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ARCADIS Design & Consultancy for natural and built assets

# WINDSOR BRIDGE REPLACEMENT PROJECT

## Economic Appraisal

Incorporating Hyder

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# ROADS AND MARITIME SERVICES WINDSOR BRIDGE REPLACEMENT PROJECT

## Economic Appraisal


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|---|---|---|
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## REVISIONS

| Revision | Date | Description | Prepared by | Approved by |
|---|---|---|---|---|
| B | 9 May 2017 | Draft for Client Review | SI, MW | MR |
| C | 25 May 2017 | Final Report | KN, MW | MR |
| D | 31 May 2017 | Updated report incorporating cost estimates as of 29 May 2017 | KN | MR |
| E | 29 June 2017 | Updated report incorporating Traffic and Options Modelling Report | KN | MR |
| F | 10 May 2018 | Updated report incorporating cost estimates and opening year as of 4 May 2018 | MW | MR |

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## APPENDIX

# 1 Introduction

## 1.1 Report Purpose

This report assesses the economic merits of the proposed Windsor Bridge Replacement project. The purpose of the cost benefit analysis (CBA) is to estimate benefit cost ratio (BCR) and net present value (NPV) of a Concept Design prepared by Roads and Maritime Services (Roads and Maritime).

This report presents the methodology, assumptions and results of the economic appraisal of the proposed Windsor Bridge Replacement project.

Ongoing consultation involving Roads and Maritime staff constituted an important element of this study. Two technical notes were prepared and reviewed by Roads and Maritime over the course of this project including:

- Technical Note 1 – Future traffic growth assumption. The traffic growth assumptions have been agreed with Roads and Maritime
- Technical Note 2 – Existing conditions and traffic performance of the Concept design.

This report is to be read in conjunction with a main traffic report titled *"Windsor Bridge Replacement Project, Traffic and Option Modelling Report"*, June 2017, Prepared by Arcadis Australia Pacific Pty Ltd (Arcadis).

## 1.2 Proposed Upgrades (Concept Design)

Roads and Maritime has developed a Concept Design for the Windsor Bridge Replacement project between Wilberforce Road and Court Street, Winsor (hereinafter referred to as 'Concept Design'). The Concept Design involves removal of the existing bridge and constructing a new three lane bridge and upgrading adjacent intersections.

The Concept Design includes the following key features:

- Removal of the existing two lane bridge and provision of a new three lane bridge consisting of two lanes in the southbound direction and one lane in the northbound direction;
- A new dual lane roundabout replacing the existing priority control at Bridge Street / Wilberforce Road / Freemans Reach Road. The new roundabout will be located approximately 35 metres south of the Bridge Street / Wilberforce Road / Freemans Reach Road intersection. The new roundabout intersection will form a four-way intersection allowing access to Macquarie Park via the western approach;
- New traffic signals replacing the existing roundabout at Bridge Street / George Street;
- Linemarking the right turn lane on Bridge Street southbound heading to Macquarie Street to formalise it as a turning lane; and
- Linemarking the left turn lane on Bridge Street northbound heading to George Street to formalise it as a turning lane.

Appendix A includes Roads and Maritime's Concept Design.

# 2 Economic Appraisal Methodology

This economic appraisal has been carried out in accordance with the guidelines provided by Transport for NSW in *Appendix 4 Economic Parameter Values and Valuation Methodologies of TfNSW's Principles and Guidelines for Economic Appraisal of Transport Investment and Initiative, Version 1.7, July 2016*, hereinafter referred to in this report as 'July 2016 TfNSW' Guidelines. This section presents the appraisal framework and key assumptions used in the economic appraisal.

## 2.1 Appraisal Framework

The economic appraisal framework was used to appraise the economic viability and was based on the generalised road user cost benefit analysis methodology. The methodology appraises the project on an incremental basis by comparing the proposed upgrades to a base case. The base case is defined as do nothing network and has been agreed with the Roads and Maritime.

The economic appraisal relies on project cost estimates as provided by Roads and Maritime. The project costs include capital costs. The project benefits include travel time savings, vehicle operating cost savings, reduction in crash costs, environmental and externality costs, residual value of the asset and maintenance savings.

The following economic performance measures are calculated to estimate the economic viability of the project:

- Benefit Cost Ratio (BCR) – ratio of the PV of total incremental benefits over the PV of total incremental costs. The BCR is the most commonly used evaluation criteria.
- Net Present Value (NPV) – the difference between the present value (PV) of total incremental benefits and the present value of the total incremental costs in the improved case.
- Internal Rate of Return (IRR) – is the discount rate at which present value of costs equals the present value of benefits.

## 2.2 Economic Parameters

Table 2-1 below shows key parameters used in the cost benefit analysis (CBA).

*Table 2-1 Key Economic Parameters*

| Economic Parameters | Description |
|---|---|
| Discount Rate | Future net benefits are discounted to the base year using a real discount rate of 7%. The appraisal also undertakes sensitivity tests at the discount rates of 4% and 10%. |
| Price Year | The benefits and costs in the evaluation are presented in 2018 prices. |
| Year 0 (Base year) | 2017 |
| Traffic Opening Year | 2020 |
| Evaluation Period | The evaluation period is assumed to be 30 year after opening to traffic. |

## 2.3 Appraisal Option

The CBA is based on costs and benefits of the “Concept Design” incremental to the base case (do nothing).

### 2.3.1 Base Case

“Do nothing” base case represents the existing traffic network within the study area as of 2017. The Windsor Bridge is a two-lane road (one lane in each direction).

### 2.3.2 Concept Design

The Concept Design involves removal of the existing bridge and constructing a new three lane bridge and upgrading adjacent intersections.

The Concept Design includes the following key features:

- Removal of the existing two lane bridge and provision of a new three lane bridge consisting of two lanes in the southbound direction and one lane in the northbound direction;
- A new dual lane roundabout replacing the existing priority control at Bridge Street / Wilberforce Road / Freemans Reach Road. The new roundabout will be located approximately 35 metres south of the Bridge Street / Wilberforce Road / Freemans Reach Road intersection. The new roundabout intersection will form a four-way intersection allowing access to Macquarie Park via the western approach;
- New traffic signals replacing the existing roundabout at Bridge Street / George Street;
- Linemarking the right turn lane on Bridge Street southbound heading to Macquarie Street to formalise it as a turning lane; and
- Linemarking the left turn lane on Bridge Street northbound heading to George Street to formalise it as a turning lane.

## 2.4 Traffic Modelling Data

The future modelling outputs for weekday morning and afternoon peak periods including vehicle kilometres travelled (VKT), vehicle hours travelled (VHT) and number of stops have been prepared by Arcadis using SIDRA network software version 7. SIDRA network models were developed for 2017, 2026 and 2036 modelling years. The vehicle kilometres travelled (VKT), vehicle hours travelled (VHT) and number of stops for base case and Concept Design were used in the calculation of the economic benefits. The SIDRA network modelling results have been normalised where requited. Appendix B documents traffic modelling outcomes including normalisation methodology.

## 2.5 Cost Parameters

For this project, the specific variables for road user benefits are determined in accordance with the guidelines provided in *Appendix 4 Economic Parameter Values and Valuation Methodologies of TfNSW’s Principles and Guidelines for Economic Appraisal of Transport Investment and Initiative, Version 1.7, July 2016* (‘July 2016 TfNSW Guideline’). Appendix C documents project specific variables used in road user benefits estimations.

## 2.5.1 Expansion Factors

The SIDRA network traffic model represents peak hours (i.e. one hour AM peak and one hour PM peak). To estimate the annual road user benefits from traffic modelling results, the annual expansion factor is used to expand AM peak one hour and PM peak one hour to annual numbers.

An annual expansion factor of 2113 was used, consistent with the July 2016 TfNSW Guideline.

## 2.5.2 Travel Time Costs

The difference in the travel time from the traffic forecasts are used to estimate savings in travel time cost for the Concept Design relative to base case.

Values of time (VOT) for light and heavy vehicles were estimated using urban parameters suggested in Table 9 in the June 2016 TfNSW Guideline and the vehicle composition observed in the study area.

## 2.5.3 Vehicle Operating Costs

The unit vehicle operating cost (VOC) is applied to the vehicle-kilometres travelled (VKT) in base case and Concept Design option to calculate the incremental VOC for VKT for the analysis period. The savings in vehicle operating costs for option are estimated by combining the incremental (relative to the base case) vehicle kilometres (VKTs) with the unit vehicle operating costs.

Vehicle operating costs (VOC) by vehicle type were estimated using resource cost parameters suggested in Table 12 in the June 2016 TfNSW Guideline and the vehicle composition observed in the study area. The VOC parameters were suggested for urban stop-start conditions.

## 2.5.4 Vehicle Operating Costs per Stop

Vehicle operating costs per stops by vehicle type were estimated using values from Table 16 of the June 2016 TfNSW Guideline.

## 2.5.5 Environmental and externality Costs

Road use produces external costs on society in terms of the economic costs of environmental impacts. Environmental costs are determined by applying externality values per vehicle-kilometres travelled (VKT) based on vehicle composition from the traffic analysis. These parameter values include noise pollution, air pollution, water pollution, greenhouse gas emissions, nature and landscape, urban separation, and upstream and downstream costs.

Environmental costs for urban roads were adopted from Table 58 and Table 60 in the June 2016 TfNSW Guideline. Environmental unit costs for passenger vehicles are expressed in cents per VKT. For heavy vehicles the environmental unit costs are expressed in dollars per 1000 tonne kilometre (tkm) travelled.

## 2.5.6 Crash Costs

Crash analysis has been carried out by comparing existing and proposed conditions to determine estimated crash reduction statistics using crash data from July 2011 to December 2016. Appendix D documents crash reductions and crash cost savings.

### 2.5.7 Residual Values

The economic appraisal includes the residual values of the road assets. The residual value reflects that fact that some infrastructure assets may have economic lives which extend beyond the evaluation period. Residual values are entered in the last year of the evaluation period to represent the unused portion of the asset life after the evaluation period.

## 2.6 Capital and Maintenance Costs

Capital costs and maintenance costs for existing and Concept Design have been provided by Roads and Maritime.

The P50 and P90 capital costs for the Concept Design are shown in Table 2-2. Appendix E includes detailed cost estimates provided by Roads and Maritime.

*Table 2-2 Capital Costs for Concept Design (P50 and P90)*

| Option | ($million) P50 | ($million) P90 |
|---|---|---|
| Concept Design | $124 | $131 |

Source: Roads and Maritime's cost estimated received on 4 May 2018

Table 2-3 shows construction period and traffic opening year for the Concept Design.

*Table 2-3 Construction and Traffic Opening Year*

| Option | Construction Period | Year Open to Traffic |
|---|---|---|
| Concept Design | 2018-2022 | 2020 |

Source: Roads and Maritime

# 3 Evaluation Results

The cost benefit analysis (CBA) for the Concept Design have considered the project benefits including travel time savings, vehicle operating cost savings, reduction in crash costs, environmental and externality costs, residual value of the asset and maintenance savings.

The results of the economic appraisal for the concept design for P50 and P90 costs are summarised in Table 3-1.

*Table 3-1 Summary of Economic Appraisal - 7% Discount Rate (P50 and P90)*

| Decision Criteria | P50 Cost | P90 Cost |
|---|---|---|
| PV Cost ($M) | $109 | $115 |
| PV Benefit ($M) | $217 | $218 |
| NPV | $108 | $103 |
| BCR | 2.0 | 1.9 |
| IRR | 12.4% | 12.0% |

The results in Table 3-1 show that:

- The road user benefit would exceed the capital cost and the project is economically viable
- The BCR for the project is estimated to be 2.0 for P50 and 1.9 for P90 respectively.
- The total road user benefit for P50 would be $217 million with a capital cost of $109 million. The total road user benefit for P90 would be $218 million with a capital cost of $115 million.

Table 3-2 provides a summary of the discounted benefits by road users for the project.

*Table 3-2 Benefits Breakdown ($million)*

| Discounted Benefits | P50 | | P90 | |
|---|---|---|---|---|
| | ($million) | Percent | ($million) | Percent |
| Savings in Travel Time | $ 191.5 | 88% | $191.5 | 88% |
| Savings in Vehicle Operating Costs (travel distance savings) | $ 3.2 | 1.5% | $3.2 | 1.5% |
| Savings in Vehicle Operating Costs (number of stops savings) | $ 13.8 | 6.3% | $13.8 | 6.3% |
| Savings in Crash Costs | $ 2.8 | 1.3% | $2.8 | 1.3% |
| Environmental and External Benefits | $ 1.5 | 0.7% | $1.5 | 0.7% |
| Residual Value | $ 4.0 | 1.8% | $4.3 | 2.0% |
| Maintenance Savings | $ 0.7 | 0.3% | $0.7 | 0.3% |
| Total PV of Benefits | $ 217 | 100% | $218 | 100% |

The results from Table 3-2 indicate that the project would provide substantial road user benefit. About 88 per cent total benefit was contributed by travel time savings. Vehicle operating costs savings (including travel distance savings and number of stops savings) contributed about eight per cent. The crash cost savings contributed about one per cent. Residual value contributed about two percent. Environmental and external benefits contributed about 0.7 per cent. Savings in maintenance costs contributed about 0.3 per cent.

### 3.1.1 Sensitivity Analyses

A sensitivity analysis was carried out as part of the economic appraisal. The economic analysis tested sensitivity of the results to discount rates and on estimation of costs and benefits.

#### 3.1.1.1 Sensitivity on Discount Rates

The sensitivity analysis was carried out for 4 per cent and 10 per cent discount rate. The results of the sensitivity analysis on discount rates for P50 and P90 are shown in Table 3-3. For P50, a 4 per cent discount rate, BCR is estimated to be 3.2 and a 10 per cent discount rate, BCR is estimated to be 1.3. For P90, a 4 per cent discount rate, BCR is estimated to be 3.0 and a 10 per cent discount rate, BCR is estimated to be 1.2.

*Table 3-3 Sensitivity Analyses Results on Discount Rates (P50 and P90)*

| Discount Rate | Decision Criteria | P50 | P90 |
|---|---|---|---|
| 4% | NPV ($M) | $249 | $244 |
| | BCR | 3.2 | 3.0 |
| 10% | NPV ($M) | $35 | $29 |
| | BCR | 1.3 | 1.2 |

#### 3.1.1.2 Sensitivity on Costs and Benefits

The results of the sensitivity analysis on the costs and benefits for P50 and P90 are provided in Table 3-4. The table provide the resulting economic parameters for a +/- 20% deviation on the cost estimates and the benefits streams, as well as the effect of a delayed delivery by one year.

For P50 costs:

- The BCR is estimated to be 1.7 if cost estimates are increased by 20 per cent (as a worst case).
- Similarly, the BCR is estimated to be 1.6 if benefits are decreased by 20 per cent (as a worst case).
- The BCR is estimated to be 2.0 if there is a delay in delivery by one year.

For P90 costs:

- The BCR is estimated to be 1.6 if cost estimates are increased by 20 per cent (as a worst case).
- Similarly, the BCR is estimated to 1.5 if benefits are decreased by 20 per cent (as a worst case).
- The BCR is estimated to 2.0 if there is a delay in delivery by one year.

*Table 3-4 Sensitivity Analyses on Costs and Benefits (P50 and P90)*

| Sensitivity Analysis | P50 | | P90 | |
|---|---|---|---|---|
| | BCR | NPV ($M) | BCR | NPV ($M) |
| Cost Estimate +20% | 1.7 | $87 | 1.6 | $80 |
| Cost Estimate -20% | 2.5 | $130 | 2.4 | $126 |
| Benefits +20% | 2.4 | $152 | 2.3 | $146 |
| Benefits – 20% | 1.6 | $65 | 1.5 | $59 |
| Delay in delivery by one year | 2.0 | $110 | 2.0 | $104 |

### 3.1.2 Summary

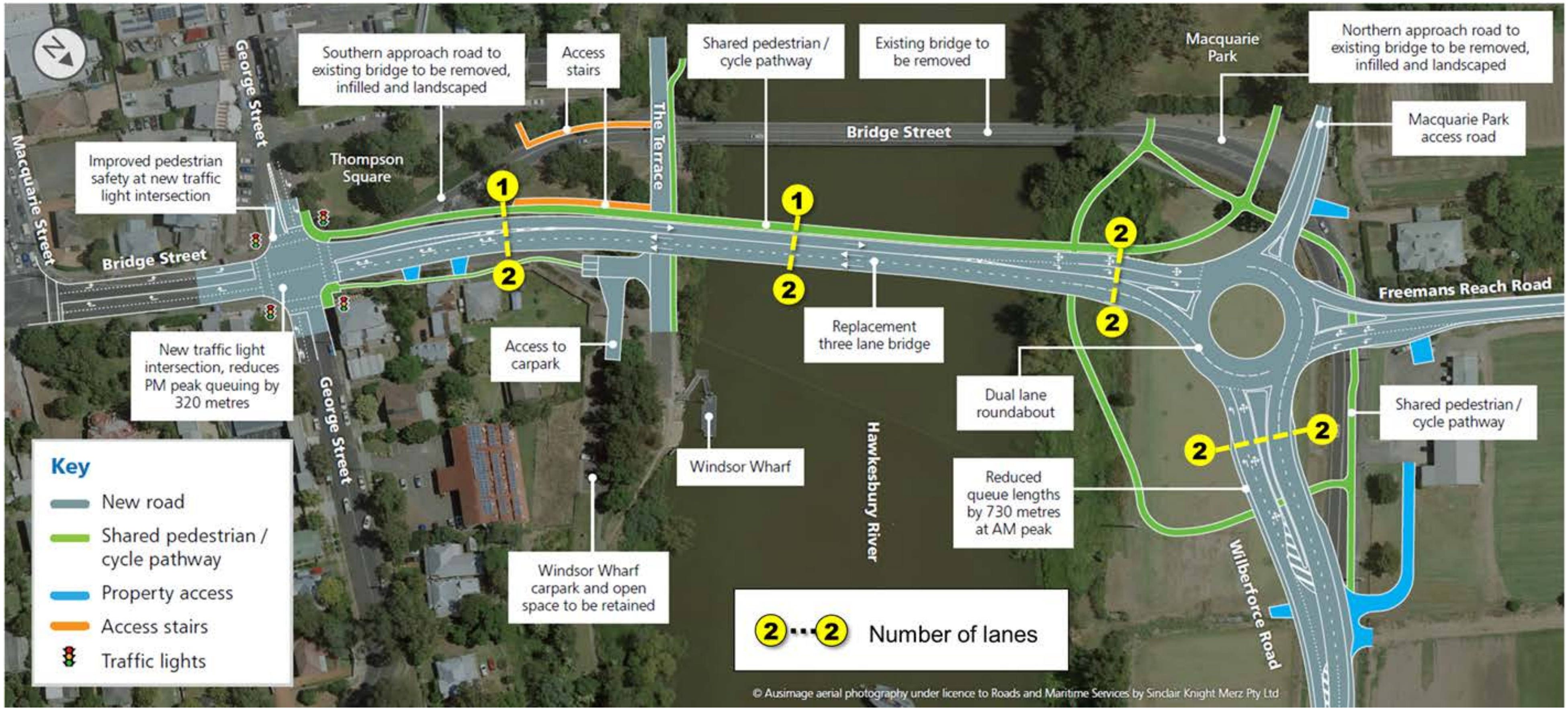
The road user benefit of the project is estimated to be exceeded the capital costs. The proposed upgrades are economically viable. The BCR for the project is estimated to be 2.0 for P50 and 1.9 for P90.

A summary of cost benefit analysis is shown below.

| BCR Summary | | |
|---|---|---|
| A | Concept Design | 30-year economic evaluation<br>Road user benefits using SIDRA Network<br>New three lane bridge replacement consist of two lanes in southbound direction and one lane in northbound direction |
| B1 | Summary of Evaluation Results<br>Cost Benefit Analysis (CBA) | Base Case – existing two lane bridge<br>Project Type: Windsor Bridge Replacement<br>Local evaluation |
| B2 | Evaluation Assumptions | Cost of upgrade (at P50), $124 million<br>Cost of upgrade (at P90), $131 million<br>Travel Time, Vehicle Operating Costs, Crash Costs, Environmental and External Costs as per Economic Appraisal Guidelines |
| C | Summary of Evaluation Results<br><br>Sensitivity Results | 7% discount rate, P50<br>Benefit/Cost Ratio 2.0<br><br>4% discount rate, P50<br>Benefit/Cost Ratio 3.2<br><br>10% discount rate, P50<br>Benefit/Cost Ratio 1.3 |
| | | 7% discount rate, P90<br>Benefit/Cost Ratio 1.9<br><br>4% discount rate, P90<br>Benefit/Cost Ratio 3.0<br><br>10% discount rate, P90<br>Benefit/Cost Ratio 1.2 |

Detailed discounted benefits and costs are included in Appendix F.

# APPENDIX A ROADS AND MARITIME'S CONCEPT DESIGN




Source: Windsor Bridge Replacement Project Update, December 2016, Roads and Maritime Services

*Figure A-1 Roads and Maritime's Concept Design*

# APPENDIX B TRAFFIC MODELLING DATA

The traffic output from SIDRA model was normalised. The normalisation process for SIDRA Network is outlined below:

- SIDRA output of “demand” flows represents total demand for the network
- SIDRA output of “arrival flows” represents number of trips that complete its journey.
- Difference between “demand flows” and “arrival flow” indicates level of “unreleased” trips for the network
- The average trip time therefore is estimated using the total network (VHT) divided by “arrival flows”. A similar logic applies to average trip length and number of stops.

Table A-1 summarises modelling input used in cost benefit analysis.

*Table A-1 Model Outputs for BCR – Concept Design*

| Item/Model | AM Peak 1 Hour | | | | | |
|---|---|---|---|---|---|---|
| | 2017 | | 2026 | | 2036 | |
| | Base Case | Concept Design | Base Case | Concept Design | Base Case | Concept Design |
| Total trip time (VHT) | 88 | 71 | 183 | 90 | 304 | 107 |
| Total distance (VKT) | 3199 | 3067 | 3642 | 3475 | 3983 | 3794 |
| Total stops | 4372 | 3754 | 9780 | 4571 | 13272 | 5575 |
| **Item/Model** | **PM Peak 1 Hour** | | | | | |
| | **2017** | | **2026** | | **2036** | |
| | **Base Case** | **Concept Design** | **Base Case** | **Concept Design** | **Base Case** | **Concept Design** |
| Total trip time (VHT) | 99 | 79 | 233 | 143 | 504 | 270 |
| Total distance (VKT) | 3124 | 3022 | 3639 | 3522 | 4016 | 3860 |
| Total stops | 3343 | 3582 | 6580 | 5573 | 9869 | 8084 |

Source: SIDRA Network. Model file: \\HC-AUS-NS-FS-01\jobs\10005593\D-Calculations\SIDRA modelling\Final model\2026\RevH

# APPENDIX C PROJECT SPECIFIC VARIABLE FOR ROAD USER BENEFITS

This Appendix B summarises the project specific variables for benefits suitable for the study, including:

- Escalation factors (2016 values to 2018 values)
- Expansion factors
- Vehicle compositions
- Values of time (VOT)
- Vehicles operating costs (VOC)
- Environmental and externality costs.

## Reference traffic data and guideline used

To determine project specific variables for road user benefits suitable for the study, the following data and guidelines were used:

- *Appendix 4 Economic Parameter Values and Valuation Methodologies of TfNSW's Principles and Guidelines for Economic Appraisal of Transport Investment and Initiative, June 2016* (hereafter referred as 'June 2016 TfNSW Guideline').
- Traffic surveys (tube counts) undertake on the Windsor Bridge in March 2017.

## Escalation factors

All parameter values suggested in June 2016 TfNSW Guideline are at March 2016 dollar. Table 82 in the June 2016 TfNSW Guideline suggested key indices used to escalate the parameters values and forecast. Table B-1 below summarises escalation factors to estimate 2018 values based on 2016 values suggested in the June 2016 TfNSW Guideline

*Table B-1 Escalation Factors 2016 to 2018 Values*

| Parameters | Vehicles | Escalation Factors 2016 to 2018 Values | Indices |
|---|---|---|---|
| Values of time (VOT) | Light vehicle | 104.80% | AWE NSW ($) |
| | Heavy vehicle | 104.29% | PPI road freight Index |
| Vehicle operating costs per kilometre (VOC/km) | Light vehicle | 104.29% | CPI Private Motoring Index |
| | Heavy vehicle | 104.29% | PPI road freight Index |
| Vehicle operating costs per stop (VOC/stop) | Light vehicle | 104.29% | CPI Private Motoring Index |
| | Heavy vehicle | 104.29% | PPI road freight Index |
| Externality and Crash costs | Light vehicle | 104.29% | CPI Sydney Index |
| | Heavy vehicle | 104.29% | CPI Sydney Index |

## Expansion factors

Traffic modelling is usually undertaken for peak hours (i.e. one hour AM peak and one hour PM peak). To estimate annual road user benefits from traffic modelling results, the annual expansion factor is used to expand AM and PM peak to annual numbers. Table B-2 below summarise cost expansion factors for Sydney roads suggested in the Table 71 in the June 2016 TfNSW Guideline.

For the study purpose, an annual expansion factor of 2113 was used, consistent with the TfNSW Guide

*Table B-2 TfNSW's Suggested Expansion Factors – Sydney Roads*

| Parameters | Values |
|---|---|
| From peak two hours to weekday | 6.29 |
| From weekday to year | 336 |
| Peak two hours (AM peak one hour + PM peak one hour) to Annual | 2113 |

## Vehicle compositions on Windsor Bridge

Table B-3 shows vehicle compositions on the Windsor Bridge obtained from March 2017 traffic survey. On the Windsor Bridge, the proportion of light vehicles was found in the order of 89%. The proportion of heavy vehicles was found in the order of 11%.

*Table B-3 Vehicle Compassions on the Windsor Bridge (March 2017 Traffic Survey)*

| Vehicle type | Vehicle Classification | Austroads Class | Descriptions | Vehicle Composition (%) | %Vehicle Composition (%) |
|---|---|---|---|---|---|
| Light Vehicles | Light | 1 | Short | 88.0% | 89.2% |
| | | 2 | Short Towing | 1.2% | |
| Heavy Vehicles | Medium | 3 | 2 axle Truck or bus | 6.8% | 10.8% |
| | | 4 | 3 Axle Truck or Bus | 1.8% | |
| | | 5 | 4 or 5 Axle Truck | 0.5% | |
| | Heavy | 6 | 3 axle Articulated | 0.2% | |
| | | 7 | 4 Axle Articulated | 0.2% | |
| | | 8 | 5 Axle Articulated | 0.2% | |
| | | 9 | 6 Axle Articulated | 0.6% | |
| | | 10 | B Double | 0.3% | |
| | | 11 | Double Road Train | 0.1% | |
| | | 12 | Triple Road Train | 0.0% | |
| **Total** | **All vehicles** | **1-12** | **All vehicles** | **100.0%** | **100.0%** |

## Values of time (VOT)

Values of time (VOT) for light and heavy vehicles were estimated using urban parameters suggested in Table 9 in the June 2016 TfNSW Guideline and the vehicle composition observed in the study area.

Table B-4 below summarises values of time (VOT) estimates for light and heavy vehicles for the study area. The parameters were projected to 2018 values using escalation factors suggested in the June 2016 TfNSW Guideline.

*Table B-4 Values of Time Estimates for the Study Area – Urban*

| Vehicle Classification | Vehicle Composition (%) | Average hourly value ($/veh-hr) 2016 Values | Forecasting Indices for 2016 to 2018 | Average hourly value ($/veh-hr) 2018 Values |
|---|---|---|---|---|
| Light Vehicle | 89.22% | $28.81 | 104.80 | $30.19 |
| Heavy Vehicle | 10.78% | $53.00 | 104.29 | $55.27 |
| **Weighted based on vehicle composition** | **100.00%** | **$31.42** | | **$32.90** |

## Vehicle operating costs (VOC)

Vehicle operating costs (VOC) by vehicle type were estimated using resource cost parameters suggested in Table 12 in the June 2016 TfNSW Guideline and the vehicle composition observed in the study area. The VOC parameters were suggested for urban stop-start conditions for different travel speeds.

Table B-5 below summarises VOC parameters by vehicle type for urban stop-start model. The parameters were projected to 2018 values using escalation factors suggested in the June 2016 TfNSW Guideline.

*Table B-5 Vehicle Operating Cost per Kilometre - Urban Stop-start Model*

| Vehicle category | Austroads Class | Value per km (cent/km) | | |
|---|---|---|---|---|
| | | Urban stop-start model (km/h) 2016 Values | Forecasting Indices for 2016 to 2018 | Urban stop-start model (km/h) 2018 Values |
| | | 30 | | 30 |
| Light Vehicle | 1 small | 38.9 | 104.29 | 40.6 |
| | 2 medium | 54.4 | 104.29 | 56.7 |
| | 2 large | 72.8 | 104.29 | 75.9 |
| Heavy Vehicle | 3 | 85.7 | 104.29 | 89.4 |
| | 4 | 111.6 | 104.29 | 116.4 |
| | 5 | 142.9 | 104.29 | 149.0 |
| | 6 | 196.1 | 104.29 | 204.5 |
| | 7 | 196.1 | 104.29 | 204.5 |
| | 8 | 214.9 | 104.29 | 224.1 |
| | 9 | 232.6 | 104.29 | 242.6 |
| | 10 | 277.1 | 104.29 | 289.0 |
| | 11 | 335 | 104.29 | 349.4 |
| | 12 | 430.1 | 104.29 | 448.5 |
| **Weighted based on vehicle composition** | **1-12** | **47.4** | | **49.5** |

## Vehicle operating costs per stop

Table B-6 below shows vehicle operating cost per stop (cent per stop) suggested in Table 16 in in the June 2016 TfNSW Guideline. The parameters were projected to 2018 values using escalation factors suggested in the June 2016 TfNSW Guideline.

*Table B-6 Vehicle Operating Cost per Stop*

| Vehicle Type | Austroads Class | Vehicle Operating Cost per Stop (cent/stop) | | |
|---|---|---|---|---|
| | | 2016 Values (Table 16) | Escalation Factors 2016 to 2018 Values | 2018 Values |
| Car | 1-2 | 6.6 | 104.29 | 6.8 |
| Light Truck | 3-6 | 22.8 | 104.29 | 23.8 |
| Heavy Truck | 7-9 | 59.9 | 104.29 | 62.5 |
| **Weighted based on vehicle composition** | **1-12** | **8.9** | | **9.3** |

## Environmental and externality costs

Road use produces external costs on society in terms of the economic costs of environmental impacts. Environmental costs are determined by applying externality values per vehicle-kilometres travelled (VKT) based on vehicle composition form the traffic analysis. These parameter values include noise pollution, air pollution, water pollution, greenhouse gas emissions, nature and landscape, urban separation, and upstream and downstream.

Table B-7 below summarises environmental and externality cost (cent per kilometre) for urban road suggested in Table 58 and Table 60 in the June 2016 TfNSW Guideline. The parameters were projected to 2018 values using escalation factors suggested in the June 2016 TfNSW Guideline. Environmental unit costs for passenger vehicles are expressed in cents per VKT. For heavy vehicles the environmental unit costs are expressed in dollars per 1000 tonne kilometre (tkm) travelled.

*Table B-7 Externality Costs – Urban Road*

| Vehicle Type | Austroads Class | Environmental and Externality Costs (cent/kilometre) Urban Road | | |
|---|---|---|---|---|
| | | 2016 Values (Table 58 and Table 60) | Escalation Factors 2016 to 2018 Values | 2018 Values |
| Light vehicle | 1-2 | 12.2 | 104.29 | 12.7 |
| Rigid truck | 3-6 | 87.5 | 104.29 | 91.3 |
| Semi-trailer | 7-9 | 199.1 | 104.29 | 207.7 |
| B-Double | 10 | 297.6 | 104.29 | 310.4 |
| A-Double | 11-12 | 396.1 | 104.29 | 413.1 |
| **Weighted based on vehicle composition** | **1-12** | **22.4** | | **23.4** |

# APPENDIX D CRASH REDUCTION AND SAFETY BENEFIT ANALYSIS

## Historical Crash Data

This Appendix C summarises crash reductions and crash cost savings (safety benefit) undertaken for the Concept Design of Windsor Bridge Replacement Project.

Recorded crash statistic for Bridge Street between Freemans Reach Road and Macquarie Street (study area) were obtained from Roads and Maritime for the period of July 2011 to December 2016.

Table C-1 below summarises recorded crashes by roads and locations. crashes recorded between July 2011 to December 2016 indicated that about 52 crashes occurred in the study area. Of all crashes reported, about 41 crashes occurred at intersections, 8 crashes occurred on the undivided road sections, and 3 crashes occurred on the divided road sections.

The severity of crashes classified as fatal, injury and non-casualty are shown in Table C-2. Of the total 52 crashes recorded in the study area between July 2011 to December 2016, no fatal crashes were recorded. About 20 crashes (38%) were recorded as injury with 20 people injured. About 32 crashes (62%) were recorded as non-casualty (tow-away).

*Table C-1 Locations of Crashes*

| Road | Total Number Crashes Recorded | Intersection* | Non-intersection | |
|---|---|---|---|---|
| | | | Two-way undivided road | Divided Road |
| Bridge Street | 23 | 17 | 4 | 2 |
| George Street | 1 | 1 | 0 | 0 |
| Macquarie Street | 4 | 3 | 0 | 1 |
| Wilberforce Road | 24 | 20 | 4 | 0 |
| **Total** | **52** | **41** | **8** | **3** |

Source: Roads and Maritime's crash data between July 2011 and December 2016, Note: * Up to 10 metres from an intersection

Table C-2 Number of Crashes by Severity

| Crash Severity | Number of Crashes Recorded | % | Casualties |
|---|---|---|---|
| Fatal | 0 | 0% | |
| Injury | 20 | 38% | 20 people injured |
| Non-casualty | 32 | 62% | |
| **Total** | **52** | **100%** | **20** |

Figure C-1 shows number of crashes per movement type. The four most common types of crashes account for around 87 per cent of the reported crashes within the study area:

- Intersection, from adjacent approaches (38%)
- Opposing vehicles; turning (21%)
- Rear-end (15%)
- Off carriageway, on curve, hit object (8%).

Crashes other than the above constitute the remaining 17 per cent.

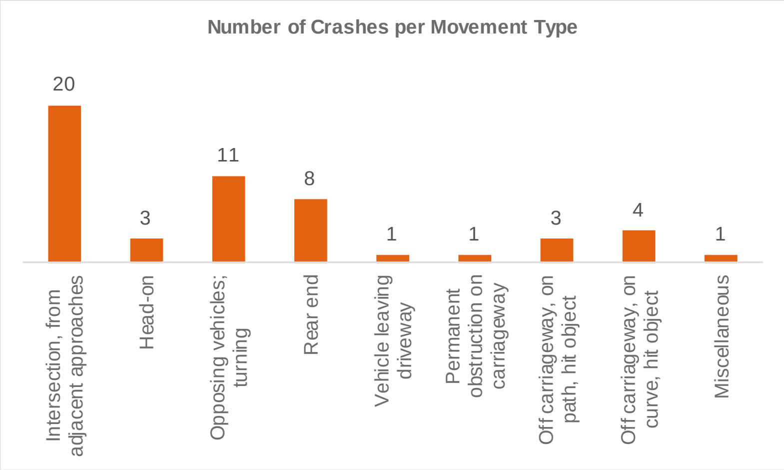
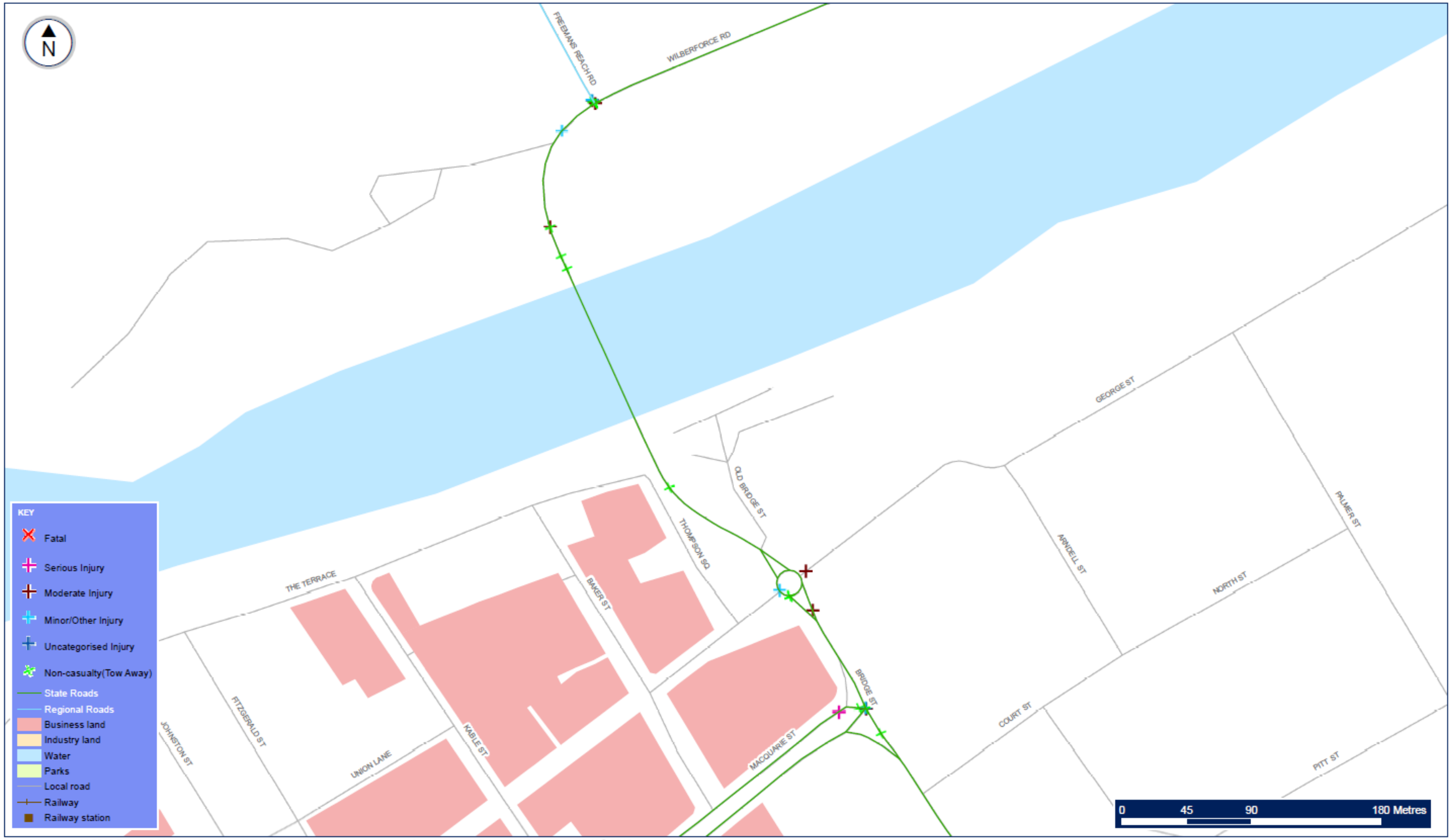



*Figure C1 Number of Crashes per Movement Type*

Figure C-2 shows crash locations on Bridge Street and approach roads. Figure C-2 indicates that crashes are mostly located at intersections. Particularly crash-prone locations are:

- Freemans Reach Road and Wilberforce Road intersection
- Bridge Street and George Street intersection
- Bridge Street and Macquarie Street intersection.






Network Optimisation Planning Sydney, October 2016

*Figure C-2 Spatial Distribution of Crashes on Bridge Street and Approach Roads*

## Crash Reduction Analysis

Crash reduction analysis was undertaken by comparing existing and proposed (i.e. with concept design) conditions to determined estimated crash reduction statistics based on historical data from July 2011 to December 2016.

Should the Windsor Bridge Replacement Project be constructed as per the Roads and Maritime's concept design, this would result in crash reduction on the Windsor Bridge and adjacent intersections. Crash reduction attributable to the bridge replacement were determined in two categories including:

- Crash reduction attributable to the Winsor Bridge replacement between George Street and Wilberforce Road as per concept design.
- Crash reduction attributable to proposed intersections upgrade at:
  - Wilberforce Road / Freeman Reach Road (new roundabout)
  - Bridge Street / George Street (new traffic signal)
  - Bridge Street / Macquarie Street (upgraded traffic signal).

### 1. Crash Reduction Attributable to the Windsor Bridge Replacement

Crash reduction attributable to the bridge replacement was determined by comparing existing and proposed (Concept design) crash rates on the Windsor Bridge between George Street and Wilberforce Road.

Table C-3 summarises crash rates on the Windsor Bridge between George Street and Wilberforce Road for existing and proposed (Concept Design) conditions. Existing crash rates per 100 million vehicle kilometres travelled (100MVKT) on the Windsor Bridge was calculated based on crash statistics from July 2011 to December 2016. Crash rates for post-upgrade were estimated assuming the existing two lane bridge will be replaced by new three lane bridge (two lanes in southbound direction and one lane in northbound direction).

The new three lane bridge is predicted to reduce casualty crash rate from 27.7 crashes per 100MVKT (existing) to 18.5 crashes per 100 MVKT (with Concept Design). Non- casualty crash rate is predicted to reduce from 23.1 crashes per 100 MVKT (existing) to 9.2 crashes per 100MVKT (with Concept Design).

*Table C-3 Crash Rates on Windsor Bridge between George Street and Wilberforce Road for Existing and Proposed (with Concept Design) Conditions*

| Statistics | | Crash Statistics on Windsor Bridge | |
|---|---|---|---|
| | | Existing Condition | Proposed Condition (with Concept Design) |
| Distance (km) | km | 0.50 | 0.50 |
| Fatal Crash | Crashes per year | 0 | 0 |
| Injury Crash | Crashes per year | 1.1 | 0.7 |
| Casualty Crash | Crashes per year | 1.1 | 0.7 |
| Non-casualty (tow away) | Crashes per year | 0.9 | 0.4 |
| ADT | Vehicles per day | 21550 | 21550 |
| Casualty Crash Rate | Crashes per 100MVKT | 27.7 | 18.5 |
| Fatal Crash Rate | Crashes per 100MVKT | 0.0 | 0.0 |
| Injury Crash Rate | Crashes per 100MVKT | 27.7 | 18.5 |

| Statistics | | Crash Statistics on Windsor Bridge | |
|---|---|---|---|
| | | Existing Condition | Proposed Condition (with Concept Design) |
| Non-casualty (tow away) | Crashes per 100MVKT | 23.1 | 9.2 |

## 2. Crash Reduction Attributable to the Intersections Upgrade

Crash reduction attributable to the intersections upgrade proposed in the Roads and Maritime's concept design was determined using Roads and Maritime's Crash Reduction Guide, August 2005.

Table C-4 shows number of intersection related crashes recorded between July 2011 to December 2016 by DCA codes for existing (without upgrade) and proposed (with Concept Design) conditions. Table C-4 includes potential reductions on crashes by DCA codes for upgrade as per Road and Maritime Guide.

*Table C-4 Existing and Proposed Crashes by DCA – Intersections Upgrade*

| DCA Code | Collision Type | Existing Condition | Proposed Condition (with Concept Design | Change | % Change |
|---|---|---|---|---|---|
| 101-109 | Intersection, from adjacent approaches | 20 | 7 | 13 | 65% |
| 202-206 | Opposing vehicles; turning | 11 | 8 | 3 | 27% |
| 301-303 | Rear end | 6 | 4 | 2 | 33% |
| 401-409 | Vehicle leaving driveway | 1 | 1 | 0 | 0% |
| 605 | Permanent obstruction on carriageway | 1 | 1 | 0 | 0% |
| 803-804 | Off carriageway, hit object | 2 | 2 | 0 | 0% |
| **Total** | | **41** | **23** | **18** | **44%** |

The analysis in Table C-4 indicated that the intersections upgrade proposed in the design has potential to reduce intersection related crashes by 44% from 41 to 23 crashes.

Table C-5 summarise annual crash rates (intersection related crashes) for existing and proposed conditions. The proposed upgrade would reduce annual crash rate from 7.5 existing to 4.2 crashes per year for proposed condition.

*Table C-5 Existing and Proposed Annual Crash Rates – Intersections Upgrade*

| Intersections Upgrade | Existing Condition | Proposed Condition (with Concept Design) | Change | % Change |
|---|---|---|---|---|
| Total crashes per year | 7.5 | 4.2 | 3.3 | 44% |

## Crash Cost Savings

The annual crash cost savings are estimated using the average crash costs by accident type, and based on the 'willingness to pay' approach sourced from Table 52 in *Appendix 4 Economic Parameter Values and Valuation Methodologies of TfNSW's Principles and Guidelines for Economic Appraisal of Transport Investment and Initiative, June 2016* ('June 2016 TfNSW Guideline').

Table C-6 shows fatality and injury costs for urban road used in the analysis. The parameters were projected to 2018 values using escalation factors suggested in Table 82 in the June 2016 TfNSW Guideline.

*Table C-6 Cost per Casualty Crash – Urban Road*

| Crash Type | Cost per Casualty Crash – Urban 2016 Values | Escalation Factors 2016 to 2018 Values | Cost per Casualty Crash – Urban 2018 Values |
|---|---|---|---|
| Fatal crash (at least one person killed) | $7,563,434 | 104.29 | $7,887,903 |
| Unknown injury type crash | $201,026 | 104.29 | $209,650 |
| Property damage only | $9,743 | 104.29 | $10,161 |

Table C-7 summarises net annual crash cost savings attributable to the concept design.

*Table C-7 Estimated Crash Cost Savings*

| Years | Crash Cost (2018 Values) | | |
|---|---|---|---|
| | Existing Condition | Proposed Condition (with Concept Design) | Net Savings |
| 2020 Opening Year | $250,289 | $164,268 | $86,021 |
| 2026 | $777,903 | $507,887 | $270,016 |
| 2036 | $809,918 | $528,899 | $281,020 |

# APPENDIX E DETAILED COST ESTIMATES PROVIDED BY ROADS AND MARITIME

# APPENDIX F DETAILED BENEFITS AND COSTS ANALYSIS

## Summary Calculations - P50 Cost

**Base Year** 2017
**Opening Year** 2020
**Analysis Period** 30 years
**Construction Cost** $123,832,930

| Analysis Period | Year | Costs | | | Benefits | | | | | | | | Net Benefit (Cost) | First Year Benefit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Construction Costs | Net Maintenance Costs | Total Costs | VHT | VKT | Stops | Crash Reduction | Externality | Maintenance Savings | Residual Value | Total Benefits | | |
| Base Year | 2017 | $ 28,938,975 | $0.00 | $28,938,975 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | -$28,938,975 | $0 |
| 1 | 2018 | $ 16,209,222 | $0.00 | $16,209,222 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | -$16,209,222 | $0 |
| 2 | 2019 | $ 29,678,093 | $0.00 | $29,678,093 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | -$29,678,093 | $0 |
| 3 | 2020 | $ 31,731,242 | $0.00 | $31,731,242 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | -$31,731,242 | $0 |
| 4 | 2021 | $ 17,091,938 | $0.00 | $17,091,938 | $7,139,864 | $267,859 | $583,358 | $262,323 | $126,439 | $60,000 | $0 | $8,439,844 | -$8,652,095 | $1 |
| 5 | 2022 | $ 183,459 | $0.00 | $183,459 | $8,270,394 | $273,656 | $710,621 | $263,810 | $129,176 | $80,000 | $0 | $9,727,658 | $9,544,198 | $0 |
| 6 | 2023 | $ - | $0.00 | $0 | $9,400,923 | $279,453 | $837,885 | $265,323 | $131,912 | $40,000 | $0 | $10,955,497 | $10,955,497 | $0 |
| 7 | 2024 | $ - | $0.00 | $0 | $10,531,453 | $285,251 | $965,149 | $266,861 | $134,649 | $80,000 | $0 | $12,263,362 | $12,263,362 | $0 |
| 8 | 2025 | $ - | $0.00 | $0 | $11,661,982 | $291,048 | $1,092,412 | $268,426 | $137,385 | $60,000 | $0 | $13,511,253 | $13,511,253 | $0 |
| 9 | 2026 | $ - | $0.00 | $0 | $12,792,512 | $296,845 | $1,219,676 | $270,016 | $140,121 | $80,000 | $0 | $14,799,171 | $14,799,171 | $0 |
| 10 | 2027 | $ - | $0.00 | $0 | $14,505,892 | $303,166 | $1,283,774 | $271,063 | $143,105 | $40,000 | $0 | $16,547,001 | $16,547,001 | $0 |
| 11 | 2028 | $ - | $0.00 | $0 | $16,219,272 | $309,488 | $1,347,871 | $272,122 | $146,090 | $80,000 | $0 | $18,374,843 | $18,374,843 | $0 |
| 12 | 2029 | $ - | $0.00 | $0 | $17,932,653 | $315,810 | $1,411,969 | $273,192 | $149,074 | $60,000 | $0 | $20,142,697 | $20,142,697 | $0 |
| 13 | 2030 | $ - | $0.00 | $0 | $19,646,033 | $322,132 | $1,476,066 | $274,274 | $152,058 | $80,000 | $0 | $21,950,563 | $21,950,563 | $0 |
| 14 | 2031 | $ - | $0.00 | $0 | $21,359,413 | $328,454 | $1,540,164 | $275,368 | $155,042 | $40,000 | $0 | $23,698,440 | $23,698,440 | $0 |
| 15 | 2032 | $ - | $0.00 | $0 | $23,072,793 | $334,775 | $1,604,261 | $276,473 | $158,026 | $80,000 | $0 | $25,526,330 | $25,526,330 | $0 |
| 16 | 2033 | $ - | $0.00 | $0 | $24,786,174 | $341,097 | $1,668,359 | $277,591 | $161,010 | $60,000 | $0 | $27,294,231 | $27,294,231 | $0 |
| 17 | 2034 | $ - | $0.00 | $0 | $26,499,554 | $347,419 | $1,732,456 | $278,722 | $163,994 | $80,000 | $0 | $29,102,145 | $29,102,145 | $0 |
| 18 | 2035 | $ - | $0.00 | $0 | $28,212,934 | $353,741 | $1,796,554 | $279,864 | $166,978 | $40,000 | $0 | $30,850,071 | $30,850,071 | $0 |
| 19 | 2036 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $0 | $32,678,010 | $32,678,010 | $0 |
| 20 | 2037 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $60,000 | $0 | $32,658,010 | $32,658,010 | $0 |
| 21 | 2038 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $0 | $32,678,010 | $32,678,010 | $0 |
| 22 | 2039 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $40,000 | $0 | $32,638,010 | $32,638,010 | $0 |
| 23 | 2040 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $0 | $32,678,010 | $32,678,010 | $0 |
| 24 | 2041 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $60,000 | $0 | $32,658,010 | $32,658,010 | $0 |
| 25 | 2042 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $0 | $32,678,010 | $32,678,010 | $0 |
| 26 | 2043 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $40,000 | $0 | $32,638,010 | $32,638,010 | $0 |
| 27 | 2044 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $0 | $32,678,010 | $32,678,010 | $0 |
| 28 | 2045 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $60,000 | $0 | $32,658,010 | $32,658,010 | $0 |
| 29 | 2046 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $0 | $32,678,010 | $32,678,010 | $0 |
| 30 | 2047 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $40,000 | $0 | $32,638,010 | $32,638,010 | $0 |
| 31 | 2048 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $0 | $32,678,010 | $32,678,010 | $0 |
| 32 | 2049 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $60,000 | $0 | $32,658,010 | $32,658,010 | $0 |
| 33 | 2050 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $36,949,100 | $69,627,110 | $69,627,110 | $0 |

| Discount Rate | Capital Costs | Net Maintenance Costs | PV of Costs | PV of Benefits | NPV | BCR | First Year Benefit | FYRR | IRR | 12% |
|---|---|---|---|---|---|---|---|---|---|---|
| 4% | $114,933,840 | $0 | $114,933,840 | $364,339,404 | $249,405,564 | 3.2 | -$7,395,847 | -6.4% | | |
| 7% | $109,082,084 | $0 | $109,082,084 | $217,431,345 | $108,349,261 | 2.0 | -$6,600,641 | -6.1% | | |
| 10% | $103,830,071 | $0 | $103,830,071 | $138,332,311 | $34,502,240 | 1.3 | -$5,909,497 | -5.7% | | |

## Summary Calculations - P90 Cost

| | | |
|---|---|---|
| **Base Year** | 2017 | |
| **Opening Year** | 2020 | |
| **Analysis Period** | 30 | years |
| **Construction Cost** | $130,686,450 | |

| Analysis Period | | Costs | | | Benefits | | | | | | | | Net Benefit (Cost) | First Year Benefit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year | Construction Costs | Net Maintenance Costs | Total Costs | VHT | VKT | Stops | Crash Reduction | Externality | Maintenance Savings | Residual Value | Total Benefits | | |
| Base Year | 2017 | $ 28,938,975 | $0.00 | $28,938,975 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | -$28,938,975 | $0 |
| 1 | 2018 | $ 17,107,586 | $0.00 | $17,107,586 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | -$17,107,586 | $0 |
| 2 | 2019 | $ 31,925,871 | $0.00 | $31,925,871 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | -$31,925,871 | $0 |
| 3 | 2020 | $ 34,134,523 | $0.00 | $34,134,523 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | -$34,134,523 | $0 |
| 4 | 2021 | $ 18,383,235 | $0.00 | $18,383,235 | $7,139,864 | $267,859 | $583,358 | $262,323 | $126,439 | $60,000 | $0 | $8,439,844 | -$9,943,391 | $1 |
| 5 | 2022 | $ 196,260 | $0.00 | $196,260 | $8,270,394 | $273,656 | $710,621 | $263,810 | $129,176 | $80,000 | $0 | $9,727,658 | $9,531,397 | $0 |
| 6 | 2023 | $ - | $0.00 | $0 | $9,400,923 | $279,453 | $837,885 | $265,323 | $131,912 | $40,000 | $0 | $10,955,497 | $10,955,497 | $0 |
| 7 | 2024 | $ - | $0.00 | $0 | $10,531,453 | $285,251 | $965,149 | $266,861 | $134,649 | $80,000 | $0 | $12,263,362 | $12,263,362 | $0 |
| 8 | 2025 | $ - | $0.00 | $0 | $11,661,982 | $291,048 | $1,092,412 | $268,426 | $137,385 | $60,000 | $0 | $13,511,253 | $13,511,253 | $0 |
| 9 | 2026 | $ - | $0.00 | $0 | $12,792,512 | $296,845 | $1,219,676 | $270,016 | $140,121 | $80,000 | $0 | $14,799,171 | $14,799,171 | $0 |
| 10 | 2027 | $ - | $0.00 | $0 | $14,505,892 | $303,166 | $1,283,774 | $271,063 | $143,105 | $40,000 | $0 | $16,547,001 | $16,547,001 | $0 |
| 11 | 2028 | $ - | $0.00 | $0 | $16,219,272 | $309,488 | $1,347,871 | $272,122 | $146,090 | $80,000 | $0 | $18,374,843 | $18,374,843 | $0 |
| 12 | 2029 | $ - | $0.00 | $0 | $17,932,653 | $315,810 | $1,411,969 | $273,192 | $149,074 | $60,000 | $0 | $20,142,697 | $20,142,697 | $0 |
| 13 | 2030 | $ - | $0.00 | $0 | $19,646,033 | $322,132 | $1,476,066 | $274,274 | $152,058 | $80,000 | $0 | $21,950,563 | $21,950,563 | $0 |
| 14 | 2031 | $ - | $0.00 | $0 | $21,359,413 | $328,454 | $1,540,164 | $275,368 | $155,042 | $40,000 | $0 | $23,698,440 | $23,698,440 | $0 |
| 15 | 2032 | $ - | $0.00 | $0 | $23,072,793 | $334,775 | $1,604,261 | $276,473 | $158,026 | $80,000 | $0 | $25,526,330 | $25,526,330 | $0 |
| 16 | 2033 | $ - | $0.00 | $0 | $24,786,174 | $341,097 | $1,668,359 | $277,591 | $161,010 | $60,000 | $0 | $27,294,231 | $27,294,231 | $0 |
| 17 | 2034 | $ - | $0.00 | $0 | $26,499,554 | $347,419 | $1,732,456 | $278,722 | $163,994 | $80,000 | $0 | $29,102,145 | $29,102,145 | $0 |
| 18 | 2035 | $ - | $0.00 | $0 | $28,212,934 | $353,741 | $1,796,554 | $279,864 | $166,978 | $40,000 | $0 | $30,850,071 | $30,850,071 | $0 |
| 19 | 2036 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $0 | $32,678,010 | $32,678,010 | $0 |
| 20 | 2037 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $60,000 | $0 | $32,658,010 | $32,658,010 | $0 |
| 21 | 2038 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $0 | $32,678,010 | $32,678,010 | $0 |
| 22 | 2039 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $40,000 | $0 | $32,638,010 | $32,638,010 | $0 |
| 23 | 2040 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $0 | $32,678,010 | $32,678,010 | $0 |
| 24 | 2041 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $60,000 | $0 | $32,658,010 | $32,658,010 | $0 |
| 25 | 2042 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $0 | $32,678,010 | $32,678,010 | $0 |
| 26 | 2043 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $40,000 | $0 | $32,638,010 | $32,638,010 | $0 |
| 27 | 2044 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $0 | $32,678,010 | $32,678,010 | $0 |
| 28 | 2045 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $60,000 | $0 | $32,658,010 | $32,658,010 | $0 |
| 29 | 2046 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $0 | $32,678,010 | $32,678,010 | $0 |
| 30 | 2047 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $40,000 | $0 | $32,638,010 | $32,638,010 | $0 |
| 31 | 2048 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $0 | $32,678,010 | $32,678,010 | $0 |
| 32 | 2049 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $60,000 | $0 | $32,658,010 | $32,658,010 | $0 |
| 33 | 2050 | $ - | $0.00 | $0 | $29,926,314 | $360,063 | $1,860,651 | $281,020 | $169,963 | $80,000 | $40,032,200 | $72,710,210 | $72,710,210 | $0 |

| Discount Rate | Capital Costs | Net Maintenance Costs | PV of Costs | PV of Benefits | NPV | BCR | First Year Benefit | FYRR | IRR 12% |
|---|---|---|---|---|---|---|---|---|---|
| 4% | $121,126,684 | $0 | $121,126,684 | $365,184,464 | $244,057,780 | 3.0 | -$8,499,653 | -7.0% | |
| 7% | $114,841,017 | $0 | $114,841,017 | $217,761,960 | $102,920,944 | 1.9 | -$7,585,766 | -6.6% | |
| 10% | $109,199,974 | $0 | $109,199,974 | $138,465,059 | $29,265,085 | 1.2 | -$6,791,470 | -6.2% | |