Transport Roads & Maritime Services

NSW GOVERNMENT

Windsor Bridge replacement project

TRAFFIC AND TRANSPORT WORKING PAPER – WORKING PAPER 4

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Roads and Maritime Services

Windsor Bridge Replacement

Traffic and transport working paper – working paper 4

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Contents

Glossary of terms and acronyms

Term	Meaning
AADT	Annual Average Daily Traffic - 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).
AAWT	Annual Average Weekday Traffic - The average 24 hour traffic volume on weekdays (Mondays to Thursdays or Fridays) throughout a 12 month period, at a specific observation point.
ADT	Average Daily Traffic is a sample of the AADT and is the traffic count averaged over a particular month, a week or a few days.
Accident Group	All the DCA codes are classified into specific groups (or ranges), based on their similarity of crash representation
bridge approach road	A relatively short length of carriageway leading up to a bridge, including embankment, pavement and safety barriers. The southern approach road is the section of road connecting the proposed southern bridge abutment to the intersection of Bridge Street and George Street. The northern approach road is the section of road connecting the proposed northern bridge abutment to the proposed roundabout at the intersection of Wilberforce Road, Freemans Reach Road and the Macquarie Park access road.
CEMP	Construction Environmental Management Plan
CTMP	Construction Traffic Management Plan
Classified Counts	Number of vehicles counted by vehicle class. Light vehicles are designation by vehicle Class 1 and 2. Heavy vehicles are designated by vehicle Class 3 to 13 depending on the number of axles and vehicle length
DCA	Definitions for Coding Accidents: A system of categorising crashes into a classification system of crash types based on the movement of vehicles / pedestrians prior to the collision
DGRs	Director General's Requirements
EIS	Environmental Impact Statement
EPA	Environmental Protection Authority
GMA	Greater Metropolitan Area
HCC	Hawkesbury City Council
HV	Heavy vehicles
JTW	Journey to work
LGA	Local government area
LOS	Level of Service - An index of the operational performance of traffic on a given traffic lane, carriageway or road when accommodating various traffic volumes under different combinations of operating conditions.

Term	Meaning
	It is usually defined in terms of the convenience of travel and safety performance.
RMS	Roads and Maritime Services
RTA	Roads and Traffic Authority (now Roads and Maritime Services)
SIDRA Intersection	Proprietary Intersection Modelling Software
SSTM	Sydney Strategic Transport Model
VISSIM	Proprietary micro-simulation traffic modelling software

Executive Summary

Roads and Maritime Services (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.

The project would include a replacement bridge 35 metres downstream of the existing bridge, modifying the existing intersections and bridge approach roads to accommodate the new bridge location and providing a shared pedestrian/cycle pathway for access to and across the replacement bridge.

The replacement bridge would provide wider lanes and shoulders and greater sight distances in comparison to the existing bridge. Modifications would also be made to the bridge approach roads and existing intersections at Bridge Street / George Street and Wilberforce Road / Freemans Reach Road. All of these factors would contribute to improvements in traffic capacity and safety.

The principal focus of the traffic and transport assessment was the route along Bridge Street between Macquarie Street on the southern side of the Hawkesbury River and Wilberforce Road on the northern side of the river. The project was developed in three general stages:

- Assessment of current and future traffic conditions.
- Testing of options according to these conditions.
- Final assessment of the project.

Desktop studies were undertaken to assess existing public transport, pedestrian, cycle and maritime conditions. Traffic models were then employed to examine a range of options for intersection design and to identify the effects of the construction and operational phases of the preferred option for the project. Based on the results of the assessment, impact mitigation and management measures have been identified for both the construction period and long term operation of the project, where required.

Project intersection options were first tested with stand-alone intersection models using SIDRA Intersection traffic modelling software to identify which intersection layouts would work best in isolation. The interaction between intersections on the northern and southern sides of the proposed replacement bridge were then examined using micro-simulation modelling of the wider road network to determine if a delay at one intersection would have an impact on the other intersection.

The modelling and analysis has shown that the project would improve traffic flow, on both the bridge approach roads and across the bridge, and would result in a substantial improvement in the overall performance of the local road network. The project would initially provide two traffic lanes across the bridge (one lane in each direction). In the future, when traffic growth increases to a point where additional lane capacity is required, the width of the proposed replacement bridge is sufficient to allow it to be changed to a three lane configuration with two southbound lanes and one northbound lane. Such widening would be accommodated within the road shoulders through new line marking, without the need for additional construction.

For 95 per cent of peak period traffic movements, a Level of Service of A or B would be achieved in 2026 with the three lane configuration.

The project would also increase the capacity of the Bridge Street corridor, with flow on benefits to regional traffic movements. This increased capacity would be achieved through improvements in intersection efficiency and the alignments of the bridge approach roads. The increased capacity of the Bridge Street corridor would support future development in the region, particularly on the northern side of the Hawkesbury River. It would also benefit Macquarie Street as a result of reduced queuing at the intersection with Bridge Street and Windsor Road, particularly in the evening peak.

The intersection types and configurations have been selected to minimise traffic queue length and delays as much as possible. To achieve this, the existing intersection at Bridge Street, Freemans Reach Road and Wilberforce Road would be modified from a 'Give Way' priority controlled intersection to a dual lane roundabout. The existing intersection at Bridge Street and George Street would be modified from a single lane roundabout to a traffic signal controlled intersection.

There would, however, be changes to access arrangements for two properties on the eastern side of Thompson Square. Specifically, under the new traffic arrangements, vehicles would no longer be able to turn right into (or out of) the properties at Number 4 and Number 6 Old Bridge Street. Vehicle access to these properties would be available via the southbound carriageway of the northern 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 on Bridge Street, right into George Street, left into either Baker or Kable Street, then left into Macquarie Street before turning left into Bridge Street and travelling north. The additional travel time involved in undertaking these manoeuvres is considered to be relatively minor and would affect a very small number of road users.

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.

A number of additional minor modifications to existing roads and access ways would occur in association with the project. These would include provision of continuous 'through' access along The Terrace (where continuous access is currently severed by the existing bridge approach road), modifying the access arrangements to the existing Windsor Wharf and altering line marking arrangements at the Macquarie Street and Bridge Street intersection to provide improved traffic flow through the intersection at George Street and Bridge Street.

The replacement bridge would have no adverse impacts on existing bus services. There would be no increases in delays on the road network and no major route deviations. In line with the overall improvement in the operational efficiency of the road network, bus services using the bridge would benefit from the predicted reductions in peak period traffic congestion.

The project would also improve access, safety and amenity for pedestrians and cyclists through the inclusion of a shared pedestrian/cycle pathway that meets current design guidelines.

The new pedestrian/cycle pathway would extend from the intersection of George Street and Bridge Street, along the western side of the southern bridge approach road, and across the western side of the replacement bridge to the entrance to Macquarie Park. The shared pedestrian/cycle pathway would also extend along Wilberforce Road (just east of Freemans Reach Road). Pedestrian and cycling access along the southern bank of the river would also be improved with the connection and redevelopment of The Terrace. In addition, the following general works would be undertaken to improve pedestrian and cyclist safety and access:

- 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.
- A cost benefit analysis was undertaken to assess the effect of the project on reducing the costs associated with vehicles crashes. The project elements that would reduce the risk of future vehicle crashes are:
- Introduction of a roundabout at the Wilberforce Road / Freemans Reach Road / Bridge Street intersection.
- Replacement of the roundabout at the intersection of Bridge Street and George Street with traffic signals.
- Increased lane width from three metres on the existing bridge to 3.5 metres on the replacement bridge.
- Improved horizontal and vertical alignment of the bridge approach roads.

Analysis of crash data indicated that the total cost of crashes in the last five years was around $2.7 million and the total anticipated cost reduction by implementing the project would be around $1.8 million or around 64 per cent reduction in the cost of crashes.

The replacement bridge would have fewer in channel piers than the existing bridge, which would improve the safety of river navigation. No adverse impacts on boating or river transport activities are anticipated to occur as a result of the project.

The overall impact of construction activity on traffic conditions is anticipated to be minor, as construction would generally be undertaken clear of existing traffic. The arrival and departure pattern of the construction workforce is anticipated to occur earlier than the normal peak traffic periods minimising the impact on local roads and their users. Deliveries of materials would be timed to occur outside peak traffic periods to minimise the potential for adverse impacts. Bulk deliveries requiring multiple trips (such as for major concrete pours) would be managed on a ‘just in time’ basis with each subsequent delivery called up on two-way radio. Delivery trucks would not be permitted to queue on local roads.

Delays for traffic using Bridge Street, George Street, Wilberforce Road and Freemans Reach Road would be expected during the construction phase in those periods when reduced speed limits are in place and when manual traffic control is in operation to facilitate the movement of construction vehicles into and out of work sites. There would also be delays during periods when existing sections of road are being connected to new road sections, although these activities would be scheduled to occur outside of peak periods.

A construction traffic management plan would be prepared as part of the Construction Environmental Management Plan. This plan would detail protocols, procedures and measures to minimise construction traffic impacts and safety risks as far as practicable. The types of measures to be implemented would include traffic switches, line marking and signage (including advanced warning variable message signage).

1 Introduction

1.1 Overview of the 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. The proposal for bridge replacement (hereafter referred to as "the project") is described in detail in **Section 2** and shown in **Figure 2-1**.

1.2 Director General's requirements

The overall purpose and objective of this report is to identify and assess the traffic and transport issues related to the project. The assessment documented within this report addresses the Director General's Requirements (DGRs) for the environmental assessment of the project as detailed in **Table 1-1**.

Table 1-1 Traffic and transport DGRs

Director General's Requirements	Where addressed
Demonstration of how the preferred bridge alignment and design meets the traffic and transport objectives of the project.	Sections 5 and 5.11
Justification for the capacity of the bridge, taking into account future growth areas and traffic (vehicular, cyclist and pedestrian) needs.	Sections 4, 5.3 and 5.8
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).	Sections 6 and 7
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 5
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.	Sections 5.9. 6.8 & 6.9
Safety of navigation in the Hawkesbury River for the water based traffic.	Sections 5.9 and 6.9

1.3 Traffic and transport project objectives

To meet the DGRs, the proposed bridge design must meet the traffic and transport objectives of the project. These objectives and associated criteria are 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 (as measured by 'level of service').
- Enables two heavy vehicles to pass on the bridge without waiting.

The proposed design of the bridge and approach roads is assessed against these objectives in **Section 4**.

1.4 Structure of the report

This report is structured in the following manner:

- **Section 2** provides a description of the project.
- **Section 3** details the existing traffic and transport environment.
- **Section 4** details the development of the project.
- **Section 5** assesses the operational performance and impacts of the project.
- **Section 6** assesses the traffic impacts of construction of the project.
- **Section 7** details impact mitigation measures for construction and operation.
- **Section 8** provides a conclusion to the report.

1.5 Methodology

The project was developed in three general stages:

- Assessment of current and future traffic conditions.
- Testing of options according to these conditions.
- Final assessment of the project.

These stages are covered in **Sections 4, 5** and **6** respectively.

The study focused on the area outlined in **Figure 2-1**, although a larger area was considered when modelling the impacts of options on the wider road network. The principal focus of the traffic and transport assessment was the route from Bridge Street (at Macquarie Street) in the south to Wilberforce Road on the northern side of the Hawkesbury River.

1.6 Assessment of current and future conditions

Data on current traffic conditions came from three main sources:

- AM and PM peak classified intersection turning counts conducted in December 2011.
- Twenty four hour classified bridge traffic counts conducted in March 2012.
- RMS count stations for various years, with the most recent being from 2005.

Further information about traffic patterns in Windsor was supplied by the *Windsor Town Centre Traffic Study* (Christopher Hallam & Associates Pty Ltd, July 2011).

Traffic profiles for major roads in the study area were constructed from the 2011 and 2012 counts. Missing profile data was filled by using scaled data from the 2005 RMS counts. The RMS counts were also used to establish the prevailing historical growth rate. The current performance of intersections was evaluated with intersection modelling software *SIDRA Intersection* (a recognised software platform for analysis

of intersection performance) and a crash analysis was undertaken for roads in the study area.

Traffic forecasts for the anticipated year of opening (2016), 10 years after opening (2026), and 15 years after opening (2031) were determined using the 2011 and 2012 counts with applied growth rates derived from the Sydney Strategic Travel Model (SSTM), which was supplied by the Bureau of Transport Statistics (BTS). This approach recognises that it would be too simplistic to apply uniform historical growth rates to all intersection movements as the intersecting roads service completely different regions with different land use and development profiles.

The Sydney Strategic Travel Model (SSTM) is a world class tool, operated by the BTS within Transport for NSW, 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, built largely in the Emme transport modelling software, 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 combines our understanding of travel behaviour with likely population and employment size and distribution, and likely road and public transport networks and services, to estimate future travel under different strategic land use and transport scenarios.

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.

Use of the SSTM and BTS projections for this project is considered appropriate given the nature of the traffic network surrounding the project. This would be different for a project in a more dynamic 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.

Current year employment is known from the Journey to Work (JTW) census data. Workplaces are one of the key travel destinations. It is therefore 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.

Desktop studies were performed to assess existing public transport, pedestrian, cycle and maritime conditions.

1.7 Testing of options

The intersection performance analysis was carried out using *SIDRA Intersection*[1] (v5.1). RMS uses Level of Service (LoS) (as described in **Table 3-8**) as the measure of intersection performance. Project options were first tested with stand-alone intersection models in *SIDRA Intersection* to determine which intersection layouts would work best in isolation. The interaction between intersections north and south of the proposed replacement bridge, including the effects of a delay on one intersection on the operation of the other, was then assessed through the application of micro-simulation modelling, using a model of the road network in and around Windsor developed and supplied by RMS. This model was coded in VISSIM modelling software, and was prepared in August 2011. SKM updated the model and undertook additional VISSIM modelling incorporating combinations of potential intersection layouts to evaluate their interaction (see **Appendix E, F** and **G** for further details).

1.8 Assessment of preferred option

The project was analysed in terms of travel times and traffic impacts. Impacts on local road and property access, public transport, maritime activities, and cyclist and pedestrian opportunities have been identified for both the construction period and long term operations.

[1] SIDRA Intersection is an intersection analysis package, which estimates intersection capacity, level of service, performance, and effectiveness of given signals.

2 Description of the project

2.1 Project scope

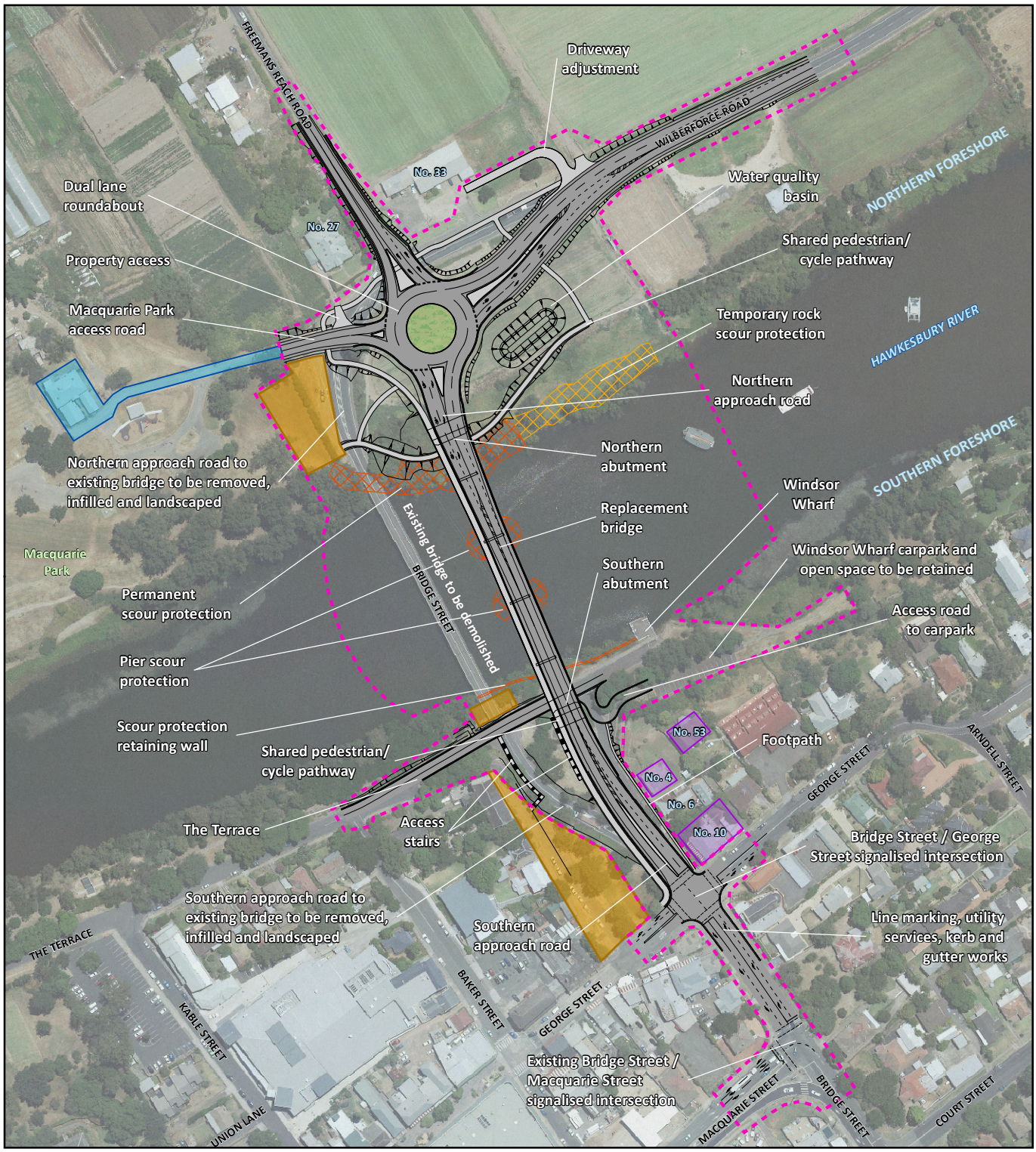
2.1.1 Overview

The key elements of the project comprise:

- Construction of a replacement bridge over the Hawkesbury River at Windsor, around 35 metres downstream of the existing Windsor bridge.
- Reconstruction of existing bridge approach roads and intersections to accommodate the replacement bridge.
- Additional 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 replacement bridge.
- Removal and backfill of the existing bridge approach roads.
- Demolition of the existing Windsor bridge.
- Ancillary works including:
  - Adjustment, relocation and/or protection of public utilities and services.
  - Construction of scour protection works on the southern and northern banks including the construction of a new retaining wall along the southern foreshore between Windsor Wharf and the existing bridge.
  - Construction of a permanent water quality basin.
  - Completion of architectural treatments for noise mitigation, as required.
  - Completion of flood mitigation works, as required
  - Installation of line marking, signage and lighting.
  - The potential need to install an overhead “prepare to stop” sign with lights near the southern bridge abutment.
  - Minor road line marking modifications outside the project boundary to safely direct motorists onto the bridge approach roads to the replacement 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.
- Additional elements of the project would include:
- Property acquisition.
- Installation and operation of temporary construction facilities, including compound sites.
- Early works involving additional field investigations for Aboriginal and non-Aboriginal heritage (including maritime heritage), which would be carried out as part of the project impact mitigation and management process.

Figure 2-1 shows the key elements of the project concept design. A full description of the project is provided in Chapter 5 of the Environmental Impact Statement (EIS).

Figure 2-1 | 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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2.1.2 The replacement bridge and intersections

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 dual lane roundabout intersection (to be constructed as part of the project).

The replacement bridge would be an incrementally launched design comprising five spans and 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 clearance under the bridge where it spans the river would be about 7.5 metres at the average high tide level.

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 two metre 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 3.3 metres wide.

The low point of the replacement bridge 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.

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 of the EIS).

2.1.3 Demolition of the existing bridge

The existing Windsor bridge would be removed following commissioning of the replacement bridge and associated bridge approach roads.

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 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.

2.1.4 Pedestrian and cycling facilities

The project would incorporate facilities for pedestrians and cyclists and include a shared pedestrian/cycle pathway that would extend from the intersection of George Street and Bridge Street, along the western side of the southern bridge approach road, across the western side of the replacement bridge to the entrance into Macquarie Park. The shared pedestrian/cycle pathway would also extend along Wilberforce Road (just east of Freemans Reach Road).

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, the following general works would be undertaken to improve pedestrian and cyclist safety and access:

- 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 of the EIS).

2.1.5 Water quality basin

The project would include construction of a permanent water quality basin to capture and treat stormwater runoff from the bridge and northern intersection prior to stormwater being discharged to the Hawkesbury River. The water quality 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.

For the southern approach road, a trash net to collect litter and a shut-off-valve to contain any spills in the stormwater system would be installed at the discharge point of the drainage system near Windsor Wharf.

2.1.6 Scour protection

Scour protection would need to be installed around the bridge abutments and the bridge piers to protect these structures from bank and/or river bed erosion during floods and high flows.

Around the two piers in the centre of the river, scour protection would extend about eight metres around each of the piers 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. 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.

During the detailed design phase, further work would be undertaken to minimise the visual impact of the scour protection.

2.1.7 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 an additional water main, 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 to be concealed by 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 supported by the replacement bridge. If the 33 kV power lines cannot be supported by the replacement bridge, they would remain as overhead lines but would be relocated between the existing poles near Number 4 Old Bridge Street and Number 33 Wilberforce Road so that they are clear of the replacement bridge. Power lines near the corner of Wilberforce Road and Freemans Reach Road would also be relocated.
- Local stormwater drainage infrastructure.
- A rising main from Windsor Wharf to the local sewer system, which is used to pump out boat sewage holding tanks.
- A gravity sewer main that runs beneath Old Bridge and Bridge streets.
- A number of water mains on both the northern and southern river banks.
- Street lighting on both the northern and southern river banks.
- Telstra assets located near the proposed southern bridge abutment, which would need to be relocated prior to construction of the bridge abutment.
- Additional Telstra assets located on the northern side of the river.

2.1.8 Urban and landscape concept design

The urban design and landscape concept design associated with the project was developed by applying project specific urban design principles and treatments. Works associated with the current concept design are described below.

Southern bank and Thompson Square area

At this stage of project development, the scope of works in Thompson Square parkland has yet to be fully defined and would be subject to further consultation with the community, government stakeholders and Hawkesbury City Council (HCC). HCC would be responsible for managing Thompson Square parkland in the longer term. For the purposes of assessment in the EIS, preliminary urban design and landscaping works for Thompson Square have been identified. These works have been developed with the objectives of providing pedestrian and cyclist access from the replacement bridge to various areas in Thompson Square and providing a base for additional urban design and landscaping works arising from the consultation process. The consultation process for the additional urban design and landscaping works for Thompson Square is ongoing and if possible the full scope of works would be presented and assessed in the Submissions Report. It is recognised, however, that the full scope of works may not have been agreed before the completion of the Submissions Report and a post-approval Urban Design and Landscaping Plan for Thompson Square parkland maybe be required.

The scope of works assessed in the EIS includes:

- Infilling the southern approach road to the existing bridge.
- Removal of some trees that are either in poor condition or 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 landscaping 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.

Bridge

The project specific urban design principles have been used to refine the visual appearance of the replacement bridge. This includes refinements to the pier shape, bridge superstructure and abutments to minimise its visual impact and provide context to the heritage values of Windsor.

Northern bank

The scope of works assessed in the EIS includes:

- Infilling the northern approach road to the existing bridge.
- 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.

2.1.9 Construction works

Temporary construction and compound sites

There would be two main construction and compound sites as follows:

- Turf farm site – On the northern side of the river within the existing turf farm between the Hawkesbury River and Wilberforce Road (Lot 2 DP 1096472 and Lot 2 DP65136).
- 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.

Other areas that would be used for construction purposes include:

- The lower Thompson Square parkland (Lot 345 DP752061) – this area would be required to allow construction of the southern bridge abutments and southern approach roads.
- Office space in a building near the project – this location has not yet been identified.

The majority of the construction activity would be concentrated on the northern bank as this would be the location of the casting yard for the incrementally launched bridge and the main point for access to the river. The construction compounds on the southern bank would support the construction of the southern abutment, southern approach road and other minor works.

Offices may be leased near Thompson Square for construction personnel.

Order of construction works

The sequence of project construction activities would be designed to minimise environmental and traffic impacts as far as practical. The likely order of construction works would be as follows:

- Pre-construction activities.
- Early works activities.
- Construction of temporary pavement both at Wilberforce Road and near the corner of George and Bridge streets to provide additional road width for construction of the subsequent 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.

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.

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 but excluding pre-construction and early works. The work would be completed in one continuous period as State funding permits.

Work hours

The majority of the construction works would be carried out during standard working hours, as detailed in **Table 2-1**.

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. Other construction activities such as service relocations and cutovers may also need to be undertaken outside normal working hours. Low noise activities may also be undertaken outside of normal working hours to optimise construction efficiency.

Table 2-1 Standard working hours

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

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.

Construction materials

An estimate of the types and quantities of materials likely to be required for the project is provided in **Table 2-2**. 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.

Table 2-2 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

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3 Existing traffic and transport environment

3.1 Site location

The project is located at Windsor in the Hawkesbury local government area about 57 kilometres north-west of Sydney. The town of Windsor is located at the top of a ridge above the south bank of the Hawkesbury River, at the foot of the Blue Mountains. The project extends from the intersection of Freemans Reach and Wilberforce roads in the north to the intersection of Bridge and Macquarie streets in the south. The location and regional context of the project are shown in **Figure 2-1.** The area surrounding Windsor is predominantly rural, although there is extensive and expanding urban development to the south and west of the town.

Windsor contains numerous buildings and sites of 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. 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 137 years old and are deteriorating as a result of age and heavy use. Elements of the bridge have deteriorated considerably and are no longer cost effective to replace or repair. The level of maintenance required to maintain adequate road safety is also no longer cost effective and the existing bridge is therefore considered to have reached the end of its economic life. The existing bridge and adjacent intersections no longer meet the demands of current peak hour traffic volumes or current road standards.

In June 2008, in recognition of the condition of the existing bridge, the NSW Government announced funding of $25 million 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.

3.2 Study area

The study area for this traffic and transport assessment focuses on Bridge Street, Windsor, and includes adjacent intersections and roads as shown in **Figure 3-1**. 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.

3.3 Route description

The principal focus of the traffic and transport assessment is the route from Bridge Street (at Macquarie Street) in the south to Wilberforce Road on the northern side of the Hawkesbury River. Windsor Road becomes Bridge Street as it passes through its intersection with Macquarie Street from where it rises to a crest at its intersection with George Street. The Bridge Street / George Street intersection currently operates as a four arm roundabout. Bridge Street then descends to the existing bridge, which crosses the river perpendicular to the river bank in a roughly northerly direction. On the northern side of the river, Bridge Street turns sharply to the right where it becomes Wilberforce Road. At this point Freemans Reach Road intersects with Wilberforce Road at a priority controlled ‘T’ intersection.

The route primarily serves the communities of Wilberforce and Freemans Reach on the northern side of the river, being one of only two crossings of the Hawkesbury River in the region.

3.4 Surrounding road network

3.4.1 Description of roads within the study area

Key roads in the study area have been classified in a hierarchy based on their role in the road network and the volume of traffic they can appropriately convey. Changes to traffic flows on roads can then be assessed within the context of the road hierarchy. The guidelines for the functional classification of roads were developed by RMS, and have been adopted for this study. They are detailed below:

- **Arterial road**: typically a main road carrying over 15,000 vehicles per day (over 1,500 vehicles per hour) and fulfilling a role as a major inter-regional link.
- **Sub-arterial road**: defined as secondary inter-regional links, typically carrying volumes between 5000 and 20,000 vehicles per day (500 to 2000 vehicles per hour). These roads supplement arterial roads in providing for through movement, to an individually determined limit that is sensitive to both roadway characteristics and abutting land uses.
- **Collector road**: provides a link between local roads and regional roads, typically carrying between 2000 and 10,000 vehicles per day (250 to 1000 vehicles per hour). At volumes greater than 5000 vehicles per day, residential amenity begins to decline noticeably. Trunk collector and spine roads with limited property access can reasonably carry traffic flows greater than 5000 vehicles per day.
- **Local road**: provides access to individual allotments, carrying low volumes, typically less than 2000 vehicles per day (250 vehicles per hour).

The key roads in the study area are described below.

Bridge Street

Bridge Street, which is shown in **Figure 3-2**, is a sub-arterial road running north-west to south-east. It is 700 metres long, extending from Macquarie Street to Wilberforce Road. It incorporates the existing Windsor bridge and forms part of State Route 69 to Singleton. Major intersecting roads include Macquarie Street, George Street and Freemans Reach Road. It is primarily one lane in each direction, with additional turning lanes provided at the intersection with Macquarie Street. The posted speed limit is 60 kilometres per hour and the road bends sharply at both ends of the bridge. Trucks and buses are limited to 40 kilometres per hour 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.

Wilberforce Road

Wilberforce Road is a sub-arterial road running north-east to 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 kilometres per hour in the section approaching Windsor bridge. About 13,000 vehicles travel on the road each day, based on 2011 intersection counts and 2005 RTA count station data. Wilberforce Road is part of a B-Doubler route running from Windsor Road via Bridge Street.

Figure 3-1 | Key roads in study area

Indicative only – subject to detailed design

LEGEND

- Concept design
- Key roads in study area

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Sydney Spatial Team - Prepared by : DD
Checked by : JC

Figure 3-2 Bridge Street at Windsor bridge (looking south towards Windsor)

Freemans Reach Road

Freemans Reach Road, shown in **Figure 3-3**, 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 kilometres per hour, decreasing to 60 kilometres per hour on the southbound approach to the intersection with Wilberforce Road. Around 7000 vehicles travel on the road each day, based on 2011 intersection counts and 2005 RMS count station data.

George Street

George Street, shown in **Figure 3-4**, is a local road within the study area. It connects Bridge Street to the 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 kilometres per hour. While there is no daily traffic volume data for this road within the study area, 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 3-3 Looking north along Freemans Reach Road from Wilberforce Road

Figure 3-4 George Street / Bridge Street intersection (looking south west)

Macquarie Street

Macquarie Street is an arterial road running north-east to 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 kilometres per hour.

Old Bridge Street

Old Bridge Street is a 100 metre long local road running north to 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

Thompson Square road is a local road running north-west to 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

The Terrace is a local road running north-east to 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.

Macquarie Park access road

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.

3.4.2 Historical traffic growth

Traffic volume data from RMS count stations at key sites in the study area were analysed to identify the average increase in traffic volumes between 1989 and 2005. The RMS count stations used are all located in Windsor within 300 metres of Windsor bridge as follows:

- Bridge Street (south of Macquarie Street) - station number 88.046.
- Wilberforce Road (north of Freemans Reach Road) - station number 88.033.
- Freemans Reach Road (north of Wilberforce Road) - station number 88.091.

The location of each count station is indicated in **Figure 3-5**.

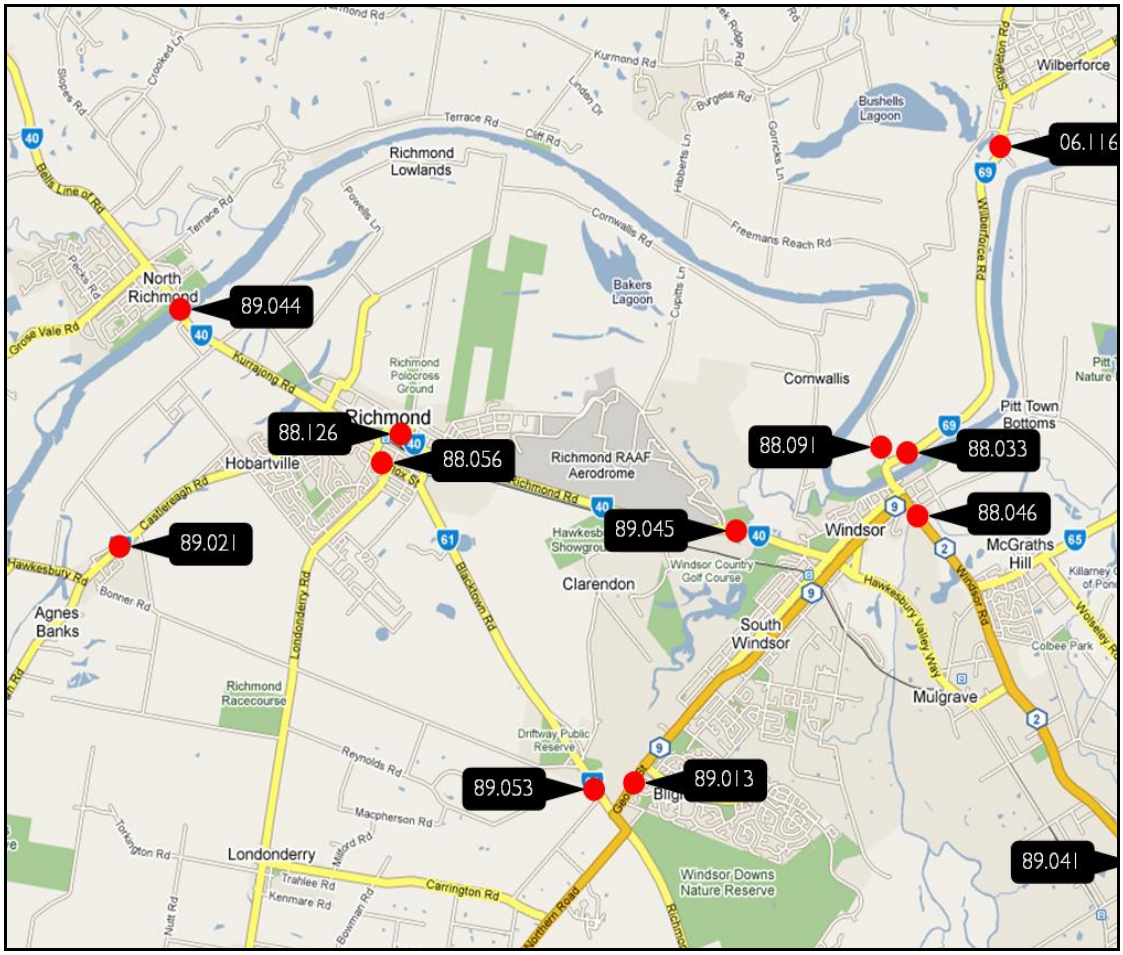


Figure 3-5 Location of RMS count stations used to establish historical growth rates

Uniform growth rates at the selected sites are presented in **Table 3-1**. The growth rates expressed are linear; that is, the absolute change calculated for the first year is applied to each subsequent year.

Table 3-1 Growth rates for RMS count stations

Station number	Uniform growth rate per annum (base year 2005)
Wilberforce Road (north of Freemans Reach Road) 88.033	0.5%
Bridge Street (south of Macquarie Street) 88.046	1.0%
Freemans Reach Road (north of Wilberforce Road) 88.091	1.1%

Annual Average Daily Traffic (AADT) volumes at the count stations between 1989 and 2005 are illustrated in **Figure 3-6**. In this graph, AADT is measured in terms of axle pairs (with the exception of the count station on Bridge Street, which is measured in terms of vehicles). It can be seen that traffic on Bridge Street has generally increased steadily between 1989 and 2005. Traffic on Wilberforce Road and Freemans Reach Road also increased gradually between 1989 and 2002 but declined slightly between 2002 and 2005.

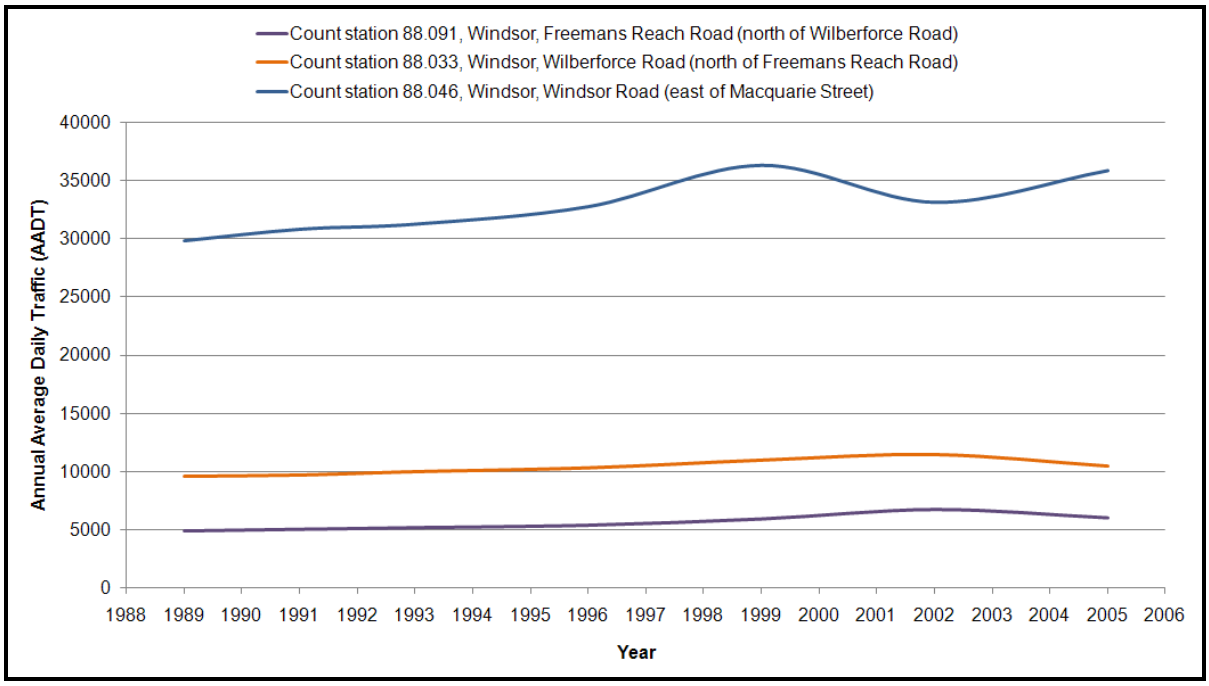


Figure 3-6 AADT at RMS count stations between 1989 and 2005

3.4.3 Traffic profiles

Bridge Street

Traffic counts by vehicle classification were undertaken in March 2012 on Bridge Street, south of Windsor bridge, to determine the hourly traffic profile over a seven day period. The numbers of vehicles per hour averaged over seven days and divided into light and heavy vehicle classifications are detailed in **Table 3-2** and shown in **Figure 3-7**.

Table 3-2 Hourly profile of vehicles in Bridge Street by classification

Time commencing	Total vehicles	Light vehicles	Heavy vehicles
12:00 AM	91	85	7
1:00 AM	60	53	7
2:00 AM	52	44	8
3:00 AM	71	60	11
4:00 AM	167	151	16
5:00 AM	578	511	67
6:00 AM	993	895	99
7:00 AM	1147	1046	102
8:00 AM	1303	1207	96
9:00 AM	1209	1114	95
10:00 AM	1124	1029	94
11:00 AM	1125	1033	92
12:00 PM	1117	1029	88
1:00 PM	1077	986	92
2:00 PM	1178	1084	94
3:00 PM	1435	1347	87
4:00 PM	1528	1436	92
5:00 PM	1546	1485	61
6:00 PM	1214	1168	46
7:00 PM	793	760	33
8:00 PM	524	505	19
9:00 PM	386	371	15
10:00 PM	258	249	10
11:00 PM	155	148	7
12:00 AM	91	85	7
Total	**19,133**	**17,796**	**1,337**

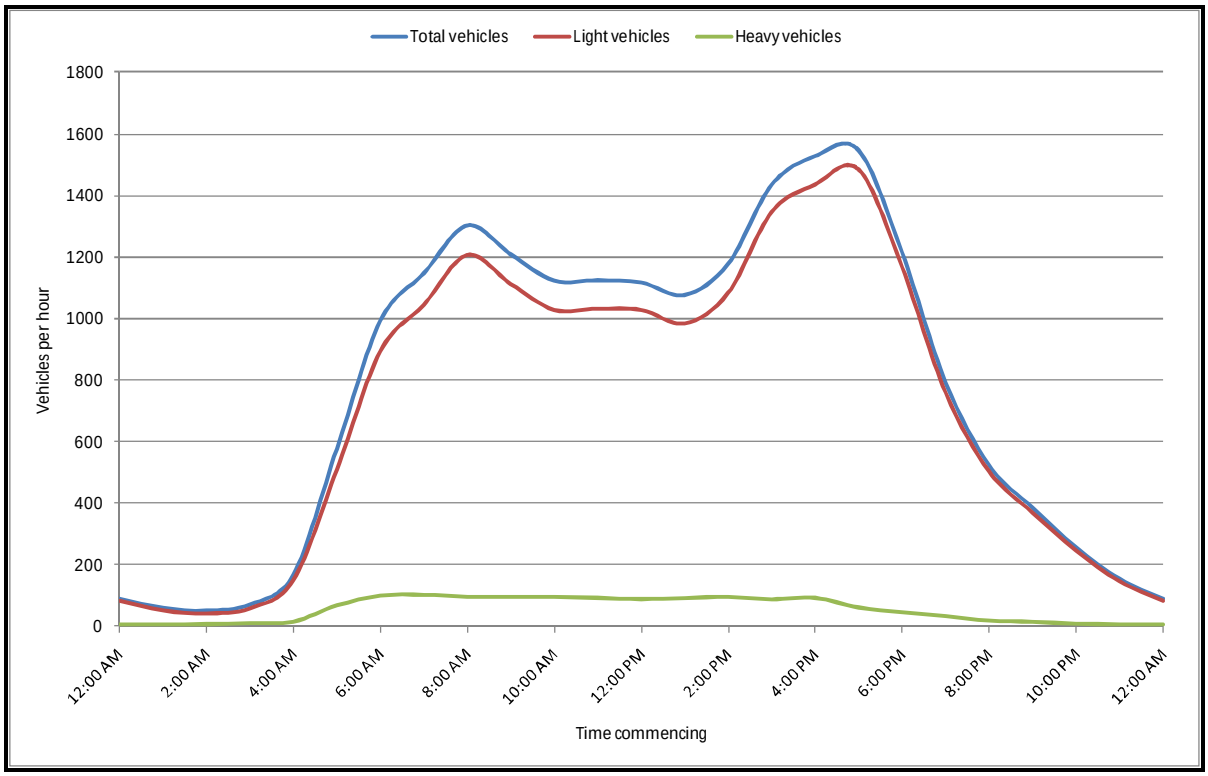


Figure 3-7 Hourly profile of vehicles in Bridge Street by classification

Most of the traffic comprises light vehicles, with only seven per cent being heavy vehicles. The morning peak occurs at 8.00am, with the majority of flow in the southbound direction towards Windsor and Sydney, while the evening peak occurs at 5.00pm with the majority of traffic travelling northbound.

Heavy vehicle traffic does not demonstrate any specific peak period, rather rising to an average of between 90 to 100 vehicles per hour at 6.00am and remaining at that level until around 4.00pm.

The numbers of vehicles per hour averaged over seven days and divided into the northbound and southbound directions are detailed in **Table 3-3** and shown in **Figure 3-8**.

Table 3-3 Hourly profile of vehicles in Bridge Street by direction

Time commencing	Total vehicles	Northbound	Southbound
12:00 AM	91	63	28
1:00 AM	60	37	23
2:00 AM	52	26	26
3:00 AM	71	23	48
4:00 AM	167	38	129
5:00 AM	578	100	478
6:00 AM	993	246	747
7:00 AM	1147	296	851
8:00 AM	1303	368	935
9:00 AM	1209	431	778
10:00 AM	1124	524	600
11:00 AM	1125	578	547
12:00 PM	1117	601	516
1:00 PM	1077	596	481
2:00 PM	1178	660	519
3:00 PM	1435	904	531
4:00 PM	1528	1027	501
5:00 PM	1546	1061	485
6:00 PM	1214	805	410
7:00 PM	793	487	306
8:00 PM	524	343	181
9:00 PM	386	267	119
10:00 PM	258	175	83
11:00 PM	155	110	45
12:00 AM	91	63	28
Total	**19,224**	**9,830**	**9,395**

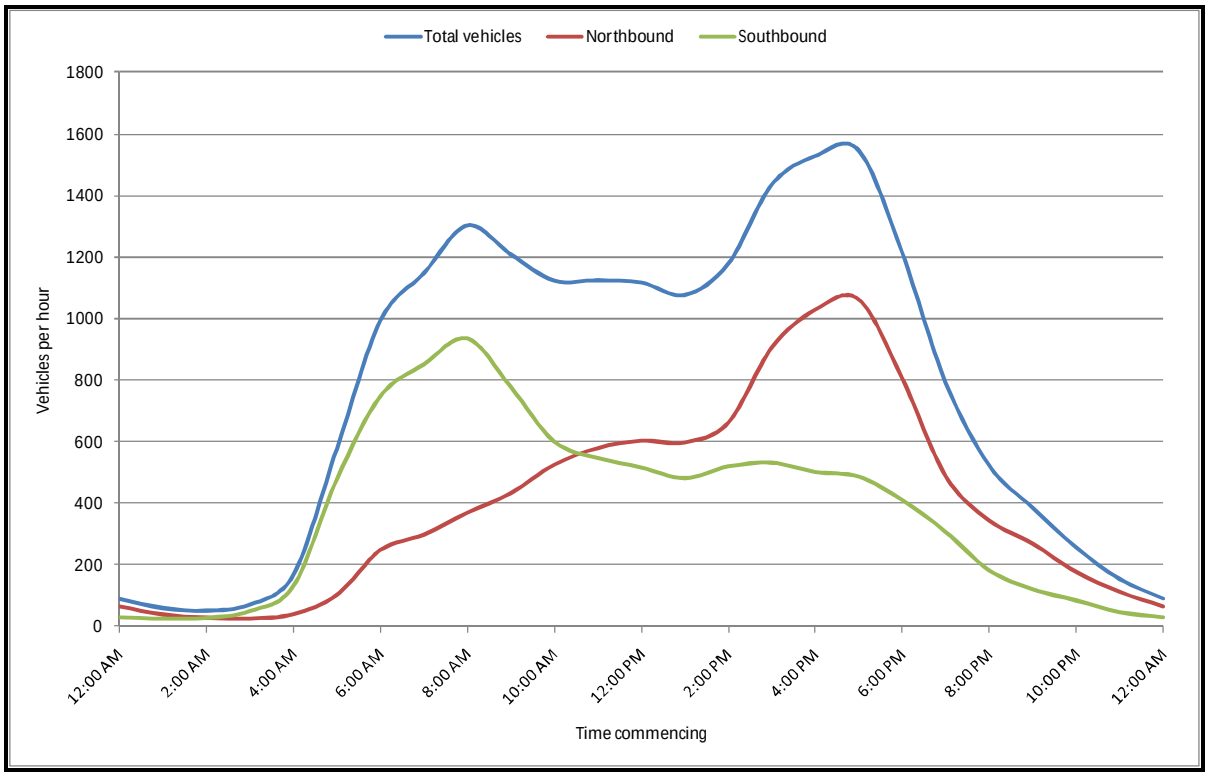


Figure 3-8 Hourly profile of vehicles in Bridge Street by direction

The majority of vehicles are travelling in the southbound direction towards Windsor and Sydney in the morning peak and northbound in the evening peak.

Wilberforce Road

Hourly traffic profiles for Wilberforce Road and Freemans Reach Road were developed by extrapolating peak hour intersection traffic surveys undertaken in 2011 with RMS count station 24 hour traffic profiles from 2005. The numbers of vehicles by classification for each hour over a 24 hour period on Wilberforce Road are presented in **Table 3-4** and shown in **Figure 3-9**. The numbers of vehicles per hour by direction are presented in **Table 3-5** and **Figure 3-10**. The figures show that the morning peak occurs around 8.00am, while the evening peak occurs around 4.00pm. Heavy vehicles account for seven per cent of overall traffic volumes.

Table 3-4 Hourly profile of vehicles in Wilberforce Road by classification

Time commencing	Total vehicles	Light vehicles	Heavy vehicles
12:00 AM	71	66	5
1:00 AM	42	36	5
2:00 AM	40	34	6
3:00 AM	50	42	8
4:00 AM	116	105	11
5:00 AM	391	346	45
6:00 AM	644	579	64
7:00 AM	795	723	72
8:00 AM	996	923	73

Time commencing	Total vehicles	Light vehicles	Heavy vehicles
9:00 AM	847	779	68
10:00 AM	799	733	67
11:00 AM	811	745	66
12:00 PM	794	731	63
1:00 PM	764	699	65
2:00 PM	838	771	67
3:00 PM	990	930	61
4:00 PM	1064	999	66
5:00 PM	995	955	40
6:00 PM	879	846	33
7:00 PM	470	450	20
8:00 PM	320	308	12
9:00 PM	247	237	10
10:00 PM	170	164	7
11:00 PM	110	105	5
12:00 AM	71	66	5
Total	**13,243**	**12,305**	**938**

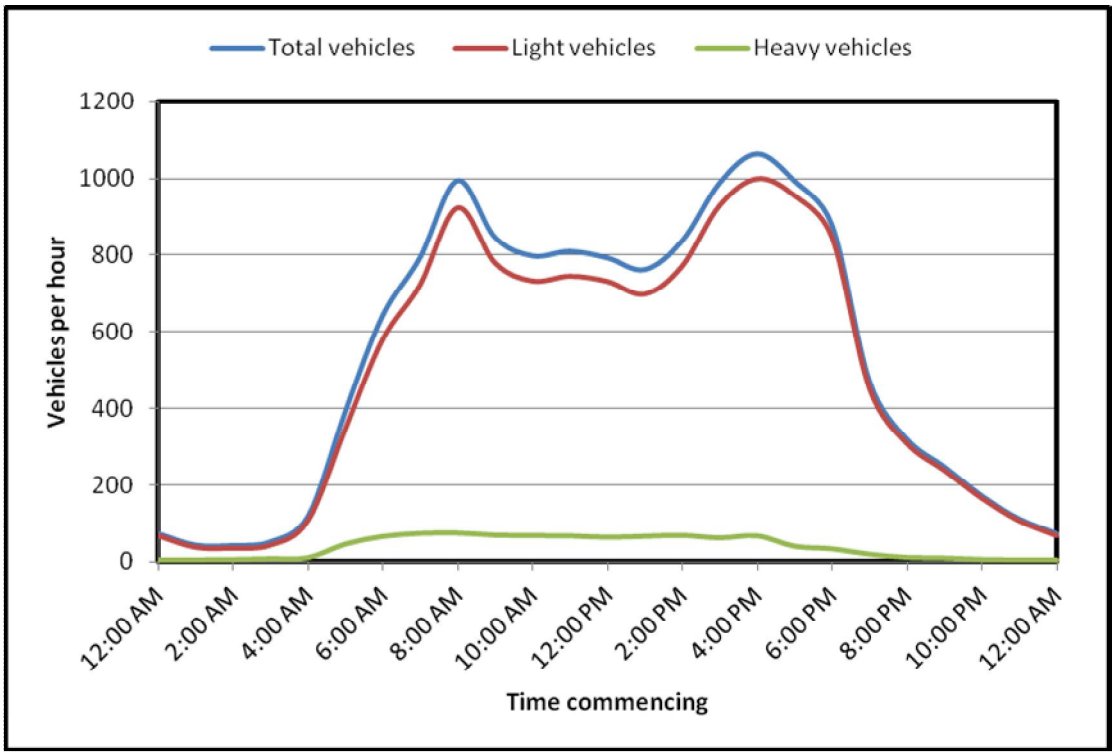


Figure 3-9 Hourly profile of vehicles in Wilberforce Road by classification

Table 3-5 Hourly profile of vehicles in Wilberforce Road by direction

Time commencing	Total vehicles	Northbound	Southbound
12:00 AM	71	46	25
1:00 AM	42	21	21
2:00 AM	40	21	19
3:00 AM	50	22	28
4:00 AM	116	25	91
5:00 AM	391	58	333
6:00 AM	644	169	475
7:00 AM	795	223	572
8:00 AM	996	279	717
9:00 AM	847	322	525
10:00 AM	799	354	445
11:00 AM	811	396	415
12:00 PM	794	409	385
1:00 PM	764	410	353
2:00 PM	838	432	407
3:00 PM	990	574	416
4:00 PM	1064	644	421
5:00 PM	995	630	365
6:00 PM	879	554	325
7:00 PM	470	297	173
8:00 PM	320	214	105
9:00 PM	247	170	77
10:00 PM	170	108	62
11:00 PM	110	80	30
12:00 AM	71	46	25
Total	**13,314**	**6,505**	**6,809**

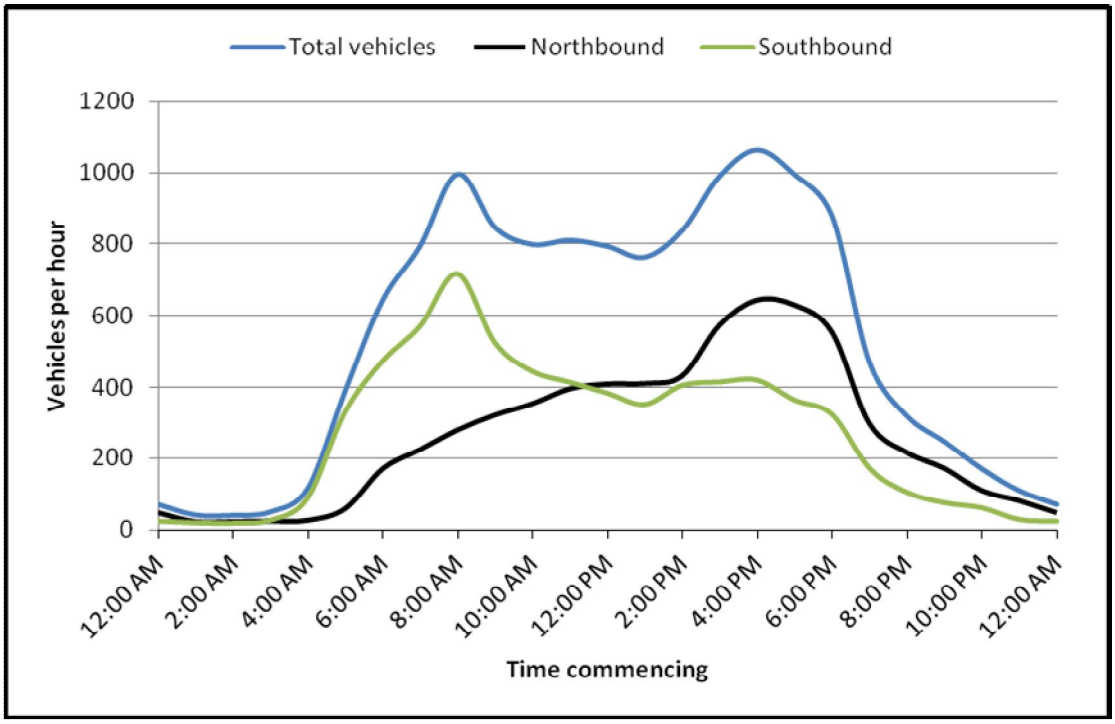


Figure 3-10 Hourly profile of vehicles in Wilberforce Road by direction

Freemans Reach Road

The numbers of vehicles per hour by classification on Freemans Reach Road are detailed in **Table 3-6** and shown in **Figure 3-11**. The numbers of vehicles per hour by direction are presented in **Table 3-7** and **Figure 3-8**. The figures show that the morning peak occurs around 8.00am, while the evening peak occurs around 5.00pm. Heavy vehicles account for around seven per cent of all vehicles.

Table 3-6 Hourly profile of vehicles in Freemans Reach Road by classification

Time commencing	Total vehicles	Light vehicles	Heavy vehicles
12:00 AM	34	32	2
1:00 AM	24	21	3
2:00 AM	18	16	3
3:00 AM	20	17	3
4:00 AM	51	46	5
5:00 AM	193	171	22
6:00 AM	417	376	41
7:00 AM	403	368	35
8:00 AM	472	438	35
9:00 AM	403	371	32
10:00 AM	343	314	29
11:00 AM	342	314	28
12:00 PM	342	316	27
1:00 PM	339	310	29
2:00 PM	403	371	32

Time commencing	Total vehicles	Light vehicles	Heavy vehicles
3:00 PM	523	491	32
4:00 PM	615	578	36
5:00 PM	666	640	26
6:00 PM	527	508	20
7:00 PM	267	256	11
8:00 PM	172	165	6
9:00 PM	145	139	6
10:00 PM	103	99	4
11:00 PM	58	56	3
12:00 AM	34	32	2
Total	**6,880**	**6,413**	**467**

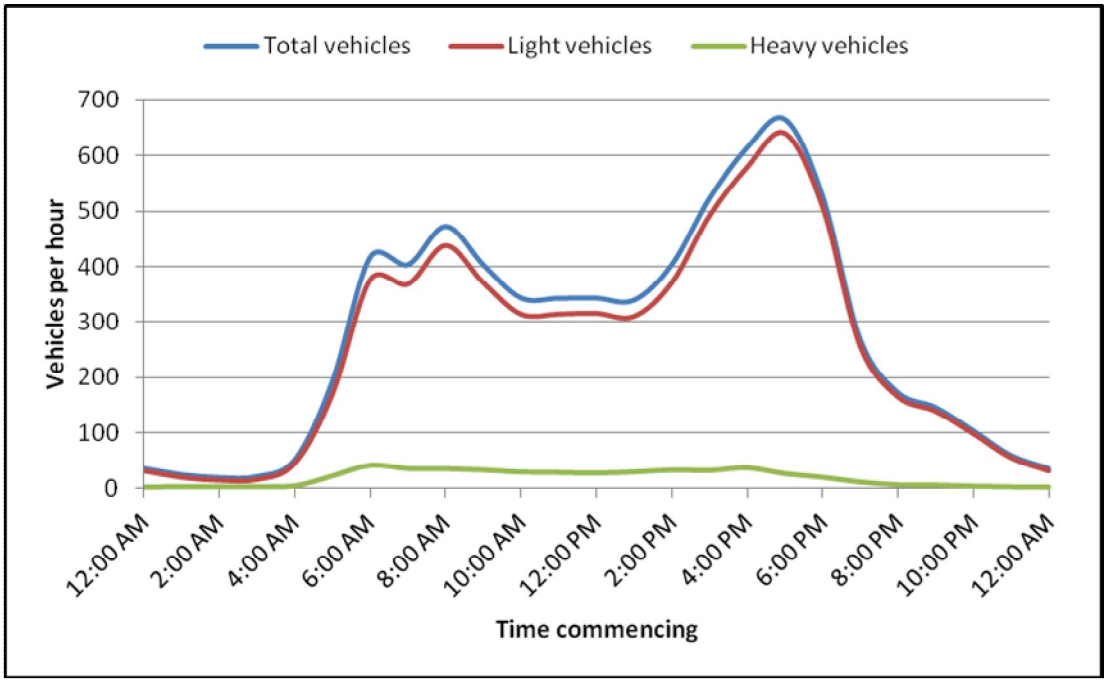


Figure 3-11 Hourly profile of vehicles in Freemans Reach Road by classification

Table 3-7 Hourly profile of vehicles in Freemans Reach Road by direction

Time commencing	Total vehicles	Northbound	Southbound
12:00 AM	34	26	8
1:00 AM	24	14	10
2:00 AM	18	12	7
3:00 AM	20	6	14
4:00 AM	51	8	42
5:00 AM	193	20	173
6:00 AM	417	86	331
7:00 AM	403	94	309
8:00 AM	472	132	340
9:00 AM	403	154	249
10:00 AM	343	160	182
11:00 AM	342	182	160
12:00 PM	342	196	146
1:00 PM	339	200	139
2:00 PM	403	253	150
3:00 PM	523	353	170
4:00 PM	615	436	178
5:00 PM	666	514	152
6:00 PM	527	389	138
7:00 PM	267	183	85
8:00 PM	172	127	45
9:00 PM	145	108	37
10:00 PM	103	75	28
11:00 PM	58	47	11
12:00 AM	34	26	8
Total	**6,914**	**3,802**	**3,112**

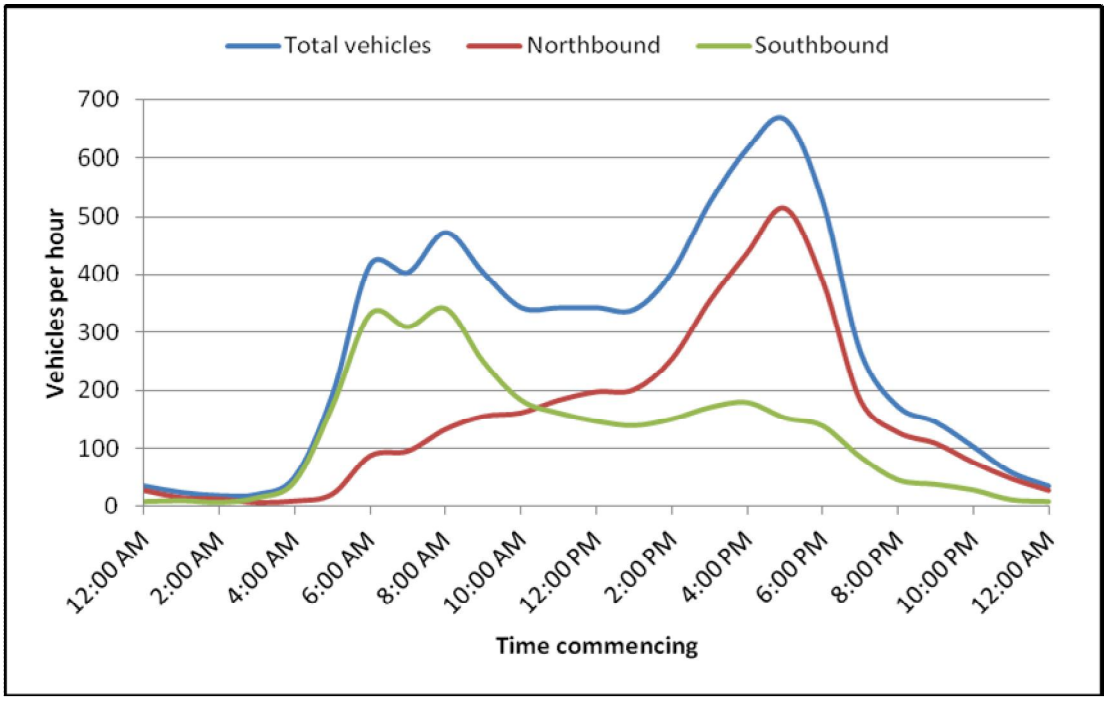


Figure 3-12 Hourly profile of vehicles in Freemans Reach Road by direction

3.5 Road network performance

3.5.1 Capacity of the existing bridge

The section of Bridge Street carried by the existing Windsor bridge is constrained by narrow (three metre wide) traffic lanes, no shoulders and a 40 kilometre per hour heavy vehicle speed limit. The narrow width of the bridge deck causes large vehicles to occasionally wait at one end of the bridge if there is another large vehicle in the process of crossing the bridge in the opposite direction. In doing so, they impede access for all other vehicles in that direction.

The bridge is currently operating at or close to capacity, indicated by the queuing and delays experienced during peak traffic periods.

Ultimately the operational performance of the bridge is constrained on its entry and exit by the operation of intersections at Bridge Street/George Street and Wilberforce Road/Freemans Reach Road. For this reason, the capacity of the existing bridge cannot be accurately calculated as an isolated element within the overall road network. It is therefore more appropriate to determine the operational performance of the section of road network which incorporates the existing bridge element. This has been considered as part of network modelling discussed in **Section 5.3**.

3.5.2 Intersection operation

Intersection analysis for the AM and PM peaks was undertaken at three key intersections in the study area using SIDRA Intersection traffic modelling software. The locations of the intersections are indicated in **Figure 2-1** including:

- Bridge Street / Macquarie Street.
- Bridge Street / George Street.
- Wilberforce Road (Bridge Street) / Freemans Reach Road.

The assessment of intersection operation is based on Level of Service Criteria outlined in **Table 3-8**.

Level of Service (LoS) is a qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and/or passengers. This measure is used in planning design and operation of roads. It also provides a basis for determining the number of lanes to be provided in the road network. The road operational conditions in terms of level of service measure are classified into five categories as listed in below **Table 3-8**.

Table 3-8 Level of Service (LoS) 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*

The average delay assessed for signalised intersections is for all movements, and is expressed in seconds per vehicle. **Table 3-9** shows the results of the intersection analysis for both the AM and PM peaks. The analysis was based on counts of turning volumes collected at the Bridge Street / George Street and Wilberforce Road / Freemans Reach Road intersections on Wednesday 7 December 2011, and SCATS data for the Bridge Street / Macquarie Street intersection on the same day. Full results are presented in **Appendix A**.

Table 3-9 Existing intersection operation, 2011 base

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 Road	Give Way	F	>100	F	>100

The results show 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 desired maximum capacity. The Wilberforce Road / Freemans Reach Road intersection is performing unsatisfactorily, which is consistent with community observations of long queue lengths and delays in peak periods.

3.6 Network modelling

The results of the stand-alone intersection traffic modelling identify the intersection performance in isolation at each of the locations considered. Whilst stand-alone traffic models are generally acceptable, it is required in this case to consider the interaction between the intersections north and south of the bridge, and whether a delay at one intersection has an impact on the operation of the other intersection. This is achieved through road network modelling.

RMS provided SKM with VISSIM models previously prepared for Windsor bridge in 2011. The details and set-up of the network models are presented in **Appendix E**.

3.6.1 Travel time and distance

Micro-simulation network models produce statistics related to all of the vehicles that enter a network under investigation, travel through that network and ultimately exit the network at some point. The statistics produced can be used as a network performance indicator to compare one scenario with another. The two aggregate statistics are defined as follows:

- Total Vehicle Kilometres Travelled (VKT) is the accumulated distance travelled by all vehicles within the road network.
- Total Vehicle Hours Travelled (VHT) is the accumulated time spent (in hours) by all vehicles during their travel within the road network.

The total distance travelled and the total travel time is dependent on the number of vehicles on the network. Therefore, in order to provide a direct comparison of the operational performance of the existing network and the project case, the average distance travelled, the average travel time and the average speed per vehicle has been reported.

3.6.2 Existing network performance

The performance indicators in terms of total distance travelled and total travel time for the existing traffic is presented in **Table 3-10**.

Table 3-10 Existing network performance indicators

Network Performance Indicator	2016 AM	2016 PM	2026 AM	2026 PM
Total Cars exiting the network [veh]	9,316	12,562	10,302	8,598
Total Heavy Vehicles exiting the network [veh]	623	710	705	537
Total Buses exiting the network [veh]	60	84	86	61
Average Distance Travelled [km], Car	2.21	2.00	2.27	2.09
Average Distance Travelled [km], HV	2.46	2.50	2.47	2.55
Average Distance travelled [km], Bus	2.36	2.44	2.53	2.64
Average travel time [min], Car	2.96	2.74	3.58	17.31
Average travel time [min], HV	3.21	3.52	3.84	19.79
Average travel time [min], Bus	2.99	3.32	3.92	21.88
Average speed [km/h], Car	45	44	38	7
Average speed [km/h], HV	46	43	39	8
Average speed [km/h], Bus	47	44	39	7
Total Vehicles exiting the network (all modes) [veh]	**9,999**	**13,356**	**11,093**	**9,196**
Average Distance Travelled (all modes) [km]	**2.22**	**2.03**	**2.28**	**2.12**
Average Travel time (all modes) [min]	**2.97**	**2.79**	**3.60**	**17.49**
Average speed (all modes) [km/h]	**45**	**44**	**38**	**7**

The results for the existing network in the 2026 PM peak clearly show that the network cannot accommodate the forecast future traffic volumes with the average speed of vehicles falling to seven kilometres per hour. The model indicated that the existing network 'gridlocked' for the second hour of the evening peak.

3.6.3 Crash history

Crashes recorded along Windsor Road and Wilberforce Road between Freemans Reach Road and George Street were analysed for the five year period ending in 2009. **Figure 3-13** shows the number of crashes over the five year period. There were a total of 16 reported crashes, comprising eleven car crashes, four light truck crashes and one pedestrian crash. However, it is noted that pedestrian and cycle crashes are known to be under-reported, and may only be reported if they involve a death or serious injury. Four of the crashes resulted in eight injuries, 12 of the crashes resulted in no injuries and none of the crashes resulted in a fatality.

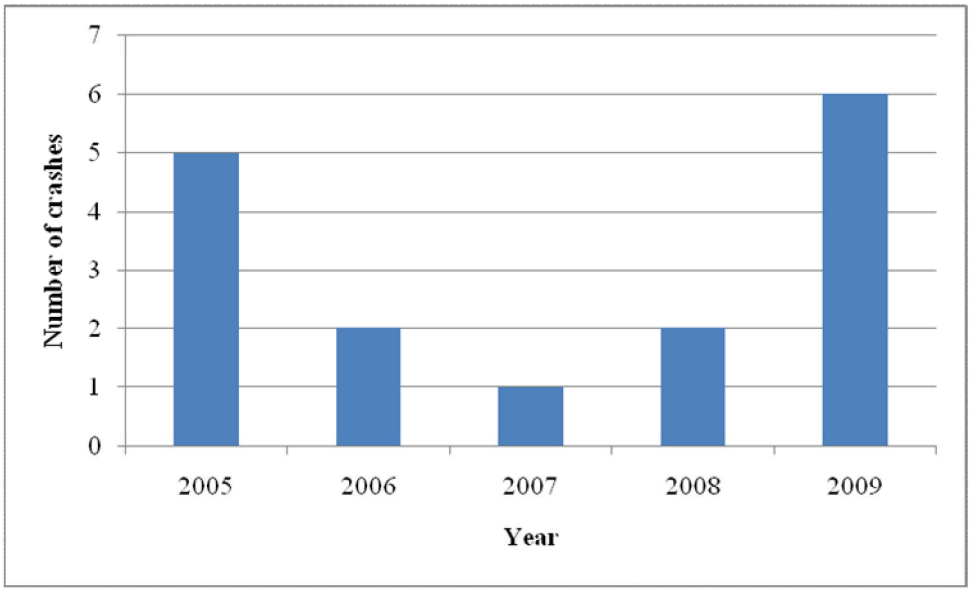


Figure 3-13 Reported crashes by year

The most commonly reported crash type was at an intersection between vehicles travelling from adjacent approaches. This type of crash occurred ten times in the 5-year period. Two crashes were associated with a head-on collision, two crashes were associated with a rear-end collision, and one crash resulted from a vehicle losing control on a curve and hitting an object. The other crash related to a collision between a vehicle and a pedestrian. A summary of crash types is presented in **Figure 3-14**.

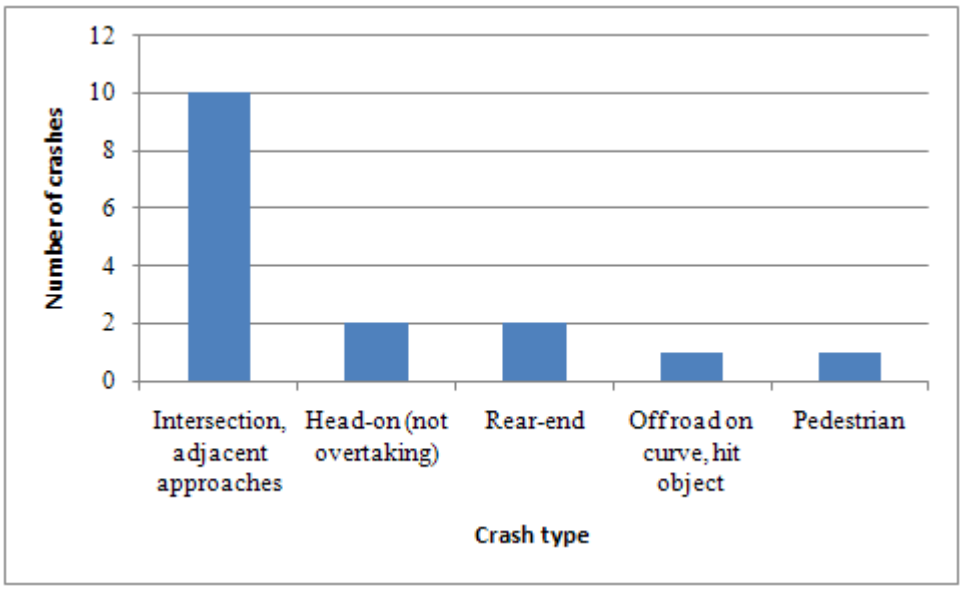


Figure 3-14 Reported crashes by type

Figure 3-15 shows the locations of the recorded crashes. RMS classifies a crash cluster as a site such as an intersection with three or more crashes in a five-year analysis period, and a crash length as a length of road over 150 metres with three or more crashes in a five-year analysis period. In this context there is one crash cluster and one crash length:

- Crash cluster – intersection of Wilberforce Road and Freemans Reach Road – eleven recorded crashes.
- Crash length – Bridge Street, from George Street to the entrance to Macquarie Park – five recorded crashes.

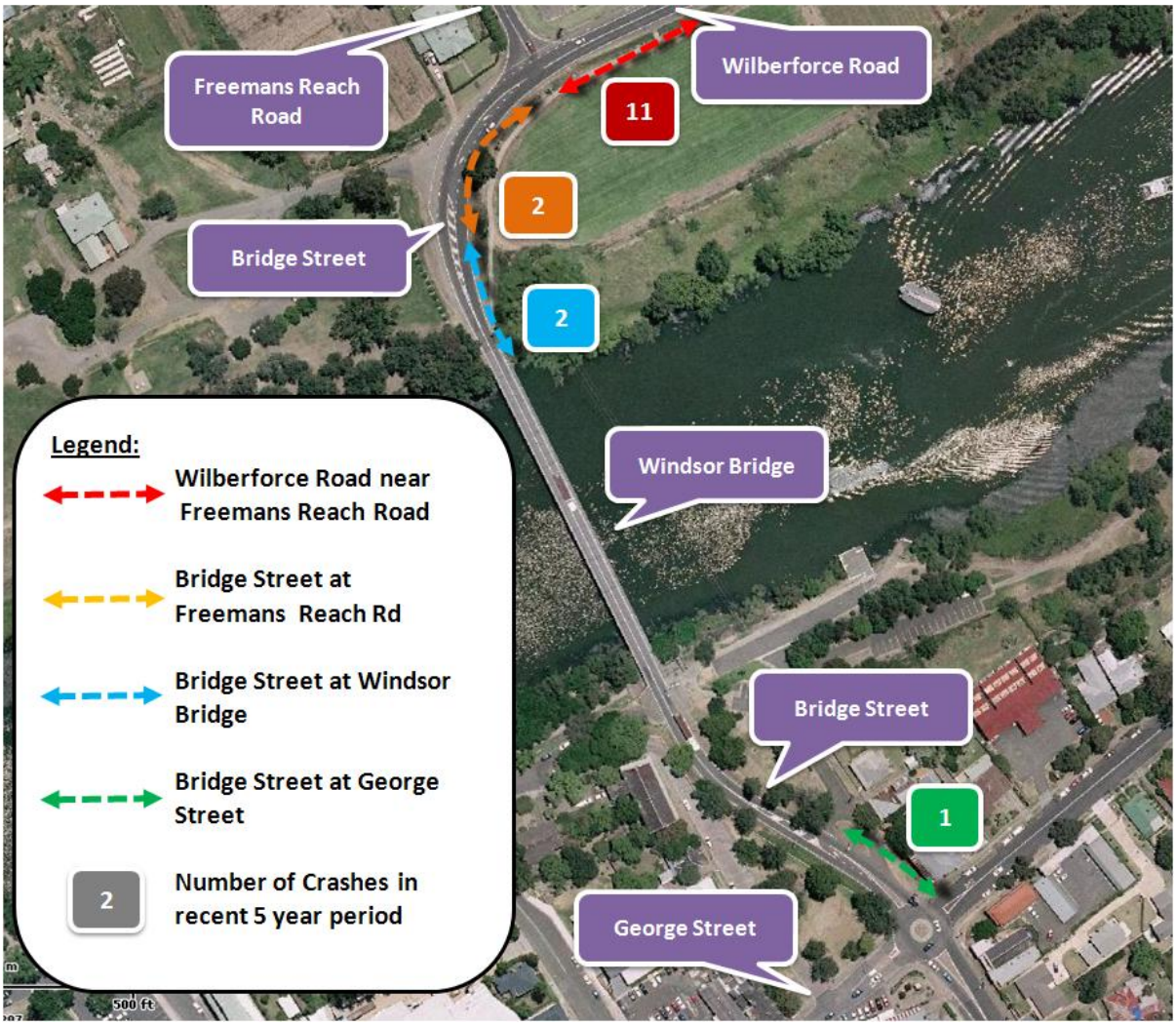


Figure 3-15 Reported crashes by location

Crashes can be assessed by dividing the week into what are known as McLean Time Periods, which are shown in **Figure 3-16**. McLean Time Periods divide the week into eleven segments of various lengths, which are detailed below:

- A: 3.00am to 9.00am Monday to Friday.
- B: 3.00am to 9.00am Saturday and Sunday.
- C: 9.00am to 3.00pm Monday to Friday.
- D: 9.00am to 3.00pm Saturday.

- E: 9.00am to 3.00pm Sunday.
- F: 3.00pm to 9.00pm Monday to Wednesday.
- G: 3.00pm to 9.00pm Thursday and Friday.
- H: 3.00pm to 9.00pm Saturday and Sunday.
- I: 9.00pm to midnight Monday, Tuesday and Sunday, and midnight to 3.00am Monday to Thursday.
- J: 9.00pm to midnight Thursday to Sunday and midnight to 3.00am Friday to Sunday.

Eleven of the 16 crashes occurred in daylight conditions, and five of the 16 crashes occurred in darkness.

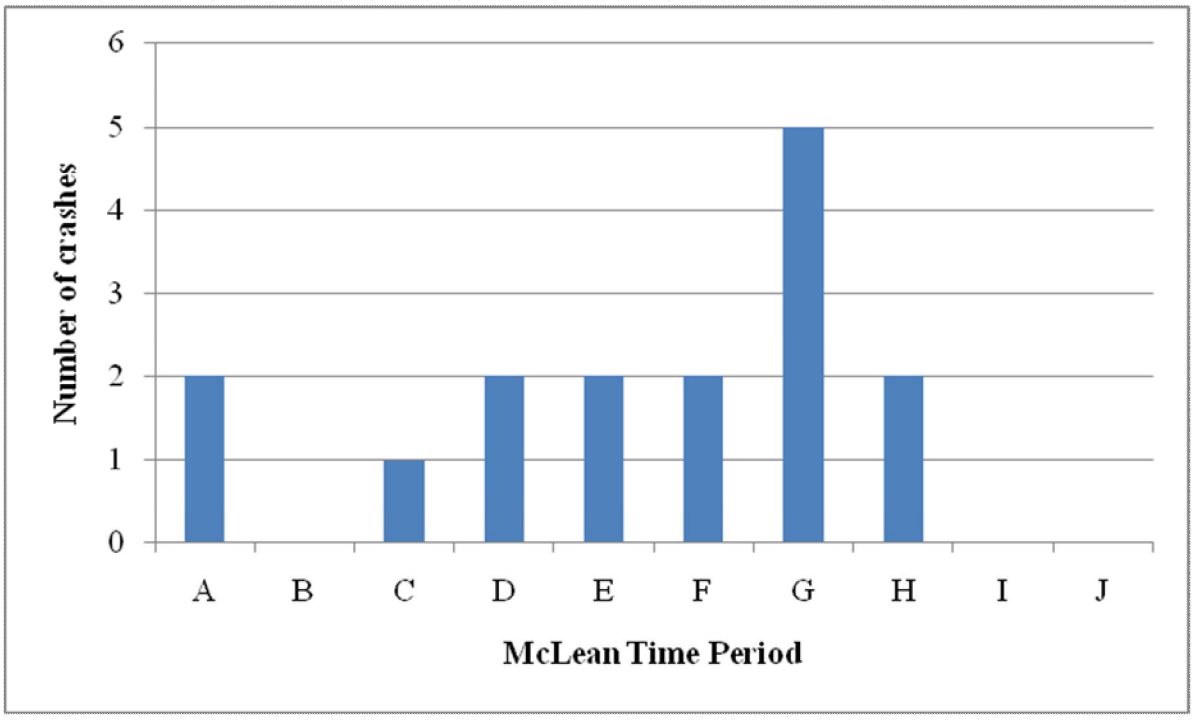


Figure 3-16 Crashes by McLean Time Period

Other factors contributing to recorded crashes were as follows:

- 13 crashes occurred in fine weather.
- Two crashes occurred in rain.
- One crash occurred in overcast conditions.

Speeding was a contributing factor to one crash, as was fatigue. Alcohol was not a contributing factor in any of the crashes.

3.7 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 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. Route 669 runs between Sackville and Wilberforce via Ebenezer. Service frequencies for Routes 668 and 669 are given in **Table 3-11**.

Table 3-11 Bus service frequencies

Route (Two-Way)	Timetabled Buses		
	AM Peak (6.00am to 9.00am)	PM Peak (4.00pm to 7.00pm)	Daily Total
668	5 to 9	7	16 to 21
669	1	1	2

Source: ComfortDelgroCabcharge - http://www.cdcbus.com.au/

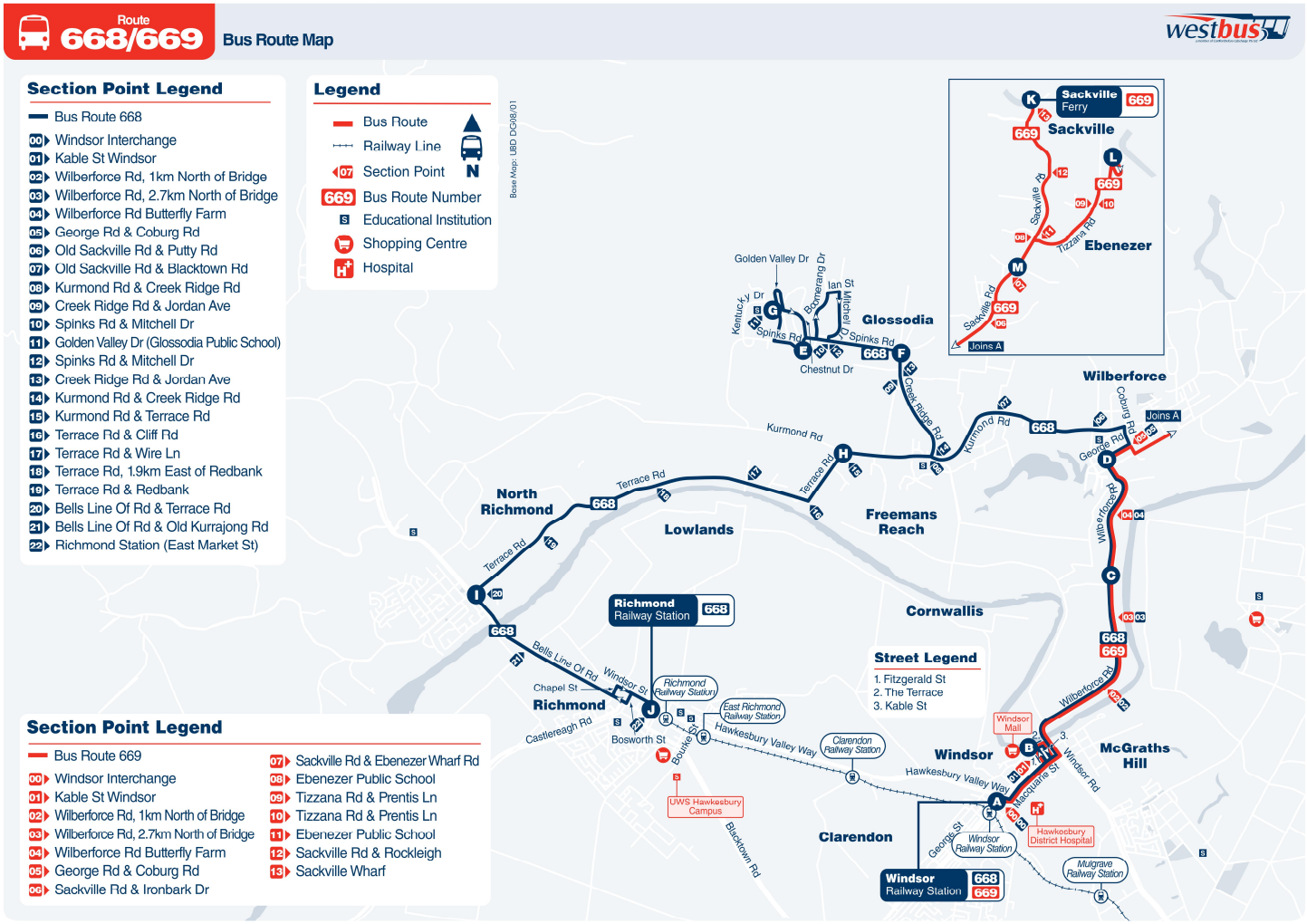
3.7.1 School buses

Westbus operate the following school bus services that cross Windsor bridge:

- Journey to school
  - Bus route 5024, arriving in Windsor at 7:50 am.
  - Route 669, arriving in Windsor at 8:13 am.
  - Bus route 5070, arriving Windsor at 8:56 am.
- Journey home
  - Bus route 5539, departing Windsor at 3:40pm to Wilberforce.
  - Bus route 5557, departing Windsor Public School at 3:30pm to Wilberforce.

Schoolchildren can also travel on the regular service 668 buses crossing Windsor Bridge. A bus route map is presented in **Figure 3-17**.

Windsor Railway Station is located within two kilometres of Windsor bridge. This provides train services on the Richmond Line, which runs from Richmond to Sydney CBD via Windsor, Blacktown and Parramatta. Trains service Windsor approximately every half hour to the city during the week until 10.45 pm, after which they depart on an hourly basis. Train services on weekends depart every half hour until 8.30, after which they depart on an hourly basis. The train trip to the city takes about 1 hour and 20 minutes.



Source: ComfortDelgroCabcharge - http://www.cdcbus.com.au/

Figure 3-17 Bus route map

3.8 Pedestrian and cycle networks

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 to the north. The shared path on the existing bridge also forms an off-road link in the local cycle network, as shown in **Figure 3-18**. This figure also shows potential future cycle routes which would be the responsibility of HCC or others to develop and fund in the future.

There are some key shared path facilities 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.

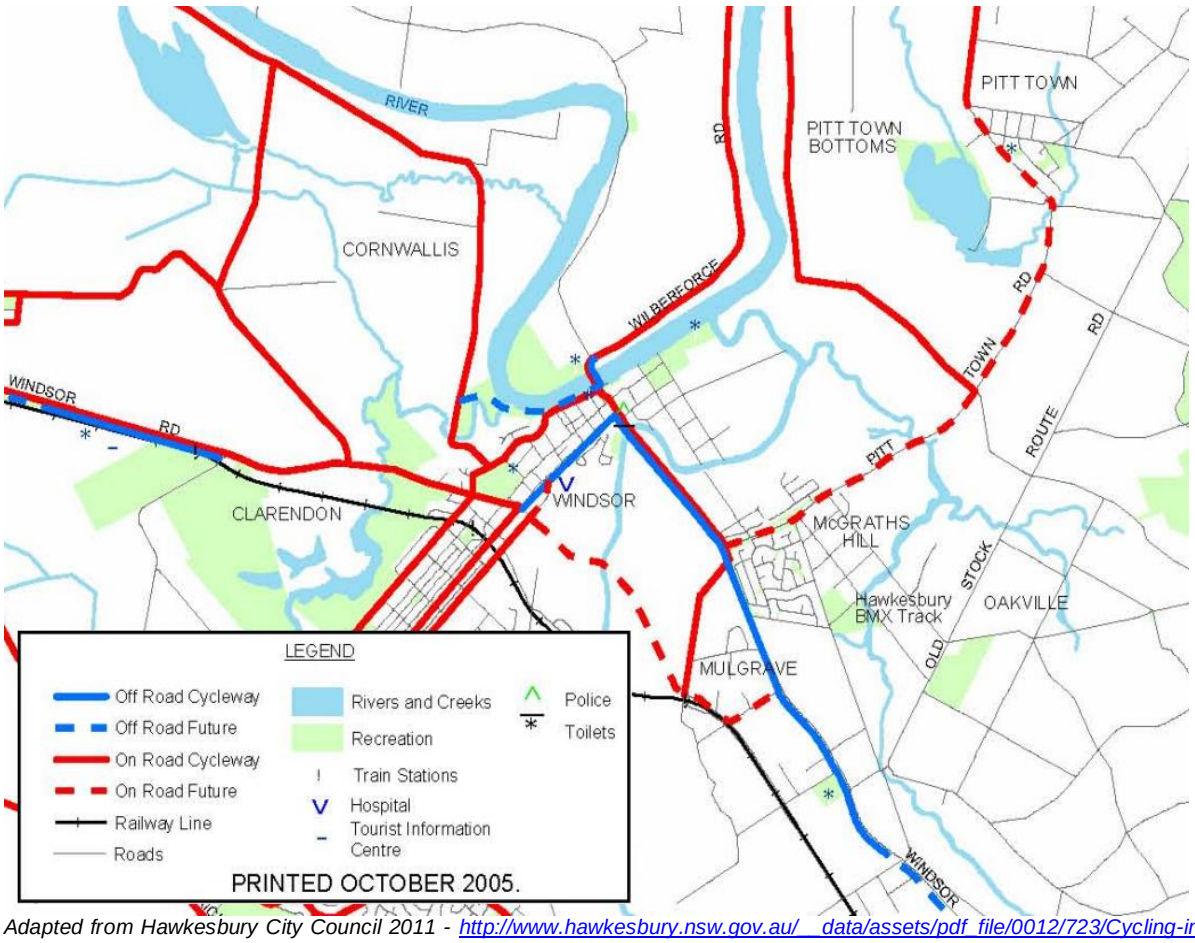
The current issue with these facilities is that they do not link to one another, particularly the Ham Common facility which does not have links at either end to enable a connection between Windsor and Richmond.

There are plans to expand the shared path network as part of the development of the Great River Walk facility, which involves provision of a trail that would ultimately 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 (Hawkesbury Mobility Plan 2010, PAMP and Bike Plan, 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.

Pedestrian access and amenity at the Bridge Street / George Street roundabout is currently poor. Pedestrian access is typically poor at roundabout controlled intersections and is made worse in this case by the fact that the intersection is located at the top of a crest. The existing intersection presents a road safety hazard for pedestrians and cyclists due to the high peak traffic volumes and poor sight distances at the intersection. No facilities are provided at the current roundabout controlled intersection to assist crossing Bridge Street and pedestrians have difficulty identifying a safe gap in which to cross during peak traffic periods. As well as being a considerable safety risk to pedestrians crossing at this point, it provides a barrier to direct pedestrian movements from the eastern section of the town, where much of the accommodation is located, to the town centre. The lack of a safe crossing at the George Street and Bridge Street intersection was identified as a major barrier to east/west pedestrian movement in the Hawkesbury Mobility Plan 2010 (GTA Consultants, 2010).

An underpass of the 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.



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

Figure 3-18 Local cycle routes

3.9 Water activities at Windsor

The following sections describe the maritime activities that occur in the Hawkesbury River near Windsor.

3.9.1 Windsor wharf cruises

Hawkesbury Paddle Wheeler

The Hawkesbury Paddle Wheeler (**Figure 3-19**) operates daily passenger cruises from Windsor Wharf on The Terrace, just downstream (east) of Windsor bridge. The 11 metre high vessel is too high to pass under the existing Windsor bridge.

Figure 3-19 Hawkesbury Paddle Wheeler

Hawkesbury River Boat Cruises

The vessel “River Dream” (**Figure 3-20**) provides regular cruises from Windsor. This low height vessel is able to pass under the existing Windsor bridge.

Figure 3-20 Hawkesbury River Boat Cruises

3.9.2 Organised water-based activities

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.

3.9.3 Personal craft

The Hawkesbury River is navigable, and tidal, for over 130 kilometres from Broken Bay to Richmond (about 13 kilometres upstream of Windsor). Between Windsor and Richmond, however, 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, water skis, 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. Given the navigation constraints upstream of Windsor (the water depth is marked as zero to two metres deep between Richmond and Windsor, and two to five metres downstream from Windsor bridge) it is unlikely that houseboats would try to pass under Windsor bridge.

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.

There is a Power Boat club on the river at Governor Philip Park, 800 metres east of Windsor bridge.

4 Development of preferred option

4.1 Background

As described in **Section 3**, intersections surrounding Windsor bridge, with the exception of Bridge Street / George Street, are currently operating at or above their capacity, necessitating upgrades in the near future. To develop appropriate upgrade designs, a range of potential intersection layouts were tested for the Wilberforce Road / Freemans Reach Road and Bridge Street / George Street intersections. These are discussed in further detail throughout this Section.

Growth rates of key roads were derived from outputs of anticipated traffic volumes from the Sydney Strategic Travel Model at the Wilberforce Road / Freemans Reach Road intersection in 2021 and 2026, representing five years and ten years, respectively, beyond the assumed date the project would be open to traffic. These growth rates are presented in **Table 4-1**.

Table 4-1 Growth rates of key roads (2011 base year)

Road	Growth to 2021 (per cent)	Growth to 2026 (per cent)
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	20.8	29.3

Using the growth rates, Average Daily Traffic (ADT) volumes over Windsor bridge in March 2012 were projected to 2021 and 2026 volumes, and are presented in **Table 4-2**. The growth figures assume that all planned urban development used to derive traffic estimates in the Sydney Strategic Traffic Model would proceed. 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 4-2 Bridge Street ADT projections

Road	2012 ADT (base)	2021 ADT	2026 ADT
Bridge Street, over Windsor bridge	19,000	22,500	24,000

4.2 Intersection options

4.2.1 Wilberforce Road / Freemans Reach Road intersection

A number of options for the upgrade of the intersection of Wilberforce Road and Freemans Reach Road were tested against the 2021 forecast traffic volumes. The year 2021 was chosen at it is ten years after the base case traffic data year (2011) and about 5 years after the opening of the project. The options considered are described below:

4.2.1.1 Existing Intersection

The intersection currently operates under give-way control, where vehicles approaching the intersection from Freemans Reach Road are required to give way to traffic on Wilberforce Road (see **Figure 4-1**). The purpose of this analysis was to assess the operation performance of the existing configuration against the 2021 forecast volumes.

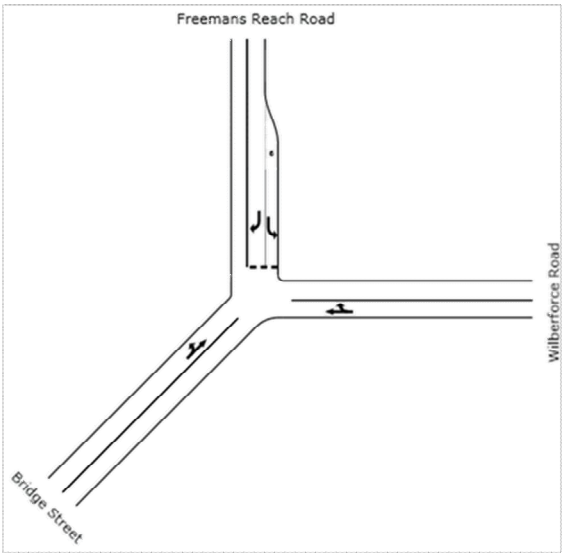


Figure 4-1 Wilberforce Road / Freemans Reach Road – Existing Intersection

4.2.1.2 Option 1

In Option 1 a single lane roundabout with a nine metre diameter was tested (see **Figure 4-2**). The objective of testing this option was to assess any improvements in the intersection's performance after conversion from a priority-controlled intersection to a roundabout.

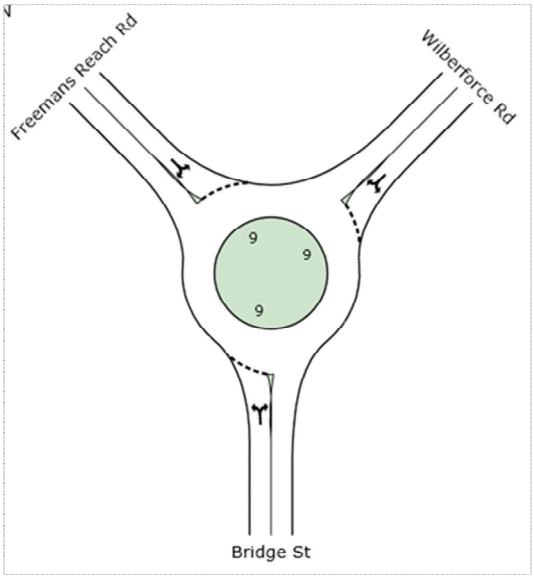


Figure 4-2: Wilberforce Road / Freemans Reach Road intersection – Option 1

4.2.1.3 Option 2

In option 2, a single lane 30 metre diameter roundabout with an additional arm for the Macquarie Park access road was tested. The objective of testing this option was to assess the intersection's performance after adding an additional arm to the roundabout (see **Figure 4-3**).

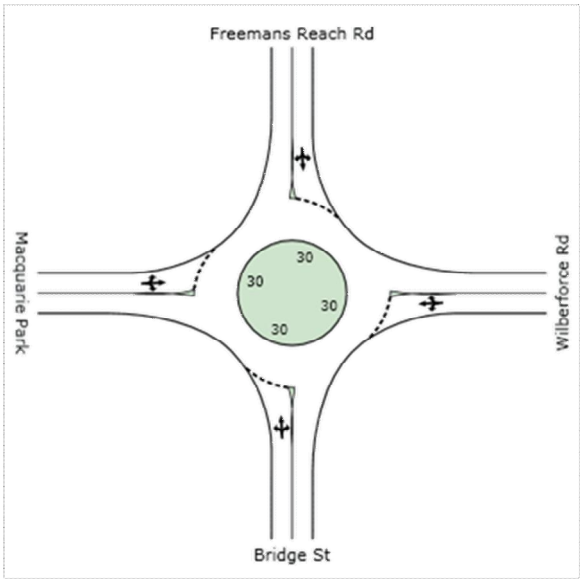


Figure 4-3: Wilberforce Road / Freemans Reach Road intersection – Option 2

4.2.1.4 Option 3

In Option 3, a partial single/dual lane roundabout with a 15 metre diameter was tested. Dual lanes were provided along the Wilberforce Road approach and Bridge Street exit (see **Figure 4-4**). The objective of testing this option was to assess the intersection's performance after providing additional capacity for left turning traffic from Wilberforce Road.

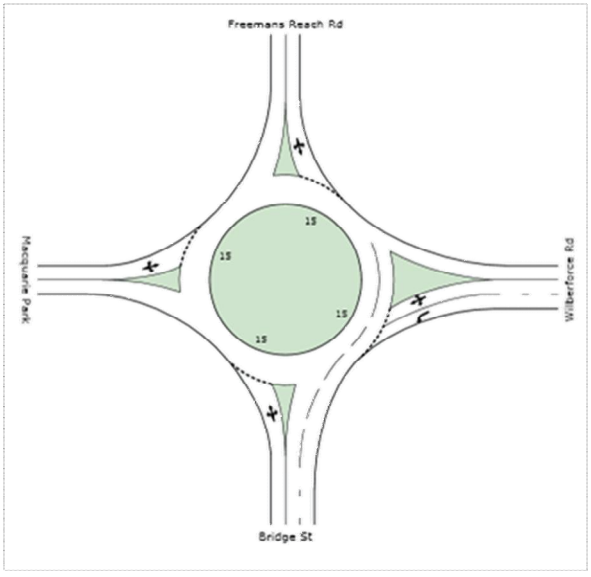


Figure 4-4: Wilberforce Road / Freemans Reach Road intersection – Option 3

4.2.1.5 Option 4

In option 4, signalisation of the intersection was tested (see **Figure 4-5**). The intersection configuration was a basic 'T intersection' with Freemans Reach Road forming the stem of the "T'. Bridge Street would be provided with a dedicated through lane plus a shared through and left turn lane. The Wilberforce Road approach would consist of two through lanes plus a dedicated right turn bay. Freemans Reach Road would be provided with a dedicated right turn lane and a shared right turn, left turn lane.

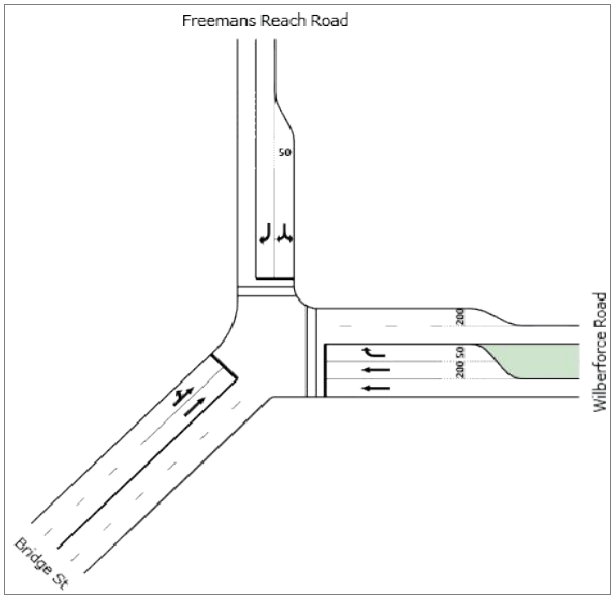


Figure 4-5 Wilberforce Road/ Freemans Reach Road intersection – Option 4

4.2.1.6 Option 5

In option 5, an alternative layout for the signalised intersection was tested. Changes compared to option 4 include realignment of the Bridge Street arm, the addition of an arm for the Macquarie Park access road, and a continuous left turn lane from Wilberforce Road to allow for uninterrupted flow (see **Figure 4-6**).

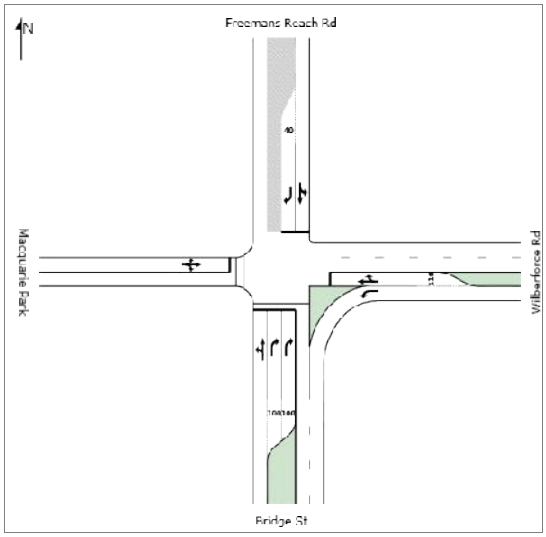


Figure 4-6 Wilberforce Road / Freemans Reach Road intersection – Option 5

4.2.1.7 Option 6

In option 6, a double lane 26 metre diameter roundabout with double entry lanes at all approaches (except from the Macquarie Park access road approach) was tested (see **Figure 4-7**).

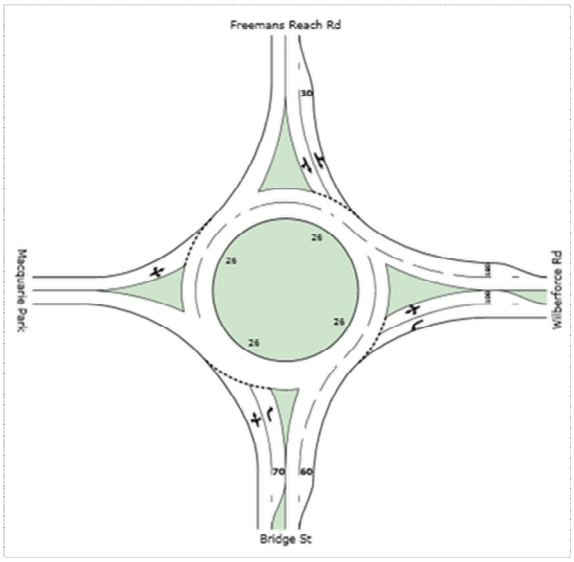


Figure 4-7 Wilberforce Road / Freemans Reach Road intersection – Option 6

The existing and upgrade design options for the Wilberforce Road / Freemans Reach Road intersection are summarised in **Table 4-3**. All options were tested with 2021 forecast traffic volumes. The SIDRA results are summarised in **Table 4-4**. The detailed intersection performance results are attached in Appendix B.

Table 4-3 Wilberforce Road/Freemans Reach Road tested intersection layouts

Existing / Upgrade Design Option	Layout Description
Existing	Existing give way
Option 1	New single lane, 3 arm roundabout
Option 2	New single lane, 4 arm roundabout (with Macquarie Park Access)
Option 3	New single/dual lane, 4 arm roundabout (with Macquarie Park Access)
Option 4	New 3 arm traffic signals
Option 5	New 4 arm signals (with Macquarie Park Access)
Option 6	New dual lane, 4 arm roundabout (with Macquarie Park Access)

Table 4-4 Wilberforce Road/Freemans Reach Road – Intersection performance for each tested option

Existing / Design Option Geometry	Forecast Year	AM		PM	
		level of service	Delay for the Worst Movement(s) for roundabouts / Overall delay for signals	level of service	Delay for the Worst Movement(s) for roundabouts / Overall delay for signals
Existing Give Way' priority control	2021	F	>100 (Freemans Reach Road)	F	>100 (Freemans Reach Road)
Option 1 (New single lane, 3 arm roundabout)	2021	F	>100 (Freemans Reach Road)	B	16 (Freemans Reach Road)
Option 2 (New single lane, 4 arm roundabout)	2021	C	40 (Freemans Reach Road)	C	33 (Macquarie Park Access)
Option 3 (New single/dual lane, 4 arm roundabout)	2021	A	14 (Wilberforce Road)	C	33 (Macquarie Park Access)
Option 4 (New 3 arm traffic signals)	2021	A	13	B	10
Option 5 (New 4 arm traffic signals)	2021	B	17	B	25
Option 6 (New dual lane, 4 arm roundabout)	2021	A	14 (Wilberforce Road)	A	13 (Macquarie Park Access)

The analysis results indicate that the intersection would underperform in 2021 under the existing 'Give Way' priority control. The intersection would experience severe delays and queuing, especially the Freemans Reach Road approach.

From the comparison of roundabout design options (option 1, option 2, option 3 and option 6), the intersection performance would be improved with the provision of additional lanes at the Wilberforce Road approach to the roundabout and dual circulating lanes. However, the performance would be further improved under traffic signal control (option 4 and option 5).

Notwithstanding the improved operational performance of traffic signals there would be a number of reasons why they are not preferred in this location. This intersection would be in a floodplain and would be subject to periodic inundation which would decrease operational reliability due to the fact that traffic signals are electronic traffic control devices and would cease to function underwater. There would also be an increase in costs for repairs following each flooding event and a consequential increase in whole of life maintenance costs.

From a heritage and amenity perspective, there was desire within the community to preserve the low speed environment within Windsor. A roundabout controlled intersection would be more conducive to this objective as all approach movements would be required to 'give way' whereas with a signalised intersection a green signal would be visible on approach reducing the tendency to decelerate. Furthermore, the location of this intersection would be in an essentially rural setting on the northern side of the river and more befitting of an unsignalised intersection treatment.

Of the four roundabout options evaluated option 6, which comprised dual circulating lanes and dual approach lanes on the three key approaches, performed the best in both peak traffic periods. The improved performance was largely derived from the fact that left turning traffic in the left lane of Wilberforce Road does not need to give way to traffic from Freemans Reach Road circulating the roundabout in the inner lane. Option 6 would also provide additional traffic capacity for future growth.

Overall, taking into account these factors, it was considered that the option 6 "Dual lane, 4 arm roundabout (with Macquarie Park Access)" would provide the best performance for the Wilberforce Road / Freemans Reach Road intersection in the long term.

4.2.2 Bridge Street / George Street intersection

Although intersection analyses shows that the existing roundabout performs well under current traffic conditions for most periods of the day, the analyses also showed that the intersection had limited spare capacity in the PM peak. The intersection analysis also indicated that by 2016 the existing roundabout would have an unacceptable level of service in the PM peak (See **Table 4-5**) Furthermore, feedback from the community expressed concern about traffic congestion in the PM peak and an overall concern about pedestrian safety when crossing at the roundabout intersection.

To improve the intersection performance at Bridge Street / George Street and to provide improved pedestrian crossing facilities, four upgrade design options were considered for analysis purposes (see **Figure 4-8** to **Figure 4-12**). Roundabout options were not considered suitable for the Bridge Street/George Street intersection as there is insufficient land available for a larger roundabout due to heritage and property constraints and a roundabout does not provide for effective and safe pedestrian crossings. The options considered included:

- Option 1 – Traffic signals with dedicated right turning bays for the Bridge Street approaches.
- Option 2 – Traffic signals with right turn prohibited from Bridge Street north into George Street west in the AM and PM peak periods.
- Option 3 – Traffic signals with shared through and right turn lane from Bridge Street into George Street west.
- Option 4 – Traffic signals with right turn prohibited from Bridge Street south into George Street east and dedicated right turn bay for Bridge Street north.

All of the above options incorporated signalised pedestrian crossings across all roads.

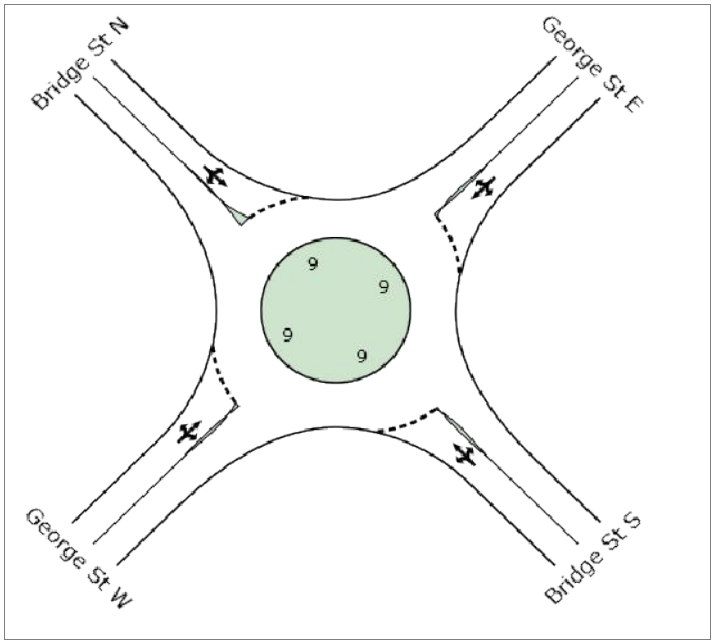


Figure 4-8 Bridge Street / George Street – existing intersection

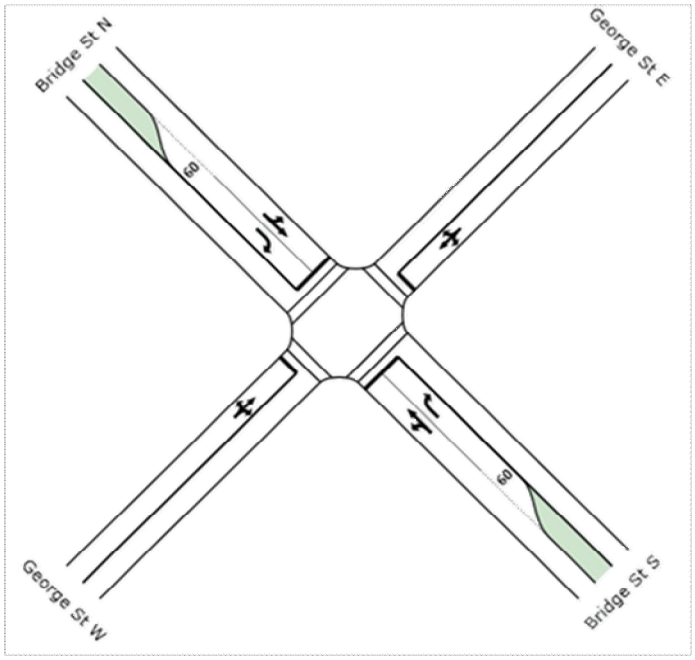


Figure 4-9 Bridge Street / George Street intersection – Option 1

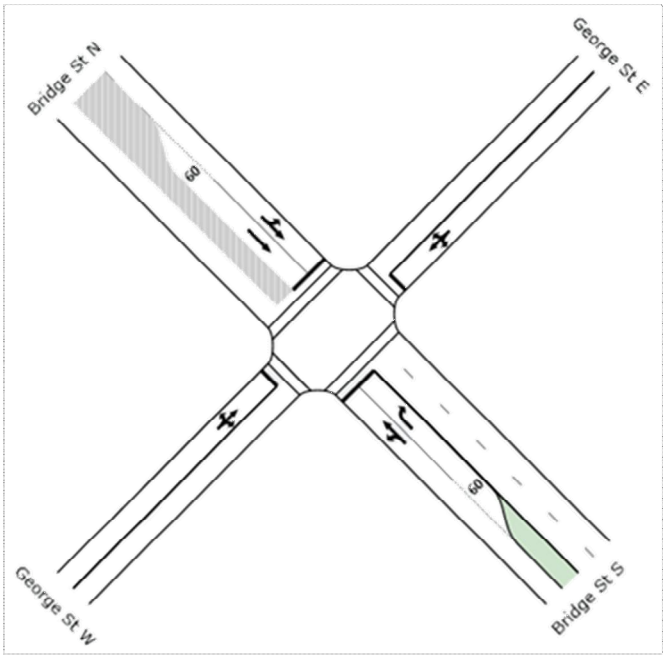


Figure 4-10 Bridge Street / George Street intersection – Option 2
Note: for Option 2 – right turns into George Street are banned in AM and PM Peak periods

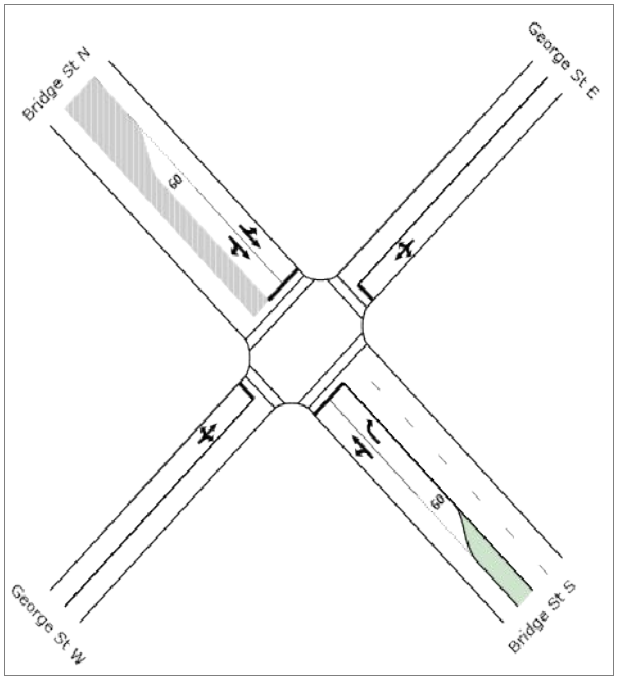


Figure 4-11 Bridge Street / George Street intersection – Option 3

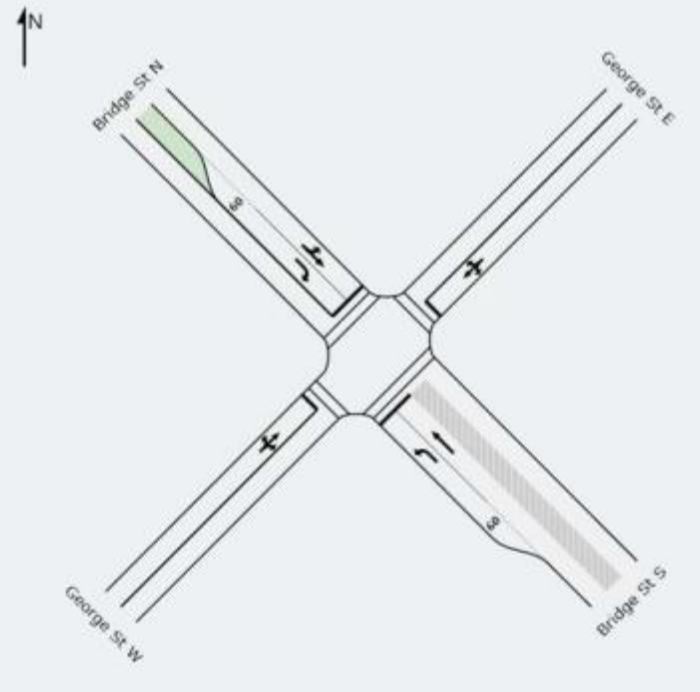


Figure 4-12 Bridge Street / George Street intersection – Option 4

A Design Life Analysis[2] (DLA) was undertaken on both the existing and options intersection layouts. The purpose of this analysis is to forecast the maximum number of years at which the intersection would be likely to operate within the acceptable level of service (i.e. level of service C or better). The annual growth rates for all turning movements were calculated based on the 2012 traffic survey data and 2026 EMME forecast volumes. The SIDRA DLA summary results are shown in **Table 4-5**. The detailed SIDRA results are attached in **Appendix C**.

Table 4-5 Bridge Street / George Street - Intersection performance for each option tested

Peak	Existing (roundabout)		Option 1	Option 2	Option 3	Option 4
	Latest year at which level of service C or better	The Worst movement	Latest year at which level of service of whole intersection is C or better			
AM	2031	Bridge Street north	2030	2030	2030	2030
PM	2016	George Street west	2021	2028	2024	2021

[2] Design Life Analysis (DLA) helps to investigate the effect of traffic growth for a given number of years using annual traffic growth rates (uniform or compound) for individual turning movements. For the selected 'Worst Lane' or 'Worst Movement LOS Target' option, SIDRA will undertake the DLA to determine the 'latest' year at which the intersection will operate at acceptable LOS (i.e. C or better). This option is suitable for roundabouts and give way / stop control intersections. For signals, the overall intersection LOS is considered when assessing the operational performance. The DLA for signalised intersections was carried out by 'trial and error' to determine the 'latest' year at which the intersection would operate at acceptable LOS (i.e. C or better).

The results indicate that the Bridge Street / George Street intersection, with the existing roundabout geometry and method of control, would underperform in the PM peak from 2016 onwards. George Street west is anticipated to experience long delays and queues. The results also show that, in the PM peak in particular, the intersection performance would be considerably improved in all four upgrade options.

Option 2 would operate at level of service "C" or better in the PM peak until 2028. While option 2 would perform the best, it would result in a ban on right hand turn movements into George Street west for vehicles on Bridge Street north in the AM and PM peak periods. While alternative access to George Street (west) would be available via other streets, the loss of direct access to George Street (west) from Bridge Street (north) was not considered acceptable.

While options 1 and 3 provided right turn opportunities for Bridge Street (north and south) into George Street, they resulted in long traffic queues in the PM peak down Bridge Street (south). These queues would extend to the intersection of Macquarie Street and Bridge Street resulting in congestion and unacceptable performance of this intersection.

Option 4 would remove the right turn facility from Bridge Street (south) and would provide a dedicated left turn only and through only lanes at the stop line. This would allow a right turn bay to be provided on Bridge Street (north) to cater for the Bridge Street (north) to George Street (west) vehicle movement. Also with the new arrangement of the intersection left turns for vehicles over 9 metres in length from Bridge Street (north) to George Street (east) would not be permitted. Option 4 performs as well as option 1 (see **Table 4-5)** while maintaining access to the Windsor town centre via George Street (west).

An alternative route to allow vehicles to access the east side of Windsor from Bridge Street would be via Court Street and Arndell Street. Modifications to line marking at the Bridge Street and Court Street intersection would be required to provide a safe right turn facility for northbound vehicles. This would need to be supported by signage highlighting key destinations to the east of Bridge Street such as Governor Phillip Park.

The revised design of the intersection allows the flexibility for the right turn from Bridge Street (north) into George Street (west) to be prohibited during peak traffic periods should traffic conditions warrant such a change.

Based on the constraints and impacts of the other options, option 4 was selected as the preferred intersection arrangement.

New signals at the Bridge Street / George Street intersection would improve capacity for future traffic. Furthermore, the provision of a signalised intersection provides an immediate benefit to pedestrians crossing Bridge Street. As discussed previously, no facilities to assist pedestrians crossing Bridge Street are provided at the current roundabout controlled intersection and pedestrians have difficulty in identifying a safe gap in which to cross during peak traffic periods. As well as being a considerable safety risk to pedestrians crossing at this point, it provides a barrier to direct pedestrian movements from the eastern section of the town, where much of the accommodation is located, to the town centre.

4.3 Bridge lane configuration

A Value Management Workshop was held on 30 April 2012 to further assess and evaluate intersection options. Participants were advised that the bridge deck carriageway layout (width) was fixed at 15.2 metres. The road alignment and carriageway width assessed as part of this traffic and transport assessment were defined by the road design presented in **Appendix D**.

The lane configuration across the bridge would initially comprise of one lane in each direction in conjunction with two metre wide shoulders. The wider lanes and provision of full shoulders of the project results in a calculated lane capacity of about 1700 vehicles per hour which is considerably higher than the 900 or so vehicles per hour currently experienced. **Section 3.5.1** described how the capacity of a traffic lane is affected by factors such as pavement width, restricted lateral clearances, the presence of heavy vehicles and grades. The key improvement in the project is provision of wider lanes and increased lateral clearance which provides a less restrictive environment for drivers. This is particularly important for larger vehicles and would negate the need for trucks to wait at the end of the bridge to allow the safe passage of trucks in the opposite direction. Also if a breakdown occurred, there would be sufficient road width, either due to the breakdown lanes or the third traffic lane, to allow traffic in both directions to pass the breakdown.

In the future when traffic levels increase to a point when additional capacity is required, the bridge would be re-line marked to provide two lanes southbound and one lane northbound. The requirement to provide an additional southbound lane could occur within the first ten years of the project's life; however, this is dependent upon the rate of traffic growth and traffic generating developments occur. The additional traffic lane would be accommodated on the existing bridge deck by reducing the width of shoulders to 0.5 metres. The three lane configuration would comprise two 3.3 metre wide southbound lanes and one 3.3 metre wide northbound lane. An additional northbound lane would not be required as it would provide no benefit for traffic as both Wilberforce Road and Freemans Reach Road are single lane roads (in each direction) and there are no intersections on either road near the crossing which would limit traffic movement on the bridge (ie essentially the traffic is free flowing). The new configuration of the George Street and Bridge Street intersection also would only have one lane for northbound traffic so the provision of two lanes across the short length of the new bridge before the roundabout and the single lane Freemans Reach Road and Wilberforce Road would provide no real benefit to travel times.

A contraflow system would be difficult to implement due to the configurations of the intersections and would provide no real benefit. Also the costs of contraflow system would be substantial for either for a manual or automated system – and an automated system would have to be designed to undergo regular immersion by floodwaters.

4.4 Preferred option

A number of options for intersection configurations have been tested with the bridge lane configuration to determine the preferred option. Collectively, these individual preferred options have been adopted to become the project which is described in detail in **Section 2** and forms the basis of this traffic and transport assessment. Key traffic and transport elements of the project are summarised below:

- A dual lane, 4 arm roundabout (option 6) would provide the best performance for the northern intersection in the long term.
- Option 4 at the intersection of Bridge Street and George Street which included the removal of the right turn facility for Bridge Street (south) was found to provide the best compromise of operational performance and accessibility.
- The replacement bridge would comprise two traffic lanes (one in each direction), each 3.5 metres wide and with adjacent two metre wide shoulders. There would also be a three metre wide shared pedestrian/cycle path on the western side of the bridge. The two metre 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. The three traffic lanes would consist of two (3.3 metre wide) southbound lanes and one (3.3 metre wide) northbound lane. Shoulder widths for the future three lane bridge would be reduced to 0.5 metres.

5 Operational impacts

The following section describes the operational impacts of the project.

5.1 Bridge capacity

The project would provide increased lane widths, shoulder widths and sight distances, which are all factors that would contribute to improved capacity compared with the existing bridge.

Ultimately the operational performance of the bridge is constrained on its entry and exit by the operation of intersections. Therefore, the capacity of the bridge cannot be accurately calculated as an isolated element within the overall road network using the methodology described in standard references. It is more appropriate to determine the operational performance of the section of road network incorporating the bridge element and has been considered as part of network modelling discussed in **Section 5.3**.

5.2 Intersection capacity

The operational performance of the individual intersections proposed as part of the project were analysed in Section 4 of this report, the results of which are presented in **Table 4-4** and **Table 4-5.**

The project would result in improved intersection capacity and performance at Wilberforce Road / Freemans Reach Road which would operate with a Level of Service (LoS) rating of "A" in 2021 indicating considerable spare capacity to accommodate future traffic growth.

The project would also replace the existing roundabout at the intersection of Bridge Street and George Street with traffic signals, which would result in an improved intersection performance and considerable spare capacity to accommodate future traffic growth.

5.3 Network performance

The results of the stand-alone intersection modelling identified the intersection layouts that would work best in isolation. Whilst stand-alone models are generally acceptable, the interaction between the intersections north and south of the bridge were also assessed to determines whether a delay at one intersection has an impact on the operation of the other intersection. This is achieved through road network modelling. The network modelling process is introduced in **Section 3.6**. The details and set-up of the network models are presented in **Appendix E**.

The design of the project would incorporate the flexibility to reconfigure the bridge to accommodate an additional southbound traffic lane in the future when traffic demand increases to a level where additional capacity would be required to prevent queuing and delay.

The provision of a single lane in each direction across the bridge in its new configuration with wider lanes and shoulders would be adequate to accommodate both the existing traffic demands and those for some time into the future. However, at such time as traffic demand from the northern side of the river increases to a point when delays become intolerable, the replacement bridge would be reconfigured to provide one northbound and two southbound lanes. This could potentially occur within the first ten years of the project's life; however, this is dependent upon the growth of traffic and development of land north of the Hawkesbury River. The additional capacity would only be required in the southbound direction in the AM peak due to the nature of the road network feeding traffic to the bridge. The southbound direction is fed by traffic from Freemans Reach and Wilberforce which combine to cross the river at this point.

The project was modelled for both lane configurations across the bridge in both the AM peak and the PM peak. The project was modelled using forecast traffic volumes in 2016, the assumed year of opening, and 2026, ten years after opening. The results are presented in the following sections.

5.3.1 Travel time and distance

The total distance travelled and the total travel time is dependent on the number of vehicles on the network. Therefore, in order to provide a direct comparison of the operational performance of each option, the average distance travelled, the average travel time and the average speed per vehicle has been reported as follows:

- Project case: 1 lane southbound; right turn from Bridge Street to George Street permitted.
- Project case: 2 lanes southbound; no right turn from Bridge Street to George Street.

5.3.1.1 Project case

The performance indicators in terms of average distance travelled, average travel time and average speed per vehicle for the two scenarios of the project case are detailed in **Table 5-1** and **Table 5-2**.

Table 5-1 Project case: One southbound lane - Network performance indicators

Network performance indicator	2016 AM	2016 PM	2026 AM	2026 PM
Total cars exiting the network [veh]	9,7021	12,661	11,483	14,449
Total heavy vehicles (HV) exiting the network [veh]	639	714	762	857
Total buses exiting the network [veh]	62	84	93	86
Average Distance Travelled [km], Car	2.17	1.98	2.23	2.03
Average Distance Travelled [km], HV	2.42	2.47	2.44	2.46
Average Distance travelled [km], Bus	2.34	2.42	2.48	2.53
Average travel time [min], Car	2.38	2.43	2.68	2.84
Average travel time [min], HV	2.75	3.13	3.02	3.57
Average travel time [min], Bus	2.57	3.16	3.24	3.87
Average speed [km/h], Car	54	49	50	42
Average speed [km/h], HV	52	47	48	41
Average speed [km/h], Bus	54	49	46	39
Total Vehicles exiting the network (all modes) [veh]	**10,403**	**13,459**	**12,338**	**15,392**
Average Distance Travelled (all modes) [km]	**2.19**	**2.02**	**2.25**	**2.06**
Average Travel time (all modes) [min]	**2.41**	**2.47**	**2.71**	**2.89**
Average speed (all modes) [km/h]	**54**	**49**	**50**	**42**

Table 5-2 Project Case: Two Southbound Lanes - Network Performance Indicators

Network Performance Indicator	2016 AM	2016 PM	2026 AM	2026 PM
Total Cars exiting the network [veh]	9,7021	12,661	11,524	14,373
Total Heavy Vehicles exiting the network [veh]	639	714	764	853
Total Buses exiting the network [veh]	62	84	93	89
Average Distance Travelled [km], Car	2.17	1.98	2.23	2.03
Average Distance Travelled [km], HV	2.42	2.47	2.44	2.46
Average Distance travelled [km], Bus	2.34	2.42	2.49	2.56
Average travel time [min], Car	2.38	2.43	2.57	2.97
Average travel time [min], HV	2.75	3.13	2.92	3.74
Average travel time [min], Bus	2.57	3.16	3.03	3.99
Average speed [km/h], Car	54	49	52	41
Average speed [km/h], HV	52	47	50	39
Average speed [km/h], Bus	54	49	49	38
Total Vehicles exiting the network (all modes) [veh]	**10,403**	**13,459**	**12,381**	**15,315**
Average Distance Travelled (all modes) [km]	**2.19**	**2.02**	**2.24**	**2.06**
Average Travel time (all modes) [min]	**2.41**	**2.47**	**2.60**	**3.02**
Average speed (all modes) [km/h]	**54**	**49**	**52**	**41**

In all circumstances, more vehicles enter and exit the network in the project case than in the existing network. That is in the existing network, queues are so long that they are outside the extremities of the model. These results are detailed in **Section 3.6.2**. To enable a direct comparison with the project case, average values per vehicle for distance, time and speed have been reported. However, this means that the results from the modelling of the existing network are effectively under reporting the extent of the queues and the associated delays.

Both scenarios of the project case would be able to accommodate the forecast future traffic volumes with the option to provide two southbound lanes performing better in all time periods. The project case with a single lane in each direction performs better than the existing case due to the increased capacity across the bridge afforded through the provision of wider lanes and the increased lateral clearance provided by the shoulders on both sides of the road. The design incorporates the flexibility to accommodate the provision of two southbound lanes at a point in time when traffic volumes increase to a point when this is warranted. The need to reconfigure the lane arrangement on the bridge could occur within the first ten years of the project's life based on forecast traffic growth for the area; however, this is dependent upon the actual rate at which traffic increases in the future. The traffic forecast adopted in this assessment is dependent upon full take up of land release on the northern side of the river, when this occurs is dependent on social and economic factors external to the project.

In 2016, the project case with one southbound lane shows a lower average speed than the existing network, however, it should be noted that the new roundabout at Wilberforce Road and Freemans Reach Road is likely to slow vehicles down, compared with existing conditions. This is because the most significant movement in the AM peak would be southbound across the bridge and the highest proportion of this traffic originates from Wilberforce Road. The existing intersection on the northern side of the river requires traffic on Freemans Reach Road to give way to traffic on Wilberforce Road.

Consequently, the existing movement on Wilberforce Road has unimpeded access to the bridge whereas in the project case they would be required to slow down to safely negotiate the roundabout. This would be a desirable outcome as one of the criteria of the project was the retention of the slow speed environment in Windsor through the adoption of a 50 kilometres per hour design speed.

5.3.2 Delay and Level of Service

The results of the VISSIM modelling for the AM and PM Peak hours are provided in **Table 5-3** and **Table 5-4** below in terms of level of service for each leg of the intersections. Detailed results for each movement are included in **Appendix C**. As can be seen in **Table 5-3**, average delays in 2016 are minor, with only localised delays in George Street as a result of the longer intersection cycle time in the peak hour requiring George Street traffic to wait to receive a green light.

In the 2026 AM peak, with only one southbound lane operating on the bridge, the level of service for the Wilberforce Road approach to the roundabout intersection would be at level of service of F. This is because the two circulating southbound lanes which exit the roundabout are required to merge into a single lane to cross the bridge resulting in delays to the Wilberforce Road traffic. However, with two lanes southbound the requirement to merge is eliminated resulting in an improved level of service of B which represents 'acceptable' conditions and some spare capacity.

The other road with a poor level of service would be George Street - however only five per cent of traffic movements in the AM peak would originate from George Street – and the other 95 per cent of traffic movement would operate at a level of service of between A and C.

Table 5-3 Project Case: Summary of results for one and two lanes southbound (AM Peak Hour) – 2016 and 2026 traffic levels

Project Case	One lane southbound 2016		One lane southbound 2026		Two lanes southbound 2026	
Approach	Average Delay per Vehicle (seconds)	Level of service	Average Delay per Vehicle (seconds)	Level of service	Average Delay per Vehicle (seconds)	Level of service
Freemans Reach Road / Wilberforce Road						
Freemans Reach Road	4	A	17	B	7	A
Wilberforce Road	8	A	74	F	16	B
Bridge Street	3	A	4	A	4	A
All	**6**	**A**	**41**	**C**	**11**	**A**
George Street / Bridge Street						
Bridge Street (N)	15	B	26	B	31	C
George Street (E)	40	D	44	D	45	D
Bridge Street (S)	5	A	5	A	8	A
George Street(W)	43	D	46	D	46	D
All	**15**	**B**	**22**	**B**	**26**	**B**

PM peak results are given in **Table 5-4**. It should be noted that the results for the two lane southbound option are not presented for the PM peak as this bridge configuration has no impact on the PM peak performance of the network.

No significant delays occur at the northern roundabout in 2016. North / South movements through the Bridge Street / George Street also flow freely; however, short peak period delays can occur on George Street due to the comparatively low green light time when compared to the Bridge Street.

Peak period delays increase further on George St west by 2026 with a resulting level of service F. Only a small number of vehicles are impacted by this delay and other intersection approaches operate satisfactorily, albeit near their capacity.

Table 5-4 Project Case: Summary of results for one lane northbound (PM Peak Hour) – 2016 and 2026 traffic levels

Approach	2016		2026	
	Average Delay per Vehicle (seconds)	Level of service	Average Delay per Vehicle (seconds)	Level of service
Freemans Reach Road / Wilberforce Road				
Freemans Reach Road	10	A	19	B
Wilberforce Road	3	A	9	A
Bridge Street	8	A	9	A
All	**7**	**A**	**9**	**A**
George Street / Bridge Street				
Bridge Street (N)	16	B	56	D
George Street (E)	53	D	89	F
Bridge Street (S)	18	B	24	B
George Street (W)	67	E	131	F
All	**29**	**C**	**55**	**D**

5.3.3 Queuing

Queuing results from the model, which correspond with the traffic flows, delay and level of service above are provided in **Table 5-5.** The 2016 AM peak queues are minimal (see **Table 5-5**). A peak queue of about 200 metres occurs on Bridge Street north (representing approximately 40 vehicles) but the average queue on this approach is typically 57 metres.

The queuing results show that by 2026 with a single southbound lane on the bridge, the two lanes exiting the roundabout are required to merge which results in an average and maximum queue length along Wilberforce Road of 77 metres and 510 metres respectively. With the provision of the second southbound lane, the merge would be eliminated and the queuing results show that there would be a marked reduction in the average and maximum queue lengths.

Table 5-5 Project Case: Summary of queuing results (AM Peak Hour) – 2016 and 2026 traffic levels

Project Case	One lane southbound 2016		One lane southbound 2026		Two lanes southbound 2026	
Approach	Average Queue (metres)	Max Queue (metres)	Average Queue (metres)	Max Queue (metres)	Average Queue (metres)	Max Queue (metres)
Freemans Reach Road / Wilberforce Road						
Bridge St	0	8	0	12	0	25
Freemans Reach	0	20	2	27	1	28
Macquarie Park	0	0	0	0	0	0
Wilberforce Rd E	2	31	77	513	9	107
George Street / Bridge Street						
Bridge St N	14	204	61	340	57	187
Bridge St S (ahead)	3	38	3	64	3	58
Bridge St S (Left)	0	0	0	0	0	0
George St E	3	28	3	16	3	16
George St W	6	42	6	55	6	55

In the PM peak, the Freemans Reach Road / Wilberforce Road intersection operates satisfactorily in both 2016 and 2026 (see **Table 5-6**).

In the year of opening in 2016, the Bridge Street / George Street intersection would operate satisfactorily with acceptable average and maximum queue lengths at all approaches to the intersection.

However by 2026, queues would occur on Bridge Street (south) for northbound traffic approaching the Bridge Street / George Street intersection. Measured from the George Street intersection, the average queue would extend for approximately 214 metres and, consequently, the adjacent Macquarie Street intersection would require to be protected by a keep clear area. The northbound maximum queue length on Bridge Street / Windsor Road, measured from Macquarie Street, would be approximately 300 metres.

Prohibiting the right turn from Bridge Street (north) to George St (west) in the PM peak would improve the performance of the intersection (see **Table 5-6**) as more green light time to the major south / north movement would be able to be allocated. The modification to the intersections operation, in the PM peak only, would reduce the maximum queue lengths on the Bridge Street South from in excess of 400 metres to around 200 metres, measured from George Street, and 130 metres, measured from Macquarie Street. The average queue would be about 63 metres in the PM peak. It should be noted that VISSIM measures the absolute maximum queue for each model run while SIDRA maximum queue lengths are based on 95th percentile values. For the right turn from Bridge Street (North) to George Street (West) permitted option, PM 95th percentile values from VISSIM at the George St / Bridge Street intersection are:

- Bridge Street North - 297 metres.
- Bridge Street South - 387 metres.
- George Street West - 216 metres.

Table 5-6 Project Case: Summary of results for one lane northbound (PM Peak Hour) – 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 St	1	29	0	22	0	13
Freemans Reach Rd	2	20	2	28	5	28
Macquarie Park	0	0	0	0	0	0
Wilberforce Rd	0	14	0	13	0	14
George Street / Bridge Street						
Bridge St N	14	95	45	333	8	126
Bridge St S (ahead)	47	181	214	431	63	226
Bridge St S (Left turn)	0	0	0	0	0	0
George St E	6	25	3	16	78	118
George St W	39	90	91	251	34	121

5.4 Regional Network Impacts

The project would provide increased capacity to the regional road network as shown by the network modelling. This benefit is largely confined to the Bridge Street corridor through the provision of operationally efficient intersections and improved horizontal and vertical alignment of the bridge and its approach roads. The increased capacity of this route would support future development within the region particularly on the northern side of the Hawkesbury River.

The improved efficiency of the Bridge Street route would also benefit Macquarie Street in the vicinity of its intersection with Bridge Street and Windsor Road due to reduced queuing particularly in the PM peak.

5.5 Crash reduction

A crash cost benefit analysis was undertaken to assess the total reduction in crash costs, as a result of implementing the project. The project elements which would have a beneficial impact on potential future crashes are:

- The introduction of a roundabout at the Wilberforce Road/ Freemans Reach Road/ Bridge Street intersection;
- The replacement of the roundabout with traffic signals treatment at the Bridge Street/ George Street intersection; and
- Horizontal and/ or vertical alignment modifications incorporated into the replacement bridge.

The *Accident Reduction Guide: Part 1 – Accident Investigation and Prevention* (RMS, 2004) guidelines provide detailed information on accident costs and cost benefits for several counter measures. These guidelines were used for the current analysis. The crash cost benefit analysis for each recorded crash was summarised in **Table 5-7**. The reduction in costs factors in both a reduction in the number and severity of crashes, however, does not provide detailed information on the actual reduction in the number of accidents.

A definition of the following acronyms and terminology used in **Table 5-7** has been provided below:

- **DCA** (Definitions for Coding Accidents): A system of categorising crashes into a classification system of crash types based on the movement of vehicles / pedestrians prior to the collision
- **Accident Group** - All the DCA codes are classified into specific groups (or ranges), based on their similarity of crash representation (for example DCAs from 100 to 109 represent various crashes involving vehicles from adjacent approaches. Similarly, DCAs between 000 – 008 represents pedestrian involved crashes).

5.5.1.1 Wilberforce Road near Freemans Reach Road

The majority of the crashes were recorded at Wilberforce Road near Freemans Reach Road (11 out of 16) and ten of these crashes occurred when vehicles were approaching from adjacent roads (DCA range 101-109), the remaining cash was of a "head-on" type (DCA range 201-501). These types of crashes are 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 total accident costs at this location are estimated to an approximate value of $1,883,800. 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; and
- 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.

The cost benefit estimates show that the roundabout treatment is expected to reduce the estimated accident costs by 70%, which equals to an approximate value of $1,318,660.

5.5.1.2 Bridge Street at Freemans Reach Road

A single "off path on curve" (DCA range 803- 804) crash was recorded and a second crash to occur at this location was classified as a "head-on" type (DCA range 201-501) crash during the 5 year period of data. The curve at the northern approach road to the existing bridge would be removed by the project. The hazard would be further mitigated by the reduced speed limit of 50 kilometres per hour and the introduction of a roundabout controlled intersection. The cost benefit estimates show that the elimination of the curve combined with the roundabout control and reduced speed limit is expected to reduce the estimated accident costs at this location by 78%, which equals to an approximate value of $294,060.

Table 5-7 Crash Cost Benefit Analysis

Location	Treatment Option in Project Case	DCA Range	Accident Group	Accident Cost	% of Reduction	Accident Cost Reduction
Wilberforce Rd Near Freemans Reach Road	Roundabout 2-Lane	101-109	1	$160,800	70%	$112,560
	Roundabout 2-Lane	101-109	1	$ 160,800	70%	$112,560
	Roundabout 2-Lane	101-109	1	$ 160,800	70%	$112,560
	Roundabout 2-Lane	101-109	1	$160,800	70%	$112,560
	Roundabout 2-Lane	101-109	1	$160,800	70%	$112,560
	Roundabout 2-Lane	101-109	1	$160,800	70%	$112,560
	Roundabout 2-Lane	101-109	1	$160,800	70%	$112,560
	Roundabout 2-Lane	101-109	1	$160,800	70%	$ 112,560
	Roundabout 2-Lane	101-109	1	$160,800	70%	$ 112,560
	Roundabout 2-Lane	101-109	1	$160,800	70%	$ 112,560
	Roundabout 2-Lane	201-501	2	$ 275,800	70%	$ 193,060
	Total Cost			**$ 1,883,800**		**$ 1,318,660**
Bridge St at Freemans Reach Rd	Roundabout 2-Lane	201-501	2	$275,800	70%	$193,060
	Change in horizontal and vertical alignment	803-804	19	$101,000	100%	$ 101,000
	Total Cost			**$ 376,800**		**$ 294,060**
Bridge St at Windsor Bridge	Change in horizontal and vertical alignment	301-303	5	$ 67,300	60%	$ 40,380
	Change in horizontal and vertical alignment	301-303	5	$ 67,300	60%	$ 40,380
	Total Cost			**$ 134,600**		**$ 80,760**
Bridge St at George St	New Traffic Signals	001-008;901-902	12	**$ 328,900**	20%	**$ 65,780**
TOTAL				**$ 2,724,100**	**64.58%**	**$ 1,759,260**

5.5.1.3 Bridge Street at Windsor Bridge:

Two 'rear-end' crashes (DCA range 300-310) were recorded in Bridge Street in the vicinity of the bridge. This type of crash typically results from abrupt braking as a result of poor sight distance to stationary vehicles ahead. These stationary vehicles may be a result of either queuing or in the case of trucks awaiting the passage of an opposing heavy vehicle. The total cost of these crashes is approximately $134,600. The improved horizontal and vertical alignment of the project would improve sightlines, reduce queuing and remove the curve from the existing northern approach road – which would reduce the risk of rear-end crashes.

The project would be expected to reduce the total crash costs by 60% and therefore the cost benefit is approximately $80,760.

5.5.1.4 Bridge Street at George Street:

A single 'pedestrian hit' crash (DCA range 000-008) was recorded at this location, which is estimated to have an approximate value of $328,900.

By providing a signalised pedestrian crossing for all legs of the George Street and Bridge Street intersection, the risk of these types of incidents would be reduced as pedestrian would have a safe, controlled crossing location.

The cost benefit estimates show that the signalised intersection would be expected to reduce the estimated accident costs by 20%, which equals to an approximate value of $65,780.

From the above analysis, the total cost of crashes in the last five years is approximately $2,724,100 and the total anticipated cost reduction by implementing the project would be approximately $1, 759,260 or approximately 64%.

5.6 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 Number 4 and Number 6 Old Bridge Street 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. The additional travel time involved in undertaking these manoeuvres is considered to be relatively minor and would affect a very small number of road users.

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.

For the property “Bridgeview” (on the corner of Wilberforce Road and Freemans Reach Road) on the northern side of the river, vehicular access would be provided via the Macquarie Park access road.

A component of the project would involve reconstructing The Terrace to provide both light vehicle and pedestrian access underneath the new bridge (including provision for emergency and maintenance vehicle access); however, the proposed bridge would have a height restriction of 3.6 metres which would prevent tourist coaches and other high vehicles from accessing Windsor Wharf.

Parking facilities for buses currently exist in Baker Street and Thompson Square road. Passengers would be able to alight from the coaches parked in either location and then walk the short distance to the wharf.

5.7 Public transport

There would be no impact on the existing bus services as a result of the project. The project would result in reduced overall delay on the road network with no major route deviations required for bus services.

Rail transport is not assessed in this report as the services are not affected by changes to Windsor bridge, and there are no traffic generating developments proposed.

5.8 Walking and cycling

The project would provide positive access and safety benefits to both pedestrians and cyclists through the inclusion of a shared pedestrian/cycle pathway meeting current design guidelines. It would extend from Wilberforce Road and Macquarie Park, across the western side of the bridge and southern approach road to the corner of George and Bridge Streets. 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 realigned road through Thompson Square.
- Pedestrian safety and access would be substantially improved through the construction of 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 proposed 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, which is currently being planned by Transport for NSW. The 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. The Great River Walk is a planned 570 kilometre recreational trail 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 pedestrian crossing at the George Street and Bridge Street intersection and the shared path across the new bridge would address key recommendations in the Hawkesbury Mobility Plan (GTA Consultants, 2010).

5.9 Maritime

The current uses of the Hawkesbury River and the Windsor Wharf, including the Hawkesbury Paddle Steamer and Hawkesbury River Boat cruises, are detailed in **Section 3.9**.

The new bridge would have a clearance of between 7.8 metres and 9.2 metres and would be supported by four piers within the river. This compares to a clearance of 7.15 metres and ten piers for the existing bridge. With the new bridge in place, operation of the paddle steamer, which is 11 metres high, would continue to be restricted to the eastern side of the replacement bridge due to insufficient clearance under the bridge. All vessels that are capable of passing under the current 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. No adverse impacts to maritime operations are anticipated from the project.

The operation of Windsor Wharf would not 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.

5.10 Community issues

The community expressed concern about perceived traffic congestion issues within the Windsor town centre, particularly queuing in George Street west in the PM peak. This queuing results from the inability of drivers to select a safe gap within the almost continuous stream of northbound traffic on Bridge Street at this time. The project addresses this concern through the provision of traffic signals at the intersection of George Street and Bridge Street which would provide a dedicated signal for George Street negating the need for drivers to select gaps.

Another concern expressed by the community was the difficulty experienced in crossing Bridge Street at George Street during peak traffic periods. The project specifically addresses this concern through the replacement of the existing roundabout at this intersection with traffic signals incorporating signalised pedestrian crossings on all approaches.

Some parts of the community were keen to ensure that the character and relatively low speed environment within Windsor was preserved. The project has adopted a design speed limit of 50 kilometres per hour. The low speed limit environment is reinforced through the provision of a roundabout at the intersection of Wilberforce Road and Freemans Reach Road which would act as a traffic calming facility by requiring all movements on the northern approach to the bridge to decelerate and give way.

5.11 Comparison of the project to project traffic and transport objectives and criteria

The project has been compared against relevant project objectives and criteria in **Table 5-8.**

Table 5-8 Comparison of project with the project objectives and criteria

Objective	Response
To improve safety for motorists, pedestrians and cyclists	
Meets the current design codes (e.g. 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/hr.	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.
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.

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6 Construction

6.1 Impacts of construction work vehicles and haulage vehicles

The construction of the project would inevitably generate construction vehicles travelling to, from, and within the project area. The construction traffic movements to / from the work sites would have the potential to impact the efficient movement and safety of other road users.

At this stage of the project development traffic generation details are limited as these would depend on the final detailed design and the contractor's work methods.

Additional traffic demand 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 2-2**, 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.

It is anticipated that most construction-related heavy traffic would travel to and from the project area predominantly from the south, although materials destined for the work areas on the northern side of the river would ideally be delivered from areas to the north.

Existing traffic would be most likely impacted where haulage routes/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. These temporary accesses would be designed and operated to confirm with relevant road safety requirements and would not impact upon the safety of the existing road network.

It can be seen from the quantities of materials and associated haulage vehicle movements in **Table 2-2** that the number of heavy vehicle trips generated by the construction of the project would be relatively low when compared to the underlying general traffic volumes. Even if all the activities in **Table 2-2** were to occur concurrently, there would be an average additional 45 truck movements a day which would be less than one percent of daily traffic movements across Windsor bridge.

The main activity that would generate concentrations of 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.

Also temporary traffic measures would be implemented to maintain the efficiency and safety of access to site compounds. Consequently, the existing operational performance of roads and intersections would not be significantly impacted by construction.

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 existing 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.

Construction worker traffic

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.

6.2 Impacts on local roads

The overall impact of construction activity is anticipated to be minor, as construction would generally be undertaken clear of existing traffic. The arrival and departure pattern of the construction workforce is anticipated to occur earlier than the normal peak traffic periods minimising the impact on local roads and their users.

Delays for traffic using Bridge Street, George Street, Wilberforce Road and Freemans Reach Road would be expected during the construction phase in those periods when reduced speed limits are in place and when manual traffic control is in operation to facilitate the movement of construction vehicles into and out of 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.

6.3 Impacts on property access

Access to properties and local roads would be maintained throughout the construction of the work, although interruptions to access would be required at various times. Any such interruptions would be for short periods and by agreement with the affected property owners and / or relevant agencies.

6.4 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.

6.5 Impacts on bus operations

There would be no disruption to existing passenger and school bus routes during construction as existing roads would be retained for local access and would be available throughout the construction period. Buses would, however, be subjected to the same minor delays as general traffic due to reduced speed limits or during manual traffic control.

6.6 Impacts on emergency vehicles

The construction activity would not have any impact on emergency vehicles, as vehicular access along all roads impacted by the work would be maintained.

6.7 Impacts on other facilities

Access to tourist accommodation and recreational facilities would not be significantly impacted by the construction of the project as these facilities are away from the project construction area.

6.8 Impacts on Windsor Wharf and Governor Phillip Park

Public vehicle access to Windsor Wharf would be closed once construction commences as the car park and The Terrace in this area would be used as construction compound. Service vehicle access to Windsor Wharf would be maintained for as long as possible until it is required to be closed for safety reasons due to the incrementally launched bridge. Pedestrian access to Windsor Wharf would be maintained at all times.

Consultation with the Hawkesbury Paddle Wheeler and River Boat Cruise operators would be undertaken throughout the construction period to ensure that launching operations take place at times when there would be minimal disruption to commercial operations. If suitable timeframes could not be identified alternative temporary arrangements would be established. These arrangements could include the provision of temporary car parks away from the bridge construction site and safe pedestrian routes from them to Windsor Wharf established.

Marine access to Windsor Wharf and the adjacent boat ramp in Governor Phillip Park is expected to be maintained throughout the construction period. Road access to Governor Phillip Park and the boat ramp would not be impacted.

6.9 Impacts on maritime operations

The following impacts on maritime operations could potentially arise during construction:

- Manoeuvring of vessels to dock at Windsor Wharf – standard practice for most vessels is to approach the wharf at a shallow angle to allow for better control and an additional margin of error during the docking process. The footprint of the construction zone could potentially impact on manoeuvrability during docking.
- Straight line navigation between the series of piers supporting the existing and new bridges – this is particularly relevant for rowing vessels, which have limited capacity to change course suddenly; high-speed watercraft such as jet skis; and vessels with a high navigational position, which have reduced lines of sight at more acute angles of incidence. Temporary navigational markers could be placed to direct vessels under the bridges at the correct locations to ensure collisions with bridge piers are avoided.
- U-turning of vessels – vessels approaching the bridges from both sides would be required to U-turn further upstream (if approaching from the Richmond side) or further downstream (if approaching from the Sackville side) to accommodate demolition of the existing bridge and construction of the replacement bridge.

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.

6.10 Impacts on Windsor town centre

Impacts on Windsor town centre would be the same as that described for the local roads. The majority of construction activities would be undertaken away from the town centre and construction traffic generation would be timed to occur outside of the existing peak traffic periods. If temporary road closures are required, alternative routes to access the town centre would be provided at all times.

6.11 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.

6.12 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.

6.13 Impacts on 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. 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.

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7 Environmental management measures

Presented in this section is a description of the environmental management measures that would be implemented during the construction and operation of the project.

7.1 Construction

The Construction Environmental Management Plan (CEMP) and contract documents would include traffic and safety management procedures which address management of traffic during construction: traffic switches, line marking, signage (including advanced warning variable message signage), earthworks and material haulage, intersection access, local property access and emergency and incident response.

A traffic management sub-plan would be prepared as part of the construction environmental management plan. This would facilitate the safe and efficient management of traffic during construction, minimising impacts on the local community. The sub-plan would include:

- 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.

7.1.1 Overall environmental management measures

The construction of the project will be managed to minimise disruption to traffic using the existing local access road network.

Risks associated with traffic management during construction are typically managed by ensuring that no activity commences on site that has an effect on traffic (including pedestrians and cyclists) without an approved Road Occupancy Licence (ROL). In addition, it should be ensured that all work on site occurs in accordance with the relevant Traffic Management Sub Plan, Traffic Control Plan (TCP) and associated ROL. Safeguards in place at work sites typically include barriers, signage, beacons and traffic controllers.

7.1.2 Construction Traffic Management Plan

The contractor will be required to develop detailed Construction Traffic Management Plans and associated Traffic Control Plans to ensure the safe and efficient movement of traffic on the adjacent road network.

7.1.3 Preparation and implementation of TCPs

All TCPs to be used during the construction activity will be developed in accordance with Australian Standard 1742.3 and the Guide to Traffic Control at Work Sites Manual, RMS, Version 4.0, 2012 by a suitably qualified person.

A TCP can only be prepared by a person who has undertaken and successfully passed RMS' Traffic Control at Work Sites Manual training course and holds current certification.

Relevant reference documents include:

- Australian Standard AS1742.3 – 2009, Manual of uniform traffic control devices – Traffic control for works on roads.
- Guide to Traffic Control at Work Sites, Version 4 (RMS, 2010).
- RMS, QA Specification G10 Control of Traffic, Edition 4/Revision 2 (2005).
- Austroads, Guide to Traffic Management Part 3: Traffic Studies and Analysis (2009).
- All work sites and TCPs will be implemented as per the authorised TCP for the appropriate stage of works by suitably qualified personnel.

7.1.4 Inspection of roadwork traffic schemes

The requirement to inspect traffic control schemes is stipulated in Section 6 of the Guide to Traffic Control at Work Sites (RMS version 4 2010 and Appendix A of Australian Standard 1742.3. There are three main types of inspection:

- Pre-start and pre-closedown inspections of short-term traffic control.
- Weekly inspections of long-term traffic control.
- Night inspections of long-term traffic control.

The checklist provided in the Guide to Traffic Control at Work Sites is generic and can be used for all three types of inspection.

The responsibility and frequency of inspections is included in Section 6.1 of the Guide to Traffic Control at Work Sites and is summarised in **Table 7-1**.

Table 7-1 Traffic control plan inspections

Inspection type	Responsibility	Frequency
Pre-start and pre-finish	Works supervisor	Daily
Weekly audit	Site supervisor	Twice a week
Night audit	Site supervisor	Once a week
Pre-opening	Traffic engineer	Prior to opening any new temporary roadwork site or major adjustment

7.1.5 Construction vehicle management

In accordance with the RMS Specification G10 (Traffic Management) for construction traffic management, vehicle movement plans (VMPs) and haulage routes would be developed as part of the overall traffic management sub-plan and will include the following provisions:

- Drivers will be inducted to VMPs to ensure that they keep to nominated routes.
- Deliveries will be timed to occur outside peak traffic periods.
- 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 vehicle movement arrangements will be developed to limit impacts on other road users (including pedestrians, vehicles and cyclists) and with specific regard to other road works in the area, local traffic movement requirements and peak traffic volumes, including long weekends and holiday periods.

7.1.6 Road occupancy licence

Applicants will be required to prepare submissions for ROLs and complete the RMS' application form, which will be submitted to RMS and the relevant local government area(s) at least ten working days prior to the proposed occupancy. RMS and / or councils will grant or reject the application within this period.

Traffic control arrangements must provide sufficient capacity to accommodate the expected traffic volumes during the period of occupancy. RMS and / or councils will not grant approval for those activities that would not satisfy this requirement.

7.1.7 Heavy vehicle movements

Designated access routes for construction and spoil vehicles will be along the arterial road network where practicable. Details of all routes used for access and haulage during construction will be developed in consultation with relevant local government authorities upon confirmation of quarry locations. Roads in the area that are likely to be used for haulage include Windsor Road, Bridge Street, Freemans Reach Road and Wilberforce Road. Wherever practical all removal and delivery of materials and plant will be timed to occur outside of the peak traffic periods to minimise delay in the area.

Spoil haulage routes and vehicle management plans (VMPs) will be developed in a format that provides a suite of individual instructions and maps to contract operators for all points of origin to respective destinations and return. In addition, layover areas will be nominated should vehicles need to 'store' prior to arriving at the spoil removal sites. Approximate travel times in AM, PM and off peaks will be developed for each route as a guide to operators and to also assist in more consistent and uniform arrival rates at each site.

Dilapidation surveys of regional and local roads used by construction traffic will be undertaken prior to their use for construction as well as after construction is complete. Monitoring will be carried out to the satisfaction of, and a dilapidation report submitted to, relevant local government authorities. The proponent (RMS) will be responsible for any necessary repair of deterioration attributable to the impacts of construction traffic.

7.1.8 Local roads

Temporary traffic management arrangements will be in place to maintain safe traffic operation on sections of the work that impact on local roads. This could be in the form of reduced speed limits, lane closures and / or additional temporary warning signs.

Where volumes of construction work vehicles/haulage vehicles entering and exiting the road network are expected to have an impact on traffic flows, temporary intersections with appropriate auxiliary turning lanes or traffic control will be provided. Through traffic will be able to deviate around vehicles waiting to turn, thus maintaining traffic flow, and safety will be improved by removing stationary turning vehicles from the through traffic lane.

7.1.9 Emergency services

No remedial measures are proposed, however, consultation with the emergency services prior to construction commencing will be undertaken.

7.1.10 Maritime operations

Mitigation measures during construction activities in the river 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.

Consultation with maritime operators will be undertaken to ensure the minimisation of impacts.

7.2 Operation

Mitigation measures for the operation of the project have largely been incorporated into the design of the project. The only additional key mitigation measure that will be implemented will be reconfiguration of the lanes on the bridge and approach roads from the initial two lane configuration to two southbound and one northbound lane when delays due to traffic growth become unacceptable.

8 Conclusions

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. The existing bridge needs to be replaced as its structural integrity is deteriorating with age and it is no longer cost-effective to maintain.

The project would provide increased lane widths, shoulders and sight distance. All these factors would contribute to improved capacity compared to the existing bridge. The bridge and approach roads would be designed to meet current design codes with lane widths which are sufficient to allow for heavy vehicles to pass without waiting.

Modifications would also be made to the existing intersections at Bridge Street / George Street and Wilberforce Road / Freemans Reach Road and the bridge approach roads to improve the capacity and safety of these roads and, therefore, also the bridge. The overall performance of the road network would be substantially improved with the project.

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 would be modified from a "Give Way" priority controlled intersection to a dual lane roundabout. The existing intersection at Bridge Street and George Street would be modified from a single lane roundabout to a traffic signal controlled intersection. A right turn from Bridge Street (south) to George Street (east) and a left turn from Bridge Street (north) to George Street (east) for vehicles over nine metres would not be permitted and an alternative access via Court Street would be required. In the future in the PM peak, the right turn from Bridge Street (north) into George Street (west) may also have to be banned to provide greater green light time to northbound traffic on Bridge Street. However at opening the intersection would have acceptable performance even with the right turn from Bridge Street (north) into George Street (west) permitted in the PM peak.

The network modelling and detailed intersection analysis undertaken as part of this study has shown that the replacement bridge and associated upgrades to intersections would serve to improve traffic flow in and on the approach to Windsor to an acceptable level with the two lanes operating across the bridge. In the future when traffic growth increases to a point when additional capacity is required, the design has sufficient flexibility to accommodate three traffic lanes, two southbound and one northbound. For 95% 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.

However, under the new traffic arrangements, vehicles would no longer be able to turn right into (or out of) two existing properties at 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. The additional travel time involved in undertaking these manoeuvres is considered to be relatively minor and would affect a very small number of road users.

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.

A number of additional minor modifications to existing roads and access ways would occur in association with the project. These would include:

- Reconstruction of The Terrace to provide both light vehicle and pedestrian access underneath the new bridge (including provision for emergency vehicle and service vehicle access).
- Reshaping access arrangements to the existing wharf and associated car parking area.
- Altering linemarking arrangements on Bridge Street between Macquarie Street and George Street intersection to provide improved traffic flow through the intersection at George Street and Bridge Street.
- Banning of the right turn movement from Bridge Street northbound to George Street eastbound.

The project would provide increased capacity to the regional road network with this benefit largely confined to the Bridge Street corridor through the provision of operationally efficient intersections and improved horizontal and vertical alignment of the bridge approach roads. The increased capacity of this corridor would support future development within the region particularly on the northern side of the Hawkesbury River.

The improved efficiency of the Bridge Street route would also benefit Macquarie Street in the vicinity of its intersection with Bridge Street and Windsor Road due to reduced queuing particularly in the PM peak.

The replacement bridge would have no impact on the operations of the existing bus services due to the improvements to the road network. There is no increased delay on the road network and there are no major route deviations. In line with the overall improvement of the operational efficiency of the bridge and associated intersections that the project provides, bus services utilising the bridge would benefit from the reduction in delay during peak periods.

The project would provide improved access and safety benefits to both pedestrians and cyclists through the inclusion of a shared pedestrian/cycle pathway meeting current design guidelines from Wilberforce Road and Macquarie Park, across the western side of the bridge and southern approach road to the intersection of Bridge Street and George Street.

Pedestrian and cyclist access along the southern bank of the river would also be improved with the connection and redevelopment of The Terrace. Improved pedestrian and cyclist safety and access would also be provided by the project through the construction of:

- A 1.2 metre wide footpath adjacent to properties fronting Old Bridge Street.
- Signalised pedestrian crossings on all four approaches to the intersection of Bridge Street and George Street.
- Pedestrian footpaths to provide 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.

The reduced number of piers supporting the proposed bridge would improve the safe navigation of the river. No adverse impacts to navigational safety are anticipated from the proposed bridge replacement.

RMS supplied a summary of crashes that have occurred in the last five years, along Bridge Street between Macquarie Street and Wilberforce Road.

A crash cost benefit analysis was undertaken to assess the total reduction in crash costs, as a result of implementing the project. The project elements which would have a beneficial impact on potential future crashes are:

- The introduction of a roundabout at the Wilberforce Road/ Freemans Reach Road/ Bridge Street intersection.
- The replacement of the existing roundabout with traffic signals at the Bridge Street/ George Street intersection.
- Horizontal and/ or vertical alignment modifications incorporated into the replacement bridge.

The crash analysis of the last five years of data showed that the total cost of crashes in the last five years is approximately $2.7 million and the total anticipated cost reduction by implementing the project would be approximately $1.8 million or approximately 64% reduction in the cost of crashes.

The overall impact of construction activity is anticipated to be minor, as construction would generally be undertaken clear of existing traffic. To minimise the impact on peak traffic periods when the local roads experience existing congestion, deliveries of materials would be timed to occur outside of these periods. In addition, to organising materials deliveries to occur outside peak traffic periods, bulk deliveries requiring multiple trips such as major concrete pours, would be managed on a ‘just in time’ basis with each subsequent delivery called up on two-way radio. Under no circumstances would delivery trucks be allowed to queue on local roads.

The arrival and departure pattern of the construction workforce is anticipated to occur earlier than the normal peak traffic periods minimising the impact on local roads and their users.

Delays for traffic using Bridge Street, George Street, Wilberforce Road and Freemans Reach Road would be expected during the construction phase in those periods when reduced speed limits are in place and when manual traffic control is in operation to facilitate the movement of construction vehicles into and out of 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.

The Construction Traffic Management Plan (CTMP) and contract documents would include traffic and safety management procedures which address management of traffic during construction: traffic switches, line marking, signage (including advanced warning variable message signage), earthworks and material haulage, intersection access, local property access and emergency and incident response.

A traffic management sub-plan would be prepared as part of the construction environmental management plan.

9 References

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