road.
- Commissioning and opening of the replacement bridge to traffic.
- Removal, backfill and landscaping of existing bridge approach roads.
- Demolition of the existing bridge.
- Urban design and landscape works.
- Removal of temporary structures and demobilisation of the construction facilities.

A detailed description of construction stages and activities is presented below. This proposed sequence of activities is indicative and may change once detailed construction planning is completed. It is also likely that some stages may overlap.

5.4.1 Pre-construction activities

Pre-construction activities include:

- Leasing and acquiring land.
- Notifying residents and the affected community of the start of works.
- Undertaking surveys to identify and mark out the construction footprint on the ground.
- Undertaking additional geotechnical and other soil/sediment investigations.
- Undertaking dilapidation surveys.

Pre-construction activities may be undertaken at various times over the duration of the project corresponding to different construction stages and project components. For each construction stage or project component, the various types of pre-construction activities may also be undertaken collectively or in isolation, depending on the specific requirements of the stage or component.

5.4.2 Early works

Presented in the following section are works that RMS is seeking approval to be undertaken as early works. These works would be undertaken if the project is approved but before approval of key management plans or other requirements. A specific Early Works Environmental Management Plan would be prepared and implemented. The proposed early works are generally minor in nature, but are important precursors to allow the major construction works to commence. These early works would consist of:

- Historic and Aboriginal heritage investigations (see **Section 5.2.11**). Approval of heritage investigation plans for these works by relevant stakeholders would be required before these works would commence.
- Applying noise mitigation treatments to those buildings that have been identified in this EIS as requiring treatment (where agreed to in consultation with affected property owners).
- Adjustment, relocation and protection of public utilities and services. Heritage investigations and clearance would be required before some public utility adjustments could be undertaken.
- Clearing of some vegetation on the river bank to allow further investigations and the establishment of temporary construction activities. This would be minimised where possible until full construction approval has been obtained.
- Site establishment activities, which would include:
  - Establishment of temporary construction facilities and compound sites, which would involve clearing, minor earthworks, installation of office accommodation, utilities and other facilities.
  - Establishment of construction site fencing, signage and lighting.
  - Establishment of construction site access points, traffic management measures, alternative public access routes and diversions. This would include any minor road modifications to Wilberforce Road, The Terrace and Bridge Street.
  - Construction of the casting bed and associated facilities for the incrementally launched bridge. This would require some minor piling and earthworks.

- Establishment of temporary drainage.
- Installation of environmental controls, including but not limited to erosion and sediment controls and barrier fencing.
- Installation of temporary jetties or pontoons, which could be secured by one or a combination of methods, including anchor blocks or temporary piles. Access to these temporary facilities would also be constructed.

5.4.3 Bridge construction activities

Bridge construction includes construction of the piers in the river, construction of the bridge abutments and construction and launching of the bridge superstructure. It includes both land-based and water-based activities as described below. The exact methods of all elements of construction have not yet been determined and possible alternatives are described below – and have been assessed in Chapter 7.

Land-based construction

The proposed replacement bridge would be constructed using the incrementally launched method. A temporary concrete casting bed and launching yard would be established on the northern side of the Hawkesbury River to castsegments of the bridge. Once a segment has been completed it would then be 'pushed' using large hydraulic jacks (i.e. launched) across the river on to the piers from north to south. For the project, each segment is likely to be about 15.7 metres long (half a span length) and would incorporate all elements of the bridge superstructure except for the traffic barriers. Other construction methods would be considered during detailed design with the aim of further reducing impacts.

The land-based construction components associated with the proposed bridge would include construction of the abutments on each foreshore. The construction activities could include (but would not be limited to) the following:

- Importation of fill. Local fill from the project construction sites would be used where possible, although additional general and select imported fill (about 10,800 cubic metres) is likely to be required.
- Completion of earthworks to create temporary level working platforms.
- Installation of piles at abutment locations by boring to the required depth, placing a steel reinforcement cage in the hole then placing concrete in each pile. Around five piles of about 900 millimetres in diameter are likely to be required directly under each abutment. Piles are required to support each abutment and to transfer bridge loads from the bridge deck through each abutment onto the ground. The final number would be subject to engineering requirements to be determined during detailed design.
- Construction of the abutment walls and retaining structures for the bridge approach roads.
- Completion of permanent earthworks as part of road works between the George Street / Bridge Street intersection and the southern bridge abutment.
- Casting of superstructure segments, post tensioning them to the previous segment and launching them out across the piers.
- Finishing works, including traffic barriers, surfacing, drainage and lighting.

Superstructure segments may either be pre-cast at an appropriately approved off-site facility (and transported to the project site) or cast on-site at a temporary concrete casting bed facility located behind the northern bridge abutment.

For the incrementally launched bridge, a casting bed of about a 15.7 metre section of the bridge (half a span) would be created in the casting yard using formwork. Steel reinforcing for the bridge would also be installed in the formwork. and once complete concrete would be pumped from concrete trucks into the formwork. The concrete would be allowed to set and cure– and then some sections of the formwork would be removed to allow the completed section to be gradually launched (i.e. pushed or pulled) using hydraulic jacks over the bridge piers. The formwork would then be reinstated within the casting yard and the process of constructing and launching a 15.7 metre section of the bridge repeated until the bridge is completed.

Some components of the bridge superstructure such as the traffic barriers may be precast at an off-site facility and attached to the bridge, prior to or after the launching process is complete.

For both the precast and cast in-situ methods, large equipment and heavy machinery such as cranes or scaffold systems would be required to lift elements of each segment into place. This equipment would be located on the work sites within the turf farm, the Windsor Wharf car park and open space areas and the lower Thompson Square parkland for the duration of the construction of each component of the bridge.

Water-based construction

The water-based construction components associated with the project would include construction of four piers in the Hawkesbury River and installation of scour protection below the water line. The construction activities for pier construction could include, but are not limited to:

- Installing piles at pier locations to the required depth by bored piling methods. A steel case would be driven to the required depth and the pile bored within this tube. A steel reinforcing cage would then be placed in the steel casing and the concrete poured into the pile from a barge or a series of temporary platforms using a concrete line pump. Around four piles of about 1500 millimetres in diameter or seven piles of 900 millimetres diameter would be required at each pier location.
- Installing pile caps and pier columns using a combination of precast or cast in-situ methods.
- Finishing works including edge barriers, surfacing, drainage and lighting.

As with the land-based components, the construction methods would be either based on precast or cast in-situ concrete components. If precast methods are used, the components of the pile caps, pier columns or bridge spans would be cast at either an appropriately approved off-site facility or within the turf farm construction and compound site, before being transported to the intended location. The components would be lifted into place by cranes.

Cast in situ methods for construction of the pile caps and pier columns would involve installation of formwork or precast concrete shells supported by a temporary scaffold system, and fixing of steel reinforcement into which concrete would be poured. The concrete line pump would be supported over water by a series of temporary platforms or barges.

There are a number of alternative options for access to the pier construction sites including:

- Barge access – pier construction may be undertaken from a combination of small and large barges. Minor dredging of river bed near the banks may be required to provide access for barges.
- Temporary partial reclamation of the river – temporary rock platforms may be constructed in the river and construction of the piers would occur from these platforms. This method of access may only be appropriate for the piers closest to the banks.
- Temporary steel jetties – temporary steel jetties may be constructed to access the pile construction locations. It may be possible to access all pier locations using this method.
- Either one or a combination of the above options may be used. Some barges and other water craft would still be required no matter what option is selected for pier access. Some equipment and materials would be transported to the work sites via barges from a suitable wharf facility within the Hawkesbury River, subject to negotiation and approval (if required). The equipment required would depend on the method selected but would generally include bulk equipment such as barge-mounted cranes, gantries or scaffold systems.

If installation of scour protection below the water line is required, two methods of construction would be used. For the scour protection in the river bed, areas would require dredging to create an excavated area to place the rock scour below the river bed level. Once a sufficient sized excavation had been dredged, rock would be placed from a barge. For rock scour protection on the bank, an excavator would be used to remove the bank material and then rock placed in the excavated area. This may be completed from a barge mounted excavator or a land-based excavator.

For the scour protection of the southern bank, a retaining wall would be constructed. This could involve drilling a bored pile about every five metres and then installing precast concrete panels between the piles or constructing a continuous piled wall. The design of the scour protection in this area would be considered further during detailed design.

5.4.4 Road construction activities

For the southern approach roadworks through Thompson Square, the roundabout at the intersection of Bridge Street and George Street would be completely removed. Some of the existing pavement would be retained and new pavement would be constructed generally within the confines of the existing kerbs where required. This work could involve a combination of saw cutting, excavation and truck operations. The existing pavement on Bridge Street between George Street and Macquarie Street would need to be replaced using a profiling machine, an asphalt paver, trucks, sweepers, rollers and bobcats. The process would involve removing the existing pavement and constructing new pavement to achieve the required road surface levels. Where possible any excavation for new pavement would not extend below the existing pavement levels to minimise any possible disturbance of unknown heritage items and sites.

New kerb and gutter would be required in George Street for a length of around 10 metres east and west of Bridge Street to allow the required road surface levels and minimum road design standards to be achieved. The new kerb and gutter located on the south western corner of the Bridge Street / George Street intersection would be located behind the existing kerb and gutter by a distance of 0.5 metres to allow for vehicles to safely turn left into George Street. Existing kerb and gutter affected by the proposed roadworks would be removed.

New kerb and gutter would also be required along Bridge Street (south of George Street) for a length of around 45 metres to allow the required road surface levels at the intersection of Bridge Street and George Street to be achieved.

The installation of traffic signals would involve constructing new foundations and installing new pits and conduits to tie into the existing traffic signal system at the intersection of Bridge Street and Macquarie Street. New conduits would need to be laid under the existing footpath (using trenching methods) along the eastern side of Bridge Street between Macquarie Street and George Street in order to connect the existing traffic signals at Macquarie Street with the proposed traffic signals at George Street. The footpath would be reconstructed once the conduits had been laid. The foundations for the traffic signal posts would be piled or excavated and may require existing services to be relocated.

Between George Street and the southern bridge abutment, the road would generally be in fill (above the existing ground surface level) and would require the importation of fill to build the road surface level up to the final road pavement level. Despite being in fill some areas would require excavation below the existing ground surface to remove geotechnically unsuitable material, for service relocations or for the footings required for retaining walls. Prior to filling, excavation works up to two metres deep would be required to expose suitable foundation conditions required to support the fill embankment and retaining walls. Where fill embankments would otherwise extend into private property or into the Thompson Square parkland, vertical retaining walls would be constructed to support the road carriageway. Retaining walls would minimise the area of road within Thompson Square.

An alternative option to a filled earth embankment for the southern approach would be construction of a land bridge for the majority of the length of approach road. This would involve boring a number of piles along the alignment of the road, constructing headstocks between the piles and then placing pre-cast concrete beams between the headstocks to form the bridge deck. Additional elements such as precast concrete panels between the bridge deck and the natural ground and traffic barriers would be installed. Some sections of the southern approach road would still require conventional filling construction methods as described above.

The Terrace, in the vicinity of the replacement bridge, would be connected to the section of The Terrace to the west of the existing bridge. To make this connection a new road pavement to Council standards would be constructed for a length of about 50 metres. To access Council's car park located adjacent to Windsor Wharf, a new connection road would also be required. This connection would involve constructing new road pavement for a length of about 30 metres between The Terrace and Council's car park immediately to the east of the southern bridge abutment.

On the northern side of the Hawkesbury River, road construction activities would involve excavating into the existing ground to a varying depth of about one to two metres using excavators to allow suitable foundation conditions to be exposed to support the road pavement. The roundabout road surface level would be at similar height to the existing ground levels.

5.4.5 Other construction activities

Other construction activities would be undertaken as required and would include:

- Installing connections and links to existing utilities, where required, along the length of the project. This would involve trenching and excavation.
- Constructing kerb and guttering.
- Installation of traffic and safety barriers.
- Drainage works, including excavating, laying and backfilling storm water pipes and pits.
- Street lighting on the replacement bridge and its approach roads where required to meet minimum road lighting levels.
- Construction of pedestrian and shared pathways as shown in **Figure 5-5** and **Figure 5-5a to c**.
- Modifying existing signs and installing new signs.
- Providing road pavement markings.
- Landscaping, fencing and finishing works.

5.4.6 Traffic management and earthworks

The majority of construction traffic movements would relate to importation of fill for the earthworks phase of the project and transport of concrete in trucks for the construction of the replacement bridge. Apart from where the approach roads to the replacement bridge tie in with existing roads, the proposed works would generally be constructed clear of existing traffic. The Construction Environmental Management Plan and contract documents would include traffic and safety management procedures which address management of traffic during construction: traffic switches, line marking, signage (including temporary advanced warning variable message signage), earthworks and material haulage, intersection access, local property access and emergency and incident response. **Section 7.2** provides further information on construction traffic impacts.

A total of about 12,300 cubic metres of fill material would be required for the construction works. The breakdown of earthworks quantities is shown in **Table 5-7**. Local fill from the project construction site in the order of 1500 cubic metres would be reused where possible, although additional imported fill of around 10,800 cubic metres would be required.

Table 5-7 Estimate of types and quantities of materials for construction

Description	Approximate quantities
Road works	
Earthworks (cut to fill)	1500 m^3
Earthworks (imported fill)	10,000 m^3
Concrete	3500 m^3
Asphalt	1000 tonnes
Dense grade base (DGB)	650 m^3
Structural steel	30 tonnes
Bridge works	
Concrete	2400 m^3
Steel reinforcement	450 tonnes
Asphalt	500 tonnes
Imported fill	800 m^3

5.4.7 Demolition of the existing bridge

A detailed methodology for the demolition of the existing bridge would be developed based upon further investigations and studies. For the purposes of the EIS a methodology has been developed and used to identify and assess potential impacts. This is described in the following sections.

Removing the bridge superstructure

The existing bridge would be demolished once the replacement bridge is open to traffic.

The walkway across the existing bridge would be demolished first. This would involve stripping out the collapsible handrail, plywood decking, storage racks and services then removing the steel beams and supporting brackets.

The bridge deck would be removed by saw cutting it into small sections and lifting each section onto trucks positioned on the bridge. Structure sections would be cut from either edge progressively using temporary braces to maintain the stability of the concrete girders until they are lifted out by crane.

The strength of the existing superstructure limits the size of the crane that can feasibly be used to lift the girders and adjacent sections of slab deck. As such, the removal of the concrete girders would be carried out using one of the following methods:

- The deck slabs between the girders could be removed prior to the girders to limit the size of the crane required.
- Girders and bridge sections could be lifted from the river using a crane supported on a barge.

A possible alternative method, involving building a platform underneath the bridge deck to allow the bridge to be broken up in situ, was investigated but found to have substantial disadvantages. Disadvantages included the high cost of building the platform, the risk to construction plant and equipment being washed away during a flood, as well as higher noise and dust levels in comparison to the above-listed crane options.

Removing the bridge substructure

The substructure, including the cast iron cylinders and cross-girders that support the existing bridge deck, would be cut into sections and then removed using a crane on a barge. Cylinder sections would be cut underwater using cutting rods, one metre below the existing river bed level, in accordance with the relevant RMS quality specifications for bridgeworks. Containment measures would be installed around underwater sections of the cylinders to protect water quality and minimise disturbance of the river bed. A cutter suction dredge with a storage tank on the barge may be used to clean up the river bed.

Existing retaining walls adjacent to each bridge abutment would be demolished using an excavator positioned on land behind each abutment or on a barge in front of each abutment. The fill material behind the retaining walls would be removed by the excavator and loaded directly onto trucks. The existing retaining walls and removed fill would be replaced by rock as part of the scour protection works for the project.

5.4.8 Decommissioning activities

At the completion of construction, the construction sites would be decommissioned and rehabilitated, with each area restored to suit its intended post-construction use. Activities involved in this stage of the project would include:

- Cleaning up the site.
- Removing site compounds, barriers, fencing, signage and other temporary structures.
- Removing material from the reclaimed areas.
- Removing material stockpiles.
- Providing full waterway access.
- Opening areas to traffic through a series of traffic switches.
- Restoring and landscaping disturbed areas.

5.5 Construction timing and duration

5.5.1 Construction period

It is anticipated that a construction period of around 20 months would be required to complete the project, including demolition of the existing bridge. The work would be completed in one continuous period as funding permits.

5.5.2 Work hours

There would be four broad categories of works for the project: bridge works, water-based works, road works and bridge demolition works. The bridge works would occur predominantly at the turf farm construction and compound site (refer to **Section 5.2.5**) while road works would occur on both sides of the Hawkesbury River. The water-based works would occur on the river and would be serviced either from a temporary jetty or pontoon on the northern and southern river banks or another appropriately approved wharf downstream of the replacement bridge location.

The majority of the construction works would be carried out during standard working hours, as detailed in **Table 5-8**. Some construction activities, in particular those requiring road closures, would need to be undertaken outside of standard working hours to prevent major disruptions to traffic and access. Low noise activities may also be undertaken outside of normal working hours to optimise construction efficiency. Activities that are likely to occur outside of standard work hours include:

- Bridge works:
  - Deliveries involving large loads or escorted over-sized vehicles.
  - Completion of large concrete pours.
  - Some barge movements.
  - Low noise activities such as steel fixing.
- Road works:
  - Works requiring major road closure, such as works at tie-in locations.
  - Low noise activities.
- Service relocations
  - Where works require road closures.
  - Cutovers from old to new infrastructure – generally need to be undertaken when demand is lowest (i.e. in the middle of the night).

Where required, construction works occurring outside of standard working hours would be in accordance with RMS' Environmental Noise Management Manual Practice Note vii (RTA, 2001). Relevant agencies and affected members of the community would be provided with notification of any works outside of standard working hours.

Table 5-8 Standard working hours

Day	Start time	Finish time
Monday to Friday	7am	6pm
Saturday	8am	1pm
Sunday and public holidays	No work	

5.6 Construction materials and equipment

5.6.1 Construction equipment

The types of construction equipment likely to be used for the project would include (but would not necessarily be limited to) the following:

- Excavation plant for pavement cutting and removal.
- Bobcats and sweepers.
- Compaction plant, including rollers, vibrating rollers, concrete vibrators and trench plate compactors.
- Pneumatic jack hammers.
- Profiling, milling and road paving plant.
- Jet-blasting and shot-blasting machines.
- Miscellaneous vehicles, including utilities, trucks, bogies and semi-trailers.
- Miscellaneous hand tools and equipment.
- Generators, lighting towers, signage and variable message boards.
- Various barges, workboats, temporary work platforms and pontoons.
- Piling rigs and various mobile cranes (up to 200 tonnes).
- Concrete and grouting pumps and transport vehicles.
- Support trusses, stress jacks and scaffold systems.
- Tower or crawler crane.
- Hydraulic jacks for launching the bridge.

5.6.2 Construction materials

An estimate of the types and quantities of materials likely to be required for the project is provided in **Table 5-7**. This information is indicative only and would be subject to refinement during detailed design.

Construction materials would be sourced locally, where possible, and opportunities for procurement of materials with recycled content would be investigated where equivalent quality can be achieved.

Concrete for the construction of the project would be sourced from an off-site local or regional batch plant and no on-site batch plant would be required.

6 Consultation

This chapter provides a summary of the community and stakeholder consultation activities undertaken prior to and during the preparation of this EIS. It also describes the future consultation activities proposed for the EIS exhibition period and construction phase of the project. The Director General's requirements have been addressed in preparing this chapter as detailed below.

Director General's requirements	Where addressed
During the preparation of the EIS, you should undertake an appropriate and justified level of consultation with relevant parties, including but not limited to:	
• Local, State and Commonwealth government authorities including the: – Department of Primary Industries – Agriculture and Fishing and Aquaculture – Heritage Council of NSW – Maritime Services – NSW Office of Water – Office of Environment and Heritage – Transport for NSW and – Hawkesbury City Council	Section 6.2
• Specialist interest groups, including Local Aboriginal Land Councils, Aboriginal stakeholders	Section 6.2
• Utilities and service providers	Section 6.2.3
• The public, including community groups and adjoining and affected landowners.	Section 6.2
• The EIS must describe the consultation process, document consultation undertaken and identify the issues raised (including where these have been addressed in the EIS).	Section 6.2

6.1 Consultation objectives and strategy

The delivery of road projects is an important issue for the community as a range of stakeholders may be directly or indirectly affected. RMS has developed a consultation strategy that covers all phases of project planning and future delivery for the project. Delivery of the strategy is ongoing. The objectives of the consultation strategy are to:

- Keep stakeholders and the community informed about the project, including decisions about project options and design.
- Clearly explain how stakeholders and the community can participate in project planning and how their input will be used in decision-making.
- Provide opportunities for stakeholders and the community to:
  - Ask questions about the project.
  - Raise and discuss any issues or concerns they may have about the project.
  - Have input to the project planning, development and delivery processes.

- Enable community expectations and concerns to be addressed in project planning and design to the greatest extent practicable.
- Manage stakeholder and community feedback and complaints in an appropriate and timely manner.

6.2 Consultation process and activities to date

In line with the Director General's requirements, RMS has undertaken an appropriate level of consultation to meet the consultation objectives. The consultation process has involved using a wide range of activities to provide information about the project to the community and stakeholders and obtain their input and feedback. This has included:

- Activities that provide information – providing accurate and timely information about the status of the project and key environmental and planning issues associated with the project.
- Activities that provide the community and stakeholders with opportunity to provide input and feedback – providing suitable opportunities for the community to provide input and/or feedback into the ongoing development of the project, including design refinement, potential environmental issues and identification of potential environmental management measures.
- Direct engagement – providing opportunities for directly and indirectly affected landowners and other relevant parties to meet privately with the project team to discuss their specific concerns.

Consultation for the project began in July 2009 with the release of a community update outlining the nine options being considered to rehabilitate or replace the existing bridge. Details of the consultation activities undertaken before and during the preparation of the EIS are provided in **Sections 6.2.2** and **6.2.3**. A total of 136 submissions were received during the display of the nine options (between July 2009 and August 2009) and 72 submissions were received during the display of the preferred option (between August 2011 and September 2011).

6.2.1 Aboriginal cultural heritage consultation

Aboriginal cultural heritage consultation was undertaken in accordance with RMS' Procedure for Aboriginal Cultural Heritage Consultation and Investigation (PACHCI), which provides for a consistent standard of consultation that meets legislative requirements, as well as a staged risk management approach to minimising impacts on Aboriginal cultural heritage.

Details of the Aboriginal cultural heritage consultation activities undertaken before and during the preparation of the EIS are provided in **Sections 6.2.2, 6.2.3** and **7.2.2**.

6.2.2 Consultation undertaken before preparation of the EIS

A summary of the consultation activities undertaken before preparation of the EIS is provided in **Table 6-1**. Further details of key public consultation activities are provided in **Table 6-2**. Feedback forms with pre-paid reply envelopes were provided to attendees of all community events. Further details of agency consultation are provided in **Section 4.1.3** of Chapter 4.

Table 6-1 Consultation undertaken before EIS preparation (July 2009 - November 2011)

Community/ stakeholder group	Individual stakeholders	Consultation activities
Councils and government agencies	Department of Planning and Infrastructure Heritage Branch and Heritage Council Office of Environment and Heritage Hawkesbury City Council Maritime Services Division of RMS	Letters Telephone calls Meetings and briefings Stakeholder workshop
Specialist interest groups, including Local Aboriginal Land Councils and Aboriginal stakeholders	Hawkesbury Nepean User Group Windsor Business Group Royal Australian Historical Society National Trust of Australia Deerubbin Local Aboriginal Land Council Darag Tribal Aboriginal Corporation	Letters Telephone calls Meetings and briefings Stakeholder workshop
The public, including community groups and adjoining and affected landowners[1]	Residents Business owners Windsor Residents First Group	Community update newsletter Public displays Project website Shopping centre display Community workshop Meetings and briefings

1. Further details of activities provided in **Table 6-2**.

Table 6-2 Details of key public consultation activities

Activity	Date(s)	Details
Community update newsletter	July 2009	Distributed to 12,000 local residents, businesses, government agencies and registered project stakeholders. The community update provided background information on the project as well as information on the project objectives and the nine options being considered. It also provided details of the community workshop to be held on 1 August 2009.
Public displays	July – August 2009	Details of the nine options were placed on display at Hawkesbury City Council (administration building and library) and Richmond Motor Registry. Written comments were invited on all the options.
Project website	July 2009 - present	Website launched, providing project information and project documents (including the July 2009 community update). An invitation for the community to provide feedback on the nine options being considered was also placed on the website.

Activity	Date(s)	Details
Shopping centre display	July 2009	Staffed display held at Riverview Shopping Centre, Windsor, to raise community awareness of the project and invite the community to the following week's workshop. Around 140 people visited the display.
Community workshop/ Information session	August 2009	Advertisements were placed in local newspapers inviting the community to attend the workshop, which was held on 1 August 2009 at Windsor Central Library. Members of the project team were available to answer questions about the project and receive feedback about the nine options being considered. About 90 people attended. Attendees were invited to provide feedback and make written comments on the options. Feedback forms and reply paid envelopes provided to attendees for this purpose.
Meetings and briefings	July – September 2009	Held between the project team and various groups and organisations including government agencies, council and local business and community groups.
Newspaper advertisements	August 2011	Newspaper advertisements for the online discussion forum and community workshop were posted in the Hawkesbury Gazette on 24 August 2011 and the Hawkesbury Courier on 25 August 2011. A newspaper article providing information about the preferred option and advertising the evening workshop and the online discussion forum was also included in the Hawkesbury Gazette on 31 August 2011. Feedback forms and reply paid envelopes were provided to attendees of community events.
Online discussion forum	26 August – 6 September 2011	An online discussion forum was launched for the public to submit suggestions, share opinions and join the discussion about the preferred option for the replacement bridge. The forum was live on the RMS project website and asked the community to comment on three chosen topics: • General thoughts about the project. • Details and design. • Issues or impacts to be considered in the environmental assessment of the project. A total of 22 comments were received on the forum.

6.2.3 Consultation undertaken during the preparation of the EIS

Preparation of the EIS commenced in November 2011 following the release of the Director General's Environmental Assessment Requirements on 24 November 2011.

A range of consultation activities have been carried out since the start of EIS preparation. These activities are listed in **Table 6-3**, with further details of key activities provided below.

Table 6-3 Consultation undertaken during EIS preparation (November 2011 to September 2012)

Community/stakeholder group	Individual stakeholders	Consultation activities
Councils and government agencies	Department of Primary Industries (Fisheries NSW and Agriculture NSW) Office of Environment and Heritage Hawkesbury City Council Maritime Services Division of RMS Heritage Council of NSW NSW Office of Water Transport for NSW Environment Protection Authority	Meetings and briefings Letters and emails Telephone and letter contact
Specialist interest groups, including Local Aboriginal Land Councils, Aboriginal stakeholders	Hawkesbury Nepean User Group Windsor Business Group Royal Australian Historical Society National Trust of Australia Deerubbin Local Aboriginal Land Council Darag Tribal Aboriginal Corporation Hawkesbury City Council Fellowship of the First Fleeters	Meetings and briefings Letters and emails Aboriginal focus group meetings
Utility and service providers	Telstra Sydney Water Endeavour Energy Hawkesbury City Council Jemena Optus	Meetings and briefings Letters and emails
The public, including community groups and adjoining and affected landowners	Residents Property owners of adjoining and affected properties Design and Heritage Community Focus Group Business owners Windsor Residents First Group Community Action for Windsor Bridge	Community update Letters and emails Displays Information session Workshop Letterbox drop of flyers Online discussion forum Online mapping portal Community focus group One-on-one meetings Project Website

Community updates

The August 2011 community update was distributed to residents and businesses in Berkshire Park, Windsor Downs, South Windsor, Windsor, McGraths Hill, Pitt Town, Wilberforce and Freemans Reach. A total of 12,000 copies were distributed. The community update:

- Summarised the options considered.
- Explained the project objectives and the selection of the preferred option.
- Described the preferred option.
- Provided details of two staffed shopping centre displays, a community information session, community workshop and display locations.
- In May 2012 a project update brochure was distributed to residents and businesses in the Windsor township and to key stakeholders and government agencies. A total of 1,500 copies were distributed. The brochure:
  - Updated the concept design for the preferred option.
  - Identified the proposed bridge type.
  - Identified options for the renewal of Thompson Square.
  - Provided information about Aboriginal and historic heritage items.

Leaflet distribution and door knocking

Leaflets advertising the online discussion forum and the community workshop for the project were distributed to 12,000 residential and business properties in Berkshire Park, Windsor Downs, South Windsor, Windsor, McGraths Hill, Pitt Town, Wilberforce and Freemans Reach. Door knocking at residences and businesses located immediately adjacent to the project was also carried out, with a community update document left at all properties visited.

Roads and Maritime Services website

The RMS project website, established before the start of EIS preparation, continued to provide information to the public throughout the EIS preparation period. The information on the website includes all public documents and media releases produced to date, including the community update, options report, and supporting documents. A ‘questions and answers’ document and workshop notes were also posted on the website.

Displays

Public information displays of the preferred option were held from 4 August 2011 to 9 September 2011 at Hawkesbury City Council, Windsor Central Library and Richmond Motor Registry. Displays were also held at Windsor Riverview Shopping Centre on 11 August 2011 and 13 August 2011, with members of the RMS project team available to provide information, answer questions and receive feedback about the project. The 11 August display was attended by 140 people and the 13 August display by 165. Community updates, feedback forms and reply paid envelopes were provided at all display locations. Shopping centre information displays were held at Windsor Riverview Shopping Centre on Saturday 1 September and at Windsor Marketplace on Saturday 8 September 2012. Community updates/brochures, feedback forms and reply paid envelopes were provided at both displays.

Information session

A community information session took place at the Deerubbin Centre (Windsor Central Library) on 20 August 2011, with 19 people attending. RMS project team members were available to provide information, answer questions and receive feedback about the project and preferred option. Community feedback forms and reply paid envelopes were also provided.

RMS staff also attended Hawkesbury-Nepean Water Users Group meetings to provide the group with information on the project on 6 February 2012, 7 May 2012 and 6 August 2012.

Workshop

A community workshop was held at Windsor Function Centre on 31 August 2011. The workshop encouraged discussion with RMS project team members and enabled the attendees to ask questions and provide feedback about the project and preferred option. Fifty eight people attended the workshop. A letter and email invitation to the community workshop was sent to stakeholders and government agencies who had previously commented on the project.

Online discussion forum

An online discussion forum to discuss the latest design and community ideas for the project ran between Monday 28 May and Friday 15 June 2012 on the RMS project website and asked the community to comment on:

- Any suggestions to improve the design.
- The composition of Thompson Square.
- The refined bridge design.

A total of 301 comments were received from the online forum.

Aboriginal focus group

An Aboriginal focus group was established to discuss the project and potential impacts on Aboriginal cultural heritage, and to seek comment on the methodology for heritage investigations. The group was comprised of eight Aboriginal stakeholders who registered their interest following invitation. Meetings of the group were held in February and May 2012. Section **7.2.2** discusses the Aboriginal consultation process in more detail.

Community focus group

A community focus group, with a focus on heritage and design, was established in November 2011. The purpose of the focus group was to allow the community to work closely with the RMS project team and contribute to the concept design development and environmental assessment for the preferred option. The group met seven times, with meetings attended by an average of 20 to 30 community and stakeholder representatives.

Deliberative forum

A deliberative forum was conducted by GA Research on behalf of RMS on 30 May 2012. The objective was to explore knowledge and perceptions of the Windsor Bridge Replacement Project among the community. The forum found that traffic, rather than the project, was the main issue in the Windsor area. Participants felt disappointed that RMS was not taking the opportunity to do anything substantial to address current and future traffic issues. . However there was a general agreement that Windsor Bridge needs to be replaced as it is seen as very narrow and dangerous. Overall the forum identified the perceived negative issues associated with the project and the concerns of the participants, including clarification of the decision making process and evidence of past consultation among others.

Other meetings and briefings

Meetings were held between the project team and various groups and organisations during preparation of the EIS including:

- Community groups.
- Windsor Business Group.
- Hawkesbury City Council.
- Office of Environment and Heritage.
- Heritage Council of NSW.
- Maritime Services division of RMS.
- Transport for NSW
- Environment Protection Authority (EPA)

Meetings were also held with residents and businesses in close proximity to the project.

6.3 Summary of issues raised

6.3.1 Issues raised by government agencies

All issues raised during consultation have been recorded and have helped inform investigations and ongoing project development. All stakeholder activity is recorded in a secure database called Consultation Manager. The database records contact details, type of activity and issues raised. All information recorded is used and managed in accordance with the *Privacy Act 1998*.

A summary of the main issues raised at various stages of the project and where these are addressed in the EIS is provided in **Table 6-4** (issues raised by government agencies), **Table 6-5** (specialist interest groups, utilities and service providers) and **Table 6-6** (the public).

Table 6-4 Summary of issues raised - Local, State and Commonwealth government authorities

Stakeholder	Issues raised	Where addressed
Department of Primary Industries (Fisheries NSW and Agriculture NSW)	• River bed and bank stability and impacts on aquatic flora and fauna. • Hawkesbury River is deemed a Class 1 (major fish habitat) waterway and mapped as 'Key Fish Habitat'. • Threatened species and key threatening processes should be specifically addressed. • Assessment should refer to the aquatic habitat and threatened species provisions of the *Fisheries Management Act 1994* and any relevant policies and guidelines.	Chapter 7 (Section 7.9)
Heritage Branch, Office of Environment and Heritage	• The project is located within a highly sensitive archaeological landscape feature, with the potential to contain some of the oldest surviving evidence of Aboriginal life along the Hawkesbury River and in NSW. • The alluvial terrace in the location of the proposed bridge is potentially of very high Aboriginal cultural heritage significance. • The project requires adequate treatment of pre-Macquarie history including Jan Barclay-Jack's research on Green Hills and the pre-Macquarie creation of a civic space precinct where Thompson Square would grow.	Chapter 7 (Sections 7.1 and 7.2) Historic Heritage working paper (Volume 2- working paper 1)
Heritage Council of NSW	• Exceptional heritage significance of Thompson Square and Windsor. • Thompson Square is of crucial importance to the heritage of the State and the preferred option is likely to have a long-term irrevocable impact on Windsor as a whole and Thompson Square in particular. The preferred option does not adequately respect the unique history and State heritage significance of this area. • Any option that passes through Thompson Square cannot be supported on heritage grounds. • Refurbishment of the existing bridge (option 9) or a bypass (option 6) would be the only acceptable options. • Consideration should be given to separating local and through traffic. • Urban design input, detailed design review and further heritage advice must be obtained so that modifications can be made to reduce impacts on Thompson Square. • Consideration should be given to reducing the overall bulk and scale of the road embankments and increasing the visual permeability of the structure to prevent imposing a solid barrier across Thompson Square.	Chapter 3, Chapter 4 and Chapter 7 (Section 7.1 and Section 7.4)

Stakeholder	Issues raised	Where addressed
	• Comprehensive archaeological investigations need to be conducted to identify the potential archaeological resource and inform detailed design. • Detailed assessment, including Statements of Heritage Impact and adequate field survey, need to be undertaken. • Specific assessment is required to identify the heritage impacts arising from construction and operation of the preferred option (including impacts arising from vibration, demolition, archaeological disturbance, changes to historical arrangements and access, changes to the landscape and vistas, and architectural noise treatment of buildings). • Proposed research design and methodology for physical archaeological works needs to be reviewed by the Department of Planning and Infrastructure and the Heritage Council, prior to commencement, to check that strategies are appropriate and in accordance with standard archaeological practice for State listed sites and areas.	
NSW Office of Water	• The number of bridge piers in the river should be minimised. • Impacts on the aquatic and riparian environment, including bed and bank stability, aquatic and riparian vegetation, aquatic and riparian fauna, and fish passage. • Measures to mitigate impacts need to be identified, including measures for stabilisation and rehabilitation of the river bank as a natural system, identification of minimum riparian widths (measured from top of bank) to be protected and enhanced, and contingency plans for remediation and rehabilitation of riparian areas. • Impacts on groundwater.	Chapter 4, Chapter 5 and Chapter 7 (Section 7.6, Section 7.7 and Section 7.9)
Transport for NSW	• Commented that the project planning process appeared to be robust and well-considered. • Transport for NSW will track and support the investment required for the project.	No response required
Hawkesbury City Council	• Interested in ongoing involvement in design development to ensure that potential impacts are managed and mitigated (especially landscape and heritage aspects). • Requested justification (other than cost) for the relatively limited width of the bridge. • Council supports RMS' selection of the preferred option and would like the works to proceed as soon as possible. • Improved connection at Freemans Reach Road and Wilberforce Road needs to be considered.	Chapter 3, Chapter 4, Chapter 5 and Chapter 7 (Section 7.1, Section 7.3, Section 7.4, Section 7.5,

Stakeholder	Issues raised	Where addressed
	• Improved access along The Terrace is required, including the connection to the wharf and Governor Phillip Park. • Project needs to increase flood immunity. • Access along The Terrace needs to be available for service vehicles and buses. • Access to Windsor Wharf needs to be provided for large coaches. • Dilapidation reports need to be prepared for all heritage and non-heritage structures adjoining the project before the start of works. • The reinstatement and rehabilitation of Thompson Square needs to provide more than just additional generic parkland. Council's existing Plan of Management should be considered. • Need to minimise the road grade to minimise traffic noise impacts. • The right turn from Bridge Street southbound into George Street westbound is important for trade and needs to be considered in both stages of the project. • The Hawkesbury Residential Land Strategy (May 2011), which addresses the Draft North West Subregional Strategy, needs to be considered in any future traffic modelling. • Council have no interest in retaining any structural element of the old bridge structure including the abutments. Other viewing platform opportunities are included in Council's River Foreshore Management Plan. • Council identified the locations of existing and proposed assets and utilities, and the locations where assets will require protection or relocation during construction.	Section 7.7 and Section 7.8)
Maritime Services Division of RMS	• The river is extensively used by recreational boaters engaged in high-speed towing and other activities. • Licensed aquatic boating activities are regularly held in the waters directly adjacent to the bridge and Governor Phillip Park and may be disrupted as a result of the project. • No supporting structures or pylons should be placed in navigable water where high-speed towing and other activities take place. • The possible shadowing effect of the bridge on the boating race course needs to be investigated. • The span width and height of the bridge may affect navigation of vessels. The possible restriction of the passage of larger commercial vessels to their permanent moorings next to the public wharf at Windsor needs to be investigated.	Chapter 3, Chapter 4 and Chapter 7 (Sections 7.3, Section 7.4, Section 7.7 and Section 7.8)

Stakeholder	Issues raised	Where addressed
Environment Protection Authority (NSW)	• The project has the potential to create dust and impact local air quality during construction. Potential impacts on local and regional air quality need to be assessed and mitigated, with materials handled in a proper and efficient manner to minimise air pollution. • The project has the potential to pollute the Hawkesbury River during construction, especially as a result of the handling and storage of waste materials. Potential water impacts need to be assessed and mitigated and waste materials need to be handled and stored in a proper and efficient manner at all times. • The proposed construction site on the northern side of the river is located on a floodplain. Materials would be stockpiled in a flood affected area. Construction activities in flood prone areas need to be thoroughly scrutinised to ensure appropriate impact mitigation and environmental management processes are identified and implemented.	Chapter 7 (Section 7.6, Section 7.7 and Section 7.10)

Table 6-5 Summary of issues raised - Specialist interest groups, utilities and service providers

Stakeholder	Issues raised	Where addressed
Royal Australian Historical Society	• The bridge replacement would affect the significant historical values of the Thompson Square landmark.	Chapter 3 and Chapter 7 (Section 7.1)
National Trust of Australia	• Impacts on Thompson Square, including visual integrity, buildings and public space.	Chapter 3 and Chapter 7 (Section 7.1 and Section 7.4)
Windsor Business Group	• Need to maintain all turning movements at the George Street and Bridge Street intersection. • Construction impacts on Thompson Square would affect businesses. • Construction activities should focus on the northern side of river. • Need for ongoing consultation with business owners continuing through construction.	Chapter 4, Chapter 5 Chapter 6 and Chapter 7 (Section 7.3 and Section 7.8)

Stakeholder	Issues raised	Where addressed
Hawkesbury Nepean User Group	• Concerned about the timing, cost and impacts of options 6 and 7 (including parking and boat racing course issues).	Chapter 4
Deerubbin Local Aboriginal Land Council	• No specific issues raised about the project. • Comments on archaeological investigation methodology were made and adopted.	Chapter 7 (Section 7.2)
Darug Tribal Aboriginal Corporation	• No specific issues raised about the project. • Comments on archaeological investigation methodology were made and adopted.	Chapter 7 (Section 7.2)
Fellowship of the First Fleeters	• Recommended interpretation of early European and Aboriginal activity in the renewal of Thompson Square. • No heritage buildings should be demolished.	Chapter 7 (Section 7.1, Section 7.2 and Section 7.4)
Endeavour Energy	• Endeavour Energy planning to upgrade a 33kV feeder from Windsor to Cattai that would impact the project. • Provided details of feasibility study for possible relocation options this 33kV upgrade. • The proposed relocation of the 11kV conduits to be laid under the shared path across the new Windsor Bridge.	Chapter 5
Sydney Water	• Provided details of existing water mains and pipes that would be affected by the project. Relocation options were provided.	Chapter 5
Telstra	• Provided details of existing and proposed Telstra services and requirements for asset protection. • Any relocations must be carried out by Telstra contractors. • EIS needs to assess impacts associated with asset relocations, including heritage impacts.	Chapter 4 and Chapter 7 (Section 7.1)

Table 6-6 Summary of issues raised – The public, including community groups and affected landowners

Issue category	Issues raised	Where addressed
Aboriginal and historic heritage	• Heritage and character of the local area, and the need to preserve this in the project design. • Potential disturbance of historic archaeological artefacts (both above and underground). • Construction activities could damage historically and archaeologically significant Aboriginal and historic heritage items and relics. • Construction and operation of the project would damage heritage buildings in Thompson Square. • The project would threaten the State heritage significance of Thompson Square. • Evidence of the early existence of First Fleeters who settled in Windsor would be destroyed. • The project will impact negatively on the surrounding heritage buildings as a result of increased noise and vibration. • Concerned about the objectivity of the archaeological review of Thompson Square. Queried whether an independent archaeological investigation would occur before the concept design was finalised. • Irreversible damage to archaeological evidence (including wharves, sandstone gutters, underground pipeline, tunnels and other early remains) would occur during construction and operation. • Irreversible damage or loss of old trees in Thompson Square would occur. • Design of the bridge could contrast with the heritage 'feel' of the town. • Any negative impacts on heritage would also affect tourism and businesses. • Alternative options which avoid Thompson Square should be considered.	Chapter 7 (Section 7.1, Section 7.2, Section 7.4 and Section 7.8)
Traffic	• Improvement in traffic conditions is required. • Concerned about the volume of traffic during and outside peak hours. • The increase in the number of heavy vehicles using the bridge (eg semi-trailers) as a result of the project.	Chapter 3, Chapter 4 and Chapter 7 (Section 7.3)

Issue category	Issues raised	Where addressed
	• Expressed dissatisfaction with the congestion caused by existing infrastructure (eg the roundabout at the corner of George Street and Windsor Road). • Expressed doubts that the preferred option would alleviate current congestion issues in the township. Concerns were raised about the lane numbers on the bridge and traffic management features at each end of the bridge. • Roundabout at the corner of George Street and Bridge Street would potentially cause both traffic and safety issues, particularly during peak periods. • The steep incline heading southbound through Windsor is currently hazardous for drivers (particularly heavy vehicles) due to delays at the roundabout at the George Street-Bridge Street intersection. • During peak periods, traffic is banked up halfway to Wilberforce along Wilberforce Road and a similar distance towards Freemans Reach on Freemans Reach Road. This congestion would be amplified by new traffic lights. • Trucks are 'choking' the roads through Windsor and need to bypass the town. • A bridge with a wider road would encourage more traffic and lead to further congestion and traffic issues. • Drivers bypass the roundabout at George Street and Bridge Street by driving through backstreets ('rat running'). • Construction traffic impacts. • Expressed dissatisfaction with traffic queues on Bridge Street. It is lucky if three vehicles are able to turn left from Macquarie Street onto Bridge Street at the traffic lights. • Traffic in Windsor seems to be worse on Tuesdays and Thursdays. • People are frustrated with the traffic delays at North Richmond and are therefore taking a detour to Wilberforce Road and crossing the Hawkesbury River via Windsor Bridge. This is why there is so much traffic in the Windsor area as people are avoiding crossing the North Richmond Bridge. • The project would not resolve the bank up of morning peak traffic on the Wilberforce side and afternoon peak traffic on the McGraths Hill side.	

Issue category	Issues raised	Where addressed
Flooding	• Maintaining access during flooding. • Bridge design needs to provide for a 1 in 50 year flood event, as opposed to 1 in 5 year event as stated in the 2011 community update. • Northern approach roads will still be under water with the new bridge. Raising the approach roads should be included in the design, extending as far as Wilberforce. • Bridge could be lengthened and the height increased. • Flood data for the last 50 years needs to be considered in the flood impact assessment. • Compliance with the 1 in 100 year flood requirement would not be achieved.	Chapter 3, Chapter 4 and Chapter 7 (Section 7.7)
Motorist safety	• Safety of motorists across the bridge and approaches. • Peak hour congestion causes southbound drivers reaching the roundabout to give way for long periods, therefore delaying the traffic behind them. This is an issue due to the steep incline on Bridge Street and can be particularly dangerous for southbound heavy vehicles idling for an extended amount of time. • Expressed support for the roundabout at the intersection of George Street and Windsor Road to be replaced with traffic lights. However, lines of sight are limited by the crest in the road, which may reduce the ability of drivers to react to a red light.	Chapter 4 and Chapter 7 (Section 7.3)
Pedestrian safety	• Unsafe conditions for local pedestrians and cyclists in the Windsor Peninsula precinct. • Pedestrian safety is compromised by lack of crossing facilities at the Bridge Street and George Street roundabout. Noted that no pedestrian crossing is proposed at the intersection of Bridge Street and George Street or in popular areas, such as the music store (corner of Bridge Street and George Street) and Thompson Square. During peak periods pedestrians are often weaving through traffic stopped at the intersection of Bridge Street and George Street. • Access to homes along the proposed route would be impeded, making entry and egress dangerous for residents and their visitors.	Chapter 4 and Chapter 7 (Section 7.3)

Issue category	Issues raised	Where addressed
Removal of the existing Windsor bridge	• The existing bridge should be retained in any capacity. • Historical significance of the project site would be affected by the project • Existing bridge could be used as a pedestrian/cycleway. This would provide more space on the replacement bridge for four traffic lanes and keep cyclists and pedestrians away from traffic. • Existing bridge could be used for recreational purposes such as fishing. • Existing bridge could be used as a direct access route to Thompson Square. • Existing bridge could be included as part of the town's heritage listed items. • Keeping the existing bridge would eliminate cost of removal. • Concerned about safety due to the condition of the existing bridge.	Chapter 3, Chapter 4 and Chapter 7 (Section 7.1)
Amenity and visual impacts	• Heavy transit bridge would destroy the amenity, ambience and village atmosphere of the town. • Height of the bridge could 'dwarf' and affect the readability and visual sight lines of Thompson Square. • Height of the bridge should be comparable to western side of Hawkesbury. • Existing heritage 'feel' of Windsor should be maintained by incorporating existing town design and colour schemes into the proposed bridge design. A highly modern structure and/or colour scheme would contrast with the town. A large ugly concrete structure will over shadow a historical town. • Thompson Square would be greatly enhanced with the proposed alignment, providing an opportunity to create a useable public space. • RMS needs to work with Council to ensure the work integrates with plans for Windsor wharf. • Higher noise levels from the new bridge and approach roads would make Thompson Square park unusable. • Higher noise levels from the new bridge and approach roads would make Macquarie Park unattractive to picnickers. • Properties adjacent to the new bridge and approach roads would experience unacceptable noise impacts.	Chapter 3 and Chapter 7 (Section 7.1, Section 7.4, Section 7.5 and Section 7.8)

Issue category	Issues raised	Where addressed
Operational noise and vibration	• Negative impacts on heritage items located above and underground. • Noise and vibration impacts on nearby residents during construction and operation. • Increased traffic noise as a result of future traffic growth. • Negative impacts on the recreational use of Thompson Square parkland and Macquarie Park due to noise.	Chapter 7 (Section 7.1, Section 7.2, Section 7.3 and Section 7.5)
Socio-economic impacts	• Local community needs must be considered, such as pedestrian and cyclist connections, recreational space, and access to business and shopping. • Once the bridge is constructed, the homeless people living under the bridge will have nowhere to go. • Project may restrict power boat racing activities. Events held in the park by the Upper Hawkesbury Power Boat Club bring significant financial support to the Windsor community by bringing hundreds of people to the area. • New structure may be targeted by anti-social behaviour, such as graffiti and vandalism. • Design should integrate recreational activities such as the Great River Walk, potential canoe and boat access, and Windsor wharf access. • Design should integrate a regatta style access platform to the river – eg Parramatta River Rowing Club. • Design should include the construction of a bridge walkway to give access to a walking trail to Wisemans Ferry.	Chapter 3 and Chapter 7 (Section 7.3, Section 7.4 and Section 7.8)
Impacts on businesses	• There would be a lack of desire to travel through and/or work in Windsor due to current and future congestion. • Vehicles heading north and requiring access to two properties on Old Bridge Street would have to cross the bridge, turn around and travel southbound to access these properties. This inconvenience could result in a loss of business. • Increased traffic congestion during peak periods would cause difficulties for travel to work, particularly if coming from a southbound direction over the bridge. • Any negative impacts on heritage would also affect tourism and businesses. • Physical presence of a wide road bridge and an increase in traffic would have a negative impact on nearby retail and hospitality businesses. • Traffic would be drawn away from Windsor's already struggling central businesses.	Chapter 3 and Chapter 7 (Section 7.3 and Section 7.8)

Issue category	Issues raised	Where addressed
Health	• Traffic-related air pollution. • Increase in traffic would pollute the area with traffic fumes.	Chapter 7 (Section 7.10)
Justification of the selection of the preferred option	• Advocated options, particularly option 6, which would bypass Windsor.	Chapter 3 and Chapter 4

6.4 Future consultation

The project team will continue to identify and manage the issues and concerns of the community during the assessment and approval process and, if the project is approved, during its construction. Further details of future consultation are provided below.

6.4.1 Consultation during the exhibition of the EIS

The Department of Planning and Infrastructure is responsible for the public exhibition of the EIS. The required public exhibition period for the EIS is at least 30 days. During the exhibition period, the public will be able to review the EIS and send submissions to the Department of Planning and Infrastructure for consideration in its assessment of the project.

The Department will advertise the dates and venues for exhibition of the EIS in the local and metropolitan press, and provide the EIS on the Department's website (for reading and downloading). RMS will also place the EIS on the project website and will distribute a community update to residents and business of Windsor and surrounding suburbs when the exhibition commences. The community update will provide an update of the project (including an overview of the concept design), explain the EIS exhibition process, provide details of the upcoming exhibitions and information sessions, and explain how comments can be submitted. A letter and email will also be sent to all community members, stakeholders and government agencies who have previously commented on the project to inform them of the exhibition of the EIS and the opportunities to make submissions.

During the public exhibition period, RMS will also hold a community information session and staffed shopping centre display to provide an opportunity for the public to directly discuss the project and EIS with key members of the RMS project team. Staffed shopping centre dislays will be held at Windsor Marketplace and Windsor Riverview Shopping Centre. Display boards will be provided at both venues to provide information on the project, the concept design, the environmental impact assessment and project planning process, and the impacts and issues identified. Unstaffed information displays will also be set up during the EIS exhibition period at the following locations:

- Hawkesbury Council Chambers.
- RMS Motor Registry, Richmond.
- RMS Office, Blacktown.
- RMS Head Office, North Sydney.
- Deerubbin Centre (Windsor Central Library).
- NSW Department of Planning and Infrastructure, Bridge Street, Sydney.
- Nature Conservation Council of NSW, Newtown.
- Meetings will be offered to stakeholders who are unable to visit the information session, information displays or EIS exhibition.

At the completion of the EIS public exhibition period, the Director General of the Department of Planning and Infrastructure will provide RMS with a copy of all submissions or a summary of the issues raised in submissions. RMS will then prepare a submissions report that will respond to the issues raised. This report will include any proposed changes to the project, including proposed changes in response to submissions. If required, a Preferred Infrastructure Report would also be prepared at this time.

All submissions made to the Department of Planning and Infrastructure during the public display period will be posted on the department's website.

6.4.2 Consultation during the construction phase

Should the project proceed to construction, the project team would continue to work with the community to ensure they are informed about the project and have opportunities to provide feedback to the project team. Key consultation activities and tools would include:

- Development and implementation of a detailed construction communications plan.
- Notification of works (including targeted letterbox drops).
- 24-hour toll-free project information phone line.
- Complaints management process.
- Regular updates on RMS' website and/or a project website.
- Newsletters, information brochures and fact sheets.
- Clear signage at construction sites.
- Media releases and project advertisements in local and metropolitan papers.
- Construction updates (including for Council, emergency services and bus operators).

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7 Assessment of key issues

This chapter provides an assessment of the key environmental issues for the project as identified in the Director General's environmental assessment requirements and as per the relevant requirements of Schedule 2, Part 3 of the Environmental Planning and Assessment Regulation 2000.

For each key issue, the existing environment is described, the potential impacts (direct, indirect and cumulative) of the project during construction and operation are assessed, the influence of relevant planning matters are considered and proposed management and mitigation measures are described. The proposed management and mitigation measures in this chapter are collated in Chapter 10.

The assessments of key issues are supported by detailed investigations, which have been documented in the working papers in Volumes 2, 3 and 4. To the extent of any inconsistency between this main volume of the EIS and the working papers, the former prevails.

7.1 State and local historic heritage and maritime heritage

This section presents the results of the assessment of State and local historic heritage impacts and maritime heritage impacts. The assessment is supported by detailed studies prepared by experienced and suitably qualified heritage consultants. The full details and results of the studies are documented in the following reports:

- Historic Heritage Assessment and Statement of Heritage Impact (presented in Volume 2 - Working paper 1).
- Maritime Archaeological Statement of Heritage Impact (presented in Volume 2 - Working paper 2).

The assessment has addressed the Director General's requirements for State and local historic heritage and maritime heritage, as detailed in **Table 7-1**, as well as the relevant requirements of Schedule 2, Part 3 of the *Environmental Planning and Assessment Regulation 2000*.

Table 7-1 Director General's requirements

Director General's requirements	Where addressed
The EIS must address the following specific matters: **Heritage –** including but not limited to:	
– impacts to State and local historic heritage (including archaeology, heritage items and conservation areas), in particular, impacts on the Thompson Square Conservation Area, heritage listed buildings and sites in the Thompson Square conservation area and the Windsor Bridge should be assessed.	Section 7.1.4
Where impacts to State or locally significant historic heritage items are identified, the assessment shall:	
– outline the proposed mitigation and management measures (including measures to avoid significant impacts and an evaluation of the effectiveness of the mitigation measures) generally consistent with the guidelines in the NSW Heritage Manual (1996).	Section 7.1.5 Section 7.4.4 Section 7.4.6

Director General's requirements	Where addressed
– be undertaken by a suitably qualified heritage consultant(s) (note: where archaeological excavations are proposed the relevant consultant must meet the NSW Heritage Council's Excavation Director criteria).	Volume 2- Working papers 1 and 2 and Section 7.1
– include a statement of heritage impact for all heritage items (including significance assessment).	Volume 2 - Working papers 1 and 2 Section 7.1.3
– consider impacts from vibration, demolition, archaeological disturbance, altered historical arrangements and access, landscape and vistas, and architectural noise treatment.	Section 7.1.4 and Section 7.5
– develop an appropriate archaeological assessment methodology, including research design, to guide physical archaeological test excavations (terrestrial and maritime) and include the results of these excavations.	Section 7.1.2 and Volume 2 - working papers 1 and 2

7.1.1 Guidelines and methodology

The study area

The study area for the heritage assessment encompasses the project footprint but also includes adjoining sites within the immediate vicinity of the project. In assessing the potential heritage impact of the project, consideration was given to visual and vibration impacts that extend beyond the project footprint and the potential for any physical impacts on adjoining properties as a result of construction activity. The project footprint incorporates the existing Windsor bridge, its abutments and approaches, and areas on the northern and southern sides of the river (including the river banks) that would be disturbed by construction and operation of the project and demolition of the existing bridge. This includes the river channel and the banks of the river where maritime infrastructure is known to have been present.

State and local historic heritage assessment

The historic heritage impact assessment was carried out in accordance with the *NSW Heritage Manual* (Heritage Office and DUAP, 1996).

An integrated program of historical research and site investigation was required to verify and extend the current understanding of the study area's evolution and development through time. The purpose was to create an integrated understanding of the built and archaeological evidence and historical sources, in order to allow the full range of heritage significance to be accurately determined. To achieve this, the assessment included the following key elements:

- Review of existing information, including statutory and non-statutory heritage registers.
- Preparation of a detailed site history based on primary and secondary sources.
- Site surveys.
- Development of an archaeological research design.
- Archaeological test excavation.
- Detailed visual analysis.

- Assessment of cultural heritage significance.
- Preparation of a statement of heritage impact (SoHI) covering all items of heritage significance that have the potential to be impacted by the project (the SoHI is presented in Volume 2 - Working paper 1).

The visual analysis involved assessment of existing historic views and vistas and the potential impacts of the project on these heritage elements.

Existing information sources

Information sources included primary historical documents such as land titles, published works, consultant reports, and reproductions of paintings, etchings, photographs, maps and plans. Current newspaper articles and historical articles were accessed online through the Trove database. Repositories used in preparing this report comprised:

- Mitchell Library of the State Library of NSW.
- State Records Office NSW (Globe Street, The Rocks and Kingswood).
- Hawkesbury Library, Hawkesbury City Council, Local Studies Collection.
- Sydney University Library.
- National Library of Australia.
- NSW Land and Property Information.
- NSW Roads and Maritime Service Archives, including former Maritime NSW records.
- Sydney Water Archives.
- Department of Public Works Annual Reports.
- Private collections.

The following databases and internet sources were also searched:

- Trove, for newspaper articles.
- National Heritage List.
- Commonwealth Heritage List.
- State Heritage Register.
- State Heritage Inventory.
- RMS Section 170 Heritage and Conservation Register (s170 Register).
- Heritage Space for heritage listings including National Trust classifications.
- Australian Heritage Places Inventory.
- Heritage Schedule of the Hawkesbury Local Environmental Plan 2012.

The assessment of the social significance of heritage sites was informed by recent community responses to the project as well as the recognition of the heritage significance of Thompson Square in the 1970s.

Site surveys

The study area was surveyed on two occasions prior to the test excavation (21 December 2011 and 17 February 2012) and once after the test excavation (19 June 2012). Areas accessed during the site surveys were limited to those that were safe and for which owners consent was received. This excluded conducting a search for the "brick drain" mentioned in an 1815 contract for the wharf (see **Section 7.1.3**). The aim of the surveys was to understand the landscape within the study area including fabric, views and vistas. The study area was photographed to compare the current landscape with historical photographs.

Archaeological investigations

The study area contains below-ground Aboriginal and historic archaeological evidence, and further archaeological evidence in the bed of the river. Three specialist archaeological consultants (Kelleher Nightingale, Biosis Research and Cosmos Archaeology) were engaged to carry out the necessary investigations. All had experience in integrating Aboriginal and historic archaeological investigations (see Volume 2 – Working papers 1, 2 and 3). As the boundaries between these archaeological domains are arbitrarily set by legislation the consultants were required to work closely to provide an integrated and comprehensive coverage. This section discusses the historic terrestrial and maritime archaeological investigations. Aboriginal heritage investigations are presented in **Section 7.2**.

Additional support was provided by specialist investigations, including archaeological remote sensing (University of Sydney), geomorphological assessment of soils (Mr Sam Player) and side-scan sonar of the riverbed (RMS Hydrographic Survey Branch).

Archaeological research design

An archaeological research design was prepared in accordance with the DGRs, and was reviewed by the Heritage Branch, Office of Environment and Heritage, and Department of Planning and Infrastructure. The research design is presented in Appendix 2 of the Historic Heritage Assessment and SoHI (Volume 2 – Working paper 1). Aboriginal archaeological investigations and preliminary geotechnical work were also planned at the same time and the research design considered opportunities arising from these investigations.

The purpose of the research design was to provide a clear direction for archaeological investigation, based on a sound understanding of the site's historical development and change through time.

The archaeological investigation was designed to maximise information yield with the smallest possible ground disturbance, in recognition of the potential significance of the resource, and the possibility that project approval may not be granted.Excavation took place on both the north and south side of the river. The size of the trenches varied considerably, the larger test trenches allowing for a clearer exposure of successive fill layers and fragmentary archaeological evidence. Trenching used a combination of hand and machine excavation by a team of experienced archaeologists under the supervision of the Principal Archaeologist.

Ground penetrating radar

During preparation of the research design a remote sensing survey of part of the upper and lower parkland areas of Thompson Square was undertaken by the University of Sydney.

The remote sensing found a possible anomaly representing the former brick barrel drain in the northeastern corner of the park. Alternatively, if this followed natural site drainage it may represent either the original drainage line or disturbed ground and fill resulting from the drain's construction. Some ground disturbance had taken place in the same vicinity with the construction of the Boat Club in the 1950s and its subsequent demolition in the 1960s.

North side of the river

The archaeological research design and initial historical assessment identified the following archaeological potential for the northern side of the river:

- Pre-settlement environment.
- Evidence of first European settlement and modifications made to the environment for clearance and agriculture.
- Farm buildings, farmhouse, fencing from 1794 grant (no site identified by historical research).
- Inn that operated c.1839 – 1880s, including structures, fences, drains, landscape improvements, artefact scatters.
- 20th century turf farming and market gardening.

With the possible exception of the inn, no target location was known for the archaeological remains. Six test pits were therefore co-located with test pits required for geotechnical assessment. The depth, size and location of the geotechnical test pits were considered sufficient to obtain a representative sample of the potential geological and archaeological features of the area.

The test pits were investigated by hand and mechanical excavation under the supervision of the principal archaeologist. Each of the pits measured about 3.0 x 0.5 metres and were excavated to a depth of about 3.0 metres.

The excavations did not reveal any structural remains of buildings, buried surfaces apart from a possible surface in test pit 4 (within the road reserve adjacent to Number 33 Old Wilberforce Road), and evidence of agricultural works such as plough marks or drainage ditches. Artefacts were limited to those of 20th century origin apart from a single earlier brick fragment in test pit 8 (within road reserve of Freemans Reach Road). Test pit 5 (within road reserve of the northern approach road to the existing bridge) revealed poured in situ concrete beams identical to those also seen on the southern side and considered to be part of the 1897 reconfiguration of the approaches to the raised bridge.

Overall the excavations indicated that the northern bank has been heavily affected by flooding, siltation and farming activity. It was concluded that the northern banks would be unlikely to contain useful archaeological evidence, and no further information on the location of specific targets was obtained.

South side of the river

The archaeological research design and initial historical assessment identified the following development stages of the southern side of the river each having archaeological potential:

- The pre-settlement environment.
- Environmental damage and change from first European settlement onwards.
- Clearing and the first buildings (store, guardhouse and wharf) from 1794 to 1795.
- The first wharf of 1795 and a boat slip.
- Tracks and paths, barracks, granaries, government buildings including domestic residences, a lock-up and Thompson's first house and garden that date between 1795 and 1800.
- Additional government buildings including a prison and a possible government wharf and tracks and paths dated between 1800 and 1810. Additional sites of substantial buildings and works are recognised to lie close to but outside the project footprint.
- A wharf, roads, cuttings, a large brick barrel drain and possible secondary drains and large quantities of fill in Thompson Square from the period 1810 to about 1820. The potential for significant archaeological evidence in building allotments on the eastern, western and southern sides of Thompson Square outside the project footprint is also recognised.
- New road surfaces, punt landings, a watch house/punt house on The Terrace from the period of around 1820 to 1840. Evidence of new government buildings on the eastern side of Thompson Square is also recognised but this is outside the project footprint.
- The redevelopment of Thompson Square in the late 19th century including: An extension to Bridge Street on the eastern side of Thompson Square in its southern half from 1855 and in its northern half in 1874, of other road surfaces on the western side of Thompson Square and resurfacing of roads in the centre of Thompson Square, evidence of drains and other services, evidence of filling in the approach to the raised bridge level of 1897, lowering of some areas in Thompson 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.
- Cutting along the western side of Thompson Square for the construction of a new approach to the bridge in 1934.
- Artefact assemblages from all periods and services from the later part of the nineteenth century onwards.

Although Windsor is well-represented pictorially from around 1809, correlating descriptions of buildings with depicted buildings remains problematic. There is no certainty that other buildings known only from documentary records were not located within the project footprint. While Thompson Square forms only a portion of the original Government reserve area, and the project footprint a fraction of that, there remains a high probability that some buildings were situated within the project footprint.

The strategy to investigate the southern bank was therefore not focused on locating buildings from the historical record but to determine whether the maximum depths of ground disturbance or soil removal required for the project would impact on an intact archaeological profile or be confined to depths already disturbed for road works or services. To reliably determine this requires excavation of test pits to a sufficient extent that soils, fills, former surfaces and other archaeological features can be differentiated and understood. The stratigraphic information from the test pits was expected to broadly describe the archaeological resource within Thompson Square, but excavation was required to determine whether these could be dated or ascribed to particular origins or purpose. Lastly, the information potential of individual deposits, and the succession of deposits and activities needed to be understood to determine the impact to archaeological significance.

Two test pits were excavated, test pit 1 in Old Bridge Street, and test pit 2 in the car park adjacent The Terrace. Six test pits for Aboriginal archaeological investigations were also used to provide additional stratigraphic information and to help the understanding of broader landscape changes. Test excavations were carried out using a small excavator and a small team of archaeologists to manually clean surfaces, fragile deposits and features.

Test trench 1 – southern bank

Test trench 1, measuring 3.9 x 4.1 metres was located about half way up Old Bridge Street. The predicted depth of impact in this location from construction is about one metre and this was used as the depth for terminating excavation. The upper surface was the road pavement of Old Bridge Street. This and its associated layers of compacted rubble measured up to 0.5 metres in depth. Below this depth a series of fragmentary deposits including some shallow excavations or depressions were found. Artefact material associated with these deposits included a small number of ceramics.

The excavation identified different phases of site activity from the natural soil profile to the present. At the base of the profile excavated was a sand layer that is typically found on the southern bank and in which other locations has been found to contain Aboriginal artefacts of probably considerable age. There was no original topsoil remaining as it had been removed by later activities, but there may be surviving microbiological evidence, such as pollens, that would provide clues to the pre-European environment.

The sand layer was overlain by a formed surface from the first half of the 19th century. This surface may have been intentionally filled but is more likely to have formed through natural accumulation of soil and artefact material over several decades. The artefacts are typical of domestic occupation – transfer printed pottery and food bone refuse and reflect the period between about 1830 to 1850, possibly earlier. The surface possibly reflects land-forming as early as around 1800, with the artefacts accumulating over perhaps a half century. The loss of surface evidence by later earthworks limits what can be interpreted from this small area.

Three large planting pits were also obvious and suggest deliberate landscaping, with smaller postholes that perhaps were for stakes to support younger trees. These were cut through at the same time, or even before the postholes. There was also a deep set square post hole from the same or earlier period. The artefacts associated with these excavations all date from the early to mid-19th century, indicating an established domestic presence in Thompson Square. The remains could be interpreted in a number of ways:

- They could be part of Andrew Thompson's garden allotment. The timber post might be part of the weatherboard house he lived in or even one of the former log granaries that, in the historical analysis, was discussed as a building adapted for use as a boathouse in the early years of the nineteenth century.
- They could be part of the extended government reserve made after Thompson's leasehold was absorbed into it after his death in 1810 and after it had been landscaped as is evident in several early nineteenth century images.
- They could be part of a garden allotment that was formed to the north of the barracks and stables that occupied the edge of the allotment, recorded as early as 1831.
- The garden was partially destroyed in 1855 by earthworks which probably formalised the extension of Windsor Road (now Bridge Street) from George Street, along the boundary of Thompson Square. It would have connected to the road to the wharf. A contractor was paid £35 for 'cutting, carting and macadamizing' a road to Windsor Wharf. No evidence of this macadam surface survived.

A service trench either associated with or post-dating the 1855 earthworks was covered by a road surface that has been dated to the mid 1880s. In 1885 there were reports that the roads on the eastern side of the Thompson Square were lowered by up to a metre to improve drainage, vehicular and pedestrian access. This work would account for the loss of the tar or bitumen that may have been used to seal the road in 1855 and any later pavement works between that year and 1885. There were few artefacts in this surface and none especially diagnostic but they dated from the later years of the nineteenth century or early years of the twentieth century.

The base of the current formation of Old Bridge Street was the third phase of road building surviving in the test pit. Again, underlying deposits were excavated to provide a level surface to build the new road from crushed sandstone fill overlain with concrete and asphalt.

The archaeological deposit reflects a succession of fills and cuts, all aimed at providing a better grade for roads from the ridge top to the river's edge. The survival of even fragmentary remains of a surface associated with a domestic residence that appears to have extended into the formal boundary of Thompson's Square, perhaps as late as the 1850s, demonstrates the value of the archaeology in this location. If nothing else, it shows that Macquarie's earnest formalising of the townscape had to deal with the realities of occupancy that ignored property boundaries and clearly intruded into public space. Test trench 1 also demonstrated the very fragmented nature of the deposits.

Test trench 2 – southern bank

Test trench 2, measuring 7.5 x 6.0 metres, was located in the car park adjacent to The Terrace. Construction impacts in this location was estimated to extend to a depth of 1.5 metres. As with test trench 1 modern road pavement was the uppermost part of the sequence. Underneath the modern road pavement a succession of compacted fills were found. While test trench 1 revealed the complexity of successive road construction, further down the slope test trench 2 displayed a simpler pattern of filling to produce a level grade near the river.

Only small areas of deposit pre-dating 1897 and the raising of the deck of Windsor bridge were able to be investigated. One deposit contained many rounded pebbles and gravels - the survey for the 1874 bridge construction suggests that such a surface was already present. Another early deposit was probably imported as fill. It was not possible to establish the extent of either of these deposits. They may or may not be representative of the earlier land surfaces but, as is usual in low areas, earlier deposits are capped by imported fill, and there is a higher likelihood that there has been little disturbance to lower, early deposits.

When Windsor bridge was raised by about 2.5 metres in 1897 the existing approach roads also needed to be elevated. Large quantities of fill were imported to raise the road. Into the top of these a series of parallel concrete beams, poured in situ, were revealed. These appear to have been used to stabilise the elevated road and embankment. They are identical to those found on the northern side of the river. They were covered by a smooth deposit of silty soil and then a coarser layer of fill was laid to create a surface to which the new clay and ironstone road servicing the raised bridge would bond.

Aboriginal archaeology test pits – South of the river

The smaller test pits dug to investigate Aboriginal archaeology also usefully revealed post-settlement deposits and indicated how extensive modification of the study area had been.

The southernmost of these pits, in Thompson Square close to George Street, demonstrates that upper land surfaces in and around the excavation has been substantially removed, apparently in the twentieth century. The material in the fill used to level the site included artefacts from as late as the 1950s. The Windsor Town Improvement Society may have initiated some of the work in the 1930s but the later chronological spread suggests that there has been later cutting and filling at the southern end of the reserve. The deposit above the intact dune sand was homogenous and suggests that anything from the nineteenth century or earlier has been removed in this area.

The second Aboriginal archaeology test pit, in the traffic island in Bridge Street, south of test trench 1, also demonstrated extensive cutting and filling during the twentieth century, here more likely from the later part of the century. Nothing from the nineteenth century was found in this pit. The third test pit, near test trench 1, provided more evidence of twentieth century land forming from the later part of the century.

The fourth test pit, located close to the car park, also demonstrated the impact of twentieth century work but there was also evidence of nineteenth century fill and Aboriginal midden material. This midden material was estuarine shells that do not occur in the Hawkesbury. They also may be associated with shell-burning to produce lime, as can be seen in the mortar of some of Windsor's historical buildings. The small sample suggests that fill has been brought from another site and used to reshape the surface of the reserve. The presence of the 1945 coin in the fill gives an approximate mid-twentieth century date for the work. This is consistent with the artefacts found in the other test pits. This soil was relatively free of artefacts except for a very small number of glass sherds. This is more likely to be a nineteenth century level.

In total the evidence from these four small pits indicates that the southern boundary of the study area has been extensively disturbed both within the road and the reserve. It suggests that a substantial program of reshaping the reserve was carried out in about the 1950s and it involved importing fill that contained both nineteenth century European material and Aboriginal midden material. This was used to shape the northern part of the lower reserve. At this time there is no archival evidence to support this conclusion. There is some evidence to suggest that intact nineteenth century levels might survive under this fill. This is consistent deposit found in both the Aboriginal archaeology test pit excavated at the northern end of the reserve and the small extension made to test trench 2.

In summary, test trench 2 and the Aboriginal archaeology test pits confirmed conclusions arising from test trench 1 - that the surface of Thompson Square has continually been modified over time by cutting and removal of deposits, and being reshaped by the addition of fill material. In the earlier period this fill could possibly have come from elsewhere in Thompson Square, but later on there is the appearance of exotic soil and stone, and possibly Aboriginal midden material. The tempo of the change, and its impact increased through time. This has resulted in the creation of a heavily dissected buried landscape. Early deposits will survive in small pockets next to late 20th century deposits. Their survival can be expected but the locations cannot be anticipated without also mapping the extent of major later disturbance.

Response to the research design

The research design set out four key questions that assessed the significance and research potential of archaeological evidence within project's footprint. A program of test excavation was considered an appropriate methodology given the unknown nature of the resource and likely impact of later site activities. The research design was based on a comprehensive historical review and consultation with stakeholder agencies. The evidence acquired from the work is discussed here in relation to those questions.

- **Will the depths of excavation required for the several components of the new bridge impact on levels that encompass intact archaeological resources?**

The construction of the project would impact intact archaeological resources, particularly on the southern side of the river within Thompson Square. At the southern end of Thompson Square the evidence suggests that the 0.5 metre depth of required excavation would only impact levels that have been created in the 20th century (as well as levels of Aboriginal archaeology). However, the overall profile of Thompson Square is that the scope of works in the past cannot be determined from previews afforded by test pits and the potential for significant features and relics here cannot be ruled out. Further the impact of these twentieth century works is likely to have profound implications for interpreting remnant nineteenth or eighteenth century material. The full scope of those later works must be understood to enable the older material to be interpreted particularly with respect to dates.

- **Can the test pits provide a sample that can be used to establish a profile that generally characterises each part of the construction area and, thus, establish what the impacts of the proposed works will be on the integrity and significance of the archaeological resource?**

Overall the test pits suggest that a deeper archaeological profile is likely to exist at the northern end of Thompson Square than at the southern end and that the northern side of the river is unlikely to have a complex profile. However, the excavations have also demonstrated that the processes of flooding, erosion and European land-forming are largely undocumented and unpredictable. The test pits have demonstrated that the depths of excavation required for the construction of the project would impact archaeological evidence of varying types along the full length of works.

- **Will the profiles provide sufficient evidence to establish dates or specific associations for archaeological evidence revealed in them?**

It is possible to establish some dates or general parameters for when most of the features found in the excavations have been created but undertaking larger excavations to establish the extent of features and their relationship could establish a better dating profile. At this time the evidence recovered from the trenches and pits encompasses a chronological span from about 1800 to about the 1970s.

- **Is it possible to determine whether the impacts of land forming and the provision of infrastructure have combined to effectively remove a substantial and significant archaeological resource?**

At the southern end of the project footprint the developed profile does appear at least in part to have been substantially damaged and this might also be true to some extent in the reserves although the processes that have removed earlier twentieth and nineteenth century levels here are part of the development history of Thompson Square.

The principal outcome of the investigation is that archaeological evidence will survive at least in some areas to around 1800, possibly earlier. Both nineteenth and twentieth century works have removed some of this very early profile but the extent of that removal is impossible to predict.

On the northern river bank there is likely to be a less complex profile but it appears to be more intact as it has not been disturbed by recent developments. Both here and within Thompson Square the processes themselves have value in describing how those places have evolved in response to their respective historical uses. Understanding the scope of the processes of change is also critical to interpreting the elements that remain in the square with respect to what they were, when they were made and how they relate to each other. Archaeological resources potentially exist beneath all areas of the project footprint.

Visual analysis

The visual setting of a place is a key component of its cultural heritage significance. How significant items are viewed and how they visually relate to each other and the surrounding landscape is crucial to cultural significance and sense of place.

A detailed visual analysis of historic views and vistas in the study area was carried out as part of the SoHI (refer to Appendix 1 of the SoHI in Volume 2 - Working paper 1). This assessment was aimed at identifying and determining the potential for impacts on existing historic views and vistas. Additional visual impact assessment, addressing the broader aspects of the visual impacts of the project, was undertaken as part of the Urban design and landscape working paper (see Volume 3 - Working paper 5).

To understand the culturally significant visual setting of the study area, the analysis involved two key steps: a search of publicly accessible archives for historical images (pictorial and photographic) of which fifty seven representative images dating from as early as 1809 through to 1959 were selected for the analysis and are presented in Appendix 1 of the SoHI; as part of the site surveys, specific attention was given to current views and vistas within the study area.

The review of historical images identified recurring vistas that were preferred by artists over a long period. These were from north of the river, facing back towards Windsor approximately along the central axis of Thompson Square. This provides a well-framed composition that features the river, usually with a few small vessels, the central square, and the densely built up ridge of Windsor. From 1874, the Windsor bridge frames the river, and after that Thompson Square begins to appear less barren. The 'classic' view of Windsor contains the river, developed Windsor, Thompson Square and the bridge as a compositional group that evolves, but remains preferred for its scenic qualities.

Assessment of cultural heritage significance

Assessing the significance of heritage items provides an informed basis for which decisions on heritage management and development impacts can be made. In NSW, heritage assessment criteria are based on the significance values outlined in the Australia International Council on Monuments and Sites (ICOMOS) *The Burra Charter* (see **Table 7-2**) and built upon by the NSW Heritage Council criteria for grading of significance (see **Table 7-2**). This approach to heritage assessment has been adopted by cultural heritage managers and government agencies as the basis for best practice heritage management in Australia.

An item or place can be considered to be of local or state significance if it meets one of the assessment criteria identified in **Table 7-2**. The grading criteria identified in **Table 7-3** help to identify what it is about an item or place that makes it significant, as well as which aspects of an item or place reduce its significance.

Once an item has been assessed against the criteria, a statement of heritage significance (statement of significance) is prepared. The statement of significance is a researched and ordered text that succinctly presents the significant attributes of an item and it forms the basis of management strategies for the item.

The data sheets (Volume 2 - Working paper 1) contain detailed assessments of significance, and apply the assessment criteria and grading of significance.

Table 7-2 NSW heritage assessment criteria (Burra Charter)

Criterion	Description	Guidelines for inclusion
A	An item is important in the course, or pattern, of NSW's cultural or natural history (or at a local level)	Shows evidence of a significant human activity Is associated with a significant activity or historical phase Maintains or shows the continuity of a historical process or activity
B	An item has strong or special association with the life or works of a person, or group of persons, of importance in NSW's cultural or natural history (or at a local level)	Shows evidence of a significant human occupation Is associated with a significant event, person, or group of persons
C	An item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or at a local level)	Shows or is associated with, creative or technical innovation or achievement Is the inspiration for a creative or technical innovation or achievement Is aesthetically distinctive Has landmark qualities Exemplifies a particular taste, style or technology
D	An item has strong or special association with a particular community or cultural group in NSW for social, cultural or spiritual reasons (or at a local level)	Is important for its associations with an identifiable group Is important to a community's sense of place
E	An item has the potential to yield information that will contribute to an understanding of NSW's cultural and natural history (or at a local level)	Has the potential to yield new or further substantial scientific and/or archaeological information Is an important benchmark or reference site or type Provides evidence of past human cultures that is unavailable elsewhere
F	An item possesses uncommon, rare or endangered aspects of NSW's cultural or natural history (or at a local level)	Provides evidence of a defunct custom, way of life or process Demonstrates a process, custom or other human activity that is in danger of being lost Shows unusually accurate evidence of a significant human activity Is the only example of its type Demonstrates designs or techniques of exceptional interest Shows rare evidence of a significant human activity or important to a community
G	An item is important in demonstrating the principal characteristics of a class of NSW's cultural or natural places; or cultural or natural environments (or at a local level)	Is a fine example of its type Has the principal characteristics of an important class or group of items Has attributes typical of a particular way of life, philosophy, custom, significant process, design, technique or activity Is a significant variation to a class of items Is part of a group which collectively illustrates a representative type Is outstanding because of its setting, condition or size Is outstanding because of its integrity or the esteem in which it is held.

Table 7-3 Grading of significance (NSW Heritage Council)

Grading	Justification	Status
Exceptional	Rare or outstanding element directly contributing to an item's local and State significance.	Fulfils criteria for local or state listing
High	High degree of original fabric. Demonstrates a key element of the item's significance. Alterations do not detract from the significance.	Fulfils criteria for local or state listing
Moderate	Altered or modified elements. Elements with little heritage value, but which contribute to the overall significance of the item.	Fulfils criteria for local or state listing
Little	Alterations may detract from the overall significance but its role, function, design or fabric can still be interpreted.	Does not fulfil criteria for local or state listing
Intrusive / Nil	Damaging to the item's heritage significance. Difficult to interpret.	Does not fulfil criteria for local or state listing

Source: Assessing Heritage Significance, NSW Heritage Office 2001.

Assessment of social significance

Social significance refers to the importance of a place to a community for social, cultural or spiritual reasons. This value can be difficult to assess, especially in the context of a proposed development that is potentially unpopular with a particular part of the community. Assessment of social significance relies on people expressing their views about what a place means to them. The assessment of the social significance in this EIS has been made in consideration of community responses to and submissions on the project.

Maritime archaeological assessment

The maritime archaeological assessment for this EIS was based on a previous maritime archaeological survey undertaken as part of preliminary investigation works for the project in 2008, and follow-up investigations undertaken in 2012. The maritime archaeological survey involved underwater and above water site inspections of two locations:

- The location of the old wharf that was built around 1815 on the southern bank of the river, to the east of the current Windsor bridge.
- The location of punt operations, including the punt landing point on the northern bank of the river.

For the underwater survey of the old wharf site, a series of transects were established in the general area of the former wharf to investigate if relics relating to the former wharf were present, or had the potential to be present on the riverbed. The search for the possible remains of the punt ramps and associated features was confined to the northern bank. No search was conducted on the southern bank as the river bed has been reclaimed and any remains of the punt ramp may be buried under the fill and the recently laid gabion walls.

The assessment undertaken in 2012 involved:

- Review of relevant statutory and non-statutory heritage registers.
- Review of all relevant maritime and historical archaeological and built heritage assessments that have been undertaken in the study area.
- Review of the results of a side scan sonar survey of the river undertaken by RMS in June 2012.
- Review of geotechnical data collected from the river channel during design investigations for the project in 2008 and 2012.
- Assessment of the potential for maritime archaeological remains to be present within the project footprint.
- A significance assessment for all known and potential archaeological remains within the maritime archaeological boundary of the study area.
- Assessment of the potential impacts of the project on maritime archaeology.
- Preparation of a maritime archaeological SoHI covering all items of maritime archaeological significance that have the potential to be impacted by the project.

The side scan sonar survey looked at a transect of the river within and immediately adjacent to the existing bridge and new bridge sites, with images of the riverbed collected using a mounted sonar unit attached to the rear of a survey vessel.

The maritime archaeological SoHI is included in Volume 2 - working paper 2. The SoHI was prepared in accordance with NSW Heritage Office guidelines and includes recommendations aimed at avoiding, minimising and mitigation impacts on maritime heritage.

7.1.2 Existing environment

This section outlines the history of the study area since European settlement and identifies items of heritage significance.

Historical context - development of Windsor

Windsor is one of the oldest towns in Australia as well as being one of the 'Macquarie towns'[1]. It has evolved through several periods of economic and social change, and has developed a high public profile as a historic place.

History of European settlement

European settlement of the place now known as Windsor dates to soon after the arrival of the First Fleet and the establishment of Sydney in 1780s and was driven by the need to produce more food for the growing colony in Sydney (Karskens, 2009). The first land grants in the area were issued in 1794 by Lieutenant Governor Grose, resulting in the establishment of 22 farms located primarily on the southern bank of the Hawkesbury River and the eastern bank of South Creek close to the Hawkesbury River confluence. Between April 1794 and the beginning of 1795, another 96 grants were made or promised, bringing a total of 118 promised grants in the first year of European settlement (Barkley-Jack, 2012). The first settlers called the place Green Hills, although Governor Grose called it Mulgrave Place. In 1801, five years after the allocation of the first land grants, over 600 people were living in the area.

The initial character of the settlement was influenced by its distance from Sydney and settlement incentives provided by the Governor. To encourage more settlement, Governor Grose offered convicts a reduction in their sentences if they took up farming in the district. Many of the new settlers were therefore ex-convicts, in addition to poor free settlers and soldiers (Karskens, 2009). Recent research has shown that the population in the first few years of settlement was 95 per cent ex-convict (Barkley-Jack, 2012). Changes to the settlement mix began to occur with the construction of a new track from Parramatta, which reduced the travel time between Sydney and the settlement from two days to eight hours (Karskens, 2009). River traffic also increased with the local construction of ships.

Settlement on the northern bank of the river commenced in the early 1790s with farms dispersed over a wide area. Much of the landscape was devoted to pastures or crop fields, with houses and out-buildings providing a focus for each farm.

Genesis of Thompson Square

The initial character of Green Hills was more of a series of individual farms rather than a settlement with a focus. The first reliable plan of Green Hills, produced during the first year of settlement in 1794, did not extend as far east as the present day area of Thompson Square, inferring that this area had not yet been developed at this time.

In 1795, military officers came to the Hawkesbury to select land to farm. The character and purpose of the settlement changed significantly in the same year with the establishment of a wharf, store and small military garrison on the south side of the river to the west of the previously established area of Green Hills (Barkley-Jack, 2012). This establishment was the genesis of Thompson Square and the town of Windsor.

[1] In November, 1810, Governor Macquarie set out to inspect the outer western Sydney districts, following the Hawkesbury and Nepean Rivers. Macquarie surveyed the available land and designated and named five settlements that would subsequently become known as the 'Macquarie Towns' – Windsor, Richmond, Castlereagh, Pitt Town and Wilberforce.

From 1795, the area associated with the wharf, store and military garrison became the focal point for the development of a government precinct, including almost all of the principal government buildings of the settlement. The government precinct that developed during this time was much larger than the present area of Thompson Square, extending east to Catherine Street, west to Baker Street and south to South Creek (Barkley-Jack, 2012).

In 1799, Andrew Thompson (for whom Thompson Square would later be named)[2] was given one acre of land on a government reserve overlooking the river (LPI, Register of Grants Series 2). This lease bordered the eastern side of the area now known as Thompson Square and the conditions of the lease indicate that this area was already reserved for government purposes at this time. The position of his grant was described as bounded on the north by the Hawkesbury River and on all sides by ground reserved for the use of the Crown.

By the early 1800s, Thompson had acquired a farm on South Creek outside the main precinct. This became his principal home at Windsor and his lease on the square became the focus of his commercial activities, including the establishment of stores and workshops. With the river providing a direct link to Sydney, the area became a focus of commercial activity. A painting from 1809 shows clusters of buildings on the eastern and western sides of an area of open space, with a road running through the open space to what is likely to be the location of the first wharf (see **Figure 7-1**). Two of the buidlings in the painting are likely to be Thompson's stores (see **Figure 7-2**).

Figure 7-1 Detail from George William Evans' 1809 watercolour showing a boat in front of what is likely to be the wharf and its associated access track (circle shows approximate location of Thompson Square)

Source: George William Evans 1809 "Watercolour Windsor" ML PXD 388 V3 Folio 7

[2] Andrew Thompson was and is a legendary figure in the development of the Hawkesbury. An ex-convict he was widely acknowledged as a good and honest man who rose to be the colony's first ex-convict magistrate. He was a personal friend of Governor Macquarie and much valued by him. For further information on Thompson see Australian Dictionary of Biography, Vol. 2.

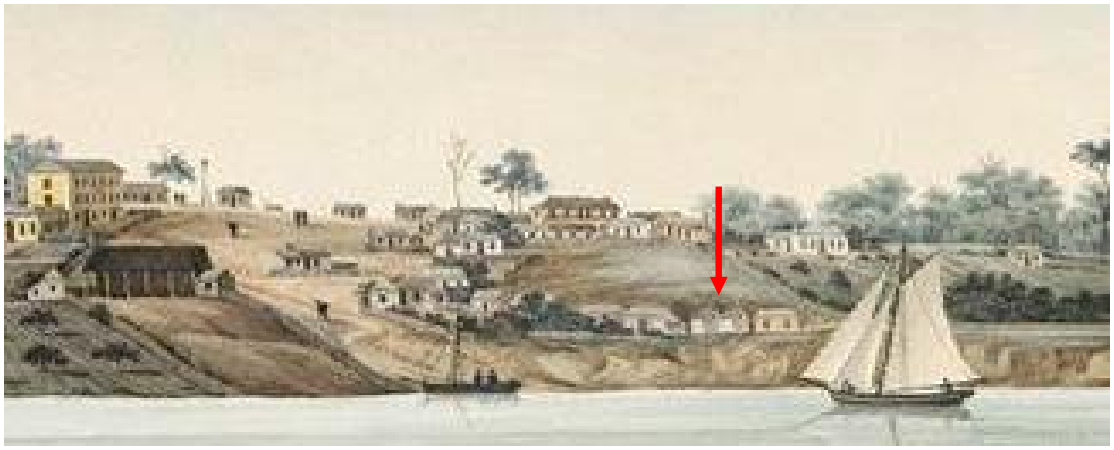

Figure 7-2 Detail from George William Evans' 1809 watercolour showing what are likely to be two of the store buildings (indicated by red arrow)

Source: George William Evans 1809 "Watercolour Windsor" ML PXD 388 V3 Folio 7

The founding of Windsor

In the early 1800s, Governor Macquarie selected five sites in the Hawkesbury–Nepean district for the creation of new towns to provide accommodation and services for settlers. In 1810, with its small government precinct and commercial area already established, the settlement of Green Hills was one of the five sites selected for a new town (Lachlan Macquarie: Tours of NSW and VDL 1810-1822: 6 December 1810 31). The completed plan for the new town, to be named Windsor, was signed by the governor in 1812. The plan involved integrating the new town with the already established government precinct and commercial area of Green Hills.

Each of the Macquarie towns were planned so as to include a large town square. For Windsor, the planned site of the large town square was the present site of McQuade Park. Given, however, that Green Hills already had an open space that functioned as a town square (being the open area between the government buildings and the river), Macquarie incorporated this area as a second town square into the town plan for Windsor. This second town square was named by Governor Macquarie as Thompson Square, in honour of the memory of Andrew Thompson (Lachlan Macquarie: Tour of NSW and VDL 1810-1822: 12 January 1811: 42-43).

Changes to Thompson Square and Windsor during the 1800s

Between 1812 and 1813, the newly founded Thompson Square was physically changed so that it conformed more to the standard ideal of a town square (see **Figure 7-3** and **Figure 7-4**). This included removing large numbers of buildings, leaving essentially only the most substantial buildings from the previous years of settlement, namely the stores, Government House, Thompson's store, Thompson's first small cottage, and the military barracks. New buildings were also constructed and old buildings renovated or adapted for new purposes (HRA Series 1 Volume 10; 690-1).

Around 1814, a new wharf was constructed at the northern end of Thompson Square to the east of the existing bridge, and a new ferry was introduced to provide a regular means of transport across the river (HRA Series 1 Volume 10; 690-1). In 1832, the privately operated ferry service was taken over by the Government and replaced by a cable punt located on the far western side of the square. With the wharf and the punt at the bottom of Thompson Square, the place became a focus of activity.

Up until the 1830s, Thompson Square retained a strong link with its genesis as a civic precinct, with the entire eastern side devoted to official purposes. In the 1830s, Thompson Square began to develop as a focal point for the local community and also became the site of a weekly market (The Australian, 7 December 1832). In the second half of the nineteenth century, the area of Thompson Square evolved into a residential and commercial precinct with the Macquarie Arms Hotel on one corner and houses of varying types along the western and eastern sides.

From the 1880s, however, the river began to silt up making navigation more difficult and shipping activity in Windsor gradually declined (Rosen, 1995). The demise of river trade resulted in a slowing of growth in the region and the population of Windsor began to decline. The Hawkesbury region and the regional centre of Windsor remained important, however, for agricultural production and the supply of food to Sydney, with the importance of this role confirmed by the opening of a railway in 1864. Nevertheless, as the river became more difficult to navigate and the railway gained in importance, Windsor went from being a rural settlement with autonomy to being dependent on its relationship with Sydney, and gradually lost its role as a port and market centre.

Figure 7-3 Historical overlay of Windsor (Meehan 1812)

Figure 7-4 Historical overlay of Windsor (Abbot 1831)

Construction of the bridge and southern approach road

Between 1815 and 1874, the only way to cross the river from Windsor was by boat, with a ferry service operating from 1815 and a punt service operating from 1832. This changed dramatically in 1874 with the opening of a new bridge at the foot of Thompson Square.

The opening of the new bridge required changes to be made to the southern and northern approaches. The outcome of this work, apart from the road access, was the delineation of two reserves in the middle of Thompson Square that were later further defined by the same post and rail fencing that was used around the roads and on the bridge.

The bridge constructed in 1874 was a low level bridge and was frequently inundated by flood waters. In response to community demand, substantial construction works were undertaken to raise the bridge by eight feet (about 2.4 metres), with works commencing in 1896 (Windsor and Richmond Gazette, 26 September 1896). A temporary bridge was built to provide a river crossing while works on the main bridge were completed. The temporary bridge was located close to and upstream of the existing bridge and was in operation during October 1896 to March 1897. During the bridge work, Thompson Square was used as a temporary storage and work area.

The new high level bridge was completed in six weeks and opened in April 1897 (Windsor and Richmond Gazette, 3 April 1897). The approach road on the southern side of the river in Thompson Square needed to be raised to accommodate the new height of the bridge. These works continued well after the bridge was completed.

The 1900s saw the introduction of motor vehicles and many associated changes to roads, including further upgrades to the bridge. In 1921, the then wooden superstructure was replaced by reinforced concrete and the cross bracing was renewed in 1941. In 1934, a new southern approach road to the bridge was cut through Thompson Square to meet the requirements of motor traffic. Further road works in the 1940s and 1950s resulted in the present southern bridge approach arrangement.

The wharf that serviced the ferry crossing appears to have been demolished or fell into ruin in the 1940s or early 1950s. It is no longer visible in aerial images of 1955. Remnants of this structure can still be seen from the bridge. The punt was removed following initial construction of the bridge in 1874 and the old punt house was demolished in around 1904.

Changes to topography and landscape

An understanding of topography and landscape is critical to cultural heritage assessment. Landform influences land use and development patterns, which in turn are influenced by the culture and values of people at that time. Changes made to the topography and landscape over time also determine the preservation of older features and archaeological deposits.

Previous archaeological investigations have revealed that Windsor and Thompson Square are underlain by a remnant ancient sand dune, created over 10,000 years ago at the end of last Ice Age (Austral Archaeology, 2009). The soil profile that overlies this sand dune is characterised by deep clays developed from the Wianamatta Group, Bringelly and Ashfield shales (Benson and Howell, 1995). Deep deposits of alluvial material (sediments, sands and gravel) occur close to the river, deposited over millennia and frequently added to by floods. These alluvial soils are highly fertile, which was a major driver for the early European settlement and agricultural development of the area.

The area of Thompson Square has undergone gradual topographic changes since European settlement. Early images of the area show a ridgeline high above the river with a steep and uneven descent to the waterline. By around 1807, the majority of land in the area of Thompson Square had been cleared and tracks had been formed down the slope and across the contours. A drawing made in 1813 shows a narrow sandy beach at the base of the slope, a feature that may have been instrumental in the choice of this particular site for settlement.

Early descriptions of the area indicate that it was once covered in a variety of vegetation, including areas of open woodland and forest, with denser vegetation along the levee banks of the river (Benson and Howell, 1995). Before the arrival of Europeans, the area now known as Thompson Square is likely to have been characterised by dense tree-cover. This vegetation was removed very soon after the arrival of Europeans in the 1790s to make way for buildings and allotments and to be used in construction.

Influence of the river and flooding

The Hawkesbury River, while providing the fertile soils and boat access to Sydney that were instrumental in the early European settlement of the area, also shaped the region through its history of frequent floods. Floods influenced where and how European people settled, as well as the scale of development. By 1810, many of the original settlers had lost crops, homes and family members to floods, and consequently gave up their land grants. This meant that those willing to take risks and stay in the area could amalgamate several land grants.

Floods have been recorded since the first days of European settlement, with 41 major floods recorded between 1799 and 1965. Thompson Square was regularly flooded and there are marks on buildings recording the peak water levels. The highest flood on record occurred in 1867 when water reached over fifteen metres above the decking of the current bridge and only parts of the town remained above flood waters.

Flood events have been accompanied by river bank and floodplain erosion, with erosion problems made worse by the practice of widespread land clearing by the early European settlers. Widespread clearing for agriculture led to the loss of fields and property, while clearing along the river bank for boat access and wharf construction led to bank destabilization and collapse.

Flood damage and bank erosion issues continue to be a feature of the area today. On the southern side of the river close to the current wharf site, stone-filled gabions were used to stabilize the banks and the approaches to the southern side of the bridge after the 1990 flood. The flood of 1992 caused a severe landslip on the banks of the river at the northern approach to the bridge, resulting in the need for shoring of the bridge pylons and reinforcement of the river banks.

Interaction with Aboriginal people

Before European settlement, the Hawkesbury region was home to a large Aboriginal population, supported by the river and the surrounding fertile land. There were two main Aboriginal language groups associated with the Hawkesbury: the Dharug and the Guringai. Evidence provided by rock carvings, paintings and archaeological sites indicates that Aboriginal people have been in the area for more than 13,000 years. The Burraberongal[3] are the named group most closely associated with Windsor and Richmond in the period of early settlement.

Contact was made between Europeans and Aboriginal people during the initial exploration of the area by Governor Philip in 1791 and continued in the following years. Conflict with the new settlers in 1794 was gradual but intensified as the spread of settlement denied Aboriginal people access to resources and their spiritual areas. From 1796, troops were stationed in the area to provide protection for white settlers and to disperse and drive away the traditional owners. Just twenty years of European settlement saw the Aboriginal population substantially reduced as Aboriginal people left the area or were killed by disease or violent conflicts with Europeans (Dharug and Lower Hawkesbury Historical Society, 1987).

[3] Also spelled Boorooberongal and other variations.

In 1889, an Aboriginal Reserve was established nearby at Sackville North, although the last of the remaining residents of this reserve are reported to have moved to La Perouse in the early years of the twentieth century (Barkley, 1994). In more recent times, the land on the northern side of the river within the project footprint was acquired by the Aboriginal Development Commission for use as a training farm in 1983 and it remained as such until it was sold in 1991 (LPI, CT Volume 3512 Folio 239). Aboriginal cultural heritage and archaeological resources are discussed in detail in **Section 7-2** and Aboriginal working paper (Volume 2 working paper 3) of this EIS.

Existing historical heritage landscape

The Thompson Square Conservation Area today represents a palimpsest of the past, starting with the first inhabitants that lived on and from the land there. The square retains archaeological evidence of pre-colonial use in the form of Aboriginal artefacts, as well as visible and archaeological evidence of early colonial life. A setting such as this is rare in an increasingly urbanised environment where constant changes are made to commercial and residential precincts. Rarer still, is the survival of such an early and legible historic landscape within the confines of the greater Sydney region.

Built environment

The earliest surviving visible evidence of the settlement of Green Hills is in the location of the historic ferry wharf site and the Macquarie Arms Hotel. Remnants of one of the early timber wharfs are still also visible in the river bank on The Terrace.

The majority of the buildings overlooking the river that survived Macquarie's formalising of the Windsor town plan were demolished to make way for new buildings in the 1840s and 1860s. The Doctors House at 1-3 Thompson Square was built in 1844 and sits on the site of an earlier inn (see **Figure 7-5**). This is one of the landmark features within Thompson Square and (as with all other historical buildings within Thompson Square) is currently in use. Adjacent to the Doctors House is an early Victorian cottage, which in turn neighbours what is now the Hawkesbury Museum, built during the 1830s. Adjacent to the Museum, on the corner of Thompson Square and George Street, is the Macquarie Arms Hotel, which is also a major landmark feature.

The south side of George Street overlooking Thompson Square is lined with buildings of various dates and 19th century architectural styles, ranging from the early Victorian era (62 George Street) to the early Inter-War period (Hawkesbury Garage). All of the buildings facing Thompson Square from George Street have been upgraded and are used as commercial premises.

Facing Thompson Square from Old Bridge Street is a row of buildings that also represent the different architectural and historical phases of the place. The former School of Arts building at 14 Bridge Street, built in 1861, is on the site of one of the old government storehouses. This building is slightly slanted toward the square and is visible from all angles at the top part of the square, except where the view is blocked by trees.

Across the road at 10 Old Bridge Street is a good example of a two-storey Regency (c. 1856) building, which is now a music shop (downstairs) and residential premises (upstairs) and has been variously used in the past as a house, a school and a maternity hospital.

Next door at 6 Old Bridge Street is an 1860s house with stables (currently used as a solicitor's office).

Next to it down the hill towards the river is 4 Old Bridge Street, built in the 1950s. Number 4 Old Bridge Street is a mid-century vernacular house built on brick piers and with verandas on two sides. It is included in the Thompson Square Conservation Area because it is almost certainly built over Andrew Thompson's buildings and garden, which were incorporated into the government domain (as are numbers 6 and 10).

The fabric within the built environment that surrounds Thompson Square includes sandstock brick walls, sandstone, machined brick, stucco render on brick and timber slab outbuildings. The open space or reserve area of Thompson Square is framed on three sides by one and two-storey buildings, the earliest being officially opened in 1815 and the latest, an anomaly in the group, being built in the 1950s. All buildings are occupied and kept in good repair. On the river side (northern side) of the square, the existing Windsor bridge connects and integrates with the open space area and the still rural landscape to the north. From the north side of the river, Windsor bridge frames Thompson Square and connects it to the north bank.

Open space

The open space area of Thompson Square comprises two small parkland areas (the upper and lower parkland areas), Old Bridge Street and the 1930s alignment of Bridge Street. This area has been part of an open public space since the town's beginnings.

The open space area has been subject to numerous changes over the last 218 years, which have been recorded both visually and in documentation. These changes include extensive clearing of land during the early settlement period, development of a road leading down to the wharf, construction of brick drain through the square, and development of the bridge and southern bridge approach road (including the original construction in 1874 and subsequent upgrades).

Over time the nature of Thompson Square has changed from a very open and informal space, to a heavily vegetated one with clearly defined boundaries and levels. This change began in the 1880s when the parkland areas within Thompson Square were fenced and ornamental plantings were undertaken (see **Figure 7-6**). By the 1940s, the density of plantings, some of which appear to be self-seeded, had assumed an appearance not dissimilar to that present today, but contrasting considerably with the earlier images of Thompson Square from before the 1880s.

Thompson Square has been divided into upper and lower parkland areas since its early development, separated by a diagonal roadway to create an easier grade. A road generally down the alignment of Old Bridge Street is visible in historical drawings and photographs dating back to the early 1800s. Today, the upper and lower parkland areas are separated by Bridge Street, which provides the southern approach to the existing bridge.

Garden
Stables
Court House
Police Magistrate
Residence of the
Gaol
Barracks
Church
Pound
Inn
Inn
Inn

The greatest impact on the public open space area of Thompson Square to date has been the construction of the 1934 Bridge Street cutting, which is a visually intrusive addition to the landscape and almost certainly destroyed earlier archaeological evidence, such as sections of the brick drain that once ran through Thompson Square (see **Figure 7-7**). Not only did the 1934 road isolate (rather than just demarcate) the lower portion of the parkland from the upper parkland, further park landscaping obscured the earlier road that ran from George Street down to the wharf and bridge. The lower reserve is currently isolated from the commercial centre of Windsor by the busy bridge approach road and is consequently difficult to access. Additionally, the large number of trees within the parkland areas, and the proliferation of introduced vegetation on both banks of the river, obscure views to and from Thompson Square and disconnect the many historical elements of the area.

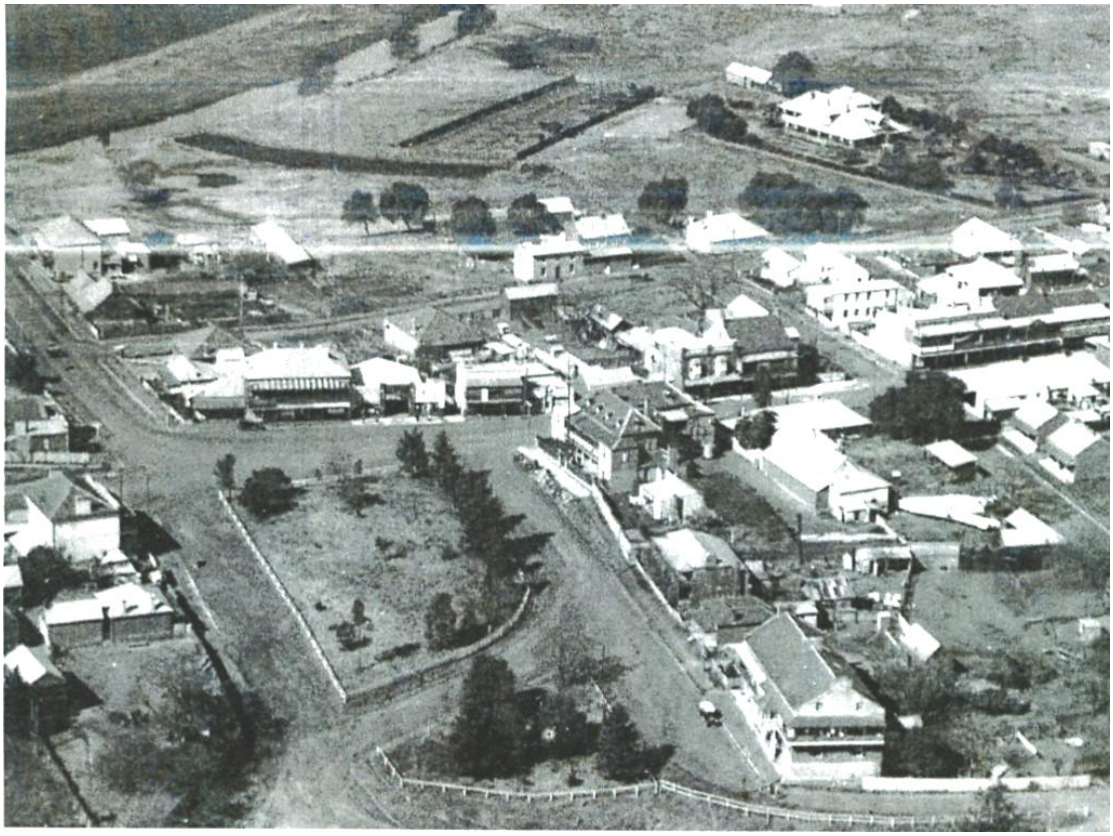

Figure 7-7 Thompson Square in 1929 before the final changes were made to the roads (JHHS 2011 No 2: 21).

Visual setting

The earliest images of Windsor identified in this assessment are illustrations dating from 1809 to 1813. More than half of the historic images of the study area are views from the north side of the river towards Windsor, usually centred on Thompson Square. By comparison, just over one third of images look in the opposite direction from the south side of the river. Views from the north side of the river towards Windsor, and the area around Thompson Square in particular, have been highly valued over time. As an important public space within the town, and as a thoroughfare and meeting point for road and river traffic, images of Thompson Square and the area around it have been repeatedly used over time to represent the town of Windsor. This provides a well-framed composition that features the river, usually with a few small vessels, the central square, and the densely built upon ridge of Windsor.

It is also evident from the number of images that the bridge became a key landmark once it was built in 1874. The bridge features prominently in over two thirds of the images as the central subject. The landmark quality of the bridge would appear to derive from both its picturesque nature, which is partly owed to its location, as well as its importance as a connector between Windsor and the west. The 'classic' view of Windsor contains the river, developed Windsor, Thompson Square and the bridge as a compositional group that evolves, but remains preferred for its scenic qualities.

Current views and vistas

Analysis of historic images shows that the amount of vegetation within Thompson Square and along the adjacent river banks has gradually increased since it was first cleared during the early period of European settlement. What was once an open clear area now contains substantial trees and vegetation that screen the buildings on each side of the square. As a result, opportunities that once existed for views to and from Thompson Square are now inhibited. The greatest impact of vegetation on views is on the northern bank of the river where dense weed growth now restricts views towards Windsor and limits access to the foreshore.

Within Thompson Square there are limited views through gaps in the trees towards the bridge, the river and beyond. The points which provide the most open and panoramic views are from the high terrace in front of the Doctors House overlooking the river, and from the ridgeline looking down the corridor of Old Bridge Street towards the river. Whereas the terrace in front of the Doctors House is easily accessible, the views down Old Bridge Street are mostly from within the road corridor, which is not easily accessible due to the roadway and the very poor pedestrian environment in this part of Thompson Square.

The other key views within Thompson Square are from within or from the edges of the Square towards the buildings on each side. The plantings within the square restrict these views to some degree. Additionally, the roadway cutting through the middle of the square and the poor pedestrian access from one side of the square alters the nature of views from the square to the surrounding buildings and the way in which these views are experienced. Specifically, the poor pedestrian access restricts the opportunity to experience dynamic and changing views while moving across the square (as opposed to static views from traffic free vantage points).

Significant views through time

Some views to and from Thompson Square have remained constant through time. Views back to Thompson Square from Freemans Reach and across from the Doctors House are still possible, with few obvious changes to the landscape. The extent of views has, however, decreased as a result of the increase in plantings within Thompson Square and along the river banks.

One element that has remained visually prominent since it was constructed in the 1840s is the Doctors House. Whereas views to and from other significant buildings that frame Thompson Square (such as the Macquarie Arms Hotel and the Hawkesbury Museum) have progressively become obscured by vegetation, the Doctors House has remained a key visual feature due to both its scale and prominent position. The Doctors House is often framed in views and images of the existing bridge.

The existing bridge has also played a prominent role in visual images of Windsor since its construction. Being in a prominent location in a particularly sensitive historic precinct, and being the earliest bridge crossing of the Hawkesbury River, the existing bridge has become an important part of Windsor's visual identity.

Listed heritage items and conservation areas

Many items of historical heritage within and adjacent to the project study area are listed on statutory and non-statutory heritage registers in recognition of their significance. Details of these listings are provided below and summarised in **Table 7-4**. For the purposes of this report, individual properties have been allocated a site number and a site name, with the site names being generally consistent with names used in the relevant heritage listings. Many items, including the properties within and adjacent to Thompson Square, are subject to multiple heritage listings.

Also identified in **Table 7-4** is the heritage significance of each item based on previous assessments and statements of significance. Further detail on heritage significance is provided in **Section 7.1.4** for items that would be impacted by the project. The heritage items identified in **Table 7-4** are presented in **Figure 7-8** (by ID number).

Table 7-4 Heritage items subject to statutory and non-statutory heritage listings

Site no.	Name	Address/ description	Individual item listing	Conservation area listing
SHR = State Heritage Register; LEP = Hawkesbury LEP 2012; NT = National Trust; RNE = Register of the National Estate.				
001	Thompson Square – Roads	Parts of Thompson Square, Bridge Street, Old Bridge Street, The Terrace and George Street.	LEP Part of I00126 RNE 3177	SHR #00126 (excluding cutting through Thompson Square) LEP C4 NT S10510
002	Thompson Square – Upper Parkland	Thompson Square, Lot 7007 DP 1029964.	LEP Part of I00126 NT S11456 and RNE 3167	SHR #00126 LEP C4 NT S11456 (reserves) and S10510 (precinct) under “Portion of land known as Thompson Square”
003	Thompson Square – Lower Parkland	1 Bridge Road, Lot 345 DP 752061. Also addressed as 3 Old Bridge Road and Thompson Square.	LEP Part of I00126 NT S11456) and RNE 3167	SHR #00126 LEP C4 NT S10510 under “Portion of land known as Thompson Square”
004	The Doctors House	1-3 Thompson Square; Lot B, DP 161643 and Lot 1, DP 196531	LEP Part of I00126 NT S11446 and RNE 3168	SHR #00126 LEP C4 NT S10510 – Thompson Square Precinct
005	House and Outbuilding at 5 Thompson Square	No. 5 Thompson Square; Lot 1, DP 7450356	SHR #00005 LEP Part of I00126 NT S11447 and RNE 3169	LEP C4 NT S10510 – Thompson Square Precinct
006	Hawkesbury Museum and Tourist Information Centre	No. 7 Thompson Square; Lot 1, DP 60716	LEP Part of I00126 NT S11448 and RNE 3170	SHR #00126 LEP C4 NT S10510 – Thompson Square Precinct

Site no.	Name	Address/ description	Individual item listing	Conservation area listing
SHR = State Heritage Register; LEP = Hawkesbury LEP 2012; NT = National Trust; RNE = Register of the National Estate.				
007	Macquarie Arms Hotel	81 George Street (also addressed as Thompson Square); Lot 1, DP 864088;	SHR #00041 LEP Part of I00126 NT S10510 and RNE 3171	LEP C4 NT S10510 – Thompson Square Precinct
008	House	No. 4 Bridge Street; Lot 10, DP 666894	LEP Part of I00126 NT S11455 and RNE 3166	SHR #00126 LEP C4 NT S10510 – Thompson Square Precinct
009	House	No. 6 Bridge (also addressed as No. 8 Bridge Street); Lot 1, DP 995391	LEP Part of I00126 NT S11451 and RNE 3173	SHR #00126 LEP C4 NT S10510 – Thompson Square Precinct
010	House and Outbuildings	No.10 Bridge Street; Part Lot A, DP 381403	LEP Part of I00126 NT S11452 and RNE 3174	SHR #00126 LEP C4 NT S10510 – Thompson Square Precinct
011	Former School of Arts building	No. 14 Bridge Street; Lot 1, DP 136637; Lots 1 and 2, DP 1127620	LEP Part of I00126 NT S11450 and RNE 3172	SHR #00126 LEP C4 NT S10510 – Thompson Square Precinct
012	House	No. 20 Bridge Street; Part Lot 2, DP 420926	LEP I147	N/A
013	House	No. 17 Bridge Street (also addressed as 68 George Street); Lot 1, DP 555685	LEP Part of I00126 NT S11453 and RNE 3175	SHR #00126 LEP C4 NT S10510 – Thompson Square Precinct
014	Shops	Nos. 62 – 68 George Street; Lots 1 and 2, DP 555685.	LEP Part of I00126 NT S11454 and RNE 3176	SHR #00126 LEP C4 NT S10510 – Thompson Square Precinct

Site no.	Name	Address/ description	Individual item listing	Conservation area listing
SHR = State Heritage Register; LEP = Hawkesbury LEP 2012; NT = National Trust; RNE = Register of the National Estate.				
015	Shops	Nos. 70 – 72 George Street (also addressed as 70 George Street); Lot 1, DP 1011887	LEP Part of I00126 NT S9737 (listed under 64–74 George Street) and RNE 3177	SHR #00126 LEP C4 NT S10510 – Thompson Square Precinct
016	Shop/ AC Stern Building	No. 74 George Street; Lot 1, DP 87241	LEP Part of I00126 NT S9737 (listed under 64–74 George Street) RNE 3177	SHR #00126 LEP C4 NT S10510 – Thompson Square Precinct
017	Shops	Nos. 80-82 George Street; Lots 10 and 11, DP 630209	LEP Part of I00126 NT 11455 (listed under 4 Bridge Street and George Street 60–82) RNE 5045195 (listed under Thompson Square Conservation Area)	SHR #00126 LEP C4 NT S10510 – Thompson Square Precinct
018	Shops	82 -88 or 84-88 George Street comprising Lot 2 DP 233054 and Lot 1 DP 233433. These items are variously called 82-88 George Street and 84 – 88 George Street.	LEP Part of I00126 NT S9736 (No. 84 is listed on data sheet– see notes adjacent)	SHR #00126 (Lot 2 233054 only) LEP C4 NT (No. 84 also listed under S10510 Conservation Area and "site adjoining Thompson Square Precinct")
019	Shops	92 George Street; Lot 1 DP 730435	LEP Part of I00126 (listed on map but missing from heritage schedule) RNE 3177	LEP C4 (partly within Conservation Area)
020	Windsor Bridge	Variously addressed as Wilberforce Road, Hawkesbury River, Bridge Street, MR 182 and Bridge No.415.	S.170 RTA #4309589 LEP I276	N/A
021	"Bridgeview" (house)	27 Wilberforce Road, Freemans Reach; Lot A DP 370895	LEP I274	N/A

Statutory listings

There are 21 items within and adjacent to the project study area that are recognised as having State and/or local heritage significance (see **Figure 7-8**). These items are listed and protected under the following NSW legislation and statutory environmental planning instruments:

- Heritage Act 1977 (Heritage Act).
- Hawkesbury Local Environmental Plan 2012 (Hawkesbury LEP).

There are currently no heritage items listed under Commonwealth legislation within or adjacent to the project study area. Thompson Square has, however, been nominated to the National Heritage Register for both a routine listing and an emergency listing. The nominations of the site to the National Heritage Register were received by the Australian Heritage Council in February 2012.

Items currently recognised as being of State heritage significance are listed and protected under the *Heritage Act 1977*. These include items listed on the State Heritage Register (SHR) and items listed on the Heritage and Conservation Register of a State government instrumentality in accordance with Section 170 of the *Heritage Act 1977*. The heritage schedule of the Hawkesbury LEP (Schedule 5 Environmental heritage) includes items of both State and local heritage significance.

There are three SHR listings within and adjacent to the study area:

- Thompson Square Precinct (SHR item #001264) (see **Figure 7-9**).
- Macquarie Arms Hotel (SHR item #00041).
- House and Outbuilding at 5 Thompson Square (SHR item # 00005).

The Thompson Square Precinct SHR item (SHR item #00126) includes most of the properties within and surrounding Thompson Square, although two properties (Macquarie Arms Hotel and the House and outbuilding at 5 Thompson Square) are excluded from the Precinct item and listed as individual items. The main thoroughfare of Bridge Street, including the 1934 road between the kerbs down to where it meets The Terrace and Windsor Bridge, is also excluded from the SHR Thompson Square Precinct boundaries. An assessment of significance of the Thompson Square Conservation Area using the NSW heritage criteria is presented in the Working Paper. The assessment of significance concludes the Thompson Square Conservation Area to be State significant under all seven criteria and that its significance extends beyond the SHR boundary (refer to **Section 7.1.3**).

[4] Referred to as “Thompson Square Conservation Area” on the Heritage Branch database.

Figure 7-8 | Heritage items within Thompson Square

Indicative only – subject to detailed design

LEGEND

- Concept design
- Construction work zone
- Cadastral boundary
- Properties requiring flood mitigation works. Works subject to further consultation with and agreement from affected property owners.
- Properties requiring noise mitigation works. Works that are feasible and reasonable would be subject to further consultation with and agreement from affected property owners.
- Works subject to further council and stakeholder consultation

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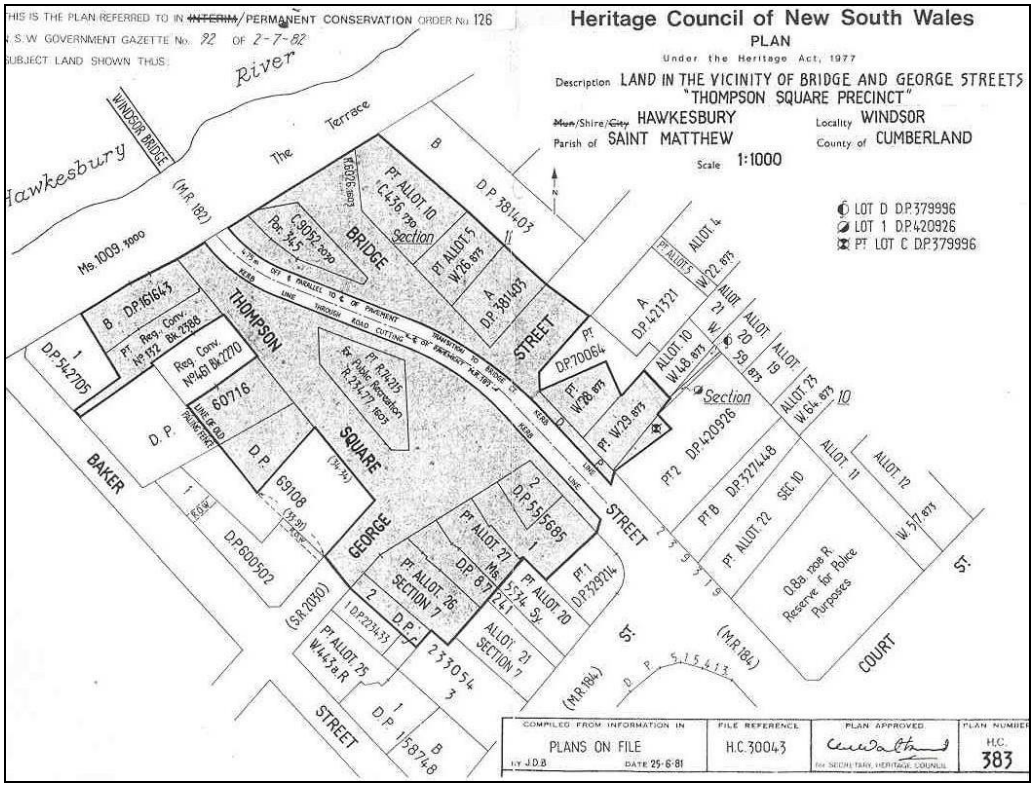


Figure 7-9 State heritage listing – Thompson Square Conservation Area

The existing Windsor bridge is listed on RMS' Section 170 Heritage and Conservation Register and is the only Section 170 Register item within the study area. An assessment of significance of the Windsor bridge using NSW heritage criteria is presented in Working Paper 1. The assessment of significance concludes the Windsor bridge to be State significant under two criteria and have local significance under four criteria.

The heritage schedule of the Hawkesbury LEP includes the Thompson Square Conservation Area (C4) and the individual properties that make up the Conservation Area. Other LEP listings within or adjacent to the study area include Windsor Bridge (LEP I276), the house "Bridgeview" on the north bank of the river (LEP I274) and the house at 20 Bridge Street (LEP I147).

It is important to note that the LEP lists additional items within the Thompson Square Conservation Area that are not included in the SHR listing. These additional items are outside the study area and are not impacted by the project.

Non-statutory listings

In addition to statutory listings, the majority of the listed heritage items in the project study area are subject to non-statutory heritage listings under the Register of the National Trust of Australia (RNT) and/or the Register of the National Estate (RNE). The National Trust is an independent, non-government, community based organisation, established in response to the increased destruction of the built and natural environment. While a listing under the RNT carries no statutory implications, such listings are a strong reflection of the significance of the item to the community. The RNE was formerly a statutory register under Commonwealth legislation but now exists only as a publicly available archive and educational resource. Like the RNT, a listing on the RNE carries no statutory requirements but reflects cultural or natural heritage values.

Additional potential (unlisted) heritage items

Additional items or properties that are considered to have potential heritage value but are not included on any statutory or non-statutory heritage registers have also been identified in this assessment. Unlisted items within the project study area are identified in **Table 7-5**. These items have also been assigned a site number and name for the purposes of this report and, apart from site number 31 and 32, are shown on **Figure 7-8**.

Table 7-5 Unlisted potential heritage items within the study area

Site no.	Site name	Address/ description
022	Green Hills Wharf site c. 1795[1]	Adjacent to upstream and downstream of southern abutment of existing Windsor bridge; within or directly adjacent to Lot 7011 DP 1030959 and Lot 7008 DP 1029964 respectively.
023	Government Wharf site c. 1815	1 Bridge Street; within or directly adjacent to Lot 7008 DP 1029964
024	Government House Wharf site c. 1800	Riverbank at the base of the former government house cottage within or directly adjacent to Lot 7008 DP 1029964
025	The Terrace	Lot 7011 DP 1030959 (upstream of existing bridge); Lot 7008 DP 1029964 (downstream of existing bridge
026	River Bank – southern	1 the Terrace; part Lot 7011 DP 1030959
027	Northern river bank and turf farm	2 and 26 Wilberforce Road, Freemans Reach; Lot 2 DP 65136 and Lot 2 DP 1096472
028	Bridge approach – north side	Parts of Wilberforce Road and Freemans Reach Road
029	Turf farm	33 Wilberforce Road, Freemans Reach; Lot 1 DP 1096472. May have archaeological potential for "Settlers Arms"
030	Macquarie Park	1 Wilberforce Road, Freemans Reach; Lot 1 DP 226141 and Lot B DP 386334; not directly in project footprint
031	Terrestrial archaeological resources	Includes any potential sites that have not been identified in this report
032	Maritime archaeological resources[1]	Includes any potential sites that have not been identified in this or the maritime working paper.

1. Refer to discussion of maritime heritage below.

Hawkesbury Cultural Plan

In May 2006, the Hawkesbury City Council commissioned the Hawkesbury Cultural Plan 2006-2011 in recognition of the role that culture plays in shaping the quality of life of the Hawkesbury. The purpose of developing the plan was to provide Council with the necessary information to effectively support cultural activities in the Hawkesbury region. Development of the plan involved collecting information from a number of sources, including via interviews and community workshops. The information collected indentified the following as key components of the area's identity and sense of place:

- Hawkesbury River and the cultural landscape.
- Heritage and history, including Aboriginal culture.
- Rural amenity and lifestyle and the friendliness of the people.
- Education facilities and support for learning.
- Proximity to the city (Sydney central business district).
- Arts and cultural facilities (eg Regional Gallery and Regional Museum) and the strength and experience of the area's arts and cultural groups.

Maritime heritage

Maritime history

A wharf was first constructed at the initial settlement corresponding to the present town of Windsor in 1795 (referred to as the c. 1795 wharf). This wharf supplied the early store and military garrison, and provided for transportation of crops out of the surrounding farms. The approximate location of the wharf is indicated in **Figure 7-1**.

A second wharf was built at Windsor around 1814 (referred to as the c.1814 wharf) and repaired in 1820 under the direction of Governor Macquarie. This wharf was located on the southern bank of the river to the east of the existing bridge and was present on the site until the late 1930s or early 1940s.

A private punt service started in 1815 using the c.1814 wharf as the southern bank landing and a point in the general location of the current bridge as the northern bank landing. In 1832, the punt was taken over and operated by the government. Around 1835, the punt was re-located upstream and a cabling system was installed for the crossing. The northern bank landing point for this punt crossing (referred to as the c.1835 punt crossing) was located just upstream of the existing bridge.

The bridge across the Hawkesbury River was built in 1874 with the punt service terminating soon after. A temporary bridge was constructed in 1896 for the raising of the main bridge across the Hawkesbury River. The temporary bridge was built in six weeks and is thought to have been located on the upstream side of the current bridge (although there in insufficient information available to confirm its location).

Results of the maritime heritage survey

The targeted maritime heritage survey undertaken as part of preliminary investigations in 2008 identified archaeological remains associated with the second (c.1814) wharf. These comprised above and below water structural remains of the known wharf site.

The above water remains of the c.1814 wharf are present on the southern side of the river to the east of the existing bridge and west of the current wharf. The remains are present in two adjacent areas: the first consists of remnant timber beams and the second of a single pile. There are also remains of a retaining wall further to the east. Rock ballast, which may be associated with the c. 1795 wharf, was also found at the site.

A brief examination was made on the northern bank adjacent to and downstream of the bridge for any evidence of the c. 1835 punt landing site. Though there was evidence of a cutting, it angles towards the water ending at the base of the bridge abutment. This suggests that the cutting may have been made during the building of the bridge to assist in its construction. Thick vegetation precluded any detailed examination of the area.

An additional underwater survey was conducted in October 2012 to investigate anomalies identified in the side scan sonar survey. Near the northern bank between 35 and 60 metres downstream from the existing bridge the remains of a timber structure were identified. There is no pre-1890 historical evidence of a retaining wall being built in this area and it is possible that the remains were potentially transported into the area during previous flood events. The other anomalies were either natural features (eg. boulders, rock platform), tree debris or of modern origin (eg. shopping trolley).

Maritime archaeological potential

The survival of artefacts and other archaeological deposits in a marine or riverine environment is dependent upon the natural and cultural processes that have occurred in the area. Natural processes in the Hawkesbury River, such as flooding and tidal movement, have resulted in sedimentation and erosion. Cultural influences, such as the demolition and removal of the former wharf, would have also influenced the extent and condition of archaeological remains.

Former Windsor wharf

Based on the 2008 survey and the follow-up desktop assessment in 2012, the area within and immediately adjacent to the c.1814 wharf site is considered to have high maritime archaeological potential. Key factors that indicate the high archaeological potential of the site are the presence of rock ballast (which is likely to be associated with the earliest forms of the wharf and indicates that artefacts are likely to have survived despite major flooding events) and the confirmed presence of structural remains associated with the c.1815 wharf.

In addition to the identified structural remains associated with the c.1815 wharf, there are likely to be other structural remains and non-structural archaeological deposits associated with the functioning of the c.1795 and c.1814 wharves in the submerged area behind the southern riverbank. Potential structural remains would include materials associated with the construction, repair and maintenance of the wharf, such as the remains of piles below the ballast layer. The potential for the presence of submerged structural archaeological remains and non-structural maritime archaeological deposits is considered to be high in the location of the rock ballast and moderate for an area of up to five metres around the boundary of the ballast.

The archaeological potential of the wharf from the bank of the river landward is difficult to determine. There has been vegetation cover over this area and there is an uneven layer of fill extending up to one metre above the remains of the wharf. It is also known from the 1814 contract for the construction of the wharf that it included land (deadman) anchors as part of the construction. This suggests that other terrestrial elements associated with the wharf, such as timber decking, piles or other bracing components (like deadman anchors) may be present. The installation of the gabion wall in the 1990s may, however, have required some excavation or modification to the bank, which may have affected the terrestrial archaeological remains associated with the wharf.

The results of the maritime heritage assessment indicate that the archaeological remains of the c.1795 and c.1815 wharves are of State significance (see **Table 7-6**).

Former punt crossing

There is considered to be only a limited potential for the presence of archaeological remains associated with the former punt crossing. Specifically, there is considered to be a moderate potential for archaeological remains associated with the c. 1835 punt landing on the northern side of the river upstream of the current bridge but a low potential for the presence of archaeological remains associated with the period of punt operation prior to 1835 and the route of the punt across the river. The only infrastructure that is likely to be present from pre-1835 operation is the cutting in the northern riverbank that appears on the early maps.

The remains associated with the c.1835 punt landing on the northern bank are anticipated to include infrastructural remains associated with the punt cable system. While structural and artefact remains may have been removed from the area by floods and scouring, cuttings made into the sandstone in this area are likely to have survived. A cutting or road surface associated with the former approach to the northern landing is still present.

From the historical record, particularly from photographic evidence, it is anticipated that any archaeological evidence of the northern bank punt landing point would be completely buried on the upstream side of the current bridge. The near-water and in-water remains of the punt would be very limited, however archaeological remains further up the bank on the northern side may have survived, such as some of the anchors or rugging lanyards that may have since been buried in reclamation. The archaeological potential within this area is considered to be moderate. Any archaeological remains associated with the punt would be of local significance (See **Table 7-6**).

7.1.3 Assessment of significance

Assessments of the significance for all heritage items potentially impacted by the project were undertaken and are presented in detail in the relevant working papers (Volume 2 - working papers 1 and 2), using the assessment criteria and gradings shown in **Tables 7-1** and **7-2**. A summary statement of heritage significance is presented below. The results of the assessments of significance for heritage items that would be directly impacted by the project are presented in **Table 7-6**. While other heritage items would be potentially impacted by the project, these impacts would be indirect and mainly as a result of the change in the heritage vistas and values of the area.

Where an item has a provisional level of significance it means that should the relic exist, it is likely to be of the identified level of significance and the existence of the item has been identified through documentary sources. Where there is insufficient evidence to determine a level of significance it means that it is possible that relics may exist due to context but other evidence has not been found.

Summary statement of significance for the project

Thompson Square is rare at a State level of significance for its historical, associative, research and social values. Some of the archaeological resource within Thompson Square and extending further south and north is also likely to be of state heritage significance, as are archaeological remains of the wharves within the body of the river. Windsor bridge is a State significant structure that is rare and has historical and technical significance. Each item has, through the historical association with the other, become part of the same landscape. Both Thompson Square and Windsor bridge contribute to state significant views of Windsor as a historic township.

Table 7-6 Summary of assessments of heritage significance for directly impacted heritage items

Criteria	Thompson Square Conservation Area	Windsor bridge	Old punt site	Green Hills Wharf (c. 1795)	Old Windsor Wharf (Govt. wharf c. 1815)	Government House wharf (c. 1800)
Criterion A- An item is important in the course or pattern of NSW's cultural or natural history (or the cultural or natural history of the local area)	State significance	State significance	Local significance	Provisional State significance	State significance	Provisional State significance
Criterion B- An item has strong or special association with the life or works of a person, or group of persons, of importance in NSW's cultural or natural history (or the cultural or natural history of the local area)	State significance	Local significance	No significance	Insufficient evidence to determine	State significance	Provisional State significance
Criterion C- An item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or the local area)	State significance	State significance	No significance	Insufficient evidence to determine	Insufficient evidence to determine	Insufficient evidence to determine
Criterion D- An item has strong or special association with a particular community or cultural group in NSW (or the local area) for social, cultural or spiritual reasons (or at a local level)	State significance	Local significance	Local significance	Insufficient evidence to determine	Insufficient evidence to determine	Insufficient evidence to determine

Criteria	Thompson Square Conservation Area	Windsor bridge	Old punt site	Green Hills Wharf (c. 1795)	Old Windsor Wharf (Govt. wharf c. 1815)	Government House wharf (c. 1800)
Criterion E - An item has the potential to yield information that will contribute to an understanding of NSW's cultural and natural history (or the cultural or natural history of the local area)	State significance	Local significance	Local significance	Provisional State significance	Local significance	Provisional State significance
Criterion F - An item possesses uncommon, rare or endangered aspects of NSW's cultural or natural history (or the cultural or natural history of the local area)	State significance	No significance	Local significance	Provisional State significance	State significance	Provisional State significance
Criterion G - An item is important in demonstrating the principal characteristics of a class of NSW's cultural or natural places; or cultural or natural environments (or at a local level)	State significance	Local significance	No significance	Insufficient evidence to determine	Insufficient evidence to determine	Insufficient evidence to determine

Social significance of Thompson Square[5]

The official significance of Thompson Square as a physical element of the town's colonial past was recognised first by the National Trust in 1975. This was followed by a Permanent Conservation Order being placed on the square in 1982 and transfer to the SHR in 1999.

The SHR listing for Thompson Square cites only “historical” and “aesthetic” values, and identifies it as “rare” in the overall significance assessment. Social values are not included in the listing. Similarly, when the National Trust first classified Thompson Square in 1975, the focus of the listing was on built fabric and the aesthetic values of the square and surrounding buildings. Social significance was not included.

Although social significance is not accounted for in the heritage listing of Thompson Square, its high level of social significance to the local and wider community is undisputed. Thompson Square has been the focus of community activities since its inception and began to receive increased attention by artists and visitors with an interest in history and historical landscapes from the 1920s onwards. The open space parklands of the square, in particular the upper parkland adjoining George Street, are still used by the public today for casual and organised outdoor activities. The existing uses contribute to the significance of Thompson Square as a place used by the people of Windsor.

A recent report commissioned by Hawkesbury City Council found that the cultural heritage of the region, which includes Aboriginal and historical heritage, is held in high esteem by the Hawkesbury community. Specifically, the Hawkesbury Cultural Plan, adopted by Council on 30 May 2006, found that the residents of the region have a strong interest in conserving the Hawkesbury’s cultural and built heritage. The Plan also found that the Windsor area represents a direct link through history to Australia’s colonial past and has a high concentration of families with links to European settlement.

Interestingly, although locals recognise the amenity value of the river, and the historical connections represented by Windsor Bridge and other sites, the focus has been almost exclusively on Thompson Square as the point of contention. Other elements such as Windsor bridge are identified as important, but at the general level ascribed to the entire historical township. A nomination to list Thompson Square on the National Heritage Register was recently submitted to the Department of Sustainability, Environment, Water, Population and Communities.

There has been considerable community consultation and opportunities for the community to provide feedback on the project (see Chapter 6). While there is support for the project from some parts of the community (especially residents in east Windsor), there is clear community opposition to the project from other parts of the community on the grounds of heritage impacts, as evidenced by banners hanging from balconies overlooking Thompson Square, articles published in the local newspaper, and submissions received on RMS' "Have your say" e-forum[6]. The Heritage Council is also opposed to the project for the “irrevocable” damage it will do to Windsor and Thompson Square” (refer to letter dated 28/10/2011 attached to the SoHI in Volume 2 - working paper 1).

[5] For the purposes of this section, “Thompson Square” refers to the precinct area and includes all the buildings surrounding the reserves and all the roads within the space defined by the Hawkesbury River to the north, and the buildings facing inwards along Old Bridge Street, George Street and the Thompson Square roadway. This definition differs from the SHR listing for Thompson Square Conservation Area.

[6] http://haveyoursay.nsw.gov.au/windsorbridge

Community opposition on heritage grounds is most strongly expressed by the "Community Action for Windsor Bridge" (CAWB) website[7] and shop front, which provides a central location for information on both opposition to the project and the project-related activities undertaken by RMS and consultants. CAWB has created a petition for opposition to the project that, at 25 May 2012 had collected 6500 signatures for the Lower House of Representatives and 800 for the Upper House (the Senate). According to the website, by 29 June 2012, the petition for the Lower House of Representatives had gathered another 1800 signatures.

A rally to protest the project was organised by CAWB on 3 June 2012. The rally was advertised as a "Public Rally to Save Thompson Square" and had a number of speakers. The keynote speaker was Mr Jack Mundey, a significant individual in the conservation movement to save "The Rocks" from development and an influential campaigner on a number of social and industrial issues. Other non-resident participants included members of the Federation of Historical Societies Inc.

The magnitude of the community reaction to the project has been considerable. The structural integrity of the existing Windsor bridge has been identified as poor and, while the bridge is suitable for current use it requires regular inspection to ensure ongoing safety. If it deteriorates further (eg due to damage or flood) it could require closure at short notice and would need extensive rehabilitation works if it was to be used and maintained into the future. The residents of Windsor and communities across the Hawkesbury would be acutely aware of their reliance on secure access across the river, having been blocked by floods on numerous occasions. The opposition to the project, despite the clear community need for a new bridge to provide a safe and reliable river crossing, is a clear indication of the strength of concerns about heritage impacts.

It is clear that the social significance of the place far exceeds what would be expected in a local context. It is also clear that the local and broader community hold Thompson Square and Windsor bridge in high esteem. The socio-economic impacts of the project are discussed in **Section 7.8**.

[7] http://cawb.weebly.com/

7.1.4 Potential impacts

An integrated design approach, including specialist heritage input, was adopted for project development. This integrated approach has resulted in a project concept design that aims to minimise adverse impacts on the heritage values of Thompson Square and the overall landscape and aesthetic significance of Windsor. Some of the key design refinements that have been incorporated into the concept design are identified in **Section 7.4.4**.

Impacts to historic heritage would remain with the design refinement measures integrated into the project. The project would impact known items of heritage significance and would be likely to impact on unknown and potential items of heritage significance within the project footprint. Heritage impacts would also extend beyond the project footprint to affect views and vistas. Impacts would arise from the construction, demolition and operation of the project. Site numbers are found in **Table 7-4** and **Table 7-5**.

Construction impacts would include:

- Potential damage to heritage items and buildings due to vibration from construction activities (see **Table 7-7**).
- Potential direct and indirect damage to known and unknown terrestrial and maritime archaeological resources.
- Temporary visual impacts of construction sites and compounds.
- The impact on Thompson Square and the northern bank during the removal and infilling of the approach roads to the existing bridge.
- Temporary closure of Thompson Square parkland areas.

Potential demolition impacts would include:

- Demolition of State heritage significant Windsor bridge.
- Direct and indirect damage to unknown maritime archaeological resources.
- Temporary visual impacts of construction sites and compounds.

Potential operational impacts would result from the final form of the project as well as potential impacts from traffic using the project and would include:

- The visual impact of the whole project and its constitute elements such as the southern and northern approach roads, the intersections and the new bridge.
- The visual and other amenity impacts from traffic using the project.
- The impact on heritage values of Thompson Square Conservation Area of the landscaping and urban design features which would be provided as part the project.

The potential impacts of the project on listed and unlisted heritage items are summarised in **Table 7-7**. Further details of impacts are provided below. A more detailed assessment of impacts on individual heritage items is provided in Chapter 10 of Volume 2 - working paper 1. For the purposes of this discussion, the Thompson Square Conservation Area (SHR item #00126) is discussed as one item even though it corresponds to three site numbers in the register (site numbers 001 - 003) also detailed in **Table 7-6**.

The project would have actual physical impacts on two heritage items that are subject to statutory heritage listings:

- Thompson Square Conservation Area (SHR item #00126), which is of State significance and listed on the SHR.
- Windsor Bridge (RMS Section 170 Register item #4309589), which is of State heritage significance and listed on RMS' Section 170 Register.

Four unlisted sites of maritime heritage significance would also be subject to direct physical impacts. Of the four, the first two in the list have been identified through documentary sources and have not been confirmed through physical evidence:

- The Green Hills wharf site (c 1795, by the southern abutment of the existing bridge).
- The Government House wharf site (c 1800).
- The old wharf site (the Government Wharf site c. 1815).
- The punt landing site.

Works associated with construction of the new bridge, demolition of the old bridge, river bank scour protection and reconnection of The Terrace have the potential to impact maritime archaeological relics at these sites, including the archaeological remains known to be present at the old wharf site. The archaeological remains of the wharfs are considered to be of State significance.

Works associated with reconnection of The Terrace also have the potential to disturb terrestrial archaeological relics.

In addition to the direct impacts on the fabric and curtilage of listed heritage items and direct impacts on archaeological relics and remains, vibration generated during construction of the project has the potential to result in physical impacts on six additional items, if appropriate environmental management measures are not implemented. These items are as follows:

- House at 4 Bridge Street.
- House at 6 Bridge Street.
- House and Outbuildings at 10 Bridge Street.
- Former School of Arts building.
- Shops at 62-68 George Street.
- The Doctors House.

Environmental measures to address these impacts are identified in **Section 7.1.5**.

The majority of identified listed heritage items and potential (currently unlisted) heritage items would also experience visual impacts as a result of the project (refer to **Table 7-7**).

Table 7-7 Potential heritage impacts on sites within the study area

Explanatory note: "provisionally" in front of a level of significance means that should the relic exist, it is likely to be of that level of significance and the existence of the item has been identified through documentary sources.

"Undetermined" has been used where it is possible that relics may exist due to context but where other evidence has not been found.

Site no.	Name	Heritage listing	Significance	Potential or known impact on fabric	Potential or known impact on curtilage	Potential or known visual impact	Potential construction vibration impacts
001	Thompson Square – Roads	SHR (#00126 – excluding 1934 cutting) LEP (I526; C4)	State	Yes	Yes	Yes	Yes – high potential
002	Thompson Square – Lower parkland	SHR (#00126) LEP (I529; C4)	State	Yes	Yes	Yes	Yes – high potential
003	Thompson Square – Upper parkland	SHR (#00126) LEP (I524; C4)	State	Yes	Yes	Yes	Yes – high potential
004	The Doctors House	SHR (#00126) LEP (I525; C4)	State	No	No	Yes	Yes: vibration-related impacts possible during infilling Thompson Square
005	House and Outbuilding (5 Thompson Square)	SHR (#00005) LEP (I527; C4)	State	No	No	Yes	No
006	Hawkesbury Museum and Tourist Information Centre	SHR (#00126) LEP (I528; C4)	State	No	No	Yes	No
007	Macquarie Arms Hotel	SHR (#00041) LEP (I442; C4)	State	No	No	Yes	No

Site no.	Name	Heritage listing	Significance	Potential or known impact on fabric	Potential or known impact on curtilage	Potential or known visual impact	Potential construction vibration impacts
008	House (4 Bridge Street). The retaining wall and potential archaeological deposit within this property are the significant items.	SHR (#00126) LEP (I73; C4)	State	Yes: Vibration-related during construction. Sandstock brick wall particularly sensitive.	No	Yes	Yes: vibration-related impacts possible – high potential
009	House (6 Bridge Street)	SHR (#00126) LEP (I206; C4)	State	Yes: Vibration-related during construction	No	Yes	Yes: vibration-related impacts possible – high potential
010	House and Outbuildings (10 Bridge Street)	SHR (#00126) LEP (I253; C4)	State	Yes: Vibration-related during construction			Yes: vibration-related impacts possible – high potential
011	Former School of Arts building	SHR (#00126) LEP (I273; C4)	State	Yes: Vibration-related during construction	No	Negligible	Yes: vibration-related impacts possible – moderate potential
012	Cottage (20 Bridge Street)	LEP (I147)	Local	No	No	No	No
013	Cottage (17 Bridge Street)	SHR (#00126) LEP (I300; #C4)	State	No	No	Negligible	No
014	Shops (62-68 George Street)	SHR (#00126) LEP (I295; C4)	State	Yes: Vibration-related during construction	No	Yes – changes to Bridge and George Street intersection	Yes: vibration-related impacts possible – inspection not undertaken
015	Shops (70-72 George Street)	SHR (#00126) LEP (I400; C4)	State	No	No	Yes	No

Site no.	Name	Heritage listing	Significance	Potential or known impact on fabric	Potential or known impact on curtilage	Potential or known visual impact	Potential construction vibration impacts
016	AC Stern Building (74 George Street)	SHR (#00126) LEP (I400; C4)	State	No	No	Yes	No
017	Shops (80-82 George Street)	SHR (#00126) LEP (I402; C4)	State	No	No	No	No
018	Shops (84 & 88 George Street)	SHR (#00126) LEP (I479; C4)	State	No	No	No	No
019	Shops (92 George Street)	LEP (I485; #C4)	State	No	No	No	No
020	Windsor Bridge	S.170 (RTA #4309589) LEP (I276)	State	Yes	Yes	Yes	N/A
021	Bridgeview	LEP (I274)	Local	No	No	Yes	Yes
022	Green Hills Wharf c. 1795	Nil	Provisionally State	Yes	Yes	No	Yes
023	Government Wharf site c. 1815	Nil	State	Yes	Yes	No	Yes
024	Government house wharf site c. 1800	Nil	Provisionally State	Undetermined	Possibly	No	N/A
025	The Terrace (west of Windsor Bridge)	Nil	Undetermined	Undetermined	Undetermined	Yes	Yes
026 (old 24)	River bank – south bank (west of Windsor Bridge)	Nil	Undetermined	Undetermined	Undetermined	N/A	N/A

Site no.	Name	Heritage listing	Significance	Potential or known impact on fabric	Potential or known impact on curtilage	Potential or known visual impact	Potential construction vibration impacts
027 (old 25)	North river bank and turf farm (east of Windsor Bridge)	Nil	Undetermined	Undetermined	Undetermined	N/A	Undetermined
028 (old 26)	Existing Bridge Approach – north side	Nil	No	No	Yes	N/A	No
029 (not numbered)	Turf farm (on Wilberforce Road – potential archaeological site)	Nil	Undetermined	Undetermined	Undetermined	No	No
030 (old 28)	Macquarie Park	Nil	Potential State	No	No	Low	No
031 No numbers	Terrestrial archaeological resources not identified in this report	Nil	Undetermined	Undetermined	Undetermined	No	Undetermined
032 No numbers	Maritime archaeological resources not identified in this or the maritime report (Cosmos Archaeology 2012)	Nil	Undetermined	Undetermined	Undetermined	No	Undetermined

Thompson Square

The project would have high physical and visual impacts on Thompson Square. In particular, the project would have potential impacts on:

- State significant archaeological relics from the early settlement period.
- Existing elements of Thompson Square, in particular the form of the Thompson Square parkland and landscaping.
- Historic views and vistas and the setting of Thompson Square.
- Building impacts due to vibration from construction and the installation of noise mitigation measures.

Impacts on archaeology

Major impacts would include disturbance and destruction of archaeological evidence from the early settlement period including:

- Terrestrial archaeological resources related to 18th and early 19th century buildings and road alignments and land modification.
- Land-based maritime archaeological resources related to the early wharf, the punt landing by the wharf, and the temporary bridge erected in 1897 (eg. retaining walls, deadman anchors).
- Archaeological evidence in Thompson Square, Windsor Road and the northern bank in the 19th and 20th centuries in response to transport changes, land-use and reconfiguration of public space.

Test excavations undertaken in May 2012 in Thompson Square confirmed that archaeological resources survive beneath the existing roads and would be likely to present in other areas potentially disturbed by construction of the project including The Terrace and parkland areas. Some of this evidence relates to understanding the pattern of the earliest European settlement in Australia, which could be ranked as exceptional (see **Table 7-4**). Surviving archaeological sites of comparable age are restricted to a handful of locations in Sydney and Parramatta, and the first settlement sites in Norfolk Island and Tasmania. Pending more extensive archaeological investigation it is not possible to say how extensive the most significant deposits are or how well they have survived.

The design of the replacement bridge and approach roads considered impacts on relics and has minimised those impacts as far as practicable. However construction of the southern approach road and southern bridge abutments would result in a disturbance of a substantial area of land within Thompson Square – and therefore the impact on the archaeological resources in this area would be significant and unavoidable. While the actual area of Thompson Square disturbed by excavation can be minimised, partial disturbance would still result in the loss of archaeological resources and could fragment the contextual relationship between archaeological resources from different periods.

While maintaining archaeological resources in-situ would be the preferred method for preservation, this would not be possible in areas impacted by excavation works. Instead as discussed in **Section 7.1.5**, open area excavation would first be undertaken to expose, investigate, record and salvage archaeological resources. This would provide a greater understanding of the historical development of Thompson Square and contribute to the historical record of the region.

Impacts on form of Thompson Square parklands

The current form of the Thompson Square parkland is a product of the gradual evolution of Thompson Square as a civic area and as an area to provide access to the river. Although Thompson Square has been modified regularly since its establishment, it has retained its overall form of a large, open space sloping down to the river. The project would have both positive and negative impacts on the form of Thompson Square parkland and has the potential to impact its significance as the focal point of the conservation area listed on the State Heritage Register.

The construction of the existing southern approach road to the existing bridge through Thompson Square parkland in 1934 has been the most significant adverse impact on the character of Thompson Square to date. It increased the physical separation of the upper and lower parklands and would have also resulted in the destruction of many significant historical relics.

One of the benefits of the project would be the in-filling of the existing southern approach road through the Thompson Square parkland and the connection of the upper and lower parkland areas (which are currently separated by the road). The result would be a greater area of continuous parkland that would slope gently to The Terrace and the river.

In addition to improving the amenity and utility of the open space area for the public, the connection of the parkland areas would be a positive step toward consolidating the visual and spatial relationship of this element of Thompson Square by creating one large, cohesive space for a variety of community and recreational uses. Opportunities would also exist to include meaningful interpretation of the past, such as part of the earlier curved road alignment. The resulting form would be closer to the earliest colonial space prior to the creation of formalised roads. The original alignment of Old Bridge Street and the old alignments to the bridge and old wharf that are still visible in the existing landscape would, however, be permanently removed through the modifications within and adjacent to the square.

Physical impacts on any remaining archaeological relics in the immediate locality of the existing approach road would be negligible as the works would involve infilling rather than excavation.

The project would include the removal of some of the older trees in poor condition within the Thompson Square parkland and replacement with new trees. This would be an opportunity to improve the functionality and visual appearance of Thompson Square parkland.

Impacts on landscaping of Thompson Square parklands

From the 1880s Thompson Square has been subject to informal landscaping with the planting of trees, the erection of a pavilion, which was removed in the early twentieth century and arris rail fencing. The asymmetry and unstructured look of Thompson Square reinforced the informal design. More recently, the Pioneers Memorial and other features such as picnic tables and chairs were added.

The concept urban and landscape design for the project to date has respected the historical development of Thompson Square by promoting an informal landscape scheme that maintains the current character of Thompson Square and maintains the unstructured character of the parkland areas.

However, the project would permanently modify the form of the parkland areas. While the landscape concept design proposes an informal scheme with few hard-paved areas, an informal planting scheme and a gently terraced slope down to the river, the modifications required to create a single unified park and the introduction of the new elements of the project would change the setting, view, vistas and character of the lower park. The concept of an informal landscape would be carried through to the final landscape plan in consideration od the historical development of the area.

Impacts on historic views and vistas and the setting of Thompson Square

Impacts on the views, vistas and setting of Thomson Square from the project would have the greatest impact to the heritage significance of Thompson Square. These would be greater than any physical impacts resulting from construction and operation of the project.

The current setting of Thompson Square and the Windsor bridge is formed by the relationship of these existing elements to the wider landscape. The entry point at the George Street and Bridge Street intersection announces arrival to Windsor via Thompson Square from the south. On the north side of the river, as Wilberforce Road approaches the edge of the river, the eye is swept along the curving road and across the river via the alignment of the existing bridge, which forms a boundary, of sorts, encompassing first the Doctors House, then the other elements of the square.

The eastern side of Thompson Square, which currently comprises of a footpath, a local road and sections of parkland, would be converted into a three lane road, shared path and new local footpath for the new southern approach road. This would impact the setting of Thompson Square, which currently retains elements of its rural ambience during low traffic periods. It would also impact the relationship of the buildings that border the eastern side of the square to the reserves and western side of the square. A photograph of the existing view from the Doctors House of the existing bridge and location of the replacement bridge is presented in **Figure 7-21**.

While the visual impact of the new southern approach road has been minimised by matching its level with the levels of the existing landforms along the eastern site of Thompson Square, the most substantial impact would be the visual impact of traffic on the new southern approach road. The approach road to the existing bridge is within a cutting and vehicles using the approach road are generally not visible and therefore views across Thompson Square are generally not impacted by traffic. The project would bring the approach road and traffic almost level with these buildings, thereby creating a permanent visual impediment to views across Thompson Square.

The new southern approach road and bridge would also impact views from Thompson Square to the river and across to the northern bank. However the existing topography and vegetation currently impact these views in many locations, so the impact on views from the project would not be as significant.

The removal of the existing Windsor bridge and construction of the new bridge would also impact the view of the Thompson Square parkland from the northern bank. Specifically, it would modify the composition of the setting by introducing a focal point across the front of Thompson Square when viewed from anywhere east of Freemans Reach Road. It would also change the outlook from Thompson Square across to the northern bank. Windsor bridge has framed the extent of Thompson Square open space and allows it to continue across the expanse of water. The existing bridge also acts as a pointer, topped by the Doctors House, to Thompson Square when viewed from the northern bank. With the demolition of Windsor bridge the visual cues and linkage with Thompson Square would be lost.

From view points on the northern bank east of the intersection of Freemans Reach Road and Wilberforce Road, the replacement bridge would obscure parts of Thompson Square parkland, however generally all the buildings around Thompson Square would be visible.

The design of the project has considered the historical sensitivity of Thompson Square, its archaeological potential and the potential for adverse impacts on historical views and vistas and its setting. As a result, aspects of the project have changed considerably since it was first proposed. Two important decisions that have been guided by the heritage significance of Thompson Square are the height of the replacement bridge and the type of bridge and its associated method of construction. The height of the original bridge design would have totally obscured iconic views from Wilberforce Road to Thompson Square, views from Thompson Square across the river to the rural landscape of Wilberforce and Freemans Reach, and views from the eastern side of Thompson Square to the western side. The current design involves a lower level bridge, which has a reduced level of impact on views to and from Thompson Square. The current design would only partially obscure views to and from Thompson Square.

After consideration of a number of different bridge types (see **Section 4.4**), an incrementally launched bridge was selected. The bridge would be launched from the northern river bank which is a positive response to the significance of Thompson Square as the construction impacts and use of Thompson Square would be minimised. Additionally, from a visual perspective, an incrementally launched bridge allows the profile of the bridge to be minimised and the features of the bridge superstructure to be designed to reflect the sensitivities of the heritage vistas. A impression of the replacement bridge from the Doctors House is presented in **Figure 7-22**. Nevertheless, despite the high level of attention to detail in design, the replacement bridge, approach roads and roundabout on the northern bank would visually dominate the surrounding rural landscape and heritage vistas.

The urban design and landscaping working paper (Volume 3 - working paper 4) has identified appropriate concepts for future landscaping of Thompson Square and the open area on the northern side of the river. These concepts have been informed and guided by the heritage assessment.

There would be additional temporary visual impacts during construction from construction sites and compounds on the northern bank and near the current Windsor Wharf.

Building impacts due to vibration from construction and the installation of noise mitigation measures

The potential impact on heritage and non-heritage buildings from vibration associated with construction activities has been assessed as part of the Noise and vibration working paper (Volume 4 – working paper 6) and are summarised in **Section 7.5**. The assessment identified that there is the potential for certain construction activities to cause vibration levels exceeding relevant structural damage criteria at buildings immediately adjacent to the construction site. However, the potential impact and risk of vibration related impacts can be mitigated by exclusion zones around buildings for specific high vibration activities, adopting alternative low vibration construction techniques, building condition surveys and vibration monitoring.

Only one heritage building would require consideration for architectural noise mitigation, namely the upper floor of 10 Bridge Street. A qualified heritage architect was engaged to inspect the upper floor of 10 Bridge Street and recommend potential architectural treatments that provide noise mitigation while not impacting on the heritage values of the building. The heritage architect (CityPlan Heritage, 2012) recommended measures that could be implemented without resulting in a significant impact to the heritage values of the building.

Windsor bridge

The existing Windsor bridge would be demolished due to its poor condition and its risk to the replacement bridge downstream. The existing bridge has been assessed to be of State significance and is listed as a heritage item on the RMS Heritage and Conservation Register and the Hawkesbury LEP. The current use of the bridge contributes to its significance as it continues to function as it was originally intended. Although the bridge superstructure was modified significantly through the removal of the timber deck and replacement with concrete girders, cross girders and deck, the original form of the bridge has been retained. Also of note is that the 1922 refurbishment was an early use of mass concrete and the construction methods where one lane was kept open, were unusual.

The demolition of the existing Windsor Bridge would be a loss to the cultural landscape of Windsor as it contributes to the historic character of the locality and is significant as an individual heritage item. Since it was built, it has featured in numerous photographs and is a component of the iconic image of Thompson Square as viewed from the northern bank as well as vistas across the river from Thompson Square.

The location of the bridge is thought to be the location of the c. 1795 wharf, the c.1814 punt wharf and the temporary bridge built for the 1897 modifications (raising the height of the existing Windsor bridge).

Rehabilitation of the bridge would be possible but would be costly and the bridge would still only have a limited life span.

“Bridgeview” at 27 Wilberforce Road and northern bank

Bridgeview, a locally heritage listed residence is located adjacent to the project near the corner of Freemans Reach Road and Wilberforce Road. Bridgeview is a fine example of a Federation bungalow with landmark qualities and is visible from Thompson Square and from Wilberforce Road. Bridgeview would not be directly impacted by the construction of the project. The impacts would be predominantly to the visual landscape as the configuration of the roads on the northern bank have not changed for a century or more and the land uses are rural agricultural.

A dual lane roundabout would be constructed just south east of Bridgeview to service Macquarie Park, Freemans Reach Road, Wilberforce Road and the northern bridge approach road.

Design changes have been made with respect to reducing the visual impact of the proposed roundabout by lowering the original finished level by about one metre. However, the roundabout would still be a substantial structure and, with the feeder roads would create a substantial visual impact when viewed from Thompson Square. Views to and from Bridgeview would also be impacted negatively but would be reduced by landscaping to obscure the road from the house.

The archaeological sensitivity of this area is considered to be variable.

Archaeological monitoring of the geotechnical test pits suggests that evidence of landscape modifications survives, particularly around geotechnical test pit 5.

Concrete beams were discovered in this area and are similar to beams found on the southern bank. These beams are possibly infrastructure built in 1897 to raise and improve the level of the approach roads. Other infrastructure associated with raising the bridge in 1897, could be present in this area.

Historical records of development of the northern bank are scarce and those that were found contained little information on the location of structures. One of the earliest inhabitants of the region, Edward Whitton, lived and farmed somewhere in or close to the project footprint. Also, historical documents describe a hotel, the Squatters Arms, on the corner of Freemans Reach and Wilberforce Roads but do not clearly describe its location. This potential archaeological site has also been considered in the discussion of archaeological resources (see Volume 2 – working paper 1 – Appendix 3) and is included in the recommendations.

The archaeological resource on the northern bank is considered to be less complex with the possibility of substantial pockets surviving in discrete areas. The impact of the project on archaeological resources of significance is not considered to be as substantial on the northern bank, compared to the southern bank.

Maritime archaeology

The project would have an impact on known and potential archaeological remains within the project footprint as follows:

- Installation of the first in-water pier on the southern side of the river and the retaining wall and rock scour protection immediately in front of the southern bank would disturb and/or destroy known and potential archaeological remains associated with the former wharf.
- Filling, landscaping and installation of rock scour on the upstream and northern side of the existing bridge may expose and impact cuttings made into the natural sandstone for the approach to the northern punt landing.

Former Windsor wharf

The design of the project has been undertaken in consultation with appropriately qualified maritime archaeological specialists. The results of this design and assessment process indicate that based on the project alignment there are no design options that would allow for the retention of the maritime archaeological remains present within the study area, particularly in the vicinity of the c.1814 wharf. The main element of the project that would impact the maritime archaeological remains of the c.1814 wharf is the necessary scour stabilisation work along the southern river bank.

Given that impacts of the project on maritime archaeological remains cannot be entirely avoided, an archaeological salvage excavation of the site would be undertaken.

Former punt crossing

The impacts on potential archaeological remains associated with the former punt crossing would be confined to the post c.1835 crossing when the punt was relocated upstream and a cable system was installed. The proposed works in this area would include filling for landscaping purposes, as well as excavation of areas where rock armor would be placed. This work is likely to expose any cuttings made for the approaches for the road then subsequently cover these cuttings in the process of filling and landscaping. The works are not likely to remove the historic road cuttings.

Archaeological remains or relics associated with the former cabling system are not expected to be present as the area has previously been exposed during flood events and no archaeological remains were observed during field survey. Furthermore, the proposed works (including removal of vegetation, infilling and landscaping) are not likely to remove any significant intact elements, if present.

Archaeological monitoring during construction is proposed for this area to enable any relics that are exposed to be recovered and recorded.

Residual impacts

Environmental management measures are proposed to further minimise impacts to historic heritage (refer to **Section 7.1.5**). However following the application of these measures there would be residual significant impacts to historic heritage, both in fabric and heritage significance, as a result of the project. Further detail on residual heritage impacts can be found in Chapter 10 of Volume 2 - working paper 1. The impacts on heritage in relation to other impacts from the project are summarised in Chapter 11.

7.1.5 Environmental management measures

State and local heritage

Thompson Square is rare at a State level of significance for its historical, associative, research and social values. Some of the archaeological resource within Thompson Square and extending further south and north is also likely to be of State heritage significance, as are archaeological remains of the wharfs within the body of the river. Windsor bridge is a State significant structure that is rare and has historical and technical significance. Each item has, through the historical association with the other, become part of the same landscape. Both Thompson Square and Windsor bridge contribute to state significant views of Windsor as a historic township.

Design refinement measures have been included in the project to minimise impacts to historic heritage archaeology and vistas. These are described in **Section 7.4.4** and assessed in **Section 7.4.5**. Environmental management measures are also proposed (see below) and further design and construction methodology improvements will continue to be investigated during the detailed design phase. Nevertheless, there would be residual significant impacts to historic heritage as a result of the project.

To avoid significant impacts on Thompson Square and the existing Windsor bridge would require selection of an alternative river crossing location and/or refurbishment of the existing Windsor bridge. These options were considered as part of options selection process detailed in Chapter 4 and did not meet as many of the project objectives and criteria in comparison to the project.

Environmental management measures for the project are presented in the following sections.

Visual impacts

The project would impact the heritage setting, views and vistas of this area of Windsor and the Hawkesbury River. **Section 7.4** identifies environmental management measures that were integrated into the design during development of the project that will reduce impacts on views and vistas. **Table 7-10** identifies environmental management measures that will be implemented during the further development of the project. As well as the environmental management measures contained in **Section 7.4.6** two additional environmental management measures are recommended:

- During detailed design additional investigations will be undertaken to further reduce the size and visual impact of the roundabout at Freemans Reach Road and Wilberforce Road.
- Opportunities to relocate above-ground utilities underground will be investigated during detailed design.
- Measures will be undertaken to ensure that the landscape scheme for the Thompson Square parkland area retains its informal character.

Construction environmental management measures

Environmental management measures will be required in and around construction sites to avoid inadvertent impacts to heritage items and large trees including:

- Prior to construction dilapidation reports will be prepared as identified in Section 7.5.6 (generally receivers within 50 metres of piling, rock breaking and vibratory compaction activities). These will be undertaken in consultation with the relevant property owners.
- Prior to commencing work on the project construction site all construction personnel will undergo a heritage induction which would contain information on heritage values and items in the area and on environmental management measures to minimise potential heritage impacts.
- All heritage items within the study area will be clearly identified on construction plans to minimise the risk of inadvertent impacts.
- Environmental management measures identified in **Section 7.5.5** will be implemented to minimise vibration risks and impacts on heritage items.
- Heritage items at risk of vibration impacts will be inspected and monitored periodically during construction to identify any construction-related impacts. If impacts are detected, work in the area will cease and appropriate environmental management measures will be implemented such as using alternative low vibration construction techniques.
- Architectural noise environmental management measures for heritage listed buildings will be developed in agreement with property owners and installed by suitably qualified professionals.

Archaeological management

While the project will seek to minimise areas of disturbance as much as possible, the project will directly disturb or quarantine archaeological resources within the project footprint and consequently, all areas impacted by the project would require archaeological environmental management. Consideration would be given to balancing the extent of the impact on the archaeology as a result of the archaeological investigations and the amount of information that could be recovered. As the history of Windsor goes back further than two centuries, an archaeological research design will be developed to meet best practice standards for the recovery of both Aboriginal and historic terrestrial and maritime archaeology, conducted as a single investigative process.

Impacts are also predicted where it is proposed that utilities will be installed along Bridge Street from Macquarie Street to the replacement bridge. Installation is likely to be by one of two methods: directional drilling or open trenching. Consideration has been given in these recommendations for managing impacts deriving from the installation of services along Bridge Street by minimising impacts.

Specific environmental management measures would include:

- An integrated archaeological project and research design will be developed in consultation with heritage agency stakeholders. The research design will seek to investigate the project footprint and realise its archaeological potential. The archaeological project and research design will set out in detail the archaeological program, the research objectives and questions, and methods of analysis and dissemination of the results.

For Windsor bridge:

- The 1874 bridge will be dismantled in a manner that allows its construction methods and evolution to be appropriately documented as an archival record prior to, and during its demolition.

For utilities installation:

- Further consultation will be undertaken with utility providers to confirm the feasibility of reducing the number and size of trenches required for the installation of utilities.

Archival recording

The changes to the surrounding landscape due to the project would be extensive. An archival record of the project footprint and the immediate vicinity will therefore be undertaken in accordance with Heritage Council guidelines for items of State significance, prior to, during and after completion of the project construction and demolition works. The Heritage Branch (on behalf of the Heritage Council), the Hawkesbury Museum and Hawkesbury City Council will be consulted on the level of appropriate archival recording. A social record of Thompson Square and the building of the replacement bridge will be undertaken to capture community views on the change to the environment.

Post-construction landscaping

Landscaping and urban design principles have been used to guide the design of the project and rehabilitation of Thompson Square (see **Sections 5.3, 7.4** and **7.6**). It is essential that during the further development of the landscape and urban design for this project, due consideration is given to the archaeological potential of the project footprint, in particular Thompson Square and the immediate waterfront. Until an extensive archaeological excavation program is complete and the interpretation of the data has been prepared, the area within and surrounding Thompson Square, including the foreshore, will be considered to be archaeologically sensitive. In the first instance, any potential archaeological resource will be treated as if it is of State significance until additional investigation is undertaken to confirm its significance.

The preferred landscape design will be one that enhances significant aspects of Thompson Square and enables it to be interpreted as a historical civic space. One of the most significant aspects of Thompson Square is its setting, and the views and vistas to and from it. Historical views that are documented in Volume 2 - Working paper 1 – Appendix 1 provide the basis for both reinforcing the historical structure of the study area and addressing change and evolution within the open space and riverside settings. Whether directly alluded to through pictorial reminders, or just enhanced by vegetation reduction, the visual curtilage will become one of the strongest passive interpretative measures that can be applied. Additionally, the potential archaeological resource is also of significance, therefore any works proposed must take this into account.

The following environmental management measures will be implemented:

- Consultation with Hawkesbury City Council, relevant heritage agencies and the community on the urban design and landscape concept for Thompson Square will be undertaken during the detailed design phase of the project.
- The urban design landscaping principles and objectives will be used to further develop the detailed design of the project.
- The concept of an informal landscape will be the basis of the final landscape plan for Thompson Sqaure.
- Post-construction landscaping will be prioritised where it would provide residences and businesses with a visual buffer to the completed project.

Interpretation

The project would provide the opportunity to include interpretive aspects to enhance the community's knowledge about the history of Windsor. The heritage reports prepared for this project (Volume 2 - Working papers 1 and 2) provide excellent sources of information for interpretive displays. Without limiting the scope of potential interpretation of heritage values, some ideas that have been successfully tried in other places are outlined below. These will be considered amongst others during development of the interpretation strategy and plan:

- An interpretation strategy within the archaeological project plan and research design, will identify opportunities for public understanding and engagement with the archaeological investigation process. This will assess and recommend strategies such as those listed below which can be done prior to completion of the interpretation plan.
  - Provide guided tours during archaeological excavations.
  - Have elements of the post-excavation archaeological analysis such as artefact sorting take place in the Museum environment, potentially with public involvement.
  - Cooperative interpretation opportunities with the Hawkesbury Museum.
- An interpretation plan will be prepared based upon all of the heritage assessments to provide a framework for making information about the site's significance publicly accessible. The interpretive plan will be informed by the urban design and landscape strategy that is proposed for Thompson Square and will be guided by the following suggestions:
  - Identification of particular vistas of historical significance or interest and ensuring these are maintained in the landscape and urban design strategy.
  - Consideration of incorporating interpretation about Thompson Square, Windsor Bridge and Freemans Reach into the Great River Walk. For instance, historic views to Thompson Square from Freemans Reach could be included as a numbered interpretive display that incorporates historic Windsor and Green Hills into a leg of the Great River Walk. This way, the replacement bridge is crossed and becomes part of the story of Windsor.
  - Inclusion of temporary and permanent interpretive displays in the Hawkesbury Museum that incorporate the pre-colonial landscape, the historic landscape, the environmental history such as floods and their effect on the geology and history of the place, based on the results of excavation.
  - Preparation of papers on aspects of the investigations and their results for magazines and journals to a range of different audiences.

- Development of a virtual reality walk for different periods of time.
- Inclusion of heritage-based interpretative ideas as expressed in the landscape plan, including reflecting the river connection, incorporating shells and flood levels in finishes to the bridge abutments.

Re-use

The existing Windsor bridge would be dismantled as part of the project. The potential reuse of components or materials from the bridge will be considered before demolition, along with kerb stones, soil, historic fills and other material recovered during construction. Consistent with RMS' sustainability objectives consideration will be given to how those materials with heritage association may be reused either off-site or within the project.

- Where possible, excess materials such as the iron piers on the existing Windsor bridge, would be re-used within the project. If re-use is not possible within the project, re-use opportunities off-site would be investigated. All components would be properly labelled with provenance.

Maritime archaeology

The environmental management measures for maritime archaeology are as follows:

- An above and below water maritime archaeological salvage excavation will be undertaken within the area considered to have a high potential to contain archaeological remains associated with the c.1814 wharf where impacts from the project are anticipated. This includes the area immediately behind the southern bank of the river within the impact footprint of the project. The salvage excavation will be conducted by a qualified maritime archaeologist in accordance with an appropriate research design. The research design will include, as a minimum, an excavation methodology, research questions and provisions for artefact analysis.
- An archaeological excavation report will be prepared at the conclusion of the salvage excavation, and submitted to the Office of Environment and Heritage for their records.
- The results of the excavation and artefact analysis will be used in on-site interpretation of the maritime history and heritage of the Windsor area.
- Archaeological monitoring by a qualified archaeologist will be undertaken in conjunction with earthworks and landscaping on the northern side of the existing bridge in the general location of the c.1835 punt landing. Any archaeological remains or relics associated with the punt crossing will be recorded and/or salvaged.
- An archaeological monitoring report will be prepared at the end of the monitoring works and submitted to the Office of Environment and Heritage for their records.

7.2 Aboriginal heritage

This section assesses Aboriginal heritage impacts of the project. The assessment is supported by an Aboriginal Cultural Heritage Assessment Report (CHAR) prepared by an experienced and suitably qualified heritage consultant, which is presented in Working paper 3 (refer to Volume 2). The Director General's requirements for Aboriginal heritage have been addressed in the assessment (as detailed in **Table 7-8** below) as well as the relevant requirements of Schedule 2, Part 3 of the *Environmental Planning and Assessment Regulation 2000*.

Table 7-8 Director General requirements for Aboriginal heritage

Director General's requirements	Where addressed
The EIS must address the following specific matters: **Heritage –** including but not limited to:	
• impacts to Aboriginal heritage (including cultural and archaeological significance), in particular impacts to potential archaeological deposits (PAD) on the northern and southern banks of the Hawkesbury River and archaeological objects/ relics below the existing built environment should be assessed.	Section 7.2.3
Where impacts are identified, the assessment shall:	
– outline the proposed environmental management measures (including measures to avoid significant impacts and an evaluation of the effectiveness of the measures) generally consistent with the Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation (Department of Environment and Conservation, 2005),	Section 7.2.4
– be undertaken by a suitably qualified heritage consultant(s),	Section 7.2 and Volume 2- working paper 3
– demonstrate effective consultation with Aboriginal communities in determining and assessing impacts and developing and selecting options and environmental management measures (including the final proposed measures), and	Section 7.2.1, Chapter 6 and Volume 2- working paper 3
– develop an appropriate archaeological assessment methodology, including research design, to guide physical archaeological test excavations of the areas of PAD identified in a manner that establishes the full spatial extent and significance of any archaeological evidence across each area of PAD, and include the results of these excavations.	Section 7.2.4 and Volume 2- working paper 3

7.2.1 Guidelines and methodology

Overview

The Aboriginal cultural heritage assessment undertaken for this EIS involved Aboriginal community consultation and a geoarchaeological and Aboriginal archaeological investigation. The assessment was undertaken in consultation with the NSW Department of Planning and Infrastructure and Office of Environment and Heritage, and in accordance with the Director General's requirements and the following guidelines:

- Office of Environment and Heritage Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation (DEC, 2005).
- RMS' *Procedure for Aboriginal Cultural Heritage Consultation and Investigation* (PACHCI). The PACHCI is generally consistent with the Office of Environment and Heritage draft guidelines and the updated DECCW (2010) consultation guidelines.

The assessment covered the areas within and adjacent to the project footprint on the northern and southern banks of the Hawkesbury River, as well as archaeological evidence below the existing built environment. The scope of the assessment included:

- A search of the *Aboriginal Heritage Information Management System* (AHIMS) database to identify any previously recorded Aboriginal sites in the study area.
- A geomorphic and archaeological background assessment of the study area.
- Geoarchaeological and Aboriginal archaeological investigations, including test excavations.
- Assessment of significance of identified Aboriginal archaeological deposits and artefacts.
- Identification of environmental management measures.

Aboriginal community consultation

RMS is committed to effective consultation with Aboriginal communities about RMS activities and the potential impacts of these activities on Aboriginal heritage. Accordingly, an Aboriginal community consultation program for the project has been developed and implemented in accordance with RMS' PACHCI and Office of Environment and Heritage guidelines (DEC, 2005 and DECCW, 2010).

The Aboriginal community consultation program involves all relevant Aboriginal stakeholders, including representatives from the Deerubbin Local Aboriginal Land Council and the stakeholders identified and registered for the project through the DEC (2005) process. Details of the consultation process and the registered Aboriginal stakeholders are provided in the CHAR (Volume 2 - Working paper 3).

The consultation process has involved the establishment of an Aboriginal Focus Group (AFG) to represent the interests of the Aboriginal community and assist RMS in the identification and assessment of impacts, development of appropriate methodologies and development of the impact mitigation strategy. An AFG meeting was held at the Windsor Museum on 29 February 2012, at which the results of the preliminary archaeological and Aboriginal cultural heritage assessments and methodologies for test excavation were presented and discussed.

A second AFG meeting was held at Argyle Street Parramatta on 24 May 2012, at which the results of the test excavations and management recommendation were presented and discussed.

A copy of the draft CHAR was provided to Aboriginal stakeholders for a 28 day review and comment period. Comments received from stakeholders were addressed in the final CHAR and copies of the original submissions are attached to the document (refer to Working paper 3).

Consultation with the local Aboriginal community is ongoing and would continue as required in the detailed design and construction of the project (if the project is approved).

Geoarchaeological and Aboriginal archaeological investigations

A robust method for the geoarchaeological and Aboriginal archaeological investigations was established in consultation with the NSW Department of Planning and Infrastructure and Office of Environment and Heritage. The investigation was designed to determine the:

- Presence or absence of sand bodies within the study area, which are linked to the presence of Aboriginal archaeological deposits.
- Presence or absence of Aboriginal archaeology within the study area in general, regardless of the presence of sand bodies.
- Integrity, extent and spatial distribution of archaeological deposits.

The archaeological assessment methodology and research design were reviewed and endorsed by the NSW Department of Planning and Infrastructure, Office of Environment and Heritage,and the AFG before the start of test excavations. Fieldwork for the investigations commenced on 2 May 2012 and were completed on 8 May 2012.

Preliminary information to guide the investigations was obtained from six geotechnical boreholes along the proposed alignment of the replacement bridge and approach roads, including three boreholes on the northern side of the river and three on the southern. These geotechnical boreholes were located both to inform the design of the bridge and provide geological information for heritage assessments.

The project footprint[8] was divided into two investigation areas, with each subject to specific archaeological investigations to inform the Aboriginal heritage assessment:

- One area on the north side of the river, referred to as Windsor bridge replacement north (WBR North).
- One area on the south side of the river, referred to as Windsor bridge replacement south (WBR South)

WBR North was located on a level floodplain area immediately adjacent to the Hawkesbury River, on an area used for turf production. Archaeological investigations within this area involved one borehole and four hand excavated test squares.

WBR South was located on the south bank of the Hawkesbury River, spanning a moderately inclined mid-slope and gently inclined upper slope area.

[8] Including the design boundary of the replacement bridge and approach road modifications, and the associated construction areas.

Geoarchaeological investigations within this area involved seven boreholes and five hand excavated test squares. The locations of the test squares were limited by urban infrastructure and guided by the geotechnical and geoarchaeological boreholes.

Each test square was around one square metre in area and one metre deep. All excavated material was wet sieved through nested 2.5 millimetre and five millimetre mesh screens, with artefacts retained for further examination.

Scientific values and significance assessment

The assessment of significance is a key step in heritage impact assessment as the significance or value of an object, site or place will be reflected in resultant recommendations for conservation, management or impact mitigation. Current best practice requires the assessment of significance according to criteria established in the Australia ICOMOS Burra Charter, 1999 (Australia ICOMOS 1999). Guidelines to the Burra Charter set out four criteria for the assessment of cultural significance:

- Aesthetic value - relates to the sense of the beauty of a place, object, site or item.
- Historic value - relates to the association of a place, object, site or item with historical events, people, activities or periods.
- Scientific value - scientific (or research) value relates to the importance of the data available for a place, object, site or item, based on its rarity, quality or representativeness, as well as on the degree to which the place (object, site or item) may contribute further substantial information.
- Social value - relates to the qualities for which a place, object, site or item has become a focus of spiritual, political, national or other cultural sentiment to a group of people.

The assessment of these values are brought together to form a comprehensive assessment of significance.

7.2.2 Existing environment

Previously recorded sites

Records of previously identified sites on the AHIMS database show that there are two potential archaeological deposits (PADs) and four isolated finds within or adjacent to the project footprint (see **Table 7-9** and **Figure 7-10**). These finds were identified during preliminary studies prior to the selection of the preferred option.

Table 7-9 Aboriginal archaeological sites previously recorded on the AHIMS database and located within the project footprint

Site name	AHIMS ID number	Site type	Location
North Bank PAD W-NP	45-5-3580	PAD	North bank
South Bank PAD W-SP	45-5-3581	PAD	South bank
W1	45-5-3582	Isolated find	North bank
W2	45-5-3583	Isolated find	North bank
W3	45-5-3584	Isolated find	North bank
W4	45-5-3585	Isolated find	North bank

Two additional Aboriginal sites have been recorded within 150 metres of the project footprint during previous Aboriginal heritage investigations for other development projects (refer to **Figure 7-10**):

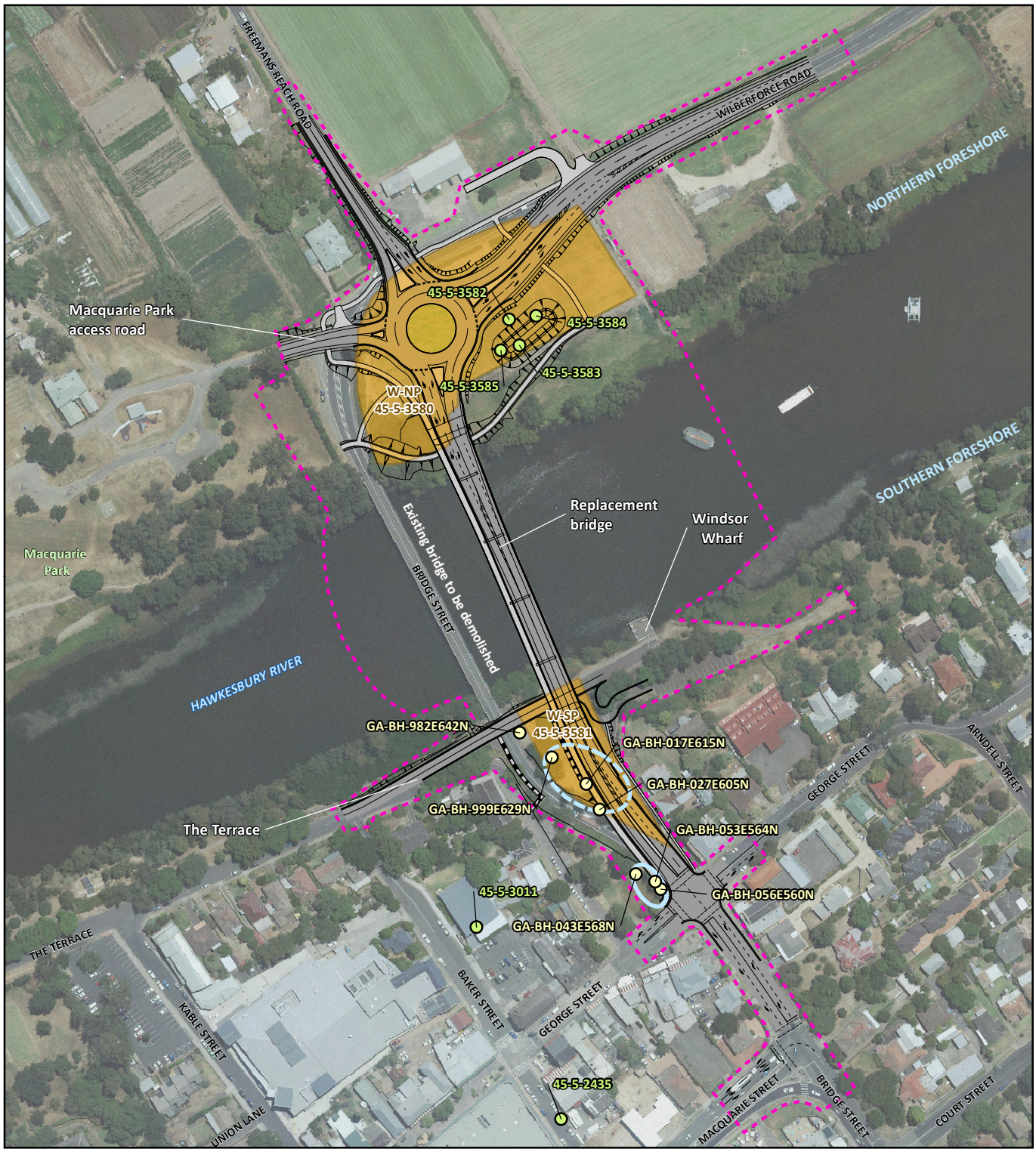
- AHIMS ID 45-5-3011, located adjacent to the Windsor Museum.
- AHIMS ID 45-5-2435, located at the corner of Baker and George Streets.

Previous Aboriginal archaeological investigations at Windsor Museum (AHIMS ID 45-5-3011) revealed a sandy deposit believed to represent an intact Pleistocene sand dune containing over 12,000 lithic items or artefacts. The majority of artefacts identified were unmodified flakes, with one grindstone also recovered. Sediment from the artefact bearing layers was dated to between 8,500 +/- 800 years and 33,900 +/- 1,700 years old and displayed moderate integrity, with the majority of archaeological deposit within the proposed development area being undisturbed.

It is the presence of similar sand bodies within the project footprint that the further archaeological investigations outlined below sought to confirm.

Previous investigations at the corner of Baker and George Streets (AHIMS ID 45-5-2435) indicated a moderate quantity of Aboriginal material interspersed within sometimes high levels of disturbance.

Figure 7-10 | Aboriginal heritage sites



LEGEND

- Concept design
- Construction work zone
- Registered Aboriginal Site location
- Test pit location
- Potential Archaeological Deposit (PAD)

Location of potential artefact sites

- Deep coarse sands
- Shallow fine sands

Indicative only – subject to detailed design

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Project investigation areas

Test excavations undertaken for the project on the northern and southern banks of the Hawkesbury River confirmed the presence of subsurface Aboriginal archaeological material within the project footprint. The previously recorded PADs on the northern bank (W-NP AHIMS ID 45-5-3580) and southern bank (W-SP AHIMS ID 45-5-3581) were confirmed as archaeological sites as a result of the test excavations.

The test excavations revealed a total of 191 stone items considered to be Aboriginal artefacts. Most of these (93 per cent) were recovered from just two test squares on the southern bank.

The majority of recovered artefacts comprised flaked debitage (the waste flakes from creating stone tools). There were also modified cobbles of quartzite or their fragments. One igneous flake, probably off an edge ground hatchet head, was also identified. Further details of the findings at the project investigation areas are provided below.

Northern bank

The investigation area on the northern bank of the river was found to contain deep homogenous floodplain sediments. It is assumed that frequent but low intensity sediment deposition events associated with flooding would have diluted the gradual accumulation of archaeological materials left behind by low intensity hunter-gather activities. The density of artefacts is therefore expected to be very low and artefacts are also expected to have been occasionally displaced during large flood events.

The four test squares on the northern bank revealed a uniform deep alluvial silty loam profile with sparse Aboriginal stone artefacts. A total of six artefacts were collected from four test squares, with five of these found within a single test square. These artefacts were small and rolled, and mixed with redeposited historical material, indicating that the artefacts have been redeposited.

As this area is subject to flooding it is likely that any remaining archaeological objects would have been moved, thereby reducing their scientific value. For this reason, the northern bank investigation area, comprising the existing cultivated turf farm and paddock between the river and Wilberforce Road, is considered to have generally low archaeological significance. There were few artefacts and a low potential for intact archaeology.

Southern bank

The investigation area on the southern bank was found to contain preserved shallow aeolian topsoils on the upper slopes and deep intact sand profiles at mid to lower-slope locations. A total of 185 artefacts were recovered from two of the five test squares, with the three remaining test squares being extensively truncated or mixed by historical road works, landscaping and probable floods.

The highest artefact density was found in the most elevated test square, which was located on the top of the river bank, above the 100 year flood level, in the south east corner of Thompson Square adjacent to George Street. This test square revealed a partially intact sand layer containing 114 stone artefacts. The remainder of artefacts were found in a mid-slope test square below the 100 year flood level. This test square revealed a layered grey humic sandy deposit with moderate artefact densities (64 artefacts) mixed in with historical material. The archaeological material included a disturbed Aboriginal shell midden, possibly redeposited during historic times.

The area of the southern bank is considered to have a higher archaeological significance than the northern bank due to the greater densities of artefacts found and the greater potential for intact artefacts to occur. The results of the geomorphic assessment and the types of artefacts recovered from the southern bank investigation area may also provide information on important cultural dates, which further adds to the significance of the area. The geomorphic assessment, for example, indicated the presence of a partially intact sand layer that has been preserved beneath historic fill material, with the majority of the identified artefacts found within this layer. Furthermore, the identified artefacts included stone tools, which can linked to specific periods of Aboriginal cultural history. No backed artefacts were identified during previous surveys at the Windsor Museum site.

Cultural significance

Throughout the Aboriginal stakeholder consultation process and discussions on-site between stakeholders and archaeologists, it has been clearly identified that the study area has cultural heritage value to the local Aboriginal community. Some of the Aboriginal cultural heritage values expressed by stakeholders include:

- Strong association with the land.
- Responsibility to look after the land, including the heritage sites, plants and animals, creeks and the land itself.
- Artefact sites, especially the high value site associated with the Windsor Museum.
- Historic Aboriginal and European interactions within Windsor.
- Landscape features especially the sand bodies along the Hawkesbury River.
- Indigenous plants and animals.
- General concern for burials, as their locations are not always known and they can be found anywhere.

Summary

Known and potential Aboriginal archaeology occurs within the study area. The study area also has cultural heritage value to the local Aboriginal community.

Significant archaeological deposits occur within parts of Windsor, including within the project footprint. The significance of the archaeological deposit is linked to the presence of sand bodies and is influenced by the extent of soil disturbance.

The Aboriginal archaeological significance of the area within the project footprint is highest on the southern bank of the river. This area has high artefact densities and intact archaeological deposits, as well as archaeological records that may provide information on important cultural dates. In contrast, the area of the project footprint on the northern bank of the river has been affected by frequent flooding, which is likely to have resulted in movement and re-deposition of artefacts. This area has lower artefact densities, a low potential to contain intact archaeological material and is considered to be of low archaeological significance.

7.2.3 Potential impacts

The impacts of the project on Aboriginal heritage would be associated with construction and demolition activities, specifically construction of the replacement bridge and demolition of the existing bridge. Once the replacement bridge is operational, there would be no further potential impacts on Aboriginal heritage.

Six known Aboriginal archaeological sites would be impacted by the project due to their location within proposed construction areas. These sites are W-NP 45-5-3580, W-SP 45-5-3581, W1 45-5-3582, W2 45-5-3583, W3 45-5-3584 and W4 45-5-3585 (refer to **Table 7-10** and **Figure 7-10**).

Five of these sites, namely W-NP 45-5-3580, W1 45-5-3582, W2 45-5-3583, W3 45-5-3584, and W4 45-5-3585, are located on the north bank of the Hawkesbury River in an area that has been disturbed by clearing, cultivation and numerous flood events. The test excavation results suggest that while additional subsurface archaeological objects might be present, these will be isolated and are likely to have been redeposited from their original location of discard, which would limit their scientific value. The Aboriginal objects associated with these five sites would be unlikely to exhibit significant value (as defined in the Burra Charter) because their archaeological context has been disturbed and is no longer intact.

The remaining site, W-SP 45-5-3581, is located on the south bank of the river and contains an archaeological deposit that is at least partially intact. The fine grained sand deposit identified on this site exhibits a largely intact cultural layer that has the potential to be dated, which alone gives the site a high scientific value. Additionally, the identification of backed artefacts indicates a possible difference between this site and the previously recorded site at Windsor Museum, including evidence of more recent occupation than previously suggested. This potentially opens new lines of research into how and when Aboriginal people used Windsor ridge. The finding of a disturbed (possibly redeposited) shell midden at this site also adds a new layer of information.

While the archaeological deposit on the south bank (W-SP 45-5-3581) is of high scientific value, the findings of the significance assessment indicate that the potentially impacted Aboriginal objects would not be suitable for outright conservation because of the overall high level of disturbance within the study area. That is, the value of W-SP 45-5-3581 resides in information rather than conservation.

A key part of conservation management involves obtaining information about the Aboriginal past that can be used to identify and preserve important sites. W-SP 45-5-3581 offers an opportunity to obtain such information with only minor adverse effects. It is therefore proposed that a portion of the W-SP 45-5-3581 archaeological deposit be salvaged before the start of project construction. Further details of the proposed impact mitigation and management strategy are provided in **Section 7.2.5**.

It is likely that similar or superior quality archaeological deposits exist along other parts of the Windsor ridge. Conserving these less disturbed archaeological deposits, rather than the disturbed W-SP 45-5-3581 deposit, would be important to heritage conservation. The information obtained from the proposed salvage activities at W-SP 45-5-3581 would improve our understanding of Aboriginal culture and heritage within Windsor and the wider region, as well as our ability to identify, interpret and preserve significant Aboriginal cultural sites.

In summary, although six Aboriginal sites would be at least partially impacted by the project, the total impact on Aboriginal heritage would be minor given that:

- Five of the sites are of low heritage significance.
- The remaining site, W-SP 45-5-3581, has high scientific value but is not suitable for conservation due to the high level of disturbance within the project footprint.
- A portion of the W-SP 45-5-3581 archaeological deposit would be salvaged to provide information on Aboriginal culture and heritage within Windsor and the wider region, and guide the future identification, interpretation and management of more intact archaeological deposits that are likely to exist along the Windsor ridge.

In terms of the integrity of the Aboriginal archaeological resources of the area, the project would only have a minor impact. Intact geological profiles within the project footprint potentially containing undisturbed Aboriginal artefacts would be relatively uncommon as most of the Thompson Square has been affected by one or more redevelopments over the past 230 years. Also most of the project footprint is located below the 100 year flood level so flood events would also have impacted the integrity of the Aboriginal archaeological resources of the area. While the project footprint may contain some areas of high scientific value in terms of Aboriginal archaeology, they are not unique and are there are likely to be other less disturbed areas especially above the 100 year flood level within Windsor.

Aboriginal cultural impacts

On the basis of discussions with Aboriginal stakeholders present during Aboriginal Focus Groups meetings and during the fieldwork program, it was clear that the Windsor area has some Aboriginal cultural value. No specific places or items were identified within the study area, rather it was indicated that Aboriginal connections were generalised and diffusely spread across the study area – a perception of value as opposed to an empirical value. Within an Aboriginal perspective a cultural continuum exists where every part of 'country' has significance and meaning and is understood by value gradients – some places/objects exhibit more significance than others. In this understanding, the Aboriginal value of the study area resides in its connections, demonstrating a link between people and place in the past and offers a link for contemporary Aboriginal people back to their past. In summary, the study area has Aboriginal cultural value because it demonstrates a connection to the (possible distant) past for contemporary Aboriginal people. However, there is no particular place or item potentially impacted by the project which has high or special cultural significance.

7.2.4 Environmental management measures

Identified sites

The environmental management measures for known Aboriginal sites are summarised in **Table 7-10**. No further archaeological work or impact mitigation would be required on the north bank of the river due to the low heritage significance and low archaeological potential of this area. On the south bank of the river, where the significant W-SP 45-5-3581 site has been identified, salvage excavation of specific portions of the archaeological deposit will be carried. A salvage excavation plan will be developed in consultation with NSW Office of Environment and Heritage which would include the following considerations:

- In the upper portion of W-SP 45-5-3581, at the corner of George and Bridge Streets, the entire extent of the archaeologically significant deposit will be salvaged via open excavation. The area of excavation would be about 100 square metres.
- In the lower portion of W-SP 45-5-3581, in the area between Bridge Street, Old Bridge Street and the wharf carpark[9], a representative sample of archaeological material will be taken to further investigate the relationship between the identified stone artefacts and shell lenses. The area of excavation will be about 25-50 square metres.
- Field and analysis methods for the salvage excavations will be consistent with the DP&I approved methodology set out in Volume 2 - working paper 3.
- DP&I will be consulted during the salvage process.
- A suitably qualified and experienced archaeologist will be appointed to oversee the salvage activities.
- Aboriginal objects recovered during salvage activities will be transferred to the Australian Museum in accordance with legislative requirements, Australian Museum Archaeological Collection Deposition Policy v1.0 January 2012.
- In the event the Australian Museum is unable to accept the objects, the objects will be transferred in accordance with a Care Agreement or similar agreement to an Aboriginal community.
- In the event that neither the Australian Museum nor the Aboriginal community are able to accept the archaeological objects, the suitably qualified and experienced archaeologist appointed to oversee the salvage activities will seek a Care Agreement or similar agreement to curate the objects.
- A written archaeological excavation report will be provided to RMS within a reasonable time following the completion of the archaeological program.

[9] Near test square 017E 630N identified in Working Paper 3.

Unidentified sites

The management measures listed below will be implemented for salvage excavation, and construction and demolition activities (including preliminary and preparatory activities such as fencing, investigative drilling, minor clearing, establishing site compounds and adjustment of services and utilities).

- In the areas where archaeological salvage is proposed, no construction or demolition activities (including preliminary and preparatory activities such as fencing, investigative drilling, minor clearing, establishing site compounds and adjustment of services and utilities) will occur until the salvage activities have been completed.
- Prior to the commencement of preliminary and preparatory construction or demolition activities, a construction heritage site map identifying the known Aboriginal heritage sites and the areas to undergo salvage excavation will be prepared to the satisfaction of RMS.
- Registered Aboriginal stakeholders will be provided with the opportunity to assist with the salvage excavation.
- Incident reporting procedures for the project will cover incidents involving Aboriginal heritage.
- Project environmental management plans will identify procedures for handling human remains, including an immediate stop to work in the vicinity of the find and reporting to appropriate authorities including the Police, Office of Environment and Heritage and Aboriginal stakeholders.

Table 7-10 Environmental management measures for potentially impacted sites

Site ID	Site type	Description	Significance	Impact	Impact mitigation measures
W-SP AHIMS ID 45-5-3581	Artefact scatter	Located on the south bank of the Hawkesbury River. A portion of the site is above the 1 in 100 year flood zone within Thompson Square at the corner of George and Bridge streets. This area contains fine grained sand layers and high artefact densities. A second more disturbed portion of the site is located below the 1 in 100 year flood zone between Bridge Street, Old Bridge Street and the wharf car park. This area contains moderate artefact densities, including displaced midden material.	High	Will be impacted	Salvage excavation of entire archaeological deposit at the corner of George and Bridge Street within the construction work zone. Salvage of a representative sample of the archaeological deposit with the lower portion of the site between Bridge Street, Old Bridge Street and the wharf car park.
W-NP AHIMS ID 45-5-3580	Artefact scatter	Located on north bank of Hawkesbury River within flood prone terrace. Deep homogenised profile with no evidence of buried soils.	Low	Will be impacted	No impact mitigation is required as the site exhibits low Aboriginal heritage significance.
W1 AHIMS ID 45-5-3582	Isolated find	Located on north bank of Hawkesbury River within flood prone terrace. Deep homogenised profile with no evidence of buried soils.	Low	Will be impacted	No impact mitigation is required as the site exhibits low Aboriginal heritage significance.
W2 AHIMS ID 45-5-3583	Isolated find	Located on north bank of Hawkesbury River within flood prone terrace. Deep homogenised profile with no evidence of buried soils.	Low	Will be impacted	No impact mitigation is required as the site exhibits low Aboriginal heritage significance.
W3 AHIMS ID 45-5-3584	Isolated find	Located on north bank of Hawkesbury River within flood prone terrace. Deep homogenised profile with no evidence of buried soils.	Low	Will be impacted	No impact mitigation is required as the site exhibits low Aboriginal heritage significance.
W4 AHIMS ID 45-5-3585	Isolated find	Located on north bank of Hawkesbury River within flood prone terrace. Deep homogenised profile with no evidence of buried soils.	Low	Will be impacted	No impact mitigation is required as the site exhibits low Aboriginal heritage significance.

7.3 Traffic and transport

This section assesses traffic, access and transport impacts of the project. The assessment is supported by a traffic and transport working paper, which is presented in Volume 2 - Working paper 4. The assessment has addressed the Director General's requirements for traffic and transport (as detailed in **Table 7-11** below) as well as the relevant requirements of Schedule 2, Part 3 of the *Environmental Planning and Assessment Regulation 2000*. This section also addresses one of the Director General's requirements for Visual Amenity, Urban Design and Landscape that relates to pedestrian and cycle access and networks.

Table 7-11 Director General's requirements

Director Generals requirements	Where addressed
Traffic and transport	
Demonstration of how the preferred bridge alignment and design meets the traffic and transport objectives of the project	Section 7.3.4
Justification for the capacity of the bridge, taking into account future growth areas and traffic (vehicular, cyclist and pedestrian) needs	Section 7.3.4
Construction traffic access to the project (including ancillary facilities) and associated management measures, in particular impacts to the road network (including safety and level of service, access to the town centre and tourist and recreational facilities, disruption to public transport services and access to properties)	Section 7.3.3 & 7.3.5
Operational traffic and transport impacts to the local and regional road network, including impacts of the new bridge alignment through the town centre and Thompson Square	Section 7.3.4
Impacts of the project (construction and operational) on the use and access to Windsor Wharf, and existing and future maritime and recreational use of the Hawkesbury River	Section 7.3.3 & 7.3.4
Safety of navigation in the Hawkesbury River for the water based traffic	Section 7.3.3 & 7.3.4
Visual Amenity, Urban Design and Landscape	
Details of integration of the bridge and Thompson Square with existing and future pedestrian and cycle networks, including design and safety measures for pedestrian and cycle access on the bridge.	Section 7.3.2, 7.3.4, 3.1 and 5.2.4

7.3.1 Guidelines and methodology

Traffic and transport project objectives

The traffic and transport project objectives and associated criteria have been used to guide the development of the project. They can be summarised as follows:

- To improve safety for motorists, pedestrians and cyclists
  - Meets the current design codes (eg traffic lane widths, shoulder widths and shared path widths).
  - Meets a road speed of 50 kilometres per hour.
  - Ensures pedestrian safety.

- To improve traffic and transport efficiency
  - Minimises queue length/delays.
  - Improves performance of the road network (level of service).
  - Enables two heavy vehicles to pass on the bridge without waiting.

How the project meets these objectives is discussed in **Section 7.3.5**.

Traffic assessment

The principal focus of the traffic assessment is the route from Bridge Street (at Macquarie Street) in the south to Wilberforce Road on the northern side of the Hawkesbury River. The study area includes adjacent intersections and roads as shown in **Figure 7-11**. Data relating to current traffic conditions came from three main sources:

- AM and PM peak intersection turning counts conducted in December 2011.
- Twenty-four hour classified bridge traffic counts conducted in March 2012.
- RMS count stations for various years pre-2005, the most recent being from 2005.

Further information about traffic patterns in Windsor was drawn from the 'Windsor Town Centre Traffic Study' (Christopher Hallam & Associates Pty Ltd, July 2011).

Traffic profiles for major roads in the study area, as well as historical growth rates were constructed using 2005, 2011 and 2012 traffic counts. The current performance of intersections was evaluated with intersection modelling software, and a crash analysis was undertaken for roads in the study area.

Traffic forecasts to the anticipated year of opening (2016) and 10 years after opening (2026) for future modelling were determined using the 2011 and 2012 counts with applied growth rates derived from the Sydney Strategic Travel Model. The Sydney Strategic Travel Model (SSTM), which was used to estimate future traffic growth, is a world class tool, operated by the Bureau of Transport Statistics (BTS) within Transport for NSW. It is used for projecting travel patterns in Sydney, Newcastle and Wollongong under different land use, transport and pricing scenarios. It can be used to test alternative settlement, employment and transport policies, to identify likely future capacity constraints, or to determine potential usage levels of proposed new transport infrastructure or services.

The SSTM is a series of models and processes that attempts to replicate, in a simplified manner, people's travel choices and behaviour under a given scenario. The SSTM uses detailed current demographics to synthesise households of different types. This allows for powerful forecasting of the travel behaviour of different market segments. The BTS applies its population projections to these different household types across the greater metropolitan area of Sydney. Workplaces are one of the key travel destinations and therefore it is important to know where workplaces are likely to be located in the future and how their distribution may change. BTS' Employment Projections are used in the SSTM to identify the location of future employment and are an important component of the commute travel model. Use of the SSTM and BTS projections for this project is considered appropriate given the nature of the road network surrounding the project. This would be different for a project in a more dynamic road network such as Sydney Airport, for example.

The SSTM considers regional strategies such as the North West Subregional Strategy however Hawkesbury local development strategies such as the Hawkesbury Residential Lands Strategy were not expressly included. Nevertheless, the household growth assumptions included in the SSTM are consistent with the dwelling targets anticipated by Hawkesbury City Council.

The use of traffic forecasts for 10 years after opening is standard practice for assessing the future performance of road developments. Estimating traffic numbers for periods greater than 10 years after opening is generally not undertaken because the estimates have a high degree of inaccuracy and are dependent upon other factors such as the rate of land development and the location of major employment destinations. The estimates of growth in traffic using the project in 2026 are presented in **Table 7-15** and are relatively high in comparison to other similar roads.

The intersection performance analysis uses Level of Service as the measure of intersection performance. The Level of Service criteria for intersections is shown in **Table 7-12**. Level of Service is a qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and/or passengers.

Table 7-12 Level of Service criteria for intersections

Level of service	Average delay per vehicle (sec/veh)	Traffic signals and roundabouts	Give way and stop signs
A	Less than 15	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity and accident study required
E	57 to 70	At capacity; at signals incidents will cause delays Roundabouts require other control mode	At capacity, requires other control mode
F	Over 70	Extra capacity required	Extreme delay, traffic signal or other major treatment required.

Source: Austroads Traffic Engineering Practice Series Part 2

Different intersection options were first tested with stand-alone intersection models (SIDRA models) to identify intersection options that provided acceptable traffic performance. Preferred intersection options were then assessed in a regional and local network road model to identify any interaction between the preferred intersection options and the overall performance of the project in the wider road network.

Other issues

For other traffic and transport related issues the following process was undertaken to assess potential impacts and develop environmental management measures:

- The existing patterns of transport, access and use as well as facilities such as paths, wharfs and routes were identified.
- For construction, preliminary construction plans and methodologies were used to identify and assess potential impacts.
- For operation, the design and functional operation of the project were used to identify and assess potential impacts.
- Environmental management measures were then developed for identified impacts.

Figure 7-11 | Key roads in study area

Indicative only – subject to detailed design

LEGEND

- Concept design
- Key roads in study area

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AUSIMAGE SKM

7.3.2 Existing environment

Road traffic

The existing Windsor bridge is a road, cyclist and pedestrian crossing of the Hawkesbury River at Windsor. Major traffic routes through Windsor include:

- Windsor Road-Bridge Street, to Wilberforce.
- Hawkesbury Valley Way, to Richmond.
- Macquarie Street, linking Bridge Street, Hawkesbury Valley Way, through to South Windsor and The Northern Road to Penrith.

Key roads in the study area have been classified within a hierarchy according to the role they fulfil in the road network and their traffic carrying capacity. The different road classifications are described in detail in the Traffic and transport working paper (Volume 4 – Working paper 4). The key roads in the study area are described below:

- **Bridge Street**, shown in **Figure 7-12**, is a sub-arterial road running north-west/south-east. It is 700 metres long in total and stretches from Macquarie Street to Wilberforce Road. It is the road which crosses over Windsor bridge, and forms part of State Route 69 to Singleton. Major intersecting roads include Macquarie Street, George Street and Freemans Reach Road. Bridge Street is primarily one lane in each direction, with additional turning lanes provided at the intersection with Macquarie Street. The posted speed limit is 60 km/h, and the road bends sharply at both ends of the bridge. Trucks and buses are limited to 40 km/h across the existing bridge. Traffic volumes over the bridge are estimated to be around 19,000 vehicles per day (Average Daily Traffic estimated from peak hour traffic surveys undertaken in 2011). Bridge Street is part of the B-Double Route from Windsor Road to Wilberforce Road.

Figure 7-12 Bridge Street at Windsor bridge (looking south towards Windsor)

Figure 7-13 Looking north along Freemans Reach Road from Wilberforce Road

- **Wilberforce Road** is a sub-arterial road running north-east/south-west from Bridge Street, connecting Windsor to Wilberforce and forming part of State Route 69 to Singleton. The road is one lane in each direction with a posted speed limit of 80 km/h in the section approaching Windsor bridge. About 13,000 vehicles travel on the road each day. Wilberforce Road is part of a B-Double Route running from Windsor Road via Bridge Street.
- **Freemans Reach Road,** shown in **Figure 7-13**, is a collector road running north-south from Bridge Street, connecting Windsor to Freemans Reach. The road has one lane in each direction with a posted speed limit of 80 km/h, reducing to 60 km/h on the southbound approach to the intersection with Wilberforce Road. About 7000 vehicles travel on the road each day.
- **George Street**, shown in **Figure 7-14**, is a local road within the study area. It connects Bridge Street to the Windsor town centre, which is to the west of the Bridge Street/George Street intersection. It connects Bridge Street to a residential area on the eastern side of the Bridge Street/George Street intersection. George Street has one lane in each direction with space for on-street parking on both sides of the street. It has a posted speed limit of 50 km/h. Daily traffic volume data for the roads within the study area is unavailable. However, the Windsor Town Centre Traffic Study' (Christopher Hallam & Associates Pty Ltd, July 2011) suggests that the eastern approach of George Street to Bridge Street experiences higher than expected volumes in peak times due its role as a link in the 'rat run' of drivers avoiding the left turn from Macquarie Street into Bridge Street. Instead, these drivers turn right from Macquarie Street into Bridge Street, then left into Court Street, left into Arndell Street, left into George Street and right into Bridge Street.

Figure 7-14 George Street / Bridge Street intersection (looking south west)

- **Macquarie Street** is an arterial road running north-east/south-west. The section within the study area links the Windsor town centre with Richmond, Penrith and Campbelltown, and forms part of Metroad 9. There are three northbound lanes and two southbound lanes, with a posted speed limit of 60 km/h.
- **Old Bridge Street** is a 100 metre long local road running north/south. It connects Bridge Street, adjacent to the George Street intersection, to Windsor Wharf. It provides access to local properties and the car parks adjacent to Windsor Wharf. There is a turning bay for northbound drivers on Bridge Street entering Old Bridge Street.
- **Thompson Square road** is a local road running north-west/south-east. It is a brick-paved road that connects George Street to The Terrace. It forms the western edge of Thompson Square parkland. The road is one-way in the north-west direction.
- **The Terrace** is a local road running north-east/south-west, parallel to the Hawkesbury River, primarily between Thompson Square and Moses Street / Tebbutt Street. The road connects the Windsor town centre to residences in the west, and is one lane in each direction with parking lanes on both sides. An 80 metre long section of The Terrace runs to the east of the junction with Baker Street, terminating at a dead-end at the western side of Bridge Street. In addition, a former part of The Terrace lies to the east of Bridge Street, consisting of a short 65 metre stretch connecting Windsor Wharf to Old Bridge Street.
- The **Macquarie Park access road** is the driveway for Macquarie Park, on the northern bank of the Hawkesbury River. It joins Bridge Street on the northern bend after Windsor bridge, near the Wilberforce Road / Freemans Reach Road intersection. A turning bay for southbound drivers from Bridge Street to Macquarie Park is marked.

The number of vehicles per hour on Bridge Street, south of Windsor bridge averaged over seven days in March 2012, are shown in **Figure 7-15**, split by classification, and in **Figure 7-16**, split by direction. Traffic is mostly made up of light vehicles, with heavy vehicles making up seven per cent of vehicles. The highest morning traffic volumes occur at 8:00am, with the majority of flow in the southbound direction towards Sydney, whilst the highest evening traffic volumes occur at 5:00pm with most traffic travelling northbound.

Intersection operation

Intersection analysis for the AM and PM peaks was undertaken at the following intersections:

- Bridge Street / Macquarie Street.
- Bridge Street / George Street.
- Wilberforce Road (Bridge Street) / Freemans Reach Road.

Table 7-13 shows the results of the analysis for both the AM and PM peaks at key intersections.

Table 7-13 Level of Service at existing intersections

Intersection	Control	AM Peak		PM Peak	
		Level of Service for worst movement	Average Delay per Vehicle (seconds)	Level of Service for worst movement	Average Delay per Vehicle (seconds)
Bridge Street / Macquarie Street	Signals	D	45.2	D	45.8
Bridge Street / George Street	Roundabout	B	20.0	B	27.4
Wilberforce Road/ Bridge Street / Freemans Reach Rd	Give Way	F	>100	F	>100

Notes: LoS = Levels of Service (refer to Table 7-12)

The intersection analysis shows that the Bridge Street / George Street intersection is operating well with acceptable delays and some spare capacity, whilst the Bridge Street / Macquarie Street intersection is operating near the maximum desired capacity. The Wilberforce Road / Freemans Reach Road intersection is also shown to perform unsatisfactorily, which is consistent with community observations of long queue lengths and delays in peak periods.

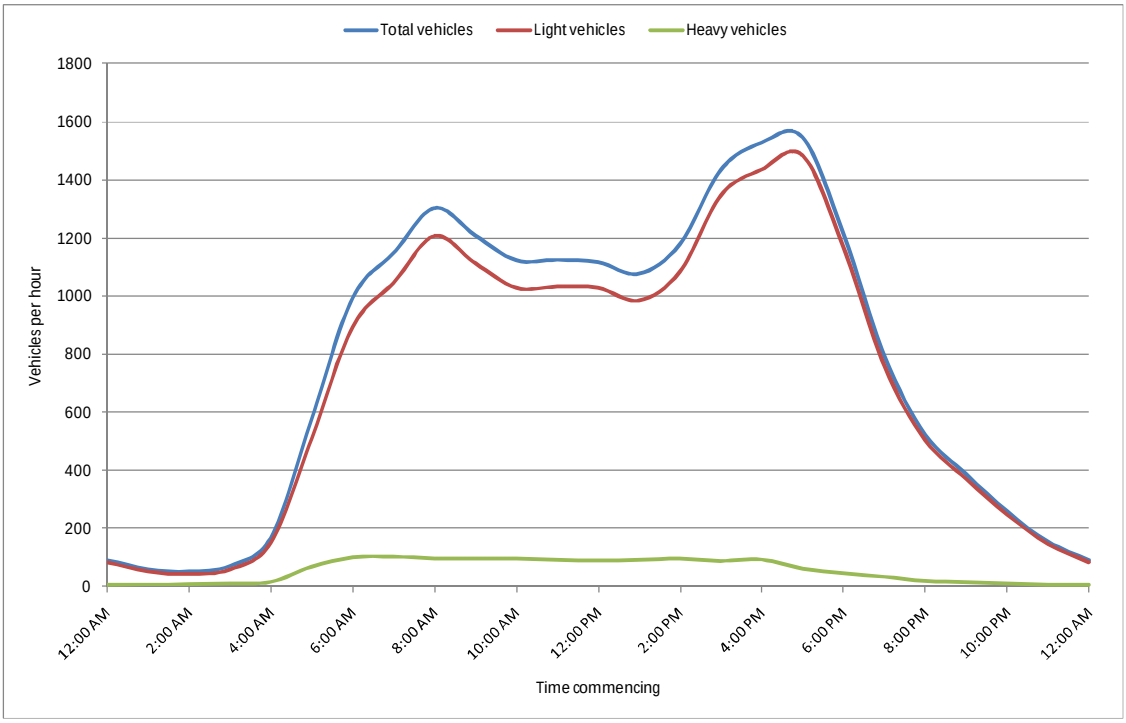


Figure 7-15 Hourly profile of vehicles in Bridge Street, split by classification

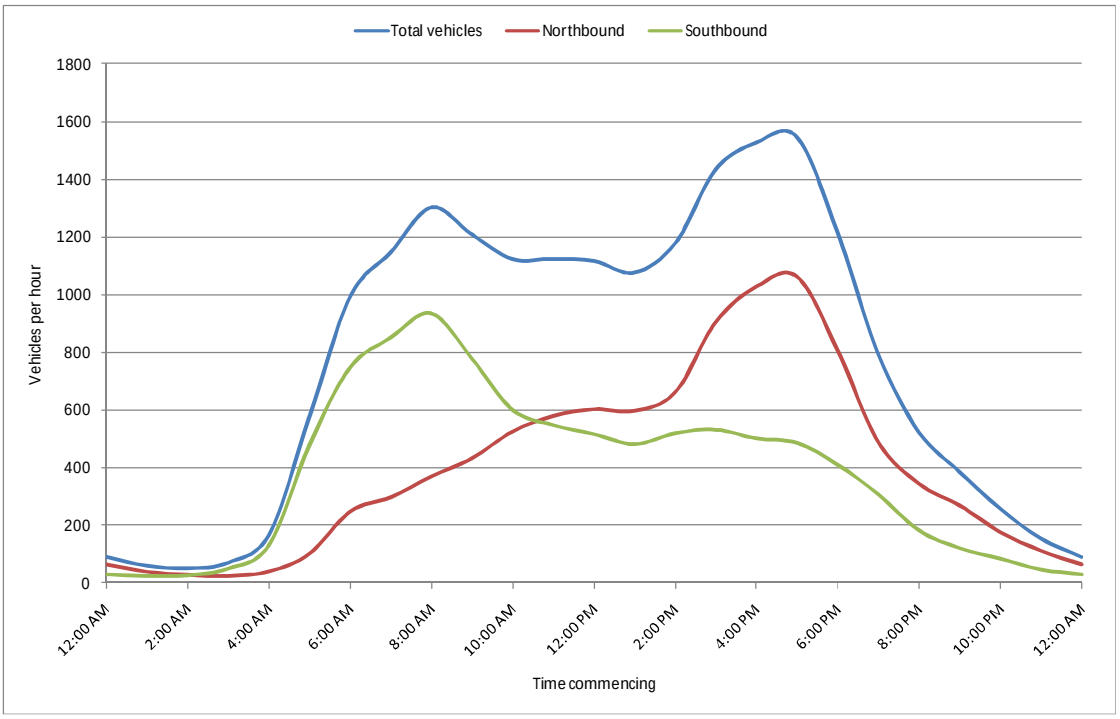


Figure 7-16 Hourly profile of vehicles in Bridge Street, split by direction

Crash history

Crashes recorded along Wilberforce Road between Freemans Reach Road and the eastern end of Windsor bridge for the five-year period ending 2009 were analysed. Of the 16 reported crashes during that period, the majority were recorded at Wilberforce Road near Freemans Reach Road and most of these crashes occurred when vehicles were approaching from adjacent roads. This type of crash occurred ten times in the five year period. There was also one head on crash at this location. On the northern approach road there was one crash associated with a head-on collision, two were rear-end collisions, and one crash resulted from a vehicle losing control on a curve and hitting an object. A single 'pedestrian hit' crash was recorded at the intersection of Bridge and George streets however pedestrian and cycle crashes are known to be under-reported.

Public transport

Bus routes in the region are provided by Westbus and Hawkesbury Valley Buses, with several routes servicing the Windsor town centre. Westbus Route 668 is the only service which travels on Bridge Street north of Macquarie Street, over the Windsor Bridge. The route accesses Glossodia and Richmond from Windsor via Wilberforce, and also provides a shuttle between Windsor and Wilberforce for passengers on Westbus Route 669. Daily school bus routes also use the Windsor bridge.

Pedestrians and cyclists

Windsor bridge carries a narrow pedestrian and cycle path on its eastern side. This shared path links The Terrace and Old Bridge Street in the south with the intersection of Wilberforce and Freemans Reach Roads in the north. The shared path on the existing bridge also forms an off-road link in the local cycle network, as shown in **Figure 7-17**. This figure also shows potential future cycle routes which would be the responsibility of Hawkesbury City Council or others to develop and fund in the future.

There are some key shared paths within the Hawkesbury LGA for both recreational and transport purposes. These include the Ham Common shared path between Richmond and Clarendon, the shared path along the Bells Line of Road between North Richmond and Kurmond and the Parramatta to Windsor off-road cycleway which follows the alignment of Windsor Road. These paths do not link with each other, particularly the Ham Common path which does not extend to either Windsor or Richmond.

A plan has been developed for a Great River Walk, which would extend for 570 kilometres along the length of the Hawkesbury-Nepean River, from the estuary at Broken Bay to its source in the Southern Highlands and beyond to Canberra (GTA Consultants, 2010). The Great River Walk would extend along the southern foreshore of the Hawkesbury River in the study area linking Governor Philip Reserve, Deerubbin Park, Macquarie Park, Howe Park, Holland's Paddock, Thompson Square and Windsor Wharf reserve.

No pedestrian crossing facilities are provided at the Bridge Street / George Street roundabout intersection. Pedestrians have difficulty identifying a safe gap in which to cross during peak traffic periods and sightlines are poor as the intersection is located at the top of a crest. The lack of pedestrian crossing facilities at this intersection is also a barrier to direct pedestrian movements from the eastern section of the town, where much of the accommodation and Governor Phillip Park is located, to the town centre.

No pedestrian crossing facilities are available on the northern bank for pedestrians wanting to cross from the shared path on the existing bridge to Macquarie Park. An underpass of the existing bridge is currently provided for pedestrians on The Terrace, but this route requires climbing a number of stairs and is, therefore, not accessible for pedestrians with restricted mobility.

Water-based activities at Windsor

The following water-based activities occur in the Hawkesbury River near Windsor:

- **Hawkesbury Paddle Wheeler** - Operates daily passenger cruises from the Wharf on The Terrace, just downstream (east) of the existing bridge. The 11 metre high vessel is too high to pass under the existing Windsor Bridge.
- **Hawkesbury River Boat Cruises** - The vessel "River Dream" provides regular cruises from Windsor. This low height vessel should be able to pass under the existing Windsor Bridge.
- **Hawkesbury River Canoe Classic** - This is an annual 111 kilometre overnight race from Windsor Bridge to Brooklyn. The 2011 event in October attracted over 500 competitors.
- **Bridge to Bridge Events** - Two annual races are held. The water ski race takes place in November each year and a power boat race is held every May. The course for both races is the Hawkesbury River from Brooklyn to Windsor (111 kilometres). Both events attract competitors from Australia and overseas. The 2010 power boat event had 57 vessels completing the course.
- **Personal craft** - The Hawkesbury River is navigable and tidal for over 130 kilometres from Broken Bay to Richmond (about 13 kilometres upstream of Windsor). However, between Windsor and Richmond, the river is very shallow in places and subject to weed infestations.

The river is used by a wide range of craft, including canoes, kayaks, motor boats and houseboats. There are five houseboat operators on the river. Houseboats cater for up to 12 people and are typically hired for periods of three days to one week. It is unlikely that houseboats would attempt to pass under the Windsor Bridge due to the shallow water upstream of Windsor.

There are numerous public and private boat ramps downstream of Windsor. The nearest ramp to the town is at the eastern end of Governor Philip Park, at the confluence of South Creek and the Hawkesbury River.

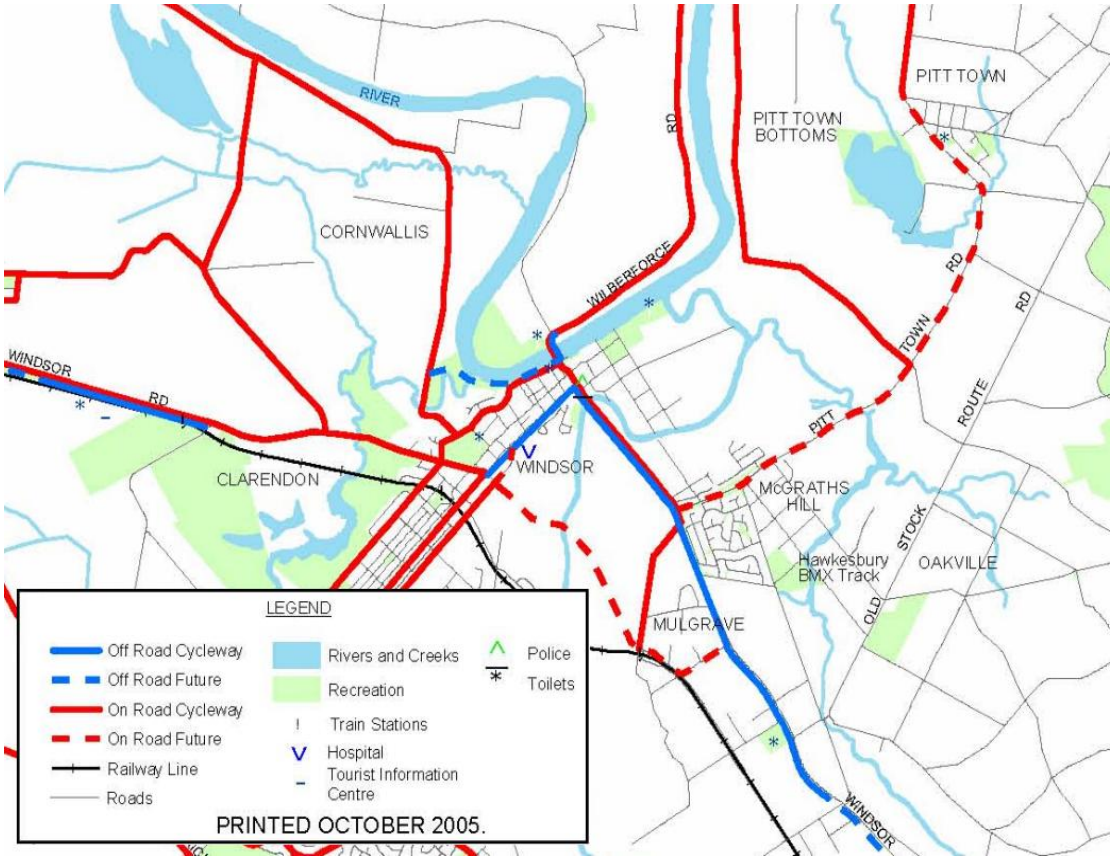


Figure 7-17 Local cycle routes

Adapted from Hawkesbury City Council 2011 – http://www.hawkesbury.nsw.gov.au/__data/assets/pdf_file/0012/723/Cycling-in-the-hawkesbury-2011-May.pdf

7.3.3 Construction impacts

Impacts on traffic

The construction of the project would generate construction traffic travelling to, from, and within the project. It is likely that most of the heavy vehicle construction traffic would originate from the south of the project. The construction traffic movements to / from the work sites would have the potential to impact the efficient movement and safety of other road users. Additional traffic movements would be generated by:

- Construction workers travelling to and from worksites.
- The delivery of heavy vehicles and machinery, and other equipment required for construction.
- The delivery of construction materials including concrete, steel, aggregates, imported fill as detailed in **Table 7-14**, as well as pre-fabricated structural elements.
- The movement of spoil generated by earthworks, including the movement of materials within the site, transferral to stockpile sites and/or removal from the project site.

The potential for the most substantial traffic impacts would be where construction site accesses intersect with existing roads. These locations are likely to be Wilberforce Road east of the intersection of Freemans Reach Road and Wilberforce Road for the northern site compound and at the intersection of The Terrace and Bridge Street for the southern site compound. Minor temporary road works would be undertaken on Wilberforce Road to provide a safe and efficient access to the northern site compound. Temporary traffic lights or similar traffic control measures would be installed for access to the southern site compound.

The quantities of materials and heavy vehicle trips generated by the construction of the project would be relatively low when compared to average daily traffic volume of about 19,000 vehicles. (see **Table 7-14**). Consequently, the existing operational performance of roads and intersections would not be significantly impacted by construction.

The activity that would generate the most heavy vehicle movements would be concrete pours for the incrementally launched bridge. These would generally occur every fortnight and involve up to twenty concrete trucks over a ten hour period. This number of concrete trucks over a ten hour period would not cause significant impacts. Other arrivals and departures of heavy vehicles would generally be evenly spread throughout the construction period.

At its peak there would be about 110 workers and other construction personnel on site who would generate about 220 traffic movements a day travelling to and from site. This represents an increase in daily traffic movements of around one percent. Most construction workers would come from south of Windsor and therefore would be travelling in the opposite direction of the AM and PM peak traffic flows. Overall the impact on road traffic capacity of construction workers travelling to and from site would be negligible.

Table 7-14 Estimate of types and quantities of materials for construction

Description	Approximate quantities	Truck Movements	Duration (months)	Average Daily Movements
Road works				
Earthworks (cut to fill)	1,500 m^3	120	1	6
Earthworks (imported fill)	10,000 m^3	800	3	14
Concrete	3,500 m^3	280	3	5
Asphalt	1,000 tonnes	80	1	4
Dense grade base (DGB)	650 m^3	52	1	2 -3
Structural steel	30 tonnes	3	3	1
Bridge works				
Concrete	2400 m^3	192	6	2
Steel reinforcement	450 tonnes	45	6	1
Asphalt	500 tonnes	50	2 weeks	5
Imported fill	800 m^3	64	1	3

The overall impact of construction on local traffic is anticipated to be minor, as construction would generally be undertaken clear of existing traffic and works potentially disrupting traffic would be undertaken outside of high traffic periods. The level of service of the existing bridge, approach roads and intersections would not be significantly impacted.

Minor delays for traffic using Bridge Street, George Street, Wilberforce Road and Freemans Reach Road would occur during construction when reduced speed limits are in place or when manual traffic control is required for construction vehicles to access and exit work sites. There would also be delays during periods when the existing sections of road are being tied in with the newly constructed sections of road, however these would be scheduled to occur outside of peak hours.

Construction haulage routes

The construction of the project would not require major earthworks and only a relatively small quantity of imported fill material (about 11,800 m^3) would be required. Consequently the number of earthworks related truck movements would be low and there would be no significant internal haul routes between project sites. The majority of truck movements associated with the construction of the project would be generated by the delivery of materials such as fill material, concrete, pre-cast elements, steel, pipes and formwork. These materials would be sourced from various locations within the region and the Sydney metropolitan area although most deliveries would originate south of Windsor and would access the project area via major arterial roads such as Windsor Road and Macquarie Street.

The demolition of the bridge would generate about 800 total truck movements (around 400 trucks travelling to and from site) over a six month period to remove demolished sections of the bridge. On average there would be about six truck movements a day (with a daily peak of about 12 truck movements) which is less than 0.1 percent of daily traffic movements. Most truck movements would be to and from locations south of the project area including metal recyclers for the steel components of the bridge that are suitable for recycling, concrete recyclers for the bridge deck and landfill for the parts of the bridge that are not able to be recycled or reused. The southern routes to access and exit the project area are Windsor Road and Macquarie Street from the southern bank and from the northern bank - Wilberforce Road, Kurmond Road and Blacktown Road /Richmond Road or Hawkesbury Valley Way and Windsor Road.

There would be demolition truck movements from both the northern bank (Wilberforce Road and Kurmond Road to Richmond) and from the southern bank (The Terrace and Baker Street). If feasible, the bridge would be demolished from south to north with the majority of truck movements from the northern bank, avoiding the local roads in Windsor. However because of the poor structural condition of the existing bridge, this may not be possible and the demolition of the bridge may have to start from the middle and progress both north and south.

Impacts on property access

Access to properties would be maintained throughout the construction of the project, although temporary interruptions to access would be required at various times. Properties most likely to be impacted by interruptions in access would be 4 and 6 Old Bridge Street.

Impacts on access to the town centre

There would be no major impacts on access to the town centre during construction. Reconstruction of the George Street/Bridge Street intersection would be undertaken in low traffic periods (ie evenings and night time) when the demand for access to the town centre would be low. If temporary road closures are required, alternative routes to access the town centre would be provided at all times.

Impacts to tourist and recreational facilities

There would be temporary impacts on access to some recreational facilities. The lower parkland areas of Thompson Square would be closed to the public during construction of the project. Once the replacement bridge is open, a portion of the upper parkland in Thompson Square would also be closed for public access for about two months to allow the safe removal and infilling of the southern approach road to the existing bridge and to undertake landscaping.

There would be some temporary changes and potentially some minor delays in access to Macquarie Park during the construction of the new access roads and paths to the park. However, pedestrian and vehicle access would be maintained at all times and any impacts would be minimised especially on weekends or for planned events in the park.

Access to Governor Phillip Park would be unaffected by the construction of the project. Apart from Thompson Square, access to other tourist facilities in close proximity to the project such as the Hawkesbury Museum, Macquarie Inn and motels would not be directly impacted during the construction.

Impacts on cyclists and pedestrians

No specific on road facilities are currently provided for cyclists within the road network impacted by the project except for the shared path on the existing bridge. Cyclists currently travel in amongst general traffic and would, therefore, be subjected to the same minor delays as general traffic.

Pedestrian access would be maintained to Windsor Wharf via Old Bridge Street. The lower Thompson Square parkland, the Windsor Wharf parkland and The Terrace east of the existing bridge would be closed to public access during construction. Other pedestrian paths would not be impacted.

Impacts on bus operations

There would be no disruption to existing passenger and school bus routes during construction as no roads would be closed. Minor delays may be experienced due to reduced speed limits or during manual traffic control.

Impacts on emergency vehicles

Construction would not impact on emergency vehicles, as vehicular access along all roads impacted by the work would be maintained.

Access to Windsor Wharf

Public vehicle access to Windsor Wharf would be closed once construction commences as the Windsor Wharf car park and The Terrace would be used as a construction compound. Service vehicle access to Windsor Wharf would be maintained for as long as possible until The Terrace is temporary closed for safety reasons due to the incrementally launched bridge. Pedestrian access to Windsor Wharf would be maintained at all times.

Impacts on maritime activities

Temporary exclusion zones and/or no wash zones around water-based construction sites and activities would be required. However at all times passage up and downstream of the construction areas would be maintained. Water-based construction activities would not impact upon the operation of Windsor Wharf.

Impacts on safety

All temporary accesses, road works and other traffic management measures would be designed and operated to confirm with relevant road safety and RMS requirements and would not impact upon the safety of the users of the existing road network.

Safe pedestrian access designed to relevant safety requirements would be provided for all path and other pedestrian facilities.

Impacts on parking

Parking for construction workers would be provided within the nominated construction compounds where possible, with only limited parking provided on the southern bank and a larger parking area on the northern bank. Preliminary discussions have been held with Hawkesbury City Council on the use of an area of Macquarie Park for overflow parking for construction workers and this would be the likely solution for construction worker's parking. As construction works on the weekend would be limited, it is unlikely that the project would require overflow parking in Macquarie Park during the weekend – which is the period of higher usage of the park.

Parking would be discouraged from the Windsor town centre and surrounding roads.

7.3.4 Operational impacts

Future traffic volumes

Future traffic volumes were determined using 2012 intersection counts and growth rates from the Sydney Strategic Travel Model. These growth rates are presented in **Table 7-15**. The project would not be expected to generate any additional traffic or change travel patterns as it is a replacement of an existing section of road.

Table 7-15 Growth rates of key roads (using 2011 as the base year)

Road	Growth to 2021 (%)	Growth to 2026 (%)
Bridge Street, over Windsor Bridge	17.3	25.3
Wilberforce Road, north of Freemans Reach Road	15.2	22.9
Freemans Reach Road, north of Wilberforce Road	20.7	29.3

Using the growth rates and average daily traffic (ADT) volumes over the Windsor bridge in March 2012, 2021 and 2026 traffic volumes were estimated and are presented in **Table 7-16**. Planning assumptions, such as the scope of developments and their timeframes may change and consequently projected traffic growth may be achieved earlier or later than predicted.

Table 7-16 Bridge Street ADT projections

Road	2012 ADT (base)	2021 ADT	2026 ADT
Bridge Street, over Windsor bridge	19,000	22,500	24,000

Intersections

For each of the key intersections, a number of different options were investigated and assessed using SIDRA intersection modelling software. A full description of the different options assessed is presented in the Traffic and transport working paper (Volume 4 – Working paper 4) and Chapter 4. Relevant results from the SIDRA assessment are presented in the tables below.

At the Freemans Reach/Wilberforce Road intersection, the existing “Give way” intersection type currently has an unacceptable Level of Service. A number of alternative intersections types were investigated and assessed using SIDRA. Traffic signals at the intersection were found to provide the best Level of Service of all options. However the intersection is in the floodplain and would be subject to periodic inundation by flood water which would decrease operational reliability and increase maintenance costs of traffic signals. Also the intersection is located in a rural setting and traffic signals would not be appropriate in this type of visual environment. A number of roundabout options were also assessed and a dual lane 4 legged roundabout intersection was identified as providing an acceptable Level of Service in 2026.

While the existing George Street/Bridge Street roundabout intersection currently has an acceptable Level of Service, by 2016 the Level of Service would decrease to an unacceptable level in the PM peak (see Traffic and transport working paper (Volume 4 – working paper 4)). Therefore alternative intersections options were investigated. Alternative roundabout designs were not considered suitable for the Bridge Street/George Street intersection as there is no available land to increase the size of the roundabout due to heritage and property constraints and a roundabout does not provide for effective and safe pedestrian crossing. The alternative intersections options investigated all included traffic lights and had various lane and turning configurations. The preferred option for the George Street/Bridge Street intersection is presented in **Figure 7-18**. The key features of the intersection would be:

- Vehicles travelling south on Bridge Street north would be able to turn right into George Street west via a dedicated right hand turn lane. Vehicles under nine metres in length would be able to turn left into George Street east.
- Vehicles travelling north on Bridge Street south would be able to turn left into George Street west via a dedicated left hand turn lane. Vehicles would not be permitted to turn right into George Street east as this would result in unacceptable Level of Service for the intersection as a whole. For vehicles wanting to access east Windsor and Governor Phillip Park, a dedicated right turn bay would be provided at the intersection of Bridge Street and Court Street about 170 metres south of the George Street/Bridge Street intersection.

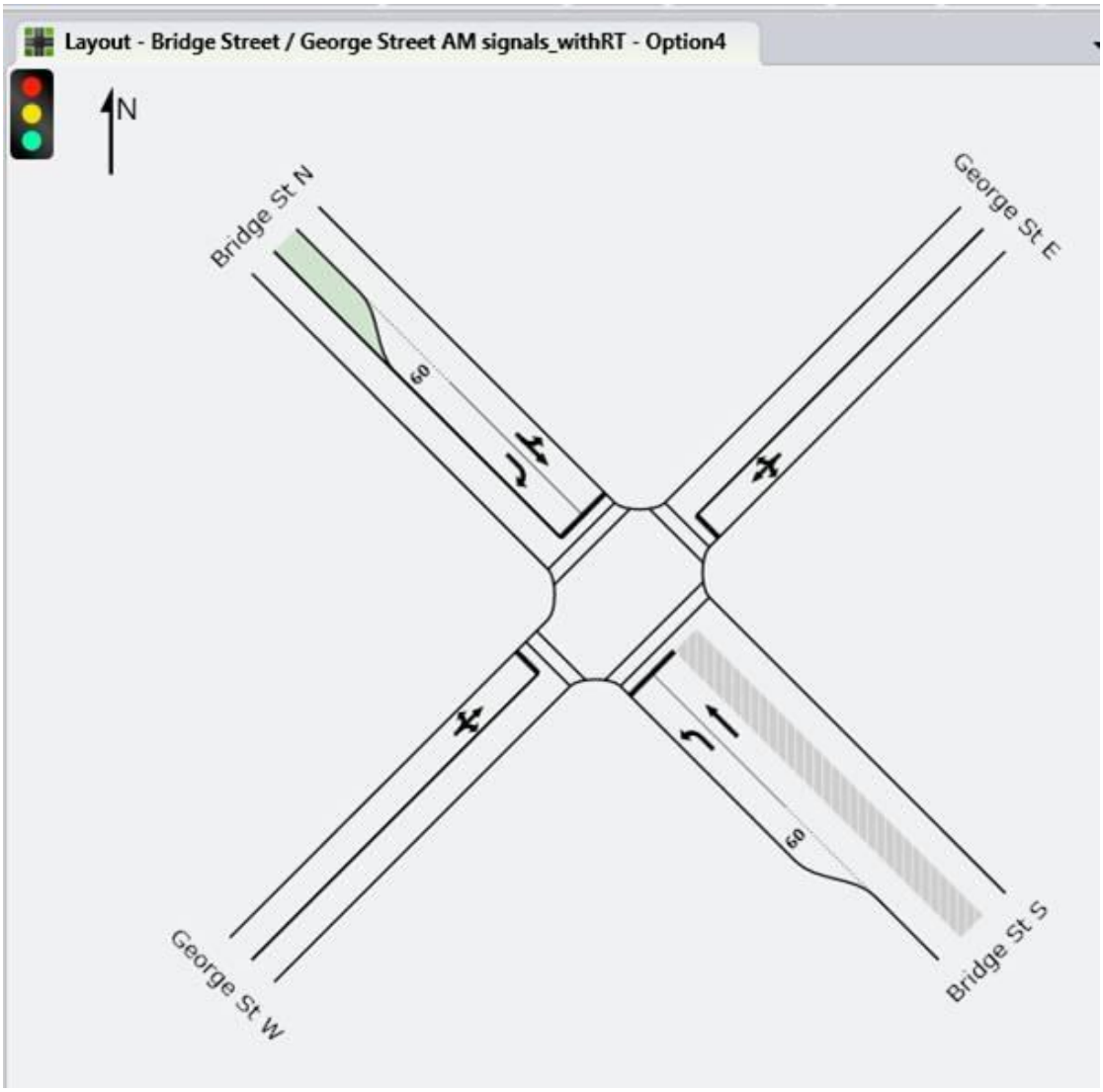


Figure 7-18 Configuration of new George Street/Bridge Street intersection

Network modelling

Due to the close proximity of the intersections, assessment of the local road network was required to confirm the performance of the preferred intersection types. The results of the network modelling for the AM and PM peak hours are provided in **Table 7-17** and **Table 7-18** below in terms of Level of Service for each leg of the intersections.

Modelling for the AM peak was undertaken for the initial road configuration of one lane in each direction on the replacement bridge and for the ultimate configuration of two lanes southbound and one lane northbound. For the PM peak the two lane southbound option was not modelled as the dominant traffic movements are northbound and providing additional southbound capacity would not alter the performance of the intersections.

With only one lane southbound on the bridge the Level of Service for Wilberforce Road in AM Peak in 2026 is predicted to be unacceptable at F. However with two lanes southbound the Level of Service would be acceptable with a Level of Service of B (See **Table 7-17**).

Therefore, when southbound traffic increases to a point when delays become unacceptable, the replacement bridge would be reconfigured to provide one northbound and two southbound lanes. The only other road predicted to have a poor Level of Service is George Street, however only five per cent of traffic movements in the AM peak originate from George Street – and the other 95 per cent of traffic movement have a Level of Service of A or B. For the PM peak (see **Table 7-18**) similar results are obtained. Based on the network modelling, the overall performance of the new intersections and lane configurations in both the AM and PM peak would be acceptable.

Table 7-17 Results of network modelling (AM Peak Hour) – 2026 traffic levels

Project Case	One lane southbound		Two lanes southbound	
Approach	**Average Delay per Vehicle (seconds)**	**Level of Service**	**Average Delay per Vehicle (seconds)**	**Level of Service**
Freemans Reach Road / Wilberforce Road				
Freemans Reach Road	20	B	8	A
Wilberforce Road	135	F	16	B
Bridge Street	4	A	4	A
All	**70**	**F**	**11**	**A**
George Street / Bridge Street				
Bridge Street (N)	26	B	22	B
George Street (E)	56	E	62	E
Bridge Street (S)	4	A	4	A
George Street (W)	50	D	53	D
All	**23**	**B**	**21**	**B**

Table 7-18 Results of network modelling (PM Peak Hour) – 2026 traffic levels

Approach	Average Delay per Vehicle (seconds)	Level of Service
Freemans Reach Road / Wilberforce Road		
Freemans Reach Road	15	B
Wilberforce Road	5	A
Bridge Street	18	B
All	**15**	**B**
George Street / Bridge Street		
Bridge Street (N)	26	B
George Street (E)	104	F
Bridge Street (S)	18	B
George Street (W)	105	F
All	31	C

Queuing

Queuing predictions for the northern and southern intersection from modelling 2026 traffic levels are provided in **Table 19** and **Table 7-20.**

In the AM peak (see **Table 7-19**) the queuing results show that with a single southbound lane on the new bridge, the two lanes exiting the northern roundabout would be required to merge which would result in an average and maximum queue length along Wilberforce Road of around 77 metres and 513 metres respectively. With the provision of the second southbound lane, the merge would be eliminated and the queuing results on Wilberforce Road show that there would be a considerable reduction in the average and maximum queue lengths.

On opening in 2016, in the PM peak (see **Table 7-20**) the queue lengths would be low and reflect the improved Level of Service of the new intersections. However over time the queues would increase due to growth in traffic and in 2026 the length of the queue of northbound traffic on Bridge Street would be unacceptable. To reduce queue lengths to acceptable levels, the right hand turn from Bridge Street north into George Street west may have to be banned in the PM peak period. This would allow more green light time for northbound traffic on Bridge Street and reduce queue length to acceptable levels (see **Table 7-20**).

While the queue lengths on Bridge Street south would extend back to the Macquarie Street/Bridge Road intersection, this would only occur for short periods of time. The maximum queue lengths presented in **Table 7-20** would occur for less than five per cent of the peak period.

Table 7-19 Summary of predicted queuing results (AM peak) – 2026 traffic levels

Project Case	One lane southbound		Two lanes southbound	
Approach	**Average Queue (metres)**	**Maximum Queue (metres)**	**Average Queue (metres)**	**Maximum Queue (metres)**
Northern Intersection				
Bridge Street	0	12	0	25
Freemans Reach Road	2	27	1	28
Macquarie Park access	0	0	0	0
Wilberforce Road	77	513	9	107
Southern intersection				
Bridge Street north	61	340	57	187
Bridge Street south (straight)	3	64	3	58
Bridge Street south (left turn)	0	0	0	0
George Street east	3	16	3	16
George Street West	6	55	6	55

Table 7-20 Summary of predicted queuing results (PM peak) – 2016 and 2026 traffic levels

Approach	2016 Right turn from Bridge St (N) to George St (W) permitted		2026 Right turn from Bridge St (N) to George St (W) permitted		2026 Prohibited right turn from Bridge St (N) to George St (W)	
	Average Queue (metres)	Maximum Queue (metres)	Average Queue (metres)	Maximum Queue (metres)	Average Queue (metres)	Maximum Queue (metres)
Freemans Reach Road / Wilberforce Road						
Bridge Street	1	29	0	22	0	13
Freemans Reach Road	2	20	2	28	5	28
Macquarie Park	0	0	0	0	0	0
Wilberforce Road	0	14	0	13	0	14
George Street / Bridge Street						
Bridge Street N	14	95	45	333	8	126
Bridge Street S (ahead)	47	181	214	431	63	226
Bridge Street-S (Left)	0	0	0	0	0	0
George Street E	6	25	3	16	78	118
George Street W	39	90	91	251	34	121

Capacity

The project has been developed and designed to cater for future growth in traffic and provide efficient traffic movements in all conditions. The bridge would initially be configured to have one southbound and one northbound lane and wide two metres shoulders. These wide shoulders would allow vehicles to pull over safely or allow two lanes of vehicles to divert around a stopped vehicle or an accident. The new bridge and approach roads would of sufficient width to be reconfigured to accommodate an additional lane for southbound traffic. This would occur when the growth in traffic has resulted in unacceptable delays and congestion. Network modelling results presented in **Table 7-17** and **Table 7-19** demonstrate that with only one southbound lane, unacceptable levels of service and queuing would occur in 2026. With the additional southbound lane, the level of service and queuing would be acceptable with the predicted 2026 traffic levels.

There would be no benefit in capacity or travel times with two lanes northbound on the bridge because:

- There are no intersections on Freemans Reach Road or Wilberforce Road near the project that would restrict northbound traffic flow so no additional capacity (or lanes) on the bridge would be required.
- The new configuration of the George Street and Bridge Street intersection would be one lane northbound – so providing two northbound lanes on the new bridge before the majority of traffic travel on to the single lane Freemans Reach Road or Wilberforce Road would provide no improvement in traffic flow.

Regional traffic

The project would provide increased capacity to the regional road network as shown by the network modelling. This benefit would be largely experienced by the Bridge Street/Windsor Road corridor and the increased capacity of this route would support future development within the region particularly on the northern side of the Hawkesbury River.

The reduction in queuing along Bridge Street south in the PM peak due to the project would also benefit the Macquarie Street/Bridge Street intersection – which is part of a regional traffic route to the west.

Freight routes

The project does not aim to create a new freight route across the Hawkesbury River as the existing Windsor bridge currently has no load restrictions. Rather the project aims to preserve the existing freight routes by providing a new bridge structure that would not be subject to load restrictions over its 100 year design life. As noted in Section 3 due to the deteriorating condition of the existing Windsor bridge, load restrictions may be required in the short term if the bridge is not replaced.

Some submissions on the project have raised concerns that the project would result in increased truck movements, especially trucks travelling between the Hunter and Sydney via Putty Road. While the project would improve the capacity and safety of a Hawkesbury River crossing at Windsor it is unlikely to encourage more trucks to use Putty Road as the project is only a 600 metre section of a 172 kilometre road between Sydney and Singleton and there are no load restrictions on the existing Windsor bridge.

Crashes

The project would result in a reduction in the number and severity of crashes as the design of the project would meet relevant road safety design guidelines. Also specific project elements which would reduce the potential for crashes include:

- The introduction of a roundabout at the Wilberforce Road/ Freemans Reach Road/ Macquarie Park access/northern approach road intersection.
- The replacement of the roundabout with traffic signals at the Bridge Street/ George Street intersection.
- The new alignment of the replacement bridge.

The majority of historical crashes were recorded at Wilberforce Road near Freemans Reach Road, with most occurring when vehicles were approaching from adjacent roads. This is due to the current method of control where Freemans Reach Road gives way to Wilberforce Road at a 'T intersection'. Under this form of control, right turning vehicles have to give way to both directions of traffic on Bridge Street and Wilberforce Road. This type of control is heavily reliant on the driver's ability to correctly select safe gaps. The provision of a roundabout at the Wilberforce Road/ Freemans Reach Road/ Bridge Street intersection would improve road safety by:

- Controlling the approaching vehicle speeds through entry and circulating carriage width geometry.
- Operating under roundabout 'right of way' control all vehicles need only 'give way' to traffic on the roundabout and as such it is easier to select safe gaps.

A single crash was also recorded on the curve at the northern end of Bridge Street on the approach to Freemans Reach Road. The project would eliminate this curve, reduce the speed limit to 50 kilometres per hour and introduce a roundabout controlled intersection resulting in an overall slower approach speed to this curve.

The traffic signal upgrade at the intersection of Bridge Street and George Street would be expected to improve pedestrian, cyclist and driver safety in this area. Similarly, the likelihood of rear-end crashes, such as those recorded on Bridge Street in the vicinity of the bridge, would be likely to be reduced due to the improved horizontal and vertical alignment of the project.

Local access

To meet current road safety standards, a raised median would be required to separate northbound and southbound traffic on Bridge Street north of the George Street and Bridge Street intersection. The raised median would prevent right turns into and from 4 and 6 Bridge Street.

Alternative permanent access arrangements to 4 and 6 Bridge Street were investigated. There is a back lane which extends from George Street along the rear of 6 and 10 Bridge Street, however it does not extend as far north to the rear of 4 Bridge Street. While it would be possible to create an access from 6 Bridge Street to the lane, a substantial brick garage appears to block access to the rear lane from the property. There are no options for alternative access to 4 Bridge Street.

While 6 Bridge Street is a commercial premise, it would be unlikely to experience a reduction in business due to the changed traffic arrangements. The building currently houses a legal practice which is a destination based business that does not rely on passing trade and whose customers would be unlikely to select the use of a legal practice based upon accessibility by vehicle.

Vehicle access to 4 and 6 Bridge Street would only be available via the northern approach through “left-in” / “left-out” turning movements. Drivers travelling from the south would need to cross the bridge, circle the roundabout and re-cross the bridge from the northern side to gain access to these properties. Vehicles exiting these properties and wanting to go northbound have a number of options to return to Bridge Street northbound (eg. turn right at Macquarie Street, right at one of the cross streets, right into George Street and then left into north bound Bridge Street).

Access to Number 33 Wilberforce Road would also be altered under the new traffic arrangements. For safety, vehicles would no longer be able to turn right into (or out of) the existing access at Number 33 Wilberforce Road. Driveway access to Number 33 Wilberforce Road would be relocated further north (away from the proposed dual lane roundabout) to a point where all tuning movements onto and off Wilberforce Road could be maintained.

For Bridgeview (Number 27 Wilberforce Road) vehicle access would be provided via the Macquarie Park access road.

The project would involve reconstructing The Terrace to provide both light vehicle and pedestrian access underneath the new bridge (including provision for emergency vehicle access).

Local parking

There would be no change to the current parking arrangements and number of car spaces on George Street and Bridge Street. Five car parking spaces in the lower Thompson Square parkland would be lost as they would be directly in the footprint of the southern approach road to the new bridge. However the number of parking spaces in the adjacent Windsor Wharf carpark would remain unchanged and there is plenty of on-street parking in nearby streets. Overall the impact of the project on parking would be minor.

Windsor Wharf

The operation of Windsor Wharf would not be affected by the project. Access to Windsor Wharf would change and would be via The Terrace under the new bridge, rather than Old Bridge Street which is the current situation. The new bridge would have a minimum clearance of 3.6 metres over The Terrace which would allow cars, Council garbage trucks, emergency services vehicles and small coaches direct access to the wharf. Large coaches over 3.6 metres in height would be required to park on the western side of the project. There is coach parking on Thompson Square road and Baker Street – which are relatively close to the wharf.

In response to Hawkesbury City Council's concerns about large coach access to Windsor Wharf RMS will investigate the possibility of increasing the clearance of the the new bridge over the The Terrace to allow large coach access during detailed design. Investigations would consider limiting impacts on heritage views and vistas.

Public transport

There would be no negative impact on the existing bus services as a result of the project. The project would result in reduced overall delay on the road network.

Pedestrians and cyclists

The project would provide substantial access and safety benefits for pedestrians and cyclists. A shared pedestrian/cycle pathway meeting current design guidelines would be provided, from Wilberforce Road and Macquarie Park, across the western side of the new bridge, along the western side of the southern approach road to the corner of George and Bridge Streets. This would result in a safe and accessible link between the northern and southern banks of the river and would be a substantial improvement on the existing pedestrian facilities.

Pedestrian and cyclist access along the southern bank of the river would also be improved with the connection and redevelopment of The Terrace. In addition, pedestrian and cyclist safety and access would be improved through the following general works which form part of the project:

- Improved pedestrian access and connectivity would be provided through the construction of a new 1.2 metre wide footpath adjacent to properties fronting Old Bridge Street. The footpath would extend from the intersection of Bridge Street and George Street and connect to The Terrace on the eastern side of the new southern approach road.
- Pedestrian safety and access would be substantially improved between the town centre and east Windsor by the new signalised pedestrian crossings across all four approaches to the intersection of Bridge Street and George Street.

- Pedestrian access and safety would be improved through the construction of new pedestrian footpaths around and across the dual lane roundabout at the junction of Freemans Reach Road, Wilberforce Road and the Macquarie Park access road.

The project would also help to facilitate part of the Great River Walk and would achieve two of the key recommendations of the Hawkesbury Mobility Plan 2010 (GTA Consutlants, 2010). The Hawkesbury Mobility Plan specifically identifies the Bridge Street and George Street intersection as a major barrier to east-west pedestrian movements and an area with poor pedestrian facilities. It recommends investigating redesign of the intersection to accommodate greater pedestrian movement.

Maritime

The new bridge would have a minimum and maximum clearance of 7.8 metres AHD and 9.2 metres AHD, respectively, and would have four piers. This compares to a clearance of 7.15 metres AHD and ten piers for the existing bridge. All vessels that are capable of passing under the existing bridge would be able to pass under the replacement bridge. The reduced number of piers supporting the new bridge would improve the safe navigation of the river. While future maritime and recreational use of the river is not currently anticipated to differ markedly from the existing uses, the increased vertical and horizontal clearances would improve opportunity for future uses. The paddle steamer, which is 11 metres in height, would continue to be restricted to the eastern side of the bridge due to insufficient clearance.

Comparison of the project to traffic and transport project objectives

The project has been compared against the traffic and transport project objectives in **Table 7-21**.

Table 7-21 Comparison of the project to traffic and transport project objectives

Objective	Response
To improve safety for motorists, pedestrians and cyclists	
Meets the current design codes (eg. traffic lane widths, shoulder widths and shared path widths).	The bridge, approach roads, shared cyclist/pedestrian paths would be designed to meet current design codes and would result in an improvement in the safety of all road and pathway users compared to the existing bridge and approach roads.
Meets a road speed of 50 km/h.	The bridge and approach roads would be designed for a 50km/h speed limit.
Ensures pedestrian safety.	Pedestrian safety would be considerably improved with a design code compliant shared path across the bridge. The pedestrian path across the existing bridge does not comply with current design codes. Also the signalised intersection at the intersection of George and Bridge Streets would provide for pedestrian crossings, where for the existing roundabout there are no provisions for pedestrian crossings. Pedestrian access and safety would be improved through new pedestrian footpaths around and across the proposed dual lane roundabout at the junction of Freemans Reach Road, Wilberforce Road and the Macquarie Park access road. There are no existing pedestrian facilities at this intersection.

Objective	Response
To improve traffic and transport efficiency	
Minimises queue length/delays.	The intersection types and configurations have been selected to minimise queue length and delays as much as possible. To achieve this, the existing intersection at Bridge Street, Freemans Reach Road and Wilberforce Road is proposed to be modified from a "Give Way" priority controlled intersection to a dual lane roundabout. The existing intersection at Bridge Street and George Street is proposed to be modified from a single lane roundabout to a traffic signal controlled intersection.
Improves performance of road network (level of service).	The overall performance of the road network would be substantially improved with the project. For 95 per cent of traffic movements in the peak periods Levels of Service of A or B would be achieved in 2026 with two lanes southbound on the bridge.
Enables two heavy vehicles to pass on the bridge without waiting.	The bridge and approach roads would be designed to meet current design codes with 3.5 metre lane widths which are sufficient to allow for heavy vehicles to pass in opposite directions without waiting.

7.3.5 Environmental management measures

Construction

A Construction Traffic Management Plan will be prepared and implemented which would enable the safe management of traffic and minimising impacts on the local community. The plan will be structured to address the following issues:

- Identification of public roads to be utilised by construction traffic.
- Management measures to ensure that construction traffic utilise the identified roads.
- Identification of any public roads that may be partially or completely closed during the construction phase and the relevant expected timings and duration of closures.
- Identification of sources of major construction materials and routes for their delivery to site.
- Temporary access and traffic arrangements to be implemented during construction.
- Access arrangements to construction sites and compounds and measures to prevent construction traffic from obstructing traffic flow inadvertently.
- Parking for construction workers.
- A response plan for any construction traffic incident.
- Monitoring, review and amendment mechanisms.

Other environmental management measures that will be included in the Construction Traffic Management Plan include:

- Traffic Control Plans will be developed and implemented for specific areas and/or phases of construction. These will be prepared in accordance with relevant guidelines and by appropriately qualified personnel.
- Traffic controls schemes will be inspected regularly and modified, if required.
- Drivers and construction workers will be inducted in the requirements of the traffic management plan.
- Deliveries and other major construction traffic movements will be timed to occur outside peak traffic periods, where possible.
- Queuing on public roads will be avoided by the use of two-way radios to call up haulage trucks from layover areas on a 'just in time' basis.
- Dilapidation surveys of roads around the project site will be undertaken prior to their use for construction as well as after construction is complete. Any damage to roads will be repaired.
- Consultation will be undertaken with the emergency services, bus operators, local business and other major stakeholders to inform them on changes in traffic management during construction.
- Construction related parking in local areas will be in accordance with the relevant parking restrictions. Opportunities to limit the impact this may have on the community will be investigated in consultation with the Hawkesbury City Council.

Environmental management measures during construction activities in the river may include introducing a temporary navigational speed limit (four knots or below) within the construction zone and/or introducing a temporary no wash zone. Exclusion zones around marine construction sites will be required, however at all stages passage up and downstream would be provided to watercraft. Other RMS maritime requirements will be complied with.

Consultation with maritime operators will be undertaken to ensure any impacts are minimised.

Operation

Environmental management measures for the operation of the project have largely been incorporated into the design of the project. The only additional key environmental management measure that will be implemented will be:

- Operational traffic levels and delays will be monitored. When delays due to traffic growth become unacceptable reconfiguration of the lanes on the bridge and approach roads from the initial two lane configuration to two southbound and one northbound lane will be undertaken.

7.4 Visual amenity, urban design and landscape

This section assesses the visual amenity, urban design and landscape impacts of the project. The assessment is supported by an Urban Design and Landscape Concept Report Working Paper, which has been included as Working Paper 5 in Volume 3 of this EIS. The Director General's requirements for the EIS identify visual amenity, urban design and landscape as a key issue. The Director General's requirements have been addressed in this chapter and the Urban design and landscape working paper (Volume 3 - Working paper 5) as detailed in **Table 7-22** below. The relevant requirements of Schedule 2, Part 3 of the *Environmental Planning and Assessment Regulation 2000* have also been addressed.

Table 7-22 Director General's requirements – visual impact, urban design and landscape

Director General's requirements	Where addressed
The EIS must address the following specific matters: **Visual Amenity, Urban Design and Landscaping** – including but not limited to:	
• a description of the visual significance of the bridge surrounds, Thompson Square, river foreshore and landscape setting, and an assessment of the visual impact of the project on the landscape and urban design character of the area, including built form (materials and finishes), urban design (height, bulk and scale), views to and from Thompson Square, the town centre and river foreshore areas, and design details such as lighting, balustrades and street furniture;	Section 7.4.2 (significance), Section 7.4.5 (visual impact) and Section 7.4.4 (design details)
• the overshadowing impact of the bridge on the public domain, including open space, parks and parklands, river foreshore areas and Thompson Square, and adjoining residential/ commercial uses; and	Section 7.4.5
• the landscape and urban design objectives for the reinstatement and rehabilitation of Thompson Square, taking into account Council's desired future landscape and urban design character of this locality. The EIS must include:	Sections 7.4.3 and Section 7.4.4
– details of landscaping treatment and integration with the public domain and historic values of Thompson Square and surrounds, in particular the integration of the existing road corridor with Thompson Square and the new bridge alignment and approach roads, and	Sections 7.4.4 and 7.4.6
– details of integration of the bridge and Thompson Square with existing and future pedestrian and cycle networks, including design and safety measures for pedestrian and cycle access on the bridge.	Sections 7.4.4 and 7.4.6

7.4.1 Guidelines and methodology

Guidelines applied

The impact assessment and urban design concept development were undertaken in accordance with the DGRs and relevant RMS guidelines, and involved consultation with Hawkesbury City Council and the local community. Guidelines applied as part of this process were as follows:

- Beyond the Pavement (RTA, 2009).
- Landscape Guideline (RTA, 2008a).
- Bridge Aesthetics (RTA, 2004).
- Environmental Impact Assessment Guidance Note: Guidelines for Landscape Character and Visual Impact Assessment (RTA, 2008b).

The study area

The study area for the visual amenity, urban design and landscape assessment is located to the north east of the Windsor town centre, incorporating the existing Windsor bridge crossing and the approach roads on both sides of the river. The study area can be divided into three distinct precincts:

- The area of Thompson Square and the built environment immediately surrounding it, including George Street, Bridge Street, Old Bridge Street and The Terrace.
- The Hawkesbury River including the Windsor bridge and the foreshores on the northern and southern embankments.
- The northern foreshore, including the intersection of Wilberforce Road and Freemans Reach Road and the entry road to Macquarie Park.

Overview of scope and key tasks

Development of the urban design concept has been an iterative process, informed by the impact assessment, with the aim of avoiding, reducing or mitigating adverse impacts wherever possible. Key steps in the process have included:

- Analysing the visual environment and landscape setting of the study area.
- Analysing how the project would interact with the visual environment and landscape setting of the study area.
- Landscape character impact assessment.
- Visual impact assessment.
- Identifying urban design and landscape strategies to avoid or mitigate adverse impacts.
- Informing the development of the engineering concept design through consultation with the engineering specialists, with the aim of minimising impacts via the design process.

The visual amenity, urban design and landscape assessment undertaken as part of this EIS involved:

- Assessment of the impacts of the project on visual amenity, urban design and landscape in the existing environment of Windsor.
- Framing a positive urban and landscape strategy for the project.
- Development of the urban design and landscape concept for the project to avoid, reduce and mitigate adverse impacts to the greatest extent practicable.

Landscape character impact assessment

Landscape character is the aggregate of built, natural and cultural factors that make up an area and provide its unique sense of place. To assist with the assessment of impacts on landscape character, the study area was divided into Landscape Character Zones based on land use, urban form, topography, vegetation and cultural heritage significance. The potential impacts of the project on landscape character were then assessed in consideration of the 'sensitivity' of the landscape and the 'magnitude' of the project. For each Landscape Character Zone, both 'sensitivity' and 'magnitude' were assessed on a qualitative basis and given a 'rating' on a scale ranging from 'negligible' to 'high'. The impact assessment grading matrix presented in **Figure 7-19** was then used to define the landscape character impact.

For the purposes of the landscape character impact assessment, the terms 'sensitivity' and 'magnitude' were defined as follows:

- Sensitivity – A measure of how sensitive the landscape is to change or the capacity of the landscape to absorb change. For the landscape character impact assessment in this EIS, the assessment of 'sensitivity' took into consideration the perceived value of the existing landscape, with judgments made about its scenic quality, cultural and historical importance, and importance to the local community.
- Magnitude – A measure of the physical size and scale of the project within the relevant Landscape Character Zone and hence the magnitude of change that would be imposed by the project within that zone. The assessment of 'magnitude' took into consideration the compatibility of the project with the existing landscape character. All elements of the project were considered, in addition to the scale of each element and its location within the existing environment.

		MAGNITUDE					
		High	**High to Moderate**	**Moderate**	**Moderate to Low**	**Low**	**Negligible**
SENSITIVITY	**High**	High impact	High impact	High to Moderate impact	High to Moderate impact	Moderate impact	Negligible impact
	High to Moderate	High impact	High to Moderate impact	High to Moderate impact	Moderate impact	Moderate impact	Negligible impact
	Moderate	High to Moderate impact	High to Moderate impact	Moderate impact	Moderate impact	Moderate to Low impact	Negligible impact
	Moderate to Low	High to Moderate impact	Moderate impact	Moderate impact	Moderate to Low impact	Moderate to Low impact	Negligible impact
	Low	Moderate impact	Moderate impact	Moderate to Low impact	Moderate to Low impact	Low impact	Negligible impact
	Negligible	Negligible impact	Negligible impact	Negligible impact	Negligible impact	Negligible impact	Negligible impact

Figure 7-19 Impact grading matrix

Visual impact assessment

A detailed field and desktop assessment was undertaken to determine the area from where the proposed works would be visible, defined as the visual envelope map (VEM). To assist with the visual impact assessment, four visual catchment zones were defined based on increasing distance from the centre of the study area (centred on the location of the replacement bridge). The four visual catchment zones are as follows (refer to **Figure 7-20**):

- Areas within a 0.25 kilometre radius.
- Areas within a 0.5 kilometre radius.
- Areas within a 0.75 kilometre radius.
- Areas within a one kilometre radius.

Within each visual catchment zone, a number of key representative viewpoints were identified based on consideration of land use. The identified viewpoints were located along streets and in other public domain areas such as Thompson Square. Views from these selected viewpoints were then analysed to identify the extent to which houses and other buildings were visible. This provided an indication of the likely level of visibility from houses, as it was not feasible to inspect private residences to check potential views directly. A total of 18 viewpoints were selected for the analysis. The locations and directions of the selected representative viewpoints are shown on **Figure 7-20** and are described in more detail in **Section 7.4.5**.

Similar to the landscape character impact assessment, the visual impact of the project on each viewpoint was assessed by considering both the 'sensitivity' of the viewpoint and the 'magnitude' of the project elements within that view. For the purposes of the visual impact assessment, the terms 'sensitivity' and 'magnitude' were defined as follows:

- **Sensitivity** – A measure of the quality and importance of the view from the viewpoint and its capacity to absorb change. This is dependent on the sensitivity of viewers to visual change. Viewers with a high sensitivity to visual impacts are those that place a high value on the existing views. These are likely to include residents who have attractive existing views, users of public open space or other areas where viewer attention is likely to be focused on the visual quality of the landscape and communities that place high cultural and historical significance on the visual landscape. People with a relatively lower sensitivity to visual impacts could include people focused on their work or other non-recreational activities and motorists whose attention is focused on driving.
- **Magnitude** - A measure of the physical size and scale of the change imposed on the viewpoint by the project. Magnitude is dependent on the nature and scale of the project elements that are visible to the viewer, the context in which the project elements are placed relative to the existing landscape and the proximity of the viewer to the visible project elements. A 'high' magnitude would result if the project elements are of a major scale and are different in scale or uncharacteristic of the existing visual character, or if there is considerable modification to the existing landscape. A 'low' magnitude would result if there is minimal alteration to the existing view and the project elements are of a scale and nature that is consistent with the existing visual character.

The assessment of visual impacts took into consideration the direction and composition of views, the manner in which the views are experienced (for example, from the road by drivers or from Thompson Square by recreational users of the parkland), the proximity of project elements to viewers, and the number of viewers likely to be affected by visual impacts. It also took into consideration the presence of intervening landforms between the viewpoint and the project. Vegetation was not considered to provide a permanent visual obstruction as it can be removed by clearing or other factors such as bush fire.

As for the landscape character impact assessment, the visual impact assessment was a qualitative analysis based on the application of 'sensitivity' and 'magnitude' ratings and the impact assessment grading matrix presented in **Figure 7-19**. The impact gradings have been measured based on their impact relative to each other within the scope of the project rather than on an absolute scale covering all potential forms of impact.

Overshadowing

The potential overshadowing impacts have been analysed using shadow diagrams prepared by Urban Circus, based on a computer model of the study area and the replacement bridge. Two sets of diagrams have been prepared and depict the shadows cast by the replacement bridge at 9:00am, midday and 3:00pm during the winter solstice (21 June) and summer solstice (21 December). The diagrams are presented later in this document (refer to **Section 7.4.5** and **Figure 7-29**).

For the purposes of the overshadowing analysis, the existing vegetation and the new tree planting have been excluded from the model. The absence of vegetation portrays a clearer depiction of the extent of overshadowing caused by the replacement bridge.

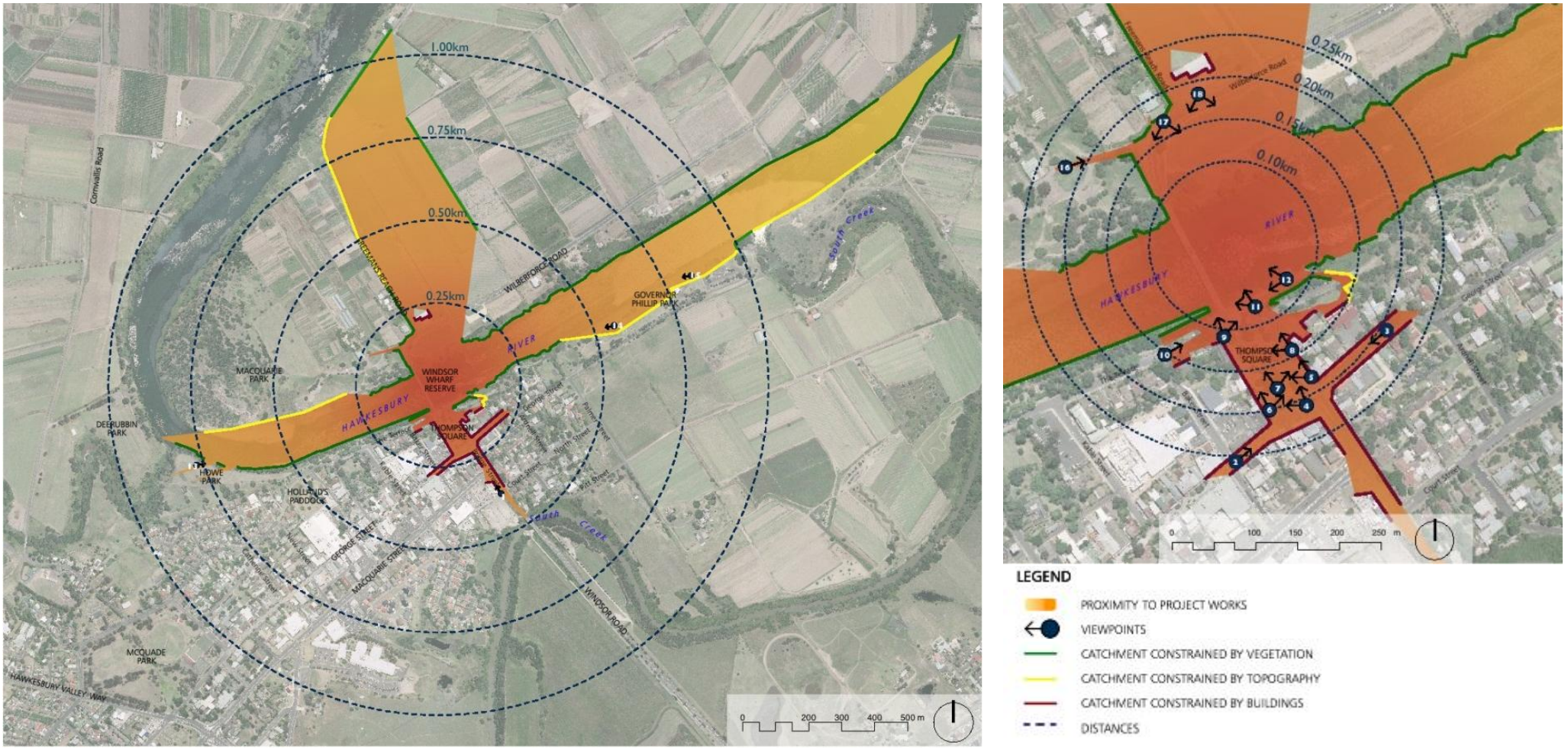


Figure 7-20 Visual catchment zones and landscape view points

7.4.2 Existing environment

This section describes the existing visual and landscape character of the study area, including the areas surrounding the existing and replacement bridges. These areas include the township of Windsor (incorporating Thompson Square) and the foreshore areas on the southern and northern banks of the Hawkesbury River.

Landscape setting

The visual character of the study area is strongly dependent on its European heritage elements, including the historic precinct of Thompson Square, as well as its location within the Hawkesbury River landscape.

Windsor is a historic, rural town located on a ridge above the southern bank of the Hawkesbury River. The southern approach to the existing bridge runs through the township and Thompson Square and descends steeply from the ridge to the river. The northern approach is less visually distinct, with the approach road being almost level with the bridge.

The town of Windsor comprises a commercial/retail core with adjoining low density residential developments. The land surrounding the township is made up of pastureland and dominated by agricultural and rural activities. Almost all of the original native vegetation has been cleared for development and agriculture.

There are considerable areas of open space and recreational land located around the built up areas and along the river foreshore. Important parks include Deerubbin Park, Howe Park, Windsor Wharf Reserve and Governor Phillip Park on the southern bank of the river, and Macquarie Park on the northern bank. Further back from the river edge are the reserves of Thompson Square and Hollands Paddock. These parks provide for a range of recreational activities and are of great importance to the local community.

Many of the parks on the southern side of the river are linked to various degrees by The Terrace, a local road that runs along the southern foreshore. The continuity of The Terrace along the foreshore is currently severed by the southern approach road to the existing bridge.

While the southern side of the river at the existing bridge crossing is dominated by the town of Windsor, the northern side is more rural in character. The northern side includes a number of turf farms with associated buildings and infrastructure, as well as the large, popular recreation area of Macquarie Park.

There are two key arrival points into Windsor, both of which are located within the study area: the George Street and Bridge Street intersection on the south side of the river and the Wilberforce Road and Freemans Reach Road intersection on the north side of the river. Both of these locations have key visual elements that signify to motorists, cyclists and pedestrians that they are arriving at Windsor.

The intersection of Bridge and George streets is approached up a relatively steep slope, rising out of South Creek. The sense of arrival at Windsor at this point is heightened by reaching the top of the ridge at George Street and the opening up of the view created by the open space of Thompson Square. A similar experience occurs when approaching the intersection of Bridge and George streets from the north after crossing the existing bridge.

The arrival point at the intersection of Wilberforce and Freemans Reach roads is situated on the Hawkesbury River floodplain and is influenced by the opening up of the view across the river to Thompson Square and the town rather than a change in topography. The view to the town is made possible by the lack of riverside and roadside vegetation and the presence of a turf farm in the foreground.

Thompson Square

Thompson Square has been a focal point for community activity since the early days of European settlement in the late 1700s. Today, Thompson Square comprises a series of single and two storey colonial buildings set around three sides of a rectangular open space area (referred to in this section as the Thompson Square parkland). The historic buildings have been recently restored and provide not only a physical edge and a sense of containment of the open space area but also a powerful and unified heritage quality that defines the character of the space. The historic buildings that provide Thompson Square with much of its visual character are the Macquarie Arms Hotel, the Doctor's House and the building at 10 Thompson Square. The heritage buildings and parkland together comprise the Thompson Square Conservation Area. These heritage elements are discussed further in **Section 7.1**.

The Thompson Square precinct incorporates a series of landscaped areas, ranging from the open space area of attractive parkland to small grassed islands adjacent to roadways and property boundaries. A range of mature trees occupy these landscaped areas creating a strong verdant character to the area. Some of these trees may form part of the historical plantings within Thompson Square (dating back to the early 1900s), although many are more recent plantings and some are seedlings that have regenerated naturally in the available spaces. Thompson Square open space area also contains a range of park elements, including picnic facilities, fencing and a memorial. Other than the placement of the memorial and its flanking trees to the George Street frontage, the landscaped space is unstructured in its form and layout. This form reflects a history of unplanned use and the primary need to accommodate road access between the town and the river.

Roadways bound the Thompson Square open space on all four sides, while Bridge Street crosses the centre of the Thompson Square open space area in a deep cutting running diagonally from east to west. This road provides the southern approach to the existing bridge and links to Wilberforce and Freemans Reach roads on the northern side of the crossing. The diagonal cutting of Bridge Street through Thompson Square results in a strong physical split of the open space into two disconnected triangular shaped reserves. The division creates a distinct upper open space area adjacent to George Street (the upper parkland) and a lower open space area adjacent to The Terrace and river foreshore (the lower parkland). The road cutting and connection to the southern bridge abutment also severs The Terrace at the point where The Terrace meets Bridge Street. This prevents pedestrian, cycle and vehicle access along The Terrace between the main area of Windsor and the wharf.

As a result of these physical constraints, current activities within Thompson Square are mostly restricted to the upper parkland. This area is strongly connected to George Street and the commercial precinct of the town. This area of Thompson Square is an important open space area for residents and visitors and is used for a range of activities, from major community events and festivals to family gatherings and picnics. A series of benches and tables are scattered around this area of the park, providing picnic facilities for casual use. Views from this area of the square are focused towards the surrounding buildings and urban scene, with views to the river restricted by trees.

The lower parkland of Thompson Square is more isolated from the commercial centre, with the Bridge Street cutting making pedestrian access from the town centre difficult. The exposure of this relatively small area of green space to the Bridge Street cutting also decreases its amenity for recreational activities. The topography within the parkland area has been artificially mounded, forming a small promontory that provides views out towards the river and northern river bank. It is separated from the river foreshore, however, by a small car park and The Terrace, with steep sloping ground at the base of the parkland increasing its physical separation. Recreational facilities in this area are limited to two picnic table settings.

River foreshore

The river bank area in the vicinity of the existing bridge is heavily vegetated and has been degraded by weed invasion and erosion, which limits direct access to the river. Macquarie Park on the northern foreshore to the west of the existing bridge is one of the few locations in the area where people can access the river directly at a large sandy beach.

Use of the remaining foreshore areas for recreational purposes is currently largely limited to the western side of the southern foreshore (west of the existing bridge). The eastern side of the southern foreshore, which includes Windsor wharf, is used mainly for car parking and servicing, rather than being a popular public space. On the northern foreshore, there is a footpath on the northern side of Wilberforce Road connecting to the footpath on the bridge. Access to Macquarie Park, a key destination for pedestrians and cyclists in this area, is constrained, however, by poor sightlines on the curved road alignment, the speed of vehicles approaching and leaving the bridge, and the cut embankment between the footpath and the entry road to Macquarie Park.

Access along the southern foreshore area is currently available via The Terrace, although this road is severed by the existing road cutting of Bridge Street and does not provide continuous vehicular or pedestrian access between the town and Windsor wharf. Hawkesbury City Council has carried out works along the western side of the southern foreshore to provide a continuous linear park with pathways and lookout points. Like The Terrace, these works are also currently interrupted by Bridge Street and the southern bridge abutment, which prevent continuous at-grade pedestrian access along the foreshore. The lack of a controlled pedestrian crossing, poor sightlines and the speed of vehicles approaching the bridge make it dangerous for pedestrians to cross Bridge Street from one side of the southern foreshore to the other at this point. The existing alternative is to use a set of stairs that lead to a dark underpass below the bridge.

Thompson Square provides the only potential open space access route for pedestrians and cyclists between the commercial area of Windsor and the river foreshore. Other access routes to the river, such as those provided by streets that intersect George Street, are not located within a parkland setting and do not provide the same level of amenity. Thompson Square therefore provides the preferred access route to the wharf and river foreshore for pedestrians and cyclists.

Pedestrian access to the river from Thompson Square is currently restricted to the existing road reserves. Access from George Street down to the river can be made via either the footpath of Old Bridge Street or the footpath or roadway on the unnamed road on the south eastern edge of the square.

Access via Old Bridge Street requires people to cross at the George Street and Bridge Street intersection, which is difficult due to the absence of a controlled pedestrian crossing, poor sightlines, the speed of vehicles and the multiple directions from which vehicles are entering into the roundabout. The steepness of the grade down Old Bridge Street also makes this route unsuitable for wheelchairs and people with restricted mobility or disabilities.

Access via the Thompson Square road, past the Doctor's House, is safer and reasonably accessible for people with restricted mobility or disabilities until they arrive at the intersection of Bridge Street and The Terrace next to the Windsor bridge abutment. At this point, a set of timber stairs provides grade separated access under the bridge to the northern side of The Terrace and ultimately to the wharf. It is possible to avoid the stairs by crossing Bridge Street at its intersection with The Terrace, although the absence of a controlled pedestrian crossing, poor sightlines and the speed of vehicles on Bridge Street, makes this a dangerous crossing.

The existing bridge

The existing bridge, originally constructed in 1874, is another listed heritage item in Windsor and contributes to the town's historic character. The existing bridge provides both vehicular and pedestrian crossing facilities, although both are narrow by current standards and restrict the safe and efficient movement of vehicles, bicycles and pedestrians. The deck of the existing bridge is relatively low, matching the height of the river bank on the southern foreshore and landing in a deep cutting on the northern foreshore. This visually integrates the bridge into the river setting.

The predominant experience of the existing bridge from the town of Windsor is of its presence as a low, horizontal line across the river. Approaching Windsor from the northern side of the river, the bridge crossing offers a strong upwards vista towards the Doctor's House, which is elevated above the current road alignment and provides a prominent urban landmark. The visual relationship between the bridge and other parts of Thompson Square is currently restricted, however, as a result of the road cutting and associated ground level differences within the square and the screening effect of trees.

The predominant experience from the bridge itself is one of being set low in the river landscape. The low rail of the existing bridge allows broad vistas up and down the river. The amenity of the pedestrian experience on the bridge is compromised, however, by the narrowness of the bridge and the limited separation between traffic lanes and the narrow pedestrian footpath. The narrowness of the bridge and footpath makes it feel unsafe and uncomfortable for pedestrians, particularly during peak traffic periods.The experience of 'crossing' the Hawkesbury is another important element of landscape character and is influenced by the topographic pattern of bridge 'approach' and 'exit', the form of the bridge itself, and the views experienced both on the approach/exit and on the crossing. The existing Windsor bridge provides a distinct experience of 'crossing', with an articulated descent to the crossing from the south and views of the river experienced both on the approaches and the crossing. Preserving the experience of 'crossing' has therefore been a key consideration in the design of the project[10].

[10] Works carried out on the Fitzroy Bridge crossing of South Creek in the 1970s resulted in a reversal of the original crossing pattern. The Fitzroy Bridge over South Creek is now approached on an incline to the crossing point and marked by a descent on the landing side. This profile creates adverse interfaces with adjoining roadside properties. The project has been designed to avoid such impacts to the greatest extent practicable.

Patterns of traffic movement

Traffic movement, including volumes, speed and changing diurnal patterns, directly affects the amenity of the project study area, as well as accessibility around and through it.

There are two main thoroughfares in Windsor, the primary route being the arterial road that follows Bridge Street through Thompson Square and onto the Windsor bridge, and the other being the Macquarie Street bypass of the commercial centre of Windsor. The patterns of traffic movement on Bridge Street are dominated by the narrow cross section of the existing bridge, the relatively steep and narrow approach road through Thompson Square, the roundabout at George Street and the signalised intersection at Macquarie Street. The volumes of traffic are at their highest level in the morning and evening peak periods.

Typically Bridge Street between Macquarie Street and George Street carries high volumes and during peak periods at relatively slow speeds. During non peak periods, however, vehicle speeds typically increase in response to reduced traffic volumes and congestion. As vehicles approach the roundabout on George Street, the speeds drop substantially as it acts as a natural traffic calming device.

Beyond the roundabout, traffic in both directions on Bridge Street generally travels at a slow speed, constrained by the narrow and steep road alignment and poor sightlines. Vehicle speeds do not substantially vary during peak and non peak periods due to these road conditions and the narrow bridge configuration. The steep grade on Bridge Street increases the noise levels generated by heavy vehicles due to the need to use low range gearing and engine breaking.

Beyond the bridge on the northern foreshore, vehicle speeds increase on both Wilberforce Road and Freemans Reach Road. Speeds are restricted, however, by the considerable congestion that occurs during the morning peak as higher volumes of vehicles negotiate the intersection of these two roads and approach the narrow bridge.

The local roads within Windsor, including George Street, Old Bridge Street, The Terrace and Thompson Square road, all carry lower volumes of traffic travelling at much slower speeds in comparison to the main traffic routes described above. The lower traffic volumes and speeds on these roads are compatible with the outdoor and street activities that are associated with the local shops, hotels and the upper parkland of Thompson Square.

Parkland and street trees

Trees contribute to the visual quality of the study area and are located within Thompson Square, along the edge of the river on both the northern and southern foreshores, and adjacent to Wilberforce Road, Freemans Reach Road and the entry to Macquarie Park. The trees comprise a combination of exotic and native species. Some of the native species are endemic to the area, such as the Swamp Oak (*Casuarina glauca*), although many, such as the Silky Oak (*Grevillea robusta*) originate from other parts of Australia. Large parts of the southern and northern foreshore are heavily weed infested, which restricts tree growth and also contributes to an unattractive character in what is otherwise a very attractive setting.

Some of the trees in the study area have been planted, although many have self seeded, particularly those close to the foreshore. Thompson Square contains a mix of mature trees, some of which appear to have been planted many decades ago, and less mature trees that have self seeded. Some of the mature trees growing in the upper parklands area near George Street are 'landmark trees' that create a considerable presence in the park and adjoining streets.

Along the boundaries of Macquarie Park and the heritage property Bridgeview, there are hedgerow plantings of native and exotic species, including Lilypillys, Photinia and Cypress Pine. These delineate the property boundaries and present an orderly and suburban character to an otherwise rural setting. A number of isolated mature Eucalypt trees also occur along the roadside and at the entrance to Macquarie Park.

Existing views

Both the southern and northern approach roads to Windsor provide glimpses of the historic town. The river foreshore area provides views upstream and downstream, as well as views of the township, the existing Windsor bridge and the foreshore parklands.

The existing bridge provides views upstream and downstream along the river, as well as views of Thompson Square. The view east from the bridge is open, extending downstream along the river, while the view to the west is more intimately focused towards the beach at Macquarie Park and the elevated bank of Howe Park.

Within Thompson Square, views from the upper parkland are focused on the surrounding buildings, with views of the river restricted by trees. The lower parkland of Thompson Square has views through trees to the river and foreshore, but only limited views of the upper area of Thompson Square.

Landscape Character Zones

To assist with the identification of landscape character impacts, the study area was divided into Landscape Character Zones (refer to **Section 7.4.2** for details of assessment methodology). Three Landscape Character Zones were identified as follows:

- Landscape Character Zone 1 - Thompson Square. This landscape character zone is dominated by the open space parkland of Thompson Square. The open space area is framed by one and two storey buildings that are part of the Thompson Square Conservation Area. The open space is diagonally dissected by Bridge Street and its cutting. It is bounded by George Street to the south and the southern foreshore of the Hawkesbury River to the north.
- Landscape Character Zone 2 - Hawkesbury River and banks. This landscape character zone comprises the Hawkesbury River and its banks, which are set into an extensive floodplain. The river banks are generally vegetated, framing upstream and downstream views. The town of Windsor sits on the ridgeline above the southern bank while the north side of the river is largely rural in character. The existing bridge across the river sits below the adjacent landform and is of a scale that complements the semi rural setting.
- Landscape Character Zone 3 - Wilberforce Road and Freemans Reach Road intersection. This landscape character zone is dominated by the large and relatively flat floodplain to the north of the Hawkesbury River. The land is predominately agricultural, consisting mainly of turf farms with large hedgerows separating plots of land. The two lane configuration of Wilberforce Road and Freemans Reach Road reinforce the rural character of the area. Macquarie Park is located to the west and contains scattered native and exotic trees.

The landscape character attributes of each identified Landscape Character Zone are summarised in **Table 7-23** to **Table 7-25**. The view from the Doctors House of the existing bridge and location of the replacement bridge is shown in **Figure 7-21**.

Table 7-23 Landscape Character Zone 1 - Thompson Square

Landscape character attribute	Description
Built form and heritage	Thompson Square is located on the north western edge of the ridge on which the Windsor township is located. It is bounded by roadways on all four sides. It is also diagonally bisected from east to west by Bridge Street and its deep cutting, which physically and visually separates the space into two distinct open space areas. Buildings surrounding Thompson Square comprise of one and two storey colonial buildings on three sides of the parkland. These recently restored buildings provide a strong physical edge and sense of containment to the square, as well as a unified heritage quality. Together, the buildings and Thompson Square comprise the Thompson Square Conservation Area.
Connectivity and access	Pedestrian access to the river, wharf and existing bridge is currently limited to the footpath along Old Bridge Street and the Thompson Square road. Access via Old Bridge Street requires pedestrians to cross at the Bridge Street intersection. This crossing is made difficult by poor sight lines, vehicle speed and multiple traffic directions entering the roundabout intersection, as well as the steep grade at this intersection. Access along the Thompson Square road is safer and more suitable than the Old Bridge Street access, until the Bridge Street intersection. At this point, access to the riverfront or across the bridge is only available via a flight of timber steps under Bridge Street, or directly across Bridge Street which is inherently dangerous due to vehicle speeds and poor sightlines to vehicles approaching the bridge.
Public domain	The upper area of Thompson Square offers the best amenity with easy access to adjoining retail premises on George Street. This area is generally a level, open grassed area with a number of scattered mature trees. Park furniture and picnic facilities are available in this area. The cutting provides visual and acoustic separation from traffic on Bridge Street. The lower area of Thompson Square has lower landscape amenity. Pedestrian access is poor due to steeper grades and the presence of road infrastructure (including a small carpark). It is physically separated from George Street. The topography has been artificially mounded, offering views towards the river, opposing riverbank and provides the only usable green space. The physical relationship of this area is poor due to the utilitarian character of the space.
Key activity areas	Thompson Square is the dominant green recreational space within Windsor and is complemented by its relationship with the variety of food and beverage outlets and the architecture of buildings along George Street. This area performs a number of functions, including functioning as a civic square or a quiet picnic location.

Figure 7-21 View of the existing bridge and location of the replacement bridge from the Doctors House

Table 7-24 Landscape Character Zone 2 – Hawkesbury River and banks

Landscape character attribute	Description
The existing bridge	The original bridge was constructed in 1874 and was raised to its current level in 1896. It provides crossing facilities for vehicles and pedestrians. The bridge deck has been aligned to match the height of the northern foreshore river bank and lands in a deep cutting on the southern foreshore, visually integrating the bridge into the river setting.
The river	This section of the Hawkesbury River is characterised by a long and generally straight reach of open water. Long and attractive views may be had in both directions from the bridge and open foreshore areas. Both northern and southern foreshore areas, the river bank adjacent to the Terrace and the Macquarie Park foreshore are well vegetated with a combination of native and exotic trees. The steep banks are heavily weed infested, detracting from the otherwise attractive river setting. The recently reconstructed Windsor wharf is located on the southern bank and is adjacent to some minor scour protection works using sandstone rocks. Flood events are regular in this area. Two small markers on the existing bridge alert visitors to the potential of flooding.
Connectivity and access	The bridge provides one lane in each direction. The pedestrian path is narrow and has limited separation from the southbound traffic lane, but provides attractive upstream and downstream views. On the southern side, the footpath terminates at the junction with the Terrace, continuing on the northern side of the Terrace to Windsor wharf in the east and linking with the timber steps under Bridge Street and along the foreshore path to the west. On the northern foreshore, the footpath continues along the southern side of Wilberforce Road.

Table 7-25 Landscape Character Zone 3 – Wilberforce Road and Freemans Reach Road intersection

Landscape character attribute	Description
Built form and heritage	Land on the northern foreshore is predominantly agricultural, consisting of turf farms, associated buildings and infrastructure and large hedgerows separating plots of land. The heritage listed single storey residence, 'Bridgeview,' is located adjacent to the intersection of Wilberforce Road and Freemans Reach Road and is prominently visible from the southern foreshore.
Connectivity and access	Pedestrian access in this zone is poor, the formal pathway in the zone limited to the bridge to the southern side of Wilberforce Road. Pedestrian access from the bridge to Macquarie Park is dangerous and constrained by poor sightlines on the curved road, the speed of vehicles approaching and leaving the bridge, as well as the cut embankment between the footpath and the entry road. The two-lane configuration of Wilberforce Road and Freemans Reach Road reinforce the rural character of the area. Vehicular access to Macquarie Park is via a narrow road on the curved approach to the bridge.
Public domain	The majority of land in this zone is rural. The large and popular Macquarie Park is located to the west of the intersection. It is grassed with scattered native and exotic trees and small carparks. Vegetation in this area mirrors the vegetation across the river in Thompson Square. A small children's playground, picnic shelter and restaurant are located near the entrance of Macquarie Park. The river can be accessed from Macquarie Park, at a large shady beach.
Key activity areas	Macquarie Park is the major public destination on the northern foreshore.

7.4.3 Urban design and landscape objectives and principles

Overarching objectives and principles

Urban design and landscape objectives and principles have been prepared for this project to guide the concept design so that the replacement bridge and approach roads are physically, visually and operationally integrated with the surrounding environment. They also guide the rehabilitation of Thompson Square.

The objectives and principles take into account the desired future landscape and urban design character for the area as set out in Hawkesbury City Council's *Plan of Management for the Windsor Foreshore Parks Incorporating the Great River Walk (*Hawkesbury City Council, 2009). They also reference RMS' Beyond the Pavement urban design policy (RTA, 2009b) and the DGRs for this project. Furthermore, the objectives and principles are based on an understanding of the existing landscape and urban values of the study area and the issues that affect or are affected by the project. The urban design and landscape objectives and principles for the project are presented in **Table 7-26**.

Table 7-26 Urban design and landscape objectives and principles

Objective	Design principles
Develop an integrated concept design that fits sensitively with the existing qualities and characteristics of Windsor and its Hawkesbury River setting	• Maintain the landmark qualities of a bridge crossing at Windsor. • Minimise the physical footprint and scale of the bridge, approach roads and associated intersections. • Ensure the design and character of the bridge and associated road works are well integrated with the adjoining built areas, open space, historic and natural settings, rather than being a dominant feature. • Minimise negative physical impacts on parklands, open space, the river and other foreshore areas adjacent to the bridge. • Design all road and bridge elements carefully to integrate and coordinate with adjoining elements and structures. Materials and detail are to be robust, low maintenance and suitable for their purpose and place. • Minimise the intrusion of road-related elements (fencing and water quality control measures) on the local landscape. • Consolidate residual land parcels to retain sufficient public open space for future river front activities.
Maintain the integrity of cultural and historic buildings, structures, elements and spaces of Windsor	• Maintain the physical and visual integrity of State-significant items including historical buildings, public spaces and their curtilage, particularly in Thompson Square. • Preserve the integrity of heritage items and areas of cultural importance to the local community. • Minimise the impact on historical archaeological sites, particularly those associated with Thompson Square. • Enhance the setting of Thompson Square and its buildings. • Minimise the impact on Aboriginal heritage sites and their associated heritage values. • Minimise or avoid alterations to heritage items, except where the removal of intrusive elements would have a positive impact on their heritage significance.

Objective	Design principles
Enhance the existing amenity, visual character and cultural landscapes of Thompson Square and Windsor	• Not precluding Council's future plans, which are yet to be determined. • Redevelop any residual road space as parkland to be integrated within Thompson Square. • Maximise opportunities to enhance the connection between Thompson Square and the commercial area at the intersection of George Street and Bridge Street. • Enhance views of Thompson Square and its buildings to and from the bridge and approach roads on both sides of the river. • Retain, and where possible improve, views to important landmarks in particular the Hawkesbury River, Thompson Square and the historic buildings around Thompson Square. • Protect and interpret the heritage values of Thompson Square and Windsor in general. • Maximise the available open space in Thompson Square by minimising the road corridor footprint and returning redundant road areas back to consolidated parkland. • Identify the most appropriate uses for Thompson Square in order to define its form and character. • Enhance the access opportunities for all users around and through Thompson Square.
Improve connectivity for vehicles, pedestrians and cyclists	• Provide safe, direct and obvious connections between the bridge and approach roads with the local road network in Windsor. • Enhance opportunities to define the northern intersection as an entry to Windsor. • Provide generous and direct cycle and pedestrian connections across the bridge and enhance the existing pedestrian and cycle networks along the approach roads. • Consider opportunities for public transport throughout the project. • Maintain and enhance connections to the existing river edge and adjoining open space network. • Provide safe pedestrian, cycle and vehicle access to Macquarie Park.

Bridge design principles

Specific architectural principles have been applied to the proposed design of the replacement bridge. These principles supplement the design guidelines set out within RMS' Bridge Aesthetics (RTA, 2004) and are summarised in **Table 7-27** (principles for siting and character) and **Table 7-28** (principles for bridge elements).

Table 7-27 Bridge design principles - Principles for siting and character

Category	Principles
Character	• In alignment, gradient and in its constituent elements, the bridge should have a dignified, calm and confident presence. • The bridge should have a robust structural character. • The bridge and its approaches should equally have a considered landscape and urban presence. • Like the existing bridge, the new bridge's character should be understated rather than overly expressive.

Category	Principles
Placement and siting	• The new bridge and its approaches should be well sited and considered in relationship to the Hawkesbury River's landscape setting, the township of Windsor, the banks, parks and approach roads. • The new bridge should have a simple linear geometry so that it continues to be expressed as a calm, succinct form in the landscape. • The experience of crossing the bridge should be clearly articulated and distinct from the experience of approaching the bridge. • The eastern bridge approach should accord as close as possible to the historic Bridge Street alignment. • The vertical alignment through the historically important Thompson Square should be as close as possible to existing ground levels.

Table 7-28 Bridge design principles – Bridge elements

Category	Principles
Deck	• The deck of the bridge should be expressed as an uncluttered horizontal plane spanning the Hawkesbury River. • The bridge's alignment as it spans between abutments should mirror the horizontal plane of the river as closely as possible. • The width of the deck should be reduced as much as possible, to minimise its bulk as viewed and experienced from Thompson Square, the Terrace and from more distant viewpoints along the river. • The pedestrian and cyclist shared path should be raised slightly above road pavement level, to improve safety for pedestrians and cyclists. • Traffic barriers should sit between the traffic lane and the shared path to minimise the bulk of the bridge as viewed from Thompson Square. • The pedestrian balustrade on the outer edge of the bridge should allow for a finer scale/edge to be developed on the Thompson Square side. • The pedestrian balustrade on the outer edge should be collapsible during flood events in accordance with established and tested RMS design solutions.
Deck soffit	• The deck soffit should be designed, treated and finished as an important facade, due to its high visibility from land and water within the public domain. • The deck soffit should be profiled to give it a modelled architectural expression, rather than a generic flat plane. • The bridge's edge detail should be fully integrated with the soffit design. • Services should be concealed wherever possible - if unavoidable, they should be recessed into the deck soffit so that they sit flush with the finished surface, or recessed away from the edge to be in shadow. • The transition of the soffit to the abutment should be resolved in three dimensions. • Consideration should be given to the treatment of the surface in terms of reflection, light and shadow.

Category	Principles
Piers	• The piers should express, through their structure, the forces that are transferred from deck to the foundations. • The piers should be designed for compliance with structural minima, to minimise their bulk. • The piers should have a paired leg expression and be slender. i.e. the proportion of their vertical height to width should be controlled such that the piers appear fine, rather than squat. • Design of the piers should reflect their role as dominant visual elements as would be seen from Thompson Square and the river foreshores. • The pile caps should be recessive and integrated with the columns. • The view through the pier structure from the Terrace and Wilberforce sides should be considered as a particular experience and articulated accordingly. • The placement, material character and any finish of the piers should discourage vandalism and graffiti.
Abutments	• The abutments should seamlessly resolve the transition from elevated deck to the ground plane, and be fully considered as a three dimensional design. • There should be consistency in the architectural language between the piers and the abutments. • The abutment walls should be considered as an integral part of Thompson Square, defining the open space. • The abutment walls should be designed as vertical walls to maximise usable space in Thompson Square and minimise land take. • The abutment walls should be formed of robust masonry elements to complement existing walls in Thompson Square. • The design of the abutment walls should explore opportunities for interpretation of flooding and flood levels.
Materials	• All materials should be selected for their robustness and durability, considering their tendencies to develop a patina as they age. • Materials should be robust and durable. • Materials should express the inherent material of the bridge construction and minimise the use of cladding. • Where special finishes are desired, they should be integral and suit the construction method, rather than be an applied finish.
Lighting	• Lighting should be an integral part of the design, rather than an unrelated attachment. • Lighting levels should comply with statutory requirements for each type of road user, including motorists, pedestrians and cyclists. • Integrated and linear lighting should be used wherever possible. • Minimise the use of vertical pole elements that are susceptible to damage in flood and compete with the horizontal plane of the deck. • Lighting sources should comprise low energy use sources wherever possible, and should have appropriate IP ratings that anticipate inundation.

An impression of the replacement bridge from the Doctors House is shown in **Figure 7-22**.

7.4.4 Urban design and landscape concept

The concept design for the project, as described in Chapter 5, is the result of an integrated design approach in which a team of environmental, heritage and urban design specialists have worked collaboratively to achieve a better integration of the project within Windsor. The integrated design approach has included the development of an urban design and landscape concept, based on the urban design and landscape principles identified in the previous section. The overriding aim of the urban design and landscape concept is to minimise the adverse impacts of the project on the heritage values of Thompson Square and the overall visual and landscape character of Windsor. The urban design and landscape concept has informed the development of the concept design for the project and will continue to inform the development and refinement of the design should the project proceed to detailed design and construction.

The urban design and landscape concept for the project is presented in the Urban Design and landscape working paper (Volume 3 - Working paper 5). The key elements of the urban design and landscape concept are summarised below.

The existing bridge

The existing Windsor bridge would be demolished as part of the project. Measures to manage the associated impacts on the heritage values of Windsor are identified in **Section 7.1.5**. These measures may include interpretive treatments and/or signage providing information about the bridge, the location of which would be determined during detailed design in consultation with Hawkesbury City Council and the community.

Figure 7-22 Impression of the replacement bridge from Doctors House

Thompson Square

The southern approach road of the new bridge is on the eastern edge of Thompson Square and would create a strong and more legible rectangular structure to the square with roadways defining the four edges of the central open space area. The existing buildings around the perimeter of Thompson Square would further strengthen this balanced spatial structure. The existing retaining wall beneath the Doctor's House would form a visual relationship with the new bridge abutment, creating a clearly defined and enclosed amphitheatre in the intervening space.

The project would involve removal of the existing diagonal road and alignment of Bridge Street through Thompson Square (see **Figure 7-23**). This would allow for connection of the upper and lower parklands, which would result in a greater area of continuous open space within Thompson Square (see **Figure 7-24**). Measures to manage the associated impacts on heritage values of the area have been detailed in **Section 7.1.5**. These measures may include interpretive treatments and/or signage providing information on the history of previous road alignments within the square. The location of interpretative treatments and/or signage would be determined during detailed design in consultation with Hawkesbury City Council and the community.

In addition to increasing the amount of continuous open space available for public use, the connection of the upper and lower parklands of Thompson Square would:

- Improve the amenity of the open space area for public use (as it would no longer be dissected by a busy roadway).
- Improve the connection of Thompson Square to the river (by providing a continuous green space connection), with potential to connect to future foreshore walkways.
- Reinforce the existing successful connection between the open space area and the street life of George Street.

Consultation with Hawkesbury City Council, relevant heritage agencies and the community on the urban design and landscape concept for Thompson Square would be undertaken during the detailed design phase of the project. A preliminary concept design for Thompson Square has been developed (see **Figure 5-8**). This preliminary concept design would be used as the basis for the further development of the concept design for the square should the project proceed to detailed design and construction.

Access and movement

Recognising the landmark location and historic importance of Windsor has been an important aspect of the engineering design process and development of the urban design concept. The design of the new bridge and approach roads, combined with appropriate urban design treatments, would make road users aware of their arrival at Windsor so that they can then respond and make decisions about breaking their journey.

In comparison to the existing bridge, the replacement bridge would provide a river crossing that is more direct and safer for vehicles, pedestrians and cyclists. Key improvements would be as follows:

- The ease, safety and amenity of pedestrian and cyclist access to The Terrace via Thompson Square road would be improved as there would no longer be a need to cross the bridge approach road.
- The provision of a wide shared pedestrian and cycle path across the replacement bridge would improve the amenity of the bridge crossing for pedestrians and cyclists travelling between the town centre and the northern foreshore area, including the Macquarie Park recreation area.
- The provision of a signalised intersection at the George Street and Bridge Street intersection would also improve pedestrian and cyclist safety at this location.

A range of alternative access routes would be available for people moving between the main street and the river foreshore through Thompson Square. In addition to the route provided by Thompson Square road, two new sets of stairs would be constructed to provide direct pedestrian access to The Terrace - one set adjacent to the new bridge abutment and another adjacent to the existing retaining wall under the Doctors House. There would also be a footpath on the eastern boundary of Thompson Square adjacent to the southern bridge approach road that would connect to The Terrace near the wharf.

The Terrace, which is currently bisected by the Bridge Street road cutting, would be reconnected as a result of the project, allowing continuous access along the river foreshore from Thompson Square Road to the wharf. This would create a valuable link between Thompson Square and the riverside parkland areas.

The new roundabout at the Wilberforce Road and Freemans Reach Road intersection would improve vehicular circulation but would constrain pedestrian and cyclist access around this area, particularly due to the double lane configuration. This impact would be mitigated by the shared pedestrian and cyclist paths which would provide two access points to Macquarie Park as well as a grade separated shared access route under the bridge.

Views and vistas

Retaining visual connections to the views and vistas of the town has been a key design consideration. The existing key arrival points to Windsor, namely the George Street and Bridge Street intersection on the south side of the river and Wilberforce Road on the north side of the river, would be retained. The roads at these arrival points would remain at similar levels and vegetation planting would be restricted to preserve sightlines to key viewpoints.

The concept design allows for retention and possible improvement of some of the visual connections and sightlines between buildings across the upper areas of Thompson Square. Existing sightlines through the open space area towards the river would also be retained and the extent of the visibility of the river may be improved in some locations.

Bridge design

The replacement bridge has a close to horizontal alignment that mirrors the horizontal plane of the water below. On the deck of the bridge, the pedestrian/cycle shared path would be raised slightly about the road pavement level, which would elevate cyclists and pedestrians and provide them with increased visibility. The required traffic barriers would be located between the traffic lane and the shared path, which would allow the balustrade on the edge of the bridge to be finer and thus reduce the potential for adverse visual impacts on Thompson Square.

On the southern approach to the bridge from Thompson Square, the approach road would largely follow the natural grade of topography down to the new bridge. This would clearly distinguish the approach road from the near horizontal bridge crossing, making the crossing a distinct experience. The southern approach to the new bridge closely follows the historic alignment of Bridge Street, which reinforces that important historical element. The design speed and resultant level of the approaches to the bridge have been selected to allow the existing ground levels of properties fronting Old Bridge Street to be retained without adjustment.

The design of the deck soffit would give the underside of the bridge a modelled, rather than a flat profile, which would improve the appearance of the bridge when viewed from below. To reduce the heavy appearance of the bridge piers and prevent the formation of strong linear shadows, the piers have been designed with a curved shape at all four corners. This also allows the piers to be narrower in profile on the outside edges of the bridge, which would make them less imposing from distant viewpoints. Light coloured concrete would be used as it is the best surface for light and reflections, and would be consistent with the finish of the bridge deck. The spacing of the piers is wide, which would give the bridge an open quality when viewed from Thompson Square, the river foreshore, the Hawkesbury River and distant viewpoints. The bridge piers would also be set well away from the riverbank, making them less susceptible to vandalism and graffiti.

The abutment walls would be constructed of light coloured concrete with a curved profile to match the bridge piers. They would also be textured with relief features (such as ridges) to disrupt the planar surface and make them less susceptible to graffiti. Opportunities for incorporating additional surface design features, such as visual markers that provide information on past flood events, would be explored during the detailed design phase.

Ancillary items

The project would require the construction of ancillary items necessary for the effective operation of the roadway. These would include retaining walls, scour protection, traffic safety barriers and balustrades, street lighting, street furniture, and water quality structures including a water quality basin. Recommendations for the design of key auxiliary elements are presented in **Table 7-29**.

Retaining walls would be made from precast concrete panels with matching capping units and would have a finish that would be practical for construction while reducing long term maintenance requirements. They would be dark coloured so to allow for the visual character of foreshore planting to dominate.

Scour protection would be designed to encourage and facilitate access to the river, and would incorporate the use of natural materials wherever possible. The visual impacts of the scour protection works would be minimised by plantings of riparian species.

The water quality basin, designed to treat runoff from the new road surface before it reaches the Hawkesbury River, would be located on the north east side of the crossing, south-east of the proposed new roundabout at the intersection of Freemans Reach and Wilberforce roads. The size of the water quality basin would be minimised as far as practicable and its perimeter would be planted with native species to provide visual screening and integrate it with the surrounding landscape.

Lighting would be provided on poles positioned at intervals along the bridge and approach roads. The placement and height of the poles would provide adequate lighting levels to the bridge and the approaches in accordance with current standards and codes. The final design, height and spacing of poles would be selected to minimise visual impacts and impacts on rural character.

Additional roadside elements necessary for the effective operation of the roadway (such as safety barriers and balustrades, kerbs and street furniture) would be designed so as to make a positive contribution to the character of both the roadway and the local landscape. The design of all ancillary elements would be finalised during detailed design in consultation with Hawkesbury City Council, the community and other stakeholders.

Table 7-29 Recommendations for the design of auxiliary features

Project elements	Recommendation	Rationale
Retaining Walls - Windsor Wharf Reserve	Retaining walls with precast concrete panels with grey concrete and dark grey exposed aggregate. A matching precast concrete capping unit should be used at the top of the wall.	• The recessive colour would allow for the visual character of the adjoining foreshore planting to dominate. This would also help to make the wall visually recede when viewed from a distance. • The integral finish to the concrete panels would be practical for construction and reduce long term maintenance requirements.
Scour protection - Northern foreshore	Construction of the rock faced scour protection with roughly dimensioned sandstone blocks, loosely coursed, would create a more ordered and more attractive appearance. The spaces between the scour protection rocks would be planted, wherever possible, with sedges to minimise the hard visual appearance of the works.	• Reduce visual impact of structure. • Facilitate informal access to the river.
Bridge - safety barriers	Concrete 'Half Type F' barrier with twin steel rail.	• Minimise barrier depth. • Maximise views along the river reach. • Twin rail expresses a greater attention to detail than a single barrier.
Street lighting Required for the length of the new works.	Lighting to be minimised to meet requirements set out in AS1158. Ensure uniformity in size, height and spacing of lights. Use galvanised steel lightposts. Lighting for The Terrace and under the bridge to be confirmed with Council.	• Reduce visual dominance of the works, to retain semi-rural character.

Planting

The project would involve removal of a number of trees from the Thompson Square parkland area and the northern river foreshore. Most of the trees to be removed from Thompson Square are located in the lower part of the parkland. Most of these trees are exotic species and are of a mature to semi mature age. The majority of the mature trees located in the upper part of the parkland would be retained and protected.

New tree plantings would be provided in the lower part of the parkland after the cutting of Bridge Street has been filled in and re-graded. These new plantings would comprise similar species to those currently existing in the square and would complement the new parkland design by improving visual character and allowing views to the river.

The landscape design of the northern foreshore has been developed to create an open parkland setting that would assist in reducing the visual impacts of the new roundabout. These new plantings and the associated regrading of ground levels have been designed to extend the Macquarie Park character beyond its current boundary.

Replanting of the river embankments would be undertaken once the scour protection works have been completed. The river embankment plantings would comprise endemic species suitable for riverine environments that experience frequent flooding.

The plantings would be designed to integrate the new works into the existing landscape setting and to further define and reinforce the unique landscape character zones. The plantings would be designed to enhance the unique sense of arrival at Windsor (from both the north and the south) and strengthen the landscape character of Thompson Square. This requires striking a balance between screening the works from sensitive visual receivers and maintaining and enhancing key views and vistas.

Design measures for environmental impact management

As discussed above, an integrated design approach was adopted for project development, resulting an urban design and landscape strategy that aims to minimise adverse impacts on the heritage values of Thompson Square and the overall landscape and visual character of Windsor. The key design measures that have been incorporated into the concept design are identified in **Table 7-30**. .

Table 7-30 Concept design measures for environmental impact management

Project element	Concept design measures
The bridge: The replacement bridge would be a prominent feature in the landscape. During the design process, a number of decisions were undertaken to minimise the impact of the new structure.	• A design speed of 50km/h will allow the bridge level to be kept as low as possible relative to existing ground levels on the northern and southern approaches. • Selection of an incrementally launched bridge type will minimise the number of piers required, keeping views through and across the bridge as open as possible. • The selected bridge type will allow the structural members to be placed below the bridge deck level, which will minimise the 'bulk' and visual impact of the structure from surrounding elevated areas. • Selection of curved form will give the bridge piers a 'finer' less bulky appearance. • The placement and design of the bridge abutments will improve access along the river foreshore, which will provide better surveillance opportunities to deter vandalism and anti social behaviour. • The placement of vehicle barriers between the travel lanes and the shared pedestrian/cycle path will allow for the placement of a pedestrian railing on the outside of the bridge. This will create a visually 'finer' and more 'transparent' edge to the bridge.
Thompson Square: Reducing the impact of the project on the existing character of Thompson Square has been a high priority for this project.	• Direct access through and around Thompson Square will be provided by the infilling of the existing Bridge Street cutting, consolidating the parkland and providing a more direct connection down to the river. • Views across the upper area of Thompson Square have been maximised through the siting of the bridge approach road as close as possible to existing ground levels. • Improved pedestrian access will be achieved with the placement of traffic signals at the Bridge Street and George Street intersection
The Terrace and river foreshore: Enhancement of The Terrace as a shared zone along the river's edge providing access to the river.	• The removal of Bridge Street will allow The Terrace to be reconnected, facilitating pedestrian and cycle movements between the foreshore parklands. • Revegetation of the foreshores will assist in integrating the scour protection works on the foreshores. • The foreshore area will be rehabilitated with suitable riparian vegetation once the scour protection works would be constructed. • Construction of the rock faced scour protection with roughly dimensioned sandstone blocks, loosely coursed, will create a more ordered and more attractive appearance. • The spaces between the scour protection rocks will be planted, wherever possible, with sedges to minimise the hard visual appearance of the works.
Northern intersection: Integration of the northern intersection works into the existing character and adjoining land uses has been thoroughly considered as part of this project.	• Pedestrian and cyclist access will be provided around the intersection and under the abutment. • New tree planting will be undertaken in the area surrounding the roundabout works, reducing the scale of the works over time as the tree planting matures. • The design of the water quality basin will be refined to create a more natural form and its size reduced to the minimum operational size. It would be planted with native riparian species.

7.4.5 Construction, demolition and operational impacts

This section details the potential impacts of the project, including its construction and operational phases. The potential visual amenity, urban design and landscape impacts of the project would be largely associated with the overall changes to the landscape that would occur as a result of the project proceeding. As such, the impact assessment focuses on the potential impacts of the completed project.

Landscape character impacts

The results of the landscape character impact assessment are presented below for each of the three identified Landscape Character Zones. A summary of the results for all three zones is provided in **Table 7-31**.

Landscape Character Zone 1 – Thompson Square

The key impacts of the proposed works in Landscape Character Zone 1 are detailed below for each of the key attributes that make up the zone.

- Built form and heritage:
  - The existing Bridge Street road pavement would be removed, the cutting wholly or partially filled, regraded and landscaped.
  - Old Bridge Street would become the alignment for the new approach road to the replacement bridge and would experience a change in elevation.
  - The footprint and scale of the new road and infrastructure will be more physically and visually apparent than the existing road, despite the removal of other road infrastructure such as the small carpark.
  - The increased width of the new approach road would further separate the buildings on Old Bridge Road from the parkland.
- Connectivity and access:
  - Removal of the existing roundabout and replacement with a four way signalised intersection at the intersection of Bridge Street and George Street.
  - Removal of existing Bridge Street and Old Bridge Street north of George Street.
  - Construction of a new shared path along the western side of the new Bridge Street, linking to the replacement bridge and Macquarie Park on the northern foreshore.
  - Construction of a new pedestrian path along the eastern side of the new Bridge Street, linking to Windsor wharf carpark.
  - Connection of The Terrace to Windsor wharf.
  - Construction of new stairs adjacent to the bridge abutment and the Thompson Square road.
- Public domain:
  - Reunification of the Thompson Square parkland areas from George Street to The Terrace, which would provide a unified green open space.
  - Removal of some existing trees from within Thompson Square.
  - Elevated southern approach road abutment and the bridge over the Terrace would present a large physical and visual barrier between Thompson Square and the parkland adjacent to the wharf. Traffic would be a dominant physical presence.

- Construction and compound sites located at the two Council carparks would be surrounded by temporary fencing during construction. These sites would consist of temporary storage facilities, site buildings, stockpile areas and other facilities and would be dismantled progressively during works where possible and restored to their pre-construction state after construction.

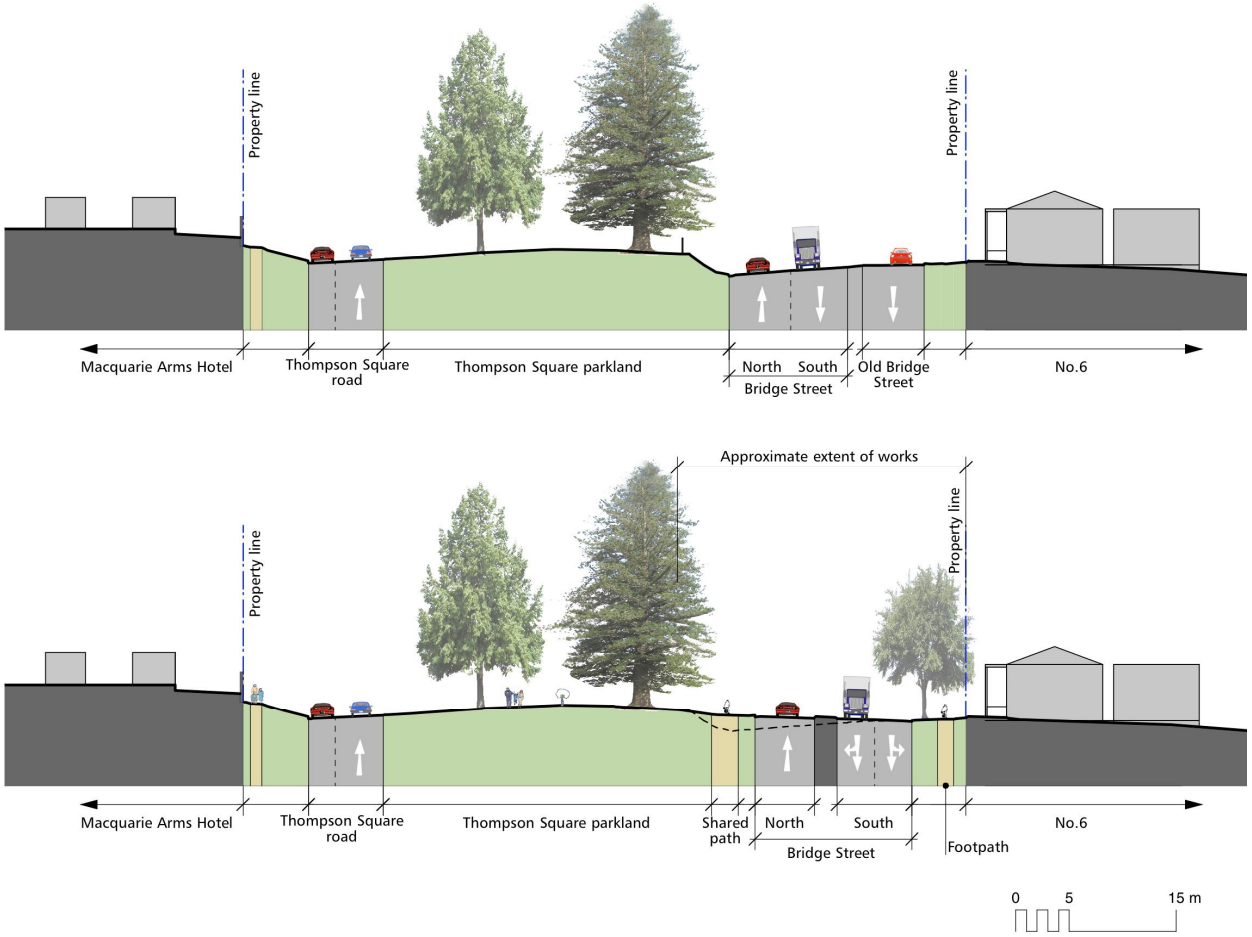
The cross sections in **Figure 7-25**, **Figure 7-26** and **Figure 7-27** show the relationship of the southern approach road and bridge abutment to lower Thompson Square and properties along Old Bridge Street. The long section along the centreline of The Terrace provides an indication of what the project would look like from the northern foreshore (see **Figure 7-28**).

The results of the landscape character impact assessment for Landscape Character Zone 1 are as follows:

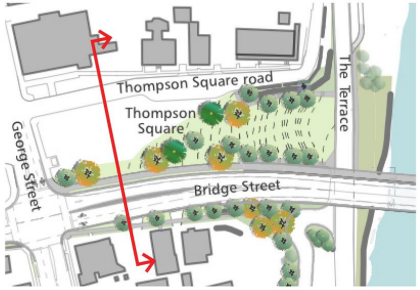
- **Sensitivity** – The sensitivity of Landscape Character Zone 1 is considered to be High due to its heritage values and the social, cultural and recreational values placed on it by the local community.
- **Magnitude** – The magnitude of change that would be imposed by the project on Landscape Character Zone 1 is considered to be High to Moderate given that the works would raise the height of the southern road approach to the bridge and visually separate the lower section of Thompson Square from Windsor Wharf. While the layout of the Thompson Square parkland would be consolidated by removal of the existing bridge approach road (Bridge Street), the footprint of the new approach road and its height at the abutment would be out of scale with the adjoining roads.
- **Landscape character impact** – Using the impact grading matrix (**Figure 7-19**), the landscape character impact of the project on Landscape Character Zone 1 is likely to be High.

Figure 7-23 Road area in Thompson Square – existing conditions

Figure 7-24 Road area in Thompson Square – future conditions



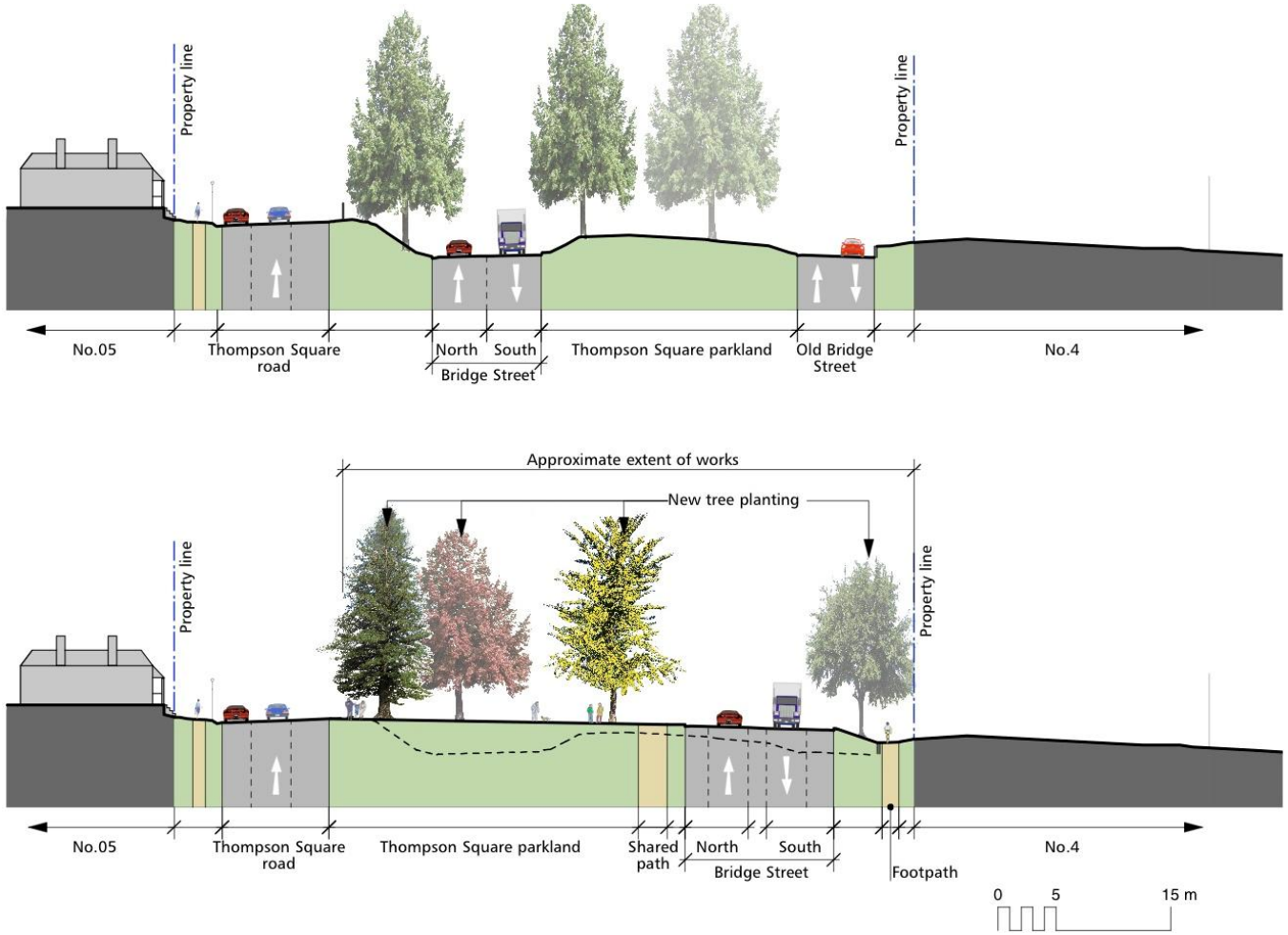
Existing conditions



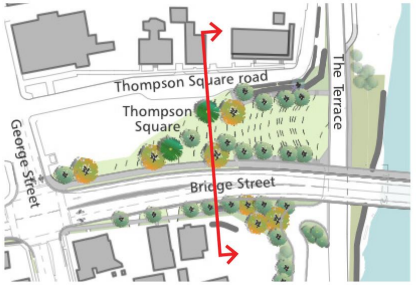
Cross Section B Location

After proposed works

Figure 7-25 Cross section of the project near the George Street intersection



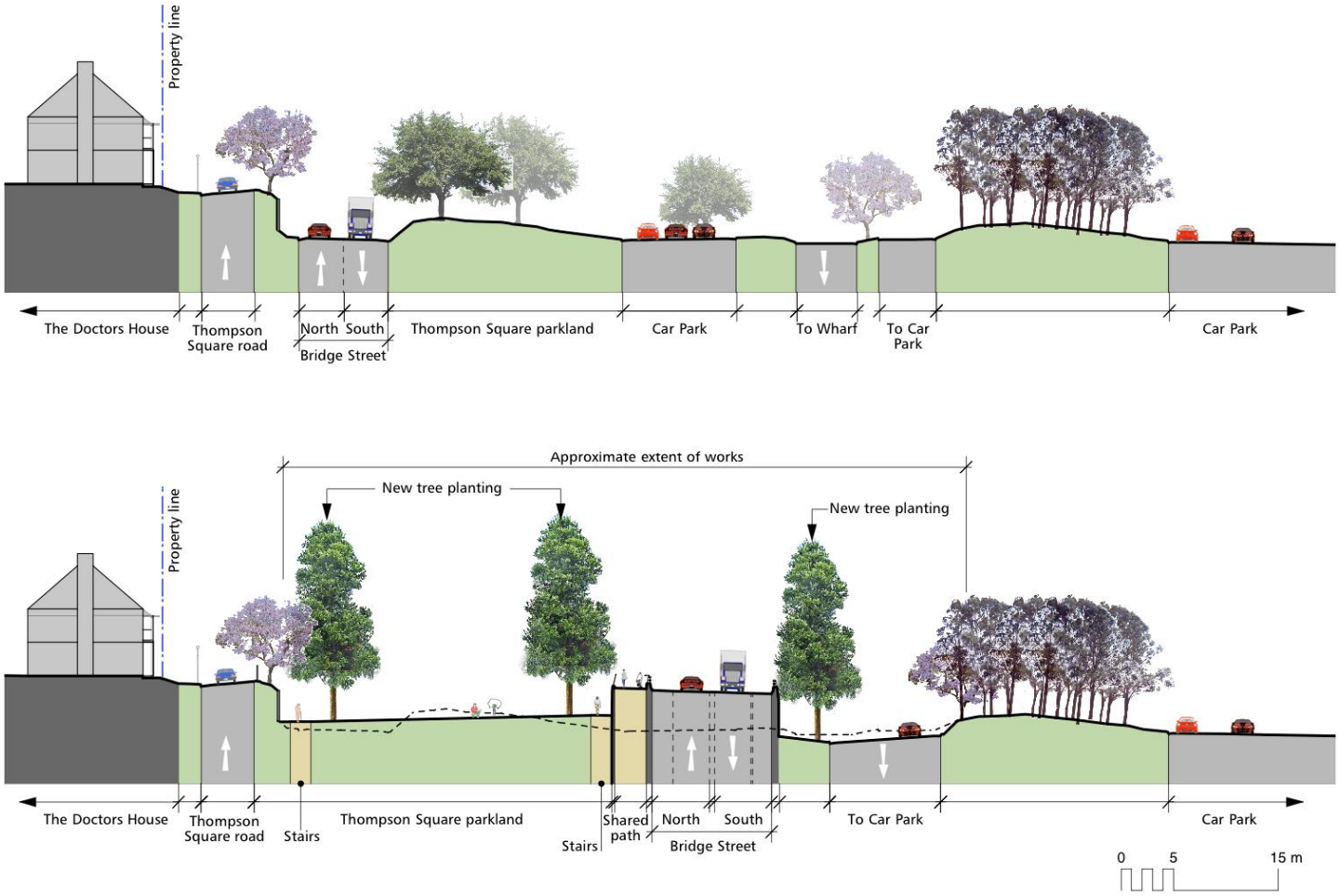
Existing conditions



Cross Section D Location

After proposed works

Figure 7-26 Cross section of the project at the southern approach road - midway



Cross Section F Location

Figure 7-27 Cross section of the project at the southern approach road – Doctors House

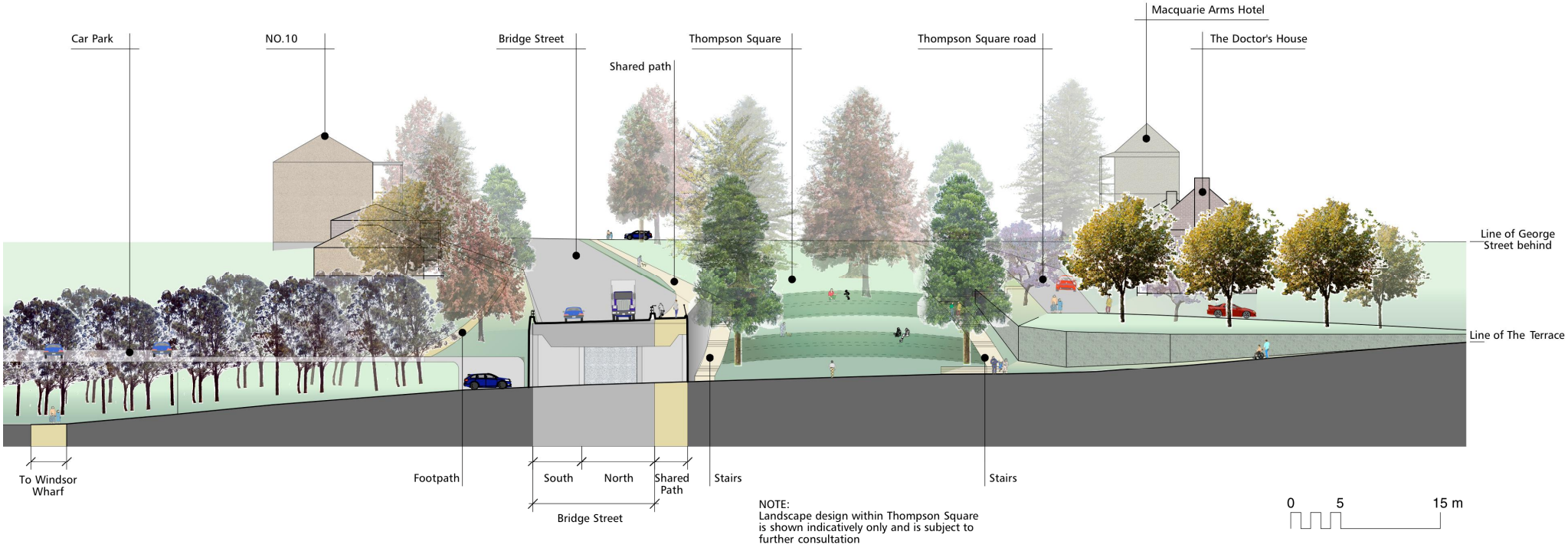


Figure 7-28 Long section of the project along The Terrace

Landscape Character Zone 2 – Hawkesbury River and banks

The key impacts of the proposed works in Landscape Character Zone 2 are detailed below for each of the key attributes that make up the zone.

- The bridge:
  - Removal of existing bridge deck, piers and abutments.
  - Construction of a new bridge about 35 metres downstream of the existing bridge. The new bridge would be about three metres higher and about nine metres wider than the existing bridge.
- The river:
  - Scour protection measures would be installed along the southern foreshore and around the bridge piers.
  - Removal of large areas of vegetation, particularly on the southern side of the river.
- Access and connectivity:
  - Construction of a shared pathway across the western side of the replacement bridge, linking Macquarie Park on the north to the Windsor town centre.
  - Redevelopment of the Terrace to improve connectivity.

During construction, temporary piers and pontoons would be constructed and land reclamation works for the construction of bridge piers may be necessary. Works would be removed following construction.

The results of the landscape character impact assessment for Landscape Character Zone 2 are as follows:

- **Sensitivity** – Due to the historic nature of the natural river setting and the generally flat topography of the surrounding area, particularly to the north, the zone is considered to have a High sensitivity.
- **Magnitude** – The project involves the placement of the existing bridge with a new bridge that is higher and wider. The replacement bridge would sit above the existing landform, making it a more dominant structure in the landscape. Scour protection works on the banks of the Hawkesbury River would also affect the river setting. The magnitude of change that would be imposed by the project on Landscape Character Zone 2 is therefore considered to be High to Moderate.
- **Landscape character impact** – Using the impact grading matrix (**Figure 7-19**), the landscape character impact of the project on Landscape Character Zone 2 is likely to be High.

Landscape Character Zone 3 – Wilberforce and Freemans Reach roads intersection

The key elements of the proposed works in Landscape Character Zone 3 are detailed below for each of the key attributes that make up the zone.

- Built form and heritage:
  - Construction of a new dual lane roundabout at the intersection of Wilberforce Road, Freemans Reach Road, the northern bridge approach road and the access road to Macquarie Park. Although the new roundabout and associated approaches would be at or close to existing grades, the footprint and scale would make this intersection a dominant feature in the rural landscape.
  - Removal of the existing northern approach road to the bridge and a section of Wilberforce Road.
  - Construction of a permanent water quality basin to capture and treat stormwater runoff from the bridge and northern intersection.
- Connectivity and access:
  - Construction of footpaths that would link Macquarie Park, the riverside and the northern side of Wilberforce Road.
- Public domain:
  - Exotic and native tree planting would be undertaken in the open space surrounding the roundabout to reduce the visual impact of the upgraded intersection.

During construction, land currently used as a turf farm located between Wilberforce Road and the Hawkesbury River would be used as the main construction and compound site. It would be surrounded by temporary fencing and would consist of storage facilities, stockpile areas, site buildings and other facilities. Following construction, or progressively during the works where possible, the site would be dismantled and restored to its pre-construction state. The results of the landscape character impact assessment for Landscape Character Zone 3 are as follows:

- **Sensitivity** – While comprising modified and open agricultural land, the zone has a scenic character that is enhanced by the vegetated entry to Macquarie Park. The sensitivity of this zone is therefore considered to be High to Moderate.
- **Magnitude** – The works increase the scale of the road infrastructure, alter existing access to properties and require minor earthworks to shape cut and fill embankments and the water quality basin. New tree planting would be undertaken in the area surrounding the road works, reducing the visual impact of the works. The magnitude of change that would be imposed by the project on Landscape Character Zone 3 is therefore considered to be Moderate.
- **Landscape character impact** – Using the impact grading matrix (**Figure 7-19**), the landscape character impact on Landscape Character Zone 2 is likely to be High to Moderate.

Summary of landscape character impact

While project impacts have been minimised to the extent possible during design development, overall the project would have an adverse impact on landscape character. The project is located in an established rural township that has high historical significance to the local community. The existing bridge dates from 1874 and sits comfortably within the scale of the landscape. Replacement of the existing bridge and upgrade of existing road infrastructure and it would have a substantial impact on all Landscape Character Zones in the study area due to the high sensitivity of the landscape and the relative scale of the works in comparison to existing bridge and road infrastructure. The replacement bridge would be of a larger scale than the existing bridge and would sit higher in the landscape. The project would result in the reunification of the two components of Thompson Square, which would change its existing character.

While the project would have a substantial impact on landscape character, some of the landscape character changes are likely to benefit the community and enhance the experience of visitors to the area in the long term. Changes that are considered to be beneficial are:

- Consolidation of open space within Thompson Square through the removal of the existing bridge approach road and connection of the upper and lower parklands.
- Connection of The Terrace along the river foreshore.
- Provision of improved pedestrian and cycle access. This includes access between Thompson Square and the river foreshore and across the bridge from Windsor to the northern foreshore and Macquarie Park. Pedestrian and cycle access would also be provided across Bridge Street at the George Street intersection.

Incorporation of the proposed visual and landscape environmental management measures would also aid in integrating the resulting changes within the existing landscape and minimise their impact on visual amenity and landscape character.

Table 7-31 Summary of landscape character impact assessment results

Landscape Character Zone (LCZ)	Sensitivity	Magnitude	Landscape character impact
LCZ1 – Thompson Square	High	High to Moderate	High
LCZ2 – Hawkesbury River and banks	High	High to Moderate	High
LCZ3 –Wilberforce and Freemans Reach roads intersection	High to Moderate	Moderate	High to Moderate

Visual impacts

The results of the visual impact assessment for the 18 identified viewpoints (refer to **Figure 7-20**) are summarised in **Table 7-32**. Of the 18 viewpoints assessed, five viewpoints have been identified as likely to experience a High visual impact, five viewpoints a High to Moderate visual impact, four viewpoints a Moderate visual impact, two viewpoints a Moderate to Low visual impact, and two viewpoints a Low visual impact. The areas that are considered likely to experience a High visual impact are as follows:

- Viewpoint 7 – Thompson Square looking north.
- Viewpoint 8 – Old Bridge Street, at the entrance to number six, looking north west.
- Viewpoint 9 – Thompson Square, adjacent to the Doctor's House, looking north.
- Viewpoint 11 – Small carpark near the intersection of Old Bridge Street and The Terrace, looking north west.
- Viewpoint 12 – Windsor Wharf, looking south west.

The areas where the potential for a High visual impact has been identified are generally located in open space areas, either close to the Hawkesbury River or within Thompson Square, where the sensitivity to visual change is high and existing views would be impacted by the replacement bridge.

Table 7-32 Key representative viewpoints and the potential visual impacts of the project

ID	Location	Description	Sensitivity	Magnitude	Impact
1	Western side of Bridge Street near shared path, opposite Court Street, looking north west. 	Viewpoint from the perspective of motorists, pedestrians and cyclists travelling north along Bridge Street. It addresses mid distance views to the intersection works at George Street.	Low - A substantial number of motorists would be affected by the changed view, but works would be undertaken within an existing road corridor within a commercial area, where sensitivity is considered low.	Low - The road would be slightly lowered at the George Street intersection. Traffic lights would replace the existing roundabout.	Low
2	George Street, at the intersection of Baker Street, looking north east. 	Viewpoint is from the perspective of a pedestrian walking east along George Street. It addresses mid distance views to the proposed intersection works at George Street.	Moderate - A moderate number of pedestrians would be affected by the changed view. There would be a substantial distance between viewers and the project.	Low - The road would be slightly lowered at the George Street intersection. Traffic lights would replace the existing roundabout.	Moderate to Low
3	George Street, 100 metres east of Bridge Street, looking south west. 	Viewpoint from the perspective of a pedestrian walking south west along George Street. It addresses mid distance views to the proposed intersection works at George Street.	Low - A small number of pedestrians would be affected by the changed view. There would be a substantial distance between viewers and the project.	Low - The road would be slightly lowered at the George Street intersection. Traffic lights would replace the existing roundabout.	Low

ID	Location	Description	Sensitivity	Magnitude	Impact
4	Seating area on south side of George Street, near Bridge Street intersection, looking north. 	Viewpoint from a pedestrian's perspective. It addresses foreground views to the works in Thompson Square and mid distance views to bridge works.	High - Thompson Square is of high scenic, social and heritage value to the community.	Moderate - The changes in Thompson Square, including the removal of a number of trees and the widened approach road to the replacement bridge would be highly visible. The new bridge may be visible following the removal of trees.	High to Moderate
5	Bridge Street, at the entrance to River Music, looking north west. 	Viewpoint from a pedestrian's perspective. It addresses foreground views to the works in Thompson Square and the road approaches to the replacement bridge.	High - A small number of pedestrians would be affected by the changed view. Thompson Square is, however, of high scenic, social and heritage value to the community.	Moderate - The existing two lane road would be replaced by a wider road with a raised concrete median. The eastern verge would be reduced, the northbound lane raised, and the embankment regraded to accommodate a 3m wide path. Some trees would be removed. Filling, regrading and landscaping of Bridge Street would reduce the extent of the road surface in this view.	High to Moderate

ID	Location	Description	Sensitivity	Magnitude	Impact
6	Thompson Square, at the entrance to Macquarie Arms Hotel, looking north. 	Viewpoint from the perspective of a pub patron in the beer garden and passing pedestrians. It addresses foreground views to the works in Thompson Square and the road approaches to the replacement bridge.	High - A small number of pedestrians and pub patrons would be affected by the changed view. Thompson Square is, however, of high scenic, social and heritage value to the community.	Moderate - The existing Bridge Street cutting would be filled and the land slightly regraded. The existing white post, rail fence and a number of small/ medium trees would be removed. The abutments to the road approach to the bridge would be visible through the trees. Views to vehicles on the new approach road would be more prominent as the road matches existing levels for a greater distance.	High to Moderate
7	Thompson Square looking north. 	Viewpoint from a park user's perspective. It addresses foreground views to the works in Thompson Square and the road approaches to the replacement bridge.	High - Park users would be affected by the changed view. Thompson Square is of high scenic, social and heritage value to the community.	High to Moderate – The amount of road pavement would be reduced and the upper and lower parklands connected. The white post, rail fence and a number of small to medium trees would be removed. The widened approach road and abutment would be prominent in this view, partially blocking views to the river.	High

ID	Location	Description	Sensitivity	Magnitude	Impact
8	Old Bridge Street, at the entrance to number six, looking north west. 	Viewpoint from a pedestrian's perspective. It addresses foreground views to the works in Thompson Square and the road approaches to the replacement bridge.	High - A small number of pedestrians would be affected by the changed view. Thompson Square is, however, of high scenic, social and heritage value to the community.	High - Existing two lane road would be replaced by a wider road with a raised concrete median. The eastern verge would be reduced, the northbound lane raised, and the embankment regraded to accommodate a 3m wide path. Some trees would be removed. Views of the river would be obscured by the abutment rising above the existing grade. The site compound in the council carpark would be visible during construction.	High
9	Thompson Square, adjacent to the Doctor's House, looking north. 	Elevated viewpoint from a pedestrian's perspective. Addresses foreground views to the works in lower Thompson Square and removal of the existing bridge, and mid distance views to road works on the northern side of the river, scour protection works on the northern bank and the replacement bridge.	High - A small number of pedestrians would be affected by the changed view. Thompson Square is, however, of high scenic, social and heritage value to the community.	High - Existing two lane bridge and approach road would be removed. The Terrace would be reinstated along the southern bank. The replacement bridge, larger in scale and higher than the existing bridge, would be clearly visible due to the removal of some existing trees along the foreshore. Scour protection works on the northern foreshore would also be visible. During construction, the temporary construction facility on the turf farm and any temporary works on the river would be visible.	High

ID	Location	Description	Sensitivity	Magnitude	Impact
10	Pedestrian path, north side of The Terrace, opposite Baker Street, looking north east. 	Viewpoint from a park user's perspective. It addresses foreground views to the works.	High to Moderate - A moderate number of pedestrians would be affected by the changed view. The riverfront public path has high scenic value.	Low - The removal of the approach road to the existing bridge and the existing bridge would be visible through foreshore vegetation. The existing path would link to the upgrade of The Terrace. Some vegetation would be removed for scour protection works.	Moderate
11	Small carpark near the intersection of Old Bridge Street and The Terrace, looking north west. 	Viewpoint is from the perspective of a motorist and a pedestrian. It addresses foreground views to the works.	High - Only a small number of viewers would be impacted but the viewpoint has high scenic and cultural values.	High - The location of this viewpoint would be covered by the new bridge abutments, resulting in a completely altered view. The existing two lane bridge would be removed. Scour protection works undertaken to both sides of the river would be highly visible. Trees would be removed on foreshore areas during scour protection works.	High
12	Windsor wharf, looking south west. 	Viewpoint from a pedestrian's and wharf user's perspective. It addresses foreground views to the bridge works.	High - Viewpoint has high scenic values.	High - The existing two lane bridge would be removed. The replacement bridge, larger in scale and higher than the existing bridge, would be clearly visible due to the removal of some existing trees along the foreshore. Scour protection works on the southern foreshore would also be visible.	High

ID	Location	Description	Sensitivity	Magnitude	Impact
13	Pedestrian path at Howe Park, looking north east. 	Viewpoint from a pedestrian's perspective. It addresses mid distance views to the bridge works.	Low to Moderate - Low number of pedestrian viewers. Work elements are distant from viewpoint and would be partially screened by existing trees.	Moderate - The removal of the existing bridge and replacement with a new bridge sitting above the existing landform would be visible.	Moderate to Low
14	Picnic shelter near the playground at Governor Phillip Park, looking south west. 	Viewpoint from a pedestrian's perspective. It addresses mid distance views to the bridge works.	High to Moderate - Popular public park. Work elements are distant from viewpoint.	Low - The removal of the existing bridge and replacement with a new bridge sitting above the existing landform would be visible through existing vegetation.	Moderate
15	Governor Phillip Park, north of carpark, looking south west. 	Viewpoint from a pedestrian's perspective. It addresses mid distance views to the bridge works.	High to Moderate - Popular public park. Work elements are distant from viewpoint.	Moderate to Low - The removal of the existing bridge and replacement with a new bridge sitting above the existing landform would be visible.	Moderate

ID	Location	Description	Sensitivity	Magnitude	Impact
16	Macquarie Park, near picnic shelter, looking north east. 	Viewpoint from a park user's perspective. It addresses foreground views to the northern approach road works.	High to Moderate - Park has high scenic values but view corridor is narrow.	Low - The approach road to the existing bridge would be removed and the cut embankment filled and regraded. The entry road would be extended to link with the proposed roundabout. New tree planting in the area surrounding the roundabout would be visible. Existing tree planting in the foreground screens the extent of the view.	Moderate
17	Wilberforce Road, west of Freemans Reach Road intersection, outside residence, looking south. 	Viewpoint from the perspective of the residence and motorists as they approach the existing bridge. It addresses foreground views to the northern approach road, roundabout, and bridge works.	High to Moderate - Close proximity to heritage listed residential dwelling 'Bridgeview'.	High to Moderate - Increased road pavement and infrastructure in the form of the roundabout linking Wilberforce Road, Freemans Reach Road, the proposed bridge and Macquarie Park access road. The existing road would be removed and the area regraded, turfed and planted. Shared paths would be located in this parkland area. The new bridge would be visually prominent from this location.	High to Moderate

ID	Location	Description	Sensitivity	Magnitude	Impact
18	Wilberforce Road, east of Freemans Reach Road intersection, outside agricultural building, looking south. 	Viewpoint from the perspective of turf farm workers. It addresses foreground views to the northern approach road, roundabout, and bridge works.	Moderate - A small number of turf farm workers in a working environment would have the potential to be affected. Motorists travelling on Wilberforce Road would have an attractive view of Windsor, however, they would be travelling at a moderate speed.	High to Moderate - Increased road pavement and infrastructure in the form of the roundabout linking Wilberforce Road, Freemans Reach Road, the new bridge and Macquarie Park access road would be visible. The existing road would be removed and the area regraded, turfed and planted. Shared paths would be located in this parkland area. The new bridge would be prominent from this location. The temporary construction facility on the turf farm site would also be visible during construction,.	High to Moderate

Overshadowing

This section considers the potential overshadowing impacts of the replacement bridge on the public domain areas of Thompson Square, the Hawkesbury River waterway, the northern foreshore and adjoining private properties.

Background

The shadow cast by the existing bridge is restricted to the water directly under the bridge and the pedestrian stairs under the southern abutment due to its relatively low elevation above the river. Early morning and late afternoon shadows extend beyond the footprint of the bridge over the river, although the numerous trees growing along both foreshores and in the adjoining parklands mostly cast their shadows over the river and the bridge.

The replacement bridge would, by contrast, cast a larger and more obvious shadow across the water and the foreshore areas around the abutments due largely to the increased elevation and width of the new structure. The areas affected by overshadowing would include the lower areas of Thompson Square and the adjoining areas along the southern foreshore; areas of the northern foreshore adjacent to the bridge abutment, and the river itself. Overshadowing diagrams for morning, midday and the afternoon in summer and winter are presented in **Figure 7-29**.

Thompson Square and the adjoining foreshore

The overshadowing from the replacement bridge would start where the southern approach road becomes elevated as it approaches the abutment. The lower areas of Thompson Square closer to the river foreshore would be affected by overshadowing in the early morning during winter when the sun's angle is low and in the north eastern sky. Overshadowing of a very small section of the parkland would occur in summer, although the majority of the parkland would not be overshadowed and park users would therefore have access to sun in other areas of the parkland.

The section of The Terrace and adjoining foreshore which would be located directly beneath the replacement bridge, immediately adjacent to the abutment, would be in deep shadow for extensive periods of the day during all seasons.

The existing vegetation, when combined with mature replacement tree planting, proposed as a part of the concept for the project, would substantially increase the amount of shading of the river and both foreshores. Given the climate in Windsor, summer shading is considered to be a positive attribute of the landscape strategy.

Adjoining private properties

The private property closest to the proposed abutment, Number 4 Old Bridge Street, could potentially be affected by some overshadowing from the replacement bridge in the late evenings as the sun is setting (see **Figure 7-29**). The area of the property most likely to be affected would be the garden area below the house and closest to the river foreshore. Trees growing along the foreshore and the adjoining car park, would also cast shadows around this time over the lowest parts of this garden. Overshadowing effects of the replacement bridge on this property are unlikely to substantially affect the use of this garden area.

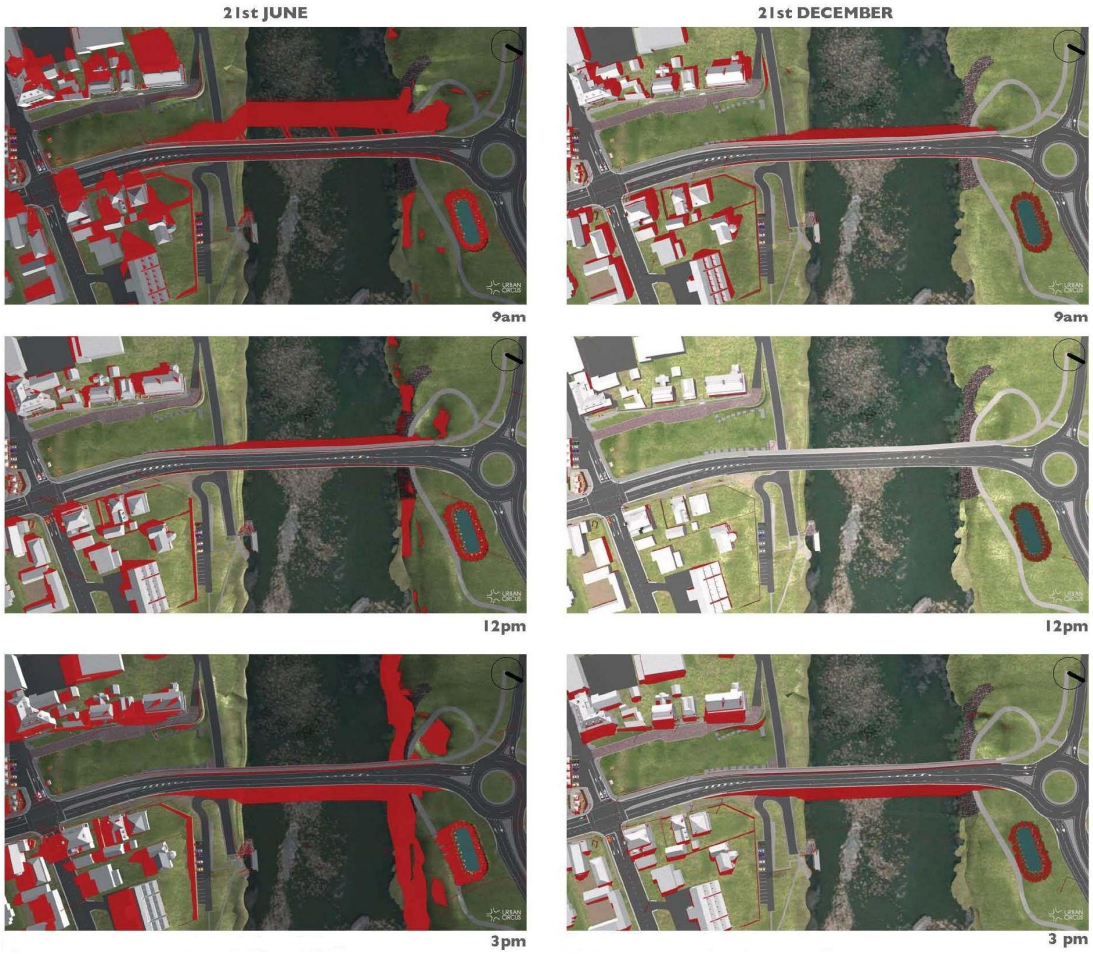


Figure 7-29 Overshadowing diagrams

The northern foreshore

Although the replacement bridge would be slightly wider at the northern end than the southern end, the lower clearance at the northern end, combined with the approach road at grade, would result in less overshadowing. Overshadowing of the northern foreshore and would be mainly restricted to underneath the bridge and an area either side. The longest shadows would occur in winter during the early morning when the area to the west of the abutment would be in shadow. These overshadowed areas would be used by pedestrians and cyclists accessing other recreational areas, rather than being a likely place where pedestrians or cyclists would stop.

The river

The bridge deck would cast a distinct shadow over the river moving from west to east throughout the whole day. The shadow would appear over the water on the western side of the replacement bridge in the morning and whilst being of a substantial width it would be diffuse in appearance. As the sun rises, the shadow would migrate closer to the replacement bridge in an easterly direction, and increase in intensity until it was aligned directly under the replacement bridge deck. As the sun tracks to the west, the shadow would continue moving to the east and become increasingly diffuse until the sun sets.

The public wharf currently provides the only stationary activity over the water in this location and whilst the replacement bridge would be closer to the wharf than the existing bridge, it is not likely to affect the wharf activities due to overshadowing, as this would occur only in the very late afternoon. Boating is unlikely to be affected by the overshadowing from the replacement bridge.

Summary of overshadowing impact

Overshadowing impacts would be mainly confined to areas directly under and adjacent to the replacement bridge. Generally these overshadowed areas are transitional locations with the users likely to be moving between other elements of the landscape – rather than locations of activity or interest.

Overshadowing of a small area of lower Thompson Square parkland immediately west of the replacement bridge and southern approach road would occur, with the highest area of over shadowing occurring on winter mornings. However, overall the overshadowing impact of the replacement bridge on the Thompson Square parkland and other key areas would be minor and transitory.

Summary of project impacts

Overall, the project would have an adverse impact on landscape character due to the introduction of dominant bridge and road elements that have greater footprint and scale in comparison to the existing bridge and road infrastructure. The project would also have a substantial impact on some views, particularly viewpoints within open space areas close to the Hawkesbury River or within Thompson Square. Overshadowing impacts are not expected to be substantial, given that most overshadowing occurs in transitory areas.

The project would, however, also result in long term benefits to the community and the enhancement of experiences within the area. Reunification of Thompson Square parkland areas would provide a larger usable open space for the community and visitors, while reinforcing its existing successful connection with George Street. Improved pedestrian and cycle connectivity through formal pathways would link previously isolated foreshore and parkland areas. The reunification of Thompson Square combined with improved pedestrian and cycle connectivity to and along the river southern foreshore, George Street and Macquarie Park would facilitate opportunities to further develop the area's cultural and recreational functions.

7.4.6 Environmental management measures

Throughout the concept design development process, urban design and landscape objectives and principles (refer to **Section 7.4.3**) have been iteratively considered with the aim of integrating the project within the existing historical and scenic landscape of Windsor. As a result, a number of potential adverse visual and landscape impacts have already been avoided or reduced as part of the concept design development process. The resulting concept design, incorporating the proposed urban design and landscape concept (refer to **Section 7.4.4**), aims to protect and enhance as far as practicable the existing visual character of the Windsor township, the Hawkesbury River and its floodplain. The measures that have already been incorporated into the concept design to reduce and manage environmental impacts are summarised in **Table 7-30** (refer to **Section 7.4.4**).

This section describes the additional environmental management measures that would be implemented during the detailed design and construction phases of the project, should the project be approved. The measures have been developed in accordance with the urban design and landscape objectives and principles identified in **Section 7.4.3**.

Construction measures

The following additional measures would be applied during the construction phase:

- Construction facilities will be contained within the construction works zone boundary and occupy the minimum area practicable.
- During construction, suitable barriers will be provided to screen views from adjacent areas.
- Temporary construction facilities and compound areas will be returned to their pre-construction state or better, either at the completion of the construction phase or progressively throughout the construction period where possible and practicable.
- Pollution and dust will be kept to a minimum through the application of pollution management measures and monitoring (refer to **Section 7-10**).
- Footpaths that will be affected by construction activities would be temporarily diverted to maintain suitable alternative access routes for pedestrians.
- Existing trees within construction area and compounds that do not need to be removed will be identified, protected and maintained throughout the construction period.
- Temporary lighting will be screened or diverted to reduce unnecessary light spill.
- Heritage items will be protected and managed in accordance with the measures identified in **Section 7.1.5**.
- Material used for temporary land reclamation will be removed once the works are complete.

Detailed design measures

It is recognised that further design development and refinement would be undertaken following approval of the project. As part of this detailed design process, the measures summarised in **Table 7-33** would be implemented with the aim of further reducing the adverse impacts of the project as far as practicable. Further consultation with the community, Hawkesbury City Council and other government stakeholders would be undertaken at this time to obtain their input to the detailed design.

Table 7-33 Detailed design management measures

Project element	Detailed design management measure
The bridge The new bridge would be a prominent feature in the landscape. During the detail design process, further measures would be examined to reduce the impact of the new structure on the area.	• Refinement of the bridge, its abutments and constituent parts and details to ensure a high quality outcome in response to its prominence within the Hawkesbury River's landscape setting and the township of Windsor. • Lighting design would be refined to integrate with the design and character of the bridge, approach roads and public domain, with consideration of minimising potential impacts associated with light spill and glare.
Thompson Square Reducing the impact of the project on the existing character of Thompson Square would be considered in greater detail during the detail design phase.	• Further consultation would be undertaken with Hawkesbury City Council and other relevant stakeholders to develop an urban design, landscape and open space use plan for Thompson Square and adjacent areas on the southern foreshore. • The concept design of Thompson Square presented in this proposal would form the basis for ongoing consultation. • Retention and protection of as many trees as possible will be undertaken but in particular the most significant existing trees would be incorporated into the design wherever possible. • Review the potential benefits of locating the shared path on the eastern side of the proposed bridge to increase the area of green space in Thompson Square. • New tree planting would be consistent and complement the existing species that are to be retained. Planting locations would facilitate direct views to the river and screen the replacement bridge where possible. • Any new lighting would strike a balance between illumination for safety and the context of the parkland and adjoining areas.
The Terrace and river foreshore Further refinement of the re-connection of The Terrace along the river's edge would be considered in the detail design phase.	• Further consultation would be undertaken with Hawkesbury City Council to develop an urban design, landscape plan for the southern foreshore and adjacent areas. • Further design refinement of The Terrace and foreshore area to achieve high quality public access and amenity along the river's edge and to the river, including the appropriate provision of lighting where required. • Detailed design of the form, materials and finishes of the foreshore retaining wall would be undertaken to maximise the integration of the wall into the river setting. • Consideration would be given to the design of The Terrace roadway including materials and form and to integrate it into the surrounding parkland. • New tree, shrub and groundcover planting would be incorporated in the foreshore areas to enhance the parkland setting and views to the river.

Project element	Detailed design management measure
The northern foreshore and intersection Integration of the northern intersection works into the existing character and adjoining land uses would be considered in greater detail during the detail design phase.	• Further consultation would be undertaken with Hawkesbury City Council to develop an urban design, landscape plan for the northern foreshore and adjacent areas. • Further design refinement would be undertaken to improve the integration of the northern intersection responding to its location and role as the northern arrival point to Windsor and Macquarie Park • Safe pedestrian and cycle connections throughout the project and links with existing path network within Macquarie Park would be further examined. • Appropriate provision for lighting would be considered and lighting infrastructure utilised only where required.
Pedestrian and cycle access Further refinement of the pedestrian and cycle access will occur in the detail design phase.	• Further consultation would be undertaken with Hawkesbury City Council to develop a pedestrian and cycle access plan for the project and the surrounding area, in order to integrate the pedestrian and cycle connections into the surrounding network.

7.5 Noise and vibration

This section assesses noise and vibration impacts of the project. The assessment is supported by a noise and vibration working paper, which is presented in Volume 4 - Working paper 6. The assessment has addressed the Director General's requirements (as detailed in **Table 7-34** below) as well as the relevant requirements of Schedule 2, Part 3 of the *Environmental Planning and Assessment Regulation 2000*.

Table 7-34 Director General's requirements - noise and vibration

Requirements	Where addressed
Assess construction and operational noise and vibration impacts of the project, in accordance with the Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009), NSW Road Noise Policy (Department of Environment, Climate Change and Water, 2011), and Assessing Vibration: a Technical Guideline (Department of Environment and Conservation, 2006).	Section 7.5.3 – Construction noise and vibration Section 7.5.4 – Operational noise and vibration

7.5.1 Guidelines and methodology

Operational Noise

The assessment of operational road traffic noise impacts has been undertaken in compliance with the *Road Noise Policy* (RNP) (DECCW, 2011) and the *Environmental Noise Management Manual* (ENMM) (RTA, 2001). These guidelines detail the criteria and methods used to assess impacts on noise sensitive receivers for road projects undertaken in NSW.

Targeted noise monitoring at three residential locations was undertaken in February and March 2012 to measure road traffic noise from the existing alignment. The noise at these locations was measured using noise loggers that continuously record noise levels. Noise monitoring was undertaken in conjunction with traffic counts to allow calibration of noise levels with traffic levels.

While noise monitoring provides a snapshot of the noise environment at specific locations, noise modelling is used to establish the baseline noise levels and noise management levels for the existing environment to allow the impact of the construction and operation of the project to be assessed. The noise monitoring undertaken at the three locations was used to calibrate the noise model developed for the project.

The noise model uses factors such as the number and type of vehicles, their speed, the road alignment and gradient and the road surface type to predict noise levels. Current and future traffic volumes used for the modelling were sourced from the Traffic and Transport working paper (Volume 4 - Working paper 4) and are based upon the outputs from the Sydney Strategic Travel Model. This model is operated by the Bureau of Transport Statistics within Transport for NSW and is used for projecting travel patterns in Sydney, Newcastle and Wollongong under different land use, transport and pricing scenarios.

The noise model was used to predict the existing and future traffic noise levels for the day and night periods, being the $L_{Aeq, (15\ hour)}$ and $L_{Aeq, (9\ hour)}$ respectively. For the purposes of road traffic noise assessments, these periods are defined as:

- $L_{Aeq, (15\ hour)}$ represents the L_{Aeq} noise level for the period 7 am to 10 pm.
- $L_{Aeq, (9\ hour)}$ represents the L^{Aeq} noise level for the period 10 pm to 7 am.

Assessment criteria

The Road Noise Policy (RNP) classifies work to an existing road as a "redevelopment". This classification applies to the project. The influence of traffic noise on existing receivers due to the project is defined in the RMS Environmental Noise Management Manual in Practice Note (i) as:

"A site is defined as having an "existing road traffic noise exposure" if the prevailing noise level from the existing road alignment(s) under consideration is equal to or greater than 55 dB(A) $L_{Aeq\ (15hr)}$ (day) or 50 dB(A) $L_{Aeq\ (9hr)}$ (night)."

The objective of any noise mitigation is to achieve these levels for at least a period of ten years after project completion. The criteria for the road redevelopment for the project have been summarised from the RNP and are presented in **Table 7-35**.

Table 7-35 Road traffic noise base criteria

		Noise Criteria	
Road category	**Type of project/land use**	**Day 7am -10pm**	**Night 10pm – 7am**
Freeway/arterial/ sub-arterial roads	Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial roads	$L_{Aeq\ (15hour)}$ 60 dB (A)	$L_{Aeq\ (9hour)}$ 55 dB (A)

In addition to the base criteria, the ENMM identifies a category of highly affected noise sensitive receivers that have been termed "acute". These receivers experience noise levels that would be greater than or equal to $L_{Aeq\ (15hour)}$ 65 dB(A) and $L_{Aeq\ (9hour)}$ 60 dB(A). In these instances an assessment of noise mitigation in accordance with ENMM practice note (iv) is required.

Assessment criteria for other non residential land uses are also detailed in the RNP. These are a special category of receiver that are not necessarily residential, but require consideration due the nature of activities associated with their use, such as passive recreation. These criteria do not require an assessment against a 'build' and 'no build' scenario in the same ways as residential sensitive receivers. Thompson Square parkland has been identified as an area of passive recreation adjacent to the project and as such has an $L_{Aeq\ 15\ hour}$ daytime noise criterion of 55 dB(A).

Operational vibration

A site-specific vibration site law was established for the ground conditions between the project and sensitive receivers on Bridge Street. The law was developed using sensitive vibration monitoring equipment to measure the vibration impacts at various distances from these locations and is explain in further detail in the Noise and vibration working paper (Volume 4 – Working paper 6).

Existing traffic data and the site law was then applied to predict levels at the building footings. These predictions were then repeated for new alignment and 2026 traffic levels to identify operational vibration impacts caused by the project.

Predicted operational vibration levels were assessed against Australian and International Standards and Guidelines, including:

- "Assessing Vibration: A Technical Guideline" (DEC, 2006).
- Australian Standard AS2670.2 'Evaluation of human exposure to whole-body vibration'. Identical to International Standard ISO 2631-1:1997.
- British Standard BS7385: Part 2 Evaluation and measurement of vibration in buildings, 0 580 22188 1 (British Standards Institution, 1993).
- BS5228:2009 Part 2 Code of Practice for noise and vibration control on construction and open sites-Vibration (British Standards Institution, 2009).
- German Standard DIN 4150: Part 3 – 1999 Effects of Vibration on Structures (German Institute for Standardisation, 1999).

Construction noise

The assessment of construction noise impacts was undertaken in compliance with the *Interim Construction Noise Guidelines* (ICNG) (DECC, 2009). These guidelines recognise the potential for impacts from construction noise on the community and have identified noise management levels and standard working hours to minimise these impacts.

The construction of the project was divided into phases based upon the types of activities and their location (see **Table 7-42**). To assess the noise impacts from each phase of construction, the location and the types of plant and equipment used were determined. This information was used in the project specific noise model to predict noise levels at sensitive receivers adjacent to the project. These predicted noise levels were compared against the noise management levels (NML) developed for each sensitive receiver to assess the potential impact of construction and the requirement for mitigation measures.

Assessment criteria

For the construction noise assessment, noise management limits for residential receivers are based upon the L_{A90} noise levels in the day, evening and night periods - with 10 dB(A) added to the L_{A90} noise level for the day time period and 5 dB(A) added the L_{A90} noise levels for the evening and night time periods (See **Table 7-36**). For non residential receivers the ICNG identifies specific noise management levels that are not based upon L_{A90} noise levels (see **Table 7-37**). Standard construction hours are also specified by the ICNG (see **Table 7-38**)

Table 7-36 NML time periods

NML time periods	Period in day
Day time	7am to 6pm
Evening	6pm to 10pm
Night time	10pm to 7am

Table 7-37 Non-residential noise management levels

Type of non-residential receiver	Noise management level
Industrial premises: external $LAeq_{(15min)}$	75 dB(A)
Offices, retail outlets: external $LAeq_{(15min)}$	70 dB(A)
Classrooms: internal $LAeq_{(15min)}$	45 dB(A)
Places of worship: internal $LAeq_{(15min)}$	45 dB(A)
Hotels Motels: external $LAeq_{(15min)}$	60 dB(A)
Passive recreational land: external $LAeq_{(15min)}$	60 dB(A)

Table 7-38 Standard hours of construction

Day	Time
Monday to Friday	7 am to 6 pm
Saturday	8 am to 1 pm
Sunday and Public Holidays	No work

Construction vibration

Where construction activities were identified within 20 metres of a residential or heritage sensitive receiver, impacts have been quantified and assessed using the site laws developed for the operational vibration assessment. Based on the site law and experience from other similar construction projects, vibration impacts on buildings greater than 20 metres away from the construction site would be negligible.

Works that are likely to generate an impact include the use of standard construction equipment (excavators, trucks etc) in close proximity to buildings or the use of rock hammers, rock breakers, compactors or piling rigs. Using in-house and published data to determine typical vibration levels associated with these activities, vibration levels at nearby sensitive receivers were predicted and compared against relevant guidelines.

7.5.2 Existing environment

The following sections identify the sensitive receivers potentially impacted by noise generated from the project, the baseline noise levels at sensitive receivers used for the operational noise impact assessment and the noise management levels used for the construction noise impact assessment. The Noise and vibration working paper (Volume 4 - Working paper 6) contains details on the noise monitoring locations and data.

Identification of sensitive receivers

The study area comprises a mixture of residential and commercial receivers, many of which are buildings or items with local and/or State heritage significance. The closest residences are located along Old Bridge Street adjacent to the southern approach road of the existing bridge and at the northern end of the project on the corner of Freemans Reach Road and Wilberforce Road.

There are around 175 sensitive receivers situated within a 200 metres radius of the project, comprising a mixture of residential and commercial buildings (including hotels, retail outlets, and offices). Noise and vibration from the construction and operation of project would not impact receivers greater than 200 metres from the project due to the topography, relatively short length of the project and the influence of other noise sources. Many of these receivers are already exposed to traffic noise from surrounding roads.

The highest impacts of operational and construction noise from the project would be limited primarily to the receivers adjacent to the project. Receivers beyond the first row of buildings would have the benefit of shielding by the intervening rows of buildings and would be impacted by other roads in the area. Therefore, only the properties immediately adjacent to the project were considered. The locations of these sensitive receivers are presented in **Figure 7-30**. While all sensitive receivers could potentially be impacted by the project, sensitive receivers R1 to R4 would experience the greatest impacts due to their close proximity to the project.

Baseline noise levels

The estimated L_{Aeq} levels for day time and night time periods at residential receivers in 2016 are presented in **Table 7-39**. These are the baseline noise levels that all operational impact predictions are compared against. It should be noted that only noise levels at residential receivers are presented in **Table 7-39** as only residential receivers require consideration for operational noise mitigation. However, if at source noise mitigation measures are applied (eg Noise barriers or low noise pavement) the benefits could be experienced by non-residential receivers.

The receivers identified as T1 and T2 (see **Figure 7-30**) are locations within Thompson Square parkland. T1 is representative of users of the parkland close to the existing road, with T2 being in the parkland at the furthest distance from the alignment. Noise predictions at these two locations would provide an indication of the highest and lowest levels within Thompson Square parkland.

Table 7-39 Predicted baseline noise levels for residential receivers (2016)

ID	Day time L_{Aeq} dB(A)	Night time L_{Aeq} dB(A)
R1	66	61
R2	65	61
R3	71	67
R4	61	57
R5	59	54
R6	58	53
R7	57	53
R8	56	52
R9	55	51
R10	55	51
R11	56	52
R12	57	53
R13	56	52
R14	57	52
R15	55	51

Noise management levels

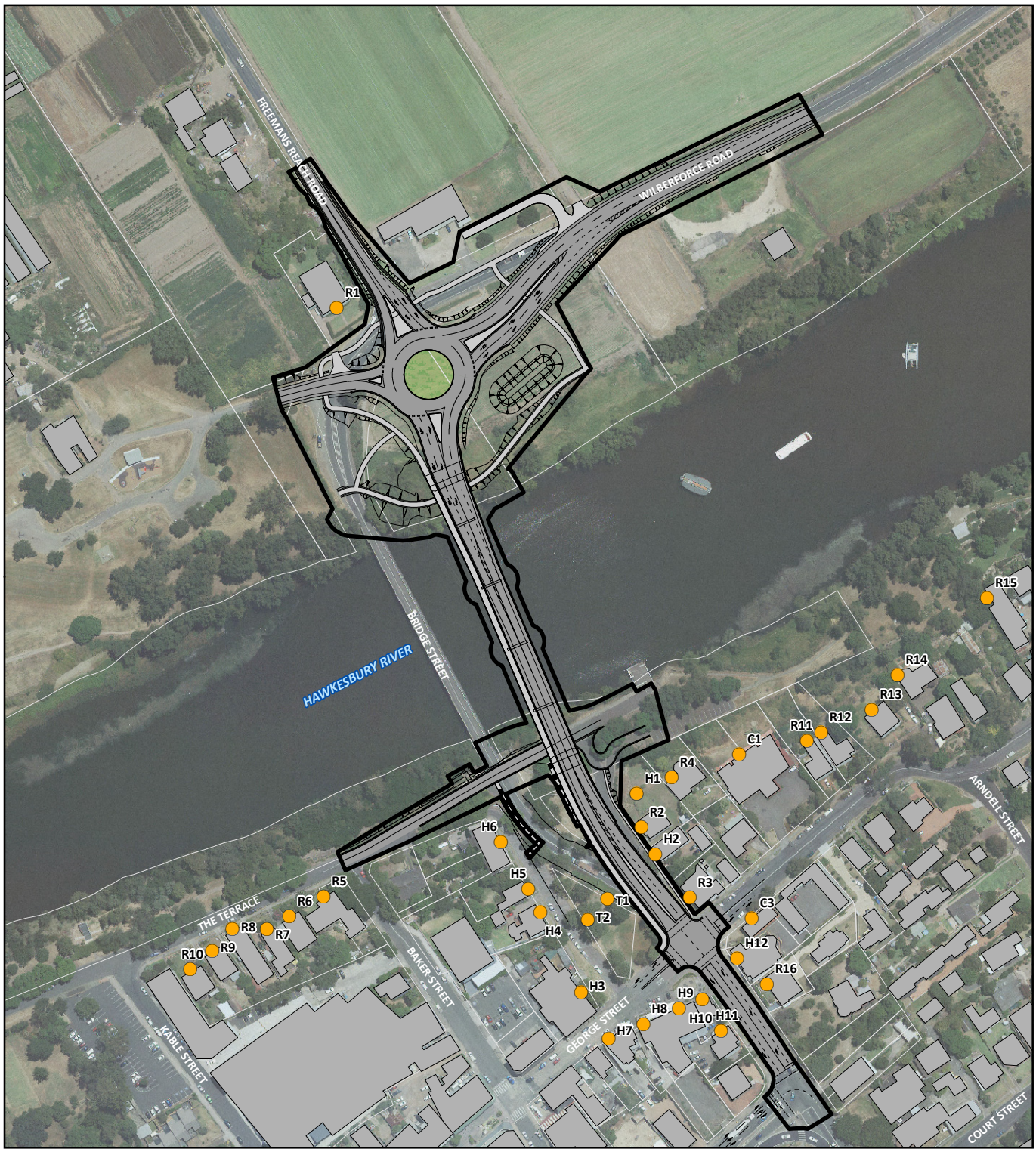
The noise management levels for potentially impacted sensitive receivers from construction activities are summarised in **Table 7-40**.

Table 7-40 Noise management levels

Receiver			*Noise Management Levels / dB(A)		
			Day time 7am – 6pm (L_{Aeq})	Evening 6pm – 10pm (L_{Aeq})	Night time 10pm – 7am (L_{Aeq})
R1	27 Freemans Reach Road		68	55	44
R2	4 Bridge Street		72	61	46
R3	10 Bridge Street	Ground Floor	70	70	70
		First Floor	72	61	46
R4	53 George Street		55	47	32
R5–R15**	See Figure 7-30 for location		55	47	32
R16***	16 Bridge Street		72	61	46
C1, C3,	See Figure 7-30 for location		60	60	60
H2 – H12	See Figure 7-30 for location		70	70	70

Daytime NML = RBL +10dB(A), Evening NML = RBL +5dB(A), Night-time NML = RBL +5dB(A), or absolute levels for commercial receivers. **In the absence of measured background noise levels at these specific locations, monitoring data at R4 assumed to be representative of noise at receivers R5-R15. * In the absence of measured background noise levels at R16, monitoring data at R3 (first floor) assumed to be representative of noise at this receiver.*

Figure 7-30 | Location of sensitive receivers



Indicative only – subject to detailed design

LEGEND

- Receiver
- Concept design
- Concept design footprint
- Building footprint
- Cadastral boundary

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Existing vibration

Attended vibration monitoring was undertaken at two locations along Bridge Street. These locations were at the kerbside (about 0.5 metres from the kerb and one metre from the line of the closest wheel) in front of 4 Bridge Street (R2) and at the kerbside in front of 10 Bridge Street (R3). Monitoring was also undertaken simultaneously at the facade of 4 and 10 Bridge Street.

The results of traffic vibration monitoring are provided in **Table 7-41**. The maximum peak particle velocity (PPV) at the buildings was less than 0.002mm/s. At these locations the road traffic would be the only source contributing to the vibration levels. These vibration levels would not be perceptible to humans and would not cause damage to heritage structures.

Table 7-41 Road traffic vibration data

Vehicle Class	Speed	Maximum recorded PPV/ mms^{-1}							
		Bridge to Roundabout (north to south) @5m from source			Roundabout to Bridge (south to north) @1m from source			Maximum PPV At Structure (mms^{-1})	Maximum PPV At Structure (mms^{-1})
		x	y	z	x	y	z	z	z
Car/SUV/4wd (under 2.5T)	5-20kmh^{-1}	0.06	0.07	0.09	0.07	0.08	0.10	<0.002	<0.002
	>20kmh^{-1}	0.06	0.07	0.09	0.07	0.08	0.11	<0.002	<0.002
Van/Lightweight truck (2.5T -)	5-20kmh^{-1}	0.06	0.07	0.10	0.08	0.09	0.11	<0.002	<0.002
	>20kmh^{-1}	0.06	0.07	0.09	0.08	0.08	0.12	<0.002	<0.002
Large Van (2 axel 5T -)	5-20kmh^{-1}	0.07	0.08	0.09	0.11	0.11	0.16	<0.002	<0.002
	>20kmh^{-1}	0.08	0.08	0.10	0.12	0.11	0.20	<0.002	<0.002
Small Truck	5-20kmh^{-1}	0.09	0.08	0.14	0.27	0.22	0.28	<0.002	<0.002
	>20kmh^{-1}	0.10	0.10	0.18	0.30	0.22	0.44	<0.002	<0.002
Large Truck	5-20kmh^{-1}	0.22	0.31	0.87	0.25	0.35	0.87	<0.002	<0.002
	>20kmh^{-1}	0.24	0.33	0.88	0.26	0.40	1.02	<0.002	<0.002

7.5.3 Construction impacts

Construction noise

Construction activities have been identified for eight phases of construction, as described in **Table 7-42**.

Table 7-42 Construction phases and major construction activities

Construction phase	Construction activities
Site establishment/early works	Archaeological investigations Utility adjustments Construction of the casting yard Installation of environmental controls Establishment of hard stand, construction compound and other construction facilities Minor road works for site access Clearing of vegetation to facilitate above activities
Bridge pier and northern abutment construction	Non-terrestrial impact piling (riverbed) up to 9 piles per pier (4 piers) Concrete pumping from northern approach Terrestrial bored piling at northern abutments
Construction and launching of bridge (including casting yard)	Bridge casting in northern casting yard Bridge form and steel work Incrementally launch bridge Concrete pumping on bridge Concrete pours and surface construction
Southern approach road construction	Terrestrial bored piling at southern bridge abutment Construction of land bridge or concrete panel fill southern approach road Paving and asphalting
Removal of casting yard and northern road construction	Earthworks and clearing for new roundabout and northern approach road Paving and asphalting
Southern end of Bridge Street tie-in and intersection	Standard road construction including earthworks Paving and asphalting Fill of existing southern cutting
Existing bridge demolition	Superstructure removal – road saws, grinders, cranes Substructure removal – oxy cutters and cranes
Use of laydown/construction compound	Use of area at the Windsor Wharf car park as a laydown area (plant storage and potential materials stockpile). To be used throughout each construction phase

Generally these phases would occur sequentially, however some phases may overlap – for example construction of the southern approach road and the construction and launching of the incrementally launched bridge may occur concurrently. **Table 7-43** summarises the predicted noise levels for each of the construction phases at each sensitive receiver and includes the cumulative impact where phases of construction would be concurrent.

The noise levels presented in **Table 7-43** are the maximum noise levels a sensitive receiver would experience in a 15 minute period and assume that all construction equipment identified for the construction activity would be operating simultaneously.

While this worst case scenario may occur occasionally, typically the noise generated would be lower that the noise levels presented in **Table 7-43**. This is because not all the construction plant and equipment would be operating simultaneously due to construction sequencing and the extremely limited construction site areas. Presented in the sections following the table is further discussion of the noise impacts from each of the construction phases.

Where NMLs are exceeded at a sensitive receiver, mitigation measures would need to be considered and this is discussed in **Section 7.5.5**. Where a sensitive receiver is exposed to noise levels of 75dB(A) or greater, as a result of construction activities, the receiver would be classed as 'highly noise affected' and would be afforded additional consideration.

Table 7-43 Summary of noise management levels

Receiver	NML / dB(A)			Phase of construction noise predictions / dB(A)							
	Daytime	Evening	Night	Establish site and early works	Bridge pier	Incremental launched bridge	Southern approach road	Northern approach road	Southern tie-in	Bridge demolition	Southern compound
R1	68	55	44	63	64	63	57	**69**	54	58	44
R2	72	61	46	67	69	61	**77**	51	69	65	43
R3	72	61	46	54	62	50	65	46	**84**	60	31
R4	55	47	32	**64**	**72**	**65**	**74**	**55**	49	**66**	**63**
R5	55	47	32	52	**65**	**60**	**58**	54	41	**65**	45
R6	55	47	32	52	**64**	**57**	**56**	54	43	**64**	38
R7	55	47	32	52	**65**	**58**	**56**	54	40	**64**	37
R8	55	47	32	51	**63**	**56**	55	53	39	**63**	42
R9	55	47	32	50	**60**	**56**	45	53	41	**61**	31
R10	55	47	32	51	**61**	**57**	47	53	45	**61**	34
R11	55	47	32	53	**65**	**59**	53	54	**56**	**60**	43
R12	55	47	32	53	**66**	**60**	**55**	54	49	**62**	50
R13	55	47	32	52	**65**	**59**	**60**	54	54	**61**	51
R14	55	47	32	50	**62**	**56**	**59**	52	46	**58**	48
R15	55	47	32	51	**63**	**57**	**59**	54	45	**59**	47
R16	72	61	46	37	47	40	49	41	**75**	52	30
H2	70	-	-	59	67	60	**70**	48	**73**	62	38
H3	70	-	-	53	65	58	65	52	**72**	59	48
H4	70	-	-	56	67	61	69	53	69	60	52
H5	70	-	-	58	68	62	**70**	53	68	61	53
H6	70	-	-	62	**72**	64	**74**	54	66	68	55
H7	70	-	-	49	62	55	58	51	**70**	56	41
H8	70	-	-	49	63	56	59	51	**73**	58	42
H9	70	-	-	49	63	56	59	51	**78**	58	41
H10	70	-	-	49	61	54	58	51	**85**	55	35
H11	70	-	-	45	56	49	52	46	**73**	49	29
H12	70	-	-	47	59	45	59	46	**84**	56	32
C1	60	-	-	53	**68**	**62**	**61**	55	47	**64**	55
C3	60	-	-	47	58	51	48	51	**76**	46	39
T1	60	-	-	54	**64**	57	**65**	50	**84**	**60**	49
T2	60	-	-	52	**63**	56	**64**	50	**73**	60	46

Green notes exceedance of daytime NML, **Red** notes daytime prediction exceeds ICNG 'highly noise affected criteria

Table 7-44 Potential works outside standard construction hours compared to noise management levels

Receiver	Evening NML / dB(A)	Activity noise prediction / dB(A)						Night-time NML / dB(A)	Activity noise prediction / dB(A)					
		Site establishment early and works	Bridge pier construction	Northern approach road		Southern approach road			Site establishment early and works	Bridge pier construction	Northern approach road		Southern approach road	
		Southern approach utilities	Bridge casting	Earthworks	Paving	Existing road removal	Paving		Southern approach utilities	Bridge casting	Earthworks	Paving	Existing road removal	Paving
R1	**55**	44	62	63	67	52	48	**44**	44	62	63	67	52	49
R2	**61**	61	51	45	50	67	59	**46**	61	51	45	50	67	59
R3	**61**	51	36	31	44	82	69	**46**	51	36	31	44	82	69
R4	**47**	60	54	50	54	47	40	**32**	60	54	50	54	47	40
R5	**47**	46	53	49	53	39	34	**32**	46	53	49	53	39	34
R6	**47**	34	52	49	52	41	36	**32**	34	52	49	52	41	36
R7	**47**	36	53	49	52	38	33	**32**	36	53	49	52	38	33
R8	**47**	43	51	48	52	37	32	**32**	43	51	48	52	37	32
R9	**47**	32	51	47	51	39	34	**32**	32	51	47	51	39	34
R10	**47**	34	52	47	51	43	38	**32**	34	52	47	51	43	38
R11	**47**	41	53	49	53	52	54	**32**	41	53	49	53	52	54
R12	**47**	42	53	49	53	46	47	**32**	42	53	49	53	46	47
R13	**47**	48	52	48	52	48	52	**32**	48	52	48	52	48	52
R14	**47**	46	50	46	50	44	39	**32**	46	50	46	50	44	39
R15	**47**	45	51	48	53	43	41	**32**	45	51	48	53	43	41
R16	**61**	35	37	34	39	68	73	**46**	35	37	34	39	68	73
H2	**70**	55	47	43	47	71	61	**70**	55	47	43	47	71	61
H3	**70**	51	52	46	50	70	65	**70**	51	52	46	50	70	65
H4	**70**	55	53	47	51	67	61	**70**	55	53	47	51	67	61
H5	**70**	56	53	47	52	66	60	**70**	56	53	47	52	66	60
H6	**70**	60	54	48	53	64	58	**70**	60	54	48	53	64	58
H7	**70**	44	50	46	49	68	63	**70**	44	50	46	49	68	63
H8	**70**	45	51	46	49	71	67	**70**	45	51	46	49	71	67
H9	**70**	45	51	46	49	73	76	**70**	45	51	46	49	73	76

Receiver	Evening NML / dB(A)	Activity noise prediction / dB(A)						Night-time NML / dB(A)	Activity noise prediction / dB(A)					
		Site establishment and early works	Bridge pier construction	Northern approach road		Southern approach road			Site establishment and early works	Bridge pier construction	Northern approach road		Southern approach road	
		Southern approach utilities	Bridge casting	Earthworks	Paving	Existing road removal	Paving		Southern approach utilities	Bridge casting	Earthworks	Paving	Existing road removal	Paving
H10	**70**	44	50	45	49	73	83	**70**	44	50	45	49	73	83
H11	**70**	38	46	38	45	67	71	**70**	38	46	38	45	67	71
H12	**70**	45	40	35	44	76	82	**70**	45	40	35	44	76	82
T1	**70**	51	50	45	49	82	67	**70**	51	50	45	49	82	67
T2	**70**	50	49	45	49	71	64	**70**	50	49	45	49	71	64

Light grey shading denotes exceedance of NML

Works outside of standard construction hours

A number of activities would be required to be undertaken outside of standard construction hours. Generally works outside of standard construction hours works are considered reasonable where the works are below the relevant NML. However often the noise of works undertaken outside of standard construction hours would be above NMLs and cannot be easily mitigated. Works that may be required outside standard construction hours are detailed in **Table 7-45.** These works are compared to sensitive receiver NMLs for evening and night time periods in **Table 7-44**.

Following detailed construction planning, additional activities may need to be undertaken outside of standard construction hours. The process of assessing additional works outside of standard construction hours would be identified in the Construction Noise and Vibration Management Plan (see **Section 7.5.5**).

Table 7-45 Works outside standard construction hours

Construction phase	Justification
The delivery of oversize bridge elements.	Delivery outside of standard hours of construction may be required due to road safety requirements. Oversize loads are generally only allowed on the roads during night time periods when traffic levels are low.
The delivery and demobilisation of plant and large construction equipment.	Delivery outside of standard hours of construction may be required due to road safety requirements. Oversize loads are generally only allowed on the roads during night time periods when traffic levels are low.
Emergency work.	Work may be required outside of standard construction hours to respond to emergency situations that pose a risk to safety or the environment.
Utility adjustments	Some services may be located within the existing alignment and traffic on the existing alignment may require diversion to allow a service adjustment to be undertaken safety. Traffic diversions on busy roads are generally only permitted outside standard construction hours to minimise the impact on the road network. Also the cutover of existing services to new services may need to be undertaken in off-peak periods which are generally outside standard construction hours.
Major traffic diversions, including full or partial road closures.	Due to traffic disruptions it would be unlikely that daytime Road Occupancy Licences would be granted and therefore night-time works would be required where works is undertaken on existing network.
Bridge works – including concrete pours, concrete bridge casting, steel fixing, formwork construction and the craning of materials during incremental launch.	These works may be required outside of standard hours due to timing constraints and requirements associated with concrete pours.

Construction phase	Justification
Road tie-in works (including paving and asphalting) –	The tie-in of the proposed northern and southern approach roads, along with bridge road surface construction. These works may be required outside of standard construction hours as they will involve possible 24 hour concrete pours and will involve working on the existing road network. Due to traffic disruptions it would be unlikely that daytime Road Occupancy Licences would be granted and therefore night-time works would be required where works is undertaken on existing network.
Other works that are required outside standard hours and are approved by the appropriate regulatory authority	These would be justified, assessed and approval sought as required.

Site establishment and early works

Site establishment and early works would be undertaken during standard construction hours, and the daytime noise management level (NML) would be exceeded at one sensitive receiver. The highly noise affected criteria would not be exceeded at any receiver. The daytime NML at R4 (54 George Street) would be exceeded as a result of archaeological investigations near the southern abutment. These works are short term with the noisiest part of the works from jack hammering of the existing road pavement and excavation of test pits. Once a test pit is opened, works are manual with hand tools with minimal noise emissions. Therefore the impacts associated with daytime archaeological works and the site establishment works as a whole would be considered to be minor.

Bridge piers

Bridge pier construction works would be undertaken in the day time. For a worst case noise assessment it has been assumed that impact piling would be used to install the piles for the bridge piers. However, it is more likely that bored piles would be used due to the geotechnical properties of the river bed and underlying bedrock. Bored piling would result in substantially lower noise impacts than impact piling. If it occurred, impact piling would be the single highest noise emitting activity and as the construction site is in the river, more sensitive receivers would be exposed to the noise as they would have direct line of sight to the construction area. As a result the daytime NML at 16 sensitive receivers along the southern riverbank and within Thompson Square parkland would be exceeded during impact piling. The highly noise affected criteria of 75dB(A) would not be exceeded at any receiver.Other works included in the bridge pier construction are works at the northern bridge abutment. The northern abutment works would be relatively quiet and noise levels at all sensitive receivers would be below the NML for daytime.

Construction and launching of bridge

The construction and launching of the bridge from the northern bank would occur predominately in the daytime, however some works outside standard construction hours may be required. Activities outside standard construction hours could include concrete pours, the operation of the jacks to push the bridge over the river and the fixing of steel and formwork in the casting yard. The latter two activities would result in the exceedances of the NML at one sensitive receiver (R4).

Concrete pours may extend into the evening or start early in the morning to meet the temperature specifications for concrete and/or to fully complete a pour for a half span of the bridge in one day. Concrete pours for the bridge would occur once every seven to ten working days.

During daytime concrete pours and paving works on the bridge, noise levels would exceed NMLs at up to 13 receivers, however the highly noise affected criteria is not predicted to be exceeded.

Southern approach road

Fifteen sensitive receivers would be exposed to noise greater than their specific NMLs from southern approach road works. This includes the exceedance of highly noise affected criteria at R2 (4 Bridge Street). Exceedances of the daytime NML for Thompson Square parkland would also occur. These exceedances are due to the close proximity of works to sensitive receivers rather than excessively noisy activities.

If paving works are required outside of standard construction hours and are in close proximity to sensitive receivers, noise levels would exceed both evening and night time NMLs by up to 30dB(A), causing sleep disturbance at two residential sensitive receivers (R3 and R16).

Northern approach road

The majority of the construction works for the northern approach road would be undertaken in standard construction hours. Two receivers would be exposed to noise above their daytime NMLs, however the exceedance would only be about 1dB(A), therefore the impact is considered to be low.

The final paving works to tie in the northern approach road with Freemans Reach Road and Wilberforce Road would be undertaken outside of standard construction hours in periods of low traffic. During these works 12 sensitive receivers would be exposed to noise levels above evening and night time NMLs.

Southern approach road tie-in

The final section of road pavement to tie in the new southern approach road with Bridge Street and George Street would occur outside the standard construction hours as temporary closure of the southern approach road to the existing bridge would be required. Closure of the southern approach road to the existing bridge could only occur at night time when traffic levels were low.

For works outside the standard construction hours, impacts would be restricted to residential dwellings on Bridge Street including R2, R3 and R16 and commercial premises that operate after 10pm.

Existing bridge demolition

Bridge demolition works would be restricted to standard construction hours and there would be 14 receivers exposed to construction noise above their day time NML, however the highly noise affected criteria would not be exceeded at any sensitive receivers. Noise exceedances would result from activities such as saw and grinder use during the demolition of the existing bridge superstructure. These activities would occur for short periods of time, with the remainder of activities associated with bridge demolition relatively quiet.

Southern laydown/compound use

The operation of the southern laydown area next to the Windsor Wharf car park would not have a significant impact throughout the duration of works. Noise emissions would be restricted to short periods where equipment or materials are being collected or delivered. Only the closest receiver to this area, R4 (53 George Street) would be exposed to noise levels exceeding their day time NML.

Construction vibration

Vibration from construction activities may cause structural damage to buildings. Heritage buildings are often particularly sensitive to vibration impacts due to their age and the materials and techniques used in their construction. Vibration from construction activities may also be perceptible to residents in buildings adjacent to the project. This may cause discomfort if the vibration is substantial and/or occurs for an extended period of time.

To assess the impact of construction vibration, activities that are known to cause substantial vibration were identified. For the project, these activities were impact piling, rock breaking (jack hammering) and vibratory rolling. The location where these activities would be undertaken and the proximity of sensitive residential receivers and heritage buildings were also determined. This information and the site law developed for vibration propagation was used to estimate vibration levels from construction at key sensitive receivers. The estimated vibration levels from high vibration activities and a comparison to relevant structural damage and human comfort vibration criteria is presented in **Table 7-46**. As vibration from construction activities would rapidly dissipate with distance from its origin, only sensitive receivers adjacent to construction sites would be potentially impacted.

While impact piling would generate the highest vibration levels, because it would be undertaken in the river for the piers and therefore is distant from sensitive receivers, it would not exceed the vibration criteria at any sensitive receivers. Rock breaking would be undertaken in close proximity to sensitive receivers especially along the southern approach road. Vibration levels from rock breaking would exceed the human comfort criterion at sensitive receiver R2 and exceed the structural damage criterion at H1 (heritage wall at 4 Bridge Street) and C2. Vibration levels from vibratory compaction would exceed the human comfort criterion at all adjacent sensitive residential receivers and would be just below the structural damage criterion for heritage structures at all sensitive heritage receivers.

Table 7-46 Construction vibration levels and potential impacts on sensitive receivers

ID	Criteria		Impact Piling		Rock Breaking		Vibratory compaction	
	Structural Damage (PPV) mms^{-1}	Human Comfort (VDV) mms^{-1}	PPV mms^{-1}	VDV mms^{-1}	PPV mms^{-1}	VDV mms^{-1}	PPV mms^{-1}	VDV mms^{-1}
R1	5	0.4	<0.2	<0.25	0.4	0.3	2.5	1
R2	5	0.4	<0.2	<0.25	3	1.9	2.5	1
R3	3	0.8	<0.2	<0.25	1.8	0.2	2.5	1
R16	5	0.4	-	-	1.8	0.2	2.5	1
H1	3	-	<0.2	-	3	1.9	2.5	1
H2	3	0.4	<0.2	<0.25	1.8	0.2	2.5	1
H6	3	0.4	<0.2	<0.25	0.4	0.3	2.5	1
H7	-	0.4	-	-	0.4	0.3	2.5	1
H8	3	0.4	-	-	0.4	0.3	2.5	1
H9	3	0.4	-	-	0.4	0.3	2.5	1
H10	3	0.4	-	-	0.4	0.3	2.5	1
H11	3	0.4	-	-	0.4	0.3	2.5	1
H12	3	0.4	-	-	0.4	0.3	2.5	1
C2	3	0.4	-	-	3	-	2.5	1

Shaded cell indicates vibration level is equal or above relative vibration criterion

7.5.4 Operational impacts

Operational Noise

A number of different scenarios were modelled to predict operational noise impacts from the operation of the project and the need for consideration of noise mitigation. The key scenarios for impact assessment are:

- The “do nothing” or “no project” option – This scenario assumes that the existing bridge and approach roads are retained. Traffic levels for the year that the project would have become operational (2016) and 10 years after opening (2026) are used to provide a basis for comparison.
- The project becomes operational – This scenario assumes that the project is built. Traffic levels at opening and 10 years after the project becomes operational (2026) are used in the model to predict noise levels and identify sensitive receivers where noise mitigation must be considered.

The results of the noise modelling for both scenarios and for each residential sensitive receiver are presented in **Table 7-47** and have also been presented as day and night time noise contours overlaid on aerial photography for the project in 2026 (see **Figure 7-31** and **Figure 7-32**)

Residential sensitive receivers not directly adjacent to the project (R5-R10 on The Terrace and R11-R15 on George Street) noise levels from the project in 2026 are predicted to decrease slightly in comparison to existing noise levels. This would be due to the improved road surface and/or the changed alignment and location of the bridge and approach roads.

Residential sensitive receivers directly adjacent to the project include R1, R2, R3 and R4. The sensitive receiver R1, at the corner of Freemans Reach Road and Wilberforce Road is predicted to benefit from a reduction in noise levels due to the relocation of the northern intersection further to the south east. Sensitive receivers R2 and R3, currently experience acute levels of noise and this is predicted to continue with the project. Noise levels at both these receivers are predicted to increase by 2026. At sensitive receiver R4, the project would result in an increase of about 2 dB(A) over existing levels.

Based on the noise impact assessment results and application of the RNP and ENMM, noise mitigation options for receivers R2, R3 and R4 must be considered and are further discussed in **Section 7.5.5**.

Thompson Square parkland

Thompson Square parkland is currently bisected by the southern approach road to the existing bridge and is subject to traffic noise from Bridge Street, Windsor Bridge and to a lesser extent George Street. The existing daytime noise levels are within the range of 72 dB(A) close to Bridge Street, down to about 63 dB(A) closer to The Terrace.

The noise levels in Thompson Square parkland with the project would be similar to existing levels ranging from 72 dB(A) to about 64 dB(A). The noise levels for both the project and no build daytime scenarios in 2026 (see **Figure 7-33** and **Figure 7-34**) indicate that both scenarios would exceed the criterion for recreational use. The area of Thompson Square parkland impacted by the higher noise levels would decrease slightly with the project especially the northern area of the parkland near the river.

This is because the new southern approach road would be along the eastern side of the parkland, rather than the existing situation where the southern approach road bisects the parkland.

Operational vibration

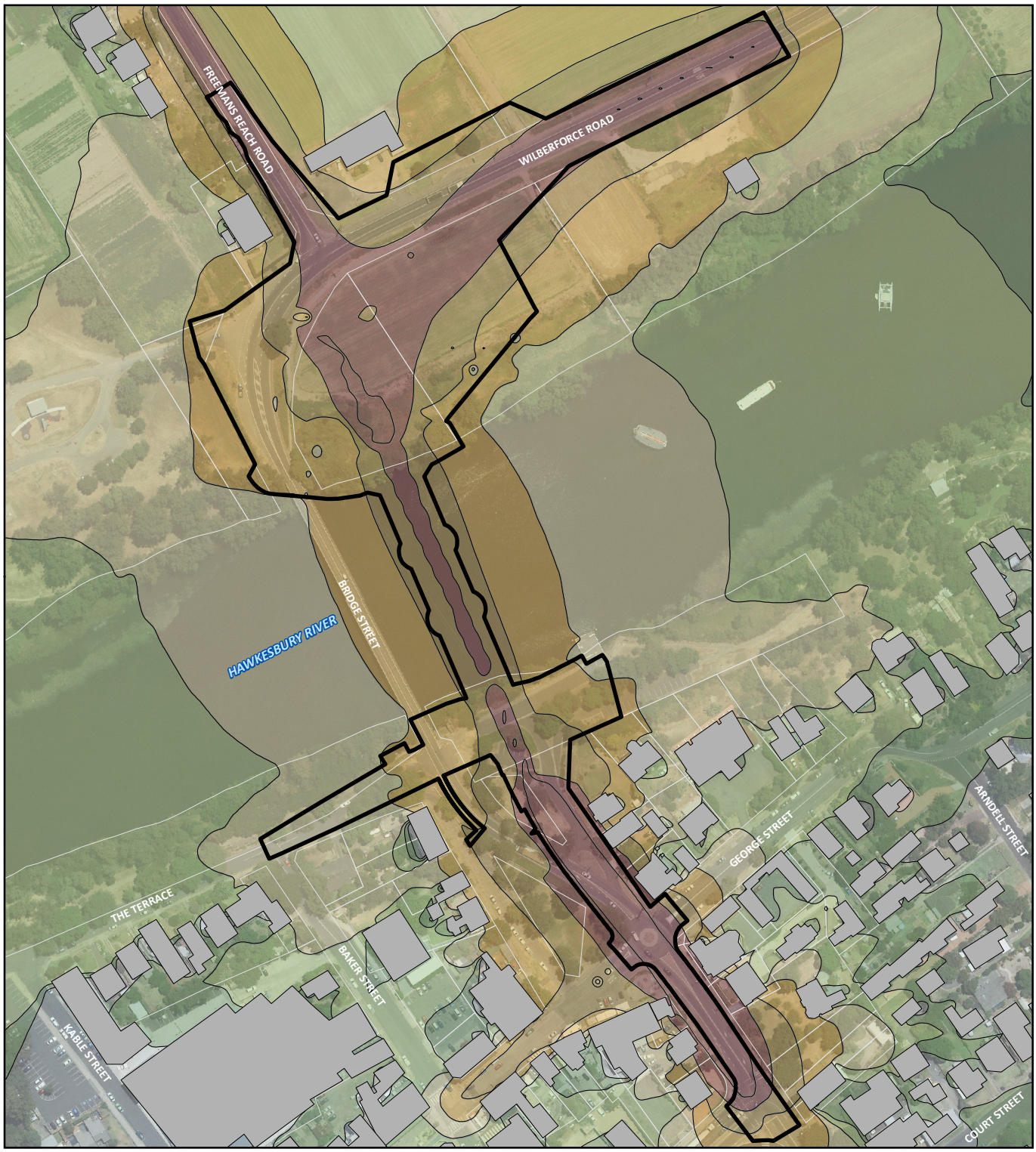
Based upon the vibration monitoring of the existing road and consideration of the new alignment and the increase in traffic over time, vibration from the operation of the project would not exceed human comfort or building damage criteria at adjacent buildings. Further details on the assessment of operational vibration can be found in the Noise and vibration working paper (Volume 4 – working paper 6). No mitigation measures would be required to minimise vibration impacts from the operation of the project.

Table 7-47 Predicted noise levels up to 2026

ID	Year of opening No project L_{Aeq}		Year of opening With project L_{Aeq}		2026 No project L_{Aeq}		2026 With project L_{Aeq}		Changes in noise levels 10 years after opening L_{Aeq}		Exceeds acute criteria 60 dB(A) night & 65 dB(A) day		Considered for noise mitigation
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	
R1	66	61	62	58	67	61	63	58	-3.7	-3.3	No	No	No
R2	65	61	70	66	65	61	71	67	5.4	6.0	**Yes**	**Yes**	**Yes**
R3	71	67	71	68	71	67	72	68	0.5	0.8	**Yes**	**Yes**	**Yes**
R4	61	57	63	59	61	57	63	59	1.9	2.6	No	No	**Yes**
R5	59	54	54	50	60	54	55	51	-4.7	-3.8	No	No	No
R6	58	53	53	49	58	53	54	50	-4.3	-3.6	No	No	No
R7	57	53	53	49	58	53	53	49	-4.4	-3.5	No	No	No
R8	56	52	53	49	57	52	53	49	-3.2	-2.5	No	No	No
R9	55	51	51	47	56	51	52	47	-4.0	-3.5	No	No	No
R10	55	51	51	47	56	51	52	48	-3.8	-3.0	No	No	No
R11	56	52	55	51	57	52	56	52	-1.0	-0.2	No	No	No
R12	57	53	55	51	57	53	56	52	-1.4	-0.7	No	No	No
R13	56	52	55	51	57	52	55	51	-1.5	-0.9	No	No	No
R14	57	52	55	51	57	52	56	51	-1.6	-1.1	No	No	No
R15	55	51	53	49	56	51	54	50	-1.8	-1.3	No	No	No

Note: shading indicates an exceedance of Road Noise Policy criteria

Figure 7-31 | Day time noise levels with the project in 2026



Indicative only – subject to detailed design

LEGEND

- Concept design footprint
- Building footprint
- Cadastral boundary

Noise assessment (dB)

- 45
- 50
- 55
- 60
- 65
- > 65

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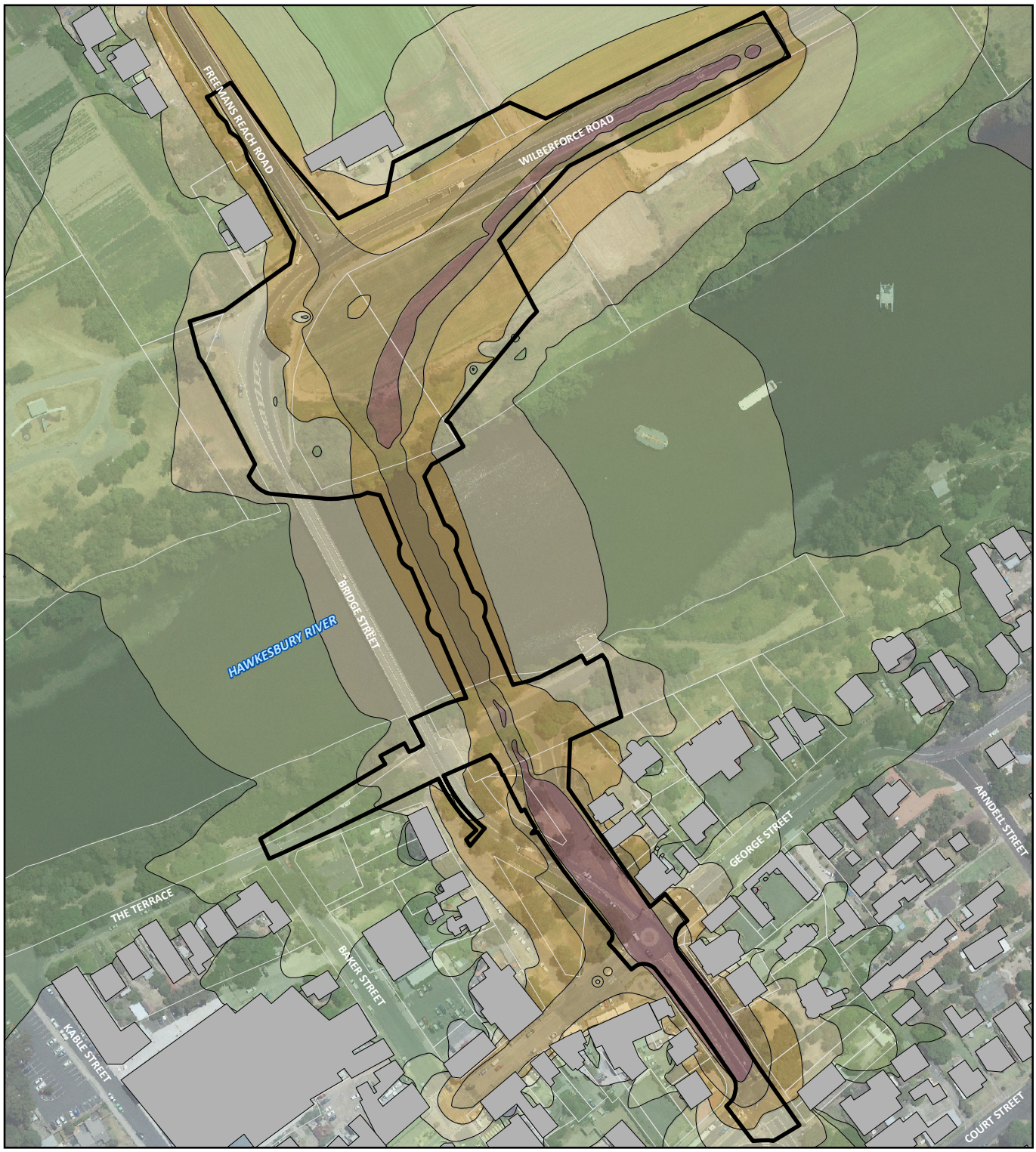
GDA 1994 | MGA Zone 56
A4 1:2,750

0 100
Metres

AUSIMAGE SKM

Figure 7-32 | Night time noise levels with the project in 2026



Indicative only – subject to detailed design

LEGEND

- Concept design footprint
- Building footprint
- Cadastral boundary

Noise assessment (dB)

- 45
- 50
- 55
- 60
- 65
- > 65

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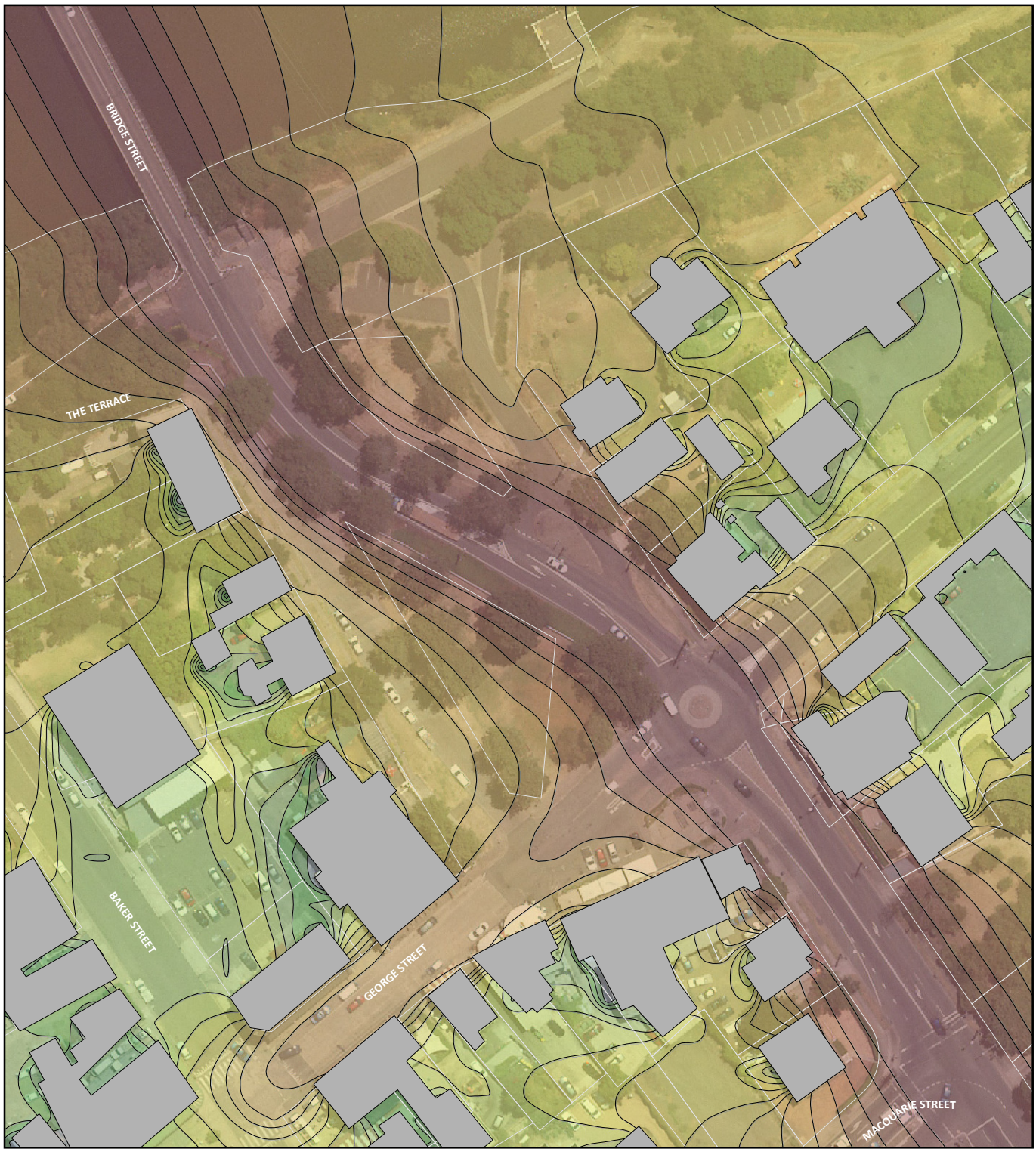
A4 1:2,750

0 100
Metres

AUSIMAGE SKM

Figure 7-33 | Noise levels in Thompson Square parkland “No build” in 2026



Indicative only – subject to detailed design

LEGEND

Building footprint
Cadastral boundary

Noise assessment (dB)

45 - 46
47 - 48
49 - 50
51 - 52
53 - 54
55 - 56
57 - 58
59 - 60
61 - 62
63 - 64
65 - 66
67 - 68
69 - 70
71 - 72
73 - 74

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GDA 1994 | MGA Zone 56
A4 1:1,200

0 40
Metres

AUSIMAGE SKM

Figure 7-34 | Noise levels in Thompson Square parkland with the project in 2026

Indicative only – subject to detailed design

LEGEND

- Concept design footprint
- Building footprint
- Cadastral boundary

Noise assessment (dB)

45 - 46	55 - 56	67 - 68
47 - 48	57 - 58	69 - 70
49 - 50	59 - 60	71 - 72
51 - 52	61 - 62	73 - 74
53 - 54	63 - 64	
	65 - 66	

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GDA 1994 | MGA Zone 56
A4 1:1,200

0 40
Metres

AUSIMAGE SKM

7.5.5 Environmental management measures

Construction

Noise

Exceedances of the project NMLs would occur at most sensitive receivers and would depend upon the location and type of construction activities. Construction noise environmental management measures will be implemented wherever possible to minimise noise impacts. These will be detailed in a Construction Noise and Vibration Management Plan (CNVMP) and will include general controls such as:

- Further detailed noise impact assessments will be undertaken of all construction works and works outside standard construction hours once detailed construction planning is complete as the location and type of construction works may change. These detailed noise impact assessments will be used to identify affected sensitive receivers and develop detailed mitigation measures.
- The nearest noise sensitive receivers will be notified of future works and expected levels of noise well in advance of the works occurring.
- Construction programming will be developed to minimise noise impacts - this may include time and duration restrictions and respite periods, and will be developed after consultation with affected receivers.
- Where possible, works outside of standard construction hours will be planned so that noisier works are carried out in the earlier part of the evening or night time.
- Where noisy works are required outside of standard construction hours, negotiated agreements will be sought with affected sensitive receivers.
- Where possible, the use of noisy plant simultaneously and/or close together will be avoided.
- Equipment and excavation work sites will be orientated away from sensitive receivers where possible to reduce noise emissions.
- Equipment will be maintained in efficient working order.
- Quieter construction methods will be used where feasible and reasonable. This may include grinding, rock splitting or terrain levelling instead of rock breaking where it is feasible and reasonable.
- Where acceptable from a work health and safety perspective, quieter alternatives to reversing alarms (such as spotters, closed circuit television monitors and ‘smart’ reversing alarms) will be used particularly during out of hours activities.
- All noise complaints will be investigated and appropriate mitigation measures implemented where practicable to minimise further impacts.
- Truck movements will be restricted to identified haulage routes and the routes outlined in the Construction Traffic Management Plan
- Noise monitoring will be undertaken to assess compliance with NMLs and assess the effectiveness of noise mitigation The use of temporary noise shielding will be considered at locations along Bridge Street where substantial exceedances of noise criteria are predicted. In addition where work is undertaken in close proximity to Thompson Square or along Freemans Reach Road, temporary noise barriers will be considered.

Vibration

A Construction Noise and Vibration Management Plan will be prepared for the project and it will contain detailed assessment methods for high risk works, identification of sensitive receivers, complaints handling process, consultation protocols, monitoring requirements and mitigation measures. Mitigation measures that will be contained in the plan include:

- Buildings/structural conditions surveys will be undertaken prior to and following construction works at receivers within 50 metres of piling, rock breaking and vibratory compaction activities, including the heritage retaining wall at 4 Bridge Street.
- No impact piling works will be undertaken within 20 metres of any heritage structure, unless additional assessment and monitoring confirm that vibration levels will be below project specific criteria.
- Rock breaking/hammering will not be undertaken within seven metres of any heritage item or building unless additional assessment and monitoring confirm that vibration levels will be below project specific criteria.
- Rock breaking/hammering will not be undertaken within five metres of any non heritage building unless additional assessment and monitoring confirm that vibration levels will be below project specific criteria.
- Where rock breaking/hammering is planned within 10 metres of any occupied dwelling, the occupants will be notified of the works and the duration of the activity will be restricted, unless otherwise agreed with affected residents.
- Where heavy plant is used within seven metres of a heritage structure, attended vibration monitoring will be undertaken to assess compliance with project specific vibration criteria.
- Where an exceedance of project specific vibration criteria for structural damage is recorded during monitoring, work will cease immediately and alternative construction methods will be used.

Operation

Noise

Based on the noise impact assessment results and application of the RNP and ENMM, noise mitigation options for receivers R2, R3 and R4 must be considered. When considering operational noise mitigation, options to mitigate traffic noise at its source are considered first. At-source mitigation options generally include low noise road pavement and noise barriers. Consultation with RMS and road design engineers was undertaken to determine the feasibility of using low noise road pavement on the project. The use of low noise pavement was not possible as:

- It is RMS policy not to use low noise pavement on bridges due to safety issues with this type of pavement from the elevated profile of the pavement at the road edges.
- It would not provide any substantial noise reduction from the southern and northern approach roads. This is because of the short length of both roads, the design speeds are low which minimises any benefits of low noise pavements and the transition from the different pavement type on the bridge would result in noise impacts.

Noise barriers were not considered suitable for the project as they would be visually intrusive and would impact upon the heritage vistas and values of Thompson Square. As at-source noise mitigation options are not feasible, the ENMM recommends architectural treatment of individual buildings for noise mitigation as the next option.

Sensitive receivers R2 and R4 are residential properties of weatherboard and masonry construction respectively. At sensitive receiver R3 the ground floor of the building is currently operated as a commercial premise, whereas the upper floor is a residential premise. Therefore only the upper floor qualifies for architectural treatment under the ENMM. In selecting appropriate architectural treatment options, the type, condition and fabric of the building needs to be considered to provide the optimum internal noise benefit. At the receiver location R3, the implementation of architectural treatments is not straightforward as the other properties due to the heritage significance of the structure. This property is recognised as; "..a rare and excellent example of Victorian Regency Style architecture." and is listed as a heritage item on the LEP. Therefore any architectural treatment options must be sympathetic to the character, style and heritage value of the building.

As discussed in **Section 7.1.5**, a qualified heritage architect was engaged to inspect the residential section of R3 and recommend potential architectural treatments that provide noise mitigation while not impacting on the heritage values of the building (CityPlan Heritage, 2012). The heritage architect recommended measures that could be implemented without resulting in a significant impact to the heritage values of the building. Appropriate architectural noise environmental management measures for heritage listed buildings will be developed based on these recommendations and in agreement with property owners, and will be installed by suitably qualified professionals.

For sensitive receivers R2 and R4, a building inspection and identification of architectural treatment options will be undertaken before construction commences. This was not undertaken for the EIS as the buildings are not heritage listed and therefore specific architectural treatments do not have to be identified at this stage. Selection of any architectural treatments would also be undertaken in consultation with the owners of affected properties. Wherever possible architectural treatments of buildings will be undertaken before major construction activities commence to provide noise mitigation during construction.

Vibration

As vibration from the operation of the project would be below relevant guidelines, no environmental management measures are required.

7.6 Soil, sediments, water and waste

This section assesses soil, sediment, water quality and waste impacts of the project. The assessment is supported by a soil, sediments and water working paper, which is presented in Volume 4 – Working paper 7. The assessment has addressed the Director General's requirements for soil, sediment, water quality and waste (as detailed in **Table 7-48**) as well as the relevant requirements of Schedule 2, Part 3 of the *Environmental Planning and Assessment Regulation 2000*.

The Director General's requirements relating to the hydrological and bed and bank stability impacts of the new bridge are addressed in the Hydrology working paper (Volume 4 – Working paper 8) and **Section 7.7** of the EIS, together with a detailed discussion of potential scour protection measures.

Table 7-48 Director General's requirements for soil, sediments, water and waste

Director General's requirements	Where addressed
Erosion and sediment impacts on the Hawkesbury River during construction/ operation;	Section 7.6.3, Section 7.6.4 and Section 7.6.5
- including an assessment of water quality;	Section 7.6.2
- mitigation measures to prevent water pollution;	Section 7.6.6
- details of the proposed storm water management measures for the containment of pollutants; and	Section 7.6.6
- waste handling.	Section 7.6.6

The assessment has been undertaken on the following aspects of soils, sediments, water and waste:

- Soil and water management.
- Contamination of soils and sediments.
- Hazardous materials.
- Acid sulfate soils.
- Groundwater.
- Waste handling.

7.6.1 Guidelines and methodology

Soil and water

The process of assessing the impact of the project on soil and water impacts and developing mitigation measures has included:

- A review of existing project literature, other studies and water quality data.
- An assessment of the catchments based on the proposed drainage system.
- An assessment of the impact of construction on soils, sediments and water quality.
- A review of water quality treatment measures that could be used to mitigate the impact of construction on water quality, following the principles of *Managing Urban Stormwater - Soils and Construction Volume 1* (Landcom, 2004) and *Volume 2D* (DECC, 2008).
- An assessment of the soil, sediment and water quality impacts of the project during its operation.
- A review of water quality treatment measures that could be used to mitigate the impact of the operation of the project on water quality following the principle of *Procedure for Selecting Treatment Strategies to Control Road Runoff* (RTA, 2003), RMS *Water Policy* (RTA, 1997), and RMS Code of Practice, *Water Management* (RTA, 1999).
- A review of suitable locations and sizes for a sediment basin and a spill containment basin.

Contamination

Site investigations were undertaken generally in accordance with the *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites* (EPA, 2000). This included:

- A Stage 1 preliminary site investigation which assessed potential contamination issues at the site that may have arisen from past and/or present activities undertaken on and/or adjacent to the site which may represent a risk to human health or the environment.
- A Stage 2 detailed site investigation was also undertaken which involved soil sampling, laboratory testing of soil samples to assess concentrations of key pollutants and comparison of results against appropriate guidelines.

Other studies (such as Birch et al, 1998) on heavy metal contamination of river bed sediments at Windsor were also reviewed and assessed for relevance to the project.

Hazardous materials

A hazardous materials audit was carried out via a visual inspection of the existing bridge structure and bridge supported services and sampling of suspect building materials. The focus of the inspection and sampling was to identify any asbestos, synthetic mineral fibres (SMF), lead based paints, nickel-cadmium batteries or Polychlorinated biphenyls (PCBs).

Acid sulfate soils

Acid sulfate soils (ASS) risk maps from the NSW Natural Resource Atlas database were reviewed to ascertain the presence of ASS within the project area. Sampling and analysis (using Suspension Peroxide Oxidation Combined Acidity and Sulfur analytical method) of river bed sediments was undertaken to determine the presence of acid sulfate soils and any requirements for management based upon the *Acid Sulfate Soils Assessment Guidelines* (ASSMAC, 1998).

Groundwater

Existing groundwater users, groundwater dependent ecosystems and aquifers in the area in and adjacent to the project were identified from groundwater bore databases and relevant reports. The presence of groundwater in the project was assessed during excavations from geotechnical studies undertaken for the project. The construction methodology and design of the project was reviewed to identify potential impacts on groundwater users and aquifers. Groundwater dependent ecosystems are also discussed in **Section 7.9.2**.

Waste management and handling

Where possible, the quantity, type and likely classification of wastes generated from the project were identified from reports on the existing bridge and concept design reports. Resource use for the project was assessed by reviewing existing information including the Concept Design Report (SKM, 2012b) and estimating the resources required for construction and their likely sources.

7.6.2 Existing environment

Soil and water

Water quality

The now defunct Office of the Hawkesbury-Nepean has identified the environmental values that apply to all the waterways within the Hawkesbury-Nepean catchment as:

- Protection of aquatic ecosystems.
- Secondary contact recreation (boating, wading, fishing etc).
- Visual amenity.

Some sections of the river and its tributaries have also been recognised as providing additional environmental values such as:

- Water for irrigation and general use.
- Livestock drinking.
- Human consumption of aquatic foods.
- Raw drinking water.
- Primary contact recreation.

Water quality monitoring at many sites in the Hawkesbury River has been routinely undertaken since the 1980s. Most monitoring has been undertaken by the Sydney Catchment Authority and Sydney Water. In 2009 the then NSW Department of Environment and Climate Change completed a full compilation and assessment of available water quality data (DECC, 2009). The assessment included an analysis of temporal trends in water quality at individual sites along the Hawkesbury River, including at Windsor bridge.

The analysis and comparison of water quality data with the ANZECC/ARMCANZ (2000) water quality guidelines prepared by DECC (2009) is provided in Soils, sediment, water and waste working paper (Volume 4 – Working paper 7). The assessment of water quality at Windsor bridge suggests:

- Conductivity, pH, and turbidity levels were frequently within the ANZECC/ARMCANZ (2000) guideline values over the whole record.
- Dissolved oxygen levels have been steady over time and the majority were within guideline values.
- There has been an improvement in phosphorus (total and filterable phosphorus) levels over time, and the majority of recent monitoring data has met the ANZECC/ARMCANZ (2000) guideline values.
- Nitrogen (total, oxides of nitrogen, and ammonium) levels and chlorophyll-a levels frequently exceed the ANZECC/ARMCANZ (2000) guideline values over the whole record.

Existing water quality treatment

The existing Windsor bridge and approach roads do not have any water quality management devices to treat stormwater runoff or capture spills of hazardous materials. The only water quality management device in close proximity to the project is a Gross Pollutant Trap located near the intersection of Baker Street and The Terrace.

Soil landscapes

The 'Soil Landscapes of the Penrith 1:100 000 Sheet' (Bannerman and Hazelton, 1990) classifies the soil landscape at the project site as Freemans Reach (fr). This soil landscape is an alluvium derived from the Narrabeen Group, Hawkesbury Sandstone and Wianamatta Group materials. The soils are typically deep brown sands and loams. It is a dynamic soil landscape where streambank erosion and deposition constantly occur, and the floodplains are subject to scour or sheet and rill erosion during floods. The soils of the Freemans Reach soil landscape are highly erodible. They generally contain a high percentage of fine sand and have low to very low organic matter contents, and are moderately dispersible. The soil's erosion hazard is very high to extreme for concentrated flows and there is a high streambank erosion hazard.

Contamination

The Stage 1 preliminary site investigations involved an assessment of historical and existing land uses and a review of contaminated sites databases to identify areas that may contain potentially contaminated soils and other materials.

The historical land use information and historical aerial photography review has indicated that the northern bank for the Hawkesbury River at the project location has primarily been used for agriculture since 1793, and the southern bank for residential and urban development since 1810. Several small scale industrial activities have also occurred in this area, however they are no longer active. Use of the river for transportation purposes began in 1795 with the construction of a wharf on the southern bank of the Hawkesbury River, and Windsor bridge, at its present location, was constructed in 1874.

Based upon the outcomes of the Stage 1 preliminary site investigation, sites and potential contaminants of concern were identified (see **Table 7-49**) and the 10 locations for soil sampling for the Stage 2 detailed investigation were determined.

Soil sampling was undertaken at 10 representative locations within the potential sites of concern identified as part of the Stage 1 investigation and samples were analysed for a wide range of contaminants. Contaminant concentrations in all soil samples were below relevant ecological and human health soil contamination guidelines, suggesting that there are no contaminated soils or materials in the project area. The detailed results from the soil sampling and analysis are presented in the Soil, sediment, water and waste working paper (Volume 4 – Working paper 7).

Table 7-49 Potential sites and sources of contamination

Site/ source	Contaminants of concern	Location
Turf farm / agricultural areas	Organochlorine Pesticides (OCP), Organophosphorus Pesticides (OPP), herbicides and heavy metals.	To the north and east of the northern approach of Windsor Bridge. Forms part of the proposed roundabout on the northern bank.
Deterioration of bridge structures underneath Windsor Bridge (i.e. crossbeams, break walls and pylons).	Heavy metals (associated with paints), asbestos, and Total Petroleum Hydrocarbons (TPH), Benzene, Toluene, Ethylbenzene, Xylene (BTEX), Polycyclic Aromatic Hydrocarbons (PAH), Polychlorinated Biphenyls (PCB) (associated with fill material behind the break walls).	Underneath the first span of the bridge on both the northern and southern sides.
Deposition of potentially contaminated sediments from upstream during flooding events.	Heavy metals, OCP, OPP, TPH, BTEX, PAH and PCB	Along river banks and sediments throughout the site.

In 1998 a major study was published on the concentrations of heavy metals in the sediments of the Hawkesbury-Nepean River (Birch et al, 1998) which included the sediments in the river around Windsor. Generally the concentrations of heavy metals in the sediments in the main channel increased marginally with distance upstream, with the sediments at Windsor recording the highest concentrations in the main channel.

Typical average concentrations of key heavy metals in the sediments around Windsor are about 26 micrograms per kilogram of copper, 39 micrograms per kilogram of lead and 110 micrograms per kilogram of zinc. These concentrations are below the low range Interim Sediment Quality Guidelines (ANZECC/ARMCANZ, 2000) and indicate that the sediments in the river around Windsor are not contaminated.

Hazardous materials

Lead based paints (ie. lead at concentrations of greater than one per cent by weight) were detected in paint samples collected from the iron piers and iron cross bracings of the existing bridge. No other potentially hazardous materials were identified.

Acid sulfate soils

Sampling of river bed sediments indicated that there are potentially low strength acid sulfate soils present within sediments near the southern bank. However as noted in the Acid Sulfate Soils Assessment Guidelines (ASSMAC 1998), estuarine sediments may give false positives to the presence of acid sulfate soil especially if there is a high proportion of organic matter in the sediments.

Groundwater

A search of the NSW Natural Resources Atlas database identified no registered groundwater bores within the project area. However one bore (GW106373) is immediately adjacent to the project and is associated with the property Bridgeview, near the corner of Wilberforce and Freemans Reach roads. Seven other bores were registered within a one kilometre radius of the site, however these were of sufficient distance away from the project as to not be impacted. Information on five of the bores was available for review, which is summarised in **Table 7-50**. The location of these bores is shown on **Figure 7-35**. The groundwater bore information suggests:

- That in areas where there are gravels and sands in the top soil profile layers, there is an aquifer of good quality and low salinity water.
- That in areas where there are no gravel and sands in the top soil profile layers, groundwater is only encountered at depths greater than at least 25 metres below ground level and the groundwater is of relatively high salinity.

Groundwater level measurements were undertaken at all geotechnical investigation locations (see **Figure 7-35**) where free groundwater or seepage was observed in boreholes. Groundwater was only encountered on the northern bank of the Hawkesbury River. A summary of the groundwater level observations recorded during the site investigations are presented in **Table 7-51**. These levels were close to the level of the river during normal flow periods (-0.5 to 0.7 m AHD). Groundwater flow would be expected to be towards the river as generally this would the lowest point in the aquifer.

Table 7-50 Registered Natural Resources Atlas database boreholes

Borehole ID	Easting	Northing	Depth (metres)	Water bearing zones (metres below surface)	Salinity (Total Dissolved Solids mg/L)	Bore Usage
GW101009	297703	6280636	107	27-30m 42-45m	6000	Domestic Stock
GW106373	297878	6279899	15	10-15m	467	Domestic
GW109520	297309	6278401	6	Not applicable	No data	Monitoring Bore
GW109521	297371	6278340	6	Not applicable	No data	Monitoring Bore
GW103069	206676	6279119	84	75-76m	2200	Domestic Stock

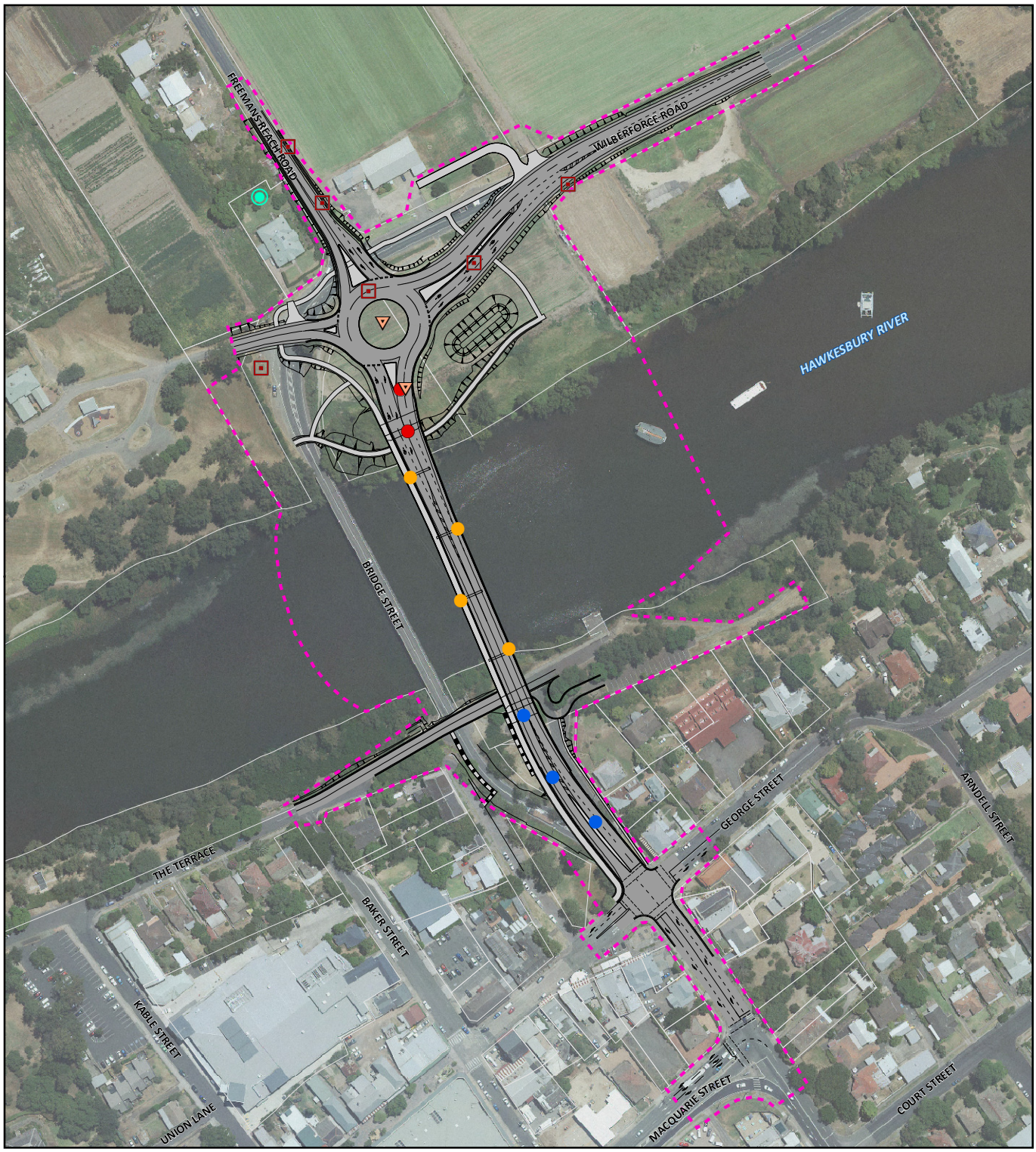
Table 7-51 Groundwater observation levels during investigations

Location ID	Surface RL (metres AHD)	Water Level (m bgl)	Water Level (m AHD)
NA-BH02	7.80	6.90	0.90
NA-CPT01	9.20	8.05	1.15
NA-CPT02	10.00	8.90	1.10

Note 1. m AHD = Metres Australian Height Datum. Note 2. m bgl = Metres Below Ground Level. Note 3. RL = Relative level.

Groundwater dependent ecosystems are “any ecosystem that uses groundwater at any time or for any duration in order to maintain its composition and condition” (Serov et al, 2012). Such ecosystems can range from highly dependent to opportunistic users of groundwater. Groundwater dependent ecosystems in the vicinity of the project were identified from recent mapping undertaken for the NSW Office of Water and National Water Commission (SKM, 2012c). The only groundwater dependent ecosystem within two kilometres of the project is a small area of Cumberland River Flat Forest in the western section of Macquarie Park, immediately adjacent to the river (see **Section 7.9.2** for additional information).

Figure 7-35 | Location of groundwater bores and geotechnical investigation sites



Indicative only – subject to detailed design

Concept design
Construction work zone
Cadastral boundary
Groundwater borehole

Stage 1: Northern Approach
Borehole
Cone penetrometer test
Test pit/sub grade testing
Stage 2: Southern Approach
Borehole
Stage 3: Overwater/barge Works
Borehole

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GDA 1994 | MGA Zone 56
A4 1:3,000

0 100
Metres

AUSIMAGE SKM

7.6.3 Construction impacts

Soil and water

The construction phase of the project would involve both land-based and water-based construction activities. These would present a risk to soil, sediment and water quality if management measures are not implemented, monitored, maintained and adjusted throughout the construction process. Soil, sediment, water and waste, demolition impacts are discussed separately in **Section 7.6.4**.

Land-based construction

The risks from land-based construction would largely be during rainfall and wind events, when sediments or pollutants resulting from construction can flow or be blown to sensitive receiving environments. The highest risk to soil, sediment and water quality would occur during construction activities such as:

- Earthworks, including stripping of vegetation and topsoil, excavation or filling.
- Stockpiling of topsoil, vegetation and other construction materials.
- Transportation of cut or fill materials.
- Movement of heavy vehicles across exposed earth.
- Removal of riparian vegetation.
- Construction in any areas of highly erodible soils.
- Construction in any contaminated land.
- Construction in any acid sulfate soils.

These activities expose soils and, without proper management, may result in sediments and associated pollutants being washed during rainfall events or blown into downstream watercourses, with consequent potential degradation of water quality. The impact of unmitigated construction activities on receiving surface waters could include:

- Increased sedimentation smothering aquatic life and affecting the ecosystems of the river.
- Increased levels of nutrients, metals and other pollutants, transported via sediment to the river.
- Fuel, chemicals, oils, grease and petroleum hydrocarbon spills from construction machinery directly polluting the river and soils.
- Spills of concrete during concrete pours directly polluting the river and soils.
- Contamination from site compounds, chemical storage areas and washdown locations.
- Increased levels of litter from construction activities polluting the river.
- Contamination of the river as a result of disturbance of contaminated land.
- Acidification of the river as a result of disturbance of acid sulfate soils during construction.
- Tannin leachate from clearing and mulching of vegetation. This impact would be unlikely as vegetation clearance would be minimal and any cleared vegetation would be removed from site shortly after clearing.

Water-based construction

Water-based construction activities would be conducted from barges and/or jetties and would include construction of the bridge piers and installation of scour protection. Construction of the bridge piers would involve the installation of piles to the required depth at each pier location, and installing pile caps and the pier columns. Rock scour protection would be installed along the northern bank and at the piers. Removal of bed and bank material is needed to allow for the required volume of rock scour protection. On the southern bank a piled retaining wall would be installed for scour protection.

The water-based construction activities would cause disturbance of river bed sediments. If unmitigated or inadequately managed, this would cause a decline in water quality and visual amenity around the construction activities, particularly due to increased turbidity levels. The water-based construction activities may result in the direct pollution of the receiving environment from fuel, oil and chemical spills or from machinery hydraulic hose failure.

Environmental management measures would be put in place to avoid or minimise these impacts (see **Section 7.6.6**).

Contamination

The risk of encountering contaminated soils during construction of the project would be low as all soil samples collected returned analytical results below the site assessment criteria. These risks would be further reduced as earthworks for the project would be relatively minor (ie. the majority of works involve placing fill on the existing land surface). However despite the low risk, contaminated soils and materials may still be encountered especially on the southern bank as this area has a long history of urban use and not all areas could be sampled at the time of the assessment. Soil at the turf farm presents a lower risk with respect to unknown contamination as it is relatively homogenous and has generally been used for agriculture.

Based upon studies of the river sediments in the Hawkesbury River (Birch et al, 1998), the river sediments at Windsor are not identified as contaminated with heavy metals and therefore the risk of impacts due to mobilising contaminated sediment during construction would be negligible.

Construction activities could result in the contamination of soils due to the spillage or leakage of fuels and/or chemicals from plant and equipment and from storage areas. However provided standard environmental management measures as detailed in **Section 7.6.6** are implemented, the risk of significant impacts would be negligible.

Acid sulfate soils

The analytical results have identified potential acid sulfate soil in the river sediments. There would be a risk of potential acid sulfate soil disturbance and exposure during piling and dredging works for the installation of scour protection (SKM, 2012b). The risk from the potential acid sulfate soil would occur once the sediment is brought to surface and is exposed to air. This would start the process of oxidation of the potential acid sulfate soil in the sediment, which would result in the production of acid. If water from rainfall or other sources comes into contact with oxidised potential acid sulfate soil, acid runoff would be produced which could lower the pH of any receiving waterways and soils - adversely impacting on aquatic and terrestrial environments. It should be noted that the oxidation of the potential acid sulfate soil would not be instantaneous and would occur over a period of weeks or months.

Environmental management measures would be put in place to avoid or minimise these impacts (see **Section 7.6.6**).

Groundwater

The main potential impacts on groundwater would be:

- Interference with the aquifer – resulting in a decrease or change in groundwater levels. impacting upon groundwater users and groundwater dependent ecosystems.
- Pollution of the groundwater resources.

The risk of these impacts from construction activities would be very low as:

- There are either no permanent aquifers (southern bank) or groundwater levels are very close to the river level (northern bank) and are not close to the ground surface.
- Apart from piling, no construction activities would potentially interfere with any permanent aquifer. No dewatering would be required for piling activities.
- Predominately the flow of groundwater would be towards the river and therefore the project would be unlikely to decrease groundwater levels at nearby groundwater bores which are further away from the river.
- The footprint of the project would be relatively small and therefore its potential impact on groundwater would also be small.
- The risk of pollution of groundwater would be minimised through the implementation of appropriate management measures detailed in **Section 7.6.6**.
- The groundwater dependent ecosystem in Macquarie Park (Cumberland River Flat Forest) is 700 metres away from the project and immediately adjacent to the river. It would not be impacted by the construction of the project because of it's distance from the project and proximity to the river.

Waste management and handling

As the project only consists of the bridge, short sections of approach roads and other relatively minor works, the construction of the project would not generate significant quantities of waste. Demolition of the existing bridge which would generate substantial quantities of waste is discussed below. The type of wastes that would be generated during construction and their management is presented in **Table 7-52**.

Although the project would require the importation of about 10,800 cubic metres of fill material, some excess spoil would be generated including:

- Soils – This includes topsoil and natural B horizon soils (ie. soils between the topsoil and underlying bedrock).
- Fill material – This includes imported soils and other material that has been used for infilling (eg. old concrete, wood).
- Natural rock – This material would be generated from bored piling activities and where excavation of bed rock is required (eg. for service relocations).
- Road construction material – This would include material generated from the demolition of the existing roads such as asphalt, geotechnically stabilised road sub-base and base material.
- River bed sediments – This material would originate from dredging for the installation of scour protection.

The natural rock and the road construction material would be geotechnically suitable for reuse for road construction. However they may not be able to be reused on the project as the northern river bank is flooded in a 1 in 3 year flood event and longer term stockpiling of excess material in this location would not be prudent due to potential water quality impacts if flooding occurred. Also there would be limited space on the southern bank, so stockpiling on this side of the river for later reuse may not be possible. If this material is unable to be reused on site alternative off-site reuse opportunities would be investigated.

Although the soils from the northern river bank would be suitable for landscaping, because of the restrictions in on-site stockpiling, the reuse of these soils for the project may not be possible. These soils would either be stockpiled off-site for later use on the project or sent to recycling facilities.

All other excess spoil materials would be likely to be geotechnically unsuitable for road construction or unsuitable for landscaping. On the southern bank, small quantities (less than 500 cubic metres) of geotechnically unsuitable fill and soil material would be generated. Based on initial contamination testing this would likely be classified as General Solid Waste (non-putrescible) and would be disposed off an appropriately licensed landfill.

Initial sampling of the river bed sediments indicates that low strength acid sulphate soils may be present near the southern bank. Further sampling would be required as part of the detailed design to confirm the presence of acid sulphate soils. The river bed sediments would not be suitable for reuse and would require disposal at an appropriately licensed landfill.

The construction of the project would require raw and processed materials such as concrete, steel, imported fill and fuel to power construction equipment. As the project is relatively small in size, the quantities of different materials required for construction would not be significant and would be able to be sourced within the region. Apart from flyash in concrete, the opportunity to use recycled material in construction would be limited as the replacement bridge and approach roads would have higher quality specifications that typically required as they would have to withstand regular immersion by flood waters. The use of recycled material in the replacement bridge may increase its chance of failure or deterioration due to risks of inconsistencies in the quality of recycled materials.

The only recycled material that would be used during construction would be the imported fill (about 10,800 cubic metres). Where possible, suitable fill material may be sourced from another construction project which has excess spoil.

Table 7-52 Type and management of waste materials generated during construction

Material	Management
General office waste – These would include paper, food packaging, food scraps and other general waste.	Where possible, recyclable material would be separated and sent to recycling facilities. Non-recyclable waste would be classified and disposed of at an appropriately licensed facility.
Vegetation – Removal of small areas of existing vegetation would be required.	All woody vegetation such as trees would be mulched and reused either on site for landscaping or sent to recycling facilities. Weeds would be bagged and sent to landfill.
Concrete – Small volumes of excess concrete would be generated from the construction of the replacement bridge and structures. Also the demolition of existing kerbs and other concrete structures may generate small volumes of concrete	Any excess concrete would send off-site to a licensed concrete recycling facility.
Steel - Small amounts of excess steel reinforcement would be generated from the construction of bridge and structures	All excess steel would be sent off-site to a licensed steel recycled facility.
General construction waste – This would consist of bags, packaging, off-cuts and other general waste generated by construction activities	Where possible, recyclable material would be separated and sent off-site to licensed recycling facilities. Non-recyclable waste would be classified as General Solid waste and disposed of at an appropriately licensed facility.
Special construction waste – This would include batteries, waste oil and containers and other potentially hazardous materials	Where possible, recyclable material would be separated and sent to recycling facilities. Non-recyclable waste would be classified as per the Waste Classification guidelines and disposed of at an appropriately licensed facility.

7.6.4 Demolition impacts

Soil and water

Demolition and removal of the existing bridge would also present a potential risk to the water quality of the river. The demolition of the existing bridge would take place after the opening of the replacement bridge.

Removal of the bridge deck and piers would involve cutting these bridge elements into discrete sections, lifting the sections out by crane and placing them on trucks for transportation to a disposal facility. The demolition activities could potentially result in rubble and debris entering the river and disturbance of the river bed material. Appropriate management measures would be in place to avoid adverse impacts on the river's water quality such as increased turbidity.

Acid sulphate soils

Acid sulfate soils may be present in the river sediments adjacent to the existing bridge. If they are present there they may also be in the hollow piers of the existing bridge and may be brought to the surface during the demolition of the existing bridge. The volume of acid sulfate soils in the piers would be very low. Sampling for acid sulfate soils in the river sediments near the existing bridge has not been undertaken, however would be undertaken before construction commences.

Hazardous materials

The hazardous material audit found that paint samples from the iron piers and iron cross bracings of the existing bridge contained high levels of lead. If during demolition of the existing bridge, this paint was to find its way into the river it could cause aquatic ecosystem, sediment quality and water quality impacts. Environmental management measures would be put in place to avoid or minimise this impact (see **Section 7.6.6**).

Waste management and handling

The existing bridge superstructure and substructure would be removed in sections, with temporary bracing installed, as required, to maintain the stability of remaining sections during the demolition process. Where possible the process of demolition would involve cutting the superstructure and substructure into sections, with each section transported off-site for further processing at a licensed facility. This approach would minimise environmental impacts, such as noise, dust, disturbance of roads and contamination of the river.

Bridge materials resulting from the demolition would be recycled where possible. Metals that have the potential to be reused include the iron piers, railings and the service conduits. Lead-based paint has been identified on some metal elements of the existing bridge and would need to be removed before recycling or reuse of materials. Any lead based paint removed from the metal elements of the existing bridge would be likely to be classified as hazardous waste under the Waste Classification Guidelines and would require disposal at an appropriately licensed facility. The concrete sections of the existing bridge would be sent to a concrete recycling facility – where it would be crushed and sold as temporary road base or for other uses. Up to 2000 tonnes of concrete would be generated from the demolition of the bridge.

Some material from the bridge demolition may not be able to be recycled and would require classification and disposal at an appropriately licensed landfill.

Other aspects

The demolition of the existing bridge would not result in any significant impacts or risks to groundwater and contamination.

7.6.5 Operational impacts

Soil and water

During the operational phase of the project, the approach roads and bridge would be sealed, cleared areas landscaped and scour protection installed. There would be no exposed topsoil and therefore little or no risk of soil erosion and transport of eroded sediments to the river. Water quality risks during operation would instead be associated with the runoff of pollutants from the new road surface, with pollutant sources including atmospheric deposition, vehicles and litter from motorists. Pollutants deposited onto road surfaces by vehicles typically include:

- Hydrocarbons and combustion derivatives.
- Lubricating oil.
- Rubber.
- Heavy metals such as lead, zinc, copper, cadmium, chromium, and nickel.
- Brake pad dust and potentially asbestos from older brake pads.

These deposits build up on road surfaces and pavement areas during dry weather and would be washed off and transported to waterways during rainfall periods. Other pollutants in the atmosphere, such as nitrogen, that are derived from local and regional sources would also be deposited and build up on the road pavement and contribute to operational impacts on water quality.

Pollutants deposited by motorists, such as non-biodegradable garbage and food wastes, could also impact water quality, amenity and aquatic conditions during operation of the project by washing into downstream watercourses.

During the operation there would also be a risk of accidental spillage of petroleum, chemicals or other hazardous liquids as a result of vehicle leakage or road accidents on the new bridge or approach roads. Although the likelihood of a potential spill would be low, the consequence to the environment could be considerable as spills of this nature would pollute the river if unmitigated.

The design of the project has considered these potential impacts and water quality control measures have been included for both the southern and northern drainage systems. These are described in greater detail in **Section 7.6.7**. As the existing bridge and approach roads do not have any water quality control measures, the provision of water quality control measures for the project would result in an improvement in stormwater quality discharged from the project and a reduction in the likelihood that spills or leaks of fuels from road accidents would find their way into the river.

Waste management and handling

During operation of the project, small quantities of waste would be generated and would potentially include spills and leakages from vehicles, litter generated by road users and sediment from the water quality control basin. In addition, small quantities of waste would be generated from road maintenance and repair activities. The volume of operational waste would be minor and would be classified and disposed of at an appropriately licensed landfill.

Other aspects

The operation of the project would not result in any significant impacts or risks to groundwater, contamination, hazardous materials and/or acid sulfate soils.

7.6.6 Environmental management measures

Construction

Soil and water

Potential impacts to soil, sediment and water from the project's land-based construction activities will be mitigated and managed by implementing local erosion and sediment controls. An erosion and sediment control plan will be developed during detailed design in accordance with Managing Urban Stormwater – Soils and Construction - Volume 1 (Landcom, 2004) and Volume 2D (DECC, 2008). The detailed erosion and sediment control plan will incorporate erosion control measures to limit the movement of soil from disturbed areas, and sediment control measures to remove any sediment from runoff prior to discharge into the river.

Appropriate measures will be implemented to contain any turbid water by applying best management practices such as silt curtains or similar. The Soil and Water Management Plan which will include the erosion and sediment control plan for land-based construction works, will also include environmental management measures to minimise the impacts of water based construction activities.

Development and implementation of a water quality monitoring program will also assist in identifying water quality issues during construction and assessing the effectiveness of mitigation measures. The water quality monitoring program will be developed during detailed design, covering pre-construction, construction and post-construction phases, and in accordance with the RMS Guideline for Construction Water Quality Monitoring (RTA, no date).

Contamination

While no contaminated soils or materials were found in the project area from the Phase 2 investigations, unknown contaminated soils and material may be encountered during construction. The following environmental management measures will be implemented to address this risk:

- During excavations, soil and fill material will be visually monitored to identify potential contaminated material or soils.
- If potentially contaminated material or soils is suspected additional investigations and monitoring will be undertaken.
- If it is confirmed that contaminated material or soils are present on site immediate measures will be put in place to ensure worker safety and protection of the environment. An appropriate investigation and remediation plan will be developed and implemented.
- All fuels and chemicals will be stored and used in compliance with appropriate guidelines and standards. A spill management procedure will be developed and implemented, if required.

Waste management and handling

The following environmental management measures will be implemented to minimise the impact of waste generation:

- Detailed waste management measures and procedures would be included in the CEMP for the project.
- Waste management measures would be based upon the philosophy of reduce, reuse, recycle and appropriate disposal.
- The project induction would cover waste management measures in the CEMP.
- All waste material requiring off-site disposal would be classified using the Waste Classification Guidelines and disposed of at an appropriately licensed facility.
- Procurement and waste management strategies would be based upon the philosophy of reduce, reuse, recycle and appropriate disposal.
- Where applicable, waste that will be re-used will comply with the conditions attached to EPA resource recovery exemptions for specific materials (e.g recovered aggregates, excavated public materials, excavated natural material exemptions).

Acid sulfate soils

The following environmental management measures will be implemented during construction to minimise the impact of acid sulfate soils.

- Further acid sulfate soils investigations would be undertaken during detailed design of the project.
- If the presence of ASS is confirmed in the river sediment, an ASS management plan would be developed and implemented. The plan will detail the management, handling, treatment and disposal of ASS and will be prepared in compliance with the Acid Sulfate Soils Assessment Guidelines (ASSMAC, 1998) and the Guidelines for Managing Acid Sulfate Soils (RTA, 2005).

Groundwater

Monitoring of groundwater at piezometers installed for project and the adjacent groundwater bore will be undertaken to identify any impacts during construction. If any impacts on groundwater levels or quality are detected, the potential cause and environmental management measures will be identified and developed.

Other aspects

The construction of the project does not require environmental management measures for hazardous materials.

Demolition

Soil and water

Environmental management measures that will be implemented during demolition of the existing bridge will include:

- Cutting and removing the existing bridge in large sections and transporting them from the site for demolition and recycling or disposal in a licensed facility. By cutting the bridge into large sections the amount and risk of debris falling into the river is reduced.
- Preventing falling debris and rubble entering the river.
- Containing any disturbance or turbidity by installing self-containment equipment such as silt curtains.
- Monitoring water quality in the river in accordance with the RMS Guideline for Construction Water Quality Monitoring (RTA, no date) to assess the effectiveness of water quality mitigation measures.
- Scheduling demolition activities to avoid or minimise works taking place during times of higher rainfall and river flows.

Acid sulfate soils

The following environmental management measures will be implemented during construction to minimise the impact of acid sulfate soils.

- Acid sulfate soils investigations will be undertaken before construction in the area around the existing bridge.
- If the presence of ASS is confirmed in the river sediment near the existing bridge, an ASS management plan will be developed and implemented. The plan will detail the management, handling, treatment and disposal of ASS and will be prepared in compliance with the Acid Sulfate Soils Assessment Guidelines (ASSMAC, 1998) and the Guidelines for Managing Acid Sulfate Soils (RTA, 2005).

Hazardous materials

Any demolition of bridge structures containing lead based paints will be undertaken in accordance with the following:

- Australian Standard AS 4361.1 – 1995, Guide to lead paint management, Part 1: Industrial applications
- Australian Standard AS 4361.2 – 1998, Guide to lead paint management, Part 2: Residential and commercial buildings
- Australian Standard AS 2601 – 2001, The demolition of structures.

The options for the management of lead based paints during the demolition of the existing bridge structure (based on the respective Australian standards) are as follows:

- Containment – this option will involve the implementation of a high level of containment to prevent dust and debris spreading beyond the immediate works site during demolition.
- Paint stabilisation – paint stabilisation will require the existing surfaces to be stabilised with another non-hazardous covering. During both stabilisation and structure removal, a moderate level of containment will be required.
- Paint removal – paint removal will require the existing painted surfaces to be removed prior to demolition. During paint removal, a high level of containment will be required. Little to no containment will be required to manage the demolition of the structure following removal of the lead based paints.

The preferred option for management of lead based paints and the associated mitigation measures will be identified during the construction and demolition planning process. The demolition plan for the existing Windsor bridge would include the details on the reuse, recycling and/or disposal of the demolished components.

Waste management and handling

The following environmental management measures will be implemented to minimise the impact of waste generation:

- Detailed waste management measures and procedures will be included in the CEMP for the project.
- Waste management measures will be based upon the philosophy of reduce, reuse, recycle and appropriate disposal.
- The project induction will cover waste management measures in the CEMP.
- All waste material requiring off-site disposal will be classified using the Waste Classification Guidelines and disposed of at an appropriately licensed facility.

Other aspects

The demolition of the existing bridge does not require environmental management measures for risks to groundwater and contamination.

Operation

Soil and water

Operational impacts to water quality would be managed by the use of water quality control devices incorporated into the project's drainage design. These are described below. The water quality controls will remove pollutants from stormwater runoff generated by the new bridge and approach roads, and will provide a mechanism for capturing any accidental spills of hazardous liquids that may occur.

Southern outlet

The southern stormwater outlet will be located about 25 metres east of the southern abutment of the replacement bridge. The catchment area for the southern stormwater system will include the southern road approach between George Street and the southern bridge abutment as well as reconstructed areas of The Terrace. There is very little available space to provide a conventional water quality treatment device, such as an in-line gross pollutant trap due to existing development and the proximity of The Terrace to the river's southern bank. Also as The Terrace may contain undiscovered archaeological sites, minimising excavation in this area would avoid potential impacts.

Instead an end of pipe net type gross pollutant trap connected to the stormwater outlet will be provided. A photograph of an example in operation is provided in Soil, sediments, water and waste working paper (Volume 4 – Working paper 7). The net will collect gross pollutants (litter) contained in stormwater runoff, preventing them from entering the river and causing a decline in the river's visual amenity and water quality. The net will be emptied on a regular basis by RMS or Hawkesbury City Council to ensure it continues functioning as intended.

To mitigate against potential spills of hazardous liquids, a lockable shut-off valve will be provided at a stormwater pit immediately upstream of the outlet. In the event of an accidental spill, the shut-off valve will be closed manually by RMS or the NSW Fire Brigade Emergency Response Team. Any accidental spill will then be contained within the stormwater system and prevented from entering the river. The spill will then be removed from the stormwater system and appropriately disposed of before reopening the shut-off valve.

Northern outlet

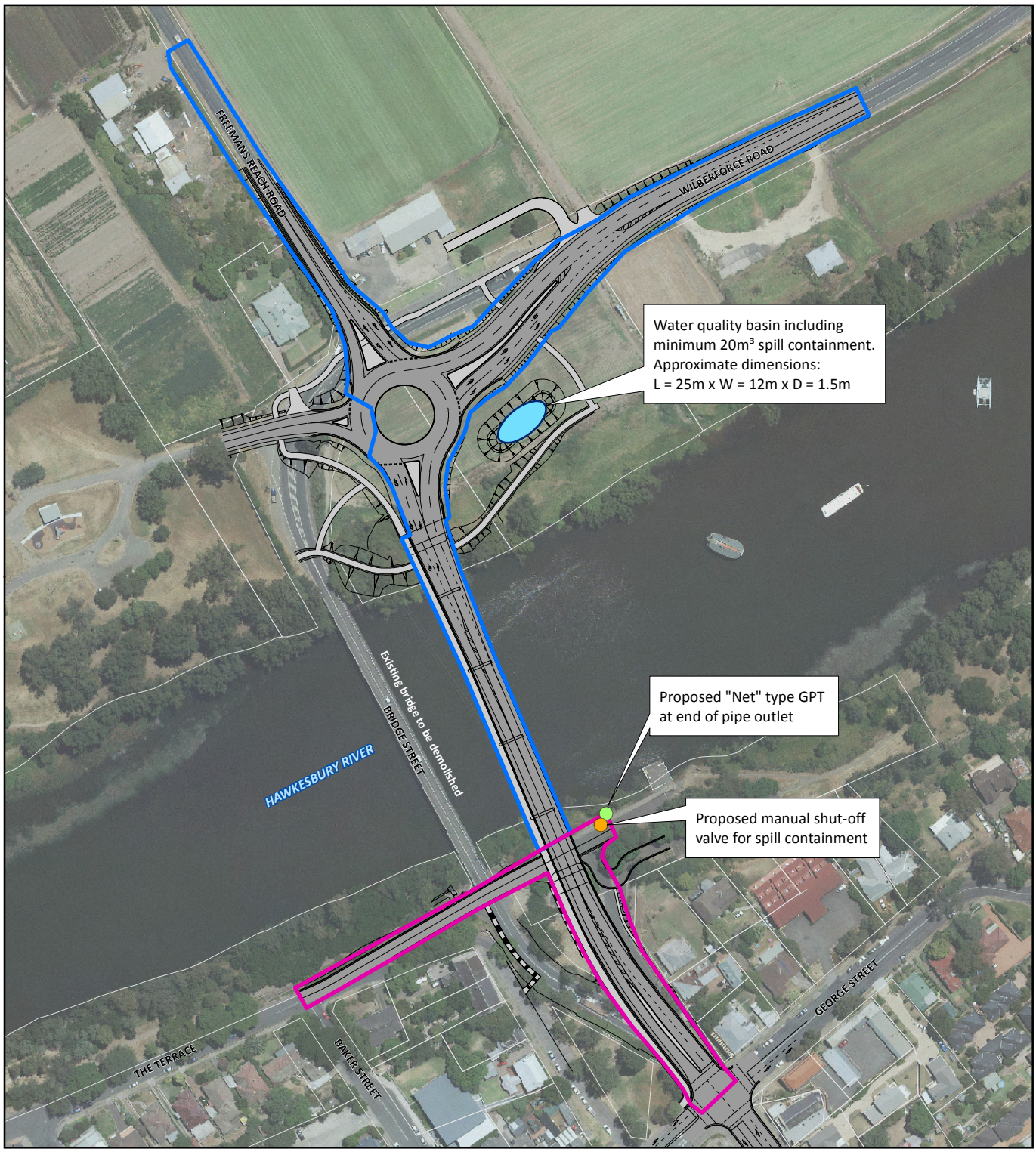
The northern stormwater system will discharge into a permanent water quality basin near the south eastern corner of the new roundabout on the northern bank. The basin will remove suspended solids and gross pollutants from stormwater runoff before discharging to the river. The basin's dimensions will be about 25 metres long, 12 metres wide, and 1.5 metres in water depth. The size of the basin will be refined during detailed design. Regular maintenance by RMS or Hawkesbury City Council will be undertaken to remove sediment and other captured pollutants from the basin.

The basin will be fitted with an underflow baffle arrangement to provide accidental spill capture and containment for a minimum volume of 20 cubic metres. The baffle will prevent hazardous liquid spills from entering the river during dry weather and smaller more frequent rainfall events. Any captured spills will be removed from the basin and disposed of appropriately.

Other aspects

The operation of the project does not require environmental management measures for risks to groundwater, hazardous materials, contamination and acid sulfate soils.

Figure 7-36 | Proposed operational phase water quality controls



Indicative only – subject to detailed design

LEGEND

Concept design
Cadastral boundary

Effective catchment areas
Northern catchment
Southern catchment

Site
WQ basin
Proposed GPT
Proposed shut-off valve

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AUSIMAGE SKM

7.7 Hydrology

This section assesses hydrology impacts of and on the project. The assessment is supported by a detailed study of the potential impacts of the project on hydrology, including local and regional flooding, which is presented in the Hydrology working paper (Volume 4 – working paper 8). The Director General's requirements for hydrology and flooding have been addressed (as detailed in **Table 7-53** below) as well as the requirements detailed in Part 3 of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000*.

Table 7-53 Director General's requirements - hydrology

Director General's requirements	Where addressed
The EIS must address the following specific matters: **Soils, Sediments and Water –** including but not limited to:	
• erosion and sediment impacts on the Hawkesbury River during construction/ operation; including an assessment of water quality; mitigation measures to prevent water pollution; details of the proposed storm water management measures for the containment of pollutants; and waste handling.	Section 7.6
• justification for the proposed flood immunity and an assessment of the flooding impacts and characteristics to and from the project, including consideration of changes to rainfall frequency and/or intensity as a result of climate change.	Section 7.7.3
• the potential impacts on flow velocities and directions, and impacts on bed and bank stability as a result of removal of the existing bridge and relocation of a new bridge downstream.	Section 7.7.3 & 7.7.4

7.7.1 Guidelines and methodology

The results of previous hydrological and hydraulic modelling were used to provide information on the existing environment. An appropriate level of additional modelling for assessing impacts for the EIS was then undertaken to identify the potential flooding impacts of the project at a regional and property level, for events up to and including the probable maximum flood. The potential bed and bank scour effects of the project were also examined.

The data used in the assessment of existing conditions and the potential impacts of the project included:

- Land use and property (sourced from Land and Property Information and Hawkesbury City Council).
- Digital terrain data derived from airborne laser survey (sourced from Hawkesbury City Council).
- Water level data for the Hawkesbury River at Windsor (sourced from Manly Hydraulic Laboratory).
- Flooding data from previous studies, including the Warragamba Flood Mitigation Dam Environmental Impact Statement Flood Study (Webb McKeown and Associates, 1994).
- Surveyed building floor levels in vicinity of the project.

- Dataset of the location of residential structures and estimated ground levels at structures in the Hawkesbury Local Government Area used in the *Draft Hawkesbury Floodplain Risk Management Study and Plan* (Hawkesbury City Council, 2012).

The study area for the project included the length of the Hawkesbury River from Freemans Reach to Wilberforce, as well as the floodplain area up to six kilometres in width. The floodplain areas predominantly comprise agricultural and rural land uses, as well as urban development within and around the townships of Freemans Reach, Wilberforce and Windsor.

The guidelines and policies considered in the assessment of hydrology and flooding impacts included:

- NSW Flood Prone Land Policy.
- NSW Floodplain Development Manual (DIPNR, 2005).
- Floodplain Risk Management Guideline - Practical Consideration of Climate Change (DECC, 2007).
- NSW Policy and Guidelines for Aquatic Habitat Management and Fish Conservation (DPI, 1999).

Building impact assessment

Information on the location and ground level height of buildings with the Hawkesbury River floodplain was obtained from the Hawkesbury City Council and is the same data that was used in the recent *Draft Hawkesbury Floodplain Risk Management Study and Plan* (Hawkesbury City Council, 2012). This data was used to identify potential buildings that would be at risk of increased flooding due to the project. There are limitations to the data set namely:

- The location of buildings was based on cadastre with reference to the garbage collection dataset for land occupancy, rather than survey of individual properties.
- The ground level data has been obtained from Airbourne Laser Survey (ALS) and ground levels between measured points are interpolated, which may not be an accurate reflection of actual ground level between two points.
- The ALS ground level data for each lot that contains a building may not accurately reflect the actual ground floor level of the building. This is because the ALS ground level data for each lot may not be taken where the building is located on a lot. For example on a lot that has a slope, the ground level data may be from the lowest point of the lot, rather than the highest point where buildings are often located.
- The data may not accurately reflect the floor level of a building as a building may be raised or located on an earth mound, a feature common of many of the buildings in the floodplain. An example of the difference between the ALS data and actual floor level (from a conventional survey) is 27 Wilberforce Road, at the corner of Wilberforce Road and Freemans Reach Road. The ALS data for this property is 10.23 metres AHD, where the survey data is 12.99 metres AHD.

- The data was prepared to assess damages to residential dwellings, which may be located on either a residential lot or associated with a commercial land use. Thus buildings that are large sheds and associated offices used for agricultural activities such as turf farming and horticulture are not explicitly captured in the data. Land use for each identified building was based on Council's zoning and broad assumptions were applied for assessment of potential damages, for example where a property is located in an agricultural zone the land use was classified as residential to reflect that dwellings are often associated with this land use. Commercial zones that are also used for residential dwellings were classified as commercial and therefore potential residential impacts may be understated.

To address these limitations in the flood study dataset, RMS undertook additional survey of actual floor levels of buildings near and immediately upstream of the project. These buildings were generally in the 5 year ARI floodplain. The assessment of flooding impacts was undertaken using both the flood study data and the additional RMS floor level survey data and the results of both assessments are presented in the EIS and associated working paper.

7.7.2 Existing environment

Overview

The Hawkesbury River is part of the greater Hawkesbury-Nepean River, which is the largest river system in the Sydney region. The Hawkesbury-Nepean River has a total catchment area of around 22,000 square kilometres, extending from Goulburn in the Southern Tablelands to the ocean at Broken Bay, incorporating the vast estuarine areas of Pittwater on Sydney's northern beaches and Brisbane Waters on the Central Coast. The catchment area includes large areas of natural bushland and mix of land uses, including agricultural, rural, urban residential, and commercial and industrial development. The major urban centres of Richmond and Penrith are located on the river upstream of Windsor.

The Hawkesbury-Nepean River system, in particular its upper catchment tributaries, incorporates several major water storage dams, which provide the primary water supply source for Sydney. The largest of these dams is Warragamba Dam (or Lake Burragorang), which is located at the confluence of the Coxs, Wollondilly and Nattai rivers around 20 kilometres upstream of Penrith. The main Hawkesbury-Nepean river channel is known as the Nepean River between Warragamba Dam and the confluence of the Grose River at Yarramundi, and the Hawkesbury River between the Grose River and Broken Bay.

Large floods in the Hawkesbury-Nepean River system inundate floodplain areas on both sides of the river downstream of Penrith, and particularly along the reach between Yarramundi and Wilberforce. Flooding is amplified in this reach as discharge to the Broken Bay estuary is restricted by the capacity of gorges downstream of Wilberforce. The township of Windsor is located on the banks of this reach. Much of the township of Windsor is built on a ridge above the river, although the existing Windsor bridge and the floodplain north of the river is at a lower elevation and has been subject to inundation during a number of major floods. Inundation of the existing bridge can last for several days.

The Hawkesbury River at Windsor is subject to tidal influences without saline intrusion. The channel is cut in silt-rich sands, which form fairly cohesive banks with inset sandy deposits of post-settlement alluvium. Between Freemans Reach and Wilberforce, the river channel has large meanders with the floodplain being up to six kilometres wide. Hawkesbury River has been classified by the Fisheries division of the NSW Department of Primary Industries as 'Key Fish Habitat'.

Flooding

Flooding of the Hawkesbury River at Windsor is influenced by flows from upstream tributaries (including upper catchment tributaries) as well as inflows from South Creek and constriction of flows through downstream gorges (located downstream of Wilberforce/Sackville). Information on peak flow levels at various locations upstream and downstream of Windsor bridge based on previous flood modelling studies is provided in **Table 7-54**. The peak flow values presented for Sackville represent the combined flow in the river channel and on the floodplain at Windsor, while the data for the remaining locations represent flow levels within the river. These data indicate a significant distribution of flow over the floodplain during large flood events. In the modelled 100 year average recurrence interval (ARI) event, for example, there was 6,200 m^3/s through the bridge at Windsor compared with 10,800 m^3/s combined flow.

Table 7-54 Modelled estimates of existing peak flood flows near Windsor bridge

Location	Peak flow for modelled flood events (m^3/s)			
	5 year ARI	20 year ARI	100 year ARI	PMF[1]
6.2 km upstream	3,790	7,140	8,310	8,420
3.5 km upstream	3,750	6,610	7,660	7,800
Windsor bridge	3,650	5,440	6,250	6,690
Sackville[2]	3,680	6,260	10,800	32,000

1. Probable maximum flood. 2. Represents combined flow of river and floodplain.

Flood inundation maps for the five, 10, 20, 50 and 100 year ARI events and the probable maximum flood are presented in Volume 4 – Working paper 8. These maps show inundation of low lying floodplain areas around Windsor, including the Bridge Street, Wilberforce Road and Freemans Reach Road approach routes to the existing Windsor bridge for the five year ARI event.

The ten highest flood levels recorded at Windsor bridge since 1857 are listed in **Table 7-55**. Modelled estimates of peak water levels along the Hawkesbury River and floodplain in the vicinity of Windsor, based on the results of previous flood studies, are presented in **Table 7-56**. These data show that peak flood levels at Windsor bridge are 11.1 metres Australian Height Datum (AHD) and 17.2 metres AHD for the five year and 100 year ARI events respectively. The existing Windsor bridge has a height of seven metres and is overtopped by about four metres and 10 metres for the five year and 100 year ARI events respectively.

Table 7-55 Top 10 highest flood levels recorded at Windsor

Year	Month	Flood level (metres)
1867	June	19.7
1864	June	15.1
1961	November	15.0
1964	June	14.8
1900	July	14.5
1978	March	14.5
1870	April	14.1
1956	February	13.8
1879	September	13.6
1990	August	13.5

Table 7-56 Existing conditions - Modelled estimates of peak water levels along the Hawkesbury River

Location	Peak water levels (m AHD) for modelled flood events			
	5 year ARI	20 year ARI	100 year ARI	PMF
River locations – upstream of project				
Downstream of Penrith Weir	19.24	22.07	25.26	30.97
Devlin Road, Castlereagh	13.77	17.34	20.1	28.92
Yarramundi	13.04	16.12	18.22	25.98
North Richmond	12.43	15.11	17.52	25.64
Hibberts Lane	11.63	13.74	17.31	25.53
Windsor Bridge	11.04	13.61	17.29	25.54
River locations – downstream of project				
South Creek Junction	10.99	13.6	17.28	25.53
Wilberforce	10.75	13.53	17.23	25.51
Sackville	7.78	10.06	13.14	22.39
Floodplain locations – upstream of project				
Agnes Banks	13.01	14.53	18.18	25.96
Richmond	16.09	16.19	17.31	25.56
Bakers Lagoon, Richmond	11.24	13.68	17.35	25.57

Emergency management

Floods in the Hawkesbury-Nepean River are classified in the Hawkesbury Nepean Flood Emergency Sub Plan (HNFESP) as either Level 1 (when the water level at Windsor is less than 15 metres AHD) or Level 2 (for floods greater than 15 metres). State Emergency Services (SES) manages evacuation during a Level 2 flood in accordance with measures provided in the HNFESP. The plan covers the area between Wallacia to downstream of Spencer. Flood evacuation routes used in this plan are for areas on the south side of the Hawkesbury River. Windsor's evacuation routes include recently constructed Windsor flood evacuation bridge (centreline height 17.8 metres AHD) over South Creek and Windsor Road at South Creek (closed at 13.5 metres AHD). The HNFESP notes that the stream gauge at Windsor (reference 212426) is used for emergency planning. This gauge is located around 50 metres upstream of the existing bridge.

Emergency management for Level 1 floods is addressed in the Hawkesbury City Local Flood Plan (a sub-plan of the Hawkesbury City Local Disaster Plan). The Plan notes that the council closes and re-opens its own roads as does RMS (Subsections 3.13.2 and 3.13.3). This plan does include a traffic management plan for flooding for Wilberforce Road and Freemans Reach Road.

Windsor bridge flood immunity

Access to Windsor from areas north of the Hawkesbury River (such as Wilberforce and Freemans Reach townships) during floods is limited by the level of the existing Windsor bridge and low lying sections of Freemans Reach Road and Wilberforce Road. Levels along Freemans Reach Road vary between 9.6 and 12.8 metres AHD with the low point at the intersection with Wilberforce Road and a second low point of 10 metres AHD around two kilometres from the intersection with Wilberforce Road. Levels along Wilberforce Road vary between 8.4 to 10.8 metres AHD between Windsor bridge and where the road crosses Buttsworth Creek. Levels are based on Airborne Laser Survey data. Additionally Wilberforce Road is potentially inundated due to local catchment runoff surcharging culverts at Buttsworth Creek. The existing bridge is around 1.4 metres lower than the low point on Wilberforce Road and 2.6 metres lower than the low point on Freemans Reach Road. Between 1987 and 2011 there have been eight events for which water levels were higher than the level of the existing bridge. The average duration of these events was 43 hours.

Flood affected properties

Existing flood risk to residential dwellings in the Hawkesbury LGA is addressed in the *Draft Floodplain Risk Management Study and Plan* (Hawksbury City Council, 2012). Property data used in this study was provided through Hawkesbury City Council for use in this EIS to estimate impacts from the project. This is supplemented for properties close to the project for which floor levels were surveyed. Additionally a wider assessment has been done to consider potential impacts to land use other than residential dwellings.

The preliminary estimates of existing regional property and land use impacts anticipated under four modelled events are presented in **Table 7-57** and **Table 7-58** respectively. These estimates show that the main land uses impacted by flooding are horticulture and grazing. Urban areas account for only 10 per cent of the inundated area in a 100 year ARI event.

Table 7-57 Existing conditions - Estimate of number of lots inundated

Location	Number of lots inundated for modelled flood events			
	5 year ARI	20 year ARI	100 year ARI	PMF[1]
Northern floodplain	270	310	470	620
Richmond floodplain south of the river up to the railway	170	230	390	1100
Southern floodplain from South Creek to Wilberforce	260	350	570	690

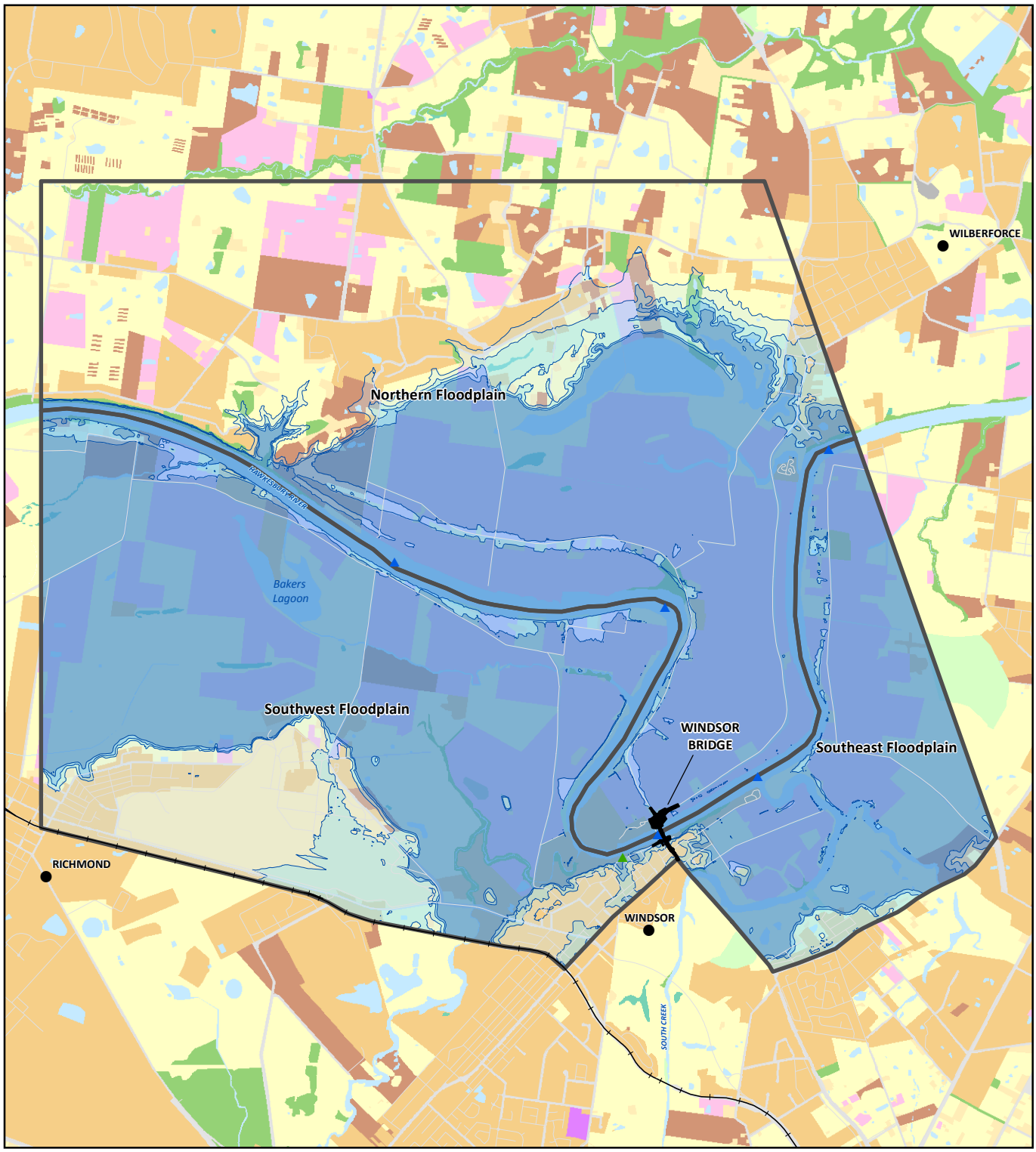
1. Probable maximum flood.

Table 7-58 Existing conditions - Preliminary estimate of land use impacts

Land use type	Area impacted for modelled flood events (ha)			
	5 year ARI	20 year ARI	100 year ARI	PMF[1]
Northern floodplain				
Grazing	200	230	300	350
Horticulture - Orchards & vegetables	240	250	250	250
Horticulture - Turf farming	540	570	580	600
Intensive animal production	0	30	50	60
Urban	70	80	120	170
Vegetated areas & water features	240	250	250	260
Richmond floodplain south of the river up to the railway				
Grazing	640	670	680	700
Horticulture - Orchards & vegetables	150	160	170	170
Horticulture - Turf farming	410	420	420	420
Intensive animal production	50	50	50	50
Urban	110	120	160	300
Vegetated areas & water features	160	160	160	160
Defence	10	10	90	260
Mining & quarrying	3	4	4	4
Southern floodplain from South Creek to Wilberforce				
Grazing	470	490	500	510
Horticulture - Cropping & vegetables	30	30	30	30
Horticulture - Turf farming	270	270	270	270
Intensive animal production	10	20	20	30
Urban	50	70	120	140
Native forest & waterways	140	140	140	140

1. Probable maximum flood.

Figure 7-37 | Land use and approximate extent of inundation



Indicative only – subject to detailed design

LEGEND

- 5 year ARI
- 20 year ARI
- 100 year ARI
- PMF
- Water level gauge station
- Model location
- Road
- Railway

Land use

- Conservation Area
- Cropping
- Grazing
- Horticulture
- Intensive Animal Production
- Mining & Quarrying
- Power Generation
- River & Drainage System
- Special Category
- Transport & Other Corridors
- Tree & Shrub Cover
- Urban
- Wetland

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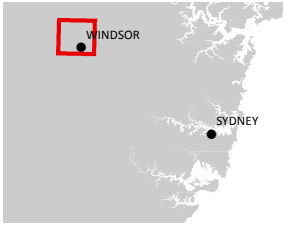

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In addition to buildings from the data provided through Hawkesbury City Council, RMS surveyed floor levels for properties near the bridge and within the upstream floodplain that are potentially impacted by the project. The location, floor level and estimated depth of existing flooding at these buildings are provided in **Table 7-59**.

Of the buildings where additional survey of floor levels was undertaken by RMS:

- Twenty four buildings on twelve properties are estimated to experience above floor inundation in a 5 year ARI event.
- Thirty-four buildings on sixteen properties are estimated to experience above floor inundation in a 20 year ARI event.
- Thirty-five buildings on sixteen properties are estimated to experience above floor inundation in a 100 year ARI event.

Estimated inundation of other properties from the Hawkesbury City Council database for existing conditions include:

- Three buildings experience above floor inundation in a 5 year ARI event.
- 130 buildings experience above floor inundation in a 20 year ARI event.
- 699 buildings experience above floor inundation in a 100 year ARI event.

It is noted these are a subset of potentially inundated properties considered in the Floodplain Risk Management Study which accounted for properties in the whole Hawkesbury LGA.

Table 7-59 Estimated depth of overfloor inundation for existing conditions

Property Address	Surveyed Floor Level (mAHD)	Estimated Existing Flood Depth above surveyed floor level (m)			
		5 year ARI	20 year ARI	100 year ARI	PMF
1 Thompson Square	14.03	-	-	3.26	11.51
5 Freemans Reach Road	13.12	-	0.49	4.16	12.41
5 Freemans Reach Road	13.47	-	0.14	3.81	12.06
5 Freemans Reach Road	11.52	-	2.09	5.76	14.01
27 Wilberforce Road	12.99	-	0.62	4.29	12.54
27 Wilberforce Road	11.17	-	2.44	6.11	14.36
33 Wilberforce Road	10.34	0.69	3.27	6.94	15.19
33 Wilberforce Road	10.97	0.06	2.64	6.31	14.56
33 Wilberforce Road	11.67	-	1.94	5.61	13.86
1A Wilberforce Road	10.88	0.18	2.74	6.41	14.66
1A Wilberforce Road	10.86	0.20	2.76	6.43	14.68
1A Wilberforce Road	10.88	0.18	2.74	6.41	14.66
1A Wilberforce Road	10.86	0.20	2.76	6.43	14.68
23 Wilberforce Road	11.11	-	2.51	6.18	14.43
23 Wilberforce Road	10.93	0.13	2.69	6.36	14.61
98 Cordners Lane	11.69	-	1.96	5.61	13.85
124 Cornwallis Road	10.51	0.74	3.15	6.79	15.03
124 Cornwallis Road	9.42	1.83	4.24	7.88	16.12
295 Freemans Reach Road	11.22	0.05	2.44	6.08	14.32
295 Freemans Reach Road	11.09	0.18	2.57	6.21	14.45
295 Freemans Reach Road	10.92	0.35	2.74	6.38	14.62
295 Freemans Reach Road	11.01	0.26	2.65	6.29	14.53
1 Gow Lane	9.23	2.09	4.44	8.07	16.31
1 Gow Lane	9.36	1.96	4.31	7.94	16.18
332 Cornwallis Road	11.42	0.07	2.27	5.89	14.13
332 Cornwallis Road	11.17	0.33	2.53	6.14	14.38
362 Cornwallis Road	11.63	-	2.07	5.68	13.92
156 Freemans Reach Road	10.81	0.35	2.83	6.49	14.73
238 Freemans Reach Road	10.69	0.43	2.94	6.60	14.84
238 Freemans Reach Road	11.53	-	2.10	5.76	14.00
238 Freemans Reach Road	10.19	0.93	3.44	7.10	15.34
238 Freemans Reach Road	10.21	0.91	3.42	7.08	15.32
490 Freemans Reach Road	11.19	0.33	2.51	6.12	14.36
521 Freemans Reach Road	11.16	0.39	2.54	6.15	14.39
521 Freemans Reach Road	10.88	0.67	2.82	6.43	14.67

7.7.3 Construction and demolition impacts

Potential impacts of flooding on the project

It is possible that a flood could occur during the construction or demolition period, which could have adverse effects on work activities and increase the risk of soil and sediment erosion. The impacts and associated environmental management measures for soil and sediment erosion are presented in **Section 7.6**. The occurrence of high river flows during construction or demolition could result in erosion of bed and bank material if the proposed scour protection measures have not yet been constructed.

Before the demolition of the existing bridge is completed, it could fail during a flood event causing damage to the new bridge. While the existing bridge is in poor condition, the new bridge would open by 2015 and the existing bridge is extremely unlikely to fail in the next three years.

Potential impacts of the project on flooding

The presence of construction infrastructure and equipment in the river (such as barges and temporary platforms) and the period when two bridges are present (whether partially constructed, demolished or complete) has the potential to increase flooding at properties upstream of the project. The increase in flood levels when both bridges are present (and complete) is estimated to be around 0.18 metres (that is 0.06 metres above the estimated increase with the replacement bridge alone) in a five year ARI event. The period between opening the new bridge and completing the demolition of the existing bridge would be about four months.

During the construction of the new bridge, increased flooding would be negligible until the launching of the new bridge commences. As the bridge is gradually launched across the river, the potential impact of flooding upstream would increase. It would take about 12 months to launch the bridge and complete finishing works before the opening of the new bridge.

Flood impacts would be greatest for properties that are near the bridge (see further information on property impacts below).

7.7.4 Operational impacts

Changes in flow distribution near Windsor

The predicted changes in peak flow volumes within the Hawkesbury River as a result of the project are presented in **Table 7-60**. The flows are representative of flow for a width of around 250 metres over the main river channel and thus do not include flow that is within the floodplains. For the project the change in flow is minor with a small reduction in the peak flow in the river (less than one per cent) in a 100 year ARI event. Peak flows reduce due to attenuation of floods when water levels increase and due to some redistribution of water onto the floodplains.

Table 7-60 Modelled estimates of changes in peak flow as a result of the project

Location upstream of Windsor bridge	Change in peak flow for modelled flood events - m^3/s and (percent change in flow compared to existing conditions)			
	5 year ARI	20 year ARI	100 year ARI	PMF[1]
6.2 km upstream	-10 (<1%)	-20 (<1%)	0	-120 (-1.5%)
3.5 km upstream	-10 (<1%)	-60 (<1%)	-50 (<1%)	-90 (-1.2%)
At Windsor bridge	-10 (<1%)	-140 (-2.5%)	-60 (-1%)	-20 (<1%)

1. Probable maximum flood.

Changes in peak water levels

The project would potentially increase flood levels on the Hawkesbury River floodplain, as the new bridge and approach road modifications would obstruct the movement of floodwaters to a greater extent than the existing bridge and approach roads.

The predicted changes in peak water levels as a result of the project are shown in **Table 7-61**. These predictions indicate that the effect of the project on flood water levels would be minor and would be greatest for the five year ARI event.

In the five year ARI flood event, the peak water level in the channel would increase by 0.12 metres just upstream of the project. The increase in water levels would decrease with distance upstream, with water level increases of 0.06 metres at North Richmond and 0.03 metres at Devlin Road, Castlereagh. Flood water levels on the Hawkesbury River floodplain would also increase upstream of the project, with an increase of 0.11 metres at Bakers Lagoon and 0.04 metres at Agnes Banks. In contrast, flood water levels downstream of the project and on the South Creek floodplain would decrease in the five year ARI event.

For the 20 year ARI event, there would be a very minor increase in peak water levels within the channel upstream of the project, with an increase of 0.03 metres just upstream of the bridge and 0.01 metres at Devlin Road. There would also be a very minor increase in peak water levels within the channel downstream of the project. On the floodplains, there would be a minor increase in water levels at Bakers Lagoon and a very minor increase around South Creek.

The model predictions for the 100 year ARI and PMF events indicate that the effects of the project on flood behaviour and peak flood levels during extreme flood events would be negligible.

Table 7-61 Change in peak flood level as a result of the project

Location	Change in peak water levels (m AHD) for modelled flood events			
	5 year ARI	20 year ARI	100 year ARI	PMF
River locations – upstream of project				
Penrith Weir	Nil	Nil	Nil	Nil
Devlin Road, Castlereagh	0.03	0.01	Nil	Nil
Yarramundi	0.04	0.01	Nil	Nil
North Richmond	0.06	0.01	Nil	Nil
Hibberts Lane	0.09	0.02	Nil	Nil
Windsor Bridge	0.12	0.03	0.01	-
River locations – downstream of project				
South Creek Junction	-0.02	0.01	Nil	Nil
Wilberforce	-0.02	0.01	Nil	Nil
Sackville	-0.02	0.01	Nil	Nil
Floodplain locations – upstream of project				
Agnes Banks	0.04	Nil	Nil	Nil
Richmond	Nil	Nil	Nil	Nil
Bakers Lagoon, Richmond	0.11	0.02	Nil	Nil

Property impacts

An assessment of the potential flood impacts to properties upstream of the project has been undertaken using the model results, ALS data over the floodplain and cadastre. Flood levels downstream of the project (in the southeast zone) are not considered as flood levels slightly reduce due to the project in the five year ARI event and have only a minor increase in a 20 year ARI event (up to 0.01m which is considered within the range of model accuracy) and no change in a 100 year ARI event.

The assessment indicates that one additional lot would experience flooding in a five year ARI in the southwest zone due to the project and up to 359 lots (in the northern and southwest zones) would be expected to experience an increase in a five year ARI flood depth due to the project. The increase of flood depths would be five percent (for example 0.05 metre increase in depth above an existing flood depth of one metre) for 200 of the lots, an additional 103 lots are estimated to have an increase up to ten percent and an additional 51 lots an estimated increase up to 15 percent. The distribution of increases to depths for various land use are presented in **Table 7-62**.

The assessment indicates that one additional lot would experience flooding in a 20 year ARI in the southwest zone due to the project and up to 581 lots (in the northern and southwest zones) would experience an increase in a 20 year ARI flood depth due to the project. For all lots potentially subject to an increase in inundation depth, the percent increase of flood depths above the existing flood depths would be less than five percent.

The majority of the area subject to inundation is used for agricultural purposes, refer to **Table 7-62**. Agricultural damage is usually quantified by considering both the depth of inundation and time of inundation, and the following are suggested criteria for damage (Read Sturgess & Associates, 2000):

- Grain and vegetable crops are expected to be lost when the flood depth is between 0 and 0.15 metres, no matter how long the land is flooded for;
- Pasture, vines and orchards are damaged when the inundation time is greater than 7 days and/or the depth of flooding is greater than 0.15 metres.
- Significant livestock losses occur when the depth of flooding is greater than 0.15 metres and/or the inundation time is greater than 7 days.

Table 7-62 Potential impacts to average flood depths on properties between Richmond and Wilberforce – 5 year ARI event

Land use groupings	Existing Conditions	Replacement Bridge	
	Average depth (metres)	Average depth (metres)	Increase in average depth (metres)
Northern Floodplain			
Grazing	2.95	2.99	0.04
Horticulture	2.15	2.21	0.06
Horticulture - turf	3.06	3.11	0.05
Intensive Animal Production	1.83	1.88	0.05
Other	4.48	4.53	0.05
Urban	3.81	3.85	0.04
South West Floodplain			
Grazing	3.79	3.86	0.07
Horticulture	2.03	2.09	0.07
Horticulture - turf	3.75	3.82	0.08
Intensive Animal Production	3.22	3.29	0.06
Other	6.19	6.28	0.09
Special Category	3.88	3.94	0.06
Urban	2.03	2.06	0.03

While the average flood impacts over the wider floodplain due to the project are minor, there would be a small number of properties that would be impacted by a higher level of flooding. Properties most vulnerable to impacts would be those located immediately upstream of the replacement bridge. Increases in flood levels would potentially result in increased flood damage costs and other impacts associated with flooding.

Higher flood damage costs and other impacts occur when commercial and residential premises are flooded. Data from the recent Draft Hawkesbury Flood Risk Management Study was used to assess the magnitude of potential impacts from increased flooding due to the project. As described in **Section 7.7.2**, the data used to predict the increase in flood levels at buildings had limitations and uncertainties. It provides an indication of likely impacts to residential properties. Results presented assume residential buildings have floor levels at the ground levels of the properties.

Potential impacts to residential buildings between Richmond and Wilberforce

Flood afflux (increase in water depths) of buildings located upstream of Windsor bridge, and on the northern floodplain, was assessed from the preliminary mapping prepared for this EIS, surveyed floor levels undertaken by RMS and buildings identified from the HCC dataset used in the FRMS. Identification of existing flood impacted properties does not represent a replication of flood assessment undertaken for the FRMS, nor does it accurately identify overfloor inundation for properties other than surveyed by RMS, as survey of floor levels was not undertaken when developing this dataset for the FRMS. It provides an indication of likely impacts to residential properties. Impacts to properties may include increased flood damages, impacts on the safety of residents and impacts to property access.

Buildings with an estimated increase in flooding of less than 0.01 metre due to the project are not included in this assessment as this increase is considered negligible and beyond the accuracy of the modelling used to determine afflux. Properties subject to flooding greater than one metre for existing conditions are not included in this assessment as the increase in flood depths is minor compared with existing flood inundation.

Table 7-63 shows the existing flood depths and estimated increase in flood levels for buildings with surveyed floor levels. The increase to flood depths is shown for the five, 20 and 100 year ARI events. Results for the PMF are not provided as there is negligible increase in flood levels for this event. These results indicate that:

- In a five year ARI event one additional residential dwellings would be experience over floor flooding (23 Wilberforce Road) due to the project and 25 buildings would experience increased flooding levels greater than 0.01 metre. Of these 25 buildings, three buildings have an existing over floor flooding of greater than one metre. Average increase in flood levels due to the project for the other 22 buildings would be 0.10 metre, with the largest increase in water depth of 0.12 metre. There would be 15 buildings with an increase in flood levels due to the project of greater than 25 percent, two of which are generally subject to low levels of flooding in the existing conditions (less than 0.1 metre). These two buildings would be at most risk of increased flood damage from increases in flood levels due to the project.
- In a 20 year ARI event there would be no additional buildings experiencing over floor flooding due to the project. Thirty four (34) buildings would experience increases in flood levels due to the project of greater than 0.01 metre however, 31 properties have an existing depth of inundation greater than one metre. The average increase in flood levels for the three properties that have increase greater than 0.01 metre and an existing depth less than one metre is 0.03 metre.
- In a 100 year ARI event there are negligible changes to flood levels at buildings due to the project.

Estimated afflux for buildings other than those surveyed, was assessed using the HCC dataset. As noted previously this data assumes residential buildings have floor levels at the ground levels of the properties. The predicted impacts for the different flodd events include:

- In a five year ARI event there would be no additional residential dwellings would be experience over floor flooding due to the project. Three residential dwellings would experience increases in flood levels of greater than 0.01 metre due to the project and of these, one dwelling has an existing depth of inundation greater than 1 metre. The increase in flood levels at these buildings due to the project would be 0.11 metre.
- In a 20 year ARI event there would be four additional residential dwellings that would experience over floor flooding due to the project. One hundred and thirty (134) residential dwellings would experience increases in flood levels greater than 0.01 metre due to the project, however 45 properties have an existing depth of flooding greater than one metre. Average increase in flood levels due to the project for the other 89 properties would be 0.02 metre with the highest experiencing an increase of 0.03 metre.
- In a 100 year ARI event there would be negligible changes to flood levels at properties due to the project.

Table 7-63 Increase to over floor inundation for buildings near Windsor Bridge

Property Address	Surveyed Floor Level (metres AHD)	Estimated Flood Depth above surveyed floor level (metres)			Estimated Increase in Flood Depths (metres)		
		5 year ARI	20 year ARI	100 year ARI	5 year ARI	20 year ARI	100 year ARI
1 Thompson Square	14.03	-	-	3.26	-	-	0.01
5 Freemans Reach Road	13.12	-	0.49	4.16	-	0.03	0.01
5 Freemans Reach Road	13.47	-	0.14	3.81	-	0.03	0.01
5 Freemans Reach Road	11.52	-	2.09	5.76	-	0.03	0.01
27 Wilberforce Road	12.99	-	0.62	4.29	-	0.03	0.01
27 Wilberforce Road	11.17	-	2.44	6.11	-	0.03	0.01
33 Wilberforce Road	10.34	0.69	3.27	6.94	0.11	0.03	0.01
33 Wilberforce Road	10.97	0.06	2.64	6.31	0.11	0.03	0.01
33 Wilberforce Road	11.67	-	1.94	5.61	-	0.03	0.01
1A Wilberforce Road	10.88	0.18	2.74	6.41	0.12	0.03	0.01
1A Wilberforce Road	10.86	0.20	2.76	6.43	0.12	0.03	0.01
1A Wilberforce Road	10.88	0.18	2.74	6.41	0.12	0.03	0.01
1A Wilberforce Road	10.86	0.20	2.76	6.43	0.12	0.03	0.01
23 Wilberforce Road	11.11	-	2.51	6.18	0.12	0.03	0.01
23 Wilberforce Road	10.93	0.13	2.69	6.36	0.12	0.03	0.01
98 Cordners Lane	11.69	-	1.96	5.61	-	0.02	<0.01
124 Cornwallis Road	10.51	0.74	3.15	6.79	0.11	0.02	<0.01
124 Cornwallis Road	9.42	1.83	4.24	7.88	0.11	0.02	<0.01
295 Freemans Reach Road	11.22	0.05	2.44	6.08	0.11	0.02	<0.01
295 Freemans Reach Road	11.09	0.18	2.57	6.21	0.11	0.02	<0.01
295 Freemans Reach Road	10.92	0.35	2.74	6.38	0.11	0.02	<0.01
295 Freemans Reach Road	11.01	0.26	2.65	6.29	0.11	0.02	<0.01
1 Gow Lane	9.23	2.09	4.44	8.07	0.11	0.02	<0.01
1 Gow Lane	9.36	1.96	4.31	7.94	0.11	0.02	<0.01
332 Cornwallis Road	11.42	0.07	2.27	5.89	0.10	0.02	<0.01
332 Cornwallis Road	11.17	0.33	2.53	6.14	0.10	0.02	<0.01
362 Cornwallis Road	11.63	-	2.07	5.68	-	0.02	<0.01
156 Freemans Reach Road	10.81	0.35	2.83	6.49	0.08	0.02	<0.01
238 Freemans Reach Road	10.69	0.43	2.94	6.60	0.07	0.02	<0.01
238 Freemans Reach Road	11.53	-	2.10	5.76	-	0.02	<0.01
238 Freemans Reach Road	10.19	0.93	3.44	7.10	0.07	0.02	<0.01
238 Freemans Reach Road	10.21	0.91	3.42	7.08	0.07	0.02	<0.01
490 Freemans Reach Road	11.19	0.33	2.51	6.12	0.10	0.02	<0.01
521 Freemans Reach Road	11.16	0.39	2.54	6.15	0.10	0.02	<0.01
521 Freemans Reach Road	10.88	0.67	2.82	6.43	0.10	0.02	<0.01

Climate change

The *Practical Consideration of Climate Change, Floodplain Risk Management Guideline* (DECCW, 2007) provides a range of predicted climate change impacts for various regions. Within the Sydney Metropolitan region the likely change in extreme rainfall is estimated to be between -3 and +12 per cent up to 2030 and -7 and +10 per cent up to 2070. These changes are applied to all frequency events and various duration events (greater than one day). The *Floodplain Risk Management Study* reported that peak flood levels are highly sensitive to increases in rainfall. A ten percent increase in rainfall results in an increase of 0.9m in peak flood level in a 100 year ARI at Windsor. Alternatively the current 100 year ARI flood would occur more frequently and would become around a 60 to 70 year ARI event with a 10% increase in rainfall. Therefore the bridge would be overtopped in more frequent events, likely subject to higher velocities, potentially greater depths of scour and increased depth of inundation. The replacement bridge would be designed to be overtopped and to withstand scouring of the piers and abutments up to 2000 year ARI event. As a result it would be unlikely to be affected by changes in rainfall and flooding events.

Coastal sea level rise produced by DECCW (as part of the *NSW Sea Level Rise Policy Statement* (DECCW, 2009)) has been assumed to be applicable to the township of Windsor. These projections are sea level rise of 40cm by 2050 and sea level rise of 90cm by 2100. The *Draft Hawkesbury Floodplain Risk Management Study* reported that sea level rises produce no significant increases in peak flood levels for the majority of the floodplain.

Other potential risks due to climate change are identified and addressed in the Climate change section (see **Section 8.4**) and are further discussed in Chapter 11 (Ecologically Sustainable Development).

Scour protection

Flooding of the Hawkesbury River has the potential to cause bed and bank scour, including scour around bridge abutments and piers. Scour may also occur due to local turbulence generated at bridge abutments and piers under normal flow (non-flood) conditions. On the southern bank of the river there is an existing retaining wall, gabions and vegetated fill where the former wharf was located. This area would be potentially impacted by increased velocities as a result of turbulence generated by the abutments and piers of the replacement bridge.

The need to prevent bed and bank scour has been addressed in project design (see **Section 5.2.7**). These design measures would provide bed and bank scour protection for both frequent and large flood events. The project also includes filling the existing low area between the northern abutments of the existing bridge and proposed replacement bridge to limit opportunities for generation of turbulence and scour.

Flood immunity

The bridge would connect Bridge Street in Windsor to Wilberforce Road and Freemans Reach Road. The project would have a minimum road level of RL 9.8 metres AHD (2.8m higher than the existing bridge). This would result in the replacement bridge being a similar height to the lowest level of Freemans Reach Road and higher than around 60 per cent of Wilberforce Road, from the bridge to Wilberforce.

The level of the replacement bridge would be optimal as it would provide a connection to the existing roads while improving the flood immunity for the crossing. A higher level would not improve regional access during floods as the northern roads would be inundated before the bridge is overtopped. Additionally extensive road works on the northern bank would be required to transition to the existing road profiles and such earthworks would inhibit the passage of floods. Having the bridge at a lower level, that is a lower flood immunity, would limit access across the river during floods as Freemans Reach Road would be accessible when the bridge is closed. This is similar to the current conditions.

The increased height of the new bridge would result in a decrease in the frequency of the river crossing closures. Using historical flood level data from 1987 to 2011 the number and length of bridge closures for the existing bridge and new bridge was estimated. If the new bridge had been in place, the number of bridge closures would have been three instead of eight and the average duration of closures would have decreased from 43 hours to 19.5 hours.

Changes in flow direction

As only a concept design of the project was available at the assessment stage, no detailed modelling of potential impacts on flow direction was undertaken. However as the existing alignment of the river banks would remain unchanged and the replacement bridge would be inundated in floods greater than the three year ARI event, the impacts on flow direction for most flood events would be negligible. The key flood events that would require more detailed assessment would be flood events around the three year ARI, namely when the replacement bridge would be partially submerged. As the replacement bridge has a slight slope from south to north, some additional flood waters may be forced to the north during partial submergence of the bridge. This may have a localised impact, however it would not be expected to be significant as the volume of water would be relatively small and the landuse is predominately agricultural. Once the detailed design of the replacement bridge is further advanced, an assessment of potential changes in flow direction would be undertaken.

[11] recorded water levels at Windsor gauge (MHL stream gauge 212426)

7.7.5 Environmental management measures

Construction measures

The potential impacts of flooding on the construction and demolition phases of the project, as well as the impacts of construction and demolition activities on flooding, can be reduced to acceptable levels with the application of standard construction site management procedures. Procedures to minimise flooding impacts during construction would include (but would not be limited to) the following:

- The extent of obstructions within the river will be minimised as far as practicable at all times during construction and demolition.
- The time between completion of construction of the replacement bridge and demolition of the existing bridge will be minimised as far as practicable.
- Construction infrastructure and equipment will be removed from the river channel and floodplain in the event of a forecast flood to minimise both the risk of damage to infrastructure/equipment and the risk of flood impacts on properties.
- Appropriate procedures to manage the effects of flooding during construction, and minimise any associated adverse environmental impacts to the greatest extent practicable, will be incorporated into a construction environmental management plan and emergency response plan (to be prepared and approved before the start of construction). The emergency response plan would include procedures to ensure adequate warning of floods is obtained and that appropriate emergency response procedures are implemented in a timely manner
- Suitable scour protection would be provided to protect the bridge abutments, piers and banks during construction.

Environmental management measures to minimise potential water quality and erosion impacts from flooding during construction are detailed in **Section 7.6**.

Operational measures

Property impacts

The following environmental management measures will be implemented to minimise impacts from flooding:

- Flood impact mitigation requirements and options for buildings potentially impacted by the project will be investigated during detailed design in consultation with the landholders. Appropriate measures will be identified, developed and implemented, as required, to minimise impacts on the building structure, building access and business opportunities.
- During the detailed design of the new bridge, detailed flood modelling will be undertaken on the final design of the project to identify any additional impacts. This will include collecting survey data at potentially impacted properties with buildings upstream of the bridge. Where impacts are identified, appropriate measures will be identified, developed and implemented, as required, to minimise impacts on the building structures, building accesses and business opportunities.
- Suitable scour protection would be provided to protect the bridge abutments, piers and banks during operation.

7.8 Land use, property and socio-economic

This section assesses the land use, property and socio-economic impacts of the project. The assessment is supported by the Land use, property and socio-economic working paper, which has been included as working paper 9 in Volume 4 of this EIS. The Director General's requirements for the EIS identify land use, property and socio-economic considerations as a key issue. The Director General's requirements have been addressed in this chapter and in the Land use, property and socio-economic working paper (Volume 4 - Working paper 9) as detailed in **Table 7-64** below. The requirements of Part 3 of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000* have also been addressed.

Table 7-64 Director General's requirements

Director General's requirements	Where addressed
The EIS must address the following specific matters: **Land use, property and socio-economic** – including but not limited to:	
• Impacts on directly affected properties and land uses, including impacts related to access, land use, property acquisition and amenity related changes.	Sections 7.8.3 and 7.8.4
• Impacts of the project on tourist and recreational uses of Thompson Square, the town centre and the Hawkesbury River and its foreshores.	Sections 7.8.3 and 7.8.4
• Social and economic impacts to the Windsor town centre businesses and the community associated with traffic, access, property, public domain and amenity related changes.	Sections 7.8.3 and 7.8.4

The project is located within the Hawkesbury LGA. This assessment has considered the impacts on the LGA as well as the suburbs of Windsor and Richmond.

7.8.1 Guidelines and methodology

Data sources

A review of the existing land use, property and socio-economic environment was undertaken to provide a baseline against which the impacts of the project can be assessed. Data from the 2006 and 2011 Australian Bureau of Statistics Census of Population and Housing have been used to describe the existing environment where it is relevant to the project and the assessment. Where available, the 2006 and 2011 Census information has been supplemented with more recent data, including from:

- The Australian Bureau of Statistics' National Regional Profiles and counts of Australian businesses.
- The Department of Education, Employment and Workplace Relations' information on unemployment.
- Space Time Research Pty Ltd information on employment forecasts by industry.
- Transport and Infrastructure Transport Data Centre, including transport indicators for the Hawkesbury LGA.

- A survey of pedestrian and cyclist movements conducted at Windsor by Skyhigh Data Australia Pty Ltd in late 2009.
- Survey of 55 Windsor businesses undertaken in December 2009. The purpose of these surveys was to collect information about the current function of the Windsor town centre and the potential impacts of bridge replacement options. Specifically, information was sought about the level of trade attributed to passing traffic, customer origin and travel patterns, the purpose of visits to the town, and reasons for choosing to visit the Windsor town centre instead of other centres.
- Community and stakeholder consultation undertaken during assessment of project options and selection of the preferred option.
- Previous land use, property and socio-economic assessments undertaken for the project (SGS Economics and Planning, 2010).
- Property and landuse information including strategic plans, zoning information, landuse databases and other information.
- Other working papers prepared for the project.

Existing land use, property and socio-economic environment

The description of the existing land use, property and socio-economic environment provides a baseline from which impacts of the project can be assessed. It included both qualitative and quantitative analysis, including:

- A review of relevant social, economic, land use and planning policies and strategies, including local and state government strategies and policies.
- Review of existing and proposed future land uses.
- Analysis of key population and demographic indicators, to identify those groups within the community that may be vulnerable to changes brought about by the project, due to such things as their level of economic resources, age, need for assistance and cultural background.
- Review of economic data, including that relating to employment, income and local business and industry indicators; housing costs and dwelling characteristics.
- A visual site analysis of local businesses, including the nature and types of businesses directly adjacent to the project and Thompson Square.
- Identification of tourist and recreational uses new to the project, including key tourist destinations and facilities.
- Analysis of existing transport and access, including journey to work data; freight forecasts; local and regional road network; and public transport, walking and cycling facilities.
- Review of existing and planned social infrastructure, including open space and community services and facilities closest to the project.

Identification of existing community values, including those relating to local amenity and character, local access and connectivity, community cohesion and environmental values. This was informed by existing local and state government social policies, outcomes of community consultation, observations from the site visit and desktop data analysis.

Impact assessment and mitigation

Potential benefits for and impacts on local and regional land use, property and the socio-economic environment were identified and evaluated. This included an assessment of direct and indirect impacts associated with the project's design, construction and operation, including:

- Property impacts, such as impacts of property acquisition and changes to access.
- Impacts on local amenity, including the public domain, social infrastructure, open space and local business.
- Changes to local and regional access and connectivity, including for properties in the vicinity of the project.
- Land use impacts, such as changes to existing land use and implications of future development.
- Impacts on the local and regional economy, including an assessment of the project's contribution to the regional economy during construction and operation and the economic benefits from improved access and connectivity across the region.
- Impacts on local business including potential changes to business income/turnover and sustainability and impacts on local employment. This included consideration of factors such as changes to passing traffic, accessibility, visibility and amenity.
- Opportunities and impacts for regional industry including through economic benefits from improved access and connectivity in the region.
- Potential impacts and opportunities for tourist and recreational access and uses in Windsor specifically, the town centre, Thompson Square, and the Hawkesbury River and its foreshores.
- Impacts on community values due to the construction and operation of the project.
- Potential impacts on social infrastructure, including both direct and indirect impacts on local, district and regional level community services and facilities.
- Based on the assessment of potential impacts, environmental management measures were identified to enhance project benefits and avoid or reduce potential adverse impacts of construction and operation.

7.8.2 Existing environment

Property and land use

Overview

The project is located adjacent to the town centre of Windsor in the Hawkesbury LGA. Land use in the LGA is guided by a number of statutory and strategic environmental planning policies and plans including:

- *Hawkesbury Local Environmental Plan 2012* (Hawkesbury LEP) – this statutory planning instrument defines land use zonings and objectives, the types of development permissible in specific zones, assessment and consent requirements, and other statutory planning matters.
- Draft North West Draft North West Sub-regional Strategy 2007 - The Draft North West Sub-regional Strategy was released by the NSW Government in December 2007. It covers the Baulkham Hills, Blacktown, Blue Mountains, Hawkesbury and Penrith local government areas. The strategy identifies a number of town centres, including Windsor and Richmond (located approximately seven kilometres from the project site), which play an important role in serving the surrounding catchments.
- Hawkesbury Community Strategic Plan 2010-2030- The Hawkesbury Community Strategic Plan 2010-2030 was adopted by the Hawkesbury City Council in October 2009. The plan sets out the key community aspirations for the community under five vision statements.
- Hawkesbury Employment Lands Strategy (Hawkesbury City Council, 2008) - The Hawkesbury Employment Lands Strategy 2008 provides a framework to support and enhance the Hawkesbury region's competitiveness. The Windsor town centre serves as the Hawkesbury local government area's traditional retail main street centre.
- Hawkesbury Residential Lands Strategy - The Hawkesbury Residential Land Strategy was released in 2011. The objectives of the strategy were to:
- Accommodate between 5,000 and 6,000 additional dwellings by 2031, primarily within the existing urban areas identified in the Department of Planning's North West Sub-regional Strategy.
- Preserve the unique and high quality natural environment of the local government area.
- Accommodate changing population, which presents new demands in terms of housing, services and access.
- Identify ongoing development pressures to expand into natural and rural areas, as well as new development both in and around existing centres.
- Identify physical constraints of flood, native vegetation and bushfire risk.

Further information on the strategic plans and an assessment of the project against the objectives, targets and/or actions in the plans is presented in Chapter 3.

Regional land use

Land use in the Hawkesbury local government area is generally characterised by pastoral and agricultural lands, business and industry, residential and tourism and recreational uses. Key characteristics of land use and development in the Hawkesbury local government area include:

- The primary retail and commercial centres within the local government area are located in Windsor and Richmond, with these providing a range of facilities for local residents and businesses, including supermarkets, community facilities, medical centres, schools and other key infrastructure services.
- Important government and community facilities such as the combined Hawkesbury District Health Service and Hawkesbury Private Hospital, located one kilometre from the Windsor town centre on Macquarie Street, and the Richmond RAAF base, located on the Hawkesbury Valley Highway at Richmond.
- Agricultural land in the region provides a substantial resource base for the Sydney basin, including dairy farming and food production. Large turf farms are located adjacent to the project area and within the Hawkesbury local government area.
- Tourism is a key industry for the region, building on the area's historic and Aboriginal heritage and natural values. The area around the project includes a number of tourist uses and attractions, such as the Hawkesbury Paddle Wheeler and the Hawkesbury Regional Gallery.
- The Hawkesbury River, which provides important environmental, amenity and recreational values, and which supports a range of tourist and primary industry uses. Recreational uses include the Bridge to Bridge Power Boat Race and the Bridge to Bridge Water Ski Classic held annually.
- Environmental features, such as the Hawkesbury River, Windsor Downs Nature Reserve, Scheyville National Park, Cattai National Park and access to the Blue Mountains National Park.
- The potential for urban growth is constrained by the area's built and natural environment, including location of national parks, bushfire prone areas, flooding along the Hawkesbury River, limited development capacity within existing centres, high value agricultural land and the Richmond RAAF base.

Windsor

- Residential uses, primarily comprising detached dwellings and rural residential living and farming properties.
- Commercial / industrial uses at Windsor and South Windsor, which support a broad mix of industrial uses.
- Education, health and community services and retail uses, which provide the region with a high level of employment self containment.
- Pastoral / agricultural uses located north and south of the Windsor town centre, extending to Ebenezer in the north, and Marsden Park in the south.
- Heritage buildings and spaces, including Thompson Square.

Commercial land use in Windsor town centre is described in **Figure 7-38**.

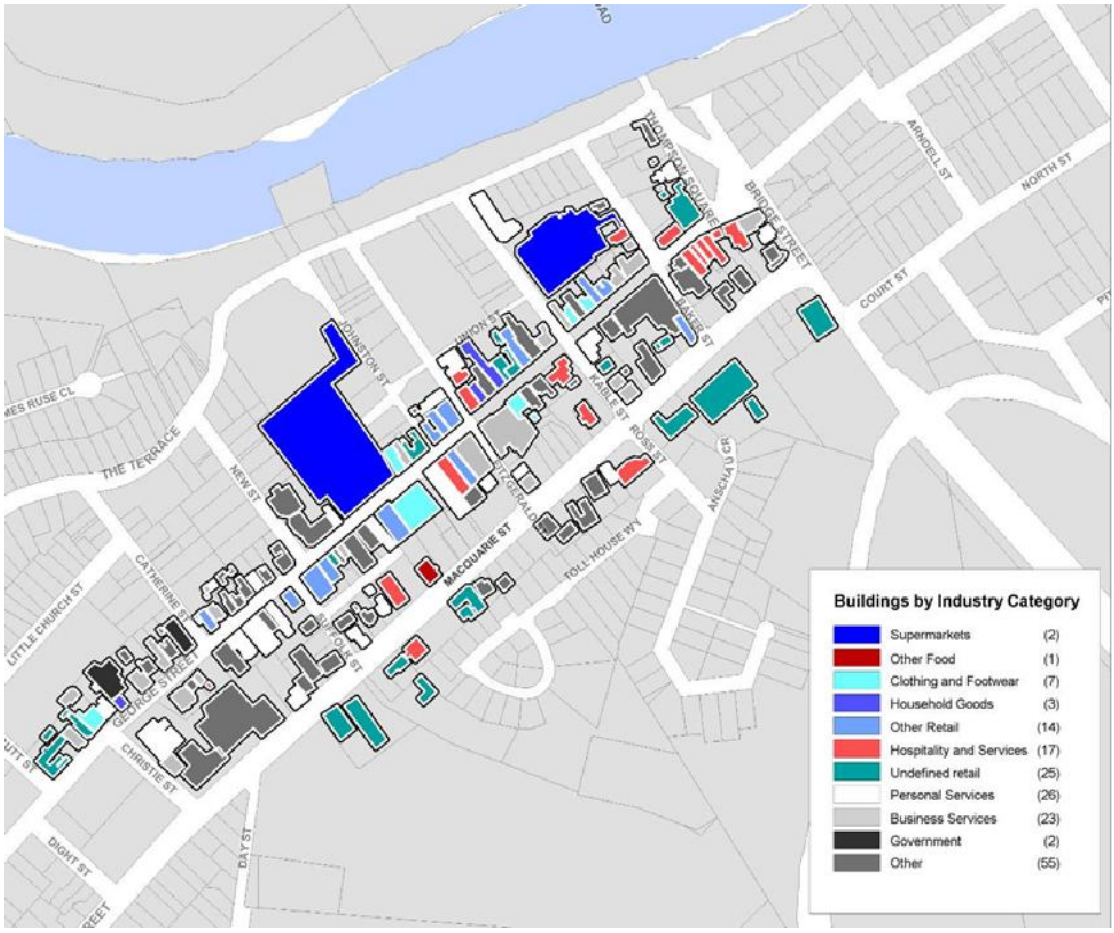

Figure 7-38 Commercial land use in Windsor town centre

Land use within the project area

The existing Windsor bridge is located adjacent to the town centre, crossing the Hawkesbury River to Freemans Reach Road and Wilberforce Road on the north bank of the river.

Land uses on the southern side of Windsor bridge include residential, commercial, retail and professional uses. Land to the south and south-west of the bridge mainly comprises urban residences. Businesses directly adjacent to the project alignment include a music shop and solicitors office. Other businesses within or near Thompson Square include accommodation, hospitality, business services and professional services.

Residential properties are more sparsely located on the northern side of the bridge, consisting mostly of open farmland and rural-residential dwellings. There is one residence at the corner of Freemans Reach Road and Wilberforce Road. Other land uses adjacent to the northern end of the project are turf farms and the recreational area of Macquarie Park.

Thompson Square parkland and the foreshore area associated with Windsor Wharf are recreational areas used for a variety of informal and formal uses. The southern approach road to the existing Windsor bridge which bisects Thompson Square parkland, reduces the functionality, accessibility and popularity of this recreational space.

Recreation and tourism

Recreation

Windsor provides for a diverse range of recreational, sporting and leisure activities, for both local and regional communities.

There are five parkland areas in Windsor, including Thompson Square and Macquarie Park. Thompson Square is located in the town centre of Windsor and comprises a small area of open space with picnic tables and gardens. The square is surrounded by historic buildings and is an important area for both the local community and tourism. Macquarie Park, located adjacent to the existing bridge on the northern side of the river, is a popular area for swimming, picnicking and organised events.

The Hawkesbury River is used for many aquatic activities, including boating, fishing, water skiing and swimming. Public boat access to the river is available from Windsor wharf and a boat ramp at Governor Phillip Park to the east of the town centre. The Hawkesbury River is one of the most popular waterways for recreational power vessels in NSW (RTA, 2011). The river is used extensively by recreational boaters engaging in high speed water skiing and racing, and the area immediately downstream of the existing Windsor bridge is used for racing by local boating clubs.

Key events on the river include the Hawkesbury Canoe Classic, the Bridge to Bridge Power Boat Race and the Bridge to Bridge Water Ski Classic from Brooklyn to Windsor. These events generate substantial financial income for local businesses (RTA, 2011).

Sporting grounds are located in Windsor, South Windsor and Richmond and cater for local and regional communities. Windsor and South Windsor together provide two golf courses, a netball centre, a ten pin bowling centre and a lawn bowls club, which are used by both local residents and surrounding communities.

Tourism

Tourism is an important industry for Windsor and the wider Hawkesbury local government area. Between September 2008 and September 2011, an average of 795,000 people visited the Hawkesbury region annually, of which over 80 per cent were day trippers. Key trends include:

- Almost 18 per cent of domestic visitors stayed overnight in the Hawkesbury local government area, with an average length of stay just under three nights.
- The majority of domestic visitors to the Hawkesbury local government area were from NSW (83 per cent), followed by visitors from the Australian Capital Territory (5.7 per cent) and Queensland (4.6 per cent).
- The primary reasons for visiting the Hawkesbury region were for holidays (50.5 per cent) or to visit friends and relatives (32.5 per cent).
- Overnight visitors generally chose to stay with friends or relatives (46.2 per cent), while 11.8 per cent of visitors stayed in hotels, motels and motor inns.

Tourist facilities within the Windsor town centre include:

- Cultural and arts facilities, including the Hawkesbury Museum and Tourist Centre, the Hawkesbury Regional Gallery and the Thompson Square precinct.
- Natural attractions such as the Hawkesbury River and its foreshores and the Windsor Downs Nature Reserve.
- Windsor Wharf, which supports river based tourism operations such as the Hawkesbury Paddle Wheeler.
- Touring routes, trails and heritage walks.
- Tourist accommodation uses, including caravan parks, hotels and motels and bed and breakfasts.

Tourist facilities located nearest to the project include:

- Thompson Square precinct.
- Macquarie Park.
- Governor Philip Park and a public boat ramp.
- Windsor Wharf.
- The Windsor Motel and the Windsor Terrace Motel, which are located within 200 metres of the project.

Several tourist attractions also contribute to the overall landscape character and heritage value of the Windsor township. For example, Thompson Square, the Hawkesbury Museum and Tourist centre and surrounding buildings are listed on several local and state heritage registers. These buildings contribute to the overall amenity and heritage character of Windsor and are valued by the local community.

Access and connectivity to the region is important in supporting day trippers and overnight visitors, particularly those from the Sydney region. The existing Windsor Bridge also supports access to regional facilities, surrounding tourist regions, and to various tourist drives, heritage walks and trails promoted in the area.

Socio-economic profile

Labour force, employment and income

Key areas of employment in the Windsor and the Richmond-Windsor urban locality include manufacturing, construction, retail trade, public administration and safety. Manufacturing is the largest employing industry in Windsor (11.4 per cent), followed by retail trade (11.0 per cent). The proportion of people employed in retail in Windsor was higher than the Hawkesbury LGA as a whole. Key occupations within these areas of employment include technical and trade positions, clerical and administrative positions, in addition to other public and private sector professional occupations.

The manufacturing industry is forecast to experience the largest reduction in contribution to employment (2.5 per cent), followed by the construction industry, which is forecast to decline by 2.3 per cent. These industries are, however, expected to remain key employers in the region.

The population of the region is ageing, which will result in health care and social assistance services becoming increasingly important areas of employment in the Hawkesbury LGA between now and 2031. Retail trade and accommodation and food service industries are also forecast to grow. Employment in the arts and recreation services industry is expected to remain stable.

Between 2006 and 2011, unemployment was consistently lower and the labour force participation was consistently higher in the Hawkesbury LGA relative to NSW. Median weekly incomes in the Hawkesbury LGA were higher than the state average in 2006, reflecting the relatively lower levels of unemployment in the Hawkesbury LGA. However, there is a higher proportion of low-income households in Windsor compared to the wider region, indicating there are pockets of relative disadvantage.

Population

In 2011, Windsor had a population of 1,803 people. At the same time, the Hawkesbury local government area had a population of 62,353 people (ABS, 2012). **Table 7-65** shows population growth for Windsor the Hawkesbury local government area and NSW between 2006 and 2011. Annual population growth in the Hawkesbury local government area was below the rate of growth for NSW during this time, while average annual population growth in Windsor exceeded the state average.

Table 7-65 Population growth 2006-2011

Region	Population	Average annual population growth 2006-2011 (percent)
Windsor	1,803	1.58
Hawkesbury local government area	62,353	0.08
NSW	7,300,000	1.13

Source: ABS (2006) Census of Population and Housing and ABS (2011) Census of Population and Housing.

The NSW Department of Planning and Infrastructure has predicted population growth in the NSW and each LGA based upon census data and fertility, migration and mortality rates. This does not take into account regional planning targets or strategies. The population of the Hawkesbury LGA is projected to increase to 90,083 by 2036, an average increase of 1.5 per cent annually. Over the same period, the average rate of population growth in NSW as a whole is projected to be lower, at 1.1 per cent annually. Predicted populations for the Hawkesbury LGA and NSW between 2006 and 2036 are shown in **Table 7-66**.

Table 7-66 Predicted populations, 2006-2036

Region	2006	2016	2026	2036	Average annual growth rate (per cent)
Hawkesbury LGA	62,105	67,222	77,877	90,083	1.5
NSW	6,816,100	7,559,600	8,322,800	9,066,100	1.1

Source: NSW Department of Planning and Infrastructure, local area population projects, 2010

As can be seen in **Table 7-65** and **Table 7-66**, actual population growth in the LGA between 2006 and 2011 has not been as high as predicted by the Department of Planning and Infrastructure.

Social infrastructure and services

Social infrastructure refers to community facilities, services and networks that help individuals, families, groups and communities meet their social needs, maximise their potential for development, and enhance community well-being. It includes community support, education and training, sport and recreation, cultural, health, and emergency facilities and services.

Within the Hawkesbury LGA, social infrastructure is generally focused in the towns of Windsor and Richmond. Windsor provides access to a range of local and regional facilities to cater for the needs of local residents, as well as the regional community. These include:

- Education facilities, including Windsor Park Public School, Windsor Public School, Windsor South Public School and Windsor High School.
- Child care services.
- Health facilities, including the Hawkesbury District Health Service, the Hawkesbury Community Health Centre and various aged care facilities.
- Emergency services, including police, fire brigade and ambulance.
- Cultural facilities, including the Hawkesbury Regional Museum, the Hawkesbury Regional Gallery and public library services.
- Community support services, including youth services, mental health services and preventative health and education services.

7.8.3 Construction impacts

Property and land use

The land acquisition requirements for the project are detailed in **Table 7-67**. Total acquisition of two rural commercial properties and partial acquisition of two additional rural commercial properties on the northern bank of the river would be required. These properties are currently used for turf farming, a common activity in the region. While the turf farm could also be suitable for a higher value horticultural enterprise (eg. vegetable production), it's close proximity to the river would make the risks and consequent losses associated with this activity higher due to the higher likelihood of flooding. The acquisition of the turf farm land would be expected to have a minor impact on land use in the region given:

- The area of land acquired would be relatively small.
- There are other opportunities for turf farming and horticulture in the region.
- The land is flood prone (below the level of the three year flood event), which limits its potential uses and value to agricultural and horticultural enterprises.

Due to the final configuration of the new roads in this area, it would not be practical to return any excess land to agricultural or horticultural production.

Appropriate compensation in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* would be provided for all land acquired as part of the project.

On the southern bank, full acquisition of two parcels of Crown land would be required, however only part of these lots would be used to accommodate the southern approach road to the replacement bridge. This would affect the lower parkland area of Thompson Square and the council carpark and foreshore area adjacent to Windsor Wharf and The Terrace (see **Table 7-67**). Specifically, 338 square metres would need to be acquired from the lower parkland area of Thompson Square (amounting to 65 per cent of the total 524 square metre area of the lower parkland) and 334 square metres would need to be acquired from the council carpark and foreshore area near the wharf (amounting to 4.7 per cent of the total 7089 square metre area of this lot). The remaining part of the lower Thompson Square parkland and the council carpark area adjacent to the wharf would be used for a temporary construction compound during the construction period and would be closed to public use during this time. Pedestrian access to Windsor Wharf would be maintained at all times throughout the construction period and the affected carpark and foreshore area would be restored and returned to public use at the completion of construction. This is further discussed in **Section 7.8.4**.

The two Crown land lots to be acquired for the project are currently subject to land claims under NSW legislation by the Deerubbin Aboriginal Land Council.

Old Bridge Street would also need to be acquired from Hawkesbury City Council to allow construction of the southern approach road to the new bridge.

During construction there would be a temporary loss of access to recreational land on the southern bank, however other land uses would not be affected.

Table 7-67 Land acquisition and use during construction

Property	Tenure	Existing land use	Impact
Northern bank			
Lot 2 DP1096472	Private	Commercial – turf farm	Total acquisition of 8960 m^2 of which about 40% would be within the operational project footprint and the remainder would be used for construction facilities.
Lot 2 DP65136	Private	Commercial – turf farm	Total acquisition of 4650 m^2 of which about 70% would be within the operational project footprint and the remainder would be used for construction facilities.
Lot 1 DP1096472	Private	Residential/ commercial – turf farm	Partial acquisition (422 m^2 of 4770 m^2)
Lot 68 DP751665	Private	Commercial – turf farm	Partial acquisition (135 m^2 of 139,600 m^2)
Southern bank			
Lot 345 DP752061	Crown land	Thompson Square	Total acquisition – 338 m^2 of the 524 m^2 lot area would be in the operational project footprint and the remainder would be used for construction facilities..
Lot 7008 DP1029964	Crown land	Park, car parking and Windsor Wharf	Total acquisition – 334 m^2 of the 7089 m^2 lot area would be would be in the operational project footprint and about 60% of remainder would be used for construction facilities.

Amenity

There would be amenity impacts on properties and land uses close to the project during construction as a result of construction noise, dust and the visible presence of construction sites and activities. Construction activities may also cause some disruptions to traffic flows and require temporary changes to traffic movements. While these impacts would be minimised wherever possible, they cannot be avoided entirely. In particular, there are likely to be some periods when construction noise impacts are substantial and the visible presence of construction activities would impact views from and to the foreshore area and the existing bridge. The measures that would be implemented to minimise traffic, visual and noise impacts during construction are presented in **Sections 7.3**, **7.4** and **7.5**.

The proposed locations for the main construction sites and compound areas would minimise impacts on the commercial centre of Windsor and the upper parkland area of Thompson Square. The sequential staging of the construction and commissioning of the replacement bridge prior to demolition of the existing bridge would also minimise impacts on local and regional traffic movements, including access to the Windsor commercial centre and Thompson Square. The construction works and staging of construction activities are described in **Section 5.4**. The land uses and properties that would experience the most substantial amenity impacts would be the three properties on Old Bridge Street and the property at the corner of Freemans Reach Road and Wilberforce Road. These properties would be in close proximity to the construction site. Other properties and landuse around Thompson Square would experience some amenity impacts, however, this would be reduced as these are located further away from the construction area.

Traffic and access

The potential impacts of the project on traffic and access during the construction period would be as follows:

- Increased traffic on local roads due to construction traffic movements, with the potential to cause minor local traffic delays (refer to **Section 7.3**).
- Minor reduction in street parking and public parking near Windsor Wharf.
- Temporary, short-term restrictions in vehicle access to Numbers 4 and 6 Old Bridge Street during construction of the southern approach road to the replacement bridge.
- Loss of public vehicle access to Windsor Wharf.
- Loss of access to the lower parkland area of Thompson Square and the eastern portion of The Terrace during construction of the replacement bridge and approach roads and during subsequent restoration and landscaping works within the parkland.
- Partial loss of access to the upper parkland area of Thompson Square during the infilling of the existing Bridge Street cutting.
- Loss of access to the upper parkland area of Thompson Square during the restoration and landscaping works within the parkland.

All of the above impacts would be temporary, being limited to the construction period. The community and affected property owners would be consulted well in advance and kept fully informed of all access changes.

Overall impacts on traffic, parking and access during construction would be minor. While there would be a temporary reduction in parking spaces, alternative parking spaces are available in nearby streets. Further details of construction traffic and access impacts, including impacts on parking spaces, are provided in **Section 7.3**.

Pedestrian access to the wharf and all properties would be maintained throughout the construction period. Pedestrian and cyclist access near the construction works, including along The Terrace and the riverbank would be maintained where possible, although access may be restricted during certain periods to maintain public safety. Access across the existing Windsor bridge would be maintained until commissioning of the replacement bridge. After the replacement bridge is commissioned, access to the existing bridge would be removed and the bridge would be demolished.

In Thompson Square, access to the upper parkland area would generally remain available throughout the construction period until the start of the restoration and landscaping works. Loss of access to the upper parkland area during the restoration and landscaping works would be short-term and would be minimised as far as practicable. There would be no significant disruptions to access of Macquarie Park, the Hawkesbury Visitor Centre, Hawkesbury Regional Museum or short term accommodation businesses.

Recreation and tourism

The potential impacts of the project on recreation and tourism during the construction period would be largely associated with the impacts on amenity, traffic and access, as described in the previous sections.

In particular, the proximity of construction activities to Thompson Square and the river foreshore, and the corresponding potential for loss of amenity in these areas, may result in a temporary reduction in patronage of recreation and tourist sites and facilities, such as Thompson Square itself, the Macquarie Arms Hotel, and the Hawkesbury Paddle Wheeler. Although it should be recognised that construction activity during the weekend (the peak period for visiting day trippers) would be limited to Saturday morning and therefore noise and dust impacts during the weekend would be substantially lower.

Construction would also have a minor impact on boating activities on the river due to the presence of temporary exclusion zones around pier construction areas, although the river would generally remain open to passage by water vessels. An exception to this would be during the demolition of the existing bridge, when access to the area of the river in the immediate vicinity of the bridge would be restricted for safety reasons.

Macquarie Park, the Hawkesbury Visitor Centre, Hawkesbury Regional Museum and short term accommodation businesses are not expected to be adversely affected as a result of construction.

Social and economic impacts to Windsor

As discussed above the project may have temporary adverse impacts on some local businesses adjacent to construction site as a result of amenity impacts. Adverse impacts on environmental amenity during construction may result in a temporary reduction in the number of recreational and tourist visitors to Windsor, and a corresponding reduction in the patronage of some local businesses such as the Macquarie Hotel, restaurants and accommodation services. It is anticipated, however, that any adverse impacts on local businesses during the construction period would be offset to some degree by the influx of project construction workers, who are likely to patronise hotels, restaurants and retail outlets during and after work hours.

Construction of the project is estimated to provide the following benefits to the local and regional economy:

- Contribution of $7.8 million to household income in north western Sydney and another $7.8 million to household income in the rest of NSW.
- Provision of $12.9 million in value added benefits to the north western Sydney region and another $13.5 million in value added benefits to the rest of NSW.
- Creation of 242 full-time equivalent jobs (including 108 jobs in the north western Sydney region, 125 jobs in the rest of NSW and nine jobs in the rest of Australia).

There would be a temporary loss in the public domain area with closure of the lower Thompson Square parkland and the Windsor Wharf foreshore area. However, the upper Thompson Square parkland and other public domain areas in Windsor would generally remain open and accessible. There would no substantial impacts on traffic or access to the Windsor town centre during construction of the project.

Access to schools, medical centres and health care facilities would be maintained during construction, however some minor delays may occur as a result of temporary traffic changes. Procedures would be put in place during construction to minimise the potential for impacts on access to the area by emergency services. With the implementation of these procedures, the project is not anticipated to have a significant impact on emergency access. There would be no significant impacts on social infrastructure.

7.8.4 Operational impacts

Land use and property

Once construction and rehabilitation of Thompson Square and other areas have been completed, there would be an overall increase in the area of usable public space both on the northern and southern side of the river.

On the northern side of the river, land acquired which is not directly in the operational project footprint and the northern approach road to the existing bridge would be landscaped. Paths linking the shared path on the new bridge to Macquarie Park would also be provided. This would create about 1400 square metres of additional accessible usable open space directly adjacent to Macquarie Park.

On the southern side of the river, the parkland areas of Thompson Square would be unified by the infilling and landscaping of the southern approach road to the existing bridge. This would create about 1400 square metres of additional accessible usable open space within Thompson Square parkland. This would be a substantial improvement compared to the existing configuration of Thompson Square parkland.

The Terrace would also be rejoined providing continuous access along the foreshore. The foreshore area associated with Windsor Wharf would also be reopened to public access with only a minor loss of area (less than five per cent of the lot) compared to the existing situation.

Overall the impacts of the project on landuse would be positive due to the increase in the area and accessibility of public open space.

Amenity

There would be amenity impacts on properties and landuses from the operation of the project.

Noise impacts from the operation of the project are described in **Section 7.5**. Overall the noise impacts from the project would be similar to the existing road and bridge. Three residential properties would qualify for architectural treatments to mitigate noise impacts. This is not because noise levels would increase significantly but rather the existing noise levels are high and the redevelopment of the road corridor triggers the requirement to consider noise mitigation. Properties on the southern and western side of Thompson Square would experience little change in noise impacts from the existing conditions. Noise levels were also assessed in Thompson Square parkland. Generally noise levels would be similar to those currently experienced in the parkland areas, with a small reduction in the area experiencing the highest noise levels.

Air quality impacts from the project would be similar to noise, with most properties experiencing similar impacts from the existing road and bridge (see **Section 7.10**).

The most significant amenity impact would be from changes in the heritage vistas and views from and to Thompson Square. These impacts are described in detail in **Section 7.1** and **7.4**. The properties that would experience the most significant impacts would be the most northern properties on Thompson Square (eg. Doctors House and 4 Old Bridge Street) as the existing road, bridge and associated traffic are generally not visible. With the project the new roads and bridge would be highly visible and would place an essentially modern structure within a heritage vista.

Access

Changes in access to properties due to the project are described in **Section 7.3.** Overall, there would only be a partial loss in access to two properties (4 and 6 Old Bridge Street). Access to these properties would be left-in left out only once the project becomes operational. This minor change in access to these two properties is not significant.

There would also be minor changes in access to at least three other properties, however, there would no actual loss of access to these properties.

Recreation and tourism

The items of significant heritage value in Windsor contribute to the overall character of the town, and subsequently increase the attractiveness of the town to tourists. Therefore, some impacts on tourism during operation may be experienced. However, impacts on tourism associated with the project are not expected to be significant, since there would still remain a large number of heritage attractions, as well as a number of natural resource and recreational attractions. Additionally, it is unlikely that tourists' main desire to visit the Windsor town centre would be to see the existing bridge, given the number of other tourism opportunities.

Further, the road and bridge design as well as changes to Thompson Square has considered archaeological impacts, impact to views and vistas and setting to arrive at a design for the bridge and the treatment of the square which is sensitive to existing character. In addition, the project would consolidate the two existing public reserves on Thompson Square to form one open space that would be designed to be a usable civic space again. This amalgamated space may be more favourable to tourism as it would provide a landscaped picnic area, recreational space and location for events. Improved pedestrian and cyclist facilities would also improve the usability of the square.

The project would also enhance opportunities for river-based tourism by increasing the navigational clearance on the Hawkesbury River, allowing more water traffic to access waters upstream of Windsor. It is also possible that tourists may visit the town centre to view changes, further contributing to tourist numbers.

Baseline tourism data in the region indicates that for over one third of domestic visitors, the primary purpose of the visit is to see family members. These visitors would not be expected to reduce the frequency or duration of visits to the town centre from changes associated with the project. The assessment therefore concludes that overall impacts on tourism during operation are expected to be minimal.

Socio-economic impacts

The main potential socio-economic impact of the project would be associated with the changes to the heritage vistas of Windsor and Thompson Square. While the change in vistas would impact the heritage values and landscape of the Thompson Square area, it is unlikely that visitors and tourists would decide not to go Windsor because of the impacts of the project. There are many factors that influence the attraction and experience of visitors to Windsor, including the historic buildings surrounding Thompson Square, the many tourist orientated retail, accommodation and food outlets, the proximity of the river and foreshore areas, and the presence of the Thompson Square open space and the community events held there. These elements would be largely unaffected by the project and would continue to draw visitors to the area.

The potential adverse socio-economic impacts associated with changes in heritage vistas would also be offset to some degree by the following benefits of the project:

- Improved vehicle, bicycle and pedestrian access in the following areas:
  - Across the river.
  - To/from Macquarie Park.
  - Between the southern foreshore and Windsor town centre via Thompson Square.
  - Along the southern foreshore.
- Improved amenity and safety of pedestrian and cyclist access within and around Thompson Square.
- Consolidation of the existing fragmented parkland area within Thompson Square, resulting in an overall increase in the amount of usable parkland area and the amenity of the parkland area.
- More public open space on the northern side of the river.
- Improved navigational clearance beneath the new Windsor bridge, enhancing recreational opportunities on the Hawkesbury River.
- Reduced traffic delays and congestion in peak periods.
- Improved flood immunity of the river crossing.

There would be some changes to access to the town centre and other areas of Windsor as a result of the project. The right turn from Bridge Street south into George Street east would be banned and access to east Windsor and Governor Phillip Park would be via Court Street. This affects relatively few motorists and would be well signposted.

The right turn from Bridge Street north into George Street west may be banned in the PM peak at some stage in the future when traffic numbers have increased. Alternative access to the town centre would be available via Macquarie Street and Kable Street. This may result in some motorist bypassing Windsor town centre, however, the number of vehicles performing this movement in the PM peak is very small.

7.8.5 Environmental management measures

Construction

Temporary access and amenity impacts would be minimised wherever possible through the implementation of appropriate environmental management measures. Construction environmental management measures for traffic and access, visual impacts, noise and vibration are detailed in **Sections 7.3**, **7.4** and **7.5**. The additional environmental management measures that would be implemented are as follows:

- Early and ongoing consultation and communication with residents and local businesses will be undertaken to provide information on construction activities, including timing, duration and likely impacts.
- Affected local business owners will be consulted prior to construction to identify appropriate measures to manage potential impacts.
- Operators of the Hawkesbury Paddle Wheeler will be consulted prior to construction to identify appropriate measures to manage the temporary access changes to Windsor wharf.
- Public access will be maintained to key areas of the Hawkesbury River during existing planned events.
- Appropriate compensation will be provided in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* for properties acquired as a result of the project.
- The town centre and businesses will be protected from the visual impacts of construction through careful placement of appropriate and visually sensitive screening wherever possible.
- Visitor access to key tourist areas and attractions will be assisted throughout the construction period though the placement of appropriate signage.
- Strategies for enhancing the local economic benefits of project construction, such as local employment strategies and sourcing materials from existing local industries, will be considered in the detailed design.
- Areas affected by construction will be reinstated and restored in accordance with the urban design and landscape concept for the project (see **Section 7.4**) as soon as practicable.

Operation

The operation of the project would generally result in positive social and economic outcomes for the local area and the Hawkesbury LGA. The project would improve local traffic conditions and access, which would cater for future growth in population and economic activity.

Measures to manage the potential adverse land use, property and socio-economic impacts of project from the changes in the heritage vistas of Thompson Square have been incorporated into the concept design. Additional measures and consultation as detailed in **Section 7.4.6** will also be implemented to further mitigate visual impacts and maximise the opportunities to create usable and attractive public open space in Thompson Square and adjacent areas.

7.9 Flora and fauna

This section assesses the potential impacts of the project on terrestrial and aquatic flora and fauna, vegetation communities and potential fauna habitats. The full details of the study are presented in the Flora and fauna working paper (Volume 4 – Working paper 10). The assessment has been prepared to meet the relevant Director General's requirements in **Table 7-68** below as well as the relevant requirements of Schedule 2, Part 3 of the *Environmental Planning and Assessment Regulation 2000*.

Table 7-68 Director General's requirements – flora and fauna

Director General's requirements	Where addressed
The EIS must address the following specific matters: **Flora and fauna** – including but not limited to:	
▪ impacts on the biodiversity values of the site and adjoining areas, including terrestrial, riparian and aquatic areas;	Section 7.9.3 and 7.9.4
▪ impacts on critical habitats, threatened species, populations or ecological communities and their habitats; and	Section 7.9.3 and 7.9.4
▪ taking into account the Draft Guidelines for Threatened Species Assessment (Department of Environment and Conservation, 2005).	Section 7.9.1

7.9.1 Guidelines and methodology

This assessment of impacts has been undertaken in accordance with relevant Commonwealth and State legislation, policy and guidelines including:

- Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).
- Environmental Planning and Assessment Act 1979 (EP&A Act).
- Threatened Species Conservation Act 1995 (TSC Act).
- Fisheries Management Act 1994 (FM Act).
- Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities (Working Draft) (DEC, 2004).
- Draft Guidelines for Threatened Species Assessment (DEC and DPI, 2005).
- Significant Impact Guidelines 1.1 Matters of National Environmental Significance (DEWHA 2009).

The assessment has also been undertaken in accordance with the Director General's requirements for this project.

The approach to undertaking the flora and fauna assessment included desktop and field investigations, including targeted surveys for threatened species, populations and ecological communities considered to have the potential to occur within the study area (the area encompassing the construction footprint and any adjoining or adjacent habitat where potential impacts may occur).

The desktop study included a review of existing information and government maintained databases relevant to the study area. A review of literature sources was also undertaken to streamline survey effort for the assessment by confirming the presence or likelihood of occurrence of threatened species, ecological communities and endangered populations within the study area. The following data sources were reviewed as part of the assessment:

- Bionet – Atlas of NSW Wildlife.
- EPBC Protected Matters Database Search.
- OEH vegetation types database.
- OEH BioBanking Threatened Species Profile Database.
- Primary Industries Records viewer.
- DPI Noxious Weeds.
- Flora and Fauna Investigations for Windsor Bridge over the Hawkesbury River (RTA, 2011).
- Native Vegetation Maps of the Cumberland Plain, Western Sydney.
- NSW Ecosystems database mapping unit descriptions.
- Current and preliminary listings on the TSC Act, EPBC Act, FM Act and Fisheries Management Amendment Act.

The condition of the existing environment, together with the findings of a previous report for the project (RTA, 2011) and the limited number of threatened species previously recorded from the area justified an approach that was based largely on opportunistic surveys and habitat assessment over one autumn sampling event. Given the relatively small size of the study area, the random meander surveys and general foot traverses that were undertaken were considered adequate. The lack of freshwater habitats for frogs, habitat for small mammals and lack of records for these threatened taxa in the study area precluded the need for any detailed surveys for these groups.

Field surveys informing the assessment were designed to identify the extent and quality of native vegetation, fauna habitats and species diversity. Threatened biodiversity with a moderate to high likelihood of occurrence were targeted during field surveys. Detailed information on the field surveys are contained in the Flora and fauna working paper (Volume 4 – Working paper 10).

State and nationally listed threatened species with the potential to occur within the locality (a radius of 10 kilometres from the construction footprint) were assessed to identify the likelihood of their occurrence within the study area based on known habitat requirements. This was compared with the habitats and their condition identified during the field survey. Species, communities and populations were assigned an unlikely, low, moderate or high likelihood of occurrence according to the criteria described in **Table 2-5** of the Flora and fauna working paper (Volume 2 – Working paper 10).

7.9.2 Existing environment

The study area is located in the developed central portion of the Hawkesbury LGA. The Hawkesbury River runs north-easterly through the study area in the South Creek sub-catchment of the Hawkesbury-Nepean catchment. The sub-catchment is heavily degraded as a result of historical vegetation clearance and urbanisation, with riparian zones often infested with woody weeds (HNCMA, 2008). The study area is representative of the degraded environment of the broader sub-catchment.

The project is wholly located within the Cumberland Plain sub-region of the Sydney Basin Bioregion on the east coast of NSW. The sub-region extends from Parramatta in the west to the Hawkesbury-Nepean River in the east and from Windsor in the north to Thirlmere in the south, with a total area of about 275,000 hectares (NPWS, 2002). While the bioregion is one of the most species-diverse in the state, the Cumberland Plain sub-region is considered to be the most developed and the most degraded (HNCMA, 2008).

The study area contains a mix of residential, commercial, public reserve, recreation and agricultural land uses. Land use zonings in the study area, as defined in the Hawkesbury LEP, comprise Natural Waterways, Recreation Waterways, Public Recreation, Local Centre, Low Density Residential and Rural Landscape zones.

A number of sensitive ecological sites and protected areas fall within the study area comprising Council managed recreation reserves. These reserves include Macquarie Park to the north of the Hawkesbury River and Thompson Square on the south side of the river within the town centre. Both Windsor Downs Nature Reserve (about 360 hectares in size) and Scheyville National Park (about 900 hectares in size) are located within the locality. No conservation reserves or State Forest lands occur within the study area, nor any areas of critical habitat.

The vegetation in the study area is patchy and is mainly confined to the banks of the Hawkesbury River. No land within the study area or the locality falls into the Priority Conservation Lands identified in the *Cumberland Plain Recovery Plan* (DECCW, 2011). Additionally, the study area does not include any land identified as part of the regional biodiversity corridors identified in the Hawkesbury-Nepean Catchment Management Area (HNCMA, 2008). Key habitats and movement corridors from the Key Habitats and Corridors project (DEC, 2003) and Climate Change Corridors project (DECC, 2007) do not extend into the study area.

The vegetation within the construction footprint is heavily fragmented, with little or no remnant vegetation and numerous exotic species. The construction footprint was not observed to contain and is not expected to support a high diversity or abundance of native fauna species that rely upon high quality habitat or large remnants.

Vegetation communities, flora and fauna are discussed in further detail below.

Vegetation communities

Four vegetation communities were identified during the field survey and have been shown on **Figure 7-39**. The attributes of these communities are outlined in **Table 7-69** and further described below. In general, the existing vegetation was found to be in poor condition and is identified as having low ecological value.

Table 7-69 Vegetation communities and conditions identified in the study area

Vegetation community	Corresponding OEH vegetation type	Area within construction footprint	Condition value
Riparian Casuarina open forest	River Oak open forest of major streams, Sydney Basin and South-East Corner	0.1 ha (1000 m^2)	Low
Modified riparian open forest (highly modified)	River Oak open forest of major streams, Sydney Basin and South-East Corner	0.4 ha (4000 m^2)	Low
Cleared grassland	Nil	0.9 ha (9000 m^2)	Low
Parkland/landscaped areas	Nil	0.3 ha (3000 m^2)	Low

Riparian Casuarina Open Forest

This vegetation community occurs on alluvial soils associated with the Hawkesbury River. Historical land clearing completely removed original native riparian vegetation communities at Windsor during early European colonisation. The resultant re-growth also appears to have been altered in structure and diversity through planting. The community occurs in a narrow strip along the southern bank of the Hawkesbury River and bordered by the footpath of The Terrace which is landscaped with White Cedar (*Melia azedarach*), Jacaranda (*Jacaranda mimosifolia*), Liquid Amber (*Liquidambar styraciflua*) and Peppercorn (*Schinus sp*.). The riverbank is dominated by River Sheoak (*Casuarina cunninghamiana*) and Swamp Oak (*Casuarina glauca*) with White Cedar (*Melia azedarach*) along the mid-bank and higher. Occasional eucalypts occur along the mid bank and the community is generally of low condition with a moderately dense but weedy understory including Green Cestrum (*Cestrum parqui*) interspersed with paperbarks (*melaleuca sp.*) and wattles (*acacia sp*.) (see **Figure 7-40**). The groundlayer is sparse but pockets of vegetation are dominated by exotic species, including ”Trad” (*Tradescantia fluminensis*).

This vegetation most closely aligns with the River Oak open forest of major streams, Sydney Basin and South East Corner vegetation type from the OEH Database for the Hawkesbury-Nepean Catchment Management Area. The condition of the community is low, however, with the commonly found understorey and groundlayer species absent due to the highly modified and partially artificial nature of the community.

Modified Riparian Open Forest

This vegetation community also occurs on alluvial soils associated with the Hawkesbury River. Within the study area it exists along the northern bank of the river adjacent to Macquarie Park (see **Figure 7-41**). Historical land clearing completely removed original native riparian vegetation communities at Windsor during early European colonisation. Whether the banks in this part of the study area are representative of highly modified re-growth or have been completely recreated by riparian replanting is unknown. A footpath traverses the mid-bank from east to west and at the time of survey the recent floods had unearthed black plastic matting along the low and mid-banks where mature casuarinas are well established. The community occurs in a narrow strip along the northern bank of the Hawkesbury River both east and west of the bridge.

The riverbank is dominated by River Sheoak (*Casuarina cunninghamiana*) and Swamp Oak (*Casuarina glauca*) with occasional plantings of paperbarks (*Melaleuca spp.*) and White Cedar (*Melia azedarach*). One Swamp Mahogany (*Eucalyptus robusta*) was observed near the bridge on the mid-bank. The understorey is generally absent although exotic vines such as Balloon Vine (*Cardiospermum grandiflorum*) and Blackberry Nightshade (*Solanum nigrum*) persist. The groundlayer is sparse but clumps of Lomandra (*Lomandra longifolia*) occur along the toe of the bank.

This vegetation most closely aligns with the River Oak open forest of major streams, Sydney Basin and South East Corner vegetation type from the OEH Database for the Hawkesbury-Nepean Catchment Management Area. However, the understorey and groundlayer species commonly found in that community are not present at the site due to the highly modified and partially artificial nature of the community. This vegetation community is considered to be in low condition within the study area.

Cleared grassland

Cleared grassland occurs along the riverbank and adjacent floodplain on the northern bank of the Hawkesbury River within the study area east of the bridge. This is an artificially constructed community most likely resulting from intensive land use since the banks were cleared of original vegetation in the first decade of the colonisation of Windsor. The floodplain is managed for turf farming and the creek bank is dominated almost entirely by exotic pasture and roadside weed species, largely herbs and grasses, with the occasional exotic tree such as the willow (*Salix babylonica*) present. One native Kurrajong (*Brachychiton populneus*) and one Swamp Oak (*Casuarina glauca*) were observed to persist in the landscape.

Shrub weeds in this community are clumped across the site and include Castor oil (*Ricinus communis*), Wild Tobacco (*Solanum mauritianum*), Lantana (*Lantana camara*), Fennel (*Foeniculum vulgare*) and Purpletop (*Verbena bonariensis*). Grass and groundcover weeds included Turkey Rhubarb (*Acetosa sagittata*), thistles and Johnson Grass (*Sorghum halapensis*). The exotic Madeira Vine (*Anredera cordifolia*) and Balloon Vine (*Cardiospermum grandiflorum*) were also prolific across the site.

Parkland/Landscaped areas

A number of parkland or landscape environments exist within the study area that are representative of early European colonisation in Australia. These include Thompson Square parkland and associated streetscaping in the southern part of the study area (such as The Terrace), and the more recently landscaped Macquarie Park north of the Hawkesbury River. These areas are typically planted with either introduced horticultural species or Australian natives chosen for their aesthetic properties, but which would not occur in local native vegetation communities. These areas consist of mature trees, with no understorey and a completely maintained exotic grass cover. They are thus of low ecological condition and value in the context of this flora and fauna assessment.

Mature trees of Thompson Square parkland include a number of Liquid Ambers (*Liquidambar styraciflua*), Silky Oaks (*Grevillea robusta*) and Kurrajongs and one Bunya Pine (*Araucaria bidwillii*). The stature of these trees suggests that some of them may be greater than 80 years old. Streetscape plantings along The Terrace and other paths within the study area are landscaped with White Cedar (*Melia azedarach*), Jacaranda (*Jacaranda mimosifolia*), Liquid Amber (*Liquidambar styraciflua*) and Peppercorn (*Schinus sp*.).

Figure 7-39 | Survey results

Indicative only – subject to detailed design

LEGEND

Concept design footprint
Study area

Scour protection

Permanent rock scour protection (if required)
Temporary rock scour protection (if required)

Fauna habitats

Cleared grasslands
Riparian forest

Vegetation communities

Riparian casuarina open forest
Modified riparian corridor
Cleared grasslands
Parklands / landscaped areas

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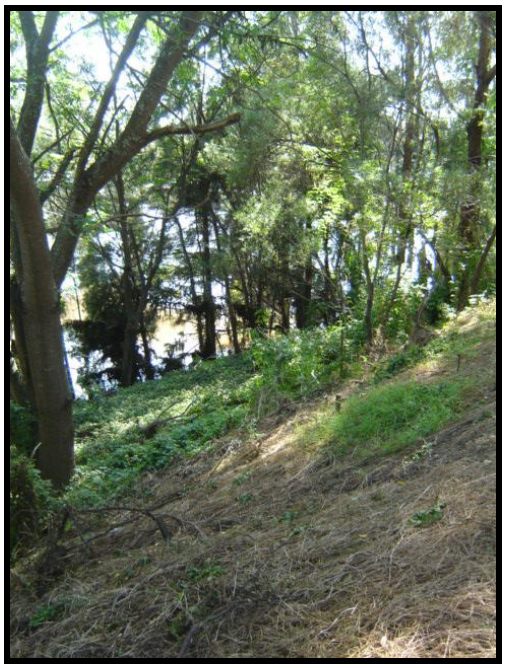


Figure 7-40 Riparian Casuarina open forest in low condition in the study area (south east of the existing bridge)

Figure 7-41 Modified riparian forest in low condition (north west of the existing bridge)

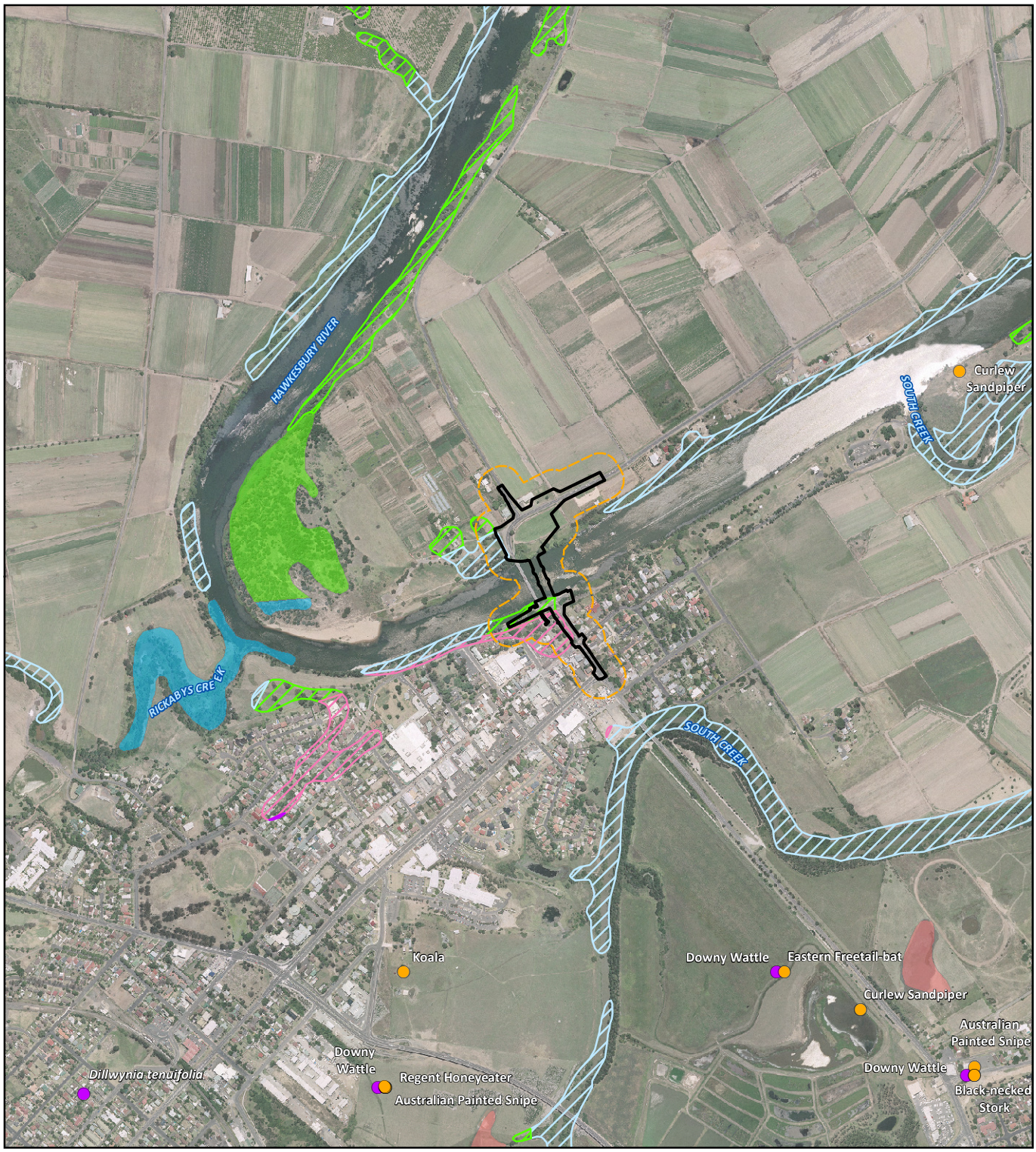
Threatened Ecological Communities

NPWS mapping of the Cumberland Plain (NPWS, 2002) suggested that two threatened ecological communities (TECs) may be present within the study area (see **Figure 7-42**). These TECs included Cumberland Plain Woodland (TSC Act/EPBC Act) and River-flat Eucalypt Forest (TSC Act). Field surveys in the study area did not record vegetation characteristics or key diagnostic species representative of the TECs identified in the NPWS vegetation mapping. Accordingly, no TECs were found during field investigations.

Groundwater dependent ecosystems

The vegetation communities within the study area occur on the Hawkesbury River floodplain. Accordingly, riparian vegetation communities are expected to have a degree of reliance upon groundwater and therefore can be considered to be groundwater dependent ecosystems (GDEs). However, these communities are likely to have evolved to be able to experience short periods of natural groundwater fluctuation without suffering any medium or long-term impacts.

Figure 7-42 | Threatened flora and fauna records and vegetation communities



Indicative only – subject to detailed design

LEGEND

- Concept design footprint
- Study area
- Threatened fauna record
- Threatened flora record

Vegetation communities, over 10% crown cover

- Alluvial Woodland
- Riparian Forest
- Freshwater Wetlands

Vegetation communities, under 10% crown cover

- Shale Plains Woodland
- Alluvial Woodland
- Riparian Forest
- Shale/Gravel Transition Forest

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Flora

Flora species

A total of 53 flora species were identified during field surveys, comprising 18 native species and 35 introduced species (see Volume 4 – Working paper 10). These species were generally associated with the vegetation communities described earlier in this section.

Twelve noxious weeds species common to riparian and aquatic habitats were recorded in the study area through field surveys and a search of the DPI noxious weeds listing (see Volume 4 – Working paper 10).

Threatened flora species

A review of the OEH NSW Bionet data (OEH, 2012) and EPBC Act Protected Matters Search Tool (DSEWPaC, 2012) identified 15 threatened flora species previously recorded in the study area (14 listed under the EPBC Act and TSC Act, and one listed under the TSC Act only) (refer to Volume 4 – Working paper 10 and **Figure 7-42**). The assessment of likelihood for these species determined these species would be unlikely or have a low likelihood to occur within the study area. No threatened flora species were identified during field surveys.

Aquatic flora

The river and riparian zone at Windsor has been substantially modified through dredging, bank scour protection, clearing of riparian vegetation and growth of weeds. The South Creek and Hawkesbury River catchment has also been substantially modified and cleared for agricultural and urban development. As a result, there are no ecologically important aquatic flora or vegetation communities of high condition that are present in the study area.

Aquatic macrophytes identified during field surveys include Slender Knotweed (*Persicaria decipiens*), Hydrilla (*Hydrilla verticillata*) and Hornwort (*Certatophyllum demersum*). No aquatic weeds were sighted during the field survey, however introduced Alligator Weed (*Alternanthera philoxeroides*), Water Hyacinth (*Eichhornia crassipes*), Salvinia (*Salvinia molesta*) and Dense Waterweed (*Egeria densa*) have been previously recorded within the Hawkesbury-Nepean catchment.

Fauna

Fauna habitat and condition

Limited potential fauna habitats occur in the study area, as habitats have been extensively cleared and fragmented during the development of agricultural and rural settlements and urban and residential development. Fauna habitats identified in the study area include riparian forest, cleared grassland and freshwater aquatic habitats (within the Hawkesbury River). The existing bridge was also identified to provide limited roosting habitat opportunities for birds and bats within the study area. These potential habitat areas have been shown on **Figure 7-39**. No critical habitat areas were identified in the study area.

Field surveys identified all vegetation within the study area to provide poor quality fauna habitat, with poor structure of canopy, midstorey and lower groundcover flora. Ground debris was generally absent. No habitat trees (hollow-bearing trees including large dead trees) were identified within the study area.

Additionally, all riparian areas were in poor condition and provided minimal resources for fauna in terms of breeding and foraging opportunities. Shelter and refuge for some bird and arboreal mammal species may be provided in the canopy of riparian areas, particularly for the Common Ringtail Possum (*Pseudocheirus peregrines*). Riparian areas also provide habitat for aquatic species such as the Sydney Hawk Dragonfly (*Austrocordulia leonardi*) and Adams Emerald Dragonfly (*Archaeophya Adamsi*).

While the existing Windsor bridge structure was identified to potentially serve as a man-made roosting habitat, no roosting birds or microbats were observed during the field surveys.

The habitats identified in the study area are likely to provide limited opportunities for shelter, breeding and foraging resources for some common frog and reptile species and a low diversity of bird and mammal species. As a result, the diversity of fauna species recorded within the study area was low.

Fauna species

A total of seven native fauna species were recorded during surveys, comprising two reptile species and five bird species. Two introduced bird species were also recorded during field surveys. The birds identified in the area were predominantly urban birds, tolerant of modified and fragmented habitats such as parrots, miners and swallows. The most abundant species observed included the Magpie (*Gymnorhina tibicen*), Welcome Swallow (*Hirundo neoxena*) and Noisy Miner (*Manorina melanocephala*). The two reptile species recorded were the Eastern Water Dragon (*Physignathus lesueurii*) and Eastern Water Skink (*Eulamprus quoyii*).

No evidence of feral animals was observed during the field survey, however the European Red Fox (*Vulpes vulpes*), Feral Cat (*Felis cattus*) and Feral Dog (*Canis familiaris*) are expected to occur within the study area.

Threatened fauna species

A review of state and federal government databases (OEH, 2012 and DSEWPaC, 2012) identified a total of 48 threatened fauna species records within the locality, comprising 13 mammals, 27 birds, one reptile, three amphibians, one invertebrate and three fish species (see **Figure 7-42)**. These species were assessed to have an unlikely or low likelihood of occurring within the study area, with the exception of five species with a moderate likelihood to occur within the study area. These species included the Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*), the Eastern False Pipistrelle (*Falsistrellus tasmaniensis*), the Eastern Freetail Bat (*Mormopterus norfolkensis*), Southern Myotis (*Myotis macropus*) and the Freckled Duck (*Stictonetta naevosa*).

It is possible that the existing bridge may provide suitable roosting habitat for a range of threatened cave-roosting microchiropteran bats in the locality. This includes the Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) and the Southern Myotis (*Myotis adversus*), both of which have been recorded roosting in artificial structures including concrete bridges. However no bats were observed roosting under the bridge at the time of the field survey.

Field surveys targeted threatened species that were considered to have a moderate or high potential to occur in the study area. No threatened species (or habitats thereof) were identified during the surveys.

Migratory species

A total of 13 migratory species were identified in the EPBC Act Protected Matters Report (February 2012) as potentially occurring within the locality, comprising eight migratory terrestrial species and five migratory wetland/marine species. A preliminary assessment of the likelihood of species occurrence in the study area identified that 10 species were unlikely or would have a low likelihood of being present in the study area (see Volume 2 – Working paper 10). The White-bellied Sea Eagle (*Haliaeetus leucogaster*), White-throated Needletail (*Hirundapus caudacutus*) and Cattle Egret (*Ardea ibis*) were considered to have a moderate likelihood of occurrence within the study area.

No migratory species were observed during the field survey. The study area does not contain any important habitat for any listed migratory species and therefore migratory species were not considered further in the assessment.

Aquatic species

The Hawkesbury River is a Class 1 Waterway, as it is a permanently flowing waterway containing a major fish habitat. No existing barriers to fish passage were observed within the study area. No threatened aquatic fauna species are expected to occur in the study area.

The Sydney Hawk Dragonfly, the Adams Emerald Dragonfly and the Macquarie Perch (*Macquaria australasica*) are threatened aquatic species listed under the FM Act that have been identified as having a potential to occur within the study area. The condition of habitat for these species is low, therefore these species are unlikely to be present in the area.

7.9.3 Construction impacts

The main potential impacts associated with the project would be associated with the loss of vegetation/habitat and resultant impacts on threatened fauna. This section summarises potential impacts discussed in the Flora and fauna working paper (Volume 4 – Working paper 10).

Vegetation communities

The project would require clearing of about 1.7 hectares (17,000 square metres) of vegetated land with about 1.2 hectares (12,000 square metres) being park or grasslands. The clearing of 1.7 hectares (17,000 square metres) of low value vegetation in the study area would not have a significant ecological impact. As part of the project all disturbed areas outside the road corridors would be rehabilitated and landscaped after construction. This would include the planting of both native and exotic trees, shrubs and grasses and planting within the riparian zone where possible. The condition and habitat value of the newly planted areas would be an improvement on the existing vegetation communities.

The project would also require removal of weed species, including noxious weeds. Provided that weeds are disposed of appropriately and weed control measures are implemented, potential impacts resulting from the project would be minimised.

While the vegetation communities in the study area are of low ecological value, there are about 0.5 hectares (5,000 square metres) of riparian vegetation along the Hawkesbury River that would require clearing for the project. This riparian community does not constitute a TEC and also is in relatively poor condition. Construction of the bridge would require the removal of woody debris/snags in addition to clearing of riparian vegetation. This type of activity has been identified to be a key threatening process under the FM Act. However given the relatively poor condition of the riparian vegetation on the river banks and the lack of any substantial snags in this section of the river, as well as the temporary and spatially limited nature of the construction of the project, the resultant impact on aquatic species and ecosystems is not considered to be substantial.

In addition, there would not be any substantial changes to flow velocities, depths of the waterway, realignment of the watercourse or the alteration of natural flow regimes of the river due to the construction of the replacement bridge. As a result, there would not be any impact on aquatic ecosystems from changes in hydrological regimes. Due to the localised nature of the proposal, as well as the temporary nature of construction works, the project would not substantially raise or lower the groundwater table to such an extent that any groundwater dependent ecosystems would be permanently impacted.

Flora

The project would have no impact on the listed threatened flora records identified during Bionet database searches, as none have been recorded within the study area. No threatened flora species are considered to have more than a low likelihood of occurrence in the study area (**Section 7.9.3**), therefore it is unlikely that the project will affect any threatened flora species. Assessments of significance were undertaken for species and species groups with a moderate to high likelihood of occurrence, including the Cumberland Plain Land Snail, Microchiropteran bats, migratory species and the Freckled Duck. These assessments found that the project is unlikely to have a significant impact on these species.

Fauna

The main impacts to fauna from the construction of the project would be associated with the clearing of potential fauna habitat and flow on effects from reduced water quality. Riparian vegetation that would be cleared as part of the project provides some degree of habitat for native and local species. However, only a small amount of low habitat value vegetation would be cleared. In addition, this community is not declared to be critical habitat for any threatened fauna species in the locality. Accordingly, the project is unlikely to have any significant impacts on biodiversity, including any threatened species, populations, ecological communities or their habitats.

The greatest potential for construction impacts on local waterways would be from sedimentation and erosion, water-based construction activities and dredging. These activities would result in increased turbidity and suspended solids in the river. Increased suspended solids can impact fish and macroinvertebrate abundance through clogging gill structures and benthic smothering. Increased particulates in the water column can also reduce light infiltration which may limit plant growth and influence predator foraging behaviour. Increased turbidity can result in a reduction of light penetration and in turn reduce the number of aquatic macrophytes or algae, altering the existing aquatic habitat. Spills of chemicals, fuels and concrete may also occur during construction. These spills would be toxic to aquatic biota and fish. However, the likelihood of this occurring would be relatively low (see **Section 7.6.5**).

About 2,700 square metres of aquatic habitat and adjoining riparian zone and about 2300 square metres of aquatic habitat on the river bed would be lost during construction the project. The potential pollution of waterways also presents a threat to aquatic habitats, however, these would be managed through the use of water quality controls and measures. These have been discussed further in **Section 7.6.6**.

While the impact of construction activities on water quality could potentially be substantial, the risks and impacts would be reduced to acceptable levels through the implementation of appropriate environmental management measures identified in the project Soil and Water Management Plans (for example, silt curtains around dredging operations). These and other environmental management measures are further discussed in **Section 7.9.5**.

Demolition of the existing bridge may result in the loss of potential roosting habitat for birds and microbats, however, construction of the replacement bridge may provide potential roosting habitat. Additionally, the existing bridge is marginal habitat for roosting fauna due to the absence of habitat trees in the study area and the lack of suitable hollow cavities in the concrete bridge structure. Assessments of significance indicate that the project is unlikely to have a significant impact on hollow roosting microchiropteran bats.

The project would not impact on habitat connectivity and fragmentation, as it does not encroach on any land identified as part of regional biodiversity corridors (see **Section 7.9.2**). Fauna injury and mortality is considered to be an unlikely effect of the project, given the low numbers of fauna (and low potential for fauna habitat) observed in the study area. Given the low habitat potential of the study area it is unlikely that noise, vibration or light associated with the construction of the project would have an adverse impact on the surrounding flora and fauna. As bridge construction works would be undertaken from the banks, the project would not block fish passage.

7.9.4 Operational impacts

The main potential impact on biodiversity from the operation of the project would be from stormwater runoff from the approach roads and the bridge or from spills of fuels or chemicals from accidents or during maintenance. These potential impacts were considered during design of the project and a permanent water quality basin has been provided on the northern bank, while a litter net and shut-off valve has been provided on the southern bank.

7.9.5 Environmental management measures

The Biodiversity Guidelines- Protecting and managing biodiversity on RTA projects (RTA, 2011) outline best practice mitigation measures for RMS projects. In accordance with these guidelines, the measures that would be implemented in conjunction with the project to minimise and avoid potential ecological impacts are listed in **Table 7-70**.

Table 7-70 Environmental management measures

Item	Timing	Environmental management measure
Pre-clearing fauna survey	Pre-construction	• Once construction areas have been surveyed and marked, a suitably qualified and experienced fauna ecologist will undertake a pre-clearing survey to identify any concerns to specific species. • A survey of the existing bridge structure will be undertaken by boat by an ecologist to confirm the bridge is not providing habitat for microchiropteran bats or other roosting bats. • Should the results of the bat survey and roost assessment indicate that the existing bridge occupied by microbats, a bat management plan will be prepared to mitigate the potential impacts on bats. The plan would include details of an appropriate work schedule, any further close inspections that may be required and exclusion and relocation of fauna away from the construction site. • WIRES will be made aware of the project and consulted if any injured fauna are encountered or if any fauna are injured as a result of the works. • An ecologist or WIRES representative will be present during the clearing of suspected vegetation that may support a habitat for fauna to manage and/or relocate any fauna present.
Site personnel induction	Pre-construction	• The project induction will include relevant information, mitigation measures and procedures on protecting the biodiversity of the area during construction.
Site planning	Pre-construction	• Locate temporary infrastructure (plant sites and offices etc) in cleared areas away from vegetation. • Apply clear boundaries for construction and exclusion zones for equipment, machinery and traffic to prevent unnecessary damage to native vegetation and fauna habitats.

Item	Timing	Environmental management measure
Identification of clearing limits	Pre-construction	• Accurately and clearly mark out the limits of clearing and trees/vegetation to be retained including riparian zones.
Erosion and sediment control and impacts on water quality	Pre-construction and construction	• Management plans and measures will be developed and implemented to minimise water quality impacts from construction. A discussion on water quality mitigation measures has been provided in **Section 7.6.6**.
Riparian areas	Pre-construction and construction	• Minimise the area of disturbance in riparian zones by clearly marking out work zones in riparian areas and protect areas with para-web fencing or similar material. • All works near riparian zones will have adequate sediment and erosion control.
Noxious weed management	Pre-construction and construction	• Establish a noxious weed management protocol. • All noxious weeds which are cleared as part of the project will be disposed of appropriately. • Inspection/maintenance procedures will be implemented to reduce the carriage of weed material on machinery.
Monitoring	Pre-construction and construction	• A monitoring program (including a weekly checklist) will be developed to check that all proposed impact mitigation measures have been effectively implemented. • In the event that impact mitigation measures do not perform effectively, the management program will be adjusted with further appropriate measures.
Potential impact on fauna habitat	Construction	• While no substantial trees with hollows were identified during the survey, if trees with hollows are found, their removal will be avoided where practicable. Where this is not possible, the tree will be maintained intact as far as possible and placed on the ground in adjoining vegetation. • Habitat trees will be inspected for fauna by ecologist or WIRES carer and habitat trees will be felled carefully to minimise impact.
Riparian and aquatic habitat	Construction	• In-stream and riparian disturbance will be minimised during construction through clearly delineated working areas. • Removal of instream woody snags (>3 m in length and >300 mm diameter) will be avoided where practicable. Any woody snags that require removal during construction will be relocated insitu.
Riparian and aquatic habitat	Construction	• In-stream disturbance from dredging will be managed and mitigated as appropriate to minimise impacts. Appropriate measures will include insitu measures to limit the risk of sediment plumes and increased turbidity, such as silt curtains (or similar).

Item	Timing	Environmental management measure
Rehabilitation	Construction and post-construction	• Areas disturbed as a result of the project will be stabilised and rehabilitated through a progressive landscaping program that takes advantage of optimal growing conditions and is appropriate to the final land use. • Where possible riparian zone rehabilitation will include appropriate native species.

7.10 Air quality

This section assesses air quality impacts of the project. The assessment is supported by an air quality study, which is presented in the Air quality working paper (Volume 4 – Working paper 11) and is summarised below. The assessment has been prepared to meet the relevant Director General's requirements in **Table 7-71** as well as the relevant requirements of Schedule 2, Part 3 of the *Environmental Planning and Assessment Regulation 2000*.

Table 7-71 Director General's requirements – air quality

Director General's requirements	Where addressed
The EIS must address the following specific matters: **Air Quality** – including but not limited to: The EIS must address air quality matters including but not limited to activities that have the potential to impact on local and regional air quality and details of the proposed mitigation measures to prevent the generation and emission of dust.	 Section 7.10.3 & 7.10.4 Section 7.10.5

7.10.1 Guidelines and methodology

The Environmental Protection Authority (EPA) has set air quality assessment criteria as part of their *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005). In general, these criteria relate to the total concentration of a pollutant in the air and not just the contribution from project-specific sources.

While the EPA also set criteria for other pollutants from motor vehicles, such as air toxics, the pollutants listed in **Table 7-72** are key pollutants for road air quality assessments. For each of the key pollutants, an acute (short term exposure) and chronic (longer term exposure) criterion has been identified by the EPA. The potential human health impacts of the key pollutants are described in the Air quality working paper (Volume 4 - Working paper 11).

Table 7-72 EPA assessment criteria for key pollutants for road air quality assessments

Pollutant	Averaging time	Criterion
Carbon monoxide	Maximum 1-hour average	30 mg/m^3
	Maximum 8-hour average	10 mg/m^3
Nitrogen dioxide	Maximum 1-hour average	246 $\mu g/m^3$
	Annual average	62 $\mu g/m^3$
Particulate matter	Maximum 24-hour average	50 $\mu g/m^3$
	Annual average	30 $\mu g/m^3$

$\mu g/m^3$ = micrograms per cubic metre. mg/m^3 = milligrams per cubic metre.

The air quality criteria have been used to assess both the existing air quality and the potential impacts of the project.

Operational assessment methodology

Vehicle emission estimates and dispersion modelling was used to quantify potential air quality impacts of the project and included consideration of background air quality, future traffic volumes and the proportion of heavy vehicles.

Review of air quality and meteorological data

Air quality monitoring can be used to characterise the existing air quality of an area and to establish "background" levels. No air quality monitoring has been carried out specifically for the project. The EPA operates an air quality monitoring and meteorological station at Richmond. As well as meteorological data, the station measures both particulate matter and nitrogen dioxide concentrations and is situated in a residential/semi-rural area. Air quality data sourced from this location would be representative of the study area. While the Richmond air quality monitoring station does not monitor carbon monoxide concentrations, 8-hour carbon monoxide concentrations are measured at Prospect also located within the northwest Sydney region. Regional air quality data for 2011 is presented in **Table 7-73**. No hourly carbon monoxide concentration records were available.

Traffic forecasts

Average daily traffic volumes from Windsor Road for 2016 and 2026 were forecasted including hourly volumes and the proportion of heavy vehicles (see Traffic and Transport working paper – Volume 4 working paper 3). **Table 7-73** summarises the traffic data used for this assessment.

Table 7-73 Summary of existing and forecast traffic for 2016 and 2026

Road		Existing (2011)		Opening year (2016)		10yrs after opening (2026)	
		No. vehicles	% Heavy vehicles	No. vehicles	% Heavy vehicles	No. Vehicles	% Heavy vehicles
Bridge Street	Northbound	9767	7.0	10,623	7.0	12,297	7.0
	Southbound	9366	7.0	10,103	7.0	11,685	7.0
Wilberforce Road	Eastbound	6459	7.2	6961	7.2	7996	7.2
	Westbound	6784	7.0	7253	7.0	8278	7.0
Freemans Reach Road	Northbound	3776	6.6	4166	6.6	4881	6.6
	Southbound	3104	7.0	3396	7.0	4012	7.0

Dispersion modelling

The Tool for Roadside Air Quality (TRAQ) developed by RMS, was used to estimate air quality impacts associated with the project. Vehicle emission factors from the World Road Association are used by TRAQ to estimate vehicle emissions factors for different road gradients, vehicle speeds and for vehicles conforming to different European emission standards (PIARC, 2004). Existing pollutant levels in the area from EPA monitoring stations was included in the TRAQ background air quality database and incorporated into the dispersion model. This is a conservative approach to estimating air quality impacts as does not consider any improvements to regional air quality resulting from improved vehicle emissions.

Construction assessment methodology

A qualitative air quality assessment was undertaken for the construction works. The assessment identified the proposed construction activities, the potential for generation of air emissions, the effects of local meteorology, and the resultant potential for impacts on sensitive receivers. Specifically tasks for assessment of the construction works were:

- Identification of the location and intensity of key construction activities.
- Identification of the types of air emissions associated with these construction activities.
- Identification of the location of sensitive receivers.
- Characterisation of the existing air quality at sensitive receiver locations.
- Assessment of the prevailing meteorological conditions in the study area and the potential for these to influence air emissions from the project.
- Assessment of the potential for air emissions from project construction to adversely affect sensitive receivers.
- Identification of options to avoid, mitigate or manage any impacts on sensitive receivers.

The existing bridge was also assessed for the presence of lead based paint and asbestos. Where the presence of lead based paint and/or asbestos was identified, measures to prevent these substances entering the environment during demolition were identified (see **Section 7.10.5**).

7.10.2 Existing environment

Land use and sensitive receivers

The land use in the study area towards the south of the Hawkesbury River is comprised mainly of commercial and residential premises while to the north the primary land use is rural residential and agricultural. The area also includes a number of parks and open space areas, such as Thompson Square parkland within Windsor town centre and Macquarie Park on the north side of the river.

Sensitive receivers for potential air quality issues include low density residential properties, and commercial properties such as motels located to the east of Bridge Street. To the west of Bridge Street, sensitive receivers are largely local businesses such as hotels and eateries. Sensitive receivers on Freemans Reach Road and Wilberforce Road include rural residential properties and a turf farm.

Climate and meteorology

The region is characterised by mild to warm summers and cold winters. Climatic data collected by the Bureau of Meteorology (BoM) at Richmond RAAF, around three kilometres west of the study area. The data reveals January is typically the warmest month with a mean daily maximum temperature of 30°C. July and August are the coolest months with a mean daily minimum temperature of 4°C. Rainfall data collected at Richmond RAAF show that February is usually the wettest month with mean rainfall of 125 millimetres, falling over an average of eight days in the month. The lowest monthly rainfall on average is in July and August, both with a mean monthly rainfall of 32 millimetres over four rain days. The mean annual rainfall is 738 millimetres with an average of 74 rain days each year (Bureau of Meteorology, 2012).

Meteorological conditions, as opposed to climatic conditions, are those which are focussed on smaller geographical and time scales. Local meteorology and, in particular, wind patterns are important for the transportation and dispersion of air pollutants. On a relatively small scale, winds are largely affected by the local topography, but at larger scales, there are synoptic scale influences, such as sea breeze circulations and regional drainage flows that can drive the meteorological conditions for a particular location. It is important to understand the local meteorological conditions in air quality assessments, especially for the early works activities where there could be significant dust generation.

Meteorological data, including temperature, wind speed and wind direction, have been obtained from the BoM Automatic Weather Station (AWS) at Richmond RAAF for 2011. On an annual basis, the most common wind directions are from the south southwest to southwest; however northeast to east north-easterly winds are also prevalent. The site experiences generally light winds with an average annual wind speed on 2.4 metres per second (m/s). The highest seasonal average wind speeds occur during spring; averaging 2.6 metres per second; here a similar trend to the annual wind direction is observed with winds frequently from the northeast to east northeast and from the south southwest to southwest. During the summer the wind direction is highly variable with winds from the northeast to southwest, with wind speeds averaging 2.5 metres per second. Autumn has the lowest seasonal average wind speed at 2.2 metres per second with winds frequently from the south southwest to southwest. Like autumn, in winter winds commonly come from the southwest. The average wind speed in winter is the same as the annual wind speed.

Air quality

To assess potential air quality impacts it is necessary to have information on existing pollutant levels in the area in which the project would be likely to contribute to these levels.

Regional air quality data for 2011 is presented in **Table 7-72**. No hourly carbon monoxide concentration records were available. In the absence of published hourly data for carbon monoxide it has been assumed that the maximum 1-hour concentration would be equal to the maximum 8-hour concentration which is recorded as a rolling average.

Background regional air quality data from the region in 2011 is assessed against EPA air quality criteria in **Table 7-72**.

There were no exceedances of the recorded carbon monoxide (8-hour average concentration of 10 mg/m^3 with an 8-hour maximum of 1.9 mg/m^3 (OEH, 2011). Both the maximum 1-hour average and annual average nitrogen dioxide concentration recorded at Richmond are well below the EPA criteria of 62 µg/m^3 and 246 µg/m^3 respectively (OEH, 2011). The maximum 24-hour particulate matter concentration of 40 µg/m^3 is below the relevant criterion. The annual average particulate matter concentration for 2011 is well below the EPA criterion of 30 µg/m^3 (OEH, 2011).

Overall the 2011 regional air quality is be considered to be good as there were no exceedances of relevant air quality criteria.

Table 7-74 Background air quality compared against relevant EPA air quality criteria

Pollutant	Averaging time	Recorded concentration	EPA criterion
Carbon monoxide	Maximum 1-hour average	1.9 mg/m^3	30 mg/m^3
	Maximum 8-hour average	1.9 mg/m^3	10 mg/m^3
Nitrogen dioxide	Maximum 1-hour average	54 µg/m^3	246 µg/m^3
	Annual average	9 µg/m^3	62 µg/m^3
Particulate matter	Maximum 24-hour average	40 µg/m^3	50 µg/m^3
	Annual average	13 µg/m^3	30 µg/m^3

7.10.3 Construction and demolition impacts

The main potential impact on air quality during construction and demolition would be generation of dust during earthworks and other construction activities. The potential for dust to be generated would depend on the silt and moisture content of the soil, the types of operations being carried out, the size of exposed areas and the prevailing wind conditions.

The use of petrol or diesel driven plant, machinery and work vehicles (including barges) would also result in some emissions to air. The types of plant and equipment required during construction would typically include excavators, cranes, graders, vibratory rollers, haul trucks, backhoes, bitumen and asphalt spraying plants, line-marking equipment, water carts and bulldozers. Primary sources of dust emissions associated with project construction would include:

- Clearing of vegetation and topsoil by bulldozers and/or backhoes.
- Excavation and levelling of soil by bulldozers, backhoes and/or excavators.
- Movement of soil and fill by dump trucks and scrapers.
- Wind erosion from unsealed surfaces and stockpiles.
- Vehicles travelling along unsealed areas.

A total of 12,300 cubic metres of fill material would be required for the construction works. Local fill from the project construction site in the order of 1,500 cubic metres would be reused where possible, although additional imported fill of around 10,800 cubic metres would be required.

There is potential for dust emissions to cause impacts if activities are located close to sensitive receptors, such as residential dwellings and/or local businesses. The magnitude of dust impacts would depend on the amount of earthworks involved at a particular location, the duration of activities, and the local meteorology at the time, particularly the wind speed and direction in relation to sensitive receivers. The following discussion provides a qualitative assessment of potential dust impacts, taking into consideration the local wind patterns and the proximity of work sites to nearby sensitive receptors.

Annually, winds within the study area are most commonly from the southwest and northeast. This highlights the potential for adverse dust impacts at sensitive receivers to the northeast and southwest of the site. Some rural properties lie to the northeast but most sensitive receivers are located to the southwest and comprise commercial and residential premises within the town centre. Construction activities conducted over spring and summer would have the highest potential for observed impacts and sensitive receivers within the town centre due to increased frequency of winds from the northeast.

A hazardous materials audit was undertaken on the structure of the existing Windsor Bridge to identify any hazardous substances of concern, such as asbestos and lead based paint. The audit took the form of a visual inspection of the bridge structure and services and sampling of suspect materials. Samples of material suspected of containing asbestos or lead based paint were collected and tested (see **Section 7.6**). No asbestos was identified, however lead based paints were detected on the iron piers and cross bracings of the bridge structure. This poses a potential risk of inhalation of fine particles containing lead based paint during demolition. Environmental management measures for demolition of the existing bridge to safeguard against exposure to lead based paints are discussed in **Section 7.6** and **Section 7.10.5**).

7.10.4 Operational impacts

The model predictions of carbon monoxide, nitrogen dioxide and particulate matter concentrations during operation of the project are provided in **Table 7-73**, **Table 7-74** and **Table 7-75**.

The following points should be noted in relation to the operational air quality assessment:

- Predicted pollutant concentrations from the project when added to background concentrations are likely to be an over estimation of pollutants as the background concentration would include existing regional vehicle emission concentrations.
- The highest pollutant concentrations would be near the kerb and concentrations would rapidly decrease with distance from the kerb, due to dispersion.
- Predicted decreases in pollutant concentrations between the existing case and the scenarios for 2016 and 2026 are due to the assumed reduction in the proportion of older vehicles on the road.
- Operational impacts are based on worst case metrological conditions and as such on average, carbon monoxide, nitrogen dioxide and particulate matter concentrations would be lower than predicted.

Carbon monoxide

The modelled carbon monoxide concentrations at the kerb due to the project for the current, 2012 and 2016 traffic volumes are presented in **Table 7-73**. Carbon monoxide concentrations along the alignment of the project in 2016 and 2026 would be lower than current concentrations due to the decrease in vehicle emissions from improved technology and lower emissions standards over time.

When the concentrations of carbon monoxide from vehicles using the project were added to the background carbon monoxide concentration, the total concentration would be well below the relevant EPA criteria.

Nitrogen dioxide

The modelled nitrogen dioxide concentrations at the kerb due to the project for the current, 2012 and 2016 traffic volumes are presented in **Table 7-74**.

Nitrogen dioxide concentrations along the alignment of the project in 2016 and 2026 would be lower than current concentrations due to the decrease in vehicle emissions from improved technology and lower emissions standards over time.

When the concentrations of nitrogen dioxide from vehicles using the project were added to the background carbon monoxide concentration, the total concentration would be well below the relevant EPA criteria.

Table 7-75 Carbon monoxide levels at the kerb

Year	Averaging Period	Distance from kerb (m)	CO concentration (mg/m^3)			EPA Criteria (mg/m^3)	Assessment
			Due to Roadway	Background	Total		
Bridge Street							
2011	Maximum 1-hour	0	0.8	1.9	2.7	30	Below criterion
	Maximum 8-hour	0	0.5	1.9	2.4	10	Below criterion
2016	Maximum 1-hour	0	0.5	1.9	2.4	30	Below criterion
	Maximum 8-hour	0	0.3	1.9	2.2	10	Below criterion
2026	Maximum 1-hour	0	0.2	1.9	2.1	30	Below criterion
	Maximum 8-hour	0	0.1	1.9	2.0	10	Below criterion
Wilberforce Road Street							
2011	Maximum 1-hour	0	0.5	1.9	2.4	30	Below criterion
	Maximum 8-hour	0	0.4	1.9	2.3	10	Below criterion
2016	Maximum 1-hour	0	0.3	1.9	2.2	30	Below criterion
	Maximum 8-hour	0	0.2	1.9	2.1	10	Below criterion
2026	Maximum 1-hour	0	0.1	1.9	2.0	30	Below criterion
	Maximum 8-hour	0	0.1	1.9	2.0	10	Below criterion
Freemans Reach Road							
2011	Maximum 1-hour	0	0.3	1.9	2.2	30	Below criterion
	Maximum 8-hour	0	0.2	1.9	2.1	10	Below criterion
2016	Maximum 1-hour	0	0.2	1.9	2.1	30	Below criterion
	Maximum 8-hour	0-10	0.1	1.9	2.0	10	Below criterion
2026	Maximum 1-hour	0	0.1	1.9	2.0	30	Below criterion
	Maximum 8-hour	0	0.1	1.9	2.0	10	Below criterion

Table 7-76 Nitrogen dioxide levels at the kerb

Year	Averaging Period	Distance from kerb (m)	Nitrogen dioxide concentration ($\mu g/m^3$)			EPA Criteria ($\mu g/m^3$)	Assessment
			Due to Roadway	Background	Cumulative		
Bridge Street							
2011	Maximum 1-hour	0	44.8	54.0	98.8	246	Below criterion
	Annual Average	0	9	9.0	18.0	62	Below criterion
2016	Maximum 1-hour	0	30.9	54.0	84.9	246	Below criterion
	Annual Average	0	6.2	9.0	15.2	62	Below criterion
2026	Maximum 1-hour	0	21.2	54.0	75.2	246	Below criterion
	Annual Average	0	4.2	9.0	13.2	62	Below criterion
Wilberforce Road							
2011	Maximum 1-hour	0	32.4	54.0	86.4	246	Below criterion
	Annual Average	0	6.5	9.0	15.5	62	Below criterion
2016	Maximum 1-hour	0	22.1	54.0	76.1	246	Below criterion
	Annual Average	0	4.4	9.0	13.4	62	Below criterion
2026	Maximum 1-hour	0	15.1	54.0	69.1	246	Below criterion
	Annual Average	0	3	9.0	12.0	62	Below criterion

Year	Averaging Period	Distance from kerb (m)	Nitrogen dioxide concentration (µg/m^3)			EPA Criteria (µg/m^3)	Assessment
			Due to Roadway	Background	Cumulative		
Freemans Reach Road							
2011	Maximum 1-hour	0	19.6	54.0	73.6	246	Below criterion
	Annual Average	0	3.9	9.0	12.9	62	Below criterion
2016	Maximum 1-hour	0	13.7	54.0	67.7	246	Below criterion
	Annual Average	0	2.7	9.0	11.7	62	Below criterion
2026	Maximum 1-hour	0	9.5	54.0	63.5	246	Below criterion
	Annual Average	0	1.9	9.0	10.9	62	Below criterion

Particulate matter

Dispersion modelling of particulate concentrations along the proposed alignment in 2016 and 2026 are lower than the existing case for particulate concentrations across both pollutant averaging periods. This is due to assumed reductions in the proportion of older vehicles resulting in improved vehicle emissions in future years.

With the exception to predicted maximum 24-hour particulate concentrations, predicted particulate concentrations along Bridge Street and Windsor Road are within the EPA criterion when added to existing background concentrations. For Bridge Street and Windsor Road the predicted 2016 and 2026 concentrations of maximum 24-hour particulates, when added to the background concentration indicated exceedences of the maximum 24-hour particulate concentration at the kerb, dissipating to concentrations within the 50µg/m^3 criterion within 10 metres of the road. These predicted exceedances would occur even if the project was not to proceed as the growth in traffic and the location of the road alignment would remain relatively the same. Also the largest source particulates in the assessment are from background levels, rather than from traffic on the road and the contribution of traffic to particulate concentrations would decrease over time. The maximum 24-hour particulate concentration at nearby sensitive receptors would be within the EPA goal.

Table 7-77 Particulate levels at the kerb

Year	Particulate matter (µg/m^3)						
	Averaging Period	Distance from kerb (metres)	Due to Roadway	Background	Cumulative	EPA Criteria (µg/m^3)	Assessment
Bridge Street							
2011	Maximum 24-hour	0	16	40.0	56.0	50	Above criterion
	Annual Average	0	6.4	13.0	19.4	30	Below criterion
2016	Maximum 24-hour	0	14.5	40.0	54.5	50	Above criterion
	Annual Average	0	5.8	13.0	18.8	30	Below criterion
2026	Maximum 24-hour	0	14.9	40.0	54.9	50	Above criterion
	Annual Average	0	5.9	13.0	18.9	30	Below criterion
Wilberforce Road							
2011	Maximum 24-hour	0	11.6	40.0	51.6	50	Above criterion
	Annual Average	0	4.6	13.0	17.6	30	Below criterion
2016	Maximum 24-hour	0	10.3	40.0	50.3	50	Above criterion
	Annual Average	0	4.1	13.0	17.1	30	Below criterion
2026	Maximum 24-hour	0	10.5	40.0	50.5	50	Above criterion
	Annual Average	0	4.2	13.0	17.2	30	Below criterion
Freemans Reach Road							
2011	Maximum 24-hour	0	7.1	40.0	47.1	50	Below criterion
	Annual Average	0	2.8	13.0	15.8	30	Below criterion
2016	Maximum 24-hour	0	6.5	40.0	46.5	50	Below criterion
	Annual Average	0	2.6	13.0	15.6	30	Below criterion
2026	Maximum 24-hour	0	6.8	40.0	46.8	50	Below criterion
	Annual Average	0	2.7	13.0	15.7	30	Below criterion

In summary no adverse air quality impacts are predicted during operation as a reduction in the proportion of older vehicles on the road would result in a reduction in roadside air quality impacts despite increased traffic volumes.

Regional air quality

The project would provide a new river crossing and intersections that have been designed to achieve a high level of service for road users and to operate efficiently. This would result in less congestion, improved travel times and reduced fuel usage. Overall, there would be a minor reduction in the amount of air pollutants emitted into the regional airshed by vehicles using the project.

7.10.5 Environmental management measures

Construction

Dust control measures will be included in the Construction Environmental Management Plan to minimise the risk of impacts on sensitive receivers. Dust environmental management measures will include:

- Covering of all materials transported to and from the construction site.
- Covering of or spraying water on stockpiles of soil or other erodible materials, particularly during dry or windy conditions.
- Suppressing dust on unsealed surfaces, temporary roadways, and other exposed areas using water trucks, hand held hoses, temporary vegetation or other appropriate practices.
- Imposing work vehicle speed limits on unsealed surfaces.
- Locating stockpiles as far away from residences as practically possible.
- Minimising the extent of disturbed areas as far as practicable.
- Rehabilitating disturbed areas as quickly as possible.
- Modifying or stopping dust generating activities during very windy conditions.
- Operating and maintaining vehicles and equipment in accordance with manufacturer's specifications.
- Visual monitoring of air quality to verify the effectiveness of controls and enable early intervention.
- Installing wheel wash facilities to reduce tracking of mud and soil off-site.
- A procedure to receive, respond and monitor complaints about air quality and other environmental issues.

Demolition

Demolition of existing bridge structures containing lead based paints will be undertaken in accordance with the following:

- Australian Standard AS 4361.1 – 1995 - Guide to lead paint management, Part 1: Industrial applications.
- Australian Standard AS 4361.2 – 1998 - Guide to lead paint management, Part 2: Residential and commercial buildings.
- Australian Standard AS 2601 – 2001 - The demolition of structures.

The options for the management of lead based paints during the demolition of the existing bridge structure (based on the respective Australian standards) are as follows:

- Containment – this option will involve the implementation of a high level of containment to prevent dust and debris spreading beyond the immediate works site during demolition.
- Paint stabilisation – paint stabilisation will require the existing surfaces to be stabilised with another non-hazardous covering. During both stabilisation and structure removal, a moderate level of containment will be required.

- Paint removal – paint removal will require the existing painted surfaces to be removed prior to demolition. During paint removal, a high level of containment will be required. Little to no containment will be required to manage the demolition of the structure following removal of the lead based paints.

Regardless of the implementation of either of these options, the management of lead based paints will entail:

- Containment of the work area and implementation of procedures and systems to prevent dust and debris spreading beyond the immediate work area.
- Exclusion of the public from the work area.
- Regular clean-up and disposal of debris during the work period.

No asbestos was identified during the site inspection and laboratory analysis. Nevertheless, in the unlikely event that asbestos is discovered, the subject works will be carried out in accordance with the Guide to the Control of Asbestos Hazards in Buildings and Structures (NOHSC, 1988) and Code of Practice for the Safe Removal of Asbestos (NOHSC, 2002). An employer must ensure that air monitoring is carried out if a risk assessment as described by the Occupational Health and Safety Regulation 2001 indicates the need for one.

Operation

No environmental management measures would be required to mitigate air quality impacts during operation of the project.

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8 Assessment of other issues

This chapter provides an assessment of the project's potential impacts that were not identified as key issues by either the Director-General's environmental assessment requirements or the environmental risk analysis (see Chapter 9).

The issues discussed in this chapter have either been directly identified by the project team or have emerged through the consultation process (see Chapter 6). The level of assessment reflects the fact that these are issues commonly associated with road projects and are appropriately addressed through the design process or by implementing best practice management and mitigation measures.

8.1 Climate change

This section assesses potential climate change impacts that need to be considered in the design of the project. The major objectives of the climate change risk assessment were to:

- Identify possible risks caused by climate change and to support the bridge concept design and project evaluation.
- Minimise future possible damage to the replacement bridge (maximise its useful life) based on identified climate change risks.
- Provide guidance for design decisions to take into account climate change adaptation and the identification of further investigations of detailed climate change options during detailed design construction and operation of the replacement bridge.

Climate change is discussed further in the Ecologically Sustainable Development assessment (see **Section 11.1.3**) and the Hydrology assessment (see **Section 7.7**).

A risk management approach has been used to incorporate climate change considerations into decision making for bridge construction, operation and maintenance to 2116 (assuming a 100 years life of the bridge and the bridge being built by 2016). This approach was undertaken in accordance with the *Australian and New Zealand Standard for Risk Management* (ISO/AS/NZS 31000: 2009) and supplemented by the *Climate Change Impacts and Risk Management – A guide for Business and Government Report* (AGO, 2006). Where appropriate, RMS' overall project risk assessment framework has been utilised to enable the climate change risk assessment to be incorporated into the RMS standard approach for risk identification.

8.1.1 Climate change and risk context

Current climate projections produced by the Australian and NSW Governments (NSW Climate Impact Profile DECCW, 2010) indicate that the climate of Sydney is likely to change significantly over the operating life of the project. The projected consequences of increased atmospheric concentrations of greenhouse gases include:

- Increased temperatures.
- Sea level rise.
- Shifts in current patterns of climate variability.
- Increased intensity of extreme events (eg. droughts, floods, severe storm events).
- Changes in seasonality and amount of precipitation (the direction and magnitude of changes will vary between geographic locations).

The projected change in key climate variables for 2050 (minimum and maximum emissions scenarios) in Windsor are:

- The mean daily maximum and minimum temperatures are expected to increase in all seasons. The magnitude of the projected increases ranges from 1.5-3°C.
- Summer rainfall is projected to increase across the Sydney and Central Coast regions, with smaller increases predicted for autumn and spring. Winter rainfall is likely to decrease moderately.
- Increased evaporation is likely in spring and summer, however modelling does not provide a clear pattern for autumn and winter.
- Sea level rise coupled with increased incidence of flooding is “virtually certain” (DECCW, 2010) to put infrastructure and property at risk. Projected increases in sea levels for the NSW coast are 40 centimetres by 2050 and 90 centimetres by 2100.
- Within the Hawkesbury-Nepean catchment the likely change in extreme rainfall is noted to be between -3 and +12% up to 2030 and -7 and +10% up to 2070. It is expected that the volume and peak discharge for various frequency events will also increase.
- The greatest changes in wind speed (increases) are likely to occur in summer. This coincides with the expected increase in storm activity for the same period.
- Increased carbonation of concrete will become a concern for structures expected to have a long service life (greater than 60 years).

8.1.2 Construction impacts

For the construction period of 2013 to 2015, the climate change impacts would be negligible and therefore have not been considered further.

There are no climate change risks identified for the demolition of the existing bridge.

8.1.3 Operation impacts

There are three broad ways in which climate change may potentially affect the project in the longer term:

1) Climate change can alter the risk of a natural hazard to which the project may be exposed (ie. increase the frequency of flooding).
2) Climate change may affect the risk posed to the surrounding environment from the operation or legacy of the project.
3) Climate change can affect the availability and supply capacity of natural and social resources required for the project.

The following components of the project were considered:

- Bridge structure (including footings, piers, abutments, retaining walls, kerbs, gutters, barriers, drainage, pavement bitumen, asphalt, street lighting, signage and closed-circuit television.
- Access roads (including vehicle crossings and ramps).
- Windsor township (including local residences).
- Natural environment (including natural vegetation).

The potential risks of climate change for the operation of the project include:

- Damage to the bridge piles in a 2000 year flood event.
- Increased scour of bridge piers and abutments.
- Increased scour of retaining walls.
- Increased frequency of inundation for flood affected properties.
- Enhanced flood levels.

The greatest risk to the project (would be related to increased rainfall intensity and increased peak flood flows. As the replacement bridge would be designed to undergo regular immersion by floodwaters many of the risks associated with increased flooding and flows would be addressed. The greatest potential risk would be extreme events such as the 1 in 2000 year flood event or high intensity rainfall events that produce extremely high flows as these may result in flow velocities greater than the design criteria. However, based upon previous studies and the Hawkesbury River catchment characteristics, these types of events would generally result in greater areas of flood water inundation for longer periods, rather than significantly increased flow velocities.

The project would contribute to increased flood levels at a number of properties immediately upstream of the new bridge during a 5 year ARI flood event. The increased bulk of the new bridge would obstruct floodwaters and increase the flood levels at these locations. This is discussed further in **Section 7.7.4**. Climate change may contribute to these properties being more regularly flooded at this level. The project would have a negligible contribution to increases in upstream flood height for floods greater than a 1 in 5 year ARI flood.

Increasing concentrations of atmospheric carbon dioxide and temperatures are projected to have an increased effect on the degradation of concrete structures such as Windsor bridge, where increased depth of penetration of the carbonation can lead to structural issues if left unchecked.

Whilst other risks as a consequence of climate change have been identified, they would not be expected to be significant and current management procedures (and some consideration during future design stages) would mitigate this risk.

8.1.4 Environmental management measures

Environmental management measures for the identified risks would be associated with consideration of the potential impacts during detailed design. The potential for increased scour of bridge piers, bridge abutments and increased frequency of inundation of flood affected properties would be considered in the detailed design process.

Mitigation measures for the properties that would experience increased flood levels due to the project are outlined in the hydrology chapter (see **Section 7.7.5**). These would involve investigation of environmental management options during the detailed design in consultation with the landholders. Appropriate measures would be identified, developed and implemented as required to minimise the impacts on the building structure, building access and business opportunities.

An adaptive management approach would be adopted for other climate change impacts.

8.2 Greenhouse gases

This section assesses the greenhouse gas impacts of the project. The major objective of the greenhouse gas assessment was to identify and assess key emissions sources and sinks so that management measures to reduce these emissions could be developed.

8.2.1 Assessment methodology and guidelines

As relevant to road infrastructure, emissions were categorised into three broad scopes as follows:

- Scope 1: All direct greenhouse gas emissions (including emissions from the fuel consumed by project plant, equipment and vehicles).
- Scope 2: Indirect greenhouse gas emissions (typically from the consumption of purchased electricity).
- Scope 3: Other indirect greenhouse gas emissions, including but not limited to the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the project, electricity-related activities (eg transmission and distribution losses not covered in Scope 2, outsourced activities and waste disposal).

These three categories have been used in this greenhouse gas assessment (see **Section 8.2.3**).

Greenhouse gases emissions from vehicles using the project have not been assessed and they would be the same even if the project was not to proceed.

8.2.2 Existing environment

Greenhouse gases absorb outgoing heat energy that is reflected from the earth. The absorption of this heat warms the air and is known as the greenhouse effect. The primary human produced greenhouse gas is carbon dioxide. Human activities such as the combustion of carbon-based fuels increase the amount of greenhouse gases in the atmosphere. This leads to greater absorption of heat and increase in atmospheric temperatures, known as the enhanced greenhouse effect.

Greenhouse gases include carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, hydroflurocarbons and perfluorocarbons. These greenhouse gases have different heat absorbing capacity, or global warming potential. To achieve a basic unit of measurement, each greenhouse gas is compared to the warming potential of carbon dioxide (CO_2). This provides a global warming potential for each greenhouse gas which can be applied to the estimated emissions. The resulting estimate is referred to in terms of CO_2-equivalent (CO_2e) emissions.

8.2.3 Construction impacts

Construction impacts include all significant emissions from initial ground breaking to the completed project. This includes earthworks, embodied emissions in construction materials and fuel used during construction and management activities. Results are presented broken down into individual construction activities and then by scope of emission (see **Table 8-1**).

Table 8-1 Summary of greenhouse gas emissions (general) for construction stage

Source	Scope 1 (tCO_2e)	Scope 2 (tCO_2e)	Scope 3 (tCO_2e)	Total (tCO_2e)
Site Offices/General Areas	228	85	34	347
Demolition and Earthworks	132	-	10	142
Construction - Pavements	334	-	492	825
Construction - Structures	248	-	2,785	3,033
Construction - Drainage	54	-	67	120
Construction - Road Furniture*	1	-	58	60
Total	**997**	**85**	**3,445**	**4,528**

* Road furniture is a generic term for items such as road safety barriers and noise walls.

Table 8-1 shows that the construction of the bridge (ie 'structures') is the construction stage with the greatest impact. This includes the emissions associated with production of the construction materials (concrete and reinforcing steel) as well as the fuel used during construction.

The stage with the next greatest impact is the laying of the pavement, for which a combination of asphalt roadway and concrete paths are included.

8.2.4 Operational impacts

Emissions associated with the operation of the bridge over a 50 year timescale have been assessed. This includes energy required for street lighting. The project emissions are shown in **Table 8-2**.

Table 8-2 Emissions associated with operation

Source		Scope 1 (tCO_2e)	Scope 2 (tCO_2e)	Scope 3 (tCO_2e)	Total (tCO_2e)
Operation	Lighting	0	284	0	284

The total project greenhouse gas emissions, from 2016 to 2066 are forecast to be approximately 4,812 tCO_2e (See **Table 8-3**). The construction element represents about 95 per cent of the total emissions over a 50 year period. Operational energy consumption contributes less than five per cent.

Table 8-3 Total project greenhouse gas emissions over 50 years (2016 – 2066)

Source	Total (tCO_2e)
Construction	4,528
Operation	284
Total	**4,812**

8.2.5 Environmental management measures

Construction

Where possible, construction material will be selected that has lower embodied greenhouse gases including:

- Concrete with a greater proportion of flyash. Higher flyash content would lower the carbon footprint of the mix.
- Recycled steel as opposed to virgin steel.
- Sourcing local materials.
- Fuel efficient plant and equipment will be selected, where practicable.
- Where practicable, biofuels will be used (biodiesel, ethanol or blends).
- Where practicable, waste material will be reused on site such as general fill, rock, aggregate and mulch from cleared vegetation.

Operation

Implementation of the project would not result in any substantial reduction in transport related greenhouse gas emissions. However, the following opportunities exist for reduction of operational greenhouse gas emissions through the following:

- Use of LED or other energy efficient lighting will be investigated during detailed design. This has the potential to reduce electrical energy consumption. Appropriate energy efficient lighting would only be used where the standard of lighting can meet AS/NZS lighting design standards for major roads and pedestrians.

8.3 Hazards and risks

Major hazards and risks from the construction, demolition and operation of the project have been identified and environmental management measures have been summarised and referenced to the relevant section in the EIS (see **Table 8-4**).

While there are other hazards and risks associated with the project, these have been adequately addressed and mitigated in previous sections or are relatively minor and do not require special consideration.

Table 8-4 Major hazards and risks

Hazard or risk	Environmental management measure
Construction	
Heritage	
An unknown archaeological site or heritage item is located during construction	**Section 7.1** and **7.2** contains detailed environmental management measures for Aboriginal and Historic heritage. The primary measures will be: - A comprehensive archaeological investigation and salvage program that would identify, remove and record all heritage items within the construction footprint. - An unexpected find protocol for heritage items.
A heritage item or building is damaged during construction due to vibration	**Section 7.5** contains detailed environmental management measures for noise and vibration impacts. The primary measures will be: - Preparation of dilapidation reports for all heritage items and buildings. - Exclusion zones around heritage items for high vibratory activities. - Use of low vibration construction techniques. - Vibration monitoring.
Traffic and transport	
A crash or accident involving a construction vehicle	**Section 7.4** contains detailed environmental management measures for traffic and transport impacts. The primary measures will be: - Preparation of a Construction Traffic Management Plan which would contain details about the management of accidents.
Soil, sediments, water and waste	
Release of turbid water from the construction site	**Section 7.6** contains detailed environmental management measures for soil, sediment and water impacts. The primary measure will be: - Preparation and implementation of a Soil and Water Management Plan which contains detailed mitigation measures to reduce the risk of the release of turbid water from construction sites including works in the river.
A chemical or fuel spill from construction sites or vehicles	**Section 7.6** contains detailed environmental management measures for soil, sediment and water impacts. The primary measure will be: - Preparation and implementation of a Soil and Water Management Plan which contains detailed mitigation measures to reduce the risk of the chemical or fuels spills and clean up and response procedures

Hazard or risk	Environmental management measure
Demolition	
The escape of lead based paint into the environment during demolition of the bridge	**Section 7.6** contains detailed environmental management measures for soil, sediment and water impacts. The primary measure will be: - Preparation and implementation of a demolition management plan which would included containment, stabilisation or removal of lead based paints on the existing bridge.
Operation	
A chemical or fuel spill due to a road accident	The design of the project includes a spill retention basin on the northern bank and a shut-off valve for the southern stormwater system to contain spills within the stormwater system.

8.4 Cumulative impacts

Cumulative impacts of the project have been considered as part of the assessment of each of the key issues (Chapter 7) and non-key issues (Chapter 8). This section considers the cumulative impacts associated with the construction and operation of the Windsor bridge replacement project and other relevant projects.

8.4.1 Background and assessment methodology

Cumulative impacts occur when incremental environmental, social or economic effects caused by past, present and reasonably foreseeable activities combine to create an impact. Cumulative impacts can result from multiple infrastructure and other development projects being constructed and/or coming into operation at approximately the same place and time.

Impacts resulting from the project may create cumulative regional or local impacts that may be short or long term. These impacts include:

- Impacts on local, regional and State traffic, transport and road users.
- Social and economic effects, including changes to land use, access, settlements, employment and businesses.
- Changes to local and regional amenity, including noise, vibration, visual quality and air quality.
- Environmental changes including effects on water quality, hydrology and biodiversity.

Assessment of the cumulative impacts also requires an understanding of other development activities within the region. Major projects listed in the Department of Planning and Infrastructure's Major Projects development assessment tracking system (http://majorprojects.planning.nsw.gov.au/) and major development applications being considered by the Hawkesbury City Council and the Joint Regional Planning Panel (JRPP) have been used as a basis for the assessment.

As the project would not be staged, there would be no cumulative impacts from multiple construction stages.

8.4.2 Major projects and other developments

Five major projects were identified within the Hawkesbury LGA that have been determined since 2006, or are currently in the planning phase of development. These projects include two water infrastructure projects, two residential subdivisions and one transport infrastructure project. One other relevant project is a new concrete batch plant in South Windsor being determined by JRPP.

The transport infrastructure project was the upgrade of the railway line between Quakers Hill to Vineyard. Stage 1 of this upgrade is largely complete and would not have any cumulative impacts in conjunction with the project.

The two water infrastructure projects are the provision of water and wastewater services to various precincts in the North West Growth Centre. The precincts that are subject to the major project applications are south of Windsor. Due to their distance from the project, their scale and their program for construction, no cumulative impacts would be expected.

One of the residential subdivision projects is located at Pitt Town and would involve the subdivision and development of about 660 urban and rural residential lots in the township. The timing for development of the lots would be dependent upon market demand. While Pitt Town is located outside the project area and to the south of the Hawkesbury River and the project, Pitt Town Road, the main access to the area, intersects with Windsor Road just south of the project. While construction of the project would coincide with development of one or more residential precincts in Pitt Town, the volume of construction traffic generated by both developments would be minor in comparison to the existing traffic on Windsor Road.

The other local residential subdivision is the Jacaranda Ponds development located at Glossidia which includes the subdivision and development of about 580 residential lots. As discussed in **Section 3.1**, Hawkesbury City Council would only support the development if there was satisfactory progress on a replacement bridge at Windsor. Therefore Jacaranda Ponds development would be unlikely to gain support from Hawkesbury City Council until the construction of a replacement bridge commences. Also to progress the development further studies and design needs to be undertaken before the final submission of planning documents to the Department of Planning and Infrastructure. The Department of Planning and Infrastructure would then need to approve the subdivision before any works on providing services to the development could commence. Based upon the current program, the replacement bridge would be complete well before any significant works on the Jacaranda Ponds development would commence.

The concrete batch plant is south of the project and is unlikely to generate significant volumes of traffic during its construction. Once the plant become operational it would generate additional traffic, however, it is likely that many of the potential customers would be to the south, east and west of Windsor in more developed areas.

No other major developments or subdivisions north of the Hawkesbury River or in Windsor adjacent to the project are known to be planned.

As discussed in Chapter 3, the *Hawkesbury Residential Land Strategy* (Hassell, 2011) was developed to guide future residential development within the Hawkesbury LGA over the next 30 years and ensure future residential development is sustainable and meets the needs of the Hawkesbury population. The Hawkesbury Residential Land Strategy nominated areas within the LGA that were suitable for future urban development based on a number of environmental, economic, land use and other criteria.

While the specific development targets of the Hawkesbury Residential Land Strategy were not expressly included in traffic growth estimates, the traffic growth due to changes in land use and residential development have been considered on a regional scale using growth rates derived from the Sydney Strategic Transport Model (SSTM). This is the accepted model used for such projections and is supplied by the Bureau of Transport Statistics. The traffic impact assessment for the project indicates that with a 25 per cent growth in traffic using the Windsor river crossing (see **Section 7.3**), the project would operate at an acceptable level of service.

8.4.3 Assessment of cumulative impacts

As the project would involve the replacement of an existing bridge and approach roads, there are unlikely to be any significant cumulative impacts from the project as:

- The project itself would not generate additional traffic.
- The existing bridge and approach roads would be removed so there would be no duplication of the bridge and roads.
- The new alignment is adjacent to the existing alignment.

Other potential cumulative impacts are discussed in **Table 8-5**.

Table 8-5 Potential cumulative impacts

Aspect	Construction	Operation
Heritage	A significant residual impact during construction would be from the disturbance of historic archaeological material. The archaeological value of the site is comprised with each new development in Thompson Square. However the project presents the opportunity for archaeological research to improve understanding of heritage in the vicinity of the project.	A significant residual heritage impact from operation of the project would be visual impact on heritage vistas and values of Thompson Square. This impact over time would not change or would be unlikely to be compounded by any future known development.
Urban design and Visual	There would be no cumulative impacts on the visual environment during construction.	The project would have a visual impact on heritage vistas and values of Thompson Square. This impact over time would not change or would be unlikely to be compounded by any future known development. Removal of the current Bridge Street alignment from the middle of Thompson Square parkland would substantially improve the form and character of the parkland space, creating a more unified and usable space, and improve pedestrian connectivity between the town centre and the river foreshore.

Aspect	Construction	Operation
Transport and Traffic	There would be increased traffic and traffic management during construction, however this is not expected to impact significantly on the level of service of the existing roads. As there are no other developments occurring concurrently, no cumulative impacts would be expected.	The operation of the project would improve traffic and transport efficiency and road network capacity. The project would also improve pedestrian and cyclist safety access around Thompson Square, to Macquarie Park and to east Windsor. There is the opportunity to integrate the project with Hawkesbury City Council's foreshore masterplan and the proposed Great River Walk.
Flora and fauna	Only a small area of vegetation would be cleared and this area mainly contains weeds. No EECs would be cleared and no threatened species would be impacted so there are no regional impacts to consider. While there would be a temporary loss of some riparian vegetation, this would be replaced and enhanced with the landscaping associated with the project.	The operation of the project would not result in cumulative impacts on flora and fauna.
Noise and vibration	There are no other known major projects that would be constructed concurrently in close proximity to the project and therefore no cumulative noise or vibration impacts are expected.	The project would not generate any additional traffic and is not located adjacent to any other major road corridors – therefore there would be no cumulative noise impacts from operation.
Air quality	There are no other known major projects that would be constructed concurrently in close proximity to the project and therefore no cumulative air quality impacts are expected.	The project would not generate any additional traffic and is not located adjacent to any other major air quality pollution sources – therefore there would be no cumulative air quality impacts from operation.
Hydrology	During construction of the project there would be a cumulative impact on flooding as the existing bridge would not yet be demolished while the new bridge is being constructed. Mitigation measures to minimise this risk have been developed. (See **Section 7.7**)	There would be no cumulative impact on hydrology from the project with other identified major projects.
Soil, sediment and water	There are no other known major projects that would be constructed concurrently in close proximity to the project and therefore no cumulative soil, sediment and water impacts are expected.	There would be an improvement in the quality of stormwater runoff from the project when compared to the existing situation.

Aspect	Construction	Operation
Land use	During construction, public land would be used for construction compounds including the Lower Thompson Square Parkland and nearby car park. During construction these areas would not be available for public use and may have cumulative effects on local business and tourism.	With the operation of the project there would be an increase in public space and parkland in Thompson Square and on the northern bank. There would be a small area of private agricultural land acquired for the project. On regional scale the area acquired is not significant and the land use is common. Therefore there would be cumulative impacts from the project.
Socio-economic impacts	There are no other known major projects that would be constructed concurrently in close proximity to the project and therefore no cumulative socio-economic impacts are expected.	There would be both positive and negative socio-economic impacts from the project. However these impacts and benefits are relatively minor and would not result in regional or longer term impacts.

8.4.4 Environmental management measures

No additional specific environmental management measures are required to minimise cumulative impacts beyond those already detailed in Chapters 7 and 8.

9 Environmental risk analysis

*A detailed environmental risk analysis was conducted as part of this EIS. This chapter outlines the environmental risk analysis process and identifies the key environmental issues. The Director General's requirements in regards to an environmental risk analysis are detailed in **Table 9-1** below.*

Table 9-1 Director General's requirements – environmental risk

Director General's requirements	Where addressed
The EIS must include an environmental risk analysis to identify potential environmental impacts associated with the project (construction and operation), proposed mitigation measures and potentially significant residual environmental impacts after the application of proposed mitigation measures. Where additional key environmental impacts are identified through this environmental risk analysis, an appropriately detailed impact assessment of this additional key environmental impact must be included in the EIS.	This chapter

9.1 Environmental risk analysis process

An environmental risk analysis has been carried out to identify and confirm the key environmental issues for the project. Key issues are those that may have major or moderate impacts (actual or perceived) and require detailed assessment to determine the level or severity of potential effects and identify appropriate impact mitigation and management measures.

The environmental risk analysis process carried out for the project included:

- Preliminary environmental investigations to help identify the key environmental issues and inform the State Significant Infrastructure Application Report (RTA 2011).
- An assessment of the key issues identified in the Director General's requirements (DGRs) for the project (refer to Appendix A for the DGRs).
- An environmental risk review to confirm the key environmental issues based on the results of the detailed investigations presented in this EIS.

These steps are described in further detail in **Sections 9.2** to **9.4** below.

9.2 Preliminary environmental investigations

Preliminary environmental investigations were carried out prior to the preparation of this EIS to inform the State Significant Infrastructure Application Report (RTA, 2011). The outcomes of these investigations identified the following as key environmental issues for the project:

- Historic heritage.
- Aboriginal heritage.
- Noise and vibration.
- Land use, property and socio-economic impacts.
- Urban design (including landscape character and visual impacts).

The outcomes of the preliminary environmental investigations were documented in the State Significant Infrastructure Application Report (RTA, 2011), which was submitted to the Director General of the NSW Department of Planning and Infrastructure in conjunction with a State Significant Infrastructure approval application. The purpose of the State Significant Infrastructure Application Report was to assist the Director General in identifying the environmental impact assessment requirements for the project, including the key issues to be addressed in the EIS.

9.3 Assessment of the key issues identified in the DGRs

The key environmental issues identified in the DGRs are consistent with but add to the key issues identified in the State Significant Infrastructure Application Report. The DGRs identified the following as the key issues to be addressed in the EIS for the project:

- Historic heritage.
- Aboriginal heritage.
- Traffic and transport.
- Visual amenity, urban design and landscaping.
- Noise and vibration.
- Soils, sediments, water and waste.
- Land use, property and socio-economic.
- Flora and fauna.
- Air quality.

The above-listed key issues have been assessed in detail as part of the preparation of this EIS. These results of this assessment are presented in Chapter 7.

9.4 Environmental risk review

An environmental risk review was undertaken as part of this environmental impact statement to help identify any additional key issues, other than those already identified in the DGRs. As required by the DGRs, the process of environmental risk analysis continued during the course of preparing the environmental assessment. The emphasis was on using the detailed information gathered during the assessment process to review the environmental aspects of the project. More specifically, the analysis:

- Identified environmental issues, including key issues in the DGRs, and any other issues.
- Examined potential impacts and proposed mitigation measures in relation to the identified issues.
- Identified the nature and extent of impacts likely to remain after mitigation measures are applied.

Based on this analysis, an environmental risk category was assigned to each potential impact. This enabled the identification of any matters that might be considered as additional key issues, and provided a basis for an appropriately detailed assessment of these additional key issues in this environmental assessment.

The environmental risk categories are described in **Table 9-2**.

Table 9-2 Environmental risk category criteria for identified environmental issues

Risk category	Description
Key issue	High or moderate impact (actual and perceived) requiring further investigation to identify specific management and mitigation measures.
Other issue	Moderate or low impact that can be managed effectively with standard and best practice management and mitigation measures.

9.5 Confirmation of the key environmental issues

A summary of the environmental risk analysis is provided in **Table 9-3**. The environmental risk analysis confirms that the DGRs included all key issues. No additional key issues were identified.

Table 9-3 Results of the environmental risk review for confirmation of key issues

Issue	Key issue in DGRs	Main potential adverse impacts	Main potential adverse impacts remaining following application of environmental management measures	Risk category following analysis	EIS reference[12]
Historic heritage	Yes	Significant adverse impacts on the State heritage listed Thompson Square Conservation Area, its archaeology and historic views and vistas and setting of Thompson Square. Demolition of the existing Windsor bridge, which is of State heritage significance and listed on RMS' section 170 register..	Significant residual adverse impacts on the State heritage listed Thompson Square Conservation Area, its archaeology and historic views and vistas and setting of Thompson Square. Demolition of the existing Windsor bridge, which is of State heritage significance and listed on RMS' section 170 register.	Key issue	Chapter 7, Section 7.1
Aboriginal heritage	Yes	Destruction or disturbance of Aboriginal objects. Loss of archaeological evidence and record of Aboriginal occupation. Potential for moderate impacts on Aboriginal cultural heritage values.	Destruction or disturbance of Aboriginal objects. Potential for minor impacts on Aboriginal cultural heritage values. No residual significant impacts are antipcipated.	Key issue	Chapter 7, Section 7.2
Traffic and transport	Yes	Major disruptions to traffic flow and parking during the construction period. Traffic flow disruptions may extend to through traffic and major arterial traffic routes linking Windsor, Sydney and the Blue Mountains.	Minor to moderate disruptions to traffic flow and parking during the construction period. Traffic flow disruptions would largely be limited to local traffic. No residual significant impacts are antipcipated.	Key issue	Chapter 7, Section 7.3

[12] Refers to relevant section of this environmental impact statement (EIS) where the issues are described in detail.

Issue	Key issue in DGRs	Main potential adverse impacts	Main potential adverse impacts remaining following application of environmental management measures	Risk category following analysis	EIS reference[12]
Visual amenity, urban design and landscaping	Yes	Major impacts on the visual amenity of the Windsor township during the construction period. Major long-term impacts on the visual character and urban design of the Windsor township during operation.	Moderate to high impacts on the visual amenity of the Windsor township during the construction period. Moderate to high long-term impacts on the visual character and urban design of the Windsor township during operation. No residual significant impacts are antipcipated.	Key issue	Chapter 7, Section 7.4
Noise and vibration	Yes	Major noise and vibration impacts during construction. Potential vibration impacts on heritage buildings. Potential for minor long-term noise impacts on two properties.	Minor to moderate noise impacts during construction. Minor risk to heritage items from construction vibration. Minor additional noise impacts for some properties during operation. No residual significant impacts are antipcipated.	Key issue	Chapter 7, Section 7.5
Soils, sediments and water	Yes	Major impacts on water quality due to erosion of soils/sediments from construction areas adjacent to the Hawkesbury River and disturbance of sediments on the bed of the Hawkesbury River. Minor to moderate risk of impacts on water quality as a result of accidental spills. Missed opportunities to minimise the amount of waste generated Moderate quantities of waste requiring disposal.	Minor, localised increases in turbidity and suspended sediment in the Hawkesbury River during the construction period (including demolition of the existing bridge). Negligible risk of impacts on water quality as a result of accidental spills. Minor quantities of waste requiring disposal. No residual significant impacts are antipcipated.	Key issue	Chapter 7, Section 7.6

Issue	Key issue in DGRs	Main potential adverse impacts	Main potential adverse impacts remaining following application of environmental management measures	Risk category following analysis	EIS reference[12]
Hydrology	Yes	Negligible impacts on flood levels for events greater than the 10 year ARI flood event Minor impacts on flood levels at some properties for events between the 3 year and 10 year ARI flood events	Negligible impacts on flood levels for events greater than the 10 year ARI flood event Minor to moderate impacts on flood levels at some properties for events between the 3 year and 10 year ARI flood events. No residual significant impacts are antipcipated.	Key issue	Chapter 7, Section 7.7
Land use, property and socio-economic impacts	Yes	Major impacts on the amenity of land uses during the construction period. Moderate socio-economic impacts during construction as a result of the impacts on the amenity of land uses. Changes in access arrangements for two properties on Bridge Street.	Minor to moderate impacts on the amenity of land uses during the construction period. Potential for minor socio-economic impacts during construction as a result of the impacts on the amenity of land uses. Changes in access arrangements for two properties on Bridge Street. No residual significant impacts are antipcipated.	Key issue	Chapter 7, Section 7.8
Flora and fauna	Yes	Moderate impacts on local and downstream aquatic habitat due to erosion of soils/sediments from construction areas adjacent to the Hawkesbury River and disturbance of sediments on the bed of the Hawkesbury River. High risk of weed spread.	Potential for minor, localised impacts on aquatic habitat during the construction period (including demolition of the existing bridge). Negligible to minor risk of weed spread. No residual significant impacts are antipcipated.	Key issue	Chapter 7, Section 7.9
Air quality	Yes	Moderate to major risk of dust impacts on the Windsor township during the construction period.	Minor risk of localised dust impacts during the construction period. No residual significant impacts are antipcipated.	Key issue	Chapter 7, Section 7.10

Issue	Key issue in DGRs	Main potential adverse impacts	Main potential adverse impacts remaining following application of environmental management measures	Risk category following analysis	EIS reference[12]
Greenhouse gas and climate change	No	Missed opportunities for minimising greenhouse gas emissions during selection of construction materials and the construction process.	Negligible impacts on greenhouse gas emissions and climate change. No residual significant impacts are antipcipated.	Other issue	Chapter 8, Section 8.1 and Section 8.2
Hazards and risks	No	Minor risks associated with use of chemicals during construction.	Negligible risks associated with use of chemicals during construction. No residual significant impacts are antipcipated.	Other issue	Chapter 8, Section 8.3

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10 Environmental management measures

This chapter collates the environmental management measures for the project that were identified through the impact assessment process. All measures listed in Table 10-1 would be incorporated into the Construction Environmental Management Plan. These plans would provide a framework for establishing how these measures would -be implemented and who will be responsible for their implementation.

Table 10-1 Environmental management measures

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Historic heritage			
Minimise visual impacts	HH1	During detailed design additional investigations will be undertaken that seek to further reduce the size and visual impact of the roundabout at Freemans Reach Road and Wilberforce Road.	Pre-construction
	HH2	Opportunities to relocate above-ground utilities underground will be investigated during detailed design.	Pre-construction
	HH3	Measures will be undertaken to ensure that the landscape scheme for the Thompson Square parkland area retains its informal character.	Pre-construction / post construction
Construction mitigation measures	HH4	Prior to construction dilapidation reports will be prepared as identified in Section 7.5.6 (generally receivers within 50 metres of piling, rock breaking and vibratory compaction activities). These will be undertaken in consultation with the relevant property owners.	Pre-construction
	HH5	Prior to commencing work on the project construction site all construction personnel will undergo a heritage induction which would contain information on heritage values and items in the area and on environmental management measures to minimise potential heritage impacts.	Pre-construction
	HH6	All heritage items within the study area will be clearly identified on construction plans to minimise the risk of inadvertent impacts.	Pre-construction
	HH7	Environmental management measures identified in Section 7.5.5 will be implemented to minimise vibration risks and impacts on heritage items.	Construction
	HH8	Heritage items at risk of vibration impacts will be inspected and monitored periodically during construction to identify any construction-related impacts. If impacts are detected, work in the area will cease and appropriate environmental management measures will be implemented such as using alternative low vibration construction techniques.	Construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
	HH9	Architectural noise environmental management measures for heritage listed buildings will be developed in agreement with property owners and installed by suitably qualified professionals.	Pre-construction
	HH10	An integrated archaeological project and research design will be developed in conjunction with heritage agency stakeholders. The research design will seek to investigate the project footprint and realise its archaeological potential. The archaeological project and research design will set out in detail the archaeological program, the research objectives and questions, and methods of analysis and dissemination of the results.	Pre-construction
Demolition of the existing bridge	HH11	The 1874 bridge will be dismantled in a manner that allows its construction methods and evolution to be appropriately documented as an archival record prior to, and during its demolition.	Demolition
Utility installation along Bridge Street	HH12	Further consultation with utility providers will be undertaken to confirm the feasibility of reducing the number of trenches required for the installation of utilities.	Pre-construction
Archival recording	HH13	Prior to commencing works and during works, an archival record of the project footprint and the immediate vicinity will be undertaken in accordance with Heritage Council guidelines for items of State significance.	Pre-construction / construction
	HH14	The Heritage Branch (on behalf of the Heritage Council), the Hawkesbury Museum and Hawkesbury City Council will be consulted on the level of appropriate archival recording. At a minimum archival recording will be undertaken in accordance with the Heritage Council guidelines for recording items of State significance prior to any further works.	Pre-construction / construction
	HH15	Archival recording prior to, during demolition and construction of the project and after completion of the project will be undertaken.	Pre-construction / construction
	HH16	A social record of Thompson Square and the building of the replacement bridge will be prepared to capture community views on the change to the environment.	Pre-construction
Post construction landscaping	HH17	Consultation with Hawkesbury City Council, relevant heritage agencies and the community on the urban design and landscape concept for Thompson Square will be undertaken during the detailed design phase of the project. The urban design landscaping principles and objectives will be used to further develop the detailed design of the project.	Pre-construction
	HH18	The concept of an informal landscape will be the basis of the final landscape plan for Thompson Sqaure.	Pre-construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
	HH19	Post-construction landscaping will be prioritised where it would provide residences and businesses with a visual buffer to the completed project.	Pre-construction
Interpretation	HH20	An interpretation strategy within the archaeological project plan and research design, will be developed to identify opportunities for public understanding and engagement with the archaeological investigation process. This will assess and recommend strategies.	Pre-construction
	HH21	An interpretation plan will be prepared based upon all of the heritage assessments to provide a framework for making information about the site's significance publicly accessible. The interpretive plan will be informed by the landscape masterplan that is proposed for Thompson Square	Pre-construction
Re-use of existing bridge	HH22	Where possible, excess materials such as the iron piers on the existing Windsor bridge, would be re-used within the project. If re-use is not possible within the project, re-use opportunities off-site would be investigated. All components would be properly labelled with provenance.	Construction
Minimise impacts to maritime archaeology	MH1	An above and below water maritime archaeological salvage excavation will be undertaken within the area considered to have a high potential to contain archaeological remains associated with the c.1814 wharf where impacts from the project are anticipated. This includes the area immediately behind the southern bank of the river within footprint of the project. The salvage excavation will be conducted by a qualified maritime archaeologist in accordance with an appropriate research design. The research design would include, as a minimum, an excavation methodology, research questions and provisions for artefact analysis.	Pre-construction
	MH2	An archaeological excavation report will be prepared at the conclusion of the salvage excavation, and submitted to the Office of Environment and Heritage for their records.	Pre-construction
	MH3	The results of the excavation and artefact analysis will be used in on-site interpretation of the maritime history and heritage of the Windsor area.	Pre-construction
	MH4	Archaeological monitoring by a qualified archaeologist will be undertaken in conjunction with earthworks and landscaping on the northern side of the existing bridge in the general location of the c.1835 punt landing. Any archaeological remains or relics associated with the punt crossing will be recorded and/or salvaged.	Pre-construction
	MH5	An archaeological monitoring report will be prepared at the end of the monitoring works and submitted to the Office of Environment and Heritage for their records.	Pre-construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Aboriginal heritage			
Minimise impacts to identified sites	AH1	A salvage excavation plan will be developed in consultation with NSW Office of Environment and Heritage which would include the following considerations: • In the upper portion of W-SP 45-5-3581, at the corner of George and Bridge Streets, the entire extent of the archaeologically significant deposit will be salvaged via open excavation. The area of excavation would be about 100 square metres or as otherwise agreed with OEH during detailed design. • In the lower portion of W-SP 45-5-3581, in the area between Bridge Street, Old Bridge Street and the wharf carpark, a representative sample of archaeological material will be taken to further investigate the relationship between the identified stone artefacts and shell lenses. The area of excavation would be about 25-50 square metres or as otherwise agreed with OEH during detailed design. • Field and analysis methods for the salvage excavations will be consistent with the Department of Planning and Infrastructure approved methodology set out in Volume 2 - working paper 3 and Department of Planning and Infrastructure will be consulted during the salvage process. • A suitably qualified and experienced archaeologist will be appointed to oversee the salvage activities.	Pre-construction
	AH2	• Aboriginal objects recovered during salvage activities would be transferred to the Australian Museum in accordance with legislative requirements, Australian Museum Archaeological Collection Deposition Policy v1.0 January 2012. • In the event the Australian Museum is unable to accept the objects, the objects will be transferred in accordance with a Care Agreement or similar agreement to an Aboriginal community. • In the event that neither the Australian Museum nor the Aboriginal community are able to accept the archaeological objects, the suitably qualified and experienced archaeologist appointed to oversee the salvage activities would seek a Care Agreement or similar agreement to curate the objects.	Pre-construction
	AH3	A written archaeological excavation report will be provided to RMS within a reasonable time following the completion of the archaeological program.	Pre-construction /construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Minimise impacts to unidentified sites	AH4	In the areas where archaeological salvage is proposed, no construction or demolition activities (including preliminary and preparatory activities such as fencing, investigative drilling, minor clearing, establishing site compounds and adjustment of services and utilities) will occur until the salvage activities have been completed in that area.	Pre-construction /construction
	AH5	Prior to the commencement of preliminary and preparatory construction or demolition activities, a construction heritage site map identifying the known Aboriginal heritage sites and the areas to undergo salvage excavation will be prepared.	Pre-construction
	AH6	Registered Aboriginal stakeholders will be provided with the opportunity to assist with the salvage excavation.	Pre-construction
	AH7	Incident reporting procedures for the project will cover incidents involving Aboriginal heritage.	Construction
	AH8	Project environmental management plans will identify procedures for handling human remains, including an immediate stop to work in the vicinity of the find, and reporting to appropriate authorities.	Pre-construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Traffic and transport			
Minimise impacts of construction work vehicles and haulage vehicles	T1	A Construction Traffic Management Plan will be prepared and implemented which would enable the safe management of traffic and minimise impacts on the local community. The plan will be structure to address the following issues: • Identification of public roads to be utilised by construction traffic. • Management measures so that construction traffic utilise the identified roads. • Identification of any public roads that may be partially or completely closed during the construction phase and the relevant expected timings and duration of closures. • Identification of sources of major construction materials and routes for their delivery to site. • Temporary access and traffic arrangements to be implemented during construction. • Access arrangements to construction sites and compounds and measures to prevent construction traffic from obstructing traffic flow inadvertently. • Parking for construction workers. • A response plan for any construction traffic incident. • Monitoring, review and amendment mechanisms.	Pre-construction / construction
	T2	Traffic Control Plans will be developed and implemented for specific areas and/or phases of construction. These will be prepared in accordance with relevant guidelines and by appropriately qualified personnel.	Pre-construction / construction
	T3	Traffic control schemes will be inspected regularly and modified if required.	Pre-construction / construction
	T4	Drivers and construction workers will be inducted in the requirements of the traffic management plan.	Construction
	T5	Deliveries and other major construction traffic movements will be timed to occur outside peak traffic periods, where possible.	Construction
	T6	Queuing on public roads will be avoided by the use of two-way radios to call up haulage trucks from layover areas on a ‘just in time’ basis.	Construction
	T7	Dilapidation surveys of roads around the project site will be undertaken prior to their use for construction as well as after construction is complete. Any damage to roads will be repaired.	Pre-construction / post construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
	T8	Consultation will be undertaken with the emergency services, bus operators, local business and other major stakeholders to inform them on changes in traffic management during construction.	
	T9	Construction related parking in local areas will be in accordance with the relevant parking restrictions. Opportunities to limit the impact this may have on the community will be investigated in consultation with the Hawkesbury City Council.	Construction
Minimise impacts to river users	T10	Environmental management measures may include introducing a temporary navigational speed limit (4 knots or below) within the construction zone and/or introducing a temporary no wash zone. Exclusion zones around marine construction sites will be required, however at all stages passage up and downstream would be provided to watercraft. Other RMS maritime requirements will be complied with.	Pre-construction / construction
	T11	Maritime operators will be undertaken so that impacts are minimised.	Pre-construction / construction
Operation	T12	Operational traffic levels and delays will be monitored. When delays due to traffic growth become unacceptable reconfiguration of the lanes on the bridge and approach roads from the initial two lane configuration to two southbound and one northbound lane will be undertaken.	Operation
Visual impact, urban design and landscaping			
Detailed design measures for the replacement bridge	V1	• Refinement of the bridge, its abutments and constituent parts and details to ensure a high quality outcome in response to its prominence within the Hawkesbury River's landscape setting and the township of Windsor. • Lighting design would be refined to integrate with the design and character of the bridge, approach roads and public domain, with consideration of minimising potential impacts associated with light spill and glare.	Pre-construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Detailed design measures for Thompson Square	V2	• Further consultation would be undertaken with Hawkesbury City Council and other relevant stakeholders to develop an urban design, landscape and open space use plan for Thompson Square and adjacent areas on the southern foreshore. • The concept design of Thompson Square presented in this proposal would form the basis for ongoing consultation. • Retention and protection of as many trees as possible will be undertaken but in particular the most significant existing trees would be incorporated into the design wherever possible. • Review the potential benefits of locating the shared path on the eastern side of the proposed bridge to increase the area of green space in Thompson Square. • New tree planting would be consistent and complement the existing species that are to be retained. Planting locations would facilitate direct views to the river and screen the replacement bridge where possible. • Any new lighting would strike a balance between illumination for safety and the context of the parkland and its adjoining areas.	Pre-construction
Detailed design measures for The Terrace and river foreshore	V3	• Further consultation would be undertaken with Hawkesbury City Council to develop an urban design, landscape plan for the southern foreshore and adjacent areas. • Further design refinement of The Terrace and foreshore area to achieve high quality public access and amenity along the river's edge and to the river, including the appropriate provision of lighting where required. • Detailed design of the form, materials and finishes of the foreshore retaining wall would be undertaken to maximise the integration of the wall into the river setting. • Consideration would be given to the design of The Terrace roadway including materials and form and to integrate it into the surrounding parkland. • New tree, shrub and groundcover planting would be incorporated in the foreshore areas to enhance the parkland setting and views to the river.	Pre-construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Detailed design measures for the northern intersection	V4	• Further consultation would be undertaken with Hawkesbury City Council to develop an urban design, landscape plan for the northern foreshore and adjacent areas. • Further design refinement would be undertaken to improve the integration of the northern intersection responding to its location and role as the northern arrival point to Windsor and Macquarie Park • Safe pedestrian and cycle connections throughout the project and links with existing path network within Macquarie Park would be further examined. • Appropriate provision for lighting would be considered and lighting infrastructure utilised only where required.	Pre-construction
Pedestrian and cycle access	V5	Further consultation would be undertaken with Hawkesbury City Council to develop a pedestrian and cycle access plan for the project and the surrounding area, in order to integrate the pedestrian and cycle connections into the surrounding network.	Pre-construction
Minimise visual impacts of construction	V6	Construction facilities will be contained within the construction works zone boundary and occupy the minimum area practicable.	Construction
	V7	Suitable barriers will be provided to screen views from adjacent areas	Construction
	V8	Temporary construction facilities and compound areas will be returned to their pre-construction state or better, either at the completion of the construction phase or progressively throughout the construction period where possible and practicable.	Construction
	V9	Pollution and dust will be kept to a minimum through the application of pollution management measures and monitoring.	Construction
	V10	Footpaths that will be affected by construction activities would be temporarily diverted to maintain suitable alternative access routes for pedestrians	Construction
	V11	Existing trees within construction area and compounds that do not need to be removed will be identified, protected and maintained throughout the construction period.	Construction
	V12	Temporary lighting will be screened or diverted to reduce unnecessary light spill.	Construction
	V13	Material used for temporary land reclamation will be removed once the works are complete.	Construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Noise and vibration			
Minimise construction noise and vibration impacts	NV1	A Construction Noise and Vibration Management Plan (CNVMP) will be prepared and will include general controls such as: • Further detailed noise impact assessments will be undertaken of all construction works and works outside standard construction hours once detailed construction planning is complete as the location and type of construction works may change. These detailed noise impact assessments will be used to identify affected sensitive receivers and develop detailed mitigation measures. • The nearest noise sensitive receivers will be notified of future works and expected levels of noise well in advance of the works occurring. • Construction programming will be developed to minimise noise impacts - this may include time and duration restrictions and respite periods, and will be developed after consultation with affected receivers. • Where possible, works outside of standard construction hours will be planned so that noisier works are carried out in the earlier part of the evening or night time. • Where noisy works are required outside of standard construction hours, negotiated agreements will be sought with affected sensitive receivers. • Where possible, the use of noisy plant simultaneously and/or close together will be avoided. • Equipment and excavation work sites will be orientated away from sensitive receivers where possible to reduce noise emissions. • Equipment will be maintained in efficient working order. • Quieter construction methods will be used where feasible and reasonable. This may include grinding, rock splitting or terrain levelling instead of rock breaking where it is feasible and reasonable. • Where acceptable from a work health and safety perspective, quieter alternatives to reversing alarms (such as spotters, closed circuit television monitors and 'smart' reversing alarms) will be used particularly during out of hours activities. • All noise complaints will be investigated and appropriate mitigation measures implemented where practicable to minimise further impacts.	Pre-construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Construction noise and vibration	NV1	• Truck movements will be restricted to identified haulage routes and the routes outlined in the Construction Traffic Management Plan • Noise monitoring will be undertaken to assess compliance with NMLs and assess the effectiveness of noise mitigation The use of temporary noise shielding will be considered at locations along Bridge Street where substantial exceedances of noise criteria are predicted. In addition where work is undertaken in close proximity to Thompson Square or along Freemans Reach Road, temporary noise barriers will be considered • Buildings/structural conditions surveys will be undertaken prior to and following construction works at receivers within 50 metres of piling, rock breaking and vibratory compaction activities, includ ing the heritage retaining wall at 4 Bridge Street. • No impact piling works will be undertaken within 20 metres of any heritage structure, unless additional assessment and monitoring confirm that vibration levels will be below project specific criteria. • Rock breaking/hammering will not be undertaken within seven metres of any heritage item or building unless additional assessment and monitoring confirm that vibration levels will be below project specific criteria. • Rock breaking/hammering will not be undertaken within five metres of any non heritage building unless additional assessment and monitoring confirm that vibration levels will be below project specific criteria. • Where rock breaking/hammering is planned within 10 metres of any occupied dwelling, the occupants will be notified of the works and the duration of the activity will be restricted, unless otherwise agreed with affected residents. • Where heavy plant is used within seven metres of a heritage structure, attended vibration monitoring will be undertaken to assess compliance with project specific vibration criteria. • Where an exceedance of project specific vibration criteria for structural damage is recorded during monitoring, work will cease immediately and alternative construction methods will be used.	Pre-construction/ Construction
Operational noise	NV2	Architectural treatments for noise mitigation would be identified by appropriate qualified professional and installed in consultation with property owners.	Pre-construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Soil, sediment and water			
Minimise impacts to soil and water from construction	SW1	An erosion and sediment control plan will be developed during detailed design in accordance with Managing Urban Stormwater – Soils and Construction Volume 1 (Landcom, 2004) and Volume 2D (DECC, 2008). This plan will incorporate erosion control measure to limit the movement of soil from disturbed areas, and sediment control measures to remove any sediment from runoff prior to discharge into the river.	Pre-construction
	SW2	Appropriate measure will be implemented to contain any turbid water by applying best management practices such as silt curtains or similar.	Pre-construction
	SW3	A water quality monitoring program in compliance with RMS guidelines will be developed and implemented to assist in identifying water quality issues during construction and assessing the effectiveness of mitigation measures.	Detailed design
Minimise impacts to soil and water from operation	SW4	Water quality controls will be incorporated into the drainage design. This will include controls such as: • An end of pipe net type gross pollutant trap connected to the stormwater outlet will be provided. • A lockable shut-off valve will be provided at the stormwater pit immediately upstream of the outlet to mitigate the potential impact of spills of hazardous liquids. • The water quality basin on the northern bank will be fitted with an underflow baffle arrangement to provide accidental spill capture.	Construction / post construction
Minimise the impacts to soil and water from demolition	SW5	The existing bridge will demolished in a way to reduce the risk of debris falling into the river.	Demolition
	SW6	Debris and rubble will be prevented from entering the river.	Demolition
	SW7	Disturbance or turbidity will be contained by installing self-containment equipment such as silt curtains.	Demolition
	SW8	Water quality in the river will be monitored in accordance with the RMS Guideline for Construction Water Quality Monitoring to assess the effectiveness of water quality mitigation measures.	Demolition

Environmental aspect and objective	ID	Environmental management measures	Phase of project
	SW9	Demolition activities will be schedule to avoid or minimise works taking place during times of higher rainfall and river flows.	Demolition
Minimise the impacts of unknown contaminated material	SW10	During excavations, soil and fill material will be visually monitored to identify the potential contaminated material or soils.	Construction
	SW11	If potentially contaminated material or soils is suspected, works will cease in the area and additional investigations and monitoring will be undertaken.	Construction
	SW12	If it is confirmed that contaminated material or soils is present on site, an appropriate remediation plan will be developed and implemented.	Construction
	SW13	All fuels and chemicals will be stored and used in compliance with appropriate guidelines and standards. A spill management procedure will be developed and implemented if required.	Construction
Minimise the impacts of waste generation	SW14	Detailed waste management measures and procedures will be included in the CEMP for the project.	Pre-construction / Construction
	SW15	Waste management measures will be based upon the philosophy of reduce, reuse, recycle and appropriate disposal.	Pre-construction / Construction
	SW16	The project induction will cover waste management measures in the CEMP.	Pre-construction / Construction
	SW17	All waste material requiring off-site disposal will be classified using the Waste Classification Guidelines and disposed of at an appropriately licensed facility.	Pre-construction / Construction
	SW18	Procurement and waste management strategies will be based upon the philosophy of reduce, reuse, recycle and appropriate disposal.	Pre-construction / Construction
	SW19	Where applicable, waste that is to be re-used will comply with the conditions attached to EPA resource recovery exemptions for specific materials.	Pre-construction / Construction
Minimise the impacts of acid sulphate soils during demolition	SW20	Further acid sulfate soils investigations would be undertaken during detailed design of the project.	Pre-construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
	SW21	If the presence of ASS is confirmed in the river sediment near the existing bridge, an ASS management plan will be developed and implemented. The plan will detail the management, handling, treatment and disposal of ASS and will be prepared in compliance with the Acid Sulfate Soils Assessment Guidelines (ASSMAC, 1998) and the Guidelines for Managing Acid Sulfate Soils (RTA, 2005).	Pre-construction
Minimise the impacts of construction on groundwater	SW22	Monitoring of groundwater at piezometers installed for the project and the adjacent groundwater bore will be undertaken to identify any impacts during construction. If any impacts on groundwater levels or quality are detected, the potential cause and environmental management measures will be identified and developed.	Pre-construction/ Construction
Minimise the impacts of hazardous materials during demolition	SW23	Demolition of bridge structures containing lead based paints will be undertaken in accordance with the following: • Australian Standard AS 436101 – 1995 Guide to lead paint management, Part 1: Industrial applications. • Australian Standard AS 4361.2 – 1998, Guide to lead paint management, Part 2: Residential and commercial buildings. • Australian Standard AS 2601 – 2001, The demolition of structures. The preferred option for management of lead based paints and the associated mitigation measures will be identified during the construction and demolition planning process. The demolition plan for the existing Windsor bridge would include the details on the reuse, recycling and/or disposal of the demolished components.	Demolition
Hydrology			
Minimise construction impacts	H1	The extent of obstructions within the river will be minimised as far as practicable at all times during construction and demolition.	Construction / demolition
	H2	The time between completion of construction of the replacement bridge and demolition of the existing bridge will be minimises as far as practicable.	Construction / demolition
	H3	Construction infrastructure and equipment will be removed from the river channel in the event of a forecast flood to minimise both the risk of damage to infrastructure/equipment and the risk of potential flood impacts on properties.	Construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Minimise impacts to property	H4	Appropriate procedures to manage the effects of flooding during construction, and minimise any associated adverse environmental impacts to the greatest extent practicable, will be incorporated into a construction environmental management plan and emergency response plan (to be prepared and approved before the start of construction). The emergency response plan would include procedures to ensure adequate warning of floods is obtained and that appropriate emergency response procedures are implemented in a timely manner.	Pre-construction and construction
	H5	Flood impact mitigation requirements and options for buildings potentially impacted by increased flooding will be investigated during detailed design in consultation with the landholder. Appropriate measures would be identified, developed and implemented, as required, to minimise impacts on the building structure, building access and business opportunities.	Pre-construction
	H6	During the detailed design of the new bridge, detailed flood modelling will be undertaken on the final design of the project to identify any additional impacts. This will include collecting survey data at potentially impacted properties with buildings upstream of the bridge. Where impacts are identified, appropriate measures will be identified, developed and implemented, as required, to minimise impacts on the building structures, building accesses and business opportunities.	Pre-construction
Minimise scour impacts	H7	Suitable scour protection would be provided to protect the bridge abutments, piers and banks during construction and operation	Construction
Land use and socio-economic			
Minimise construction impacts to land use, the community and local business.	SE1	Early and ongoing consultation and communication with residents and local businesses will be undertaken to provide information on construction activities, including timing, duration and likely impacts.	Pre-construction/ Construction
	SE2	Affected local business owners will be consulted prior to construction to identify appropriate measures to manage potential impacts.	Pre-construction
	SE3	Operators of the Hawkesbury Paddle Wheeler will be consulted prior to construction to identify appropriate measures to manage the temporary access changes to Windsor wharf.	Construction
	SE4	Public access will be maintained to key areas of the Hawkesbury River during existing planned events.	Pre-construction/ Construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
	SE5	Appropriate compensation will be provided in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* for properties acquired as a result of the project.	Pre-construction/ Construction
	SE6	The town centre and businesses will be protected from the visual impacts of construction through careful placement of appropriate and visually sensitive screening wherever possible.	Pre-construction/ Construction
	SE7	Visitor access to key tourist areas and attractions will be assisted throughout the construction period though the placement of appropriate signage.	Pre-construction/ Construction
	SE8	Strategies for enhancing the local economic benefits of project construction, such as local employment strategies and sourcing materials from existing local industries, would be considered in the detailed design.	Post construction / operation
	SE9	Areas affected by construction would be reinstated and restored in accordance with the urban design and landscape concept for the project (see Section 7.4) as soon as practicable.	Post construction / operation
Flora and fauna			
Induction	FF1	The project induction will include relevant information, mitigation measures and procedures on protecting the biodiversity of the area during construction.	Pre-construction
Site planning	FF2	Temporary infrastructure (plant sites and offices etc) will be located in cleared areas away from vegetation. Clear boundaries will be applied for construction and exclusion zones for equipment, machinery and traffic to prevent unnecessary damage to native vegetation and fauna habitats.	Pre-construction
	FF3	Clearing limits will be accurately and clearly marked including trees/vegetation to be retained including riparian zones.	Pre-construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Pre-clearing fauna survey	**FF4**	• Once construction areas have been surveyed and marked, a suitably qualified and experienced fauna ecologist will undertake a pre-clearing survey to identify any concerns to specific species. • A survey of the existing bridge structure will be undertaken by boat by an ecologist to confirm the bridge is not providing habitat for microchiropteran bats or other roosting bats. • Should the results of the bat survey and roost assessment indicate that the existing bridge occupied by microbats, a bat management plan will be prepared to mitigate the potential impacts on bats. The plan would include details of an appropriate work schedule, any further close inspections that may be required and exclusion and relocation of fauna away from the construction site. • WIRES will be made aware of the project and consulted if any injured fauna are encountered or if any fauna are injured as a result of the works. • An ecologist or WIRES representative will be present during the clearing of suspected vegetation that may support a habitat for fauna to manage and/or relocate any fauna present.	Construction
Erosion and sediment control	FF5	Management plans and measures will be developed and implemented to minimise water quality impacts from construction. A discussion on water quality mitigation measures has been provided in Section 7.6.6.	Pre-construction
	FF6	• Minimise the area of disturbance in riparian zones by clearly marking out work zones in riparian areas and protect areas with para-web fencing or similar material. • All works near riparian zones will have adequate sediment and erosion control.	Pre-construction
Weed control	FF7	• Establish a noxious weed management protocol. • All noxious weeds which are cleared as part of the project will be disposed of appropriately. • Inspection/maintenance procedures will be implemented to reduce the carriage of weed material on machinery.	Pre-construction/ Construction
Monitoring	FF8	• A monitoring program (including a weekly checklist) will be developed to check that all proposed impact mitigation measures have been effectively implemented. • In the event that impact mitigation measures do not perform effectively, the management program will be adjusted with further appropriate measures.	Pre-construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Minimise habitat loss	FF9	• While no substantial trees with hollows were identified during the survey, if trees with hollows are found, their removal will be avoided where practicable. Where this is not possible, the tree will be maintained intact as far as possible and placed on the ground in adjoining vegetation. • Habitat trees will be inspected for fauna by ecologist or WIRES carer and habitat trees will be felled carefully to minimise impact.	Pre-construction
Minimise impacts to riparian and aquatic habitat	FF10	• In-stream and riparian disturbance will be minimised during construction through clearly delineated working areas. • Removal of instream woody snags (>3 m in length and >300 mm diameter) will be avoided where practicable. Any woody snags that require removal during construction will be relocated insitu.	Pre-construction /construction
	FF11	• In-stream disturbance from dredging will be managed and mitigated as appropriate to minimise impacts. Appropriate measures will include insitu measures to limit the risk of sediment plumes and increased turbidity, such as silt curtains (or similar).	Pre-construction /construction
Rehabilitation	FF12	• Areas disturbed as a result of the project will be stabilised and rehabilitated through a progressive landscaping program that takes advantage of optimal growing conditions and is appropriate to the final land use. • Where possible riparian zone rehabilitation will include appropriate native species.	Pre-construction /construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Air quality			
Minimise dust and vehicle emissions	AQ1	Dust control measures will be included in the Construction Environmental Management Plan to minimise the risk of impacts on sensitive receivers. Dust environmental management measures will include: • Covering of all materials transported to and from the construction site. • Covering of or spraying water on stockpiles of soil or other erodible materials, particularly during dry or windy conditions. • Suppressing dust on unsealed surfaces, temporary roadways, and other exposed areas using water trucks, hand held hoses, temporary vegetation or other appropriate practices. • Imposing work vehicle speed limits on unsealed surfaces. • Locating stockpiles as far away from residences as practically possible. • Minimising the extent of disturbed areas as far as practicable. • Rehabilitating disturbed areas as quickly as possible. • Modifying or stopping dust generating activities during very windy conditions. • Operating and maintaining vehicles and equipment in accordance with manufacturer's specifications. • Visual monitoring of air quality to verify the effectiveness of controls and enable early intervention. • Installing wheel wash facilities to reduce tracking of mud and soil off-site. • A procedure to receive, respond and monitor complaints about air quality and other environmental issues.	Construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Manage hazardous substances	AQ2	Demolition of existing bridge structures containing lead based paints will be undertaken in accordance with the following: • Australian Standard AS 4361.1 – 1995 - Guide to lead paint management, Part 1: Industrial applications. • Australian Standard AS 4361.2 – 1998 - Guide to lead paint management, Part 2: Residential and commercial buildings. • Australian Standard AS 2601 – 2001 - The demolition of structures**.**	Demolition
	AQ3	The options for the management of lead based paints during the demolition of the existing bridge structure (based on the respective Australian standards) are as follows: • Containment – this option will involve the implementation of a high level of containment to prevent dust and debris spreading beyond the immediate works site during demolition. • Paint stabilisation – paint stabilisation will require the existing surfaces to be stabilised with another non-hazardous covering. During both stabilisation and structure removal, a moderate level of containment will be required. • Paint removal – paint removal will require the existing painted surfaces to be removed prior to demolition. During paint removal, a high level of containment will be required. Little to no containment will be required to manage the demolition of the structure following removal of the lead based paints.	Demolition
	AQ4	Regardless of the implementation of either of these options, the management of lead based paints will entail: • Containment of the work area and implementation of procedures and systems to prevent dust and debris spreading beyond the immediate work area. • Exclusion of the public from the work area • Regular clean-up and disposal of debris during the work period.	Demolition
	AQ5	In the unlikely event that asbestos is discovered, the subject works will be carried out in accordance with the Guide to the Control of Asbestos Hazards in Buildings and Structures (NOHSC, 1988) and Code of Practice for the Safe Removal of Asbestos (NOHSC, 2002). An employer must ensure that air monitoring is carried out if a risk assessment as described by the Occupational Health and Safety Regulation 2001 indicates the need for one.	Construction

Environmental aspect and objective	ID	Environmental management measures	Phase of project
Climate change			
Minimise the impact of increased inundation	CC1	The potential for increased scour of bridge piers, bridge abutments and increased frequency of inundation of flood affected properties will be considered in the detailed design process	Detailed design
Greenhouse gases			
Minimise greenhouse gas emissions during construction	GHG1	Construction material selection will include recycled material and local materials where possible including: • Concrete with a greater proportion of flyash. Higher flyash content would lower the carbon footprint of the mix. • Recycled steel as opposed to virgin steel. • Sourcing local materials.	Construction
	GHG2	Fuel efficient plant and equipment will be selected where practicable.	Construction
	GHG3	Biofuels will be used where practicable.	Construction
	GHG5	Where practicable, waste materials will be reused on site such as general fill, rock, aggregate and mulch from cleared vegetation.	Construction
Minimise greenhouse gas emissions during operation	GHG6	Use of LED or other energy efficient lighting will be investigated during detailed design. This has the potential to reduce electrical energy consumption. Appropriate energy efficient lighting would only be used where the standard of lighting can meet AS/NZS lighting design standards for major roads and pedestrians.	Operation

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11 Project justification and conclusion

This chapter presents a justification of the project and a conclusion to the environmental impact statement. It considers a range of issues including project benefits, protection of the environment, the objects of the EP&A Act, ecologically sustainable development and community consultation. The relevant DGR for this section is presented in ***Table 11-1****.*

Table 11-1 Director General's requirements

Director General's requirements	Where addressed
A statement of the objectives of the project, including a description of the strategic need, justification, objectives and outcomes for the project, the aims and objectives of relevant strategic planning and transport policies, including NSW 2021, the Metropolitan Plan for Sydney 2036 and the draft North West Subregional Strategy.	This chapter and Chapter 3.

11.1 Justification

11.1.1 Project justification

Windsor bridge provides an important link for communities on each side of the Hawkesbury River in the Windsor locality, as well as an important regional link between western Sydney, the Blue Mountains and the Hunter region. Around 19,000 vehicles use the bridge each day, with around seven per cent of these being heavy vehicles. The nearest alternative bridge crossing of the Hawkesbury is located around 10 kilometres away at Richmond, requiring a road detour of around 20 kilometres to drive between the southern and northern sides of the river at Windsor.

There are a number of reasons why a replacement river crossing at Windsor is required including:

- Deterioration in the condition of the existing bridge – Elements of the existing bridge are over 130 years old and substantially deteriorated.
- The existing bridge and approach roads do not meet current engineering and safety standards.
- The existing bridge has a lower flood immunity than the surrounding roads.
- The poor current and future traffic performance and capacity of the existing bridge and intersections.

In July 2009 RMS identified ten potential options for a new river crossing at Windsor: two options involving the refurbishment of the existing bridge, two options involving a bypass of Windsor and six for a new replacement bridge. Project objectives and criteria were developed to guide the assessment of the different options while a range of investigations were undertaken on key environmental aspects to support this assessment. Options for other aspects of the project such as bridge type, intersection types and urban design were also developed and assessed by the project team, adopting an integrated design approach with engineers, urban designers and architects working collaboratively with environmental and heritage specialists. The project development process also involved comprehensive community and stakeholder consultation input, including suggestions for refurbishment and alternative alignments that were also reviewed.

RMS selected the project as described in Chapter 5 as the preferred option based on an assessment of all the options against the project objectives and criteria. A summary of how the preferred option (the project) addresses the project objectives and criteria is provided in **Table 11-2**.

Table 11-2 Assessment of the preferred option (the project) against project objectives and criteria

Project objectives and criteria	Assessment of the project against objectives and criteria
To improve safety for motorists, pedestrians and cyclists	
Meets the various design codes	The project has been designed to meet RMS and Ausroads design codes for road and pedestrian safety.
Meets a road speed of 50 km/h	The project has been designed for a 50 kilometre per hour design speed. The design speed has been lowered to allow a reduction in the height of the southern approach road to minimise heritage impacts.
Ensures pedestrian safety	The project incorporates many features to improve pedestrian safety including: • A wide shared path across the new bridge and beside the approach roads to provide safe access across the river. • Traffic signals at the George Street and Bridge Street intersection which allows pedestrian crossings to be incorporated across all legs of the intersection – where none now exists. • Other pedestrian facilities such as paths and crossings which link various pedestrian routes and provide safer access for pedestrians.
To improve traffic and transport efficiency	
Minimises queue length/delays	The project has been designed to minimise queue lengths and delays especially during peak periods. The traffic and transport assessment demonstrates that the road configuration and new intersections will provide high levels of service on opening and into the future.
Improves performance of road network	Network modelling undertaken for the project demonstrates that the project would improve the performance of the road network compared with the existing situation. As well as providing a higher capacity bridge to cater for future growth in traffic, the new northern and southern intersections would provide a high level of service on opening and into the future.
Enables two heavy vehicles to pass on the bridge without waiting	The width of traffic lanes for both the two and three lane configurations would comply with appropriate guidelines and would allow heavy vehicles to pass without waiting.
Improves load capacity of the crossing to meet current load standards	The replacement bridge would have a load capacity to meet current load standards
To improve the level of flood immunity	
Provides a crossing that has a higher level of flood immunity than the existing bridge	The project would have a flood immunity of about a 1 in 3 year ARI flood event – which would be higher than the flood immunity of the existing bridge which is about a 1 in 2 year ARI flood event. There was no advantage in providing a higher flood immunity as the Freemans Reach Road and Wilberforce Road would be cut by floodwaters for events greater than the 1 in 3 year ARI flood event.

Project objectives and criteria	Assessment of the project against objectives and criteria
Provides a crossing with a flood immunity that is compatible with the surrounding approach roads	The flood immunity of Freemans Reach Road and Wilberforce Road was assessed and for both roads is about 1 in 3 year ARI. The project flood immunity would be compatible with these roads.
To meet long term community needs	
Provides an efficient connection for local traffic	The project would provide a very efficient connection for local traffic as it provides a direct connection to the town centre
Provides an efficient connection for regional traffic	The project provides a reasonably efficient connection for regional traffic by providing direct access to Windsor Road and to Macquarie Street.
Provides a pedestrian and cyclist connection to surrounding locations	The project would substantially enhance pedestrian and cyclist connections between the northern and southern bank, between the town centre and east Windsor, between the foreshore and George Street and to Macquarie Park.
Minimises impacts on recreational spaces	The project would have a minimal direct impact on recreational spaces – and would result in an increase in the area of public open space in Thompson Square and on the northern bank.
Minimises impacts of noise	While noise levels at sensitive receivers immediately adjacent to the project would be high, these receivers are already impacted by noise from the existing road and architectural noise mitigation would be provided to affected residential properties. The project would not have any impacts on properties currently not affected by road noise.
Minimises impacts to businesses and the shopping environment	The project has been designed to maintain access to business and shops in the town centre by allowing access to George Street (west) for both northbound and southbound traffic. Amenity impacts experienced by businesses adjacent to the project would be similar to those experienced from the existing road and intersections. Overall the project would have negligible impacts on businesses and the shopping environment.
Minimises impacts on property access	The project would result in the loss of direct access from the northbound direction for two residential properties, however direct access would still be available from the southbound direction. This would be the only loss of access due to the project.
Minimises need for acquisition	On the northern bank full acquisition of two properties and partial acquisition of two further properties, all of which currently used for turf farming would be required. The land is flood prone. On the southern bank two Crown properties would be acquired and the majority of land (>90%) would be retained as public open space. Overall the land acquisition required would be minimal especially in comparison to other crossing options.
Provides a 100 year life span for the bridge	The replacement bridge would be designed and constructed to have a 100 year life span.

Project objectives and criteria	Assessment of the project against objectives and criteria
To minimise the impact on heritage and the character of the local area	
Minimises impact on Aboriginal and non- Aboriginal heritage and conservation areas	The project would have an adverse impact on the Historic heritage and to a lesser extent Aboriginal archaeology. The project would directly impact Thompson Square Conservation Area and any archaeological resources within the project footprint. While mitigation measures have been incorporated in the project design and would be implemented during the further design and construction of the project, impacts on heritage and the Thompson Square Conservation Area would not be totally mitigated.
Protects the town built heritage and its setting	Apart from the visual impact of the project, the town built heritage around Thompson Square would be protected. The main potential impacts would be during construction and mitigation measures have been developed to protect heritage buildings and items. There would be both benefits and adverse impacts on the heritage setting of Thompson Square from the project. The project would allow the reunification of the currently bisected Thompson Square parkland and would enhance views to the river with foreshore improvements, removal of weeds and landscaping. However the modern bridge would contrast with the heritage setting of Thompson Square.
Minimises visual impact and impacts on the character of local area	The project would be higher in the landscape than the existing bridge and would be a modern structure in an essentially heritage and rural landscape. While mitigation measures have been incorporated in the design of the project to reduce its visual intrusiveness, it generally would have a high visual impact. However the project would only be one element in character of the local area. Other important elements such as heritage buildings adjacent to and outside the project area would be directly impacted.
To be a cost effective and an affordable outcome	
Provides a cost effective solution - capital cost	The project would provide a cost effective solution as it requires only short approach roads and paths to connect to existing infrastructure and only minimal land acquisition.
Provides a cost effective solution - maintenance	The project would be designed to have minimal maintenance costs.
Provides a cost effective solution - investment on return	An economic analysis was prepared for the project using the most up to date costs and other design information. The benefit cost ratio for the project was 14.6 indicating that the project provides substantial value for money and an excellent return on the investment.
Minimises the impact of construction in regards to length and timing	Due to the relatively short approach roads, the construction period would be reduced. As the majority of the construction activities would be undertaken from the northern bank, impacts from construction on urban areas on the southern bank would be minimised.

The preferred option addresses the project objectives and provides a higher value for money than other options considered. However, it does not address the project objective of minimising impact on heritage and character as well as other options that were considered While other options have lower heritage impacts, the costs and other potential impacts of these alternative options are considered to exceed their benefits.

Mitigation measures have been incorporated in the design and construction of the project to reduce heritage impacts, however, the impacts would not be eliminated.The replacement of Windsor bridge would clearly be in the public interest as the existing bridge does not effectively meet ongoing safety and traffic requirements. With future traffic growth predicted at between 25 to 30 per cent by 2026 due to primarily increased urban development in the townships on the northern bank of the Hawkesbury River, traffic and safety issues would increase. The existing Windsor bridge has reached the end of its design life and the most appropriate long-term cost effective option would be to build a new replacement bridge.

The views of the community have also been taken into account in the consideration of the public interest. Some members of the community strongly oppose the project due chiefly to concerns about impacts on the heritage values and vistas of Thompson Square. However, there is also considerable support within the community for the preferred option as it is seen by parts of the community as the most practical option and does not expose currently unaffected residential areas to impacts from traffic and noise.The project would provide a new bridge, approach roads and intersections that address the deficiencies of the existing crossing of the Hawkesbury River. The project design meets accepted design standards, improves the level of flood immunity to that of the surrounding approach roads, and provides safer crossings for pedestrians. The existing bridge would be removed thereby removing the risk of deterioration and failure.

The improved intersections and higher capacity bridge would provide acceptable traffic performance immediately and into the future when the bridge would be reconfigured to provide three lanes (two lanes southbound and one lane northbound).

11.1.2 Objects of the EP&A Act

The objects of the EP&A Act provide a framework within which the justification of the project can be considered. A summary of this assessment is provided in **Table 11-3**.

Table 11-3 Justification of the project in consideration of the objectives of the EP&A Act

EP&A Act objective	Comment
To encourage the proper management, development and conservation of natural and artificial resources, including agricultural land, natural areas, forests, minerals, waters, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment.	Overall the project would manage, develop and conserve natural and artificial resources appropriately and would result in social and economic benefits to the community. However there would be the loss of the existing Windor bridge. Environmental management measures have been developed for the construction, demolition and operational phases for all environmental aspects. These management measures comply with relevant national, State and RMS guidelines, policies and legislation. The design of the project has been developed to conserve natural and artificial resources through measures such as minimising land acquisition, providing efficient connections to the existing road network and minimising impacts on flora, fauna and water quality. The project would not directly impact threatened species, ecologically endangered communities and key habitats and would involve minimal clearing of mainly weed infested vegetation. The project would provide efficient and safe road crossing of the Hawkesbury River which would support the social and economic welfare of the community. The project would improve flood immunity compared to the existing bridge, reducing the frequency and duration of closures of the river crossing. However the project is not intended to be a new flood evacuation route. The project has also been designed to withstand regular inundation by flood waters and would be able to cope with climate change impacts such as increased flooding. Greenhouse gas reduction measures have also been identified to minimise emissions during the construction and operation of the project The removal of the southern approach road to the existing bridge would increase the area of open space in Thompson Square and pedestrian linkages between recreational areas, along the foreshore and across the river would be substantially improved. The project would have a significant impact on the heritage vistas of the Thompson Square Conservation Area. While this impact has been minimised through sympathetic urban design, the selection of bridge type with lower visual impact and other measures, the impact on heritage vistas of the Thompson Square Conservation Area cannot be totally mitigated. The project would also involve the demolition of the heritage listed existing Windsor bridge. However the project would meet most of the other functional and environmental project objectives and criteria and would provide the best value for money for the community.

EP&A Act objective	Comment
To encourage the promotion and co-ordination of the orderly and economic use and development of land.	The project would support the further urban development of the villages and townships north of the Hawkesbury River by providing an essential river crossing and road link to Windsor and the greater metropolitan area of Sydney. It would also support agricultural and horticultural development north of the river by providing a safe and efficient link to markets and services south of the river. The project would allow businesses, agricultural / horticultural enterprises and residents north of the river efficient and safe access to services, employment and markets – which would make urban and agricultural development of land north of the Hawkesbury River more attractive and economically viable. Businesses in Windsor would be largely unaffected by the project as motorists would still be able to access the town centre and the noise and air quality impacts from the project would be similar to the impacts from the existing bridge. While there would be impacts on the heritage vistas of Thompson Square, the other important heritage elements of the town that attract tourists would not be affected. Also with a larger usable open space in Thompson Square and improved pedestrian access across the river to Macquarie Park, to the foreshore and to east Windsor, the area would become more attractive to visitors. During construction there would be some temporary amenity and access impacts on businesses, however these will be minimised through the implementation of environmental management measures detailed in the EIS.
To encourage the protection, provision and co-ordination of communication and utility services.	The project would involve the relocation of a number of communication and utility services, which would be undertaken in consultation with the relevant service providers as described in Chapter 5.
To encourage the provision of land for public purposes	The project itself is a public purpose and would provide roads, paths and a bridge that would be used by the public. The project would also increase usable public open space on both the northern and southern banks and improve safe access for the public to parks and other recreational areas.
To encourage the provision and co-ordination of community services and facilities.	The project includes the reconfiguration of Thompson Square by the removal of the southern approach road to the existing bridge which currently bisects Thompson Square parkland. As a result the area of usable green space in Thompson Square parkland would increase – and the parkland would be landscaped to maximise its potential community uses in consultation with the community and Hawkesbury City Council. Other community facilities that would be provided as a result of the project include: • A shared path across the bridge that would provide a safe and efficient link between Macquarie Park and the Windsor town centre. • Safe pedestrian crossing of Bridge and George Street to provide a link between east Windsor and the town centre. • Reconnecting The Terrace to provide pedestrian access along the river.

EP&A Act objective	Comment
To encourage the protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats.	The project would only have minor potential impacts on the natural environment. No threatened species, populations and ecological communities, and their habitats would be affected by the project. The environmental management measures identified for the construction and operation of the project would minimise and in some cases reduce any impacts from land, water and air pollution on the natural environment.
To encourage ecologically sustainable development.	Ecologically sustainable development has been considered in **Section 11.1.3**.
To encourage the provision and maintenance of affordable housing.	Not relevant to the project.
To promote the sharing of the responsibility for environmental planning between different levels of government in the State.	Not relevant to the project.
To provide increased opportunity for public involvement and participation in environmental planning and assessment.	The options development and selection process for the project has involved a comprehensive community and stakeholder participation process. Feedback from community and stakeholders has been sought on different options for the location of the new river crossing, the bridge type and the final form and use of Thompson Square. Where possible community and stakeholder feedback has been included in the development of the design. Also concerns and issues raised by the community and stakeholders on the preferred option have been noted and addressed wherever possible in the design, environmental impact assessment and development of mitigation measures. Details of consultation activities are contained in Chapter 6. There will be further opportunities for the public to be involved in the project through the submissions process for the EIS and through the further development of the design and use of Thompson Square and other areas.

11.1.3 Ecologically sustainable development

Ecologically sustainable development (ESD) is development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. The principles of ESD have been an integral consideration throughout the development of the project.

ESD requires the effective integration of economic and environmental considerations in decision-making processes. The four main principles supporting the achievement of ESD are discussed below.

Precautionary principle

The precautionary principle (as defined in Schedule 2 of the *Environmental Planning and Assessment Regulation 2000*) states that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:

- Careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment.
- An assessment of the risk-weighted consequences of various options.

The environmental impacts of the project have been comprehensively assessed in the EIS using appropriate guidelines, policies and procedures. The assessment approach has meant the impacts of the project are certain, predictable and largely able to be mitigated. Apart from impacts on historic heritage, the project would not result in serious or irreversible damage to the environment provided the identified environmental management measures are implemented.

Impacts of the project on historic heritage include direct impacts on in-situ terrestrial and maritime archaeological resources within the project footprint. While these archaeological resources would be directly impacted, a comprehensive archaeological investigation and salvage program would be undertaken before construction to enable archaeological recording of the historical development of Thompson Square and the river bank and also the salvage of any relics that may still exist. With these investigation and salvage activities the archaeological resources of areas impacted by the project would not be irreversibly lost.

The other major impact from the project would be on the heritage vistas and values of Thompson Square. Appropriately qualified and experienced engineers, architects, heritage specialists and urban design practitioners have been involved in the project development process attempting to minimise impacts wherever practicable. The impacts have been thoroughly assessed and environmental management measures and design solutions have been developed to further minimise these visual impacts. The community and government stakeholders have also been extensively consulted to obtain their feedback on design options for the project. Additional consultation and further refinement of the design is also planned before construction commences which aims to further mitigate the visual impact of the project. While these measures would reduce the overall visual impact of the project, it is recognised that the project would still have a significant impact on the heritage views and vistas of Thompson Square.

This impact is, conceivably, reversible as the replacement bridge and approach roads could be removed from the square at a later date – as has been demonstrated by the numerous redevelopments and reconfigurations of Thompson Square over the past 230 years. However, demolition of the existing bridge, which contributes to the heritage views and vistas, would be an irreversible impact. While other options for a river crossing at Windsor have been identified that avoid impacts on Thompson Square, they would have other potential impacts or would not meet the functional requirements for the river crossing. All options were assessed against project objectives and criteria that considered their risk of environmental impacts, their functional performance and their costs and benefits to the community. On the basis of this assessment, the project as described in Chapter 5 was determined to be the best solution on-balance.

Greenhouse gas reduction measures have been identified to minimise emissions from the project, while the implications of climate change have been considered during the design of the project. The replacement bridge has been designed to overtop during floods and to withstand regular inundation by flood waters. A formal flood evacuation route has been constructed by RMS separately as part of the Windsor Road Upgrade Program.

Inter-generational equity

Inter-generational equity (as defined in Schedule 2 of the *Environmental Planning and Assessment Regulation 2000*) requires that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.

The preferred option for the project was assessed and selected in consideration of a set of project objectives and criteria which reflected economic, social and environmental costs and benefits. While the preferred option did not meet some project objectives as well as other options met those objectives, on balance it was considered to be the best option. Other options such as a bypass of Windsor may have had lower heritage impacts, however, there were other environmental impacts and social costs of these options and the financial costs were considerably higher. The other options did not provide sufficient benefits to outweigh their costs.

Apart from heritage, the project would at least maintain the health, diversity and productivity of the environment and for some aspects would enhance the environment. Impacts from the project such as noise and air quality would be similar compared to if the project was not to proceed. Other features of the project such as improved water management and provision of additional areas of usable public open space in Thompson Square and on the northern bank would improve the local environment. However the heritage vistas of Thompson Square would be adversely impacted by the project, as has occurred previously with the redevelopment of Thompson Square on numerous occasions over the past 230 years.

The project would also provide an essential, efficient and safe local and regional link in the existing road networks, with capacity for future traffic growth. Where possible the assessment of impacts from the project have taken into account future growth in traffic – to determine whether the project would have impacts on future generations. Based upon these impact assessments, apart from the loss of heritage vistas and values the project would not have significant additional impact on future generations. The project has also intrinsic design features (eg designed to undergo regular immersion by floodwaters) which allow its ability to cope with potential future impacts of climate change.

Conservation of biological diversity and ecological integrity

Conservation of biological diversity and ecological integrity (as defined in *Schedule 2 of the Environmental Planning and Assessment Regulation 2000*) states that conservation of biological diversity and ecological integrity should be a fundamental consideration.

The project would not result in any significant impacts on biodiversity or the ecological integrity of the local and regional environment. There are no threatened species, ecologically endangered communities or key terrestrial habitats within or adjacent to the project area. Environmental management measures detailed in the EIS would minimise the impacts of construction on the Hawkesbury River and the ecological integrity of the river would be protected. Compared to the existing bridge, the project would reduce risks to biological diversity and ecological integrity through improved operational water treatment and the removal of lead based paint from the existing bridge.

Improved valuation and pricing of environmental resources

Improved valuation, pricing and incentive mechanisms (as defined in *Schedule 2 of the Environmental Planning and Assessment Regulation 2000*) states that environmental factors should be included in the valuation of assets and services, such as:

(i) polluter pays, that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement.
(ii) the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste.
(iii) environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

As noted previously, the project would not have a significant impact on the natural environment and the amenity impacts would not significantly increase over the existing situation. Some aspects of the project would result in a reduction in environmental risks and impacts. The project would not generate significant additional pollution or wastes.

The major environmental impact of the project is the impact on heritage vistas and values of Thompson Square Conservation Area. In recognition of this cost, considerable effort has been invested in minimising the impact of the project on this aspect including selecting a bridge type that has a lower visual impact and urban design and landscaping of Thompson Square open space and other areas in and adjacent to the project. Development of the design would be ongoing to further identify opportunities to minimise the impacts of the project on the heritage vistas of Thompson Square.

RMS also intends to deliver the construction of the project via an alliance contract. This type of delivery method involves establishing a collaborative team of design, construction, other specialist practitioners and RMS personnel to design and construct the project. Unlike conventional delivery methods, an alliance contract can provide incentives for innovative solutions, environmental performance and minimising impacts.

11.2 Conclusion

This EIS has addressed the key issues identified in the DGRs issued under Part 5.1 of the EP&A Act and the requirements of Schedule 2, Part 3 of the *Environmental Planning and Assessment Regulation 2000*. Checklists showing where the DGRs and the requirements of Schedule 2, Part 3 of the *Environmental Planning and Assessment Regulation 2000* are addressed are provided in **Appendix A** and **B**.

While Windsor bridge replacement project addresses the project objectives it would result in significant impacts on the heritage vistas of Thompson Square Conservation Area and its archaeological resources. These impacts have been minimised as much as possible through reducing the height the bridge, selecting a bridge type that has a lower visual profile and including appropriate urban design features and landscaping, however, they cannot be ameliorated completely. These impacts are unavoidable unless an alternative option was selected, however the alternative options would have other impacts and do not provide as high value for money as the project.

In terms of the historical context of Thompson Square, it has been and is the primary location for crossing the Hawkesbury River at Windsor. Crossing of the river pre-1874 was via a ferry or punt crossing and post 1874 via the existing bridge. Consequently a road from George Street to either the wharves or the bridge has been a constant feature of Thompson Square, although the alignment, size and layout of roads in Thompson Square has varied considerably over 200 years. While other options for a river crossing at Windsor may have less or no impacts on Thompson Square, they would generally result in noise, traffic and visual amenity impacts on residential areas which do not currently experience these issues – as well as other environmental impacts. Also many of the alternative options would cost significantly more than the project and benefits that they may provide do not justify the additional costs.

Other operational impacts of the project such as noise, air quality and flooding would be similar to impacts from the existing bridge and approach roads.

Construction of the project would result in short-term temporary impacts on noise, air quality, water quality, traffic and access. However, these impacts would be minimised through the development and implementation of construction environmental management plans and careful planning of construction activities. Only minimal clearing of vegetation would be required and no threatened species, ecologically endangered communities or habitat areas would be impacted.

There are a number of benefits to Thompson Square from the project including the consolidation and creation of a larger green space area in Thompson Square parkland and improved pedestrian and cyclist paths and crossings linking Thompson Square with Macquarie Park, The Terrace and east Windsor. This would improve both the use and accessibility of the Thompson Square parkland and would return Thompson Square to a form closer to the earliest colonial space prior to the creation of formalised roads.

The project has been designed to accommodate future growth in traffic and would provide a cost-effective, efficient and safe route for local and regional traffic. It would provide a crossing of the Hawkesbury River with a higher flood immunity than the existing bridge and appropriate for the surrounding road network. In comparison to the other options for a road crossing of the Hawkesbury River at Windsor, the project provides the best value for money and apart from its impacts on heritage, which have been discussed in detail, it will have minimal additional impacts on the surrounding environment.

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Appendix A – Director General's Requirements and checklist

Director General's Requirement	Where addressed in the EIS
General requirements	
The Environmental Impact Statement (EIS) must be prepared in accordance with, and meet the minimum requirements of, Part 3 of Schedule 2 of the Environmental Planning and Assessment Regulation 2000 (the Regulation), including:	This EIS (including Certification) and Application for State Significant Infrastructure
1. the information required under clause 6 of Schedule 2 of the Regulation.	Certification and Application for State Significant Infrastructure
2. the content listed in clause 7 of Schedule 2 of the Regulation, including but not limited to:	This EIS (refer to table of contents)
o a summary of the environmental impact statement;	Executive summary
o a statement of the objectives of the project, including a description of the strategic need, justification, objectives and outcomes for the project, the aims and objectives of relevant strategic planning and transport policies, including NSW 2021, the Metropolitan Plan for Sydney 2036 and the draft North West Subregional Strategy;	Chapter 3 (project need, objectives and strategic justification) and Chapter 11 (justification and conclusions)
o an analysis of feasible alternatives to the carrying out of the project and project justification, including: ➢ an analysis of alternatives/options considered having regard to the project objectives (including an assessment of the environmental costs and benefits of the project relative to alternatives and the consequences of not carrying out the project), and the provision of a clear discussion of the route development and selection process, the suitability of the chosen alignment and whether or not the project is in the public interest, and ➢ justification for the preferred project taking into consideration the objects of the Environmental Planning and Assessment Act 1979.	Chapter 3 (project justification), Chapter 4 (description and analysis of project alternatives and justification for selection of preferred option) and Chapter 11 (justification for the project, including taking into account the objects of the Environmental Planning and Assessment Act)
o an analysis of the project including an assessment, with a particular focus on the requirements of the listed key issues, in accordance with clause 7(1)(d) of Schedule 2 of the Regulation (where relevant), including an identification of how relevant planning, land use and development matters (including relevant strategic and statutory matters) have been considered in the impact assessment (direct, indirect and cumulative impacts) and/or in developing management/ mitigation measures; and	Chapter 2 (statutory matters), Chapter 3 (planning matters), Chapter 5 (project description), Chapters 7 to 10 (existing conditions, potential impacts and mitigation measures for key and other issues)
o detail how the principles of ecologically sustainable development will be incorporated in the design, construction and ongoing operation phases of the project.	Section 11.1.3

Director General's Requirement	Where addressed in the EIS
Key issues	Chapter 7
The EIS must address the following specific matters:	
Heritage – including but not limited to:	Sections 7.1 and 7.2
• impacts to State and local historic heritage (including archaeology, heritage items and conservation areas), in particular, impacts on the Thompson Square Conservation Area, heritage listed buildings and sites in the Thompson Square conservation area and the Windsor Bridge should be assessed.	Section 7.1.4
Where impacts to State or locally significant historic heritage items are identified, the assessment shall:	
o outline the proposed mitigation and management measures (including measures to avoid significant impacts and an evaluation of the effectiveness of the mitigation measures) generally consistent with the guidelines in the NSW Heritage Manual (1996),	Section 7.1.5, 7.4.4 & 7.4.6
o be undertaken by a suitably qualified heritage consultant(s) (note: where archaeological excavations are proposed the relevant consultant must meet the NSW Heritage Council's Excavation Director criteria),	Working papers 1 & 2 Section 7.1
o include a statement of heritage impact for all heritage items (including significance assessment),	Working papers 1 & 2 Section 7.1.3
o consider impacts from vibration, demolition, archaeological disturbance, altered historical arrangements and access, landscape and vistas, and architectural noise treatment, and	Section 7.1.4 and Section 7.5
o develop an appropriate archaeological assessment methodology, including research design, to guide physical archaeological test excavations (terrestrial and maritime) and include the results of these excavations;	Section 7.1.2 and Working papers 1 & 2
• impacts to Aboriginal heritage (including cultural and archaeological significance), in particular impacts to potential archaeological deposits (PAD) on the northern and southern banks of the Hawkesbury River and archaeological objects/ relics below the existing built environment should be assessed.	Section 7.2.3
Where impacts are identified, the assessment shall:	
o outline the proposed mitigation and management measures (including measures to avoid significant impacts and an evaluation of the effectiveness of the measures) generally consistent with the Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation (Department of Environment and Conservation, 2005),	Section 7.2.4
o be undertaken by a suitably qualified heritage consultant(s),	Section 7.2 & working paper 3
o demonstrate effective consultation with Aboriginal communities in determining and assessing impacts and developing and selecting options and mitigation measures (including the final proposed measures), and	Section 7.2.1, Chapter 6 and working paper 3

Director General's Requirement	Where addressed in the EIS
o develop an appropriate archaeological assessment methodology, including research design, to guide physical archaeological test excavations of the areas of PAD identified in a manner that establishes the full spatial extent and significance of any archaeological evidence across each area of PAD, and include the results of these excavations.	Section 7.2.1 and working paper 3
Transport – including but not limited to:	Section 7.3
• Demonstration of how the preferred bridge alignment and design meets the traffic and transport objectives of the project	Section 7.3.4
• Justification for the capacity of the bridge, taking into account future growth areas and traffic (vehicular, cyclist and pedestrian) needs;	Section 7.3.4
• Construction traffic access to the project (including ancillary facilities) and associated management measures, in particular impacts to the road network (including safety and level of service, access to the town centre and tourist and recreational facilities, disruption to public transport services and access to properties);	Section 7.3.3 and 7.3.5
• Operational traffic and transport impacts to the local and regional road network, including impacts of the new bridge alignment through the town centre and Thompson Square;	Section 7.3.4
• Impacts of the project (construction and operational) on the use and access to Windsor Wharf, and existing and future maritime and recreational use of the Hawkesbury River; and	Section 7.3.3 and Section 7.3.4
• Safety of navigation in the Hawkesbury River for the water based traffic.	Section 7.3.3 and Section 7.3.4
Visual Amenity, Urban Design and Landscaping – including but not limited to:	Section 7.4
• a description of the visual significance of the bridge surrounds, Thompson Square, river foreshore and landscape setting, and an assessment of the visual impact of the project on the landscape and urban design character of the area, including built form (materials and finishes), urban design (height, bulk and scale), views to and from Thompson Square, the town centre and river foreshore areas, and design details such as lighting, balustrades and street furniture;	Section 7.4.2 (visual significance), Section 7.4.5 (visual impact) and Section 7.4.4 (design details)
• the overshadowing impact of the bridge on the public domain, including open space, parks and parklands, river foreshore areas and Thompson Square, and adjoining residential/ commercial uses; and	Section 7.4.5
• the landscape and urban design objectives for the reinstatement and rehabilitation of Thompson Square, taking into account Council's desired future landscape and urban design character of this locality.	Sections 7.4.3 and Section 7.4.4
The EIS must include:	

Director General's Requirement	Where addressed in the EIS
o details of landscaping treatment and integration with the public domain and historic values of Thompson Square and surrounds, in particular the integration of the existing road corridor with Thompson Square and the new bridge alignment and approach roads, and	Section 7.4.4
o details of integration of the bridge and Thompson Square with existing and future pedestrian and cycle networks, including design and safety measures for pedestrian and cycle access on the bridge.	Section 7.3.2, 7.3.4, 3.1 and 5.2.4
Noise and Vibration – including but not limited to:	Section 7.5
• Assess construction and operational noise and vibration impacts of the project, in accordance with the Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009), NSW Road Noise Policy (Department of Environment, Climate Change and Water, 2011), and Assessing Vibration: a Technical Guideline (Department of Environment and Conservation, 2006).	Section 7.5.4 (construction noise and vibration) and Section 7.6.5 (operational noise and vibration)
Soils, Sediments and Water - including but not limited to:	Sections 7.6 and 7.7
• erosion and sediment impacts on the Hawkesbury River during construction/ operation; including an assessment of water quality; mitigation measures to prevent water pollution; details of the proposed storm water management measures for the containment of pollutants; and waste handling;	Section 7.6.2 (existing water quality), Sections 7.6.3 to 7.6.5 (potential impacts), and Section 7.6.6 (mitigation and management measures)
• justification for the proposed flood immunity and an assessment of the flooding impacts and characteristics to and from the project, including consideration of changes to rainfall frequency and/or intensity as a result of climate change; and	Section 7.7.3
• the potential impacts on flow velocities and directions, and impacts on bed and bank stability as a result of removal of the existing bridge and relocation of a new bridge downstream.	Section 7.7.3
Land use, property and socio-economic – including but not limited to:	Section 7.8
• Impacts on directly affected properties and land uses, including impacts related to access, land use, property acquisition and amenity related changes.	Section 7.8.3 and 7.8.4
• Impacts of the project on tourist and recreational uses of Thompson Square, the town centre and the Hawkesbury River and its foreshores.	Section 7.8.3 and 7.8.4
• Social and economic impacts to the Windsor town centre businesses and the community associated with traffic, access, property, public domain and amenity related changes.	Section 7.8.3 and 7.8.4
Flora and Fauna - including but not limited to:	Section 7.9
• impacts on the biodiversity values of the site and adjoining areas, including terrestrial, riparian and aquatic areas;	Section 7.9.3 and 7.9.4

Director General's Requirement	Where addressed in the EIS
• impacts on critical habitats, threatened species, populations or ecological communities and their habitats; and	Section 7.9.3 and 7.9.4
• taking into account the Draft Guidelines for Threatened Species Assessment (Department of Environment and Conservation, 2005).	Section 7.9.2
Air Quality – including but not limited to:	Section 7.10
The EIS must address air quality matters including but not limited to activities that have the potential to impact on local and regional air quality and details of the proposed mitigation measures to prevent the generation and emission of dust.	Section 7.10.4 (potential impacts) and Section 7.10.5 (mitigation measures)
Environmental Risk Analysis – notwithstanding the above key assessment requirements, the EIS must include an environmental risk analysis to identify potential environmental impacts associated with the project (construction and operation), proposed mitigation measures and potentially significant residual environmental impacts after the application of proposed mitigation measures. Where additional key environmental impacts are identified through this environmental risk analysis, an appropriately detailed impact assessment of this additional key environmental impact must be included in the EIS.	Chapter 9
Consultation	Chapter 6
During the preparation of the EIS, you should undertake an appropriate and justified level of consultation with relevant parties, including but not limited to:	
• Local, State and Commonwealth government authorities including the: – Department of Primary Industries – Agriculture and Fishing and Aquaculture – Heritage Council of NSW – Maritime Services – NSW Office of Water – Office of Environment and Heritage – Transport for NSW and – Hawkesbury City Council	Section 6.2
• Specialist interest groups, including Local Aboriginal Land Councils, Aboriginal stakeholders	Section 6.2
• Utilities and service providers	Section 6.2.3
• The public, including community groups and adjoining and affected landowners.	Section 6.2
The EIS must describe the consultation process, document consultation undertaken and identify the issues raised (including where these have been addressed in the EIS).	Sections 6.1 to 6.3

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Appendix B – Environmental Planning and Assessment Regulation 2000

Requirement	Where addressed in the EA
6 Form of the environmental impact statement	
An environmental impact statement must contain the following information:	
a) the name, address and professional qualifications of the person by whom the statement is prepared,	Certification page
b) the name and address of the responsible person,	Certification page
c) the address of the land: i) in respect of which the development application is made, or ii) on which the activity or infrastructure to which the statement relates is to be carried out,	Certification page
d) a description of the development, activity or infrastructure to which the statement relates,	Certification page
e) an assessment by the person by whom the statement is prepared of the environmental impact of the development, activity or infrastructure to which the statement relates, dealing with the matters referred to in this Schedule, and	Certification page
f) a declaration by the person by whom the statement is prepared to the effect that: i) the statement has been prepared in accordance with this Schedule, and ii) the statement contains all available information that is relevant to the environmental assessment of the development, activity or infrastructure to which the statement relates, and iii) that the information contained in the statement is neither false nor misleading.	Certification page
7 Content of the environmental impact statement	
1) An environmental impact statement must also include each of the following:	
a) a summary of the environmental impact statement,	Executive summary
b) a statement of the objectives of the development, activity or infrastructure,	Section 3.3 - Project objectives
c) an analysis of any feasible alternatives to the carrying out of the development activity or infrastructure, having regard to its objectives, including the consequences of not carrying out the development, activity or infrastructure,	Chapter 4 – Project development and alternatives
d) an analysis of the development, activity or infrastructure, and	Chapter 4 and Chapter 5
i) a full description of the development, activity or infrastructure,	Chapter 5 – Project description

Requirement	Where addressed in the EA
ii) a general description of the environment likely to be affected by the development activity or infrastructure, together with a detailed description of those aspects of the environment that are likely to be significantly affected, and	Executive summary Chapter 7 – Assessment of key issues
iii) the likely impact on the environment of the development, activity or infrastructure, and	Chapter 7 – Assessment of key issues
iv) a full description of the measures proposed to mitigate any adverse effects of the development, activity or infrastructure on the environment, and	Chapter 7 – Assessment of key issues and Chapter 10
v) a list of any approvals that must be obtained under any other Act or law before the development, activity or infrastructure may lawfully be carried out,	Section 2.2.1 NSW legislation
e) compilation (in a single section of the environmental impact statement) of the measures referred to in item (d)(iv),	Chapter 10 – Environmental management measures
f) the reasons justifying the carrying out of the development, activity or infrastructure in the manner proposed, having regard to biophysical, economic and social considerations, including the principles of ecologically sustainable development set out in subclause (4) of Schedule 2 Part 3 Section 7.	Chapter 11 – Project justification and conclusions Section 11.1.3 – Ecologically sustainable development
2) Subclause (1) is subject to the environmental assessment requirements that relate to the environmental impact statement.	DGRs are addressed throughout the document.
3) Not applicable	
4) Principles of ecologically sustainable development	Section 11.1.3

Appendix C – Technical reports on the condition of existing Windsor Bridge

U/W Bridge Inspection

Contract 10.2535.0889

B 415 Windsor Bridge Follow-up Inspection

15.6.2011

COMPANY DIRECTORS

Martin Woschitzka
PH: (02) 6656 4411

Mob: 0418 666 220

Chris Connell
PH: (02) 6654 1930
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Email: info@commercialdivingsolutions.com

Date: 20.6.2011

RTA Parramatta
Attn: Peter Ton

B 415 Windsor Bridge over Hawkesbury River, Follow-up inspection

In accordance with your requirements and email from 10.6.2011, Commercial Diving Solutions Pty Ltd (CDS P/L) carried out the required follow-up inspection, re-documentation (photos) and fixing of glass slides in 12 locations on the 15.6.2011.

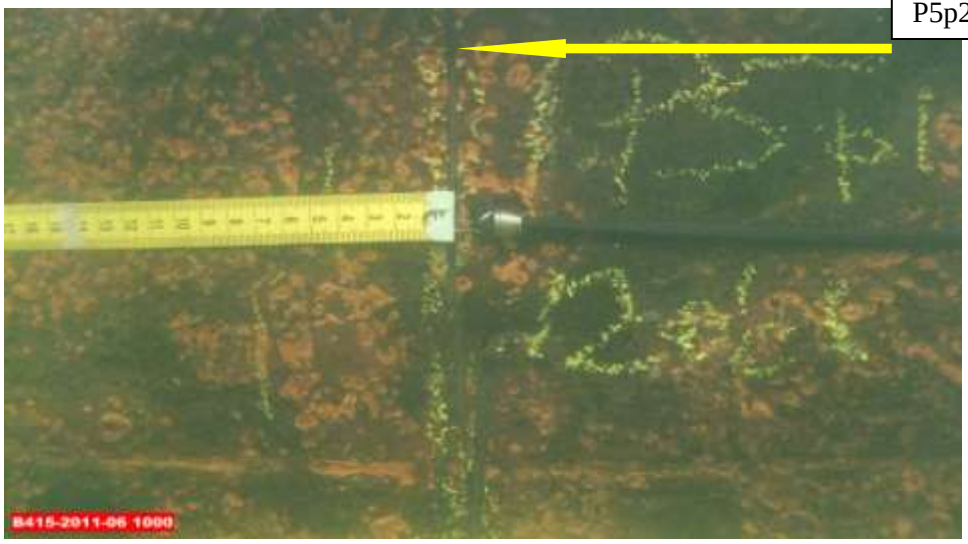
When comparing data and photos from the original inspection (9.4. to 20.4.2011) to this data set which was obtained after the Load Testing of the Bridge, carried out by RTA on the night from 8.6. to 9.6.2011, no evidence appears to be present that the horizontal cracks in piles P5p1, P5p2 and P6p2 have changed, widened or shifted. The same appears to be the case for the small vertical crack in P5p1.

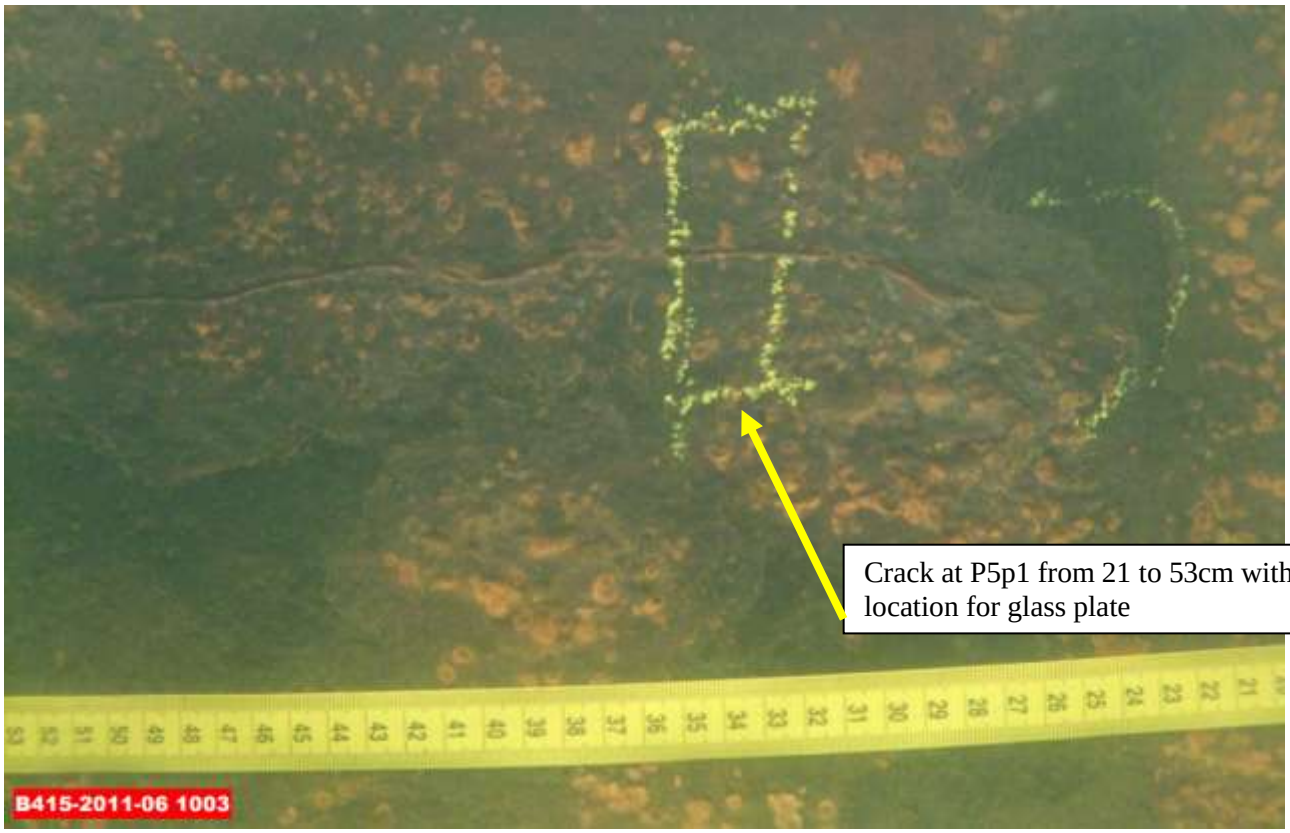
CDS was also engaged to fix a series of 12 glass plates to 4 locations over the cracks on these 3 piles. The 12x glass plates/slides (75mmx20mmx1mm) were attached over the cracks with 2part epoxy in the documented locations.
Graphite for the required areas was removed to a depth of about 10 to 15mm and epoxy balls that embedded the slides above and below the cracks were used to fix the glass plates.

For ease of reference, a continuous yellow tape measure was fixed near each of the cracks in clockwise direction with reference 0.00m starting at the upstream, 12o'clock mark at each of the 3 locations. To aid in reproducibility, a vertical grind mark approximately 1mm wide and 200mm log was ground into each of the 3x 12o'clock locations at P5p1, P5p2 and P6p2. These marks can be clearly seen in the photos and should be relocatable in future.

All Photos, in sequential order for each crack location, are contained in the folder "B415 Windsor Bridge Follow-up Inspection 15.6.2011" in the Subfolders "P5p1 insp2"(photos 1000 to 1035), "P5p2 insp2"(photos 1036 to 1074) and "P6p2 insp2"(photos 1075 to 1101).

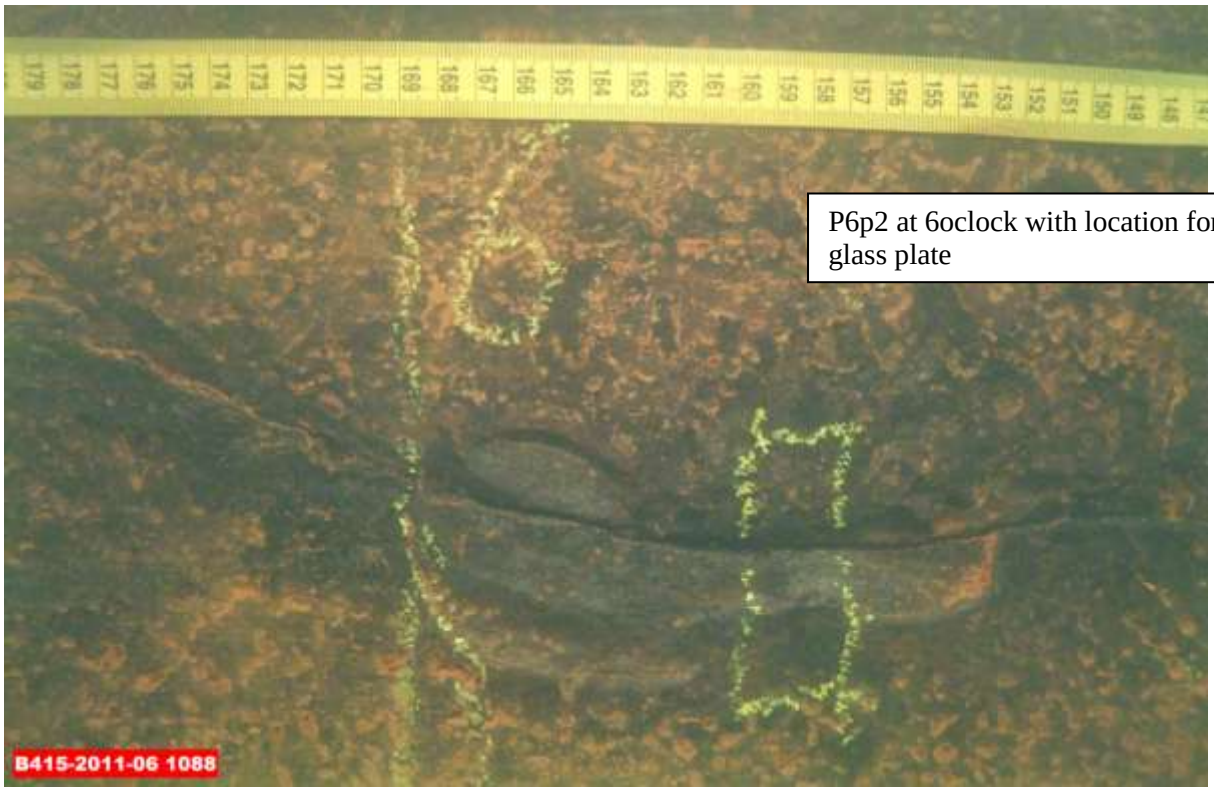
Some sample photos are set out below:





Crack at P5p1 from 21 to 53cm with location for glass plate

Glass plate on P5p1 at above location

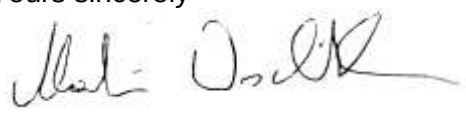


P6p2 at 6oclock with location for glass plate

P6p2 with glass plate installed near 6o'clock

We trust the inspection has been completed to your requirements.
Please contact us if you require further clarification.

Yours sincerely



Martin Woschitzka
Director
COMMERCIAL DIVING SOLUTIONS PTY LTD

ATT:

- 2x DVDs with electronic reports and Photo file “B415 Windsor Bridge Follow-up Inspection 15.6.2011”

Commercial Diving Solutions Pty Ltd
3 Fairview Road
SAPPHIRE BEACH NSW 2450

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U/W Bridge Inspection

Contract 10.2535.0889

B 415 Windsor Bridge

9.5.2011 to 20.5.2011

COMPANY DIRECTORS

Martin Woschitzka
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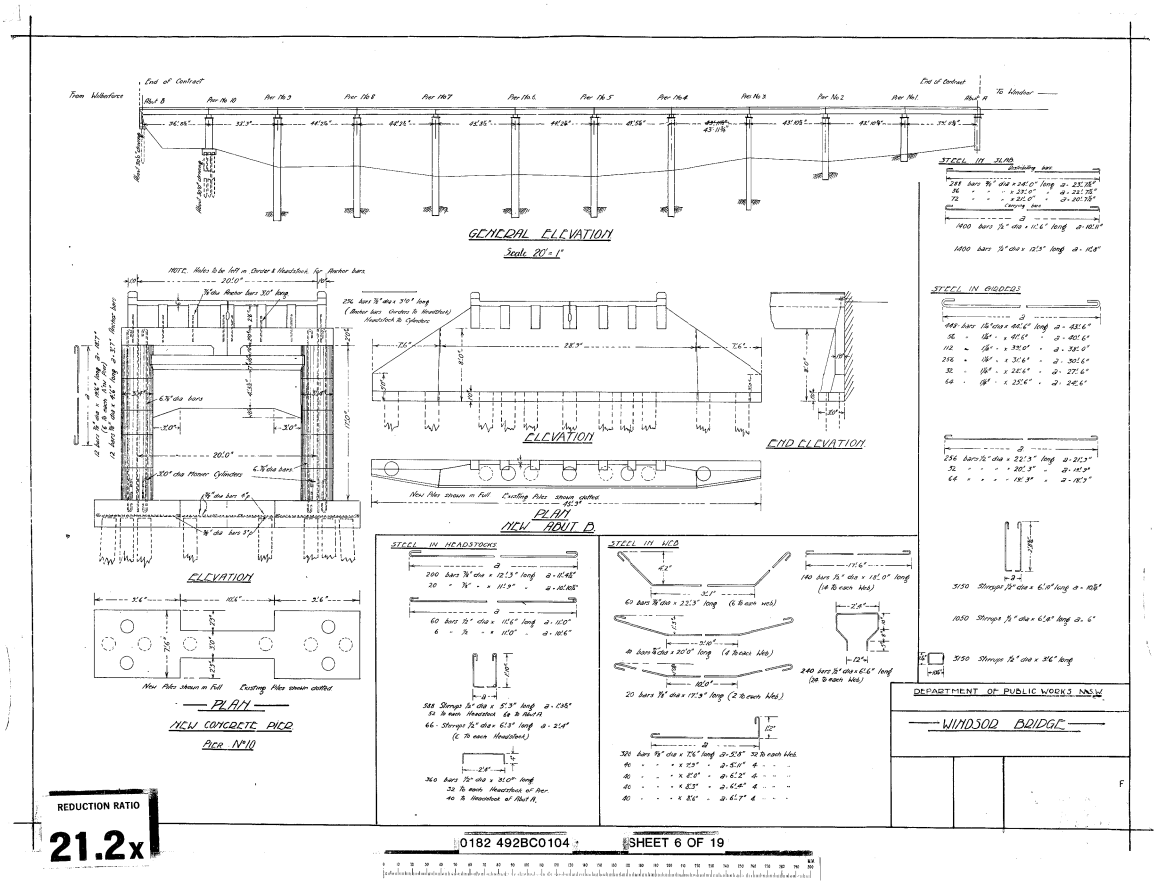
Email: info@commercialdivingsolutions.com

Date: 2.6.2011

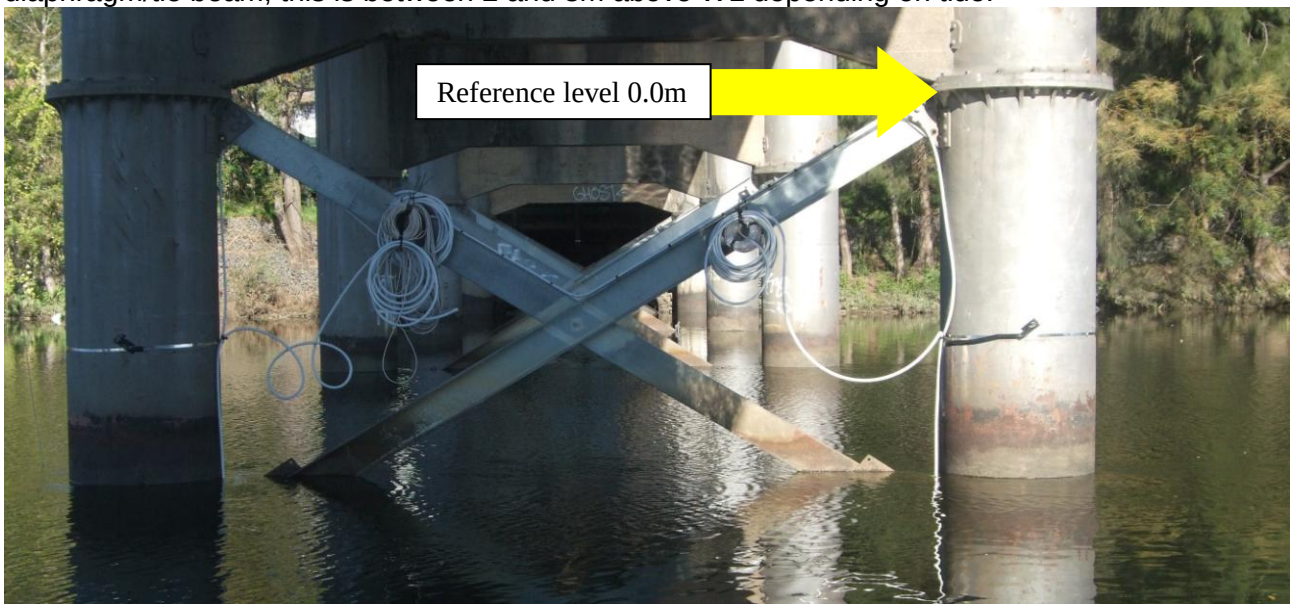
RTA Parramatta
Attn: Peter Ton

B 415 Windsor Bridge over Hawkesbury River

In accordance with the requirements of contract 10.2535.0889, Underwater Bridge Inspections within Hunter region, Commercial Diving Solutions Pty Ltd (CDS P/L) carried out the required underwater element cleaning and inspection works including condition rating for the underwater portions of elements on Piers 2 to 9. (Piers 1 and 10 were not immersed or in water too shallow for diving inspection at time of inspection). Works commenced 9.5.2011 and were completed 20.5.2011. A total of 89 working hours (11 days) with a 4MDT were spent to complete the required inspection works on this bridge which included also Principal ordered additional work of drilling and recovery of 17 cores and fitting of 4underwater sets of metal braces with attached monitoring sensors and wiring.



As directed, the piles for cleaning and inspection on piers 2 to 9 were numbered 1(US) and 2(DS) for each pier, ie Pier 5 pile 2 would be “P5p2” .
Reference for all measurements is from bottom edge of Caisson Flange directly below concrete diaphragm/tie beam, this is between 2 and 3m above WL depending on tide.



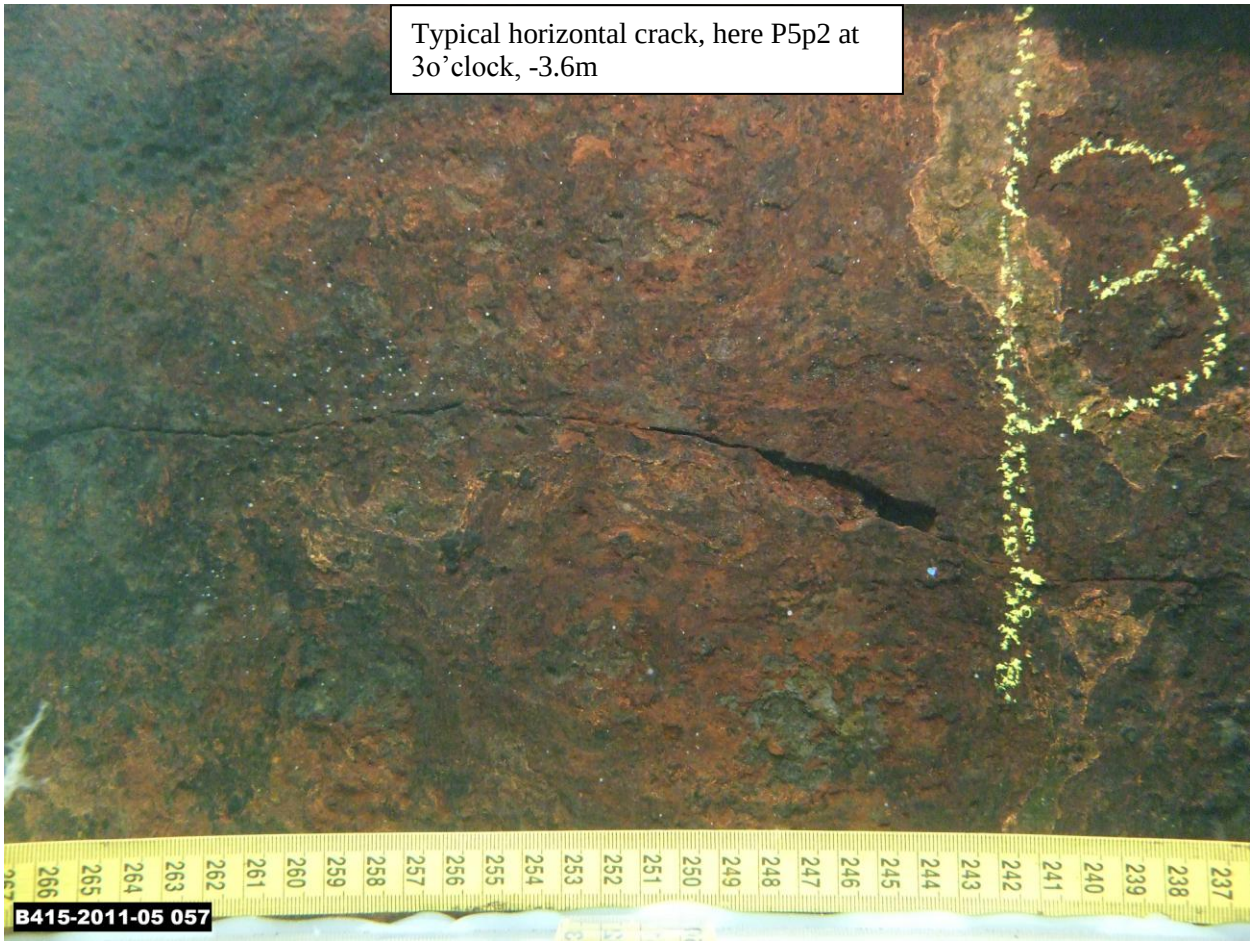
The piles of this bridge are approx. 1.08m diameter cast iron caissons (measured circumference of 3.37m) that are mass(concrete?) filled. Each pile consists of several approx. 1.84m high segments which are bolted together by internal caisson flanges(as per core recovered from segment join) and has a height adjusted last segment at it's top that is finished with an external flange, just below the concrete diaphragm.
Note that bottom edge of this flange forms the RL of depth and other location measurements in this report

Water conditions at time of inspection:
Fresh water, with water visibility of approx.0.3 to 0.5m with sandy riverbed at the piles and no obvious scouring. There was a daily tidal range of up to 1m noticeable during diving work. The current ran out at up to 2kn and in at up to 1kn.

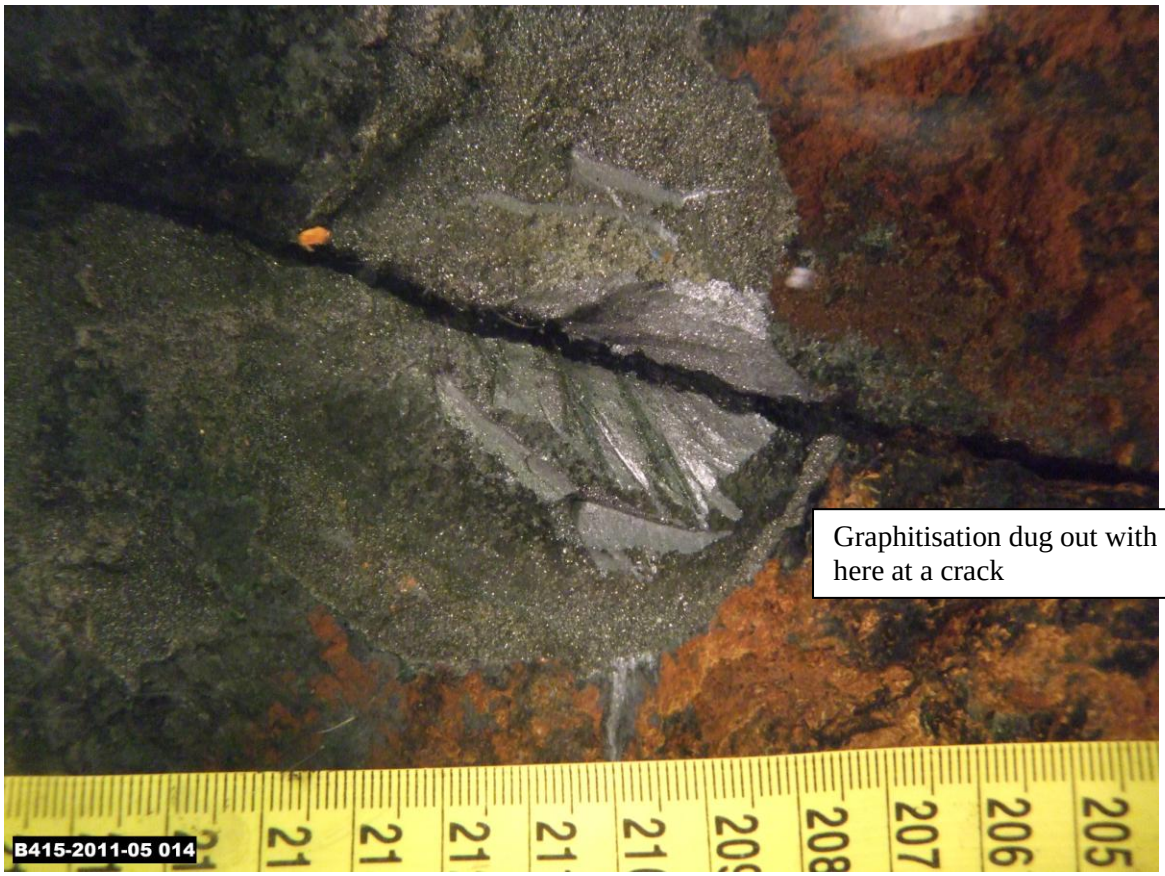
Horizontal ring cracks were found on 3 caissons of this bridge (P5p1, P5p2 and P6p2). One small vertical crack was found on P5p1.

All inspected below water surfaces of the cast iron caissons of this bridge appeared heavily built up with nodules of about 30 to 50mm diameter, up to 50mm high and all covered with a thin layer (up to 20mm) of marine growth. After removing/cleaning the surface layer (some marine growth and a carbonised, black and rusty layer up to 30mm thick), an even graphitised layer about 5-15mm thickness (and up to 20mm in isolated areas) is covering most areas of the underwater surfaces that were investigated and inspected. Near Bed Level the noduling is less pronounced and graphitisation appears to be much thinner. (less than 3 mm)

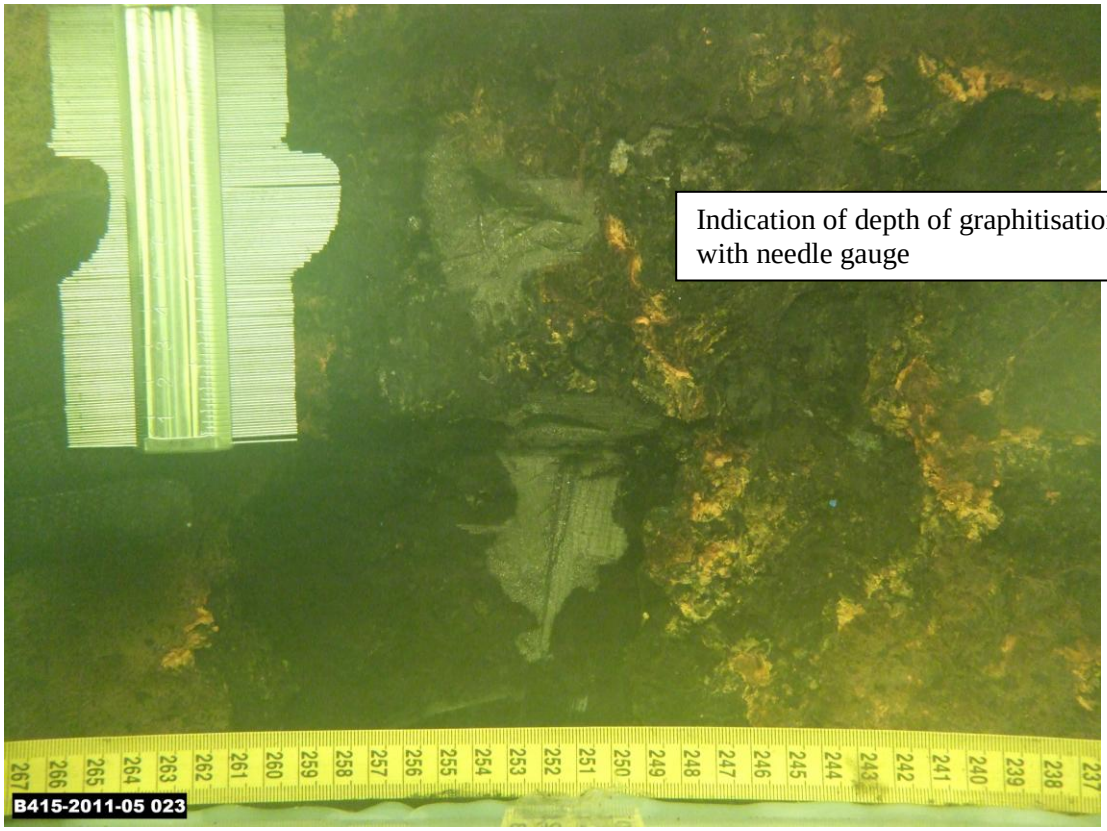
The 17 Core samples that were taken appear to confirm this "global" graphitisation pattern.
Core samples were handed to Fred Salome (CTI Consultants) for analysis.



Typical horizontal crack, here P5p2 at 3o'clock, -3.6m

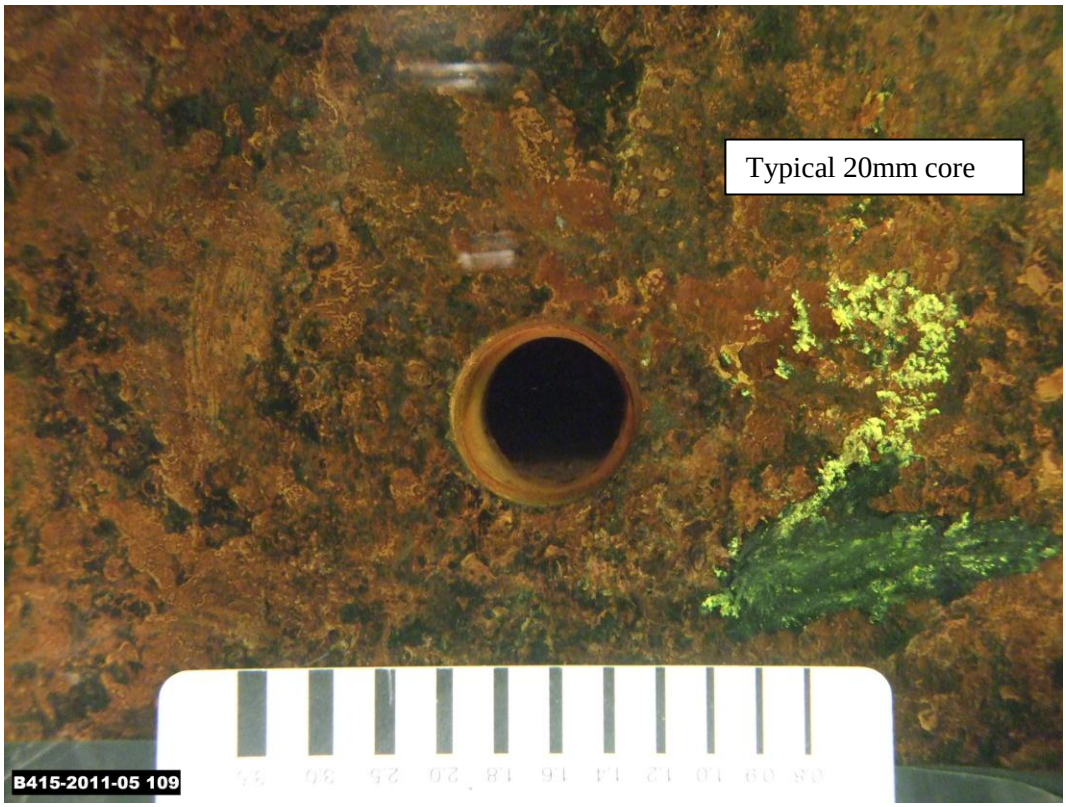


Graphitisation dug out with sharp edge, here at a crack



Indication of depth of graphitisation with needle gauge

50mm core intersecting crack
B415-2011-05 119

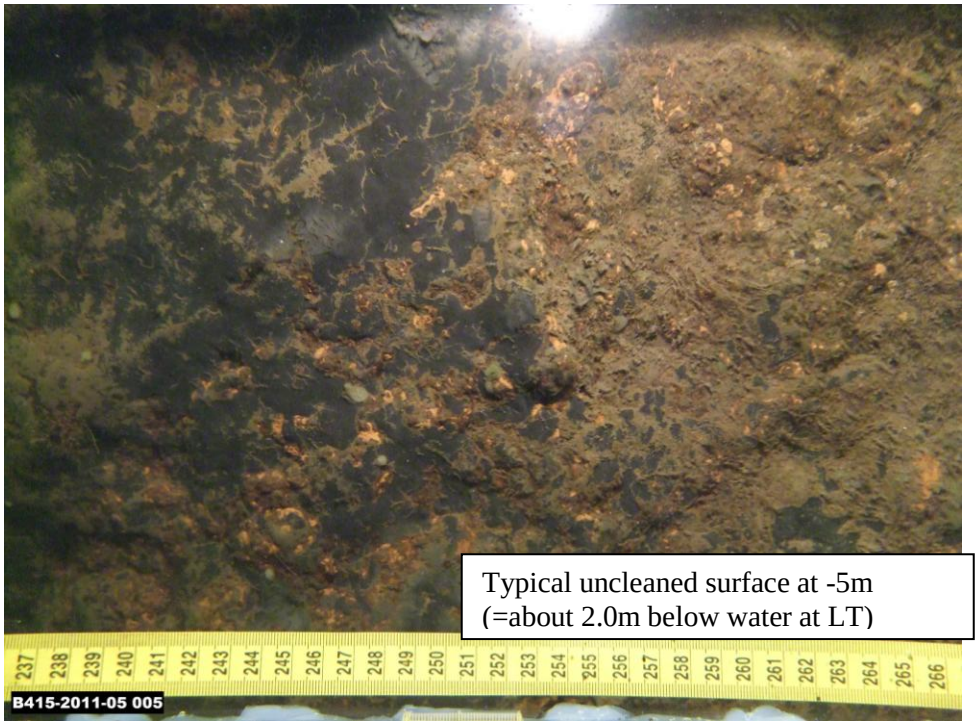

Typical 20mm core
B415-2011-05 109

Pile Cleaning – (B350 / clause 4.5.1)

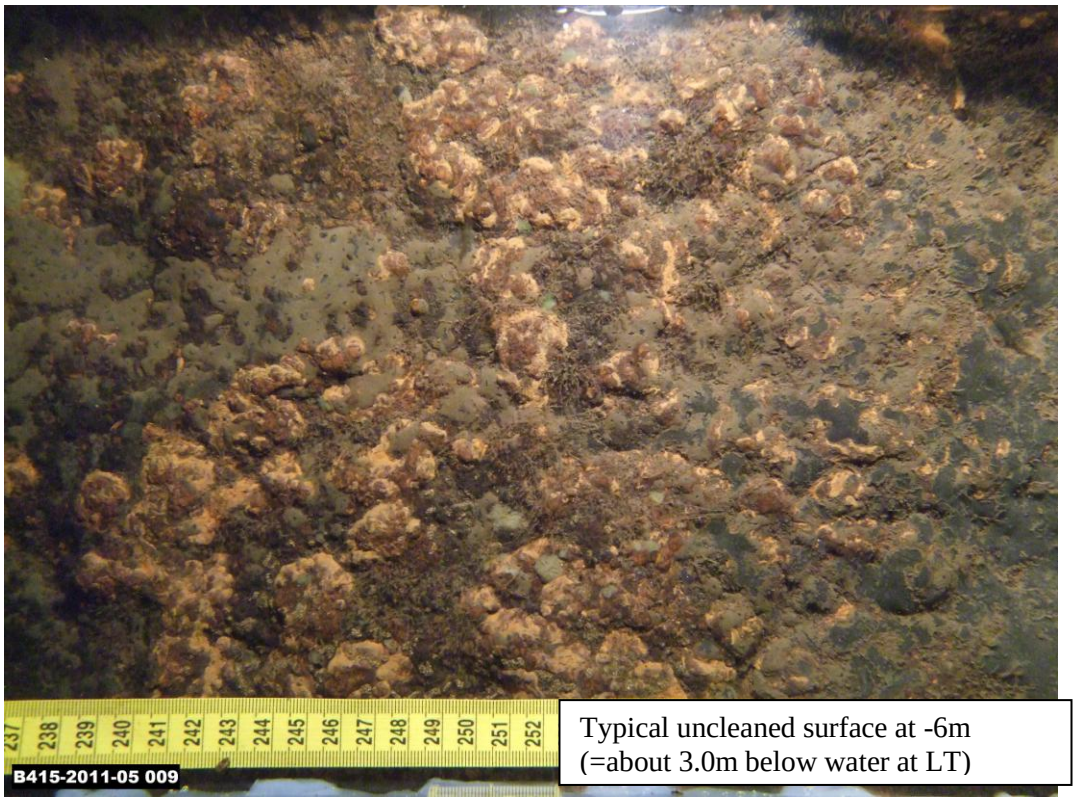
Full HP water cleaning on 14 piles of Piers 2 to 8 was carried out. A High-Pressure Water Unit with on site water extraction and adjusted, moderate nozzle pressure of approximately 200 bar, EWP at turbo nozzle approx 280-300 bar with angle of attack of approx. 35-45 degrees was used for better efficiency than hand tools. The cleaning system delivers a clean surface with all marine growth and most carbonisation removed for ease of caisson inspection. Please note that minimal graphitised material only is removed in this process.

Typical uncleaned surface, note the different growth/noduling at various depths:

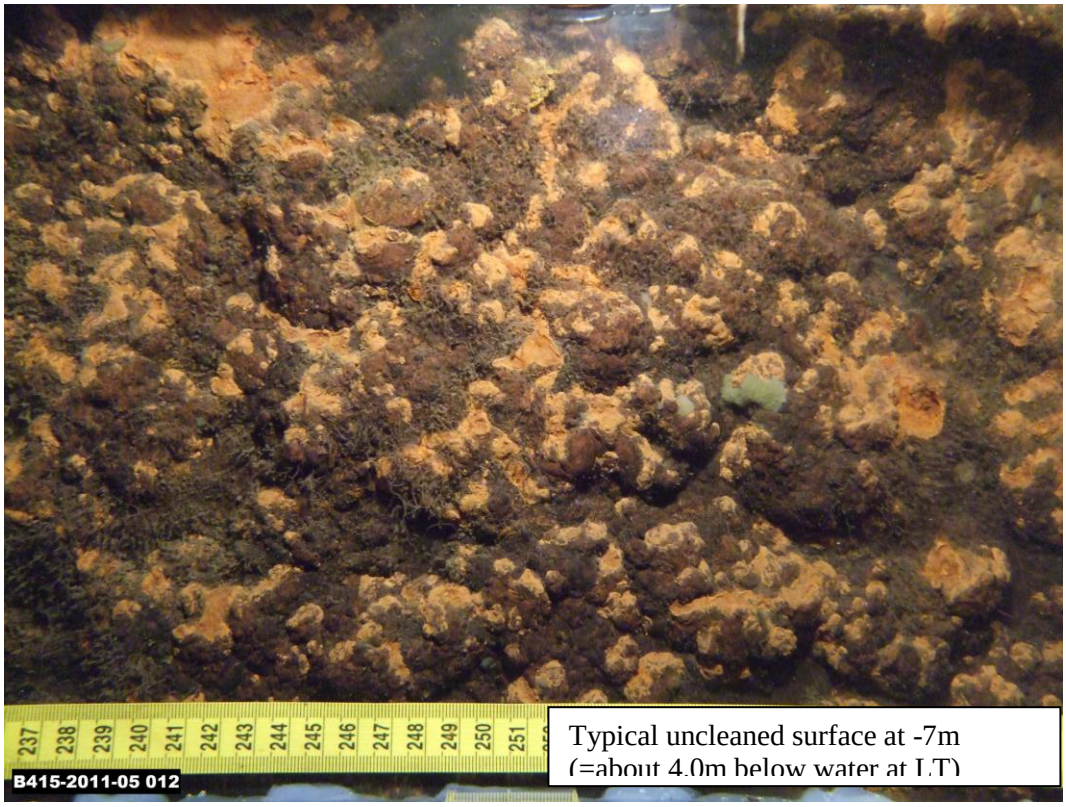
Typical uncleaned surface at -3m
(=about 0.1-0.3m below water at LT)



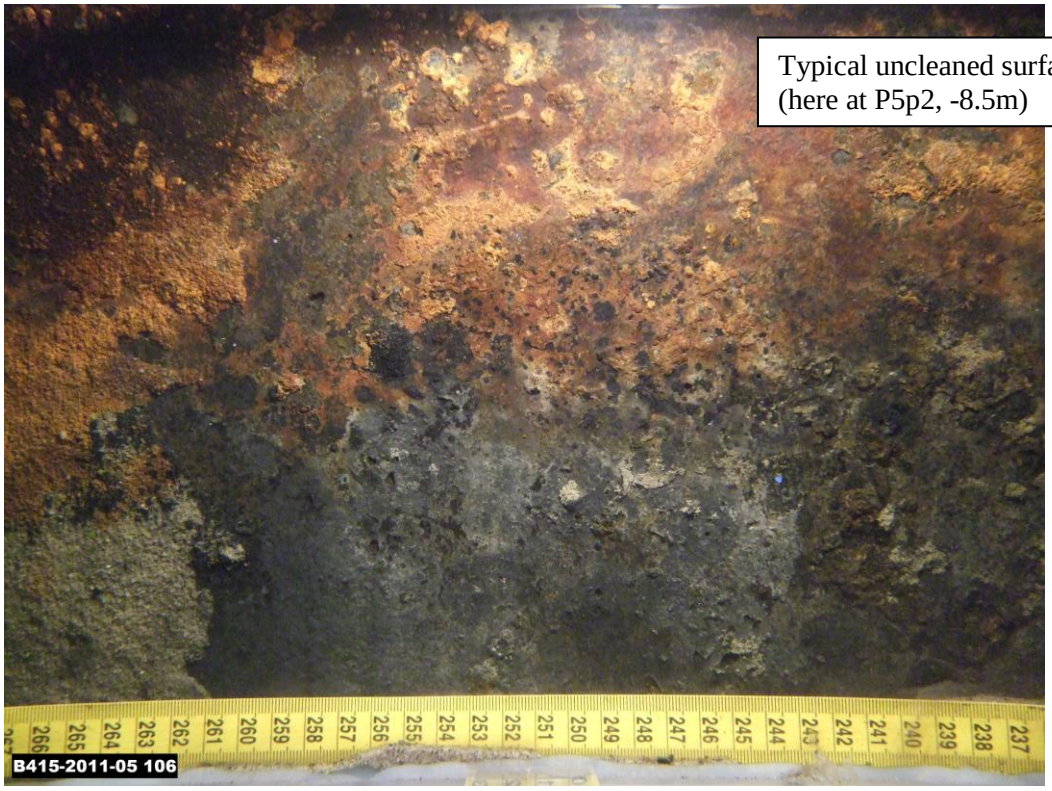
Typical uncleaned surface at -5m
(=about 2.0m below water at LT)



Typical uncleaned surface at -6m
(=about 3.0m below water at LT)



Typical uncleaned surface at -7m
(=about 4.0m below water at LT)



Typical uncleaned surface at BL
(here at P5p2, -8.5m)

Once the pile surface was pressure cleaned, a black, clean graphitised surface presented. This surface only stayed black for a couple of hours before oxydising and appearing completely rusty 24 hours later:

Cleaned surface, immediately after clean,
here at old core from previous inspection

Typical pile surface 2 hours after clean

Typical pile surface 24 hours after clean

All photos used in this report and more sample pictures are in the file “B 415 Windsor Bridge photos” in relevant labelled subfolders on the attached DVD together with electronic copy of this report.

Following is the detailed inspection report on elements as per the amended cleaning schedule for this bridge which asked for all piles of piers 2 to 8 to be fully cleaned and inspected.

Please note that we have numbered piles as directed and also show river bed levels measured from the depth reference (Bottom edge of Caisson flange below concrete tie beam) at the element.

Individual element depths are up to 2.5m deeper (average:1.5m) than natural bed levels approx. 15m up- and 15m downstream from the piers indicating ongoing scouring and changing river bed levels. The attached sketch summarises the measured depths from RL (bottom of Caisson flange) as at 19.5.2011. At time of measurements RL was 2.5m above water level.

Bed Level Depths from RL (Bottom Edge of caisson flange below concrete tie beam) at piles and approx. 15m US and DS

○ Indicates cleaned and inspected piles

WINDSOR ↑

←Downstream Upstream →

Approx. 15m			Approx. 15m	
• -2.7m	○ -2.7m	**PIER 1**	-2.7m ○	-2.7m •
• -5.7m	○ -6.5m	**PIER 2**	-6.3m ○	-5.9m •
• -6.3m	○ -7.2m	**PIER 3**	-7.9m ○	-5.4m •
• -6.8m	○ -7.6m	**PIER 4**	-8.1m ○	-5.5m •
• -6.9m	○ -8.5m	**PIER 5**	-8.1m ○	-5.6m •
• -6.3m	○ -7.6m	**PIER 6**	-7.5m ○	-5.3m •
• -6.4m	○ -7.5m	**PIER 7**	-7.1m ○	-5.7m •
• -7.0m	○ -7.3m	**PIER 8**	-7.3m ○	-5.3m •
• -6.2m	○ -6.5m	**PIER 9**	-6.3m ○	-5.6m •
• -2.7m	○ -2.7m	**PIER 10**	-2.7m ○	-3.0m •

TO WILBERFORCE ↓

UNDERWATER BRIDGE INSPECTION - FORM A

SUMMARY REPORT FOR BRIDGE / WATERWAY

Bridge No.:	B 415
Bridge Name / Description:	Windsor Bridge
Date(s) of Inspection:	9.5.2011 to 20.5.2011
Inspection Conditions:	Est. Water Temp. 12ºC Weather: fine River Flow: tidal, up to 2kn run-out current .
Water Quality:	Fresh
Water Visibility:	Cloudy, visibility up to 0.5m
Waterway Bed Material:	Sandy
Waterway Bed Scour: (show bed depths in General Inspection Report for Individual Elements)	Up to 2.5m, 1.5m average
Waterway Bed Debris:	Old car U/S of P5p1, some driftwood on all U/s areas of U/S piles
General Comments: (Underwater Bridge Condition Summary)	Graphitisation found in all underwater areas inspected Coring recovered 17 cast iron plugs, 24mm max thickness, these show 0-20mm of graphitisation, variation appears to depend on cored area, worst in the first 2-3m below LWL.

LIST OF ATTACHMENTS

1. Water Test Report: N/A
2. General Inspection Report For Individual Elements
3. Detailed Inspection Reports (see General Inspection Report for summary)
4. Video Camera Logs (number of logs attached) .0, not required

Total normal hours worked (team)	Total overtime hours worked (team)	Total hours of travelling to bridge (team)	Diving Team Size (persons)
80	**9**	**17**	**4**

Dive Team:

Diving Supervisor: Martin Woschitzka

Lead Diver (underwater): C. Connell, G May

Other(s): K Welling, J Webster

.....

UNDERWATER BRIDGE INSPECTION – FORM B

GENERAL INSPECTION REPORT FOR INDIVIDUAL ELEMENTS

Bridge Name: Windsor Bridge…….. **Bridge No:** 415.....

Depth reference for all elements: Bottom edge of caisson flange below concrete tie beam

Abutment or Pier No.	**Element or Pile No.**	**Element Code** (refer Annexure B350/E)	**Bed Depth below nominated reference** (refer Clause 5)	**Nominated for Detailed Inspection?** (Yes/No)	**Detailed Inspection Reports** (No. Pages attached)	**Video Camera Log of Cleaned Surfaces?** (Yes/No)	**Comments on Element Condition** *(Mandatory for Individual Elements not nominated for detailed inspection. All Individual Elements on the bridge must be accounted for as line entries on this form, and more than one page may be required)*
1	1	SPIL	-2.7m	N		N	Too shallow for diving inspection
1	2	SPIL	-2.7m	N		N	Too shallow for diving inspection
2	1	SPIL	-6.3m	Y ,full clean	1	N	All inspected U/W areas inspected show graphitisation
2	2	SPIL	-6.5m	Y ,full clean	1	N	All inspected U/W areas inspected show graphitisation
3	1	SPIL	-7.9m	Y ,full clean	1	N	All inspected U/W areas inspected show graphitisation
3	2	SPIL	-7.2m	Y ,full clean	1	N	All inspected U/W areas inspected show graphitisation
4	1	SPIL	-8.1m	Y ,full clean	1	N	All inspected U/W areas inspected show graphitisation
4	2	SPIL	-7.6m	Y ,full clean	1	N	All inspected U/W areas inspected show graphitisation
5	1	SPIL	-8.1m	Y ,full clean	2	N	All inspected U/W areas inspected show graphitisation, horizontal and vert. cracks
5	2	SPIL	-8.5m	Y ,full clean	2	N	All inspected U/W areas inspected show graphitisation, horizontal crack

Bridge Name: Windsor Bridge…….. **Bridge No:** 415.....

Depth reference for all elements: Bottom edge of caisson flange below concrete tie beam

Abutment or Pier No.	**Element or Pile No.**	**Element Code** (refer Annexure B350/E)	**Bed Depth below nominated reference** (refer Clause 5)	**Nominated for Detailed Inspection?** (Yes/No)	**Detailed Inspection Reports** (No. Pages attached)	**Video Camera Log of Cleaned Surfaces?** (Yes/No)	**Comments on Element Condition** *(Mandatory for Individual Elements not nominated for detailed inspection. All Individual Elements on the bridge must be accounted for as line entries on this form, and more than one page may be required)*
6	1	SPIL	-7.5m	Y ,full clean	1	N	All inspected U/W areas inspected show graphitisation
6	2	SPIL	-7.6m	Y ,full clean	2	N	All inspected U/W areas inspected show graphitisation, horizontal crack
7	1	SPIL	-7.1m	Y ,full clean	1	N	All inspected U/W areas inspected show graphitisation
7	2	SPIL	-7.5m	Y ,full clean	1	N	All inspected U/W areas inspected show graphitisation
8	1	SPIL	-7.3m	Y ,full clean	1	N	All inspected U/W areas inspected show graphitisation
8	2	SPIL	-7.3m	Y ,full clean	1	N	All inspected U/W areas inspected show graphitisation
9	1	SPIL	-6.3m	Y ,full clean	1	N	All inspected U/W areas inspected show graphitisation
9	2	SPIL	-6.5m	Y ,full clean	1	N	All inspected U/W areas inspected show graphitisation
10	1	SPIL	-2.7m	N		N	Too shallow for diving inspection
10	2	SPIL	-2.7m	N		N	Too shallow for diving inspection

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 2 Element No. 1 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 11m^2 total surface area

A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	11m^2	Graphitisation over entire pile surface underwater, up to 15mm thick,
4		
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -1.12m, -2.96m, -4.80m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 15mm	3
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5	Bed level at pile: -6.3m	
7.0		
7.5		
8.0		

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 2 Element No. 2 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 11m^2 total surface area

A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	11m^2	Graphitisation over entire pile surface underwater, up to 15mm thick,
4		
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -1.52m, -3.535m, -5.19m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 15mm	3
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5	Bed level at pile: -6.5m	
7.0		
7.5		
8.0		

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 3 Element No. 1 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 17m^2 total surface area

A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	17m^2	Graphitisation over entire pile surface underwater, up to 15mm thick,
4		
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -0.97m, -2.81m, -4.65m, -6.49m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 15mm	3
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0		
7.5		
8.0	Bed level at pile: -7.9m	

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 3 Element No. 2 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 15m^2 total surface area

A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	15m^2	Graphitisation over entire pile surface underwater, up to 15mm thick,
4		
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -1.04m, -2.88m, -4.72m, -6.56m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 15mm	3
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5	Bed level at pile: -7.2m	
7.0		
7.5		
8.0		

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 4 Element No. 1 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 17m^2 total surface area

A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	17m^2	Graphitisation over entire pile surface underwater, up to 15mm thick,
4		
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -1.67m, -3.51m, -5.37m, -7.20m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 15mm	3
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0		
7.5		
8.0	Bed level at pile: -8.1m	

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 4 Element No. 2 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 16m^2 total surface area

A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	16m^2	Graphitisation over entire pile surface underwater, up to 15mm thick,
4		
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -1.72m, -3.56m, -5.40m,-7.26m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 15mm	3
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0		
7.5	Bed level at pile: -7.6m	
8.0		

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 5 Element No. 1 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 17m^2 total surface area

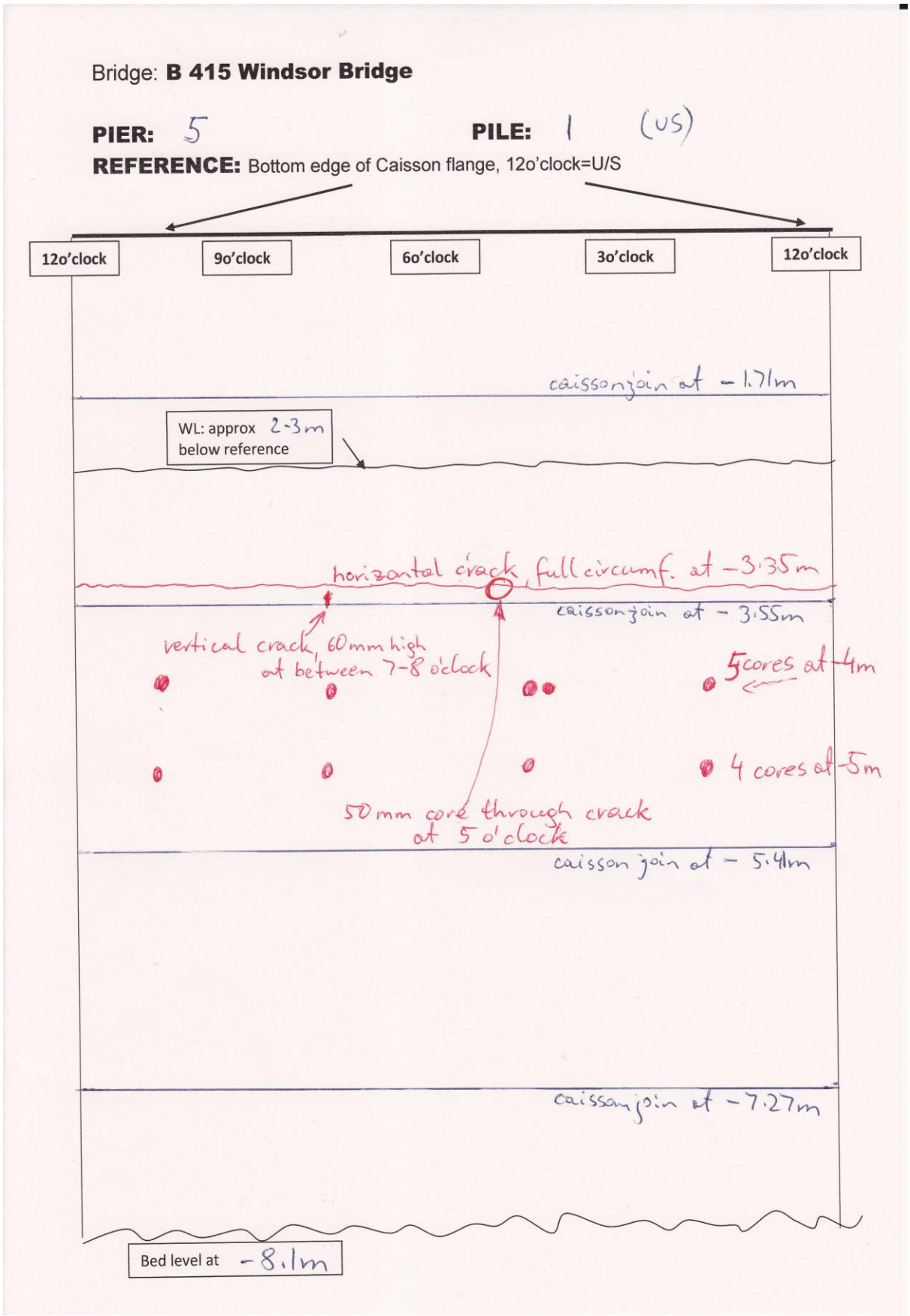
A. CONDITION RATING

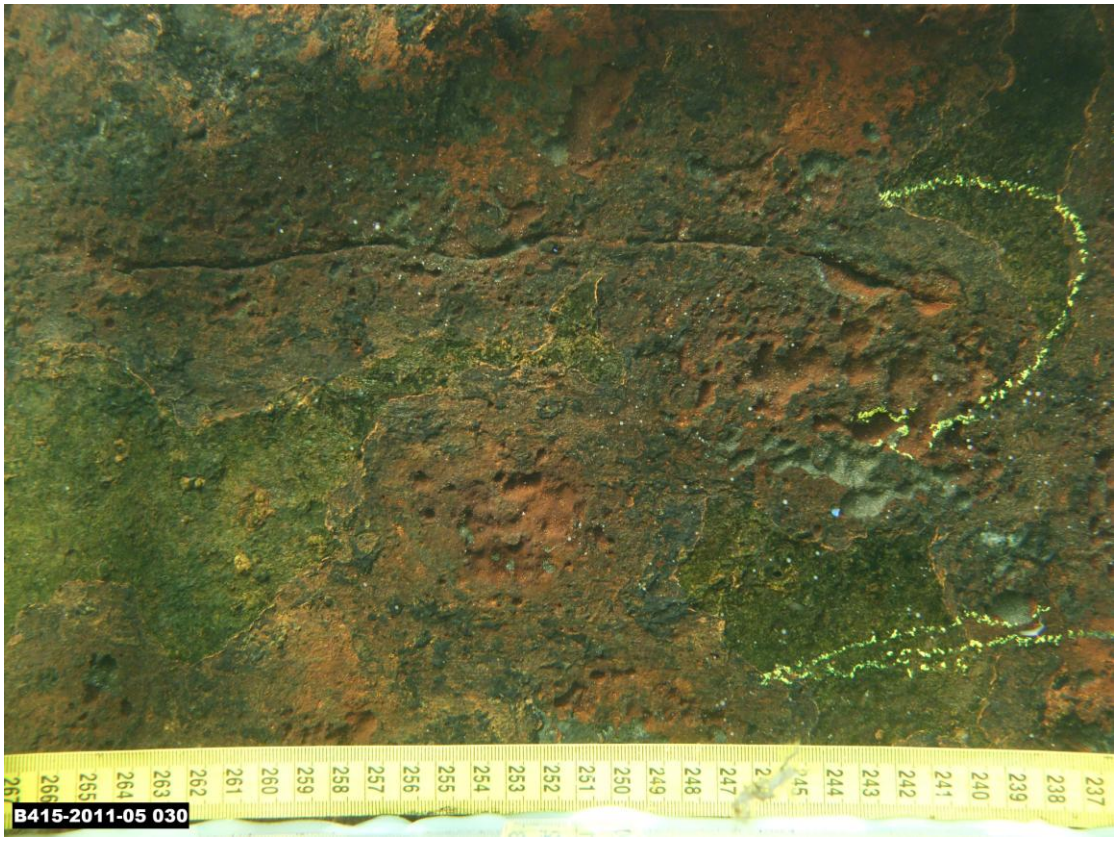
Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	14m^2	Graphitisation over entire pile surface underwater, up to 20mm thick,
4	3m^2	Horizontal crack all round at about -3.35m
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -1.71m, -3.55m, --5.41m, -7.25m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 20mm	3
	10 core samples taken at locations shown next page	
2.0		
2.5		
3.0		
3.5	Horizontal crack all round about 200-250mm above caisson join	4
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0		
7.5		
8.0	Bed level at pile: -8.1m	


Bridge: B 415 Windsor Bridge
PIER: 5
PILE: 1 (US)
REFERENCE: Bottom edge of Caisson flange, 12o'clock=U/S
12o'clock
9o'clock
6o'clock
3o'clock
12o'clock
caisson join at -1.71m
WL: approx 2-3m below reference
horizontal crack, full circumf. at -3.35m
caisson join at -3.55m
vertical crack, 60mm high at between 7-8 o'clock
5 cores at -4m
4 cores at -5m
50mm core through crack at 5 o'clock
caisson join at -5.41m
caisson join at -7.27m
Bed level at -8.1m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B415-2011-05 032

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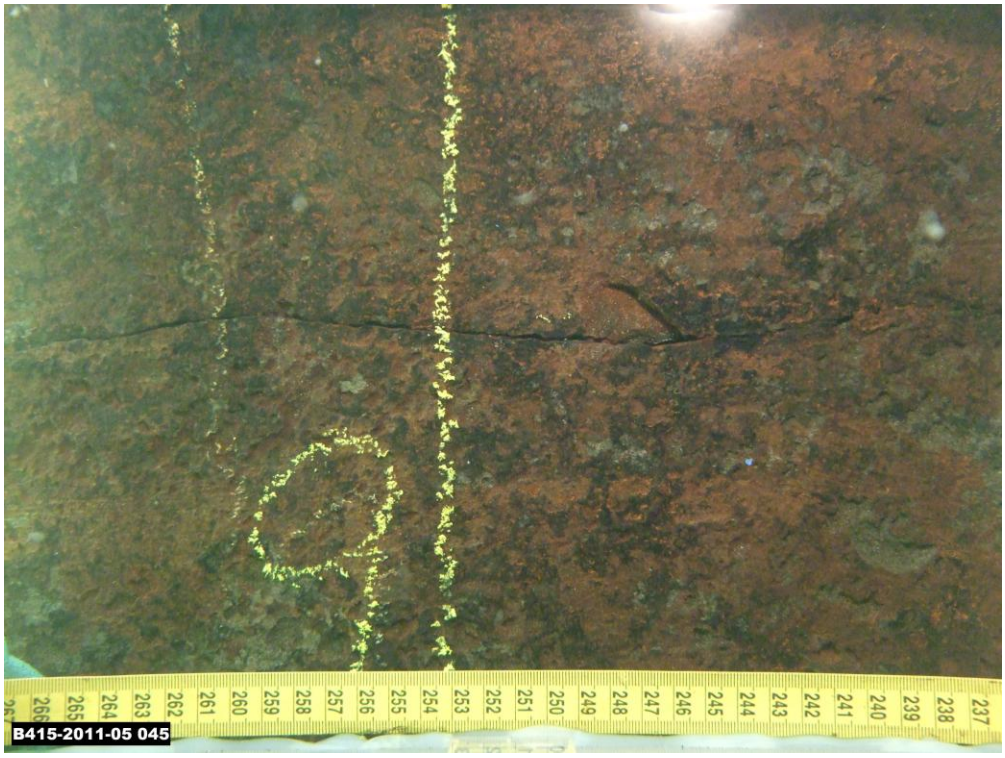
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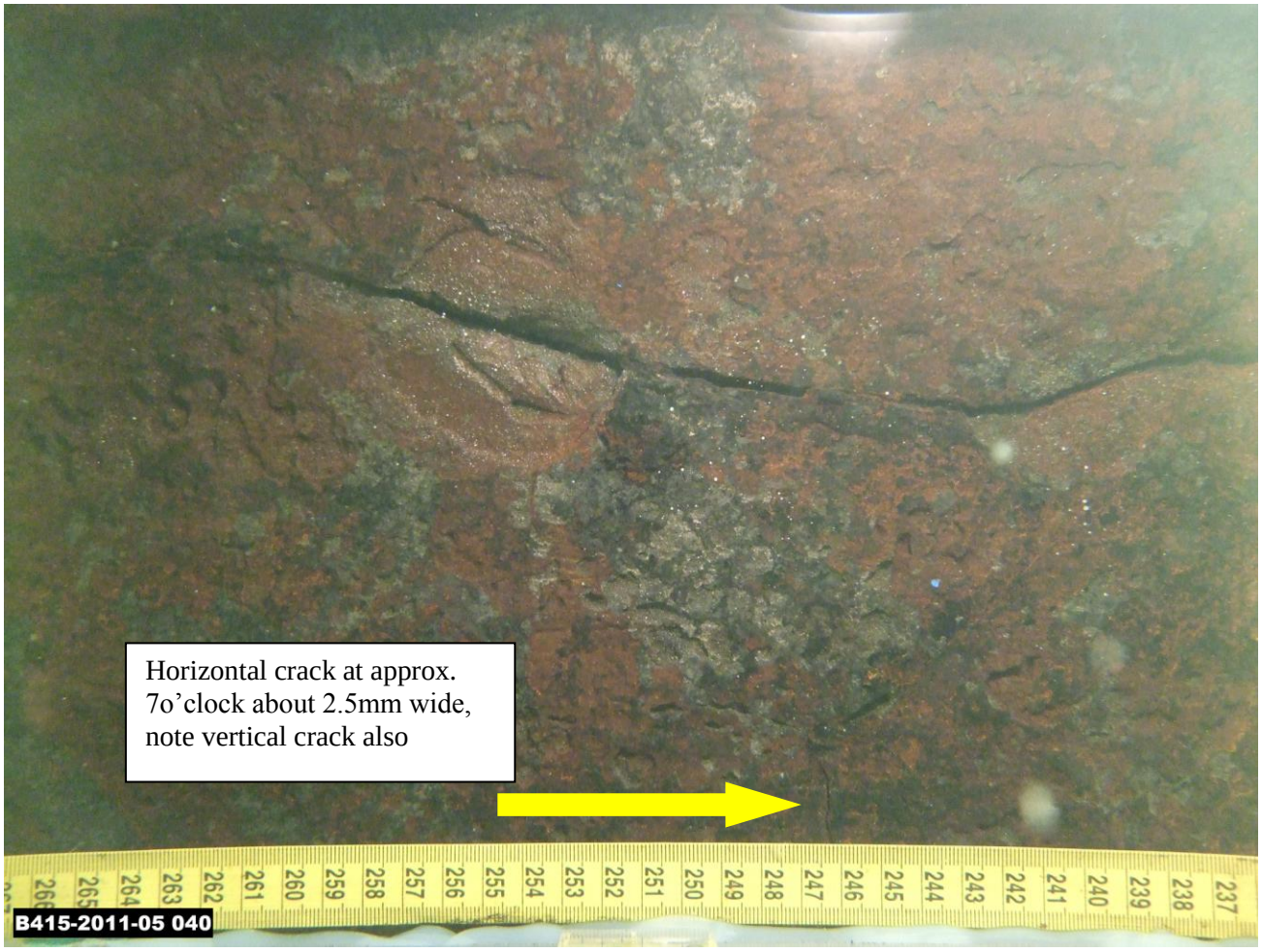

Horizontal crack at approx. 7o'clock about 2.5mm wide, note vertical crack also
B415-2011-05 040

Same vertical crack, at approx 7o'clock, at caisson join -3.55m (note: picture taken 24hrs after clean
B415-2011-05 041

Same vertical crack again, note: picture taken 0.5hrs after clean
B415-2011-05 138

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 5 Element No. 2 Cleaning Method: High-pressure water

Element Code & Type: SPIL, approx 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 18m^2 total surface area

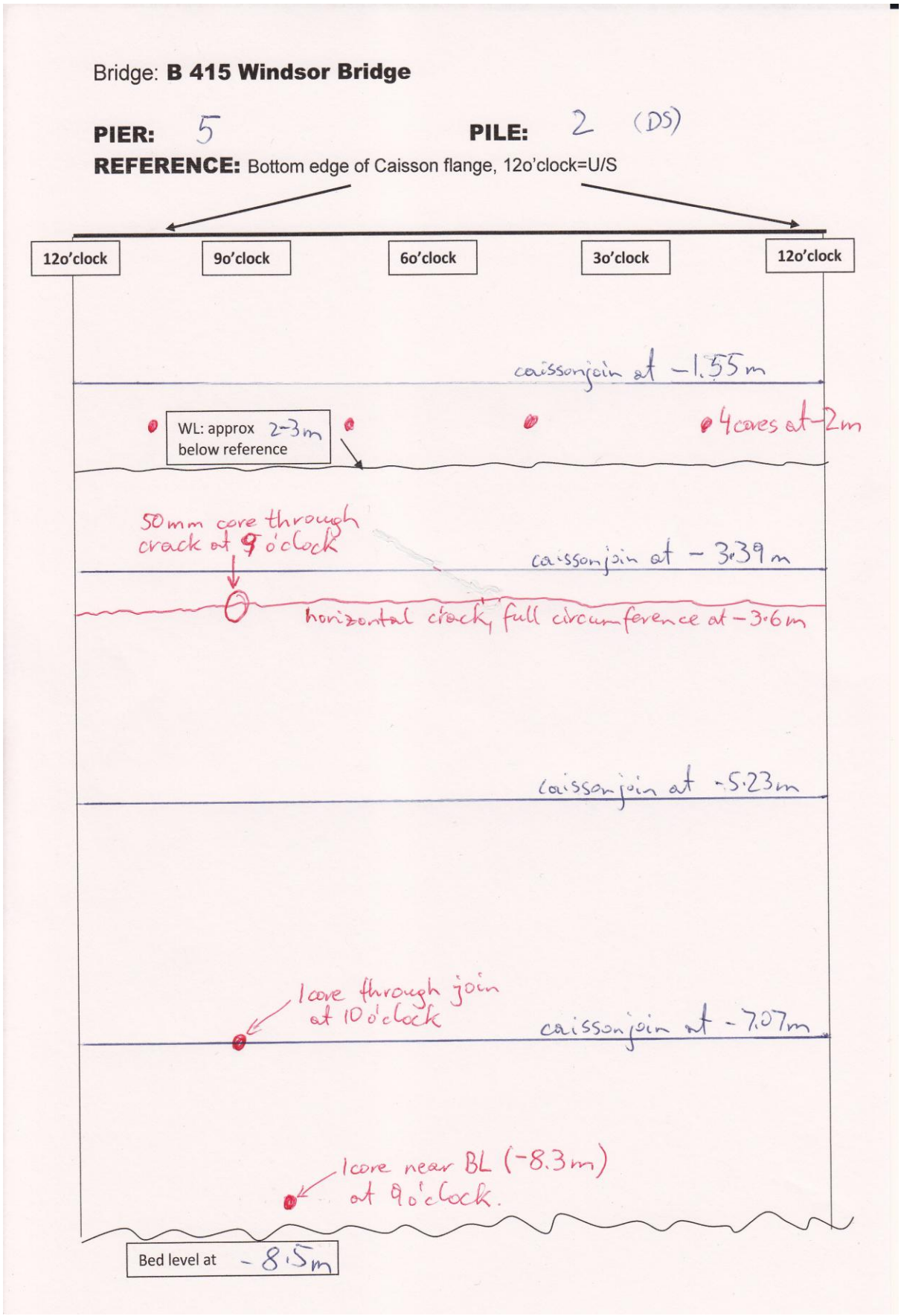
A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	15m^2	Graphitisation over entire pile surface underwater, up to 20mm thick,
4	3m^2	Horizontal crack all round at about -3.6m
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -1.55m, -3.39m, -5.23m, -7.07m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 20mm	3
1.5	7 core samples taken at locations shown next page	
2.0		
2.5		
3.0		
3.5	Horizontal crack all round about 200-250mm below caisson join at about -3.6m	4
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0		
7.5		
8.0	Bed level at pile: -8.5m	


Bridge: B 415 Windsor Bridge
PIER: 5
PILE: 2 (DS)
REFERENCE: Bottom edge of Caisson flange, 12o'clock=U/S
12o'clock
9o'clock
6o'clock
3o'clock
12o'clock
caissonjoin at -1.55m
WL: approx 2-3m below reference
4cores at -2m
50mm core through crack at 9 o'clock
caissonjoin at - 3.39m
horizontal crack, full circumference at -3.6m
caissonjoin at -5.23m
1core through join at 10 o'clock
caissonjoin at -7.07m
1core near BL (-8.3m) at 9o'clock.
Bed level at -8.5m

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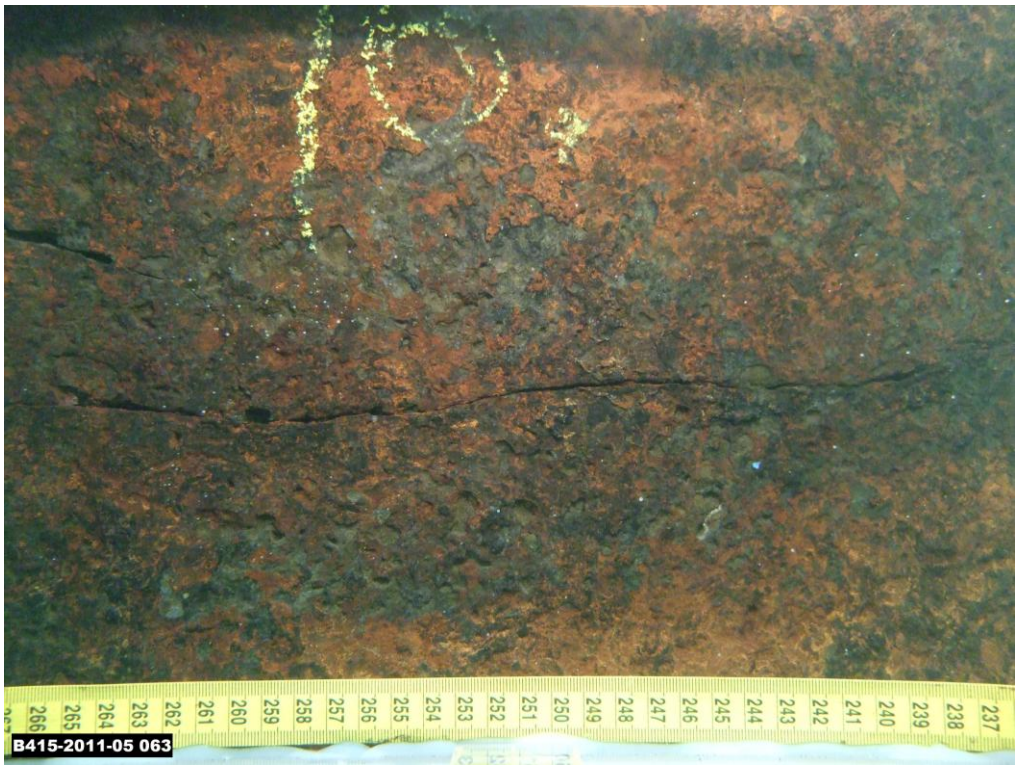
B415-2011-05 056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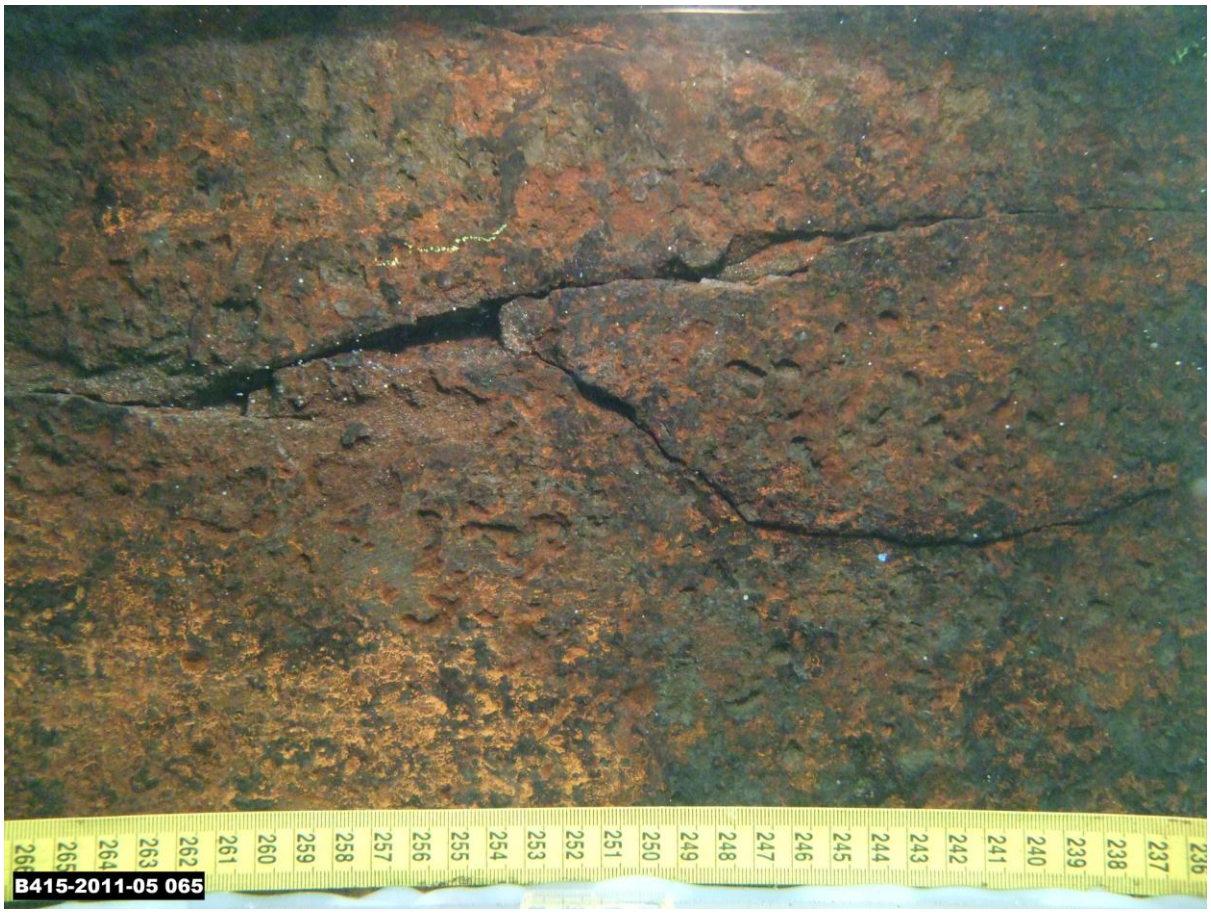
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B415-2011-05 070

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 6 Element No. 1 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 15m^2 total surface area

A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	15m^2	Graphitisation over entire pile surface underwater, up to 15mm thick,
4		
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -0.57m, -2.41m, -4.26m, -6.11m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 15mm	3
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0		
7.5	Bed level at pile: -7.5m	
8.0		

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 6 Element No. 2 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 15m^2 total surface area

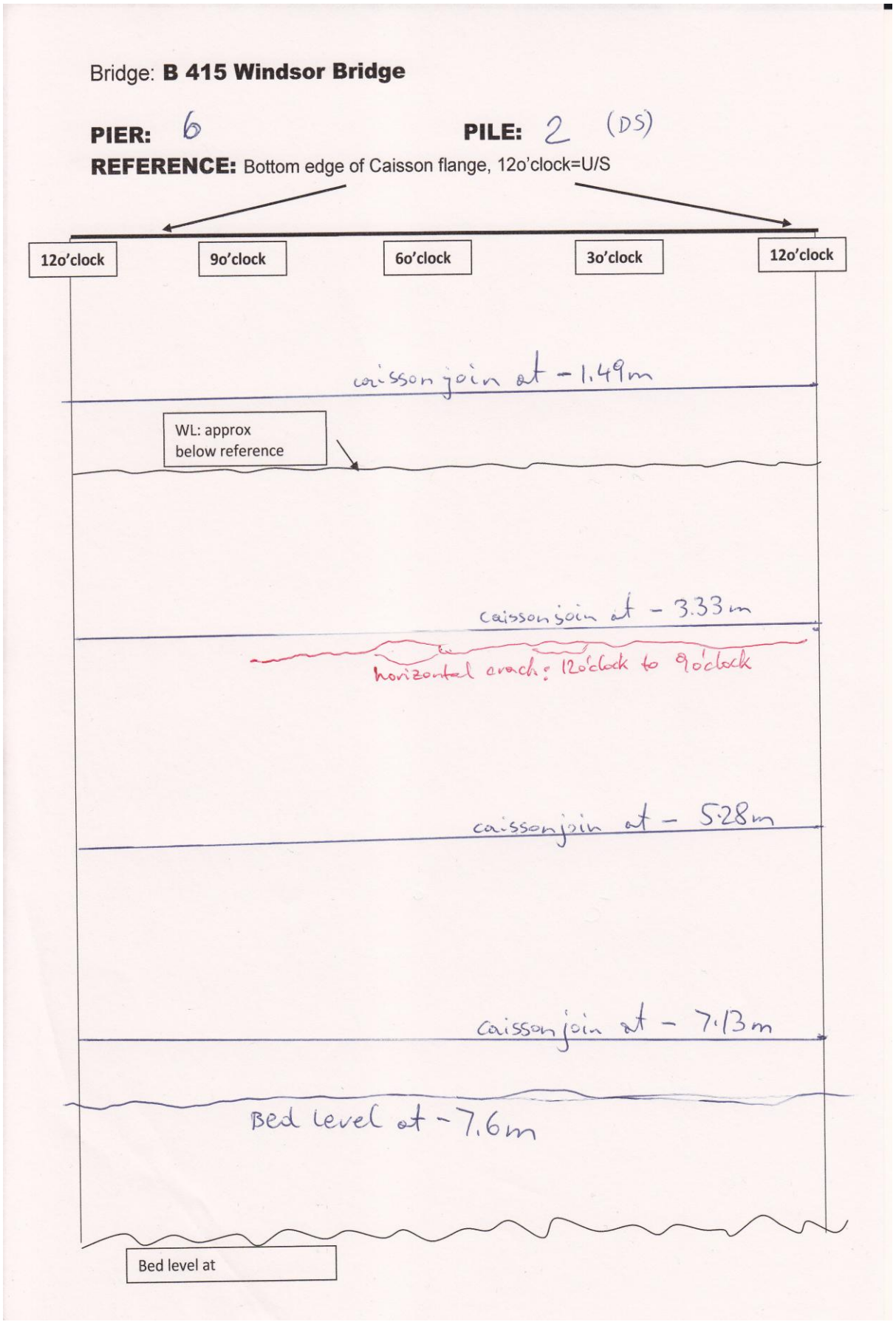
A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	12m^2	Graphitisation over entire pile surface underwater, up to 15mm thick,
4	3m^2	Horizontal crack from just after12o'clock to 9o'clock at about -3.4m
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

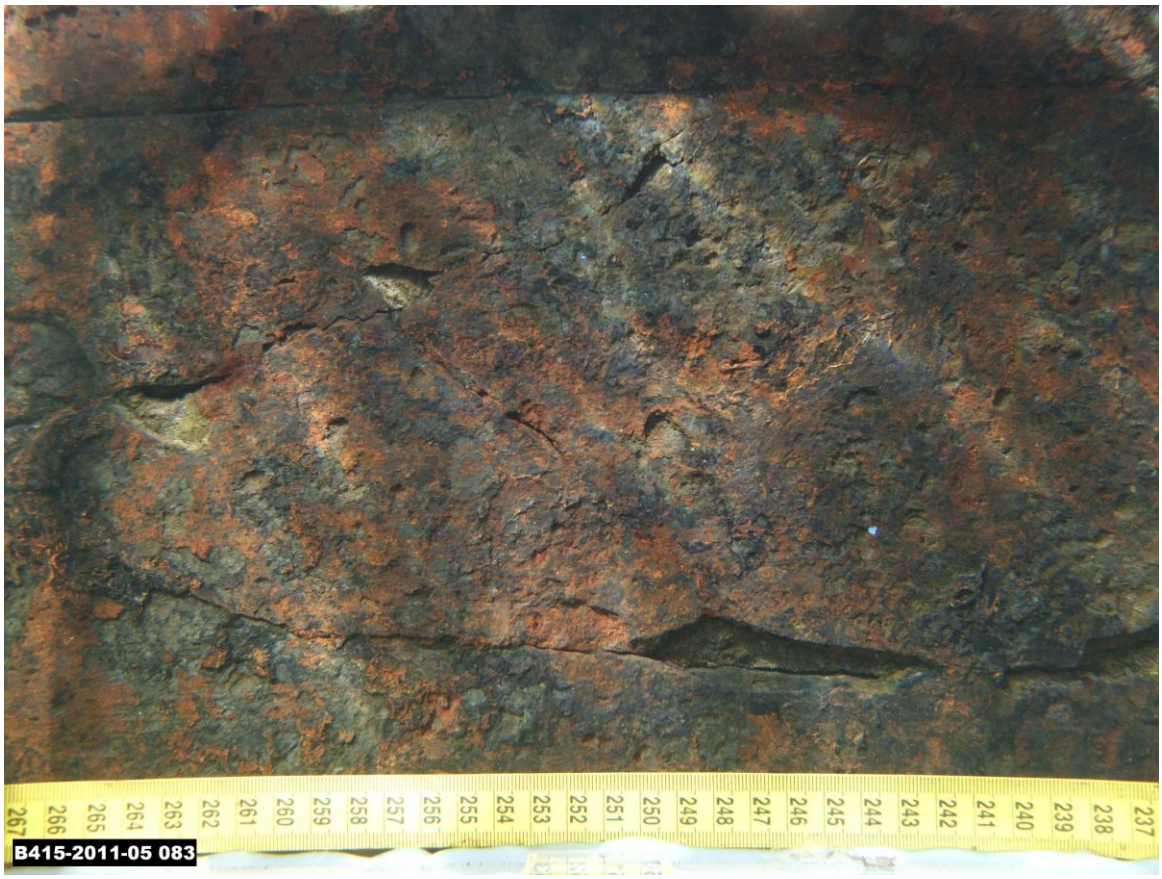
Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -0.57m, -2.41m, -4.26m, -6.11m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 15mm	3
1.5		
2.0		
2.5		
3.0		
3.5	Horizontal crack from just after12o'clock to 9o'clock at about -3.4m	4
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0		
7.5	Bed level at pile: -7.5m	
8.0		


Bridge: B 415 Windsor Bridge
PIER: 6
PILE: 2 (DS)
REFERENCE: Bottom edge of Caisson flange, 12o'clock=U/S
12o'clock
9o'clock
6o'clock
3o'clock
12o'clock
caisson join at -1.49m
WL: approx below reference
caisson join at -3.33m
horizontal crack: 12o'clock to 9o'clock
caisson join at -5.28m
caisson join at -7.13m
Bed level at -7.6m
Bed level at

B415-2011-05 075

B415-2011-05 080

B415-2011-05 081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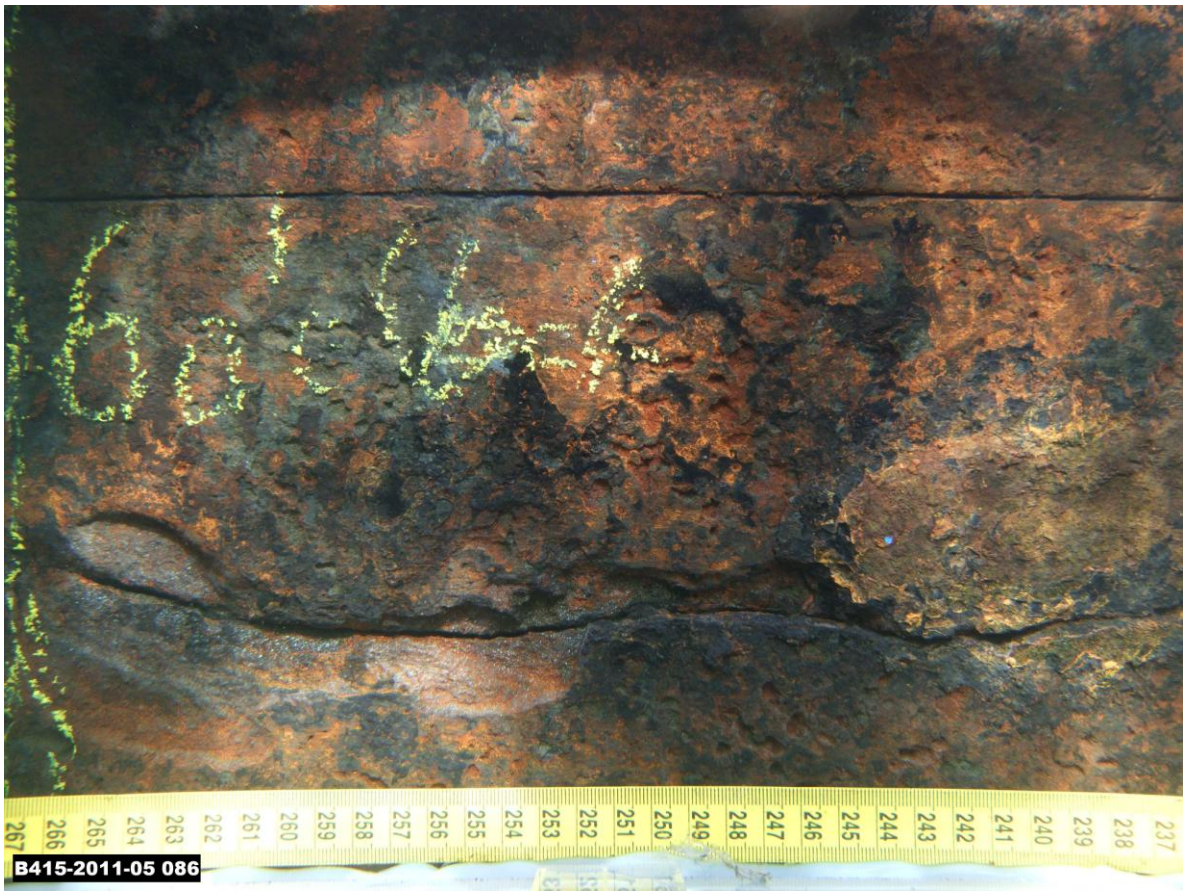
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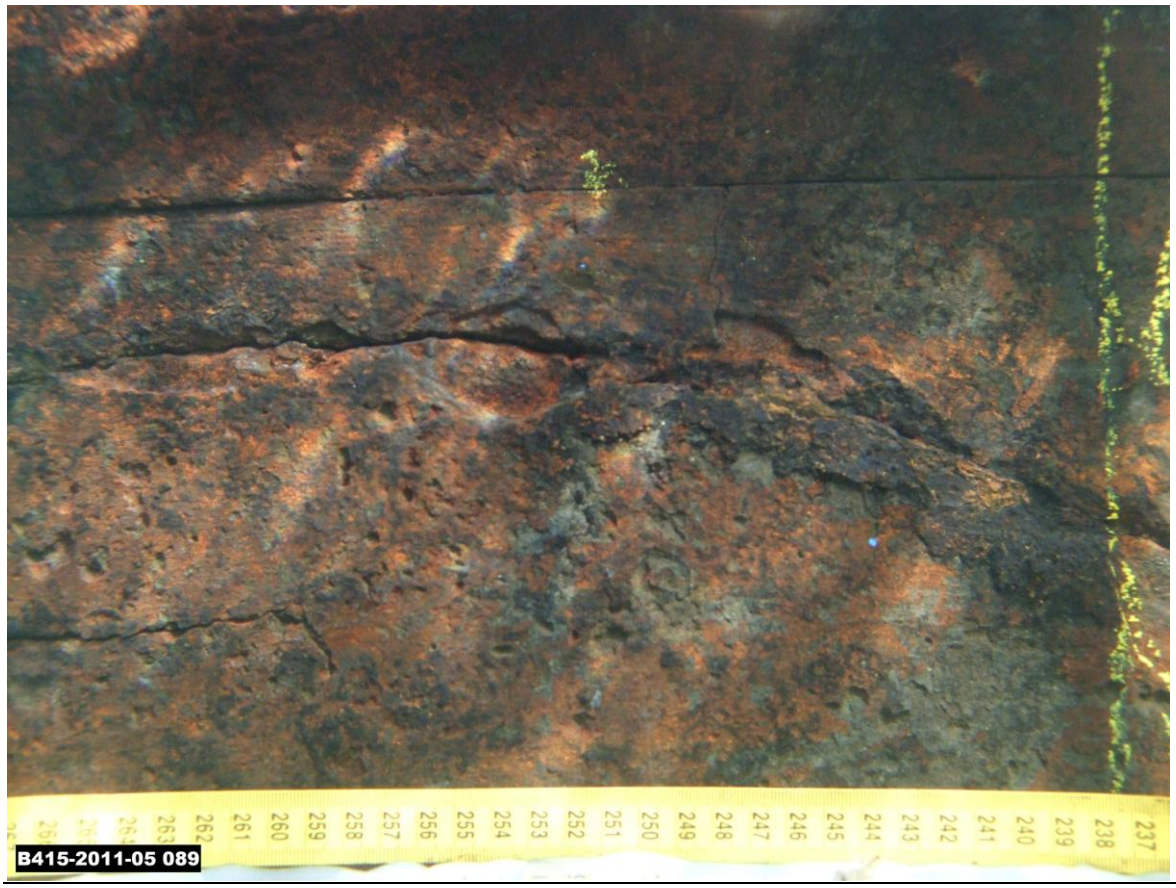
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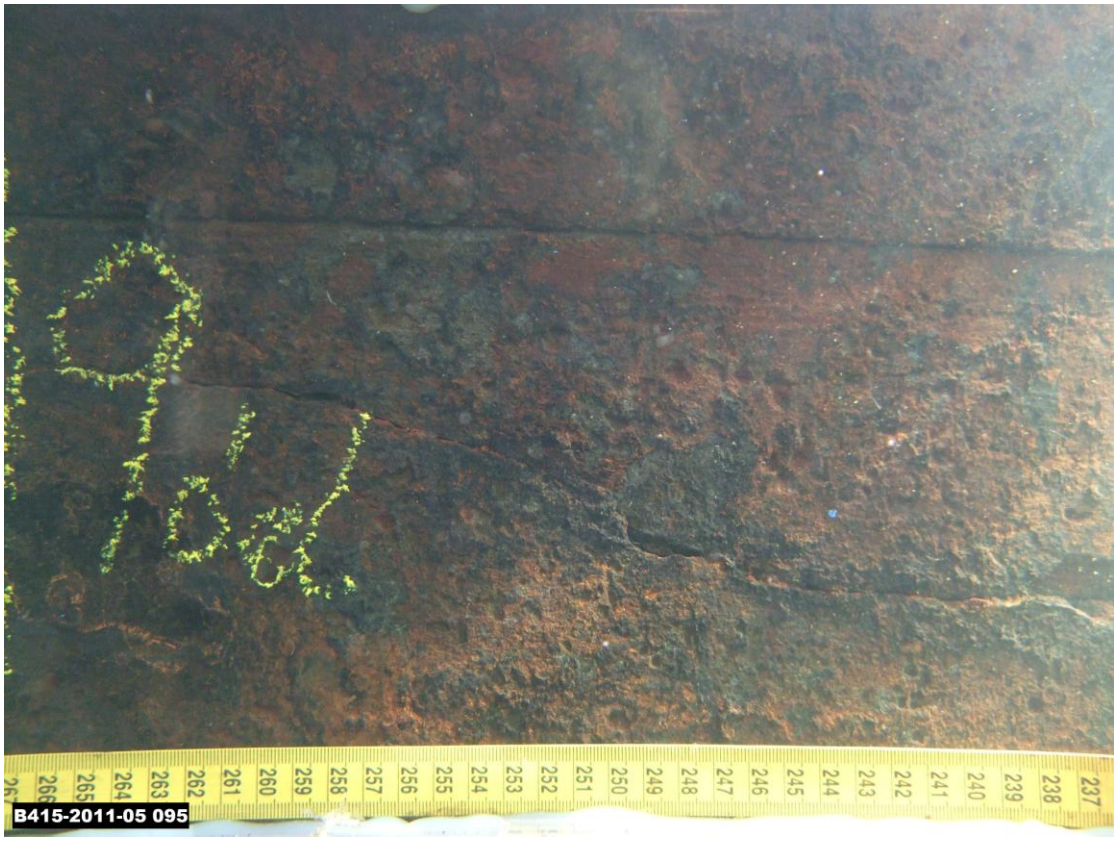
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UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 7 Element No. 1 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 14m^2 total surface area

A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	14m^2	Graphitisation over entire pile surface underwater, up to 15mm thick,
4		
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -1.75m, -3.59m, -5.43m,	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 15mm	3
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0	Bed level at pile: -7.1m	
7.5		
8.0		

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 7 Element No. 2 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 15m^2 total surface area

A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	15m^2	Graphitisation over entire pile surface underwater, up to 15mm thick,
4		
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -1.70m, -3.54m, -5.38m, -7.22m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 15mm	3
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0		
7.5	Bed level at pile: -7.5m	
8.0		

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 8 Element No. 1 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 15m^2 total surface area

A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	15m^2	Graphitisation over entire pile surface underwater, up to 15mm thick,
4		
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -0.57m, -2.41m, -4.26m, -6.10m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 15mm	3
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0		
7.5	Bed level at pile: -7.3m	
8.0		

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 8 Element No. 2 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 15m^2 total surface area

A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	15m^2	Graphitisation over entire pile surface underwater, up to 15mm thick,
4		
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -1.55m, -3.39m, -5.24m, -7.08m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 15mm	3
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0		
7.5	Bed level at pile: -7.3m	
8.0		

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 9 Element No. 1 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 12m^2 total surface area

A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	12m^2	Graphitisation over entire pile surface underwater, up to 15mm thick,
4		
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -1.30m, -3.14m, -4.99m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 15mm	3
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5	Bed level at pile: -6.3m	
7.0		
7.5		
8.0		

UNDERWATER BRIDGE INSPECTION - FORM C

DETAILED INSPECTION REPORT (NOMINATED PILES or PILE CAP SURFACES)

Bridge Name: Windsor Bridge **Bridge No: 415**

Pier/Abutment No. 9 Element No. 2 Cleaning Method: High-pressure water

Element Code & Type: SPIL, aprox 1.08m dia, cast iron caisson, concrete filled

Total quantity & unit for element: HP cleaned and inspected, approx. 12m^2 total surface area

A. CONDITION RATING

Condition State	Estimated quantity in Condition State	Remarks
1		
2		
3	12m^2	Graphitisation over entire pile surface underwater, up to 15mm thick,
4		
Total		

B. DETAILED WRITTEN LOG FOR CLEANED FACE OR STRIP

Depth reference: Bottom edge of Caisson flange directly below concrete tie beam

Depth below reference (m)	Description of Defect or Condition	Condition State
	Caisson joins at: -0.69m, -2.53m, -4.37m, -6.21m	
	Entire underwater surface of pile is showing graphitisation. On probing, thickness of graphitised layer varies between 5 and 15mm	3
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5	Bed level at pile: -6.5m	
7.0		
7.5		
8.0		

Pile cap cleaning and inspection: (B350 /clause 4.4.6)

There are no pile caps forming part of this inspection

Video Camera Log of Deterioration: (B350 / clause 4.6)

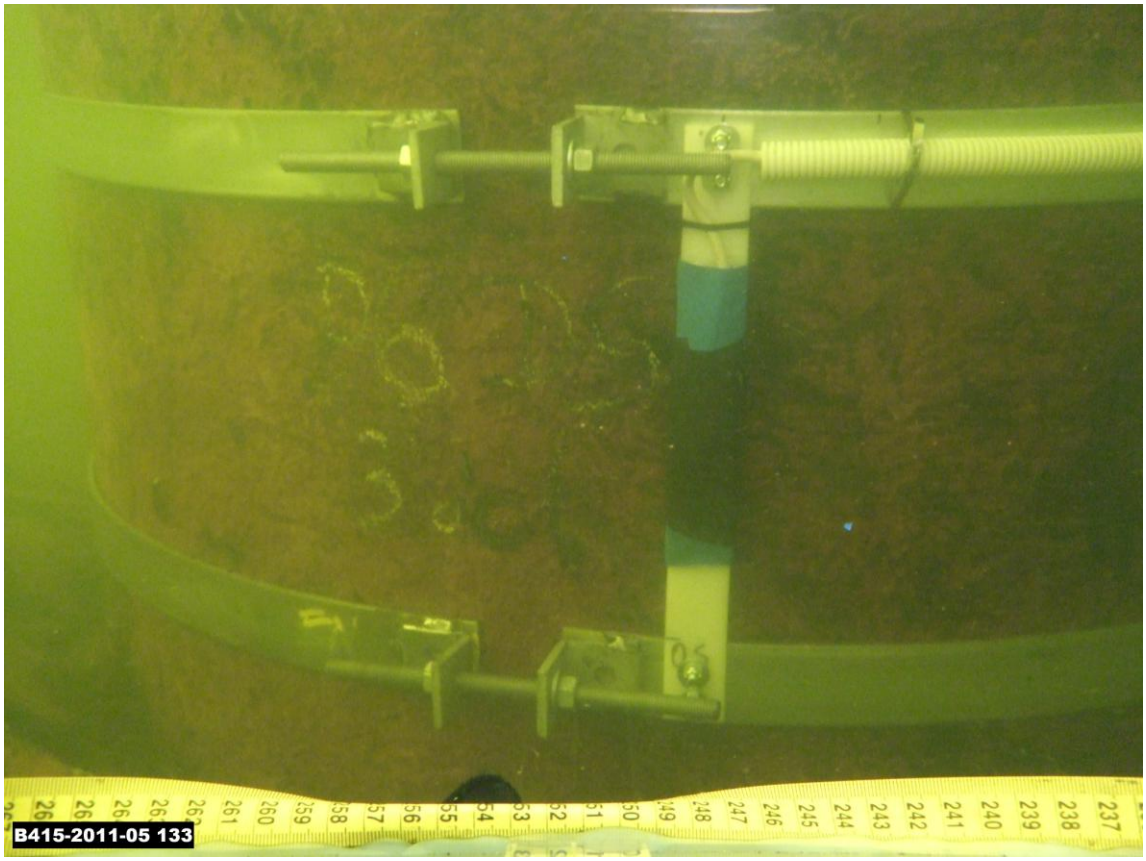
No video camera log was requested

Water Sample Test Results: (B350 / clause 6)

2 water samples (1x from -0.5m below water and 1x -5m below water) were taken and handed over to Fred Salome, CTI Consultants, for analysis on 11.5.2011. No further samples were requested/required to be taken for analysis by CDS Pty Ltd.

Principal requested additional work: (B350 / clause 9)

4 sets of Steel Bands with monitoring sensors (supplied by Endurance Consulting, B. McInnes) were required to be fitted to the piles of Piers 4 and 6 with sensors to be aligned at 3o'clock and 9o'clock on the piles.
The bands were fitted at following depths:
P4p1: -7.49m to top of band
P4p2: -6.72m to top of band
P6p1: -7.14m to top of band
P6p2: -6.45m to top of band



Core Sampling: (B350 / clauses7, 7.5.1, 7.5.2)

Coring in 16 location was requested and carried out between 11.5. and 20.5.2011. A total of 17 cores were recovered, 1 core was re-taken due to an apparent misalignment of entry angle.
Above water samples were 24-26mm thick with little or no graphitised layer visible.
Underwater core samples recovered showed graphitised layers ranging 5 to 20mm thick on plugs that were about 24mm thick overall (including graphitised outer surface layers)
4 of these cores were taken above the HWL mark on P5p2,-2m.
5 cores were taken in the top third of the first submerged Caisson segment on P5p1,-4m.
4 cores were taken in the bottom third of the first submerged Caisson segment on P5p1,-5m
2x 50mm diameter cores were taken through horizontal cracks: one at P5p1, -3.35m 5o'clock. The other one at P5p2, -3.39m, 9o'clock
1 core was taken through the caisson segment join at P5p2, -7.07m, 10o'clock
1 core was takennear Bed Level at P5p2, -8.3m, 9o'clock.
All but the last two cores were handed over to Fred Salome, CTI consultants, immediately after recovery of these cores.
Only the last 2 cores taken on Fri,20.6.2011(P were sent to CTI Consultants by mail the following week.
All core holes were photographed and the pictures are contained in the attached Folder "B415 Core holes".

Core Hole Repairs: (B350 / clauses 7.3.3, 7.4)
Principal ordered for the core holes not to be repaired.

We trust the inspection has been completed to your requirements.
Please contact us if you require further clarification.

Yours sincerely

Martin Woschitzka
Director
COMMERCIAL DIVING SOLUTIONS PTY LTD

ATT:

- DVD with electronic reports and Photo file “B415 Windsor Bridge Photos”

Bridge over Hawkesbury River at Windsor
Load Testing

Test Report

Prepared For:

NSW Roads and Traffic Authority

June 2011

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1. Introduction

1.1 General

Endurance Consulting was engaged by the NSW Roads and Traffic Authority (RTA) to provide structural measurements of Windsor Bridge over Hawkesbury River at Windsor. Performance load testing (static testing) and measurement of ambient traffic (dynamic testing) for a minimum period of 6 months is required. This document outlines the installation and presents the results of load testing.

1.2 Bridge Description

The Reinforced Concrete (RC) Beam Bridge consists of eleven spans and was built in 1931. 10 sets of 3'6" diameter wrought iron piers extend to the river bed. Figure 1-1 shows the instrumented piers.

1.3 Requirements

Measurements at piers 4, 5, 6 and 7 are required for the analysis of static load testing and ambient traffic monitoring. Bending strain in the piers is of concern, so at each location a strain gauge installed on both the south and north side allows bending to be resolved. A sampling frequency above 200 Hz is expected sufficient to capture bridge dynamic events.

Figure 1-1. RTA Bridge – Windsor Bridge Piers

2. Instrumentation

2.1 Instrumentation Layout

Figure 2-1 below shows the numbering conventions for the installed strain gauges at piers 4 to 7.

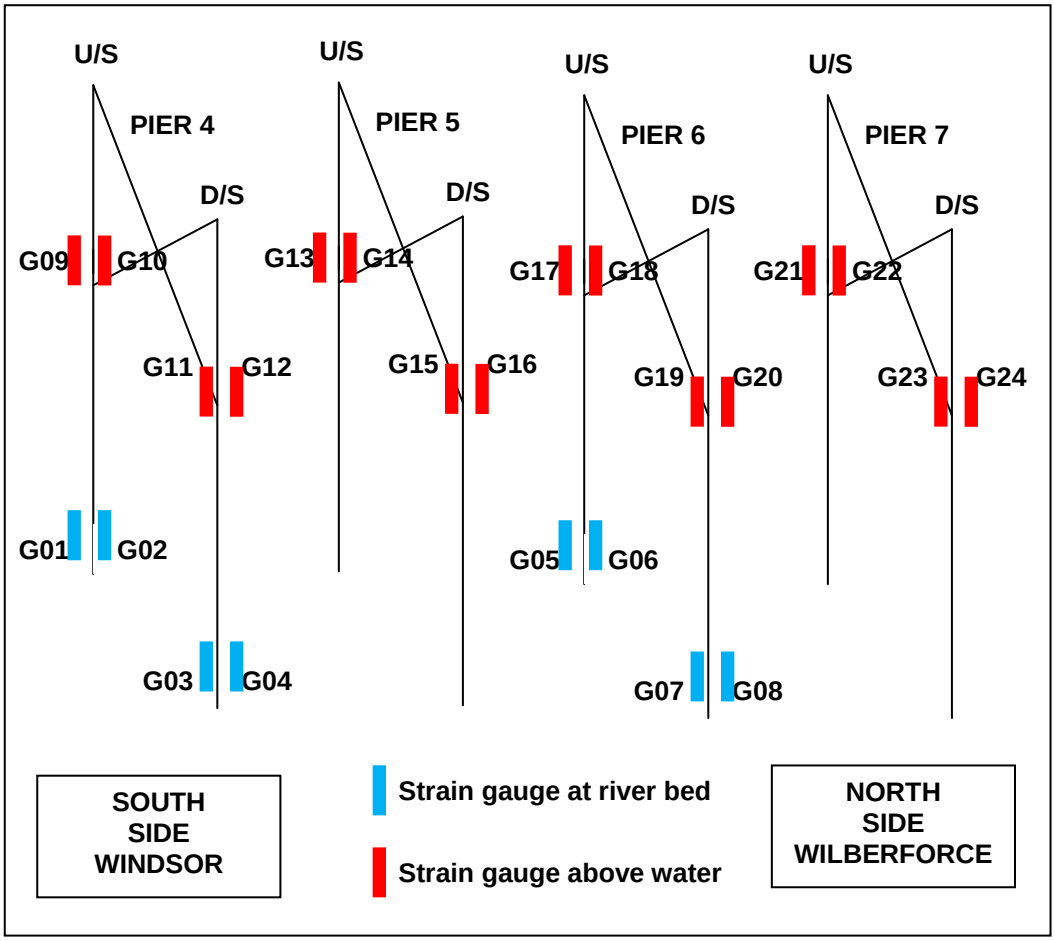

Figure 2-1. Instrumentation Layout

Table 2-1 below further indicates the positioning of the strain gauges.

Table 2-1. Sensor Locations

Transducer	Name	Pier	Side / Depth*
Demountable Strain Gauge at River Bed	**G01**	P4 U/S	S/S 7.49m
	G02	P4 U/S	N/S 7.49m
	G03	P4 D/S	S/S 6.72m
	G04	P4 D/S	N/S 6.72m
	G05	P6 U/S	S/S 7.14m
	G06	P6 U/S	N/S 7.14m
	G07	P6 D/S	S/S 6.45m
	G08	P6 D/S	N/S 6.45m
Foil Strain Gauge	**G09**	P4 U/S	S/S 1.65m
	G10	P4 U/S	N/S 1.65m
	G11	P4 D/S	S/S 1.65m
	G12	P4 D/S	N/S 1.65m
	G13	P5 U/S	S/S 1.65m
	G14	P5 U/S	N/S 1.65m
	G15	P5 D/S	S/S 1.65m
	G16	P5 D/S	N/S 1.65m
	G17	P6 U/S	S/S 1.65m
	G18	P6 U/S	N/S 1.65m
	G19	P6 D/S	S/S 1.65m
	G20	P6 D/S	N/S 1.65m
	G21	P7 U/S	S/S 1.65m
	G22	P7 U/S	N/S 1.65m
	G23	P7 D/S	S/S 1.65m
	G24**	P7 D/S	N/S 1.65m
Displacement	**DDT01****	P4 D/S	kerb

U/S – Upstream, D/S – Downstream, S/S – South Side, N/S – North Side

**All depth measurements are taken from the underside flange of the bolted pier connections*

***G24 was replaced with DDT01 during testing only*

2.2 Data Acquisition Hardware

National Instruments hardware acquired all channels at a sampling frequency of 2000Hz. This data was then re-sampled to 200Hz employing appropriate anti-aliasing filters. Labview software was used for data processing. Figure 5-1 shows the location of the hardware.

2.3 Expansion Joint Transducer

For the period of the static testing a dynamic displacement transducer was installed at the Pier 4 expansion joint. The sensor was mounted on the downstream kerb as shown in photo Figure 5-4.

2.4 Strain Gauges

The following strain gauges were used to obtain the required measurements:

- Strap-On Strain Gauges – 8 off, 300mm gauge length, 350 ohm full bridge strain sensing elements fastened between two 50x5mm flat bar rings. Installed by CDS Pty Ltd. Straps were initially manufactured to a circumference of 3730mm whereas the actual pier circumference was 3370mm. On-site modifications took place resulting in the strain elements now aligning 180mm to the outboard side on the centreline.
- Foil Strain Gauges – 16 off, TML WFCA-6 120 ohm half bridge gauges.

Figures 2-2 and 2-3 below show two types of strain gauges

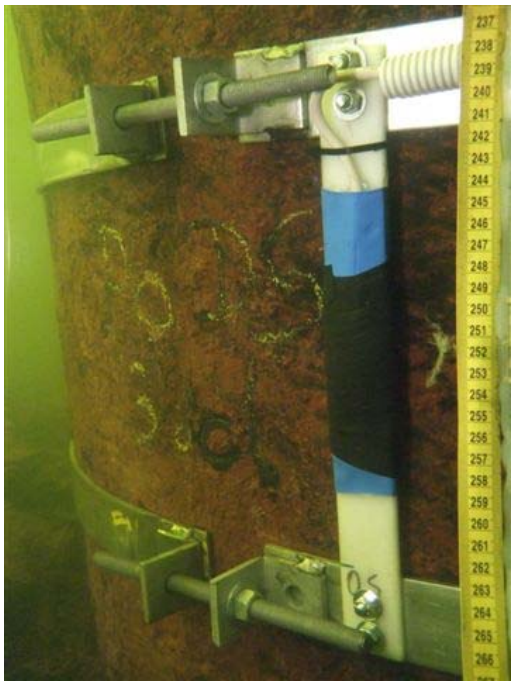

Figure 2-2. Instrumentation – Strap-On Gauge

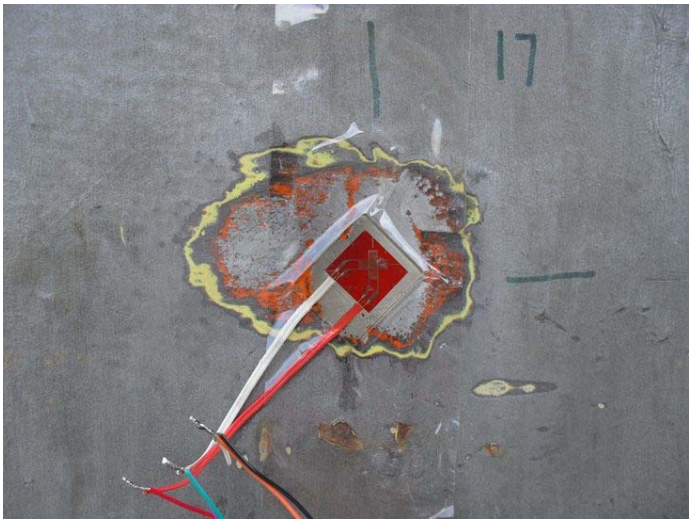

Figure 2-3. Instrumentation – Foil Strain Gauge

3. Static Test Results

3.1 Test Conditions

Planned load testing with the RTA Test Truck was carried out on the night of 8 June 2011. Normal carriageway was used for all tests. Three load levels were tested during the crawl tests as indicated in Table 3-1. Braking tests were also conducted on approach to Pier 4 and Pier 7 from both directions.

3.2 Test Vehicle and Loadings

The planned load testing was conducted by using an RTA dedicated test vehicle as shown in Figure 3-1.

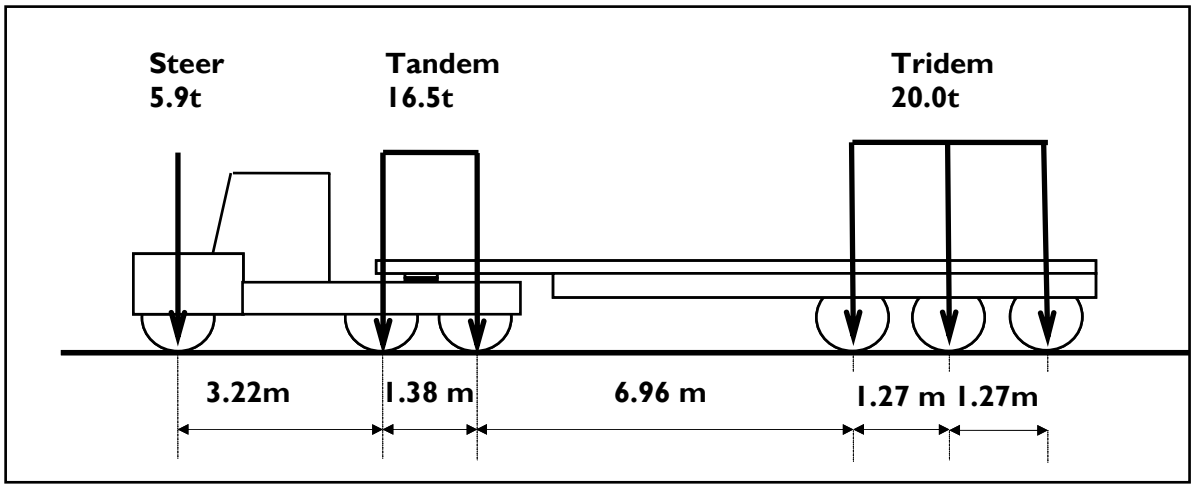

Figure 3-1. RTA Test Vehicle

The three loading levels used in performance load testing are shown in Table 3-1.

Table 3-1. Approximate Loadings

Test Truck	Load Level	Group Loads (t)			Equivalent GVM (t)
		Steer	Tandem	Tridem	
RTA	1	5.9	16.5	20.0	42.4
	2	5.9	16.5	25.0	47.4
	3	5.9	16.5	30.0	52.4

3.3 Results Presented

For each test the maximum strain relative to the unloaded strain has been calculated and presented in tabular form (Section 3.4). Section 3.5 displays selected example waveform (time series). Bending results for each pair of gauges are calculated as:

Bending Strain = (North Side Strain – South Side Strain) / 2

The bending strains are generally low so only the absolute maximum has been reported for each test.

3.4 Tabulated Static Test Results

Tabulated results are found in Tables:

- 3-2. Results for test with no braking
- 3-3. Results of test with braking on approach to Pier 4.
- 3-4. Results of tests with braking on approach to Pier 7.

The following abbreviations are used in the tables:

P# Pier#

US Upstream

DS Downstream

RB River Bed

AW Above Water

SS South Side

NS North Side

DDT Dynamic Displacement Transducer

Table 3-2. Non- Braking Test Results

TRIDEM LOAD LEVEL		20t	20t	20t	20t	25t	25t	30t	30t
SPEED (km/hr)		Crawl	Crawl	40	40	Crawl	Crawl	Crawl	Crawl
BRAKING		NO	NO	NO	NO	NO	NO	NO	NO
DIRECTION		South	North	South	North	South	North	South	North
TIME		10:28	01:10	11:03	11:04	11:29	11:36	11:58	12:05
Gauge #	Location	Compressive Strain (microstrain)							
G01	P4 US RB SS	2.9	9.9	4.2	10.7	3.5	11.1	3.6	12.0
G02	P4 US RB NS	2.6	6.7	3.3	8.1	3.4	7.3	3.7	8.2
G03	P4 DS RB SS	7.0	3.4	8.2	2.6	8.0	3.7	9.0	3.9
G04	P4 DS RB NS	7.5	2.9	7.6	3.1	8.6	2.4	9.9	3.3
G05	P6 US RB SS	5.8	19.4	7.3	21.3	7.0	23.0	7.4	25.6
G06	P6 US RB NS	6.9	19.8	7.3	22.2	9.1	22.7	9.6	25.4
G07	P6 DS RB SS	17.1	6.0	18.0	5.4	19.0	5.7	21.3	6.5
G08	P6 DS RB NS	23.3	8.2	23.3	7.9	26.5	7.1	29.2	8.3
G09	P4 US AW SS	6.7	15.2	6.9	17.6	7.4	16.8	8.9	18.9
G10	P4 US AW NS	6.3	15.6	6.7	18.7	6.6	19.4	7.2	22.1
G11	P4 DS AW SS	18.5	8.3	19.7	6.7	21.9	7.5	25.5	9.1
G12	P4 DS AW NS	12.6	6.6	12.0	7.0	13.9	7.6	15.5	8.3
G13	P5 US AW SS	6.9	19.6	7.7	22.3	8.8	21.7	10.1	24.5
G14	P5 US AW NS	6.5	17.6	7.6	19.9	6.1	21.7	8.0	25.0
G15	P5 DS AW SS	10.0	4.9	9.2	4.8	12.0	4.8	13.9	5.3
G16	P5 DS AW NS	16.3	6.2	15.1	5.8	13.4	7.6	18.6	8.8
G17	P6 US AW SS	7.4	17.9	8.0	19.5	7.3	19.8	10.7	22.7
G18	P6 US AW NS	6.1	15.1	6.6	14.5	6.8	18.6	7.3	21.6
G19	P6 DS AW SS	19.2	7.9	20.0	8.7	18.8	7.9	26.0	7.9
G20	P6 DS AW NS	21.4	8.0	20.2	7.4	22.5	8.8	25.2	10.8
G21	P7 US AW SS	7.8	19.7	9.0	21.4	9.8	21.6	11.1	24.7
G22	P7 US AW NS	6.0	17.5	8.1	18.4	7.0	20.7	7.7	23.6
G23	P7 DS AW SS	19.3	7.7	19.5	8.7	22.2	7.6	25.9	8.4
DDT (mm) Min	P4 DS Kerb	-0.24	-0.13	-0.27	-0.11	-0.28	-0.08	-0.26	-0.09
DDT (mm) Max	P4 DS Kerb	0.69	0.31	0.67	0.32	0.76	0.31	0.87	0.35
Bending Strain	Absolute Max	7.7	6.2	8.9	7.7	9.3	7.0	11.0	8.2

Table 3-3. Braking at Pier 4 Test Results

TRIDEM LOAD LEVEL		20t	20t	20t	20t	20t	20t	20t	20t
SPEED (km/hr)		20	20	30	30	40	40	50	50
BRAKING		@ P4	@ P4	@ P4	@ P4	@ P4	@ P4	@ P4	@ P4
DIRECTION		South	North	South	North	North	South	South	North
TIME		12:52	12:54	12:58	01:00	01:05	01:07	01:15	01:17
Gauge #	Location	Compressive Strain (microstrain)							
G01	P4 US RB SS	3.7	9.9	4.3	10.3	10.5	4.4	4.9	10.0
G02	P4 US RB NS	3.8	6.4	3.8	6.6	8.0	2.8	3.7	6.6
G03	P4 DS RB SS	7.6	3.3	8.2	3.3	2.9	8.9	9.2	2.9
G04	P4 DS RB NS	9.3	3.8	9.1	4.1	5.3	7.5	8.3	3.8
G05	P6 US RB SS	7.5	21.4	6.7	21.2	21.3	7.7	7.8	20.1
G06	P6 US RB NS	7.9	21.4	7.9	20.5	21.1	7.3	8.5	20.7
G07	P6 DS RB SS	16.9	6.1	17.0	5.8	6.2	17.4	16.7	5.8
G08	P6 DS RB NS	23.5	7.4	22.9	7.5	7.9	22.5	23.2	8.8
G09	P4 US AW SS	7.3	15.4	6.9	15.3	15.9	6.8	7.3	15.5
G10	P4 US AW NS	6.7	15.9	7.1	16.5	15.7	6.4	6.9	15.6
G11	P4 DS AW SS	20.1	8.3	19.2	8.0	8.2	20.4	19.0	7.2
G12	P4 DS AW NS	12.7	6.9	13.7	6.6	6.4	13.2	12.9	6.3
G13	P5 US AW SS	7.4	19.6	8.1	19.7	20.3	7.2	7.4	18.8
G14	P5 US AW NS	7.7	17.7	7.8	17.4	18.1	7.5	7.8	17.4
G15	P5 DS AW SS	9.9	4.8	10.1	4.4	4.7	9.0	9.2	4.6
G16	P5 DS AW NS	15.5	6.4	15.8	5.8	6.6	15.4	15.0	6.1
G17	P6 US AW SS	7.8	17.6	8.0	17.5	17.9	7.6	8.6	18.3
G18	P6 US AW NS	8.3	15.2	7.4	15.9	15.1	7.0	7.9	15.2
G19	P6 DS AW SS	19.8	7.7	20.8	7.9	7.7	19.8	19.4	8.1
G20	P6 DS AW NS	22.4	8.4	21.2	8.5	9.0	20.9	20.4	8.5
G21	P7 US AW SS	9.4	20.3	9.1	19.8	20.0	9.4	10.0	19.3
G22	P7 US AW NS	7.9	17.7	7.2	16.7	16.6	7.1	7.6	20.5
G23	P7 DS AW SS	20.6	8.9	19.0	8.8	8.2	18.8	20.4	8.0
DDT (mm) Min	P4 DS Kerb	-0.21	-0.13	-0.22	-0.10	-0.15	-0.26	-0.22	-0.10
DDT (mm) Max	P4 DS Kerb	0.67	0.30	0.64	0.29	0.28	0.60	0.61	0.29
Bending Strain	Absolute Max	8.7	6.4	8.2	6.4	6.2	8.4	8.5	7.4

Table 3-4. Braking at Pier 7 Test Results

TRIDEM LOAD LEVEL		20t	20t	20t	20t	20t	20t	20t	20t
SPEED (km/hr)		20	20	30	30	40	40	50	50
BRAKING		@ P7	@ P7	@ P7	@ P7	@ P7	@ P7	@ P7	@ P7
DIRECTION		South	North	South	North	South	North	South	North
TIME		01:20	01:22	01:26	01:27	01:30	01:33	01:35	01:37
Gauge #	Location	Compressive Strain (microstrain)							
G01	P4 US RB SS	3.8	9.8	3.5	9.8	3.6	9.8	3.7	10.0
G02	P4 US RB NS	3.4	6.6	2.9	7.1	3.3	7.0	2.9	6.9
G03	P4 DS RB SS	7.2	2.9	7.2	2.9	7.6	2.7	7.5	3.0
G04	P4 DS RB NS	8.5	3.0	8.0	2.7	8.8	3.2	7.9	3.1
G05	P6 US RB SS	6.9	20.2	7.5	22.4	8.5	20.4	11.4	21.9
G06	P6 US RB NS	7.4	21.6	7.9	23.1	7.4	22.3	8.1	24.4
G07	P6 DS RB SS	17.3	6.3	17.5	8.1	17.7	8.6	20.4	9.2
G08	P6 DS RB NS	22.9	7.8	24.2	8.8	23.2	9.2	22.7	10.2
G09	P4 US AW SS	8.0	16.0	7.3	15.0	8.5	14.7	7.3	16.2
G10	P4 US AW NS	6.9	16.7	6.5	16.3	6.2	16.6	6.0	16.4
G11	P4 DS AW SS	22.8	8.4	21.7	7.7	23.8	7.5	21.8	7.9
G12	P4 DS AW NS	13.0	6.9	13.5	6.7	13.3	6.6	13.1	6.6
G13	P5 US AW SS	7.7	19.7	7.9	20.5	7.8	21.7	8.1	19.8
G14	P5 US AW NS	8.0	18.7	6.8	19.9	7.1	20.0	7.4	19.2
G15	P5 DS AW SS	11.0	4.7	10.6	4.6	10.4	5.6	10.5	4.5
G16	P5 DS AW NS	17.0	6.2	16.0	6.5	15.4	6.3	15.6	6.3
G17	P6 US AW SS	7.9	17.9	7.4	18.4	7.5	19.0	7.9	19.0
G18	P6 US AW NS	6.5	15.3	6.9	17.5	7.0	16.6	7.5	17.0
G19	P6 DS AW SS	20.4	7.9	18.9	8.6	18.4	9.6	19.1	8.5
G20	P6 DS AW NS	21.2	8.0	21.4	9.6	21.8	10.3	21.8	10.1
G21	P7 US AW SS	8.5	20.4	9.6	21.1	8.3	20.5	8.5	20.2
G22	P7 US AW NS	7.7	17.1	7.2	17.3	6.8	17.1	8.0	17.0
G23	P7 DS AW SS	18.8	7.3	21.0	8.0	19.4	8.0	18.6	7.4
DDT (mm) Min	P4 DS Kerb	-0.23	-0.14	-0.27	-0.22	-0.28	-0.23	-0.51	-0.27
DDT (mm) Max	P4 DS Kerb	0.67	0.30	0.66	0.27	0.70	0.29	0.64	0.31
Bending Strain	Absolute Max	9.5	6.7	9.1	6.8	10.8	7.2	9.1	6.9

3.5 Results Discussion

The following observations can be made from the test period and the presented results:

- Bending strain is not the dominant strain in the piers. All strain gauges go into compression under loading in all test instances.
- The braking tests did not increase bending strain results or expansion gap openings.
- The expansion gap opening is due to the method of measurement being sensitive to the flexure of the spans. Braking tests did not increase the values so it considered that they did not contribute to the expansion joint opening.
- Pier 4 river bed gauges on both upstream and downstream display less axial compression then the corresponding above water gauges.
- Pier 6 river bed gauges correlate well with the results from the above water gauges.

3.6 Graphical Static Test Results

Figures 3-2 to 3-9 graphically represent a sample of the above data. Plots are shown for tests at times 10:28PM and 11:03PM. (Negative indicates compressive strain).

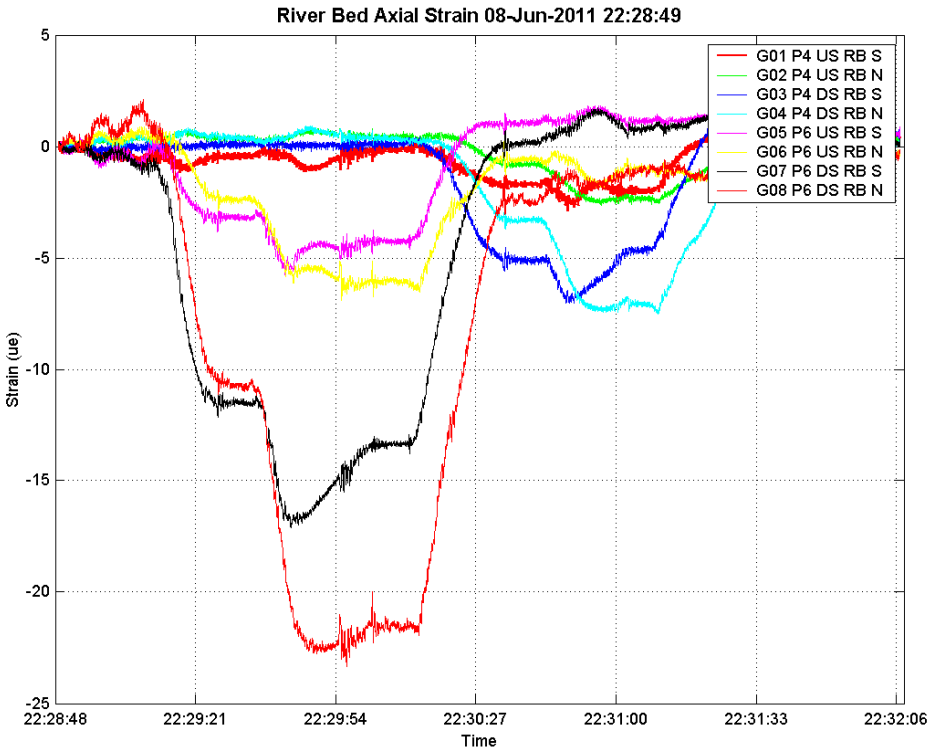

Figure 3-2. 10:28PM Axial Strain (RB)

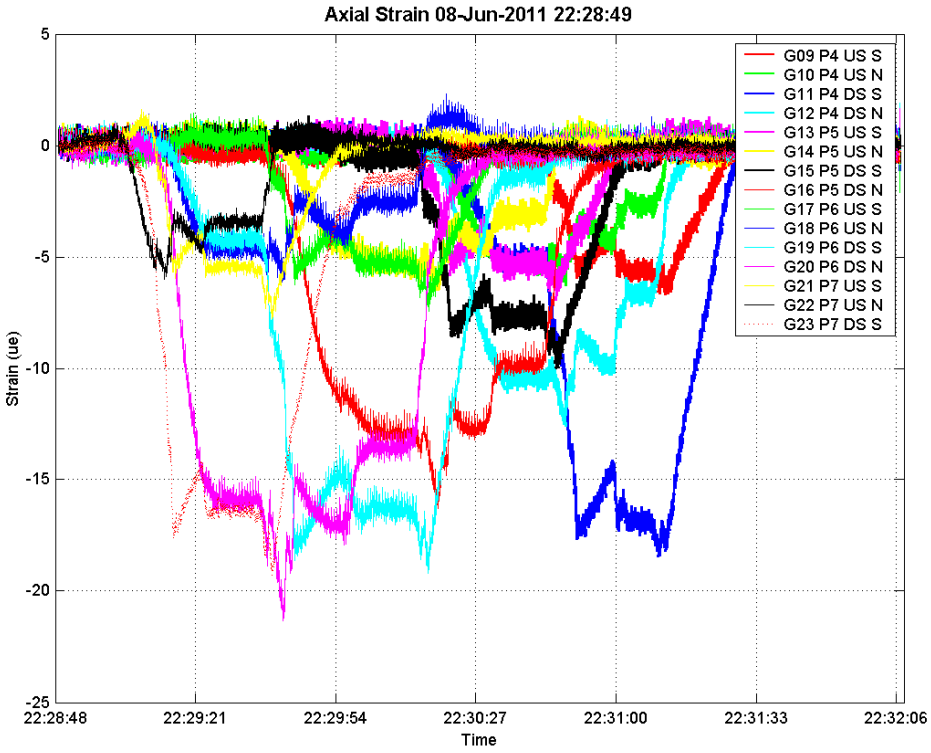

Figure 3-3. 10:28PM Axial Strain (AW)

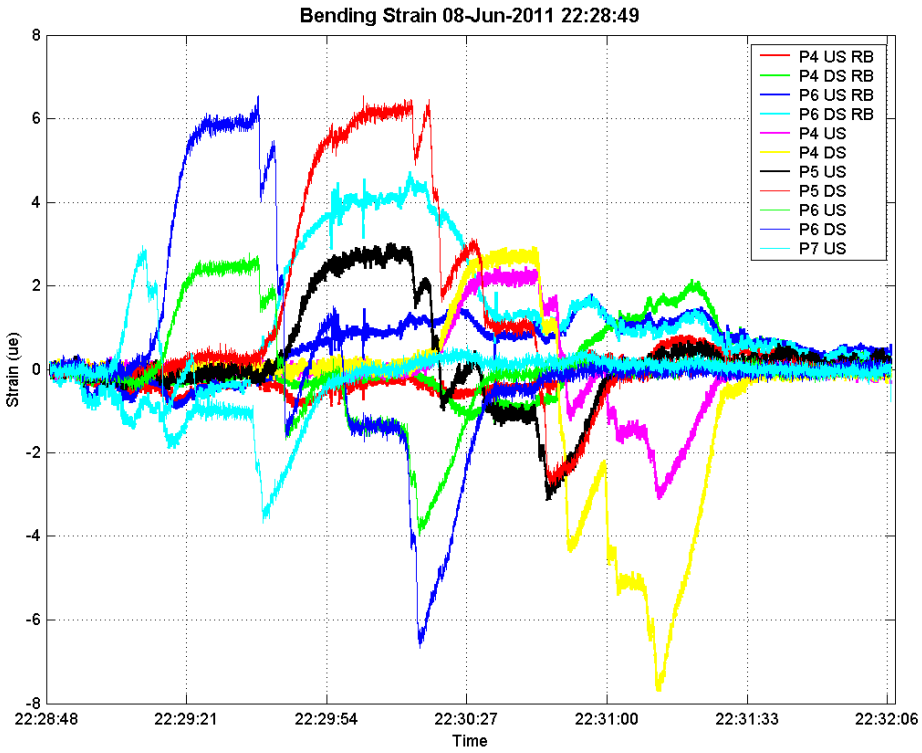

Figure 3-4. 10:28PM Bending Strain

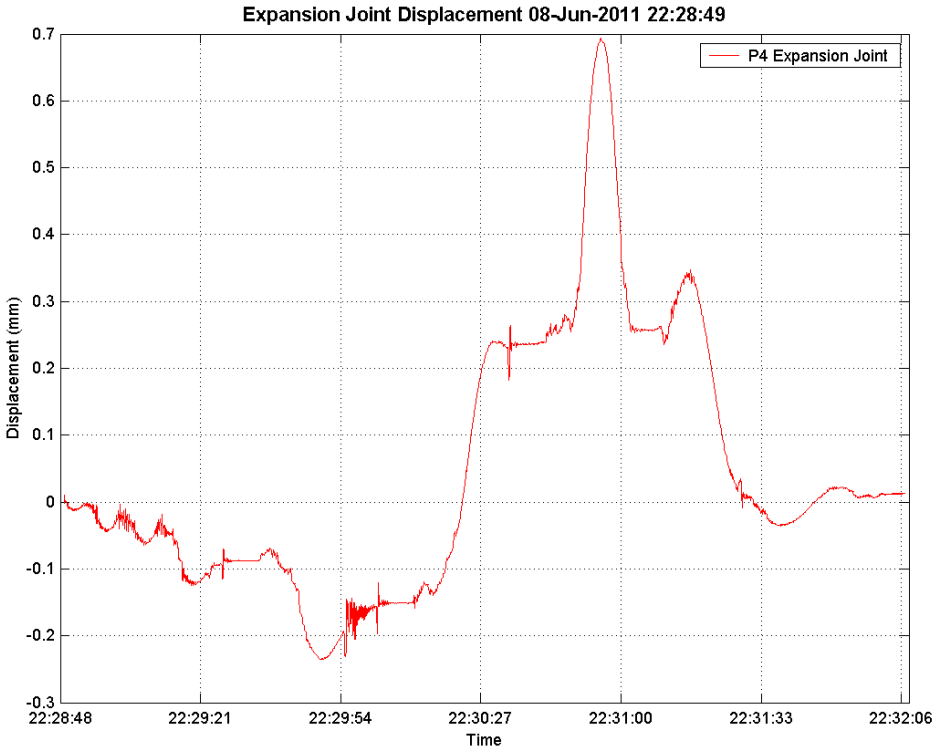

Figure 3-5. 10:28PM Expansion Joint

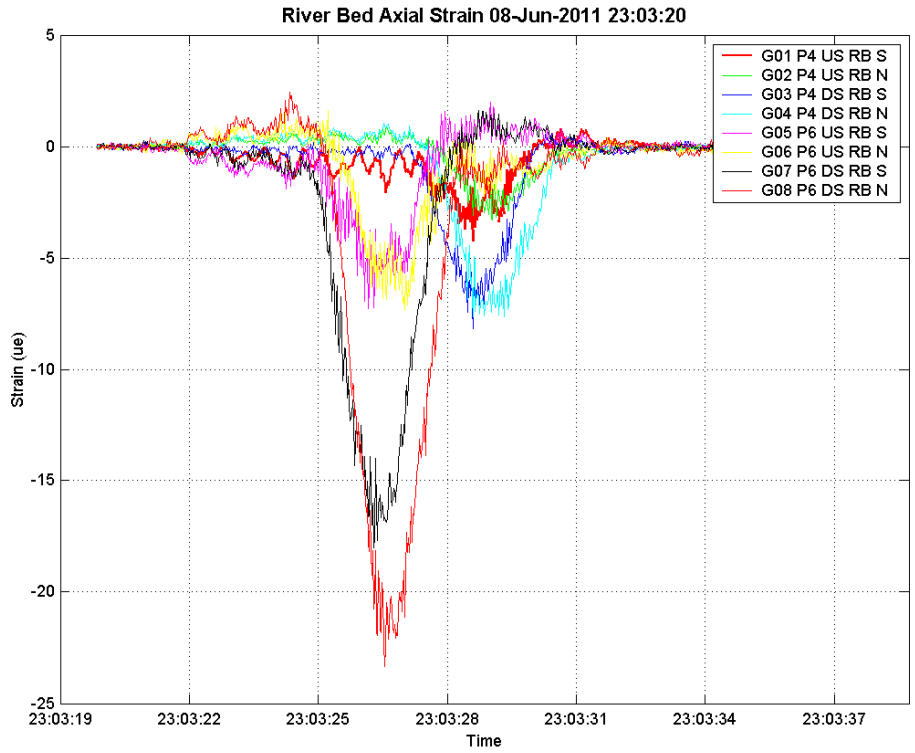

Figure 3-6. 11:03PM Axial Strain (RB)

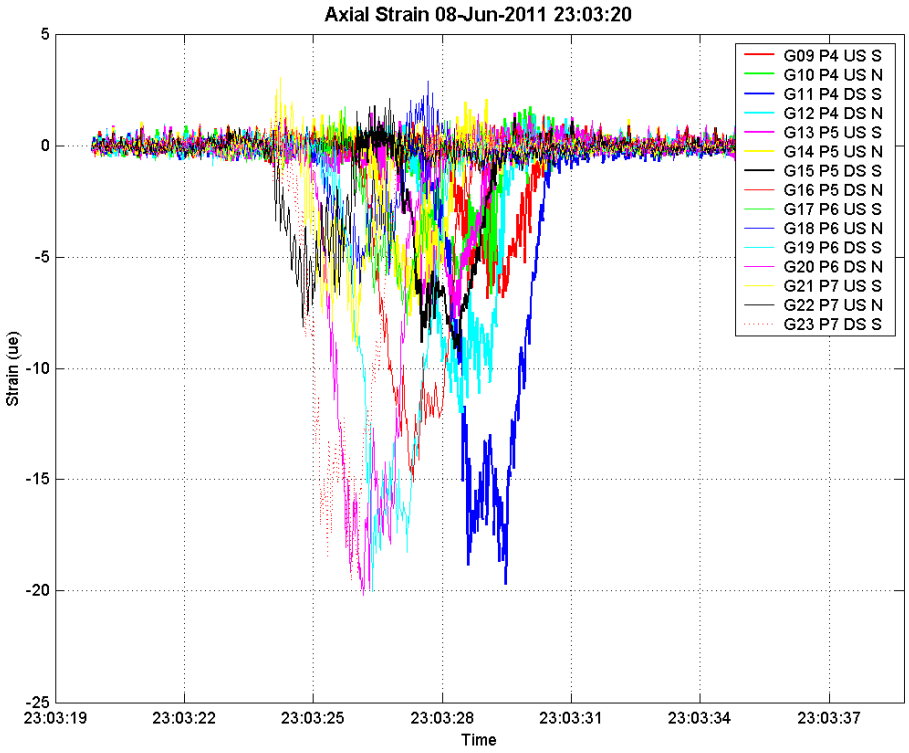

Figure 3-7. 11:03PM Axial Strain (AW)

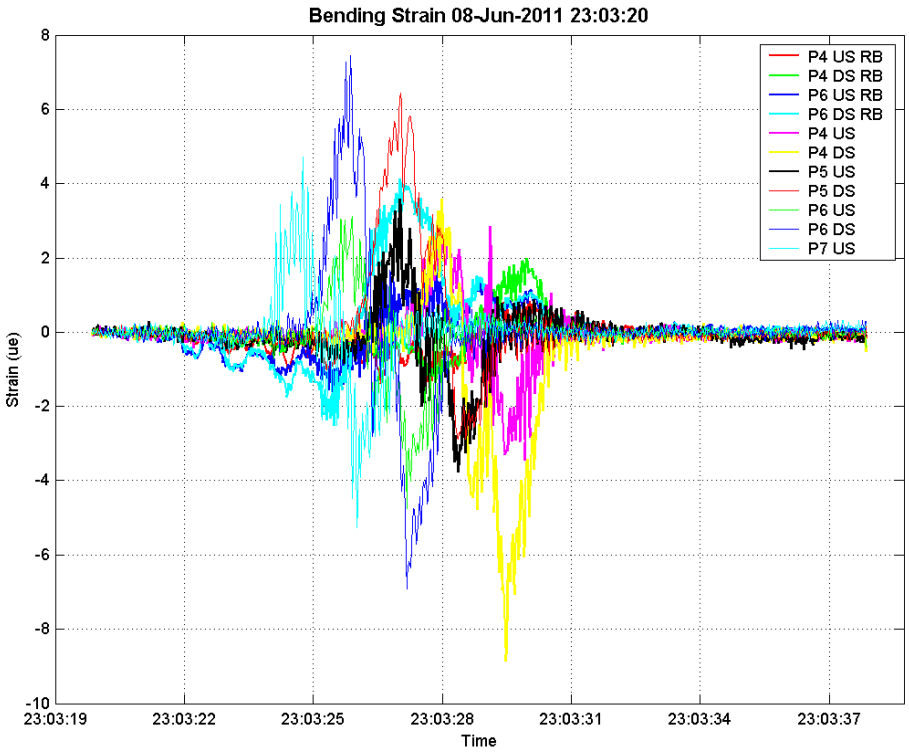

Figure 3-8. 11:03PM Bending Strain

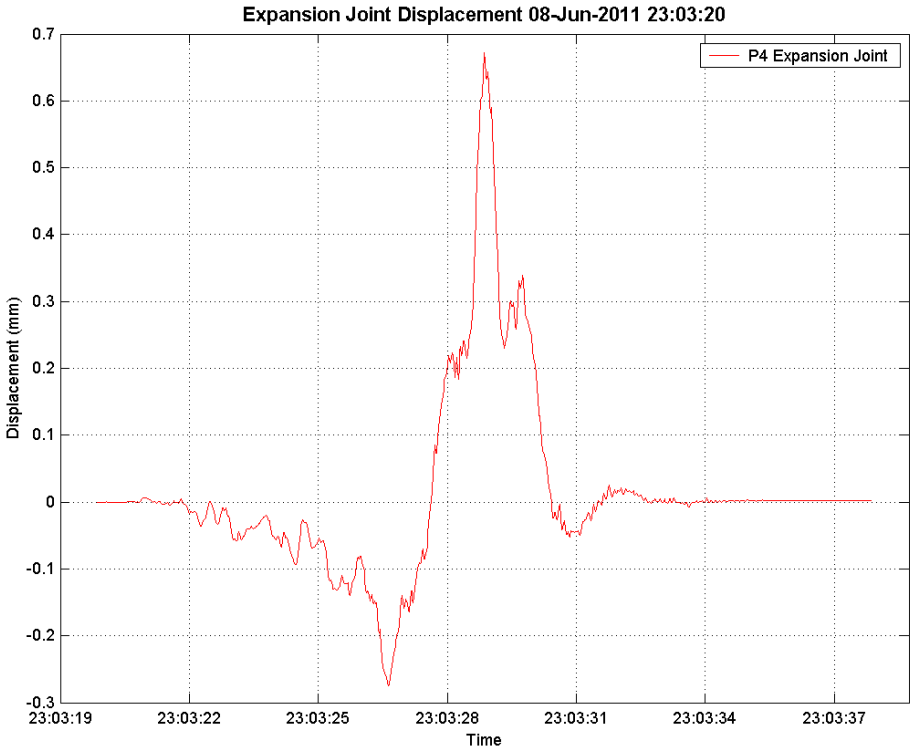

Figure 3-9. 11:03PM Expansion Joint

4. Dynamic Test Results (Monitoring of Ambient Traffic)

4.1 Test Overview

Installation of continuous power via solar panels was completed on 17 June 2011 and dynamic testing of ambient traffic was initiated that day. Data from 17 to 24 June is presented in this section. A 40 second period of time series data is acquired to enable full post-processing.

4.2 Results Processing

Traffic events which cause strain deviations above a set point have been logged and are presented in Sections 4.3. The nominal trigger set points used were G18 - 15 με, and G20 -20με for axial strains. Waveforms of peak events were viewed to confirm that the event fitted the expected profile and was indeed a vehicle.

Additional data can be viewed on the website www.endcon.com.au/clients/nswrta/bn415 .

4.3 Scatter Plots

Figure 4-1 to 4-12 show axial strain scatter plots for each pier upstream and downstream with a red line mark indicating the load level 1 test at 40kph results from Section 3.3. Figure 4-13 to 4-24 show bending strain scatter plots for each pier upstream and downstream.

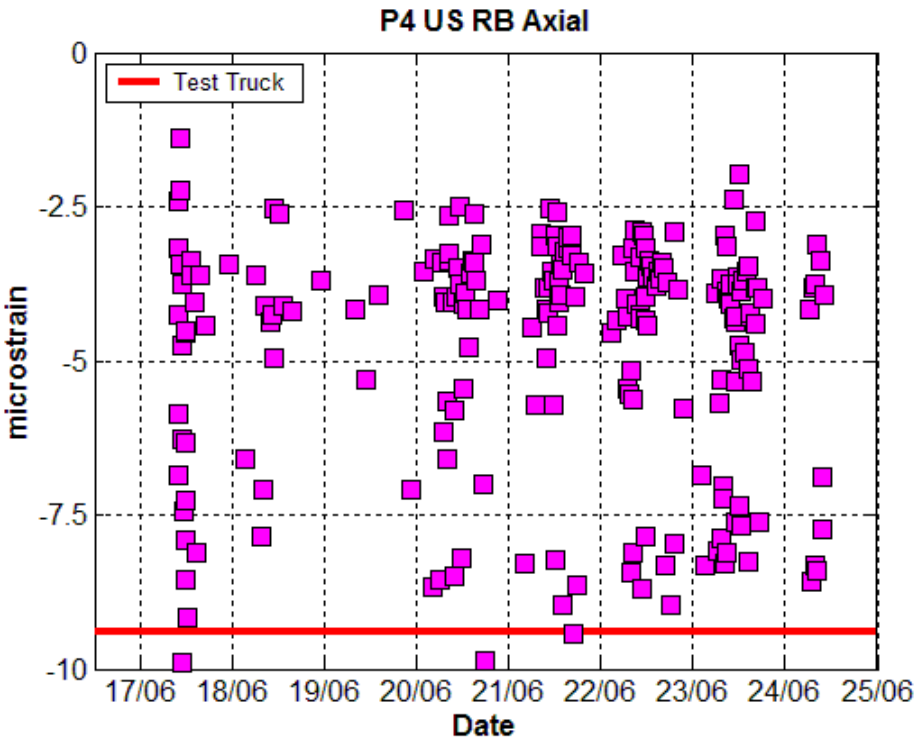

Figure 4-1. Scatter Plot - Pier 4 Upstream Axial Strain (RB)

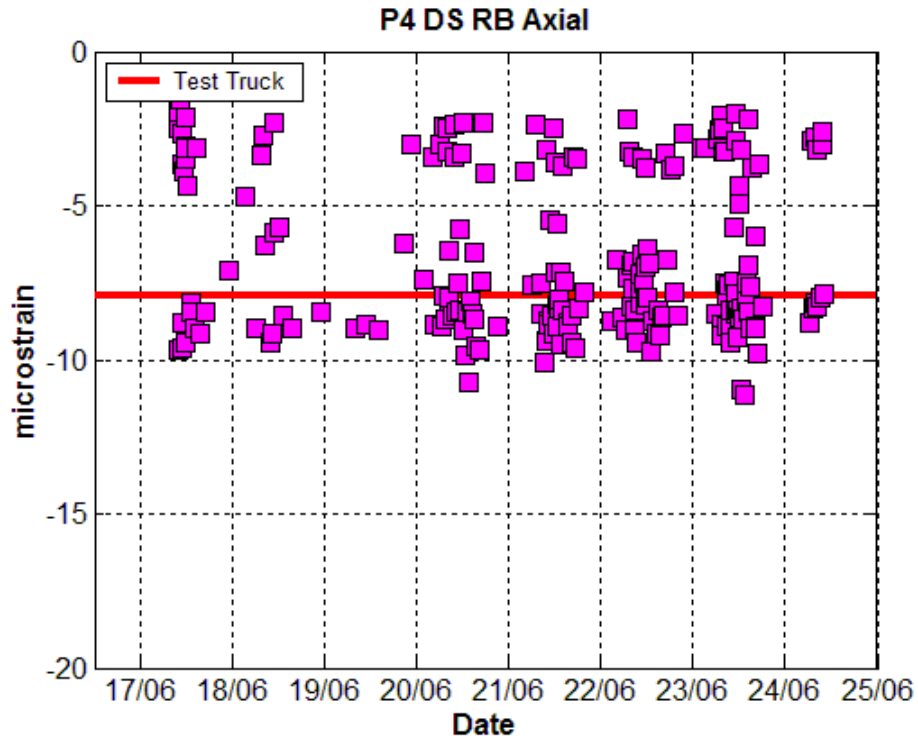

Figure 4-2. Scatter Plot - Pier 4 Downstream Axial Strain (RB)

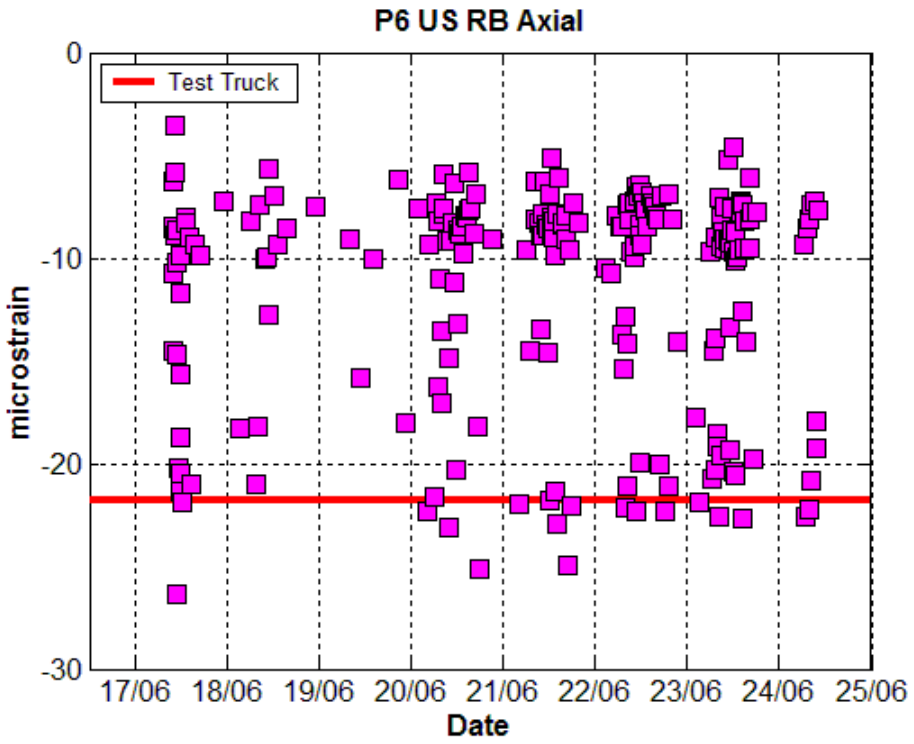

Figure 4-3. Scatter Plot - Pier 6 Upstream Axial Strain (RB)

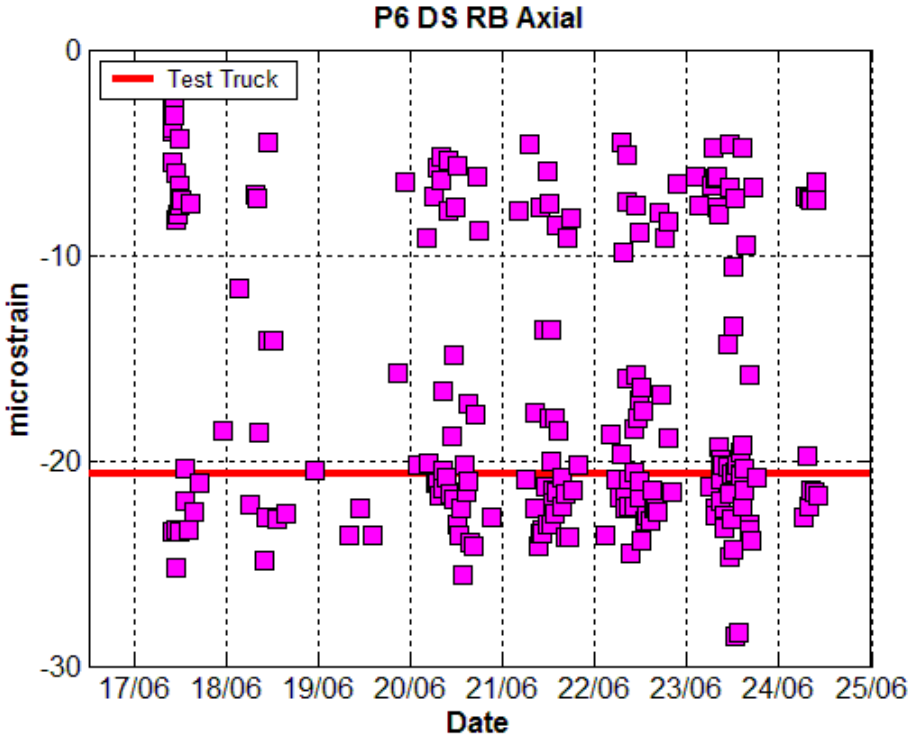

Figure 4-4. Scatter Plot - Pier 6 Downstream Axial Strain (RB)

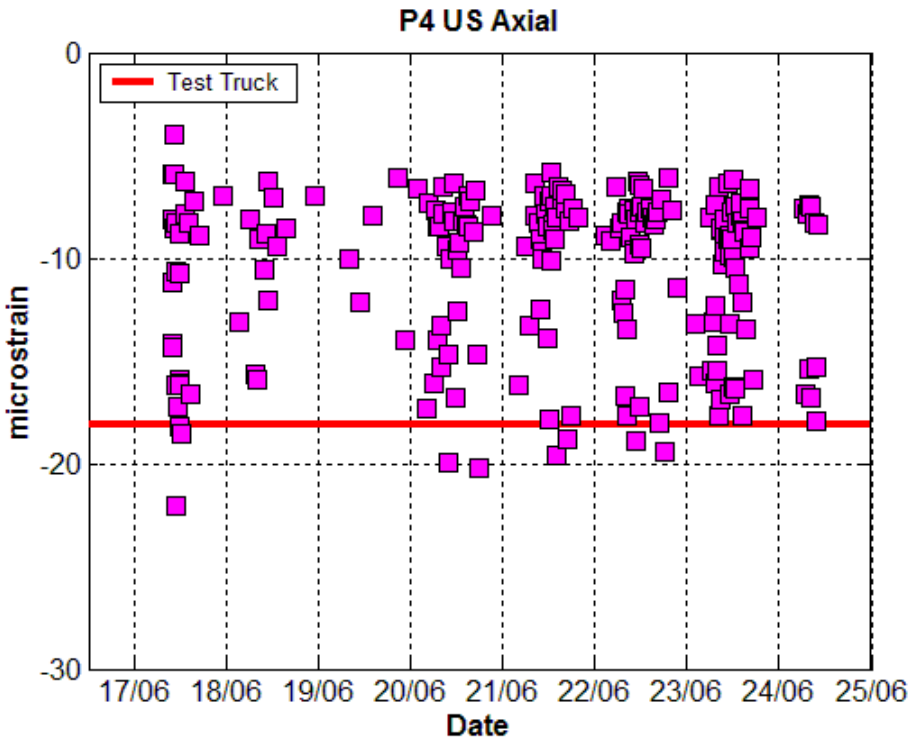

Figure 4-5. Scatter Plot - Pier 4 Upstream Axial Strain

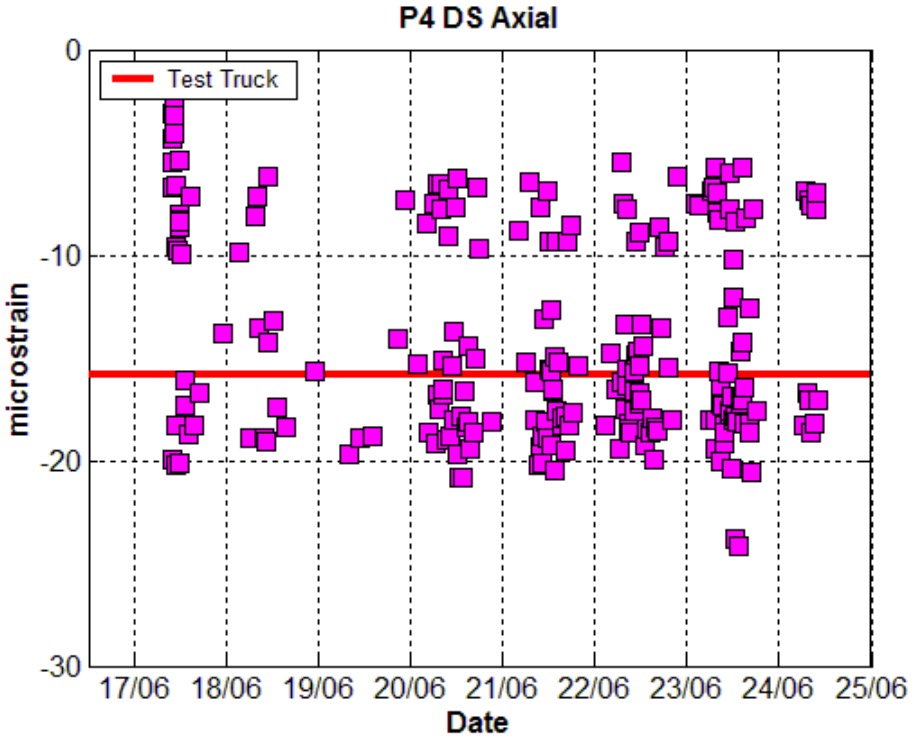

Figure 4-6. Scatter Plot - Pier 4 Downstream Axial Strain

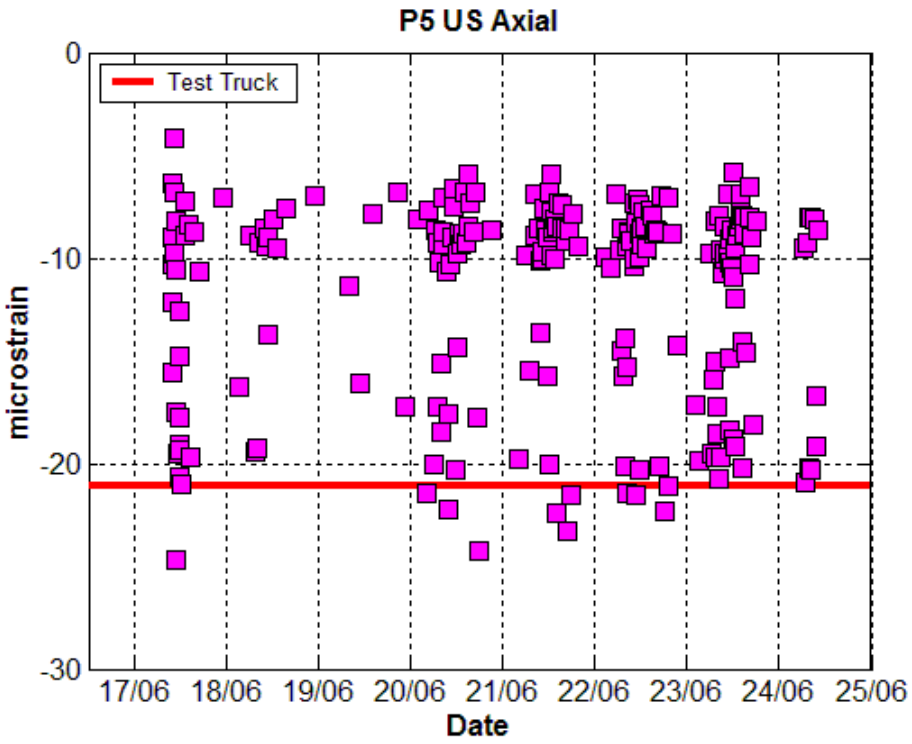

Figure 4-7. Scatter Plot - Pier 5 Upstream Axial Strain

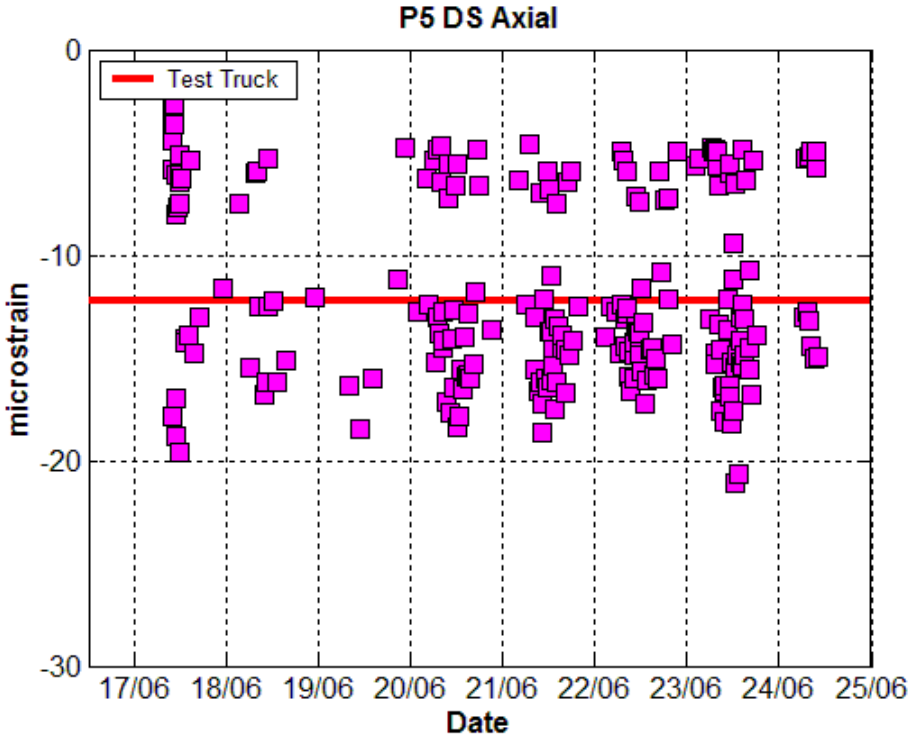

Figure 4-8. Scatter Plot - Pier 5 Downstream Axial Strain

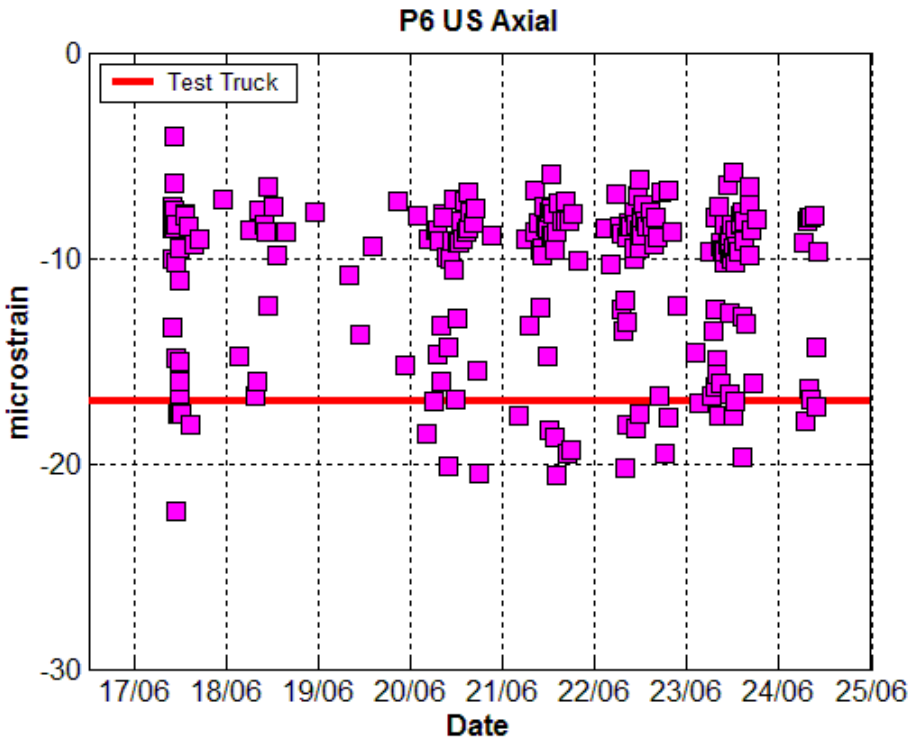

Figure 4-9. Scatter Plot - Pier 6 Upstream Axial Strain

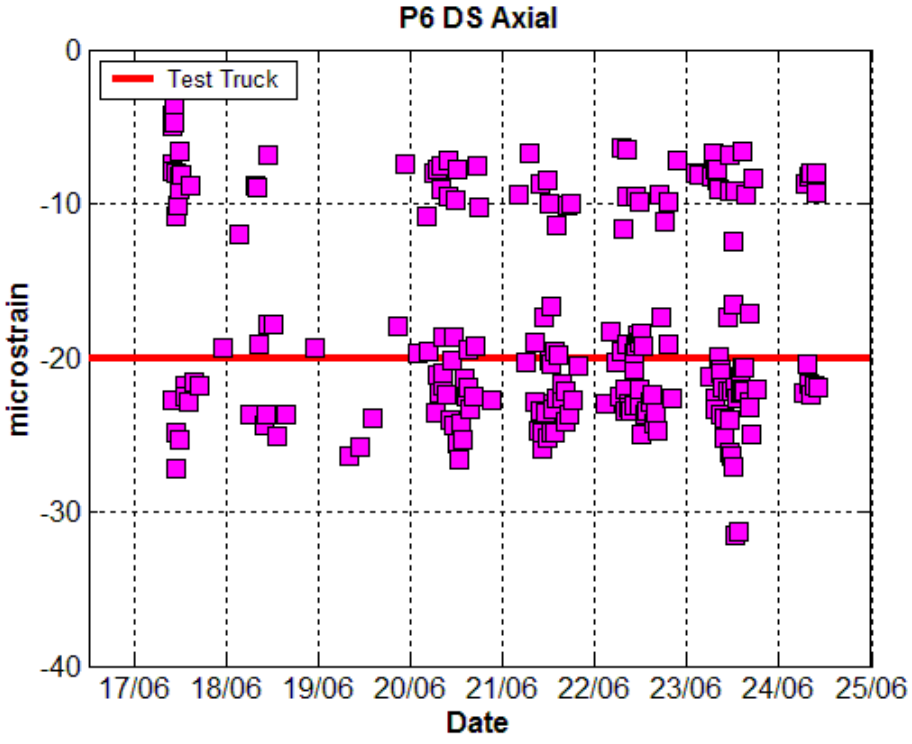

Figure 4-10. Scatter Plot - Pier 6 Downstream Axial Strain

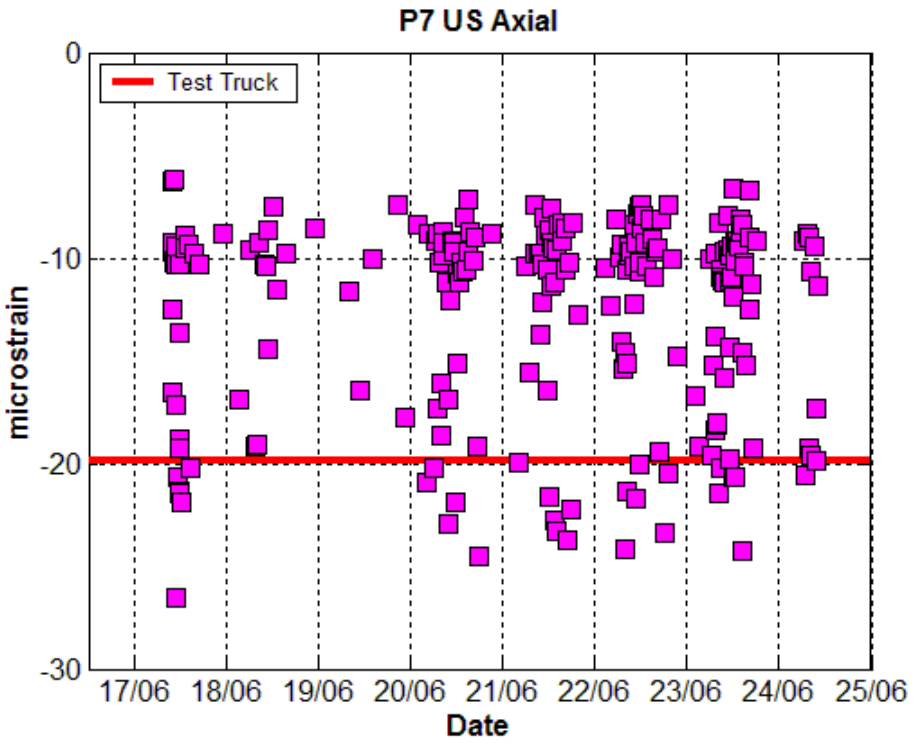

Figure 4-11. Scatter Plot - Pier 7 Upstream Axial Strain

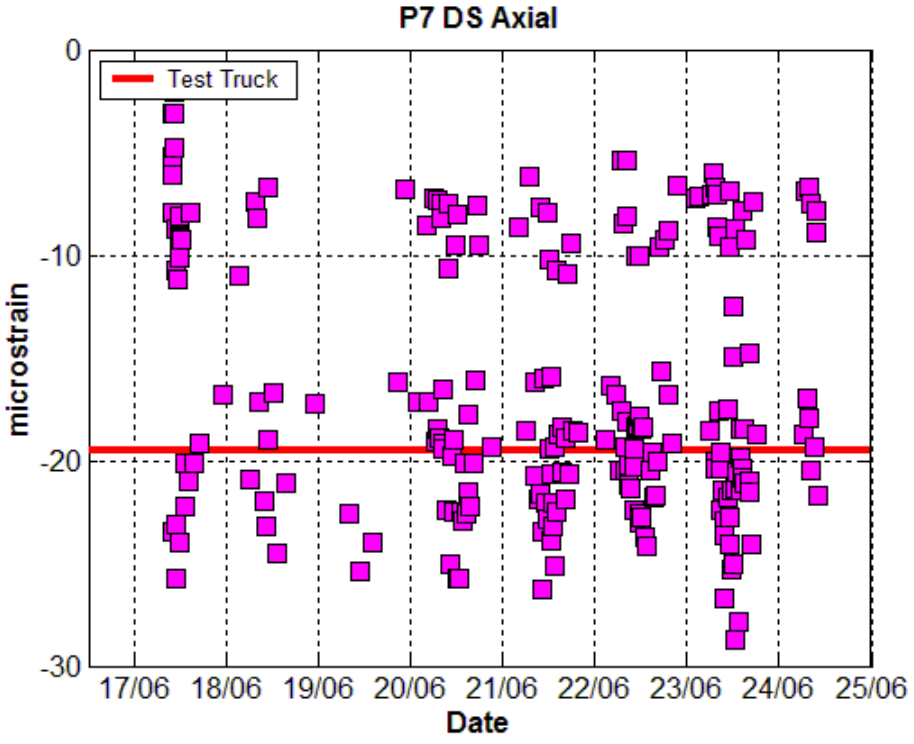

Figure 4-12. Scatter Plot - Pier 7 Downstream Axial Strain

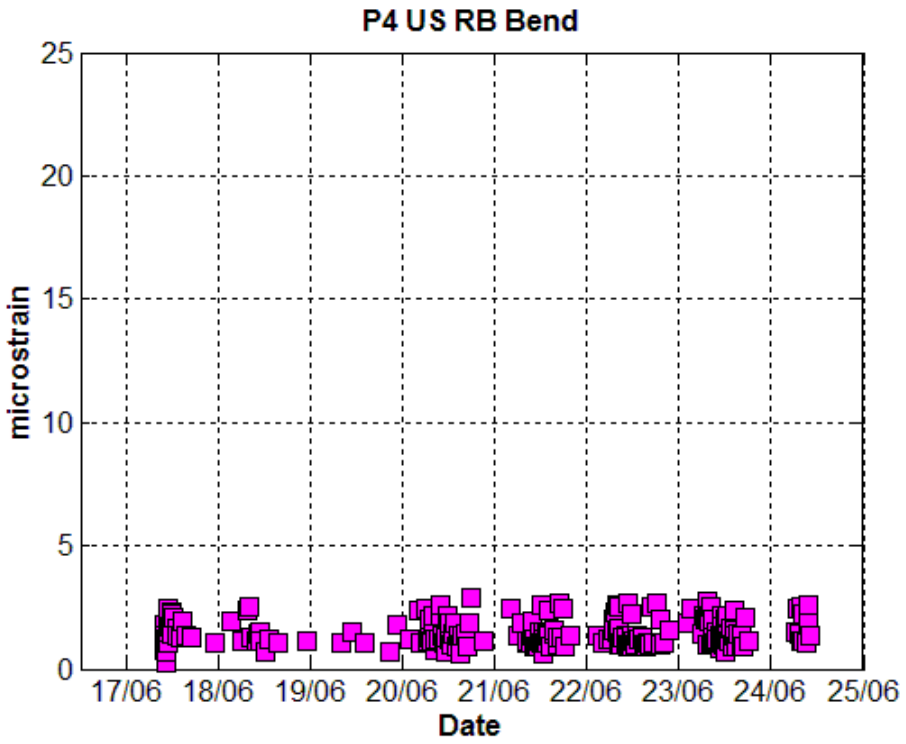

Figure 4-13. Scatter Plot - Pier 4 Upstream Bending Strain (RB)

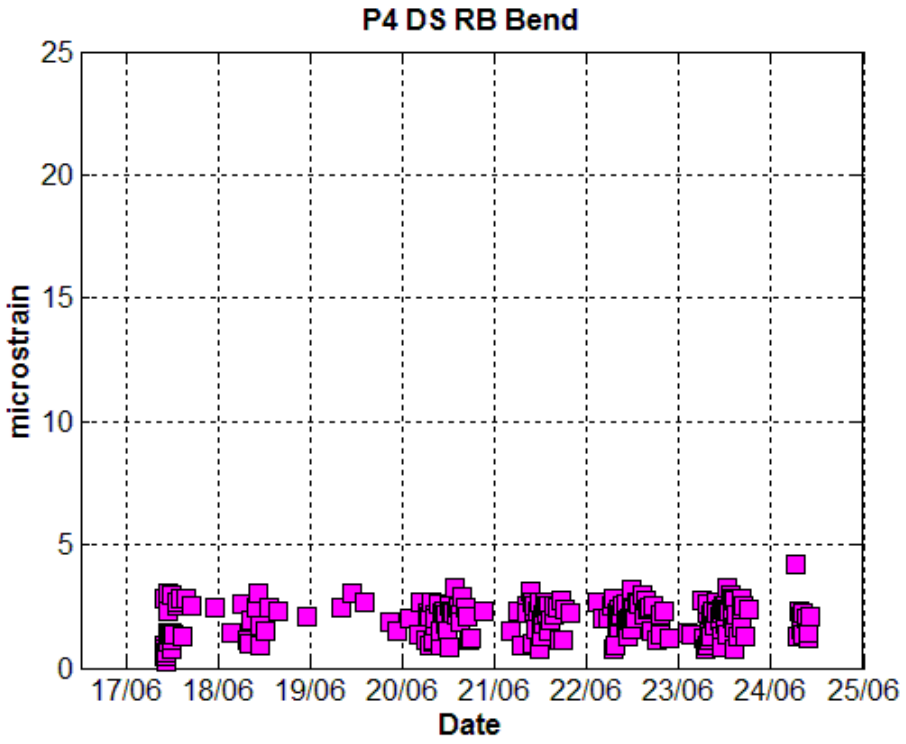

Figure 4-14. Scatter Plot - Pier 4 Downstream Bending Strain (RB)

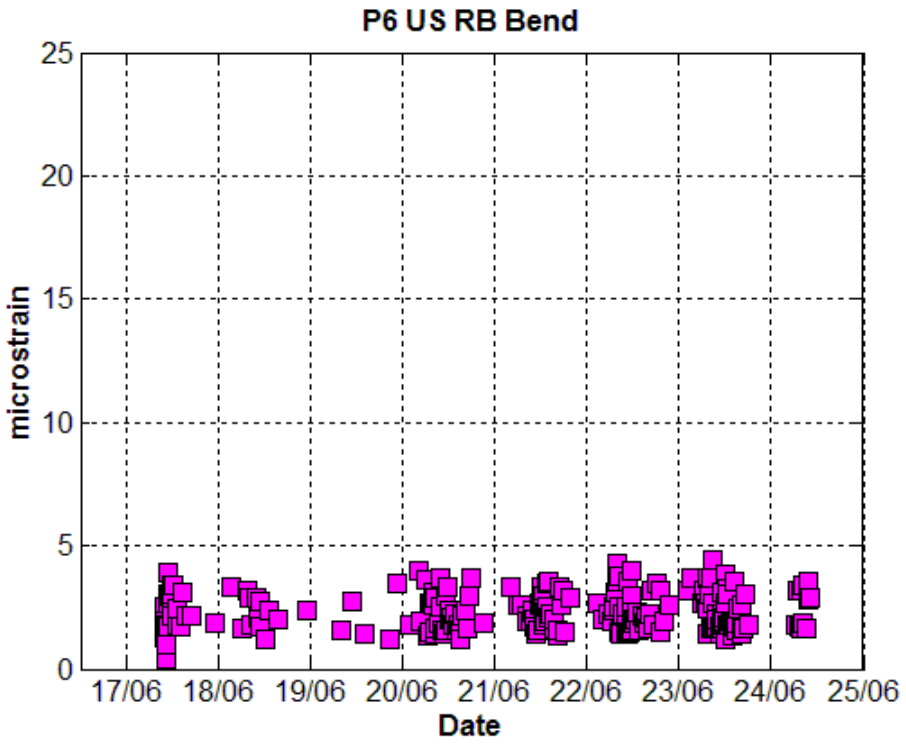

Figure 4-15. Scatter Plot - Pier 6 Upstream Bending Strain (RB)

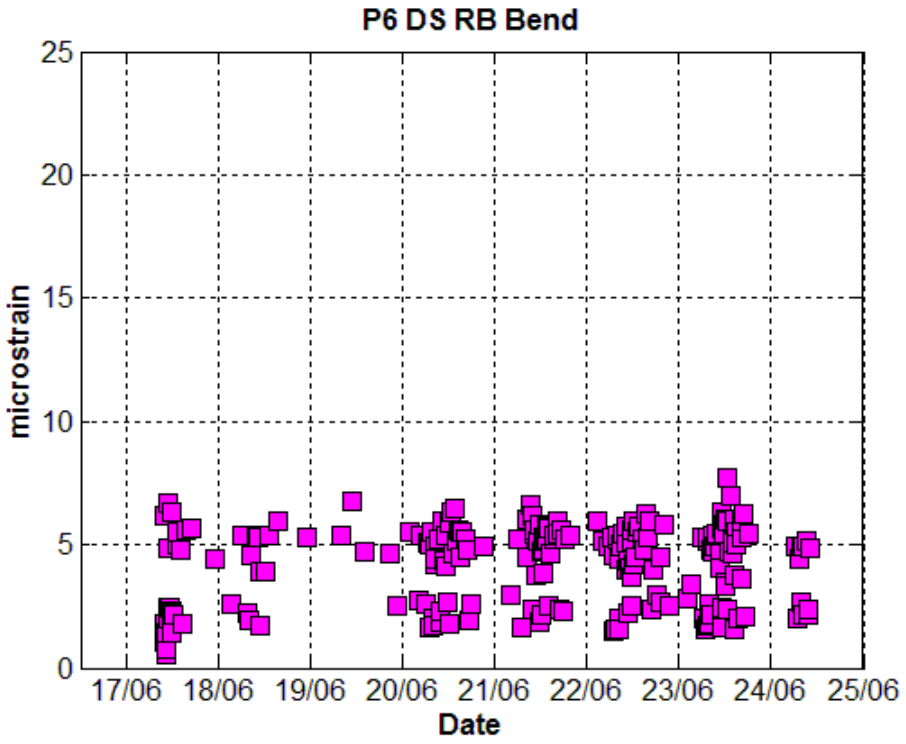

Figure 4-16. Scatter Plot - Pier 6 Downstream Bending Strain (RB)

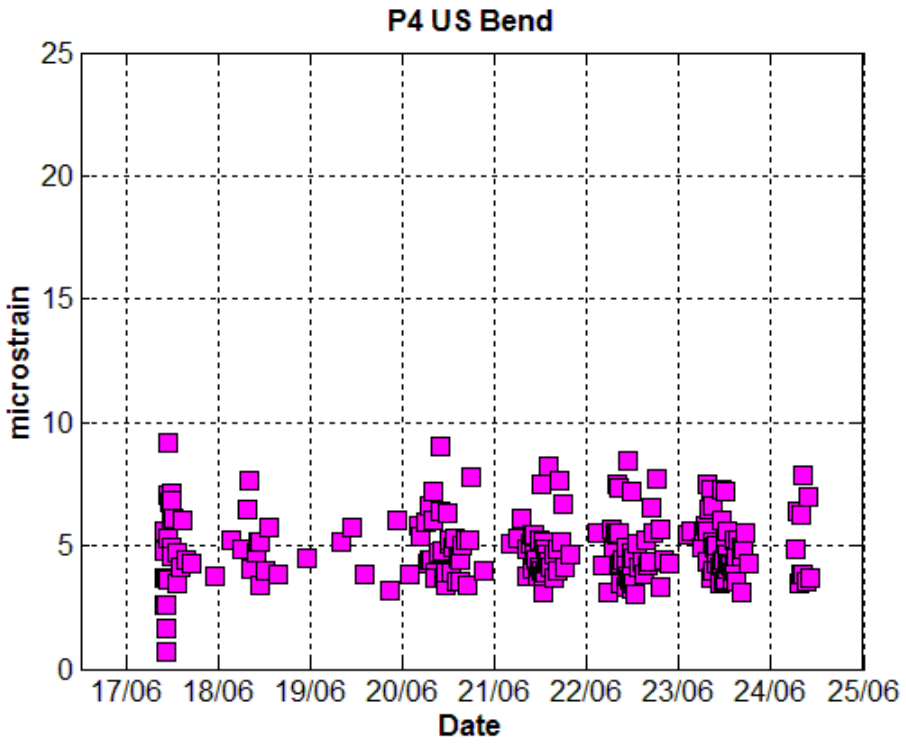

Figure 4-17. Scatter Plot - Pier 4 Upstream Bending Strain

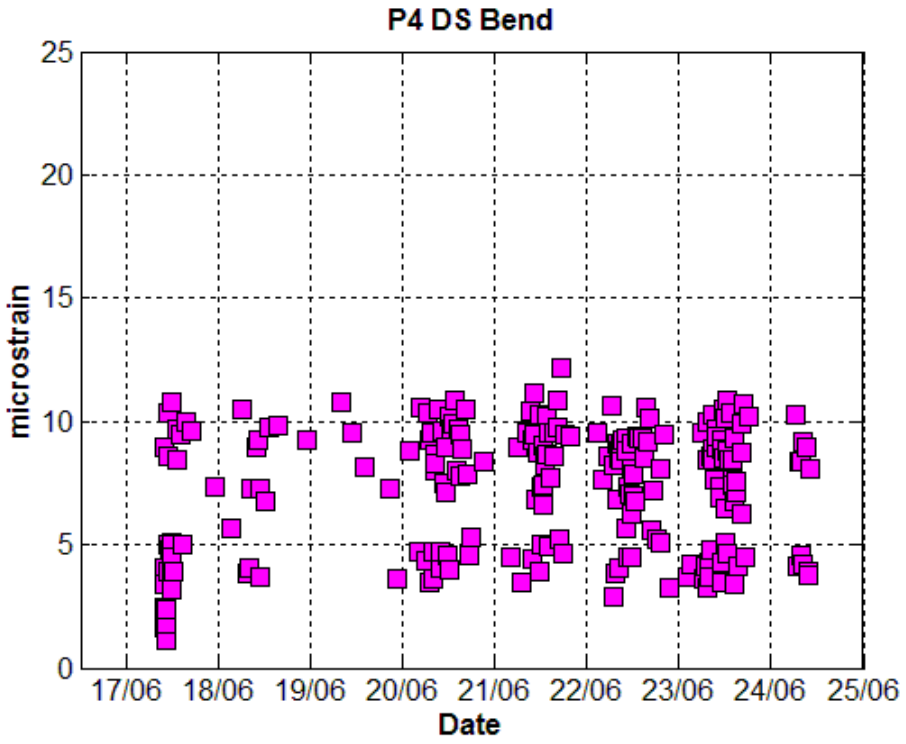

Figure 4-18. Scatter Plot - Pier 4 Downstream Bending Strain

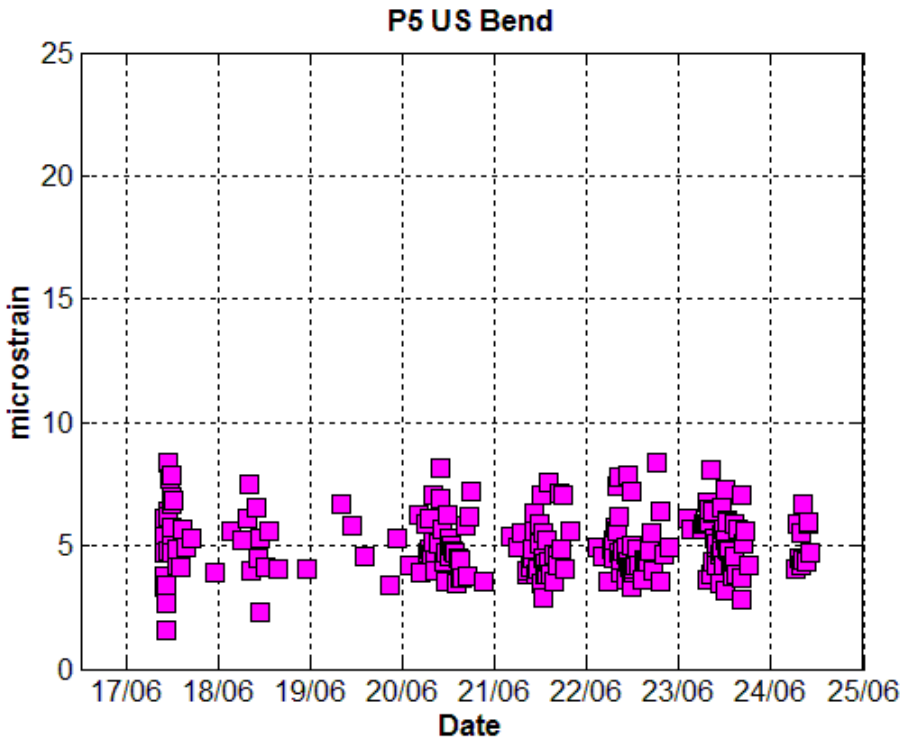

Figure 4-19. Scatter Plot - Pier 5 Upstream Bending Strain

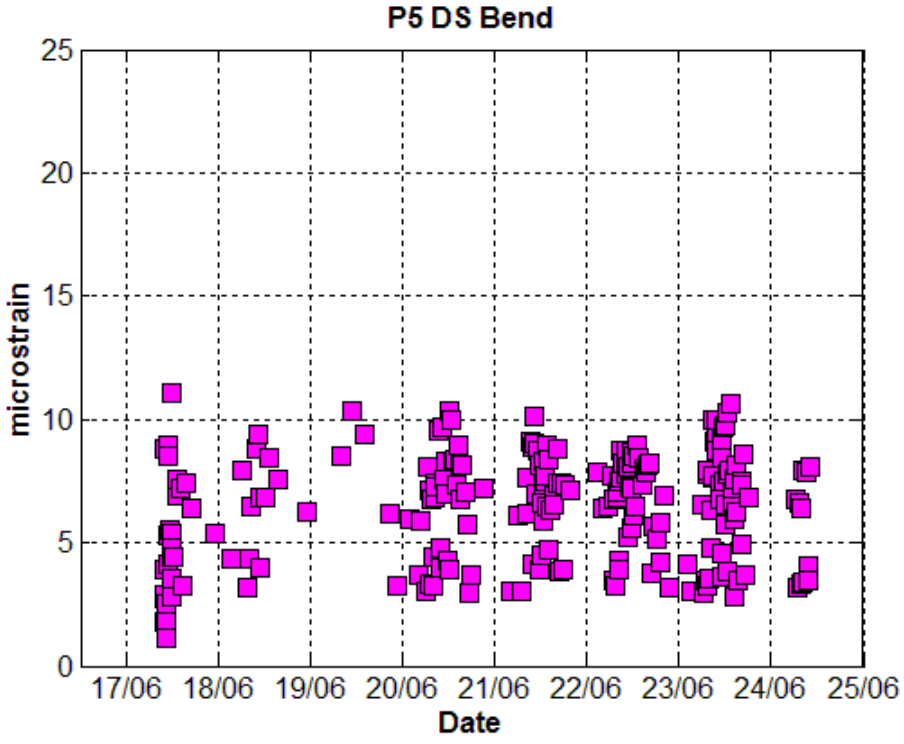

Figure 4-20. Scatter Plot - Pier 5 Downstream Bending Strain

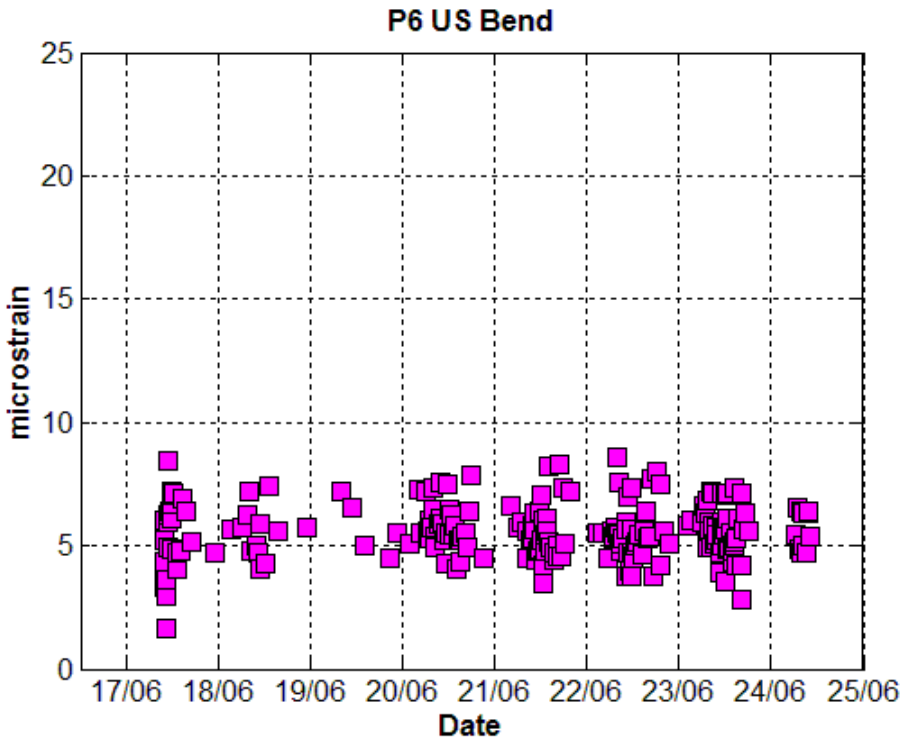

Figure 4-21. Scatter Plot - Pier 6 Upstream Bending Strain

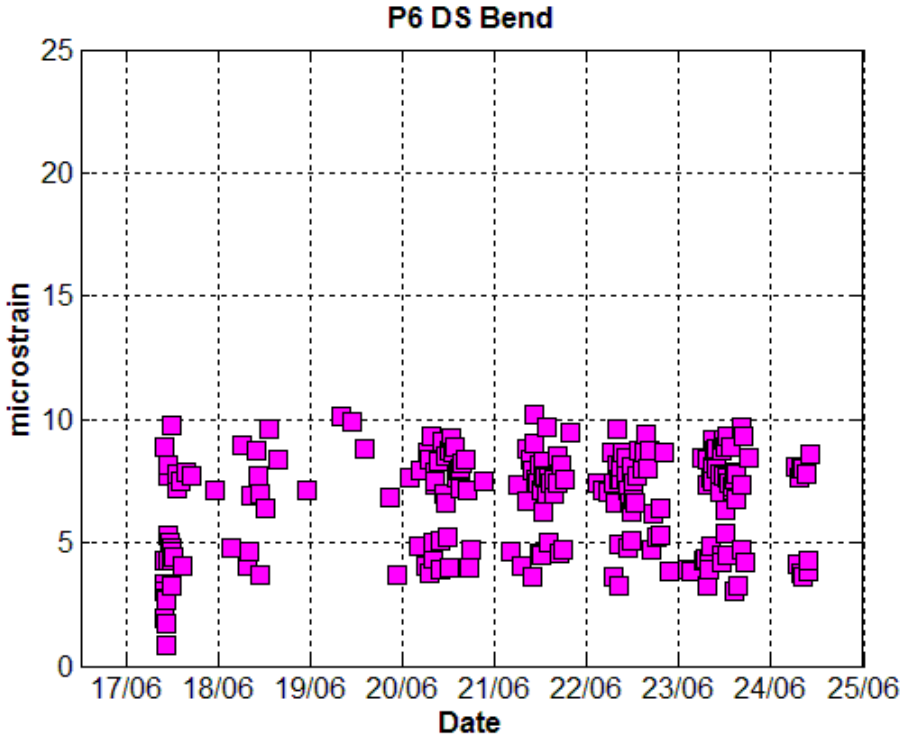

Figure 4-22. Scatter Plot - Pier 6 Downstream Bending Strain

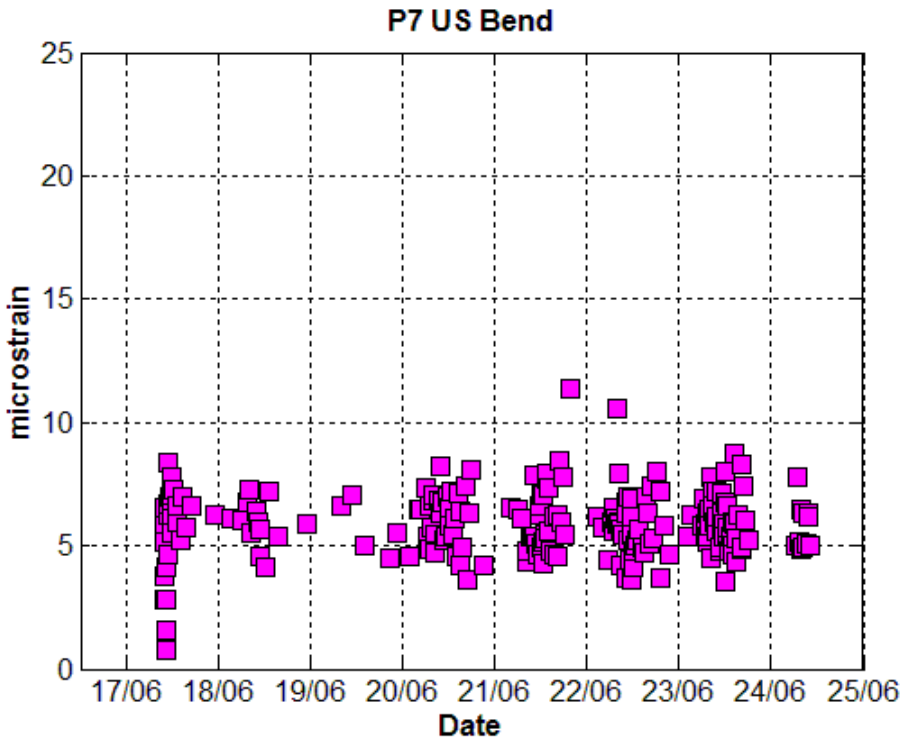

Figure 4-23. Scatter Plot - Pier 7 Upstream Bending Strain

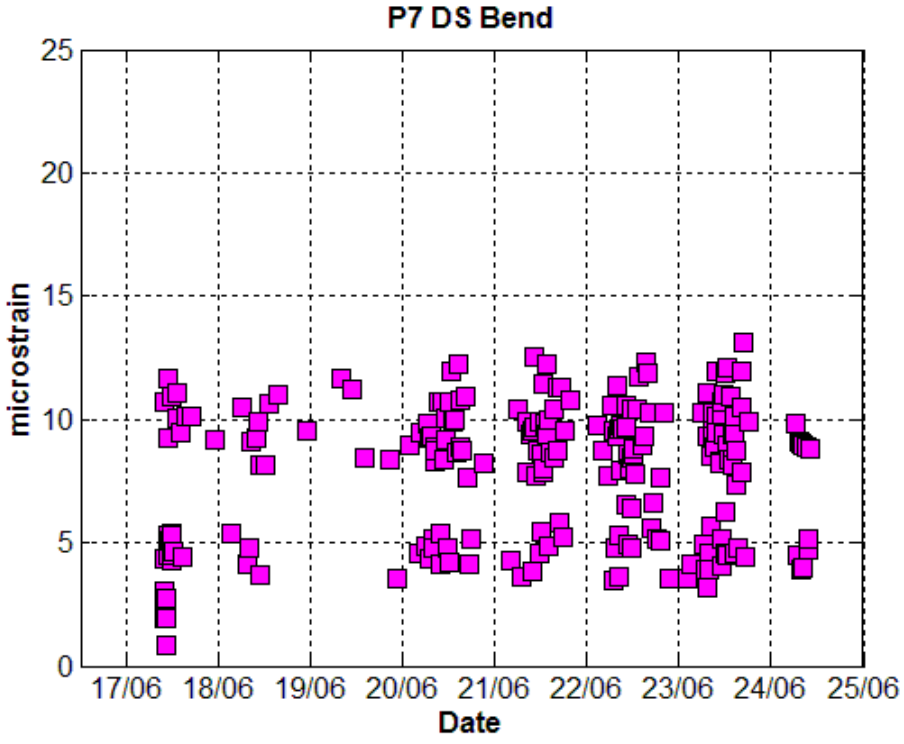

Figure 4-24. Scatter Plot - Pier 7 Downstream Bending Strain

5. Figures

Figure 5-1. Data Acquisition Location

Figure 5-2. Strap-On Strain Gauge for River Bed

Figure 5-3. Typical Pier Cabling

Figure 5-4. Expansion Joint DDT

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Graphitisation Investigation

Windsor Bridge

Prepared for: Roads & Traffic Authority NSW 110 George St Parramatta NSW 2150		**Contact:** Peter Ton **Phone:** (02) 8837 0843 **Mob:** (0407 295 624
Date: July 13th, 2011	**Job Number:** 2739	**Report Number:** C11231 **Rev:** 0riginal

Report No. C11231

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Revision	Date	Reason for Revision	Approved By
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1 INTRODUCTION

As part of its ongoing asset management program, the Roads and Traffic Authority of NSW (RTA) has been gathering data on the condition of its bridge structures.

Many older bridges have cast iron piers[1] footed in rivers or estuaries and over recent years, concerns have been raised about the condition of many of these structures. One of the main concerns is the possibility of graphitisation of the cast iron piers, especially in the splash and tidal zones in coastal environments.

CTI Consultants have been providing assistance to the RTA in the assessment of graphitisation of cast-iron bridge piers since 1999, and have previously carried out graphitisation surveys on cast iron bridge columns of a number of bridges including the Unwins Bridge and Undercliff Bridge over the Cooks River at Tempe, the Pacific Highway Bridge over Wyong Creek, the old truss bridge over the Shoalhaven River (Nowra Bridge) at Nowra and the Bridge over the Patterson River at Hinton.

The results of the previous surveys showed that, in general, the extent of graphitisation was surprisingly low in the tidal and splash zone, but that graphitisation in the immersed sections of piers was considerably more advanced, with depths of graphitisation up to 25 mm being reported even in brackish and fresh water conditions.

CTI conducted a previous study on the columns of the Windsor Bridge on the Hawkesbury River in 2005, the findings of which were reported in CTI Report C10174, dated 30/04/2005. Based on a limited, random core sampling program, this investigation revealed high rates of graphitisation, with residual wall thickness being as low as 12 mm in places. This investigation also raised uncertainty about the original design thickness of the column castings, thought to be 30 mm from available drawings, but with site observations suggesting a 25 mm wall thickness.

In order to gain a more thorough understanding of the dimensions and wall thickness of the cast-iron column segments at Windsor (and other bridges), CTI proposed an additional program of core sampling, involving eight cores to be taken from the same segment, four cores at the cardinal points at both the upper and lower quarter circumferences. The divers would first be asked to identify the seams between the individual castings by cleaning a strip approximately 200 mm wide down the side of the selected column. This would allow the length of the segments to be established.

This report contains the details and findings of the latest investigation into the condition of the cast-iron piers of the bridge at Windsor. Although a stand-alone report, the reader is referred to the previous CTI Reports (C9666, C9880 and C10174) which contain background information on the composition, strength and corrosion of cast iron bridge piers as well as the above-water and under-water findings for the other bridges mentioned above.

[1] The cast iron columns of these piers are usually filled with concrete or rubble, but the iron casing provides the principal load bearing function.

2 METHODOLOGY

2.1 Details of Survey

The survey was conducted over the period from Monday, May 9th, 2011 to Saturday, May 21st, 2011.

All underwater work and inspections were provided by Commercial Diving Solutions Pty Ltd of Sapphire, NSW, (Manager Martin Woschitzka) under the on-site direction of Mr John Selway of the RTA Hunter Region. The inspection work was to coincide with the installation of other instrumentation on the bridge, directed by Mr Peter Ton of the RTA Bridge Section.

Fred Salome of CTI attended site at regular intervals to brief the divers on the requirements of the cleaning and core sampling program, and to receive updated results and samples as these became available.

2.2 Site Nomenclature

The bridge is oriented in an essentially NS direction. The piers are numbered from the south. Columns are denoted as D – Downstream or U - Upstream

The divers adopted a convention of referring to the upstream (West) direction as 12 o'clock, and working in a clockwise direction from there so that North is 3 o'clock and so on.

All reported heights on the piers were measured from a reference level corresponding to the lower of the two flanges on the columns.

The water level varied between approximately 2 and 3 m below the reference height, and the river bed was at approximately 8 m below the reference height (ie 5 to 6 m deep) for most of the river's width.

View of above water part of bridge pier showing lower flange used as reference level for recording height on piers

2.3 Inspection Procedures

2.3.1 Pre-Inspection

Before carrying out any cleaning tasks, the divers inspected the columns for visual signs of corrosion, noting the prevalence of marine growth, instances of loose rust tubercules and the relative incidence of hard nodules.

2.3.2 Cleaning

Vertical strips of approximately 150 mm width were cleared (using scraping and high pressure water) on target columns. The main purpose of this was to identify the seams between the individual castings comprising the columns, but this also allowed the columns to be checked for horizontal (circumferential) cracks.

Where cracks were encountered on any column, the entire circumference was cleaned.

2.3.3 Depth of Graphitisation

Cleaned areas were explored for depth of graphitisation by focussed application of the high pressure water nozzle or by probing with a chisel. The pins of a profile gauge were pushed into the excavated graphite layer to indicate its thickness, and photographed. This allowed the range of metal loss (= depth of graphitisation) to be determined.

2.3.4 Wall Thickness

Small diameter (20 mm) core samples were taken through the wall of the columns at selected locations, to allow the residual wall thickness to be measured directly. Where the graphite layer remained on the core undisturbed, the original total wall thickness could also be deduced (assuming no loss of graphite had occurred under service conditions, see discussion below).

2.4 Analysis of Water

Water samples were taken by the divers from near the surface, at mid-depth and close to the sea-bed.

CTI forwarded these samples to Envirolab Services of Chatswood, NSW, for analysis of a range of water quality parameters as further described in the results section below.

2.5 Metallurgical Examination

One sample taken from the lowest segment of Pier 5 visible above the sea-floor was examined metallurgically, for comparison with samples analysed as part of the 2005 survey.

2.5.1 Sample Preparation

The core samples was mounted and polished, and the microstructure viewed under a metallurgical microscope both in the un-etched and etched condition.

The un-etched condition was viewed at 120X magnification to identify the type of cast iron and to indicate the size, shape and distribution of the graphite phases.

To obtain an indication of the composition of the iron matrix, the samples were etched in 3% Nital and viewed at 250X magnification.

2.5.2 Hardness Testing

A Vickers Hardness test, using a 20 kg load, was performed on the cast iron sample to obtain an indication of the tensile and compressive properties of the material.

In cast irons, the strength is determined by the size and distribution of the graphite flakes and the composition of the matrix. The lower grades of cast iron tend to have a fully ferritic softer matrix compared to a fully pearlitic harder matrix for the higher strength grades.

2.5.3 Chemical Composition

Part of the sample was sent to Spectrometer Services for elemental composition analysis by electric arc spectroscopy.

3 RESULTS

3.1 Description

The piers are footed in the river-bed which is approximately 5m deep.

There is diagonal bracing in the atmospheric zone with a tie-beam located at approximately the low water mark, as indicated in Figure 1. The tidal range is of the order of 1 metre.

Note that the cross bracing at present is fixed to the columns by means of cleats at the top, with the cleats having been riveted onto the cast iron columns. However at the base, the bracing is secured by means of collars clamped around the columns, at the bottom of the tidal range (see arrows in Figure 1).

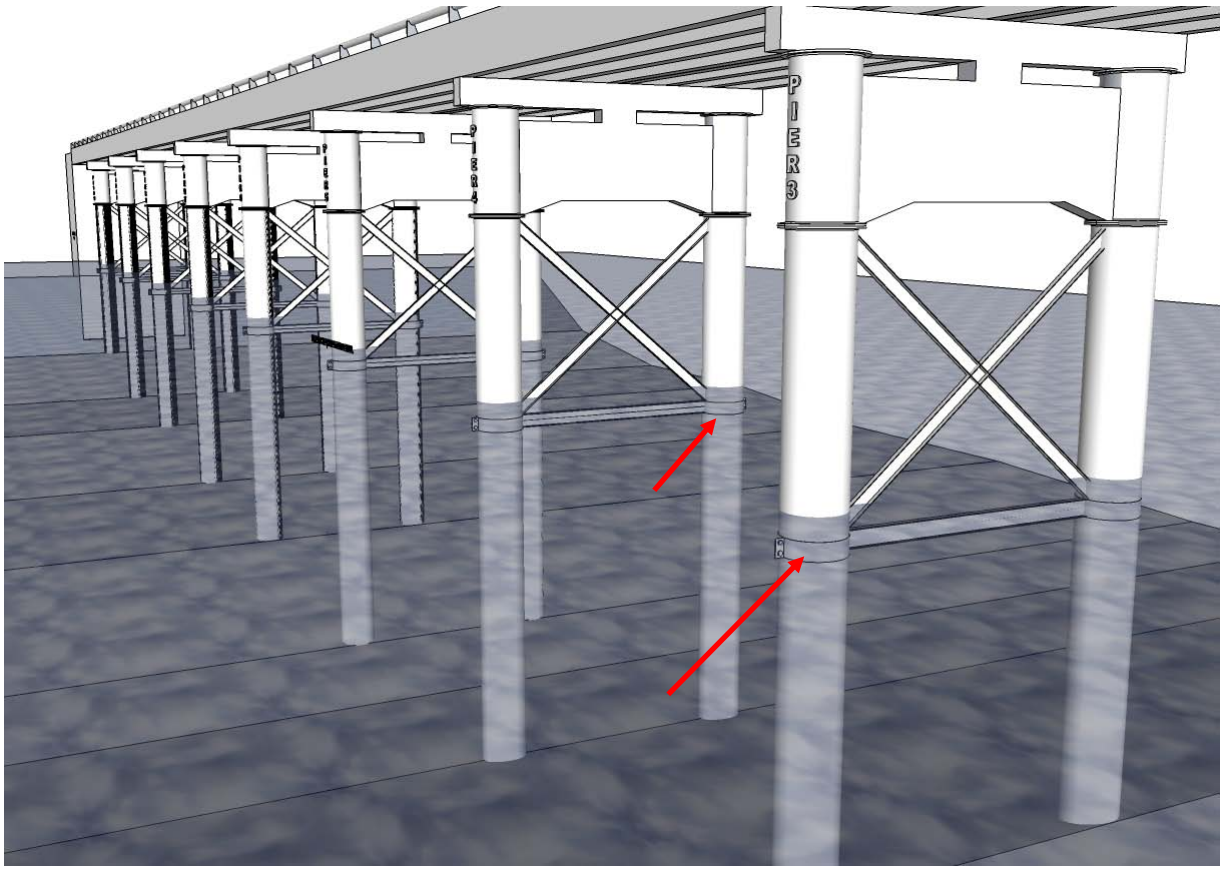


Figure 1 Sketch Showing General Arrangement of Piers

3.2 Design of Castings

After performing the strip cleaning of each pier, the individual castings were found to be 1.84 m in height (ie. 6 feet).

Core sampling into one of the seams (Pier 5 Downstream, mid-water level) revealed there to be an internal flange, with a bolt hole intersected by the core as indicated by the concave shape at its end. This confirms the castings are joined by internally bolted flanges.

Core from seam between sections as retrieved by divers - length > 50mm, with cast-in rebate for gasket (two halves taped together)

Inner ends of the two halves of the core were a concave shape, indicating the core intersected a bolt hole

3.3 Wall Thickness

3.3.1 Original Thickness

Core sampling of one casting (on pier 5) was conducted on two circumferences, at the upper and lower quarters, with samples taken at four equidistant points on each circumference (NW, NE, etc). The graphite layer on the core samples was largely undisturbed during the coring so that the total original wall thickness could be measured.

The results are presented in Table 1, which also includes the results from the 2005 survey. Together these indicate that the castings were made with a wall thickness ranging from 22 to 38 mm, but with most samples falling between 22mm and 29mm.

The results are considerably lower than found for the above water extension castings in 2005 and are lower than the indications on drawing which suggested a 30 mm wall thickness.

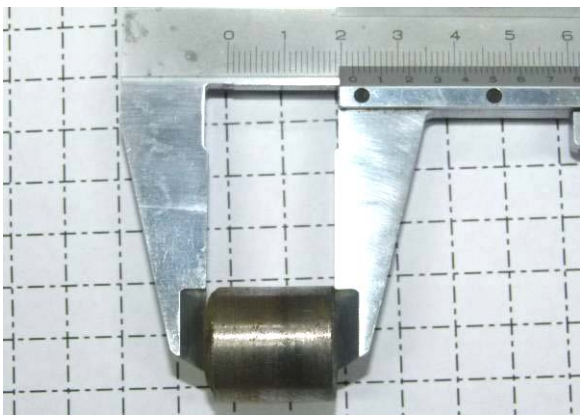
However, a core was taken from the base of column 5D, as the divers reported the surface condition before cleaning to be significantly different, with fewer and smaller tubercules or lumps in the marine growth layer. The length of this core was only 22mm, but it had only minimal graphitisation, less than 1 mm.

Metallurgical assessment of this core (refer section 3.6 below) confirmed it to be of the same type and composition as the remainder of the castings, as determined as part of the 2005 survey.

As it is considered highly unlikely that a lower wall thickness would have been used at the base of the columns, it is concluded that the original thickness was indeed greater than 22 mm, and that the graphitised layer has been worn away.

Scouring or sediment (essentially sand) loading at the base of a column during periods of high flow might be assumed to be significant and can provide a possible mechanism for the gradual erosion of the graphitised layer.

Another possible cause of loss of the marine growth or graphitised layers is prior cleaning and assessment. A thorough search of available records may provide further information on the likelihood of this having occurred.



Core from base of 5D, total length 22mm

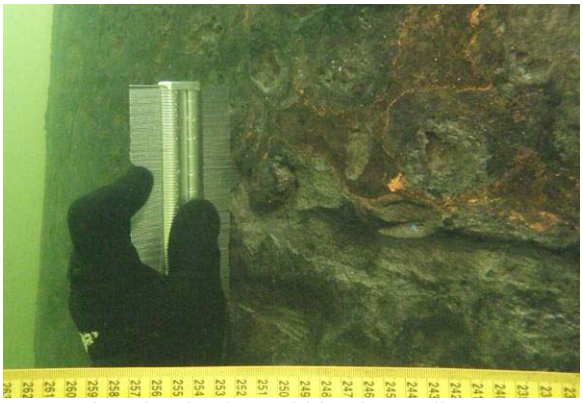
Surface of core showing minimal (< 1 mm) graphitisation

3.3.2 Remaining Thickness

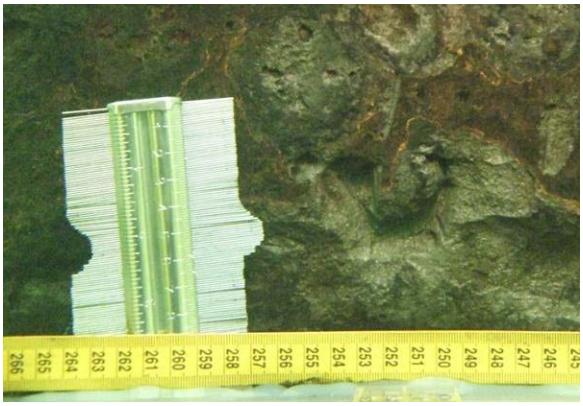
The remaining effective wall thickness (ie. exclusive of graphitised material) as measured during May 2011 ranges widely, from a maximum of 27 mm to a low of 2 mm.

There was no distinct or discernible pattern to the distribution of the residual wall thickness.

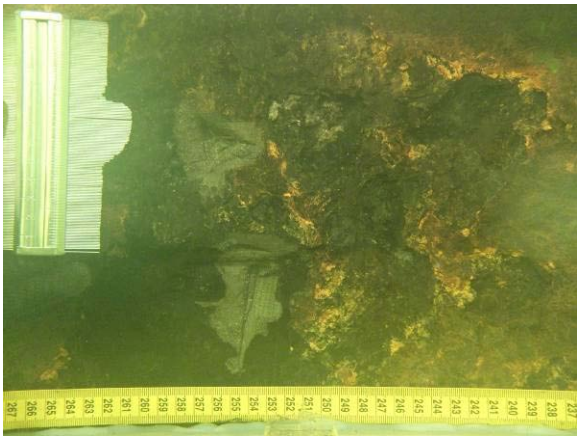
It should be noted that in addition to the core samples taken, the divers also measured the depth of graphitisation by excavating through the graphitised layer. This frequently showed depths of graphitisation in excess of 20mm, so that the residual cast iron thickness will be less than 10 mm and perhaps, in some instances, negligible.



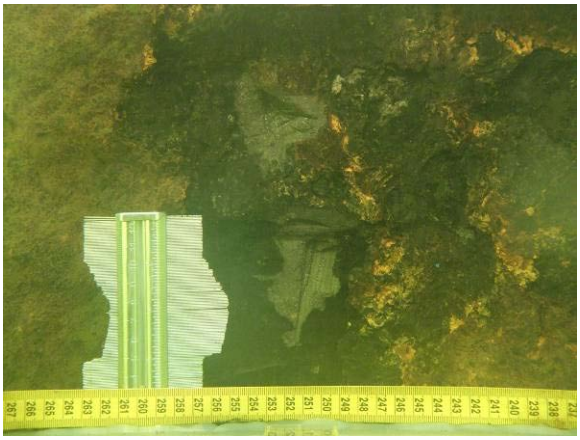
Measuring depth of graphitisation – diver pushing pins of profile gauge into excavation through graphite layer



Profile gauge withdrawn from excavation allows depth of graphitisation to be measured



Profile gauge withdrawn from excavation allows depth of graphitisation to be measured

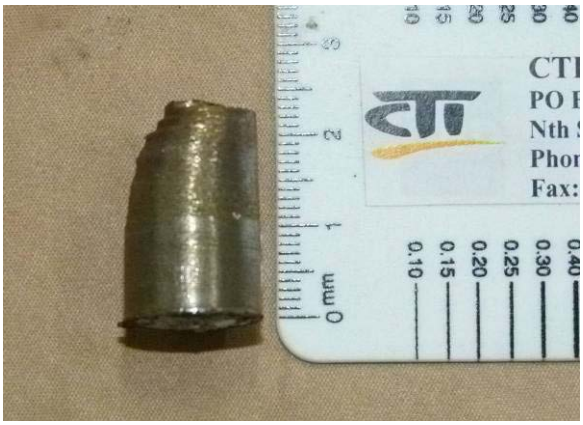


Profile gauge withdrawn from excavation allows depth of graphitisation to be measured

Table 1 Summary of Core Samples (2005 and 2011)

Date Cored	Pier	Column	Aspect	Height	Casting Length	Residual Cast Iron	Comment
Above Water							
10/03/2005	1	D		Above water, above flange	35	35	Column extension
10/03/2005	1	D		300mm below flange	26	26	Upper limit of immersed column sections
May 2011	5	D		Ref less 2m	26	26	Above MHWS
May 2011	5	D		Ref less 2m	23	23	Above MHWS
May 2011	5	D		Ref less 2m	25	25	Above MHWS
May 2011	5	D		Ref less 2m	26	23	Above MHWS
Below Water							
10/03/2005	1	D		1600mm below flange	25	25	
11/03/2005	5	D		Underwater	31	> 20	At internal thickening
11/03/2005	5	D		Underwater	~30	20	1.6m from bed
11/03/2005	7	D		Underwater	~ 38	18	1.6m from bed
11/03/2005	9	U		Underwater	~38	27	1.6m from bed
May 2011	5	U	NW	Ref less 4m	22	6-10	~ 0.7m below water
May 2011	5	U	NE	Ref less 4m	24	14-15	~ 0.7m below water
May 2011	5	U	SE	Ref less 4m	24	10-11	~ 0.7m below water
May 2011	5	U	SW	Ref less 4m	22-23	8-13	~ 0.7m below water
May 2011	5	U	SW	Ref less 4m	22-23	2-9	~ 0.7m below water
May 2011	5	U	NW	Ref less 5m	22	14-17	~ 1.7m below water
May 2011	5	U	NE	Ref less 5m	29	21-27	~ 1.7m below water
May 2011	5	U	SE	Ref less 5m	~28	18-20	~ 1.7m below water
May 2011	5	U	SW	Ref less 5m	27	16-21	~ 1.7m below water
May 2011	5	D		Ref less 3.6 m	23	11	50mm core through crack
May 2011	5	U		Ref less 3.35 m	27	15-17	50mm core through crack
May 2011	5	D		Ref less 8m	22	21	Sea-Bed core

Typical appearance of cores is illustrated in the following photographs.



5D NE aspect, above water; no graphitisation

5U NE aspect, upper quarter of immersed casting, showing 9-10mm of graphitisation and 14-15mm remaining cast iron

5U SW aspect, upper quarter of immersed casting, showing up to 18 mm of graphitisation and as little as 2mm remaining cast iron

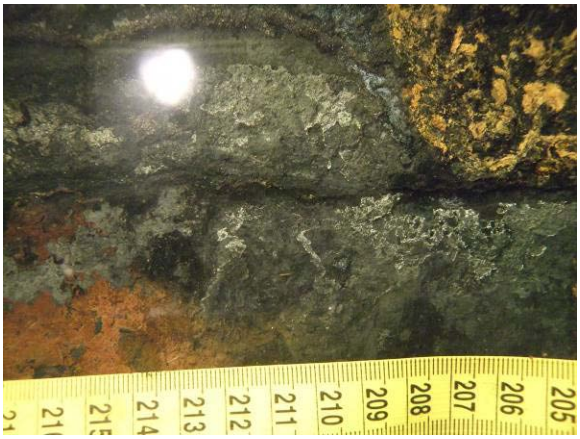
5U SW aspect, lower quarter of immersed casting, showing up to 11 mm of graphitisation and as little as 16mm remaining cast iron

3.4 Cracking in Columns

During the inspection, three horizontal (circumferential) cracks were detected in columns.

The Upstream Column of Pier 5 (5U) had a full circumferential crack, approximately 200mm above the seam at the top of first fully immersed section. This placed the crack just below the collar for the bracing, and it probably coincides with the beginning of the internal thickening of the casting to create the flange. The crack was at its widest on the downstream (6 o'clock) side of the pier, where it was estimated to be in excess of 1 mm.

There was also a vertical crack on the column, starting at the same seam (at 6 o'clock, east or downstream) and extending approximately 100 mm upwards. Its width was measured to be up to 2 mm wide at its base, tapering upwards.



Circumferential crack on column 5U

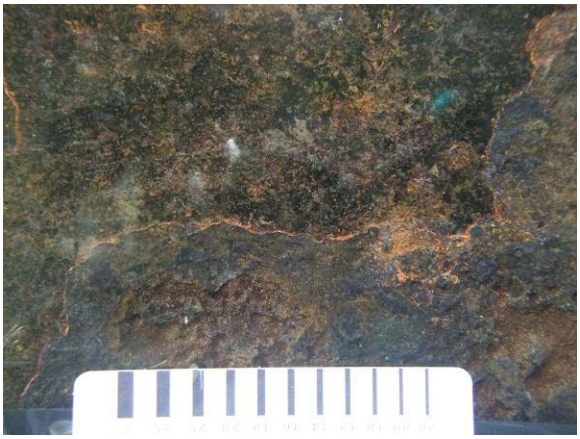
Circumferential crack on column 5U

Vertical cack on column 5U on downstream side, estimated to be > 2 mm wide at its base

Cleaning and excavating graphite layer shows crack to extend beyond the outer graphite layer

The Downstream column of Pier 5 (5D) also had a full circumferential crack but in this case, the crack was approximately 200mm below the seam at the top of the first fully immersed casting. The crack was cored using a 50mm diameter bit, and confirmed the crack to be full depth. Graphitisation had followed the line of the crack for some distance, indicating the crack to be of some age.

5D crack, at its widest on East, downstream side (6 o'clock)



5D crack, narrow on West, upstream side (12 o'clock)

Core (50mm diameter) through crack on 5D showing it to extend full depth through the casting

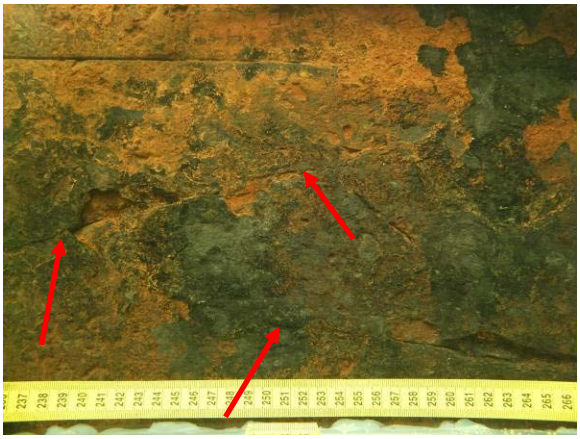
Graphitisation follows line of crack indicating crack to be of reasonable age

The third circumferential crack was on the downstream column of pier 6 (6D), also situated below the first immersed seam, and extended for three quarters of the circumference, from 12 o'clock to 9 o'clock.

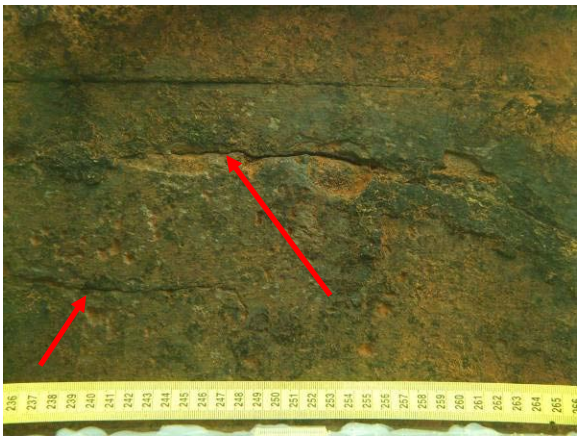
This crack was more complex, bifurcating at approximately 6 o'clock and developing parallel cracks for some distance. This suggests significant damage to the upper casing including the internal flange.

At its southern end (9 o'clock), the crack slanted upwards and joined the seam.

Crack on 6D some 200mm below seam, with occasional frayed edges



Crack bifurcates, indicating top of casting is essentially broken



Twin cracks running parallel to each other

Crack slants upward and joins seam at 9 o'clock (south aspect)

3.5 Water Quality

The results of the river water analyses are presented in Table 2.

Table 2 River Water Analysis Results

Test	CTI 38629 (Surface)	CTI 38630 (Mid depth, 2.5 m)	CTI 38631 (Bottom, 5 m)
Chloride (mg/L)	29	29	29
Sulphate (mg/L)	7	7	7
Electrical Conductivity (μS/cm)	170	170	170
Total Dissolved Solids (grav, mg/L)	86	100	96
pH	6.6	6.7	6.7
Hardness ($mgCaCO_3/L$)	24	25	23
Calcium (mg/L)	3.8	4.1	3.8
Iron (mg/L)	0.3	0.4	0.7
Potassium (mg/L)	2.0	2.2	2.0
Sodium (mg/L)	15	16	15

These results indicate that there has been no significant layering of the water, with no significant differences in any of the parameters tested. The water is essentially fresh water with a low hardness (soft).

The level of chloride and sodium present, at 29 ppm and 15 ppm respectively, are in fact well below potable water standards which have permissible chloride levels at 250 ppm and sodium at 180 ppm.

Therefore the waters sampled at Windsor Bridge during the survey indicate essentially fresh water with no marine influence. Although subject to tidal height water variations, this simply results in fresh water moving backwards and forwards by the pushing action of incoming tides, without sea water actually being present.

3.6 Metallurgical

3.6.1 Sample Details.

The cast iron core sample (CTI 38888) was taken by the divers at sea-bed level from the downstream Column of Pier 5 (5D) on 20/5/2011.

3.6.2 Microstructure and Hardness

The results of the metallurgical assessment are given in Table 3, which also reproduces the results for the earlier 2005 samples.

Table 3 Results of Metallurgical Tests and Estimates of Tensile Strength

Sample No.	Hardness (Hv_{20})	Microstructure	Estimated UTS*
CTI 25791	180 - 200	No evidence of graphitisation. Coarse flake graphite in fully pearlitic matrix plus relatively high levels of phosphide eutectoid (Figures 1 & 2 in 2005 Report)	220 to 240 MPa
CTI 25792	160 - 175	No evidence of graphitisation. Coarse flake graphite and fine rosette graphite in a ferritic/pearlitic matrix. relatively high levels of phosphide eutectoid (Figures 3 & 4 in 2005 Report)	180 to 200 MPa
CTI 25793	160 - 180	Graphitisation on outer surface. Coarse flake graphite in ferritic/pearlitic matrix plus relatively high levels of phosphide eutectoid (Figures 5 & 6 in 2005 Report)	180 to 200 MPa
CTI 25794	160 - 175	Graphitisation on outer surface. Coarse flake graphite and some rosettes of medium to fine graphite in a ferritic/pearlitic matrix plus medium levels of phosphide eutectoid (Figures 7 & 8 in 2005 Report)	180 to 200 MPa
CTI 25795	145 - 155	Graphitisation on outer surface. Coarse flake graphite and some rosettes of medium to fine graphite in a nearly fully ferritic matrix plus medium levels of phosphide eutectoid (Figures 9 & 10 in 2005 Report)	140 to 160 MPa
CTI 38888	160 - 175	Slight graphitization on outer surface. Coarse flake graphite and some rosettes of medium to fine graphite in a ferritic/pearlitic matrix plus relatively high levels of phosphide eutectoid (refer Figures 2 & 3)	180 to 200 MPa

* Based on shape and size of graphite flake, type of matrix and hardness.

The micrographs for the sample from 5D are shown below.

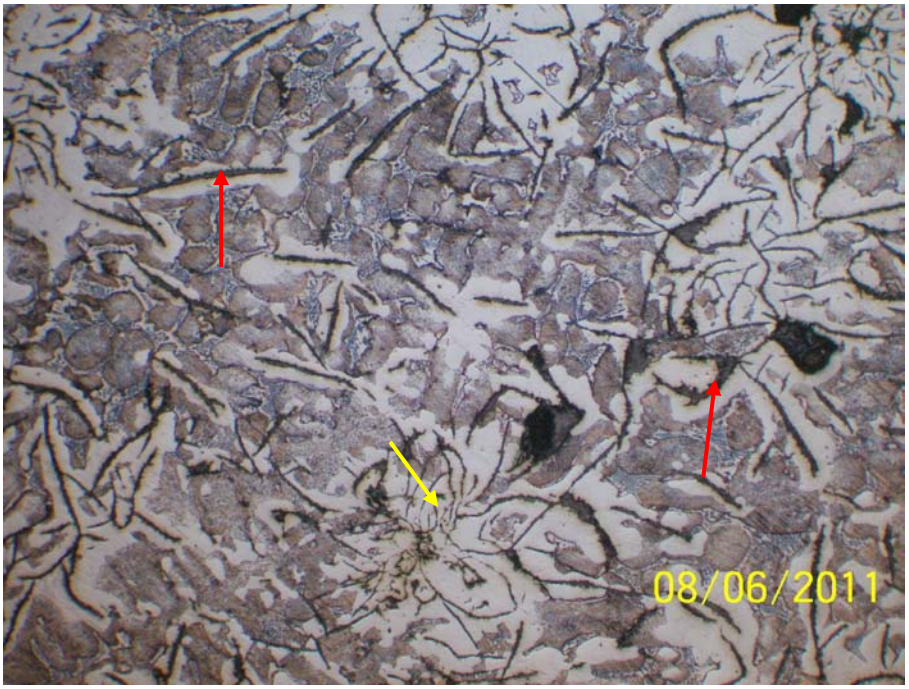


Figure 2 Core Sample CTI 38888 (etched) showing coarse graphite flakes (red arrow) and "rosettes" of medium and finer carbon flakes (yellow arrow) in a ferritic/pearlitic matrix. Magnification –X120; Etchant – 3% Nital.

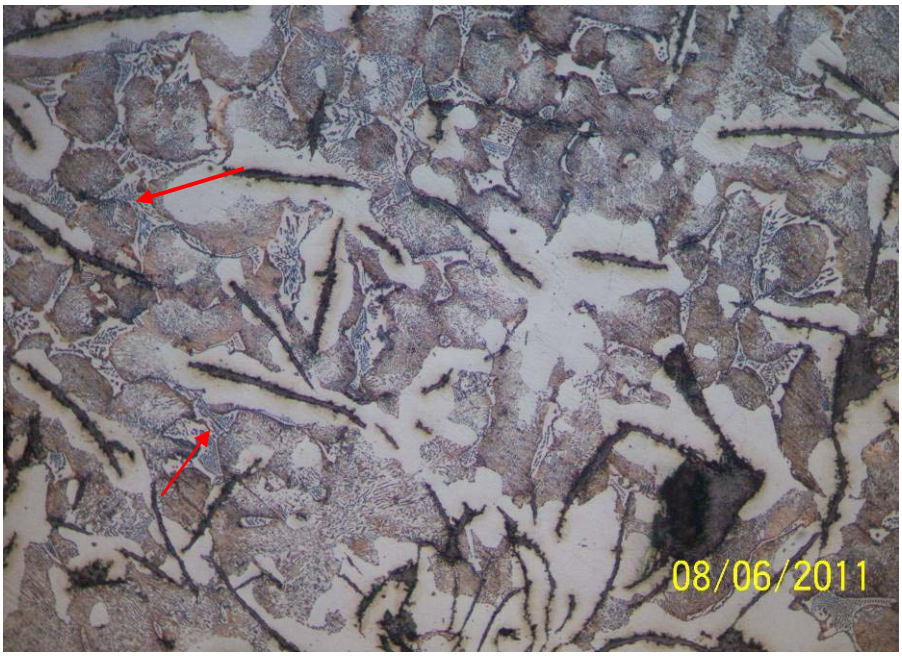


Figure 3 Core Sample CTI 38888 (etched) showing coarse and medium graphite flakes in a ferritic/pearlitic matrix containing relatively high levels of phosphide eutectoid (refer arrows). Magnification -X280; Etchant – 3% Nital.

3.6.3 Chemical Composition

The results of the chemical analysis are given in Table 4, which also reproduces the results for the earlier 2005 samples.

Table 4 Compositional Analysis

Sample	C (%)	Mn (%)	Si (%)	S (%)	P (%)	Ni (%)	Cr (%)	Cu (%)
CTI 25791	3.54	1.6	2.1	0.021	0.95	<0.01	<0.01	0.02
CTI 25792	3.16	0.66	2.6	0.048	1.2	<0.01	<0.01	0.01
CTI 25793	3.40	0.91	2.2	0.040	1.2	<0.01	<0.01	0.01
CTI 25794	3.15	0.76	2.4	0.075	1.4	<0.01	<0.01	<0.01
CTI 25795	3.16	0.69	2.70	0.060	1.1	<0.01	<0.01	0.01
CTI 38888	3.2	0.82	2.5	0.05	1.15	0.02	0.02	0.01

3.6.4 Discussion

The core sample from column 5D at sea-bed level was of grey cast iron as indicated by the presence of flake graphite. The size of the graphite flakes and the high level of phosphide eutectoid in the sample indicate the cast iron pier was relatively old and the tensile strength would be relatively low compared to modern day grey or SG iron.

There was no significant difference in chemical composition for the major elements although the nickel and chromium contents are very slightly higher in the sample from column 5D. The microstructure and hardness of the cast iron samples collected in 2005 and the sample from column 5D are similar.

4 DISCUSSION & CONCLUSIONS

4.1 Original Wall Thickness

The evidence from the two surveys to date indicates that the wall thickness of the immersed castings was of the order of 22 to 29 mm, say 25 mm on average.

This is based on the premise that no significant amount of the graphitised layer has been lost, so that the outer surface of the graphite represents the outer surface of the column at time of construction.

However there is now some reason to doubt this, with the core from the bottom of Column 5D having very little graphitisation and a total indicated wall thickness of only 22mm. As this is considered improbable, the above premise must be questioned.

It is now thought probable that erosion (at times of high river flow) has resulted in the marine growth layer and some of the graphitised layer being worn away, so that the original outline of the outer surface of the castings has, at least in some places, been irrecoverably lost.

4.2 Graphitisation

The condition of the columns as detected during the present survey reveals that graphitisation has advanced to significant proportions. Indications are that in places there is more than 20mm of graphitised material present.

There is no clear pattern to the extent of graphitisation, other than an apparent tendency for higher depth of graphitisation to occur on the upstream (West) side of the columns. This may be linked to debris disturbing the otherwise protective layer of marine growth, allowing more ready diffusion of oxygen to the corrosion front.

The high degree of graphitisation has occurred despite the river water at the bridge being essentially fresh, with no significant salt loading. It should be noted that evidence is emerging from other RTA bridges where cast-iron graphitisation in freshwater settings appears to be generally greater than for salt or brackish waters.

This phenomenon is being explored in a parallel report on graphitisation in other bridges in the Hunter and Northern regions.

4.3 Residual Wall Thickness

Residual cast iron (ie. effective wall thickness) varies but in places is very low, almost negligible. Bearing in mind the limited extent of the core survey, it is possible that full depth graphitisation may have occurred in places.

The average residual wall thickness from the underwater cores taken to date is approximately 15 mm, but the limited nature of the sampling suggests that a more conservative thickness should be used in any structural analysis.

4.4 Cracking

Horizontal cracking is present in three of the columns, including both columns in pier 5. They occur at quite shallow depths, and may be related to the location of the bracing collars just above where they occur.

There is also a short vertical crack on the upstream column of pier 5.

It appears that the cracks are not new and have been present for quite some time, at least a few decades and possibly longer.

Nevertheless 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 their probable impact on the bridge's capacity.

5 ADDITIONAL OBSERVATION

Although the scope of the investigation was limited to the underwater sections of the piers, it was noticed that on Pier 4, there are vertical cracks in the brackets securing the upper end of the diagonal bracing to the piles. Cracks are present in this bracket on both upstream and downstream columns.

The photograph below illustrates one of these cracks, on the downstream column of Pier 4. Note also that there is one bolt missing from this detail.

INSPECTION AND STRUCTURAL ASSESSMENT REPORT FOR

Bridge name:	Windsor Bridge
Location:	Bridge St, Windsor
Owner:	RTA
Date:	April 15, 2011
Report no:	C10-69-000-A

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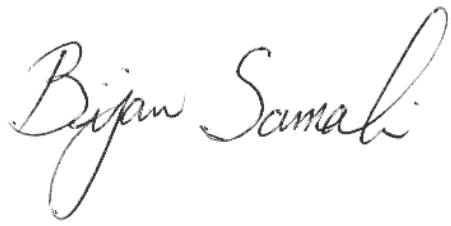

Bijan Samali – access:UTS Consultant

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PART ONE: SUMMARY OF OUTCOMES

1.1 Background to the Testing Program

The superstructure of Windsor Bridge was tested using Dynamic Frequency Analysis or DFA (as detailed in the Appendix A) to measure the global stiffness of the deck, in comparison to previous testing in 2003, to help establish the level of degradation to the superstructure's stiffness.

1.2 Brief Description of the bridge

The Windsor Bridge, which forms part of Bridge St. over Hawkesbury River in Windsor, NSW was built in 1874 and is a 7 meter wide, two lane carriageway and consists of eleven simply supported spans. The bridge deck is made of reinforced concrete slabs supported by eight concrete girders. Exact dimensions and design details were provided by the RTA of NSW.

PART TWO: INSPECTION PHASE

2.1 Background

The purpose of the bridge inspection was to determine any deterioration of structural condition, performance and capacity of the structure, measured by any changes to its flexural stiffness over the past seven years and to recommend appropriate management options. Inspection of the bridge components and an assessment of its condition were conducted according to the procedure and standard condition rating system as defined by Vicroads Bridge Inspection Manual (VBIM). The condition rating system reflects the performance, integrity and durability of the structure and its principal components.

The scope of the engineering inspection included:

- Detailed inspection of all bridge components, including testing and analyses as necessary to supplement visual inspection.
- Reporting on the condition, structural adequacy, evidence of distress, mode of deterioration, and projected deterioration.
- Recommendation of management actions and/or maintenance/rehabilitation treatment options.

For this bridge, however, the visual inspection was not comprehensive due to lack of adequate lighting at the time of testing and the fact that RTA of NSW had already performed such an inspection. Despite this, the visual inspection confirmed better overall conditions for spans 1 and 2 compared with spans 3 and 4.

PART THREE: FIELD TESTING PHASE

3.1 Introduction

An overview of the DFA procedure used in this project is presented below, with details of the instrumentation set-up and procedures for testing as noted in Appendix A. Graphs pertaining to field test results are presented in Appendix B.

This section presents a summary of the DFA results.

3.2 Flexural stiffness of the tested bridge

Table 3.1 shows the first natural frequency of each span tested and a relative span EI, compared to previously obtained EI of the subject bridge (span 1 only) by UTS in 2003, using DFA method.

The benchmark flexural (or bending) stiffness (EI) was calculated for span 1 from previous testing and using the recent measured natural frequency of span 1, a relative EI was calculated for that span. The governing equation is given below.

$$\omega = \sqrt{\frac{n * pi^2 * EI}{p * A * L^4}}$$

Where:

ω = natural frequency in rad/sec
n = mode number
EI = Stiffness
p = density of concrete
A =cross sectional area of tested span
L = span length

Table 3.1 - Results of relative stiffness using the proposed dynamic method

Span No.	First Natural Frequency (Hz)	Relative stiffness to previous testing
1 (2003)	12.5	100%
1 (2010)	11.4	84%
2	11.2	Not applicable
3	10.1	Not applicable
4	10.2	Not applicable

PART FOUR: CONCLUSIONS AND RECOMMENDATIONS

4.1 Assessment of the Bridge as Tested

The EI calculation, representing the bending stiffness of span 1, in comparison to previous testing, shows a drop in stiffness of 16% for span 1. It is not possible to establish the drop of bending stiffness for spans 2,3 and 4 as these spans were not tested in 2003.

The first flexural (bending) natural frequencies were obtained from relevant peaks in the Summation of Frequency Response Functions (FRF) graphs shown in Figures B.1 to B.4 in Appendix B for spans 1 to 4, respectively. Figure B.5 illustrates the Summation of FRF for Span 1 obtained in 2003. In this figure the relevant frequency is one for the span without added mass.

Based on these findings, it is clear that span 1 of the bridge has deteriorated over the past seven years by 16% and some load limits may have to be applied to slow down the rate of further deterioration. If the RTA intends to decommission the bridge in near future, the bridge in its present condition and loading will be safe for some time. However, if the RTA intends to maintain the bridge, further testing and employing parallel finite element analyses is recommended to translate this deterioration into a quantifiable load limit.

APPENDIX A –
Description of the Testing Procedures

A1 Field Testing - Setup and Procedures

Instrumentation

Accelerometers (piezo-resistive type) with high sensitivity and low frequency-range are installed on the superstructure to record the accelerations of the bridge deck. A large 12 lb Modally Tuned ICP Sledge Hammer is used to provide the excitation for the field tests along with a specially built drop mass sensor where higher excitation is required. A Computer based data acquisition system with 32 channel signal conditioners is used to record hammer force and acceleration response signals during the tests. Data processing, including Fast Fourier Transform (FFT) and Frequency Response Function (FRF) calculations are executed using a specifically developed MATLAB programme.

Test Setup

Accelerometers are mounted on the superstructure at mid span to monitor the vibration. Base plates are manufactured to allow the sensors to be bonded to the superstructure with minimal delays to traffic

Testing Procedure

The bridge 'as is', without additional mass, is impacted by the modal hammer or exciter at the centre of the carriage way at mid-span.

A2 Data Processing and Analysis

From recorded dynamic response time histories, using FFT, the auto spectrum of the given signal can be obtained. After auto spectra of the impact force and response of the bridge are obtained, the Frequency Response Functions can be computed. A computer programme has been developed using MATLAB software for this purpose. This software offers a great deal of flexibility when processing the test data. It produces the required Frequency Response Functions at a given bandwidth with good resolutions. Advanced Modal Analysis software, LMS CADA-X from LMS Company is also used in the analysis stage where highly nonlinear and coupled dynamic modes occur, for which normal peak picking method is no longer valid.

A3 Dynamic properties of the tested bridge

From the results of the modal analysis, dynamic properties of the tested bridge such as natural frequencies, damping ratio and mode shapes, can be obtained. However, the dynamic method requires only the first flexural natural frequency for subsequent analyses.

APPENDIX B –
Test Results

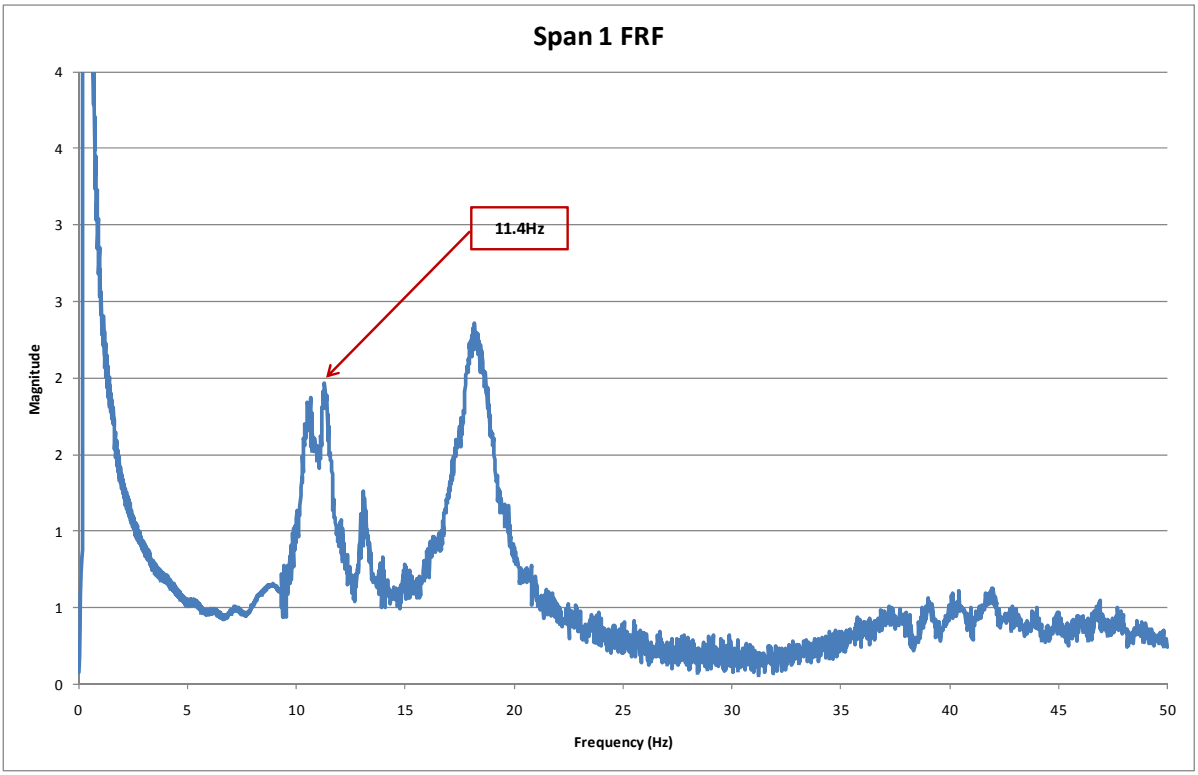

Figure B.1 Sum FRFs for span 1 of the subject bridge

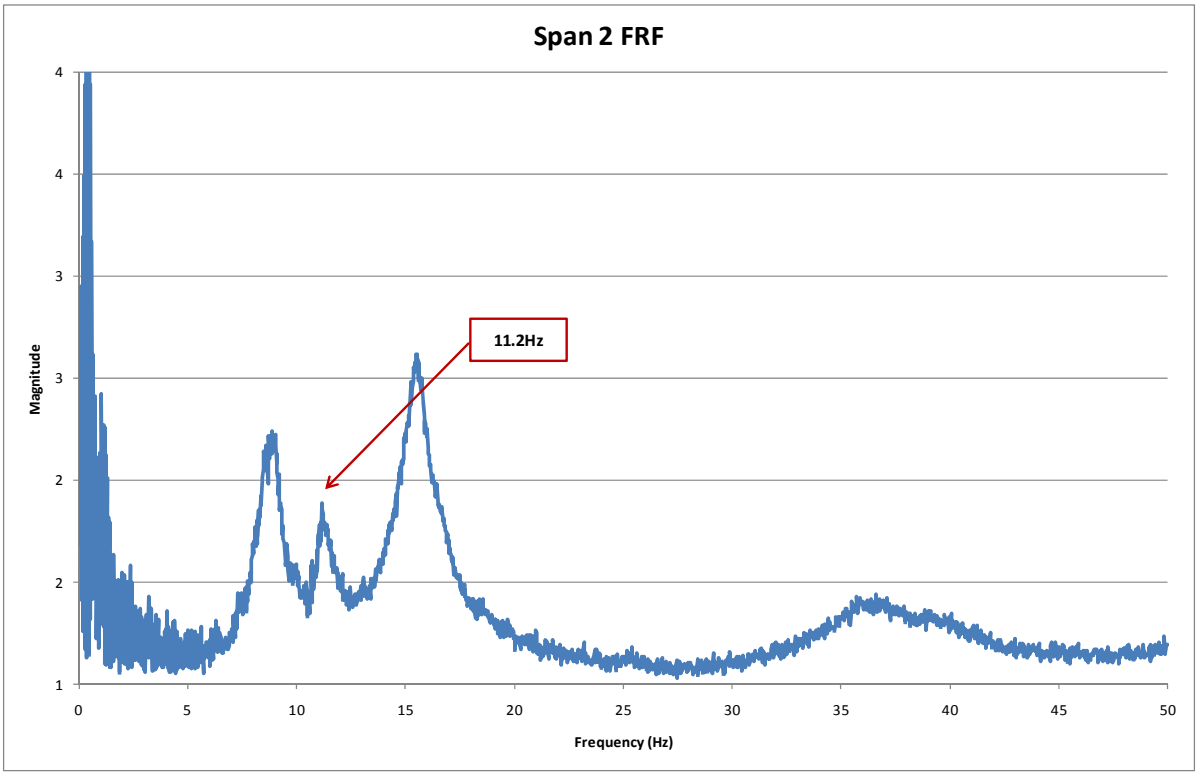

Figure B.2 Sum FRFs for span 2 of the subject bridge

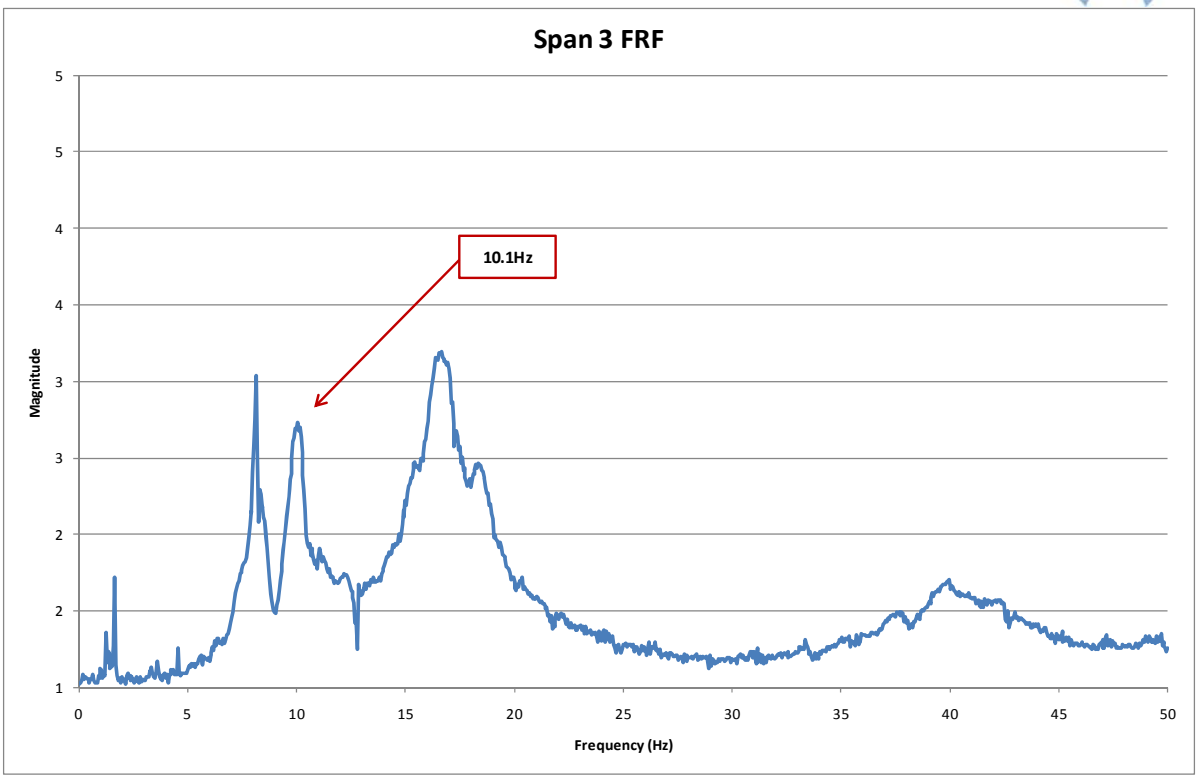

Figure B.3 Sum FRFs for span 3 of the subject bridge

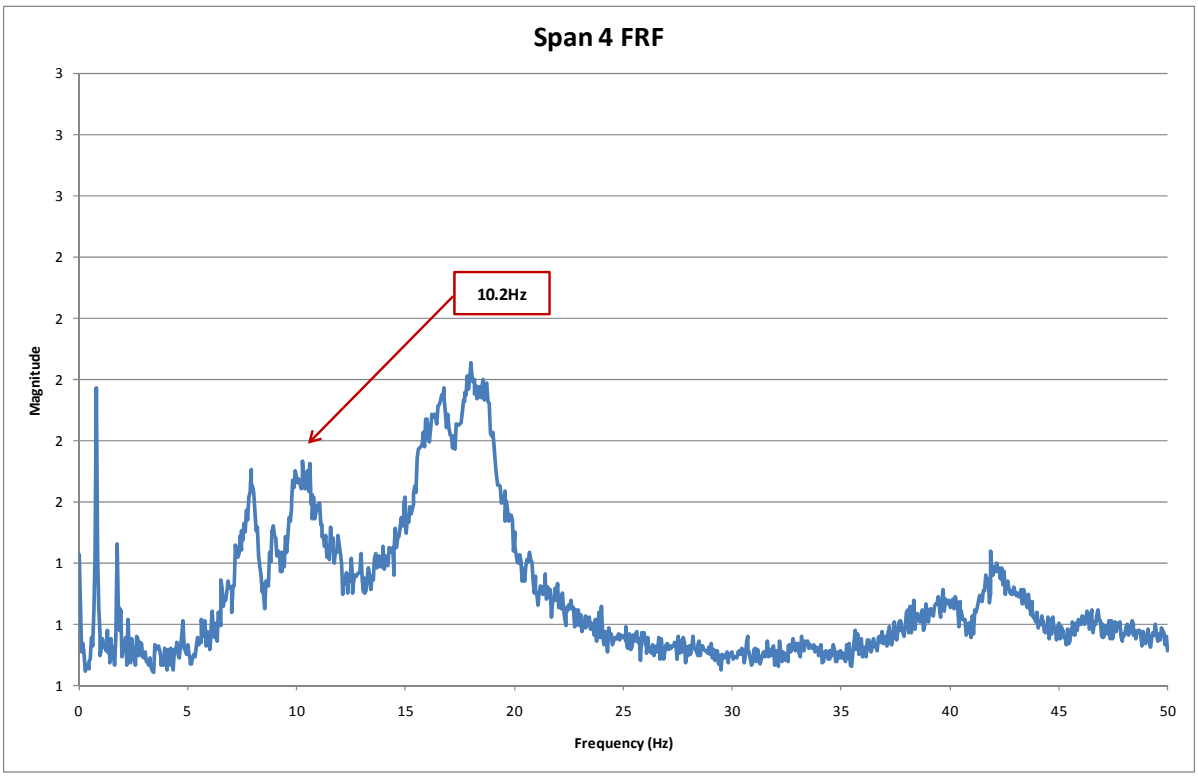

Figure B.4 Sum FRFs for span 4 of the subject bridge

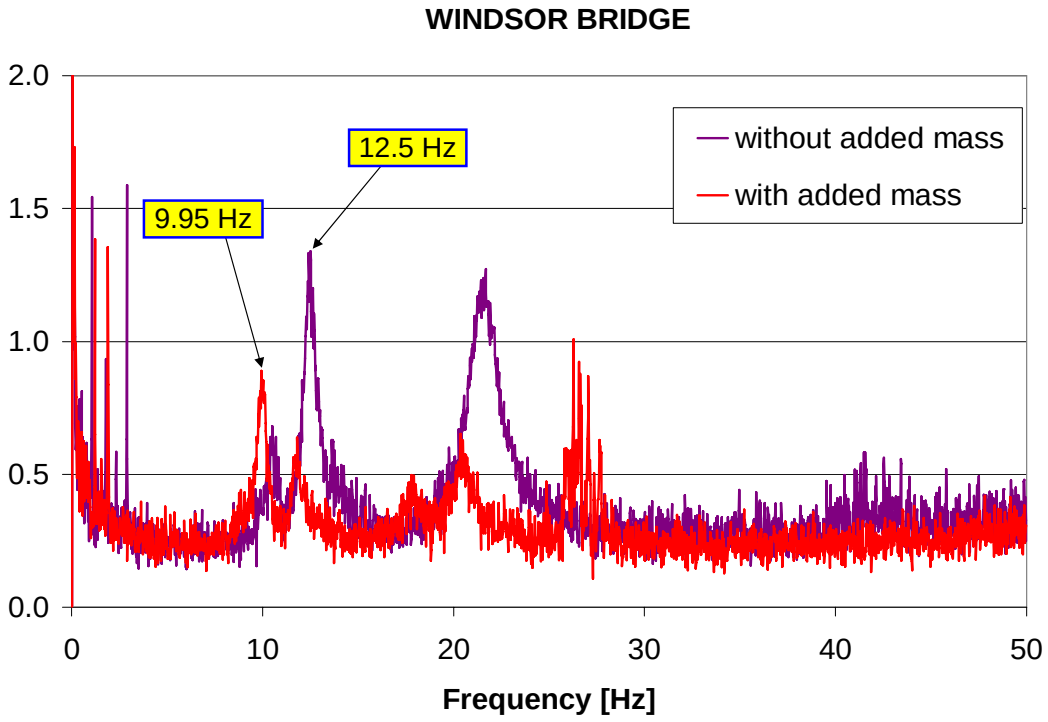

Figure B.5 - Sum FRFs for span 1 of Windsor Bridge with and without added mass in 2003