Bindubi Street - William Hovell Drive Grade Separated Interchange Feasibility Study
Infrastructure Finance and Capital Works
09-Jul-2019
Doc No. 2

Feasibility Study Report

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Client: Infrastructure Finance and Capital Works

ABN: 66 676 633 401

Prepared by

AECOM Australia Pty Ltd
Level 2, 60 Marcus Clarke Street, Canberra ACT 2600, Australia
T +61 2 6201 3000 F +61 2 6201 3099 www.aecom.com
ABN 20 093 846 925

09-Jul-2019

Job No.: 60588975

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Quality Information

Document	Feasibility Study Report
	60588975
Ref	p:\cbr\60588975\500_deliv\504_deliverables\feasibility study report\final\60588975_bindubi st-william hovell drive_feasibility report_rev.b.docx
Date	09-Jul-2019
Prepared by	[redacted]
Reviewed by	[redacted]

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
A	24-May-2019	Draft Report	[redacted]	
B	09-Jul-2019	Final Report		[redacted]

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List of Abbreviations

AACA	: Aboriginal Archaeological Constraints Assessment
ACT	: Australian Capital Territory
AEC	: Area of Environmental Concern
AGRD	: Austroads Guide to Road Design
ARI	: Average Recurrence Interval
ATAP	: Australian Transport Assessment and Planning
BCR	: Benefit-Cost Ratio
BGW	: Box-Gum Woodland
BNT	: Bicentennial National Trail
BS	: Bindubi Street
BSE	: Bindubi Street Extension
CBA	: Cost Benefit Analysis
CBR	: California Bearing Ratio
CFA	: Continuous Flight Auger
CFF	: Conservator of Flora and Fauna
CoRTN	: Calculation of Road Traffic Noise
CSTM	: Canberra Strategic Transport Model
DBYD	: Dial Before You Dig
DCP	: Dynamic Cone Penetrometer
DEM	: Digital Elevation Map
DSUI	: Design Standard for Urban Infrastructure
EIS	: Environmental Impact Statement
EPBC Act	: Environment Protection and Biodiversity Conservation Act
EPSDD	: Environment, Planning and Sustainable Development Directorate
ESA	: Environmental Site Assessment
GDE	: Gungahlin Drive Extension
GIS	: Geographical Information System
HC	: Human Capital
HCM	: Highway Capacity Manual
IC	: Intersection Count
IFCW	: Infrastructure Finance and Capital Works
IPT	: Inter-town Public Transport
JGD	: John Gorton Drive
MCA	: Multi-Criteria Analysis
MUSIC	: Model for Urban Stormwater Improvement Conceptualisation
NC Act	: Nature Conservation Act
NMG	: Noise Management Guidelines
NPV	: Net Present Value
OD	: Origin-Destination
PD Act	: Planning and Development Act
PSP	: Preliminary Sketch Plan
TBL	: Triple Bottom Line
TCCS	: Transport Canberra and City Services
VHT	: Vehicle Hours Travelled
VKT	: Vehicle Kilometres Travelled
VOC	: Vehicle Operating Cost
WHD	: William Hovell Drive
WHS Act	: Work Health and Safety Act
WSUD	: Water Sensitive Urban Design
WTP	: Willingness-to-Pay

Executive Summary

Infrastructure Finance and Capital Works (IFCW) on behalf of Environment, Planning and Sustainable Development Directorate (EPSDD) commissioned AECOM to undertake a feasibility study to determine the preferred treatment of the Bindubi Street (BS) and William Hovell Drive (WHD) intersection that can accommodate future traffic and transport demand. The intersection is located northwest of Glenloch Interchange and on the eastern extent of the Molonglo Valley Stage 3 (Molonglo 3) development. BS is planned to extend across WHD, forming Bindubi Street Extension (BSE), which will then ultimately connect with John Gorton Drive (JGD) within Molonglo 3. This results in the formation of a four-way intersection at BS and WHD, as shown in Figure ES-1.

Figure ES-1: Location of BS and WHD Intersection

The project's primary objective is to investigate options and deliver a feasibility study for a suitable design layout grade for the BS – WHD intersection. The intersection design will need to consider its inter-operability with the nearby traffic arrangements of Glenloch Interchange, Coulter Drive and JGD. While grade separation is a main consideration, AECOM has also investigated possible at-grade solutions.

Options Analysis

Initial traffic modelling results have indicated that a 'Do Nothing' approach (i.e. a four-way at-grade intersection) at the BS – WHD intersection will perform very poorly, with very high average delays incurred by the major traffic movements. The following intersection upgrade options were conceptualised to improve the intersection's traffic performance:

- Option 1: At-grade quadrant intersection
- Option 2: At-grade quadrant intersection with flyover (bridge over WHD)
- Option 3: Diamond interchange
- Option 4: Small at-grade quadrant intersection with flyover (Option 2 variant with a smaller loop)

The four options were evaluated using Multi-Criteria Analysis (MCA), which was informed by detailed traffic modelling and analysis, preliminary environmental investigations, opinion of probable costs, land take estimates, and qualitative assessments of accessibility and urban amenity. A Design Options Report was prepared, which was then presented and discussed in a Design Options Workshop with ACT Government stakeholders. After the workshop, the design options were re-assessed in an MCA that is structured using a Triple Bottom Line (TBL) approach. The final MCA results indicated that

Option 4 is the best upgrade option for the intersection and was therefore selected as the preferred option to be progressed to Preliminary Sketch Plan (PSP) design.

Preliminary Sketch Plan (PSP) Design – Limited

The preferred option's layout was further refined, designing the proposed interchange with the following considerations:

- Topography – The horizontal and vertical alignments of each road component were optimised to integrate well with the existing environment and constraints.
- Existing road network – The design takes into account the existing road infrastructure, including Glenloch Interchange, as well as traffic operations, both current and future.
- Existing utilities – The alignments are designed to minimise impacts on existing utilities, proposing service relocations where appropriate.
- Ecology, heritage, contamination and noise – The conceptualisation of the intersection upgrade layout considered impacts on the environment.
- Future light rail – There is allowance for future light rail to be constructed on the median and between the proposed twin bridges over WHD.
- Construction staging and traffic management – The design of the interchange takes into consideration how it will be constructed and how the construction activities will impact current traffic movements.
- Cost – The design minimises costs without sacrificing service levels, providing the most cost-effective solution.

This is a feasibility study and while the design drawings developed as part of this study are at a PSP level, they are not a complete set and are only limited to General Arrangement (Site Plans), Longitudinal Sections and Typical Cross-Sections.

The final PSP design layout of the proposed grade-separated interchange is shown below in Figure ES-2. The upgraded intersection has the following operational features:

- Separates the BS/BSE and WHD traffic via twin bridges over WHD, greatly reducing the conflicts at the intersection
- Provides uninterrupted flow for the westbound through movements on WHD
- Introduces a loop ramp at the northwest quadrant of the intersection that facilitates the following movements:
  - Right-turning traffic from BSE heading towards Glenloch Interchange; this will be signal-controlled at the downstream end of the ramp
  - Right-turning traffic from WHD westbound heading towards BS; this will be signal-controlled as well
  - Left-turning traffic from WHD eastbound heading towards BS
- Includes a continuous ramp for left-turning traffic from BS heading towards Glenloch Interchange that ultimately merges onto the existing eastbound carriageway of WHD
- Provides an off-ramp for left-turning traffic coming from Glenloch Interchange heading towards BSE. This off-ramp also facilitates on-road cycling movements from Glenloch Interchange heading towards either BS or BSE.
- Provides an on-ramp for WHD westbound, facilitating movements for left-turning traffic from BSE and right-turning traffic from BS. Note that the forecasted demands for these movements are very low.
- Allows for a 12-metre median (measured from the inner edges of the through travel lanes between the two carriageways) along the BS/BSE for future construction of light rail

- Includes the construction of twin bridges over WHD, linking BS with BSE. The new bridges consist of a symmetrical 27 m long twin span, Super-T bridge with piers in the central median of WHD.

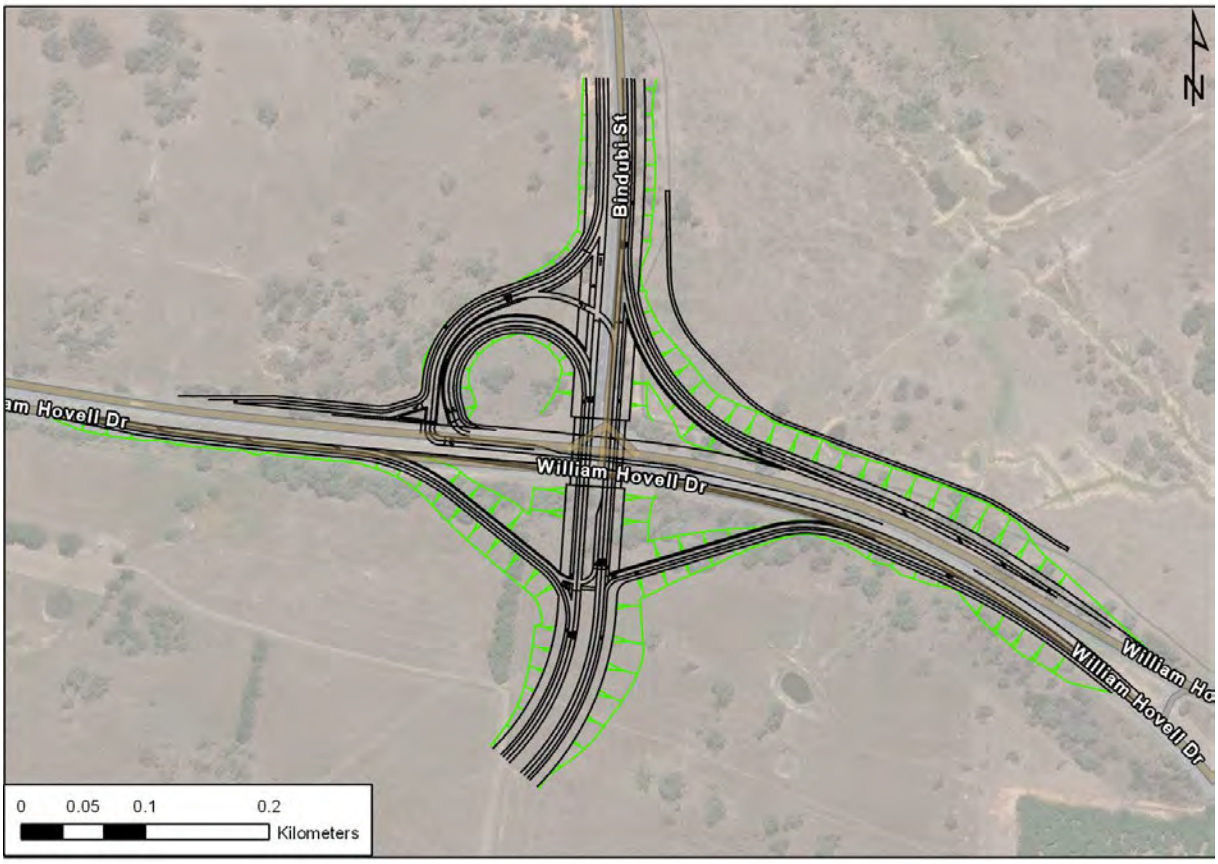


Figure ES-2: PSP design of the preferred intersection option (Option 4)

Preliminary Cost Estimate and Cost Benefit Analysis (CBA)

Preliminary costs have been estimated and the total cost of the intersection upgrade is expected to be **$47.8 million (inclusive of GST and 40% Contingency)**. This cost is expected to be further refined to P50/P90 estimates in the next stage of the project.

The CBA results indicate positive results, with a **BCR of 4.7** and **NPV of $122.21 million** under a discount rate of 7%. Sensitivity analysis was undertaken with discount rates of 4% and 10% and the results show that the project remains economically viable with resulting BCRs significantly higher than 1.0. The CBA results demonstrate the significant benefits of de-congestion of a major intersection and provide robust quantitative support to establish that this is a low-cost high impact project.

Conclusions and Recommendations

The technical and economic feasibility of upgrading the BS – WHD intersection has been investigated. Possible upgrades, including both at-grade and grade separated options, were initially conceptualised and assessed via an MCA process that was presented to and discussed with ACT Government stakeholders. A preferred option, the small at-grade quadrant with flyover, was selected and progressed to PSP design (at a limited level).

Based on the outcomes of the investigations undertaken and the results of the CBA, the proposed grade-separated solution for the BS – WHD intersection is therefore considered technically and economically feasible. There are constraints and challenges in implementing the upgrade that require significant capital works expenditure to overcome, but the economic returns to road users and the community provide sufficient justification to build this major transport infrastructure.

The following are recommended for consideration in the next stage of design:

- Possible reduction of the asphalt base course at the ramps/loops and BS that are projected to carry less traffic
- Additional geotechnical to confirm the preliminary design CBRs.
- Additional geotechnical investigation to confirm groundwater level
- Development of bridge foundation design parameters
- Full engineering survey of the whole site of works
- Completion of a full PSP or Final Sketch Plan (FSP) design submission to confirm the design subject to receipt of a detailed engineering survey
- Arboricultural assessment of the identified potential scarred tree at the northwest quadrant of the BS – WHD intersection
- The interchange should be constructed prior to the duplication of BS and BSE construction to avoid significant traffic management implications and redundant works as would occur if BS duplication and BSE were the initial construction.
- Road safety audit to include an assessment on on-road cycling facilities and their interaction with high speed traffic and heavy vehicles.

1.0 Introduction

1.1 Background

Infrastructure Finance and Capital Works (IFCW) on behalf of Environment, Planning and Sustainable Development Directorate (EPSDD) engaged AECOM to undertake a feasibility study to determine the preferred treatment of the Bindubi Street (BS) and William Hovell Drive (WHD) intersection that can accommodate future traffic and transport demand.

The BS – WHD intersection is located northwest of Glenloch Interchange and on the eastern extent of the Molonglo Valley Stage 3 (Molonglo 3) development as shown in Figure 1. It is envisaged that BS will extend across WHD, forming Bindubi Street Extension (BSE), which will then connect with John Gorton Drive (JGD) within Molonglo 3. This results in the formation of a four-way intersection at BS and WHD.

Figure 1: Location of BS and WHD Intersection

The intersection between BS/BSE and WHD is a critical component of the arterial road network surrounding Molonglo. It provides a direct link between the future Molonglo 3 development east of JGD and WHD. It will also facilitate future Inter-town Public Transport (IPT) routes from Molonglo to Belconnen.

Notwithstanding the capacity constraints at Glenloch Interchange, the intersection needs to perform at acceptable levels to ensure that the flow of traffic along both BS and WHD are not unreasonably delayed. This will become particularly challenging once the whole Molonglo development is complete, with WHD expected to absorb a significant proportion of the traffic demand generated by Molonglo. This is in addition to the demand already being generated by nearby Belconnen suburbs and the future demand generated by West Belconnen.

In the morning peak period, the intersection will be the point of convergence of Glenloch-bound traffic coming from WHD in the west, BS in the north and BSE in the south. Conversely, in the afternoon peak, the reverse flow occurs with the intersection absorbing the peak flow from Glenloch Interchange before it gets distributed between WHD, BS and BSE. It is therefore very important to design a suitable intersection layout that will address these peak flow movements and keep the intersection's service levels within acceptable standards.

1.2 Objective

The project’s primary objective is to investigate options and deliver a feasibility study for a suitable design layout grade for the BS – WHD intersection. The intersection design will need to consider its inter-operability with the nearby traffic arrangements of Glenloch Interchange, Coulter Drive and JGD. While grade separation is a main consideration, AECOM has also investigated possible at-grade solutions.

1.3 Options Analysis

Initial traffic modelling results have indicated that a ‘Do Nothing’ approach (i.e. a four-way at-grade intersection) at the BS – WHD intersection will perform very poorly, with very high average delays incurred by the major traffic movements. The following design options, shown in Figure 2 to Figure 4, were then conceptualised to improve the intersection’s traffic performance:

- Option 1: At-grade quadrant intersection

Figure 2: At-grade quadrant intersection

- Option 2: At-grade quadrant intersection with flyover (bridge over WHD)

Figure 3: At-grade quadrant intersection with flyover

- Option 3: Diamond interchange

Figure 4: Diamond interchange

- Option 4: Small at-grade quadrant intersection with flyover (Option 2 variant with a smaller loop)

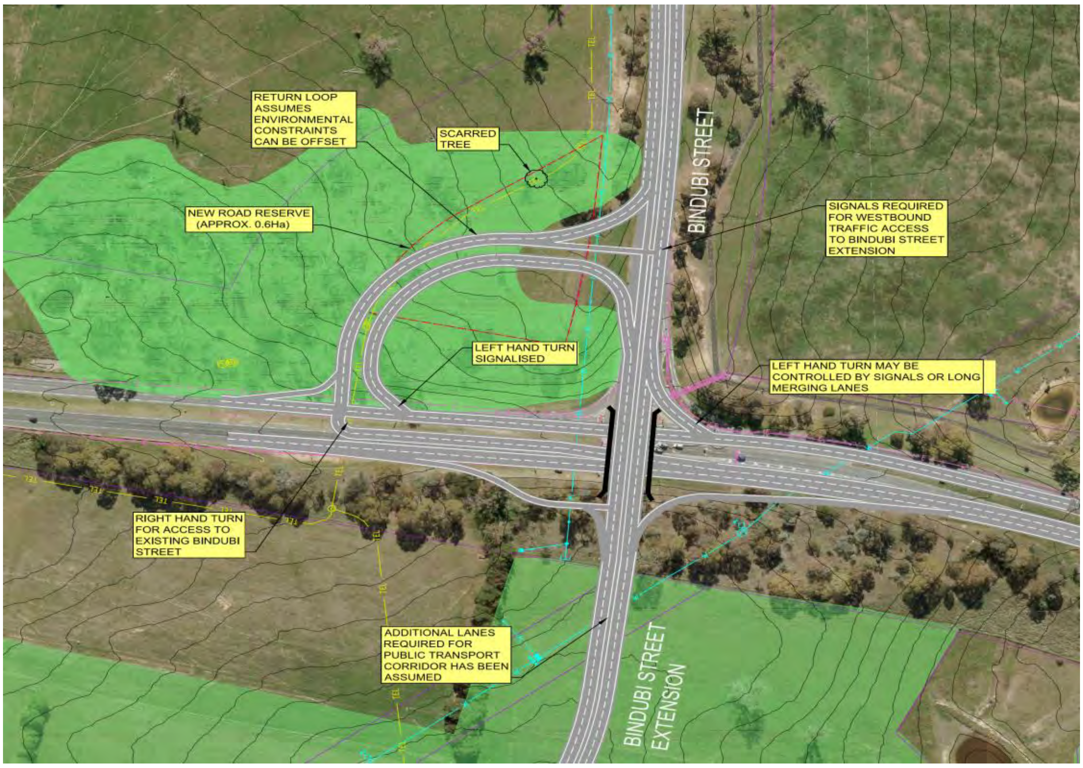


Figure 5: Small at-grade quadrant intersection with flyover

Each of these options were assessed and compared against each other using Multi-Criteria Analysis (MCA). Initially, the following categories were used:

- Traffic performance
- Safety
- Social impacts
- Environmental impacts
- Feasibility

These categories were further broken down into 12 qualitative and quantitative assessment criteria, with weightings that were initially agreed with EPSDD. GIS mapping, traffic microsimulation modelling, crash analyses, environmental analyses, high-level constructability reviews and preliminary cost estimation were undertaken to inform the evaluation and scoring of these criteria.

The design options and the initial MCA results were then summarised in the Design Options Report (included here as Appendix A), which had a draft recommendation of selecting Option 2 as the preferred option because it satisfactorily addresses the traffic issues and minimises the impacts on the Box-Gum Woodland (BGW) located at the northwest quadrant of the intersection. Option 4 was a close second as the preferred option. Its traffic performance is very similar to Option 2, but it was given a lower score in *Environmental impacts* because the smaller loop ramp cuts through the BGW.

The Design Options Report was presented to ACT Government stakeholders on 15 March 2019 in a Design Options Workshop. The advice provided by the representative from the Conservator of Flora and Fauna (CFF) was that the condition of the BGW is relatively poor and is therefore unlikely to be a major constraint in the development of design options. Furthermore, CFF advised that while Option 2 tries to avoid directly impacting the BGW by building a larger loop ramp, it will also isolate the BGW such that it could degrade over time. Minimising the size of the loop ramp is therefore preferred because it will result in reduced impacts on the BGW, which then means that Option 4 should score higher than Option 2 in terms of environmental impacts.

It was agreed during the Design Options Workshop to update the MCA to follow a Triple Bottom Line (TBL) approach and update the weightings of each criterion. The revised MCA adopted the following categories and corresponding weightings:

- Social – 25%
- Environmental – 25%
- Economic – 50%

The assessment criteria assigned for each of these categories, including the agreed weightings and descriptions of how each was measured/scored, are summarised in Table 1.

Table 1: Updated MCA criteria for options analysis

Category	Criteria	Measurement	Unit	Comment
Social (25%)	Network legibility (3%)	Readability of option for visitors to area	H/M/L	Options were ranked based on a discussion regarding how easy a network layout is for a driver to understand. H=5, M=3, L=1
	Protects urban amenity (2%)	Potential visual and noise impacts of option	(-) H/M/L	H=1, M=3, L=5, i.e. Low is good.
	Accessibility (10%)	Accessibility of option for active travel	H/M/L	Based on traffic signals increasing the ability of pedestrians to be able to navigate through the intersection. i.e. the more traffic signals, the higher the rating
	Improves user safety for all modes (10%)	Potential reduction crashes for option	crash savings ($)	Reduction rates are based on the RTA Accident Reduction Guide, which specifies rates for different upgrade types. These are then applied to crashes to determine the reduction. Crash costs are calculated as WTP costs.
Environmental (25%)	Biodiversity impacts (10%)	Potential of option to impact biodiversity	(-) H/M/L	Based on a discussion by the project team and therefore professional opinion. Incorporates notes and agreements in the Workshop on 15/03/2019
	Community impacts (6%)	Potential of option to impact heritage, community gardens or property access	(-) H/M/L	Based on a discussion by the project team and therefore professional opinion.
	Air emissions (9%)	Environmental emissions	(-) tonne	Based on Aimsun results
Economic	Whole of Life Costs (25%)	Costs expected to be accrued during construction and required maintenance	(-) $	Present Value of (Detailed in WOLC tab): 1. Capital cost 2. Maintenance costs over a 30-year life 3. Land acquisition costs

Category	Criteria	Measurement	Unit	Comment
	Benefits (25%)	Estimated 2031 benefits	$	NOT whole-of life benefits. Just the sum of travel time cost and accident cost savings for 2031.

The updated MCA results, outlined in Table 2, places Option 4 as the highest-ranking option and therefore the selected design layout to progress into Preliminary Sketch Plan (PSP) design. This preferred design option has been discussed and agreed with IFCW, EPSDD and TCCS.

Table 2: MCA results – values in parentheses are raw scores

Category	Criteria	Option 1	Option 2	Option 3	Option 4
Social (25%)	Network legibility (3%)	0.03 (L)	0.03 (L)	0.15 (H)	0.09 (M)
	Protects urban amenity (2%)	0.10 (L)	0.10 (L)	0.06 (M)	0.10 (L)
	Accessibility (10%)	0.50 (H)	0.10 (L)	0.30 (M)	0.10 (L)
	Improves user safety for all modes (10%)	0.10 (-$0.40M)	0.33 ($0.66M)	0.50 ($1.44M)	0.33 ($0.66M)
Environmental (25%)	Biodiversity impacts (10%)	0.30 (M)	0.30 (M)	0.10 (H)	0.50 (L)
	Community impacts (6%)	0.30 (L)	0.30 (L)	0.18 (M)	0.30 (L)
	Air emissions (9%)	0.09 (23.46t)	0.45 (19.35t)	0.27 (21.45t)	0.44 (19.45t)
Economic (50%)	Whole of Life Costs (25%)	1.25 ($26.62M)	0.39 ($80.94M)	0.25 ($89.43M)	0.48 ($74.81M)
	Benefits (25%)	0.25 ($21.30M)	1.24 ($92.50M)	0.73 ($56.03M)	1.25 ($93.43M)
Total Score		**2.92**	**3.23**	**2.54**	**3.59**
Rank		**3**	**2**	**4**	**1**

1.4 Study Limitations and Assumptions

This is a feasibility study and while the design drawings developed as part of this study are at a Preliminary Sketch Plan (PSP) level, they are not a complete set and are only limited to General Arrangement (Site Plans), Longitudinal Sections and Typical Cross-Sections.

The design layout of the is limited to the intersection only and does not extend further than necessary. Improvements to nearby intersections, such as Glenloch Interchange and Coulter Drive – WHD intersection, are considered to be undertaken as part of other feasibility and/or design studies.

The development of the intersection upgrade design assumes that BSE is already in place and BS has been duplicated. In terms of operations, BS is assumed to maintain its posted speed limit at 80 km/h. BSE on the other hand, while having two lanes per direction, is assumed to only accommodate one lane to general traffic and the other one exclusive to transit.

The BS/BSE corridor is the assumed Inter-town Public Transport (IPT) route between Molonglo and Belconnen. A 12-metre median has been allowed for future light rail.

Stormwater and WSUD requirements are limited to preliminary design advice showing stormwater overland flow directions and indicative drainage structure locations

Construction staging and traffic management are limited to preliminary advice only.

Conceptual street lighting advice will be limited to indicative street lighting offset and spacing requirements. No street lighting design will be undertaken as part of this feasibility study

Preliminary bridge design is limited to determining bridge span length requirements and typical cross sections.

1.5 This Document

This document provides details of the feasibility study undertaken for the upgrade of the BS – WHD intersection. It includes summaries of preliminary investigations undertaken earlier in the study, particularly during the options analysis process, details of the (limited) Preliminary Sketch Plan design, updated cost estimates, and economic analysis via a Cost Benefit Analysis (CBA).

This report is structured to describe preliminary work done to establish the preferred option, design criteria and requirements, preliminary cost estimates and the CBA process to determine the project's economic feasibility.

The following are brief descriptions of each section of the report:

- **Section 1.0** provides background information on the project, the options analysis process, and the study limitations and assumptions
- **Section 2.0** summarises the preliminary environmental investigations undertaken and how the findings informed the study
- **Section 3.0** presents a summary of the traffic modelling and analysis results, which were used in the assessment of options
- **Section 4.0** includes details of the civil infrastructure design (at a limited PSP level), as well as preliminary geotechnical, stormwater/WSUD, utilities, street lighting, and construction staging advice
- **Section 5.0** outlines the Safety in Design process
- **Section 6.0** provides preliminary cost estimates of the proposed intersection upgrade
- **Section 7.0** presents the CBA process and outcomes
- **Section 8.0** outlines the study's conclusions and recommendations for future work

2.0 Environmental Considerations

Environmental considerations were accounted for during the assessment of different design options and were discussed during the Design Options Workshop. It should be noted that at the Design Options Workshop, CFF advised that Options 2 and 3 were expected to have a larger detrimental impact on the environment because:

- Option 2: results in a large section of enclosed land that would be hard to maintain and would likely suffer long term
- Option 3: realignment of the existing BS cuts directly through a row of trees that are known to help facilitate east-west movements of wildlife.

The following sections summarise the preliminary environmental investigations undertaken as part of the feasibility study.

2.1 Biodiversity

A biodiversity constraints assessment was conducted as part of the options analysis process to identify key ecological features of the existing environment within the project area and the likelihood of occurrence of matters protected under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and the Nature Conservation Act 2014 (NC Act).

The biodiversity constraints assessment results showed that BGW patches to the west of BS and north of WHD should be avoided and conserved as far as practical within the new design. The design should seek to retain large remnant habitat trees wherever possible (both within and outside mapped patches of BGW). A significant impact to EPBC Act, BGW would trigger an EPBC referral which is to be avoided if possible. A significant impact to NC Act BGW would trigger an Environmental Impact Statement (EIS) under the Planning and Development (PD) Act and should be avoided if possible.

Further details on the preliminary biodiversity investigations can be found in the Design Options Report in Appendix A.

2.2 Heritage

Key findings of the preliminary heritage assessment undertaken during the options analysis phase of the study are presented in this section. Further details, including recommendations, can be found in the Design Options Report in Appendix A.

2.2.1 Aboriginal

An Aboriginal Archaeological Constraints Assessment (AACA) was conducted as part of the options analysis process to identify known and potential Aboriginal heritage constraints within the project area and to provide appropriate management advice for further design development.

The key findings of this due diligence assessment are as follows:

- Seven previously identified Aboriginal sites have been identified within the project area
- No new Aboriginal objects were identified during the visual inspection component of this assessment
- Land adjacent to Black Mountain Creek located in the north eastern portion of the Project area is considered archaeologically sensitive and likely to contain subsurface archaeological deposit
- Land within the Project area has been subject to varying levels of disturbance, with the most severe impacts occurring as a result of road and dam construction
- The potential for impacts to Aboriginal objects within the project area is considered to be high.

The Aboriginal heritage assessment recommends avoiding impacts to Aboriginal site where possible. Should impacts be unavoidable, archaeological salvage incorporating surface collection of surface sites, archaeological test and potential open area excavation of PAD sites/areas of archaeological sensitivity should be undertaken.

The identified potential scarred tree (Site 14) should be subject to arboricultural assessment for the purpose of ascertaining the origin of the scar to inform management. The scarred tree is directly impacted by the alignment of the proposed loop ramp (see Section 4.3.1.2) so the arboricultural assessment is a critical step in determining how to address this impact.

2.2.2 Historical

The historical research indicated that the study area was cleared paddocks used for grazing purposes from at least 1911 onwards. There is no indication that structures were erected within the Project area. A site inspection confirmed that are no standing structures within the study area and it is considered unlikely to be subsurface archaeological deposits contained within the Project area. Therefore, historic heritage is not considered to form a constraint on the design of the proposed intersection upgrades.

One of the recommendations in the historical heritage assessment is that access for users of the Bicentennial National Trail (BNT) should be maintained. Consultation with Bicentennial National Trail Limited may be warranted towards this end.

2.3 Contamination

An Environmental Site Assessment (ESA) was undertaken to identify potential Areas of Environmental Concern (AECs) within the study area. This section provides a brief summary of the following risks posed by each AEC to the proposed BS – WHD interchange:

- RobC_AEC10 - Dam

  Based on the results of chemical analyses performed by WSP (2016), there are no plausible linkages identified between RobC_AEC10 and the relevant identified receptors.

- WSP_AEC30 - Firing Range

  Based on the uncertainty surrounding the presence of UXO and/or EOW within the current Study Area (as a result of ricochet etc.), potential risk exists to the following sensitive receptors:

  - On and off-site construction workers
  - On and off-site itinerant recreational users.

- WSP_AEC31 – Herbicide and pesticide usage

  Based on the results of chemical analyses performed by WSP (2016) and the topography (i.e. expected stormwater flow direction from AEC31), there are no plausible linkages identified between WSP_AEC31 and the relevant identified receptors.

- AEC 7 – Cook Community Garden

  Based on the absence of chemical inventory information (for chemicals used at the Cook Community gardens) and chemical analyses, and along with the local topography and stormwater infrastructure suggesting run off from the Cook Community Gardens is directed to the greased swale and culvert servicing BS, potential risks exist to the following sensitive receptors:

  - On and off-site construction workers
  - Stormwater drains and receiving ephemeral streams along BS and east within Block 1549.

- AECOM_AEC1 – Waste dumping and surface wastes

  Based on the uncertainty surrounding the potential for additional dumping (either presently on-site and unidentified, or to be placed in the period between reporting and development), potential risk exists to the following sensitive receptors:

  - On and off-site construction workers; and
  - On and off-site itinerant recreational users.

To manage the risks identified above, the following actions have been recommended:

- Sediment and/or shallow soil testing within the grassed drainage swale located on the western verge of BS to identify if CoPC are present in sediments/soils receiving run off from the Cook Community Gardens (AEC7)
- Incorporation of the UFMP (WSP 2017) into the Construction Environmental Management Plan (CEMP) as required for the BS – WHD interchange and subsequent implementation to manage potential risks associated with WSP_AEC30 and AECOM_AEC1
- Noting the extent of the area included in the UFMP, consideration should be given to the erection of warning signage for public access areas within the Study Area.

2.4 Noise

The BS – WHD interchange has the potential to change the existing noise environment at nearby existing and proposed sensitive receivers. This noise assessment undertaken for the preferred option provides preliminary advice regarding likely noise mitigation requirements in accordance with the Roads ACT Noise Management Guidelines (NMG).

The assessment focusses on the BS/BSE – WHD intersection, including a portion of the BSE one kilometre from the intersection, for the purposes of considering the full impact of intersection upgrade.

This section summarises the relevant findings of the noise assessment, but more detailed discussions are included in the letter report in Appendix B.

2.4.1 Criteria

The proposed interchange would be considered as an upgrade of an existing road in an existing area, however the BSE would be considered as a new road. The noise level criteria for road upgrades and new roads are outlined in Table 3 and Table 4. These noise criteria apply to the maximum traffic flow for upgraded and new roads. For the purposes of this study, traffic demand forecasts for the year 2041 have been considered to be the maximum traffic flow.

Table 3: Traffic noise levels resulting from upgraded road in existing areas of noise sensitive land use, expressed as $L_{Aeq(15hour)}$, dB(A)

Sound Pressure Level, $L_{Aeq(15hour)}$ dB(A), daytime, 7am to 10pm	
Existing traffic noise level at adjacent buildings(1)	**Traffic noise level at adjacent buildings after road works completed**
> 60	Equal to existing level (not greater than 65)
55 – 60	60
< 55	Not more than 5 dB(A) above existing level

Notes:

(1) Measured at the most affected façade and includes façade reflection

(2) The traffic noise levels incorporate an allowance for reflection from the facade of the building under investigation. Measurements should be taken at one metre forward of the building facade. In cases where the building is not yet constructed, measurements should be taken at a distance of one metre in front of the proposed building facade, or one metre forward of the minimum set-backs required under the Territory Plan, and 2.5 dB(A) added to the measurement to allow for future facade reflection. Measurements should be taken at a height of 1.2 - 1.5 metres above ground level.

Table 4: Maximum external traffic noise level (target level) at the development from a new road

Sound Pressure Level	
Land Use	**Target noise level**
Residential and community facilities daytime $L_{Aeq(15\ hour)}$	60 dB(A)

Sound Pressure Level	
Land Use	**Target noise level**
Residential night-time $L_{Aeq(9\ hour)}$	55 dB(A)

Notes:

(1) The acceptable traffic noise levels incorporate an allowance for reflection from the facade of the building under investigation. Measurements and predictions should be taken at one metre forward of the building facade. In cases where the building is not yet built, measurements should be taken at a distance of one metre in front of the proposed building facade, and 2.5 dB(A) added to the measurement to allow for future facade reflection. Measurements should be taken at a height of 1.2 - 1.5 metres above ground level or the known floor level.

(2) Note that, for second and subsequent levels of a building, additional set-back distance is required to achieve the required criterion value in the table owing to the reduction in the sound energy from ground attenuation over soft ground. A combination of set-back distance and other measures (e.g. use of appropriate insulation materials in construction) to meet the guideline requirements.

2.4.2 Road Traffic Noise Modelling

Road traffic noise levels were calculated using the Calculation of Road Traffic Noise (CoRTN) algorithm. The UK Department of Transport devised the CoRTN algorithm and with suitable corrections, this method has been shown to give accurate predictions of road traffic noise under Australian conditions. Generally assuming no change in the traffic mix or average speed, a doubling of the traffic volume or halving of distance to the road is required to produce a 3 dB(A) increase in the resultant noise.

Details of traffic volumes used in the modelling and the noise modelling parameters are found in the letter report in Appendix B.

The road traffic noise levels calculated at existing receivers are presented in Table 5 below for both the existing situation and after the BS – WHD intersection upgrade.

Table 5: Road traffic noise levels in 2018 and 2041 at existing residential receivers

Address	Road type	Existing road noise level	Criteria	Design 2041	Exceedance
121 William Hovell Drive Northern Facade	Upgraded road	57 $L_{Aeq(15h)}$	60 $L_{Aeq(15h)}$	60 $L_{Aeq(15h)}$	No
121 William Hovell Drive Southern Facade	New Road Daytime	Not applicable	60 $L_{Aeq(15h)}$	57 $L_{Aeq(15h)}$	No
	New Road Night-time	Not applicable	55 $L_{Aeq(9h)}$	50 $L_{Aeq(9h)}$	No

Road traffic noise levels were calculated south of WHD and north and south of the proposed BSE. These road traffic noise levels were used to calculate the buffer distances required, shown in Table 6, to achieve noise levels that meet the criteria in Table 4 within the proposed medium density residential areas.

Table 6: Buffer distances required in medium density residential areas to achieve road traffic noise criteria

Road	Buffer distance (m)
William Hovell Drive	135 m
Bindubi Street Extension	75 m

Where residential development is proposed within these buffer distances then noise mitigation measures would be required. This could include barriers or building design features such as upgraded glazing and the provision of mechanical ventilation.

The preliminary noise assessment shows that the road traffic noise levels resulting from the proposed BS – WHD interchange would meet the criteria detailed in the NMG. There is no requirement for further consideration of mitigation measures at this stage.

The findings in this preliminary noise assessment should be confirmed during the detailed design phase of the project.

3.0 Traffic Analysis

Traffic considerations were considered during the options analysis stage and all options were modelled and considered. The performance of each option was assessed using traffic microsimulation modelling, weaving assessment using Highway Capacity Manual (HCM) procedures and crash analysis.

The following sections contain summaries/excerpts from the detailed traffic modelling and analysis previously undertaken. Further details can be found in the Transport Analysis section of the Design Options Report in Appendix A.

3.1 Existing Traffic Demand (2018)

Traffic surveys were conducted to understand the existing traffic demand at the intersection and the surrounding road network. The traffic survey data were also used to calibrate and validate the base microsimulation model, which was developed using Aimsun.

The following surveys were undertaken:

- Origin-Destination (OD) survey
- Intersection Count (IC) survey

The locations of the OD and IC surveys are shown in Figure 6 and Figure 7, respectively. The OD survey station locations were selected to cordon the entering and exiting traffic within the road network surrounding the BS – WHD intersection. The intersection turning movement counts were collected at the following intersections:

1. William Hovell Drive – Coppins Crossing Road
2. William Hovell Drive – Coulter Drive
3. William Hovell Drive – Bindubi Street
4. Glenloch Interchange
5. Lakeside Interchange

Figure 6: Origin-Destination survey station locations

Figure 7: Intersection Count survey locations

The surveys were conducted on a weekday (Thursday 22 November 2018) for both AM and PM peak periods (AM peak – 7:30am to 9:30am, PM peak – 4:30pm – 6:30pm). Intersection counts were recorded for light and heavy vehicles in fifteen-minute intervals.

The OD surveys were done using number plate matching and the data for the AM and PM peak periods are shown in Table 7 and Table 8, respectively. The origin and destination numbering in these tables are consistent with the OD station numbers shown in Figure 6. The percentage matching in the AM and PM surveys was, on average, at 97% and 94%, respectively, so the data accuracy and reliability are very good.

The OD data confirms that most of the traffic demand in the AM peak are heading towards the City via Parkes Way (OD Station 6), with over 7,000 vehicles mostly coming from WHD and Gungahlin Drive Extension (GDE). The reverse is true in the PM peak, with over 6,800 vehicles coming from Parkes Way and distributed across WHD, GDE and Tuggeranong Parkway.

Table 7: OD Data - AM Peak, 7:30am-9:30am

O \ D	1	2	3	4	5	6	7	8	9	Total
1	1	5	384	7	5	1382	4	122	780	2690
2	5	0	208	2	2	1043	4	103	615	1982
3	160	203	0	9	5	10	0	7	0	394
4	5	0	16	1	3	684	1	83	404	1197
5	3	0	0	13	37	2502	26	691	4418	7690
6	295	226	15	549	1032	5	16	12	476	2626
7	0	0	0	1	8	2	0	8	3	22
8	29	42	0	64	143	180	8	0	160	626
9	290	253	2	514	3276	1224	22	1184	35	6800
Total	788	729	625	1160	4511	7032	81	2210	6891	24027

Table 8: OD Data - PM Peak, 7:30am-9:30am

O \ D	1	2	3	4	5	6	7	8	9	Total
1	3	10	137	7	5	403	1	50	293	909
2	2	0	221	3	7	297	2	65	224	821
3	318	178	0	10	0	13	0	2	1	522
4	1	1	10	7	12	405	0	74	429	939
5	18	11	1	15	54	1150	5	409	2687	4350
6	1335	584	4	1433	1774	15	3	56	1673	6877
7	2	1	0	2	10	7	0	9	19	50
8	204	138	7	200	750	86	11	0	614	2010
9	588	353	1	622	3890	811	10	83	35	6393
Total	2471	1276	381	2299	6502	3187	32	748	5975	22871

Intersection turning movement counts at the BS – WHD intersection and Glenloch Interchange in the AM (8:00-9:00) and PM (5:00-6:00) peak hours are shown in Figure 8 and Figure 9, respectively. The PM peak is busier than the AM peak at the BS – WHD intersection, with total intersection throughput of 4,225 veh/h in the PM peak and 3,891 veh/h in the AM peak. WHD carries more than double the traffic on BS. The eastern leg of the intersection is busiest with 3,866 veh/h in the AM peak and 4,208 veh/h in the PM peak. BS carries 1,316 veh/h in the AM peak and 1,793 veh/h in the PM peak.

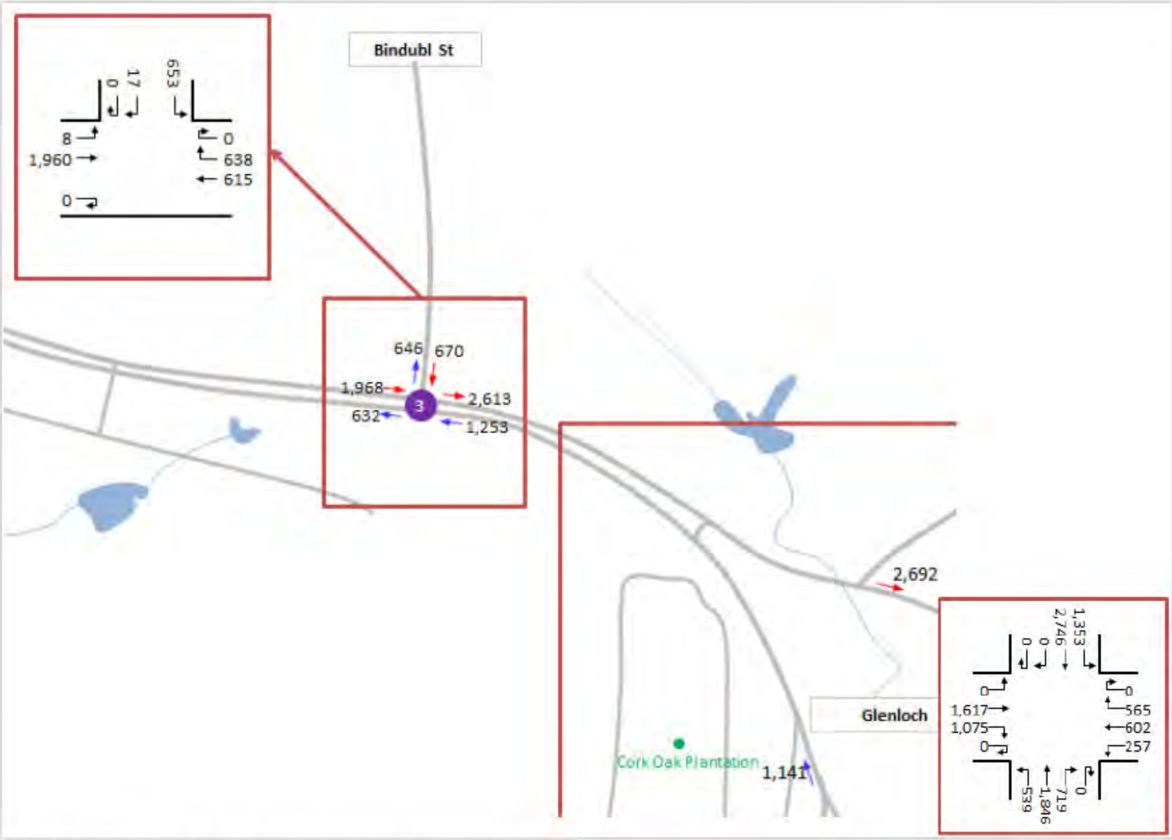


Figure 8: 2018 AM peak intersection turning movements

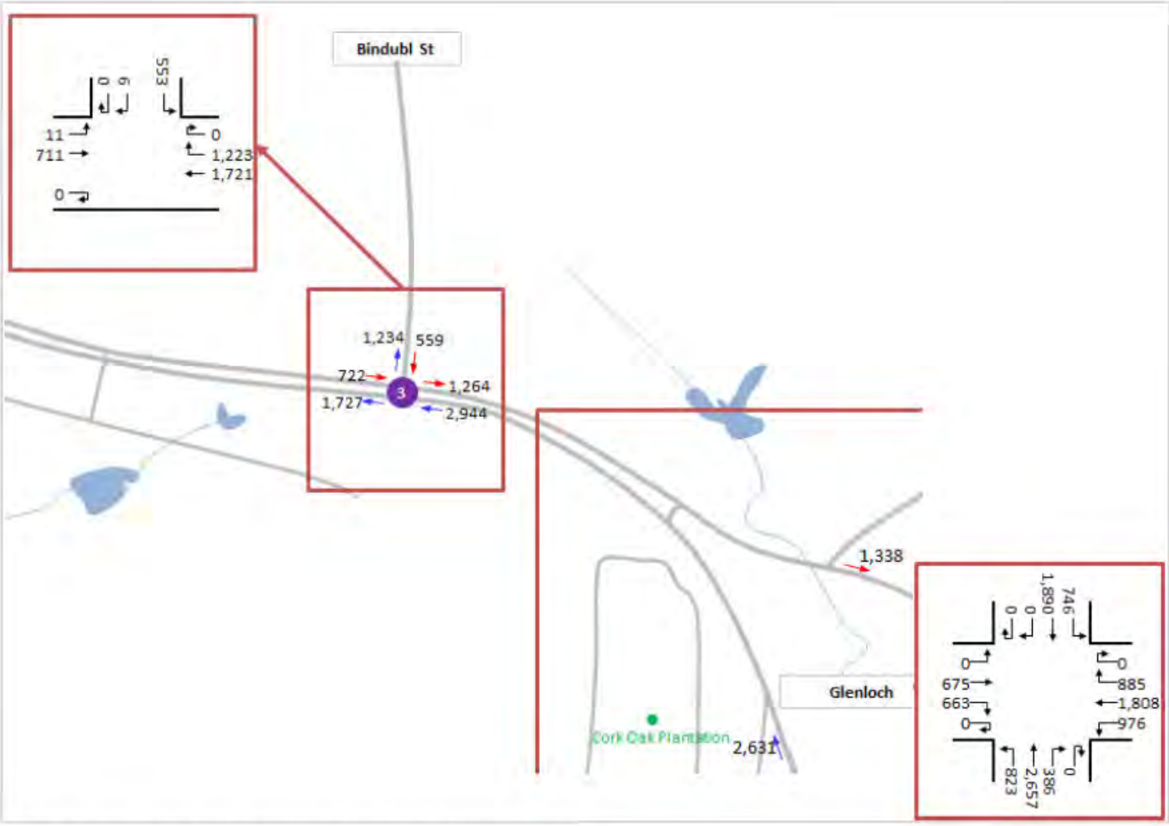


Figure 9: 2018 PM peak intersection turning movements

From the analysis of the 2018 survey data, it was found that in the AM peak, there is a split of traffic travelling eastbound from WHD and BS destined for either Parkes Way or Tuggeranong Parkway. Of 649 vehicles per hour exiting BS in the AM peak 58% are destined for Parkes Way and 42% for Tuggeranong Parkway. This split in traffic is currently managed by different signal phases for WHD and BS traffic, although some lane changing still occurs for vehicles turning right onto Tuggeranong Parkway. It is not a significant issue now but could be for future interchange options.

In the 2018 PM peak, there is a split of traffic travelling westbound from Tuggeranong Parkway and Parkes Way to WHD and BS. The main issue in the PM peak is traffic weaving to turn right at BS – of 1,132 vehicles turning right in the PM peak hour 63% are from Parkes Way and 37% from Tuggeranong Parkway. A total of 423 veh/h from Tuggeranong Parkway have to weave across about 1,808 veh/h from Parkes Way.

3.2 Traffic Demand Forecasts

The existing traffic flows were increased to account for growth by factoring corridor traffic movements by demand estimates obtained from the Canberra Strategic Transport Model (CSTM). The expected growth in traffic through the intersection is summarised in Figure 10. This shows a doubling of traffic over the next 20 years. It indicates roughly an average of 2.9% per annum compound peak hour traffic growth over this time period, which would be difficult to sustain given capacity limitations in the adjoining road system.

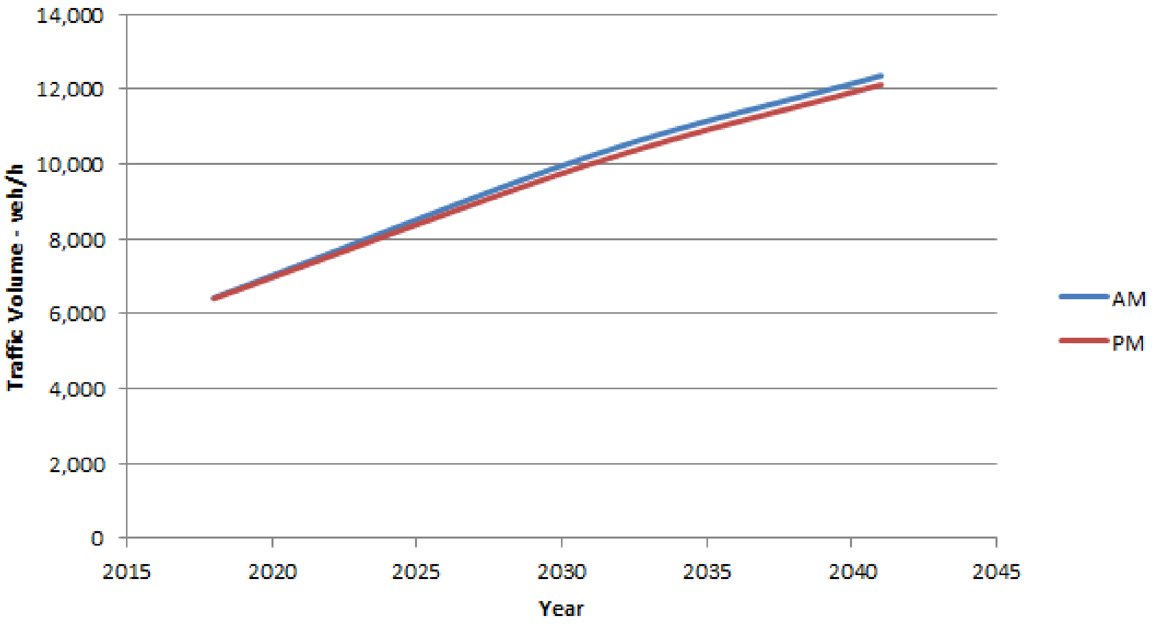


Figure 10: Traffic demand growth at the BS-WHD intersection

The forecast growth in origin-destination movements from 2018 to 2031 and 2041 varies. In the AM peak, the most significant increase in traffic is the right turn from BSE to eastbound on WHD, growing to 811 veh/h in 2031 and 1,108 veh/h by 2041. This will conflict with strong existing movements from both WHD west and BS, creating a challenge to cater for this traffic. From now to 2031 there would also be a large increase in AM peak hour traffic from BS wanting to turn right onto Tuggeranong Parkway (from 274 veh/h in 2018 to 721 veh/h in 2031). This could affect eastbound weave issues if a new eastbound ramp is proposed from BS, as a new ramp would reduce the spacing to Glenloch Interchange and create new weaving issues on this section of road.

In the PM peak, the westbound weave movement is forecast to increase significantly in the next 12 years, exacerbating the existing problems. The right turn into BS is predicted to almost double by 2031 – increasing from of 1,132 veh/h to 2,185 veh/h. Much of this increase will be from Tuggeranong Parkway (69%), further exacerbating the weave. By 2031, a total of 1,148 veh/h from Tuggeranong Parkway have to weave across about 3,166 veh/h from Parkes Way.

3.3 Road Crash History

TCCS provided crash data for the five-year period from 1 January 2014 through 31 December 2018. This enables an assessment of the likely contributory factors to crashes in the area and the development of an understanding of the impact that proposed interchange options are expected to have on road safety.

To better understand and characterise the crash data the site was broken down into areas, shown in Figure 11. These areas include the immediate vicinity of the intersection and each of the existing legs (500 m in length).

The crash data was reviewed to identify crash patterns and trends and assist in understanding the contributory causes of crashes. The analysis of crashes shows that a total of 130 crashes occurred within the combined extent of all areas associated with the intersection and its approaches. Of these there was one fatality, 14 injury and 115 property damage only crashes. The one fatality occurred on BS during the day when a driver struck an off-road object.

A breakdown of crashes by area and crash severity is summarised in Table 9. The highest density of crashes is in the vicinity of the intersection (38) and east of the intersection (52).

Table 9: Breakdown of crashes into severity and location

Areas	Fatalities	Injuries	Property Damage Only	Total
Intersection Area	0	3	35	**38**
William Hovell Drive – East Area	0	7	45	**52**
William Hovell Drive - West Area	0	2	25	**27**
Bindubi Street Area	1	2	10	**13**
Total	**1**	**14**	**115**	**130**

Figure 11: Location of crashes in the 2014 - 2018 period by severity

3.4 Operational Analysis Results

3.4.1 Weaving Analysis

Weaving is defined as the crossing of two or more traffic streams travelling in the same direction and usually occur when merge segments are closely followed by diverge segments. Weaving segments require drivers to engage in lane-changing manoeuvres where there is additional conflict and therefore a reduction in capacity.

The BS and WHD intersection and Glenloch Interchange are located about 1 km apart. This creates likely issues with weaving and difficulty providing a suitable interchange arrangement at BS. While the proximity between the Glenloch Interchange and the BS/WHD intersection mean that it is impossible to eliminate the weave in the eastbound and westbound directions, the Option 4 design layout mitigates the weaving issues to satisfactory levels without needing to relocate the intersection to the west.

Details of the weaving analysis undertaken during the options analysis process can be found in the Design Options Report in Appendix A

3.4.2 Aimsum Micro-simulation Modelling

Detailed micro-simulation models were developed using Aimsun 8.2.1. Calibrated 2018 AM and PM peak models were initially developed using the 2018 OD and IC survey data. Future 2031 and 2041 base models were then created using the calibrated model data and traffic growth from CSTM forecasts. Details of the base model development and key model assumptions can be found in the Design Options Report in Appendix A.

The modelling results for the preferred option (Option 4) compared against the Base scenarios are summarised in Table 10. While the existing signalised T-intersection performs reasonably well in 2018 with average delay times of 55 and 48 seconds in the AM and PM peaks, respectively, it worsens significantly in 2031. The intersection performance is particularly very poor in the 2031 AM peak period, in which the average intersection delay is estimated to go over 12 minutes and average speed dropping to less than 9 km/h. As an at-grade four-way signalised intersection (additional southern BSE leg), it does not have sufficient capacity to support the increased level of traffic demand, mainly generated by Molonglo and partly by new developments in West Belconnen. These results confirm that a future signalised at-grade solution is not suitable at this intersection and further treatments need to be developed to support the forecasted traffic demand.

The assessment of the upgrade options show that Option 4 provides the best network performance results, significantly better than either the at-grade quadrant or diamond interchange options. It improves the performance of the intersection substantially compared to the 'Do Nothing', at-grade signalised intersection Base scenario.

It should be noted that the results are averages for all vehicles in the sub-area network shown as a red dashed line in Figure 12.

Table 10: Results of Aimsun model runs

Option/Scenario	Average Speed (km/h))	Average Travel Time (s)	Average Delay Time (s)	Average Number of Stops per Vehicle
2018 Base AM	56.6	135	55	1
2031 Base AM	8.9	813	736	7
2031 Option 4 - AM	44.5	200	123	2
2041 Option 4 - AM	57.2	135	57	1
2018 Base PM	58.4	130	48	1
2031 Base PM	27.0	401	322	4
2031 Option 4 - PM	69.0	101	20	0
2041 Option 4 - PM	54.8	135	53	1

Figure 12: Aimsun modelled area (Diamond Interchange option shown)

3.4.3 Crash Analysis

Expected crash reductions for alternative options were tabulated by applying reductions available from road safety literature to the 5-year crash incidence experienced at the site. Where crash reductions were not available thorough research, engineering judgement and experience were used to determine potential reductions.

The analysis initially involved quantifying the cost of crashes that have occurred in each area by RUM (Road User Movement) code. The 2015 crash cost rates were obtained from Roads ACT and were factored by inflation to create 2018 costs.

Crash costs by type were used to value future crash reductions. When crash types were encountered that did not have indicative costs; the cost of an average property damage crash was substituted in the analysis. Costs are either Human Capital (HC) costs where the value is equal to the losses suffered because a person can no longer work. Willingness-to-Pay (WTP) realises that leisure is also valuable to a person and therefore uses a statistical method to price a person's leisure as well as the time they spend at work.

Crash reduction rates are directly from either the Austroads Treatment of Crash Locations or the RTA Accident Reduction Guide except where assumptions have been explicitly discussed. Both documents provide guidance on likely reductions due to treatments.

Option 4 is expected to provide a significant benefit with discounted benefits (both HC and WTP) being greater than $630,000 over a five-year period.

3.4.4 Network Access and Legibility

Network access and legibility were also criteria in the MCA. Thus, an indication of the relative performance of each option against these criteria was assessed.

Access for vehicular traffic is reflected by the results of the traffic modelling, which shows that Option 4 provides the best outcome in terms of travel times. Any option with at-grade signals would provide additional opportunities for active travel movements, so the quadrant options were considered to provide a better outcome for active travel. Public transport movements along BS would have least delays in Option 4, so this option would perform best in relation to public transport access.

The legibility of alternative options relates to whether the interchange design commonly exists in the ACT and drivers know what to expect. This is particularly important for drivers that do not regularly travel through this area (e.g. visitors, tourists). Option 4 was scored as ‘Fair’ given the layout is not a typical intersection type, with some movements not as straightforward as expected.

4.0 Civil Infrastructure

The design standards selected for the project and adopted in subsequent road design comply with the provisions detailed within the standards and guidelines listed below and their referenced documents.

The speed limits in the vicinity of the project area are:

- Posted speed limit on WHD is 80 km/h with a design speed of 90 km/h
- Posted speed limit on BS is 80 km/h with a design speed of 90 km/h
- Posted speed limit on BSE is 70 km/h with a design speed of 80 km/h

4.1 Design Standards and Criteria

Below is a list of the guidelines and standards that have been used during the design process.

- ACT Territory and Municipal Services (TaMS) – Design Standards for Urban Infrastructure (DSUI)
- Austroads Guide to Road Design (AGRD) Part 2: Pavement Structural Design
- Austroads Guide to Road Design (AGRD) Part 3: Geometric Design
- Austroads Guide to Road Design (AGRD) Part 4: Intersections and Crossings – General
- Austroads Guide to Road Design (AGRD) Part 4A: Unsignalised and Signalised Intersections
- Austroads Guide to Road Design (AGRD) Part 6: Roadside Design Safety and Barriers
- Australian Standards AS/NZS 1158 – Lighting for Roads and Public Spaces
- NSW RMS Supplement to Austroads Guide to Pavement Technology Part 2 (2018)
- AS5100: 2017 Bridge Design

The design criteria based on relevant guidelines and standards is tabulated in Appendix C. These were discussed and agreed with IFCW/EPSDD during the early stages of the study.

4.2 Project Inputs and Assumptions

The Feasibility design is based upon available information, which includes

- Information gathered from WAE drawings
- Location of utilities (supplied in CAD/DWG format by utilities authorities)
- ACTMAPi 1 m digitised contours
- Environmental investigations and mapping of environmental constraints based on available data
- ACT B-Double route map, indicating that WHD and BS are B-Double routes
- Liaison with utilities providers
- Preliminary geotechnical investigation – refer to Section 0

4.3 Road Geometry

The overall geometry for the interchange is outlined:

- The BS bridge is located on the existing alignment of the duplicated BS with connection to the future BSE
- Existing BS is a dual carriageway with two lanes in each direction between Belconnen Way and Lyttleton Crescent/Bandjalong Crescent. South of Lyttleton Crescent/Bandjalong Crescent up to William Hovell Drive, Bindubi Street has only one lane per direction although this is planned for future duplication.
- BSE will be a dual carriageway with two lanes in each direction

- Ramps to provide connections to WHD
- An additional through lane on WHD westbound from Glenloch Interchange, merging to two lanes west of BS/BSE

The adopted geometry on the ramps are very close to maximum values specified in the AGRD due to the following reasons:

- Close proximity (less than 1 km) to Glenloch Interchange
- Minimise land take on adjacent blocks
- Environmental impacts, e.g. BGW

Preliminary Sketch Plan (PSP) drawings are included in Appendix D.

4.3.1 Horizontal Alignment

4.3.1.1 Bindubi Street (BS) and Bindubi Street Extension (BSE)

The alignment of the BS duplication and BSE (MC01) are derived from the following assumptions:

- BS duplication alignment is obtained from the centreline of the existing road.
- BSE alignment is obtained from the latest Planning Design Framework for Molonglo Valley Stage 3 (08/10/2018).
- The design vehicle on BSE is a semi-trailer.
- The design vehicle on BS is a B-Double based on the Road Transport (Mass, Dimensions and Loading) regulation 2010, Section 21 (Class 2 notices). Provision of B-Double movement would increase the footprint of the interchange and subsequently increase the impacts on environmental and land take on adjacent blocks. Therefore B-Double access has not been catered for in this interchange design. We believe this will not have a major impact on the existing B-Double network as alternative access to and from Belconnen district such as the Belconnen Westfield, Kippax and Jamison Plaza can be accessed through the current approved routes via WHD and Belconnen Way.

4.3.1.2 Ramp connections to BS

There are two ramps from BS providing connection to WHD eastbound (MC03 and MC04) and one ramp from WHD westbound to BS (MC02). The horizontal alignments of these three ramps have the following features:

- The dual lane off-ramp from BS (MC04) to WHD adopts a 171.5 m radius. This radius with a maximum superelevation of 5% (f = maximum) is an absolute minimum criterion for a design speed of 90 km/h. This radius is adopted to minimise land take on the north eastern corner of the project site and to reduce the required length of the ramp merging onto WHD. At the end of this radius, vehicles will be required to merge into one lane traffic where vehicles will merge onto WHD with 4 second travel length and taper.
- The loop ramp (MC03) adopts compound curves of 54 m and 55 m radii. These are absolute minimum radii for a design speed of 60 km/h with a 5% maximum superelevation (f = maximum). These radii are adopted to reduce land take on the north western corner of the project site and to minimise the project footprint. Traffic lane widths have been increased to 3.9 m wide to allow semi-trailer turning movement at this ramp.
- The ramp from WHD westbound to BS (MC02) adopts an absolute minimum radius of 75 m to allow for a design speed of 70 km/h from the two right-turn lanes on WHD. This is followed by a reverse curve of 75 m radius to tie back into BS. The two 3.5 m right-turn lanes on WHD westbound to the off-ramp MC02 does not cater for B-Double turning movements due to the limited median width on WHD. It is recommended for detailed survey to be undertaken in the next stage of design to confirm the available median width on WHD.

  It should be noted that MC02 directly impacts the identified potential scarred tree located at the northwest quadrant of the intersection. It is recommended to undertake an arboricultural assessment to ascertain the origin of the scar to inform management, which may include conservation or removal.

4.3.1.3 Ramp connections to BSE

There are two ramps (MC05 and MC06) connected to WHD westbound. The horizontal alignments of the two ramps have the following features:

- The ramp from WHD westbound to BSE (MC06) provides sufficient deceleration a design speed of 70 km/h at the ramp.
- The ramp from BSE to WHD westbound (MC05) has a short radius of 55 m at the start of the ramp to minimise land take on the south eastern corner of the project site and to facilitate the right-turn lane from BS southbound. Similar to the loop ramp (MC03), this adopted radius of 55 m is the absolute minimum radius for a design speed of 60 km/h. An absolute minimum radius of 163 m (f = maximum) for a design speed of 90 km/h has been adopted closer to the end of the ramp.

The provision of a right-turn lane from BS southbound onto the on-ramp MC05 is based on the following assumptions:

- A very small volume of traffic turning right onto the on-ramp.
- The design vehicle for this movement is a single unit truck/bus.
- This right-turn lane can be removed in the future to accommodate light rail on the median.

4.3.2 Vertical Alignment

4.3.2.1 Bindubi Street (BS) and Bindubi Street Extension (BSE) (MC01)

The alignment of the BS duplication and BSE (MC01) are derived from the following assumptions:

- BS duplication alignment is obtained from the existing levels at the centreline of the existing road.
- BSE alignment is assumed to have 2.5% longitudinal grade past the bridge and match with the existing ground level at Ch 1820.

4.3.2.2 Ramp connections

The geometry of the ramps adopting values that are exceeding the desirable values and very close to the maximum value of 8% specified in the AGRD Part 4C are as follows:

- The off-ramp from WHD to BS (MC02) has a 6.5% grade, approximately 40 m long with a K-sag value of 2.1. This situation is considered sufficient under the assumption that cars will approach this sag curve at low speeds due to entering from a signalised intersection right-turn from WHD. The design speed for this ramp is 70 km/h.
- The loop ramp from BSE to WHD eastbound (MC03) has 6% grade for approximately 100 m. This vertical curve is constrained by the level difference between WHD and BS. The design speed for this ramp is 60 km/h.
- The on-ramp from BS to WHD eastbound (MC04) has 7% grade for a short length of approximately 5-10 m. The design speed for this ramp is 90 km/h.
- The on-ramp from BSE to WHD westbound (MC05) has a design speed of 60 km/h at the start of the ramp on BSE and 90 km/h approaching WHD. It has a 10% grade (exceeding the maximum grade of 8%) for a short length of approximately 5 m. It is recommended for this steep grade of 10% be accepted given such a short length of the grade. In addition to this, refinement on the on-ramp is required at the location MC05 is grading away from MC01 grade line. The possible refinement such as introducing a dedicated left-turn lane on BSE prior to the change in grade on MC05 from BSE can be considered to cater for deceleration and optimisation of the grade line to match the height requirements at WHD.
- The off-ramp from WHD to BSE southbound (MC06) has 8% grade for approximately 150 m. It is assumed that vehicles will approach this intersection at a speed less than or equal to an

operating speed of 40 km/h. The steep 8% uphill grade at this ramp will also assist in supporting the deceleration of vehicles as vehicles approach the intersection.

4.4 Road Reservation

To accommodate the intersection upgrade, the existing road reservation boundaries need to be updated. The proposed changes to the boundaries are illustrated in Figure 13.

In the northwest quadrant, Block 1400 (shown as the triangular area with red boundaries in Figure 13) is proposed to be included in the road reservation to allow for the construction of the loop ramp. There are no other changes suggested for this quadrant, but there could be an opportunity in the future to reclaim some land from the road reservation by pulling back the northwestern boundary such that it is closer and parallel to the outer edge of the loop ramp.

In the northeast quadrant, the existing boundaries at the corner need to be adjusted to 55 m from the edge of the travel lane of the proposed left-turning ramp (on-ramp) to WHD. It will then taper at both ends to match with the existing boundaries at the eastern side of BS and northern side of WHD. This boundary adjustment is based on the proposed relocation of the overhead High-Voltage (HV) line and the cycle path, including the BNT of 10 m general width.

At the southern leg of the intersection, i.e. the BSE 'stub', the proposed boundaries adjacent to the on and off-ramps are at 45 m offsets from the edge of travel lane on both ramps. For BSE, the western boundary is proposed to be offset 52 m from the centre line of MC01, while a 62 m offset is proposed for the eastern boundary to accommodate the relocation of the 900 mm bulk water main within the road reservation.

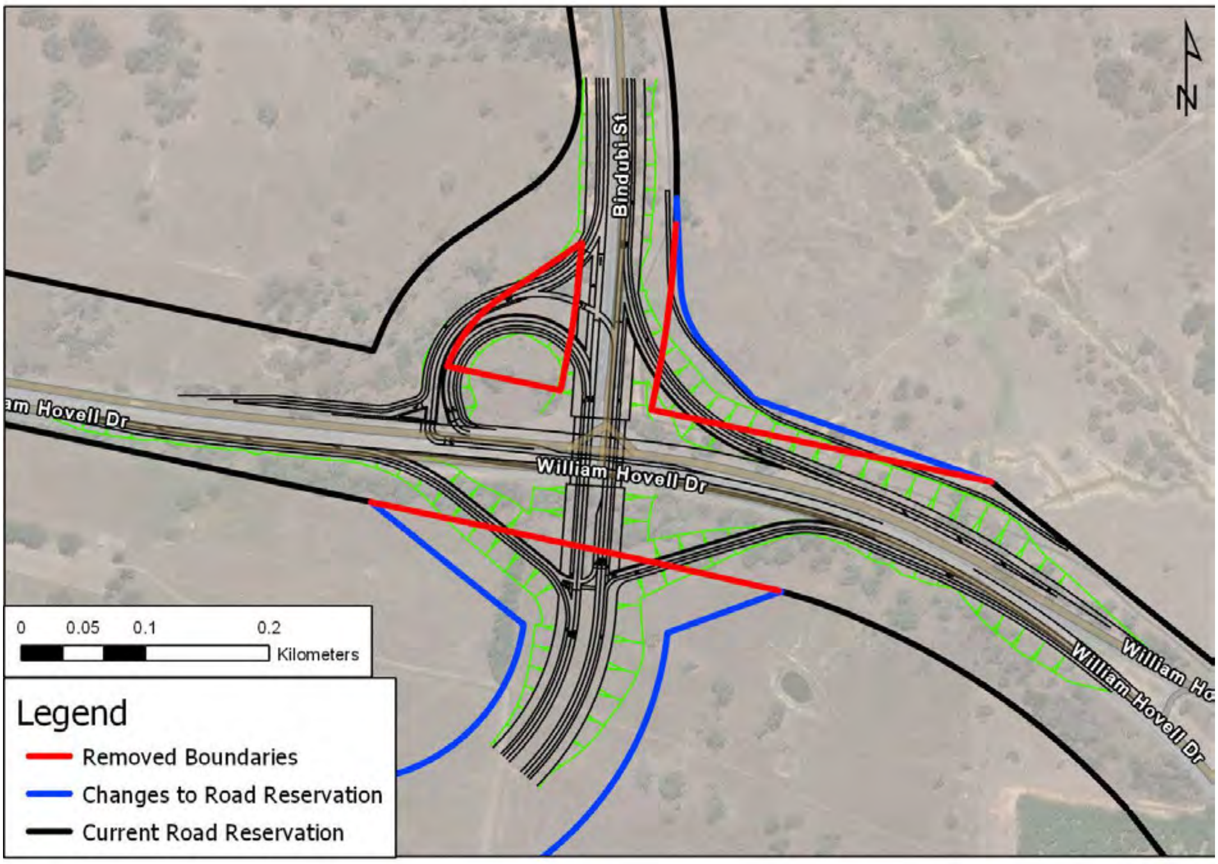


Figure 13: Proposed road reservation changes

4.5 Typical Cross Section

The typical cross section for BS and BSE consists of the following:

- BS dual carriageway
  - 2 x 3.5 m wide traffic lanes for each carriageway
  - 12 m wide median for future IPT
  - 2.5 m wide on-road cycle lane for each carriageway
  - 8 m wide verge for each carriageway which include provision for the following:
    - 2.5 m wide shared path
    - Street lighting
    - Stormwater network
    - Shared trench (presently a requirement for Evoenergy)
- BSE dual carriageway
  - 2 x 3.5 m wide traffic lanes for each carriageway
  - 12 m wide median for future IPT
  - 2.5 m wide on-road cycle lane for each carriageway
  - 2.5 m wide shared path
  - 8 m wide verge for each carriageway to include provision for the following:
    - 2.5 m wide shared path
    - Street lighting
    - Stormwater network
    - Shared trench (presently a requirement for Evoenergy)
- Bridge over WHD
  - 2 x 3.5 m wide traffic lanes for each carriageway
  - 12 m wide median measured from edge line to edge line for future light rail
  - 2.5 m wide on-road cycle lane for each carriageway
  - 3 m wide shared path from barrier to barrier for each direction
- Ramps (general)
  - 3.5 m wide traffic lane (width of traffic lane varies depending upon the turning path requirements for the design vehicle)
  - 2.5 m wide on-road cycle lane
  - 1.5 m wide right-hand shoulder
  - 3 m wide verge to include provision for street lighting
- Relocation of Bicentennial National Trail (BNT)
  - provision of a 10 m wide corridor on the propose relocated route of the BNT has been created

All roads are proposed to be kerbed.

4.6 Intersections

The following are the proposed signalised intersections within the interchange:

- Intersection 1 on WHD eastbound
  - Two right-turn lanes WHD westbound to BS northbound
  - Two left-turn lanes WHD eastbound from BS northbound
- Intersection 2 on BS
  - Two left-turn lanes WHD eastbound to BS northbound
  - Single lane BS northbound
- Intersection 3 on BS
  - Single lane WHD eastbound to BS southbound.
  - Single lane BS northbound
  - Two lanes BS southbound
- Intersection 4 on BSE:
  - Two lanes BSE northbound
  - Two lanes BSE southbound and right-turn lane onto WHD westbound ramp
  - Cyclist crossing BSE from WHD westbound

The locations of these signalised intersections are shown on Figure 14.

Further refinement of Intersection 1 is to be considered in the next phase of design particularly at the two right-turn lanes on WHD westbound to allow better turning manoeuvrability for semi-trailers. Further refinement may include shortening the two right-turn lanes to accommodate for wider turning lane widths at the intersection onto MC02.

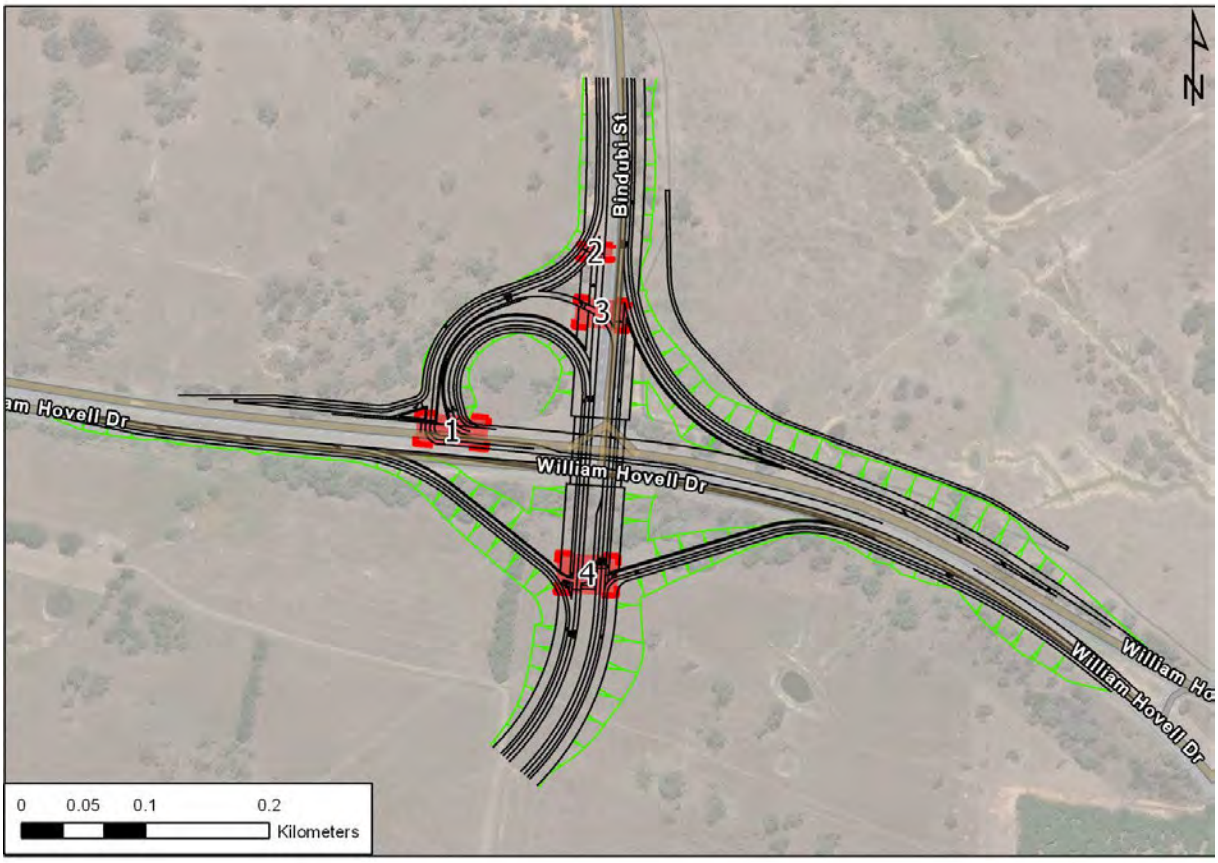
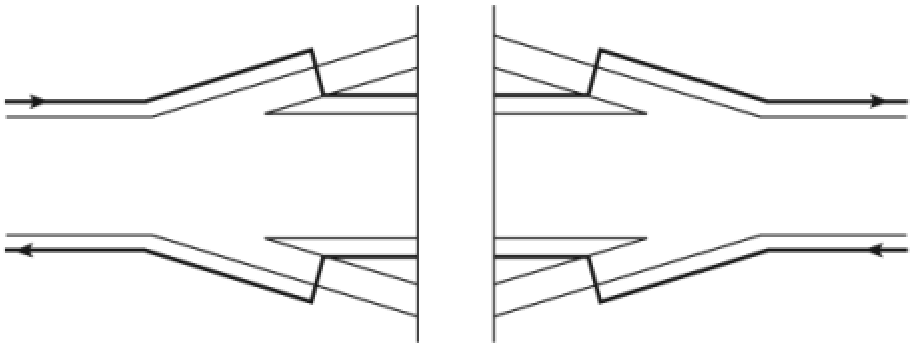


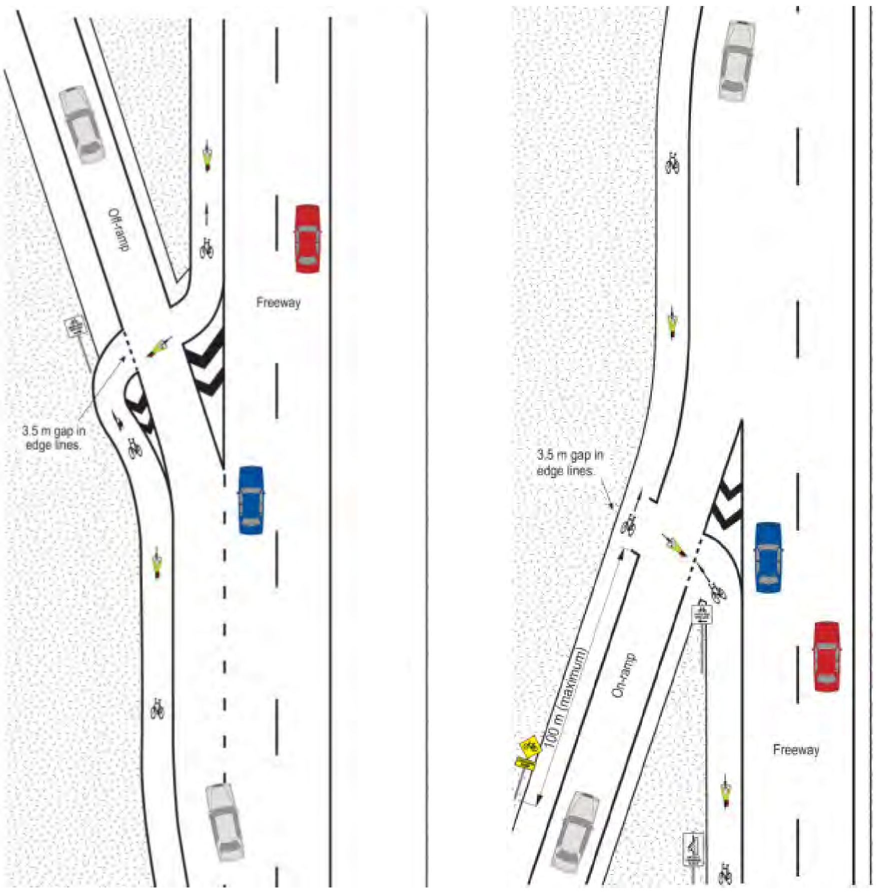
Figure 14: Signalised intersection locations within the interchange

On-road cyclist crossings are provided at signalised intersections. At unsignalised on-ramp and off-ramp connections, provision of on-road cyclist crossings will be provided in accordance with AGRD Part 4C (refer to Figure 15 and Figure 16 below) The crossing facilities will consist of sealed shoulders guiding cyclists to cross these ramps perpendicularly and to provide good line of sight.



Source: AGRD Part 4C: Figure 14.1 (a)

Figure 15: Crossing points at interchange ramps for on-road cyclists



Source: AGRD Part 4C: Figure 14.2

Figure 16: Typical arrangement of on-road cycle lane crossing facility

4.7 Preliminary Geotechnical Assessment

The preliminary geotechnical investigation was carried out by D&N Geotechnical Pty Ltd (D&N). The objective of the investigation is to provide an initial assessment of subsurface conditions and geotechnical constraints/opportunities for the proposed site.

The following sections summarise the investigation process. Further details can be found in the Preliminary Geotechnical Investigation Report in Appendix E.

It should be noted that subsurface conditions can be complex and may vary over relatively short distances – and over time. The geotechnical model and recommendations in D&N's report are based on limited subsurface investigations at discrete locations. The engineering logs describe subsurface conditions only at the investigation locations.

Further investigations may be required to support detailed design if there are scope limitations or changes to the nature of the project.

4.7.1 Method of Investigation

Fieldwork for the geotechnical investigation was carried out over two separate phases (17 April 2019 and 23 April 2019), and comprised the following main activities:

- Site walkover to map existing features and observe pavement distress
- Service clearance, including positive identification of all assets
- Drilling of 4 boreholes, shown in Figure 17, to auger refusal, at between 1.15 m and 3.0 m
- Collection of representative subsurface samples for submission to a NATA registered laboratory
- Completion of 2 Dynamic Cone Penetrometer (DCP) tests to depths of between 0.3 m and 0.9 m

Figure 17: Borehole locations

All borehole locations were recorded using hand held GPS equipment (accurate to ±3 m). Co-ordinates are included on the respective borehole logs, for reference.

Selected soil samples were submitted to a NATA accredited laboratory for a suite of tests (as defined in Table 11).

Table 11: Laboratory tests for the preliminary geotechnical assessment

Test Type	Test Method	No. of Tests
California Bearing Ratio (SMDD, 4-day soak, 4.5 kg surcharge)	AS1289.6.1.1	2
Field Moisture Content	AS1289.2.1.1	2
Atterberg Limits, incl. Linear Shrinkage	AS1289.3.9.2	2
Soil Aggressivity (pH, EC, Sulphate and Chlorides)	AS1289.3.6.1	2

4.7.2 Investigation Results

The 1:100,000 scale Geological Map of Canberra (Sheet 8727) indicates the site is underlain by the Early Silruian Mount Painter Volcanics, comprising of Dacitic ignimbrite with lithic xenoliths and dacitic autoliths, minor tuff and ashstone.

The results of the subsurface condition investigations, particularly the main geotechnical units encountered, are summarised in Table 12. The D&N report in Appendix E includes Engineering Borehole Logs that can be referred to for specific details on encountered subsurface conditions.

Table 12: Summary of main geotechnical units

Unit		Material Origin	Material Description	Depth Range to Top of Unit (m)	Range of Unit Thickness (M)
1		Topsoil / FILL	SILT, brown, varying amounts of sand and gravel	0	0.15 – 0.20
2		Residual Soil(1)	Sandy CLAY, high plasticity, medium to coarse sand, typically very stiff to hard consistency	0.2	0.7
3	a	Bedrock	DACITE, very low to low strength, extremely weathered	0.15 – 0.90	0.43 – 1.25
	b		DACITE, highly to moderately weathered, low to medium strength	0.6 – 2.0	To Limit of Investigation

(1) Only observed in BH03

Groundwater was not observed within any of the borehole locations at the time of our investigation.

Laboratory test results are summarised in Table 13 and Table 14.

Table 13: Summary of soil classification and CBR laboratory test results

BH ID	Depth (m)	PI (%)	LL (%)	PL (%)	CBR Swell (%)	MDD (t/m^3)	OMC (%)	CBR (%)	Moisture Content (%)
BH02	0.2 – 0.5	9	26	17	0.5	2.03	10.5	30	7.1
BH03	0.4 – 0.6	14	32	18	1.0	1.89	14.3	16	9.5

Table 14: Summary of soil aggressivity test results

BH ID	Depth (m)	pH	Chloride (mg/kg)	Sulphate (as S) (mg/kg)	Electrical Conductivity (dS/m)
BH03	0.3 – 0.6	7.9	58	66	0.02

BH ID	Depth (m)	pH	Chloride (mg/kg)	Sulphate (as S) (mg/kg)	Electrical Conductivity (dS/m)
BH04	0.3 – 0.5	9.2	57	67	0.04

4.7.3 Earthworks

D&N only provided general advice regarding perceived geotechnical constraints. Further investigations should be undertaken to inform the detailed design.

Existing fill material

The investigation indicates that fill is up to about 0.2 m thick, comprising existing general fill material associated with the construction of the adjacent road corridor and associated landscaping. It is expected that deeper lying fill associated with services trenches (e.g. reticulated water main) would also be present across the site footprint.

Unless there are records confirming that any fill has been compacted in accordance with an engineering specification, it should be classified as 'uncontrolled' and should not be used as a foundation for structures or pavements in its current condition due to the potential for differential settlement. Therefore, where structure footings or pavements are proposed, this material should be excavated and re-compacted (if suitable) or replaced with a select fill material up to design subgrade level.

Site preparation and fill placement

Where natural soils/extremely weathered bedrock is exposed at subgrade, they should not require extensive treatment provided it is not disturbed by traffic or water ingress. Where predominantly silty soils are exposed, they will be highly susceptible to disturbance and may need to be removed if affected by water ingress and cannot be readily compacted.

Where natural soils are exposed, and no filling is required, subgrade and foundation preparation should consist of bulk excavation to subgrade level followed by geotechnical assessment of the exposed stratum. Subgrades should be graded to drain effectively and should be cleaned of any softened material prior to placement of fill/pavement materials.

All compacted replacement fill and subgrade preparation should be constructed under geotechnical inspection and testing in accordance with the Transport Canberra City Services (TCCS) *Standard Specification for Urban Infrastructure Works*, Edition 1, 2002.

The actual extent of subgrade treatment will largely depend upon preceding weather conditions and construction methodology; and should be treated as advised by the project geotechnical consultant.

Excavations and temporary batters

It is expected that excavations at the site will generally be limited to 'boxing-out' for pavements, trenching for re-location/additional underground services and grading of abutment slopes/approach road ramps.

Unsupported excavations in natural soils and bedrock may be practicable where there is enough space to allow for the creation of batter slopes, and where sensitive structures are not located within a distance from the crest equal to the depth of excavation. For preliminary design purposes, the recommended unsupported batter slopes are outlined in Table 15.

Table 15: Recommended preliminary unsupported batter slopes

Unit	Material Origin	Temporary Batters	Permanent Batters
-	Controlled Fill	1(H):1(V)	2(H):1(V)
2	Residual Rock	1.5(H):1(V)	2(H):1(V)
3	Weathered Bedrock	1(H):1(V)	1.5(H):1(V)

Further earthworks guidelines and details are included in the D&N report in Appendix E.

Subgrade trafficability

Based on the borehole logs, site preparatory earthworks for pavement areas are likely to expose a subgrade comprising predominantly extremely weathered dacite bedrock and/or residual clay soils with some isolated uncontrolled fill areas.

The residual soils and fill areas are expected to behave poorly if exposed to heavy construction traffic, particularly when wet. A platform of granular material such as road base or crushed concrete may be needed to support construction plant. Where heavy plant such as piling rigs, or mobile cranes are to traffic the site, specific analysis of working platform requirements may be required to assess working platform thickness.

To help reduce, but not eliminate trafficability issues associated with wet weather, exposed subgrades should be graded such that they promote surface drainage and prevent ponding.

Re-use of site won soils

From a geotechnical viewpoint, all site soils (excluding Topsoil) should generally be suitable for use as Engineered Fill, provided any unsuitable material such as organics, waste or oversized particles are removed (if present).

Further observation, sampling and testing by the geotechnical representative may be required during construction to confirm material suitability for the respective proposed usage.

4.7.4 Subgrade CBR

Based on the fieldwork results and the subgrade preparation recommendations (see Appendix E), the following preliminary CBR values could be considered for the design of pavements:

- Residual Soil 10 %
- Weathered Bedrock 30 %

Provision should be allowed for the undertaking of additional geotechnical investigations and CBR testing on likely subgrade materials prior to construction.

The prepared subgrade should be observed by an experienced geotechnical engineer, prior to proceeding with the above pavement layers, to confirm that the design value adopted is consistent with the exposed conditions.

4.7.5 Foundations

Preliminary geotechnical parameters for shallow and deep footings are presented in the following sections. The values outlined may be refined with further geotechnical investigation (e.g. advancement of deeper boreholes and retrieval of intact rock core). It is likely that Unit 3 bedrock would become less weathered and have a higher material strength with depth, which could lend itself to an increase in the suggested geotechnical design parameters.

Shallow footings

Suitable footing systems for the project may comprise shallow strip and/or pad footings founded in the residual soil and weathered bedrock. Footing may be proportioned to achieve the allowable bearing pressures outlined in Table 16.

Table 16: Allowable bearing pressures - shallow footings

Unit	Material Origin	Allowable Bearing Pressure (kPa)
2	Residual Soil	150
3a	Extremely Weathered Material	700
3b	Highly to Moderately Weathered Bedrock	1,000

Deep footings

Where design loads exceed the allowable bearing pressures in Table 16, piled footings may be required to transfer column loads into the underlying Unit 3 Bedrock. It is expected that open bored piles should be suitable for the site. Provision should be made for casing off any fill material or granular soils which may be susceptible to caving.

It is noted that for the footings to be classed as a pile, it must have a length to diameter ratio of greater than 5 (L/d>5), where d = footing diameter.

Table 17 below shows the ultimate geotechnical parameters, which may be adopted for preliminary design of bored or continuous flight auger (CFA) piles. Further details and advice on pile foundation design, including seismic design parameters and soil aggressivity, are included in the D&N report in Appendix E.

Table 17: Geotechnical foundation design parameters for non-displacement piles

Unit	Material Origin	Unit Weight (kN/m^3)	Ultimate End Bearing Capacity (MPa)	Ultimate Skin Friction (kPa)
2	Residual Soil	19	-	50
3a	Extremely Weathered Material	21	3	75
3b	Highly to Moderately Weathered Bedrock	22	5	150

4.8 Preliminary Pavement Design

A rationalised single thickness design for the entire interchange is considered in this stage of design.

A Full Depth Asphalt type pavement is based on the design traffic loading for the most heavily trafficked section of the interchange which is the westbound carriageway on WHD, east of the interchange, at a signalised intersection.

The adopted key design parameters are included in Table 18.

Table 18: Preliminary pavement design key parameters

Design Parameter	Value Adopted
Design Period	40 years
Start of Design Period	2026
Reliability factor	95%
Design traffic loading (HVAG)	3.78×10^7
Preliminary Subgrade CBR	10%
Pavement design speed	20 km/h
WMAPT	23° C
Traffic growth	Expected to occur between 2018 and 2041, after which the growth rate has been assumed to be 0%
% Heavy vehicles	3%

The preliminary Full Depth Asphalt pavement profile is outlined in Table 19 below.

Table 19: Full Depth Asphalt pavement profile

Layer	Thickness (mm)	Material
Wearing course	40	AC14 (A10E binder) as per NSW RMS QA Specification R116(4)
Base course/s	200	AC20 (A10E binder) as per NSW RMS QA Specification R116
Total Pavement Thickness	***240***	
Sprayed Seal	-	Size 7 mm low cutter seal
Upper Zone of Formation (SMZ – Upper Layer)	150	SMZ – Upper Layer as per NSW RMS QA Specification 3071 (CBR ≥ 33%)
Upper Zone of Formation (SMZ – Lower Layer)	150	SMZ – Lower Layer as per NSW RMS QA Specification 3071 (CBR ≥ 19%)
Upper Zone of Formation (other than SMZ)	Varies(1) (0 to 900)	Upper Zone of Formation (other than SMZ) as per NSW RMS QA Specification R44 (CBR ≥ 10%)
General Fill	Varies(2)	General Fill as per NSW RMS QA Specification R44 (CBR ≥ 10%)
Total Earthworks Thickness	***Min. 300(1)(2)***	

Notes:

(1) Varies depending on whether the earthworks construction falls under the category of Embankment, Shallow Embankment, Cutting or Cut/Fill Transition Zone
(2) Varies, as required, depending on embankment height
(3) SMZ = Select Material Zone
(4) A high Polished Aggregate Friction Value (PAFV) of 58+ may need be considered for the wearing course at tight radius loops and ramps (default PAFV for wearing course is 48)

4.9 Stormwater and WSUD Requirements

4.9.1 Existing Stormwater Network

The existing stormwater network within the area of works consists of three culverts for cross road drainage shown in Figure 18. There is existing road drainage emptying from the BS and WHD intersection into Culvert No. 2. Table 20 shows the existing culverts' types and sizes.

The approach adopted in the stormwater design is modification to the existing stormwater network and is undertaken with minimal alteration to the existing catchment boundaries and to the network itself. This is justified as the changes to the intersections are unexpected to have a large impact on the movement of stormwater in the area.

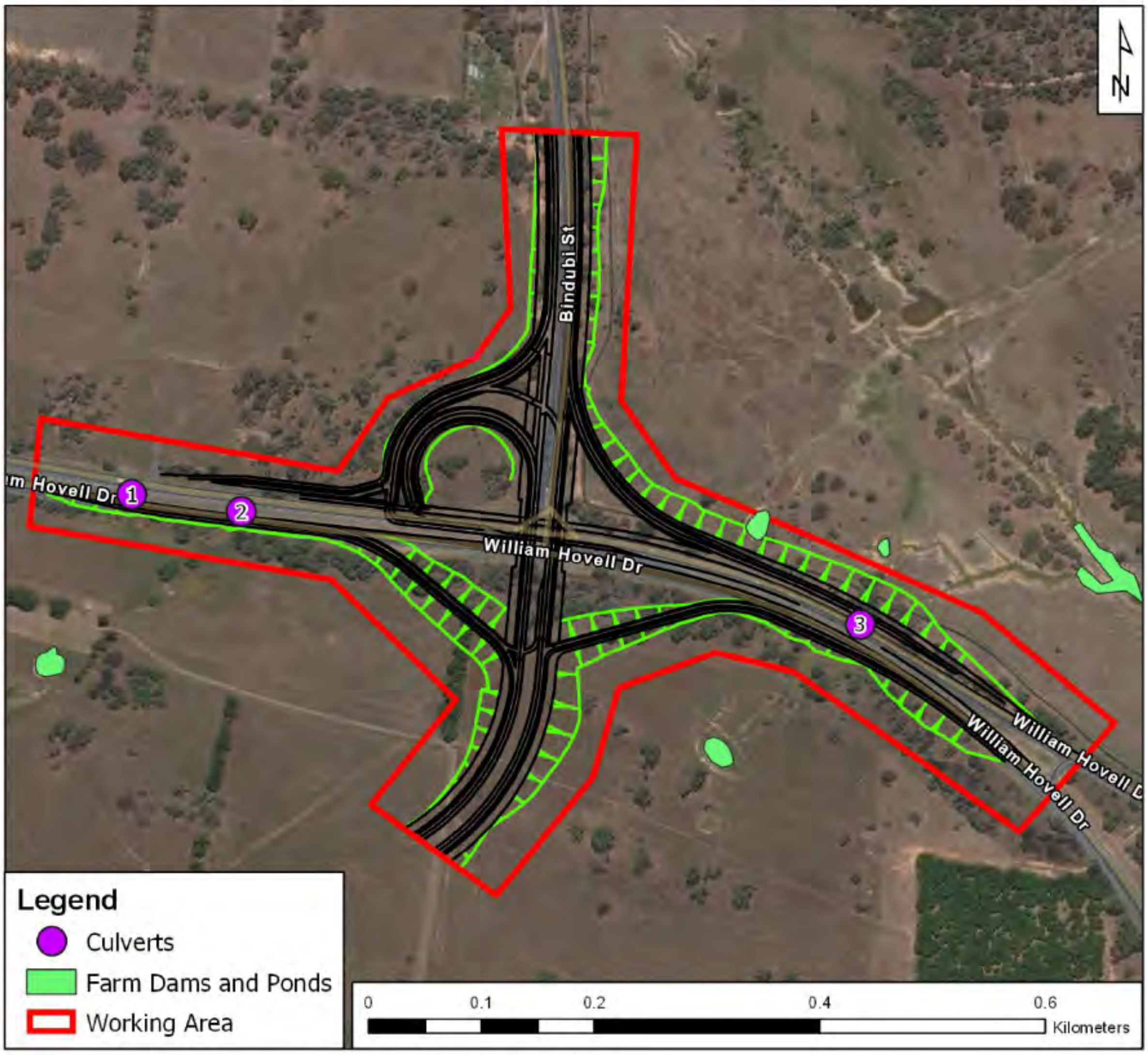


Figure 18: Locations of existing stormwater infrastructure

Table 20: Existing culvert types and sizes

Culvert ID	Type	Size
1	Box Culvert	3000 mm W x 600 mm H
2	Box Culvert	3000 mm W x 600 mm H
3	Pipe Culvert	1050 mm diameter

4.9.2 Catchment Analysis

The analysis of the BS and WHD interchange feasibility assessment has been carried out in accordance with the TCCS Design Standard for Urban Infrastructure (DSUI – DS01 Stormwater). Catchments were determined using ArcGIS and a Digital Elevation Map (DEM) based on 1 m contours. Inside the working area there are three culverts each servicing different catchments.

The existing BS and proposed BSE are generally located on a ridgeline near the interchange, which resulted in the following two main catchment areas (also shown in Figure 19):

- Northwestern catchment area which is sloping southwest and crossing WHD via two 0.6 m H x 3 m W box culverts west of the interchange.
- Southeastern catchment area which is sloping northeast and crossing WHD via 1050 mm diameter culvert.

Table 21 provides information on the catchments and their corresponding culverts

Table 21: Catchment details

Catchment	Culvert ID	Catchment Area (ha)	Notes
1	1	29.7	
2a	2	18.4	Grassed area to the northwest of the BS – WHD intersection.
2b		5.6	Runoff from the impervious road surface that is carried to Culvert No. 2. This is existing.
3a	3	13.6	Currently contains a dam that would have some mitigation of flows depending on the antecedent conditions.
3b		2.4	Runoff from the impervious road surface that is carried to Culvert No. 3. This will be added.

These catchments and culvert locations in relation to the limited PSP design are shown in Figure 19. Flow directions have been calculated across this map (multiple calculations per metre) with the arrows showing a simplified accumulation of 200m by 200m areas by taking the majority flow direction.

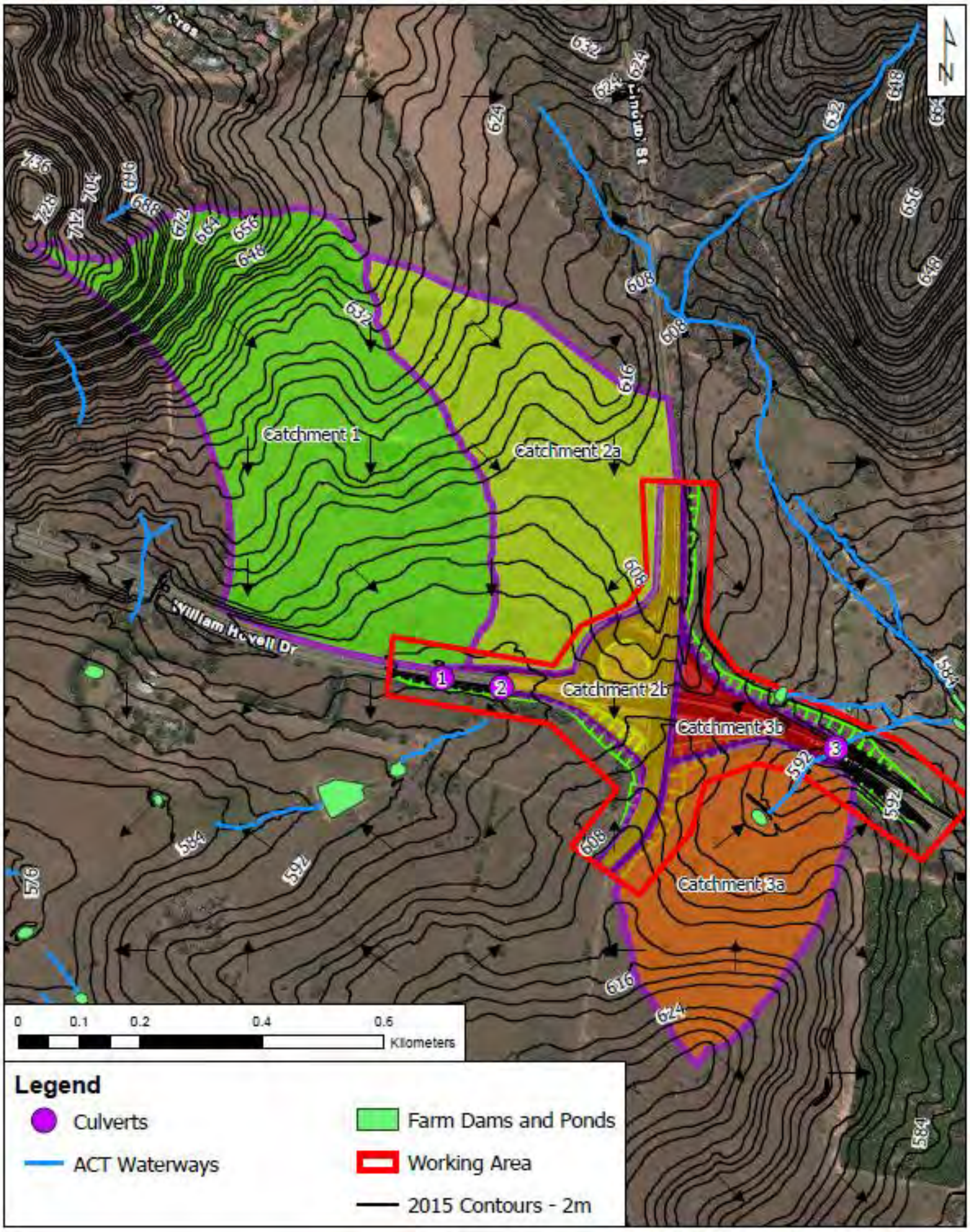


Figure 19: Catchment map indicated for each culvert within the expected working area

The catchments are projected onto an exaggerated three-dimensional DEM to provide context and these are shown in Figure 20 and Figure 21.

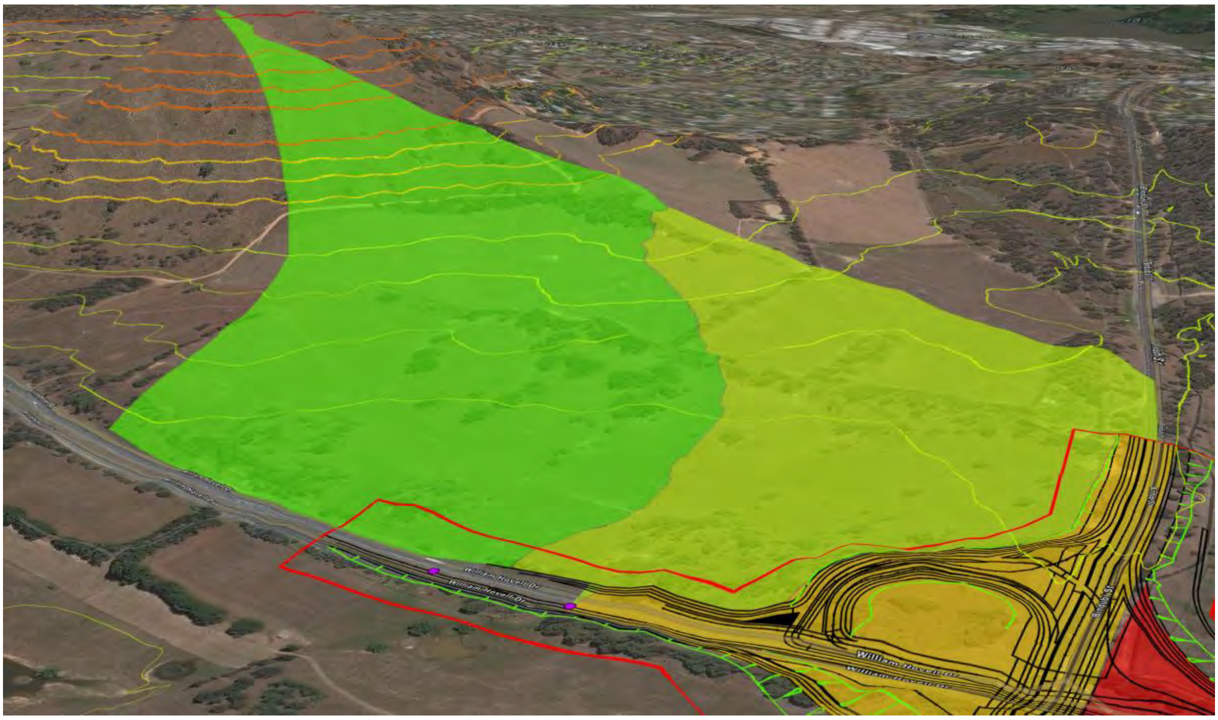


Figure 20: Catchments 1 and 2 (vertical axis has been exaggerated)

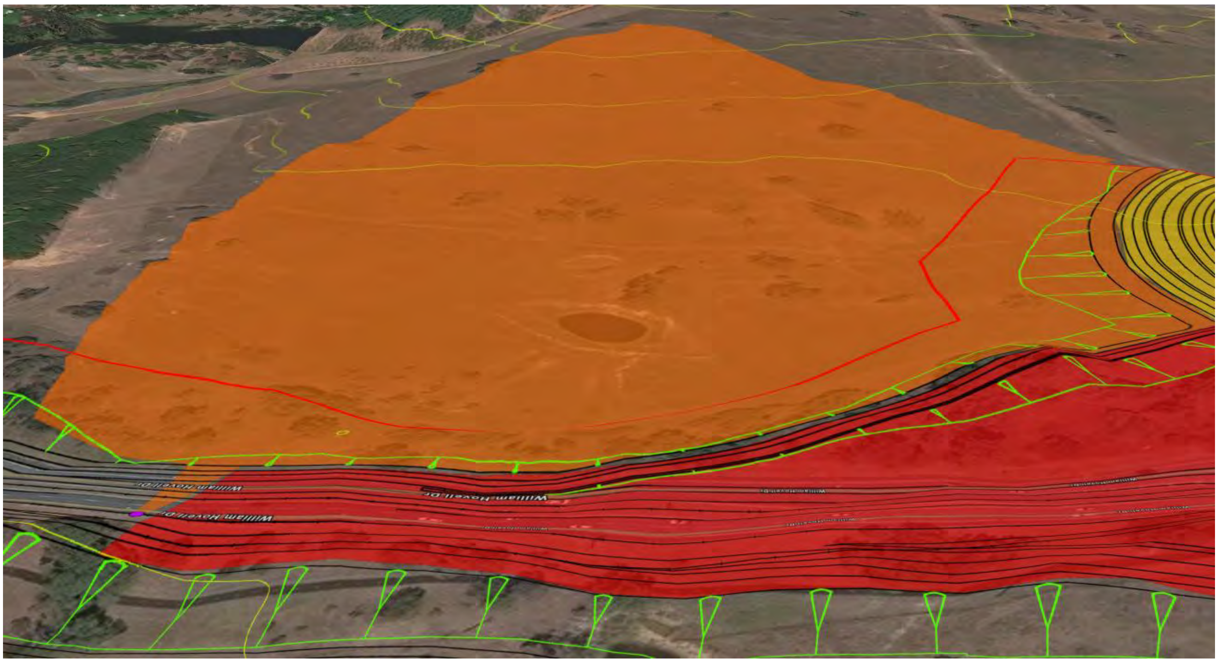


Figure 21: Catchment 3 (vertical axis has been exaggerated)

The following inputs were used as input to the Rational method to calculate the preliminary peak flows for the minor and major storm events:

- Catchment areas based on 1 m interval contours and available detailed survey.
- The time of concentration was determined using the properties of catchment areas at different discharge points such as flow path lengths and slope of catchment area.

- The respective rainfall intensity was determined for the time of concentration based on Table 1.14 of DSUI-DS01 (Canberra Design Rainfall Intensities in mm/hr). Time of concentration values were rounded down to the nearest entry to provide a conservative estimate of the rainfall intensity.
- Runoff coefficient was calculated based on Figure 1.1 of DSUI-DS01 (runoff Coefficients for Urban Catchments) using Category 6. Category 7, which is Park Lawns and meadows, is likely more directly applicable to these areas, but it was decided that using category 6 would provide a good conservative measure to account for the ability of the soil to absorb water. The runoff for catchment 2b and 3b (the road surface) was set to 0.9.
- The Average Recurrence Interval (ARI) being considered is 100 years.

A summary of the inputs that are found from the catchment analysis are shown in Table 22.

Table 22: Inputs from catchment analysis

Catchment	Catchment Area (ha)	Slope (%)	Length (m)	Time of Concentration (min)
1	29.7	12	1230	30
2a	18.4	5	1020	32
2b	5.6	2	300	7.5
3a	13.6	6	602	18
3b	2.4	2	160	6.3

Table 23 presents the catchment areas and 100-year ARI peak design flows within the project area.

Table 23: Catchment and stormwater flows

Catchment	Catchment Area (ha)	Slope (%)	Length (m)	Time of Concentration (min)	Intensity (I) (mm/hr)	Runoff Coefficient (Ci)	Q(100)
1	29.7	12	1230	30.0	79	0.45	2.9
2a	18.4	5	1020	32.0	79	0.45	1.8
2b	5.6	2	300	7.5	169	0.66	1.7
3a	13.6	6	602	18.0	106	0.53	2.1
3b	2.4	2	160	6.3	180	0.68	0.8

To determine the suitability in the case of a 100 year flood the minimum freeboard required is 0.3 m. The results of the analysis for each of the culverts are summarised below in Table 24, which shows that they are acceptable.

Table 24: Comparison of expected water height during a 100-year flood against the height differential between the invert and road height

<table>
<tr><th>Catchment</th><th>Q(100)</th><th>Existing Size (mm)</th><th>Invert Height (m)</th><th>Road Height (m)</th><th>Headwater Depth in Diameters</th><th>Freeboard (m)</th></tr>
<tr><td>1</td><td>2.9</td><td>3000W x 600H</td><td>595.4</td><td>596.9</td><td>1.4</td><td>0.66</td></tr>
<tr><td>2a</td><td>1.8</td><td rowspan="2">3000W x 600H</td><td rowspan="2">595.8</td><td rowspan="2">597.2</td><td rowspan="2">1.6</td><td rowspan="2">0.45</td></tr>
<tr><td>2b</td><td>1.7</td></tr>
<tr><td>3a</td><td>2.1</td><td rowspan="2">1050 diameter</td><td rowspan="2">591.6</td><td rowspan="2">595.1</td><td rowspan="2">2</td><td rowspan="2">1.40</td></tr>
<tr><td>3b</td><td>0.8</td></tr>
</table>

4.9.3 Water Sensitive Urban Design (WSUD)

The existing stormwater management system is expected to be adequate and is already combined with WSUD measures. The nature of the site being surrounded by grass means that the water run-off is inhibited, and the velocity is decreased which allows for particles to settle and removes contaminants. In many areas the water is collected in small farm dams and ponds which allow for reuse and prevents the runoff from affecting further areas.

According to *Draft Variation 354 (DV354) – Waterways: water sensitive urban design general code review and associated consequential amendments*, major road projects (including upgrading existing roads) need to meet the target of the stormwater pollutant reduction: at least 90% gross pollutants, 60% suspended solids, 45% total phosphorous and 40% total nitrogen. As it is still in draft form, the current Territory Plan continues to apply, but in case DV354 takes into effect, the following WSUD measures could be considered to treat road runoff before flowing into waterways such as Coppins Creek:

- Grass swales (or bio-swales) can carry stormwater runoff and filter sediment depositions. Open channel swales with small bunds at the intervals or discharge points can provide infiltration and minor sediment control. Bio-swales with additional subsurface gravel or sand-filled trench can improve runoff quality during both low-intensity flows or high flows. However, more regular inspection of bio-swales should be conducted to identify signs of erosion and maintain their effectiveness.
- Permanent ponds such as sediment ponds and bio-retention ponds can improve stormwater quality and capture significant amounts of sediment and nutrients. Based on the proposed design layout of the interchange, the pond for Catchment 2b can either be located inside the loop ramp at the northwest quadrant or integrated with a future estate development pond at the southwest quadrant. If the former is adopted, the details of the pond including size, and spillway and outlet features will be determined during the next stage of design. The pond can also be used as temporary sediment control during construction. Compared to a sediment pond, a bio-retention pond is more expensive to build and requires more regular maintenance, so it may not be a cost-effective option to treat runoff from Catchment 2b (area of around 5.6 ha). Both sediment and bio-retention ponds need to be cleaned regularly to maintain their function.

DV354 also requires a MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model to assess the effectiveness of the proposed WSUD measures, so this needs to be considered in the next stage of the project. In addition, asset management and maintenance discussions with TCCS need to be undertaken prior to detailed design of the pond/s to determine the most appropriate WSUD measure for the site.

4.10 Bridge

4.10.1 Bridge Types

A bridge type options analysis was undertaken to determine the preferred twin bridge type option for the concept design of the new bridge. Two bridge type options were considered as part of this feasibility study:

- Super-T Bridge (two span)
- Steel trough girder with in-situ concrete deck (single span)

The Super-T Bridge was determined to be the preferred bridge type due to the difference in cost between the two bridge types subsequent from longer girders and thicker structural depth requirements for the superstructure. Constructability and safety were also raised as concerns due to potentially temporary formwork over the existing WHD road corridor. The concept design for the new bridge was therefore based on the Super-T Bridge type.

As an alternative, the single span steel trough girder bridge can be investigated should this be required. However, the structural depth would increase requiring the grade line to be raised thus increasing earthworks and may impact on the grade lines of connecting ramps. The trough girders can be either prefabricated and lifted into place or incrementally launched. The former method would require complex transport and lift methods due to size, but it would allow an option for construction over the roadway without the need for long term closure or launching.

4.10.2 Super-T Bridge Options

For the development of the concept design, a number of options have been considered with regard to the span lengths and placement of the central median pier. These options included:

- Options 1 & 2 – Central pier at the middle of the existing median
- Options 3 to 6 – Central pier in the middle of the two travel lanes

Option 1 and 2 considers a symmetric and asymmetric bridge span lengths with the central pier at the middle of the existing median respectively. Option 1, shown in Figure 22, allows for a span length of 30 m while Option 2, shown in Figure 23, allows for a span length of 28 and 30 m. Batter slopes of 2:1 and 1.5:1 (H:V) have been allowed for in the two options. These two options were not developed further due to the central pier's close proximity to the deceleration lane for the right-turn into the loop ramp.

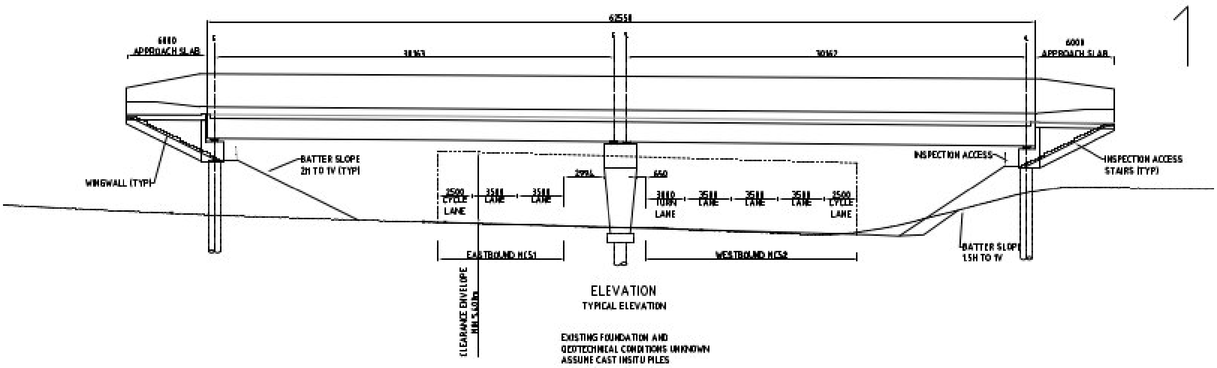


Figure 22: Super-T Option 1

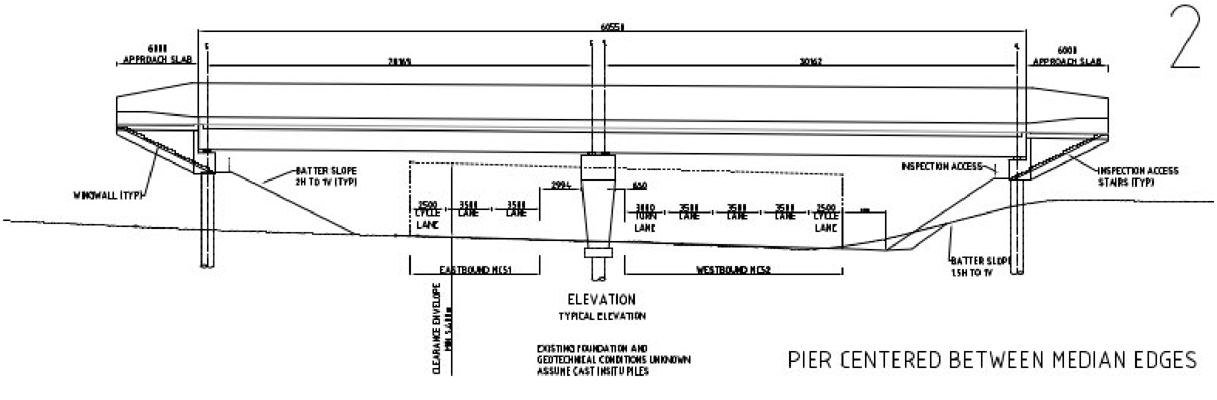


Figure 23: Super-T Option 2

Options 3 to 6, shown in Figure 24 and Figure 25, considers symmetric and asymmetric bridge span lengths with the central pier at the middle of the two travel lanes. Option 3 is the only option out of the four with a symmetric span length. Options 4 to 6 consider increasing the span length of the southern span to allow for batter slope clearance from the edge of the on-road cycle lane on the westbound carriageway to the toe of the batter. Preference was given to Option 3 as the central median pier provided sufficient clearance between the edges of two traffic lanes and was the only symmetrical option.

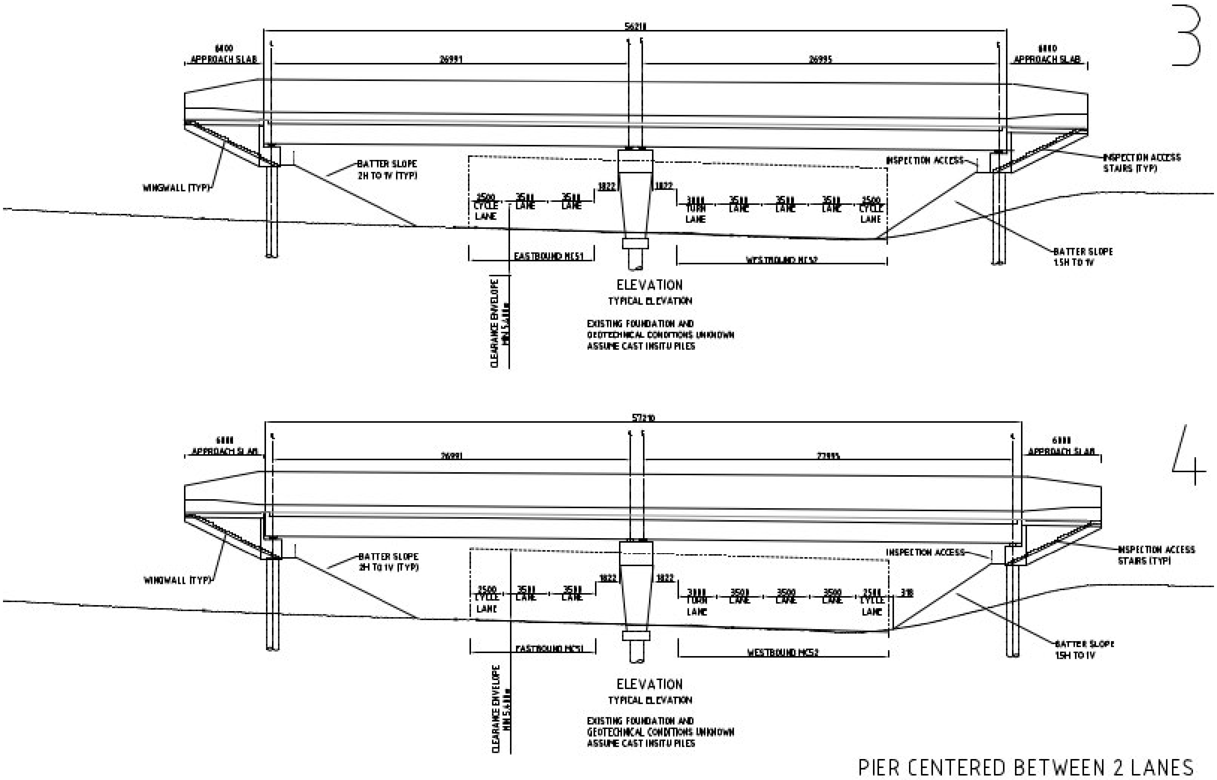


Figure 24: Super-T Options 3 and 4

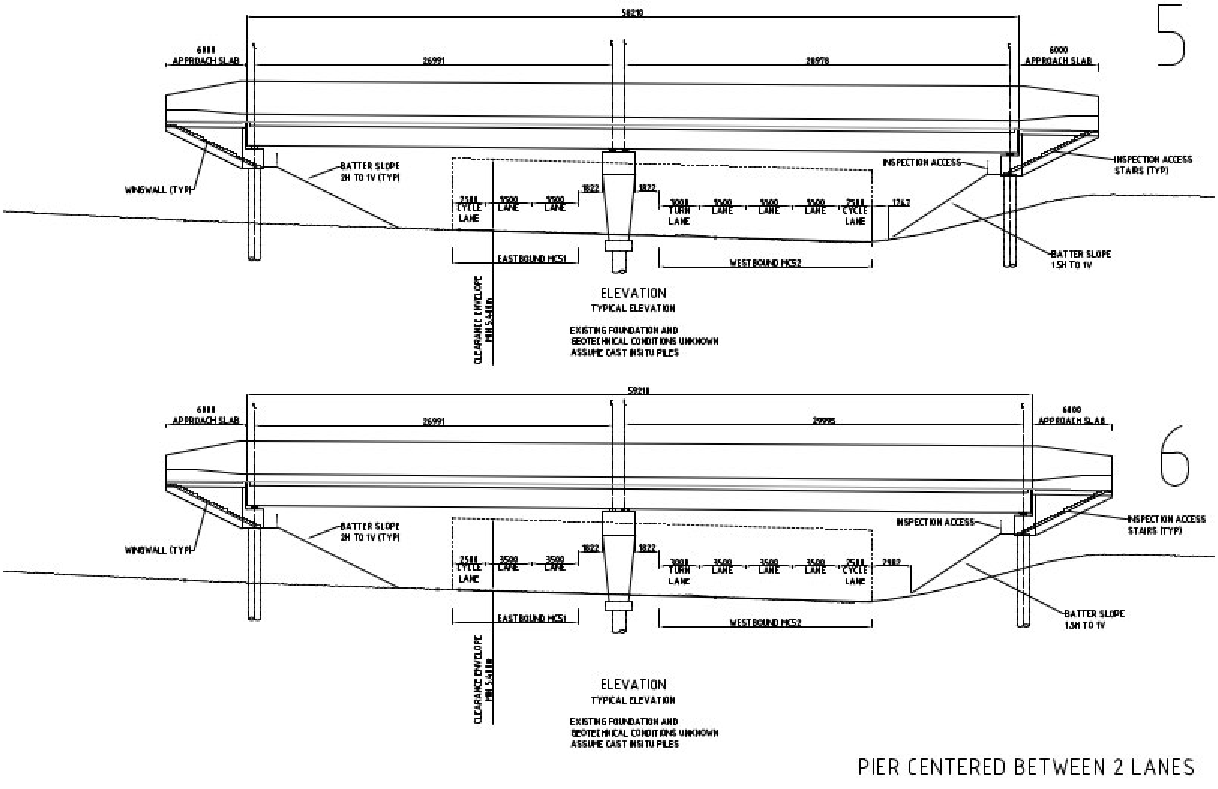


Figure 25: Super-T Options 5 and 6

4.10.3 New Bridge Concept Design

The concept design for the new bridge consists of a symmetrical 27 m long twin span Super-T bridge with piers in the central median of WHD. Each bridge structure will utilise seven industry standard

1500 mm deep Super-T girders supporting a 225 mm thick cast-in-place deck slab with a structural depth of 1.8 m. The girders will be supported on elastomeric bearings and headstock. An allowance for a 6.0 m long approach slab has been made.

It should be noted that the girder depth is on the conservative side to account for the uncertainty in the span length. Technically, at a 27 m span length, the next Super-T size down (i.e. 1200 mm deep) could be used but that would be close to the limit.

Each bridge structure will carry two 3.5 m traffic lanes, a 2.5 m wide on-road cycle lane, a 1.0 m shoulder and a 2.5 – 3.0 m shared path. An allowance for an 8.6 m median infill bridge to be placed in the future to support light rail has been made. A medium performance level RCO barrier with a cycle rail has been provided at the edge of on-road cycle lane, TCCS standard balustrade and safety screens has been provided on the outer edges of each bridge.

The typical cross-section of the proposed twin bridges is shown in Figure 26.

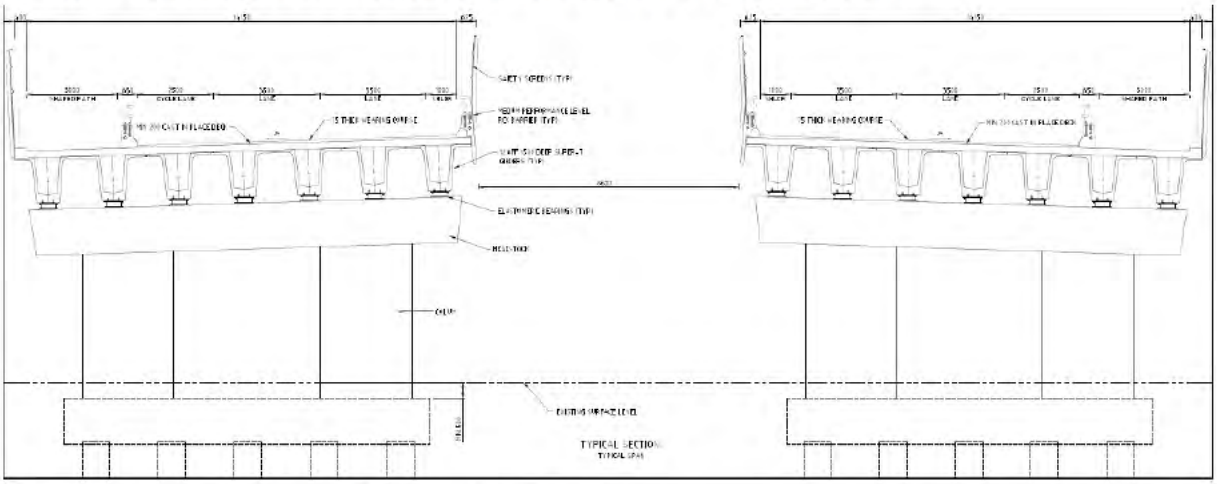


Figure 26: Typical cross-section of the proposed twin bridges

The central median pier on WHD will consist of an F-type roadside barrier with an offset of 1 m from the edge of travel lane with crash cushions. The same arrangement has been adopted at Canberra Avenue on the Monaro Highway Bridge as shown in Figure 27.

Figure 27: F-Type roadside barrier arrangement within median (Source: Google Maps)

4.11 Utilities and Services

AECOM has undertaken an assessment of impacted utilities based on the Dial Before You Dig (DBYD) information and liaison with utility authorities.

Correspondence with the utility authorities is included in Appendix F.

4.11.1 Water

Dial Before You Dig (DBYD) information shows an existing 900 mm diameter bulk water main on north eastern side of BS that continues diagonally across WHD and crosses BSE. There is an air valve on this bulk water main located on the southern verge of WHD which is likely to be impacted by the works. There is an existing 100 mm diameter reticulation main located on the western verge of BS which extends across WHD. This reticulation main is end-capped on the southern verge of WHD.

Figure 28: Existing water mains within the project area

A protection slab is proposed over the existing 900 mm diameter bulk water main under the on-ramp to WHD eastbound (MC04) due to an additional fill placed on this bulk main. The proposal has been provided to Icon Water and acceptance of the proposal is yet to be received.

The 900mm diameter bulk water main is proposed to be relocated when crossing BSE at two locations (approximately Ch 1645 and Ch 2110 on MC01), locating this section of the bulk main along the south eastern verge of BSE, as shown in Figure 29. The reasons for relocating this bulk water main are as follows:

- Minimise length of this main crossing under future pavement and its impacts on the proposed pavement for any future maintenance works.
- Rationalise the alignment of this bulk main and its easement i.e. maintaining the bulk main realignment route on the same side of the verge along BSE rather than crossing BSE at 2 different locations. This would remove the existing easement requirement on the southwestern area between Ch 1645 and Ch 2110 on MC01.
- Improve access to the bulk main as it is relocated adjacent to BSE.

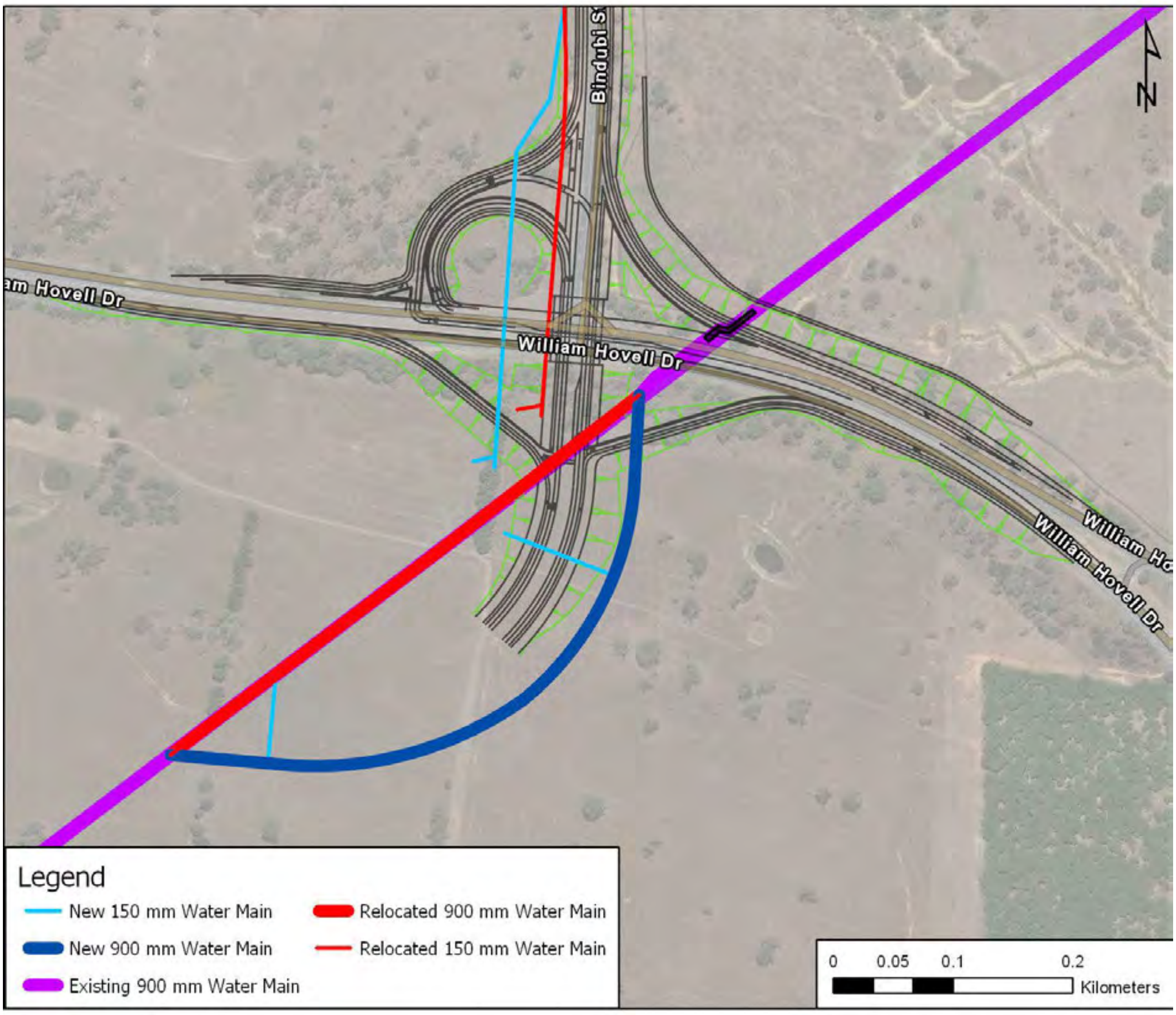


Figure 29: Proposed bulk water main relocation

Provision for 150 mm water main crossings on BSE from this bulk main are located at approximately Ch 1735 and Ch 2040 on MC01.

The existing 100mm diameter water main crossing WHD is proposed to be relocated further west from approximately Ch 1270 to Ch 1670 on MC01 due to the extent of earthworks.

Icon Water have indicated no concerns with the above proposal with the exception of the protection slab proposal as they would need to discuss it internally. However, they highlighted that detailed information on the following is required in the next stage of design:

- Provision of easement
- Land configuration to ensure safety of future development in case of pipe burst
- Access to the pipeline
- Safety and protection of pipeline
- Proposed development boundaries, pressure zoning and supply plans

4.11.2 Electricity and Street Lighting

There is an existing overhead 11 kV high voltage (HV) power line located on the northeastern quadrant of the interchange and it runs east towards Glenloch Interchange. Pole #34110 is located at the western end of this overhead power line and it is providing electrical supply to the signalised intersection and the streetlight network located on both BS and WHD. These are shown in Figure 30

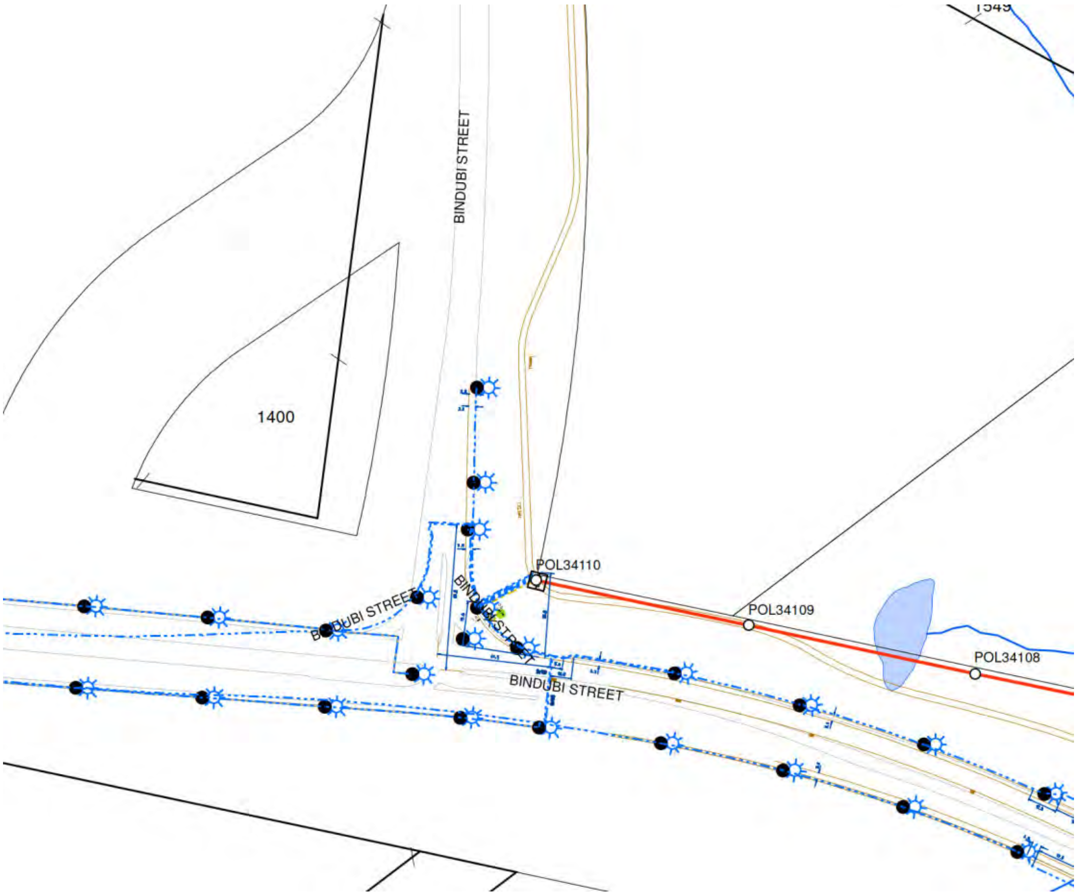


Figure 30: Existing electricity and streetlight conduits within the project area

The existing overhead power line will be impacted and will require realignment. The existing overhead power line is proposed to be realigned further north away from the extent of earthworks

The proposal was discussed with Evoenergy and the outcome of discussion is outlined below:

- They have no concerns regarding the realignment of the overhead power line.
- Relocation assets should not be located within private land.
- Relocation can be considered under an application for electricity network connection or alteration and the application to be lodged, at a minimum, six months prior to the actual relocation completion date.
- Provision for 6 x 150 mm electrical conduits and 2 x 63 mm communication conduits along each side of BSE and across WHD for future site servicing of adjacent development blocks.

4.11.3 Telstra

There are existing 2 x P100 Telstra conduits along the western verge of BS, continuing across WHD and splitting into two directions with one running west and the other running south.

It is proposed to relocate these conduits to be relocated further west due to the extent of earthworks from approximately Ch 1270 to Ch 1640 on MC01.

Telstra indicated no objection with the proposal. Telstra also indicated that their network contains a series of pits and conduits that contain a 50 mm copper cable. It is expected for the proposal to be a relatively routine relocation work.

Provision for 4 x 100 mm conduits has been made along BS and BSE for future site servicing of adjacent developments. Provision for these conduits will need to be discussed and confirmed with utility authorities in the next stage of design.

4.12 Street Lighting

Preliminary street lighting design has not been undertaken in this PSP. The following parameters have been assumed in estimating the opinion of probable of construction costs:

- 12.5 m street light pole with 4.5 m outreach in the vicinity of the project area
- 50 m spacing between poles

4.13 Preliminary Landscaping Advice

The BS – WHD interchange landscape design utilises repetition of elements to compound the sense of motion/velocity through space.

The peripheral treatment to the interchange is that of large eucalyptus spaced at decreasing intervals the closer they are positioned to the centre of the interchange. This rhythmic pattern of trees will create a sense of increasing tempo as users of the interchange transition towards its centre. This impression of increasing tempo encourages drivers to slow down whilst utilising the interchange.

The internal landscaping treatment also exploits a sense of rhythm, by utilising banded planting to compound a sense of motion through the interchange. This internal rhythm makes users overtly aware of their own velocity, in an effort for them to moderate their speeds through the interchange.

A preliminary hand-drawn sketch of the potential landscaping treatments for the interchange is shown in Figure 31.

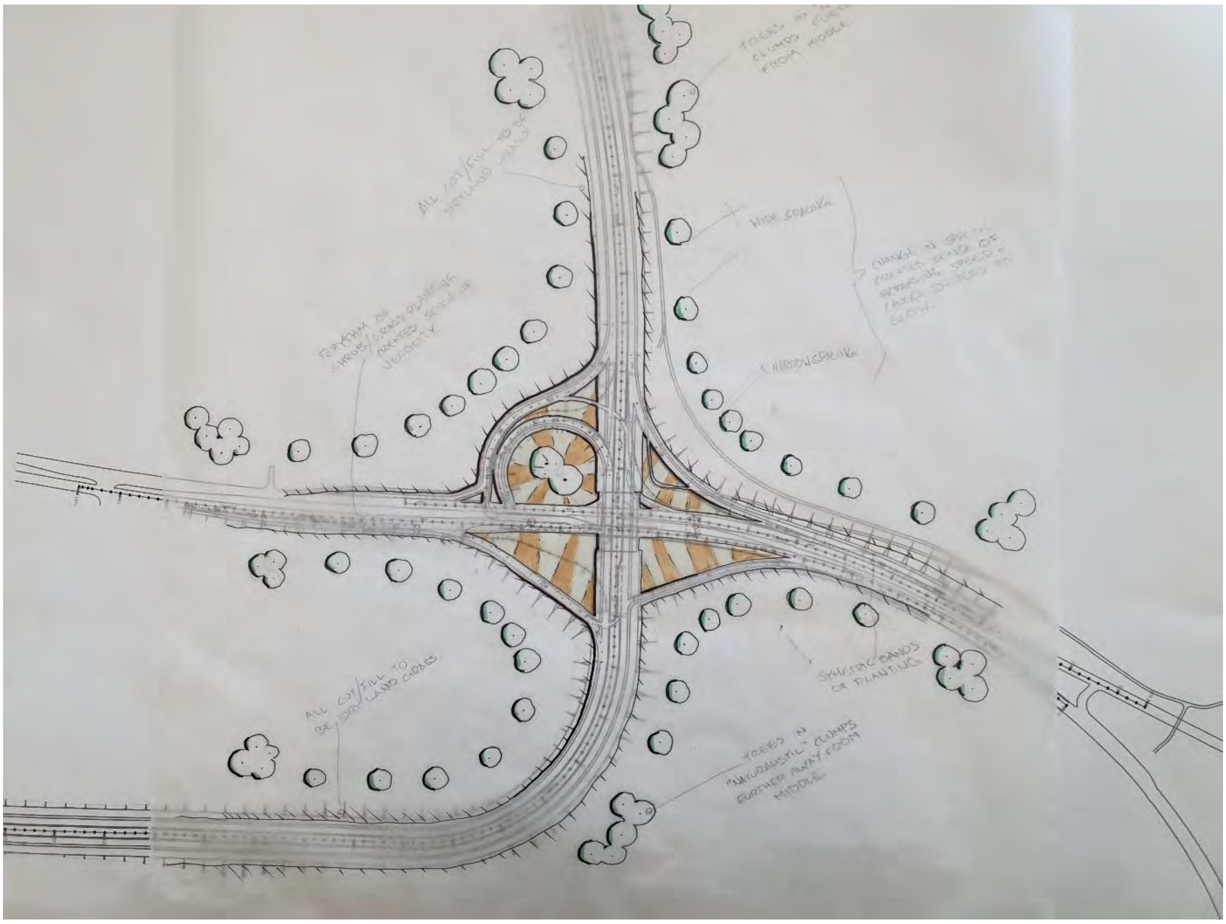


Figure 31: Preliminary sketch of potential landscaping treatments

4.14 Preliminary Construction Staging and Traffic Management

The following sections discuss the preliminary proposed staging of works and traffic management.

The assumptions on the existing traffic arrangement prior to construction of the interchange are as follows:

- Single carriageway two-way two lane on BS
- BSE has not been constructed

4.14.1 Early Works

The stormwater culvert crossing extensions, relocation and/or protection works of existing utilities are proposed to be undertaken in the early stage of works to ensure that these assets are protected or clear of the civil works. Relocation of BNT and Belconnen to City shared path is also proposed to be undertaken at this early stage of works.

4.14.2 Stage 1

It is proposed in Stage 1 that the existing traffic arrangement is maintained and that the following areas are constructed (refer to Figure 32):

- Left-turn slip lane on WHD eastbound and the off-ramp MC02 and most of the on-ramp MC03 connections
- Both BS northbound and southbound dual carriageway from Ch 1280 to approximately Ch 1320 MC01
- On-ramp MC04
- All proposed works south of WHD
- The two right-turn lanes on WHD westbound west of the existing intersection without impacting the operation of the existing intersection

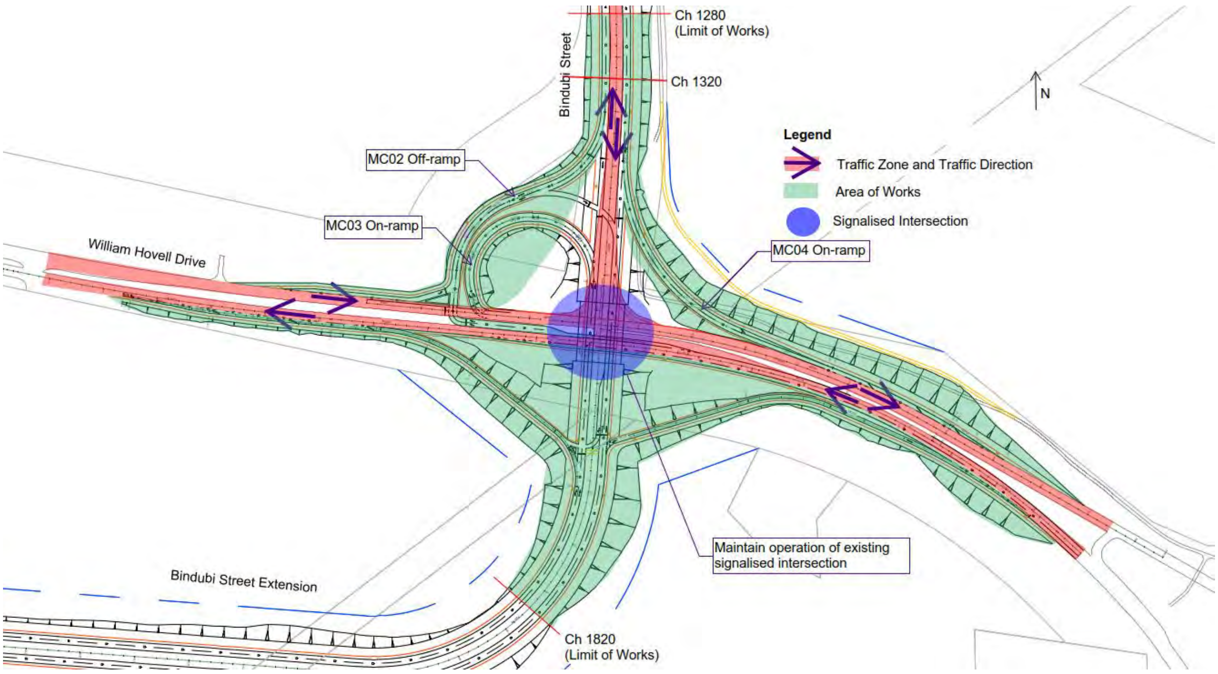


Figure 32: Proposed Stage1 of construction

4.14.3 Stage 2

The right-turn traffic volume from BS to WHD westbound is very low. It is therefore proposed for this traffic to be detoured using the existing road network, onto Coulter Drive and WHD westbound. If provision for this movement is to be accommodated, the possibility of additional temporary track and installation of temporary traffic signal is required on WHD.

All the other traffic movements are maintained at the intersection during Stage 2. Road users will be using the ramps and turning lanes constructed in Stage 1.

It is proposed to construct the following areas in Stage 2:

- The remainder of BS north and south, including the bridge and ramp connections.
- The remainder of the right-turn slip lane on WHD westbound

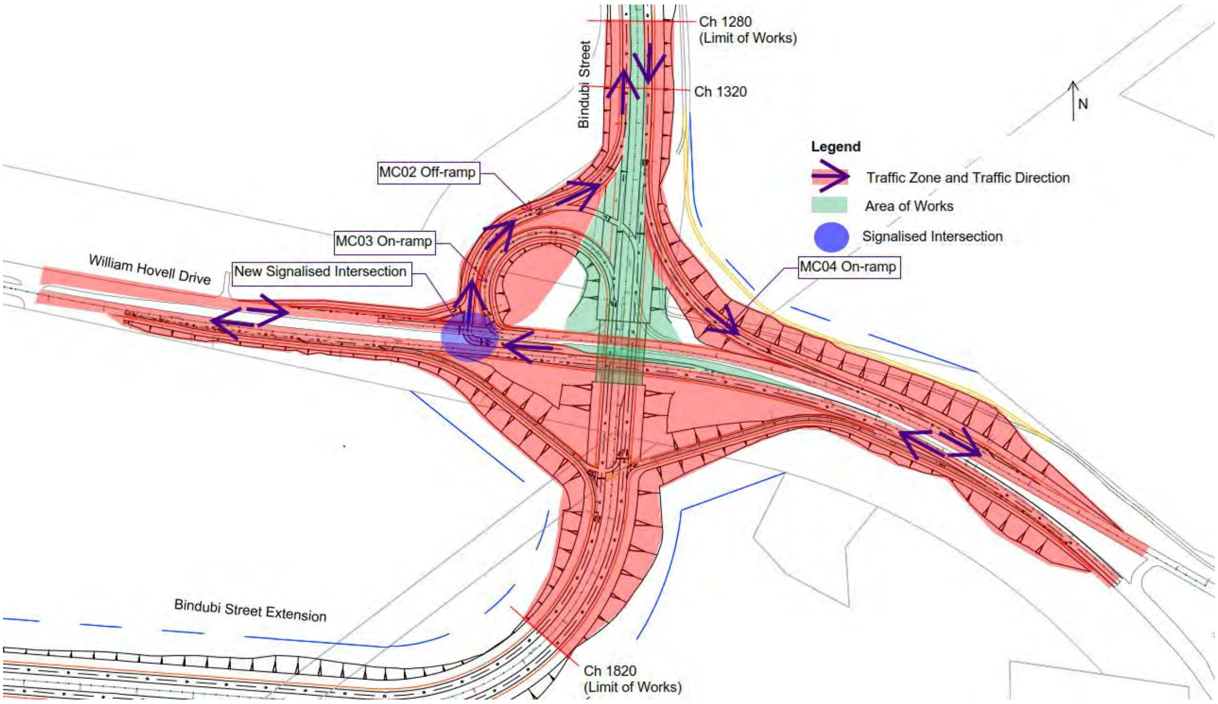


Figure 33: Proposed Stage 2 of construction

4.14.4 Stage 3

The traffic lanes will be at the final arrangement and works likely to be included in this part of construction staging would be reinstatement or restoration works or works outside the traffic lanes.

5.0 Safety in Design

5.1 General

The Work Health and Safety Act (2011) (WHS Act) require the Work Health and Safety Design Process to be documented as a standard part of the design documentation process.

In accordance with the WHS Act 2011, Section 295 that the objective of this report is to state "the hazards relating to the design of the structures that, so far as the designer is reasonably aware –

a. create a risk to the health or safety of persons who are to carry out any construction work on the structure or part; and

b. are associated only with the particular design and not with other designs of the same type of structure."

The Safety in Design consideration includes a risk register and risk mitigation plan analysis and will consider risks to the project during the design, construction, operation, maintenance and demolition phases of the project.

According to Worksafe ACT:

"*Safe design is a design process that eliminates, or minimises, potential and actual work health and safety hazards by involving decisions makers and considering the life cycle of the designed plant, substance or structure*."

For designers, this means applying systematic risk management techniques when making choices about design, materials and method of manufacture or construction to enhance safety of those who will use, handle, store, construct, assemble, dismantle, dispose or be affected by the operation of the plant, substance or structure."

Also, it is fundamentally critical for the Safety in Design information to be transferred between all people involved the life cycle of the project.

5.2 Approach

A flow chart of the Work Health and Safety Design Process is shown in Figure 34. The main steps in this process include:

1. Risk Identification

Both standard industry risks and project specific risks were identified by the project team. The risks have been assessed using the Consequence and Likelihood Scales and the Risk Analysis Matrix developed in accordance with Australian Standard AS/NZS 4360-2004.

2. Risk Mitigation

The above identified risks must be mitigated through one of the following approaches:

- Elimination
- Substitution
- Engineering controls
- Administration
- Personal protection.

These mitigation measures are arranged in a hierarchical order with elimination is the best approach to mitigating a risk.

3. Lifecycle Consideration.

The WHS Act (2011) requires the design to consider the full lifecycle of the project including:

- Construction
- Usage/Operation
- Maintenance
- Decommissioning

4. Capability and Performance Details plus Design Assumptions.

The design parameters and design assumptions for this project have been documented in other sections of this report.

5. Consultation and Coordination.

To date there has been consultation about the project with the road authority (TCCS) and other ACT Government stakeholders plus the various underground infrastructure providers such as Icon Water, Evoenergy and Telstra. Further consultation is required with maintenance personnel.

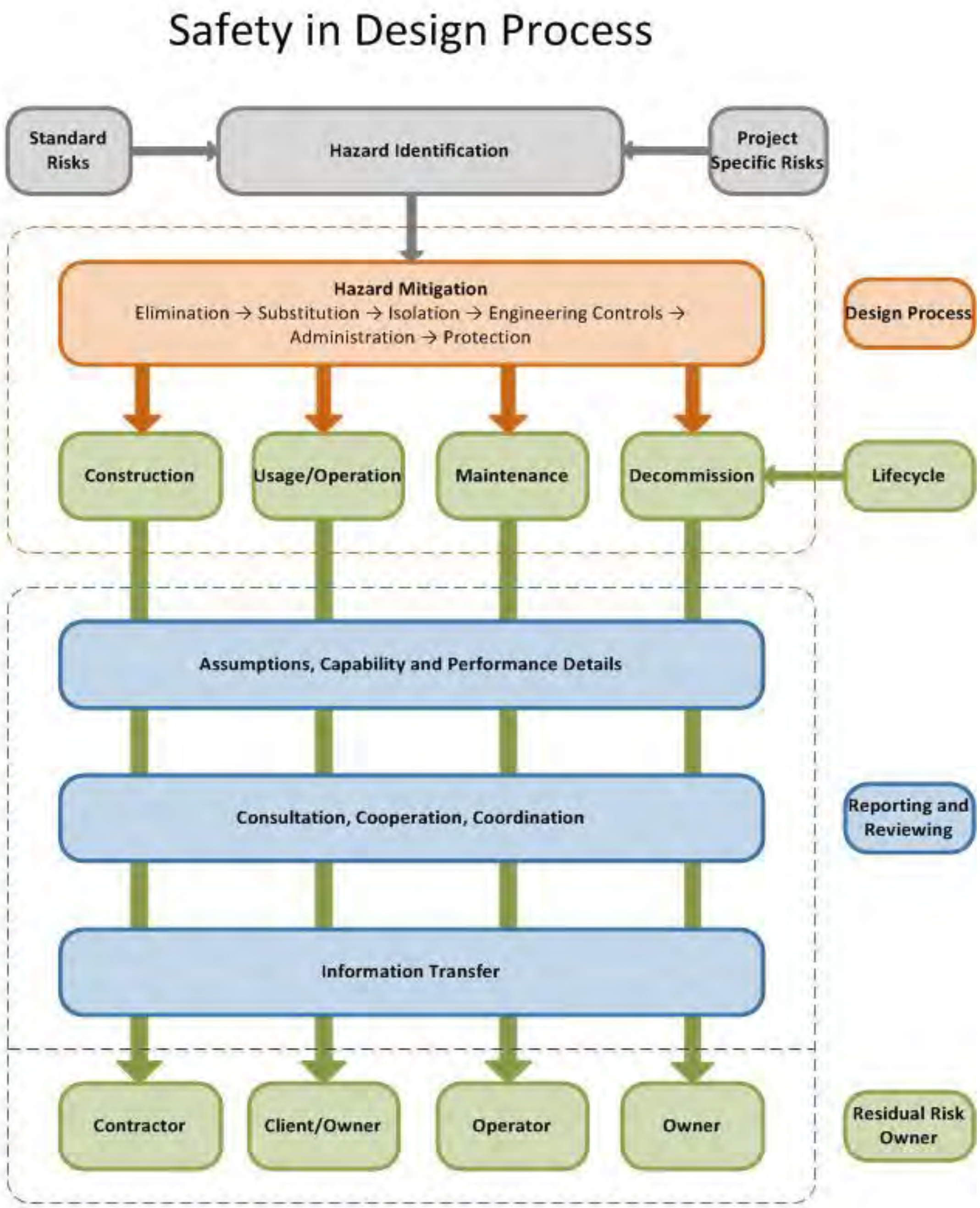
6. Information Transfer.

The identification of safety risks and how they are mitigated in the design is documented in the Safety in Design Register provided in Appendix G. This register is split into the four lifecycle phases and then then further split into the following three stages:

- Firstly, the hazard is identified along with the cause. The scale of the consequence and the likelihood is assessed to set the level of risk
- Secondly, ways to control the risk are determined and the scale of the consequence and the likelihood is assessed to set the level of the mitigated risk. A position is nominated to be responsible for managing the risk.
- Thirdly, there is the monitoring and close out of the risk. There is also direction on the management of any residual risk.

7. Residual Risk Owner

Unless the risk can be eliminated by the designer there is likely to be a residual risk which must be managed by another party, i.e. the Residual Risk Owner. The Residual Risk Owner is nominated along with a brief direction on how the ongoing risk is to be managed. Depending on the stage in the lifecycle of the project, the residual risk owner maybe the contractor, the owner, or the maintenance operator. It is also important that this safety in design process does not relieve contractors, owners, workers, users and operators from identifying and mitigating other safety risks within their particular areas of experience.



Notes:

1. The Safety in Design Process has been undertaken in accordance with the current (2011) harmonised Work Health and Safety legislation established by the Commonwealth and State/Territory Governments.
2. This process identifies risks to the personal safety of workers and users of the facility. It is only one part of the overall project risk management plan.
3. This process identifies safety risks specific to a particular project and contractors, workers, owners, users and operators must also refer to the other supporting Regulations and Codes of Practice that cover general safe behaviour.
4. This process does not relieve contractors, workers, owners, users and operators from identifying and mitigating other safety risks within their particular areas of experience.
5. Contractors, owners and operators must continue to manage the residual risks identified by this process.

Figure 34: Work Health and Safety Design Process

5.3 Key Considerations and Findings

The key design considerations and findings resulting from the Safety in Design are summarised in the following table. The more regular safety in design issues will be documented in the Safety in Design Register which is provided in the Appendices. The table also assesses the risk level which because the consequence is the possibility of death or life threating injuries and the likelihood is at least possible (Could happen and happen on other projects), then the risk level is usually high. Possible mitigation measures are being proposed and assessed as the design continues to be developed.

Table 25: Key design considerations and findings

No.	Hazard Description	Hazard Cause	Risk Level	Possible Mitigation	Residual Risk
DESIGN PHASE					
D1	Potential confusion that may result in accidents.	Close proximity between the proposed interchange (Bindubi Street) and Glenloch Interchange	Extreme	Clear directional signage in advance of the proposed interchange.	High
D2	Constraint intersection layouts that may results in heavy vehicles unable to proceed at the intersections.	Route used by heavy vehicles	Extreme	Specify minimum lane widths and check heavy vehicle turning paths. Clearly document movements where heavy vehicles are prohibited including the right-turn lane for BS southbound to WHD westbound	High
D3	Collisions between cyclist and vehicles especially at bicycle crossings	Potential for cyclist to be struck by passing traffic	High	Ensure the location of bicycle crossings meets sight distance requirements. Install cyclist crossing ahead sign to provide warning to vehicles.	Medium
CONSTRUCTION PHASE					
C1	Brownfields site with collisions between public traffic and construction plant / workers (construction under traffic)	High volumes of traffic passing through a constrained space	Extreme	The design allows for construction of duplication works off line to minimise impacts to existing traffic. TTM plans to clearly document the standard of vehicle, pedestrian protection measures and reduction of speed.	High
C2	Heavy vehicles not staying within the lanes causing accidents	Constrained Space / Poor sight lines	Extreme	TTM plans to specify minimum lane widths, to include heavy vehicle turning paths and to clearly document the standard of vehicle,	High

No.	Hazard Description	Hazard Cause	Risk Level	Possible Mitigation	Residual Risk
DESIGN PHASE					
				pedestrian protection measures and reduction of speed.	
C3	Cyclists colliding with construction plant and facilities	Constrained Space / Poor sight lines	High	TTM plans to consider segregating the cyclists, general traffic and construction plants. TTMS plans to show protection measures that are legible to cyclists and pedestrians.	Medium
C4	Falling from height while constructing bridge	Limited work area due to existing verge topography	Extreme	Contractor to provide appropriate work platforms for safe construction in accordance with working at heights requirements.	High
C5	Debris falling from structure impacting pedestrians / cyclists / vehicles in close vicinity	Construction of new bridge including central median piers	Extreme	TTM plans to consider closure of traffic lane during construction and enforce reduction of speed. Contractor to ensure this hazard is controlled and appropriate safety measures are in place.	High
C6	Contamination found during excavation works	Contamination	High	Include the requirement for CEMP, management of uncontrolled find and proposed mitigations	Low
C7	Electrocution or explosion	100 mm diameter water main, 900 mm diameter bulk water main, overhead and HV cables and other trunk utilities	Extreme	Specify locating the utilities with hydraulic drilling and include utility requirements in the tender documentation. Include in the tender documentation the requirements for the Tenderer to include their management system and process	High

No.	Hazard Description	Hazard Cause	Risk Level	Possible Mitigation	Residual Risk
DESIGN PHASE					
				in identifying the utilities.	
C8	Impacts to nearby residents such as confusion to public traffic which may cause accidents.	Uninformed residents	Extreme	Include communication strategies to inform the nearby residents of the works such as: • Letter drops • VMS Construction progress update through social media and Roads ACT's media section.	Medium
C9	Confusion to public traffic at intersections due to the construction works which may cause accidents.	Legibility of the temporary arrangement through the works due to changing traffic arrangements /conditions	Extreme	Consider temporary or utilising permanent traffic signals at the intersections during construction.	Medium
C10	Increased impact to Box Gum Woodland (areas of environmental significance) and Aboriginal Heritage scarred tree	Machinery use, access tracks and construction of retaining walls	Extreme	Specify and locate box gum woodland area on drawings and include requirement to fence off the areas prior to civil works in tender documentation. Ensure fences are erected around the Aboriginal Heritage scarred tree prior to construction.	Medium
C11	Pedestrians or Bicentennial National Trail users hit by construction plant	Constrained space / Poor sight lines	Extreme	TTM plans to specify suitable protection measure if construction occurs in close vicinity of existing path networks and Bicentennial National Trail. Other considerations to be further assessed in the design documentations are:	High

No.	Hazard Description	Hazard Cause	Risk Level	Possible Mitigation	Residual Risk
DESIGN PHASE					
				• Possible temporary route for equestrians using the whole length of the Bicentennial National Trail. • Controlled crossings. Maintained communications including during special events with the Equestrian Associations and Bicentennial National Trail users.	

6.0 Preliminary Cost Estimate

The preliminary cost estimate for the construction of the proposed grade-separated interchange is **$47.8 million (GST Inclusive)**. A 40% contingency is added to the overall costs. Consultancy and management fees are excluded.

The estimate of probable construction costs has been prepared based on measurements taken from the Draft PSP (Limited) drawings within the area of works notated on the drawings except for the 900 mm diameter bulk water supply main as noted below. Some specific elements of the measurements and cost estimates are as follows:

1. Earthworks

   A preliminary model of the interchange was prepared to determine the volume of materials required for the interchange formation. The model indicates limited materials available from excavations (7,000 m^3) and a filling requirement of 128,000 m^3 requiring the importation of around 120,000 m^3 material to make up the deficit.

2. Utility Relocations

   The major utility to be relocated is the 900 mm diameter bulk water supply lin. Approximately 590 m will be relocated from a point south of the limit of works shown on the plans to accommodate the total relocation required for BSE south of the interchange.

3. Bridgeworks

   Bridge cost estimates are based on twin two-span Super-T substructure with an overall length of 56.2 m and width of 15.2 m.

   An alternative to the two-span Super-T, a single span bridge of the same length with a steel trough girder layout (multiple girders under an in-situ concrete deck) could be provided. The probable cost of this form of construction would be $15.0 million compared to the two-span Super-T of $9.4 million, including GST but excluding the overall project contingency of 40%.

4. Construction Rates

   Rates for the various construction elements have been determined using Gundaroo Drive Stage 1 and Horse Park Drive Duplication tendered rates where applicable.

   The rates adopted are inclusive of 10% GST.

5. Land acquisition costs are excluded.
6. All approval costs are excluded.

P50/P90 cost estimation is expected to be undertaken in the next stage of design to improve the accuracy of the construction cost estimate.

The breakdown of costs according to the major items is presented in Table 26. The detailed Bill of Quantities (BOQ) is included in Appendix H.

Table 26: Breakdown of costs

Item No.	Item	Cost (Incl GST)
1.00	PRELIMINARIES	$2,937,000.00
2.00	EARTHWORKS	$6,228,178.75
3.00	UNDERGROUND SERVICES	
3.01	General	$225,850.00
3.02	Utility Relocations	$1,710,500.00
3.05	Stormwater Drainage	$890,800.00
3.06	Subsoil Drainage	$800,218.00
3.07	Conduits	$378,000.00

Item No.	Item	Cost (Incl GST)
3.08	Water Supply (included in Item 3.02)	$0.00
4.00	FLEXIBLE PAVEMENT CONSTRUCTION	$7,284,121.41
6.00	CONCRETE KERBS AND FOOTPATHS	$1,227,720.00
7.00	ROAD FURNITURE	$287,500.00
8.00	INCIDENTAL WORKS	$1,003,600.00
9.00	LANDSCAPE	$728,194.68
10.00	TRAFFIC CONTROL DEVICES	$200,000.00
11.00	TRAFFIC SIGNALS	$430,000.00
12.00	STREET LIGHTING	$415,200.00
13.00	BRIDGEWORKS	$9,405,000.00
SUB-TOTAL (Including GST)		**$34,151,882.84**
CONTINGENCY (40%)		$13,660,753.14
TOTAL (Including GST)		**$47,812,635.98**

7.0 Cost Benefit Analysis

A Cost Benefit Analysis (CBA) of the preferred option, Option 4, was undertaken in accordance with the Australian Transport Assessment and Planning Guidelines (ATAP 2018). The assessment methodology and analysis parameters were drawn from the ATAP Guidelines and the ATAP PV2 Road Parameter Values (2016).

The assessment considered the following potential impacts of the project:

- Improvements to road safety as a result of new road treatments
- Travel time savings from improved traffic flow and reduced congestion
- Improved environmental outcomes from reduced greenhouse gas emissions and noise pollution
- Potential vehicle operating cost savings as a result of improved traffic flow and lower congestion
- Changes to road network capital and operational costs.

7.1 General Modelling Parameters

The general modelling parameters used in the cost benefit analysis are shown in Table 27. The modelling has assumed a one-year construction period in 2026 and 30 years of impacts which commence the year following construction completion.

Table 27: General modelling parameters

Parameter	Value
Prices year	FY2019/20
Discount year	FY2019/20
Real discount rate	7%
Construction start period	FY2026/27
Total construction period	1 year
First full year of impacts	FY2027/28
Last year of impacts	FY2057/58

7.2 Costs

7.2.1 Capital costs

Capital costs for Option 4 were estimated at $47.812 million. The project is assumed to be constructed in 2026.

7.2.2 Maintenance costs

AECOM estimated maintenance costs for both the base case and project case. This includes costs to maintain the existing pavement, pavement for the intersection in the project case and additional maintenance costs of the flyover.

Table 28: Maintenance costs

Maintenance type	Unit	Frequency	Cost (FY$19)
Pavement maintenance costs			
Heavy patch replacement	0.5% of total area	Five years	$1.00/Metre^2
Mill and re-sheet	Total area	Ten years	$53.10/Metre^2
Additional maintenance cost (project option only)			

Maintenance type	Unit	Frequency	Cost (FY$19)
Flyover maintenance[1]	0.5% of construction cost	Annual	$333.50

Resurfacing maintenance cost estimates are based on the pavement area within the limit of works. Relevant pavement estimates were provided by the civil design assessment:

- Base case pavement area is 9,054 m^2
- Option 4 pavement area is 32,519 m^2

7.3 Benefits

The economic assessment measured a series of benefits against the costs of the project. Traffic performance profiles, Vehicle Kilometres Travelled (VKT) and Vehicle Hours Travelled (VHT), for the base case and project case were used to measure the potential benefits. Project benefits were assessed over 30 years from completion of construction.

Traffic analysis provided estimates of VHT and VKT for a two-hour AM weekday peak period in 2018, 2031 and 2041. An expansion factor was applied to derive annual figures for the years modelled (2018-2031 and 2041)[2]. The VHT and VKT estimates are detailed in Table 29 and form assumptions to measure traffic growth for each year in the cost-benefit model.

Table 29: Traffic modelling results – annualised VKT and VHT

Scenario	2018	2031	2041
VKT			
Base case	203,398,787	167,756,115	171,298,244
Project case	203,398,787	214,525,150	234,621,259
VHT			
Base case	3,442,631	9,546,833	9,882,639
Project case	3,442,631	5,512,189	6,616,617
Average Speed			
Base case	59 km/h	18 km/h	17 km/h
Project case	59 km/h	39 km/h	35 km/h

As identified in previous traffic analysis, the existing intersection will experience significant congestion by 2031[3]. VKT figures in Table 29 show a decrease in base case VKT between 2018 and 2031 and very low growth beyond 2031. The cause of the this is twofold. Firstly, the congestion causes stalled traffic that is unable to move freely through the intersection. Secondly, over time, some additional vehicles that would use the intersection are choosing another route to avoid the congested traffic.

Added capacity introduced in the project case addresses the congestion constraints of the intersection while meeting growth in demand for the road network. The increased demand and eased congestion in the project case cause VKT levels to be significantly higher than the base case.

VHT results in the model reflect the reduced time spent at the intersection in the project case. Even with the higher VKT results, the project case performs better for travel time. These results reflect that an increased number of vehicles are using the network and are able to do so with shorter travel times.

[1] Flyover maintenance cost estimate is standard AECOM CBA methodology based on industry experience

[2] An expansion factor of 7.21 derived a weekday estimate. The weekday estimate was then multiplied by 345 to derive an annual figure. sourced from Transport for New South Wales Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives (2018), Table 72.

[3] Design Options Report – Bindubi Street-William Hovell Drive Grade Separated Interchange Feasibility Study, AECOM (2019)

This is reflected in the higher average speeds in the project case. As a result, the project will lead to significant travel time benefits.

The analysis showed the project case benefits to be negative for environmental and vehicle operating cost benefits. These negative benefits are correlated with the increase in VKT. Increased utilisation of the road incurs higher costs than the base case because the increased capacity of the road in the project case allows a larger number of vehicles to flow through and induces demand from elsewhere in the network.

A summary of the project case benefits is shown in Table 30.

Table 30: Summary of project case (Option 4) benefits

Category	Project Case (million)
Crash cost benefits	$7.88
Travel time benefits	$414.20
Environmental benefits	-$52.33
Vehicle operating cost benefits	-$214.69
Total benefits	**$155.04**

7.3.1 Crash cost benefits

Crash rates were assumed to be proportional to levels of traffic. Using the crash rates detailed in Section 3.3, an annual crash rate per 100 million VKT was used to determine the potential safety benefits of the project.

The crash analysis found that improved infrastructure in the project case will reduce the likelihood of crashes at the intersection[4]. Using a crash reduction factor, crash rates were reduced by 50% in the project case[5].

Crash costs were sourced from the ATAP guidelines[6]. Vehicle crash rates and cost are shown in Table 31.

Table 31: CBA crash rates and associated costs

Crash Type	Base case annual crash rate (per/100 million VKT)	Project case annual crash rate (per/100 million VKT)	Crash Cost ($2019)
Fatal	0.1	0.05	$3,201,514
Injury	1.4	0.70	$601,269
Property	11.48	5.74	$27,504

7.3.2 Travel time benefits

Forecast VHT was used to estimate the benefits of reduced travel times. The value of time is sourced from the ATAP guidelines and is split among light vehicle (car) and heavy vehicle (freight truck), as shown in Table 32.

Table 32: Value of time

Vehicle type	Value of time/passenger hour ($2019)
Light	$17.90

[4] Design Options Report – Bindubi Street-William Hovell Drive Grade Separated Interchange Feas bility Study, AECOM (2019)
[5] Crash rate reduction factor was sourced from VicRoads based on grade separation infrastructure improvements
[6] ATAP Road Parameter Values 2016, table 18. The costs are provided in $2013 and were escalated to $2019 for the model

Vehicle type	Value of time/passenger hour ($2019)
Heavy	$29.50

7.3.3 Environmental benefits

Environmental externalities are costs of the project such as air pollution, greenhouse gas emissions and noise pollution. A benefit of the project is the extent to which these costs can be reduced. Environmental benefits were measured using VKT of the base case and project case against externality cost factors outlined in the ATAP guidelines.

The ATAP guidelines split externality unit costs into light vehicle and heavy vehicle costs, as shown in Table 33.

Table 33: Externality unit costs

Vehicle type	Externality unit cost ($2019)
Light	0.131
Heavy	0.327

7.3.4 Vehicle operating cost benefits

Vehicle operating costs (VOCs) are applied to light and heavy vehicles, with costs sourced from the ATAP guidelines[7]. These are summarised in Table 34. VOCs were measured against VKT to compare the project case and base case.

Table 34: Vehicle operating costs

Vehicle type	Vehicle operating cost/VKT
Light	$0.587
Heavy	$1.346

7.4 Results

The CBA has been undertaken over a 31-year appraisal period, including a one-year construction period and 30 years of operational impacts. The analysis is reported in terms of two economic indicators, Net Present Value (NPV) and Benefit Cost Ratio (BCR).

Net Present Value measures the difference between costs and benefits, whilst accounting for the timing of the cash flows. Net cash flows are discounted at a specific discount rate. A project with an NPV greater than zero indicates that the Present Value (PV) of the benefits exceed the PV of the costs and is therefore considered economically viable.

The **Benefit Cost Ratio** measures the benefits received per dollar of project cost. It is used to indicate economic value for money. BCR is calculated by dividing the PV of the total benefits by the PV of the total costs. A project with a BCR greater than one indicates that the PV of the benefits exceeds the PV of the costs and is therefore considered to provide value for money.

Table 35 presents the CBA for Option 4 (project case). The PV costs of the project represent the net costs incurred over and above the costs incurred in the base case.

Table 35: Cost benefit analysis results

Option	Present value costs	Present value benefits	NPV	BCR
Option 4	$32.83m	$155.04m	$122.21m	4.7

[7] ATAP Road Parameter Values 2016, table 35.

The CBA shows that the proposed interchange has a positive NPV and a BCR substantially greater than one. This indicates that Option 4, the preferred option, is considered to be economically feasible and provides value for money. The intersection currently creates bottle-necked traffic on a major arterial road in Canberra. While relatively low-cost, the project significantly improves traffic performance. The benefits of improved flow of traffic and an increasingly utilised road network provides high return on investment.

The CBA found that the significant travel time and crash cost benefits of the project outweigh the costs incurred.

Table 36 shows that while negative benefits are incurred, overall the project is economically viable.

Table 36: Option 4 benefits

Category	Project case (millions)
Crash cost benefits	$7.88
Travel time benefits	$414.20
Environmental benefits	-$52.33
Vehicle operating cost benefits	-$214.69
Total benefits	**$155.04**
Total cost	**$32.83**
BCR	**4.7**

7.5 Sensitivity Testing

Sensitivity analysis was undertaken with discount rates of 4% and 10% (see Table 37 and Table 38). The purpose of this is to test the economic viability of the project under different future financial and economic conditions.

Table 37: Sensitivity testing results

Discount rate	Present value costs (millions)	Present value benefits (millions)	NPV (millions)	BCR
4%	$41.64	$235.96	$194.31	5.7
7%	$32.83	$155.04	$122.21	4.7
10%	$26.41	$104.47	$78.06	4.0

Table 38: Sensitivity testing of benefits

Category	4% (millions)	7% (millions)	10% (millions)
Safety benefits	$12.44	$7.41	$5.28
Travel time benefits	$715.64	$391.38	$253.21
Environmental benefits	-$96.53	-$49.87	-$30.16
Vehicle operating cost benefits	-395.58	-$204.58	-$123.86
Total benefits	**$235.96**	**$144.33**	**$104.47**
Total cost	$41.64	$30.70	$26.41
BCR	**5.7**	**4.7**	**4.0**

Results of the sensitivity testing show that under different discount rates, the project remains economically viable with a BCR significantly higher than 1.0. The CBA results demonstrate the significant benefits of de-congestion of a major arterial road. The results show this is a low-cost, high impact project.

8.0 Conclusions and Recommendations

8.1 Conclusions

The technical and economic feasibility of upgrading the BS – WHD intersection has been investigated. Possible upgrades, including both at-grade and grade separated options, were initially conceptualised and assessed via an MCA process that was presented to and discussed with ACT Government stakeholders. A preferred option, the small at-grade quadrant with flyover, was selected and progressed to PSP design (at a limited level).

The resulting intersection upgrade design took into consideration the following:

- Topography – The horizontal and vertical alignments of each road component were optimised to integrate well with the existing environment and constraints.
- Existing road network – The design takes into account the existing road infrastructure, including Glenloch Interchange, as well as traffic operations, both current and future.
- Existing utilities – The alignments are designed to minimise impacts on existing utilities, proposing service relocations where appropriate.
- Ecology, heritage, contamination and noise – The conceptualisation of the intersection upgrade layout considered impacts on the environment.
- Future light rail – There is allowance for future light rail to be constructed on the median and between the proposed twin bridges over WHD.
- Construction staging and traffic management – The design of the interchange takes into consideration how it will be constructed and how the construction activities will impact current traffic movements.
- Cost – The design minimises costs without sacrificing service levels, providing the most cost-effective solution.

Preliminary costs have been estimated and the total cost of the intersection upgrade is expected to be **$47.8 million (inclusive of GST and 40% Contingency)**. This cost is expected to be further refined to P50/P90 estimates in the next stage of the project.

The CBA results indicate positive results, with a **BCR of 4.7** and **NPV of $122.21 million** under a discount rate of 7%.

Based on the outcomes of the investigations undertaken and the results of the CBA, the proposed grade-separated solution for the BS – WHD intersection is therefore considered technically and economically feasible. There are constraints and challenges in implementing the upgrade that require significant capital works expenditure to overcome, but the economic returns to road users and the community provide sufficient justification to build this major transport infrastructure.

8.2 Recommendations

The following are recommended for consideration in the next stage of design:

- Possible reduction of the asphalt base course at the ramps/loops and BS that are projected to carry less traffic
- Additional geotechnical investigation to confirm the preliminary design CBRs.
- Additional geotechnical investigation to confirm groundwater level
- Development of bridge foundation design parameters
- Full engineering survey of the whole site of works
- Completion of a full PSP or Final Sketch Plan (FSP) design submission to confirm the design subject to receipt of a detailed engineering survey

- Arboricultural assessment of the identified potential scarred tree at the northwest quadrant of the BS – WHD intersection
- The interchange should be constructed prior to the duplication of BS and BSE construction to avoid significant traffic management implications and redundant works as would occur if BS duplication and BSE were the initial construction.
- Road safety audit to include an assessment on on-road cycling facilities and their interaction with high speed traffic and heavy vehicles.

Appendix A

Design Options Report

Appendix B

Preliminary Noise Assessment Report

Appendix C

Design Criteria

Appendix D

Preliminary Sketch Plan (PSP) Drawings - Limited

Appendix E

Preliminary Geotechnical Assessment Report

Appendix F

Correspondence with Utility Authorities

Appendix G

Safety in Design Risk Register

Appendix H

Bill of Quantities