



Transport
Roads & Maritime
Services

MEMORIAL AVENUE UPGRADE

Review of Environmental Factors

November 2014

(blank page)

Roads and Maritime Services

Memorial Avenue Upgrade from Old Windsor Road to Windsor Road

Review of environmental factors
November 2014

This report has been prepared for Roads and Maritime Services in accordance with the terms and conditions of appointment for Memorial Avenue upgrade – Concept Design and Review of Environmental Factors Contract No. 13.2592.2460, dated 20 December 2013. Hyder Consulting Pty Ltd (ABN 76 104 485 289) cannot accept any responsibility for any use or reliance on the contents of this report by any third party.

Version	Date	Revision Description
1.0	31 July 14	Preliminary draft issued to Roads and Maritime
2.0	8 September 14	Full draft issued to Roads and Maritime
3.0	8 October 14	Second draft issued to Roads and Maritime
4.0	16 October 14	Final issued to Roads and Maritime

Executive summary

Roads and Maritime Services proposes to upgrade about 2.2 kilometres of Memorial Avenue (MR642) between Windsor Road and Old Windsor Road, Kellyville (the proposal).

The key features of the proposal include:

- Widening Memorial Avenue from a two-lane road to a four-lane divided road for a length of about 2.2 kilometres
- Building a wide central median along Memorial Avenue to allow the road to be widened to six lanes, when required
- Upgrading the intersections of Memorial Avenue with Windsor Road, Arnold Avenue (west), and Old Windsor Road / Sunnyholt Road
- Closing the intersections of Memorial Avenue with Hector Court, Rutherford Avenue, and Arnold Avenue (east)
- Providing traffic lights at the intersections of Memorial Avenue with Arnold Avenue and Severn Vale Drive
- Providing left-in and left-out access for Burns Road and Stone Mason Drive
- Widening the alignment of Windsor Road generally to the west of the existing road between President Road and Wrights Road
- Slightly widening the alignment of Old Windsor Road for about 300 metres either side of the intersection
- Building a bridge to carry traffic travelling along Memorial Avenue over Strangers Creek
- Providing a speed limit of 70 kilometres per hour along Memorial Avenue
- Providing a three-metre-wide shared pedestrian/cyclist path on both sides of Memorial Avenue
- Providing bus priority capability at traffic lights, and creating indented bus bays on both sides of Memorial Avenue
- Relocating and/or temporarily diverting underground utilities, including water, telecommunications, electricity and gas.

The construction of the proposal is expected to generally be completed away from the existing road (or 'offline') in two stages. The timing of construction has not been determined at this stage, but the construction period is expected to be around two years.

The project would be funded by the NSW Government and through developer contributions from adjacent developments.

Need for the proposal

In 2005, a *Burns Road-Memorial Avenue, Kellyville, Route Strategy* was developed by then Roads and Traffic Authority (RTA, now Roads and Maritime). The strategy concluded that an upgrade of Burns Road-Memorial Avenue could bring significant benefits to the corridor and its road users.

Traffic volumes along Memorial Avenue are forecast to almost double between 2014 and 2036, from 25000 annual average daily traffic (AADT) to 45,000 AADT. This growth would be primarily driven by nearby urban development, including the Balmoral Road Release Area. A total of 6,000 new dwellings are proposed in the Balmoral Road Release Area, identified in The Hills Development Control Plan (DCP) 2012. These homes are expected to accommodate a population of about 13,000 people.

The *Memorial Avenue Upgrade Traffic and Transport Assessment* (Hyder Consulting 2014) identified the Old Windsor Road/Memorial Avenue/Sunnyholt Road intersection is over capacity in both the morning and afternoon peak periods, and the Windsor Road/Memorial Avenue intersection is nearing capacity. Other intersections along Memorial Avenue are either satisfactory or near capacity, but congestion based on predicted traffic flows is expected to increase without upgrades.

Benefits of the proposal include:

- Providing capacity to support projected traffic volumes on Memorial Avenue between Windsor Road and Old Windsor Road, including at the intersections with these arterial roads
- Improving travel times within the proposal area
- Providing facilities for walking and cycling as well as efficient bus movement within the proposal area
- Enhancing urban design and visual variety within the proposal area, to complement the changing landscape of the Balmoral Road Release Area
- Improving the drainage system, particularly at identified low points along Memorial Avenue so that the road is serviceable during one in 100-year floods
- Improving safety by providing a new road design and intersection upgrades compliant with current safety standards.

Objectives

The objectives of the proposal are to:

- Improve road safety in line with the *NSW Road Safety Strategy 2012–2021* 'Safe System Directions' and 'Safer Road' key focus
- Improve liveability and sustainability, support economic growth and productivity by providing road capacity for projected traffic volumes
- Improve travel times
- Improve quality of service, sustainability and liveability by providing facilities for walking and cycling and future public transport needs
- Improve urban design and visual quality
- Improve the drainage system.

Options considered

Four options were considered and assessed as part of the development of this proposal. These were:

- Option 1: Do nothing

- Option 2: Upgrade Memorial Avenue to four lanes, without upgrading intersections with Windsor Road and Old Windsor Road/Sunnyholt Road
- Option 3: Upgrade Memorial Avenue to four lanes, and upgrade the at-grade intersections with Windsor Road and Old Windsor Road/Sunnyholt Road
- Option 4: Upgrade Memorial Avenue to four lanes, upgrade the at-grade intersection with Windsor Road, and change the at-grade intersection with Old Windsor Road/Sunnyholt Road to a grade-separated intersection.

Option 3 was selected as the preferred option because it best meets all the project objectives. The option

- Complies with objective one, in line with the Safe System Directions key focus. The intersection upgrades would address traffic issues to/from Windsor Road and Old Windsor Road and contribute to improved traffic conditions on Memorial Avenue
- Meets the objective to improve quality of service, sustainability and liveability by providing facilities for walking and cycling and future public transport needs. Shared paths along both sides of Memorial Avenue, connecting with existing shared paths on Windsor Road and Old Windsor Road, provides facilities for walking and cycling that connect to the larger network
- Provides an opportunity to improve the urban design and visual quality and the drainage system.

Statutory and planning framework

This proposal was assessed under Part 5 of the *Environmental Planning and Assessment Act 1979*. In this Review of Environmental Factors (REF), Roads and Maritime has also considered Clause 228 of the *Environmental Planning and Assessment Regulation 2000* and Matters of National Environmental Significance (MNES).

The *State Environmental Planning Policy (Infrastructure) 2007* (ISEPP) applies to this proposal. Clause 94 of ISEPP permits development on any land for the purpose of a road or road infrastructure facilities to be carried out by or on behalf of a public authority without consent.

Community and stakeholder consultation

Roads and Maritime consulted with:

- The local community in November and December 2013 to get their feedback on a preliminary concept design. As part of this process, Roads and Maritime sent a Community Update newsletter to local residents and hosted two community information sessions. Roads and Maritime will also consult with the community during the public exhibition of this REF.
- The Hills Shire Council and Blacktown City Council, in accordance with Part 2 of the ISEPP. Council representatives were also consulted during the development of the concept design. Representatives of The Hills Shire Council, Transport for NSW and Roads and Maritime had regular meetings to discuss the proposal as it was developed and address technical issues.

- Utility authorities including Integral Energy, Jemena, Optus, Sydney Water and Telstra.
- Surrounding property owners were advised in writing of the technical surveys and investigations before they were carried out to inform this REF.

Environmental impacts

Roads and Maritime engaged Hyder Consulting to manage the environmental assessment process for the REF. A number of detailed technical investigations were completed to assess the potential impacts of the proposal, and identify safeguards and management measures to mitigate these impacts. The assessment found the highest potential for environmental impacts in the areas of:

- Traffic and transport
- Biodiversity
- Hydrology
- Noise and vibration
- Visual amenity
- Contamination.

Traffic and transport

Construction of the proposal would have some short-term, temporary impacts on traffic and transport, including potential traffic delays. Construction would be staged, scheduled, and managed to minimise these impacts.

However, once it is built, the proposal would result in positive traffic impacts. In particular, the proposal would:

- Reduce traffic delays at the following intersections:
 - Old Windsor Road / Memorial Avenue / Sunnyholt Road
 - Windsor Road / Memorial Avenue
 - Arnold Avenue (West) / Memorial Avenue.
- Provide bus priority lanes (ie queue-jump lanes) and indented bus bays at new traffic signals on Memorial Avenue at Arnold Avenue and Severn Vale Drive both eastbound and westbound. These would improve the operation of bus services by allowing buses a head start in the east–west direction along Memorial Avenue
- Provide a three-metre wide off-road shared pedestrian/cyclist path on both sides of Memorial Avenue, to improve the safety of pedestrians and cyclists.

Biodiversity

The proposal would result in the following impacts on biodiversity:

- The removal of remnant and planted street trees and landscaped vegetation in a 11.078 hectare area, 0.414 hectares of which is native vegetation. Of the native vegetation to be removed, about 0.257 hectares is endangered ecological community, comprising 0.190 hectares of Cumberland Plain

Woodland and 0.067 hectares of Swamp Oak Floodplain Forest

- Removal of 0.414 hectares of potential foraging habitat, potential removal of one hollow-bearing tree and replacement of culvert structures. These changes would impact on threatened fauna. Furthermore, the Grey-headed Flying-fox would be impacted by the loss of potential foraging habitat comprising scattered regrowth and planted trees.
- Removal of aquatic and riparian vegetation over a small area of 0.173 hectares, 0.068 hectares of which is instream vegetation. The creeks are highly degraded and existing fish and frogs likely to be impacted would be hardy and common species. No impacts on threatened aquatic species are anticipated as a result of the work. Additionally, fish passage would be maintained throughout the construction process at all creek crossings.

Due to the limited impacts, the proposal is unlikely to have a significant impact on any threatened species, population or community listed under the *Threatened Species Conservation Act 1995 (TSC Act)* or the Commonwealth *Environment Protection and Biodiversity Act 1999 (EPBC Act)*. Consequently, a species impact statement, or a referral to the federal Department of the Environment (DoE) under the EPBC Act are not required.

Hydrology

The proposed drainage structures would improve existing drainage conditions by providing sufficient hydraulic capacity to effectively convey stormwater flows under Memorial Avenue during one in 100-year ARI flood events.

The proposal has the potential to increase salinity in the vicinity of the proposal area by compacting soils in areas of fill and embankments and by potentially concentrating saline discharges. Further salinity investigations would be carried out during detailed design.

There is minor potential during construction for temporary water quality impacts through sedimentation of waterways and through pollution from spills, leaks or poor waste management. These would be managed through construction management safeguards, including the development of a comprehensive erosion and sediment control strategy.

Noise and vibration

The increase in noise levels between the design year 'no-build' and 'build' options is more than 2dB(A) in noise catchment areas (NCAs) 2, 4 and 5 which is a perceptible difference according to the Roads Noise Policy. In the design year 2026 noise levels are predicted to be acute at 117 properties.

There are 52 residences within the proposal area that have been identified for noise mitigation. At-property treatment, such as window glazing and air conditioning, would be considered for dwellings where other noise mitigation measures are either exhausted or are not feasible or cost effective.

Construction phase noise levels at residences are expected to exceed noise management levels in most NCAs, and with the exception of NCA 4, residences may also be "highly noise affected". Other sensitive receivers, such as childcare centres and commercial properties, are expected to be slightly less affected than residences as they generally only operate during the day and are often set back further from the road.

The assessment estimated construction vibrations to cause a high potential for structural damage in NCAs 6 and 7. To ensure this risk is minimised, the contractor would be required to undertake vibration monitoring to measure compliance with the adopted vibration criteria. The contractor would also be required to undertake building condition surveys prior to any construction work being carried out.

Visual amenity

Without landscaping, the proposal would have an adverse impact on visual amenity and landscape character. While the proposal, for the most part, is to take place in an established road corridor, there would be visual impacts due to the removal of trees, increase in road pavement width, and intersection upgrades. The greatest impacts occur where large numbers of trees would need to be removed. For example, a number of trees would be removed at the slight bend in Memorial Avenue near Pellizzer Boulevard and there is limited space to provide replacement trees due to the corridor width. At Strangers Creek, the removal of trees would open up the road corridor, where some enclosure currently exists and this would impact the views of nearby properties at Kellyville Memorial Park.

Landscape and urban design mitigation strategies have been developed from the outcomes of the landscape character and visual assessments and have been incorporated into the Urban Design and Landscape Concept Design.

Contamination

The proposal is likely to require excavation of soils at a former service station site on the corner of Memorial Avenue and Windsor Road. The site has the potential for soil contamination as a result of previous use. Further investigations would be required prior to construction to determine the risk of contamination, and provide guidance on potential treatment.

Justification and conclusion

The proposed Memorial Avenue upgrade would best satisfy Roads and Maritime's objectives for this transport corridor.

The proposal would alleviate congestion and accommodate future traffic generated by the Balmoral Road Release Area and the North West Rail Link. The proposal would also provide capacity for projected traffic volumes on Memorial Avenue between Windsor Road and Old Windsor Road, including intersections with these arterial roads.

The proposal would also improve safety by providing new traffic lights at intersections, turning lanes at intersections and a median to separate traffic travelling in opposite directions. The proposal also includes shared paths to improve safety for cyclists and pedestrians and bus priority lanes and indented bus bays for efficient bus movement.

This REF finds the proposal is unlikely to have a significant impact on the environment and therefore an environmental impact statement (EIS) is not required.

Display of the review of environmental factors

This review of environmental factors is on display for comment between 17 November 2014 and 12 December 2014. You can access the documents in the following ways:

Internet

The documents will be available as pdf files on the Roads and Maritime Services website at

<http://www.rms.nsw.gov.au/projects/sydney-west/kellyville-memorial-avenue-upgrade/index.html>.

Display

The review documents can be viewed at the following locations:

The Hills Shire Council

3 Columbia Court, Baulkham Hills
Monday to Friday between 8.30am and 4.30pm

Castle Hill Library

Corner of Castle and Pennant streets, Castle Hill
Monday to Friday 10am to 8pm
Saturday 10am to 5pm
Sunday 1pm to 5pm

How can I make a submission?

To make a submission on the proposal, please send your written comments to:

Memorial Avenue Upgrade Project Team
Roads and Maritime Services
PO Box 973
Parramatta CBD NSW 2124

Or email your comments to:

Memorial.Avenue.Upgrade@rms.nsw.gov.au

Submissions must be received by Friday, 12 December 2014

Privacy information

All information included in submissions is collected for the sole purpose of assisting in the assessment of this proposal. The information may be used during the environmental impact assessment process by relevant Roads and Maritime Services staff and its contractors.

Where the respondent indicates at the time of supply of information that their submission should be kept confidential, Roads and Maritime Services will attempt to keep it confidential. However there may be legislative or legal justification for the release of the information, for example under the *Government Information (Public Access) Act 2009* or under subpoena or statutory instrument.

The supply of this information is voluntary. Each respondent has free access at all times to the information provided by that respondent but not to any identifying information provided by other respondents if a respondent has indicated that the representation should be kept confidential.

Any respondent may make a correction to the information that they have provided by writing to the same address the submission was sent.

The information will be held by the Roads and Maritime Services, 27-31 Argyle Street Parramatta NSW.

What happens next?

Following the submissions period, Roads and Maritime will collate the submissions. Acknowledgement letters will be sent to each respondent. The details of submission authors will be retained and authors will be subsequently advised when project information is released.

After consideration of community comments, Roads and Maritime will determine whether the proposal should proceed as proposed, or whether any alterations to the proposal are necessary. The community will be kept informed regarding this decision.

If the proposal goes ahead, Roads and Maritime will proceed with preparing a final design and tenders will be called for construction of the project.

If you have any queries, please contact the Roads and Maritime project team on 1800 784 847.

Contents

Executive summary	i	
1	Introduction	1
1.1	Proposal identification.....	1
1.2	Purpose of this report	4
2	Need and options considered	5
2.1	Strategic need for the proposal.....	5
2.2	Existing road and infrastructure	9
2.3	Proposal objectives	19
2.4	Alternatives and options considered.....	19
2.5	Preferred option	25
2.6	Design refinements.....	25
3	Description of the proposal	26
3.1	Overview of the proposal	26
3.2	Detailed description of the proposal	27
3.3	Design	35
3.4	Construction activities.....	60
3.5	Ancillary facilities	71
3.6	Public utility adjustment	77
3.7	Property acquisition	84
4	Statutory and planning framework.....	90
4.1	State environmental planning policies	90
4.2	Local environmental plans	93
4.3	Other relevant legislation	97
4.4	Commonwealth legislation.....	99
4.5	Confirmation of statutory position	99
5	Stakeholder and community consultation	100
5.1	Consultation strategy	100
5.2	Community involvement to date	100
5.3	Aboriginal community involvement	103
5.4	ISEPP consultation	103
5.5	Government agency and stakeholder involvement.....	104
5.6	Ongoing or future consultation.....	107
6	Environmental assessment.....	108
6.1	Hydrology and water quality	108
6.2	Topography, Geology and Soils	129
6.3	Traffic and transport	149
6.4	Noise and vibration	164
6.5	Biodiversity	192
6.6	Aboriginal heritage.....	222
6.7	Non-Aboriginal heritage	228
6.8	Air quality	235

6.9	Land use and socio-economic impact	241
6.10	Landscape Character and visual impacts.....	249
6.11	Climate change and greenhouse gas	271
6.12	Resource use and waste management	274
6.13	Cumulative Impact	278
6.14	Summary of beneficial effects.....	282
6.15	Summary of adverse effects	282
7	Environmental management.....	283
7.1	Environmental management plans (or system)	283
7.2	Summary of safeguards and management measures.....	283
7.3	Licensing and approvals	312
8	Conclusion	313
8.1	Justification	313
8.2	Objects of the EP&A Act.....	313
8.3	Conclusion	316
9	Certification.....	318
10	References	319

List of figures

Figure 1-1: Memorial Avenue upgrade – Windsor Road to Old Windsor Road	2
Figure 2-1: Local road hierarchy	11
Figure 2-2 Existing cycle routes within and surrounding the proposal area.....	15
Figure 2-3 Cattai Creek catchment	17
Figure 3-1a: Memorial Avenue upgrade.....	31
Figure 3-2: Typical cross section near the North West Rail Link overbridge	37
Figure 3-3: Typical cross section west of the intersection of Memorial Avenue with Free Settlers Drive and Arnold Avenue (West)	38
Figure 3-4: Typical cross section near the unnamed drainage line.....	39
Figure 3-5: Typical cross section near Pellizzer Boulevard	40
Figure 3-6: Cross-section east of Strangers Creek.....	41
Figure 3-7: Typical cross section near Kellyville Memorial Park	42
Figure 3-8: Typical cross-section near the intersection of Memorial Avenue and Burns Road leading to Windsor Road.....	43
Figure 3-9: Proposed layout of Windsor Road / Memorial Avenue intersection and Memorial Avenue / Severn Vale Drive intersection.....	50
Figure 3-10: Proposed layout of Memorial Avenue / Arnold Avenue (West) / Free Settlers Drive intersection and Old Windsor Road / Memorial Avenue/ Sunnyholt Road intersection	51
Figure 3-11: Proposed bridge at Strangers Creek	53
Figure 3-12: Cross section of proposed westbound deck at Strangers Creek crossing	54
Figure 3-13: Location of culverts at Elizabeth Macarthur Creek	57
Figure 3-14: Proposed layout of culverts at Elizabeth Macarthur Creek	58
Figure 3-15: Proposed construction staging	67
Figure 3-16 Potential ancillary and stockpile location	76

Figure 3-17a: Potential acquisitions for the proposal	87
Figure 3-18b: Potential acquisitions for the proposal	88
Figure 3-19c: Potential acquisitions for the proposal	89
Figure 4-1: Existing land use zones within and surrounding the proposal area.....	94
Figure 6-1: Hydrological features of the proposal area	109
Figure 6-2: The main catchments surrounding the site.....	110
Figure 6-3: Indicative location of groundwater boreholes within 2 kilometres of the proposal area (Source: NSW Natural Resource Atlas 2014)	114
Figure 6-4: Elizabeth Macarthur Creek: 100-year ARI flood levels before and after the upgrade.....	120
Figure 6-5: Strangers Creek: 100-year ARI flood levels before and after the upgrade	121
Figure 6-6 - Strangers Creek Water Quality Options and Constraints	124
Figure 6-7 - Elizabeth Macarthur Creek Water Quality Options and Constraints....	125
Figure 6-8: Topography of the proposal area.....	130
Figure 6-9: Geological and soil features in the proposal area.....	134
Figure 6-10: Acid Sulfate soils in the proposal area.....	135
Figure 6-11: Salinity hazard map of the proposal area	136
Figure 6-12: Strangers Creek catchment and construction constraints	139
Figure 6-13– Elizabeth Macarthur Creek catchment and constraints	139
Figure 6-14: Traffic modelling study area.....	149
Figure 6-15: Road hierarchy in the study area (Source: Classified Roads Map Greater Sydney Area, Roads and Maritime Services 2011)	150
Figure 6-16: Peak hour turning volumes for two key intersections	153
Figure 6-17: Existing queue lengths at critical parts of the network in the AM and PM peak	155
Figure 6-18: Noise Catchment Areas and monitoring locations in the study area ..	166
Figure 6-19: Orthogonal axes for human exposure to vibration.....	171
Figure 6-20: Residences identified for further noise treatment	187
Figure 6-21: Flora and fauna survey effort.....	194
Figure 6-22: Typical vegetation of the Swamp Oak Forest community.....	197
Figure 6-23: Cumberland Plain Woodland in the centre of the proposal area	198
Figure 6-24: Native regrowth <i>Acacia decurrens</i> north of Memorial Avenue.....	199
Figure 6-25: Native rehabilitation vegetation within the study area south of Memorial Avenue	200
Figure 6-26: Typha wetland vegetation within the study area.....	201
Figure 6-27: Developed/landscaped vegetation within the study area.....	202
Figure 6-28: Vegetation communities identified in the study area following field survey.....	204
Figure 6-29: Fauna habitats identified in the study area	208
Figure 6-30: Threatened fauna species and hollow-bearing trees within the study area	209
Figure 6-31: Fauna habitats potentially impacted by the proposal.....	213
Figure 6-32: Potential hollow-bearing tree within the proposal area	214

Figure 6-33: LEP heritage listing map with the study area outlined in red (Artefact 2014).....	230
Figure 6-34: Businesses and social infrastructure within and servicing the proposal area.....	242
Figure 6-35: Landscape character zones.....	253
Figure 6-36: Impact Assessment Grading Matrix.....	255
Figure 6-37: Summary of Landscape Character Impacts	257
Figure 6-38: Visual Envelope Map illustrating the location of key viewpoints	258

List of tables

Table 2-1: Current and forecast average daily traffic for Memorial Avenue (vehicles) 5	
Table 2-2: Description of local roads intersecting Memorial Avenue (from east to west).....	12
Table 2-3: Existing hydraulic structures within the proposal area	18
Table 3-1: Design criteria for Memorial Avenue.....	35
Table 3-2: Urban Design objectives and principles.....	44
Table 3-3: Intersections with Memorial Avenue, and proposed upgrades (from east to west) (refer Figure 3-9 and Figure 3-10)	47
Table 3-4: Existing and proposed cross-drainage infrastructure.....	55
Table 3-5: Retaining walls.....	59
Table 3-6: Estimate of quantities of materials required to build the proposal	70
Table 3-7 Assessment of proposed compound and stockpile sites	73
Table 3-8: Existing utilities and proposed adjustments	77
Table 3-9: Potential property acquisitions	85
Table 4-1: SREP 20 clauses 5 and 6 matters for consideration in this REF	91
Table 4-2: Consistency of the proposal with zoning objectives in <i>The Hills Local Environmental Plan 2012</i>	95
Table 5-1: Summary of community issues and Roads and Maritime responses	101
Table 5-2: Summary of stakeholder consultation.....	104
Table 5-3: Summary of issues raised by utilities providers	106
Table 6-1: Existing hydraulic structures within the proposal area	111
Table 6-2: Proposed cross-drainage structures	116
Table 6-3 Comparison of pavement area and flows between existing and proposed	122
Table 6-4: Proposed hydrology and water quality safeguards and management measures	125
Table 6-5: Soil landscape and location	131
Table 6-6: Soil Loss	140
Table 6-7: Contaminants of potential concern	141
Table 6-8: Proposed safeguards and management measures for topography, geology and soils	142
Table 6-9: Commuter mode share, Memorial Avenue study area	151
Table 6-10: Travel speeds on Memorial Avenue	154
Table 6-11: Existing level of service results at six key intersections.....	156
Table 6-12: Modelled level of service and delays at key intersections	160

Table 6-13: Safeguards and management measures for traffic and transport.....	162
Table 6-14: Noise monitoring locations.....	165
Table 6-15: Measured noise levels	167
Table 6-16: Noise catchment areas	168
Table 6-17: Non-residential sensitive receivers	169
Table 6-18: Construction noise management levels at residential receivers	170
Table 6-19: Preferred and maximum levels for human comfort	171
Table 6-20: Road traffic noise assessment criteria for residential land uses	173
Table 6-21: Road traffic noise assessment criteria for non-residential land uses...	173
Table 6-22: Relative increase criteria.....	174
Table 6-23: Noise model validation.....	174
Table 6-24: Construction activity & equipment list	176
Table 6-25: Typical construction equipment & sound power levels	177
Table 6-26: Predicted L_{Aeq} construction noise levels.....	178
Table 6-27: Predicted L_{Amax} construction noise levels for night works (residential).	179
Table 6-28: Typical vibration emission levels from construction plant	181
Table 6-29: Summary of operational noise modelling results	183
Table 6-30: Proposed safeguards and management measures for noise and vibration	188
Table 6-31: Vegetation communities corresponding with threatened ecological communities (TECs).....	195
Table 6-32: Native vegetation types in the proposal area.....	196
Table 6-33: Noxious weeds recorded in the study area.....	203
Table 6-34: Vegetation mapped within proposal area.....	210
Table 6-35: Areas of fauna habitat to be removed for the proposal.....	212
Table 6-36: Safeguards and management measures for biodiversity.....	217
Table 6-37: Significance values for previously recorded Aboriginal heritage sites .	225
Table 6-38: Safeguards and management measures for Aboriginal heritage.....	226
Table 6-39: Proposed safeguards and management measures for non-Aboriginal heritage	233
Table 6-40: Ambient air quality impact assessment criteria (DEC 2005).....	235
Table 6-41: Air quality monitoring data at Prospect for pollutants relevant to the assessment.....	236
Table 6-42: Proposed air quality safeguards and management measures.....	239
Table 6-43: Safeguards and management measures for land use and socio-economic impact	247
Table 6-44: Landscape Character Zones.....	251
Table 6-45: Landscape character summary assessment	255
Table 6-46: Viewpoint assessment	260
Table 6-47: Safeguards and management measures landscape character and visual amenity.....	268
Table 6-48: Safeguards and management measures for climate change and greenhouse gas emissions	273
Table 6-49: Safeguards and management measures for waste and resource management	275

Table 6-50: Safeguards and management measures for cumulative impact.....	280
Table 7-1: Summary of site specific environmental safeguards.....	284
Table 7-2: Summary of licensing and approval required.....	312
Table 8-1: How the proposal is consistent with the objectives of the EP&A Act	314

Appendices

Appendix A	Consideration of clause 228(2) factors and matters of national environmental significance
Appendix B	Concept Design (Hyder Consulting 2014)
Appendix C	Traffic and Transport Assessment (Hyder Consulting 2014)
Appendix D	Hydrology and Hydraulics Assessment (Hyder Consulting 2014)
Appendix E	Cultural Heritage Assessment Report (Artefact Heritage 2014)
Appendix F	Non-Aboriginal Heritage Assessment and Statement of Heritage Impacts (Artefact Heritage 2014)
Appendix G	Biodiversity Assessment (Hyder Consulting 2014)
Appendix H	Stage 1 Preliminary Contamination Assessment (Hyder Consulting 2014)
Appendix I	Noise and Vibration Assessment (Renzo Tonin and Associates, 2014)
Appendix J	Urban Design and Landscape Report (Spackman Mossop Michaels, 2014)
Appendix K	<i>Land Acquisition Information Guide</i> (Roads and Maritime, 2012)
Appendix L	Community consultation report (Roads and Maritime, 2014)
Appendix M	ISEPP consultation letters

1 Introduction

This chapter:

- Introduces the proposal
- Provides the context of the environmental assessment
- Establishes the objectives of the proposal
- Explains the project development history
- Provides the purpose of this report.

1.1 Proposal identification

Roads and Maritime propose to upgrade about 2.2 kilometres of Memorial Avenue (MR642) between Windsor Road and Old Windsor Road, Kellyville (the proposal). The proposal also includes upgrades to the intersections of Windsor and Old Windsor Roads and minor road widening for a distance of about 550 metres along Windsor Road and 700 metres along Old Windsor Road. The proposal would include widening Memorial Avenue to four lanes (two lanes in each direction) with a central median strip along the length of the road which accommodate a possible future upgrade to a six-lane configuration (three lanes in each direction). The majority of the proposal is located in The Hills Shire Council local government area (LGA), about 35 kilometres north-west of the Sydney Central Business District. Works to the west of Old Windsor Road are within the Blacktown City Council LGA. Figure 1-1 shows the location of the proposal.

Memorial Avenue is a State arterial road that runs east–west between Windsor Road and Old Windsor Road. It is a two-lane, two-way road and carries about 25,000 vehicles per day. Memorial Avenue links suburbs such as Glenwood, Stanhope Gardens and Parklea with suburbs such as Castle Hill and Kellyville.

Memorial Avenue crosses Elizabeth Macarthur Creek and Strangers Creek, within the Hawkesbury Nepean River catchment. Non-residential developments in the vicinity include The Hills Clinic (a private psychiatric hospital), the Baptist Community Service Retirement Facility and Gracelands Early Education Centre. Kellyville Memorial Park is accessed directly off Memorial Avenue and provides local recreational and sporting facilities.

The area is characterised by rural residential land that is in transition to low and medium density urban development and associated urban land uses. There are established rural-residential uses, and new urbanised subdivisions in accordance with the development plans for the Balmoral Road Release Area. Memorial Avenue bisects the Balmoral Road Release Area, which is planned to accommodate a population of about 13,000 people. The North West Rail Link (which is under construction) crosses Memorial Avenue via a rail bridge between Elizabeth Macarthur Creek and Old Windsor Road. Woolworths also plans to develop a supermarket on Memorial Avenue near Hector Court.

The project is needed to cater for future growth arising from residential and commercial development in the area.

Memorial Avenue Upgrade - Review of Environmental Factors



The key features of the proposal include:

- Widening Memorial Avenue from a two-lane road to a four-lane divided road for a length of about 2.2 kilometres
- Building a wide central median along Memorial Avenue to allow the road to be widened to six lanes, when required
- Upgrading the intersections of Memorial Avenue with Windsor Road, Arnold Avenue (west), and Old Windsor Road / Sunnyholt Road
- Closing the intersections of Memorial Avenue with Hector Court, Rutherford Avenue, and Arnold Avenue (east)
- Providing traffic lights at the intersections of Memorial Avenue with Arnold Avenue and Severn Vale Drive
- Providing left-in and left-out access for Burns Road and Stone Mason Drive
- Widening the alignment of Windsor Road generally to the west of the existing road between President Road and Wrights Road
- Slightly widening the alignment of Old Windsor Road for about 250 metres either side of the intersection
- Building a bridge to carry traffic travelling along Memorial Avenue over Strangers Creek
- Providing a speed limit of 70 kilometres per hour along Memorial Avenue
- Providing a three-metre-wide shared pedestrian/cyclist path on both sides of Memorial Avenue
- Providing bus priority capability at traffic lights, and creating indented bus bays on both sides of Memorial Avenue
- Relocating and/or temporarily diverting underground utilities, including water, telecommunications, electricity and gas.

The concept design is provided in Appendix B and a detailed description of the proposal is provided in Chapter 3. This design may be refined after the public display of this Review of Environmental Factors (REF) and during detailed design.

The proposal would generally be built away from the existing road (or 'offline') in two stages, centred on Severn Vale Drive:

- Stage 1: Widening the southern alignment to the west of Severn Vale Drive and widening the northern alignment to the east of Severn Vale Drive
- Stage 2: Widening the northern alignment to the west of Severn Vale Drive and widening the southern alignment to the east of Severn Vale Drive

This approach would help minimise disruption to traffic. The construction stages are detailed in Section 3.4 and the total construction period is expected to be around two years. The timing of construction would be determined after, and if, the proposal is

approved.

For the purposes of this REF, the 'proposal area' refers to the area that would be directly impacted by the proposal, as shown on Figure 1-1. It encompasses the concept road design, including batters, cuts and embankments. It also includes the total construction footprint, site compound locations, stockpile sites and other areas that would be temporarily disturbed.

1.2 Purpose of this report

This Review of Environmental Factors (REF) has been prepared by Hyder Consulting on behalf of Roads and Maritime Services Sydney Region. Roads and Maritime is the proponent and the determining authority under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The purpose of the REF is to describe the proposal, to document its likely impacts on the environment, and to detail protective measures to be implemented to manage and reduce these impacts.

The description of the proposed works and associated environmental impacts have been undertaken in context of clause 228 of the *Environmental Planning and Assessment Regulation 2000*, the *Threatened Species Conservation Act 1995* (TSC Act), the *Fisheries Management Act 1994* (FM Act), and the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). In doing so, the REF helps to fulfil the requirements of section 111 of the EP&A Act – that Roads and Maritime examine, and take into account to the fullest extent possible, all matters affecting or likely to affect the environment by reason of the activity.

The document also details findings of the REF when assessing:

- Whether the proposal is likely to have a significant impact on the environment and therefore the necessity for an environmental impact statement to be prepared and approval to be sought from the Minister for under Part 5.1 of the EP&A Act
- The significance of any impact on threatened species as defined by the TSC Act and/or FM Act, in section 5A of the EP&A Act and therefore the requirement for a Species Impact Statement
- The potential for the proposal to significantly impact a matter of national environmental significance or Commonwealth land and the need to make a referral to the Commonwealth Department of the Environment for a decision by the Commonwealth Minister for the Environment on whether assessment and approval is required under the EPBC Act.

2 Need and options considered

This chapter describes the need for the proposal in terms of its strategic setting and operational need. It provides a discussion of the options considered and the selection of the preferred option for the proposal.

2.1 Strategic need for the proposal

Baulkham Hills Shire Council released a draft Balmoral Road Release Area Structure Plan (draft Balmoral Road Release Area Structure Plan) in 2003. The 410 hectare Balmoral Road Release Area is identified in *The Hills Development Control Plan (DCP) 2012*. A total of 6,000 new dwellings are proposed in the Balmoral Road Release Area, which will accommodate about 13,000 people.

Prior to 2008, Memorial Avenue west of Arnold Avenue (east) was referred to as Burns Road. In 2005, a *Burns Road-Memorial Avenue, Kellyville, Route Strategy* was developed by the Network Planning Section of the then Roads and Traffic Authority (RTA, now Roads and Maritime) (before 2008, Memorial Avenue west of Arnold Avenue (east) was referred to as Burns Road). The route strategy concluded that an upgrade of Burns Road-Memorial Avenue could bring significant benefits to the proposal corridor and its road users. Benefits of an upgrade includes improvement of travel times and reduction of crashes.

A Strategic Concept Plan for the Memorial Avenue upgrade was prepared by Roads and Maritime Network Planning Section in 2006. This plan provides a 40 metre road corridor for the upgrade and includes two new signalised intersections. The corridor was reserved under *The Hills Shire Council Local Environmental Plan (LEP)* in 2012.

Traffic volumes along Memorial Avenue are forecast to almost double between 2014 and 2036 (refer Table 2-1). Much of this growth would be driven by nearby urban development, such as in the Balmoral Road Release Area (see Figure 1-1).

Table 2-1: Current and forecast average daily traffic for Memorial Avenue (vehicles)

2014	2019	2026	2036
25,000	33,000	42,000	45,000

Sources: Existing traffic source Hyder Consulting (2014); Future forecasts from Roads and Maritime Sydney Strategic Model (EMME/2)

The *Memorial Avenue Upgrade Traffic and Transport Assessment* (Hyder Consulting 2014) identified the existing level of service at intersections within the proposal area during both the morning (7–9am) and afternoon (4–6pm) peaks. The modelling found:

- The Old Windsor Road/Memorial Avenue/Sunnyholt Road intersection in both the morning and afternoon peak periods are over capacity (Level of service F)
- The Windsor Road/Memorial Avenue intersection is near capacity (Level of service D).

The assessment found the level of service at other intersections along Memorial Avenue are either satisfactory or near capacity, but congestion as identified in Table 2-1 is expected to increase without upgrades. (More detail is provided in Section 6.4

of this report.)

The assessment also found that travel speed reduces significantly along the section of Memorial Avenue between Windsor Road and Old Windsor Road during morning and afternoon peaks. This can be as much as 25 kilometres per hour less than the posted speed limit of 60 or 70 kilometres per hour (dependent on location along Memorial Avenue).

There were 72 crashes on Memorial Avenue between July 2007 and June 2012. One crash resulted in fatalities, while 37 crashes resulted in injuries. Most crashes (78 per cent) occurred at intersections. The most common crash type was rear-end (45 per cent), followed by adjacent approaches at intersections (15 per cent), which is typical of congested road networks.

The proposed upgrade would cater for future growth arising from residential and commercial development in the area by providing additional capacity for projected traffic volumes on Memorial Avenue between Windsor Road and Old Windsor Road, and at the intersections of these arterial roads. The proposal would also improve travel times and safety by providing new traffic lights at intersections, turning lanes at intersections and a median to separate traffic travelling in opposite directions.

2.1.1 Relevant strategies and plans

The proposal is consistent with a number of strategic plans and policies at the State, regional and local level.

Burns Road – Memorial Avenue, Kellyville, Route Strategy (RTA 2005)

The benefits of upgrading Memorial Avenue were first documented in 2005, when the then Roads and Traffic Authority (now Roads and Maritime) developed the *Burns Road – Memorial Avenue, Kellyville, Route Strategy* (until 2008, Memorial Avenue west of Arnold Avenue (east) was known as Burns Road).

The strategy concludes that an upgrade of Burns Road – Memorial Avenue could bring significant benefits, including better travel times and fewer crashes.

NSW 2021: A Plan to Make NSW Number One (NSW Government 2011)

NSW 2021: A plan to make NSW number one (NSW Government 2011) (NSW 2021) is a 10-year plan to rebuild the State economy, return quality services, renovate infrastructure, restore accountability to government, and strengthen local environment and communities.

The plan identifies a number of goals to improve the transport network, such as reducing travel times and improving road safety.

The proposal is consistent with these goals as it addresses the priority action areas of relieving congestion, providing adequate road capacity for projected population growth, and improving road safety.

Metropolitan Plan for Sydney 2036 (Department of Planning 2010)

The *Metropolitan Plan for Sydney 2036* aims to address the challenges facing Sydney's future through an integrated, long-term planning framework based on strategic direction and policy settings. Objectives guiding the policies for transport

include development targeted around planned transport capacity. The proposal is consistent with these objectives as it would provide adequate road capacity for the projected population growth in the Balmoral Road Release Area, and improve road safety through the introduction of a divided road. This would reduce the risk of head-on crashes.

In addition, the 'city of cities' concept adopted under the Metropolitan Plan is driven by the notion of Sydney as a network of economic and residential hubs interconnected by transport networks. An overarching objective of this strategy is to improve the efficiency of these networks in the face of increased demand from a growing population, while considering the established targets for sustainable growth. These objectives are directly applicable to the purpose of the proposal.

Metropolitan Strategy for Sydney (Department of Planning and Environment, draft)

The draft *Metropolitan Strategy for Sydney* sets out a new plan for the city's future to 2031. It is aligned with the Long Term Transport Masterplan and State Infrastructure Strategy. It also features an implementation plan, with regular reporting rules, to ensure accountability and delivery of the strategy.

The proposal is consistent with Objective 26 of the strategy, namely, 'Improve accessibility and connectivity for centres and for new urban areas'. (The final strategy is due to be released later in 2014.)

North West Subregional Strategy (draft) (DoP 2007)

The north-west subregion is a major growth area within the Greater Metropolitan Region. The draft North West Subregional Strategy identifies a number of key directions and actions for the north-west subregion, including some relating to transport improvements that are relevant to the proposal, including:

- Implement the planned North West Rail Link
- Integrate transport and land use opportunities.

It also mentions improvements to road network pinch-points on Windsor Road and Old Windsor Road, and the construction of a new railway station at Burns Road (now Memorial Avenue) as part of the development of the North West Rail Link. This strategy will be revised following the finalisation of the Metropolitan Strategy for Sydney (see above).

NSW Long Term Transport Master Plan (Transport for NSW 2012)

The *NSW Long Term Transport Master Plan* sets the direction for transport planning for the next 20 years, providing a framework for transport policy and investment decisions that respond to key challenges.

The Master Plan contains the following proposals:

- Upgrading the Greater Sydney bus and road network to provide essential infrastructure for growth centres
- Increasing the capacity of access roads to support the construction of the North West Rail Link. In this regard, it mentions the need to upgrade Burns Road to Memorial Avenue – between Windsor Road and Old Windsor Road – from a

two-lane road to a four-lane divided carriageway.

North West Rail Link (NWRL) Corridor strategy (NSW Government, 2013)

The *North West Rail Link (NWRL) Corridor Strategy* has been prepared to guide development during the next 20-25 years in the vicinity of the North West Rail corridor. The aim of the strategy is to engage with the community, land owners, state and local government agencies to identify future visions for precincts surrounding NWRL stations and establish frameworks for managing future land use change.

The Strategy includes structure plans for each station and its surrounds. Memorial Avenue provides a boundary to three station precincts – Kellyville to the north, and Bella Vista and Norwest to the south. The structure plans have been formulated on the principles of Transit Oriented Development. Transit Oriented Developments are generally mixed use communities within walking distance of a transit node that provide a range of residential, commercial, open space and public facilities in a way that makes it convenient and attractive to walk, cycle or use public transport.

The proposal is consistent with this strategy as it caters for future growth arising from residential and commercial development, as well as providing access to the North West Rail Link. The dedicated shared path also provides opportunity for walking and cycling connection to public transport.

Hills 2026 Community Strategic Direction (Baulkham Hills Shire Council, 2008)

The *Hills 2026 Community Strategic Direction* is a 20 year outlook for the Hills Shire. It creates a picture of where the community would like to be in the future. Residents, business owners, school students and community representatives participated in a range of activities to establish shared outcomes for the future of the Hills Shire.

The need for effective, safe and well managed local roads and transport infrastructure is identified.

The proposal is consistent with the direction as it would accommodate future growth and needs of the Hills area. The proposal would also provide for a safer road environment and reduce current traffic congestion along Memorial Avenue.

State Infrastructure Strategy (NSW Government 2012)

The *State Infrastructure Strategy* was prepared to ensure infrastructure is planned and delivered according to strategic economic and community needs. The strategy looks across a broad range of sectors and identifies priority projects and programs.

The strategy recognises the importance of the North West Rail Link in connecting the North West Growth Centre to employment opportunities, and notes that ‘there will also be a need for road investment to improve the connectivity of the North West Growth Centre to the existing urban area.’ The proposal is consistent with the strategy as it would provide a major access route to the future Kellyville North West Rail Link station.

NSW Bike Plan (RTA and DECCW 2010)

The *NSW Bike Plan* is a comprehensive plan to encourage people in NSW to ride bicycles more often and to be able to do so safely. It details a 10-year plan for new bicycle infrastructure to be funded by the NSW Government.

The proposal is consistent with the Bike Plan as it would provide shared paths on both sides of Memorial Avenue between Windsor Road and Old Windsor Road, provide crossing improvements at intersections along Memorial Avenue. It would also retain existing cyclist and pedestrian facilities at the intersections of Windsor Road/Memorial Avenue and Old Windsor Road/Memorial Avenue/Sunnyholt Road.

National Road Safety Strategy 2011–2020 (ATC 2011)

The *National Road Safety Strategy* aims to set out a path for national action to reduce fatal and serious injury crashes on Australian roads. The proposal is consistent with the strategy as it would provide a divided carriageway and traffic signals at intersections to improve road safety.

2.2 Existing road and infrastructure

2.2.1 Arterial roads

This section describes the three arterial roads within the proposal area (Memorial Avenue, Windsor Road and Old Windsor Road) and the intersecting local roads. The local road hierarchy is shown in Figure 2-1.

Memorial Avenue

Memorial Avenue is located in the suburb of Kellyville within The Hills Shire Council LGA. It is a sealed, two-lane two-way, undivided road and carries about 25,000 vehicles per day (2014). It is a designated B-double route for vehicles up to 26 metres.

The road functions as an arterial road, connecting Windsor Road in the east with Old Windsor Road in the west.

At a regional level, Memorial Avenue is a key strategic route and provides access to Blacktown, Glenwood, Stanhope Gardens, Parklea, Baulkham Hills, Castle Hill and Kellyville. It is also an integral component of the transport network within the Balmoral Road Release Area.

At a local level, Memorial Avenue provides direct access to Kellyville Memorial Park and several residences. It also provides indirect access to a childcare centre (Gracelands Early Education Centre), on the corner of Arnold Avenue (West) and Memorial Avenue. Memorial Avenue would also provide access to a proposed shopping centre beside the intersection of Memorial Avenue with Severn Vale Drive (identified on Figure 3-1a to Figure 3-1d).

Memorial Avenue has a single lane each direction for most of its length. At the western end, Memorial Avenue widens to two lanes about 250 metres before the intersection with Old Windsor Road. A third lane is provided about 85 metres out from Old Windsor Road. This arrangement allows two lanes for travelling through the intersection to Sunnyholt Road, one dedicated lane turning right onto Old Windsor Road, and a slip lane turning left onto Old Windsor Road. There are dedicated bus lanes for about 80 metres on the westbound lane either side of the approach to the T-way intersection. There is also a dedicated bus lane eastbound between the T-way and Old Windsor Road. These lanes facilitate access to the T-Way for buses travelling to and from Old Windsor Road and Sunnyholt Road.

At the eastern end of Memorial Avenue, a second lane is provided from about 400

metres before the intersection with Windsor Road. About 150 metres out from Windsor Road, Memorial Avenue becomes three lanes. This arrangement allows one dedicated lane turning left onto Windsor Road and two dedicated lanes turning right on Windsor Road.

The posted speed limit on Memorial Avenue is 60 kilometres per hour between Windsor Road and Arnold Avenue (west), and 70 kilometres per hour between Arnold Avenue (west) and Old Windsor Road.

Memorial Avenue has a kerb and gutter between Windsor Road and Kellyville Memorial Park, just east of Strangers Creek crossing, and between Elizabeth Macarthur Creek crossing and Old Windsor Road. Between Strangers Creek and Elizabeth Macarthur Creek, there is generally a two metre shoulder connecting to a grassed verge. The shoulders vary between paved and gravel. New kerbs and gutters have been constructed recently on the westbound lane between Free Settlers Drive and Rutherford Avenue.

There is currently no provision for kerb-side parking along the length of Memorial Avenue. Car parking is provided at Kellyville Memorial Park, with access directly off Memorial Avenue. Car parking for community facilities such as Gracelands Early Education Centre and the Hills Clinic are accessed off local roads adjoining Memorial Avenue. To the south of Memorial Avenue, there is a commuter carpark for the T-way which is accessed off Old Windsor Road.

Windsor Road

Windsor Road is a sealed, multi-lane undivided arterial road providing a connection between Windsor in the north and Northmead in the south. It is a designated B-double route. Within the proposal area, it has a posted speed limit of 60 kilometres per hour.

Within the proposal area, Windsor Road provides for two through lanes in each direction, with an additional lane turning right onto President Road from the northbound carriageway and an additional lane turning right onto Memorial Avenue from the southbound carriageway.

Old Windsor Road

Old Windsor Road is a sealed, multi-lane undivided arterial road providing a connection between Windsor Road in the north and the Cumberland Highway in the south. It connects the suburbs of Stanhope Gardens and Kellyville Ridge with the suburbs of Westmead and Constitution Hill. The mid-line of Old Windsor Road is the boundary between the Hills Shire Council and Blacktown City Council. It is a designated B-double route. Within the proposal area, it has a posted speed limit of 80 kilometres per hour.

Within the proposal area, Old Windsor Road provides for two through lanes in each direction, with an additional lane turning left onto Sunnyholt Road and an additional lane turning right onto Memorial Avenue from the northbound carriageway, and two additional lanes turning right onto Sunnyholt Road and an additional lane turning left onto Memorial Avenue from the southbound carriageway.

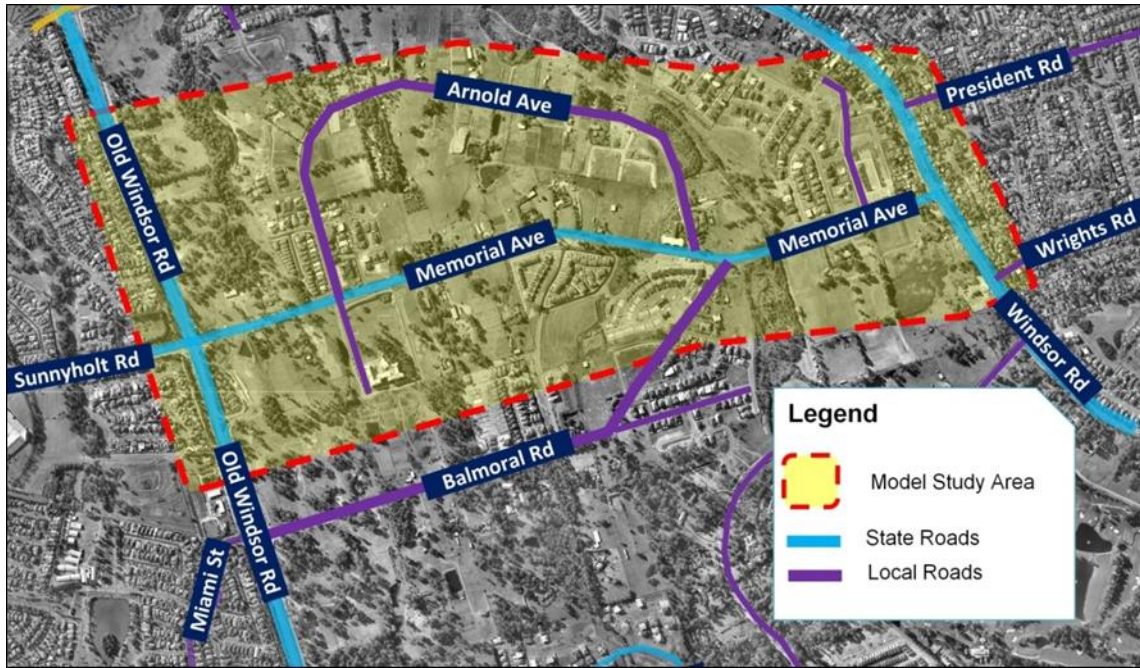


Figure 2-1: Local road hierarchy

2.2.2 Intersections with local roads

Eight local roads intersect the proposal area, including two intersections with Windsor Road and six intersections with Memorial Avenue. Table 2-2 presents a description of these intersections.

Table 2-2: Description of local roads intersecting Memorial Avenue (from east to west)

Intersecting road	Control method	Road description/ characteristics	Traffic movements	Provides access to
Burns Road (north of Memorial Avenue)	No traffic signals	Burns Road is a two-way, two-lane unmarked road used for residential access. The speed limit is unmarked. Street lighting and kerb and gutter are provided.	Memorial Avenue has a single lane each way near Burns Road. Left turn only is permitted from Memorial Avenue into Burns Road From Burns Road there is left turn only onto Memorial Avenue. There is currently no access to or from Burns Road south of Memorial Avenue.	Residential area
Hector Court	No traffic signals	Hector Court is a two-way, two-lane marked road and is typically used for residential access. The speed limit is 70 km/h. The road features overhead wiring and timber power poles. There are no provisions for kerb and gutter or street lighting until the intersection with Affleck Circuit (about 150 metres from the intersection with Memorial Avenue).	Memorial Avenue has a single lane each way at the intersection of Hector Court. Left and right turns from Memorial Avenue are permitted from the through lanes (no dedicated turning lanes). From Hector Court, it is permitted to turn both left and right onto Memorial Avenue.	Balmoral Road, residential area
Arnold Avenue (east)	No traffic signals	Arnold Avenue is a two-way, single lane unmarked road used for residential access. The speed limit is unmarked. The road features overhead wiring and timber power poles. There are no provisions for street lighting or kerb and until about 150 metres from the western entrance to Arnold Avenue.	Memorial Avenue has a single lane each way at the intersection of Arnold Avenue (east). Left and right turns from Memorial Avenue are permitted from the through lanes (no dedicated turning lanes). From Arnold Avenue (east) it is permitted to turn both left and right onto Memorial Avenue.	Residential area

Intersecting road	Control method	Road description/ characteristics	Traffic movements	Provides access to
Rutherford Avenue	One-way slip lane	Rutherford Avenue is a two-way, two-lane unmarked road used for residential access. The speed limit is unmarked, and there is street lighting and kerb and gutter.	Currently there is no access from Memorial Avenue onto Rutherford Avenue. There is one slip lane allowing left turn only from Rutherford Avenue onto Memorial Avenue.	Residential area
Arnold Avenue (west)	No traffic signals	Arnold Avenue is a two-way, two-lane unmarked road used for residential access. The speed limit is unmarked. The road features overhead wiring and timber power poles. There are no provisions for street lighting or kerb and gutter until about 150 metres from the western entrance to Arnold Avenue.	Memorial Avenue has a single lane each way at the intersection of Arnold Avenue (west). Left and right turns from Memorial Avenue are permitted from the through lanes (no dedicated turning lanes). From Arnold Avenue (west) it is permitted to turn both left and right onto Memorial Avenue.	Residential area, childcare centre
North-West Transitway (T-way)	Traffic signals	The T-way provides two-way, two-lane dedicated bus lanes in a north-south direction. The T-way features street lighting. The speed limit is 40 km/h on approach in each direction.	There are two eastbound through lanes and one dedicated bus lane turning south from Memorial Avenue onto the T-way. There are two westbound through lanes, one dedicated bus slip lane turning left onto the T-way (north), and one dedicated bus lane turning right onto the T-way (south). Northbound on the T-way there is one through lane for buses to continue on the T-way, and a left turn lane onto Memorial Avenue. Southbound on the T-way there is one through lane to continue on the T-way.	Access for buses only.
Sunnyholt	Traffic signals	Sunnyholt Road is a two-way, divided	From Sunnyholt Road there are two	Stanhope

Intersecting road	Control method	Road description/ characteristics	Traffic movements	Provides access to
Road		arterial road with two through lanes in each direction and auxiliary lanes to facilitate movements at intersections. It also accommodates a two-lane, dedicated busway between Old Windsor Road and George Street in Blacktown. Sunnyholt road crosses the Westlink M7. It features street lighting and shared paths on both sides of the road approaching the intersection with Old Windsor Road and Memorial Avenue. The speed limit is 70 km/h.	through lanes for general use plus a dedicated bus lane through to Memorial Avenue. There is also a left-turn slip lane onto Old Windsor Road (north) and two dedicated lanes turning right onto Old Windsor Road (south).	Gardens, Glenwood, Blacktown

2.2.3 Pedestrian and cyclist facilities

There is no dedicated footpath along Memorial Avenue. Currently, pedestrians must use either the verge or road to walk along Memorial Avenue. Pedestrian crossing facilities are available at intersections with Windsor Road and Old Windsor Road.

An on-road cycleway is provided within the road shoulder on Memorial Avenue. A designated off-road cycleway is provided on Old Windsor Road. Figure 2-2 shows the different types of cycle routes that are currently available in the proposal area.

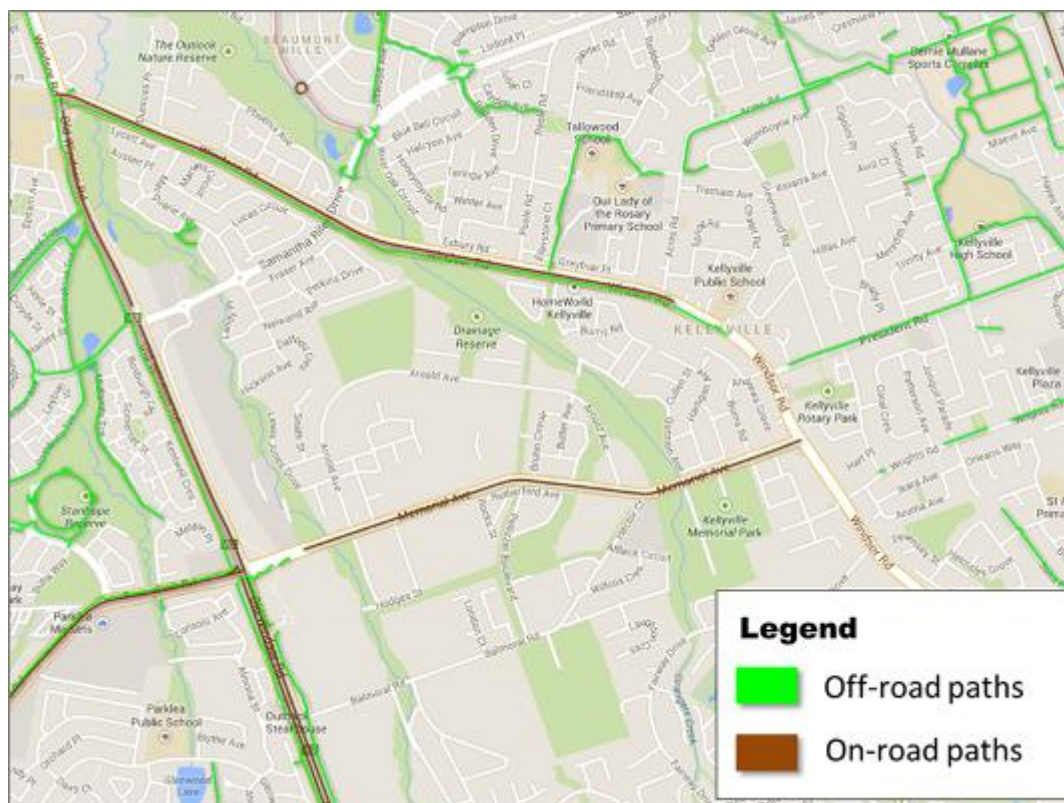


Figure 2-2 Existing cycle routes within and surrounding the proposal area

2.2.4 Bus routes and services

The proposal area is primarily serviced by Hillsbus. Route 619 follows Memorial Avenue, providing services between Rouse Hill and Macquarie Park. A number of the Hillsbus routes travel along Old Windsor Road, Sunnyholt Road and Windsor Road.

Most of the services passing through the proposal area traverse Windsor Road and Old Windsor Road, and disperse to destinations to the north and south. To the north, bus services terminate at Rouse Hill (routes 607x, 617x, 602x, 612x, 619, T64, T65 and T66) and Riverstone (route T75). To the south, services terminate at Parramatta (routes T64, T65 and T66). To the east, services terminate at Macquarie Park (route 619) and North Sydney (route 602x). To the west, services terminate at Blacktown (route T75). Important intermediate locations served by these bus routes include Burns Station, on the corner of Old Windsor Road and Memorial Avenue.

Buses operated by Hillsbus on route 619 frequent these stops roughly every hour non-peak hour and on weekends and every half hour during morning and afternoon

peaks (6:30–8:30am and 3:30–6:30 pm). Route 619 includes the following services:

- Rouse Hill Town Centre to Macquarie Park
- Macquarie Park to Rouse Hill Town Centre
- Broughton Street, Milsons Point to Lane Cove Library
- Penrose Street/Burns Bay Road to North Sydney.

There are ten bus stops within the proposal area:

- Memorial Avenue (eastbound) about 40 metres east of the T-way
- Memorial Avenue (westbound) about 60 metres west of the T-way
- Memorial Avenue (eastbound) about 35 metres east of Arnold Avenue (west)
- Memorial Avenue (westbound) about 100 metres east of Free Settlers Drive
- Memorial Avenue (eastbound) near 23 Memorial Avenue
- Memorial Avenue (westbound) opposite 21 Memorial Avenue
- Memorial Avenue (eastbound) about 50 metres east of Arnold Avenue (east)
- Memorial Avenue (westbound) about 30 metres west of Hector Court
- Memorial Avenue (westbound) about 10 metres west of Windsor Road
- Windsor Road (northbound) about 75 metres north of Memorial Avenue.

Hillsbus and Busways also operate school bus services that use Memorial Avenue. These include:

- Glenwood High School (Busways)
- The Hills Grammar School (Busways)
- Oakhill College (Hillsbus and Busways)
- Our Lady of the Rosary Catholic Primary School (Hillsbus)
- Kellyville Public School (Hillsbus)
- Galston High School (Hillsbus)
- Gilroy Catholic College (Hillsbus)
- St Michael's Catholic Primary School (Hillsbus)
- William Clarke College (Hillsbus)
- Castle Hill High School (Hillsbus)
- Mount St Benedict College (Hillsbus).

Memorial Avenue is also used for 'dead runs' (that is, special trips or trips to/from the depot).

The proposal intersects the T-way, which connects Rouse Hill and Parramatta. A park-and-ride facility is located at the intersection of Old Windsor Road and Memorial Avenue, at the western end of the proposal area.

2.2.5 Existing drainage

There are two major creek crossings within the proposal area, at Strangers Creek and Elizabeth Macarthur Creek. Both of these creeks, and one other minor waterway to the west of Strangers Creek, are managed by Sydney Water. These creeks flow in a northerly direction and form part of the Cattai Creek catchment which eventually joins the Hawkesbury River at a location midway between Windsor, Richmond and Sackville. The Cattai Creek catchment and the Memorial Avenue proposal area is shown in Figure 2-3. The relevant land is zoned in The Hills Shire Council's DCP as 'SP2 Infrastructure (Stormwater Management System)'. The creeks are ephemeral and have mildly sloping banks.

Strangers Creek is classified as a second order watercourse under the Strahler system and Elizabeth Macarthur Creek is classified as a third order stream. The Strahler system is based on waterways being assigned an "order" according to the number of additional tributaries associated with each waterway.

Both creeks were also classified *Class 3 – Minimal Fish Habitat* following ecology survey, in accordance with the NSW Classification of Fish Habitat (Fairfull and Witheridge 2003).

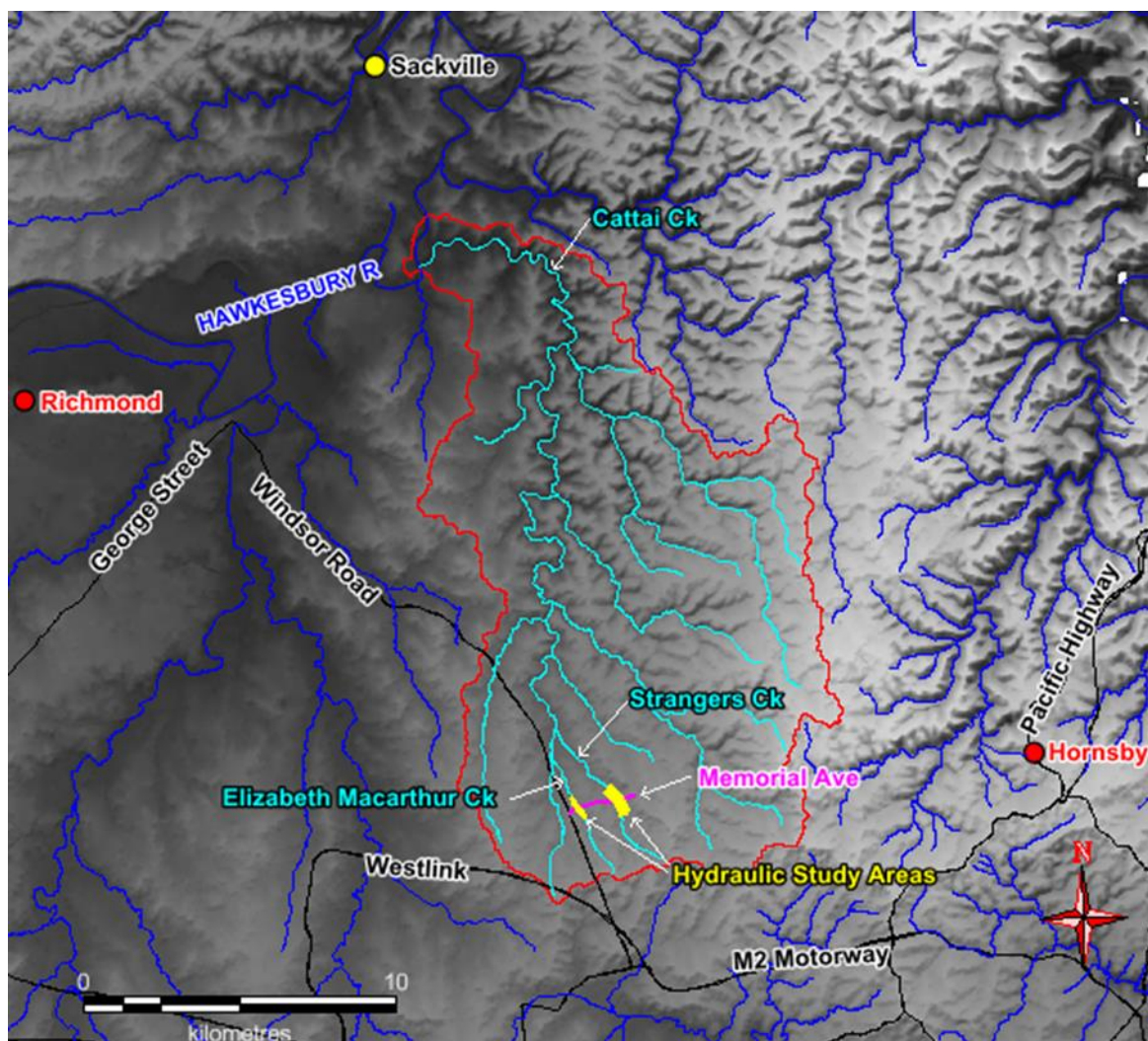


Figure 2-3 Cattai Creek catchment

Strangers Creek is located in the eastern half of the proposal area and crosses under Memorial Avenue between Hector Court and Hartigan Avenue. Strangers Creek is highly modified, draining a largely undeveloped catchment area of about 36 hectares near Norwest Boulevard, to the south of the proposal area. In larger flood events, the creek overtops and flows travel across Norwest Boulevard. Strangers Creek crosses below Memorial Avenue via a pipe culvert. Upstream of the culvert is a basin and flow control weir.

Elizabeth Macarthur Creek is located in the western section of the proposal area and crosses under Memorial Avenue between Arnold Avenue and Old Windsor Road via three box culverts. The catchment draining to Elizabeth Macarthur Creek between Samantha Riley Drive (to the north of the proposal area) and Celebration Drive (to the south of the proposal area) is largely undeveloped; however, there is significant urbanisation in these areas as part of the North West Growth Centre, as well as ongoing development within the Balmoral Road Release Area.

There are also two minor waterway crossings located at low points along Memorial Avenue. An unnamed drainage line is located about 270 metres east of the intersection with Rutherford Avenue, next to the newly developed land release area. A tributary of Strangers Creek is located about 40 metres west of the Hills Clinic, with shrubs and trees located on either side of the Memorial Avenue road crossing. There are single pipe culverts at both locations.

The existing hydraulic structures within the proposal area are outlined in Table 2-3.

Table 2-3: Existing hydraulic structures within the proposal area

Structure No.	Location	Culvert dimensions
1	Elizabeth Macarthur Creek	Three multi-cell box culverts (3 m wide x 0.9 m high)
2	Strangers Creek	Four pipe culverts (1.5 m diameter) and basin (and flow control v-notch weir upstream)
3	Tributary of Strangers Creek	Three pipe culverts (750 mm diameter with submerged inlet and outlet)
4	Unnamed drainage line	One pipe culvert (450 mm diameter)

The current drainage structures do not have capacity to accommodate one in 100-year ARI storm events, and overland flows currently overtop the roadway. There are also currently only two sections with a kerb and gutter. Between Elizabeth Macarthur Creek and Strangers Creek flows travel freely overland.

2.2.6 Utilities

Roadside utilities within the proposal area include streetlights, overhead telecommunications wires, power poles and overhead electric wires. Overhead wires are generally along both sides of Memorial Avenue from the T-way east to Windsor Road, as well as beside the northbound carriageway of Windsor Road.

There are also underground utilities within the proposal area, including water, sewer, gas (including high pressure gas mains), telecommunications (including

communications line and optic fibre) and electricity. More information regarding existing utilities is provided in Section 3.6 of this REF.

2.3 Proposal objectives

The objectives of the proposal are to:

- Improve road safety in line with the *NSW Road Safety Strategy 2012–2021* ‘Safe System Directions’ and ‘Safer Road’ key focus
- Improve liveability and sustainability, support economic growth and productivity by providing road capacity for projected traffic volumes
- Improve travel times
- Improve quality of service, sustainability and liveability by providing facilities for walking and cycling and future public transport needs
- Improve urban design and visual quality
- Improve the drainage system.

2.4 Alternatives and options considered

In 2003, Baulkham Hills Shire Council released the draft Balmoral Road Release Area Structure Plan, identifying Memorial Avenue-Burns Road as a key part of the road network. In 2005, the *Burns Road – Memorial Avenue, Kellyville, Route Strategy* was developed by the Network Planning Section of the then Roads and Traffic Authority (now Roads and Maritime). The route strategy informed The Hills Shire Council and (former) DIPNR (Department of Infrastructure, Planning & Natural Resources) about road reservation requirements along the Memorial Avenue corridor and the section of Windsor Road between President Road and Showground Road, as well as the layout requirements for various intersections in the area.

The objectives of the route strategy were in line with the following RTA community / business outcomes targeted in *The Journey Ahead 2003-08*:

- Improving road safety (by reducing the number and severity of road crashes)
- Moving people and goods efficiently (by reducing delays and improving travel times, especially for high-occupancy vehicles; and by reducing regional transport costs)
- Developing sustainable land use and transport solutions (by integrating planned road improvements with the urban growth of Sydney’s North-West Sector; and by paying particular attention to the needs of pedestrians, cyclists and bus passengers)
- Valuing the environment (by planning for growth in the proportion of trips made by foot, bicycle or public transport; and by reducing the local impact of vehicle trips)
- Making the best use of resources (by aligning the road network improvements program with urban growth)

A strategic route was developed based on these objectives. Consideration was also

given to other roads that run in an east-west direction, connecting Windsor Road in the east to Old Windsor Road in the west, and are parallel to Burns Road-Memorial Avenue. These roads are:

- Samantha Riley Drive (local road): located 1.2 kilometres north of Burns Road-Memorial Avenue. This link opened to traffic in February 2004, connecting Windsor Road to Old Windsor Road, with traffic signals at both its ends.
- Norwest Boulevard (local road): located 2.5 kilometres south of Burns Road-Memorial Avenue, connecting Windsor Road to Old Windsor Road, and serving Norwest Business Park and the suburb of Bella Vista. It also has traffic signals at both its ends. A grade separation at the intersection of Old Windsor Road and Norwest Boulevard was constructed in 2005-2006.

A number of alternatives were investigated during the development of the strategic route. These included:

- The provision of a new alignment for Memorial Avenue outside of the existing road corridor. However, this approach was rejected as it would not be consistent with The Balmoral Road Release Area Structure Plan (The Hills Shire Council 2003), and because it would have impacts on areas not currently impacted by a road corridor, such as traffic noise. It would also require considerable property acquisition and vegetation removal
- Alternative models of transport (rail and bus) that would support the 'do nothing' option described in Section 2.4.2. However, this approach was rejected as it would not address the objectives for the proposal and would not provide for the full range of trips required to service the Balmoral Road Release Area
- The provision of a dedicated bus lane along Memorial Avenue. This would involve increasing the width of the road by an additional seven metres, thus requiring additional vegetation removal and land acquisition (with associated environmental and social impacts). This approach was rejected as it would not be consistent with The Balmoral Road Release Area Structure Plan (The Hills Shire Council, 2003) and would complicate tie-ins with local roads. The Memorial Avenue corridor was also not identified as a Strategic Bus Corridor following the Unsworth Inquiry into Bus Services in NSW. Identified transport corridors include the North-West T-way and the proposed North West Rail Link.

In view of these findings, it was determined that the best alternative was to upgrade Memorial Avenue along the established arterial road corridor as it would best achieve the proposal objectives. In particular, it would:

- Improve travel times and reduce congestion along Memorial Avenue by maintaining the most direct link between Windsor Road and Old Windsor Road
- Increase road capacity along Memorial Avenue
- Integrate with and improve access to the Balmoral Road Release Area and the North West Rail Link
- Align with key strategic planning documents for the area, including the Balmoral Road Release Area Structure Plan

- Minimise environmental impact by keeping the road upgrade within an established road corridor.

Having established the strategic route, the next step in the assessment process was to develop a preferred option for the proposal. The options considered are presented in the following sections.

2.4.1 Methodology for selecting a preferred option

Specific proposal objectives were developed to assess options and guide the development of the design going forward. These are shown in Section 2.3 and repeated here:

- Improve road safety in line with the NSW Road Safety Strategy 2012–2021 Safe System Directions and Safer Road Key Focus
- Improve liveability and sustainability and support economic growth and productivity by providing road capacity for projected traffic volumes on Memorial Avenue between Windsor Road and Old Windsor Road
- Improve travel times
- Improve quality of service, sustainability and liveability by providing facilities for walking and cycling and future public transport needs
- Improve urban design and visual quality
- Improve the drainage system.

The options that were considered are outlined in Section 2.4.2. The advantages and disadvantages of each option are discussed in Section 2.4.3. The preferred option was selected based on the evaluation of all options against the proposal objectives listed above. Value for money was also considered in the assessment of options.

2.4.2 Identified options

This section provides an overview of the design options considered for the proposal. As outlined above, the options do not involve any substantial deviation from the existing road alignment.

Option 1: Do nothing

The ‘do nothing’ option would retain the existing alignment of Memorial Avenue and be limited to ongoing work to maintain the condition of the road.

Option 2: Upgrade Memorial Avenue to four lanes, with future provision for six lanes, no upgrade of intersections with Windsor Road and Old Windsor Road/Sunnyholt Road

This option would provide two lanes in both directions along Memorial Avenue. It would include a posted speed limit of 70 kilometres per hour and a wide median. A three-metre off-road shared path would be accommodated on both sides of the road. Widening would generally take place on the northern side of the road between Windsor Road and the proposed Severn Vale Drive, and the southern side of the road between Severn Vale Drive and Old Windsor Road.

The option incorporates upgrades to drainage along Memorial Avenue, as well as provision of visual and urban design components such as median planting.

Option 3: Upgrade Memorial Avenue to four lanes, with future provision for six lanes, upgrade of at-grade intersections with Windsor Road and Old Windsor Road/Sunnyholt Road

This option would provide the same upgrade along Memorial Avenue as Option 2, but would extend the limits of work to include at-grade intersection upgrades (that is, upgrades at the same level) with Windsor Road and Old Windsor Road. The at grade upgrade at Old Windsor Road would include provision of additional through lanes in both directions on Old Windsor Road, an additional right hand turn lane from Old Windsor Road on to Memorial Avenue, and a left slip lane from Memorial Avenue on to Old Windsor Road. The at grade upgrade at Windsor Road would include additional through lane in each direction on Windsor Road, two additional turning lanes from the northbound and southbound carriageways of Windsor Road, and two additional left turn lanes from Memorial Avenue northbound onto Windsor Road.

A shared path would be included with this option, similar to Option 2, with works at the intersections allowing for connections into existing shared paths along Old Windsor Road and Windsor Road. The option would also incorporate upgrades to drainage along Memorial Avenue and at the intersections, if required, as well as provision of visual and urban design components such as median planting.

Option 4: Upgrade Memorial Avenue to four lanes, with future provision for six lanes, upgrade the at-grade intersection with Windsor Road, and provide a grade-separated intersection with Old Windsor Road/Sunnyholt Road

This option would provide the same upgrade along Memorial Avenue as Option 3, but would include grade separation at the intersection of Memorial Avenue with Old Windsor Road and Sunnyholt Road. Under this option, two through lanes would be provided in each direction on Old Windsor Road via an elevated overpass.

2.4.3 Analysis of options

Option 1: Do nothing

Option 1 was considered in association with strategic traffic modelling by Roads and Maritime (2005). This option would not cause property or environmental impact associated with vegetation clearing.

However, it was not deemed to be a practical solution as the existing road configuration would not accommodate forecast traffic flows or provide improved access to the Balmoral Road Release Area. The option also would not meet the proposal objectives. Therefore, Option 1 was not considered further.

Option 2: Upgrade Memorial Avenue to four lanes, with no upgrade at intersections with Windsor Road and Old Windsor Road/Sunnyholt Road

Traffic modelling carried out by Hyder Consulting (2014) identified that the high through traffic from Windsor Road, Old Windsor Road and Sunnyholt Road, and relatively high levels of traffic turning into and out of these roads are significant contributing factors to traffic congestion along Memorial Avenue. Substantial traffic delays at these intersections at either end of the proposal area have been observed in both morning and afternoon peak periods, resulting in long traffic queues along Old

Windsor, Windsor Road, Sunnyholt Road and Memorial Avenue.

Traffic modelling has shown a current level of service F (over capacity) at the Old Windsor Road/Memorial Avenue/Sunnyholt Road intersection in both morning and afternoon peak periods and level of service D (near capacity) at the Windsor Road/Memorial Avenue intersection. The level of service at these intersections could be expected to decrease without upgrades, based on the forecast traffic increases.

Given this option would not provide adequate capacity for forecast traffic from the year 2019, the option does not meet the second and third objectives to provide road capacity for projected traffic volumes on Memorial Avenue between Windsor Road and Old Windsor Road or improve travel times.

This option also does not comply with objective one as the Safe System Directions key focus requires a holistic view of the road transport system. By not including intersection upgrades at Windsor Road and Old Windsor Road, this option represents an isolated rather than a holistic approach to improving the Memorial Avenue corridor.

Whilst this option does provide for improvements to quality of service, sustainability and liveability; urban design and visual quality; and the drainage system, options 3 and 4 provide greater opportunity to make broader improvements in these areas.

As a result of the failure to meet three of the objectives, and options 3 and 4 providing greater opportunity to meet the remaining three objectives, this option was not considered further.

Option 3: Upgrade Memorial Avenue to four lanes, and upgrade the at-grade intersections with Windsor Road and Old Windsor Road/Sunnyholt Road

Traffic modelling (Hyder Consulting, 2014) identified that an at-grade upgrade to the intersection at Old Windsor Road/Memorial Avenue/Sunnyholt Road would improve traffic capacity and level of service (refer to Table 6-12). This at-grade upgrade at Old Windsor Road, combined with the four-lane upgrade of Memorial Avenue, would extend the intersection service life up to 2026, after which time additional traffic improvements would be required. Additionally, an at-grade upgrade to the intersection at Windsor Road, combined with the four-lane upgrade of Memorial Avenue, would extend the intersection service life up to 2036.

This option meets the second and third objectives to provide road capacity for projected traffic volumes on Memorial Avenue between Windsor Road and Old Windsor Road and improve travel times. Currently the delay in the PM peak at Windsor Road/Memorial Avenue is 50 seconds. On opening with an upgraded intersection, the PM peak delay would be 36 seconds. At Old Windsor Road, the current delay in the AM peak is 155 seconds, with an upgraded intersection, the AM peak delay on opening would be 69 seconds.

This option complies with objective one by applying a more holistic approach to improving the Memorial Avenue corridor than Option 2, which is in line with the Safe System Directions key focus. The intersection upgrades would address traffic issues to/from Windsor Road and Old Windsor Road and contribute to improved traffic conditions on Memorial Avenue.

This option meets the objective to improve quality of service, sustainability and liveability by providing facilities for walking, cycling and future public transport needs.

The provision of a shared path along both sides of Memorial Avenue, and connecting into existing shared paths on Windsor Road and Old Windsor Road, provides facilities for walking and cycling which connect to the larger network. The option also provides opportunity to improve the urban design and visual quality along with the drainage system. Therefore, this option meets all the proposal objectives.

Option 4: Upgrade Memorial Avenue to four lanes, upgrade the at-grade intersection with Windsor Road, and provide a grade-separated intersection with Old Windsor Road/Sunnyholt Road

Option 4 was created as a variation of Option 3 to improve the service life of the intersection of Memorial Avenue with Old Windsor Road and Sunnyholt Road beyond 2026. Similar to Option 3, this option meets the second and third objectives to provide road capacity for projected traffic volumes on Memorial Avenue between Windsor Road and Old Windsor Road and improve travel times. This option provides a level of service C at 2026 (satisfactory operation) and D at 2036 (near capacity) based on forecast traffic volumes, an improvement on Option 3 which has a level of service F by 2026 (over capacity). Further discussion of level of service is provided in section 6.3.2.

However, the proposed upgrade opening date of 2019 coincides with the opening of the North West Rail Link. There are two proposed stations near Memorial Avenue – Kellyville Station to the north, and Bella Vista Station to the south. Trains are proposed to operate at least every five minutes in the peak. Whilst the traffic forecasting took into account a potential reduction of trips in cars attributable to the North West Rail Link, the actual reduction is difficult to quantify. Analysis in the *North West Rail Link Environmental Impact Statement* (Transport for NSW, 2013), based on the Bureau of Transport Statistics estimates, indicates that in 2021 there could be approximately 12,000 fewer car trips (two way, two hour AM peak) made as a result of the NWRL project. By 2036 the corresponding reduction could be about 18,000 fewer car trips (two way, two hour AM peak).

This uncertainty of future road traffic demand and uptake of public transport services by the local community places a question over the current economic viability of Option 4.

Constructing Option 4 would also impact on liveability, walking and cycling facilities and access to public transport. To enable construction of the overpass, Old Windsor Road would be required to be temporarily realigned to the east, impacting on the current T-way and its parking facilities. This diversion could be up to 18 months duration. This is directly next to the construction area for the North West Rail Link, and would be carried out along similar timeframes. This would potentially create unacceptable delays to traffic and impacts to access of private property, cycle, pedestrian and public transport facilities.

Whilst this option also meets objectives four and six, they are achieved in the same manner as Option 3. The grade separation is not required to adequately address these objectives. The option would also have impacts on the urban design and visual quality given the scale of the new built elements associated with the overpass, so does not satisfy objective five as well as option 3.

The higher up-front costs associated with Option 4 are not justified as it does not satisfy the all the objectives of the proposal due potential impacts on liveability, urban design and visual quality. Option 3 provided a better value for money option whilst also satisfying all of the objectives. For these reasons, Option 4 was not considered

further.

2.5 Preferred option

Option 3 was selected as the preferred option as it would best achieve the proposal objectives as well as providing value for money. In particular, it would:

- Improve safety by offering a new road design – complete with intersection upgrades – that complies with safety standards for arterial roads and is in line with the NSW Road Safety Strategy 2012–2021
- Provide capacity for forecast traffic on Memorial Avenue between Windsor Road and Old Windsor Road, including the intersections of these arterial roads
- Improve travel times within the proposal area, particularly at the upgraded intersections with Old Windsor Road and Windsor Road
- Provide facilities for walking and cycling which connect into the existing cycle and pedestrian network, as well as efficient bus movement, within the proposal area
- Provide an opportunity to enhance urban design and visual quality within the proposal area, in accordance with the changing landscape of the Balmoral Road Release Area
- Improve the drainage system, particularly at identified low points along Memorial Avenue.

A detailed description of the preferred option (the proposal) is presented in Section 3.1. This option would be further developed during detailed design.

2.6 Design refinements

During the concept design process, refinements were made to the preferred option in relation to Windsor Road and Old Windsor Road, and the bridge over Strangers Creek. The refinements were made for the following reasons:

- The preferred option did not include any widening along Windsor Road or Old Windsor Road. Traffic modelling showed that providing additional through lanes as well as turning lanes on Windsor Road and Old Windsor Road within the proposal area would help to reduce congestion and improve travel time. This design refinement was therefore adopted
- The preferred option included a twin 39-metre long bridge (three spans of 13 metres, separate bridges for eastbound and westbound carriageways) over Strangers Creek to meet flood immunity from a one in 100-year ARI storm event. Additional modelling during concept design found that smaller twin 18-metre single span bridges would be sufficient to meet the criteria. The provision of single span bridges remove the requirement for piers in the waterway, reducing environmental impact compared to the longer three span bridges.

3 Description of the proposal

This chapter describes the proposal and provides descriptions of existing conditions, the design parameters, major design features, the construction method and associated infrastructure and activities.

3.1 Overview of the proposal

The proposal (Figure 3-1a to Figure 3-1d) is to upgrade a 2.2 kilometre section of Memorial Avenue, between Windsor Road and Old Windsor Road. The proposal also includes upgrades to the intersections of Windsor and Old Windsor Roads and minor road widening for a distance of about 550 metres along Windsor Road and 700 metres along Old Windsor Road. Key features of the proposal are to:

- Widen Memorial Avenue to a four-lane divided road. The width of the upgraded Memorial Avenue would vary from about 38 metres to 45 metres. The road widening would consist of:
 - Widening Memorial Avenue generally to the north of the existing road between Windsor Road and Hector Court. At this location, Memorial Avenue would be widened about 27 metres on the northern side and about five metres on the southern side
 - Widening Memorial Avenue generally to the south of the existing road between Hector Court and Old Windsor Road. At this location, Memorial Avenue would be widened about four metres on the northern side and about 23 metres on the southern side
- Widen Windsor Road between President Road and Wrights Road for a distance of about 550 metres. Windsor Road would be widened about seven metres on the eastern side and about 10 metres on the western side of the existing alignment. Widening is generally within the road reserve. The widening would provide:
 - An additional southbound through lane
 - An additional northbound through lane
 - Signalised left turn slip lanes on Windsor Road southern approach
 - An additional westbound right turn lane from Windsor Road northern approach
- Widen Old Windsor Road for a distance of about 350 metres either side of the intersection with Memorial Avenue/Sunnyholt Road. Old Windsor Road would be widened about seven metres on the eastern side and five metres on the western side of the existing alignment. The widening would provide:
 - An additional southbound through lane
 - An additional northbound through lane
 - An additional right turn lane from Old Windsor Road southern approach
- Provide a central median on Memorial Avenue. Its width would vary, from about nine metres up to about 12 metres, with the exception of the approach to Old Windsor Road, near the proposed North West Rail Link, where the median would narrow to 2.9 metres. The wide median would enable Memorial Avenue to accommodate six lanes if required in the future
- Provide a kerb and gutter for the full length of Memorial Avenue
- Maintain the medians along Windsor Road and Old Windsor Road near

Memorial Avenue, although an additional northbound right-turn lane would be included in the Old Windsor Road median

- Provide a verge of variable width on both sides of Memorial Avenue, Windsor Road, Old Windsor Road and Sunnyholt Road within the proposal area
- Provide a three-metre wide shared path within the verge on both sides of Memorial Avenue. This would tie in with the existing shared paths along Windsor Road and Old Windsor Road. The shared path next to the northbound carriageway on Old Windsor Road would be shifted slightly to the west to accommodate the road widening
- Provide bus priority capability at traffic lights and indented bus bays on both sides of Memorial Avenue to allow buses a head start in the east–west direction
- Provide bus priority capability at the Memorial Avenue traffic lights heading northbound on Windsor Road and an indented bus bay beyond the traffic lights
- Upgrade three intersections with Memorial Avenue:
 - The Windsor Road intersection would have an additional through lane in both directions, and additional right and left turning lanes into Memorial Avenue. Memorial Avenue would have an additional left slip lane onto Windsor Road (northbound) and an additional westbound lane on Memorial Avenue
 - The Arnold Avenue (west) intersection would be upgraded to a signalised four-way intersection with an additional through lane and dedicated left and right turning bays in each direction along Memorial Avenue, two additional right turning lanes from Arnold Avenue (west) and a new approach on Free Settlers Drive
 - The Old Windsor Road intersection would have an additional through lane in both directions, an additional lane turning right from the Old Windsor Road into Memorial Avenue from Old Windsor Road and an additional left turn slip lane onto Old Windsor Road from Memorial Avenue
- Build a new intersection with Memorial Avenue at Severn Vale Drive and realign Arnold Avenue (east) about 100 metres east of current alignment
- Replace the pipe culvert with a bridge over Strangers Creek (this would be an 18-metre span concrete plank bridge with vertical abutments)
- Upgrade the multi-cell box culverts at Elizabeth Macarthur Creek with a reinforced concrete box culvert, and upgrade the pipe culverts at two low points along Memorial Avenue
- Provide 1:4 landscaped earthen batters along the alignment beside public land, and 1:2 batters and/or retaining walls beside private land (to minimise property impact)
- Provide safety barriers alongside fill retaining walls and at the culvert and bridge locations along Memorial Avenue
- Relocate and/or temporarily divert underground utilities, including water, telecommunications, electricity and gas, within the verges.

3.2 Detailed description of the proposal

This section provides a detailed description of the proposal. Proposed road widening works, including earthworks and landscaping, are detailed below from east to west.

The bridge over Strangers Creek is discussed in section 3.3.4. The culverts at Elizabeth Macarthur Creek are discussed in section 3.3.5 and other drainage works are discussed in section 3.3.6. Proposed intersection arrangements are discussed in section 3.3.3. Proposed retaining walls discussed in section 3.3.7.

Underground utilities, including water, telecommunications, electricity and gas, would be relocated and/or temporarily diverted within the verges (see section 3.6 for detail).

This design may be refined following public display of this REF and during detailed design. Figure 3-1a to Figure 3-1d show the proposed concept design, while concept design drawings are provided in Appendix B.

Windsor Road to Hector Court

Windsor Road would be widened between President Road and Wrights Road for a total distance of about 550 metres (see Figure 3-1a). Windsor Road would be widened about seven metres on the eastern side and about 10 metres on the western side of the existing alignment. Widening is generally within the road reserve designated in The Hills Shire Local Environment Plan, although some strip acquisition would be required as some existing property boundaries overlap the road reserve. The proposed intersection arrangement is shown on Figure 3-9.

The existing median on Windsor Road near Memorial Avenue would be shifted west to the north of Memorial Avenue to make way for an additional right turn lane, and widened and kerbed south of Memorial Avenue. The proposed shared path along Memorial Avenue would tie into the existing shared path on the western side of Windsor Road. The existing shared path on the eastern side of Windsor Road would not be affected.

Memorial Avenue would be widened between Windsor Road and Hector Court by about 27 metres on the northern side and about five metres on the southern side (see Figure 3-1b). The central median would vary in width between nine metres and 15 metres. Verge widths of about four metres would be provided along this section, with a three-metre wide shared path provided within the verge on both northern and southern side of Memorial Avenue. A kerb and gutter would be provided, tying in with the existing kerb and gutter at Windsor Road. Indicative cross-sections are shown in Figure 3-6 and Figure 3-7.

Tie-ins at Burns Road and Stone Mason Drive would be adjusted (by others) to the new widened Memorial Avenue, in order to maintain the current left-in, left-out access onto Memorial Avenue.

At Strangers Creek, twin bridges would be provided and the existing culverts removed (see section 3.3.4 and Figure 3-11). The road and bridge alignment at this location would be raised by about 3.5 metres above the existing height. Fill would be required for about 100 metres either side of Strangers Creek in order to raise the road to provide one in 100 year flood immunity. Safety barriers would be provided on both sides of Memorial Avenue, both east and west of the bridges.

A new four-way signalised intersection would be constructed with Memorial Avenue at Severn Vale Drive (see section 3.3.3 and Figure 3-10). Arnold Avenue (east) would be realigned (by others) about 100 metres east of the current alignment to tie into Severn Vale Drive to the north of Memorial Avenue. Bus priority lanes are would also be provided in both directions along Memorial Avenue at the approach to the intersection, with indented bus bays provided on the other side of the intersection.

Hector Court and Arnold Avenue (east) (where it currently joins Memorial Avenue) would become cul-de-sacs as part of the development of the Balmoral Road Release Area and once the upgrade is complete.

Batters would be provided at a 2:1 gradient either side of Strangers Creek and on the western side of the Severn Vale Drive intersection to minimise impact on private property. Along the eastern side of the Severn Vale Drive intersection, batters at a 4:1 gradient would be provided.

At the intersection of Windsor Road and Memorial Avenue, existing gateway planting would be retained and enhanced to indicate transition of road type. Informal avenue planting (native) would be provided on the northern and southern sides of Memorial Avenue between Windsor Road and Burns Road/Stone Mason Drive (see Appendix J). Near Kellyville Park, exotic avenue planting would be provided on the southern side of Memorial Avenue to articulate the recreational facility. Native tree planting is also proposed along the 4:1 batters east of the Severn Vale Drive intersection. There would also be planting in the median between Burns Road/Stone Mason Drive and Severn Vale Drive.

Hector Court to Arnold Avenue (west)

Between Hector Court and Arnold Avenue (west), Memorial Avenue would be widened about four metres on the northern side and about 23 metres on the southern side (see Figure 3-1b). A central median would be provided with a varying width of between nine and 12 metres. Verge widths of about four metres would be provided along this section, with a three-metre wide shared path provided within the verge. Property access would be via the new local road network, with access to Memorial Avenue provided at the signalised intersections at Severn Vale Drive and Arnold Avenue (west). Figure 3-4 and Figure 3-5 provide indicative cross-sections.

The road level would be lowered by up to 1.8 metres for a distance of about 140 metres from the intersection of Memorial Avenue and Severn Vale Drive to about 40 metres east of the tributary of Strangers Creek. At the tributary of Strangers Creek, the existing culvert would be replaced with three 900 millimetre pipe culverts (see section 3.3.6). The road alignment at this location would be raised by about 1.1 metres above the existing height. Fill would be required for about 30 metres either side of the tributary in order to raise the road to provide one in 100 year flood immunity.

The road would be lowered by up to 2.3 metres deep from about 40 metres east of Pellizzer Boulevard to about 90 metres east of the unnamed drainage line. At the unnamed drainage line, the existing pipe culvert would be replaced with a new 750 millimetre pipe culvert (see section 3.3.6). Fill would be required to raise the road alignment by about 3.1 metres from about 120 metres west to about 90 metres east of the unnamed drainage line. This would provide one in 100 year flood immunity. Safety barriers would be provided at both culvert locations.

The road would be lowered by up to 2.0 metres deep for a distance of about 160 metres near Rutherford Avenue/Thomas Boulton Circuit.

The Arnold Avenue (west) intersection would be upgraded to a signalised four-way intersection (see section 3.3.3 and Figure 3-10). The slip lane out of Rutherford Avenue onto Memorial Avenue would be closed (by others). Bus priority lanes would also be provided in both directions along Memorial Avenue at the approach to the intersection, with indented bus bays provided on the other side of the intersection.

Batters would be provided along this section at a 2:1 gradient to reduce impact on private property. Retaining walls would also be provided in front of residential developments near Rutherford Avenue, the tributary of Strangers Creek and the unnamed drainage line (see section 3.3.7 for detail). Planting within the verge would be provided on both sides of Memorial Avenue near The Hills Clinic for a distance of about 100 metres. Median planting would be provided for a distance of about 150 metres in front of Kellyville Memorial Park. Further median planting would be provided for a distance of about 350 metres, starting from about 100 metres east of the Arnold Avenue (west)/Memorial Avenue intersection (see Appendix J for detail).

Arnold Avenue (west) to Old Windsor Road

Between Arnold Avenue (west) and Old Windsor Road, Memorial Avenue would be widened about four metres on the northern side and about 23 metres on the southern side (refer to Figure 3-1c). A central median would be provided between nine and 12 metres width, narrowing at the approach to Old Windsor Road, near the proposed NWRL, to 2.9 metres. Verge widths of about four metres would be provided along this section, with a three-metre wide shared path provided within the verge. The shared paths along Memorial Avenue would tie in with the existing shared path along the western side of Old Windsor Road. Kerb and gutter would be provided, tying in with the existing kerb and gutter at Old Windsor Road. Indicative cross-sections are shown in Figure 3-2 and Figure 3-3.

The three existing box culverts at Elizabeth Macarthur Creek would be replaced with four reinforced concrete box culverts (see section 3.3.5 and Figure 3-13). Fill would be required for about 150 metres either side of the creek to raise the road alignment by about three metres above the existing height. This would provide one in 100 year flood immunity. Safety barriers would be provided both sides of Memorial Avenue next to the culverts.

At the intersection of Memorial Avenue and the T-way, the current layout would not be altered except the tie-in to Memorial Avenue would need to be adjusted to accommodate the road widening, and a pedestrian crossing added at the north side to accommodate the shared path along Memorial Avenue.

Old Windsor Road would be widened for a distance of about 350 metres either side of the intersection with Memorial Avenue/Sunnyholt Road (refer to Figure 3-1c and Figure 3-1d). Old Windsor Road would be widened about seven metres on the eastern side and five metres on the western side of the existing alignment (see section 3.3.3 and Figure 3-9). The existing median along Old Windsor Road would be maintained, with the additional northbound right-turn lane on to Memorial Avenue provided within the median. The shared path along the western side of Old Windsor Road would be shifted slightly to the west to accommodate the road widening.

Batters with 2:1 gradient are provided where required along this section. Retaining walls are required between Elizabeth Macarthur Creek and the T-way (see section 3.3.7 for detail). These would be protected with safety barriers.

Similar to Windsor Road, gateway planting would be provided near the intersection of Memorial Avenue and Old Windsor Road to indicate the change in road type. Median planting would be provided for a distance of about 75 metres near the North West Rail Link viaduct.

Memorial Avenue Upgrade - Review of Environmental Factors



Figure 3-1a: Memorial Avenue upgrade

Memorial Avenue Upgrade - Review of Environmental Factors



LEGEND

- Proposal Area
- Concept Design
- Shared Pedestrian / Cycle Path

DATA SOURCES
Nearmap 2013-09-02, LPI, DOP

NSW Transport
Roads & Maritime
Services

HYDER CONSULTING PTY LTD
ABN 76 104 485 289
Level 5, 141 Walker St
North Sydney NSW 2060
Australia
P: +61 (0) 2 8907 9000
F: +61 (0) 2 8907 9001

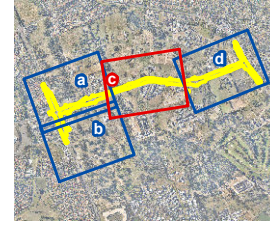


Figure 3-1b: Memorial Avenue upgrade

Memorial Avenue Upgrade - Review of Environmental Factors

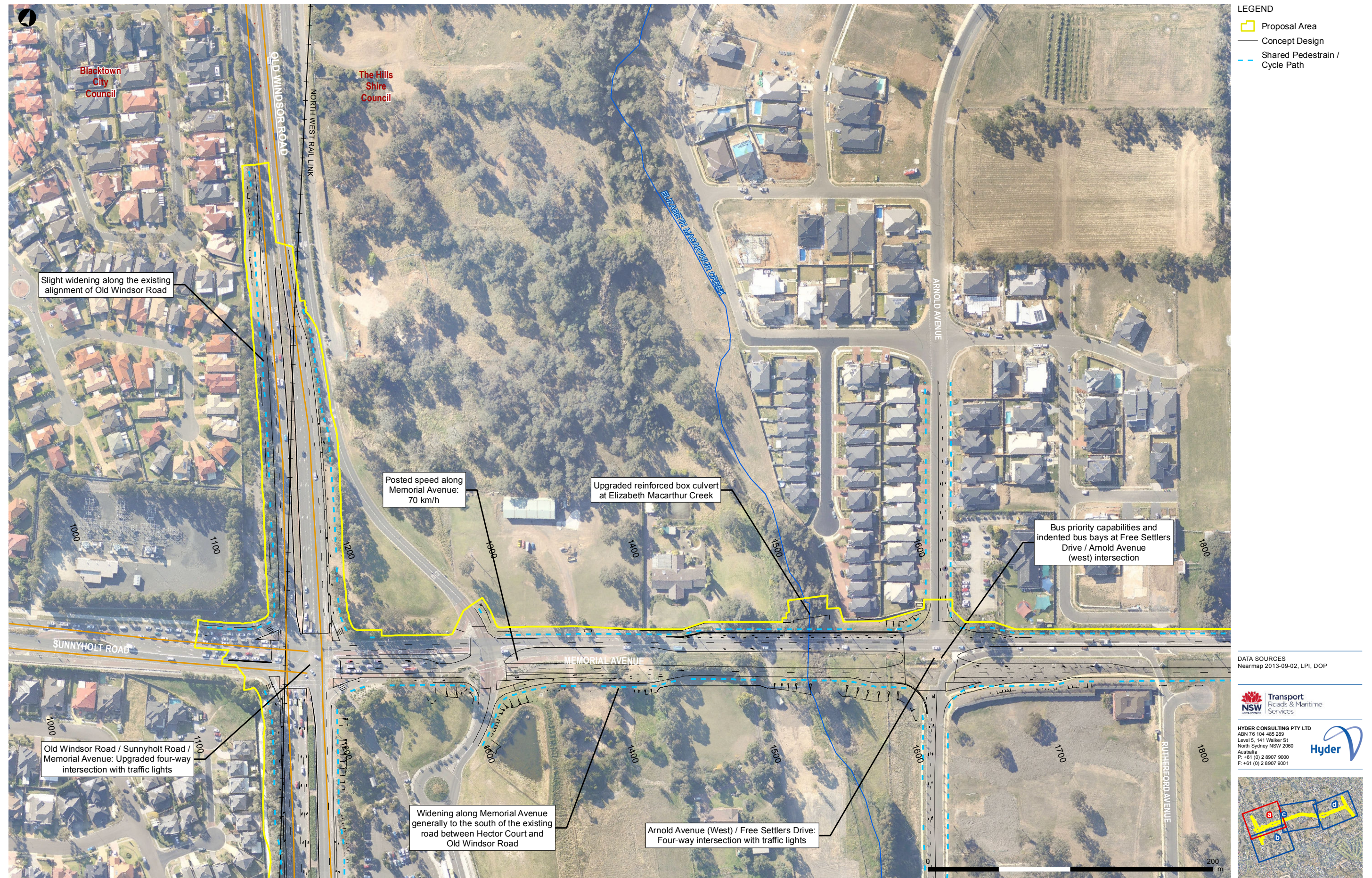


Figure 3-1c: Memorial Avenue upgrade

Memorial Avenue Upgrade - Review of Environmental Factors



- LEGEND**
- Proposal Area
 - Concept Design
 - Shared Pedestrian / Cycle Path

DATA SOURCES
 Nearmap 2013-09-02, LPI, DOP

NSW Transport
 Roads & Maritime
 Services

HYDER CONSULTING PTY LTD
 ABN 76 104 485 289
 Level 5, 141 Walker St
 North Sydney NSW 2060
 Australia
 P: +61 (0) 2 8907 9000
 F: +61 (0) 2 8907 9001

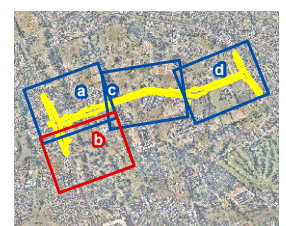



Figure 3-1d: Memorial Avenue upgrade

3.3 Design

This section presents the design criteria, the limits of the proposal, engineering constraints and the major design features of the concept design (Appendix B). The proposal would be further refined through detailed design once it is approved.

3.3.1 Design criteria

Table 3-1 presents the design criteria used for the concept design for the upgrade of Memorial Avenue. Indicative cross sections are presented in Figure 3-2 to Figure 3-8.

Table 3-1: Design criteria for Memorial Avenue

Criteria	Value	Explanation
Speed limit	70 km/h	The speed limit reflects future land use around Memorial Avenue, and its function as an arterial road.
Grade	Maximum grade 8% Desirable 1% Minimum 0.3%	The maximum grade of 8% would be used on the eastbound approach to Windsor Road on Memorial Avenue, and matches the existing grade up the hill to Windsor Road.
Design vehicle	Semi-trailers up to 19 metres long turning at intersections with Arnold Avenue and Severn Vale Drive B-doubles up to 26 metres long at intersections with Old Windsor Road and Windsor Road	Windsor Road, Memorial Avenue and Old Windsor Road are suitable for semi-trailers and designated B-double routes.
Road surface type: - Memorial Avenue - Local road - Local road overlay - Shared path	Deep strength asphalt over lean mix concrete sub base Asphalt over dense-graded base Asphalt overlay Concrete path	Similar to other recent projects in western Sydney. Used to widen existing local roads. Used near the interface of new work to tie in to existing roads.
Stopping sight distance	103 metres (minimum)	To provide a safe level of visibility with a posted speed of 70 km/h.
Minimum curve radius	315 metres	Minimum radius with 3% super-elevation.
Corridor width	38–45 metres	A 40-metre wide corridor is

Criteria	Value	Explanation
		reserved in <i>The Hills Local Environmental Plan 2012</i> .
Through lane width - Kerbside lane - Median lane	3.8 metres 3.3 metres	Measured to the invert of kerb.
Right-turn lanes	3.0 metres	In accordance with Austroads.
Left-turn lanes	3.8 metres	In accordance with Austroads.
Shared path width	3.0 metres	2.5 metres minimum at the bus stops.
Medians	2.4–15 metres	Medians would be 15 metres wide in mid-block sections and 2.4 metres wide where there are two 3-metre right-turn lanes in the median at intersections.
Batters/retaining walls (gradient)	1:4 and 1:2 (vertical to horizontal)	1V:4H landscaped earthen batters would be used where they can spill into land owned by Roads and Maritime, The Hills Shire Council or Sydney Water. 1V:2H batters would be used where they can be contained within the road corridor beside private property. Retaining walls would be used where batters cannot be contained within the road corridor beside private property.
Drainage	100-year ARI	Provide flood immunity from a 1 in 100-year ARI storm event.

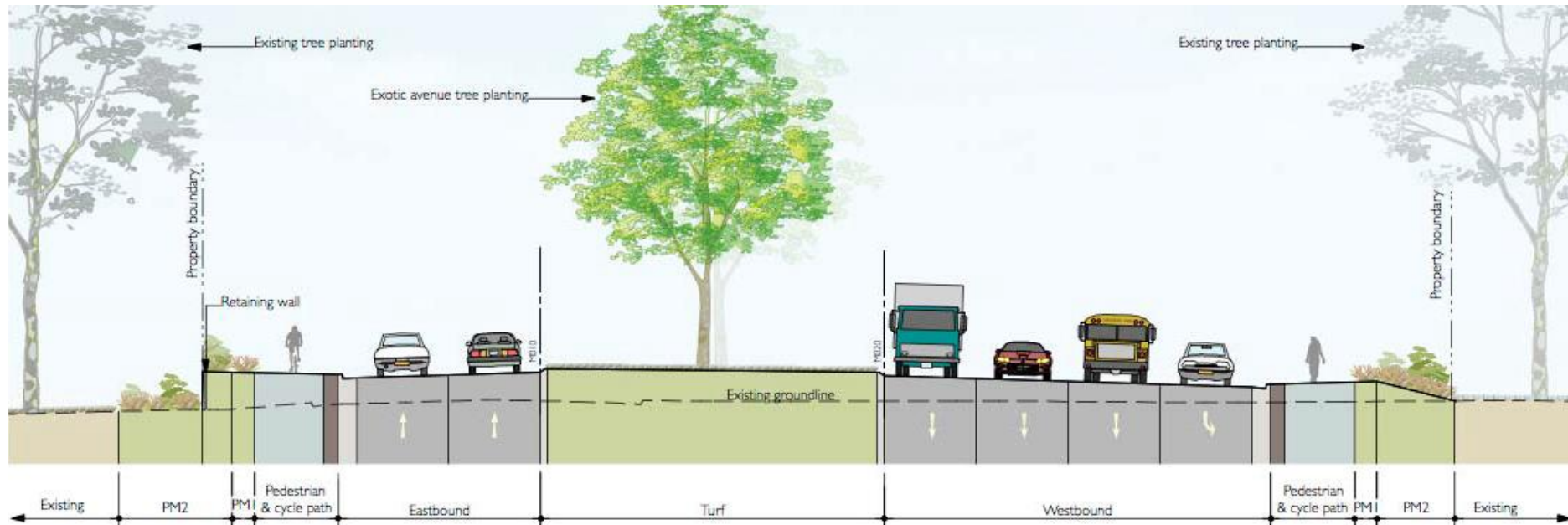


Figure 3-2: Typical cross section near the North West Rail Link overbridge

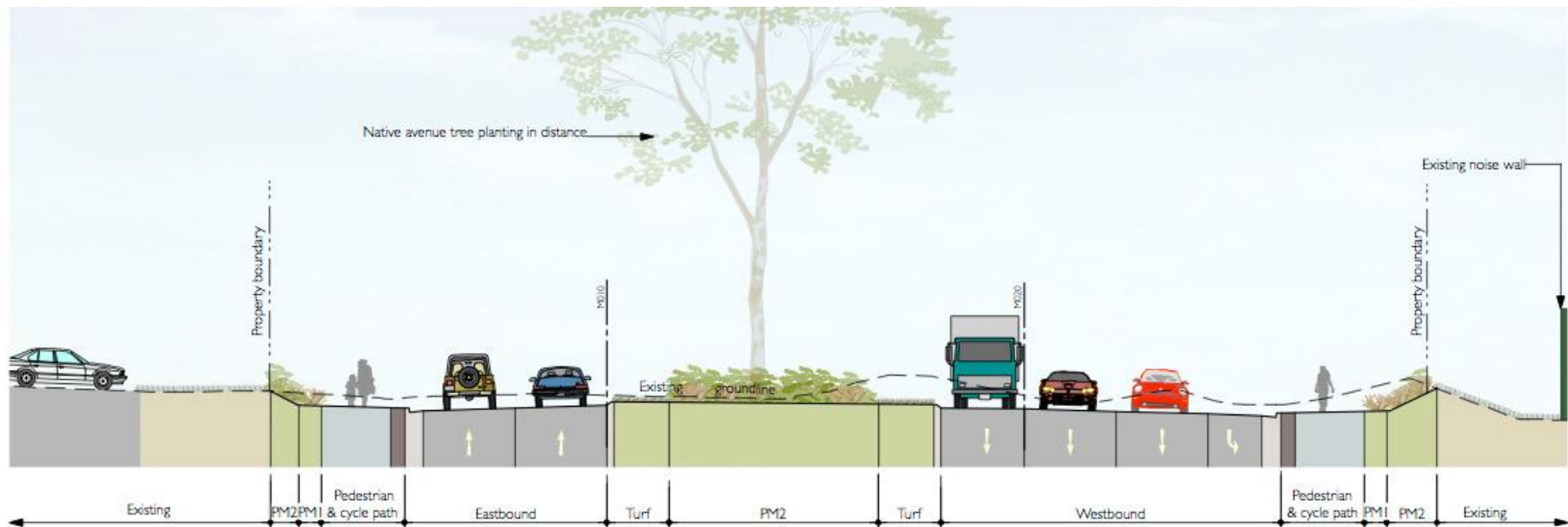


Figure 3-3: Typical cross section west of the intersection of Memorial Avenue with Free Settlers Drive and Arnold Avenue (West)

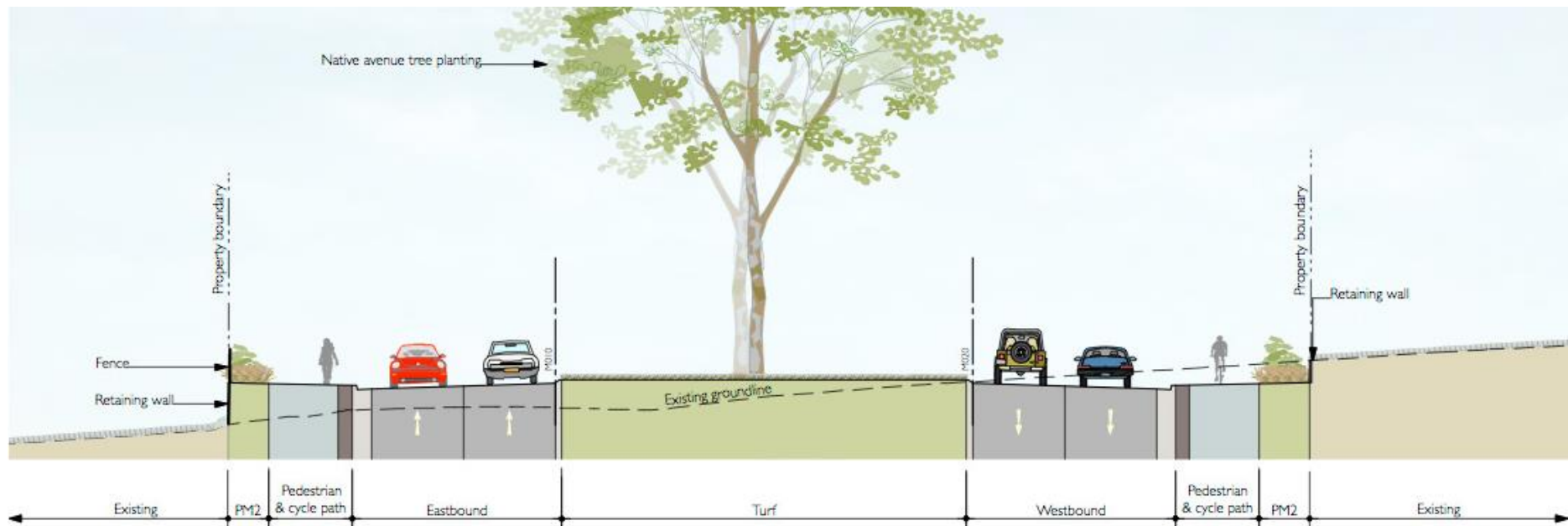


Figure 3-4: Typical cross section near the unnamed drainage line

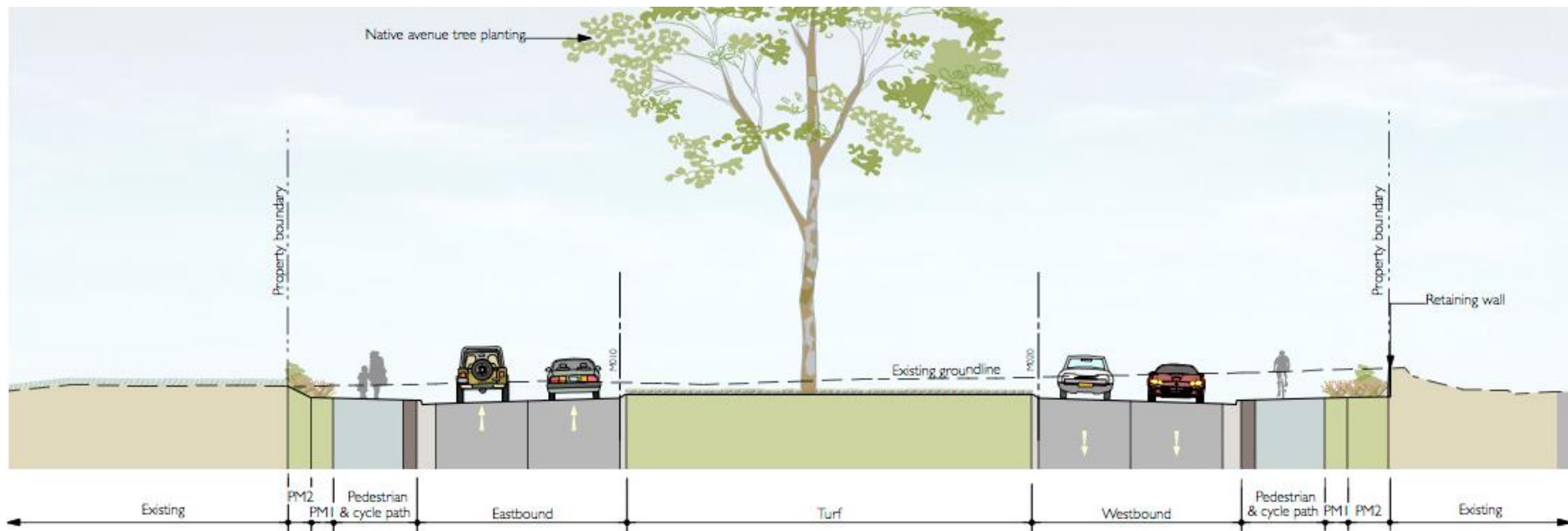


Figure 3-5: Typical cross section near Pellizzer Boulevard

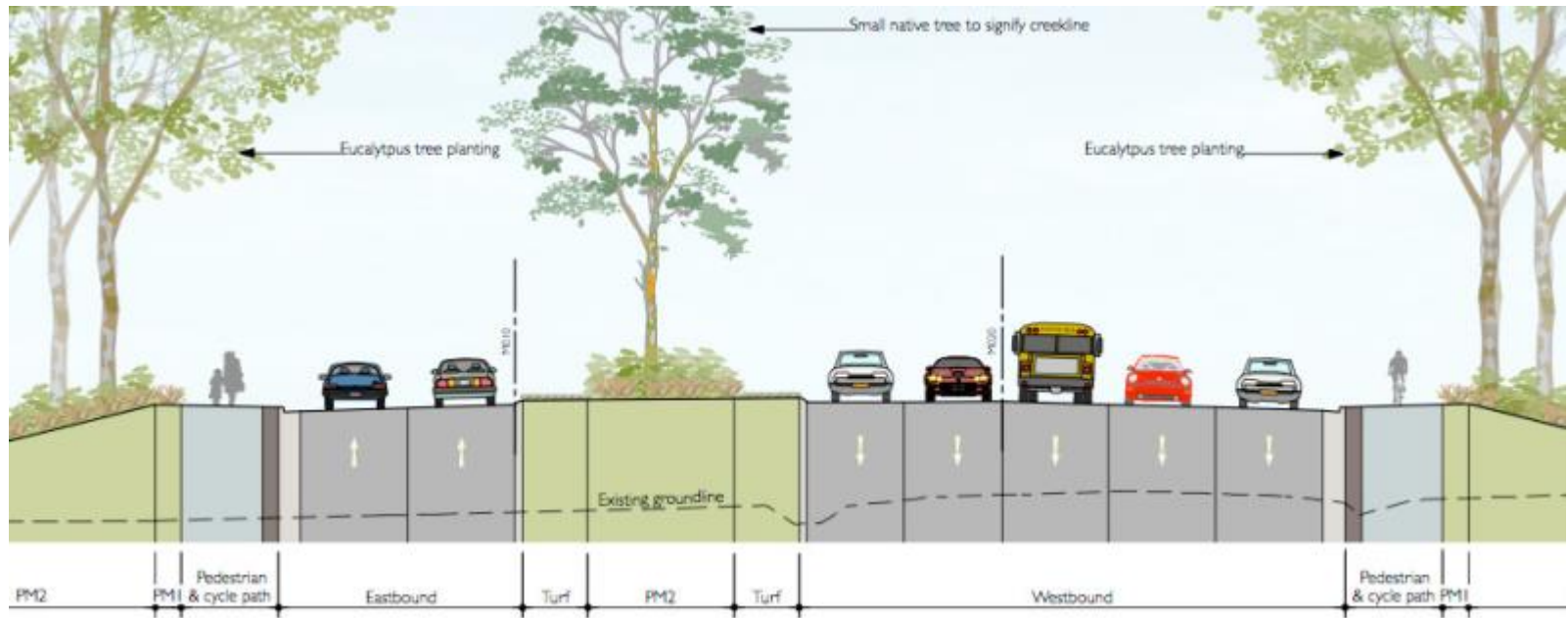


Figure 3-6: Cross-section east of Strangers Creek

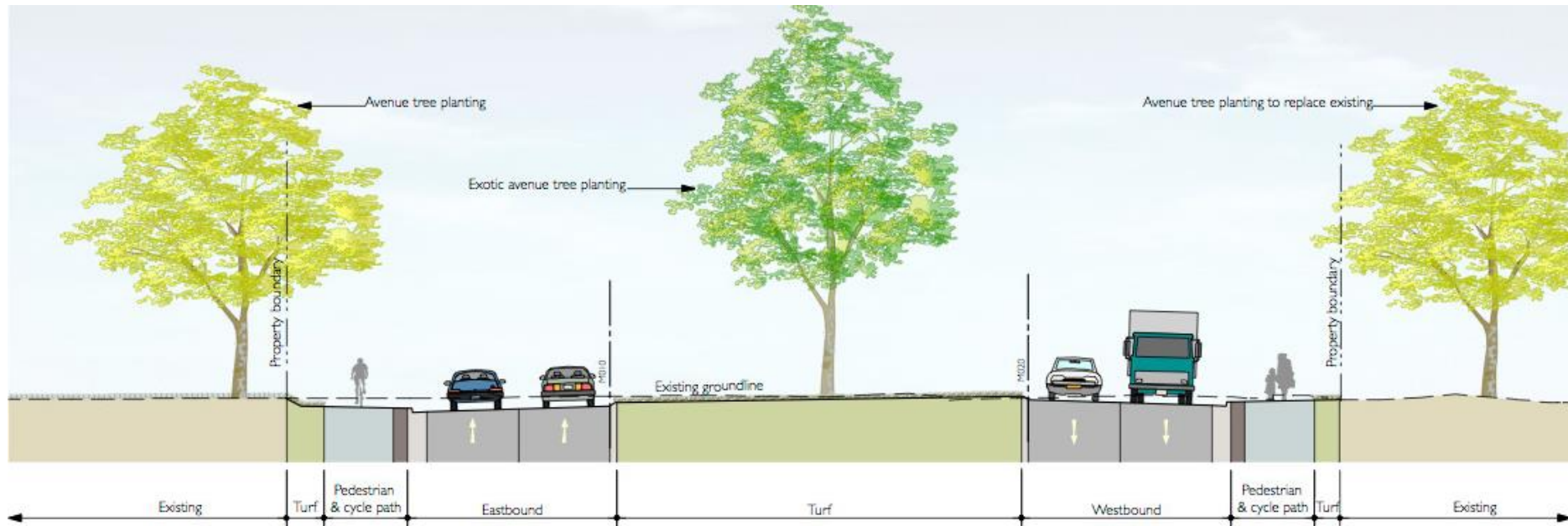


Figure 3-7: Typical cross section near Kellyville Memorial Park

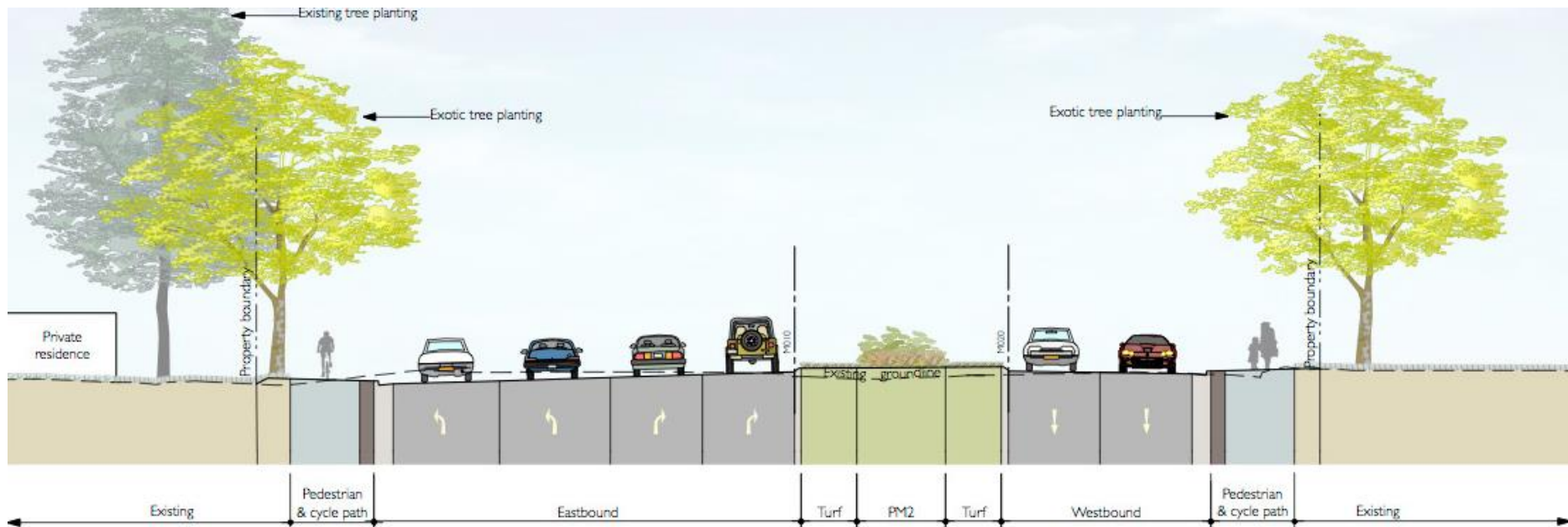


Figure 3-8: Typical cross-section near the intersection of Memorial Avenue and Burns Road leading to Windsor Road

Urban and landscape design objectives and principles

Spackman Mossop Michaels was commissioned to prepare an Urban Design Report for the proposal (2014). They identified the urban design objectives and principles in Table 3-2 to guide the development of the concept design outcome for the Memorial Avenue upgrade.

Table 3-2: Urban Design objectives and principles

Objective	Principles
Improve the quality of the public domain throughout the corridor	<ul style="list-style-type: none"> • Improve pedestrian and cyclist amenity along and across the corridor, especially by providing connecting paths from bus stops to residential areas and along open space corridors • Provide planting to screen views from/ to residences • Ensure planting reinforces the landscape character zones described in this report within an overall structure • Utilise a combination of trees and understorey treatments which respond to the existing adjacent context • Utilise a similar palette of roadside elements as for recent road upgrade projects carried out in the North West Growth Centres.

Objective	Principles
<p>Facilitate the provision of good urban design outcomes to future residential areas adjoining the road</p>	<ul style="list-style-type: none"> • Work with appropriate authorities to develop a visual, urban design and landscape character of the road corridor by promoting planning/ design strategies that achieve a high quality environment and amenity at the interface between Memorial Avenue and future residential areas • Ensure the provision of safe, convenient and enjoyable pedestrian and cycle connections in the most appropriate/ accessible location within the locality in the context of future growth and urban development patterns • Provide more formal structured planting to the major intersections at Windsor Road and Old Windsor Road where possible, and along the frontage of Kellyville Memorial Park. This planting would define the entry and approach to these intersections and recreational destination • Avoid the need for noise walls by advocating for development controls such as adequate development setbacks, building orientation, layout and building height controls • Avoid residential boundary fencing along the road corridor by promoting an active street address with a character consistent with the desired outcomes for the road corridor.
<p>Provide a flowing road alignment that is responsive to, and integrated with the natural and built landscape</p>	<ul style="list-style-type: none"> • Physically, and where possible, visually separate lanes to reduce horizontal scale and perceived road corridor width. Utilise medians and verges to maximise existing tree retention. Potentially revegetate and break up wide pavement surfaces • Devise a planting/ revegetation strategy that takes into account the long-term visual quality and functional changes within the road corridor • Protect creeks and creek banks by maximising tree retention and planting at creek crossings and aligning shared paths alongside the road.

Objective	Principles
Protect and enhance existing views, character and cultural values of the corridor	<ul style="list-style-type: none"> • Retain and reinforce the diverse character of the route, including the distinctive character of the urban areas and the distinction between urban and non-urban areas • Recognise and incorporate existing cultural sites along the route • Retain existing view corridors, particularly at elevated points, to establish a sense of place along Memorial Avenue • Maximise tree planting opportunities.
Develop a simple and unified palette of roadside elements and details that are attractive and easily maintained	<ul style="list-style-type: none"> • Standard roadside elements may include road furniture (safety barriers, pedestrian and shared path fencing, bus stops, street lighting, signage), retaining walls, shared paths, bridges and noise mitigation. Specific principles have been developed for shared paths, fencing, bus stops, lighting fixtures, retaining walls, bridges and culverts.

The full report is included in Appendix J and more detail is presented in Section 6.10 of this report.

3.3.2 Engineering constraints

A number of constraints were identified for the design and construction of the proposal. The main engineering constraints are:

- The North West Rail Link overbridge (currently under construction)
- The 40-metre corridor identified in *The Hills Local Environmental Plan 2012*
- The need to maintain access to/from adjoining properties and local roads during construction and operation to support existing land uses
- The planned development associated with the Balmoral Road release area
- The need to minimise impact on utilities and disruption to existing services.

3.3.3 Intersections

The proposal includes the upgrade of three intersections and building a new intersection with Memorial Avenue. Details of these upgrades are provided in Table 3-3 and Figure 3-9 to Figure 3-10.

Table 3-3: Intersections with Memorial Avenue, and proposed upgrades (from east to west) (refer Figure 3-9 and Figure 3-10)

Intersecting road	Existing control method	Road description/ characteristics	Movements	Provides access to	Proposed upgrade	
Windsor Road	Four-way intersection with traffic lights	Windsor Road is a sealed, multi-lane undivided arterial road providing connection between Windsor in the north and Northmead in the south. It is a designated B-double route. Within the proposal area, it has a posted speed limit of 60 kilometres per hour.	Windsor Road provides for two through lanes in each direction, with an additional lane turning right onto President Road from the northbound carriageway and an additional lane turning right onto Memorial Avenue from the southbound carriageway.	Local businesses, residential areas, Windsor and Northmead, and surrounding suburbs.	An additional through lane in each direction on Windsor Road. Two additional turning lanes from the northbound and southbound carriageways of Windsor Road Two additional left turn lanes from Memorial Avenue northbound onto Windsor Road.	About 550 metres of widening between President Road and Wrights Road.
Severn Vale Drive	This would be a new road, built as part of the Balmoral Road Release Area development.			Balmoral Road Release Area, planned supermarket development.	Four-way intersection with traffic lights.	About 30 metres along either side of Severn Vale Drive.
Arnold Avenue (west)/ Free Settlers Drive	T intersection without traffic lights	Arnold Avenue is a two-way, two-lane unmarked road used for residential access. The speed limit is unmarked. The road features overhead wires and timber power poles. There is no street lighting or kerb and channel until	Memorial Avenue has a single lane each way at the intersection of Arnold Avenue (west). Left and right turns from Memorial Avenue are permitted from the through lanes (no dedicated turning	Residential area, childcare centre.	Four-way intersection with traffic lights, dedicated right turn lane and shared through/left turn lane on to Memorial from Arnold Avenue (west) and Free Settlers Drive.	About 15 metres along Arnold Avenue (west). About 20 metres along Free Settlers Drive.

Intersecting road	Existing control method	Road description/ characteristics	Movements	Provides access to	Proposed upgrade	Extent of works on local road
		about 150 metres from the western entrance to Arnold Avenue.	lanes). From Arnold Avenue (west) it is permitted to turn both left and right onto Memorial Avenue.			
Old Windsor Road and Sunnyholt Road	Four-way intersection with traffic lights	Sunnyholt Road is a two-way, divided arterial road with two through lanes in each direction and auxiliary lanes to facilitate movements at intersections. It also has a two-lane, dedicated busway between Old Windsor Road and George Street in Blacktown. Sunnyholt Road crosses the Westlink M7. It has street lighting and shared paths on both sides of the road approaching the intersection with Old Windsor Road and Memorial Avenue. The speed limit is 70 km/h.	Old Windsor Road near the intersection with Memorial Avenue has two through southbound lanes and one dedicated right turn lane onto Sunnyholt Road. Northbound there are two through lanes, one dedicated right turn lane onto Memorial Avenue and a left slip lane onto Sunnyholt Road. From Sunnyholt Road there are two through lanes for general use plus a dedicated bus lane through to Memorial Avenue. There is also a left-turn slip lane onto Old Windsor Road (north)	Stanhope Gardens, Glenwood, Blacktown	Slight widening along Old Windsor Road. Provision of additional through lanes in both directions on Old Windsor Road, an additional right hand turn lane from Old Windsor Road on to Memorial Avenue, and a left slip lane from Memorial Avenue on to Old Windsor Road.	Work along Sunnyholt Road for about 70 metres approaching the intersection with Old Windsor Road and Memorial Avenue. Widening along Old Windsor Road for about 350 metres north and south of the intersection with Memorial Avenue / Sunnyholt Road.

Intersecting road	Existing control method	Road description/ characteristics	Movements	Provides access to	Proposed upgrade	Extent of works on local road
			and two dedicated lanes turning right onto Old Windsor Road (south). Sunnyholt Road, two through lanes for general use plus a dedicated bus lane through to Memorial Avenue. A left-turn slip lane onto Old Windsor Road (north) and also two dedicated lanes turning right onto Old Windsor Road (south).			

Memorial Avenue Upgrade - Review of Environmental Factors



Figure 3-9: Proposed layout of Windsor Road / Memorial Avenue intersection and Memorial Avenue / Severn Vale Drive intersection

NSW Transport
Roads & Maritime
Services

HYDER CONSULTING PTY LTD
ABN 76 104 485 289
Level 5, 141 Walker St
North Sydney NSW 2060
Australia
P: +61 (0) 2 8907 9000
F: +61 (0) 2 8907 9001

Memorial Avenue Upgrade - Review of Environmental Factors



Figure 3-10: Proposed layout of Memorial Ave / Arnold Ave (W) / Free Settlers Dr intersection & Old Windsor Rd / Memorial Ave/ Sunnyholt Rd intersection

3.3.4 Bridge over Strangers Creek

It is proposed to convert the four 1500 millimetre culverts at Strangers Creek to two 18-metre span concrete plank bridges with vertical abutments (one eastbound bridge, one westbound bridge). Piers would be located out of the creek alignment along the embankment. Distance between piers would be about 16.5 metres. The bridges would accommodate two lanes in each direction along Memorial Avenue, plus an additional left-turn lane and two right-turn lanes on the westbound bridge. The bridges have been designed to meet the one in 100 flood level.

Indicative concept design details are included in Appendix B. In summary:

- The eastbound bridge would be about 12 metres wide and about 3 metres higher than the existing road level
- The westbound bridge would be about 22 metres wide and about 2.5 metres higher than the existing road level
- There would be a minimum clear span of about 16.5 metres between bridge abutments
- Planks would be 0.7 metres deep with a topping slab of 0.3 metre depth
- There would be a 0.5-metre clearance between the peak one in 100-year flood water level on the upstream side of road corridor and the underside of the bridge
- Piles would be built outside of the low-flow channel.

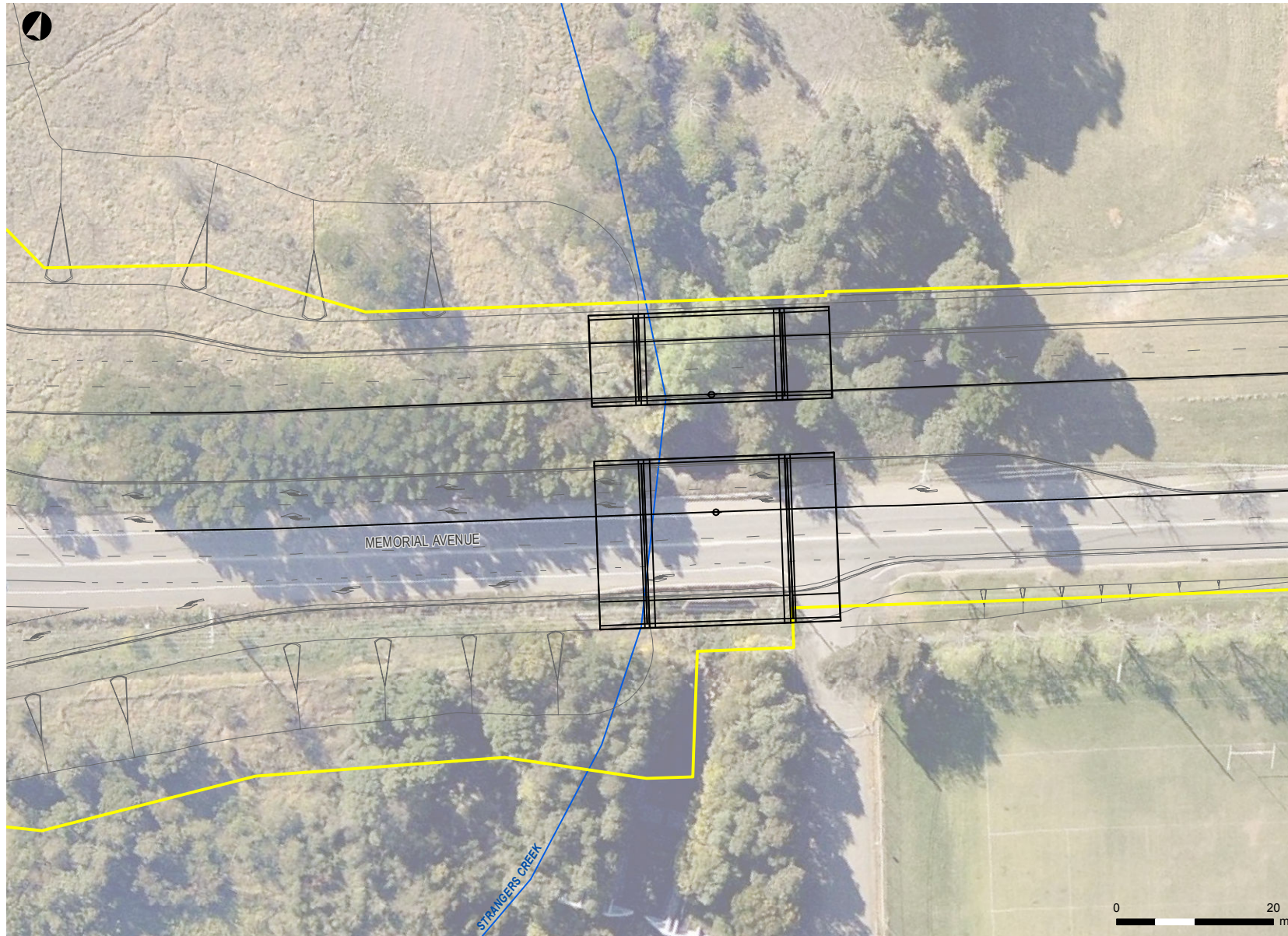
There are no bridge foundations or bridge abutments within the waterway which minimises the intrusion of bridge structure and the impact on waterway embankments. The embankments of waterway are provided with batter and scour protection to minimise the impact on the waterway during design life of the bridge. Maintenance access is provided in front of the abutment within the scour protection.

Scour protection would be provided up to 12.5 metres beyond the bridge structures at Strangers Creek to taper creek shape to natural creek shape. Scour protection would be designed to withstand the forces of the designated flood (one in 100 year flood). The batter would be a spill-through batter with slope gradient of 1.5:1.




No bridge scuppers are provided on the bridge decks. They are drained via the pit and pipe pavement drainage network which has been designed to a minimum of a 10 year ARI capacity. Drainage would flow towards the kerb or pits and collected in the drainage system. Flow in excess of the pavement drainage system capacity may lead to some overflow discharging directly into Strangers Creek. The bridge abutment embankment slopes are protected with select stone fill rock batter. The rock batter serves to resist scouring of the embankment and the ground surrounding the abutment foundation. The channel itself would be protected with appropriate vegetation and erosion control matting to prevent scour of the waterway channel. It is not required to place rock protection within the creek channel or banks.

Indicative location and cross-sections of the proposed bridge are shown in Figure 3-11 and Figure 3-12.

Memorial Avenue Upgrade - Review of Environmental Factors



LEGEND

-  Concept Design
-  Proposal Area
-  Bridge

DATA SOURCES
 Nearmap 2013-09-02, LPI



HYDER CONSULTING PTY LTD
 ABN 76 104 485 289
 Level 5, 141 Walker St
 North Sydney NSW 2060
 Australia
 P: +61 (0) 2 8907 9000
 F: +61 (0) 2 8907 9001


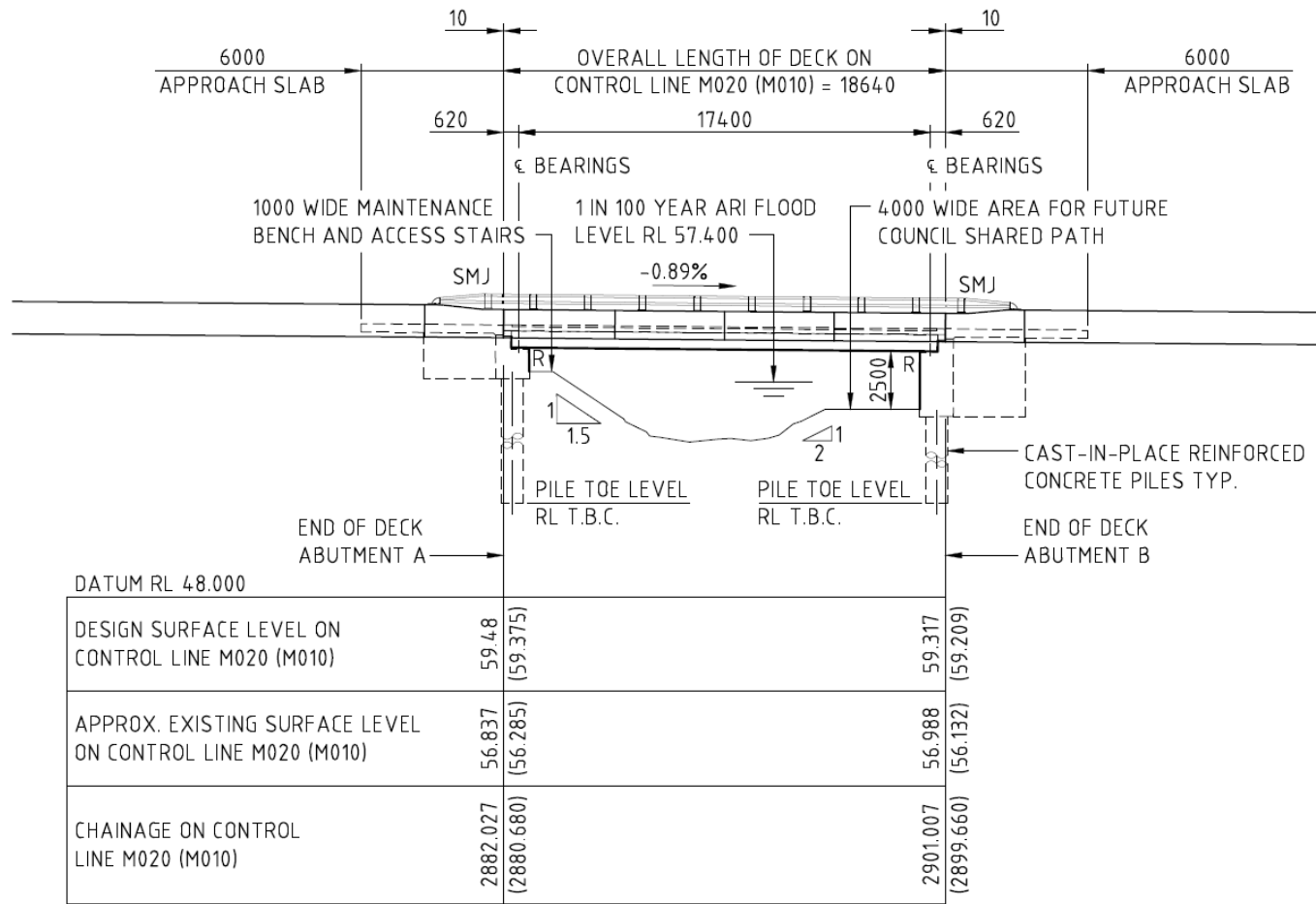



Figure 3-11: Proposed bridge at Strangers Creek



ELEVATION

WESTBOUND BRIDGE SHOWN
EASTBOUND BRIDGE SIMILAR EXCEPT WHERE SHOWN IN BRACKETS

Figure 3-12: Cross section of proposed westbound deck at Strangers Creek crossing

3.3.5 Culverts at Elizabeth Macarthur Creek

The existing three-cell culverts at Elizabeth Macarthur Creek would be replaced with four reinforced concrete box culverts. Each culvert would be three metres wide by 1.8 metres high. The location of the culverts is shown in Figure 3-13 with an indicative cross-section shown in Figure 3-14. Headwalls would be located at the outlets of the culvert structure to reduce property impacts.

Scour protection would be required for up to five metres upstream and downstream of the culvert, with channel works required approximately 12.5 metres upstream and downstream of the culvert to taper creek shape from wider culverts to natural creek shape.

3.3.6 Other drainage features

Hyder Consulting prepared a Hydrology and Hydraulics Assessment (2014, Appendix D), which informed the design of cross-drainage infrastructure. The assessment identified that the proposal would require two new culverts to manage cross-drainage flows from drainage lines north of the proposal, with the existing drainage structures decommissioned or removed.

Existing and proposed cross-drainage infrastructure is listed in Table 3-4. The proposed infrastructure would be refined during detailed design.

Table 3-4: Existing and proposed cross-drainage infrastructure

Catchment	Location	Existing pipe/ culvert dimensions	Proposed upgrade
Strangers Creek	Tributary of Strangers Creek crossing	Pipe culvert, dimensions unknown	3 x 900 mm pipe
Strangers Creek	Unnamed drainage line	Pipe culvert, dimensions unknown	1 x 750 mm pipe

There is restricted width in the road shoulder to accommodate longitudinal drainage. Design has been developed with the assumption that flow can encroach up to 0.8 metres into the trafficable lane during the one in 10 year storm. Headwalls would be located at the culvert outlets to minimise property impacts.

Pit and pipe systems are proposed under the new kerbs along Memorial Avenue, Windsor Road and Old Windsor Road. The new systems would connect to the existing systems along Windsor Road and Old Windsor Road/Sunnyholt Road. All surface flows from Memorial Avenue drain to pit and pipe systems up to the one in 10 year storm.

Scour protection works at the tributary of Strangers Creek and the unnamed drainage line would extend for a distance of about four to five metres beyond the outlets of the culverts.




Clean water channels would control and divert all the external catchment flows into Elizabeth Macarthur Creek, Strangers Creek, the unnamed drainage line and the tributary of Strangers Creek.

Section 6.1 addresses the outcomes of the modelling and the potential impact of the

proposal on hydrology and flooding.

Memorial Avenue Upgrade - Review of Environmental Factors



- LEGEND**
-  Concept Design
 -  Proposal Area
 -  Culvert

DATA SOURCES
Nearmap 2013-09-02, LPI

 **NSW** Transport Roads & Maritime Services

HYDER CONSULTING PTY LTD
 ABN 76 104 485 289
 Level 5, 141 Walker St
 North Sydney NSW 2060
 Australia
 P: +61 (0) 2 8907 9000
 F: +61 (0) 2 8907 9001

 **Hyder**



Figure 3-13: Location of culverts at Elizabeth Macarthur Creek

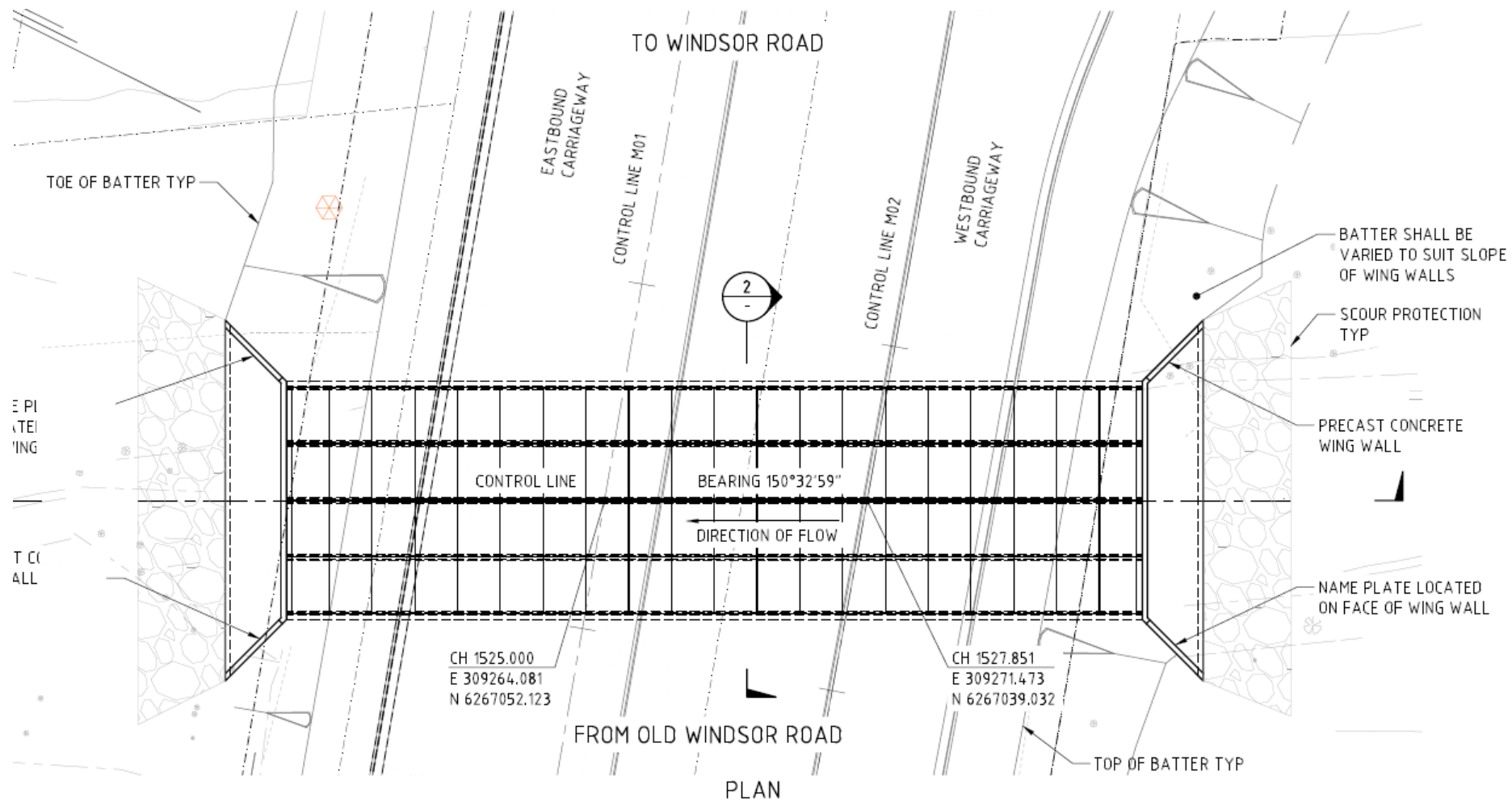


Figure 3-14: Proposed layout of culverts at Elizabeth Macarthur Creek

3.3.7 Batters and retaining walls

Landscaped earthen batters would be constructed at a number of locations along Memorial Avenue (as described in section 3.2). The batter locations are shown in the concept design drawings in Appendix B. Batters would be 4:1 adjoining publicly owned land, and 2:1 adjoining privately owned land to minimise property impact.

Due to the narrow road corridor, retaining walls would be provided at ten locations to minimise encroachment onto adjoining properties. Details of the proposed retaining walls are shown in Table 3-5.

Table 3-5: Retaining walls

Wall code	Cut/fill	Length (m)	Max. height (m)	Location
MW11	Fill	129	2.27	Eastbound, between the T-way and Elizabeth Macarthur Creek
MW12	Fill	159	1.35	Eastbound, near Thomas Boulton Circuit
MW13	Fill	225.5	3.12	Eastbound, near Farmhouse Avenue
MW14	Fill	145.5	1.1	Eastbound, between Bruhn Circuit and Arnold Avenue (east). In the vicinity of the tributary of Strangers Creek.
MW15	Fill	68	2.9	Eastbound, east of Strangers Creek, near Gormon Avenue.
MW61	Fill	10.5	0.39	Along Arnold Avenue (west)
MW2I	Fill	80	1.76	Westbound, between the T-way and Elizabeth Macarthur Creek
MW2J	Cut	177.5	2.04	Westbound, between Rutherford Avenue and the unnamed drainage line
MW2K	Cut	313	2.26	Westbound, next to Rutherford Avenue, from Rocks Street past Pellizzer Avenue
MW2L	Cut	200	1.77	Westbound, from the tributary of Strangers Creek to Hector Court.

3.4 Construction activities

3.4.1 Work methodology

While the precise construction approach would be identified during detailed design and by the contractor, it is envisaged that the proposal would be constructed in two stages:

- Stage 1: Widening the southern alignment to the west of Severn Vale Drive and widening the northern alignment to the east of Severn Vale Drive
- Stage 2: Widening the northern alignment to the west of Severn Vale Drive and widening the southern alignment to the east of Severn Vale Drive

The proposed staging of the work is in Figure 3-15. The proposal would generally be built away from the existing roadway (or 'offline') within the proposal area to minimise disruption. Current road capacity would be maintained during peak periods, where possible, with speed reductions through the site until work is completed.

An overview of the general method of construction is provided below. More detailed methodology is provided following this for the major stages and construction elements of the proposal, including the bridges and culverts.

Construction would generally involve the following sequence of activities, subject to detailed work methodologies for each stage:

- Pre-construction activities, including notification of relevant authorities and the community of the start of work
- Project Management Plan (PMP) prepared by the Contractor, and reviewed and approved by Roads and Maritime
- Installation of erosion and sediment controls
- Establishment of stockpile and compound sites
- Establishment of no-go areas and site boundary
- Implementation of traffic management measures, including speed reduction, temporary traffic controls and signs
- Identification and pot-holing of existing utilities
- Clearing and grubbing activities, including removal of vegetation
- Property adjustments, including fencing and resident access
- Relocation and/or adjustment of affected utilities and services by both open excavation and under bore
- Removal and stockpiling and/or spoiling of topsoil
- Earthworks involving excavation and fill, including stockpiling of material where necessary
- Trimming of subgrade, recompacting and stabilising
- Rock hammering and road surface removal
- Crushing of suitable rock material using crushing and screening plant and

equipment

- Longitudinal and transverse drainage work
- Construction of culverts
- Haulage, spreading and placing of select material for road construction (this may include the use of recycled concrete material)
- Construction of road surfaces consisting of bound and unbound granular material such as aggregates, lean mix concrete and bitumen seals
- Construction of kerbs and medians
- Placement of asphalt concrete
- Construction of shared pedestrian/cycle paths
- Construction of roadside furniture, including safety barriers
- Installation of street lighting
- Installation of traffic control signals
- Installation of signs and line marking
- Topsoiling and landscaping
- Construction of bridges and retaining walls, including bored piles, pile caps and concrete footings, bridge girders, bridge slabs and approaches, concrete barriers, drainage, fencing and services conduits and ducts
- Embankment works in Strangers Creek to create permanent channel
- Decommissioning of stockpile and compound sites
- Site clean-up.

The work methodology for the proposal would be fully developed during the detailed design phase. Construction activities would be guided by a Construction Environmental Management Plan (CEMP) to facilitate works being undertaken within the specified works area and incorporation of all safeguards and management measures contained in this REF.

Stage 1 major construction activities

The major construction activities proposed to be carried out during stage one of construction are detailed below.

- Clearing would be carried out at the following locations:
 - Along Old Windsor Road, up to five metres both east and west of the existing alignment south of Memorial Avenue. The north of Memorial Avenue clearing would be up to five metres to the west of the existing Old Windsor Road alignment and four metres to the east
 - A strip of about three metres on the southern side of Memorial Avenue between Old Windsor Road and the bus T-Way
 - A strip between 24 metres and 35 metres wide between the bus T-Way and Free Settlers Drive on the southern side of Memorial Avenue
 - A strip between 25 metres and 35 metres wide between Free Settlers Drive and Hector Court on the southern side of Memorial Avenue
 - A strip of land 25 metres to 45 metres wide between Hector Court and

Windsor Road, to the north of Memorial Avenue

- Along Windsor Road, up to 10 metres west of the existing alignment to the north of Memorial Avenue. South of Memorial Avenue, clearing would be up to seven metres to the east and 25 metres to the west.
- Earthworks:
 - Construction of a shallow cut batter to the west of the existing northbound carriageway of Old Windsor Road, south of Sunnyholt Road
 - To the west of Elizabeth Macarthur Creek a fill retaining wall 80 metres long and up to 1.7 metres high would be constructed to the south of the future westbound carriageway
 - Three cut retaining walls would be constructed between Free Settlers Drive and Hector Court on the southern side of Memorial Avenue to facilitate the improved vertical alignment of the road
 - Construction of a retaining wall 70 metres long and up to 2.9 metres high east of Strangers Creek
- Construction of new lanes:
 - Along Old Windsor Road a new northbound through lane would be constructed and the left turn slip lane lengthened. A new southbound through lane would be constructed and the left turn slip lane relocated east
 - Between the bus T-Way and Free Settlers Drive, the future westbound carriageway of Memorial Avenue would be constructed to the south of the existing road
 - Between Free Settlers Drive and Hector Court, the future westbound carriageway of Memorial Avenue would be constructed to the south of the existing road
 - East of Hector Court, the future eastbound carriageway of Memorial Avenue would be constructed to the north of Memorial Avenue, up to the t-intersection with Windsor Road
 - At Windsor Road, a new northbound through lane would be constructed for a distance of about 230 metres north of Memorial Avenue and 280 metres south of Memorial Avenue. A new southbound through lane would be constructed for a distance about 140 metres north of Memorial Avenue and 280 metres to the south. Two new two left turn slip lanes from Windsor Road onto Memorial Avenue would also be constructed.
- Construction of a new intersection at the location of Severn Vale Drive, the north part of the signalised intersection would be constructed. The 'stub' of Severn Vale Drive would be constructed only, as The Hills Shire Council would construct the remainder of this new road to the north in the future
- Adjustment of local roads:
 - Free Settlers Drive would be modified to suit the new road alignment, although no physical works would be done in Free Settlers Drive south of Memorial Avenue other than line marking
 - Adjustment of the intersection with Burns Road, although no physical works would be done in Burns Road.

Stage 2 major construction activities

- Only minor clearing would be required as the majority of stage 2 works would be on the existing road
- Earthworks:
 - To the west of Elizabeth Macarthur Creek a fill retaining wall 130 metres

- long and up to 2.3 metres high would be constructed to the north of the recently constructed westbound carriageway
 - Between Arnold Avenue and Hector Court three retaining walls would be constructed to facilitate the improved vertical alignment of the road, a cut wall 160 metres long to a maximum height of 1.4 metres, a fill wall 225 metres long to a maximum height of 3.1 metres, and a fill wall 145 metres long to a maximum height of 1.1 metres
- Construction of new lanes:
 - At Old Windsor Road, the four traffic islands at the intersection with Memorial Avenue/Sunnyholt Road would be adjusted to suit the addition of through lanes on Old Windsor Road and the duplication of Memorial Avenue, and a northbound new right turn lane in Old Windsor Road would be added in the median
 - Between the bus T-Way and Free Settlers Drive, the future eastbound carriageway of Memorial Avenue would be constructed to the north of the recently constructed westbound carriageway
 - Between Arnold Avenue and Hector Court, the eastbound carriageway of Memorial Avenue would be constructed to the north of the recently constructed westbound carriageway
 - East of Hector Court, the westbound carriageway of Memorial Avenue would be constructed to the south of Memorial Avenue, up to the t-intersection with Windsor Road.
- At the location of Severn Vale Drive, a new road proposed by The Hills Shire Council, the south part of a signalised intersection would be constructed to the south of the recently constructed eastbound carriageway. The 'stub' of Severn Vale Drive would be constructed only, as The Hills Shire Council would construct the remainder of this new road to the south in the future
- Adjustment of local roads:
 - At the intersection of the eastbound carriageway of Memorial Avenue, Arnold Avenue would be modified to suit the new road alignment, although no physical works would be done in Arnold Avenue north of Memorial Avenue other than line marking
 - Adjustment of the intersection with Stone Mason Drive, although no physical works would be done in Stone Mason Drive.

Construction of bridges over Strangers Creek

The following work would be carried out to build drainage infrastructure and the twin bridges over Strangers Creek:

- Installation of sediment controls to prevent site material from entering waterway
- Clearing of vegetation for construction access tracks (all access tracks would be within the proposal area)
- Construction of access tracks, including placement of a layer of clean rock to create a stabilised surface)
- Fish passage would be maintained throughout construction

Construction of Eastbound Bridge over Strangers Creek

- Complete approach embank works including piling platforms
- Install bored piles for the eastbound bridge abutments. Work would be carried out from the approach embankment using piling rig and equipment

- Construction of eastbound bridge abutment headstocks
- Completion of embankment earthworks, including abutment scour protection and provision for future footpath construction by council
- Erect precast planks for eastbound bridge between abutments using a cranes located on the approach embankments
- Construction of the bridge deck and kerbs
- Completion of road approaches for the eastbound bridge

Construction of Westbound Bridge over Strangers Creek

- Switching of traffic to the upgraded eastbound carriageway
- Maintain existing culverts during substructure works
- Complete approach embank works for piling platforms
- Install bored piles for the westbound bridge abutments. Work would be carried out from the approach embankment using piling rig and equipment
- Construction of westbound bridge abutment headstocks
- Diversion of any water flow to two of the four existing culverts, away from the work area. The diversion inlet would be protected to minimise erosion
- Removal of two of the existing pipe culverts and disposal of concrete off site
- Excavation of waterway profile and construction of new channel transition to allow realignment of the channel
- Diversion of flow to the new channel. Removal of the two remaining culverts and disposal of concrete off-site.
- Excavation and reshaping of the waterway profile to provide the new permanent channel alignment Removal of waterway diversion and realignment of flow to permanent channel
- Erect precast planks for eastbound bridge between abutments using a cranes located on the approach embankments
- Construction of the bridge deck and kerbs
- Completion of road approaches for the westbound bridge
- Revegetation and landscaping of riparian areas around the new bridge and along the new channel.

Construction of culverts at Elizabeth Macarthur Creek

Construction of culverts at Elizabeth Macarthur Creek would generally involve the following steps:

- Maintain existing culverts, divert flow through two of the existing cells using sandbags or similar non-intrusive measures.
- Excavate channel approximately 12 metres upstream and downstream of new culverts to match width of proposed new culverts. Placed rock scour protection to be placed approximately 5 metres upstream and downstream. Remainder of channel to be protected with appropriate vegetation and erosion control matting.
- Construction of two new cells adjacent to the existing structure, installation of the culvert base slab, placement of culvert cells and construction of head walls

- Diversion of the creek using sandbags or other non-intrusive measures through the newly constructed section of the culvert
- Construction of the remaining half of the culvert structure, installation of the culvert base slab, placement of culvert cells and construction of head walls
- Removal of creek diversion sand bags and final configuration to ensure low flows are directed to the low flow culvert
- Fish passage would be maintained throughout construction
- Scour protection would be required for up to five metres upstream and downstream of the culvert, with channel works required approximately 12.5 metres upstream and downstream of the culvert structure.

Construction of other cross-drainage features

Construction of other cross-drainage features (such as culverts) would generally involve the following steps:

- Establish erosion and sedimentation controls
- Excavation of temporary channel around the existing culvert alignment
- Diversion of existing drainage line to the temporary channel
- Removal of the existing culvert structure
- Construction the new culvert structure, including excavation of the drainage line, placement of culvert cells and construction of head walls
- Re-diversion of the drainage line through the constructed culvert
- Removal of the temporary diversion
- Scour protection installed upstream and downstream of the culvert structure for a distance of about four to five metres.

Construction of Retaining Walls

The retaining wall construction follows conventional construction practice. The construction approach would minimize impacts to the surrounding environment whilst ensuring safety to construction workers. Retaining walls have been located 0.5 metres from the road corridor boundary to allow for construction of them. In areas of cut, piled or gravity walls are the most likely outcome given the road corridor constraints, and in fill gravity walls appear to be the only option.

The anticipated construction sequence could follow the stages listed below:

Cut Walls

- Construct bored piles
- Excavate to pile cut off level
- Construct reinforced concrete capping beam
- Excavate the material in front of the wall at 1 metre vertical increments
- Install strip drains
- Clean side face of piles to sound concrete with high pressure hose

- Place hydrophilic sealant to pile face
- Spray 150mm of concrete (reinforced with one layer of mesh reinforcement)
- Drill and epoxy starter bar reinforcement for blockwork wall footing
- Construct concrete upstand and provide temporary bracing to masonry blockwork formwork as necessary
- Attach sandstone veneer facing

Fill Walls

- Construct bored piles
- Excavate to pile cut off level
- Construct reinforced concrete capping beam
- Construct reinforced concrete wall (structural wall)
- Install drainage mat to back of structural wall
- Place backfill behind the wall panels
- Construct parapet at top of wall (where necessary)
- Construct blockwork skin (tie to structural wall face)

Memorial Avenue Upgrade - Review of Environmental Factors

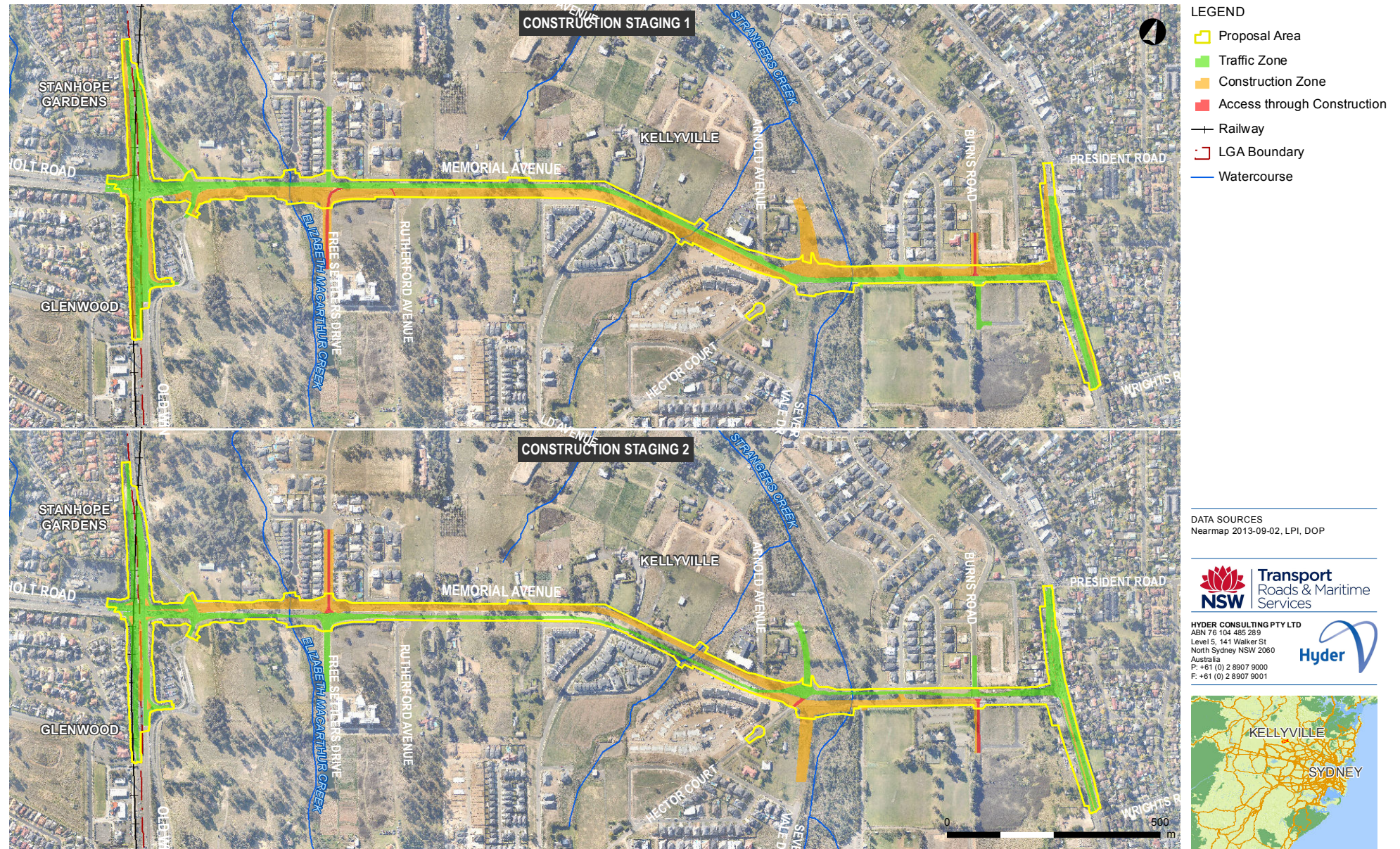


Figure 3-15: Proposed construction staging

3.4.2 Construction hours and duration

The proposed construction period would be about two years. Work would be generally carried out during the following standard working hours in accordance with the *Interim Construction Noise Guideline* (DECC 2009):

- Monday to Friday: 7am to 6pm
- Saturday: 8am to 1pm (between 7–8am, inaudible work would be permitted)
- Sunday and public holidays: No work.

It is anticipated that some work may be required outside of the standard working hours to avoid major delays to commuter traffic and to maintain the safety of the workforce, particularly for work along Windsor Road and Old Windsor Road. In particular, night work (between 8pm to 7am) may be required for traffic control switches, road surfacing and bridge construction, and may include high noise-generating activities.

Where work is required outside of the standard working hours, the procedure contained in Roads and Maritime's *Environmental Noise Management Manual 2001, Practice Note vii – Roadworks Outside of Normal Working Hours* (RTA 2001) would be followed, as well as the *Interim Construction Noise Guidelines* (DECC 2009) and any safeguards contained in this REF. This would include notifying the local community of any work planned to be carried out outside standard construction hours.

3.4.3 Plant and equipment

The following equipment would be used to build the proposal:

- Excavators (used with buckets, rippers and hydraulic hammers)
- Front-end loaders
- Graders and rollers
- Crushing and screening plant for recovered earthworks and demolition material
- Drill and piling rigs
- Concrete-cutting saws
- Rock crushers
- Chainsaws
- Backhoes
- Trenching machines
- Bulldozers
- Cranes
- Chipping machines
- Milling machines
- Concrete vibrators
- Concrete paving machines

- Jack hammers
- Bitumen spraying and asphalt paving tools
- Concrete agitator trucks
- Concrete pumps
- Hand tools
- Welding equipment
- Diesel generators
- Air compressors
- Water trucks
- Road sweepers
- Line-marking plant
- Semi-trailers and large haulage trucks
- Truck and dog tippers
- Generators and lights for night-time work
- Light commercial and passenger vehicles
- Scrapers
- Compactors
- Under-bore equipment.

The plant and equipment listed above may be subject to change upon refinement of design and during the construction planning phase.

Not all of the above plant and equipment would be in use on all construction sites at any one time, and a number of the pieces of identified equipment would only be used on an intermittent or temporary basis.

3.4.4 Earthworks

The proposal would require earthwork along some sections of the alignment. Earthworks generally entail removing and stockpiling topsoil and temporarily stockpiling suitable cut material for use as fill in other locations. This would involve moving of excavated materials along the alignment to fill embankment areas and batters.

Earthworks would likely require the use of trucks, bulldozers, excavators, scrapers, graders, water carts, compactors, rollers, and crushing and screening plant.

Earthworks volumes have been estimated based on the concept design. There is an overall cut volume of 58,500 cubic metres and an overall fill volume of 68,500 cubic metres. These calculations do not include top soil or earthworks in and around drainage lines. Current estimates show negative difference of about 10,000 cubic metres of fill. Material may need to be imported to address this shortfall and any material not suitable for reuse on site. Suitability of excavated material for re-use on site would be determined following further geotechnical investigations during detailed design stage.

The major cuts and fills are:

- Fill up to three metres high for a distance of about 300 metres from the T-way to the intersection of Memorial Avenue and Arnold Avenue (west)/Free Settlers Drive, either side of Elizabeth Macarthur Creek
- Cut up to 2.0 metres deep for a distance of about 160 metres next to Rutherford Avenue/Thomas Boulton Circuit
- Fill up to 3.1 metres high from about 120 metres west of the unnamed drainage line to about 90 metres east of the unnamed drainage line, a total distance of about 210 metres
- Cut up to 2.3 metres deep from about 90 metres east of the unnamed drainage line to about 40 metres east of Pellizzer Boulevard
- Fill up to 1.1 metres high for a distance of about 30 metres either side of the tributary of Strangers Creek
- Cut up to 1.8m deep for a distance of about 140 metres from about 40 metres east of the tributary of Strangers Creek to the intersection of Memorial Avenue and Severn Vale Drive
- Fill up to 3.5 metres high for a distance of about 100 metres either side of Strangers Creek

Cut-and-fill volumes and locations would be refined through detailed design.

3.4.5 Construction materials

Road surfacing materials would generally be imported to the work site from licensed suppliers within or near the Sydney region.

Water for dust suppression would typically be sourced from temporary sedimentation ponds from within the worksite (if they are surcharged with water); otherwise, water would be sourced from local standpipe outlet(s) (water access points). The likely water quantity required is unknown at this stage. The estimated quantities of materials that would be required for the proposal are shown in Table 3-6.

Table 3-6: Estimate of quantities of materials required to build the proposal

Material type	Approximate volume range (m ³)
Select fill material (imported)	10,000-20,000
Roadbase	500-2,500
Drainage backfill	2,500-7,500
Asphalt	7,500-15,000
Topsoil	5,000-10,000
Concrete	10,000-20,000
Steel	100-200 tonnes

3.4.6 Traffic management and access

Memorial Avenue would remain open to traffic throughout construction of the proposal and access to properties would be maintained.

Building the proposal would require about 100 to 150 truck movements per day. Truck movements may increase to 200 to 250 per day at certain stages. The use of local roads would be avoided where possible. It is anticipated that Memorial Avenue would be the main haulage route.

Construction impacts would be managed through a Traffic Management Plan (as part of the CEMP), in accordance with AS 1742 3 – 2009 and *Traffic Control at Work Sites* (RTA 2010). The Traffic Management Plan would include the guidelines, general requirements and procedures to be used when activities or areas of work have a potential impact on existing traffic arrangements. It would also include the details of any haulage routes, detours and temporary lane closures, in accordance with the Road Occupancy Licence (ROL).

A full assessment of impacts and associated safeguards and management measures is provided in Section 6.3. A detailed construction traffic and access assessment would be carried out before construction, after the detailed staging and construction methodology has been developed.

3.5 Ancillary facilities

The proposal includes three potential auxiliary sites that may be used as compound or stockpile sites. Smaller stockpile and storage areas may also be required along the length of the proposal within the proposal area.

The potential locations for the auxiliary sites (Figure 3-16) are located at:

- The northwest corner of the intersection of Memorial Avenue and Windsor Road
- The southwest corner of the intersection of Memorial Avenue and Windsor Road
- The current car park at Kellyville Memorial Park.

In general, the compound facilities would include portable buildings with amenities (such as lunch facilities and toilets), secure and bunded storage areas for site materials, including fuel and chemicals, office space for on-site personnel and associated parking. Stockpile sites would be used for storage of raw and excavated materials, such as topsoil and cut materials, prior to use or reuse during construction of the proposal.

The property on the northwest corner would be directly impacted by the proposal and would be subject to full acquisition. The site on the southwest corner of the intersection is currently vacant and owned by Roads and Maritime. There is potential contamination at this site, however the site would be suitable for use if no ground disturbance were to occur.

The current car park at Kellyville Memorial Park is located on the southern side of Memorial Avenue (Figure 3-16). The use of the car park at Kellyville Memorial Park would be subject to negotiation with The Hills Shire Council. Council is currently planning to upgrade the facilities which would include a new car park accessed off Stone Mason Drive. The car park relocation is expected to be completed prior to commencement of construction works on Memorial Avenue, allowing potential use of the existing car park during construction.

The final location of compound and stockpile sites would be determined during

detailed design. Any additional site(s) not detailed in this REF would require further assessment. The compound and stockpile areas would also be subject to the site location criteria set out in the Roads and Maritime Stockpile Site Management Procedures (RTA 2011). Wherever practicable, sites would be located:

- Within the proposal area (Figure 1-1), and outside threatened ecological communities (TECs), Aboriginal sites and heritage items
- In areas not prone to flash flooding and more than 50 metres from a watercourse
- In areas previously disturbed and that do not require the removal of native vegetation
- In plain view of the public to deter theft and illegal dumping
- Outside the drip line of trees and on level ground wherever possible (stockpile sites only).

Assessment of the proposed auxiliary facilities has been carried out and the results shown in Table 3-7.

Roads and Maritime's Environment Manager, Sydney would be consulted before the start of work to determine if any further environmental impact assessment is required for any ancillary facilities.

Table 3-7 Assessment of proposed compound and stockpile sites

Criteria	Within the proposal area defined in this REF, outside threatened ecological communities (TECs), Aboriginal sites and heritage items	In areas not prone to flash flooding and more than 50 metres from a watercourse	In areas previously disturbed and that do not require the removal of native vegetation	In plain view of the public to deter theft and illegal dumping	Outside the drip line of trees and on level ground wherever possible
Northwest corner of Memorial Avenue and Windsor Road	The site is partially within the proposal area defined in this REF. The remainder of the site would be acquired by Roads and Maritime. There are no threatened ecological communities (TECs), Aboriginal sites or heritage items at the site.	The proposed site is located more than 400 metres from the nearest waterway (Strangers Creek). Hydraulic modelling carried out as part of this REF indicates the proposed site is not prone to flash flooding.	The site is currently used for residential purposes. No native vegetation would be required to be removed.	The site is clearly visible from Memorial Avenue.	The site is out of the drip line of large trees and the ground is relatively level.
Southwest corner of Memorial Avenue and Windsor Road	The site is partially within the proposal area defined in this REF. The site is currently owned by Roads and Maritime. There are no	The proposed site is located more than 400 metres from the nearest waterway (Strangers Creek). Hydraulic modelling	The site is currently cleared and cement slabs in place from its former use as a service station. No native	The site is clearly visible from Memorial Avenue.	The site is out of the drip line of large trees and the ground is relatively level.

Criteria	Within the proposal area defined in this REF, outside threatened ecological communities (TECs), Aboriginal sites and heritage items	In areas not prone to flash flooding and more than 50 metres from a watercourse	In areas previously disturbed and that do not require the removal of native vegetation	In plain view of the public to deter theft and illegal dumping	Outside the drip line of trees and on level ground wherever possible
	threatened ecological communities (TECs), Aboriginal sites or heritage items at the site.	carried out as part of this REF indicates the proposed site is not prone to flash flooding.	vegetation would be required to be removed.		
Kellyville Memorial Park	The proposed site is outside, but immediately next to, the proposal area. It is not included in the proposal area as the site is still being used as a carpark, but would likely become available prior to construction starting. The use of the car park would need to be negotiated with The Hills Shire Council. There are	The proposed site is located about 140 metres from the nearest waterway (Strangers Creek). Hydraulic modelling carried out as part of this REF indicates the proposed site is not prone to flash flooding.	The site is currently used as a car park for Kellyville Memorial Park and so is cleared and paved.	The site is clearly visible from Memorial Avenue.	As the site is already cleared, there are locations available that would meet this requirement.

Criteria	Within the proposal area defined in this REF, outside threatened ecological communities (TECs), Aboriginal sites and heritage items	In areas not prone to flash flooding and more than 50 metres from a watercourse	In areas previously disturbed and that do not require the removal of native vegetation	In plain view of the public to deter theft and illegal dumping	Outside the drip line of trees and on level ground wherever possible
	no threatened ecological communities (TECs), Aboriginal sites or heritage items at the site.				

Memorial Avenue Upgrade - Review of Environmental Factors



Figure 3-16: Potential ancillary and stockpile location

Each site would be securely fenced with temporary fencing, and would have signage advising the general public of access restrictions.

The sites would be leased for the duration of construction. Once construction is complete, the site compounds, work areas and stockpile sites would be removed, and the site would be cleared of all rubbish and materials and rehabilitated to pre-work condition.

3.6 Public utility adjustment

Hyder Consulting has prepared a strategic assessment of utilities within the proposal area to identify impact on utilities. The following utilities have been noted and would require some form of relocation or protection during construction:

- Sydney Water – sewer, potable water, recycled water
- Telecommunications assets – Telstra, Optus and PipeNetworks
- Gas assets – Jemena Gas
- Electricity assets – Endeavour Energy

Table 3-8 provides more information on proposed adjustments to utilities. These would be confirmed during detailed design.

Table 3-8: Existing utilities and proposed adjustments

Existing utilities	Description	Location	Proposed impact
Water	Water Main (Recycled) 450mm dia DICL	West side of Old Windsor Road, from 350m south of Sunnyholt Road to immediately south of Sunnyholt Road. Total length of relocation is approximately 313m.	Relocated to western verge of widened Old Windsor Road
	Water Main (Recycled) 450mm dia DICL	South side of Memorial Avenue, from immediately east of Old Windsor Road to immediately west of Hector Court. Total length of adjustment is approximately 1550m.	Relocate to verge of proposed westbound carriageway
	Water Main (Recycled) 450mm dia DICL	North side of Memorial Avenue, from immediately west of Hector Court to east side of Windsor Road. Total length of adjustment	Relocate to verge of proposed eastbound carriageway

Existing utilities	Description	Location	Proposed impact
		is approximately 746m.	
	Water Main (Recycled) 250mm dia uPVC	North side of Memorial Avenue, from immediately east of T-Way to immediately west of Arnold Avenue (West). Total length of adjustment is approximately 955.5m.	Relocate to verge of proposed eastbound carriageway
	Water Main (Potable) 300mm dia DICL	North side of Memorial Avenue, from immediately east of T-Way to immediately west of Arnold Avenue (West) Total length of adjustment is approximately 955.5m.	Relocate to verge of proposed eastbound carriageway
	Water Main (Recycled) 200mm dia uPVC	North side of Memorial Avenue, from immediately east of Arnold Avenue (West) to immediately west of Arnold Avenue (East) Total length of adjustment is approximately 1060m.	Relocate to verge of proposed eastbound carriageway
	Water Main (Potable) 200mm dia DICL	North side of Memorial Avenue, from immediately east of Arnold Avenue (West) to immediately west of Arnold Avenue (East). Total length of adjustment is approximately 1060m.	Relocate to verge of proposed eastbound carriageway
	Water Main (Potable) 150mm dia DICL	North side of Memorial Avenue, from 150m east of Arnold Avenue (West) to Hector	Relocate to verge of proposed eastbound carriageway

Existing utilities	Description	Location	Proposed impact
		Court. Total length of adjustment is approximately 1150m.	
	Water Main (Potable) 150mm dia CICL	South side of Memorial Avenue, from immediately east of Hector Court to west side of Windsor Road. Total length of adjustment is approximately 600m.	Relocate to verge of proposed westbound carriageway
	Water Main (Recycled) 375mm dia uPVC	North side of Memorial Avenue, from immediately east of Hector Court to east side of Windsor Road. Total length of adjustment is approximately 560m.	Relocate to verge of proposed eastbound carriageway
	Water Main (Potable) 300mm dia DICL	North side of Memorial Avenue, from immediately east of Hector Court to east side of Windsor Road. Total length of adjustment is approximately 560m.	Relocate to verge of proposed eastbound carriageway
	Water Main (Recycled) 450mm dia uPVC	North side of Memorial Avenue, from immediately east of Hector Court to east side of Windsor Road. Total length of adjustment is approximately 560m.	Relocate to eastern verge of widened Windsor Road
	Water Main (Recycled) 250mm dia uPVC	East side of Windsor Road, from immediately south of President Road to Memorial Avenue. Total length of adjustment is approximately 400m.	Relocate to eastern verge of widened Windsor Road
	Water Main (Potable) 300mm dia DICL	East side of Windsor Road, from immediately south of President Road to	Relocate to eastern verge of widened Windsor Road

Existing utilities	Description	Location	Proposed impact
		Memorial Avenue. Total length of adjustment is approximately 400m.	
	Water Main (Recycled) 450mm dia uPVC	East side of Windsor Road, from Memorial Avenue to 100m north of Wrights Road. Total length of adjustment is approximately 190m.	Relocate to eastern verge of widened Windsor Road
	Water Main (Potable) 300mm dia DICL	East side of Windsor Road, from Memorial Avenue to 100m north of Wrights Road. Total length of adjustment is approximately 190m.	Relocate to eastern verge of widened Windsor Road
	Water Main (Recycled) 250mm dia uPVC	East side of Windsor Road, from Memorial Avenue to 100m north of Wrights Road. Total length of adjustment is approximately 190m.	Relocate to eastern verge of widened Windsor Road
	Water Main (Potable) 150mm dia DICL	East side of Windsor Road, from Memorial Avenue to 100m north of Wrights Road. Total length of adjustment is approximately 190m.	Relocate to eastern verge of widened Windsor Road
	Water Main (Potable) 150mm dia DICL	West side of Windsor Road, from immediately south of Memorial Avenue to 120m south of Memorial Avenue Total Length of adjustment is approximately 120m.	Relocate to western verge of widened Windsor Road
Gas	Gas Main Medium Pressure (Network, 300kPa) 160mm dia PE	North side of Memorial Avenue, from 80m east of T-Way to Arnold Avenue (West). Total length of adjustment is	Relocate to verge of proposed eastbound carriageway

Existing utilities	Description	Location	Proposed impact
		approximately 246m.	
	Gas Main Medium Pressure (Network, 300kPa) 160mm dia PE	North side of Memorial Avenue, from immediately east of Arnold Avenue (East) to Hector Court. Total length of adjustment is approximately 125m	Relocate to verge of proposed eastbound carriageway
	Gas Main Medium Pressure (Network, 300kPa) 160mm dia PE	South side of Memorial Avenue, from immediately east of Hector Court to 100m east of Strangers Creek. Total length of adjustment is approximately 427m	Relocate to verge of proposed westbound carriageway
Tele communications	Telecommunications cables	South side of Memorial Avenue, from immediately east of Old Windsor Road to immediately west of Elizabeth Macarthur Creek. Total length of adjustment is approximately 280.5m	Relocate to verge of proposed westbound carriageway
	Optic fibre telecommunications cables	North side of Memorial Avenue, from 60m east of T-Way to immediately west of Arnold Avenue (West). Total length of adjustment is approximately 241.5m	Relocate to verge of proposed eastbound carriageway
	Optic fibre telecommunications cables	South side of Memorial Avenue, from Arnold Avenue (East) to 100m east of Strangers Creek. Total length of adjustment is approximately 223m.	Relocate to verge of proposed westbound carriageway
	Telecommunications cables	North side of Memorial Avenue, from Burns Road to west side of Windsor	Relocate to verge of proposed eastbound carriageway

Existing utilities	Description	Location	Proposed impact
		Road. Total length of adjustment is approximately 250m.	
	Optic fibre telecommunications cables	West side of Windsor Road, from immediately south of Memorial Avenue to 120m south of Memorial Avenue. Total length of adjustment is approximately 124m.	Relocate to western verge of widened Windsor Road
	Telecommunications cables	West side of Windsor Road, from immediately north of Memorial Avenue to 100m north of Memorial Avenue. Total length of adjustment is approximately 100m.	Relocate to western verge of widened Windsor Road
Electricity	Underground electricity (HV)	South side of Memorial Avenue, from immediately east of Old Windsor Road to 200m east of Old Windsor Road. Total length of adjustment is approximately 165m.	Relocate to verge of proposed westbound carriageway
	Overhead electricity (HV)	South side of Memorial Avenue, from 200m east of Old Windsor Road to west side of Windsor Road. Total length of adjustment is approximately 1900m.	Relocate to verge of proposed westbound carriageway
	Overhead electricity (HV)	North side of Memorial Avenue, from 150m east of Old Windsor Road to 300m of Arnold Avenue (East). Total length of adjustment is approximately 1040m.	Relocate to verge of proposed eastbound carriageway
	Overhead electricity (HV)	North side of Memorial Avenue, from Arnold Avenue	Relocate to verge of proposed eastbound carriageway

Existing utilities	Description	Location	Proposed impact
		(East) to west side of Windsor Road. Total length of adjustment is approximately 770m.	
	Overhead electricity (HV)	West side of Windsor Road, from immediately south of Memorial Avenue to 80m north of Wrights Road. Total length of adjustment is approximately 233m.	Relocate to western verge of widened Windsor Road
	Overhead electricity (HV)	West side of Windsor Road, from immediately north of Memorial Avenue to immediately south of President Road. Total length of adjustment is approximately 50m.	Relocate to western verge of widened Windsor Road
	Underground electricity	South side of Memorial Avenue, from immediately west of Arnold Avenue (West) to 200m east of Arnold Avenue (West). Total length of adjustment is approximately 245m.	Relocate to verge of proposed westbound carriageway
	Underground electricity	South side of Memorial Avenue, from Farmhouse Avenue to 400m south of Arnold Avenue (East). Total length of adjustment is approximately 160m.	Relocate to verge of proposed westbound carriageway
	Underground electricity	South side of Memorial Avenue, from 100m south of Burns Road 100m south of Windsor Road. Total length of adjustment is approximately 258m.	Relocate to verge of proposed westbound carriageway
	Underground electricity	North side of Memorial Avenue, from Arnold Avenue	Relocate to verge of proposed eastbound carriageway

Existing utilities	Description	Location	Proposed impact
		(West) to 100m north of Arnold Avenue (West). Total length of adjustment is approximately 94m.	
	Underground electricity	East side of Windsor Road, from Memorial Avenue to 60m north of Memorial Avenue. Total length of adjustment is approximately 63m.	Relocate to eastern verge of widened Windsor Road
	Underground electricity	East side of Windsor Road, from 40m south of Memorial Avenue to 100m south of Memorial Avenue. Total length of adjustment is approximately 72m.	Relocate to eastern verge of widened Windsor Road
	Underground electricity	East side of Windsor Road, from 150m north of Memorial Avenue to 170m north of Memorial Avenue. Total length of adjustment is approximately 26m.	Relocate to eastern verge of widened Windsor Road

Additionally, the Balmoral Road Release Area and North West Rail Link will be catalysts for extensive development in and around the proposal area, which would likely trigger a substantial expansion of utilities.

Roads and Maritime would consult with utility provider throughout detailed design and the pre-construction phase to ensure that the proposal allows for future utilities.

Changes to utilities would be within the verge of the proposal along both sides of the road. The exact location of utilities would be determined during detailed design.

3.7 Property acquisition

Some properties would need to be either partially or fully acquired to build the proposal.

Figure 3-17 and Table 3-9 present preliminary details of the proposed acquisition requirements. They show that:

- Eight properties would be fully acquired, six of which are privately owned
- Thirty-one properties would be partially acquired

- There would be a total acquisition area of about 2.96 hectares.

Any requirement to lease areas would be determined during detailed design.

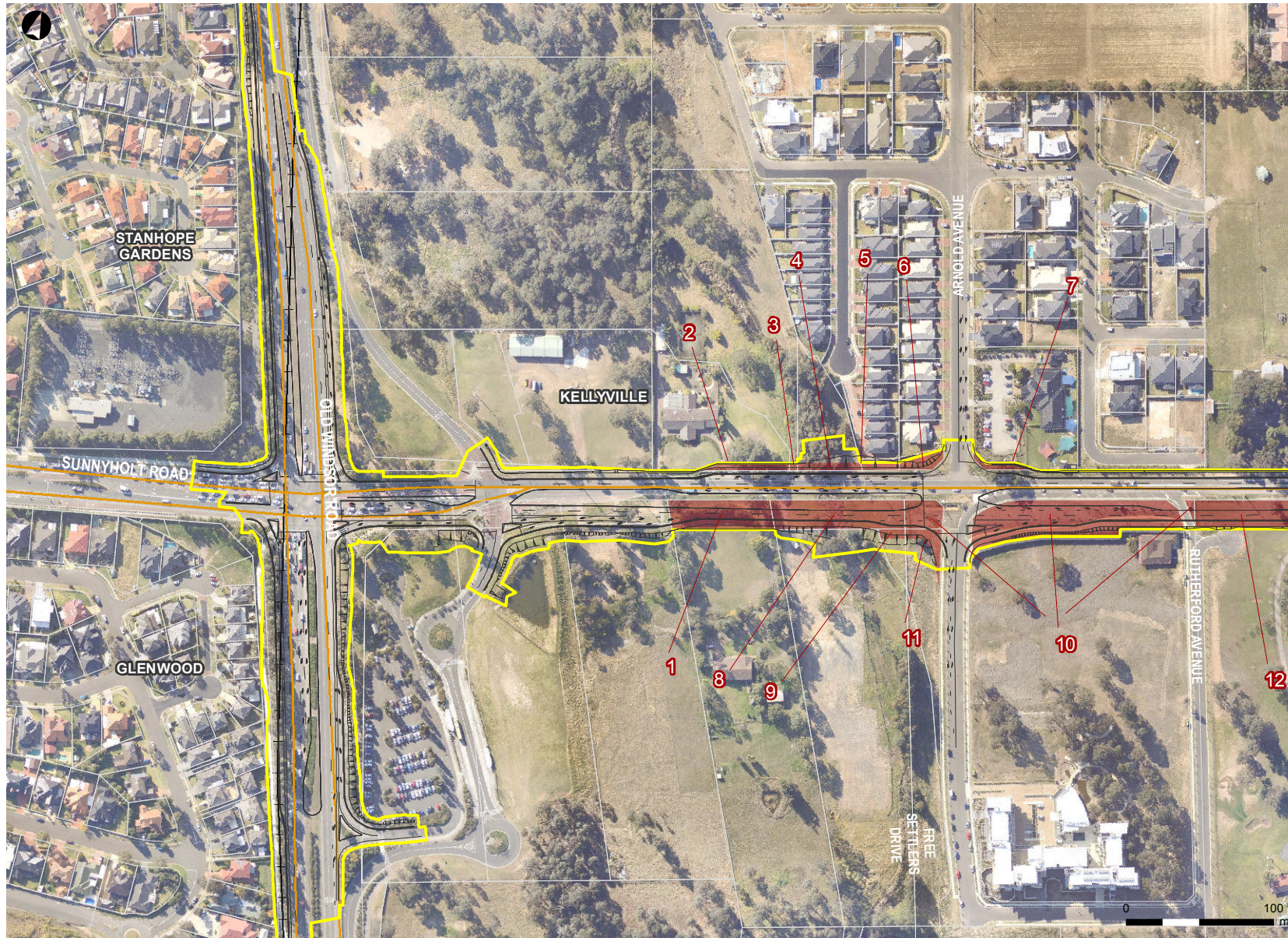
Properties that need to be acquired would be confirmed during detailed design in consultation with landowners. All property valuations and acquisitions would be carried out in accordance with landowners. All property valuations and acquisitions would be carried out in accordance with the *Land Acquisition Information Guide* (Roads and Maritime 2012; Appendix K) and the *Land Acquisition (Just Terms Compensation) Act 1991*.

Table 3-9: Potential property acquisitions

Reference No.	Lot	DP No	Area to be acquired (ha)	Full or partial acquisition?	Current ownership
1	Lot 2	DP241547	0.1398	Partial	Private
2	Lot 2	DP1159032	0.0291	Partial	Private
3	Lot 221	DP1121027	0.0029	Partial	Sydney Water
4	Lot 211	DP1149830	0.0238	Partial	Sydney Water
5	Lot 20	DP1162522	0.0141	Partial	Private
6	Lot 101	DP1179289	0.0278	Full	Private
7	Lot 2016	DP1149043	0.0195	Partial	Private
8	Lot 2	DP1180837	0.1802	Full	Private
9	Lot 3	DP1180837	0.0105	Partial	Private
10	Lot 101	DP1163410	0.3879	Full	Private
11	Lot 402	DP1125136	0.0306	Partial	Private
12	Lot 42	DP10702	0.196	Partial	Private
13	Lot 43	DP10702	0.1958	Partial	The Hills Shire Council
14	Lot 1	DP203813	0.1387	Partial	Private
15	Lot 11	DP1176789	0.1387	Partial	Private
16	Lot 10	DP1129346	0.1389	Full	Private
17	Lot 1	DP1163540	0.0044	Partial	Private
18	Lot 1003	DP1172742	0.511	Full	Private
19	Lot 1001	DP1172742	0.0187	Partial	Private
20	Lot 2	DP1131540	0.003	Partial	Private
21	Lot 2	DP1087781	0.0876	Partial	Private
22	Lot 1	DP1087781	0.0035	Partial	Private
23	Lot 1	DP1109248	0.0543	Partial	Private
24	Lot 35	DP1149683	0.0308	Full	Sydney Water
25	Lot 105	DP1154282	0.0398	Full	Sydney

Reference No.	Lot	DP No	Area to be acquired (ha)	Full or partial acquisition?	Current ownership
					Water
26	Lot 1	DP135989	0.0028	Partial	Private
27	Lot 1	DP504421	0.0369	Partial	Private
28	Lot 2	DP504421	0.0339	Partial	The Hills Shire Council
29	Lot 1	DP167534	0.1003	Full	Private
30	Lot 3	DP19177	0.0263	Partial	Private
31	Lot B	DP349914	0.0055	Partial	The Hills Shire Council
32	Lot A	DP349914	0.0091	Partial	Private
33	Lot B	DP393864	0.0147	Partial	Private
34	Lot A	DP393864	0.0139	Partial	Private
35	Lot 6	DP19177	0.0248	Partial	The Hills Shire Council
36	Lot 7	DP19177	0.0325	Partial	Private
37	Lot D	DP368901	0.0271	Partial	Private
38	Lot 2	DP135989	0.1508	Partial	Private
39	Lot 3	DP135989	0.0578	Partial	Private

Memorial Avenue Upgrade - Review of Environmental Factors



LEGEND

- Proposal Area
- Concept Design
- Existing Property Boundary
- Acquisition Area

Reference No.	Lot & DP
1	2/DP241547
2	2/DP1159032
3	221/DP1121027
4	211/DP1149830
5	20/DP1162522
6	101/DP1179289
7	2016/DP1149043
8	2/DP1180837
9	3/DP1180837
10	101/DP1163410
11	402/DP1125136
12	42/DP10702

DATA SOURCES
Nearmap 2013-09-02, LPI

HYDER CONSULTING PTY LTD
 ABN 76 104 485 289
 Level 5, 141 Walker St
 North Sydney NSW 2060
 Australia
 P: +61 (0) 2 8907 9000
 F: +61 (0) 2 8907 9001



Figure 3-17a: Potential acquisitions for the proposal

Memorial Avenue Upgrade - Review of Environmental Factors



- LEGEND**
- Proposal Area
 - Concept Design
 - Existing Property Boundary
 - Acquisition Area

Reference No.	Lot & DP
12	42/DP10702
13	43/DP10702
14	1/DP203813
15	11/DP1176789
16	10/DP1129346
17	1/DP1163540
18	1003/DP1172742

DATA SOURCES
Nearmap 2013-09-02, LPI



HYDER CONSULTING PTY LTD
 ABN 76 104 485 289
 Level 5, 141 Walker St
 North Sydney NSW 2060
 Australia
 P: +61 (0) 2 8907 9000
 F: +61 (0) 2 8907 9001



Figure 3-17b: Potential acquisitions for the proposal

Memorial Avenue Upgrade - Review of Environmental Factors

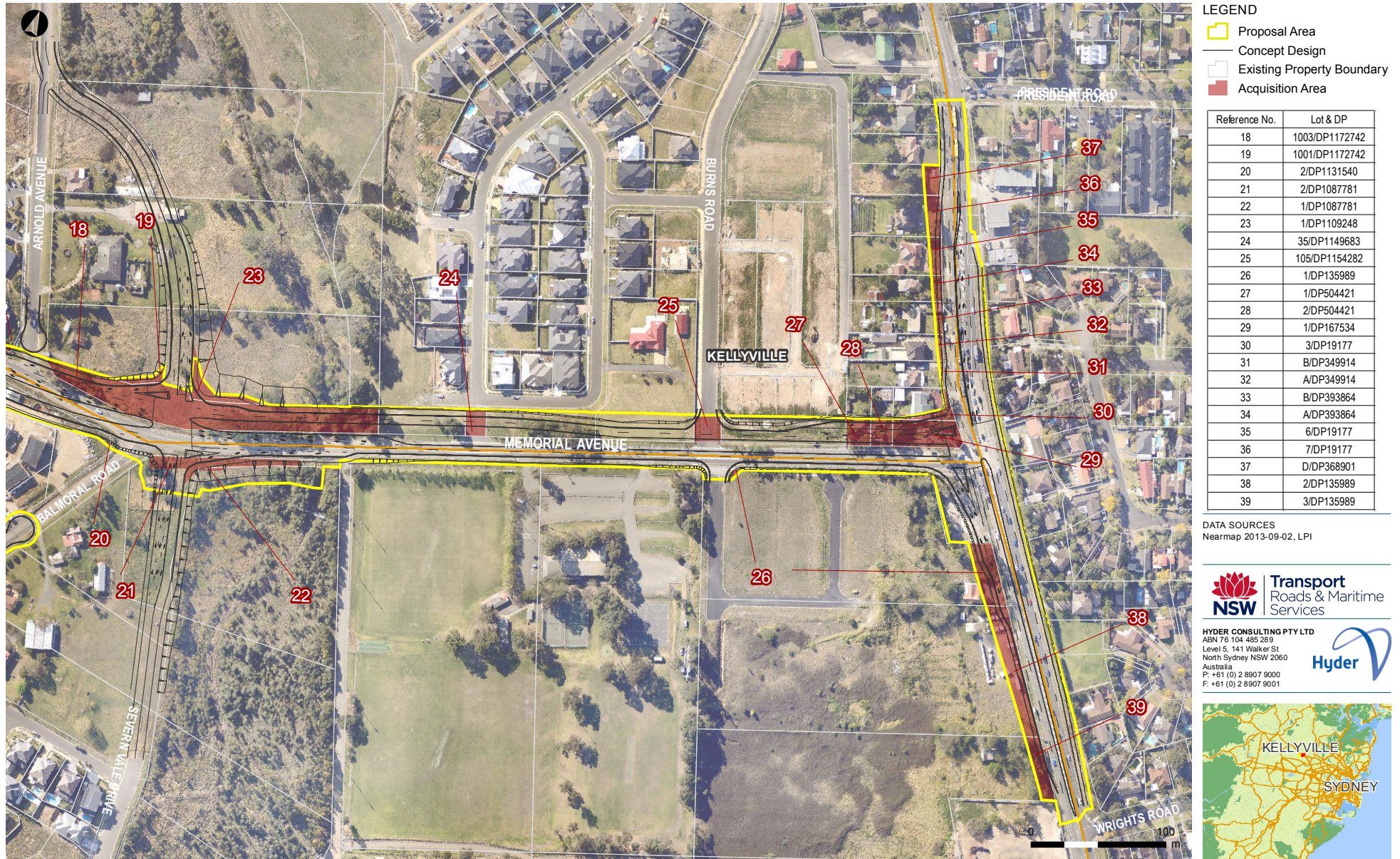


Figure 3-17c: Potential acquisitions for the proposal

4 Statutory and planning framework

This chapter provides the statutory and planning framework for the proposal and considers provisions of relevant State environmental planning policies, local environmental plans and other legislation.

4.1 State environmental planning policies

4.1.1 State Environmental Planning Policy (Infrastructure) 2007

State Environmental Planning Policy (Infrastructure) 2007 (ISEPP) aims to facilitate the effective delivery of infrastructure across the State.

Clause 94 of ISEPP permits development on any land for the purpose of a road or road infrastructure facilities to be carried out by or on behalf of a public authority without consent.

As the proposal is for a road and road infrastructure facilities and is to be carried out by Roads and Maritime Services, it can be assessed under Part 5 of the *Environmental Planning and Assessment Act 1979*. Development consent from the two councils is not required.

The proposal is not located on land reserved under the *National Parks and Wildlife Act 1974* and would not affect land or development regulated by *State Environmental Planning Policy No. 14 – Coastal Wetlands*, *State Environmental Planning Policy No. 26 – Littoral Rainforests*, *State Environmental Planning Policy (State and Regional Development) 2011* or *State Environmental Planning Policy (Major Development) 2005*.

Part 2 of the ISEPP contains provisions for public authorities to consult with local councils and other public authorities before the start of certain types of development. Consultation, including consultation as required by ISEPP (where applicable), is discussed in Chapter 5 of this REF.

4.1.2 Sydney Regional Environmental Plan No 19 – Rouse Hill Development Area

Sydney Regional Environmental Plan No 19 – Rouse Hill Development Area (SREP 19) generally aims to accommodate part of the long-term growth of the Sydney Region by providing a mechanism for identifying land suitable for urban purposes and by providing for the orderly and economic development of that land suitable for urban purposes, and by providing for the orderly and economic development of that land.

The proposal area falls within the Balmoral Road Release Area, and would improve network efficiencies at this location. *The Hills Local Environmental Plan 2012* provides local environmental planning provisions for land in the Balmoral Road Release Area to guide orderly and sustainable development. Section 4.2 of this REF describes the relevance of the *The Hills Local Environmental Plan 2012*.

4.1.3 Sydney Regional Environmental Plan No 20 – Hawkesbury-Nepean River

Sydney Regional Environmental Plan No 20 – Hawkesbury-Nepean River (SREP 20)

aims to protect the environment of the Hawkesbury-Nepean River system by ensuring that the impacts of future land uses are considered in a regional context.

Clause 4(1)(b) states that a public authority proposing to carry out development which does not require development consent must consider:

- The general planning considerations set out in Clause 5
- Specific planning policies and recommended strategies set out in Clause 6.

Table 4-1 demonstrates how this REF addresses these planning considerations.

Table 4-1: SREP 20 clauses 5 and 6 matters for consideration in this REF

Matter of consideration	Response
5(a) The aim of SREP 20, 'to protect the environment of the Hawkesbury-Nepean River system by ensuring that the impacts of future land uses are considered in a regional context'	This REF considers the potential impacts of the proposal on the environment taking into consideration other key developments within the region, including the Northern T-way and Balmoral Road Release Area.
5(b) The strategies listed in the Action Plan of the Hawkesbury-Nepean Environmental Planning Strategy	This REF considers the strategies listed in the Action Plan, particularly in the development of safeguards and management measures.
5l Whether there are any feasible alternatives to the development or other proposal concerned	Section 2.4 of this REF describes the alternatives and options considered with regards to the proposal.
5(d) The relationship between the different impacts of the development or other proposal and the environment, and how those impacts will be addressed and monitored	Section 6.13 of this REF describes potential cumulative impacts and proposed safeguards and management measures.
6(1) Total catchment management is to be integrated with environmental planning for the catchment	The drainage and water quality safeguards and management measures (refer to Section 6.1.3 of this REF) consider and are consistent with total catchment management principles.
6(2) The environmental quality of environmentally sensitive areas must be protected and enhanced through careful control of future land use changes and through management and (where necessary) remediation of existing uses	Safeguards and management measures are proposed to protect and enhance the environmental quality of environmentally sensitive areas, including waterways (refer to Section 6.1.3 of this REF).
6(3) Future development must not prejudice the achievement of the goals of use of the river for primary contact recreation (being recreational activities involving direct water contact, such as swimming) and aquatic ecosystem protection in the river system. If the	The proposal would be built and operated to maintain or improve water quality in receiving waterways (refer to Section 6.1.3 of this REF).

Matter of consideration	Response
<p>quality of the receiving waters does not currently allow these uses, the current water quality must be maintained, or improved, so as not to jeopardise the achievement of the goals in the future. Where water quality goals are set by the Government these are to be the goals to be achieved under this policy</p>	
<p>6(4) Aquatic ecosystems must not be adversely affected by development which changes the flow characteristics of surface or groundwater in the catchment</p>	<p>Aquatic ecosystems would not be adversely impacted by the proposal (refer Section 6.5 of this REF).</p>
<p>6(5) The importance of the river in contributing to the significance of items and places of cultural heritage significance should be recognised, and these items and places should be protected and sensitively managed and, if appropriate, enhanced</p>	<p>Section 6.6 of this REF describes potential impact on cultural heritage and proposed safeguards and management measures.</p>
<p>6(6) Manage flora and fauna communities so that the diversity of species and genetics within the catchment is conserved and enhanced</p>	<p>Section 6.5 of this REF describes potential impact on flora and fauna communities and proposed safeguards and management measures.</p>
<p>6(7) The scenic quality of the riverine corridor must be protected</p>	<p>The proposal is not located within the Hawkesbury-Nepean riverine corridor.</p>
<p>6(8) Agriculture must be planned and managed to minimise adverse environmental impacts and be protected from adverse impacts of other forms of development</p>	<p>Section 6.9 of this REF describes potential impact on surrounding land uses, including agriculture, and proposed safeguards and management measures.</p>
<p>6(9) Rural residential development should not reduce agricultural sustainability, contribute to urban sprawl, or have adverse environmental impacts (particularly on the water cycle or on flora and fauna)</p>	<p>The proposal would not involve rural residential development.</p>
<p>6(10) All potential adverse environmental impacts of urban development must be assessed and controlled</p>	<p>The proposal would not involve urban development.</p>
<p>6(11) The value of the riverine corridor as a significant recreational and tourist asset must be protected</p>	<p>The proposal is not located within the Hawkesbury-Nepean riverine corridor.</p>
<p>6(12) Development should complement the vision, goal, key principles and action plan of the Metropolitan Strategy</p>	<p>Section 2.1.1 of this REF demonstrates that the proposal is aligned with relevant strategies and plans, including the <i>Metropolitan Plan for Sydney 2036</i>.</p>

4.2 Local environmental plans

As outlined in Section 4.1.1, ISEPP removes the requirement for development consent from councils. Instead, the proposal would be assessed under Part 5 of the EP&A Act. Nevertheless, an evaluation is provided below of the proposal in relation to the objectives of land use zones within which it is located.

4.2.1 The Hills Local Environmental Plan 2012

Under *The Hills Local Environmental Plan 2012* land along the existing Memorial Avenue is zoned as:

- R1 (General residential)
- R2 (Low residential)
- R3 (Medium density residential)
- R4 (High density residential)
- B2 (Local centre)
- B7 (Business park).

Most of the proposal area beyond the existing road is zoned SP2 (SP2 Infrastructure, (classified road)). The land zoning within and surrounding the proposal area is presented in

Figure 4-1 and Table 4-2 outline the current zoning objectives for each of the impacted zones and the consistency of the proposal against these objectives.

Memorial Avenue Upgrade - Review of Environmental Factors



Figure 4-1: Existing land use zones within and surrounding the proposal area

Table 4-2: Consistency of the proposal with zoning objectives in *The Hills Local Environmental Plan 2012*

Zone	Objectives	Consistency of proposal with objectives, and permissibility
R1 (General residential)	<ul style="list-style-type: none"> • To provide for the housing needs of the community • To provide for a variety of housing types and densities • To enable other land uses that provide facilities or services to meet the day to day needs of residents • To enable other land uses that support the adjoining or nearby commercial centres and protect the amenity of the adjoining or nearby residential areas 	<p>Permitted with development consent.¹</p> <p>The proposal is consistent with the third and fourth objectives as it would improve traffic flow within and to/from the Balmoral Road Release Area</p>
R2 (Low residential)	<ul style="list-style-type: none"> • To provide for the housing needs of the community within a low density residential environment • To enable other land uses that provide facilities or services to meet the day to day needs of residents • To maintain the existing low density residential character of the area 	<p>Permitted with development consent.¹</p> <p>The proposal is consistent with the second objective as it would improve traffic flow within and to/from the Balmoral Road Release Area</p>
R3 (Medium density residential)	<ul style="list-style-type: none"> • To provide for the housing needs of the community within a medium density residential environment • To provide a variety of housing types within a medium density residential environment • To enable other land uses that provide facilities or services to meet the day to day needs of residents • To encourage medium density residential development in locations that are close to population centres and public transport routes 	<p>Permitted with development consent.¹</p> <p>The proposal is consistent with the third objective as it would improve traffic flow within and to/from the Balmoral Road Release Area</p>
R4 (High density residential)	<ul style="list-style-type: none"> • To provide for the housing needs of the community within a high density residential environment • To provide a variety of housing types within a high density residential environment • To enable other land uses that provide facilities or services to meet the day to 	<p>Permitted with development consent.¹</p> <p>The proposal is consistent with the third objective as it would improve traffic flow within and to/from the</p>

Zone	Objectives	Consistency of proposal with objectives, and permissibility
	day needs of residents <ul style="list-style-type: none"> To encourage high density residential development in locations that are close to population centres and public transport routes 	Balmoral Road Release Area
B2 (Local centre)	<ul style="list-style-type: none"> To provide a range of retail, business, entertainment and community uses that serve the needs of people who live in, work in and visit the local area To encourage employment opportunities in accessible locations To maximise public transport patronage and encourage walking and cycling 	Permitted with development consent. ¹ The proposal is consistent with the second objective as it would improve traffic flow within and to/from the Balmoral Road Release Area
B7 (Business park)	<ul style="list-style-type: none"> To provide a range of office and light industrial uses To encourage employment opportunities To enable other land uses that provide facilities or services to meet the day to day needs of workers in the area To make provision for high technology industries that use and develop advanced technologies, products and processes. 	Permitted with development consent. ¹ The proposal is consistent with the third objective, as it would provide walking and cycling facilities.
SP2 (SP2 Infrastructure (classified road))	<ul style="list-style-type: none"> To provide for infrastructure and related uses To prevent development that is not compatible with or that may detract from the provision of infrastructure 	Permitted without consent ¹ . The proposal is consistent with both of these objectives.

¹ Council consent is not required in accordance with Clause 94 of ISEPP (refer to Section 4.1.1 of this REF)

4.2.2 Blacktown Local Environmental Plan 1988

The boundary of The Hills Shire Council and Blacktown Shire Council is the midline of Old Windsor Road. The land that falls within the proposed scope of works within the Blacktown Council local government area is zoned as:

- Zone No. 5 (b) (Special Uses—Arterial Road and Arterial Road Widening Zone)

The objective of the zone is to identify land required for existing or proposed arterial roads including the widening of existing arterial roads. As the proposal aims to widen Memorial Avenue (an arterial road), it is consistent with the objectives of the zone.

The proposal is permitted without consent in accordance with Clause 94 of ISEPP (refer to Section 4.1.1 of this REF).

4.3 Other relevant legislation

4.3.1 *Protection of the Environment Operations Act 1997*

Under Part 3.2 of the Act, scheduled development work, as defined in Schedule 1, requires an environment protection licence. Schedule 1, Clause 35 Road construction (meaning the construction, widening or re-routing of roads) is relevant to the proposal.

The clause defines scheduled activities as those that result in the existence of four or more traffic lanes (not including bicycle lanes or lanes used for entry or exit) on a road classified or proposed to be classified as a main road (but not a freeway or tollway) under the *Roads Act 1993* for at least three kilometres in the metropolitan area.

The Memorial Avenue upgrade includes the widening of about 2.2 kilometres of road from two lanes to four lanes between Windsor Road and Old Windsor Road. The proposal also includes work on Old Windsor Road for about 600 metres and on Windsor Road for about 550 metres. The total distance of works is about 3.3 kilometres.

Therefore, the proposal does fall under Schedule 1 of the *Protection of the Environment Operations Act 1997* and an environment protection licence would be required. If the proposal proceeds, Roads and Maritime would ensure the appropriate licence is in place before construction starts.

4.3.2 *Fisheries Management Act 1994*

The *Fisheries Management Act 1994* provides for the identification, conservation and recovery of threatened fish, aquatic invertebrates and marine vegetation. The Act also covers the identification and management of key threatening processes affecting threatened species or causing other species to become threatened.

Section 220 of the *Fisheries Management Act 1994* requires the Minister to issue a permit for causing a barrier to fish passage.

The proposal would be carried out so that fish passage would be maintained throughout construction. This would be verified during detailed design. Should it be determined that this is not feasible, a permit to block fish passage would be obtained under section 220(1) of the Act prior to construction.

Removal of the culverts at Strangers Creek and replacement of culverts at the other waterways would involve dredging/reclamation works that would require notification under section 199 of the Act.

4.3.3 *National Parks and Wildlife Act 1974*

The *National Parks and Wildlife Act 1974* is administered by the Office of Environment and Heritage. It provides statutory protection for all Aboriginal 'objects' (Section 90) and 'places' (Section 84).

The proposal would not impact any known Aboriginal sites, and Roads and Maritime

would not need to obtain an Aboriginal Heritage Impact Permit (AHIP) for this project.

4.3.4 *Heritage Act 1977*

The *Heritage Act 1977* protects items of environmental heritage (natural and cultural) in NSW. State significant items listed on the NSW State Heritage Register (SHR) are protected under the *Heritage Act 1977* against any activities that may damage an item or affect its heritage significance.

There are no known items of heritage significance located within or adjacent to the proposal area.

The *Heritage Act 1977* also protects 'relics', which can include archaeological material, features and deposits. There are no known relics located within or adjacent to the proposal area.

The *Heritage Act 1977* also requires all government agencies to identify and manage heritage assets in their ownership and control. In accordance with Section 170, Roads and Maritime has established a register which includes all items of environmental heritage listed on the State Heritage Register, an environmental planning instrument, or which may be subject to an interim heritage order it owns or manages. Roads and Maritime ensures that items entered in the register are maintained with due diligence in accordance with State Owned Heritage Management Principles approved by the Secretary of Planning and Environment on advice from the Heritage Council of NSW.

A single item listed on the Roads and Maritime Services Section 170 register is within the proposal area - Old Windsor Road and Windsor Road Heritage Precinct. Further discussion is included in Section 6.7.

4.3.5 *Threatened Species Conservation Act 1995*

The *Threatened Species Conservation Act 1995* (TSC Act) protects threatened species, populations and ecological communities and their habitats in NSW. Should the proposal potentially impact on threatened species, populations, ecological communities or their habitats, an assessment of significance is required in accordance with Section 5A of the EP&A Act.

Two threatened ecological communities listed under the TSC Act were identified in the proposal area: Cumberland Plain Woodland and Swamp Oak Floodplain Forest. The proposal would directly impact a total of 0.576 hectares of native vegetation, of which 0.189 hectares has been mapped as threatened ecological communities.

No local native threatened plant species listed under the TSC Act were recorded in the proposal area and, in view of targeted surveys, none are considered likely to occur. Terrestrial fauna surveys identified the presence or potential presence of eight fauna species listed under the TSC Act.

Specialists carried out assessments of significance under the TSC Act and Significant Impact Assessments under the EPBC Act for all threatened species, populations and communities known to occupy or highly likely to occupy the proposal area.

A licence may be required under Section 91 of the *Threatened Species Conservation Act 1995* if an action is likely to result in:

- Harm to, or picking of, a threatened species, population or ecological community
- Damage to critical habitat
- Damage to a habitat of a threatened species, population or ecological community.

4.4 Commonwealth legislation

4.4.1 *Environment Protection and Biodiversity Conservation Act 1999*

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) a referral is required to the Australian Government for proposed 'actions that have the potential to significantly impact on matters of national environmental significance or the environment of Commonwealth land'. These are considered in Appendix G and Chapter 6 of this REF.

The assessment of the proposal's impact on matters of national environmental significance and the environment of Commonwealth land found that there is unlikely to be a significant impact on Matters of National Environmental Significance. Accordingly, the proposal has not been referred to the Commonwealth Department of the Environment.

4.5 Confirmation of statutory position

As stated in Section 4.1.1, *State Environmental Planning Policy (Infrastructure) 2007* (ISEPP) is the mechanism to determine the approval pathway for the proposal. It allows the proposal to be carried out without development consent from local councils.

The proposal is thereby subject to assessment under Part 5 of the EP&A Act. The proponent and determining authority for the proposal is Roads and Maritime.

5 Stakeholder and community consultation

This chapter presents the consultation carried out to date for the proposal and the consultation proposed for the future. It includes the consultation strategy and the consultation outcomes with the general community, the Aboriginal community, relevant government agencies and stakeholders.

5.1 Consultation strategy

Community consultation for this project is being carried out in line with the *Community Engagement and Communications Resources Manual* (Roads and Maritime 2011). The consultation strategy developed for the proposal involves a combination of means to involve community members throughout the project including:

- Community Update newsletters
- Website information
- Media releases
- Newspaper advertisements
- Information drop-in sessions
- Project email, phone and mail address.

A critical aspect of the consultation process is to receive comment, feedback and suggestions on this REF and the road concept design during the public exhibition period. Submissions received during this period will be considered and addressed in a Submissions Report. Concerns and solutions arising from the Submissions Report will contribute to the concept design.

During construction of the proposal, the communication strategy would involve keeping road users up to date with traffic changes, night work, road closures and detours via on-site message signs, website information, bulk emails and letterbox drop to local residents, businesses and stakeholders. Those residents, businesses and stakeholders directly affected by the construction program would be contacted by phone and email and would be able to attend face-to-face meetings with Roads and Maritime to discuss specific matters like driveway accesses or other matters that may arise.

5.2 Community involvement to date

Roads and Maritime consulted with the community on a preliminary concept design for the proposal between December 2013 and January 2014. Roads and Maritime encouraged the community and stakeholders to provide their feedback at information sessions and to the project team via mail, email or phone. The proposal was communicated in the following ways:

- An update on the Roads and Maritime website
- Newspaper advertisement

- Display posters set up at local venues
- Community Update distribution
- Local MP's website

Additionally, Roads and Maritime convened two community information sessions at Wrights Road Community Centre, Kellyville on Tuesday 10 December 2013 and Thursday 12 December 2013.

Comments on the preliminary concept design closed on 31 January 2014. A total of 54 submissions were received. A community consultation report was prepared by Roads and Maritime to respond to comments and is attached as Appendix L. A summary of issues raised is presented in Table 5-13. Overall there was support for the upgrade of Memorial Avenue. A number of submissions acknowledged the need for Memorial Avenue to be upgraded and requested this occur as a priority due to increased traffic in the area.

Table 5-1: Summary of community issues and Roads and Maritime responses

Issue	Details of requirements	Roads and Maritime response
Local road access	<p>Residents should be able to make right turns into or from access roads at the intersections with Memorial Avenue.</p> <p>Local resident assess and use of this area needs to be prioritised over through traffic.</p>	<p>Memorial Avenue is a state arterial road with controlled access.</p> <p>Two intersections with traffic lights are proposed at Arnold Avenue West and at Severn Vale Drive. These lights would allowing traffic to safety access Memorial Avenue and local roads. Alternate access arrangements would be provided through the Balmoral Road release area precinct local road network. The development of the local road network is being managed by The Hills Shire Council. Council advises that all internal roads in the Balmoral Road Release area precinct are expected to be completed within three to five years.</p>
Pedestrians / cyclists	<p>A pedestrian overbridge across Memorial Ave linking bus stops, residential areas and the Kellyville Village shopping centre should be provided.</p>	<p>Roads and Maritime proposes signalised pedestrian crossings to be provided at the Severn Vale Drive intersection. This is adjacent to Kellyville Memorial Park providing access for pedestrians and cyclists across Memorial Avenue. However, the Balmoral Road release area Master Plan outlines a proposal for a pedestrian overbridge near Thomas Boulton Circuit as part of the precinct development. This facility would be provided by others.</p>

Issue	Details of requirements	Roads and Maritime response
	The upgrading should provide adequate shared paths for pedestrians and cyclists on both sides of the road.	Roads and Maritime confirms the proposal includes shared paths on both sides of Memorial Avenue.
Bus facilities	If indented bus bays remain a feature of the design, then consideration should be given to incorporating long tapers at the egress from the bays to allow the bus to accelerate to a higher speed prior to merging into passing.	Roads and Maritime would assess vehicle and pedestrian safety and the need for free flowing traffic when considering indented bus bays along Memorial Avenue,
Intersections	Need either traffic lights or roundabouts at local intersections along Memorial Avenue. Providing a signalised intersection at Arnold Avenue and widening of Memorial Avenue is long overdue.	New signalised intersections would be provided at Arnold Avenue West and at Severn Vale Drive. These intersections would provide for all turning movements.
	Right turn bay length on Windsor Road for turning into Memorial Avenue is currently inadequate and the traffic consistently banks back beyond the turn bay. Double right turning lanes are needed.	Noted. Roads and Maritime would identify the most appropriate layouts for the intersections at Windsor Road and at Old Windsor Road based on traffic modelling analysis.
Community consultation	Community needs to be advised about the date of commencement and completion of works. What are the timeframes for starting construction?	Consultation with the community and stakeholders is an important aspect of this project. Roads and Maritime would keep the community informed as the planning and construction progress. Once the planning is complete and funding for this proposal is confirmed, the program of works would be prepared by Roads and Maritime. This would then be communicated to the community through newsletters, media releases and project website updates.

Issue	Details of requirements	Roads and Maritime response
Safety	Lack of safety barriers, poor lighting and lack of pedestrian crossing facility.	Roads and Maritime would conduct a road safety audit to examine the safety aspects of the concept design prior to moving forward with detailed design. Appropriate initiatives to improve road safety would be adopted.

This community feedback has been considered by Roads and Maritime during preparation of the concept design and this Review of Environmental Factors.

5.3 Aboriginal community involvement

Roads and Maritime has consulted with the Aboriginal community in line with Stage 2 of the *Procedure for Aboriginal Cultural Heritage Consultation and Investigation* (PACHCI).

The proposal area lies within the boundaries of the Deerubbin Local Aboriginal Land Council (DLALC). The DLALC was contacted by the Roads and Maritime Aboriginal Cultural Heritage Advisor. Mr Steve Randall of the DLALC attended the proposal area survey. No areas of particular cultural significance were addressed by DLALC in their survey report (refer to Appendix E).

The impact assessment found the proposal would not impact known Aboriginal sites and/or places or areas of potential. No further archaeological investigations were recommended. If changes are made to the proposal that may impact Aboriginal sites or archaeological deposits, Roads and Maritime would follow the PACHCI.

5.4 ISEPP consultation

Part 2 Division 1 of the *State Environmental Planning Policy* (Infrastructure) (ISEPP) outlines particular circumstances where consultation with councils and other public authorities is required. These circumstances include where:

- Council managed infrastructure is affected (Clause 13)
- Local heritage items are affected (Clause 14)
- Work is adjacent to a national park (Clause 15)
- Work involves structures in or over navigable waters (Clause 16)

Under the proposal, Clause 13 of ISEPP is triggered in relation to matters of stormwater. The proposal also triggers consultation under Clause 15 of ISEPP as both Strangers Creek and Elizabeth Macarthur Creek (and immediate vicinity) are prone to flooding.

Written correspondence with The Hills Shire Council and Blacktown City Council to fulfil ISEPP requirements was carried out. Copies of ISEPP consultation letters are provided in Appendix L. The outcomes of consultation for each ISEPP clause will be provided in the submissions report.

5.5 Government agency and stakeholder involvement

Roads and Maritime has consulted with government authorities and agencies throughout the development of the proposal. This included regular meetings with key project stakeholders about the design and any issues that may have arisen. Stakeholders were also invited to participate in value management, rRisk and constructability workshops.

The purpose of this consultation was to help identify key environmental issues and opportunities as part of the concept design process. The consultation was also to discuss potential management measures and assessment requirements. Correspondence and meetings were held with the Hills Shire Council, Transport for New South Wales, Sydney Water, Telstra, Endeavour Energy, Jemena and the National Broadband Network. Matters raised in this correspondence are detailed below.

5.5.1 The Hills Shire Council

A meeting was held with The Hills Shire Council on 22 January 2014. A representative of The Hills Shire Council was also present at Stakeholder Meetings on 12 February 2014 and 28 August 2014, and the Value Management, Risk and Constructability Workshops. Table 5-2 shows the key comments raised.

Table 5-2: Summary of stakeholder consultation

Issue	Details of requirements	Roads and Maritime response
Noise walls	Council advised that developers adjacent to the road have been making their own assessment of whether noise walls are required to take account for the proximity of houses to Memorial, which they are aware is to be upgraded, and implementing noise attenuation measures as they develop properties.	No noise walls are proposed as part of the concept design. Property treatments are proposed at residences that exceed the relevant criteria (see section 6.4.4). Any new development needs to assess the noise from Memorial Ave and implement any noise treatments.
Project interfaces	Woolworths plan to build a new supermarket in the area immediately south of Memorial Avenue between Hector Circuit and Severn Vale Drive. They are keen to know the planned level of the Memorial Avenue upgrade at this location so that they can plan their development.	Provision for this development has been made in the concept design. Temporary access would be provided during construction.

Issue	Details of requirements	Roads and Maritime response
	<p>The Hills Shire Council plan to construct a shared path bridge over Memorial Avenue. The overbridge would connect Pellizzer Boulevard and Thomas Boulton Circuit.</p> <p>Roads and Maritime's Concept Design needs to allow for this bridge in terms of clearance at the road upgrade. The Hills Shire Council would need to design appropriate approaches to the bridges in the shared path footway reserve either side of the upgrade.</p>	<p>Provision for Council's shared path bridge has been made in the concept design</p>

5.5.2 Blacktown City Council

A representative of Blacktown City Council was present at the stakeholder meeting on 12 February 2014. There were no concerns raised by Council.

Blacktown City Council was also invited to attend the value management workshop on 13 June 2014 and the constructability workshop on 15 July 2014.

5.5.3 Transport for New South Wales (TfNSW)

A meeting was held with Transport for New South Wales on 7 February 2014 to discuss the interface with the North West Rail Link.

A representative of Transport for New South Wales was also present at a stakeholder meeting on 12 February 2014, and the value management, risk and constructability workshops. Comments were in relation to the provision of indented bus bays and access to bus stops during construction. The indented bus bays provided in the design comply with the Transport for New South Wales requirements. Access to bus stops would be retained during construction, with some temporarily relocated (see section 3.4).

5.5.4 Sydney Water

A meeting was held with Sydney Water on 31 January 2014 to discuss flood modelling. Sydney Water is also the planning authority for flooding and drainage along Elizabeth Macarthur Creek, Strangers Creek, and the tributary of Strangers Creek. A representative of Sydney Water was also present at the stakeholder meeting on 28 August 2014.

Sydney Water raised the issue of Balmoral Road and Memorial Avenue both being affected by flooding during large storms. This has been taken into account in the concept design.

5.5.5 Utilities providers

A utilities strategy meeting was held on 28 August 2014 to discuss impacts to utilities due to the proposal and proposed utility relocations. Representatives from Telstra, Jemena, Sydney Water and The Hills Shire Council were present at the meeting.

Representatives from Endeavour Energy and the National Broadband Network were not able to attend the meeting, but provided feedback on the design. A summary of the issues raised are in Table 5-3.

Table 5-3: Summary of issues raised by utilities providers

Provider	Summary of issue	Roads and Maritime response
Jemena	<ul style="list-style-type: none"> • Where existing crossings of gas mains are to be extended to accommodate the dual carriageway upgrade, the entire crossing needs to be replaced so that joints in the main are not located under the road • Where existing bends in gas mains end up under new road pavement, they are to be relocated to the verge so that they are accessible • Where gas mains would be crossing under the dual carriageway at intersections, they should be located so that a minimum of the main is located under the road pavement. 	Gas mains are proposed to be relocated to the verges to allow for ongoing maintenance access.
Sydney Water	<ul style="list-style-type: none"> • Sydney Water does not know the depth of the 900mm diameter water main on the east side of Old Windsor Road. If this main is shallow, it may need to be relocated as part of the widening of Old Windsor Road. 	At this stage, the pipe at this location does not require relocation.
Telstra	<ul style="list-style-type: none"> • Telstra have an optic fibre feed to a large asset located within Kellyville Memorial Park. The feed is located just west of Burns Road. 	It is proposed to relocate the optic fibre feed to Kellyville Memorial Park from Burns Road to the verge of the proposed eastbound lane.

Provider	Summary of issue	Roads and Maritime response
Endeavour Energy	<ul style="list-style-type: none"> • There is an existing 33kV overhead feeder along the northern side of Memorial Avenue and turns into Arnold Avenue. This 33kV feeder needs to be retained as it is a supply to the Endeavour Energy's Kellyville Zone Substation • Particular attention in the design stage would need to be paid to the intersection of Memorial Avenue and Windsor Road where Endeavour has a mix of 11kV and 22kV circuits which are unbonded at one pole in Windsor Road. 	<p>It is proposed to relocate the existing 33kV at this location to the verge of the proposed eastbound carriageway.</p> <p>It is proposed to relocate the overhead electricity near the intersection of Memorial Avenue and Windsor Road to the western verge of the widened Windsor Road.</p>

5.6 Ongoing or future consultation

This REF will be placed on public exhibition and community comments would be invited from Monday 17 November to Friday 12 December 2014. Additionally, Roads and Maritime will holding information sessions during the exhibition period. Details of these information sessions will be provided in a community update newsletter.

Following the public display of the REF, all comments received by Roads and Maritime will be recorded and addressed in a Submissions Report. The Submissions Report will detail how each comment raised would be considered in finalising the proposal design. The Submissions Report will be made available to the public via Roads and Maritime's website. The community will be kept informed of any further changes to the proposal resulting from this and any future consultation process.

If a decision is made to proceed with the proposal, the following consultation would be carried out during the construction phase:

- Ongoing consultation with key agency and local government stakeholders to help manage impacts during construction (refer to Section 6). These would include Industry and Investment (Fisheries), The Hills Shire Council, Blacktown City Council, utility providers, bus companies utilising Memorial Avenue, and Transport for NSW
- Follow-up meetings to discuss access arrangements with those landholders whose property access would be directly affected by the proposal
- Ongoing updates throughout the planning phase and construction period for the immediately affected community and users of Memorial Avenue
- Ongoing updates of the Roads and Maritime project webpage as required.

6 Environmental assessment

This chapter provides an assessment of the potential environmental impacts associated with the construction and operation of the proposal. All aspects of the environment potentially impacted by the proposal are considered. The assessment considers the factors specified in the guidelines *Is an EIS required?* (DUAP 1999) and *Roads and Related Facilities* (DUAP 1996) as required under clause 228(1)(b) of the Environmental Planning and Assessment Regulation 2000. The factors specified in clause 228(2) of the *Environmental Planning and Assessment Regulation 2000* are also considered in Appendix A. Site-specific safeguards are provided to reduce the potential impacts.

6.1 Hydrology and water quality

6.1.1 Existing environment

Waterways and catchments

Memorial Avenue is located within mainly rural residential land that is in transition to low and medium density urban development and associated urban land uses. The road crosses Elizabeth Macarthur Creek, Strangers Creek, a tributary of Strangers Creek and an unnamed minor drainage line (which all generally run from south to north). The proposal is located in the Cattai Creek catchment, a sub-catchment of the Hawkesbury Nepean River.

Figure 6-1 shows the hydrological features of the proposal area. The catchment boundaries of the main waterways crossing the site are shown in Figure 6-2.

Memorial Avenue Upgrade - Review of Environmental Factors



Figure 6-1: Hydrological features of the proposal area

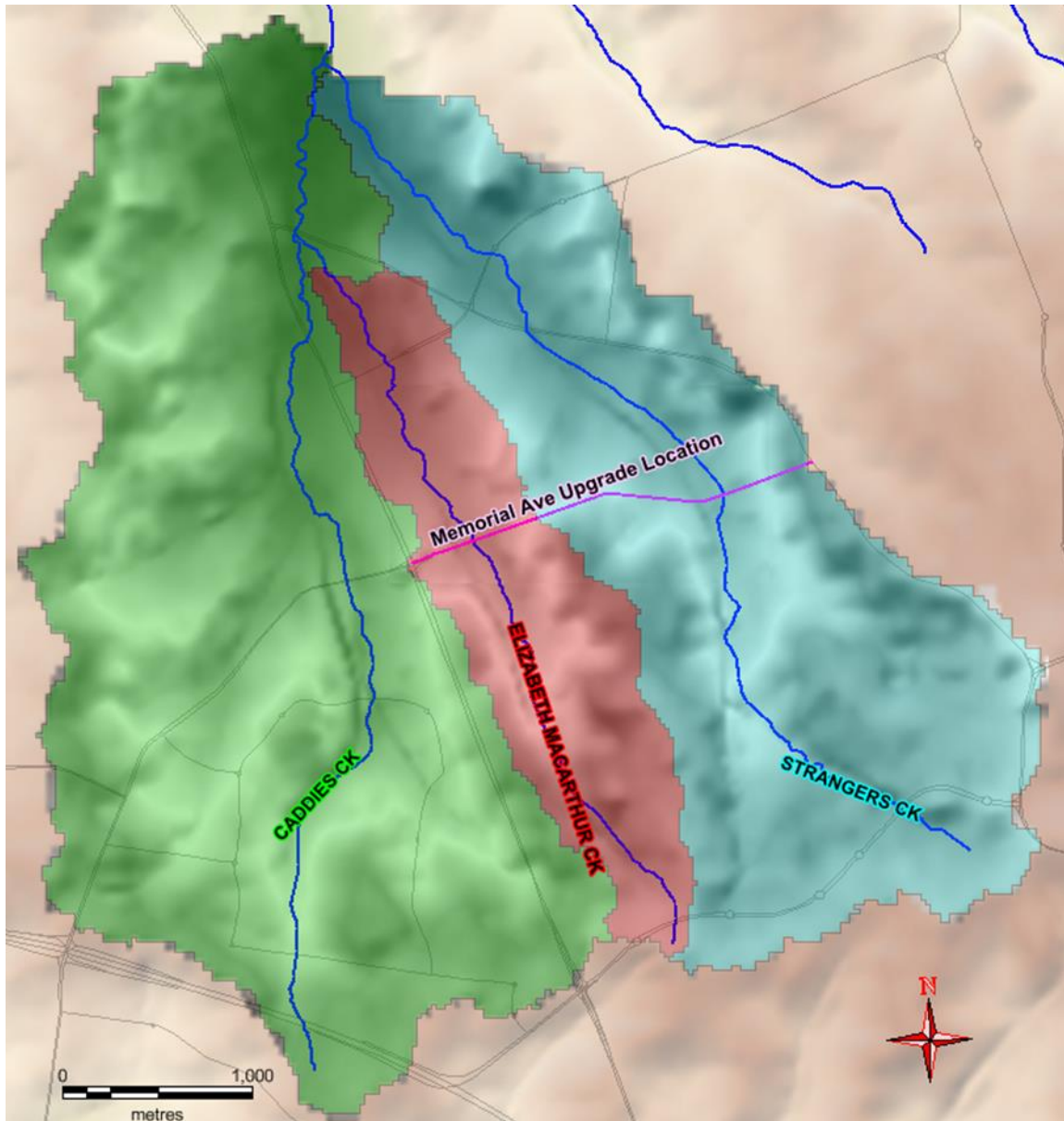


Figure 6-2: The main catchments surrounding the site

Elizabeth Macarthur Creek, Strangers Creek, and the tributary of Strangers Creek are managed by Sydney Water. The relevant land is zoned in The Hills Shire Council’s Development Control Plan (DCP) as ‘SP2 Infrastructure (Stormwater Management System)’. The waterways have mildly sloping banks and, with the exception of Strangers Creek, are ephemeral.

Strangers Creek is located in the eastern half of the proposal area and crosses under Memorial Avenue between Hector Court and Hartigan Avenue. The creek is a highly modified drainage system consisting of a series of ponds interconnected with drainage culverts.

The catchment area upstream of Memorial Avenue is about 400 hectares. Strangers Creek runs under Memorial Avenue through four pipe culverts. Upstream of the culverts is a detention basin and flow control v-notch weir limit the flow rate into Strangers Creek and control upstream flood levels. Strangers Creek is a 4th order stream and classified Class 3 – Minimal Fish Habitat in accordance with the NSW

Classification of Fish Habitat (Fairfull and Witheridge 2003).

Elizabeth Macarthur Creek is located in the western section of the proposal area and crosses under Memorial Avenue between Arnold Avenue and Old Windsor Road. The creek runs under Memorial Avenue through three multi-cell box culverts. The catchment area upstream of Memorial Avenue is about 160 hectares. The area draining to Elizabeth Macarthur Creek between Celebration Drive (south/upstream of the proposal) and Samantha Riley Drive (north/downstream of the proposal) is largely undeveloped. However, significant urbanisation is currently underway as part of the North West Growth Centre. A particular area of future development is the Balmoral Road Release Area. Development in the upstream catchment (south of Celebration Drive) is well established, consisting of a mixture of residential and commercial development. Elizabeth Macarthur Creek is a second order stream and classified as a Class 3 – Minimal Fish Habitat (Fairfull and Witheridge 2003).

Land surrounding the tributary of Strangers Creek has been highly modified up and downstream of Memorial Avenue such that there is no formal channel connecting to the proposal area. The unnamed drainage line is adjacent to a newly developed land release. Both of these waterways are classified Class 4 – Unlikely Fish Habitat (Fairfull and Witheridge 2003).

A description of the hydrological regime and water quality near the proposal area is provided below.

Hydrology

A Hydrology and Hydraulics Assessment was undertaken by Hyder Consulting (2014, Appendix D). The assessment:

- Identified the existing drainage infrastructure and hydrological conditions along Memorial Avenue
- Informed the drainage infrastructure design for the proposal
- Identified the future hydrological functioning of the proposal area once the proposal is built.

The information in this section is based on the outcomes of that assessment.

The existing hydraulic structures within the proposal area are outlined in Table 6-1.

Table 6-1: Existing hydraulic structures within the proposal area

Structure No.	Location	Culvert dimensions
1	Elizabeth Macarthur Creek	Three multi-cell box culverts (3 m wide x 0.9 m high)
2	Strangers Creek	Four pipe culverts (1.5 m diameter) and basin (and flow control v-notch weir upstream)
3	Tributary of Strangers Creek	Three pipe culverts (750 mm diameter with submerged inlet and outlet)
4	Unnamed drainage line	One pipe culvert (450 mm)

Structure No.	Location	Culvert dimensions
		diameter)

The current drainage structures listed in Table 6-1 do not have capacity to accommodate one in 100-year ARI storm events, and overland flows currently overtop the roadway. Currently at Elizabeth Macarthur Creek, about 51% of peak flow passes through the culverts during the one in 100 year event, with the remaining 49% flowing over the roadway. At Strangers Creek during the one in 100 year event, about 50% of peak flow passes through the culverts with the remaining flowing over the roadway.

There are also currently only two sections with a kerb and gutter (see section 2.2.1). Between Elizabeth Macarthur Creek and Strangers Creek flows travel freely overland.

Water quality

Surface water

The proposal is located in areas of new and ongoing development in north-western Sydney. The urbanisation of upstream areas has resulted in increased sedimentation and degradation, with poor water quality associated with stormwater discharges into creeks. During site visits to the proposal area between 19 and 21 March 2014, the following observations were made in relation to the water quality in the various waterways (see Appendix G):

- Elizabeth Macarthur Creek was observed to have a muddy substrate, low turbidity and a moderate stream flow
- Strangers Creek was observed to have a rocky and muddy substrate, low turbidity and a slow stream flow
- The tributary of Strangers Creek was observed to have low water clarity, likely due to dirty water runoff from nearby developments
- No observations were made at the unnamed drainage line.

The Hills Shire Council has been monitoring water quality in Strangers Creek and Elizabeth Macarthur Creek as part of water quality monitoring program since 2006. At each site, council officers test the water for the following parameters: dissolved oxygen, temperature, pH and conductivity. Three water samples are collected at each site and are sent to a National Association of Testing Authorities (NATA) accredited laboratory for analysis of faecal coliforms, E.coli, total nitrogen, total phosphorous, biological oxygen demand (BOD) and total suspended solids (TSS).

Results for a number of parameters (including dissolved oxygen, E.coli, total nitrogen and total phosphorous) tested during 2006-2013 were frequently outside the acceptable range for secondary contact under the ANZECC guidelines (ANZECC 2000) (The Hills Shire Council 2013).

The results for dissolved oxygen and pH were also outside the acceptable range recommended by these guidelines for fresh and marine water quality for physical and chemical stressors in lowland river systems in south-eastern Australia.

Groundwater

The proposal lies within the Sydney Basin Central groundwater source, which is bounded by the Hawkesbury River catchment to the north and west and the Shoalhaven River catchment to the south and south-west (NSW Office of Water 2014). Groundwater vulnerability refers to the permeability of an area, with higher vulnerability areas being those where spills have the potential to rapidly contaminate groundwater resources (CANRI cited in RTA 2006). Groundwater vulnerability in the proposal area is low. Groundwater quality throughout the proposal area is characterised as saline (CANRI cited in RTA 2006).

There are 15 groundwater bores within two kilometres of the proposal area. Two bores are used for recreational purposes, one for domestic purposes, and one for monitoring; there is no data on the other bores.

The permanent level of the groundwater table varies considerably in the areas around the proposal area and is estimated to be at a depth of:

- 1.6 metres (400 metres southeast of the proposal area)
- Eight metres (250 metres north and west of the proposal area)
- 53 metres in the far north (500 metres from the proposal area).

Groundwater bores near the proposal area are shown in Figure 6-3 (each bore is identified by a blue dot).

Memorial Avenue Upgrade - Review of Environmental Factors



Figure 6-3: Indicative location of groundwater boreholes within 2 kilometres of the proposal area (Source: NSW Natural Resource Atlas 2014)

Groundwater quality was tested as part of geotechnical investigations by Hyder Consulting in June 2014. Samples were collected from a borehole (borehole #1) located to the west of Strangers Creek just north of Memorial Avenue (easting 310565.642, northing 6267307.488). The depth to groundwater at this location was recorded as 2.6 metres.

Groundwater samples from borehole #1 were sent to an accredited laboratory for testing; the report indicates the groundwater at this location has a pH of 7.5 and a conductivity of 560 microsiemens per centimetre.

The ANZECC guidelines recommend that groundwater should be managed in such a way that when it comes to the surface it would not cause the established water quality objectives for the local waterways to be exceeded (ANZECC 2000). Therefore, the groundwater quality results have been compared to the ANZECC guidelines for physical and chemical stressors in lowland river systems in south-eastern Australia.

Acceptable ranges under the guidelines for lowland river systems are: 6.5 to eight for pH and 125 to 2200 microsiemens per centimetre for conductivity. Therefore, both the pH and the conductivity of the groundwater at borehole #1 are within the acceptable range. The pH and conductivity results have also been compared to the ANZECC guideline values for recreational water use (secondary contact) and have been found to be within the acceptable range. No other groundwater quality results were available for comparison to the ANZECC guideline values.

6.1.2 Potential impacts

The proposal has the potential to impact on hydrology and water quality during both construction and operation. The potential impacts of the project on hydrology and water quality are outlined below.

Construction

Hydrology

The proposal would require:

- The construction of culverts at three locations and a bridge to manage cross-drainage flows
- The decommissioning or removal of four existing drainage structures.

These cross-drainage structures are summarised in Table 6-2.

Table 6-2: Proposed cross-drainage structures

Structure No.	Location	Proposed upgrade
1	Strangers Creek	Remove culverts and install twin 18 m span concrete plank bridges with vertical abutments
2	Tributary of Strangers Creek	Remove culvert and install three 900 mm diameter pipes
3	Minor drainage line	Remove culvert and install one 750 mm diameter pipe
4	Elizabeth Macarthur Creek	Remove culverts and install four reinforced concrete box culverts 3 m wide x 1.8 m high

Strangers Creek

The construction of the bridges can be completed without the need for significant diversions. The bridge would be constructed from both banks, and girders would be installed using a crane located away from the waterway.

Significant earthwork within the creek line would be required during construction of the bridge over Strangers Creek. The current culverts are wider than the natural creek width, so ground shaping would be required within Strangers Creek to reform embankments and establish a new waterway profile. To minimise potential impacts on creek flows and flooding, the flow would be diverted to two of the existing culverts whilst the other two are removed and the creek alignment established. The flow would then be switched to the new creek alignment while the remaining two culverts are removed. This would ensure that low flows are not dammed at any stage, and that fish passage can be maintained in the named creeks identified as fish habitat.

The construction of the bridges, including embankment works would have a negligible effect on local hydrology as existing culverts would remain operational during construction. The adoption of an appropriate construction methodology as outlined in Section 3.4.1, would result in minimal disturbance to the existing hydrological regime during construction.

Tributary of Strangers Creek and unnamed drainage line

Construction of the culverts at the tributary of Strangers Creek and the unnamed drainage line would require temporary diversions during construction. This would involve excavation of a temporary channel around the existing culvert alignment and diversion of existing drainage line to the temporary channel whilst the new culvert is constructed.

These drainage lines are intermittent and carry very little flow (see Table 6-3). The catchment areas are very small, 4.56 hectares for the unnamed drainage line and 23.89 hectares for the tributary of Strangers Creek (compared to 159 hectares at Elizabeth Macarthur Creek and 397 hectares at Strangers Creek). Due to the small catchment areas, it is anticipated that works at these locations would result in minimal disturbance to the existing hydrological regime. Waterway diversions along with erosion and sediment control measures would be implemented prior to construction to further reduce the potential impact on hydrology at these drainage lines during construction.

Elizabeth Macarthur Creek

The construction of the culverts can be completed without the need for significant diversions. Culvert construction can be completed by utilising the existing crossing, and constructing a number of the new cells adjacent. The channel can then be directed into the newly constructed crossing, while the remainder of the new culvert is installed. This would ensure that low flows are not dammed at any stage, and that fish passage can be maintained in the named creeks identified as fish habitat. The construction process is outlined in Section 3.4.1.

Ground shaping would be required at either end of the proposed culverts at Elizabeth Macarthur Creek to accommodate the extra culvert width and the invert levels necessary to provide appropriate drainage. This would be undertaken following construction of the new culverts, resulting in minimal impacts on local hydrology as existing culverts would remain operational during construction.

Surface water, cuts and fills

The placement of fill and excavation of cuts, would not impact on local hydrology as existing culverts would remain operational during construction. Waterway diversions would be planned prior to construction as part of the contractor's erosion and sedimentation control plan for the project and established early in the construction schedule to direct clean and dirty water around the site. This would result in minimal disturbance to the existing hydrological regime during construction.

Water quality

During construction, pollutants such as soil nutrients and construction waste have the potential to enter Strangers Creek, Elizabeth Macarthur Creek, the tributary of Strangers Creek and the unnamed drainage line, particularly during high rain events. Spillage of fuel during refuelling and leakage of hydraulic and lubricating oil from plant and equipment or rinse water from plant washing and concrete washouts would also have the potential to enter drainage lines.

If the potential impacts of pollution are not controlled, they could cause declining water quality and affect the aquatic ecology.

The creeks within the proposal area have been assessed as being highly degraded with generally poor water quality. Following the implementation of the safeguards and mitigation measures outlined in Section 6.1.3, there would be only minor potential for temporary water quality impacts as a result of the proposal.

Groundwater quality

Potential impacts on groundwater may occur during construction of the bridge over Strangers Creek, which would require piling to a depth of between about 10 to 15 metres to install the bridge piers. Intersection with the water table may result in discharges of groundwater to the surrounding environment, including runoff of turbid or saline water into Strangers Creek.

Groundwater testing found that the pH and conductivity adjacent to Strangers Creek are at acceptable levels for lowland rivers in south-eastern Australia and therefore the influence of these parameters on the in-stream water quality is expected to be negligible.

However, when groundwater comes to the surface during construction it is likely to mix with eroded sediments and therefore has the potential to reduce water quality and negatively impact the aquatic environment in Strangers Creek.

Piling of the bridge piers is a short-term construction activity. Provided the associated safeguards and mitigation measures outlined in Section 6.1.3 are implemented, the associated environmental impacts are expected to be minor, localised and temporary.

The need to compact soils in areas of fill and embankments may impede flow and raise the water table) and potentially concentrate saline discharges. Exposed salt may be redistributed closer to the soil surface or into waterways, potentially affecting the natural and built environments (see Section 6.2.3). Further salinity investigations would be carried out during detailed design.

Operation

Hydrology

Overall, the proposed drainage structures would improve existing drainage conditions by providing sufficient hydraulic capacity to effectively convey stormwater flows under Memorial Avenue during 100-year ARI flood events.

Strangers Creek

The culverts that carry Strangers Creek below Memorial Avenue have insufficient capacity to convey stormwater flows under the one in 100-year floods, resulting in water overtopping the road. Under the proposal, the culverts would be replaced by an 18 metre plank bridge that could accommodate existing one in 100-year flows; preventing flows from overtopping the road.

Figure 6-5 provides a comparison of the one in 100-year flood levels at Strangers Creek before and after the Memorial Avenue upgrade. Flood levels under the one in 100-year flood conditions upstream of Memorial Avenue would be about 400 millimetres lower than existing levels, and flood levels downstream of Memorial Avenue would be about 40 millimetres higher than existing levels. These changes to flood levels are considered to be minor and would be limited to small areas of land to the south of Memorial Avenue. This land is currently owned and used by Sydney Water for flood mitigation. There would be no impact on privately owned land as a result of the proposal.

For Strangers Creek the flow from any storm event are relatively large (over 50 tonnes every second in the 100 year ARI). The extra flow due to additional impervious area from the proposed road is insignificant in comparison. Any increase in runoff volume due to the increased pavement area of the proposal would be imperceptible compared with the flows generated by the overall catchment.

Tributary of Strangers Creek and unnamed drainage line

The proposal involves increasing the culvert capacity at the tributary to Strangers Creek and at the unnamed drainage line to accommodate stormwater flows during one in 100-year flood events. Once these culverts are upgraded, flows would no longer overtop Memorial Avenue.

For these crossings the upstream catchment areas are small compared with Elizabeth Macarthur Creek and Strangers Creek, and the proposal has a greater influence on their flows (see Table 6-3). The unnamed drainage line would have the

impervious area increased but the catchment area decreased, resulting in a reduction in flow. The tributary of Strangers Creek would have both an increase in impervious area and a minor increase in catchment area, resulting in an increase in flow. The absolute increase in peak flow magnitude is relatively small at 0.17 cubic metres per second for the one in 100 year flood. The impact on surrounding property due to this increase is expected to be negligible due to the relatively steep nature of the terrain.

Elizabeth Macarthur Creek

As discussed in Section 6.1.1, the culverts that carry Elizabeth Macarthur Creek below Memorial Avenue have insufficient capacity to convey stormwater flows under the existing one in 100 year floods, resulting in water overtopping the road. Under the proposal, the culverts would be replaced by four box culverts that could convey one in 100 year flows; so that water would no longer overtop the road.

The proposed culverts would take all the flow under the new road, so the flow path would be narrower compared to the present. Figure 6-4 provides a comparison of 100-year ARI flood levels at Elizabeth Macarthur Creek before and after the proposed Memorial Avenue upgrade. These show the road related impacts (in the third panel) are expected to be in the vicinity of -0.0- to 0.01 metres. Once the proposal is built, flood levels under one in 100-year flood conditions upstream of Memorial Avenue would be about 10 to 100 millimetres lower than existing levels, and flood levels immediately downstream of Memorial Avenue would be about 10 to 50 millimetres higher than existing levels. These changes to flood levels are considered to be minor and would be contained within the existing creek width. There would be no impact to privately owned land as a result of the proposed upgrade.

Any increase in runoff volume due to the increased pavement area of the proposal would be negligible compared with the flows generated by the overall catchment.

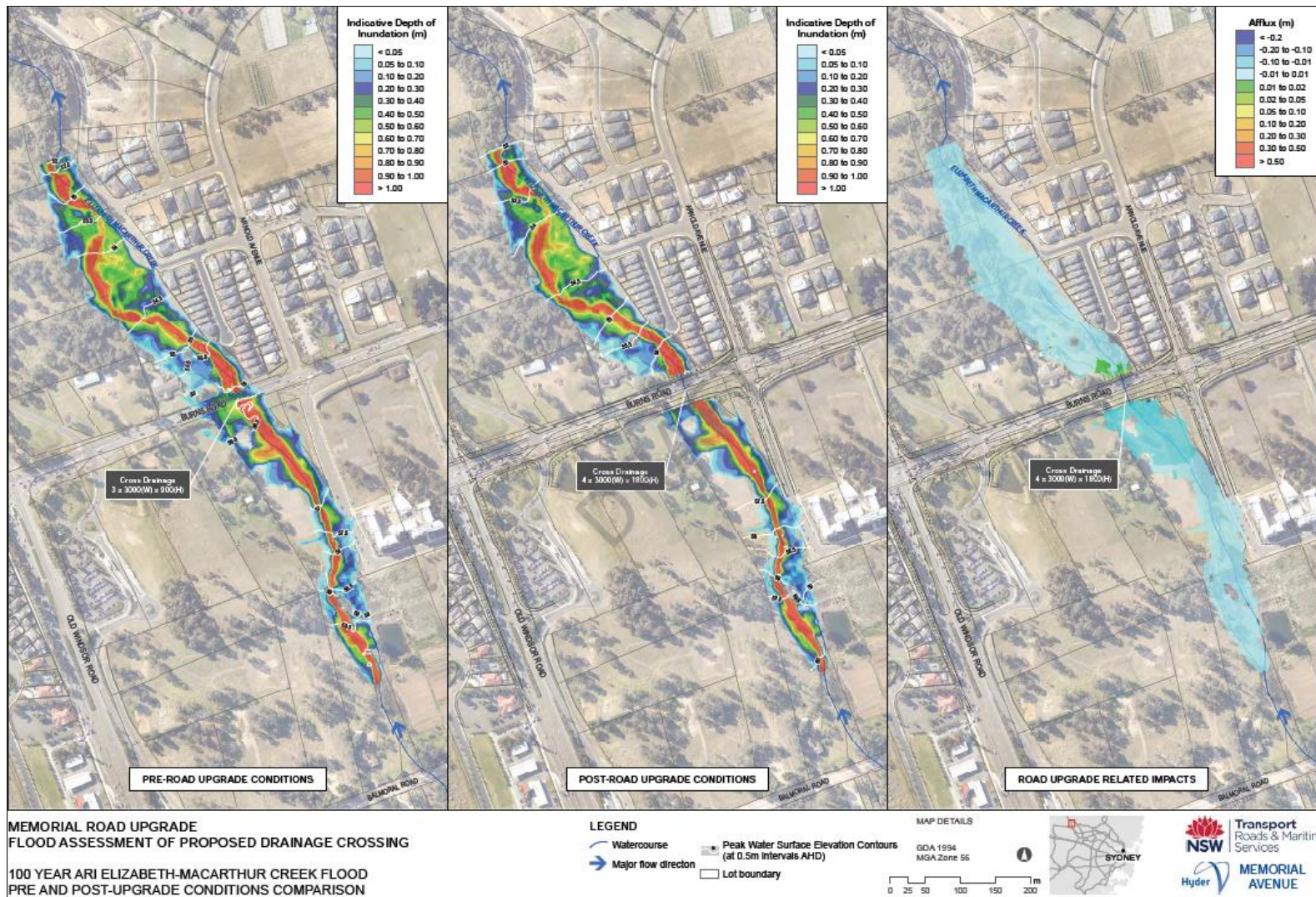


Figure 6-4: Elizabeth Macarthur Creek: 100-year ARI flood levels before and after the upgrade

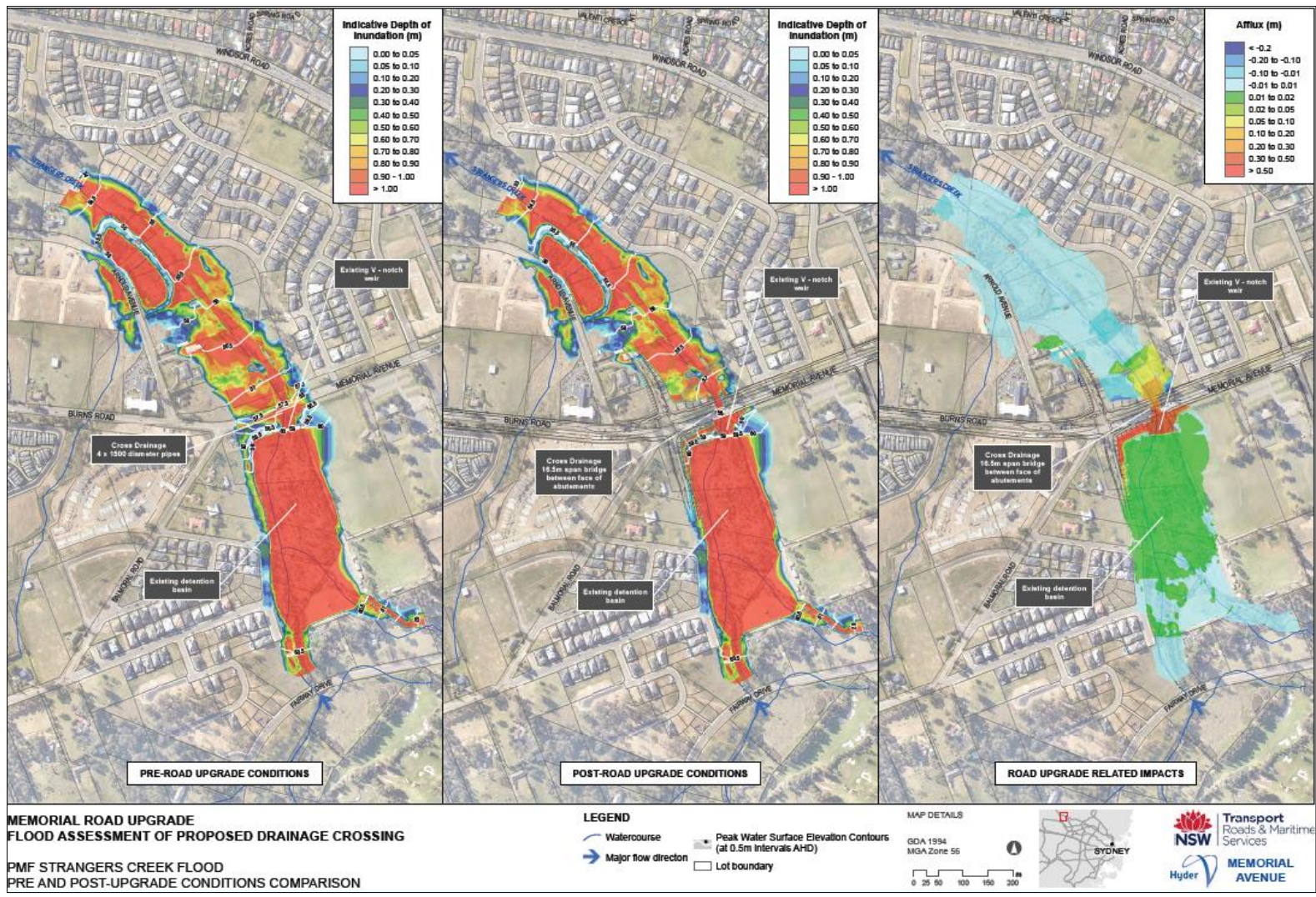


Figure 6-5: Strangers Creek: 100-year ARI flood levels before and after the upgrade

Surface flows

The proposal would increase the area of pavement than is currently present. This would cause an increase in local flow from pavement drainage. Water that currently flows overland where there is no kerb and gutter would be directed to outlets at the four drainage points detailed above.

For the two larger catchments the flow increase due to increased pavement area is imperceptible compared to the catchment flows, so just the pavement increase values are shown. Table 6-3 shows a comparison of pavement area and flows between the existing road and proposed upgrade.

Table 6-3 Comparison of pavement area and flows between existing and proposed

		Outfall Location			
		Elizabeth Macarthur Creek	Strangers Creek	Unnamed drainage line	Tributary of Strangers Creek
Existing	Total Catchment Area (ha)	159	397	4.56	23.89
	Road Pavement Area (ha)	1.03	1.04	0.36	0.50
	Peak Flow 2 Year ARI (m ³ /s)	-	-	0.76	2.56
	Peak Flow 10 Year ARI (m ³ /s)	-	-	1.21	4.62
	Peak Flow 100 Year ARI (m ³ /s)	33	51	1.87	7.10
Proposed	Total Catchment Area (ha)	159	397	4.31	24.33
	Road Pavement Area (ha)	1.53	1.44	0.61	1.16
	Peak Flow 2 Year ARI (m ³ /s)	-	-	0.76	2.67
	Peak Flow 10 Year ARI (m ³ /s)	-	-	1.21	4.76
	Peak Flow 100 Year ARI (m ³ /s)			1.80	7.27
Increase	Total Catchment Area (ha)	0	0	-0.25	0.44

Road Pavement Area (ha)	0.50	0.40	0.25	0.66
Peak Flow 2 Year ARI (m ³ /s)	-	-	-0.01	0.11
Peak Flow 10 Year ARI (m ³ /s)	-	-	0.00	0.14
Peak Flow 100 Year ARI (m ³ /s)	-	-	-0.07	0.17

Due to some increased surface flows, the local peak flow would increase immediately downstream of drainage outlets. The proposal design includes scour protection at every outlet to reduce the flow velocities and reduce erosion.

At Strangers Creek the flow patterns of the waterway would change slightly because in that flows that currently overtop the roadway would be directed along the creek. The flow pattern changes are mostly confined to the creek and would dissipate within 100 metres. Outside the creek on the floodplain there is minimal change.

Water quality

Operation when, runoff from the roadway entering watercourses would cause potential impacts to water quality. Vehicles using the road could cause contaminants to build up on impervious surfaces, median areas, and roadside corridors during dry weather. When it rains, these contaminants could be washed into surrounding watercourses. The contaminants of most concern relating to road runoff are:

- Suspended sediment from the paved surface and landscaped batters during the establishment period
- Heavy metals attached to particles washed off the paved surface
- Oil, grease and other hydrocarbon products
- Litter from the road corridor
- Nutrients from biological matter including nitrogen and phosphorus.

These contaminants are already present in the water course due to the existing road and surrounding developments. Increased traffic may increase these contaminant loads, however the predicted increase in traffic would occur even without the upgrade due to surrounding developments.

The potential effects of these contaminants on surrounding waterways include:

- Increased sediment loads, which reduce light penetration through the water column, impacting aquatic flora and fauna
- Decay of organic matter and some hydrocarbons, which can decrease dissolved oxygen levels and affect fish and aquatic life
- Increased nutrients (nitrogen and phosphorus), which stimulate excessive growth of algae and aquatic plants, leading to toxic conditions
- Increased levels of heavy metals (including aluminium and iron), which are toxic to aquatic biota and fish

- Increased levels of litter, oils and grease.

The corridor is tightly constrained along its length by the existing road reserve boundary, and the presence of a number of newly constructed subdivisions. In the vicinity of the creeks established vegetation is present that would be preserved where possible. The provision of permanent water quality treatment solutions is very limited due to these constraints. The possibility of diverting low flows from the pavement drainage system could be further investigated at the detailed design stage. Potential areas where this is a possibility are shown in the figures below.

Figure 6-6 - Strangers Creek Water Quality Options and Constraints

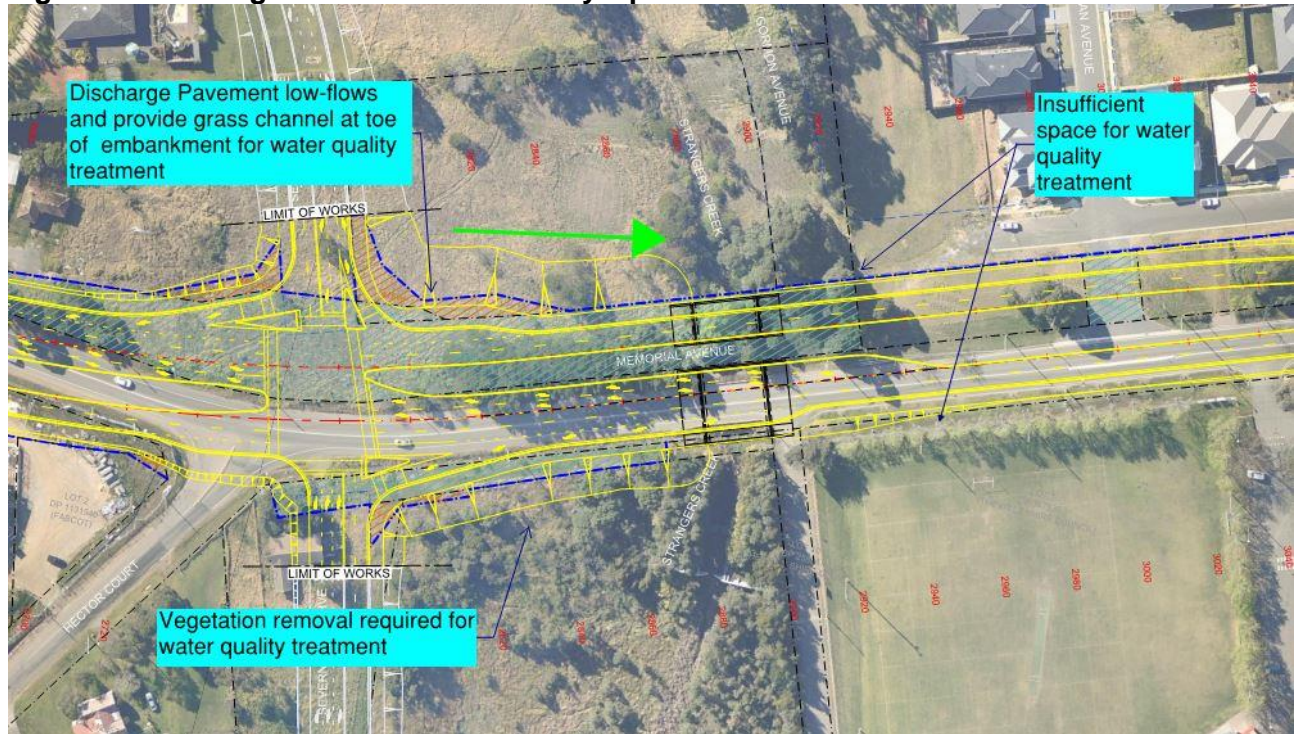
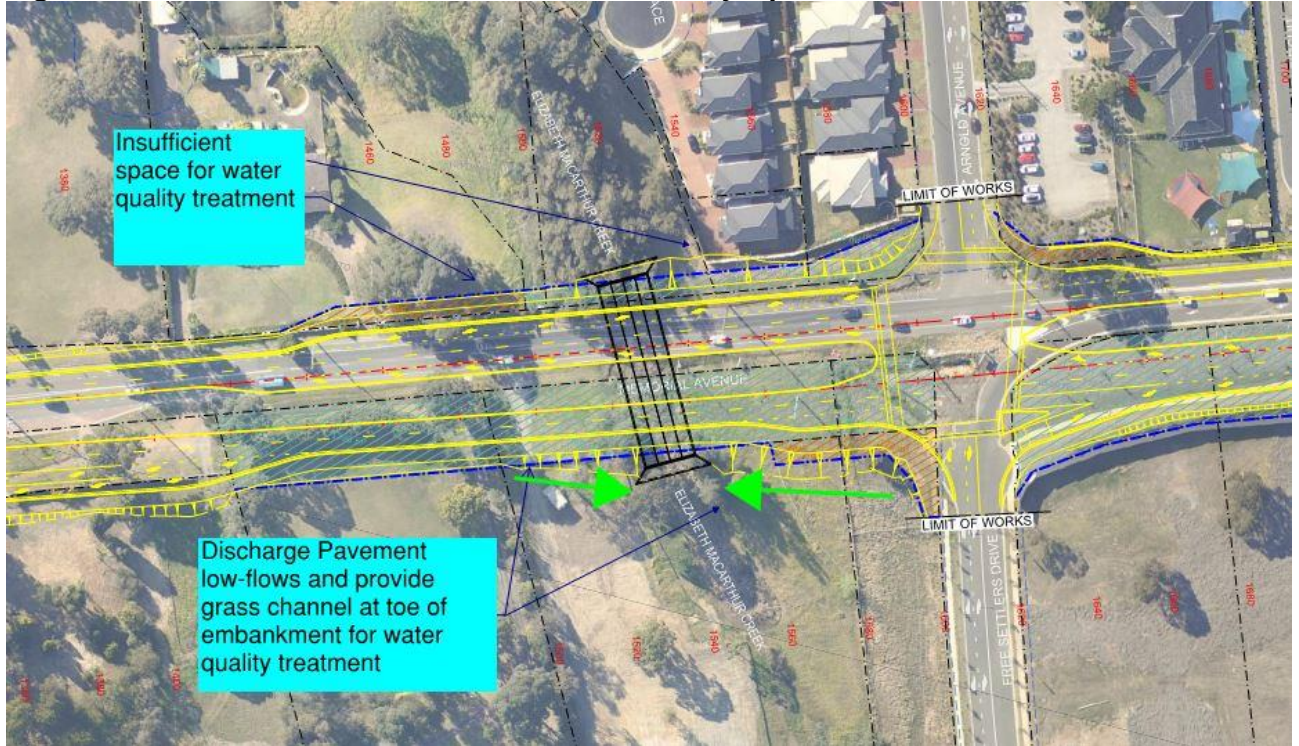


Figure 6-7 - Elizabeth Macarthur Creek Water Quality Options and Constraints



Given the proposal would not generate additional pollution in the area, pavement runoff would not be subject to water quality treatment prior to discharge to downstream watercourses. The options presented in the figures above, could be further investigated at detailed design stage. The adjacent developments would be required to provide stormwater management, including water quality improvements, which would ultimately benefit the surrounding waterways.

Overall, the proposal is likely to have a minor impact on surface water quality.

Groundwater quality

During operation of the proposal there is potential for contaminants from the road surface to run off into surrounding areas and penetrate into the groundwater system. The contaminants of most concern are outlined above in relation to surface water impacts. There is not expected to be any significant increase in risks to groundwater contamination associated with the proposal. As mentioned above, these contaminants are already present due to the existing road and surrounding developments.

6.1.3 Safeguards and management measures

The safeguards and management measures outlined in Table 6-4 would be implemented before and during construction of the proposal to minimise impacts on hydrology and water quality.

Table 6-4: Proposed hydrology and water quality safeguards and management measures

Impact (Location)	Environmental safeguards	Responsibility	Timing
Water quality	<ul style="list-style-type: none"> A Soil and Water Management Plan (SWMP) would be prepared 	Construction	Pre-

Impact (location)	Environmental safeguards	Responsibility	Timing
	<p>as part of the Construction Environmental Management Plan in accordance with the requirements of Roads and Maritime contract specification G38 before construction begins. The SWMP would address:</p> <ul style="list-style-type: none"> - The <i>Roads and Maritime Code of Practice for Water Management</i> - The <i>Roads and Maritime Erosion and Sedimentation Procedure</i> (RTA 2008) - The Blue Book - <i>Roads and Maritime Technical Guidelines – Temporary Stormwater Drainage for Road Construction</i> (Roads and Maritime 2011). <p>The SWMP would also include and address:</p> <ul style="list-style-type: none"> - The identification of catchment areas and the direction of on-site and off-site water flow - The likely runoff from each road sub-catchment - Separation of on-site and off-site water - The direction of runoff and drainage points during each stage of construction - The locations and sizing of sediment traps such as sumps or basins - The process for dewatering off site including basins. - The locations of other erosion and sediment control measures (e.g. rock check dams, swales, scour protection and sediment fences) - The staging plans, location, sizing and details of creek alignment and realignment controls for scour protection and bank and bed stabilisation 	contractor	construction

Impact (location)	Environmental safeguards	Responsibility	Timing
	<p>including those used during construction and long term during road operation</p> <ul style="list-style-type: none"> - Progressive site-specific Erosion and Sedimentation Control Plans (ESCPs). The ESCPs would be updated at least fortnightly - A process for monitoring and preparing for wet weather - Provision of an inspection and maintenance schedule for ongoing maintenance of temporary and permanent erosion and sedimentation controls 		
Water quality	<ul style="list-style-type: none"> • The SWMP would be reviewed by a soil conservationist and updated to address their comments and recommendations. 	Construction contractor	Pre-construction
Water Quality	<ul style="list-style-type: none"> • Detailed design to further investigate the provision of additional water quality treatment near Strangers Creek and Elizabeth Macarthur Creek. 	Roads and Maritime	Detailed design
Drainage lines and flow paths causing scouring	<ul style="list-style-type: none"> • Channel bank and bed stabilisation measures would be maintained until riparian vegetation is completely re-established. 	Construction contractor	Construction
Spills	<ul style="list-style-type: none"> • Emergency wet and dry spill kits would be kept on site at all times. All staff would be made aware of the location of the spill kits and trained in their use. 	Construction contractor	Construction
Spills	<ul style="list-style-type: none"> • All fuels, chemicals and liquids would be stored in an impervious bunded area within the construction compound, a minimum of 50 metres away from: <ul style="list-style-type: none"> - Rivers, creeks or any areas of concentrated water flow - Flooded areas - Slopes above 10%. <p>Refueling would be done in a similarly contained area.</p>	Construction contractor	Construction

Impact (location)	Environmental safeguards	Responsibility	Timing
Flooding due to increases in peak flow velocities	<ul style="list-style-type: none"> Further flood modelling, including a detailed afflux assessment, would be carried out during detailed design to confirm impacts on surrounding land uses. 	Roads and Maritime	Detailed design
Groundwater	<ul style="list-style-type: none"> Further investigations would be carried out during detailed design to confirm levels of soil salinity and potential impacts on groundwater. 	Roads and Maritime	Detailed design

6.2 Topography, Geology and Soils

6.2.1 Existing environment

Topography

The elevation of the proposal area varies between about 54 and 84 metres above the Australian Height Datum (AHD), shown in Figure 6-8. Land slopes gently towards each of the creeks where elevation is lowest (54–56 metres AHD). The highest elevation is at the intersection of Memorial Avenue with Windsor Road in the east (80–84 metres AHD) and is slightly lower at the intersection with Old Windsor Road in the west (62–64 metres AHD).

Memorial Avenue Upgrade - Review of Environmental Factors



- LEGEND**
- Concept Design
 - Proposal Area
 - 10m Contours

DATA SOURCES
 Nearmap 2013-09-02, LPI

NSW Transport
 Roads & Maritime
 Services

HYDER CONSULTING PTY LTD
 ABN 76 104 485 289
 Level 5, 141 Walker St
 North Sydney NSW 2060
 Australia
 P: +61 (0) 2 8907 9000
 F: +61 (0) 2 8907 9001



Figure 6-8: Topography of the proposal area

Geology and soils

The 1:100,000 Geological Map of the Penrith Region¹ indicates the proposal area is predominantly underlain by Ashfield Shale of the Wianamatta Group. This is described as dark grey to black claystone-siltstone and fine sandstone-siltstone laminate.

Along the western end of Memorial Avenue the Ashfield Shale may be overlain by Quaternary Alluvium, typically made up of fine grained sand, silt and clay. The CSIRO Australian Soil Resource Information System indicates the soils in this area are predominately light to medium clays².

The soil landscapes of the Penrith 1:100 000 sheet were mapped by Bannerman and Hazelton (1990). There are two different soil landscapes mapped within the proposal area: the residual Blacktown soil landscape and the erosional Luddenham soil landscape. The features and location of the mapped soil landscapes in the proposal area are presented in Table 6-5.

Table 6-5: Soil landscape and location

Soil landscape	Features	Location in proposal area
Blacktown (Residual)	Shallow to moderately deep hard-setting mottled texture contrast soils; red and brown podzolic soils on crests, draining to yellow podzolic soils on lower slopes and drainage lines. On gently undulating rises on Wianamatta Group Shales.	Most of the proposal area and near Memorial Avenue.
Luddenham (Erosional)	Shallow dark podzolic soils or massive earthy clays on crests; moderately deep red podzolic soils on upper slopes; moderately deep yellow podzolic soils and prairie soils on lower slopes and drainage lines. Landscape is undulating to rolling low hills on Wianamatta Group shales, often associated with Minchinbury Sandstone.	Small section of eastern end of proposal area and near Memorial Avenue and Windsor Road.

Source: Geological Series Sheet 9030 – Penrith 1991, Geological Survey of NSW, Department of Minerals and Energy

The Blacktown Soil Landscape is characterised by shallow to moderately deep (less than one metre) deposits of red and brown podzolic soils in more elevated areas, grading to yellow podzolic soils on lower slopes and drainage lines. This soil landscape tends to present poor soil drainage, is prone to waterlogging, and has

¹ Geological Series Sheet 9030 – Penrith 1991, Geological Survey of NSW, Department of Minerals and Energy

² www.asris.csiro.com.au , searched on 31st January 2014

localised moderate to strong subsoil salinity, is moderately reactive and highly plastic.

Luddenham soils are generally moderately deep (<1.5 metres) red podzols. These soils have high soil erosion hazard, are highly plastic and moderately reactive.

Geological and soil features are shown on Figure 6-9.

A geotechnical investigation was undertaken and found residual clays overlying shale and siltstone bedrock in the substance, with localised alluvial clay deposits in test locations near water courses. Intermittent topsoil profiles of around 0.2 metres depth were recorded. Well compacted fill layers ranging from 0.4 to 1.9 metres in depth from ground level were found in most test locations next to Memorial Avenue.

Alluvial soil deposits typically comprised brown, red brown and grey brown silty clays of medium to high plasticity. These clays were generally of firm to very stiff consistency at Elizabeth Macarthur Creek, and of very stiff to hard consistency in the areas adjacent to Strangers Creek. Alluvial soil profiles ranged from 1.8 to 2.6 metres in thickness.

Residual soil profiles were generally comprised of silty clays, pale grey to grey in colour with occasional orange brown and red brown mottling. These clays were typically of medium to high plasticity and of stiff to very stiff consistency. Fragments of extremely weathered shale were detected in the clay matrix directly overlying the soil-rock interface. Residual soil profiles ranged from 0.9 to 2.3 metres in thickness and were most prevalent around the approximate central high point of the alignment from Arnold Avenue West to Arnold Avenue East.

The bedrock comprised shale and siltstone, largely grey to dark grey with some brown and grey brown strata encountered in the upper weathered zones. The rock profile was typically of extremely low to low strength and extremely to moderately weathered at depths less than six metres. Below six metres depth the rock was slightly weathered and of medium to very high strength, with strength generally increasing with depth. Bedrock was encountered at depths ranging from 1.2 to 4.4 metres below ground level.

Contaminated land

Hyder Consulting prepared a Phase 1 Preliminary Contamination Assessment (Hyder 2014) (Appendix H). The investigation identified potential risks associated with contamination based on past and present uses in, and beside, the proposal area and to identify areas that may require remediation or management during construction.

The investigation was carried out in accordance with Office of Environment and Heritage (OEH) guidelines, including *Contaminated Sites – Guidelines for Consultants Reporting on Contaminated Sites* (OEH 2011), and standard industry practice.

The Phase 1 Environmental Site Assessment comprised a desktop proposal – including a review of historical information, such as aerial photographs and contaminated land databases – and development of a conceptual site model.

Based on the available information, and the size, location, layout and local setting of the area, it is likely that land use has historically been used for residential and small-scale agricultural activities. The probability is low that any industrial activities have

occurred within the proposal area. However, it is possible that underground infrastructure for storing fuel, oil or other chemicals has been present in the area. Furthermore, farming machinery requiring fuel, oil or other chemicals could present a risk of contamination from leakage.

The NSW Environmental Protection Authority (EPA) contaminated land database was also reviewed. There are no records of the proposal area or adjoining properties being registered as contaminated or having been notified to the NSW EPA as potentially contaminated. The closest property identified on the *Protection of the Environment Operations Act 1997* register of licences, applications and notices is about 2.1 kilometres east of the proposal area.

The following sites within or near the proposal area may contain contaminants:

- Former service station partially within the proposal area on the south-western corner of Memorial Avenue and Windsor Road
- Former service station partially within the proposal area on the northbound side of Windsor Road, opposite Wrights Road
- An operational service station beside the southbound carriageway on Windsor Road, about 60 metres south of Presidents Road
- The Hills Clinic Hospital
- Kellyville Memorial Park.

Other potential sources of contamination within the proposal area include localised areas of contamination from point sources such as oil and fuel spills from vehicles travelling along the existing road. The relatively flat topography of surrounding lots also indicates that imported fill may have been used to level the land. Any imported fill materials from unknown sources have the potential to contain contaminants and potentially affect the surface soils and groundwater.

Overall, the proposal area is generally considered to have a low to medium risk of harm to human health and the environment as a result of contaminants.

Acid sulfate soils

Disturbance of acid sulfate soils as a result of drainage, excavation or exposure can lead to the formation of sulfuric acid. The CSIRO Australian Soil Resource Information System indicates the proposal area has an 'extremely low' potential for acid sulfate soils to be encountered, shown on Figure 6-10.

Furthermore, due to the relatively shallow depth of the proposed work, construction is not expected to interact with acid sulfate soils. As a result, there is considered to be a very low potential for exposure of acid sulfate soils during construction.

Salinity

The Community Access to Natural Resource Information (CANRI) database identifies the salinity hazard for the proposal area. As shown in Figure 6-11, the proposal area is located within a 'localised hazard' zone with the areas beside main creeks having an 'extensive salinity hazard'. Notwithstanding this, no areas within the proposal area have been identified as having known salinity issues.

Memorial Avenue Upgrade - Review of Environmental Factors

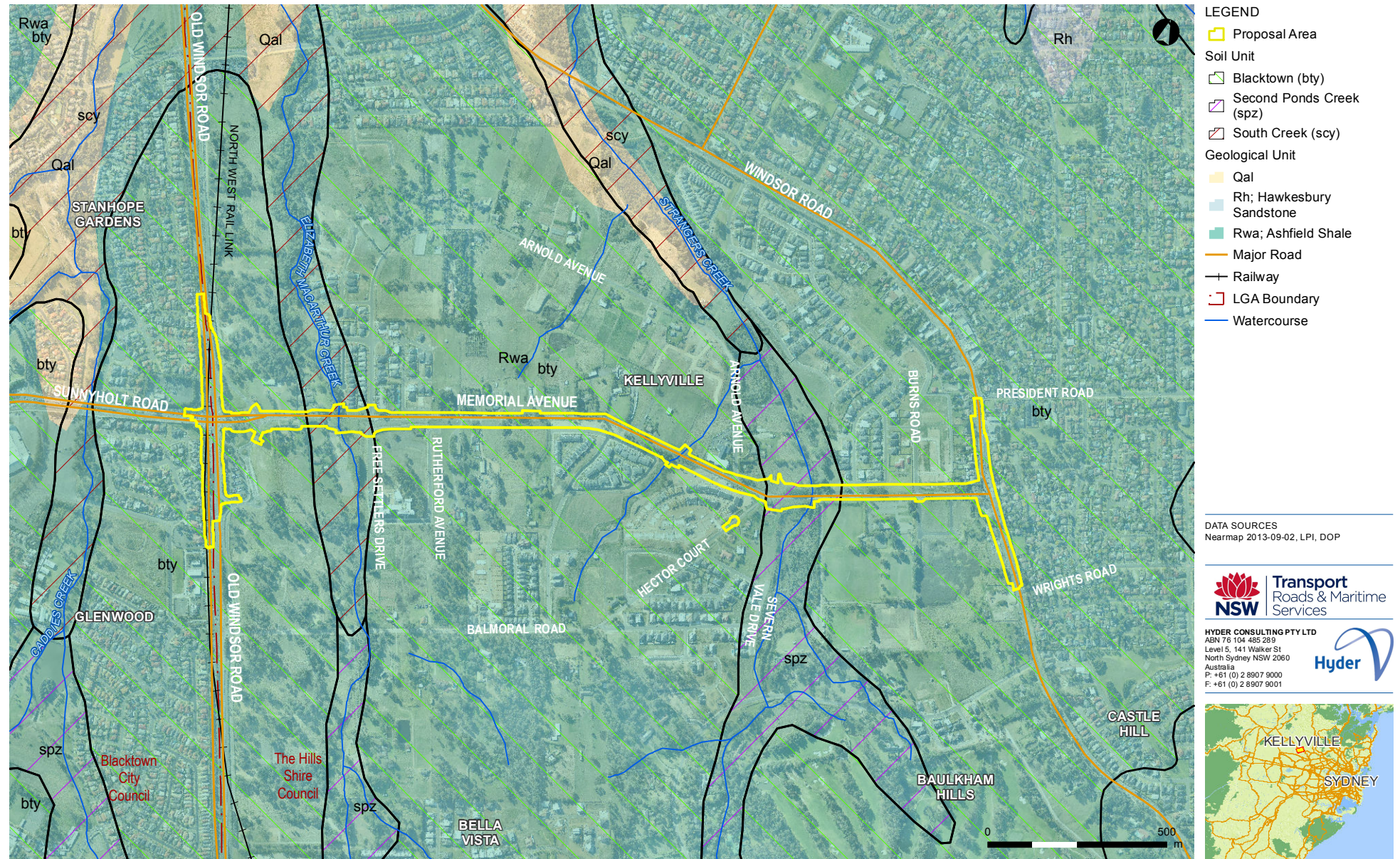


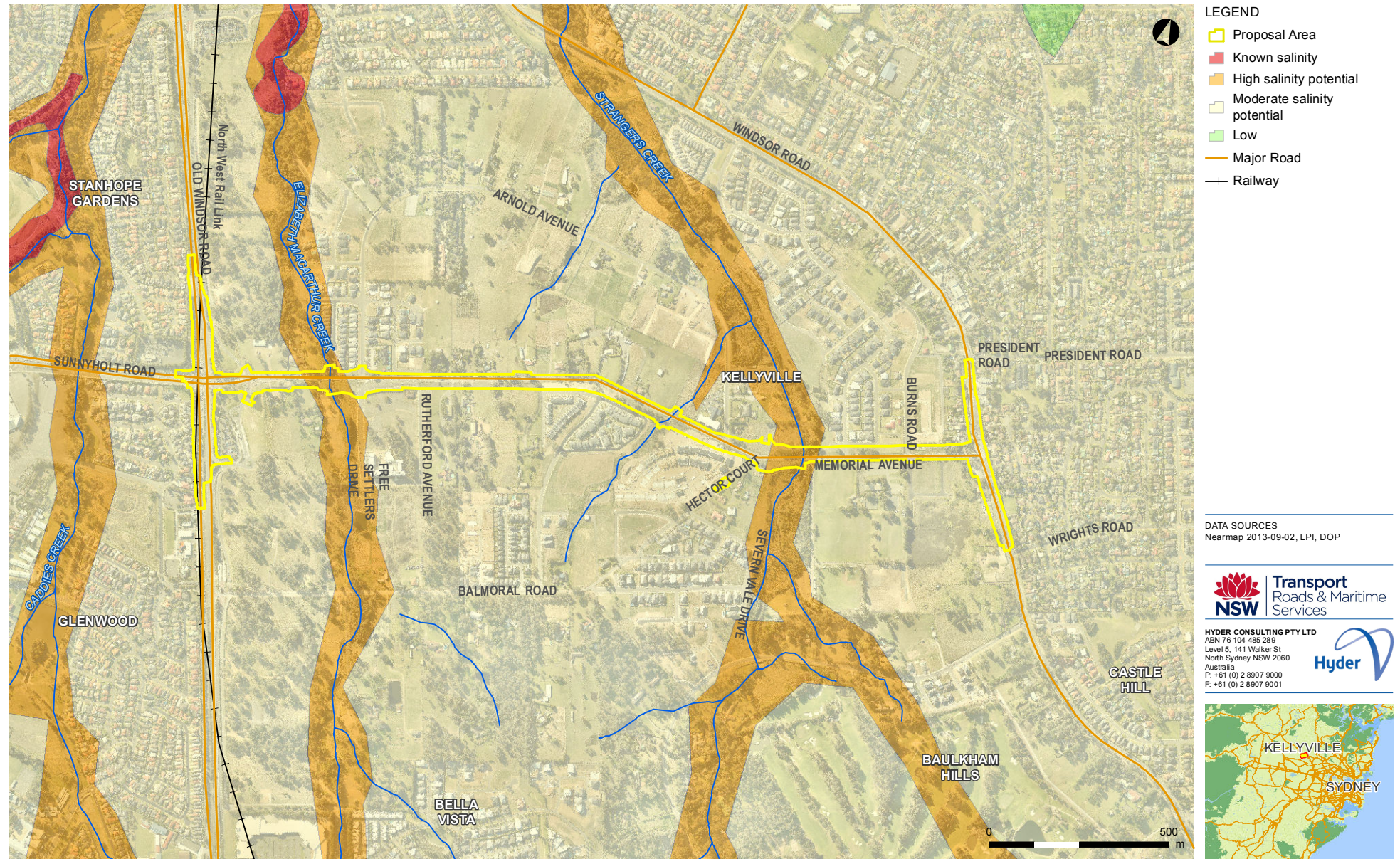
Figure 6-9: Geological and soil features in the proposal area

Memorial Avenue Upgrade - Review of Environmental Factors



Figure 6-10: Acid Sulfate soils in the proposal area

Memorial Avenue Upgrade - Review of Environmental Factors



6.2.2 Potential impacts

Construction

Building the proposal could have potential impacts relating to erosion and sedimentation, contaminated soils, acid sulphate soils, and salinity. These issues are outlined below.

Erosion and sedimentation

The potential impacts on soils, topography and geology would be primarily due to the erosion of exposed soils and stockpiles, and associated potential sedimentation of surrounding land and drainage lines. The soils and topography of the proposal area have been assessed as having moderate to very high erosion potential. Large areas of exposed soil have the potential to be eroded through wind and water leading to loss of topsoils and potential sedimentation of surrounding land and drainage lines. Construction activities with the potential to expose soils to erosion include vegetation removal and grubbing processes; removal of surfaces that provide protection from erosion (e.g. removal of the road surface); excavation and earthwork; and stockpiling of soils for later use in road construction.

Key areas of excavation with the potential to cause erosion and sedimentation are at the three cut locations (next to Rutherford Avenue/Thomas Boulton Circuit, east of the unnamed drainage line to about 40 metres east of Pellizzer Boulevard, and from about 40 metres east of the tributary of Strangers Creek to the intersection of Memorial Avenue and Severn Vale Drive). These cuts are a maximum of 700 millimetres high, and therefore would not create large areas of cut slopes or generate large volume of soil loss. They are also not located in the immediate vicinity of any known waterways, so pose only a minor potential impact to water quality impact if safeguards and mitigation measures are implemented.

There are three retaining walls proposed in the vicinity of known waterways. These are MW15 (in fill near Strangers Creek), MW14 (in fill near the tributary of Strangers Creek) and MW2L (in cut near the tributary of Strangers Creek). Up to 3 metres of fill is required at Strangers Creek, Elizabeth Macarthur Creek and the unnamed drainage line to raise the road alignment in order to be above the one in 100 flood level. About 1 metre of fill is also required at the tributary of Strangers Creek. Any exposed soils prior to stabilisation have the potential to be eroded through wind and water leading to potential sedimentation of the waterways.

Vegetation removal around Strangers Creek and Elizabeth Macarthur Creek has the potential to cause sedimentation of waterways through the destabilisation of the existing creek banks. This is more likely at the location of the proposed Strangers Creek bridge construction and during the removal of the existing culverts.

Managing Urban Stormwater: Soils and Construction (Landcom 2004) prescribes that a SWMP be developed for the site with provision for minimising erosion and capture of sediment laden stormwater with capacity to allow sediments to settle before any water discharge from site. As a part of the Hydrology and Hydraulics Assessment undertaken by Hyder (2014), an assessment was undertaken to develop an erosion and sediment control strategy.

Catchments for each construction stage have been calculated based on the current construction staging design. Given the topography of the site, and the two-stage construction approach, the catchments are typically small, resulting in low soil loss. There are four catchments along the alignment of the project, at Elizabeth Macarthur

Creek, Strangers Creek and two unnamed drainage lines. Elizabeth Macarthur Creek and Strangers Creek are the main areas for concern for sedimentation during construction.

There are two construction stages, which are broadly defined as:

- Stage 1 – Constriction of Westbound carriageway from Old Windsor Road to Severn Vale Drive, and construction of eastbound carriageway from Severn Vale Drive to Windsor Road. Traffic would remain on the existing carriageway.
- Stage 2 – Construction of westbound carriageway from Windsor Road to Severn Vale Drive, construction of eastbound carriageway from Severn Vale Drive to Old Windsor Road.

Stage one involves construction of the new carriageway offline and would involve the bulk of the earthworks. Stage 2 would involve construction of the new carriageway typically over the existing and would involve minimal earthworks. For the purposes of assessment of erosion and sedimentation control, Stage 1 involves the most risk as this is where cuts and fill would be carried out

An assessment of the provision of construction sedimentation basins has been carried out for the two stages, and has focused on the two named creeks. Typically the corridor is constrained and there is minimal space for basins to be constructed. Figure 6-12 and **Figure 6-12: Strangers Creek catchment and construction constraints**

detail the potential locations for basins and the constraints associated with them.

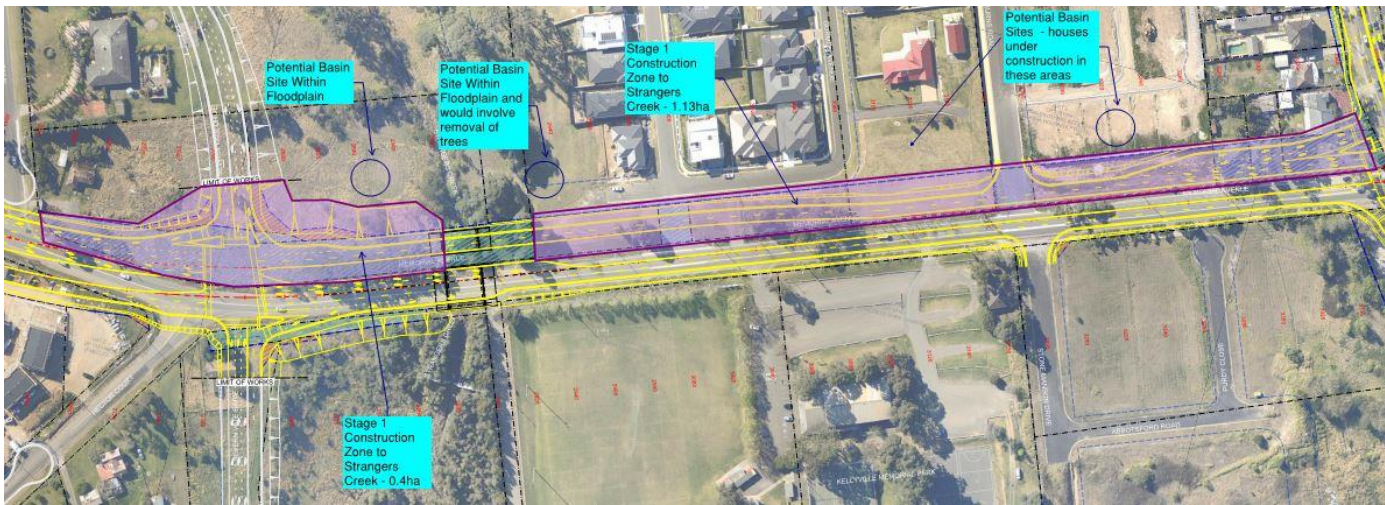


Figure 6-12: Strangers Creek catchment and construction constraints

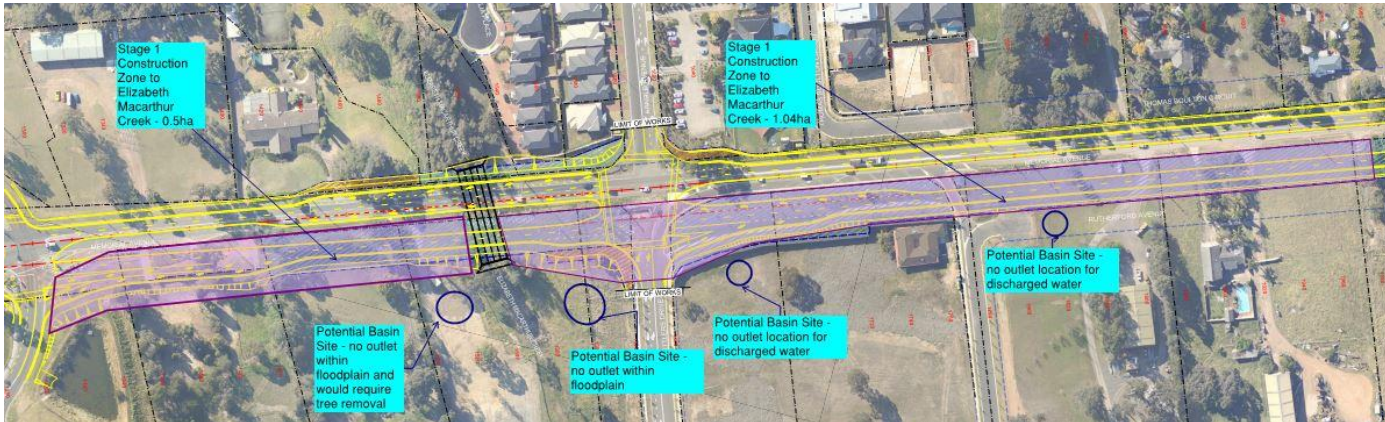


Figure 6-13– Elizabeth Macarthur Creek catchment and constraints

Soil loss has been calculated for the catchments draining to the named creeks, with the calculations provided in Table 6-6 below.

Table 6-6: Soil Loss

	B1580	B2460	B2850	B2900
Catchment Area	1.04	0.796	1.065	1.113
Soil loss (m ³ /ha/yr)	115	142	115	115
Estimate Annual Soil Loss (m ³ /yr)	122	113	122	128
Sediment basin storage volume, m ³	20	8	9	5

Soils and Construction – Managing Urban Stormwater” Volume 1 (Landcom, 2004) and Volume 2D (DECC, 2008) allows for localised erosion and sediment control measures to be used in the absence of large scale sediment retention basins where the average annual soil loss from a disturbed area, as derived by application of the “Revised Universal Soil Loss Equation” (RUSLE), is less than 150 cubic metres per annum. The results of the RUSLE equation calculations are provided in Table 6-6 show that soil loss per year is less than 150m³. Based on these calculations and the constraints depicted in the figures above, construction sedimentation basins are not proposed for this project.

The design has adopted conservative values for the assessment of construction sedimentation basins, and have used appropriate site data for topography and catchment definition. Based on the above the ERSED controls during construction could be managed with local controls and appropriate prevention of erosion rather than a reliance on sediment capture at outlets.

For the construction phase, the implementation of effective localised erosion and sediment control measures aimed at minimising erosion and the volume of sediment which is transported from disturbed areas would be key in the absence of any large scale sediment retention basins. Measures would include use of the following smaller scale elements:

- Temporary revegetation/rehabilitation works to reduce the extent of disturbed surfaces
- Application of temporary surface treatments or blanketing on exposed earth surfaces
- Sediment barriers and sumps, in series where necessary
- Vegetative buffer strips.

Erosion and sedimentation controls would be further addressed during detailed design in order to mitigate impacts during construction.

Contaminated soils

The proposal is likely to require excavation of soils on the former service station sites (one on the corner of Memorial Avenue and Windsor Road and one on Windsor

Road opposite Wrights Road). Both sites have the potential for soil contamination as a result of their previous use.

The contaminants of potential concern at each site, and potential receptors (i.e. area of potential impact), are summarised in Table 6-7.

Table 6-7: Contaminants of potential concern

Site description	Potential soil contaminants	Potential receptor
Former service station (corner of Memorial Avenue and Windsor Road)	Benzene, toluene, ethylbenzene, and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbons, phenols and lead	Groundwater Downstream water body habitats such as Strangers Creek Surrounding soil Construction workers during earthwork activities
Former service station (Windsor Road opposite Wrights Road)	As above (BTEX, PAHs, petroleum hydrocarbons, phenols and lead)	Groundwater. Downstream water body habitats such as Strangers Creek Surrounding soil Construction workers during earthwork activities.
Operational service station (Windsor Road near Presidents Road)	As above (BTEX, PAHs, petroleum hydrocarbons, phenols and lead)	Groundwater Downstream water body habitats Surrounding soil Construction workers during earthwork activities
The Hills Clinic Hospital	Biological, cytotoxic, clinical, chemical and pharmaceutical wastes	Construction workers during earthwork activities
Kellyville Memorial Park	Organochlorine pesticides (OCP)	Construction workers during earthwork activities

Further investigations would be required during detailed design to determine the risk of contamination, and provide guidance on potential treatment.

Construction work would also occur beside the operating service station on Windsor Road, near Presidents Road. The proposal has been designed to avoid any impacts on this service station, and there would not be a significant risk of encountering contaminants during construction.

There is also potential to encounter contaminated surface soil and fill materials near Kellyville Memorial Park, the Hills Clinic Hospital and locations where recent residential and commercial development has occurred.

To minimise impact, a Phase 2 Detailed Site Investigation would be carried out during detailed design. This would clarify the findings of the Phase 1 Preliminary

Contamination Assessment and identify specific areas needing remediation, and/or soil treatment before or during excavations.

Salinity

Excavation associated with construction would occur in localised areas of moderate to high potential salinity. Key risk areas are in the vicinity of Strangers Creek and Elizabeth Macarthur Creek. Excavations at these locations have the potential to change the local soil profile, which may expose more reactive and saline soils. Exposure to saline or more reactive soils may impact on the foundations for the twin bridges at Strangers Creek or the new culverts at Elizabeth Macarthur Creek. There is also moderate potential for exposure of saline soils at the tributary of Strangers Creek and the unnamed drainage line.

Saline soils can have a detrimental effect on vegetation growth and salinity can make soils unsuitable for reuse. Removal of large areas of vegetation has the potential to raise the groundwater table, which can increase soil salinity (see section 6.1.2).

Saline soils would be considered in the detailed design of the road with respect to damage to infrastructure and the suitability of excavated material for fill. During construction work the implications of salinity on the road would continue to be considered.

Operation

The proposal, when built, would not present an erosion risk as all exposed soils would have been revegetated, so the proposal would be unlikely to contribute to sediment loading within the adjacent waterways. Given that the proposal would not be a direct cause of additional pollutant generation in the area pavement runoff would not be subject to water quality treatment prior to discharge to downstream watercourses. The adjacent developments would be required to provide stormwater management, including water quality improvements, which would ultimately benefit the surrounding waterways. Standard Roads and Maritime environmental management procedures would be implemented during operation.

6.2.3 Safeguards and management measures

The safeguards and management measures outlined in Table 6-8 would be implemented before and during construction of the proposal to minimise impacts on topography, geology and soils.

Table 6-8: Proposed safeguards and management measures for topography, geology and soils

Impact	Environmental safeguards	Responsibility	Timing
Erosion and sediment control	<ul style="list-style-type: none"> • During detailed design an Erosion and Sedimentation Management Report is to be prepared. The report is to include (as a minimum): <ul style="list-style-type: none"> - Identify site catchment and sub-catchments, high risk areas and sensitive areas - Sizing of each of the above areas and catchments - Proposed staging plans for the project to ensure appropriate erosion and sediment controls measures are possible 	Roads and Maritime	Detailed design

Impact	Environmental safeguards	Responsibility	Timing
	<ul style="list-style-type: none"> - The likely volume of run-off from each catchment and sub-catchment in accordance with the Managing Urban Stormwater: Soils and Construction, Volume 1 and 2 (Landcom, 2004) - Direction of water flow, both off and on site - Diversion of off-site water around or through the site or details of separation of on-site and off-site water - The direction of runoff and drainage points during each stage of construction - The locations and sizing of sediment basins / sumps as well as associated drainage to direct site water to the basin or sumps - A mapped plan identifying the above at all major construction stages - A review process by a soil conservationist and a process for updating the report to address any recommendations 		
Erosion and sediment control	<ul style="list-style-type: none"> • A soil conservationist from the Roads and Maritime Erosion, Sedimentation and Soil Conservation Consultancy Services Register would be engaged to review the Erosion and Sedimentation Management Report. 	Roads and Maritime	Detailed design
Erosion and sediment control	<ul style="list-style-type: none"> • An Erosion and Sedimentation Control Plan (ESCP) would be prepared prior to construction and is to include as a minimum: <ul style="list-style-type: none"> - Identify site catchment and sub-catchments, high risk areas and sensitive areas - Sizing of each of the above areas and catchments - The likely run-off from each sub-catchment - Separation of on-site and off-site water - The direction of run-off and drainage points during each stage of construction - Direction of flow of on-site and 	Contractor	Prior to construction

Impact	Environmental safeguards	Responsibility	Timing
	<p>off-site water</p> <ul style="list-style-type: none"> - The locations and sizing of sediment basins or sumps and associated catch drains and/or bunds - The locations of other erosion and sediment control measures (eg rock check dams, swales and sediment fences) - Controls/measures to be implemented on wet weather events - A mapped plan identifying the above - A dewatering procedure for onsite water and basins - A process for reviewing and updating the plan on a fortnightly basis and/or when works alter. 		
Erosion and sediment control	<ul style="list-style-type: none"> • Wet weather plans for a rain event would be included and shown on the ESCPs outlining the controls to be implemented in preparation for a rain event. 	Construction contractor	Pre-construction and construction
Erosion and sediment control	<ul style="list-style-type: none"> • Environmental Work Method Statements (EWMS) would be prepared for high-risk activities such as: <ul style="list-style-type: none"> - Clearing and grubbing - Earthwork - Temporary creek diversions - Work within 20 meters of a creek or drainage line. - Drainage work - Utilities relocations - Bridge and culvert construction. <p>Environmental Work Method Statements (EWMS) would include:</p> <ul style="list-style-type: none"> - Description of the work/activities and machinery - Outline of the sequence of the work/activities, including interfaces with other construction activities - Identification of potential environmental risks/impacts due to the work/activities and associated with wet weather 	Construction contractor	Pre-construction and construction

Impact	Environmental safeguards	Responsibility	Timing
	<p>events</p> <ul style="list-style-type: none"> - Evaluation of methods to eliminate/reduce the environmental risk - Mitigation measures to reduce environmental risk. - Any safeguards resulting from consultation with public authorities and other stakeholders, where appropriate - A map indicating sensitive locations, likely potential environmental impacts, and work areas - Identification of work areas and exclusion areas - Operational and monitoring measures to reduce environmental impact - A process for assessing and reporting the performance of the implemented environmental control measures - A process for resolving environmental issues or conflicts and reporting outcomes. 		
Erosion and sediment control	<ul style="list-style-type: none"> • A Stabilisation Plan is to be prepared and included in the SWMP. The stabilisation plan is to include but not be limited to the following: <ul style="list-style-type: none"> - Identification and methodology of techniques for stabilisation of site. - Identification of area on site for progressive stabilisation. - Stabilisation is to be undertaken of areas, including stockpiles and batters, exposed for a duration of 2 weeks or greater. For example covering with geotextile fabric, stabilised mulch, soil binder or spray grass. - Identification of areas on site for progressive permanent 	Contractor	Prior to construction

Impact	Environmental safeguards	Responsibility	Timing
	stabilisation such as implementation of landscaping		
Erosion and sediment control	<ul style="list-style-type: none"> Localised erosion and sediment control measures would also be implemented to minimise erosion and the volume of sediment transported from disturbed areas. Measures would include use of the following elements: <ul style="list-style-type: none"> Temporary revegetation /rehabilitation work to reduce the extent of disturbed surfaces Temporary surface treatments or blanketing on exposed earth surfaces Sediment barriers and sumps, in series where necessary Vegetated buffer strips. 	Construction contractor	Pre-construction and construction
Erosion and sediment control	<ul style="list-style-type: none"> Control measures would be implemented at egress points to minimise dirt and mud tracking. 	Construction contractor	Construction
Erosion and sediment control	<ul style="list-style-type: none"> All stockpiles would be designed, established, operated and decommissioned in accordance with <i>Roads and Maritime Stockpile Management Procedures</i> (RMS 2011a). Stockpile sites would be located: <ul style="list-style-type: none"> At least 50 metres from the nearest waterway In an area of low ecological and heritage conservation significance On relatively level ground Outside the 1 in 10-year ARI floodplain. 	Construction contractor	Construction
Erosion and sediment control	<ul style="list-style-type: none"> Topsoil would be stockpiled separately for possible reuse in landscaping and rehabilitation. 	Construction contractor	Construction
Erosion and sediment control	<ul style="list-style-type: none"> An accredited soil conservationist would be engaged to regularly inspect work throughout the construction phase. 	Construction contractor	Construction

Impact	Environmental safeguards	Responsibility	Timing
Erosion and sediment control	<ul style="list-style-type: none"> Any material transported onto road surfaces would be swept and removed at the end of each working day and before rainfall. 	Construction contractor	Construction
Contamination	<ul style="list-style-type: none"> A Stage 2 – Detailed site investigation in accordance with NSW EPA guidelines would be prepared and would include preparation of a sampling, analysis and quality plan in accordance with the Roads and Maritime Contaminated Land Management Guidelines. This plan would include site specific sampling and analysis of soil at the site on the corner of Old Windsor Road and Memorial Avenue. 	Roads and Maritime	Detailed design
Contamination	<ul style="list-style-type: none"> Following the Stage 2 – Detailed site investigation, a Contaminated Land Management Plan would be prepared in accordance with the <i>Contaminated Land Act 1997</i> and relevant EPA Guidelines as part of the CEMP and would include: <ul style="list-style-type: none"> - Outline of occupational health and safety measures - Contamination management measures. - Incident reporting in accordance with the RMS Environmental Incident Management Procedure. - Identification of rehabilitation requirements, classification, transport and disposal requirements of any contaminated land within the construction footprint. - In the event that indications of contamination are encountered (known and unexpected, such as odorous or visually contaminated materials), work in the area would cease until a contamination assessment can be prepared to advise on 	Roads and Maritime	Detailed design

Impact	Environmental safeguards	Responsibility	Timing
	the need for remediation or other action, as deemed appropriate.		

6.3 Traffic and transport

The Traffic and Transport Assessment of the proposal (refer Appendix C of this REF) considered existing traffic around the proposal area and modelled the future traffic performance under the proposed Memorial Avenue upgrade. The study supported the development of the REF and identified potential traffic impacts on the road network from the proposal.

The traffic modelling assessment:

- Identified key network issues affecting the performance of Memorial Avenue and adjoining roads
- Determined the level of service of the proposed upgrade taking into account expected traffic growth for 2019, 2026 and 2036
- Identified interim and long-term options for improvements to traffic flow on Memorial Avenue and associated intersections
- Identified the timing of interim and long-term intersection upgrades required at the Memorial Avenue/Windsor Road and Memorial Avenue/Old Windsor Road/Sunnyholt Road intersections.

The study area for the Traffic and Transport Assessment is shown in

Figure 6-14.

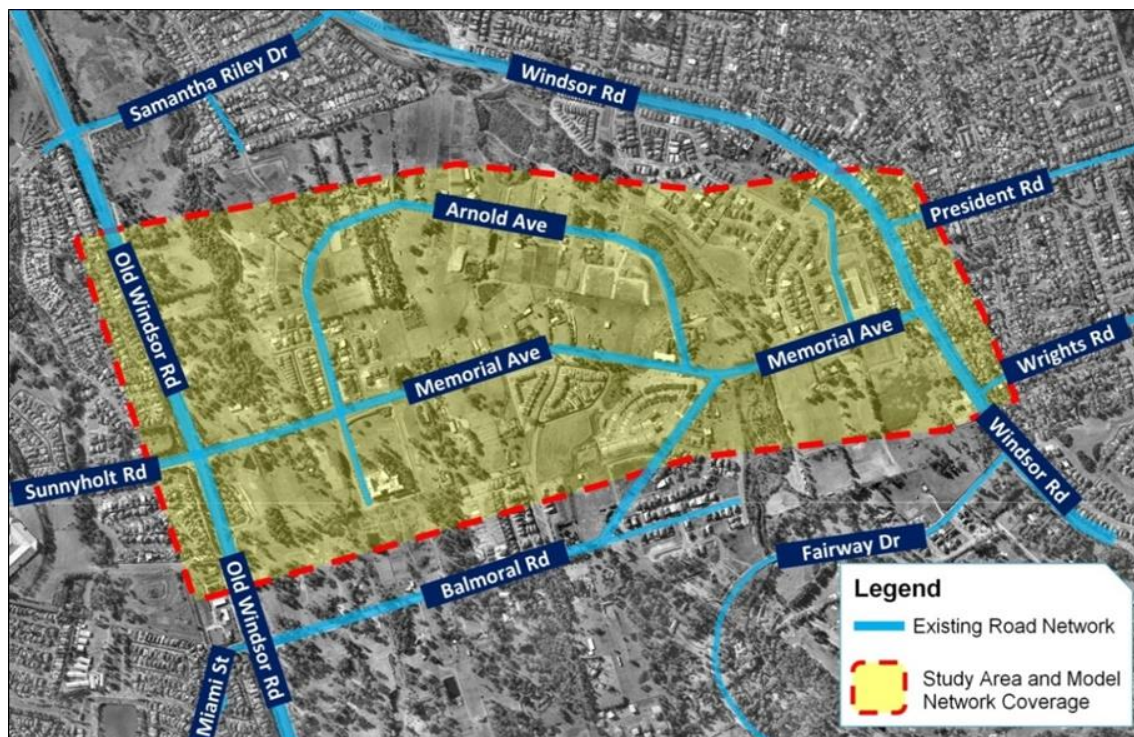


Figure 6-14: Traffic modelling study area

6.3.1 Existing environment (traffic and transport conditions)

Route and speed environment

Memorial Avenue is a two-lane, two-way road. It is a key strategic route that provides east–west access to Blacktown, Glenwood, Stanhope Gardens, Parklea, Baulkham Hills, Castle Hill and Kellyville and a connection between Windsor Road and Old Windsor Road. It carries about 25,000 vehicles per day and is a designated B-double route for vehicles up to 26 metres.

The posted speed limit on Memorial Avenue is 60 kilometres per hour between Arnold Avenue and Windsor Road and 70 kilometres per hour between Old Windsor Road and Arnold Avenue. Near the study area, a 60 kilometres per hour speed limit applies to Windsor Road and an 80 kilometres per hour speed limit applies to Old Windsor Road.

Road hierarchy

Within the study area, Memorial Avenue, Old Windsor Road and Windsor Road are State Roads. Arnold Avenue and Balmoral Road are local roads. The road hierarchy is shown in Figure 6-15.

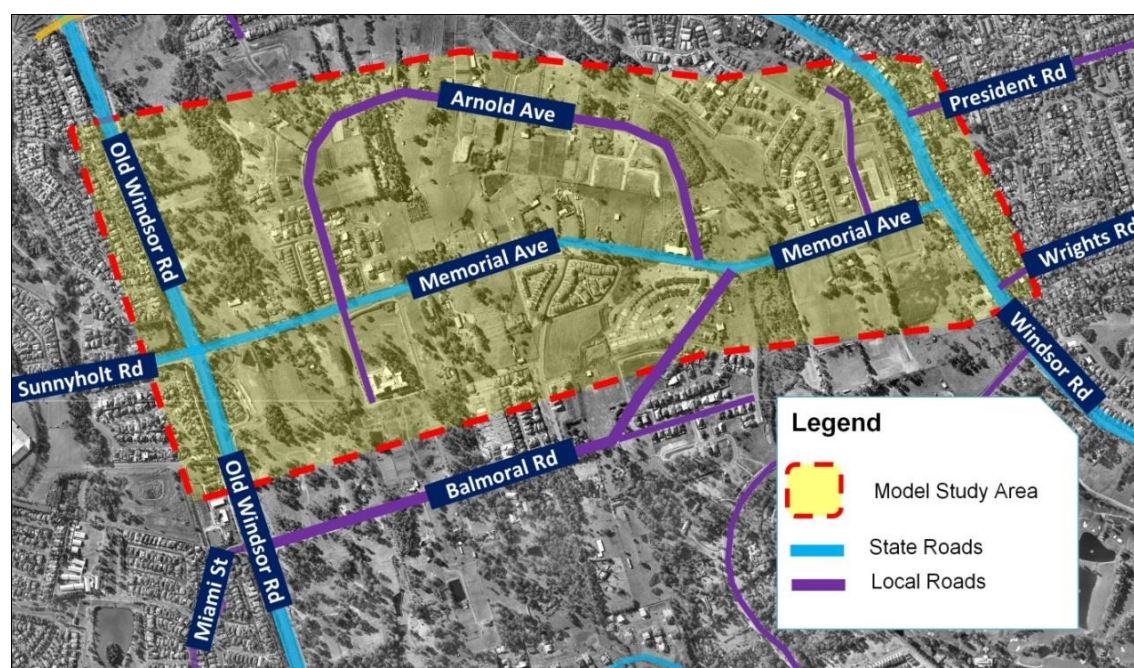


Figure 6-15: Road hierarchy in the study area (Source: Classified Roads Map Greater Sydney Area, Roads and Maritime Services 2011)

Travel patterns

The Bureau of Transport Statistics (BTS) provides journey to work data for the Sydney Greater Metropolitan Area (GMA). The data contains a comprehensive sample of commuter travel, collected during the 2011 Census. Table 6-9 summarises the work trips by mode of travel reported for the study area.

Table 6-9: Commuter mode share, Memorial Avenue study area

Travel mode	Outbound trips from study area	% Outbound trips	Inbound trips to study area	% Inbound trips
Car driver	380	67%	323	75%
Car passenger	31	5%	18	4%
Train	27	5%	5	1%
Bus	45	8%	8	2%
Walked only	6	1%	4	1%
Other	5	1%	3	1%
Worked at home/ Did not travel/ Not stated	74	13%	70	16%
Total	569	100%	432	100%
Selected travel zones (TZ11): 4568,4567,4572,4571,4513				
2006 TZ Travel zones: 2715, 2718, 2808				

Source: Bureau of Transport Statistics 2011

Analysis of travel patterns from the journey to work data indicates that:

- About 41 per cent of the study area's workers live and work within The Hills Shire Council local government area (LGA)
- Inbound work trips from outside the LGA are generally from Blacktown and Rouse Hill, which account for some 24 per cent of total trips
- A significant proportion of morning and afternoon peak trips to/from the study area have an origin or destination in the surrounding LGAs (including Blacktown and Parramatta)
- About 73 per cent of the study area's residents travelled outside of The Hills Shire LGA for work purposes. Of those, about 11 per cent travelled to Central Sydney and 10 per cent were to Parramatta.

Public transport

The study area is primarily serviced by Hills Buses. Route 619 runs along Memorial Avenue, providing services between Rouse Hill and Macquarie Park. Most services passing through the study area traverse Old Windsor Road and Windsor Road, to reach destinations to the north and south. Details of the bus network are in 2.2.4.

The Memorial Avenue Transitway is located in the south-eastern corner of the Old Windsor Road/Memorial Avenue intersection and is an important intermediate location served by bus.

The study area currently has no direct rail service. The nearest railway station is Blacktown, about 10 kilometres away. There is no direct bus service connecting the study area and Blacktown station.

Walking and cycling

There is no dedicated footpath along Memorial Avenue. Pedestrians and cyclists currently use either the grass verge or road. Pedestrian crossings are at intersections with Old Windsor Road and Windsor Road.

Cyclists currently use the road shoulder along Memorial Avenue. There are designated off-street cycle paths along Old Windsor Road in both directions. There is a pedestrian path on the western side of Windsor Road, but no dedicated cyclist facilities.

Heavy vehicles

Heavy vehicles were counted on Memorial Avenue where it crosses Strangers Creek and Elizabeth Macarthur Creek. The number of heavy vehicles in the study area ranges from 1300 to 1700 vehicles per day on weekdays, depending on the location. The proportion of heavy vehicles on Memorial Avenue was found to be about six to seven per cent of total traffic.

Crash data

Roads and Maritime provided crash data for the five years from July 2007 to June 2012. The crash data includes Memorial Avenue for its entire length (2.2 kilometres) and the intersections with Windsor Road and Old Windsor Road.

Section 2.1 details the crash data for the study area. The highest number of crashes was reported at intersections, with rear-end crashes the most common.

Traffic surveys

Traffic surveys were completed in February 2014 to support the Traffic and Transport Assessment including:

- Intersection turning movement counts for critical peak periods
- Daily automatic traffic counts on midblock locations for a one week period
- Queue length surveys at critical intersections
- Midblock traffic counts for a one-week period
- Origin–destination (OD) survey
- Travel speed survey.

The findings of the traffic surveys are summarised below. (Detailed information from the traffic survey is in the Traffic and Transport Assessment in Appendix C).

Weekly traffic profile

The average daily traffic volumes in the study area for weekdays and weekends indicate that:

- Memorial Avenue carries about 25,000 annual average daily traffic (AADT) vehicles per day on critical day (Friday)
- Average weekend traffic is about 18 per cent lower than weekday traffic.

Daily traffic profile

The traffic profile suggests morning and afternoon peak hour durations as follows:

- Morning (AM) peak between 7–9am
- Afternoon (PM) peak between 4–6pm.

Peak hour traffic volumes at key intersections

Figure 6-16 shows peak hour turning volumes at the two key intersections at Windsor Road / Memorial Avenue and Old Windsor Road / Memorial Avenue / Sunnyholt Road. The following points are noted from peak hour volumes shown:

- There is heavy through traffic (1000 vehicles per hour) from Sunnyholt Road to Memorial Avenue during the AM peak
- There is heavy right-turn traffic (1000 vehicles per hour) from Memorial Avenue to Windsor Road during the AM peak
- There is heavy left-turn traffic (750 vehicles per hour) from Windsor Road to Memorial Avenue during the PM peak
- There is heavy right-turn traffic (800 vehicles per hour) from Memorial Avenue to Sunnyholt Road during the PM peak
- There is heavy right-turn traffic from Memorial Avenue to Windsor Road (1000 vehicles per hour), which is opposed by the heavy southbound through traffic (2000 vehicles per hour) during the AM peak.

Factors contributing to traffic congestion include the high through traffic on Windsor Road, Memorial Avenue, Sunnyholt Road and Old Windsor Road, as well as the relatively high turning traffic into and out of these roads.

(Detailed turning volumes for the AM and PM peak hour for all surveyed locations are shown in Appendix C.)

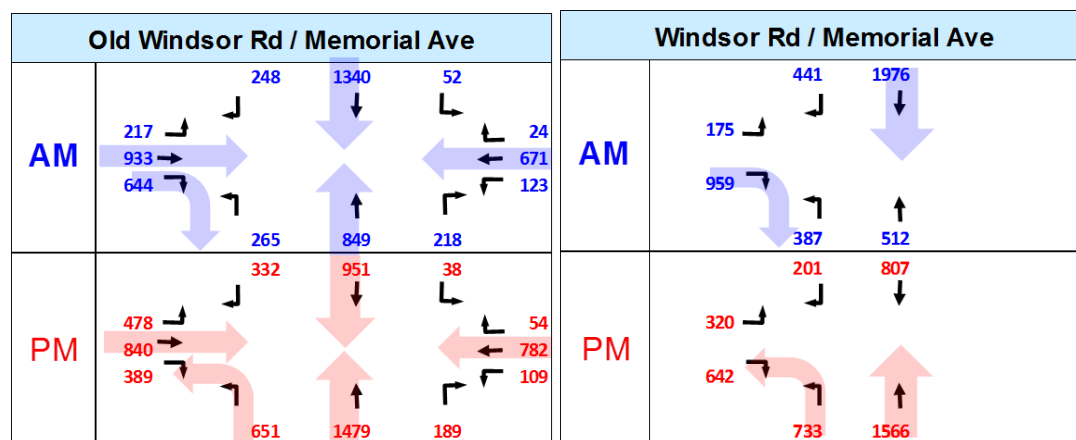


Figure 6-16: Peak hour turning volumes for two key intersections

Origin–destination patterns

The origin–destination trip patterns to and from the study area were estimated using the origin–destination survey. Significantly, about 90 per cent of all traffic passing through Memorial Avenue has origins and destinations outside the study area.

Travel speeds on Memorial Avenue

Travel speed data is presented in Table 6-10, which shows that in both the AM and PM peaks, travel speeds reduce significantly along the section of Memorial Avenue between Old Windsor Road and Windsor Road. Speeds can be up to 25 kilometres per hour less than the posted speed limit of 60 or 70 kilometres per hour.

Table 6-10: Travel speeds on Memorial Avenue

Direction	Time Period	Travel speed on Memorial Avenue (km/h)		
		Maximum	Minimum	Average
Eastbound	AM peak	60	20	38
	PM peak	62	31	45
Westbound	AM peak	55	19	33
	PM peak	51	13	22

6.3.2 Traffic modelling

The Traffic and Transport Assessment modelled the current transport network performance, as well as the future traffic performance under the proposed upgrade. The results of the assessment are in Appendix C and summarised below.

Existing network capacity

Substantial traffic delays occur in both the morning and afternoon peak periods, resulting in long traffic queues along Old Windsor Road, Windsor Road, Sunnyholt Road and Memorial Avenue. Long delays are caused by capacity constraints at the intersections of Old Windsor Road/Sunnyholt Road/Memorial Avenue and Windsor Road/Memorial Avenue intersections. Figure 6-17 shows queue lengths (shown in red) for both AM and PM peak hours.

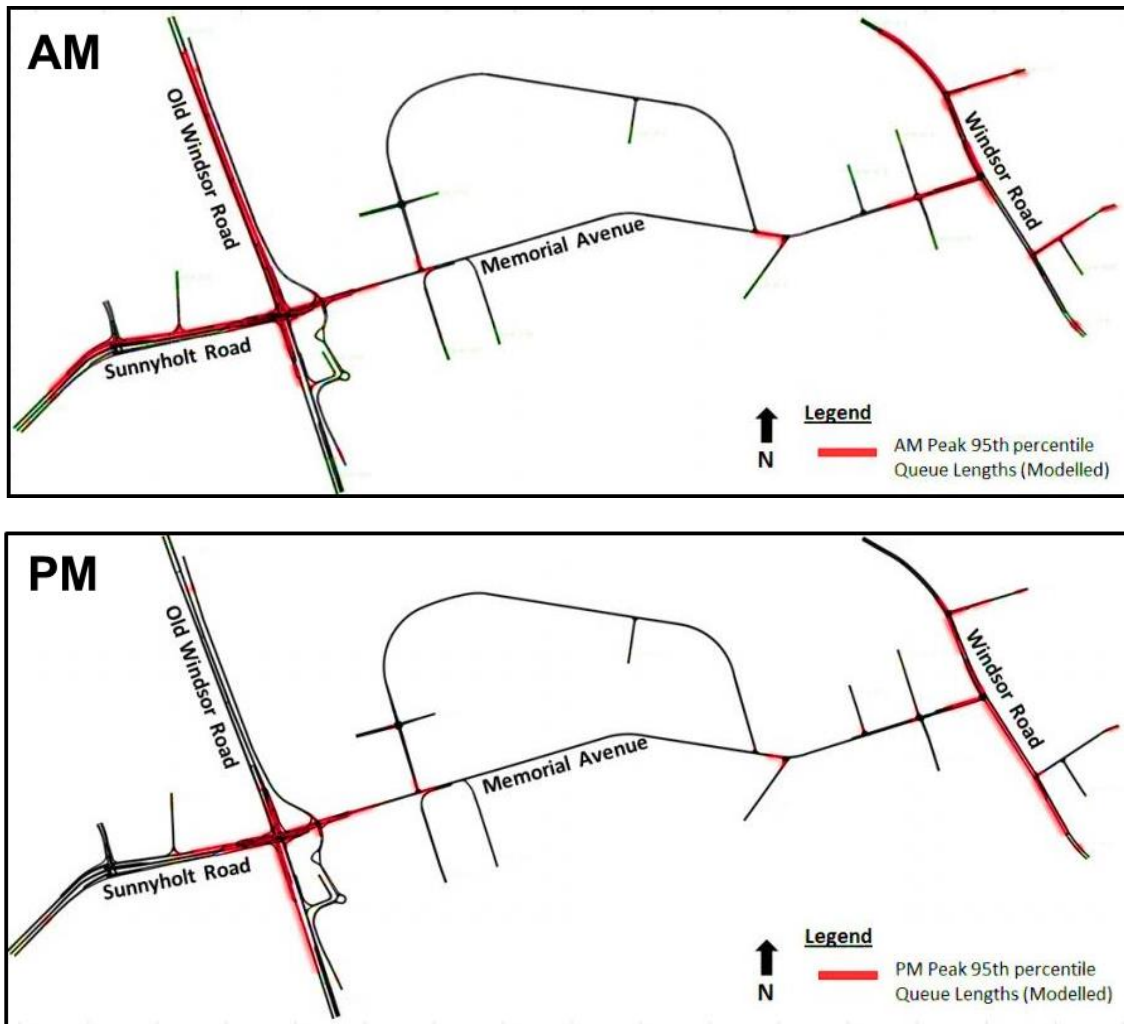


Figure 6-17: Existing queue lengths at critical parts of the network in the AM and PM peak

The existing network capacity was further investigated for eight key intersections. Level of service (LoS) of these intersections was reported in accordance with the Roads and Maritime guideline, *Guide to Traffic Generating Developments*, Issue 2.2 (Roads and Maritime, October 2002).

The guidelines recommend that for priority intersections such as a roundabout and sign-controlled intersections, the LoS value is determined by the critical movement with the highest delay whereas, for an intersection with traffic signals, LoS criteria relate to the average intersection delay measured in seconds per vehicle.

The performance of an intersection is measured by the intersection average delay per vehicle, which in turn leads to a LoS measure for the intersection. These measures are:

- LoS A – average delay per vehicle is less than 14 seconds. Good operation
- LoS B – average delay per vehicle is between 15 and 28 seconds. Good operation with acceptable delays and spare capacity
- LoS C – average delay per vehicle is between 29 and 42 seconds. Satisfactory operation

- LoS D – average delay per vehicle is between 43 and 56 seconds. Operating near capacity
- LoS E – average delay per vehicle is between 57 and 70 seconds. Operating at capacity; incidents at signals will cause excessive delays
- LoS F – average delay per vehicle is more than 70 seconds. Extra capacity required.

Table 6-11 shows existing (2014) LoS results for the eight intersections assessed for both the AM and PM peak hours. Note: I-3 and I-4 are at the extents of the proposed works, upgrades to these intersections do not form part of this proposal.

The modelling predicts:

- LoS F (over capacity) at the Old Windsor Road/Memorial Avenue/Sunnyholt Road intersection in both the AM and PM peak periods
- LoS D (near capacity) at the Windsor Road/Memorial Avenue intersection.

Table 6-11: Existing level of service results at six key intersections

ID	Intersection	Control type	AM peak (8 9)		PM peak (5 6)	
			Delay (sec)	LoS	Delay (sec)	LoS
I-1	Old Windsor Road / Memorial Avenue / Sunnyholt Road	Signal	155	F	74	F
I-2	Windsor Road / Memorial Avenue	Signal	53	D	50	D
I-3	Windsor Road / President Road	Signal	78	F	16	B
I-4	Windsor Road / Wrights Road	Priority (Sign)	70	E	45	D
I-5	Arnold Avenue (West) / Memorial Avenue	Priority (Sign)	29	C	53	D
I-6	Arnold Avenue (East) / Memorial Avenue	Priority (Sign)	20	B	16	B
I-7	Memorial Avenue / Hector Court	Priority (Sign)	21	B	21	B
I-9	Memorial Avenue / T-way	Signal	20	B	35	C

Future traffic volumes on Memorial Avenue

Estimates of future traffic volumes on Memorial Avenue have taken into account passing traffic growth due to land developments in the North West Growth Centre, new development traffic from about 5400 dwellings proposed in the Balmoral Road Release Area, and potential reduction of car mode attributable to the North West Rail Link.

Average daily traffic forecasts were prepared for three future years of 2019, 2026

(interim) and 2036 (ultimate). It was found that:

- In 2019, average traffic on Memorial Avenue is forecast to be about 33,000 vehicles per day
- By 2026, average traffic on Memorial Avenue is forecast to be about 42,000 vehicles per day
- By 2036, average traffic on Memorial Avenue is forecast to be about 45,000 vehicles per day, almost double that of today's traffic (25,000).

Access

Roads within the study area provide access to:

- Private driveways
- Gracelands Early Education Centre on the corner of Memorial Avenue and Arnold Avenue
- Kellyville Memorial Park, Northwest Polecats Rugby Club, iPlay Tennis Academy, Jigsaw Dance Studio and the Hills Clinic psychiatric hospital
- Various retail premises (including Repco and Caltex on Windsor Road).

6.3.3 Potential impacts

Construction

During construction, the proposal would have temporary traffic impacts on nearby roads. Impacts would result from the hauling of construction materials, and from service vehicles travelling along Memorial Avenue, service roads and access roads. During construction, truck movements are expected to increase by 100 to 150 movements per day. However, truck movements may increase by 200 to 250 movements per day at certain stages of construction; for example, during cut and fill work associated with the two significant cuts between Arnold Avenue and Severn Vale Drive, and significant fills at Severn Vale Drive and between the two significant areas of cut.

Potential impacts caused by construction vehicle traffic would include:

- Increased travel times due to reduced speed limits around construction sites
- Increased travel times due to increased truck and construction machinery movements
- Temporary partial or complete closure of roads with the potential for related increased travel times due to the need for short detours
- Temporary, short-term alterations to property access
- Traffic switching in areas where the upgrade impacts parts of the existing road surface.

Existing access arrangements would be maintained where possible to properties on Memorial Avenue during construction. Alternative temporary access would be provided where required.

Overall, the additional traffic associated with construction activities would be temporary and would not result in a substantial increase on existing vehicle numbers.

Depending on project timing and staging, there is the potential for several other developments near the proposal area to be under construction at the same time, thereby increasing the traffic impacts outlined above.

Mitigation measures to manage these potential impacts are described in Section 6.3.4.

Public transport

Potential impacts on bus services would include temporary increased travel times as well as temporary or permanent relocation of bus stops along Memorial Avenue. Construction staging would cause temporary lanes closures, whilst allowing traffic flow to continue along Memorial Avenue; however there may be delays due to construction traffic and deliveries. Bus stops would be temporarily relocated, where required, to allow access whilst construction works are being undertaken. Access to the T-way would not be impacted during construction.

Walking and cycling

Currently, pedestrians and cyclists utilise the verge or road as there is no dedicated pathway along Memorial Avenue. Temporary pedestrian and cyclist access would be maintained during construction, however, delays and inconveniences may be experienced due to altered access and increased travel times.

The widening of Old Windsor Road would require the relocation of the existing shared path to the west (next to the northbound lane). Temporary alternate pedestrian and cyclist access would be provided during construction. Existing paths and access would be maintained on Windsor Road and Old Windsor Road southbound as well as local roads accessed from Memorial Avenue.

Access

Access to individual properties may be affected by construction activities. Properties that are likely to be impacted include private residences/driveways; public areas (such as the Kellyville Memorial Park); the Hills Clinic psychiatric hospital; and business and retail premises (such as Repco, the Caltex service station, the Northwest Polecats Rugby Club, iPlay Tennis Academy, Jigsaw Dance Studio and a proposed supermarket on Memorial Avenue.

Impacts would include temporary detours and diversions.

Operation

Traffic impacts

Under the proposal, major changes to the road configuration would include:

- Upgrade of the intersection at Old Windsor Road / Memorial Avenue / Sunnyholt Road
- Upgrade of the intersection at Windsor Road / Memorial Avenue
- Establishment of traffic signals at the intersection of Arnold Avenue (West) / Memorial Avenue
- Establishment of a new intersection with traffic signals at Memorial Avenue / Severn Vale Drive and closure of Hector Court at Memorial Avenue

The traffic impacts associated with these changes have been estimated based on the modelling carried out for the Traffic and Transport Assessment (Appendix C). Table 6-12 outlines the changes to LoS and traffic delays at key intersections for the existing year (2014) as well as years 2019, 2026 and 2036. Diagrams of each of the proposed intersection layouts are shown in Section 3.3.3.

Table 6-12: Modelled level of service and delays at key intersections

Ref #	Intersection name	Time (AM/PM)	Existing (2014)	2019	2026	2036
			Level of service / delay (seconds)			
1	Old Windsor Road / Memorial Avenue / Sunnyholt Road	AM	F/155	E/69	F/104	-
		PM	F/74	E/62	F/72	-
2	Windsor Road / Memorial Avenue	AM	D/53	D/42	D/47	D/49
		PM	D/50	C/36	C/39	C/39
3	Arnold Avenue (West) / Memorial Avenue	AM	C/29	C/37	D/50	F/102
		PM	D/53	B/26	C/32	C/40
4a*	Memorial Avenue / Hector Court (existing intersection/no-change scenario)	AM	B/21	F/>100	F/>100	F/>100
		PM	B/21	F/>100	F/>100	F/>100
4b*	Memorial Avenue / Severn Vale Drive (proposed intersection)	AM	-	C/35	C/42	D/52
		PM	-	C/34	C/41	D/45

* The existing Memorial Avenue / Hector Court intersection would be closed under the proposal and access to this area would be via the proposed Memorial Avenue/Severn Vale Drive intersection. LoS under a no-change scenario has been modelled to allow comparison of performance of a no-change scenario and the upgrade.

As indicated in Table 6-12 (above), the proposal would result in positive traffic impacts at the four major intersection upgrades upon opening. At these intersections, the LoS and delay times would be better than the current (2014) performance. These benefits are described below.

Old Windsor Road / Memorial Avenue / Sunnyholt Road

At-grade upgrades to the existing traffic signals at Old Windsor Road / Memorial

Avenue / Sunnyholt Road intersection would substantially improve traffic capacity and LoS upon opening. The proposed upgrade to this intersection would have a service life up to 2026, based on current modelling.

Windsor Road / Memorial Avenue

The proposed at-grade upgrades to existing traffic signals at the Windsor Road/Memorial Avenue intersection would substantially improve traffic capacity and LoS. With upgrades in place, the model forecasts acceptable LoS C and D in 2036 for the AM and PM peak periods. Following completion of upgrade, the Windsor Road / Memorial Avenue Intersection would have a service life up to 2036.

Arnold Avenue (West) / Memorial Avenue

The layout of the Arnold Avenue (West) / Memorial Avenue intersection is constrained by the existing road widths. The proposed upgrade would improve traffic capacity and LoS from the current level C/D in 2014 to level B/C in 2019. The PM peak would continue to function at LoS C until 2036. During the AM peak, the intersection would have a service life up to 2036.

Memorial Avenue / Severn Vale Drive

Traffic performance at the existing Memorial Avenue/Hector Court intersection has been compared to future traffic performance at the proposed new intersection at Memorial Avenue / Severn Vale Drive (which would effectively replace the Memorial Avenue/Hector Court intersection which would be closed as part of the upgrade).

The Memorial Avenue / Hector Court intersection is currently operating at LoS C (satisfactory) but is predicted to reduce to LoS F under a no-change scenario due to the predicted increased traffic flow. With the installation of the proposed Memorial Avenue / Severn Vale Drive intersection, traffic signals would provide a level of service C in 2019 and 2026 and level of service D in 2036.

Impacts on other modes of travel

There would be no impact on current bus routes when the upgrade is operational. The existing T-way that runs parallel to Old Windsor Road and the dedicated bus lanes at the Old Windsor Road / Memorial Avenue intersections would be retained.

The proposal includes bus priority lanes at traffic signals and indented bus bays on both sides of Memorial Avenue at Arnold Avenue and Severn Vale Drive. Bus priority lanes (ie queue-jump lanes) allow buses a head start in the east-west direction along Memorial Avenue. This would provide more efficient operation of bus services. Figure 3-9 and **Figure 3-10** (see section 3.3.3) shows the proposed bus priority lanes at Arnold Avenue and Severn Vale Drive intersections. These locations are generally in the same location as current bus stops.

Pedestrians and cyclists

A three-metre wide off-road shared pedestrian / cyclist path would be provided on both sides of Memorial Avenue between Old Windsor Road and Windsor Road as part of the proposal. Any pedestrian and cycle paths along Old Windsor Road and Windsor Road impacted by the proposal during construction would be re-established to the existing condition at proposal completion. Pedestrian crossings would be provided on all approaches at new traffic signals at Memorial Avenue / Arnold

Avenue and Memorial Avenue/Severn Vale Drive. Walking distance from the pedestrian crossings to the bus stops is about 30 metres. The crossings would provide direct access to the bus stops on both sides of Memorial Avenue at Arnold Avenue and Severn Vale Drive. The existing crossing at Burns Road, located about 400 metres east of the Memorial Avenue / Severn Vale Drive intersection would be retained.

The proposed intersection upgrades at Old Windsor Road/Memorial Avenue/Sunnyholt Road and Windsor Road/Memorial Avenue would retain the existing cyclist and pedestrian crossing facilities. Existing pedestrian crossings at the T-way intersection (southern approach) would also be retained.

The proposal does not include dedicated pedestrian and cyclist access to local roads. Existing access would be retained.

6.3.4 Safeguards and management measures

The safeguards and management measures outlined in Table 6-13 would be implemented before and during construction of the proposal to minimise impacts on traffic and transport.

Table 6-13: Safeguards and management measures for traffic and transport

Impact	Environmental safeguards	Responsibility	Timing
Construction traffic impacts	<ul style="list-style-type: none"> • A Traffic Management Plan (TMP) would be prepared as part of the Construction Environmental Management Plan. The TMP would be prepared in accordance with <i>Traffic Control at Worksites</i> (Roads and Maritime 2010), <i>Australian Standard AS1742</i> and the worksite manual <i>Roads and Maritime Specification G10</i>. The TMP would outline: <ul style="list-style-type: none"> - Traffic controls to manage and regulate traffic movements, including minimising traffic switching - Maintenance of continuous, safe and efficient movement of traffic for both the public and construction workers - Haulage routes/access arrangements to minimise impacts on local routes - Temporary speed restrictions to ensure a safe driving environment around work zones - Access provisions for local 	Construction Contractor	Pre-Construction

Impact	Environmental safeguards	Responsibility	Timing
	<p>roads and properties, including the use of temporary turn-around bays</p> <ul style="list-style-type: none"> - Maintenance of pedestrian and cyclist access - Provision of appropriate warning and advisory signposting - Requirements and methods to consult and inform the local community of impacts on the local road network and traffic - Measures to minimise traffic conflict and congestion that may occur due to the cumulative increase in construction vehicle traffic caused by other developments. 		
Access	<ul style="list-style-type: none"> • Vehicular property access would be maintained where possible including pre-schools, places of worship and commercial premises. If driveway access cannot be maintained the resident would be consulted. 	Construction contractor	Construction
Access	<ul style="list-style-type: none"> • Road users, pedestrians and cyclists would be informed of changed conditions, including likely disruptions to access during construction. 	Construction contractor	Construction
Temporary impacts on bus services	<ul style="list-style-type: none"> • Access to bus stops and safe stopping locations would be maintained during construction in consultation with bus operators. <p>Ongoing updates on locations and access to bus stops would be provided to the community during the construction period to minimise disruption.</p>	Roads and Maritime and construction contractor	Construction

6.4 Noise and vibration

A Noise and Vibration Assessment was undertaken to assess the potential impacts from the construction and operation of the proposal (Renzo Tonin and Associates, 2014). A complete copy of the Noise Assessment Report is available in Appendix I of this REF. The assessment considers the potential noise and vibration impacts of the construction and operation of the proposal and identifies where traffic noise mitigation measures should be considered.

6.4.1 Methodology

The Noise and Vibration Assessment has been prepared in accordance with the following policies and guidelines:

- NSW Road Noise Policy (RNP) (DECCW 2011)
- NSW Interim Construction Noise Guideline (ICNG) (EPA 2009)
- RTA Environmental Noise Management Manual (ENMM) (RTA 2001)
- Assessing vibration: A technical guideline (DECCW 2006)
- British Standard 6472-1992, Evaluation of human exposure to vibration in buildings (1-80Hz)
- German Standard DIN 4150 –Part 3, Structural vibration in buildings -Effects on Structures

Study Area

For the purpose of this assessment, the study area is defined by noise catchment areas (NCAs). NCAs are areas that are likely to have similar noise exposures on the basis of factors such as topography, road design, setbacks and types of residences or other noise receptors. The study area is divided into eight NCAs. These are described below and shown in Figure 6-18.

Noise Monitoring

Long-term noise monitoring was conducted in the study area from Tuesday 11th to Tuesday 25th February 2014 at monitoring locations M1-M4 and from Tuesday 15th to Wednesday 23rd July 2014 at monitoring locations M5 and M6. Noise monitoring locations are identified in Table 6-14. It was not possible to conduct noise monitoring at all NCAs along Memorial Avenue due to the limited number of residential dwellings within this semi-rural area, significant setback distances of some dwellings from Memorial Avenue, residential subdivision construction works potentially affecting the measured noise levels, and obstruction from boundary fences along the road corridor. However, the monitoring that was carried out was adequate for the purposes of the assessment.

Table 6-14: Noise monitoring locations

Location	NCA	Address	Description
M1	2	32 Memorial Avenue	Front of the property in the free field approximately 35m from the existing road corridor
M2	3	25 Memorial Avenue	Front yard at the property boundary in the free field approximately 8m from the road corridor
M3	3	19 Memorial Avenue	Front yard of the property in the free field approximately 14m from the road corridor
M4	5	16 Gorman Avenue	Front yard of the property in the free field approximately 50m from the road corridor
M5	7	8 Windsor Road	Front yard of the property in the free field approximately 18m from the road corridor
M6	8	10 Rothwell Circuit	Rear yard of the property in the free field approximately 20m from the road corridor with 1.8m boundary fence between noise monitor and Old Windsor Road



Figure 6-18: Noise Catchment Areas and monitoring locations in the study area

6.4.2 Existing environment

The ambient noise environment in the study area is highly influenced by traffic from Memorial Avenue, Old Windsor Road to the west and Windsor Road to the east.

Long-term noise monitoring was conducted to quantify ambient noise levels. The purpose of the noise monitoring is to establish:

- existing traffic noise levels for benchmarking and validation of the operational noise model, and
- background noise levels for the setting of construction noise goals for the project.

A summary of the long-term noise monitoring results are presented in Table 6-15 including rating background level (RBL). The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours).

Table 6-15: Measured noise levels

Location	L _{Aeq} Traffic Noise Levels		L _{A90} Background Noise Level (RBL)		
	Day, L _{Aeq} , 15hr	Night, L _{Aeq} , 9hr	Day	Evening	Night
M1	62	58	49	46	37
M2	72	66	54	48	42
M3	71	65	53	50	41
M4	59	56	49	50	44
M5	68	63	55	50	34
M6	61	58	49	48	38

Noise sensitive receivers

The NSW Road Noise Policy, 2011 (RNP) sets guidelines for the assessment of traffic noise on sensitive land uses such as schools, hospitals, places of worship and recreation areas.

Table 6-16 summarises the NCAs which have been broadly identified, based on residential receivers.

Table 6-17 identifies non-residential sensitive receivers.

Table 6-16: Noise catchment areas

NCA	Location	Description
NCA 1	Old Windsor Road to Thomas Boulton Circuit Northern side of Memorial Avenue	<ul style="list-style-type: none"> • Low to medium density suburban land • Recent subdivision development with current continuation of subdivision construction to the east.
NCA 2	Old Windsor Road to 30 Memorial Avenue Southern side of Memorial Ave	<ul style="list-style-type: none"> • Mixture of low density rural land and high density commercial • Recent demolition of residential dwellings.
NCA 3	Thomas Boulton Circuit to Arnold Avenue Northern side of Memorial Avenue	<ul style="list-style-type: none"> • Low density rural land with residential and commercial receivers.
NCA 4	Rocks Street to Hector Court Southern side of Memorial Avenue	<ul style="list-style-type: none"> • Medium density suburban land • Recent subdivision development with current continuation of subdivision construction to the west and throughout Grace Crescent
NCA 5	Arnold Avenue to Windsor Road Northern side of Memorial Avenue	<ul style="list-style-type: none"> • Mixture of medium density new subdivision and existing residential receivers along Memorial Avenue • Current subdivision construction at the intersection of Memorial Avenue and Arnold Avenue • Mixture of residential and commercial receivers along Windsor Road.
NCA 6	Hector Court to Windsor Road Southern side of Memorial Avenue	<ul style="list-style-type: none"> • Low density residential receiver west near Hector Court • Commercial receivers along Windsor Road.

NCA	Location	Description
NCA 7	Windsor Road Eastern side of Windsor Road from President Road to Wrights Road	<ul style="list-style-type: none"> • Medium density residential receivers • Commercial receivers towards northern end on eastern side of Windsor Road.
NCA 8	Old Windsor road Western side of Old Windsor Road from Kentwell Crescent to Rothwell Circuit	<ul style="list-style-type: none"> • Medium density residential receivers.

Table 6-17: Non-residential sensitive receivers

ID				
S1	1	43 Memorial Avenue	Industrial building	Industrial
S2	1	24 Arnold Avenue	Gracelands Early Childhood Centre	Classroom
S3	2	8 Free Settlers Drive	The Gracewood Community Retirement Village	Commercial (ground floor)
S4	3	15-17 Memorial Avenue	The Hills Clinic	Hospital ward
S5	6	Memorial Avenue	Kellyville Cricket Club	Active recreation
S6	7	3-5 President Road	Kellyville Preschool Kindergarten	Classroom
S7	7	3 Windsor Road	RepcO	Commercial
S8	7	5 Windsor Road	Caltex	Commercial
S9	8	6 Rothwell Circuit	Fit Kidz Day Care Centre	Classroom
S10	8	Lot 4, 1190 Old Windsor Road	Outback Steakhouse	Commercial

6.4.3 Noise and vibration criteria

Construction noise criteria

The ICNG guides the assessment of construction noise in NSW. The ICNG provides two methods for assessment of construction noise, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration and involves the measurement and prediction of noise levels, and assessment against set criteria and has therefore been applied to this project.

The ICNG recommends that standard construction work hours should typically be as follows:

- Monday to Friday: 7am to 6pm.
- Saturday: 8am to 1pm.
- No work on Sundays or public holidays.

Additionally, it recommends quantitative noise management noise at residences for standard construction hours and outside of recommended standard hours. These are shown in the Noise and Vibration Assessment report (Renzo Tonin and Associates 2014); Appendix I. Table 6-18 identifies the adopted Noise Management Levels (NMLs) for receivers within the various NCAs along the route. The NMLs for each NCA are derived from the RBL results of the nearest long term noise monitoring location.

Table 6-18: Construction noise management levels at residential receivers

NCA	L _{A90} Rating Background Level (RBL)			Noise Management Level L _{Aeq} (15min)		
	Day	Evening	Night	Day	Evening	Night
1	49	46	37	59	51	42
2	49	46	37	59	51	42
3	53	50	41	63	55	46
4	53	50	41	63	55	46
5	49	50	44	59	55	49
6	49	50	44	59	55	49
7	55	50	34	65	55	39
8	49	48	38	59	53	43

The ICNG also presents the following noise management levels for non-residential premises, relevant to receivers in the study area:

- Active recreation areas (such as parks) - external LAeq (15 min) 65 dB(A).
- Passive recreation areas - external LAeq (15 min) 60 dB(A).
- Industrial premises - external LAeq (15 min) 75 dB(A).
- Commercial premises - external LAeq (15 min) 70 dB(A).
- Classrooms, hospitals, places of worship - internal LAeq (15 min) 45 dB(A).

For schools, hospitals and places of worship where an internal management level of 45dB(A) is specified, the equivalent external management level is 55dB(A) assuming 10dB(A) noise reduction through an open window.

In addition to the above criteria, where any works are planned to extend over two or more consecutive nights, the ICNG recommends to protect against sleep disturbance, as guided by research provided in the ECRTN. Based on this, an upper external noise limit of L_{Amax} 65 dB(A) is set as a NML for the purposes of this construction noise assessment.

Construction vibration criteria

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the DECC 'Assessing Vibration; a technical guideline' (DECC, 2006). The guideline provides criteria which are based on the British Standard BS 6472-1992 'Evaluation of human exposure to vibration in buildings (1-80Hz)'. When applying the criteria, it is important to note that the three directional axes are referenced to the human body, i.e. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore, application of the criteria requires consideration of the position of the people being assessed, as illustrated in Figure 6-19.

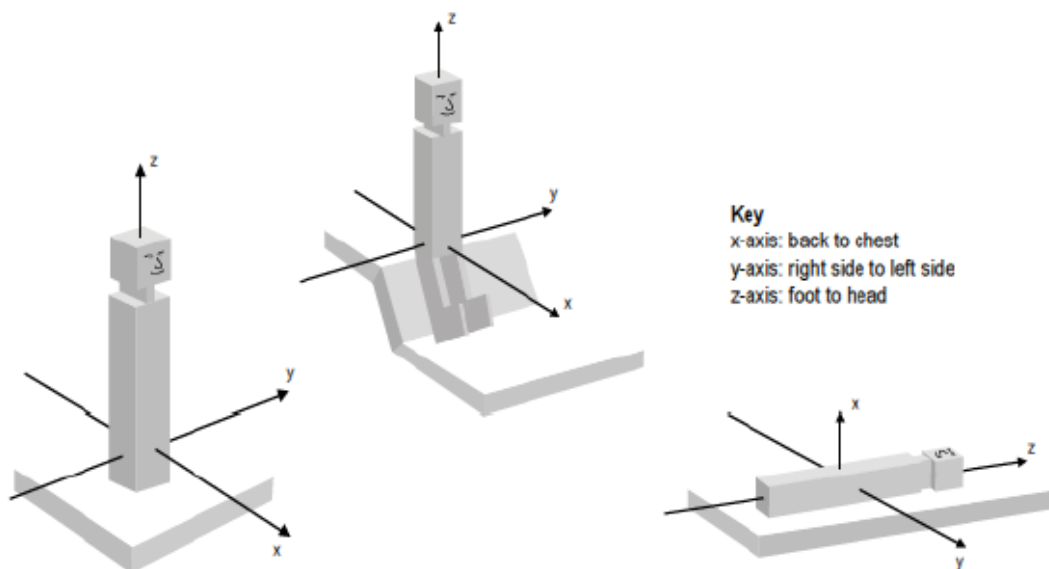


Figure 6-19: Orthogonal axes for human exposure to vibration

Safe limits for construction generated vibration have been determined using the vibration limits set out in the German Standard DIN 4150 Part 3-1999 Structural Vibration in Buildings –Effects on Structures. The minimum 'safe limit' of vibration at low frequencies for commercial and industrial buildings is 20mm/s. For dwellings it is 5mm/s and for particularly sensitive structures (e.g. historical with preservation orders etc.), it is 3mm/s. These limits increase as the frequency content of the vibration increases.

Preferred and maximum values for continuous and impulsive vibration for human comfort are provided Table 6 17 and in the Noise and Vibration Assessment (Renzo Tonin and Associates 2014) in Appendix I.

Table 6-19: Preferred and maximum levels for human comfort

Location	Assessment period ^[1]	Preferred values		Maximum values	
		z axis	x and y	z axis	x and y

			axis		axis
Continuous vibration (weighted RMS acceleration, m/s², 1-80Hz)					
Critical areas ^[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive vibration (weighted RMS acceleration, m/s², 1-80Hz)					
Critical areas ^[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day- or night-time	0.64	0.46	1.28	0.92
Intermittent vibration (Vibration Dose Values, VDV, m/s^{1.75}, 1-80Hz)					
Critical areas ^[2]	Day- or night-time	0.10		0.20	
Residences	Daytime	0.20		0.40	
	Night-time	0.13		0.26	
Offices, schools, educational institutions and places of worship	Day- or night-time	0.40		0.80	
Workshops	Day- or night-time	0.80		1.60	

1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

- Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992

Operational noise criteria

The assessment of road traffic noise impact is guided by the *NSW Road Noise Policy, 2011(RNP)* and *RTA Environmental Noise Management Manual (ENMM, 2001)*. Memorial Avenue provides connection between Old Windsor Road and Windsor Road arterials, and is therefore defined as a sub-arterial in the RNP. Based on the ENMM guidance, the upgrade of Memorial Avenue is classed as a 'road redevelopment' as it is an upgrade of an existing road generally within the current corridor. The 'redevelopment' criteria for residential type receivers, as set out in the RNP apply, and are shown in Table 6-20. In assessing feasible and reasonable mitigation measures, an increase of up to 2dB(A) represents a minor impact that is considered barely perceptible to the average person.

Table 6-20: Road traffic noise assessment criteria for residential land uses

Road category	Type of project/land use	Assessment criteria	
		Day time (7am 10pm)	Night time (10pm 7am)
1. Free way/ arterial/ sub-arterial roads	Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial roads	L _{Aeq} , 15 hour 60 dBA (external)	L _{Aeq} , 9 hour 55 dBA (external)

The RNP also sets guidelines for the assessment of traffic noise on sensitive land uses such as schools, hospitals, places of worship and recreation areas. The assessment criteria are shown in Table 6-21.

Table 6-21: Road traffic noise assessment criteria for non-residential land uses

Existing sensitive land use	Assessment criteria (dBA)	
	Day (7am 10pm)	Night (10pm 7am)
1. School classrooms	L _{Aeq, 1hr} 40 (internal) when in use.	-
2. Hospital wards	L _{Aeq, 1hr} 35 (internal)	L _{Aeq, 1hr} 35 (internal)
3. Places of worship	L _{Aeq, 1 hr} 40 (internal).	L _{Aeq, 1 hr} 40 (internal).
4. Open space (active use)	L _{Aeq, 1 hr} 60 (external) when in use.	-
5. Open space (passive use)	L _{Aeq, 1 hr} 55 (external) when in use.	-
6. Childcare facilities	Sleeping rooms L _{Aeq, 1 hr} 35 (internal). Indoor play areas L _{Aeq, 1 hr} 40 (internal). Outdoor play areas L _{Aeq, 1 hr} 55 (external).	-

Maximum noise level

The RNP does not specify a night-time L_{max} noise limit or noise goal. This is primarily because research conducted to date in this field has not been definitive and the relationship between maximum noise levels, sleep disturbance and subsequent health effects is not currently well defined.

According to the policy however, the likely maximum or peak noise levels are to be broadly assessed and reported for the night-time period, which is considered by the EPA as being 10pm to 7am. The assessment of maximum noise levels are only applicable at residential receivers.

The ENMM outlines that the maximum noise level assessment method should be used to prioritise and rank mitigation strategies but should not be applied as a decisive criterion itself. The methodology employed assesses the impacts based on the emergence of the L_{Amax} over the L_{Aeq} (1 hour) noise level. A maximum noise pass-by event is defined as the emergence of the L_{Amax} level above the L_{Aeq} level by 15 decibels.

Relative Increase Criteria

The traffic noise impact from the proposed road 'redevelopment' would need to also comply with the 'Relative Increase Criteria' as discussed in Section 2.4 of the RNP. The relative increase criteria are to be applied to the external areas of existing residential and sensitive land uses impacted upon by the redeveloped road.

The relative increase criteria as set out in the RNP applicable to this project are produced below and apply for all NCAs.

Table 6-22: Relative increase criteria

Type of development	Total traffic noise level increase, dB(A)
Redevelopment of existing road	Existing traffic $L_{Aeq}(\text{period}) + 12$ dB (external)

Note: 'Existing traffic' refers to the traffic noise levels for the relevant 'no build' option

6.4.4 Noise model and validation

Noise predictions are based on a method developed by the United Kingdom Department of Environment entitled "Calculation of Road Traffic Noise (1988)" known as the CoRTN (1988) method. This method has been adapted to Australian conditions and extensively tested by the Australian Road Research Board and as a result it is recognised and accepted by the NSW Environment Protection Authority. The model predicts noise levels for steady flowing traffic and noise from high truck exhausts is also taken into account. Results of the model are discussed in section 6.4.5 below.

The noise model was validated using the long-term noise monitoring results. Table 6-23 below summarises the results of the validation, providing a comparison of the modelled traffic noise levels for existing conditions compared to the measured traffic noise levels.

Table 6-23: Noise model validation

Location	$L_{Aeq,15hr}$ Daytime noise level			$L_{Aeq,9hr}$ Night time noise level		
	Measured	Modelled	Variation	Measured	Modelled	Variation
32 Memorial Avenue	62.3	62.6	-0.3	57.8	58.9	-1.1

25 Memorial Avenue	72.1	71.5	0.6	66.2	67.8	-1.6
19 Memorial Avenue	70.9	69.2	1.7	65.4	65.4	0.0
16 Gorman Avenue	59.2	61.7	-2.5	55.5	57.9	-2.4
8 Windsor Road	67.6	68.0	-0.4	62.8	62.9	-0.1
10 Rothwell Circuit	64.1	65.1	-1.0	58.3	59.6	-1.3
Mean variation			-0.4			-1.1

The noise model validation results show that the noise model outputs are typically in good agreement with the noise monitoring results and there is a high level of confidence that can be placed on the noise model for predicting future traffic noise levels.

At 16 Gorman Avenue the model is predicting approximately 2.5dB higher than the measured noise levels during both the day and night periods. The model may be under predicting the acoustic shielding from the terrain and boundary fencing along Burns Road (perpendicular to Memorial Avenue), combined with the effect of traffic travelling slower than the posted speed in this area as it approaches the Windsor Road intersection, particularly during peak periods when vehicles are queuing on Memorial Avenue.

The mean variation between the measured and modelled traffic noise levels is an acceptable tolerance and therefore no model calibration corrections were applied to the noise model when generating the operational noise predictions for future traffic noise scenarios.

6.4.5 Potential impacts

Construction noise

Generally, construction activities during day and night would have the potential to cause some short-term impacts. Noise disturbance is likely to be dependent on:

- The location and proximity to each other of various plant items.
- The work that is being undertaken at any given time and whether it involves all machinery operating at the maximum sound power levels assessed.

Construction noise and vibration impacts have been assessed in terms of assumed construction activities and methodologies. Specific construction activities would be determined at the detailed design stage of the proposal. The proposed construction period would be approximately 24 months commencing in 2017.

Works would mostly be undertaken during standard working hours; however, due to the nature of the proposal it is anticipated that some work may be required outside of the standard working hours to avoid major delays to commuter traffic and ensure the safety of the workforce.

Where works would be required outside of the standard working hours outlined above, the procedure contained in the RMS Environmental Noise Management Manual 2001, "Practice Note vii – Roadworks Outside of Normal Working Hours" would be followed. The Interim Construction Noise Guideline requires justification of work outside of prescribed hours and the need to incorporate all feasible and reasonable work practises to minimise potential adverse impacts. The construction

noise and vibration management plan for the project (as a part of the CEMP) would address these requirements.

This section of the REF therefore focuses on the more typical works during standard construction hours and potential night works.

Table 6-24 lists the general construction activities and the associated major plant and equipment likely to be used by the contractor to carry out the necessary construction work for this project.

Table 6-24: Construction activity & equipment list

Activity	Plant/equipment
Site clearance	Chain Saw Tracked Excavator Dump Truck Bull Dozer
Utility, property, service adjustment	Tracked Excavator Dump Truck Mobile Crane
Pavement and kerb demolition	Milling Machine Tracked Excavator Tracked Excavator (with Rock Breaker) Front end loader Backhoe Dump Truck
Installation of drainage pits & lines	Tracked Excavator Drilling Rig Dump Truck Front end loader Backhoe
Supply, lay and compact road fill, sub base and surface Supply, lay and compact footpath, kerb and gutter	Mobile Crane Concrete Truck Concrete pump Grader Pavement Laying Machine Roller Generator
Traffic signals, signposting and line marking	Mobile Crane

	Truck
--	-------

Table 6-25 lists the sound power levels of the plant and equipment likely to be used by the contractor to carry out the necessary construction work for this project.

Table 6-25: Typical construction equipment & sound power levels

Plant Description		
	L _{Aeq}	L _{Amax}
Rock Breaker	117	125
Concrete Saw	115	118
Mobile Crane	110	116
Compactor	110	116
Front End Loader	110	112
Pavement Laying Machine	109	118
Bulldozer	109	115
Tracked Excavator	107	115
Grader	107	115
Road Milling Machine	108	111
Concrete Truck	106	110
Dump Trucks	105	110
Rollers	104	110
Truck (>20 tonne)	103	106
Concrete Pump	102	104
Backhoe	101	108
Power Generator	100	106

Table 6-26 presents a summary of the predicted L_{Aeq} noise levels for each activity associated with the construction phase. The assessment point is at the boundary for residential receivers and at the most affected occupied point of the premises (typically at the front facade) for other sensitive receivers.

Table 6-27 presents a summary of the predicted L_{Amax} noise levels during potential night time works for residential receivers. The assessment point is at the building facade assuming a bedroom window.

Table 6-26: Predicted L_{Aeq} construction noise levels

Activity		NCA1	NCA2	NCA3	NCA4	NCA5	NCA6	NCA7	NCA8	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
NML	Day	59	59	63	63	59	59	65	59	75	55	70	55	65	55	70	70	55	70
	Evening	51	51	55	55	55	55	55	53	75	55	70	55	65	55	70	70	55	70
	Night	42	42	46	46	49	49	39	43	75	55	70	55	65	55	70	70	55	70
Site clearance		75	83	85	72	74	79	74	76	56	82	59	71	59	56	75	73	75	75
Site clearance (without chainsaw)		70	78	80	67	69	74	69	71	51	77	54	66	54	51	70	68	70	70
Utility & service adjustment		70	79	80	67	70	75	70	72	52	77	54	66	55	52	70	69	71	70
Earthworks phase	Pavement & kerb demolition	77	86	87	74	77	82	77	79	59	84	61	73	62	59	77	76	78	77
	Pavement & kerb demolition (without rock breaker)	73	82	83	70	73	78	73	75	55	80	57	69	58	55	73	72	74	73
	Drainage pits & lines	73	81	83	70	73	78	73	74	55	80	57	69	58	54	73	71	73	73
	Supply, lay & compact road & footpath	73	81	83	70	72	77	72	74	54	80	57	69	58	54	73	71	73	73
Traffic signals, signposting & line marking		68	77	79	65	68	73	68	70	50	75	53	64	53	50	68	67	69	68

Notes: **Bold** font represents exceedance of greater than 10dB(A) above the daytime NML (20dB(A) above daytime RBL).
 Red font represents exceedance of the 75dB(A) **highly affected** noise objective
 S1, S2...S10 denote non-residential sensitive receivers identified in Table 6-17

Table 6-27: Predicted L_{Amax} construction noise levels for night works (residential)

Activity		NCA1	NCA2	NCA3	NCA4	NCA5	NCA6	NCA7	NCA8
Sleep disturbance upper limit night		65	65	65	65	65	65	65	65
Site clearance		74	71	77	72	73	75	75	77
Site clearance (without chainsaw)		74	71	77	72	73	75	75	77
Utility & service adjustment		71	68	75	69	70	73	73	75
Earthworks phase	Pavement & kerb demolition (with rock breaker)	86	83	90	84	85	88	88	90
	Pavement & kerb demolition (without rock breaker)	74	71	78	72	73	76	76	78
	Drainage pits & lines	80	77	84	78	79	81	82	83
	Supply, lay & compact road & footpath	71	68	74	69	70	72	72	74
Traffic signals		72	69	75	69	70	73	73	75
Line marking		71	68	75	69	70	73	73	75

Notes: **Bold** font represents exceedance of night time sleep disturbance upper limit.
Noise level predictions for L_{Amax} sleep disturbance have been made at the building façade

Noise impacts from construction activities would affect the majority of receivers. Construction phase noise levels at residences are expected to exceed the NMLs in most NCAs, and with the exception of NCA 4, residences may also be “highly noise affected”. Other sensitive receivers are expected to be slightly less affected than residences as they generally only operate during the day and are often set back further from the road. Nonetheless Gracelands Early Education Centre (S2) and Fit Kidz Day Care Centre (S9) may be “highly noise affected”, particularly during the earthworks phase.

Construction activities are proposed to be undertaken primarily during the recommended standard hours, however, some out-of-hours activities would also be required at certain times throughout the 24-month construction period. This is necessary to minimise traffic delays and disruption associated with road closures.

The predictions for L_{Amax} noise levels at night are above the goals for residences

which highlight the potential for sleep disturbance during night works. The greatest potential for sleep disturbance would be at NCAs 3 and 8, however there is potential for sleep disturbance across all NCAs. Activities that would occur during the night-time period would generally include utility adjustment works, construction of tie-ins with adjoining sections and intersection construction activities. These are likely to have noise related impacts which it may not be possible to reduce levels to below the noise affected construction noise management level.

Pavement & kerb demolition works have the highest predicted L_{Amax} noise levels, therefore having the highest potential to cause sleep disturbance across all NCAs. Undertaking these works without a rock breaker greatly reduces the potential for sleep disturbance. During construction, these works would be scheduled for less sensitive times of the day, or if required to be undertaken at night, staged to avoid extended impact at residential areas.

Predicted noise levels for both day and night assume all listed equipment for individual tasks are operating concurrently. This approach is conservative and has been adopted to ensure the full extent of possible noise impacts are assessed (what might occur in the worst-case). Therefore, the noise generated during construction works would generally be below the predictions presented.

Construction vibration

Construction vibration impacts have been assessed in terms of assumed construction activities and methodologies. Specific construction activities would be determined at the detailed design stage of the project.

The vibration generated from construction works would vary depending on the level and type of activity carried out at each site during each activity.

Table 6-28 below identifies the dominant vibration generating plant and their typical vibration levels based on library data and measurements from past projects. Potential vibration generated to receivers for this project would be dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver structure.

Site specific buffer distances for vibration significant plant items (e.g. vibratory rollers, compactors, pile boring, pole drilling) must be measured on site. Unlike noise, vibration can't be 'predicted'. There are many variables from site to site, for example soil type and conditions; sub surface rock; building types and foundations; and actual plant on site. The data relied upon in this assessment (tabulated above) is taken from a database of vibration levels measured at various sites or obtained from other sources (e.g. BS5228-2:2009). They are not specific to this project.

Table 6-28: Typical vibration emission levels from construction plant

Plant vibration source	PPV vibration level (mm/s) at distance from plant							
	5m	10m	15m	20m	30m	40m	50m	100m
Compactor (852G)	5.3	2.0	2.2	1.4	<1			
Drilling machine – Pneumatic (Atlas Copco (ROC 812HC 20T)	3.2	1			<0.1		<0.1	
Drilling Rig – Air Trac Rotary (Ingersoll/Rand CM350)	4.4	1.4			0.6		<0.1	
Excavator ≤30T (travelling)	8.0	3.4	1.6					
Excavator ≤30T (digging)	5.8	4.0	0.0					
Excavator & Rock Hammer (27T)	10.5	2.5						
Excavator & Heavy Rock Hammer (e.g. 1500 kg)	4.5	1.3		0.4	0.2	0.15	0.02	
Grader (20 tonne)	2.0		0.2					
Jack hammers	2.0	1.0	0.2	0.1	0.0	0.1		
Piling Rig – Bored (Soilmec 60T)*	2.4	0.2	0.2					
Piling Rig – Vibratory (Mertz M26)	29-36	16-40	7-17	19-22	2-13	1-15	1-7	1-3.5
Truck & Trailer (45T net)	14.5	10.3	3.4					
Vibratory Roller ≤ 17T (Smooth Drum)	24.5	8.9	4.2					
Vibratory Roller ≤ 17T (Pad Footed)	15.1	10.3	3.2					

* Data based on sand/clay soil conditions

Based on the vibration data presented above, vibration generated by construction plant was estimated and potential vibration impacts to residences from vibratory rolling assessed. The assessment estimated a high potential for structural damage from vibratory rolling in NCAs 6 and 7. This represents the worst case scenario in terms of vibration and thus vibration levels would be expected to be lower than those presented for much of the construction period.

It was also found that there is a high probability of human disturbance leading to complaints at NCAs 6, 7 and 8. In relation to human comfort it is expected that vibration levels from vibratory rollers would exceed the human comfort criteria given the likely duration of activities.

It is unknown at this stage whether piling would be required for construction of the bridge over Strangers Creek, or what type of piling might be employed. However the nearest residences are more than 50m from where piling would occur and therefore it is very unlikely that vibration from piling would be an issue. Use of bored piling over impact or vibratory piling would minimise any impacts.

During construction, the contractor would be required to undertake vibration monitoring to measure compliance with the adopted vibration criteria. The contractor would also be required to undertake building condition surveys prior to any construction work being carried out. The locations would be determined by the contractor, based on proposed construction methodology and recorded in the Contractor's Noise and Vibration Management Plan.

Operational noise

Operational noise modelling has been conducted based on predicted traffic volumes. The scenarios predicted are:

- 'Opening year' 2019, 'no-build' and 'build' options, day and night periods
- 'Design Year' 2029, 'no-build' and 'build' options, day and night periods

Further noise mitigation is considered at receivers where design year noise levels are acute, that is greater than or equal to LAeq,15hr 65dB(A) or LAeq,9hr 60dB(A), or where noise levels exceed the RNP noise assessment criteria and have increased by more than 2dB(A).

The predicted noise levels produced by the noise model are in Appendix I. A summary of the results are shown in Table 6-29.

Table 6-29: Summary of operational noise modelling results

NCA	Does the project increase noise levels by more than 2dB(A) for predicted levels above the RNP noise assessment criteria?	Number of 'acute' properties in Design Year 2029	Number of properties where further noise mitigation would be considered*
1	No	8	2
2	Yes	1	1
3	No	6	5
4	Yes	42	0
5	Yes	26	11
6	No	3	2
7	No	14	13
8	No	20	18
	Total	120	52

*Note: noise affected properties that were approved for development after the road upgrade was proposed and made known to Council are not considered for further treatment. The Hills Shire Council DCP requires new developments to provide noise mitigation to achieve the noise goals outlined in the NSW State Environmental Planning Policy (Infrastructure) 2007.

The outcomes of noise modelling are:

- The increase in noise levels between the design year 'no-build' and 'build' options is more than 2dB(A) in NCAs 2, 4 and 5
- Design year 2029 noise levels are predicted to be acute at 120 properties. Further noise mitigation is considered at receivers where design year noise levels are acute, that is greater than or equal to LAeq,15hr 65dB(A) or LAeq,9hr 60dB(A), or where noise levels exceed the RNP noise assessment criteria and have increased by more than 2dB(A).
- There are several residential subdivisions that were approved after the road upgrade was proposed, and noise mitigation for these recent developments lies with the developer. These properties are not considered for noise treatment as part of this project
- 52 properties have been identified for further consideration of noise mitigation, which includes the Gracelands Early Education Centre at 24 Arnold Avenue. These are identified on Figure 6-20.

As some residences within the project area are exposed to a noise level increase of more than 2dB(A), and/or exposed to acute noise levels, an assessment of feasible and reasonable noise mitigation options is required. Final noise mitigation treatments would not be decided until the detailed design phase to allow for all design changes to be considered in the noise assessment. A discussion of proposed treatments is included below.

The proposal includes new signalised intersections at Arnold Avenue and Severn Vale Drive. This would potentially create interrupted (or stop-and-go) traffic flow conditions compared to the largely uninterrupted flows that are currently found on Memorial Avenue. Noise levels can be higher near intersections than along

equivalent sections of road with continuous traffic flow. The noise prediction method defines a correction for signalised intersections which is dependent on distance from the road. Assuming a reduced traffic speed as vehicles approach an intersection to stop, and adding the correction, noise calculations were conducted with and without signalised intersections. It is expected that the L_{eq} noise levels would change by less than 1dB(A) at the nearest residence due to the introduction of the signalised intersection compared to free-flowing traffic. The assessment found that while the introduction of intersections may alter the character of noise that the surrounding receivers experience, the new intersections themselves would not significantly alter the level of noise at those receivers.

Roads and Maritime installs audio-tactile push buttons to pedestrian crossing traffic control signals to provide improved accessibility for hearing and visually impaired people. The nearest residence to the Severn Vale Drive intersection push button would be approximately 80 metres (after property acquisitions). The nearest residence to the Arnold Avenue intersection is approximately 25 metres. At both intersections, the audio-tactile push button noise is predicted to comply with the 60dB(A) goal.

If in the event noise from push buttons was generating complaints, there are several mitigation measures available. A three setting volume switch (ie. high, medium and low) is available inside the push button housing. Furthermore, the push button unit also incorporates an automatic gain control, which actively reduces the noise source level based on the instantaneous ambient noise level immediately prior to the walk phase signal being activated. During periods of low background noise, automatic gain control would reduce the volume, thereby minimising noise disturbance, particularly at night.

Maximum Noise Level

For the purpose of this assessment, a maximum noise event is defined as any vehicle pass by for which $L_{Amax} > 65\text{dB(A)}$ and $L_{Amax} - L_{Aeq(1hr)} \geq 15\text{dB(A)}$.

Allowing for changes in the road to receiver distance as a result of the project widening, the maximum noise levels in 2026 are predicted to be 69 - 89dB(A) externally. This represents a 4 - 5dB(A) increase for receivers in NCA 2, 4, and 5 as these are the areas where the road widens significantly towards the residences. Residences in other NCAs would experience L_{Amax} levels similar to current levels.

Based on future traffic growth and specifically the increase in night time heavy vehicles, receivers along Memorial Avenue can expect an increase in the number of maximum noise events from approximately 48 per night to 88 per night. While L_{Amax} noise levels at a property do not determine whether noise mitigation should be applied, they can assist in the prioritisation and selection of mitigation.

Relative Increase Criteria

The project complies with the relative increase criteria of existing traffic $L_{Aeq}(\text{period}) + 12 \text{ dB}$ (external).

Receivers alongside Memorial Avenue are already exposed to high levels of traffic noise. Since this project is an upgrade of an existing road and only minor changes to the road width and alignment are being proposed, noise modelling presented in Appendix I shows that the noise level change at any receiver between the build and no build scenarios is small, well below 12dB(A). There are no locations where the project would cause an increase of more than 12dB over the existing noise levels.

Proposed Treatments

Further noise mitigation is considered at receivers where design year noise levels are acute, that is greater than or equal to $LA_{eq,15hr}$ 65dB(A) or $LA_{eq,9hr}$ 60dB(A), or where noise levels exceed the RNP noise assessment criteria and have increased by more than 2dB(A).

Section 3.4.1 of the RNP indicates the following priority order for noise mitigation:

- i.* Road design and traffic management
- ii.* Quieter pavement surfaces
- iii.* In-corridor noise barriers/mounds
- iv.* At-property treatments or localised barriers/mounds

After road design and traffic management opportunities have been included in the road design and non-compliances still remain, the other additional mitigation measure should be applied where reasonable and feasible. The following discussion comments on the feasibility and reasonableness of the remaining mitigation options in accordance with the order of priority stated above.

Quiet pavement surface

There are nine residences along the Memorial Avenue corridor that are identified for further consideration of noise mitigation and if a low noise pavement was applied to Memorial Avenue only, this would be reduced to three residences. All of the other residences within the study area that are identified for further consideration of noise mitigation are adjacent to Windsor Road and Old Windsor Road near the intersections with Memorial Avenue. Intersections where traffic slows down and then accelerates are not ideal for quiet pavements as they generally don't work at low speeds and can cause increased wear and maintenance. While a low noise pavement would provide some reduction in traffic noise, it is probably not feasible near intersections, and may not be cost effective along the length of Memorial Avenue due to the relatively small number of residences that require treatment.

Noise barriers

At the time of announcement of the Memorial Avenue upgrade the residences along the road corridor were largely semi-rural in nature, isolated on large lots or in small groups. The RTA's ENMM notes that noise barriers are not cost effective where residences are isolated or in small groups, rather architectural treatments to dwellings are a more cost effective solution. Subsequently roadside noise barriers are not recommended for this project.

At property treatment

At-property treatment would be considered for dwellings where other noise mitigation measures are either exhausted or are not feasible or cost effective. According to the ENMM, building treatments (in no particular order) may comprise:

- Fresh air ventilation systems that allow existing windows and doors to be kept shut
- Upgraded windows and glazing and solid core doors on the exposed facades of masonry structures only (these techniques are unlikely to produce any noticeable benefit for light frame structures with no acoustic insulation in the walls)
- Upgrading window and door seals
- Sealing wall vents

- External screen walls or property boundary fencing.

Residences identified for further treatment are shown on Figure 6-20.

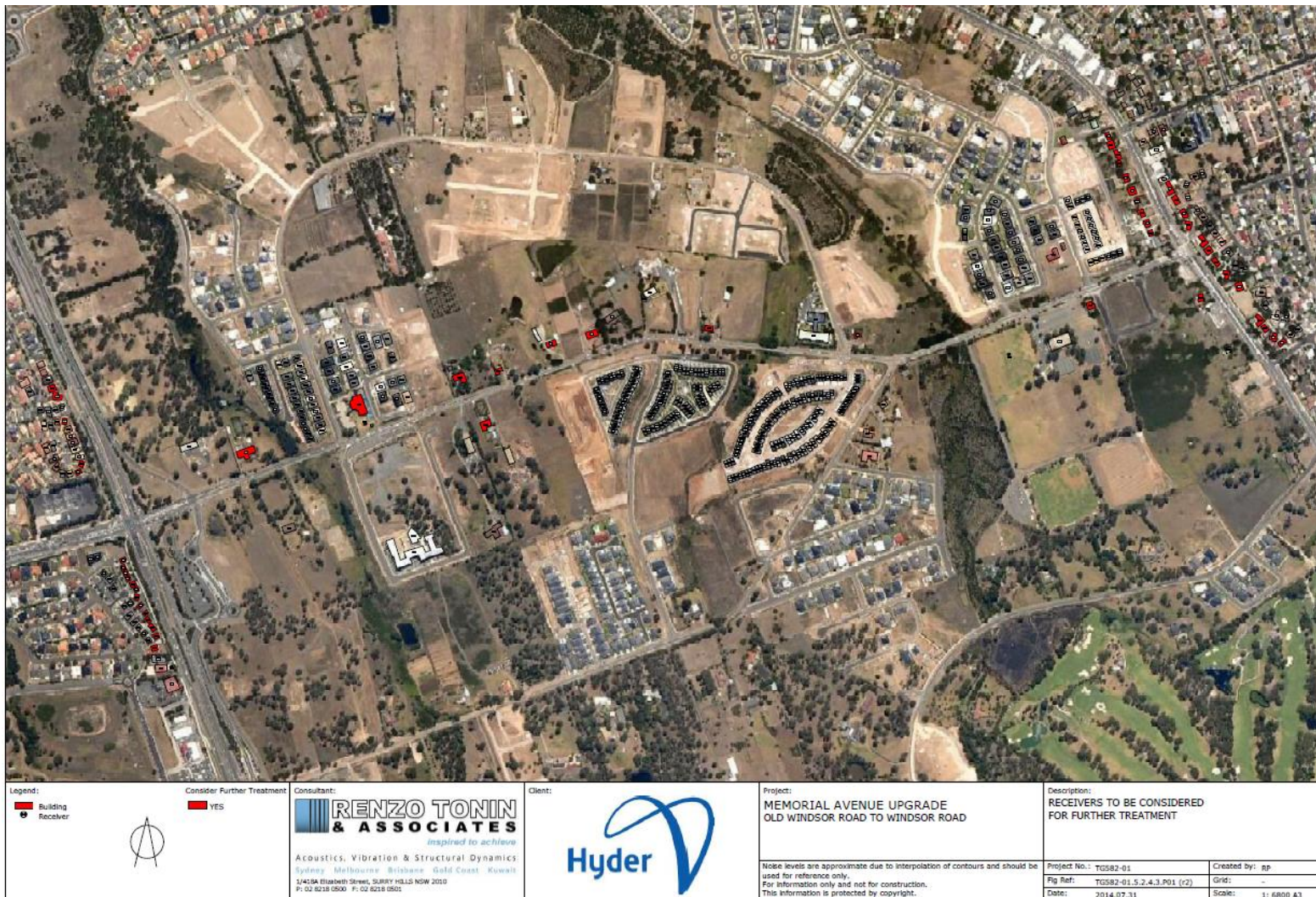


Figure 6-20: Residences identified for further noise treatment

6.4.6 Safeguards and management measures

Table 6-30 summarises the proposed safeguards and management measures recommended to minimise the potential impacts of the proposed works on noise and vibration.

Table 6-30: Proposed safeguards and management measures for noise and vibration

Impact	Environmental safeguards	Responsibility	Timing
Construction noise and vibration	<ul style="list-style-type: none"> • A Construction Noise and Vibration Management Plan (CNVMP) in accordance with OEH/EPA's <i>Interim Construction Noise Guideline</i> (DECCW 2009) would be prepared as part of the CEMP. This plan would detail the mitigation, monitoring and community liaison measures and would include but not be limited to: <ul style="list-style-type: none"> - Identification of potentially affected properties and residences (including a detailed map) - A map indicating the locations of likely potential impacts - A risk assessment to determine potential risk for activities likely to affect residents - Mitigation measures to reduce excessive noise during construction activities including those associated with truck movements - A process for assessing the performance of the implemented mitigation measures - A process for identifying management measures for highly noise affected receivers including consultation with affected residences - A process for resolving issues and complaints. 	Construction contractor	Pre-construction
Construction noise and vibration	<ul style="list-style-type: none"> • A vibration assessment is to be prepared and included in the NVMP. The vibration assessment is to include (as a minimum): <ul style="list-style-type: none"> - Identification of potentially affected properties/receivers 	Construction contractor	Pre-construction

Impact	Environmental safeguards	Responsibility	Timing
	<ul style="list-style-type: none"> - A risk assessment to determine the potential for discrete work activities to affect receivers - A map indicating the locations considered likely to be impacted and those requiring building condition surveys - Outline a monitoring program - A process for assessing the performance of the implemented mitigation measures - A process for resolving issues and conflicts. 		
Construction noise and vibration	<ul style="list-style-type: none"> • Works would be carried out during standard working hours (ie 7am – 6pm Monday to Friday, 8am –1pm Saturdays). Any work that is performed outside normal work hours or on a Sunday or public holiday is to minimise noise impacts in accordance with <i>Roads and Maritime's Environmental Noise Management Manual Practice Note 7 – Roadworks Outside of Normal Working Hours</i> (RTA 2001) and the <i>Interim Construction Noise Guidelines</i> (DECC 2009). 	Construction contractor	Construction
Construction noise and vibration	<ul style="list-style-type: none"> • Where feasible, and particularly in areas in close proximity to sensitive receivers, noise and vibration generating activities with impulsive, tonal or low frequency characteristics (such as jack hammering, rock breaking, rock hammering, vibratory rolling) would only be carried out: <ul style="list-style-type: none"> - in continuous blocks, up to but not exceeding 3 hours each; and - with a minimum respite period of one hour between each block. 	Construction contractor	Construction
Construction noise and vibration	<ul style="list-style-type: none"> • Where vibration is found to exceed project criteria, management measures would be implemented to control vibration. In terms of human comfort 	Construction contractor	Construction

Impact	Environmental safeguards	Responsibility	Timing
	<p>criteria, measures would include modifications of construction methods and respite periods. For potential structural damage impacts, modification of construction methods or equipment would be necessary.</p>		
Construction vibration	<ul style="list-style-type: none"> The CNVMP would include an assessment of the structures such as buildings that need building condition surveys. 	Construction contractor	Construction
Construction noise	<ul style="list-style-type: none"> Simultaneous operation of noisy plant within the discernible range of a sensitive receiver would be limited/ avoided where possible. 	Construction contractor	Construction
Construction noise	<ul style="list-style-type: none"> Noise-emitting plant would be directed away from sensitive receivers where possible. 	Construction contractor	Construction
Construction vibration	<ul style="list-style-type: none"> Vibration testing of actual equipment on site would be carried out prior to their commencement of operation to determine acceptable buffer distances to the nearest affected receiver locations. 	Construction contractor	Pre-construction and construction
Construction vibration	<ul style="list-style-type: none"> Building condition surveys would be undertaken for buildings identified in the NVMP. A copy of the report would be sent to the landholder. 	Roads and Maritime	Pre-construction
Construction noise and vibration	<ul style="list-style-type: none"> All employees, contractors and subcontractors would receive a project induction which would include: <ul style="list-style-type: none"> - all relevant project specific and standard noise and vibration mitigation measures; - relevant license and approval conditions; - permissible hours of work; - any limitations on high noise generating activities; - location of nearest sensitive receivers; - construction employee parking 	Construction contractor	Construction

Impact	Environmental safeguards	Responsibility	Timing
	areas; - designated loading/unloading areas and procedures; - site opening/closing times (including deliveries); and - environmental incident procedures.		
Operational noise	<ul style="list-style-type: none"> During the detailed design stage of the proposal, further investigations of all feasible and reasonable mitigation options would be undertaken for affected receivers in accordance with the Road Noise Policy (DECCW 2011) and <i>RTA's Environmental Noise Management Manual Practice Note 4</i> (RTA 2001). 	Roads and Maritime	Detailed design
Operational noise	<ul style="list-style-type: none"> A post-construction noise monitoring program (including simultaneous traffic counts) would be undertaken in accordance with the RMS Environmental Noise Management Manual within 6 to 12 months of opening once traffic flows have stabilised in order to verify the noise assessment. 	Roads and Maritime	Post-construction

6.5 Biodiversity

Hyder Consulting prepared a biodiversity assessment to assess potential impacts of the proposal on terrestrial and aquatic flora and fauna, and to identify environmental safeguards and management actions (Hyder 2014). The biodiversity assessment is summarised below and the complete assessment report is included in Appendix G. For the purposes of this assessment, the study area is defined as the areas likely to be affected by the proposal, either directly or indirectly.

6.5.1 Methodology

Literature and database review

The initial step involved:

- Database searches to identify State and Commonwealth records of threatened entities and Commonwealth matters of national environmental significance (MNES)
- A review of relevant information to provide an understanding of ecological values occurring or potentially occurring in the study area and wider region
- A review of regional vegetation mapping by National Parks and Wildlife Service (NPWS) (2002)/Tozer (2003), Department of Environment and Climate Change (DECC) (2007) and The Hills Shire Council (2010)
- A search of the Australian Government's Atlas of Groundwater Dependent Ecosystems

Field survey

Terrestrial flora and fauna

A terrestrial flora and fauna survey of the study area was conducted over three days and two nights from 19 to 21 March 2014 (refer to **Figure 6-21**). The survey methodology complied with the *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities* (Working draft) (DEC 2004).

The flora survey involved:

- Sampling a small patch of vegetation using one 0.1-hectare quadrat (this was deemed sufficient given the highly modified nature of the vegetation in the study area)
- Assessing the vegetation condition and rating it according to the degree to which it resembled relatively natural, undisturbed vegetation. The condition assessment was based on visual assessment of the current habitat condition for each of the vegetation communities within the study area. The vegetation condition data obtained from the quadrat was compared with the Vegetation Type Benchmark for the identified vegetation type (DECC 2008).
- Targeted searches for threatened plant species with potential habitat within the study area. Threatened flora species targeted were those considered to have a high to moderate likelihood of occurrence in the study area.

The fauna survey involved:

- Traversing the entire study area on foot to observe and record all species and

evidence of fauna presence

- Placing ultrasonic bat call detection equipment (Anabat) in potential flyways to record the echolocation calls of microchiropteran bats. Two Anabats were deployed for two nights at Strangers Creek and Elizabeth MacArthur Creek
- Analysing Anabat survey data with reference to Bat Calls of NSW (Pennay et al. 2004) and Anabat Techniques Workshop Course Manual (Livengood Consulting 2010)
- Making a general assessment of each fauna habitat type occurring within the study area. This included an assessment of fauna habitat complexity, condition of fauna habitats, the availability of habitat features and the value of habitat features to threatened species previously recorded within the locality.

Aquatic flora and fauna

Aquatic assessments were carried out at Elizabeth Macarthur Creek and Strangers Creek. Aquatic assessments recorded:

- Channel features, including channel width, substrate, water colour and turbidity
- Instream habitat, including rocks/pebbles, coarse woody debris (CWD) and aquatic vegetation
- Riparian features, including bank width and slope and riparian vegetation.

Memorial Avenue Upgrade - Review of Environmental Factors

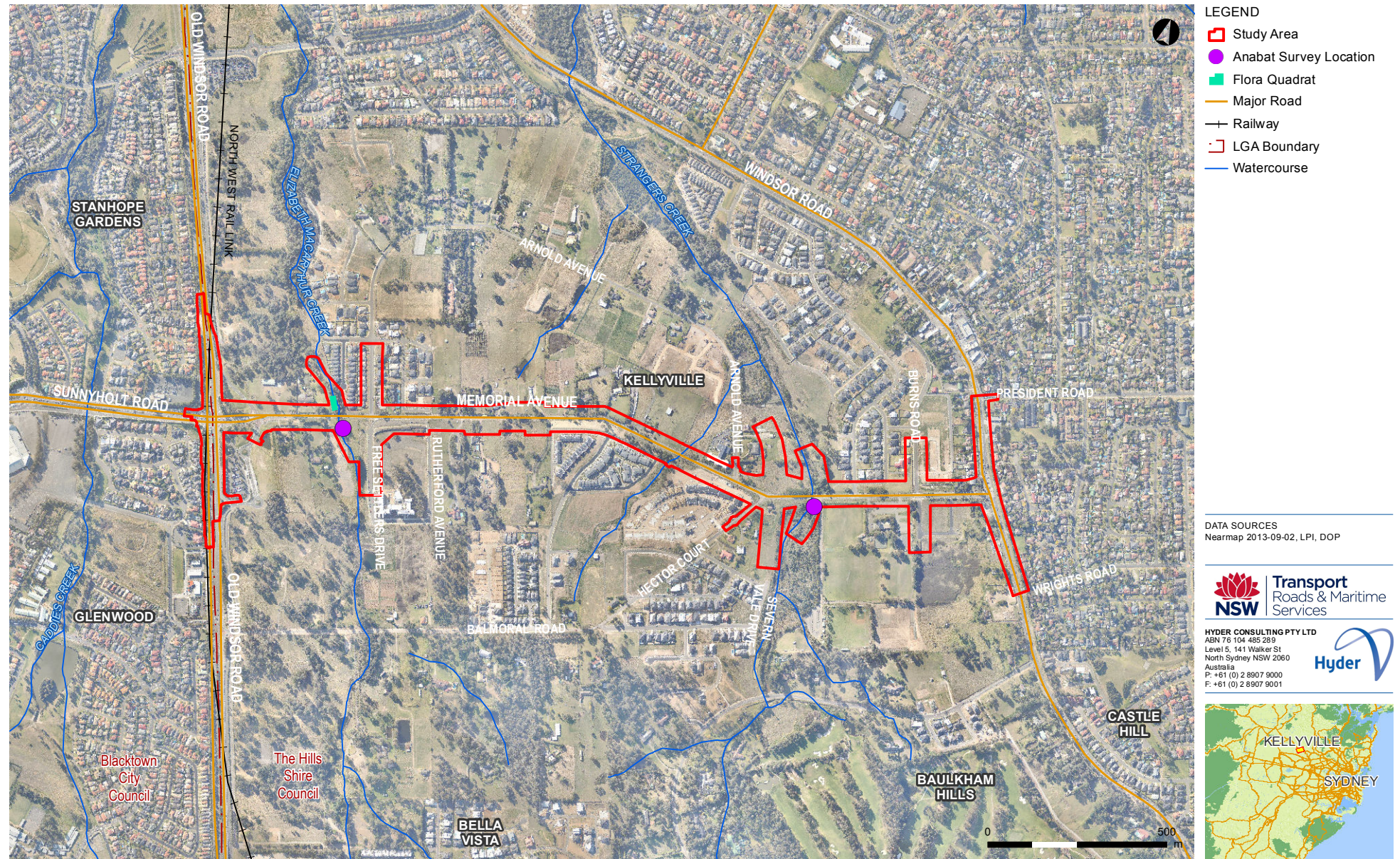


Figure 6-22: Flora and fauna survey effort

6.5.2 Existing environment

Vegetation communities identified through desktop research

National Parks and Wildlife Service (2002)/Tozer (2003) mapped four different plant communities in the study area that all correspond with threatened ecological communities listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the NSW *Threatened Species Conservation Act 1995* (TSC Act) (refer Table 6-31).

Table 6-31: Vegetation communities corresponding with threatened ecological communities (TECs)

Vegetation map unit (NPWS 2002/Tozer 2003)	Corresponding TEC under the EPBC Act	Corresponding TEC under the TSC Act
Shale Hills Woodland	Cumberland Plains Shale Woodland and Shale Gravel Transition Forest (EPBC CPW) (Critically Endangered)	Cumberland Plain Woodland in the Sydney Basin Bioregion (CPW) (Critically Endangered)
Shale Plains Woodland		
Alluvial Woodland	Not listed	River-flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (RFEF) (Endangered) Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions (SOFF) (Endangered)
Turpentine-Ironbark Margin Forest	Turpentine-Ironbark Forest in the Sydney Basin Bioregion (Critically Endangered)	Sydney Turpentine-Ironbark Forest (Endangered)

National Parks and Wildlife Service (2002) has assigned conservation significance to remnant vegetation mapped in the Cumberland Plain. Remnant vegetation within the study area has been mapped with the following conservation significance:

- Core habitat: A patch of Turpentine-Ironbark Margin Forest slightly overlapping the northern edge of the proposal area
- Support to core habitat: Shale Hills Woodland slightly overlapping the southern edge of the study area
- Other remnant vegetation: Most of the Shale Hills Woodland and Shale Plains Woodland within the study area is mapped as this category.

The Hills Shire Council (2010) mapped most of the vegetation in the study area as New Unclassified 2005. A small patch of vegetation adjoining the north-western corner of the junction of Memorial Avenue and Arnold Avenue is mapped as Cumberland Plain Woodland. Aerial photos of the study area show that this area has since been cleared and now supports residential development.

Database searches identified five threatened ecological communities listed under the EPBC Act and 27 listed under the TSC Act as likely or known to occur within 10 kilometres of the study area.

Field survey of vegetation communities

Desktop research (see above) was followed by field survey. It was found that the vegetation of the study area is highly modified, with most native vegetation historically cleared for agriculture and, more recently, for residential development. Much of the vegetation in the study area was planted. Field survey identified six vegetation types:

- Disturbed Swamp Oak Forest (TEC)
- Disturbed regrowth Cumberland Plain Woodland (TEC)
- Disturbed native regrowth
- Native rehabilitation
- Typha wetland
- Developed/landscaped.

The observed distribution of vegetation communities in the study area was not consistent with the vegetation mapping by NPWS (2002)/Tozer (2003), as there has been considerable development and vegetation clearing since the area was mapped. As a result, the mapping was refined after field survey for this REF (Figure 6-28).

The field survey confirmed the presence of two threatened ecological communities in the proposal area: Disturbed Swamp Oak Forest and Disturbed Regrowth Cumberland Plain Woodland. These two vegetation types are broadly equivalent to the vegetation types as defined in the NSW Vegetation Type Database (refer Table 6-32). However, they are highly degraded fragments or scattered trees with a modified understorey dominated by exotic species.

Table 6-32: Native vegetation types in the proposal area

Identified vegetation type	Equivalent vegetation type	Size within proposal area
Disturbed Regrowth Cumberland Plain Woodland	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin	0.151ha
Disturbed Swamp Oak Forest	Swamp Oak – Prickly Tea-tree – Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner	0.038ha

These six vegetation types in the study area are described below.

Swamp Oak Floodplain Forest (SOFF)/Disturbed Swamp Oak

Adjoining Elizabeth Macarthur Creek on the northern side of Memorial Avenue is a stand of *Casuarina glauca* (Swamp Oak) with an understorey dominated by exotic species (Figure 6-22). The mid layer is absent, except for occasional shrubs of *Ochna serrulata* (Mickey Mouse Plant). The ground layer is characterised by dense Swamp Oak leaf litter and patches of the exotics *Tradescantia fluminensis* (Wandering Jew) and *Ehrharta erecta* (Panic Veld-grass). The exotic creepers *Passiflora caerulea* (Blue Passion Flower) and *Solanum seaforthianum* (Brazilian Nightshade) are abundant in the ground layer and climbing trees.



Figure 6-22: Typical vegetation of the Swamp Oak Forest community

The Swamp Oak Forest is in poor condition, with very few native species present – only four were recorded in quadrat 1, which sampled this community. The vegetation scored well below the benchmark values for this community in the Vegetation Types Database.

In conclusion, this vegetation type meets the criteria for Swamp Oak Floodplain Forest in the Sydney Basin, NSW North Coast and South East Corner bioregions under the TSC Act, but is in poor condition.

Cumberland Plain Woodland in the Sydney Basin Bioregion (CPW)/Disturbed Regrowth Cumberland Plain Woodland

In the west, centre and east of the study area are scattered trees of *Eucalyptus tereticornis* (Forest Red Gum) and *Eucalyptus crebra* (Narrow-leaved Ironbark) on road verges and in rural/residential properties (Figure 6-23). The trees are mature but not old growth, and are likely to be regrowth. There are very few native understorey species in these areas, with exotic grasses such as *Paspalum dilatatum* (Paspalum), *Pennistenum clandestinum* (Kikuyu) and *Chloris gayana* (Rhodes Grass) dominant.

Along the roadside there are occasional patches of native groundcover species such as *Aristida vagans* (Threeawn Speargrass), *Microlaena stipoides* (Weeping Grass) and *Glycine tabacina*, but these are minor in extent. This vegetation is in very poor condition, with the native ground layer largely absent and trees varying in condition from good health to poor health. 0.283 hectares of this vegetation community was recorded within the study area, 0.151 hectares being within the proposal area.



Figure 6-23: Cumberland Plain Woodland in the centre of the proposal area

Paragraph 6 of the Final Determination for Cumberland Plain Woodland in the Sydney Basin Bioregion under the TSC Act states that the structure of the community varies according to past and current disturbances, and that most tree-dominated stands are regrowth. It further states that:

After total or partial clearing, the tree canopy may remain sparse or may regrow to form dense stands of saplings and small trees, which are typically associated with a ground layer of reduced cover and diversity. Either or both of the upper-storey and mid-storey may be absent from the community.

Although the ground layer of the community may be reduced in cover or diversity, there is no indication in the Final Determination that patches completely lacking the characteristic ground layer species can be included in the community.

The study area supports characteristic trees of the critically endangered ecological community Cumberland Plain Woodland in the Sydney Basin Bioregion that are likely to be regrowth. Some of these trees have been repeatedly lopped to maintain clearance around overhead power lines. There are occasional herb and grass species typical of Cumberland Plain Woodland growing on road verges, but their occurrence was sparse.

In conclusion, given the lack of characteristic native understorey species beneath

most of the trees, this vegetation type is unlikely to meet the criteria for Cumberland Plain Woodland as stated in the Final Determination for this community. For the purposes of impact assessment, however, the mapped areas of disturbed regrowth Cumberland Plain Woodland are considered to form fragmented and degraded regrowth Cumberland Plain Woodland under the TSC Act.

In addition, the vegetation does not meet the criteria for Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest as defined under the EPBC Act.

Disturbed native regrowth

This vegetation type incorporates areas dominated by native shrub regrowth, usually with a disturbed exotic-dominated ground layer. To the west of the main arm of Strangers Creek to the north of Memorial Avenue are dense stands of *Acacia decurrens* (Black Wattle) with a sparse understorey of *Pennisetum clandestinum*, *Chloris gayana*, *Cynodon dactylon* (Couch), the native herb *Pratia purpurascens* (Whireroot) and *Sida rhombifolia* (Paddy's Lucerne) (Figure 6-24). On the southern side of Memorial Avenue and to the west of Strangers Creek is native shrubland dominated by *Acacia decurrens* with a ground layer dominated by weeds; it is unclear whether this is regrowth or the result of previous bush regeneration. 0.738 hectares of this vegetation type was recorded within the study area, 0.261 hectares being within the proposal area.



Figure 6-24: Native regrowth *Acacia decurrens* north of Memorial Avenue

Native rehabilitation

The areas adjoining the main (eastern) arm of Strangers Creek support planted native trees, shrubs and groundcover. Trees are five to six metres high and include *Angophora floribunda* (Rough-barked Apple), *Eucalyptus tereticornis*, *Eucalyptus moluccana* (Grey Box) and *Casuarina glauca*. 0.638 hectares of native rehabilitation

vegetation was recorded within the study area, 0.072 hectares being within the proposal area

On the southern side of Memorial Avenue is a dense shrub layer of *Acacia floribunda* (White Sally), *Acacia decurrens*, *Bursaria spinosa* (Blackthorn), *Kunzea ambigua* (Tick-bush) and *Leptospermum polygalifolium* (Tantoon) (Figure 6-25). The vegetation is in relatively good condition, with high cover of native species and low abundance of exotics. This area has been subject to intensive planting and slope stabilisation.

On the northern side of Memorial Avenue, the midstorey is characterised by *Melaleuca decora* (White Cloud Tree), *Melaleuca styphelioides* (Flax-leaved Paperbark), *Bursaria spinosa* and the invasive exotic trees *Ligustrum sinense* (Small-leaved Privet) and *Ligustrum lucidum* (Broad-leaved Privet). This vegetation also includes a large multi-trunked tree of *Salix alba x fragilis* (Willow) in the centre of Strangers Creek. It is in poorer condition, with high cover of invasive exotic species.



Figure 6-25: Native rehabilitation vegetation within the study area south of Memorial Avenue

Typha wetland

The section of Elizabeth Macarthur Creek south of Memorial Avenue supports dense stands of *Typha orientalis* (Broad-leaf Cumbungi) interspersed with native and exotic herbs and sedges such as *Persicaria decipiens* (Slender Knotweed), *Alternanthera dentata* (Common Joyweed), *Tradescantia fluminensis*, *Aster subulatus* (Wild Aster), *Rumex conglomeratus* (Clustered Dock) and *Juncus acutus* (Spiny Rush) (Figure 6-26). 0.107 hectares of this vegetation type was recorded within the study area, 0.054 hectares being within the proposal area.

The Typha wetland in the creek is adjoined on both sides by uneven ground (possibly fill) supporting a dense carpet of *Pennisetum clandestinum* (Kikuyu) and *Paspalum dilatatum* (Paspalum) with *Plantago lanceolata* (Plantain) also abundant. There are scattered trees of *Callistemon citrinus* (Scarlet Bottlebrush), *Callistemon viminalis* (Weeping Bottlebrush), *Eucalyptus tereticornis* (Forest Red Gum) and *Schinus areira* (Pepper Tree) in the exotic grassland next to the creek.



Figure 6-26: Typha wetland vegetation within the study area

Developed/landscaped

The majority of the study area supports cleared, developed areas. The vegetated areas comprise planted street trees, landscaping, residential gardens and grass or weed cover. Commonly occurring street trees are *Corymbia citriodora* (Lemon-scented Gum), *Eucalyptus microcorys* (Tallowwood), *Eucalyptus saligna* (Sydney Blue Gum), *Eucalyptus nicholii* (Narrow-leaved Black Peppermint), *Grevillea robusta* (Silky Oak), *Liquidambar styraciflua* (Liquidambar), *Lophostemon confertus* (Brush Box) and *Araucaria heterophylla* (Norfolk Island Pine). The ground cover in these areas mostly comprises mown residential lawns and planted garden beds, slashed exotic grasses on road verges and some areas of dense weed cover.

The western section of the study area next to Old Windsor Road includes extensive areas of landscaping in roadside areas and in the median, associated with the previous upgrades of this road. These areas are characterised by planted trees with a mown exotic grass understorey, massed native shrub planting and edge and median plantings of dense *Lomandra longifolia* (Spiny-headed Mat-rush).

21.202 hectares of developed or landscaped vegetation was recorded within the study area, 9.373 hectares being within the proposal area, Vegetation typical of this vegetation type is shown in Figure 6-27.



Figure 6-27: Developed/landscaped vegetation within the study area

Groundwater Dependent Ecosystems

A search of the Atlas of Groundwater Dependent Ecosystems (GDEs) did not find any known or potential GDEs mapped within the study area (BOM 2014). The closest potential GDEs include GDEs reliant on subsurface groundwater 380 metres downstream of the Elizabeth MacArthur Creek culvert and 360 metres south of Memorial Avenue (between Hodges Street and Balmoral Road). Vegetation downstream of Elizabeth Macarthur Creek is mapped Cumberland River Flat Forest with a high potential for groundwater interaction. Vegetation between Hodges Street and Balmoral Road is mapped Cumberland Shale Hills Woodland with a moderate potential for groundwater interaction. Furthermore, riparian vegetation of Strangers Creek at least 600 metres up and downstream of the existing culvert is mapped with a high potential for groundwater interaction (Cumberland River Flat Forest and Cumberland Shale Plains Woodland).

Vegetation communities within the study area at Strangers Creek and Elizabeth Macarthur Creek could also have groundwater interaction, given their proximity to high potential subsurface GDEs within the same waterbodies.

Flora species

A total of 160 plant species were recorded in the study area, comprising 63 local native species, 10 non-local native species and 87 exotic species. The majority of species recorded, including local native species, are planted specimens in residential gardens or roadside street tree or landscape plantings. Local native species recorded consist mostly of regrowth and planted trees and shrubs in road verges and residential properties, occasional native groundcover species in slashed or mown grassland, and native tree, shrub and groundcover species planted in rehabilitation areas associated with Strangers Creek. Figure 6-28 shows the vegetation communities identified in the study area.

Threatened flora

Database searches found records of 23 threatened flora species listed under the TSC Act and 24 listed under the EPBC Act known to occur or with potential habitat within 10 kilometres of the study area. It was found that potential habitat for two local native threatened flora species listed under the EPBC Act, *Acacia pubescens* (Downy Wattle) and *Grevillea juniperina* subsp. *juniperina* (Juniper-leaved Grevillea) exists in the study area. However, following targeted surveys, it was concluded that these species have a low likelihood of occurrence in the study area.

Another two threatened flora species listed under the EPBC Act and TSC Act – *Eucalyptus nicholii* (Narrow-leaved Black Peppermint) and *Syzygium paniculatum* (Magenta Lilly-pilly) – were recorded in the study area. It was noted in the likelihood of occurrence assessment that these two species, as well as *Eucalyptus scoparia* (Wallangarra White Gum) – which was considered to have a moderate likelihood of occurrence – do not naturally occur within the locality of the study area and any records are likely to be planted specimens.

The locations of the recorded individuals of *Eucalyptus nicholii* and *Syzygium paniculatum* in the study area, as street trees and fenceline plantings in rural/residential gardens, suggest that they are planted. These planted individuals are not of conservation significance.

Weeds

Ten of the 87 exotic species recorded in the study area are listed as noxious weeds in the Hawkesbury River County Council control area, which encompasses the Hills Shire LGA (refer Table 6-33).

Table 6-33: Noxious weeds recorded in the study area

Scientific name	Common name	Control class
<i>Asparagus asparagoides</i> *	Bridal Creeper	4
<i>Celtis sinensis</i>	Chinese Hackberry	4
<i>Cortaderia selloana</i>	Pampas Grass	3
<i>Genista monspessulana</i>	Montpelier Broom	3
<i>Ligustrum lucidum</i>	Broad-leaved Privet	4
<i>Ligustrum sinense</i>	Small-leaved Privet	4
<i>Opuntia</i> spp.*	Prickly Pear	4
<i>Rubus anglocandicans</i> (part of the <i>R. fruticosus</i> agg. spp.)*	Blackberry	4
<i>Salix alba x fragilis</i> *	Willow	4
<i>Senecio madagascariensis</i>	Fireweed	4

* Weed of National Significance

Memorial Avenue Upgrade - Review of Environmental Factors

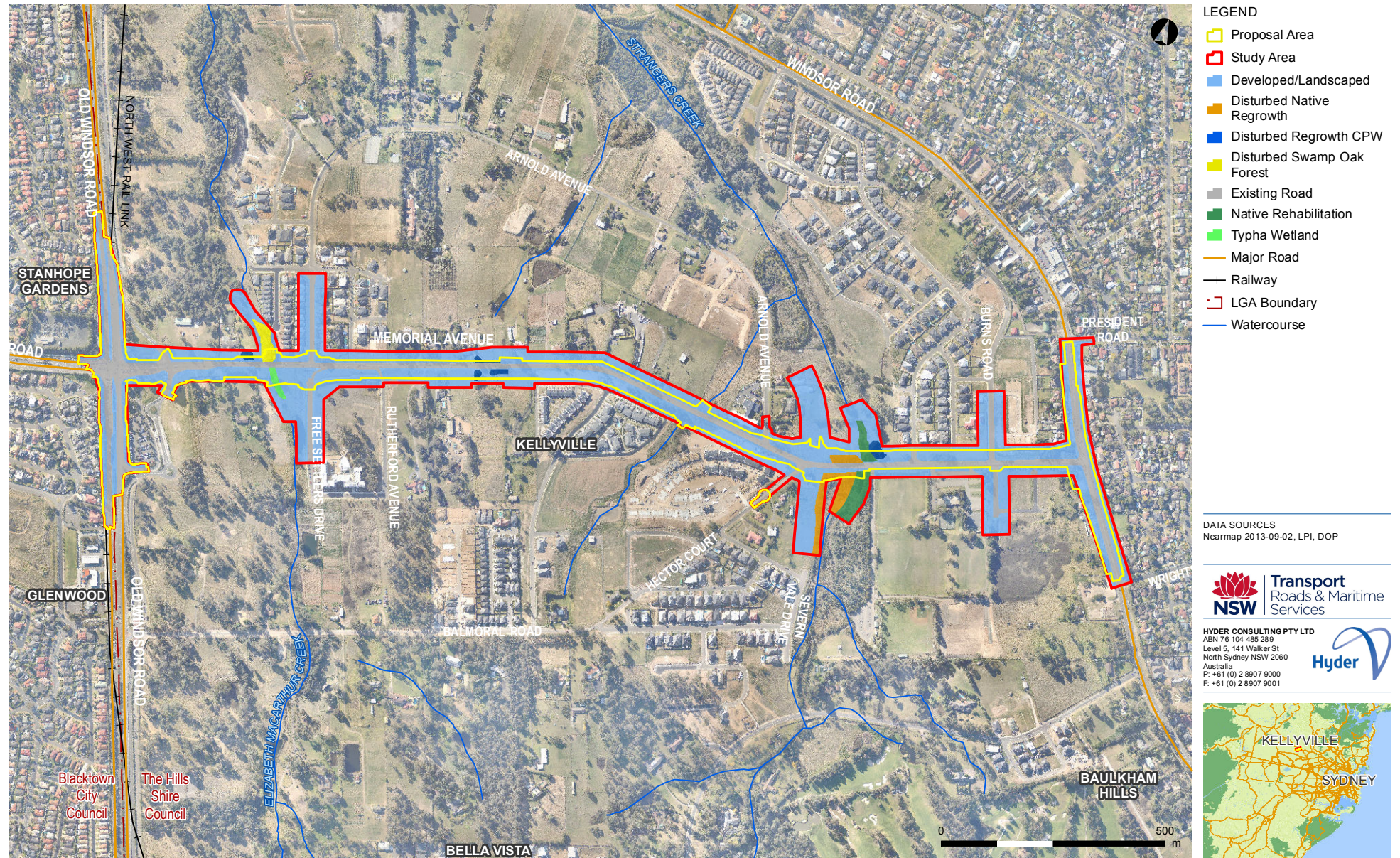


Figure 6-29: Vegetation communities identified in the study area following field survey

Terrestrial fauna habitat

Terrestrial fauna habitats in the study area are generally limited. The study area comprises three broad fauna habitat types: riparian woodland, disturbed roadside vegetation and aquatic vegetation. Fauna habitat features within each habitat type are described below and mapped in Figure 6-29.

Riparian woodland

Small patches of riparian woodland are present at the three creeks that pass through the study area (Strangers Creek, Elizabeth MacArthur Creek and a tributary of Strangers Creek).

Riparian vegetation provides some habitat connectivity along Elizabeth MacArthur Creek and Strangers Creek. Riparian vegetation could provide shelter and nesting habitat for arboreal and ground-dwelling fauna species that occur in fragmented and disturbed habitats. There are also foraging opportunities for a range of fauna species in the riparian woodland.

Canopy cover is higher than in the rest of the study area and flowering shrubs and Casuarinas are present. This vegetation would provide foraging habitat for microbats, including threatened species. One hollow-bearing tree was recorded in riparian vegetation along Elizabeth MacArthur Creek, 150 metres from the proposal area.

Disturbed roadside vegetation

The study area generally comprises a disturbed roadside corridor of scattered native and exotic trees, weedy groundcover and landscaped native vegetation. The area is urban and there is minimal habitat connectivity within and beyond the road corridor. Street trees provide some refuge for highly mobile fauna along the road corridor.

Two trees with potential hollows were recorded close to the proposal area. Figure 6-30 shows the location of the hollow-bearing tree in riparian woodland and potential hollow-bearing trees near the proposal area. The tree furthest to the west is 13 metres from the proposal area and the tree furthest to the east is five metres from the proposal area. The potential hollow-bearing trees are only likely to contain small hollows if present which would provide roosting habitat for microbats (including threatened species) and non-threatened birds.

The culverts at the three creek crossings would also provide roosting habitat for some microbat species, including threatened species.

Street trees and remnant vegetation in the study area would provide shelter for common fauna species including birds, reptiles and mammals, and some foraging and nesting opportunities for birds and reptiles.

Aquatic vegetation

The creeks that pass through the study area – Strangers Creek, Elizabeth MacArthur Creek and a tributary of Strangers Creek – are highly modified and degraded. Emergent and floating aquatic vegetation is present at each creek in very small amounts, and there is a large patch of *Typha orientalis* (Broad-leaf Cumbungi) in Elizabeth MacArthur Creek (Figure 6-28).

These creeks would provide habitat for common frog species, such as

Limnodynastes peronii (Striped Marsh Frog), which was recorded at Strangers Creek. Grassy swales with ponding water and emergent vegetation near the creeks would also provide habitat for frogs.

Terrestrial fauna species

Common fauna species were identified in the study area; most were birds and there was one frog. A rabbit warren and scats were observed at the western end of the study area and fox scats were also identified. Nine microbat species were recorded on the Anabat with varying degrees of confidence in the analysis, including four threatened microbats. No species were observed utilising any hollows within the study area.

Threatened terrestrial fauna

Database searches found records of 42 threatened fauna species listed under the TSC Act, 21 threatened fauna and 12 migratory species listed under the EPBC Act known to occur or with potential habitat within 10 kilometres of the study area. It was found that only one threatened fauna species listed under the EPBC Act, *Pteropus poliocephalus* (Grey-headed Flying Fox), also listed under the TSC Act, had a moderate likelihood of occurrence in the study area. The study area contains highly modified and disturbed foraging habitat for this species.

Analysis of Anabat call data determined that one threatened microchiropteran species (microbats), *Mormopterus norfolkensis* (Eastern Freetail Bat) was present on site at Elizabeth Macarthur Creek. This species is listed as Vulnerable under the TSC Act. Furthermore, potential call sequences of three additional threatened microbats also listed Vulnerable under the TSC Act were identified. This included:

- *Falsistrellus tasmaniensis* (Eastern False Pipstrelle) (Strangers Creek)
- *Myotis macropus* (Southern Myotis) (Strangers Creek)
- *Miniopterus schreibersii oceanensis* (Eastern Bentwing-bat) (Elizabeth Macarthur Creek)

The study area also provides potential habitat for the following threatened microbat species, also listed as Vulnerable under the TSC Act, which are considered to have a moderate likelihood of occurrence:

- *Miniopterus australis* (Little Bentwing Bat)
- *Saccolaimus flaviventris* (Yellow-bellied Sheath-tail-bat)
- *Scoteanax rueppellii* (Greater Broad-nosed Bat).

No other threatened or migratory species listed under the TSC Act or EPBC Act are likely to occur in the study area, nor were any observed during field surveys.

Aquatic habitat

Elizabeth Macarthur Creek

Elizabeth Macarthur Creek passes under the western end of Memorial Avenue via three square box culverts. The creek flows in a northerly direction and is part of the Cattai Creek catchment.

It is a highly degraded and modified creek with a muddy substrate, low turbidity and a moderate flow at the time of the site visit. The creek is classified Class 3 – Minimal

Fish Habitat in accordance with the NSW Classification of Fish Habitat (Fairfull and Witheridge 2003).

Upstream of the creek crossing and within two metres downstream is dense *Typha orientalis* within the channel, which would provide breeding habitat and shelter for fish and frogs. The channel is about six metres wide. The riparian zone upstream of the culvert comprises dense grass and occasional shrubs. A few mature trees are scattered along the banks including *Eucalyptus tereticornis* (Forest Red Gum) and *Schinus areira* (Pepper Tree).

Downstream of the culvert is a stand of Swamp Oak Forest within the riparian zone of the creek. The creek is heavily shaded and there is some instream vegetation including floating, emergent and submerged species. There are snags and overhanging vegetation and exposed tree roots on the channel banks, which would provide shelter and breeding habitat for fish and frogs, but would be unlikely to provide habitat for threatened species.

Tributary of Strangers Creek

A tributary of Strangers Creek passes below Memorial Avenue in the middle of the study area. Land surrounding the tributary has been highly modified and there is no formal channel. The creek is classified Class 4 – Unlikely Fish Habitat in accordance with the NSW Classification of Fish Habitat (Fairfull and Witheridge 2003).

During the field survey, the tributary was found to contain small pools of standing water with some emergent aquatic vegetation (*Typha orientalis*). Water clarity was low, likely due to dirty water runoff from nearby developments. The channel banks and riparian zone contained dense grass and weeds and there are *Salix alba x fragilis* (Willows) in the riparian zone downstream.

Strangers Creek

Strangers Creek passes under the eastern end of Memorial Avenue via four concrete pipe culverts. The creek flows in a northerly direction and is part of the Cattai Creek catchment.

It is a highly degraded and modified creek with a rocky and muddy substrate, low turbidity and a slow stream flow at the time of the site visit. The creek is classified Class 3 – Minimal Fish Habitat in accordance with the NSW Classification of Fish Habitat (Fairfull and Witheridge 2003).

Upstream of the creek crossing the channel has been modified with constructed gabion rock baskets instream and on the channel banks for about 40 metres. The channel is about five metres wide. There is dense *T. orientalis* beyond the gabion rock channel and immediately downstream of it, next to the culvert opening which could provide breeding habitat and shelter for fish and frogs. The riparian zone upstream of the culverts comprises rehabilitated native woodland.

Downstream of the culverts the channel is eroded and contains minimal instream vegetation. The channel is about five metres wide. Exotic trees and shrubs line the channel banks. Further from the banks, the riparian zone contains native trees and shrubs including eucalypts and acacias. Snags are present which could provide breeding habitat for fish, but are unlikely to provide habitat for threatened species.

Memorial Avenue Upgrade - Review of Environmental Factors

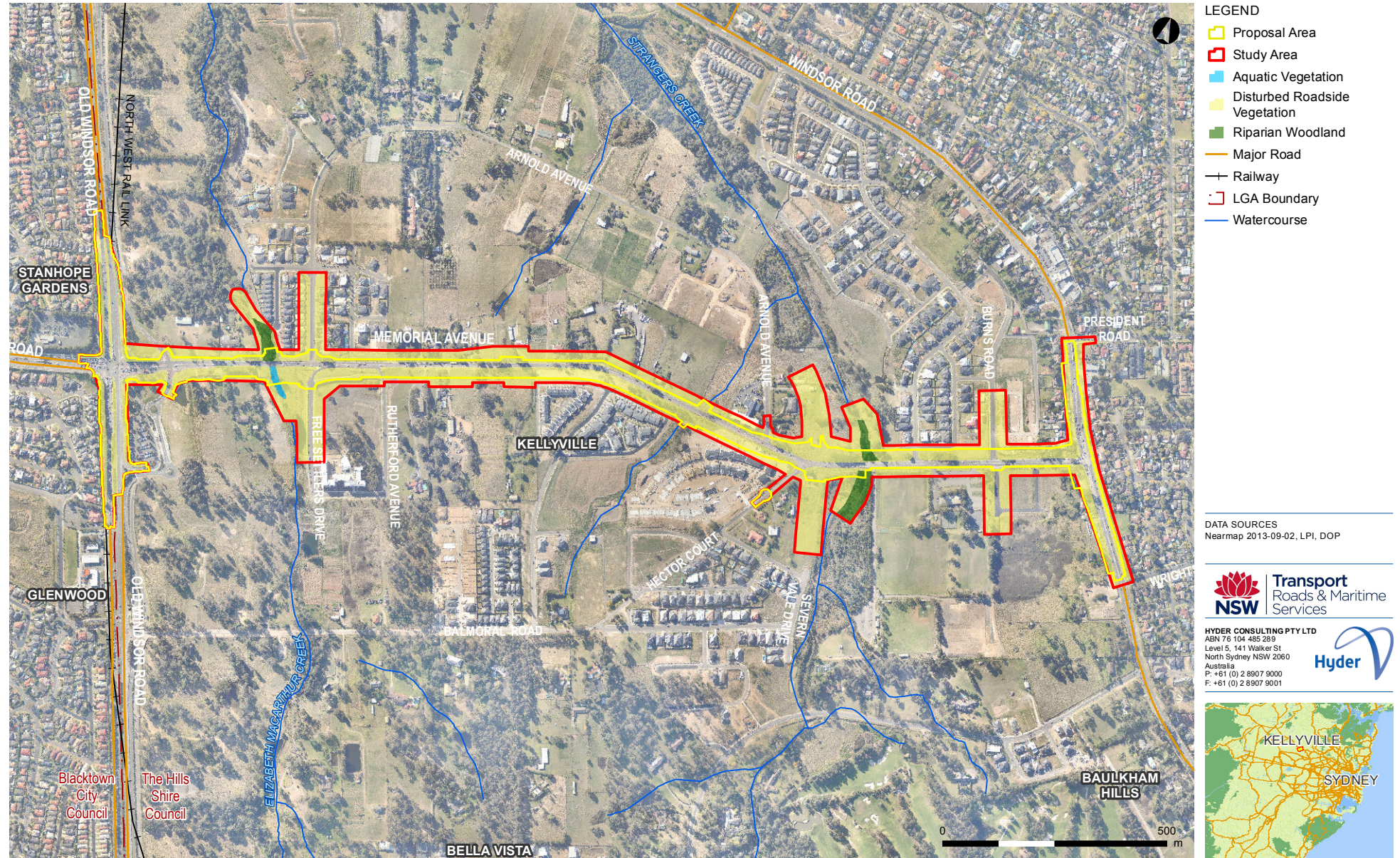


Figure 6-30: Fauna habitats identified in the study area

Memorial Avenue Upgrade - Review of Environmental Factors

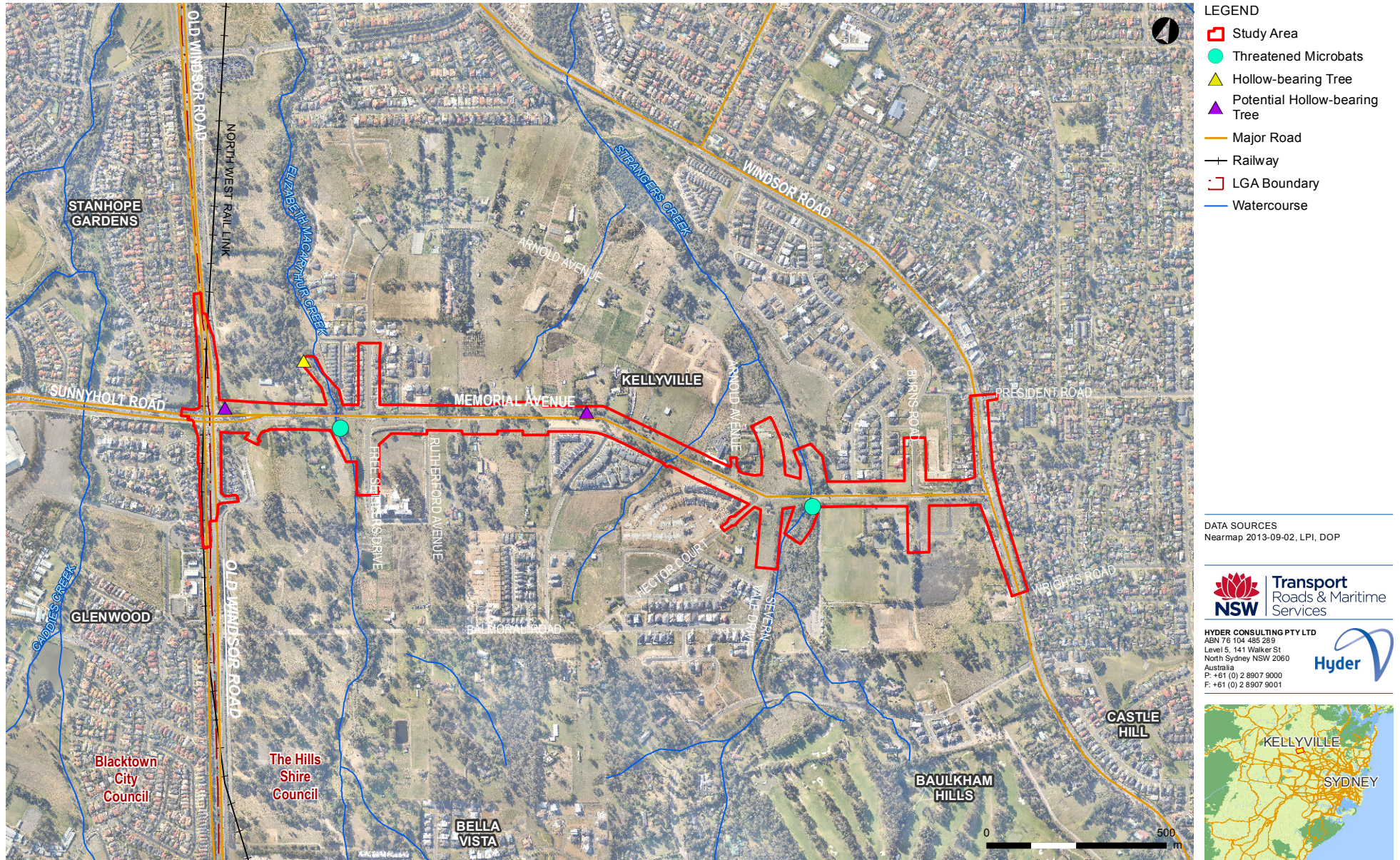


Figure 6-31: Threatened species and hollow-bearing trees within the study area

Aquatic fauna species

Threatened aquatic fauna

Two threatened fish species were identified in the database searches: *Macquaria australasica* (Macquarie Perch), which is listed as Vulnerable under the EPBC Act and Endangered under the FM Act; and *Prototroctes maraena* (Australian Grayling), which is listed as Vulnerable under the EPBC Act and Protected under the FM Act. Both species are considered to have a low likelihood of occurrence in the study area.

6.5.3 Potential impacts

Construction

Construction of the proposal would require the removal of native vegetation and habitat, which would have impacts on native fauna. These impacts are outlined below.

Loss of native vegetation

Most of the vegetation in the study area consists of cleared and disturbed areas, landscaped road verges with planted street trees, and planted native gardens. The proposal would mostly impact cleared, developed area and landscaped vegetation. A total of 0.65 hectares of native vegetation would be directly impacted within the proposal area. Other impacts include removal of small amounts of vegetation comprising two threatened ecological communities (TECs): *Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregion* and *Cumberland Plain Woodland in the Sydney Basin Bioregion*. Both TECs are listed under the TSC Act. Impact to these communities would not be significant. The areas of each vegetation community that occur within the proposal area are listed in Table 6-34 and are shown in Figure 6-28.

Table 6-34: Vegetation mapped within proposal area

Vegetation community	Equivalent threatened ecological community	Area of vegetation community occurring within the study area (ha)	Area to be removed within proposal area (ha)
Disturbed Swamp Oak Forest	Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions (TSC Act)	0.243	0.067
Disturbed regrowth Cumberland Plain Woodland	Cumberland Plain Woodland in the Sydney Basin Bioregion (TSC Act)	0.283	0.190

Vegetation community	Equivalent threatened ecological community	Area of vegetation community occurring within the study area (ha)	Area to be removed within proposal area (ha)
Native rehabilitation	N/A	0.638	0.106
Disturbed native regrowth	N/A	0.738	0.224
Typha wetland	N/A	0.107	0.063
Developed/Landscaped	N/A	21.599	10.664
Total		23.608	11.314

Weeds and pathogens

Ten of the 87 exotic species recorded in the study area are listed as noxious weeds in the Hawkesbury River County Council control area, which encompasses The Hills Shire LGA. Invasive exotic grasses such as *Pennisetum clandestinum* (Kikuyu), *Chloris gayana* (Rhodes Grass) and *Ehrharta erecta* (Panic Veld-grass) also represent a threat to native vegetation. These grasses are currently abundant at the existing road edge and increased movement of people, vehicles, machinery, vegetation waste and soil during and following construction of the proposal may facilitate the introduction or spread of these weeds within and outside the study area.

The proposal also has the potential to increase the spread of a number of pathogens that threaten native biodiversity values.

Given the low biodiversity values recorded in the study area, it is unlikely that further spread of weeds and/or pathogens as a result of the proposal would greatly impact on native vegetation. Weeds are already widespread and dominant in the study area, and there is little native vegetation in the study area or nearby.

However, measures should be implemented to avoid the spread of weeds, particularly adjoining any areas of retained native vegetation and the rehabilitation areas next to Strangers Creek.

Loss of flora habitat

The only threatened flora species recorded in the study area were planted specimens of the non-local native species *Eucalyptus nicholii* and *Syzygium paniculatum*. These plants are not considered to be of conservation value in the locality of the study area.

In addition, the proposal would not result in loss of potential habitat for threatened flora species –the areas of disturbed native vegetation are not considered to provide potential habitat for threatened plant species, given that the understorey in these roadside areas are dominated by exotic species, mainly dense exotic grass cover.

Loss of fauna habitat

Clearing of vegetation for the proposal would result in the removal of fauna habitat. The areas of each fauna habitat type that occur within the proposal area are listed in Table 6-35 and shown in Figure 6-31.

Table 6-35: Areas of fauna habitat to be removed for the proposal

Fauna habitat type	Area to be removed within proposal area (ha)
Riparian woodland	0.173
Disturbed roadside vegetation	11.078 (includes 0.414 hectares of native vegetation)
Aquatic vegetation	0.063
Total	11.314

The proposal would result in the removal of remnant and planted street trees and landscaped vegetation within an area of about 11.078 hectares, 0.414 hectares of which is native vegetation. Vegetation removal would result in potential impacts on nesting, roosting and foraging habitat for native and exotic birds, mammals and reptiles. This would include common urban birds such as Noisy Miner (*Manorina melanocephala*), Crimson Rosella (*Platycercus elegans*) and Spotted Pardalote (*Pardalotus punctatus*), microchiropteran bats (at culverts) and other native and exotic mammals such as Rabbits (*Oryctolagus cuniculus*) and common skinks such as the Eastern Striped Skink (*Ctenotus robustus*).

Riparian habitat at three creeks would also be impacted (0.173 hectares) – aquatic vegetation at Elizabeth MacArthur Creek and Strangers Creek would be removed on the edge of the road corridor over an area of 0.063 hectares, and a few exotic trees would be removed within the riparian zone of the tributary of Strangers Creek. Impacts to aquatic and riparian vegetation could result in impacts to native fish and frogs such as Striped Marsh Frog (*Limnodynastes peronii*) and terrestrial fauna that occur in riparian habitats or forage in waterways, such as native waterbirds.

Memorial Avenue Upgrade - Review of Environmental Factors



Figure 6-32: Fauna habitats potentially impacted by the proposal

Hollow-bearing trees

Two potential hollow bearing trees were recorded close to the project boundary. One was recorded near the intersection of Old Windsor Road and Memorial Avenue and is unlikely to be affected by the proposal. The other potential hollow bearing tree was recorded about 125 metres east of the unnamed drainage line. The construction would encroach within five metres of this potential hollow-bearing tree (Figure 6-32). The tree's root systems could be impacted by earthwork, and it may need to be removed. Removal of this tree could impact arboreal fauna roosting/nesting in hollows, if they are present. One hollow-bearing tree is located further from the proposal area, along Elizabeth Macarthur Creek. It is unlikely that this hollow-bearing tree would be impacted by the proposal due to the distance from the proposal area.



Figure 6-32: Potential hollow-bearing tree within the proposal area

Mortality of fauna species

Fauna injury or mortality is most likely to occur during vegetation clearing activities, but may also result from collisions with vehicles or plant. The majority of fauna species recorded within the proposal area were highly mobile bird species and mammals. These species are likely to be able to move away from vegetation clearing activities quite readily. Any fauna inhabiting the hollows in hollow-bearing trees may be injured during tree-felling. This could potentially include hollow-dependent birds and mammals and threatened microchiropteran bat species. Those animals that are unable to disperse away from areas under active clearing are also particularly susceptible to injury or death. This includes amphibians, reptiles and fish during construction work on the creeks such as the Eastern Striped Skink (*Ctenotus robustus*) and Striped Marsh Frog (*Limnodynastes peroni*), species identified during site surveys.

Alteration and degradation of aquatic habitats

The proposal would involve replacing the three culverts at Elizabeth MacArthur Creek with four three-metre wide culverts, and the culverts at Strangers Creek with a plank bridge 18 metres long. Works at Strangers Creek would also require bank reshaping up and downstream of each crossing. The culvert at the tributary of Strangers Creek would be replaced with three 900 mm diameter pipes.

Fish passage would be maintained throughout the construction process at all creek crossings (further discussion in Section 6.1.2). Aquatic and riparian vegetation would be removed over a small area of 0.173 hectares, 0.063 hectares of which is instream vegetation. Snags may also be removed from these creeks, though this would only

occur within the disturbance footprints at each creek.

Removal of aquatic vegetation and snags would have impacts on potential breeding and foraging habitat for frogs and fish. There is also potential for sedimentation and spills to affect water quality in the creeks during the construction process which could affect fish and frogs, including downstream of the proposal area.

However, the creeks are highly degraded and fish and frogs likely to be impacted would be hardy and common species. Therefore, no impacts on threatened aquatic species are anticipated as a result of the work.

Impacts to Groundwater Dependent Ecosystems

Potential impacts on groundwater may occur during construction of the bridge over Strangers Creek which would require piling to a depth of about 10 to 15 metres to install the bridge piers. A locally lowered watertable may result which is would likely have minor, if any, impacts to GDEs at or near this creekline. Works at Elizabeth MacArthur Creek are unlikely to result in any drawdown impacts to groundwater and subsequently, any GDEs at or near this creekline.

Impacts on threatened species, populations and communities

Assessments of Significance were carried out for eight threatened species (seven microchiropteran bats and one megachiropteran bat) and two TECs as follows:

- Cumberland Plain Woodland in the Sydney Basin Bioregion (CPW) (Critically Endangered – TSC Act)
- Swamp-oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions (SOFF) (Endangered – TSC Act)
- *Mormopterus norfolkensis* (Eastern Freetail-bat) (Vulnerable – TSC Act)
- *Falsistrellus tasmaniensis* (Eastern False Pipistrelle) (Vulnerable – TSC Act)
- *Miniopterus schreibersii oceanensis* (Eastern Bentwing-bat) (Vulnerable – TSC Act)
- *Myotis macropus* (Southern Myotis) (Vulnerable – TSC Act)
- *Miniopterus australis* (Little Bentwing-bat) (Vulnerable – TSC Act)
- *Pteropus poliocephalus* (Grey-headed Flying Fox) (Vulnerable – TSC Act & EPBC Act)
- *Saccolaimus flaviventris* (Yellow-bellied Sheath-tail-bat) (Vulnerable – TSC Act)
- *Scoteanax rueppellii* (Greater Broad-nosed Bat) (Vulnerable – TSC Act).

The proposal would remove 0.190 hectares of Cumberland Plain Woodland and 0.067 hectares of Swamp-oak Floodplain Forest.

There would be impacts on threatened microbats due to:

- The removal of 0.414 hectares of potential foraging habitat for all species
- The potential removal of one potential hollow-bearing tree
- The removal of culverts.
- These changes would impact the particular species that roost in these habitats.

Furthermore, the Grey-headed Flying-fox would be impacted by the loss of potential foraging habitat comprising scattered regrowth and planted trees across the proposal area.

Due to the limited impacts, the proposal is unlikely to have a significant impact on any threatened species, population or community listed under the TSC Act or EPBC Act. Consequently, a species impact statement is not required. A referral to the Commonwealth Department of the Environment under the EPBC Act is also not required.

Operation

Once the Memorial Avenue upgrade is complete, there would be potential impacts on biodiversity from edge effects, habitat fragmentation and changes to aquatic habitats, as outlined below.

Edge effects

There would be potential indirect impacts on native vegetation in the study area from edge effects associated with the creation of a new road edge. These effects could include weed invasion, altered hydrology and increased sedimentation and runoff.

The areas of native vegetation to be removed from the existing edge of Memorial Avenue are currently subject to edge effects, with disturbed soils and large patches of weedy exotic species, particularly close to the road edge. The widening of the road could potentially expand the existing edge effects, but most areas of vegetation further back from the road edge are already highly disturbed.

Habitat fragmentation

The proposal area is located in a highly modified and fragmented environment that has been historically cleared for urban and agricultural development and the road corridor. Some habitat connectivity exists along Strangers Creek and Elizabeth Macarthur Creek.

The removal of vegetation at these creeks would be over a small area (0.173 hectares) and impacts on habitat connectivity would be minor given vegetation removal would be carried out on the edge of the road reserve which already fragments the vegetation.

Alteration and degradation of aquatic habitats

Alterations to the natural flow regimes of rivers and streams is recognised as a major factor contributing to loss of biological diversity and ecological function in aquatic ecosystem and is recognised as a Key Threatening Process (KTP) under the FM Act. Construction of the bridge at Strangers Creek would alter flow patterns of the creek in the immediate vicinity of the bridge through changes to the shape of the banks. The creek banks at Elizabeth MacArthur Creek would also be reshaped to allow for the culvert to increase in width. However, there would be a negligible increase in flow volumes at both creeks as a result of the proposal (see Section 6.1.2). As such, impacts to aquatic ecosystems from changes to flow regimes are therefore unlikely to occur at either creek. There would be a small increase in flow at the tributary of Strangers Creek. However, this creek is identified as unlikely fish habitat and minor changes to the flow regimes of the tributary are unlikely to impact aquatic ecosystem function.

Scour protection would be installed at Strangers Creek and Elizabeth Macarthur Creek which would alter aquatic habitats in the immediate vicinity of each creek crossing. Whilst there would be a minor loss of instream vegetation and snags in this area as a result of the works and placement of scour protection, impacts are over a small area and are unlikely to impact aquatic ecosystems health of either creek.

6.5.4 Safeguards and management measures

The safeguards and management measures outlined in Table 6-36 would be implemented before and during construction of the proposal to minimise impacts on biodiversity.

Table 6-36: Safeguards and management measures for biodiversity

Impact	Environmental safeguards	Responsibility	Timing
Impacts on threatened species	<ul style="list-style-type: none"> • A Biodiversity Management Plan would be prepared and included within the CEMP. The BMP would include but not be limited to the following: <ul style="list-style-type: none"> - A map clearly showing vegetation clearing boundaries and no-go zones - A site walk-over with the site personnel including RMS representatives to confirm clearing boundaries before the start of work - Identification (marking) of the clearing boundary and identification (marking) of habitat features to be protected. Eg. – use of flagging tape - A procedure for a suitably qualified ecologist to undertake pre-clearing surveys immediately before vegetation removal. Target species would include threatened microbats - Management measures identified as a result of the pre-clearing survey report, with actions to respond to the recommendations made - Incorporation of management measures identified as a result of the pre-clearing survey report, completed by an ecologist, (G40, section 2.4) and nomination of actions to respond to the recommendations made. This should include details of measures to be implemented to protect clearing limits and no go areas 	Roads and Maritime and construction contractor	Pre-construction

Impact	Environmental safeguards	Responsibility	Timing
	<ul style="list-style-type: none"> - A detailed clearing process in accordance with RMS Biodiversity Guidelines (2011) including requirements of Guide 1,2, 4 & 9. - Identify in toolbox talks where biodiversity would be included such as vegetation clearing or works in or adjacent to sensitive locations - Identify control/mitigations measures to prevent impacts on sensitive locations or no go zones - A stop works procedure in the event of identification of unidentified species, habitats or populations - A requirement that culverts be checked for roosting microbats by a suitably qualified ecologist with experience in microbat survey prior to construction. In the event microbats are found, a microbat management plan would be developed - A requirement that culvert work and vegetation removal be carried out outside of summer, if possible (the breeding season of most threatened microbats that could be roosting on site) - A procedure for clearing potential habitat, including hollow-bearing trees in accordance with Roads and Maritime' <i>Specification G40</i>. An experienced, licensed wildlife carer or ecologist would be present to supervise vegetation clearing and capture then relocate fauna if required. Fauna handling and vegetation removal would be in accordance with Roads and Maritime' <i>Biodiversity Guidelines 2011</i>. An experienced, licensed wildlife 		

Impact	Environmental safeguards	Responsibility	Timing
	<p>carer or ecologist would be notified or be on call to supervise vegetation clearing and capture then relocate fauna if required. Fauna handling would be in accordance with Roads and Maritime' <i>Biodiversity Guidelines 2011 – Guide 9</i>.</p> <ul style="list-style-type: none"> - Protocols to prevent the introduction or spread of pathogens (e.g. chytrid fungus and <i>Phytophthora</i>) in accordance with Roads and Maritime' <i>Biodiversity Guidelines 2011 – Guide 7</i>. - Provision of education to all personnel taking part in construction activities with regards to the importance of clearing limits, land uses and threatened species and communities and their legislative responsibilities. 		
Impacts on threatened species	<ul style="list-style-type: none"> • If unexpected threatened flora or fauna are discovered, work would stop immediately and Roads and Maritime' <i>Unexpected Threatened Species Find Procedure</i> in its <i>Biodiversity Guidelines 2011</i> would be implemented. 	Roads and Maritime and construction contractor	Construction
Impacts on threatened species	<ul style="list-style-type: none"> • The design would be reviewed during the detailed design stage to determine whether it is possible to retain the hollow-bearing tree near the unnamed drainage line. 	Roads and Maritime and designer	Detailed design
Impacts to riparian areas	<ul style="list-style-type: none"> • Riparian areas disturbed by the proposal would be rehabilitated as soon as practicable - Where vegetation would be planted in disturbed riparian areas, only native species indigenous to the region would be used 	Roads and Maritime and construction contractor	Pre-construction
Impacts on the aquatic	<ul style="list-style-type: none"> • Creek bank stabilisation would be installed before and during the creek realignment work to 	Roads and Maritime and construction	Detailed design and

Impact	Environmental safeguards	Responsibility	Timing
environment	minimise bank erosion, topsoil loss and sedimentation of the waterway.	contractor	construction
Impacts on the aquatic environment	<ul style="list-style-type: none"> • Appropriate erosion and sediment controls would be established throughout the proposal area, including at creek crossings, and water quality monitoring would occur throughout construction. 	Roads and Maritime and construction contractor	Construction
Impacts on the aquatic environment	<ul style="list-style-type: none"> • Fish passage would be maintained at all times. If required, water would be pumped to maintain flow at all times in the event of low flow ponding during creek works. 	Construction contractor	Construction
Impacts on the aquatic environment	<ul style="list-style-type: none"> • Temporary waterway diversions would be scheduled during periods of predicted low flow to minimise impacts. 	Roads and Maritime and construction contractor	Construction
Impacts on the aquatic environment	<ul style="list-style-type: none"> • DPI (Fisheries) would be notified of reclamation/dredging work prior to construction. Consideration would be given to any response within 28 days of notification. 	Roads and Maritime	Pre-construction
Weeds and pathogens	<ul style="list-style-type: none"> • Actions for weed management would be developed as part of the Vegetation Management Plan in accordance with the requirements of Roads and Maritime' <i>Specification G36</i> and <i>Specification G40</i>. The plan would include, but not be limited to the following measures: <ul style="list-style-type: none"> - The identification of the type and location of weeds of concern (including noxious weeds) within the proposal area - The identification of sensitive receivers (such as native vegetation and waterways) within or near the proposal area - Measures to prevent the spread of weeds and fungi, including hygiene procedures for equipment, footwear and clothing 	Roads and Maritime and construction contractor	Pre-construction

Impact	Environmental safeguards	Responsibility	Timing
	<ul style="list-style-type: none"> - A requirement that weeds (including Declared noxious weeds) be managed and disposed of in accordance with requirements of the <i>Noxious Weeds Act 1993</i> and <i>Roads and Maritime' Biodiversity Guidelines 2011 – Guide 6</i> - Communication strategies to improve contractor awareness of weeds and weed management. 		
Weeds and pathogens	<ul style="list-style-type: none"> • Any application of herbicide for weed management would be carried out in accordance with the requirements of the <i>Pesticides Act 1999</i> and herbicide that is appropriate to the sensitivity of the area would be used. Approval by Roads and Maritime' Regional Environmental Officer would be obtained prior to use. 	Construction contractor	Pre-construction and construction

6.6 Aboriginal heritage

An Aboriginal archaeological survey and an Aboriginal heritage assessment were carried out for the proposal. The objective of the survey and assessment was to comply with the *Roads and Maritime Procedure for Aboriginal Cultural Heritage Consultation and Investigation* (PACHCI) and applicable Office of Environment and Heritage (OEH) regulations including the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales 2010* (Code of Practice).

The investigations aimed to accurately locate previously registered Aboriginal sites, potential unrecorded sites, and potential archaeological deposits (PADs) and to assess their archaeological significance.

The complete assessment report (*Memorial Avenue, Kellyville – PACHCI Stage 2 Aboriginal Archaeological Report* (Artefact Heritage 2014)) is attached as Appendix E of this REF. The outcomes of these investigations are summarised in this section.

6.6.1 Methodology

The Aboriginal heritage study area is defined as a linear transect about two kilometres long along Memorial Avenue, Kellyville between Windsor Road and Old Windsor Road. The study area includes the extents required for the proposal including: the road widening along Memorial Avenue; new intersections at Arnold Avenue West and at Severn Vale Drive and the upgrades of intersections at Windsor Road and Old Windsor Road.

The field investigation and assessment involved:

- Desktop investigation, including searches of the Native Title and Aboriginal Heritage Information System (AHIMS) database, and consideration of previous archaeological survey reports within and adjacent to the study area
- Detailed site archaeological survey
- Consultation with the Aboriginal community.

The search of the AHIMS database was done on 13 February 2014 and the Native Title search was done on 10 March 2014.

A survey of the study area was conducted by Artefact Heritage, accompanied by a representative of the Deerubbin Local Aboriginal Land Council (DLALC). This survey occurred on 19 and 20 March 2014. The study area was covered on foot and a hand-held Global Positioning System was used to track the path of the surveyors and to record the coordinates of sites, features and location of landform units within the study area. Due to the length of the study area, and its location along an established road corridor associated with pockets of new residential development, the study area was broken down into 19 arbitrary survey units.

All ground exposures were examined for stone artefacts, shell or other traces of Aboriginal occupation. Old growth trees were examined for signs of cultural scarring or marking. Photographs were taken to record representative sections of the study area (see Appendix E).

6.6.2 Historical land use

Before the settlement of the area by Europeans, the study area and the surrounds would have been covered by Cumberland Plain Woodland. Cumberland Plain Woodland was dominated by eucalypt species such as Forest Red Gum (*Eucalyptus tereticornis*) and Grey Box (*Eucalyptus moluccana*) with groundcover consisting primarily of Kangaroo Grass (*Themeda australis*) (Benson and Howell 1990).

Aboriginal people were highly mobile hunter-gatherers utilising different landform units and resource zones. Varying resources are likely to have only been available seasonally, which may have necessitated the need for movement and trade of resources across the landscape (Attenbrow 2010: 78).

Since European settlement of Sydney, the study area has been used chiefly for agricultural and pastoral activities. Settlement in the region took place during the early 19th century with the district flourishing as an agriculture region. Farming across the Cumberland Plain consisted primarily of grazing and cropping. Significant development did not occur in the local area until the early 1990s.

By 1860 the study area was a series of five rural allotments located between Windsor Road and Old Windsor Road, with much of the surrounding farmland described as dairy farms and orchards. By the early 1930s the area between Windsor Road and Old Windsor Road was steadily being sold off as smaller allotments. By this stage, Burns Road – later known as Memorial Avenue – had been built, which allowed for the subdivision of the larger farm allotments.

The study area has remained rural in character, with the small lot semi-rural subdivision and market gardens evident today established in the mid-20th century.

6.6.3 Existing environment

Landforms across the local area consist of broad crests with gently sloping inclines. The study area is located within a gently sloping landform context. The study area is located within an area that has been subject to landform modification and ground disturbance as a result of road construction, urban development and agriculture.

Elizabeth Macarthur Creek, Strangers Creek, a tributary of Strangers Creek and an unnamed second order watercourse intersect the study area and would have provided fresh water and associated resources to inhabitants in the past.

Caddies Creek, a major higher order watercourse, is located about 550 metres west of the study area. Smalls Creek is located about 1.2 kilometres east of the study area. Numerous lower order creek and drainage lines are within 1.5 kilometres of the study area.

Sites and places

The search of the AHIMS database identified 69 Aboriginal sites near the study area (**Error! Reference source not found.**). Five of these recorded Aboriginal sites are located within the study area and one additional Aboriginal site is likely to overlap with the study area. These six sites are:

- 45-5-0981 (a duplicate AHIMS site: duplicates 45-5-0989)
- 45-5-0989 (a duplicate AHIMS site: duplicates 45-5-0981)

- 45-5-3063
- 45-5-3844
- 45-5-3847
- 45-5-2652 (overlapping site: a Potential Archaeological Deposit).

The AHIMS website locates site 45-5-2365 within the study area boundary however verification of the recorded location has confirmed that the site is about 200 metres outside the study area.

No previously unrecorded Aboriginal objects or PADs were identified in the field survey.

6.6.4 Assessment of archaeological potential

Archaeological potential is closely related to the levels of ground disturbance within a given area. However, other factors are also taken into account when assessing archaeological potential, such as whether artefacts were located on the surface, or whether the area is within a sensitive landform unit according to the predictive statements.

The study area has been subject to generally high levels of disturbance. It is located along an existing road corridor that is bordered by rural allotments, market gardens and recent residential development.

A portion of one identified area of archaeological potential (AHIMS site 45-5-2652) is located within the study area. The south-eastern portion of this site has been impacted by residential development. That portion of the PAD was investigated during an archaeological test excavation program. The results indicated that there is a very low density of Aboriginal objects beneath the surface and no further archaeological investigation was recommended.

The western portion of site 45-5-2652, also within the study area, has not been impacted and appears to be in the same condition as when it was originally recorded in 2002. As the subsurface investigation in the south-eastern portion of site 45-5-2652 retrieved very few artefacts, it is likely that by association the overall archaeological potential of site 45-5-2652 is low.

The study area has therefore been assessed as having a low archaeological potential.

6.6.5 Assessment of archaeological significance

Archaeological significance refers to the archaeological or scientific importance of a landscape or area. This is characterised using archaeological criteria such as archaeological research potential, representativeness and rarity of the archaeological resource, and potential for educational values. Table 6-37 provides a summary of the significance assessment.

The remainder of the study area does not provide good research potential as there were no identified areas of archaeological potential. Representativeness values are low and it is not an area of rarity within the local region. The area does not have Aboriginal heritage and/or archaeological educational potential.

The study area is therefore assessed as having low archaeological significance.

Cultural values and significance can only be addressed by Aboriginal peoples who have cultural knowledge of the area. No areas of particular cultural significance have been addressed by DLALC in their survey report (Appendix E).

Table 6-37: Significance values for previously recorded Aboriginal heritage sites

Site name	Site status / description	Research potential	Scientific/ archaeological value	Representative value	Rarity value	Overall significance
45-5-0981 / 45-5-0989 (duplicate AHIMS site)	The site has been destroyed under Section 90 Consent to Destroy number 710.	N/A	N/A	N/A	N/A	N/A
45-5-3063	The site has been disturbed under two Aboriginal Heritage Impact Permits (2241, 2319).	N/A	N/A	N/A	N/A	N/A
45-5-3844	The site has been destroyed under the Part 3A development of a retirement facility.	N/A	N/A	N/A	N/A	N/A
45-5-3847	The site has been destroyed under the Part 3A development of a retirement facility.	N/A	N/A	N/A	N/A	N/A
45-5-2652 (Potential Archaeological Deposit (PAD))	<p>An intact portion of Aboriginal site 45-5-2652 is located within the study area. It is understood that the intact portion of 45-5-2652 would not be impacted by the proposal.</p> <p>One impacted portion of site 45-5-2652 is located within the study area. It appears that these impacts were conducted in accordance with permits 2002, 2013, 3636 and 3638.</p>	Low	Low	Low	Low	Low

6.6.6 Potential impacts

Construction

Six Aboriginal sites listed on the AHIMS site register are located within the study area. Sites 45-5-0981/45-5-0989, 45-5-3063, 45-5-3844, 45-5-3847 and a portion of 45-5-2652 have been destroyed.

An intact portion of AHIMS site 45-5-2652 is located within the study area but the proposed road upgrade would not intersect this site, and the site would not be impacted by the proposal.

There is potential to impact previously unrecorded Aboriginal sites during construction while carrying out activities that involve ground disturbance and excavation. However, the study area has a low archaeological potential and a low archaeological significance and the proposed work would be contained within areas specified as having high levels of disturbance. The impact assessment has therefore found that there would be no impact on known Aboriginal sites, places or areas of potential under the proposed work by Roads and Maritime.

Operation

It is expected that there would be no impacts on known Aboriginal sites, places or areas of potential once the proposal is built and operational.

6.6.7 Safeguards and management measures

The overall guiding principle for Aboriginal heritage management is that where possible Aboriginal sites would be conserved. If conservation is not possible, measures would be taken to mitigate against impacts to Aboriginal sites.

Table 6-38 summarises the proposed safeguards and management measures for known sites that would be impacted by the proposal, as well as proposed safeguards and management measures for any potential Aboriginal objects which may be identified during construction.

The safeguards and management measures outlined in Table 6-38 would be implemented before and during construction of the proposal to minimise impacts on known sites that would be impacted by the proposal, as well as any potential Aboriginal objects that may be identified during construction.

Table 6-38: Safeguards and management measures for Aboriginal heritage

Impact	Environmental safeguards	Responsibility	Timing
Impacts to known Aboriginal heritage sites	<ul style="list-style-type: none"> Aboriginal Heritage Management procedures would be included in the CEMP. These would include but not be limited to the following measures: <ul style="list-style-type: none"> An environmental risk assessment to determine potential risks for discrete work elements or activities that could affect Aboriginal heritage items 	Roads and Maritime and construction contractor	Pre-construction and construction

Impact	Environmental safeguards	Responsibility	Timing
	<ul style="list-style-type: none"> - Specific mitigation measures to avoid risk of harm or protect Aboriginal heritage - Provisions for seeking further advice from an archaeologist should the proposed road design be altered in a manner that could impact the intact portion of site 45-5-2652 - If intact AHIMS sites are within 25 m of the proposal area, these would be identified on construction plans and exclusion fencing and signage would be placed at the boundary of the proposal area at this location to prevent indirect or inadvertent impacts to the site - A stop work procedure in the event of actual or suspected potential harm to a heritage feature/place - Aboriginal heritage induction for workers so they are made aware of the location of sites and their responsibilities under the <i>National Parks and Wildlife Act</i> and any relevant permits. Induction would occur before work begins. 		
Possible disturbance to unknown Aboriginal heritage due to construction activities	<ul style="list-style-type: none"> • In the event of an unexpected find of an Aboriginal heritage item (or suspected item), work would cease in the affected area and Roads and Maritime' Regional Environmental Officer and Senior Environmental Specialist (Aboriginal heritage) would be contacted for advice on how to proceed. The <i>Roads and Maritime Unexpected Archaeological Finds Procedure</i> (2011) would be implemented. 	Construction contractor	Construction

6.7 Non-Aboriginal heritage

A non-Aboriginal heritage assessment and Statement of Heritage Impacts (SOHI) was prepared for the proposal (Artefact Heritage 2014) and is provided in Appendix F. The outcomes of this assessment and SOHI are summarised in this section. Non-Aboriginal heritage investigations were undertaken within the proposal area shown in Figure 6-33.

6.7.1 Methodology

A desktop investigation was undertaken which included a review of the following heritage listings:

- State Heritage Register
- Section 170 Register
- Blacktown LEP
- Hills Shire LEP
- Australian Heritage Database
- The National Trust of Australia

Site inspections of the proposal area were undertaken on 20, 21 March 2014 and 17 July 2014.

6.7.2 Historical land-use context

The development of European settlement within the local area was characterised by both government run properties and large privately run farms. Both Windsor and Old Windsor Roads enabled relatively reliable access between the newly developed agricultural areas and Parramatta and Sydney. As early as 1789 explorations west of Parramatta, which included the area around the current proposal area, were being undertaken. Settlement began to spread out from Parramatta by the early 1790's with land grants in Kellyville in 1793.

A track developed as an extension of the Sydney Road from Parramatta to Windsor to serve the agricultural community in the Hawkesbury area. The first improvements were ordered by Governor Hunter in 1797 and landholders undertook the widening of the road to 20 feet (6 metres). This is regarded as the date for the creation of the original Windsor Road as a carriageway. In 1805 Surveyor James Meehan surveyed an alignment between Parramatta and Kellyville which became the basis for the new Windsor Road established in 1812-1813.

Both Windsor and Old Windsor Road have been substantially modified to cater for modern traffic. Significant elements of the old road still remain as bypassed sections which retain original surfaces, boundary stones and alignment markers. These sections retain characteristics evocative of the historic, rural character of the Cumberland Plain, both within the current road reserve and in redundant sections outside the reserve.

Early European settlement was attracted to the area around Kellyville as early as the 1790s due to its arable soil and trees suitable for logging. During the nineteenth and the early part of the twentieth century, the region was primarily rural and was

dominated by farms. The region saw a flourishing of market gardens after the Second World War due to the influx of European immigrants. This resulted in the subdivision of the larger farming properties into smaller farming lots. More recent developments within the region have resulted in a decline of agricultural activities, which are primarily reduced to occasional small market gardens and hobby farms.

The proposal area has retained some of the small lot semi-rural character to the present day. The rural nature of the proposal area is still evident with numerous market garden plots. The Kellyville/Rouse Hill area has undergone major residential redevelopment over the last 20 years with the location of the current proposal area, although still semi-rural, becoming increasingly inundated by infrastructure to support the increasing residential development.

6.7.3 Existing environment

The proposal area was found to be highly disturbed throughout. Severe disturbances included landscape modifications in the form of cuttings and redistribution of soils, the construction of houses, roads, footpaths and above ground and sub-surface services. The proposal area also contained the remains of previously demolished residences. Evidence of soil redistribution was noted and large amounts of bluestone metals were evident throughout the proposal area. The northern side of Memorial Avenue had evidence of cutting and benching.

Two creeks pass through the proposal area; Elizabeth Macarthur and Strangers Creeks. Memorial Avenue spans these watercourses via large concrete culverts.

The proposal area centres upon the road alignments of Memorial Avenue, Old Windsor road and Windsor Road. As such, the proposal area is subject to major disturbances and modifications associated with the numerous phases of construction and maintenance to the roads. Intersections where Memorial Avenue meets Old Windsor Road and Windsor Road feature traffic lights. Extensive subsurface disturbances are likely to be associated with the installation of this infrastructure.

Heritage items

Database searches identified the following heritage items in the proposal area:

- Old Windsor Road and Windsor Road Heritage Precinct (Section 170 register)
- Archaeological heritage item A2 – Old Windsor Road (Hills Shire LEP)
- Heritage Item I28 – Windsor Road (Hills Shire LEP)

Old Windsor Road (from Seven Hills Road to Windsor Road, Listing ID 2963) is listed on the Register of the National Estate and is also located in the proposal area, however, it is a non-statutory Commonwealth item.

Additionally, Heritage item I101 – House at 9-11 Windsor Road, listed on the Hills Shire LEP, is located in close proximity to the proposal area. The Hills Shire LEP heritage listings in relation to the proposal area are shown in Figure 6-33.



Figure 6-33: LEP heritage listing map with the study area outlined in red (Artefact 2014)

6.7.4 Assessment of archaeological potential

There is very limited potential for archaeological remains of structures associated with early 20th century occupation of the area to exist in the proposal area. Analysis of plans from the 19th century indicates that the proposal area was unlikely to have contained substantial structures prior to the early 1900s. Examination of the 1943 aerial photograph of Sydney also suggests that any structures that were located in the proposal area are further north and south, and therefore outside the proposal area. The proposal area has also been subject to numerous impacts which are likely to have damaged or removed any archaeological remains. These impacts include upgrades to the Memorial Avenue road corridor and the establishment of footpaths and culverts, the installation of subsurface services, subdivision, the construction of residences and landscaping associated with these residences and the demolition of early structures.

The westernmost extent of the proposal area includes about 700 metres of Old Windsor Road, listed on The Hills LEP as an archaeological item. The western extent of Memorial Avenue was not constructed until the 20th century and its construction would have impacted on any original fabric of Old Windsor Road in this location. Furthermore, this intersection would have been subject to extensive subsurface impacts associated with the installation of traffic light systems. As such, it is highly unlikely that intact archaeological remains associated with the earlier phases of Old Windsor Road would be retained within the proposal area.

A number of boundary stones along Old Windsor Road were identified in the Windsor Road and Old Windsor Road Conservation Management Plan to the north of Memorial Avenue. These boundary stones are located outside the proposal area and were most likely buried during construction of the Northwest Transitway during the past decade. There is therefore limited potential to encounter archaeological remains associated with the early construction or use of Old Windsor Road within the proposal area.

Similarly, the about 550 metres of Windsor Road which is included in the proposal area is unlikely to retain any intact archaeological remains associated with the original road. Successive phases of construction and maintenance of Windsor Road have disturbed the eastern portion of the proposal area, particularly at the intersection of Windsor Road and Memorial Avenue where the installation of traffic light systems would have extensive subsurface impacts.

Overall, the proposal area has limited to no potential to contain archaeological remains associated with occupation of the proposal area, or with the undisturbed remains of either Old Windsor Road or Windsor Road.

6.7.5 Assessment of archaeological significance

The proposal area does not meet the threshold for Local Significance under the NSW Heritage assessment criteria. Although the proposal area does have some historical value and partially retains an indication of earlier subdivision patterns, this has been largely removed by modern intensive residential occupation. Any archaeological remains found within the proposal area are unlikely to reach the local significance threshold.

Windsor Road and Old Windsor Roads, as first laid out in 1794 and re-aligned in 1812-1813, are of State and national significance. They incorporate the second road

to be laid out in the colony and played an important role in the settlement of the Hawkesbury region and the development of the colony of NSW.

Windsor Road and Old Windsor Road retain characteristics evocative of the historic, rural character of the Cumberland Plain, both within the current road reserve and in redundant sections outside the reserve. Together they are vital in understanding the cultural landscapes of the region. Remaining historic road fabric, both inside and outside the current road reserve, demonstrates the methods of road construction and maintenance over two centuries. However, successive phases of construction and maintenance of both roads impact upon the likelihood of intact archaeological evidence remaining.

Considered by themselves, the sections of Old Windsor Road and Windsor Road impacted by the proposal do not exhibit any significance beyond their continuing representation of an original road alignment.

6.7.6 Potential impacts

Construction

Old Windsor Road (A2) (The Hills LEP 2012)

The proposal would impact about 700 metres of Old Windsor Road, extending north and south of the intersection with Memorial Avenue. This section of Old Windsor Road has been subject to severe disturbances including landscape modification in the form of cutting and benching, the construction of roads, footpaths above ground and underground services. The fabric has been altered numerous times and is no longer classed as significant. However the alignment of the road is considered significant as it represents the original alignment of the road. The proposal would impact the fabric of the road, but would not alter the alignment of the road. The proposed works involve widening at existing ground level, construction of pavement and line marking, with no significant excavation.

Windsor Road (I28) (The Hills LEP 2012)

The proposal would impact about 550 metres of Windsor Road, extending north and south from the intersection with Memorial Avenue. This section of Windsor Road has been subject to severe disturbances which include landform alteration in the form of cutting and re-deposition of soils for a public park, a concrete slab (and a now demolished building) and above ground and sub-surface services. As the fabric has been altered numerous times it is no longer classed as significant. However the alignment of the road is considered significant as it represents the original alignment of the road. The proposal would impact the fabric of the road, but would not alter the alignment of the road. The proposed works involve widening at existing ground level, construction of pavement and line marking, with no significant excavation.

House at 9-11 Windsor Road (I101) (The Hills LEP 2012)

The house at 9-11 Windsor Road is about 15 metres to the north-east of the proposal area. The proposal would not directly impact the heritage listing. However works associated with the proposal may involve temporary aesthetic impacts due to road works and presence of machinery. This impact is mitigated as the property is largely shielded by a wooden paling fence and mature trees. There is also a potential for vibration from works to affect the property.

Old Windsor Road and Windsor Road Heritage Precinct (S. 170)

The proposal would impact about 550 metres of Windsor Road and 700 metres of Old Windsor Road, where the respective roads intersect Memorial Avenue. Road widening is proposed at both intersections to be in the region of five to 15 metres, and more intrusive impacts (excavation) would occur on the intersections themselves. As the fabric of these roads in these particular locations has been altered previously on numerous occasions, they are no longer of significance. However the alignment of the road is considered significant as it represents the original alignment of the road. It is expected that the proposal would impact the modern fabric of the road but would not alter its alignment.

Operation

No operational impacts to known non-Aboriginal heritage items are expected.

6.7.7 Safeguards and management measures

Table 6-39 summarises the proposed safeguards and management measures recommended to adhere to statutory obligations and minimise the potential impacts of the proposed works on non-Aboriginal heritage.

Table 6-39: Proposed safeguards and management measures for non-Aboriginal heritage

Impact	Environmental safeguards	Responsibility	Timing
Impacts to known non-Aboriginal heritage items	<ul style="list-style-type: none"> Detailed design should seek to minimise changes to the form and alignment of Windsor Road and Old Windsor Road. 	Roads and Maritime	Pre-construction
Impacts to known non-Aboriginal heritage items	<ul style="list-style-type: none"> Subsurface impacts to the fabric of Old Windsor Road would be avoided by the proposal. If subsurface impacts are unavoidable, a section 139(4) exception notification would be required. 	Roads and Maritime and construction contractor	Pre-construction and construction
Possible disturbance to unknown non-Aboriginal heritage due to construction activities	<ul style="list-style-type: none"> If potential archaeological relics or works associated with Old Windsor Road and Windsor Road are identified, the Roads and Maritime Services 'Unexpected Archaeological Finds Procedure 2012' would be implemented. 	Construction contractor	Construction

Impact	Environmental safeguards	Responsibility	Timing
Impacts to known non-Aboriginal heritage item	<ul style="list-style-type: none"> The curtilage of the House at 9-11 Windsor Road would be avoided and the vibration management plan would be followed in relation to any potential vibration impacts to this property. 	Roads and Maritime and construction contractor	Pre-construction and construction

6.8 Air quality

Hyder Consulting prepared an assessment of the potential impacts of the proposal on air quality. The assessment is presented below.

6.8.1 Air quality assessment criteria

The ambient air quality criteria applicable to this assessment are specified in the Environment Protection Authority (EPA) publication *Approved Methods for Modelling and Assessment of Air Pollutants in NSW* (DEC 2005). These assessment criteria identify ambient air quality levels that adequately protect human health, and relate to the total concentration of pollutants in the air, and not just the contributions from project-specific sources.

Table 6-40 identifies the key pollutants for air quality assessments for road projects. For each key pollutant, it identifies criteria for:

- Acute (short-term exposure) ground-level concentration
- Chronic (longer term exposure) ground-level concentration.

These air quality criteria have been used to assess both the existing air quality and the potential impacts of the proposal.

Table 6-40: Ambient air quality impact assessment criteria (DEC 2005)

Pollutant	Goal	Averaging period	Source
Nitrogen dioxide	12 pphm*	1-hour	NEPC (1998)
	3 pphm	Annual	NEPC (1998)
Particulate matter <10µm (PM ₁₀)	50mg/m ³ **	24-hour	NEPC (1998)
	30mg/m ³	Annual	EPA (1998)
Carbon monoxide	25 ppm***	1-hour	WHO (2000)
	9 ppm	8-hour	NEPC (1998)

* parts per hundred million

** mg/m³ equals milligrams per cubic metre and g/m² equals grams per cubic metre

*** parts per million

NEPC: National Environment Protection Council

WHO: World Health Organisation

6.8.2 Existing environment

Air quality

Ambient air quality in Sydney's north-west is largely influenced by:

- Motor vehicle emissions
- Commercial and industrial businesses, such as service stations and sewage treatment plants
- Domestic activities, including backyard burning, wood-fired home heaters and lawn mowing

- Construction, particularly residential development in the North West Growth Centre and, near the proposal, in the Balmoral Road Release Area
- Event-based emissions, including bushfires, pollen or dust storms.

Development associated with the NWRL (at the western end of the proposal area) may also decrease local air quality due to dust and exhaust emissions.

There are no heavy industrial or extractive operations near the proposal area that are likely to generate significant amounts of air pollution.

Data on ground-level concentration collected by the Office of Environment and Heritage (OEH) was used for the assessment. The OEH has monitored air quality at William Lawson Park in Prospect (about seven kilometres from the proposal area). This data is presented in Table 6-41 (data on acute ground-level concentration air quality was not available from the OEH database).

Table 6-41: Air quality monitoring data at Prospect for pollutants relevant to the assessment

Pollutant	Nitrogen dioxide (pphm*)	Particulate matter <10µm (PM ₁₀) (mg/m ³ **)	Carbon monoxide (ppm***)
Goal	3	30	9
Averaging period	Annual	Annual	8-hour
2009	1.1	25.8	0.3
2010	1.2	15.4	0.4
2011	1	15.8	0.3
2012	1	17.3	0.3
2013	1.1	27.2	0.1

* parts per hundred million

** mg/m³ equals milligrams per cubic metre and g/m² equals grams per cubic metre

*** parts per million

Table 6-41 shows that average annual ground-level concentrations for nitrogen dioxide, particulate matter <10 µm and carbon monoxide near the proposal area were below the assessment criteria from 2009 to 2013, with motor vehicles the main emission source of each pollutant. Elevated levels of particulate matter in 2009 and 2013 were attributable to severe dust storms and extensive bushfires in the Sydney basin.

Table 6-41 also indicates that the proposal area generally experiences good air quality. However, air quality may experience a slight temporary decline at a local scale due to the planned development of the Balmoral Road Release Area, North West Growth Centre and NWRL.

Climate and meteorology

The region is characterised by mild to warm summers and cold winters. Climate statistics for the proposal area have been collected by the Bureau of Meteorology at the Seven Hills weather station (about five kilometres from the proposal area) since 1950 (Bureau of Meteorology 2014). Data relevant to the construction and operation of the proposal includes:

- February is typically the wettest month and July is typically the driest month. Average annual rainfall is 914 millimetres with an average of 84.9 days of rain annually
- Mean 9am wind speed ranges from 4.2 kilometres per hour in April to 6.0 kilometres per hour in October and November. Winds are predominantly from the south-west, but east to north-east winds are also prevalent.

Sensitive receivers

Sensitive receivers to air quality impacts in the proposal area include residential areas, childcare institutions, and parks and open spaces for community recreational use. Identified air quality sensitive receivers include:

- Gracelands Early Education Centre (24 Arnold Avenue)
- The Hills Clinic Hospital (15–17 Memorial Avenue)
- Kellyville Memorial Park (Memorial Avenue)
- Baptist Community Services Retirement Facility (Free Settlers Drive)
- Kellyville Chiropractic (cnr Memorial Avenue and Windsor Road).

These locations are identified on Figure 6-34 in section 6.9.1.

6.8.3 Potential impacts

The assessment of the proposal's potential impact on air quality (during both construction and operation) involved:

- Identifying ambient air quality assessment criteria and air pollutants of concern during operation and construction (refer to Section 6.8.1)
- Determining the air quality of the existing environment using OEH air quality monitoring data (refer to Section 6.8.2)
- Identifying sources of air emissions during construction and operation, as well as key factors that influence emissions from identified sources
- Qualitatively evaluating likely changes in emission sources as a result of construction and operation of the proposal
- Relating likely changes in emission sources to potential air quality impact at local and regional scales, taking into account existing background levels and relevant air quality objectives
- Identifying mitigation measures to avoid and minimise air quality objective exceedences.

Construction

Construction activities that could impact air quality include:

- Vegetation clearing
- Stripping, stockpiling and managing topsoil
- Earthwork, excavation, construction of roads and footpaths, leading to the creation of airborne dust, particularly in dry and windy conditions
- Transport and handling of soils and materials to, from, and around the proposal

area

- Vehicles travelling on unsealed areas, which can create airborne dust
- Construction vehicles and machinery, which create exhaust fumes
- Application of asphalt for road surfacing
- Spray painting for line marking.

Of these activities, the main potential impact on ambient air quality during construction would be from dust generation. High risk activities include stripping of topsoil and bulk earthworks, particularly at the large cut locations next to Rutherford Avenue/Thomas Boulton Circuit, east of the unnamed drainage line to about 40 metres east of Pellizzer Boulevard, and from about 40 metres east of the tributary of Strangers Creek to the intersection of Memorial Avenue and Severn Vale Drive.

The magnitude and extent of any dust impact would be subject to the volume and duration of earthwork occurring at any one time and location, as well as meteorological conditions, such as wind speed, wind direction and precipitation. There is potential for dust emissions to impact sensitive receivers to the north-east and, to a lesser extent, the east to south-east of the proposal area, based on the prevailing wind direction outlined in Section 6.8.3. However, it is unlikely that dust would considerably disperse from the immediate proposal area, due to the light wind speeds experienced in the locality.

In addition, emissions from construction vehicles and machinery may result in short-term, localised impact on ambient air quality. Building the proposal would require about 100 to 150 truck movements per day. Truck movements may increase to 200 to 250 per day at certain stages of the project for example, during cut and fill work associated with the two significant cuts between Arnold Avenue and Severn Vale Drive, and significant fills at Severn Vale Drive and between the two significant areas of cut.

Overall, therefore, the potential impact on ambient air quality as a result of construction of the proposal is likely to be short-term and localised due to the staged approach to construction and the light winds and relatively low levels of pollutants currently experienced in the area.

Operation

The proposal would increase the carrying capacity of Memorial Avenue to accommodate forecast traffic growth. Predicted traffic flows (AADT) are provided in Section 6.3. However, the increase in traffic would happen even without the upgrade to Memorial Avenue due to local residential, commercial and transport developments.

The proposal would help to offset potential increases in emissions from increased traffic by:

- Increasing the carrying capacity of Memorial Avenue would help to create more free-flowing traffic, which produces fewer emissions than congested, stop-start traffic
- Improving connections to public transport facilities in the area, and thereby facilitating the use of the North West Rail Link
- Providing off road shared paths for pedestrians and cyclists on both sides of Memorial Avenue.

Impacts to air quality outside the immediate road corridor are anticipated to be negligible. Given the minimum 5.3-metre setback that is proposed to accommodate a landscaped verge and shared path on both sides of the road, it is unlikely that the operation of the proposal would cause exceedences at sensitive receivers. The air quality impacts during operation could be minimised through maintenance and/or improvement of existing levels of service through improved traffic flow conditions as population and traffic grows.

6.8.4 Safeguards and management measures

The safeguards and management measures outlined in Table 6-42 would be implemented before and during construction of the proposal to minimise impacts on air quality.

Table 6-42: Proposed air quality safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing
Dust	<ul style="list-style-type: none"> An Air Quality Management plan (AQMP) would be prepared as part of the CEMP. The plan would include but not be limited to: <ul style="list-style-type: none"> A map identifying locations of sensitive receivers Identification of potential risks/impacts due to the work/activities as dust generation activities Management measures to minimise risk including a progressive stabilisation plan A process for monitoring dust on site and weather conditions A process for altering management measures as required. 	Construction contractor	Pre-construction
Dust and odour	<ul style="list-style-type: none"> To minimise or prevent air pollution and dust, loads that may produce dust or odour would be covered, and water would be sprayed on unsealed access roads and open areas during conditions conducive to dust generation. 	Construction contractor	Construction
Exhaust emissions	<ul style="list-style-type: none"> Construction equipment (including all internal combustion engines) would be properly maintained and running efficiently to ensure exhaust emissions are minimised, where practicable, and comply with the <i>Protection of Environment Operations Act 1997</i>. 	Construction contractor	Construction
Exhaust	<ul style="list-style-type: none"> Machinery would be turned off 	Construction	Construction

Impact	Environmental safeguards	Responsibility	Timing
emissions	when not in use.	contractor	

6.9 Land use and socio-economic impact

6.9.1 Existing environment

Land use

Memorial Avenue is a 2.2-kilometre two-lane, two-way arterial road providing an east–west connection between Windsor Road and Old Windsor Road.

Land use zones surrounding the proposal area are presented in Figure 4-1 of this REF. Land use is in a state of change: there are some established rural-residential uses, and some new urbanised subdivisions in accordance with the development plans for the Balmoral Road Release Area.

There are 102 lots intersecting the proposal area with direct access to the proposal area. These have the following uses:

- Six dwellings with direct access to Windsor Road
- Five businesses with direct access to Windsor Road, including a Caltex/Woolworths Petrol Station and Repco (southbound carriageway) and Sheds Plus, Kellyville Chiropractic and a nursery (northbound carriageway)
- Fifteen dwellings with direct access to Memorial Avenue
- One health institution (The Hills Clinic) with direct access to Memorial Avenue
- One recreation and sporting complex (Kellyville Memorial Park) with direct access to Memorial Avenue.

There are no lots with direct access to Old Windsor Road within the proposal area.

Memorial Avenue provides indirect access to Gracelands Early Education Centre, on the corner of Arnold Avenue (west) and Memorial Avenue. It also provides indirect access to the Baptist Community Service Retirement Facility via Free Settlers Drive.

A 'Woolworths' supermarket and shopping centre is planned to be developed adjacent to the intersection of Memorial Avenue with Severn Vale Drive. It is likely that this would be built before the proposed upgrade of Memorial Avenue.

There are also a number of dwellings and dwellings under construction within the Balmoral Road Release Area near the proposal area, along Burns Road, Hector Court, Arnold Avenue and Rutherford Avenue.

Existing and planned non-residential land uses within and servicing the proposal area are presented in Figure 6-34.

Memorial Avenue Upgrade - Review of Environmental Factors



Figure 6-34: Businesses and social infrastructure within and servicing the proposal area

Socio-economic profile

The proposal area is almost entirely within The Hills Shire local government area (LGA), and the Kellyville Statistical Area (Level 2) (Figure 6-34). A small portion of the proposal area is within the Blacktown LGA, with the north-western and south-western boundaries of the proposal area within the Parklea-Kellyville Ridge and Glenwood Statistical Areas (Level 2), respectively. Since all the properties within the proposal area are within Kellyville, this socio-economic profile is limited to the Kellyville Statistical Area (Level 2).

As is the case with land use, the socio-economic profile of the proposal area and surrounds is changing. The population of Kellyville more than doubled over the 10 years between the 2001 and 2011 Census (ABS 2012), recorded as 23,746 in 2011. This rate of growth is expected to continue with the ongoing development of the Balmoral Road Release Area. The area is characterised by couple families with children dependent on access to employment, community and recreational facilities. Of the people who travelled to work, just over 91 per cent were recorded to have travelled by car, either as a driver or passenger in the 2011 Census.

6.9.2 Potential impacts

During construction and operation, the proposal would have the following impacts on the local community and other road users:

- Impact on property and land use, including potential acquisition (Section 3.7)
- Impact on traffic and transport (Section 6.3.3)
- Impact on amenity, including noise and vibration (refer Section 6.4.4), air quality (refer Section 6.8.3), and landscape and visual quality (refer Section 6.10).

The potential impacts are presented below.

Construction

Impact on property and land use

The proposal would occur within the existing road corridor of Memorial Avenue where possible, but the road widening would require the acquisition of neighbouring land on both sides of Memorial Avenue and Windsor Road, with a total acquisition area of about 3.06 hectares (the areas of potential acquisition are identified in Table 3.7 and

Figure 3-17). At this stage, it is likely that:

- Eight properties would need to be fully acquired (six are privately owned)
- Thirty-five properties would need to be partially acquired
- A strip of Kellyville Park (on Memorial Road) would need to be acquired, though this would not affect its ability to serve recreational needs

In addition, there may be a need to lease land for construction purposes. This would be determined during detailed design.

Final acquisitions required would be confirmed through detailed design in consultation with landowners. All property valuations and acquisitions would be carried out in accordance with the Roads and Maritime *Land Acquisition Information*

Guide (Roads and Maritime 2012; Appendix K) and the *Land Acquisition (Just Terms Compensation) Act 1991*.

Property acquisition could have the following socio-economic impact on affected landholders:

- Impact on health and wellbeing: Some residents whose properties fall within the proposal area may experience an impact on health and wellbeing associated with the uncertainty of knowing how their property would be affected, and the timeframes over which the impact would occur. Roads and Maritime would minimise uncertainty by ongoing consultation with potentially affected landowners and by providing information on the process of acquisition
- Impact on property improvements: Some of the proposed partial acquisitions may result in changes to driveways. If part of a property is acquired, Roads and Maritime would adjust property entry arrangements to maintain access at all times. This may include use of a temporary access road to provide access to a number of properties from Memorial Avenue and Windsor Road during construction. These adjustments would take place before or during roadwork. In addition, Roads and Maritime would relocate fences and, where required, reinstate access to the road network. Fencing along the new property boundary would be relocated or, if necessary, built new to a standard similar to the existing fence on the property. If necessary, Roads and Maritime would prepare a plan detailing property adjustments for consideration by the land owner. If this plan is acceptable it may form part of the contract for sale
- Impact on future development potential: Roads and Maritime has considered potential impacts of the proposal on current and planned future uses of land; however, it cannot make further assumptions as to the intentions of landholders to undertake future development, including any additional or separate road easements that may be required for future subdivisions. The proposal has been developed in full consideration of the Balmoral Road Release Area, including planned (approved) developments along Memorial Avenue
- Impact of utility disruptions: The relocation of utilities may temporarily disrupt services such as power, water, sewer, gas and telecommunications, which may impact properties within and around the proposal area. This impact would be minimal as the disruptions would be short-term and all property owners would be notified in advance of the disruption.

Impact on traffic and transport

During construction, there would be minimal impact on traffic and transport services because:

- Access to all local roads and properties within the proposal area would be maintained wherever possible, though road users may experience some minor traffic delays, access restrictions, or increased travel times. Safe access for emergency services, including fire, ambulance and police would need to be considered during the construction period
- Safe access to bus stops would be maintained at all times, and disruptions to services minimised
- Existing cyclist and pedestrian facilities on Windsor Road and Old Windsor Road would be maintained, though there may be slight detours or alterations to ensure safety.

There are a number of alternate routes that may be accessed during construction. The north of Memorial Avenue, Samantha Riley Drive can be accessed via Arnold Avenue and Gainsford Drive. Samantha Riley Drive provides signalised access to both Windsor Road and Old Windsor Road. To the south of Memorial Avenue, Pellizzer Boulevard and Hector Court provide access to Balmoral Road. Balmoral Road provides left turn only access to Old Windsor Road.

Impact on amenity

During construction, there would be a temporary increase in traffic, noise and dust and reduced visual amenity. There may also be disruptions associated with the relocation of utilities such as overhead electrical wires and underground gas mains.

Construction may also involve some night work, which would adversely affect nearby properties in terms of noise and light spill. These reductions in amenity could temporarily affect sensitive receivers close to the proposal area, including Kellyville Chiropractic, The Hills Clinic, Gracelands Early Education Childcare Centre, Baptist Community Services Retirement Facility, and adjacent residences. Some people may also experience anxiety associated with disruption to daily activities.

Operation

Impact on traffic and transport

The proposal would provide new infrastructure to improve local and regional access; road safety and traffic capacity; capacity for public transport; pedestrian and cyclist facilities; and landscaping along Memorial Avenue. Section 6.3.3 discusses traffic and transport impacts associated with the proposal in more detail.

Local traffic and access (private vehicles)

The proposal would upgrade Memorial Avenue to two lanes each way, with a median. Any property access directly provided from Memorial Avenue would become a left-in/left-out arrangement. This would increase travel distances for a number of property owners as they would have to drive to a suitable location to make a U-turn to travel in the opposite direction. The furthest distance required to be travelled would be about 800 metres from 31 Memorial Avenue east to Arnold Avenue (east) in order to make a U-turn to travel west. These arrangements would be in place until the area is fully developed, at which time all residential access onto Memorial Avenue would be removed, with traffic directed to the upgraded signalled intersections through a series of new residential streets.

Access to Memorial would be permanently altered following construction at Arnold Ave (east) and Hector Court. Both would be converted to a cul-de-sac arrangement with no direct access to Memorial Avenue. Access to Memorial Ave would be via a new signalised intersection. Signalised intersections would provide safer right turn access to Memorial Avenue than non-signalised arrangements. Motorists on Arnold Ave (east) would be directed onto Severn Vale Drive (north), resulting in an increased travel distance of about 500 metres for access to/from the Hills Clinic. Motorists on Hector Court would be directed to Severn Vale Drive (south) via Affleck Circuit, an increased distance of about 200 metres.

Arnold Avenue (west) is constrained by the existing road alignment at the approach to the intersection with Memorial Avenue. In order to function efficiently, there would be no on street parking permitted during AM and PM peak times for a distance of

about 80 metres from the intersection. Street parking is currently available to residents at this location, this change would negatively impact these residents. These residents have off-street parking in the form of driveways and garages, so impacts would more likely occur when residents have visitors or if they have multiple cars that cannot be accommodated off the street. Off street parking would still be available during off-peak times.

The proposal would have a positive long-term impact for businesses in the region as it would reduce congestion and improve connectivity between Windsor Road and Old Windsor Road as development of the Balmoral Road Release Area generates additional pressure on the road network. If the upgrade were not developed, motorists would experience longer travel times and congestion, which can have a significant impact on business activities and economic growth both locally and regionally (CRWG 2006).

Another benefit of the proposal is that Memorial Avenue would remain serviceable up to the 100-year ARI event. As a result, residents would have improved security of access to their properties.

Public transport

There would be no impact on current bus routes. The existing Burns T-way that runs parallel to Old Windsor Road and the dedicated bus lanes at the Old Windsor Road/Memorial Avenue intersections would be retained. Local bus users would benefit from the more efficient operation of bus lanes with bus priority at traffic signals and indented bus bays on both sides of Memorial Avenue at new traffic signals Arnold Avenue and Severn Vale Drive.

Cyclists and pedestrians

The proposed shared path along both sides of Memorial Avenue would improve opportunities for safe cyclist and pedestrian movement within the proposal area. The new shared paths would connect to existing cyclist and pedestrian facilities along Windsor Road and Old Windsor Road which would be maintained.

Impact on amenity

Once Memorial Avenue is upgraded to a four-lane divided arterial road, there would be an altered amenity for local residents and road users.

The increase in noise levels between the design year 'no-build' and 'build' options is more than 2dB(A) in NCAs 2, 4 and 5 which is a perceptible difference according to the RNP. In the design year 2026 noise levels are predicted to be acute at 117 properties.

There are 52 residences along the Memorial Avenue corridor that are identified for further consideration of noise mitigation. Noise mitigation measures would be determined during detailed design. At-property treatment would be considered for dwellings where other noise mitigation measures are not feasible.

The proposal would also have an adverse impact on visual amenity and landscape character. While the proposal, for the most part, is to take place in an established road corridor, there would be visual impacts due to the removal of trees, increase in road pavement width, and intersection upgrades. The greatest impacts occur where the magnitude of the works is the greatest, for example, a large number of trees

would need to be removed at the slight bend in Memorial Avenue near Pellizzer Boulevard where there is limited space to provide replacement trees due to the corridor width, and at Strangers Creek, where the removal of trees would open up the road corridor, where some enclosure currently exists. It also occurs where the sensitivity is high for viewers at Kellyville Memorial Park.

The Gracelands Childcare Centre would also be affected by the proposal. Property acquisition would be required for a strip of land fronting Memorial Avenue to accommodate the indented bus bay. The strip of land is next to the car park, however widening of the road would bring traffic slightly closer to the centre. Treatments, such as a barrier, would be negotiated with the Centre operator.

Landscape and urban design mitigation strategies have been developed from the outcomes of the landscape character and visual assessments and have been incorporated into the Urban Design and Landscape Concept Design.

6.9.3 Safeguards and management measures

The safeguards and management measures outlined in Table 6-43 would be implemented before, during and after construction to minimise land use and socio-economic impact.

Table 6-43: Safeguards and management measures for land use and socio-economic impact

Impact	Environmental safeguards	Responsibility	Timing
Impact on businesses and the community	<ul style="list-style-type: none"> A complaints handling register would be included in the CEMP. 	Construction contractor	Pre-construction and construction
Impact on businesses and the community	<ul style="list-style-type: none"> Access would be maintained wherever possible. Prior to any temporary unavoidable disruption to access, consultation would be undertaken with the affected property owner/s. 	Construction contractor	Pre-construction and construction
Impact on businesses and the community	<ul style="list-style-type: none"> Safe access to bus stops would be maintained at all times and bus companies would be advised before changes to traffic conditions. 	Construction contractor	Pre-construction and construction
Impact on businesses and the community	<ul style="list-style-type: none"> Existing cyclist and pedestrian access along Windsor and Old Windsor Road would be maintained but may need to be altered during construction to ensure safety. Road users, pedestrians and cyclists would be informed of changed conditions, including likely disruptions to access during construction. 	Construction contractor	Construction
Impact on businesses	<ul style="list-style-type: none"> Residents would be informed before any interruptions to utility 	Construction contractor	Pre-construction

Impact	Environmental safeguards	Responsibility	Timing
and the community	services that may occur during the relocation of utilities.		and construction
Impact on businesses and the community	<ul style="list-style-type: none"> Community consultation would be carried out in accordance with Roads and Maritime's <i>Community Involvement Practice Notes and Resource Manual</i> (2012) 	Roads and Maritime	Detailed design, pre-construction and construction
Impact on businesses	<ul style="list-style-type: none"> Temporary signage would be provided during construction to inform traffic of alternative access to the businesses along Windsor Road and Memorial Avenue. 	Roads and Maritime and construction contractor	Pre-construction and construction
Impact on property owners due to land acquisition	<ul style="list-style-type: none"> Property acquisition would be managed in accordance with the provisions of Roads and Maritime's <i>Land Acquisition Policy</i> and the <i>Land Acquisition (Just Terms Compensation) Act 1991</i>. 	Roads and Maritime	Pre-construction

6.10 Landscape Character and visual impacts

An Urban Design Report has been prepared for Roads and Maritime Services (Roads and Maritime), by Spackman Mossop Michaels as part of this Review of Environmental Factors (REF). A copy of the report is available in Appendix J of this REF and a summary provided below.

6.10.1 Methodology

The method used to undertake this study follows the 'Guideline for Landscape Character and Visual Impact Assessment' (Roads and Maritime, 2013) and is summarised as follows:

- Undertaking an initial site visit and field investigation, reviewing relevant literature, analysing aerial photographs and topographic maps to understand the study area
- Reviewing the engineering concept design on a regular basis, and other supporting material to gain an appreciation of the project
- Developing an Urban Design Strategy comprising objectives and principles to guide the development of the concept design
- Defining landscape character through a study area analysis, including a detailed site investigation
- Identifying and describing landscape character zones and evaluating the proposal's impact on them
- Evaluating the impact of the project on these landscape character zones by combining the sensitivity of the zone and the magnitude of the works to provide an overall impact rating as indicated by the Impact Assessment Grading Matrix
- Identifying the visual catchment of the proposed works for the visual impact assessment
- Selecting viewpoints within the visual catchment representing a range of different land uses
- Evaluating the visual impact of the project by comparing the sensitivity of viewpoints and the magnitude of the impact of the project upon them to provide an overall impact rating as indicated by the Impact Assessment Grading Matrix
- Developing the Urban and Landscape Concept Design, described in plans, sections/ elevations, precedent photographs and other drawings as appropriate
- Identifying urban design and landscape opportunities and methods of mitigating adverse visual impacts, both within and outside of the project scope to assist the ongoing development of the Concept Design and for consideration in the detail design phase of the project.

6.10.2 Existing environment

The study area generally consists of cleared rolling hills, dotted with housing on five acre lots. Remnant woodland can be found along the Elizabeth Macarthur Creek and Strangers Creek corridors, along the North-West Rail Link (NWRL) corridor, and scattered along the roadside and within the pastures. However, the area is rapidly changing, and it is estimated that about 90% of the study area, part of the Balmoral Road Release Area, would be occupied with housing by 2020. There are already

new housing developments located along Memorial Avenue, around Arnold Avenue (west), Pellizzer Boulevard, and Burns Road. The NWRL, running parallel to Old Windsor Road, would also change the existing of the area.

Landform & Topography

Memorial Avenue has been constructed to follow the undulating topography of the local area. The road corridor is characterised by the crossing over of a ridgeline and the gentle fall into Elizabeth Macarthur and Strangers Creek that feed into Caddies Creek in the north. The terrain of the wider landscape surrounding the study area is predominantly characterised by rolling hills and small valleys that are typical of the Cumberland Plain Woodland Forest.

Vegetation

The vegetation within the study area generally consists of Cumberland Plain Endangered Ecological Community which is highly modified as a result of past and current land uses, particularly clearing. The most extensive stands are located on the northern side of the road corridor at the intersection of Old Windsor Road and Memorial Avenue. Other smaller groupings occur at various locations next to the road. The remainder of the corridor is a mixture of pasture grasses in the paddocks and exotic tree plantings associated with the residences. Deciduous avenue plantings occur between Windsor Road and Kellyville Memorial Park, although their habit has been substantially altered due to pruning.

Cultural & Scenic Values

Defining the experience of the drive along Memorial Avenue, are a number of factors which combine to give the road its character. Overall, the visual character of the Memorial Avenue corridor is characterised by a mix of rural/agricultural and remnant indigenous landscapes, with the ever increasing residential developments being constructed as part of the Balmoral Road Release Area.

The existing roadside vegetation enhances the visually pleasant driving experience of the two lane road over the rolling topography. Much of the motorist's experience when travelling along Memorial Avenue relies on the 'borrowed' landscape outside the road corridor, particularly over the nearby paddocks and further afield to the vegetated ridgelines and the Blue Mountains.

For much of its length, Memorial Avenue currently consists of a two lane road (one for each direction), which in its current configuration, adds to its rural residential character.

Landscape Character Zones

Roads and Maritime's 'Guideline for Landscape Character and Visual Impact Assessment' (Roads and Maritime, 2013) provides the following definition of landscape character:

'The combined quality of built, natural and cultural aspects that make up an area and provide its unique sense of place.'

Applying this definition to the specific conditions within the study area, and the features of the proposal, the landscape character assessment also considers how the area is used and how it functions as a part of the overall North-West Growth Centre.

The study area has been divided into seven Landscape Character Zones (LCZ), as illustrated in Figure 6-35. The zones correspond to landscape character types in the area and allow for a more detailed discussion of the character of each zone, of the

proposal within it, and of the likely impact on the landscape character to be experienced as a result of the proposal. Each zone has been defined through the development of an understanding of land use, topography, and vegetation in combination with other factors.

Generally, the existing landscape character of Memorial Avenue is a mixture of low-medium density residential housing established between larger semi-rural lots. However, the character of the area is rapidly changing with the construction of housing to the north and south of Memorial Avenue, associated with the Balmoral Road Release Area. There are also a number of remnant vegetation areas, in particular, along the creek corridors.

The Landscape Character Zones are described in Table 6-44 below.

Table 6-44: Landscape Character Zones

LCZ	Character	Description
LCZ 1	Old Windsor Road intersection and NWRL Corridor	The western end of the LCZ consists of transport infrastructure including Memorial Avenue, Old Windsor Road and dedicated T-way bus slip lanes, bus stops and a large carpark south of Memorial Avenue. However, this area is generally well vegetated and screened from the road by low mounding. To the east, there are a few small rural residential properties and the Elizabeth Macarthur Creek corridor.
LCZ 2	Arnold Avenue (west) residential	Memorial Avenue rises slightly out of Elizabeth Macarthur Creek and is a two lane road with wide verges. New residential development and a childcare centre are located on the northern side and a new five storey retirement and aged care centre ('The Gracewood Community') is located on the southern side. This building is setback about 180 metres from the road and the Memorial Avenue frontage is bounded by a noise wall with an up to 15 metre wide native garden bed.
LCZ 3	Rural residential	The central section consists of rolling rural residential pastures, with scattered residences and associated farm buildings, particularly on the northern side. There are good views over the pastures, terminated by remnant woodland in the foreground, to the Blue Mountains. Memorial Avenue is a two lane road, and with its adjoining land uses, creates a distinct 'country road' character within this zone.
LCZ 4	Pellizzer Boulevard residential	The existing landscape character is undergoing extensive modification. The previous rural residential acreage now contains residential estates of different housing stock and separated from Memorial Avenue by internal access roads.

LCZ	Character	Description
LCZ 5	Strangers Creek	This small, flat LCZ is a dedicated trunk drainage corridor through which Strangers Creek flows. Despite previous clearing, it is now generally well vegetated with woodland, particularly to the road edges. Memorial Avenue continues as a two lane road through this zone.
LCZ 6	Kellyville Memorial Park	This zone is located on the southern side of Memorial Avenue and consists of a sporting complex containing a number of fields, cricket pitches, tennis courts and a large amenities building. An informal gravel carpark, delineated by telegraph poles, is located next to the road. A heavily pruned row of deciduous trees is located along the park frontage.
LCZ 7	Burns Road residential	Memorial Avenue is quite steep in this zone and increases in width from a two lane road to four lanes as it approaches Windsor Road. The land either side of Memorial Avenue is zoned residential with new houses and houses under construction on the northern side. The southern side consists of open grassed areas with road infrastructure in place for future residential development.

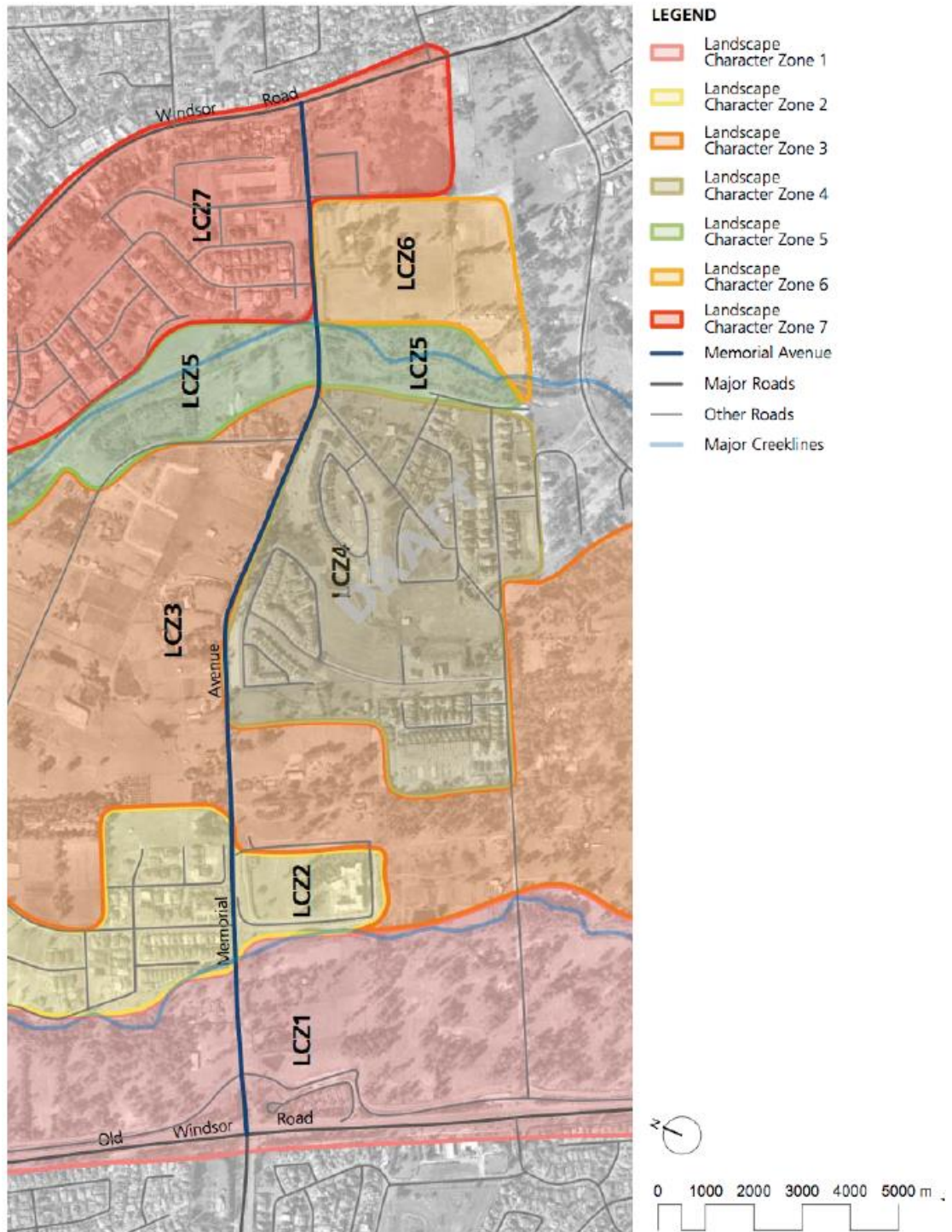


Figure 6-35: Landscape character zones

6.10.3 Potential impacts

Construction

During construction of each of the stages, the potential visual impacts would include:

- Temporary construction compounds and ancillary facilities
- Temporary stockpiles
- Vegetation clearing

- Presence of plant and equipment on site.

Construction activities and plant would be visible from the surrounding land uses and road corridor. These impacts shall be short-term and not extensive, due to the linear, staged nature of the proposal. Key areas of potential impact are in the vicinity of proposed compound sites, near the intersection of Memorial Avenue and Windsor Road, and the current car park at Kellyville Park. Views from the road would include site sheds, stockpiled building materials, construction vehicles, plant and equipment.

The cut sites require excavation which has the potential to cause temporary visual impact. These are located near the westbound carriageway between Rutherford Avenue and the unnamed drainage line, near the westbound carriageway next to Rutherford Avenue, from Rocks Street past Pellizzer Avenue, and near the westbound carriageway from the tributary of Strangers Creek to Hector Court.

Overall, the impact would be minor, given the transient nature of views from vehicles. In the long-term, with the development of the surrounding residential land, the visual impact of the proposal would be negligible.

Operation

The landscape character zones enable detailed assessment of the character of the study area, of the proposal within it, and of the magnitude, sensitivity and impact likely on the landscape character of each zone to be experienced as a result of the proposal.

In landscape character assessment, magnitude refers to the type of proposal and its compatibility with the existing landscape character. All anticipated elements of the proposal, including the alignment, road infrastructure, planting, lighting, etc, are considered. The scale of elements (height, length), as well as its location or setting (within woodland, rural land, or over creek crossings), all have a bearing on the magnitude of the physical presence of the proposal.

A high magnitude results if the proposal is a major development or piece of road infrastructure and contrasts highly with the surrounding landscape, or entails heavy modification of the existing landscape, for example, the large scale removal of existing vegetation. A moderate magnitude rating would result if the proposal is moderately integrated into the landscape. A low magnitude rating would occur if the proposal is of a small scale and integrates well into the landscape.

The magnitude impact rating also considers whether the proposal has a positive or negative impact on the landscape character of the zone. For example, a proposal may be of a large scale but may provide beneficial outcomes such as increased open space, enhancement of the areas 'sense of place', better connectivity and a safer road environment.

Sensitivity refers to how sensitive the character of the setting is to the proposed change. A judgement has been made as to the quality of the landscape, its cultural and historical importance to the community, scenic quality, and overall composition of the place and its inhabitants. The following sensitivity judgements have been used as the basis for this assessment:

- Places with high social, recreational, and historical significance to local residents have higher sensitivity
- Generally, water and natural environments are more highly valued than modified areas, though views over rolling farmland are still highly valued
- Areas of unique scenic quality have higher sensitivity
- A pristine environment would have greater sensitivity with less ability to absorb

new elements in the landscape than modified landscapes or those areas with contrast and variety of landscape types.

Impact is the combination of the magnitude and sensitivity rating in accordance with the Impact Assessment Grading Matrix (refer to Figure 6-36).

Potential landscape/ visual impact		Magnitude of change				
		High	High to moderate	Moderate	Moderate to low	Low
Sensitivity of landscape / view	High	High	High	High to moderate	High to moderate	Moderate
	High to moderate	High	High to moderate	High to moderate	Moderate	Moderate
	Moderate	High to moderate	High to moderate	Moderate	Moderate	Moderate to low
	Moderate to low	High to moderate	Moderate	Moderate	Moderate to low	Moderate to low
	Low	Moderate	Moderate	Moderate to low	Moderate to low	Low

Figure 6-36: Impact Assessment Grading Matrix

Overall, the proposal would have an adverse impact on landscape character. While the proposal, for the most part, is to take place in an established road corridor, it would impact on all Landscape Character Zones to some degree, due to the removal of trees, increase in road pavement width, and intersection upgrades. As the magnitude of the works is similar across all LCZs, the greatest impacts are found within the zones that have the most modification, for example, the new and developing residential areas at Arnold Avenue (west), Pellizzer Boulevard, and Burns Road.

The impacts on each Landscape Character Zone is summarised in Table 6-45 and Figure 6-37.

Table 6-45: Landscape character summary assessment

Landscape character zone	Impact assessment result	Comment
LCZ 1	Moderate - Low	Low sensitivity due to extensive transport infrastructure. There are only three rural residential properties, trunk drainage land and some remnant woodland. Impacts include doubling of the road surface to half of the LCZ, including property adjustments and the removal of some roadside vegetation.
LCZ 2	Moderate	Moderate sensitivity as despite being modified, new and existing tree plantings provide some coherence to the landscape. The proximity of the residential dwellings and The Gracewood Community also add to the

Landscape character zone	Impact assessment result	Comment
		sensitivity. Impacts include doubling of the road surface, upgraded intersection and removal of existing vegetation.
LCZ 3	Moderate	Moderate sensitivity as despite being modified, the existing character is a generally cohesive landscape of rural residential properties. Impacts include doubling of the road surface, extensive retaining walls and removal of existing vegetation.
LCZ 4	Moderate - Low	Low sensitivity due to highly modified landscape by new residential development. Impacts include doubling of the road surface, extensive retaining walls, new signalised intersection and removal of existing vegetation.
LCZ 5	Moderate	Moderate sensitivity as there is currently a coherent landscape of regenerated riparian and woodland plantings. Impacts include doubling of the road surface, new bridge structure and removal of existing vegetation.
LCZ 6	Moderate	Moderate sensitivity as there is currently a coherent landscape character tied together by avenue planting. Impacts include doubling of the road surface, upgraded intersection and removal of existing vegetation.
LCZ 7	Moderate - Low	Low sensitivity due to highly modified landscape undergoing further change with new residential development. Impacts include doubling of the road surface, upgraded signalised intersection and removal of existing vegetation.

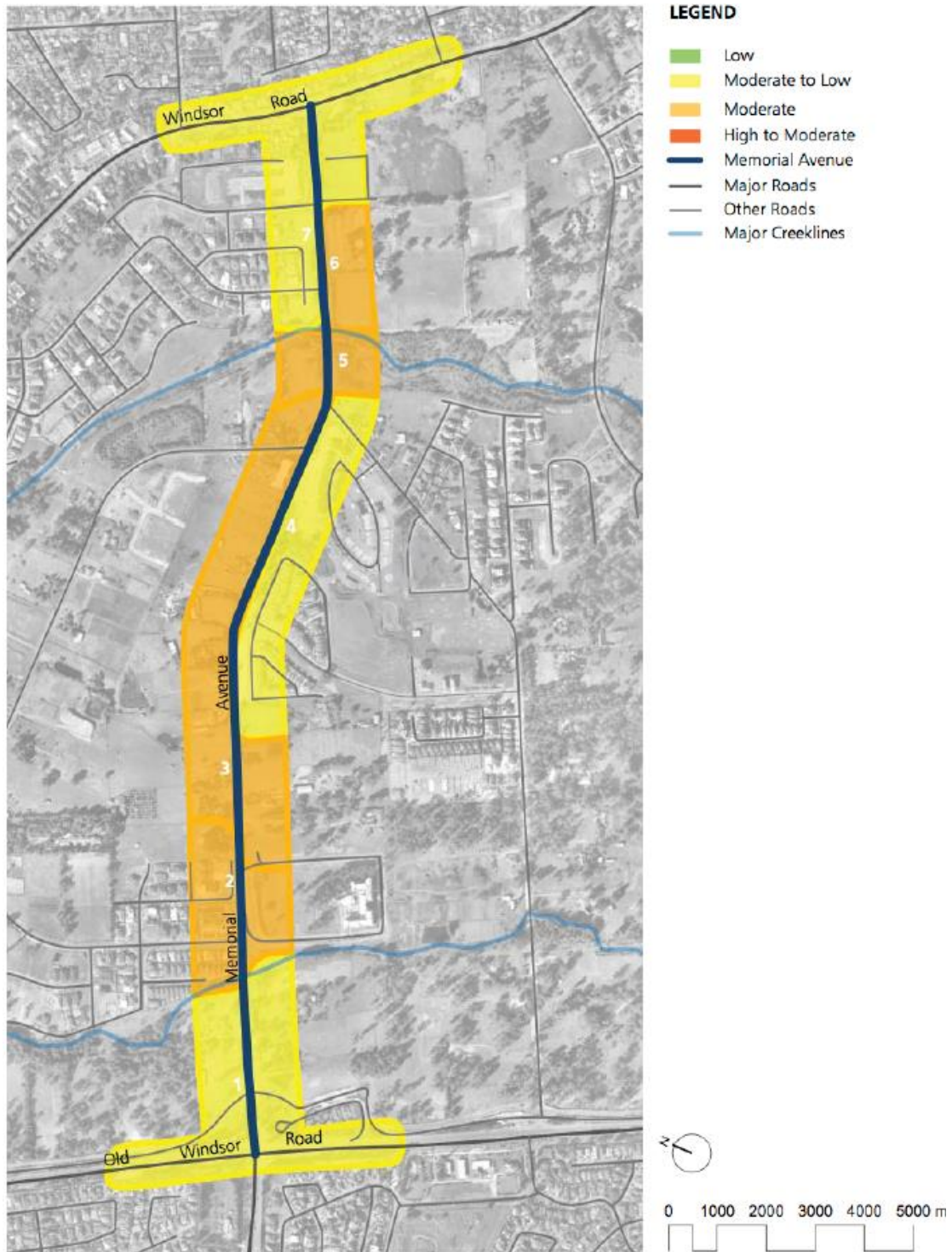


Figure 6-37: Summary of Landscape Character Impacts

Visual impact assessment

The extent from which the proposal would be visible from adjoining areas varies along the length of the study area. It is influenced by topography, vegetation, rural properties and associated buildings. A detailed field and desktop assessment was undertaken to determine the area from where the proposal would be visible, defined as the Visual Envelope Map, as illustrated in Figure 6-38.

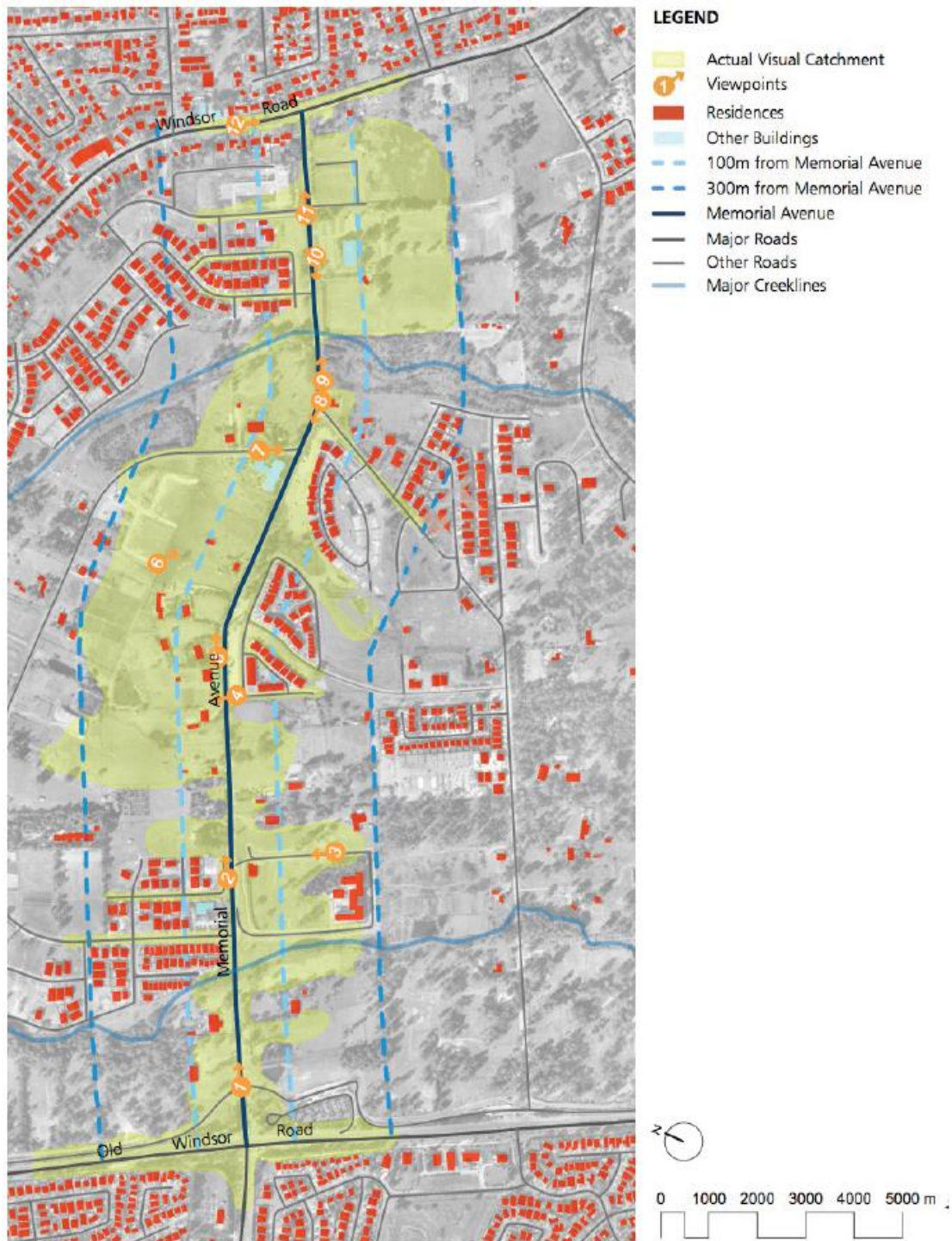


Figure 6-38: Visual Envelope Map illustrating the location of key viewpoints

Views to the proposal are generally constrained by the low ridgelines associated with the rolling landscape of the valley, and large stands of native vegetation. The visual receivers of the proposal include residents, tourists, pedestrians and motorists.

Within the Visual Envelope Map, a total of 12 viewpoints have been identified along the road corridor and at public domain areas. The magnitude of change to existing views and the sensitivity of the viewer was assessed for each of the chosen viewpoints. Magnitude of change to existing views refers to the nature and scale of the proposal, and the extent and proximity of the view to it. Sensitivity is the measure



of the visual importance of the view and is dependent on:



- Distance between viewer and the proposal
- The category of viewer, for example, residence, workplace, shops, open space
- The elements of the proposal that are visible
- Importance of the view, for example, identified in tourist guides, do people deliberately seek the view.


Impact is the combination of the magnitude and sensitivity rating in accordance with the Impact Assessment Grading Matrix (refer to Figure 6-36)



Locations and directions of chosen viewpoints are representative of the range of viewpoints both within and beyond the road corridor. The viewpoints are summarised in Table 6-46.


Table 6-46: Viewpoint assessment



Viewpoint	Visible elements	Assessment	Impact assessment result
 <p>Viewpoint 1 - Memorial Avenue, near the T-way bus lane intersection, looking east</p>	<p>Elements of the proposal visible:</p> <ul style="list-style-type: none"> • The existing kerbline beyond the intersection would move slightly to the right • Widening of the median • New 3.0 metre wide pedestrian and cycle path • New planting to the verge and median. 	<p>Sensitivity – low. Highly modified with transport infrastructure dominating including T-way bus lanes and NWRL corridor (behind viewer).</p> <p>Magnitude – low.</p> <ul style="list-style-type: none"> • Widening of the road pavement and median • Minimal tree loss • New planting to the verge and median reduces the rating. 	<p>Low</p>
 <p>Viewpoint 2 - Memorial Avenue, next to Thomas Boulton Circuit, looking east</p>	<p>Elements of the proposal visible:</p> <ul style="list-style-type: none"> • Widened road pavement to five lanes including a right turn lane into Arnold Avenue for westbound traffic • New 12 metre wide median • New 3.0 metre wide pedestrian and cycle path on both sides of the road • New retaining walls above the road on both sides 	<p>Sensitivity - moderate Existing rural residential with new residential being built.</p> <p>Magnitude – moderate.</p> <ul style="list-style-type: none"> • Widening of the road pavement and median • Removal of existing trees. 	<p>Moderate</p>



Viewpoint	Visible elements	Assessment	Impact assessment result
 <p>Viewpoint 3 - Rutherford Avenue, near 'The Greenwood Community', looking north</p>	<ul style="list-style-type: none"> • New planting to the verge and median. <p>Elements of the proposal visible:</p> <ul style="list-style-type: none"> • Closure of Rutherford Avenue at Memorial Avenue • New avenue tree planting to new median. 	<p>Sensitivity - moderate</p> <ul style="list-style-type: none"> • Next to retirement and aged care centre • Attractive avenue planting to Rutherford Avenue. <p>Magnitude – low.</p> <ul style="list-style-type: none"> • Removal of existing slip lane • Vehicles closer to the viewer due to widening of the road. 	<p>Moderate - Low</p>
 <p>Viewpoint 4 - Verge between Memorial Avenue and Rutherford Avenue near Rocks Street</p>	<p>Elements of the proposal visible:</p> <ul style="list-style-type: none"> • Widening of the road pavement to include two lanes in each direction • New 12 metre wide median with avenue tree planting • New 3.0 metre wide pedestrian and cycle path on both sides of the road • Removal of existing trees on both sides of the road. 	<p>Sensitivity – moderate</p> <ul style="list-style-type: none"> • Attractive rural residential views • High degree of modification due to new residential development behind viewer. <p>Magnitude – moderate.</p> <ul style="list-style-type: none"> • Widening of the road pavement and median • Removal of existing trees. 	<p>Moderate</p>

Viewpoint	Visible elements	Assessment	Impact assessment result
<p>intersection</p>  <p>Viewpoint 5 - Memorial Avenue, at bus stop about 650 metres east of Arnold Avenue (west), looking east.</p>	<p>Elements of the proposal visible:</p> <ul style="list-style-type: none"> • Widening of the road pavement to include two lanes in each direction • New 12 metre wide median with avenue tree planting • New 3.0 metre wide pedestrian and cycle path on both sides of the road • New retaining wall, up to 2.6 metres high to the right of the view • Removal of existing trees on both sides of the road. 	<p>Sensitivity – moderate.</p> <ul style="list-style-type: none"> • Attractive rural residential landscape to the north • Pedestrians and bus users affected by the changed view • High degree of modification due to new residential development to the south reduces the rating. <p>Magnitude – high</p> <ul style="list-style-type: none"> • Widening of the road pavement and median • New retaining wall • Removal of existing trees reduces the buffer between the road and new housing. 	<p>High Moderate</p> <p>-</p>

Viewpoint	Visible elements	Assessment	Impact assessment result
 <p>Viewpoint 6 - Butler Avenue, looking south east</p>	<p>Elements of the proposal visible:</p> <ul style="list-style-type: none"> • Low fill retaining wall • Removal of some existing trees. 	<p>Sensitivity – low.</p> <ul style="list-style-type: none"> • View over open paddocks to new housing • High degree of modification due to new residential development under construction behind viewer • Distance from the works reduces rating. <p>Magnitude – negligible.</p> <p>Removal of some existing trees to the right of the view may expose more of the new housing.</p>	<p>Negligible</p>
 <p>Viewpoint 7 - Arnold Avenue, at the entrance to The Hills Clinic, looking south</p>	<p>Elements of the proposal visible:</p> <ul style="list-style-type: none"> • Closure of Arnold Avenue at Memorial Avenue • Widening of the road pavement to include two new eastbound right turn lanes into new Severn Vale Drive intersection and two new westbound lanes • New 12 metre wide median with avenue tree planting • New 3.0 metre wide pedestrian and cycle path on both sides of 	<p>Sensitivity – low.</p> <p>High degree of modification due to new residential development under construction.</p> <p>Magnitude – low.</p> <ul style="list-style-type: none"> • Widening of the road pavement and median • New retaining wall • Existing buildings and vegetation obscure most of the works. 	<p>Low</p>

Viewpoint	Visible elements	Assessment	Impact assessment result
	<p>the road</p> <ul style="list-style-type: none"> • New retaining wall, up to 1.6 metres high in front of new housing. 		
 <p>Viewpoint 8 - Memorial Avenue, 40 metres east of Hector Court, looking west</p>	<p>Elements of the proposal visible:</p> <ul style="list-style-type: none"> • Widening of the road pavement • New signalised intersection at Severn Vale Drive accommodating two right turn lanes and one left turn in each direction • New 7.5 metre wide median • Closure of Hector Court at Memorial Avenue • New 3.0 metre wide pedestrian and cycle path on both sides of the road • Removal of existing trees to the right of the view. 	<p>Sensitivity – low. High degree of modification due to new residential development to the south.</p> <p>Magnitude – moderate.</p> <ul style="list-style-type: none"> • Creation of new eight lane intersection • Removal of existing trees. 	<p>Moderate - Low</p>

Viewpoint	Visible elements	Assessment	Impact assessment result
 <p>Viewpoint 9 - Memorial Avenue, 40 metres east of Hector Court, looking east</p>	<p>Elements of the proposal visible:</p> <ul style="list-style-type: none"> • Widening of the road pavement to include two lanes in each direction with two westbound right turn lanes into the new Severn Vale Drive intersection • New 7.5 metre wide median widening to 12 metres • New bridge over Strangers Creek • New 3.0 metre wide pedestrian and cycle path on both sides of the road • Removal of existing trees in the foreground to the left of the view. 	<p>Sensitivity – moderate.</p> <ul style="list-style-type: none"> • Attractive view along tree lined road • High degree of modification due to new residential development under construction behind viewer. <p>Magnitude – high.</p> <ul style="list-style-type: none"> • Widening of the road pavement and median • New bridge • Removal of existing trees. 	<p>High moderate -</p>
 <p>Viewpoint 10 - Kellyville Memorial Park car</p>	<p>Elements of the proposal visible:</p> <ul style="list-style-type: none"> • Widening of the road pavement to include two lanes in each direction • New 12 metre wide median • New 3.0 metre wide pedestrian and cycle path on both sides of the road • Closure of Hartigan Avenue at Memorial Avenue 	<p>Sensitivity – high.</p> <ul style="list-style-type: none"> • Attractive tree lined road next to sporting fields and recreation area • Some modification due to new residential development to the right of the view. <p>Magnitude – moderate.</p> <ul style="list-style-type: none"> • Widening of the road pavement 	<p>High moderate -</p>

Viewpoint	Visible elements	Assessment	Impact assessment result
park, looking west along Memorial Avenue	<ul style="list-style-type: none"> • Removal of existing roadside trees on both sides of the road. 	and median <ul style="list-style-type: none"> • Removal of existing trees. 	
 <p>Viewpoint 11 - Memorial Avenue, 25 metres west of Burns Road, looking east</p>	Elements of the proposal visible: <ul style="list-style-type: none"> • Widening of the road pavement to include two lanes in each direction, widening to include an additional two left turn lanes onto Windsor Road • New 12 metre wide median narrowing to 7.5 metres • Upgrade of the intersection of Memorial Avenue with Burns Road and Stone Masons Drive • New 3.0 metre wide pedestrian and cycle path on both sides of the road. 	Sensitivity – moderate. <ul style="list-style-type: none"> • Modification due to new residential development to the left of the view • Reasonably attractive tree lined street. Magnitude – moderate. <ul style="list-style-type: none"> • Widening of the road pavement and median • Removal of existing trees. 	Moderate
	Elements of the proposal visible: <ul style="list-style-type: none"> • Slight widening of the road pavement to the west of Windsor Road (to the right of the view) • Upgrade of the intersection of Windsor Road and Memorial Avenue • Removal of existing trees and house at the corner of Memorial 	Sensitivity – low. Busy arterial road with motorists focussing their attention on driving. Magnitude – low. <ul style="list-style-type: none"> • Slight widening of the road pavement • Removal of existing trees. 	Low

Viewpoint	Visible elements	Assessment	Impact assessment result
Viewpoint 12 - Windsor Road, 100 metres north of Memorial Avenue, looking south	Avenue.		

Ratings of High-Moderate impact occur where the magnitude of the works is the greatest, for example, a large number of trees would need to be removed at the slight bend in Memorial Avenue near Pellizzer Boulevard where there is limited space to provide replacement trees due to the corridor width, and at Strangers Creek, where the removal of trees would open up the road corridor, where some enclosure currently exists. It also occurs where the sensitivity is high for viewers at Kellyville Memorial Park.

It is unlikely that any individual residential views would alter significantly, given that the current character of the area would be quite different once the Balmoral Road Release Area is complete. Three of the viewpoints - VP5, VP9 and VP10 have been assessed to have High-Moderate impact, however only VP9 is taken from the perspective of future residents in the new development under construction at the corner of Hector Court. This location would be further impacted in the future by a new cross street constructed by Council (Severn Vale Drive) and new residential properties on the northern side of Memorial Avenue.

Landscape and urban design mitigation strategies have been developed from the outcomes of the landscape character and visual assessments, as a way of mitigating the potential impacts, and have been incorporated into the Urban Design and Landscape Concept Design (see Appendix J).

6.10.4 Safeguards and management measures

The safeguards and management measures outlined in Table 6-47 would be implemented before and during construction of the proposal to minimise impacts on landscape character and visual amenity.

Table 6-47: Safeguards and management measures landscape character and visual amenity

Impact	Environmental safeguards	Responsibility	Timing
Landscape character and visual impacts	<ul style="list-style-type: none"> • The following would be considered during detailed design: <ul style="list-style-type: none"> - The design of and materials to be used for retaining walls. For walls in fill situations, walls should be appropriate to future adjoining land uses - It is proposed to plant low shrub and groundcover planting to the base of the walls to reduce the walls visibility when viewed from the surrounding landscape - Roadside elements such as safety barriers, fencing, bus stops, street lighting, etc., are to be consistent with those used in other road upgrade projects within the North West Growth Centre - The design and location of the new bridge over Strangers Creek 	Roads and Maritime	Detailed design

Impact	Environmental safeguards	Responsibility	Timing
	<p>and associated earthworks should be designed to minimise impacts on the creek bed, banks and vegetation</p> <ul style="list-style-type: none"> - The number and location of existing trees to be retained within verge areas and median would be confirmed following a detailed survey of the study area - Investigate alternative types and colours of paved surfaces to minimise visual impact. 		
Landscape character and visual impacts	<ul style="list-style-type: none"> • The landscape and urban design strategy for the proposal would be finalised during detailed design in consideration of design principles and objectives as described in Section 3.2 of the REF and Appendix J. 	Roads and Maritime	Detailed design
Landscape character and visual impacts	<ul style="list-style-type: none"> • During detailed design, the design including landscape plans are to incorporate the design principles outlined in the Landscape Character, Visual Impact Assessment and Urban Design Report. These include: <ul style="list-style-type: none"> - To ensure that the design reinforces the identity and functionality of a transit boulevard road type - To ensure that existing land uses is considered and integrated in to the design of the road alignment - To contribute to the future urban planning of the adjoining development precincts including its transport and access needs - To respond to natural patterns including creek lines and drainage corridors and vegetation communities. This includes the use of local plants consistent with the existing communities either side of the alignment in order to unify the crossing with the existing corridor, and, use of advance stock to escalate the re-vegetation where appropriate - To provide a unified and 	Roads and Maritime	Detailed design

Impact	Environmental safeguards	Responsibility	Timing
	<p>consistent approach to the design of bridges along the corridor.</p> <ul style="list-style-type: none"> - The consideration of landscaping treatment to reduce the incidence of graffiti. - To achieve an integrated, safe and minimal maintenance design. 		
Landscape character and visual impacts	<ul style="list-style-type: none"> • During detailed design, the landscape design principles and streetscape (planting) would be reviewed to ensure that they are consistent with the outcomes of the biodiversity assessment. This would be done in consultation with RMS environment staff. 	Roads and Maritime	Detailed design
Landscape character and visual impacts	<ul style="list-style-type: none"> • If cut-off drains or swales are required as a permanent fixture, their location, size and treatment would be finalised during detailed design so that they blend into the landform and landscape character. 	Roads and Maritime	Detailed design

6.11 Climate change and greenhouse gas

This section identifies the potential climate change and greenhouse gas impact of the proposal and mitigation measures to reduce any adverse impact. It also identifies potential impact of climate change on the proposal, and measures taken to manage these implications at each stage of the project.

6.11.1 Policy setting

NSW 2021 sets the NSW Government agenda for change (OEH 2012). It sets goals and targets that support practical action to tackle climate change, including:

- Increase in the mode share of commuter trips made by public transport, including increasing the proportion of total journeys to work made by public transport to 28 per cent by 2016
- Increase in the mode share of walking trips made in the Greater Sydney region, at a local and district level to 25 per cent of total journeys by 2016.

Roads and Maritime has also developed a Climate Change Plan to:

- Reduce Roads and Maritime's carbon footprint
- Help reduce the carbon footprint of NSW road transport
- Adapt the Roads and Maritime road transport system to the impact of climate change
- Manage the Roads and Maritime transition to a low carbon economy.

Roads and Maritime reports annually to OEH on its greenhouse gas emissions and direct energy consumption, in accordance with the NSW Government Sustainability Policy. The Roads and Maritime Energy and Greenhouse Summary Report includes information on greenhouse gas emissions from energy usage associated with the operation of Roads and Maritime properties, street lighting, traffic signals and vehicles. Roads and Maritime tracks greenhouse gas emissions from general NSW road transport as part of its Vehicle Emissions Measure which is reported upon annually.

6.11.2 Potential impacts

Impact of climate on the proposal

Climatic factors would not constrain construction of the proposal except during adverse weather conditions such as prolonged heavy rain or very high winds, which could occur during the construction period. Adverse weather in the area would not affect the construction provided appropriate safeguards to avoid erosion and sedimentation were installed around any excavated or exposed areas.

The proposal would be located along the existing Memorial Avenue alignment, the operation of which is not constrained by any climatic factors. It is unlikely climatic factors would impact on operations of the proposal, provided motorists and other users of the proposal took due care during adverse weather conditions.

Impact of climate change on the proposal

The climate of NSW is changing. Average temperatures in NSW have been steadily rising since the 1960s. The period from 2000–2010 was the State's hottest decade on record. The *NSW Climate Impact Profile* (DECCW 2010) suggests that projected climate change for the Sydney Region is likely to be significant, including:

- Average annual temperatures to increase by up to two degrees Celsius and extreme temperatures to increase significantly by 2050
- Changes in seasonal rainfall, including increases in summer rainfall and a decrease in winter rainfall by 2050
- Increased frequency and intensity of annual extreme rainfall events (both frequency and intensity) could increase by up to 20 per cent by 2050.

Over the long term, increases in temperature may affect the integrity of road surfaces and other construction, either directly or indirectly through evaporative changes, along with changes to soil moisture content or soil instability, which may eventually impact the foundations of road structures, through softening of road surfaces.

Increased rainfall and flood events associated with projected climate change may also increase the flooding behaviour of local creek systems resulting in localised flooding of Memorial Avenue, drainage and stormwater and erosion impacts on resulting in sediment loss from the site of the proposed road upgrade.

Construction impact of the proposal on climate change

The construction phase of the proposal would result in the production of greenhouse gases, including carbon dioxide, methane and nitrous oxide. Key sources of greenhouse gas emissions associated with the construction of the proposal include:

- Vegetation removal, resulting in release of stored carbon dioxide to the atmosphere
- Operation of construction equipment, resulting in release of fugitive carbon dioxide and nitrous oxide emissions from fuel use (petrol, diesel) in plant and vehicles in construction, disposal and transport of materials
- Possible fugitive methane emissions from use of natural gas for the operation of construction equipment
- Use of materials with high embodied energy content, such as concrete
Landfilling any carbon-based waste resulting in emissions of methane
- On-site electricity usage.

It is anticipated that construction equipment would be the main emissions source during construction. The amount of greenhouse gas emissions associated with the construction of the proposal would be heavily dependent on the quantity of bulk earthwork required as well as the extent of vegetation removal.

Operation impacts of the proposal on climate change

The primary source of greenhouse gas emissions during operation would be associated with vehicles using Memorial Avenue; however, the number of vehicles using Memorial Avenue is not anticipated to increase as a result of the proposal. The proposal would result in reduced emissions associated with increased efficiency of the road network. This is attributable to increased level of service through additional

capacity, improved traffic flow and provision of new road surfaces.

Other greenhouse gas emission sources likely to be associated with the operational phase of the proposal include:

- Electricity usage for street lighting and signals
- Maintenance activities.

Roads and Maritime is responsible for maintaining 18,028 kilometres of State roads, 2970 kilometres of regional and local roads in the unincorporated area of NSW, 5071 bridges, nine car ferries and 22 road tunnels. Accordingly, the contribution of the proposal (which would upgrade of 2.2 kilometres of road on an existing alignment) to Roads and Maritime's annual greenhouse gas emissions is not considered to be significant. To understand the full effects of the proposal, a detailed greenhouse gas assessment would need to be carried out.

6.11.3 Safeguards and management measures

The safeguards and management measures outlined in Table 6-48 would be implemented before and during construction of the proposal to take account of climate change and greenhouse gas emissions.

Table 6-48: Safeguards and management measures for climate change and greenhouse gas emissions

Impact	Environmental safeguards	Responsibility	Timing
Climate change	<ul style="list-style-type: none"> • Design would consider the potential effects of climate change on the proposal, including drainage requirements. 	Roads and Maritime	Detailed design
Energy efficiency	<ul style="list-style-type: none"> • The selection process for vehicle and plant would consider energy efficiency and related carbon emissions. 	Construction contractor	Pre-construction and construction
Energy efficiency	<ul style="list-style-type: none"> • Equipment would be serviced frequently to ensure it is operating efficiently. 	Construction contractor	Construction
Energy efficiency	<ul style="list-style-type: none"> • Machinery would be operated efficiently to ensure optimal performance, minimise down time and improve fuel efficiency. 	Construction contractor	Construction

6.12 Resource use and waste management

6.12.1 Potential impacts

Construction

The proposal would generate and require earthwork, concrete, steel, asphalt, fill materials and landscaping supplies as detailed in Section 3.4.5. During construction, the proposal would generate the following waste:

- General solid waste (non-putrescible), including scrap metal from reconstruction and/or replacement of existing road infrastructure; construction waste from excess materials such as asphalt and concrete; and redundant pavement material from restoration and/or reconstruction of sections of the existing road
- General waste (putrescible) including paper waste, food waste and general rubbish generated by the construction workforce
- Green waste from vegetation clearing and grubbing
- Liquid waste including stormwater runoff from construction areas; sewage; and small volumes of excess fuel, oils and other chemicals from vehicle maintenance
- Excess spoil from earthwork, where excavated material is not suitable for reuse within the proposal.

During detailed design, the quantities of the above waste streams would be estimated, taking into account excess cut material that would be suitable for reuse, asphaltic concrete which would be suitable for reuse, and whether the workforce would use portable toilet facilities or sewer connections.

Stockpile site management would comply with management principles consistent with Roads and Maritime's *Stockpile Site Management Procedure*.

Where possible, materials would be sourced on site, locally or within the Sydney region. It would be preferred that any excess or unsuitable material be recycled on other Roads and Maritime projects. If neither of these is possible, waste would be disposed of at a licensed facility.

Guideposts, signage, fuel (for the operation of machinery and vehicles), chemicals and water would also be required during construction. The quantity of water required for the proposal is not yet available, but would be estimated during detailed design. During construction, water for construction shall be harvested from the sediment sumps. This water saving would be implemented by the construction contractor.

None of the materials required for the proposed upgrade are in short supply or difficult to obtain; however, options for using materials with recycled content and lower carbon footprint would be investigated during procurement, where these options are considered cost and performance effective.

Operation

Moderate quantities of waste (including vehicle oils and greases, and green waste) would be generated during operation of the proposal.

6.12.2 Safeguards and management measures

Table 6-49 outlines the proposed safeguards and management measures in terms of waste and resource use for construction of the proposal.

Table 6-49: Safeguards and management measures for waste and resource management

Impact	Environmental safeguards	Responsibility	Timing
Increases in production of waste materials	<ul style="list-style-type: none"> • A Resource and Waste Management Plan (RWPM) would be developed as a component of the CEMP, which would include: <ul style="list-style-type: none"> - The type and volume of all materials - Destinations for each resource/waste type either for on-site reuse or recycling, off-site reuse or recycling, or disposal at a licensed waste facility - Quantity and classification of excavated material generated as a result of the proposal - Disposal strategies for each type of material - Details of how waste would be stored and treated on site - Identification of all non-recyclable waste - Identification of strategies to 'avoid', 'reduce', 're-use', and 'recycle' - Identification of available recycling facilities on and off site - Identification of suitable methods and routes to transport waste - Procedures and disposal arrangements for unsuitable excavated material or contaminated material - Site clean-up for each stage. 	Construction contractor	Pre-construction and construction
Increases in production of waste materials	<ul style="list-style-type: none"> • Waste management measures developed in accordance with the waste hierarchy established under the WARR Act for the proposal would be included in 	Construction contractor	Pre-construction and construction

Impact	Environmental safeguards	Responsibility	Timing
	the CEMP.		
Increases in production of waste materials	<ul style="list-style-type: none"> Training in waste management principles would be included in site inductions for the workforce. 	Construction contractor	Pre-construction and construction
Increases in production of waste materials	<ul style="list-style-type: none"> Types of waste collected, amounts, date/time and details of disposal shall be recorded in a waste register. 	Construction contractor	Pre-construction and construction
Sourcing of recycled materials	<ul style="list-style-type: none"> Roads and Maritime contractors would be required to propose recycled-content materials where they are cost and performance competitive. 	Construction contractor	Construction
Reuse and recycling of materials	<ul style="list-style-type: none"> Workspaces would be maintained, kept free of rubbish and cleaned up at the end of each working day. 	Construction contractor	Construction
Waste disposal	<ul style="list-style-type: none"> Solid and liquid wastes, as well as fuels, lubricants and chemical containers would be disposed of in accordance with OEH requirements. 	Construction contractor	Construction
Waste disposal	<ul style="list-style-type: none"> Suitable waste disposal locations would be identified and used to dispose of litter and other wastes on-site. Suitable containers would be provided for waste collection. 	Construction contractor	Construction
Waste disposal	<ul style="list-style-type: none"> Material identified for recycling would be stockpiled in an adequately bunded area (in accordance with the <i>Roads and Maritime Stockpile Site Management Guidelines</i>, 2011). 	Construction contractor	Construction
Waste disposal	<ul style="list-style-type: none"> Fuel and chemical storage areas would be appropriately sized and imperviously bunded. 	Construction contractor	Construction
Procurement	<ul style="list-style-type: none"> Procurement would endeavour to use materials and products with a recycled content and low carbon footprint where it is cost and performance effective to do so. 	Construction contractor	Pre-construction and construction
Waste management	<ul style="list-style-type: none"> All wastes would be managed in accordance with the <i>Protection of the Environment Operations</i> 	Construction contractor	Construction

Impact	Environmental safeguards	Responsibility	Timing
	<i>Act 1997.</i>		
Waste management	<ul style="list-style-type: none"> A dedicated concrete washout facility would be provided during construction so that runoff from the washing of concrete machinery and equipment could be collected and disposed of at an appropriate waste facility. 	Construction contractor	Construction

6.13 Cumulative Impact

The interaction of individual elements of the proposal and the additive effects of the proposal with other concurrent and future projects have the potential to give rise to cumulative impact. This impact is addressed in this section.

6.13.1 Potential impacts

Current road projects

The proposal forms part of a series of planned road upgrades and under-construction upgrades in Sydney's north-west. Current projects include Richmond Road upgrade and Schofields Road upgrade and extension. The concurrent development of the proposal and these roads could result in short-term adverse cumulative impact associated with:

- Traffic delays and access
- Changes to the visual amenity of the area during construction
- Construction noise
- Air pollution
- Resource use and waste management.

As with other concurrent development (see below), coordination would be required between design and development parties to minimise negative cumulative impact associated with short-term traffic delays and access during construction.

However, once the road upgrades are operational, there would be a positive cumulative impact on road safety and travel times in the medium term, particularly as traffic volumes increase as a result of expected population growth in the region.

Upgrade of Wrights Road intersection by The Hills Shire Council

The Hills Shire Council plans to upgrade the Wrights Road intersection to a full signalised intersection, most likely at the same time that the Memorial Avenue Upgrade is constructed. This has the potential to cause additional traffic impacts along Windsor Road associated with lane closures and construction traffic movements.

Concurrent development – Balmoral Road Release Area

The 410-hectare Balmoral Road Release Area is planned to house 6400 dwellings and a population of about 16,000 people. To service the development, a number of new roads are being developed to intersect Memorial Avenue, including Burns Road, Severn Vale Drive and Free Settlers Drive.

The concurrent development of the proposal and these developments could result in short-term adverse cumulative impact associated with traffic delays and access, waste and resource use, air pollution (particularly dust), and visual impact.

Concurrent development – North West Rail Link

The \$8.3 billion North West Rail Link (NWRL) is Australia's largest public transport

infrastructure project currently under construction and a priority rail project for the NSW Government (TfNSW 2014). Work has commenced and the NWRL is anticipated to be open to customers by the end of 2019. Associated work nearby, and interacting with Memorial Avenue, includes a bridge over Memorial Avenue approaching the intersection with Old Windsor Road.

There is a construction site near the intersection of Memorial Avenue and Old Windsor Road. The site is the starting point for the construction of the sky train and the project's second concrete mixing plant. Access to the Memorial Avenue construction site is from Balmoral Road (left in, right out) and Memorial Avenue (all movements). It is anticipated this site will be in use until 2016.

Designers of the proposal and the NWRL have consulted where access and linkages are relevant. Consultation would continue throughout detailed design and construction.

The concurrent development of the proposal and the NWRL could result in negative cumulative impact associated with resource use, waste management, air pollution, dust and visual quality.

However, once the projects are built, there would be positive cumulative impact from upgrading public transport and improving traffic congestion and road safety and reducing associated travel times and pollution. This outcome is consistent with the Metropolitan Transport Plan (DoP 2010) which is an integrated, long-term planning framework focussed on managing Sydney's growth to 2036, with a focus on a more connected city with improved accessibility.

Cumulative biodiversity impact

The proposal area is characterised by rural/residential development, recent higher-density residential developments and lands currently subject to clearing and construction for development projects.

The proposal is located within the Balmoral Road Release Area and there is extensive current and future development planned for this area. Given the long history of clearing and modification of biodiversity values in the area, and the poor condition of the fragments of native vegetation that remain, it is considered that the proposal would not greatly add to the cumulative impact on biodiversity in the area.

Socio-economic impact

When completed, the proposal, as well as other current road projects and the NWRL, would result in cumulative benefits for the Balmoral Road Release Area and nearby established communities in terms of enhanced accessibility, road safety, improved flow of traffic, and improved pedestrian and cyclist facilities.

These transport upgrades would also, cumulatively, result in localised increases in traffic noise and air pollution within the region. Air quality and noise impacts would be addressed on a project-by-project basis, during detailed design, to minimise impact on sensitive receivers.

6.13.2 Policy setting

In NSW, waste storage, handling, transport, recovery and disposal is regulated by the *Protection of the Environment Operations Act 1997* and the *Protection of the*

Environment Operations (Waste) Regulation 2005. This Act and Regulation are administered by the NSW Environment Protection Authority (EPA) to prevent degradation of the environment, eliminate harmful wastes, reduce the amount of waste generated and establish priorities for waste re-use, recovery and recycling.

The *Waste Avoidance and Resource Recovery Act 2001* (WARR Act) requires the consideration of resource management options against the following priorities:

- Avoidance, including actions to reduce the amount of waste generated
- Recovery, including reuse, recycling, reprocessing and energy recovery
- Disposal, in a way that is environmentally responsible.

Roads and Maritime is committed to implementing this hierarchy throughout its operations.

The NSW Government Sustainability Policy includes a Waste Reduction and Purchasing Policy. It requires State government agencies to develop and implement a Waste Reduction and Purchasing Policy to minimise waste generated across all government sectors and help increase the market for materials containing recycled content.

Roads and Maritime's contractors are required to propose recycled-content materials where they are cost and performance competitive and are at least the environmental equivalent of the non-recycled alternatives. Waste minimisation quantities, initiatives and barriers are also reported on all projects.

6.13.3 Safeguards and management measures

The impacts of other projects do not form part of this assessment and would be assessed and addressed separately.

Table 6-50 outlines the safeguards and management measures that would be employed for this proposal to manage potential cumulative impact.

Table 6-50: Safeguards and management measures for cumulative impact

Impact	Environmental safeguards	Responsibility	Timing
Cumulative impact during construction	<ul style="list-style-type: none"> • Cumulative impact would be considered in the CEMP, addressing any cumulative construction traffic, noise and vibration and air quality impact as required. 	Contractor	Pre-construction and construction
Cumulative impact during construction	<ul style="list-style-type: none"> • Work would be staged to minimise impact along the entire length of the proposal area, where possible. 	Contractor	Construction
Cumulative impact during	<ul style="list-style-type: none"> • Cumulative impact management measures within the CEMP would be reviewed in response to any 	Contractor	Construction

Impact	Environmental safeguards	Responsibility	Timing
construction	complaints received.		

6.14 Summary of beneficial effects

The key beneficial impacts associated with this proposal include:

- Providing capacity for projected traffic volumes on Memorial Avenue between Windsor Road and Old Windsor Road, including at the intersections of these arterial roads
- Improving travel times within the proposal area
- Providing facilities for walking and cycling as well as efficient bus movement within the proposal area
- Providing an opportunity to enhance urban design and visual aspect within the proposal area, to complement the changing landscape of the Balmoral Road Release Area
- Improving the drainage system, particularly at identified low points along Memorial Avenue so that the road is serviceable during 100-year floods
- Improving safety by offering a new road design and intersection upgrades that is compliant with current safety standards for arterial roads.

6.15 Summary of adverse effects

The key adverse impacts associated with this proposal include:

- The proposal would include removal of about 0.151 hectares of disturbed regrowth Cumberland Plain Woodland. Other indirect impacts on native vegetation communities in the study area include edge effects and weed invasion
- The increase in noise levels between the design year 'no-build' and 'build' options is more than 2dB(A) in NCAs 2, 4 and 5 which is a perceptible difference according to the RNP. 52 residences within the proposal area have been identified for further noise mitigation. There would also be temporary noise and vibration impacts during construction
- The proposal would have an adverse impact on visual amenity and landscape character. While the proposal, for the most part, is to take place in an established road corridor, there would be visual impacts due to the removal of trees, increase in road pavement width, and intersection upgrades
- There would be some short-term minor impacts on traffic along Memorial Avenue during construction
- Construction of the proposal would result in property impacts at a number of locations within the proposal area with some land acquisition required
- Construction activities have the potential to contribute to soil erosion and impacts on air and water quality.

A range of management and mitigation measures have been developed for avoiding, minimising and mitigating potential adverse impacts (refer to Table 7-1).

7 Environmental management

This chapter describes how the proposal would be managed to reduce potential environmental impacts throughout detailed design, construction and operation. A framework for managing the potential impacts is provided with reference to environmental management plans and relevant Roads and Maritime Services QA specifications. A summary of site-specific environmental safeguards is provided as detailed in Chapter 6 and the licence and/or approval requirements required prior to construction are also listed.

7.1 Environmental management plans (or system)

A number of safeguards and management measures have been identified in order to minimise adverse environmental impacts, including social impacts, which could potentially arise as a result of the proposal. Should the proposal proceed, these management measures would be incorporated into the detailed design and applied during the construction and operation of the proposal.

A Project Environmental Management Plan (PEMP) and a Contractors Environmental Management Plan (CEMP) would be prepared to describe safeguards and management measures identified. These plans would provide a framework for establishing how these measures would be implemented and who would be responsible for their implementation.

The plans would be prepared prior to construction of the proposal and must be reviewed and certified by the Roads and Maritime Services Environmental Officer, Sydney Region, prior to the commencement of any on-site work. The CEMP would be a working document, subject to ongoing change and updated as necessary to respond to specific requirements. The CEMP and PEMP would be developed in accordance with the specifications set out in the QA Specification G36 – Environmental Protection (Management System), QA Specification G38 – Soil and Water Management (Soil and Water Plan) and the QA Specification G40 – Clearing and Grubbing.

7.2 Summary of safeguards and management measures

Environmental safeguards outlined in this document would be incorporated into the detailed design phase of the proposal and during construction and operation of the proposal, should it proceed. These safeguards would minimise any potential adverse impacts arising from the proposed work on the surrounding environment. The safeguards and management measures are summarised in Table 7-1.

Table 7-1: Summary of site specific environmental safeguards.

No.	Impact	Environmental safeguards	Responsibility	Timing
G1	General	<ul style="list-style-type: none"> • All environmental safeguards must be incorporated within the following: <ul style="list-style-type: none"> - Project Environmental Management Plan - Detailed design stage - Contract specifications for the proposal - Contractor's Environmental Management Plan 	Project manager	Pre-construction
G2	General	<ul style="list-style-type: none"> • The Roads and Maritime Services Project Manager must notify the Roads and Maritime Services Environmental Officer [Sydney region] at least 5 days prior to work commencing. 	Project manager	Pre-construction
G3	General	<ul style="list-style-type: none"> • All businesses and residences likely to be affected by the proposed work must be notified at least 5 working days prior to the commencement of the proposed activities. 	Project manager	Pre-construction
G4	General	<ul style="list-style-type: none"> • Environmental awareness training must be provided, by the contractor, to all field personnel and subcontractors. 	Contractor	Pre-construction and during construction as required.
WQ1	Water quality	<ul style="list-style-type: none"> • A Soil and Water Management Plan (SWMP) would be prepared as part of the CEMP in accordance with the requirements of Roads and Maritime contract specification G38 before construction begins. The SWMP would address: <ul style="list-style-type: none"> - The Roads and Maritime Code of Practice for Water Management - The Roads and Maritime Erosion and Sedimentation Procedure (RTA 2008) 	Construction contractor	Pre-construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		<ul style="list-style-type: none"> - The Blue Book - Roads and Maritime Technical Guidelines – Temporary Stormwater Drainage for Road Construction (Roads and Maritime 2011). <p>The SWMP would also include and address:</p> <ul style="list-style-type: none"> - The identification of catchment areas and the direction of on-site and off-site water flow - The likely runoff from each road subcatchment - Dust suppression mechanisms - Separation of on-site and off-site water - The direction of runoff and drainage points during each stage of construction - The locations and sizing of sediment traps such as sumps or basins - The locations of other erosion and sediment control measures (eg rock check dams, swales, scour protection and sediment fences) - The staging plans, location, sizing and details of creek alignment and realignment controls for scour protection and bank and bed stabilisation including those used during construction and long term - Progressive site-specific Erosion and Sedimentation Control Plans (ESCPs). The ESCPs would be updated at least fortnightly - A process for monitoring and preparing for wet weather <ul style="list-style-type: none"> • Provision of an inspection and maintenance schedule for ongoing maintenance of temporary and permanent erosion 		

No.	Impact	Environmental safeguards	Responsibility	Timing
		and sedimentation controls.		
WQ2	Water quality	<ul style="list-style-type: none"> The SWMP would be reviewed by a soil conservationist and updated to address their comments and recommendations. 	Construction contractor	Pre-construction
WQ3	Water Quality	<ul style="list-style-type: none"> Detailed design to further investigate the provision of additional water quality treatment near Strangers Creek and Elizabeth Macarthur Creek. 	Roads and Maritime	Detailed design
WQ4	Drainage lines and flow paths causing scouring	<ul style="list-style-type: none"> Channel bank and bed stabilisation measures would be maintained until riparian vegetation is completely re-established. 	Construction contractor	Construction
WQ5	Spills	<ul style="list-style-type: none"> Emergency wet and dry spill kits would be kept on site at all times. All staff would be made aware of the location of the spill kits and trained in their use. 	Construction contractor	Construction
WQ6	Spills	<ul style="list-style-type: none"> All fuels, chemicals and liquids would be stored in an impervious bunded area within the construction compound, a minimum of 50 metres away from: <ul style="list-style-type: none"> Rivers, creeks or any areas of concentrated water flow Flooded areas Slopes above 10%. Refueling would be done in a similarly contained area. 	Construction contractor	Construction
HF1	Flooding due to increases in peak flow velocities	<ul style="list-style-type: none"> Further flood modelling, including a detailed afflux assessment, would be carried out during detailed design to confirm impacts on surrounding land uses. 	Construction contractor	Construction
GW1	Groundwater	<ul style="list-style-type: none"> Further investigations would be carried out during detailed design to confirm levels of soil salinity and potential impacts 	Roads and Maritime	Detailed design

No.	Impact	Environmental safeguards	Responsibility	Timing
ES1	Erosion and sediment control	<p>on groundwater.</p> <ul style="list-style-type: none"> • During detailed design an Erosion and Sedimentation Management Report is to be prepared. The report is to include (as a minimum): <ul style="list-style-type: none"> - Identify site catchment and sub-catchments, high risk areas and sensitive areas - Sizing of each of the above areas and catchments - Proposed staging plans for the project to ensure appropriate erosion and sediment controls measures are possible - The likely volume of run-off from each catchment and sub-catchment in accordance with the Managing Urban Stormwater: Soils and Construction, Volume 1 and 2 (Landcom, 2004) - Direction of water flow, both off and on site - Diversion of off-site water around or through the site or details of separation of on-site and off-site water - The direction of runoff and drainage points during each stage of construction - The locations and sizing of sediment basins / sumps as well as associated drainage to direct site water to the basin or sumps - A mapped plan identifying the above at all major construction stages - A review process by a soil conservationist and a process for updating the report to address any recommendations 	Roads and Maritime	Detailed design
ES2	Erosion and	<ul style="list-style-type: none"> • A soil conservationist from the Roads and Maritime Erosion, 	Roads and Maritime	Detailed design

No.	Impact	Environmental safeguards	Responsibility	Timing
	sediment control	Sedimentation and Soil Conservation Consultancy Services Register would be engaged to review the Erosion and Sedimentation Management Report.		
ES3	Erosion and sediment control	<ul style="list-style-type: none"> • An Erosion and Sedimentation Control Plan (ESCP) would be prepared prior to construction and is to include as a minimum: <ul style="list-style-type: none"> - Identify site catchment and sub-catchments, high risk areas and sensitive areas - Sizing of each of the above areas and catchments - The likely run-off from each sub-catchment - Separation of on-site and off-site water - The direction of run-off and drainage points during each stage of construction - Direction of flow of on-site and off-site water - The locations and sizing of sediment basins or sumps and associated catch drains and/or bunds - The locations of other erosion and sediment control measures (eg rock check dams, swales and sediment fences) - Controls/measures to be implemented on wet weather events - A mapped plan identifying the above - A dewatering procedure for onsite water and basins - A process for reviewing and updating the plan on a fortnightly basis and/or when works alter. 	Contractor	Prior to construction
ES4	Erosion and sediment control	<ul style="list-style-type: none"> • Wet weather plans for a rain event would be included and shown on the ESCPs outlining the controls to be implemented in preparation for a rain event. 	Construction contractor	Pre-construction and construction

No.	Impact	Environmental safeguards	Responsibility	Timing
ES5	Erosion and sediment control	<ul style="list-style-type: none"> • Environmental Work Method Statements (EWMS) would be prepared for high-risk activities such as: <ul style="list-style-type: none"> - Clearing and grubbing - Earthwork - Temporary creek diversions - Work around the bridge and culverts - Drainage work - Utilities relocations - Bridge and culvert construction. <p>Environmental Work Method Statements (EWMS) would include:</p> <ul style="list-style-type: none"> - Description of the work/activities and machinery - Outline of the sequence of the work/activities, including interfaces with other construction activities - Identification of potential environmental risks/impacts due to the work/activities and associated with wet weather events - Evaluation of methods to eliminate/reduce the environmental risk - Mitigation measures to reduce environmental risk. - Any safeguards resulting from consultation with public authorities and other stakeholders, where appropriate - A map indicating sensitive locations, likely potential environmental impacts, and work areas - Identification of work areas and exclusion areas - Operational and monitoring measures to reduce 	Construction contractor	Pre-construction and construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		<p>environmental impact</p> <ul style="list-style-type: none"> - A process for assessing and reporting the performance of the implemented environmental control measures - A process for resolving environmental issues or conflicts and reporting outcomes. 		
ES6	Erosion and sediment control	<ul style="list-style-type: none"> • A Stabilisation Plan is to be prepared and included in the SWMP. The stabilisation plan is to include but not be limited to the following: <ul style="list-style-type: none"> - Identification and methodology of techniques for stabilisation of site. - Identification of area on site for progressive stabilisation. - Stabilisation is to be undertaken of areas, including stockpiles and batters, exposed for a duration of 2 weeks or greater. For example covering with geotextile fabric, stabilised mulch, soil binder or spray grass. - Identification of areas on site for progressive permanent stabilisation such as implementation of landscaping 	Contractor	Prior to construction
ES7	Erosion and sediment control	<ul style="list-style-type: none"> • Localised erosion and sediment control measures would also be implemented to minimise erosion and the volume of sediment transported from disturbed areas. Measures would include use of the following elements: <ul style="list-style-type: none"> - Temporary revegetation /rehabilitation work to reduce the extent of disturbed surfaces - Application of temporary surface treatments or blanketing on exposed earth surfaces - Sediment barriers and sumps, in series where necessary 	Construction contractor	Pre-construction and construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		- Vegetated buffer strips.		
ES8	Erosion and sediment control	<ul style="list-style-type: none"> Control measures would be implemented at egress points to minimise dirt and mud tracking. 	Construction contractor	Construction
ES9	Erosion and sediment control	<ul style="list-style-type: none"> All stockpiles would be designed, established, operated and decommissioned in accordance with <i>Roads and Maritime Stockpile Management Procedures</i> (RTA 2011a). Stockpile sites would be located: <ul style="list-style-type: none"> At least 50 metres from the nearest waterway In an area of low ecological and heritage conservation significance On relatively level ground Outside the 1 in 10-year ARI floodplain. 	Construction contractor	Construction
ES10	Erosion and sediment control	<ul style="list-style-type: none"> Topsoil would be stockpiled separately for possible reuse in landscaping and rehabilitation. 	Construction contractor	Construction
ES11	Erosion and sediment control	<ul style="list-style-type: none"> An accredited soil conservationist would be engaged to regularly inspect work throughout the construction phase. 	Construction contractor	Construction
ES12	Erosion and sediment control	<ul style="list-style-type: none"> Any material transported onto road surfaces would be swept and removed at the end of each working day and before rainfall. 	Construction contractor	Construction
CM1	Contamination	<ul style="list-style-type: none"> A Stage 2 – Detailed site investigation in accordance with NSW EPA guidelines would be prepared and would include preparation of a sampling, analysis and quality plan in accordance with the <i>Roads and Maritime Contaminated Land Management Guidelines</i>. This plan would include site specific sampling and analysis of soil at the site on the 	Roads and Maritime	Detailed design

No.	Impact	Environmental safeguards	Responsibility	Timing
CM2	Contamination	<p>corner of Old Windsor Road and Memorial Avenue.</p> <ul style="list-style-type: none"> • Following the Stage 2 – Detailed site investigation, a Contaminated Land Management Plan would be prepared in accordance with the <i>Contaminated Land Act 1997</i> and relevant EPA Guidelines as part of the CEMP and would include: <ul style="list-style-type: none"> - Outline of occupational health and safety measures - Contamination management measures. - Incident reporting in according with the RMS Environmental Incident Management Procedure. - Identification of rehabilitation requirements, classification, transport and disposal requirements of any contaminated land within the construction footprint. - In the event that indications of contamination are encountered (known and unexpected, such as odorous or visually contaminated materials), work in the area would cease until an contamination assesement can be prepared to advise on the need for remediation or other action, as deemed appropriate. 	Roads and Maritime	Detailed design
TT1	Construction traffic impacts	<ul style="list-style-type: none"> • A Traffic Management Plan (TMP) would be prepared as part of the CEMP. The TMP would be prepared in accordance with <i>Traffic Control at Worksites</i> (Roads and Maritime 2010), <i>Australian Standard AS1742</i> and the worksite manual <i>Roads and Maritime Specification G10</i>. The TMP would outline: <ul style="list-style-type: none"> - Traffic controls to manage and regulate traffic movements, including minimising traffic switching - Maintenance of continuous, safe and efficient movement 	Construction Contractor	Pre-Construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		<p>of traffic for both the public and construction workers</p> <ul style="list-style-type: none"> - Haulage routes/access arrangements to minimise impacts on local routes - Temporary speed restrictions to ensure a safe driving environment around work zones - Access provisions for local roads and properties, including the use of temporary turn-around bays - Maintenance of pedestrian and cyclist access - Provision of appropriate warning and advisory signposting - Requirements and methods to consult and inform the local community of impacts on the local road network and traffic - Measures to minimise traffic conflict and congestion that may occur due to the cumulative increase in construction vehicle traffic caused by other developments. 		
TT2	Access	<ul style="list-style-type: none"> • Vehicular property access would be maintained where possible including pre-schools, places of worship and commercial premises. If driveway access cannot be maintained the resident would be consulted. 	Construction contractor	Construction
TT3	Access	<ul style="list-style-type: none"> • Road users, pedestrians and cyclists would be informed of changed conditions, including likely disruptions to access during construction. 	Construction contractor	Construction
TT4	Temporary impacts on bus services	<ul style="list-style-type: none"> • Access to bus stops and safe stopping locations would be maintained during construction in consultation with bus operators. 	Roads and Maritime and construction contractor	Construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		Ongoing updates on locations and access to bus stops would be provided to the community during the construction period to minimise disruption.		
NV1	Construction noise and vibration	<ul style="list-style-type: none"> • A Construction Noise and Vibration Management Plan (CNVMP) in accordance with OEH/EPA's <i>Interim Construction Noise Guideline</i> (DECCW 2009) would be prepared as part of the CEMP. This plan would detail the mitigation, monitoring and community liaison measures and would include but not be limited to: <ul style="list-style-type: none"> - Identification of potentially affected properties and residences (including a detailed map) - A map indicating the locations of likely potential impacts - A risk assessment to determine potential risk for activities likely to affect residents - Mitigation measures to reduce excessive noise during construction activities including those associated with truck movements - A process for assessing the performance of the implemented mitigation measures - A process for identifying management measures for highly noise affected receivers including consultation with affected residences - A process for resolving issues and complaints. 	Construction contractor	Pre-construction
NV2	Construction noise and vibration	<ul style="list-style-type: none"> • A vibration assessment is to be prepared and included in the NVMP. The vibration assessment is to include (as a minimum): <ul style="list-style-type: none"> - Identification of potentially affected properties/receivers - A risk assessment to determine the potential for discrete 	Construction contractor	Pre-construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		<p>work activities to affect receivers</p> <ul style="list-style-type: none"> - A map indicating the locations considered likely to be impacted and those requiring building condition surveys - Outline a monitoring program - A process for assessing the performance of the implemented mitigation measures - A process for resolving issues and conflicts. 		
NV3	Construction noise and vibration	<ul style="list-style-type: none"> • Works would be carried out during standard working hours (ie 7am – 6pm Monday to Friday, 8am –1pm Saturdays). Any work that is performed outside normal work hours or on a Sunday or public holiday is to minimise noise impacts in accordance with <i>Roads and Maritime’s Environmental Noise Management Manual Practice Note 7 – Roadworks Outside of Normal Working Hours</i> (RTA 2001) and the <i>Interim Construction Noise Guidelines</i> (DECC 2009). 	Construction contractor	Construction
NV4	Construction noise and vibration	<ul style="list-style-type: none"> • Where feasible, and particularly in areas in close proximity to sensitive receivers, noise and vibration generating activities with impulsive, tonal or low frequency characteristics (such as jack hammering, rock breaking, rock hammering, vibratory rolling) would only be carried out: <ul style="list-style-type: none"> - in continuous blocks, up to but not exceeding 3 hours each; and - with a minimum respite period of one hour between each block. 	Construction contractor	Construction
NV5	Construction noise and vibration	<ul style="list-style-type: none"> • Where vibration is found to exceed project criteria, management measures would be implemented to control vibration. In terms of human comfort criteria, measures 	Construction contractor	Construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		would include modifications of construction methods and respite periods. For potential structural damage impacts, modification of construction methods or equipment would be necessary.		
NV6	Construction vibration	<ul style="list-style-type: none"> The CNVMP would include an assessment of the structures such as buildings that need building condition surveys. 	Construction contractor	Construction
NV7	Construction noise	<ul style="list-style-type: none"> Simultaneous operation of noisy plant within the discernible range of a sensitive receiver would be limited/ avoided where possible. 	Construction contractor	Construction
NV8	Construction noise	<ul style="list-style-type: none"> Noise-emitting plant would be directed away from sensitive receivers where possible. 	Construction contractor	Construction
NV9	Construction noise	<ul style="list-style-type: none"> Non-tonal reversing beepers (or an equivalent mechanism) would be fitted and used on all construction vehicles and mobile plant regularly used on site for periods of over two months. 	Construction contractor	Construction
NV10	Construction vibration	<ul style="list-style-type: none"> Vibration testing of actual equipment on site would be carried out prior to their commencement of operation to determine acceptable buffer distances to the nearest affected receiver locations. 	Construction contractor	Pre-construction and construction
NV11	Construction vibration	<ul style="list-style-type: none"> Building condition surveys would be undertaken for buildings identified in the NVMP. A copy of the report would be sent to the landholder. 	Roads and Maritime	Pre-construction
NV12	Construction noise and vibration	<ul style="list-style-type: none"> All employees, contractors and subcontractors would receive a project induction which would include: <ul style="list-style-type: none"> - all relevant project specific and standard noise and vibration mitigation measures; 	Construction contractor	Construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		<ul style="list-style-type: none"> - relevant license and approval conditions; - permissible hours of work; - any limitations on high noise generating activities; - location of nearest sensitive receivers; - construction employee parking areas; - designated loading/unloading areas and procedures; - site opening/closing times (including deliveries); and - environmental incident procedures. 		
NV13	Operational noise	<ul style="list-style-type: none"> • During the detailed design stage of the proposal, further investigations of all feasible and reasonable mitigation options would be undertaken for affected receivers in accordance with the Road Noise Policy (DECCW 2011) and <i>RTA's Environmental Noise Management Manual Practice Note 4</i> (RTA 2001). 	Roads and Maritime	Detailed design
NV14	Operational noise	<ul style="list-style-type: none"> • A post-construction noise monitoring program (including simultaneous traffic counts) would be undertaken in accordance with the RMS Environmental Noise Management Manual within 6 to 12 months of opening once traffic flows have stabilised in order to verify the noise assessment. 	Roads and Maritime	Post-construction
FF1	Impacts on threatened species	<ul style="list-style-type: none"> • A Biodiversity Management Plan would be prepared and included within the CEMP. The BMP would include but not be limited to the following: <ul style="list-style-type: none"> - A map clearly showing vegetation clearing boundaries and no-go zones - A site walk-over with the site personnel including RMS 	Roads and Maritime and construction contractor	Pre-construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		<p>representatives to confirm clearing boundaries before the start of work</p> <ul style="list-style-type: none"> - Identification (marking) of the clearing boundary and identification (marking) of habitat features to be protected. Eg. – use of flagging tape - A procedure for a suitably qualified ecologist to undertake pre-clearing surveys immediately before vegetation removal. Target species would include threatened microbats - Management measures identified as a result of the pre-clearing survey report, with actions to respond to the recommendations made - Incorporation of management measures identified as a result of the pre-clearing survey report, completed by an ecologist, (G40, section 2.4) and nomination of actions to respond to the recommendations made. This should include details of measures to be implemented to protect clearing limits and no go areas - A detailed clearing process in accordance with RMS Biodiversity Guidelines (2011) including requirements of Guide 1,2, 4 & 9. - Identify in toolbox talks where biodiversity would be included such as vegetation clearing or works in or adjacent to sensitive locations - Identify control/mitigations measures to prevent impacts on sensitive locations or no go zones 		

No.	Impact	Environmental safeguards	Responsibility	Timing
		<ul style="list-style-type: none"> - A stop works procedure in the event of identification of unidentified species, habitats or populations - A requirement that culverts be checked for roosting microbats by a suitably qualified ecologist with experience in microbat survey prior to construction. In the event microbats are found, a microbat management plan would be developed - A requirement that culvert work and vegetation removal be carried out outside of summer, if possible (the breeding season of most threatened microbats that could be roosting on site) - A procedure for clearing potential habitat, including hollow-bearing trees in accordance with Roads and Maritime' <i>Specification G40</i>. An experienced, licensed wildlife carer or ecologist would be present to supervise vegetation clearing and capture then relocate fauna if required. Fauna handling and vegetation removal would be in accordance with Roads and Maritime' <i>Biodiversity Guidelines 2011</i>. An experienced, licensed wildlife carer or ecologist would be notified or be on call to supervise vegetation clearing and capture then relocate fauna if required. Fauna handling would be in accordance with Roads and Maritime' <i>Biodiversity Guidelines 2011 – Guide 9</i>. - Protocols to prevent the introduction or spread of pathogens (e.g. chytrid fungus and <i>Phytophthora</i>) in accordance with Roads and Maritime' <i>Biodiversity Guidelines 2011 – Guide 7</i>. 		

No.	Impact	Environmental safeguards	Responsibility	Timing
		<ul style="list-style-type: none"> - Provision of education to all personnel taking part in construction activities with regards to the importance of clearing limits, land uses and threatened species and communities and their legislative responsibilities. 		
FF2	Impacts on threatened species	<ul style="list-style-type: none"> • If unexpected threatened flora or fauna are discovered, work would stop immediately and RMS' <i>Unexpected Threatened Species Find Procedure</i> in its <i>Biodiversity Guidelines 2011</i> would be implemented. 	Roads and Maritime and construction contractor	Construction
FF3	Impacts on threatened species	<ul style="list-style-type: none"> • The design would be reviewed during the detailed design stage to determine whether it is possible to retain the hollow-bearing tree near the unnamed drainage line. 	Roads and Maritime and designer	Detailed design
FF4	Impacts to riparian areas	<ul style="list-style-type: none"> • Riparian areas disturbed by the proposal would be rehabilitated as soon as practicable <ul style="list-style-type: none"> - Where vegetation would be planted in disturbed riparian areas, only native species indigenous to the region would be used 	Roads and Maritime and construction contractor	Pre-construction
FF5	Impacts on the aquatic environment	<ul style="list-style-type: none"> • Creek bank stabilisation would be installed before and during the creek realignment work to minimise bank erosion, topsoil loss and sedimentation of the waterway. 	Roads and Maritime and construction contractor	Detailed design and construction
FF6	Impacts on the aquatic environment	<ul style="list-style-type: none"> • Appropriate erosion and sediment controls would be established throughout the proposal site, including at creek crossings, and water quality monitoring would occur throughout construction. 	Roads and Maritime and construction contractor	Construction
FF7	Impacts on the aquatic environment	<ul style="list-style-type: none"> • Fish passage would be maintained at all times. If required, water would be pumped to maintain flow at all times in the event of low flow ponding during creek works. 	Construction contractor	Construction

No.	Impact	Environmental safeguards	Responsibility	Timing
FF8	Impacts on the aquatic environment	<ul style="list-style-type: none"> Temporary waterway diversions would be scheduled during periods of predicted low flow to minimise impacts. 	Roads and Maritime and construction contractor	Construction
FF9	Impacts on the aquatic environment	<ul style="list-style-type: none"> DPI (Fisheries) would be notified of reclamation/dredging work prior to construction. Consideration would be given to any response within 28 days of notification. 	Roads and Maritime	Pre-construction
FF10	Weeds and pathogens	<ul style="list-style-type: none"> Actions for weed management would be developed as part of the Vegetation Management Plan in accordance with the requirements of Roads and Maritime' <i>Specification G36</i> and <i>Specification G40</i>. The plan would include, but not be limited to the following measures: <ul style="list-style-type: none"> The identification of the type and location of weeds of concern (including noxious weeds) within the proposal area The identification of sensitive receivers (such as native vegetation and waterways) within or near the proposal area Measures to prevent the spread of weeds and fungi, including hygiene procedures for equipment, footwear and clothing A requirement that weeds (including Declared noxious weeds) be managed and disposed of in accordance with requirements of the <i>Noxious Weeds Act 1993</i> and <i>Roads and Maritime' Biodiversity Guidelines 2011 – Guide 6</i> Communication strategies to improve contractor awareness of weeds and weed management. 	Roads and Maritime and construction contractor	Pre-construction

No.	Impact	Environmental safeguards	Responsibility	Timing
FF11	Weeds and pathogens	<ul style="list-style-type: none"> • Any application of herbicide for weed management would be carried out in accordance with the requirements of the <i>Pesticides Act 1999</i> and herbicide that is appropriate to the sensitivity of the area would be used. Approval by RMS' Regional Environmental Officer would be obtained prior to use. 	Construction contractor	Pre-construction and construction
AH1	Impacts to known Aboriginal heritage sites	<ul style="list-style-type: none"> • Aboriginal Heritage Management procedures would be included in the CEMP. These would include but not be limited to the following measures: <ul style="list-style-type: none"> - The location of all Aboriginal sites within and adjacent to proposal area. These would be marked on relevant site plans - An environmental risk assessment to determine potential risks for discrete work elements or activities that could affect Aboriginal heritage items - Specific mitigation measures to avoid risk of harm or protect Aboriginal heritage - Provisions for seeking further advice from an archaeologist should the proposed road design be altered in a manner that could impact the intact portion of site 45-5-2652 - If intact AHIMS sites are within 25 m of the proposal area, these would be identified on construction plans and exclusion fencing and signage would be placed at the boundary of the proposal area at this location to prevent indirect or inadvertent impacts to the site - A stop work procedure in the event of actual or suspected 	Roads and Maritime and construction contractor	Pre-construction and construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		<p>potential harm to a heritage feature/place</p> <ul style="list-style-type: none"> - Aboriginal heritage induction for workers so they are made aware of the location of sites and their responsibilities under the National Parks and Wildlife Act and any relevant permits. Induction would occur before work begins. 		
AH3	Possible disturbance to unknown Aboriginal heritage due to construction activities	<ul style="list-style-type: none"> • In the event of an unexpected find of an Aboriginal heritage item (or suspected item), work would cease in the affected area and RMS' Regional Environmental Officer and Senior Environmental Specialist (Aboriginal heritage) would be contacted for advice on how to proceed. The <i>RMS Unexpected Archaeological Finds Procedure (2011)</i> would be implemented. 	Construction contractor	Construction
NH1	Impacts to known non-Aboriginal heritage items	<ul style="list-style-type: none"> • Detailed design should seek to minimise changes to the form and alignment of Windsor Road and Old Windsor Road. 	Roads and Maritime	Pre-construction
NH2	Impacts to known non-Aboriginal heritage items	<ul style="list-style-type: none"> • Subsurface impacts to the fabric of Old Windsor Road would be avoided by the proposal. If sub-surface impacts are unavoidable, a section 139(4) exception notification would be required. 	Roads and Maritime and construction contractor	Pre-construction and construction
NH3	Possible disturbance to unknown non-Aboriginal heritage due to construction activities	<ul style="list-style-type: none"> • If potential archaeological relics or works associated with Old Windsor Road and Windsor Road are identified, the Roads and Maritime Services 'Unexpected Archaeological Finds Procedure 2012' would be implemented. 	Construction contractor	Construction

No.	Impact	Environmental safeguards	Responsibility	Timing
NH4	Impacts to known non-Aboriginal heritage item	<ul style="list-style-type: none"> The curtilage of the House at 9-11 Windsor Road would be avoided and the vibration management plan would be followed in relation to any potential vibration impacts to this property. 	Roads and Maritime and construction contractor	Pre-construction and construction
AQ1	Dust	<ul style="list-style-type: none"> An Air Quality Management plan (AQMP) would be prepared as part of the CEMP. The plan would include but not be limited to: <ul style="list-style-type: none"> A map identifying locations of sensitive receivers Identification of potential risks/impacts due to the work/activities as dust generation activities Management measures to minimise risk including a progressive stabilisation plan A process for monitoring dust on site and weather conditions A process for altering management measures as required. 	Construction contractor	Pre-construction
AQ2	Dust and odour	<ul style="list-style-type: none"> To minimise or prevent air pollution and dust, loads that may produce dust or odour would be covered, and water would be sprayed on unsealed access roads and open areas during conditions conducive to dust generation. 	Construction contractor	Construction
AQ3	Exhaust emissions	<ul style="list-style-type: none"> Construction equipment (including all internal combustion engines) would be properly maintained and running efficiently to ensure exhaust emissions are minimised, where practicable, and comply with the <i>Protection of Environment Operations Act 1997</i>. 	Construction contractor	Construction
AQ4	Exhaust	<ul style="list-style-type: none"> Machinery would be turned off when not in use. 	Construction contractor	Construction

No.	Impact	Environmental safeguards	Responsibility	Timing
	emissions			
SE1	Impact on businesses and the community	<ul style="list-style-type: none"> A complaints handling register would be included in the CEMP. 	Construction contractor	Pre-construction and construction
SE2	Impact on businesses and the community	<ul style="list-style-type: none"> Access would be maintained wherever possible. Prior to any temporary unavoidable disruption to access, consultation would be undertaken with the affected property owner/s. 	Construction contractor	Pre-construction and construction
SE3	Impact on businesses and the community	<ul style="list-style-type: none"> Safe access to bus stops would be maintained at all times and bus companies would be advised before changes to traffic conditions. 	Construction contractor	Pre-construction and construction
SE4	Impact on businesses and the community	<ul style="list-style-type: none"> Existing cyclist and pedestrian access along Windsor and Old Windsor Road would be maintained but may need to be altered during construction to ensure safety. Road users, pedestrians and cyclists would be informed of changed conditions, including likely disruptions to access during construction. 	Construction contractor	Construction
SE5	Impact on businesses and the community	<ul style="list-style-type: none"> Residents would be informed before any interruptions to utility services that may occur during the relocation of utilities. 	Construction contractor	Pre-construction and construction
SE6	Impact on businesses and the community	<ul style="list-style-type: none"> Community consultation would be carried out in accordance with Roads and Maritime's <i>Community Involvement Practice Notes and Resource Manual</i> (2012) 	Roads and Maritime	Detailed design, pre-construction and construction
SE7	Impact on businesses	<ul style="list-style-type: none"> Temporary signage would be provided during construction to inform traffic of alternative access to the businesses along Windsor Road and Memorial Avenue. 	Roads and Maritime and construction contractor	Pre-construction and construction
SE8	Impact on	<ul style="list-style-type: none"> Property acquisition would be managed in accordance with 	Roads and Maritime	Pre-construction

No.	Impact	Environmental safeguards	Responsibility	Timing
	property owners due to land acquisition	the provisions of Roads and Maritime's <i>Land Acquisition Policy</i> and the <i>Land Acquisition (Just Terms Compensation) Act 1991</i> .		
LC1	Landscape character and visual impacts	<ul style="list-style-type: none"> • The following would be considered during detailed design: <ul style="list-style-type: none"> - The design of and materials to be used for retaining walls. For walls in fill situations, walls should be appropriate to future adjoining landuses. For example, in residential areas, walls would be a combination of split-faced and smooth-faced blockwork in a recessive colour. Gabion walls should be considered for rural or open space areas. - It is proposed to plant low shrub and groundcover planting to the base of the walls to reduce the walls visibility when viewed from the surrounding landscape - Roadside elements such as safety barriers, fencing, bus stops, street lighting, etc, are to be consistent with those used in other road upgrade projects within the North West Growth Centre - The design and location of the new bridge over Strangers Creek and associated earthworks should be designed to minimise impacts on the creek bed, banks and vegetation - The number and location of existing trees to be retained within verge areas and median would be confirmed following a detailed survey of the study area - Investigate alternative types and colours of paved surfaces to minimise visual impact. 	Roads and Maritime	Detailed design
LC2	Landscape	<ul style="list-style-type: none"> • The landscape and urban design strategy for the proposal 	Roads and Maritime	Detailed design

No.	Impact	Environmental safeguards	Responsibility	Timing
	character and visual impacts	would be finalised during detailed design in consideration of design principles and objectives as described in Section 3.2 of the REF and Appendix J.		
LC3	Landscape character and visual impacts	<ul style="list-style-type: none"> • During detailed design, the design including landscape plans are to incorporate the design principles outlined in the Landscape Character, Visual Impact Assessment and Urban Design Report. These include: <ul style="list-style-type: none"> - To ensure that the design reinforces the identity and functionality of a transit boulevard road type - To ensure that existing land uses is considered and integrated in to the design of the road alignment - To contribute to the future urban planning of the adjoining development precincts including its transport and access needs - To respond to natural patterns including creek lines and drainage corridors and vegetation communities. This includes the use of local plants consistent with the existing communities either side of the alignment in order to unify the crossing with the existing corridor, and, use of advance stock to escalate the re-vegetation where appropriate - To provide a unified and consistent approach to the design of bridges along the corridor. - The consideration of landscaping treatment to reduce the incidence of graffiti. - To achieve an integrated, safe and minimal maintenance 	Roads and Maritime	Detailed design

No.	Impact	Environmental safeguards	Responsibility	Timing
		design.		
LC4	Landscape character and visual impacts	<ul style="list-style-type: none"> During detailed design, the landscape design principles and streetscape (planting) would be reviewed to ensure that they are consistent with the outcomes of the biodiversity assessment. This would be done in consultation with RMS environment staff. 	Roads and Maritime	Detailed design
LC5	Landscape character and visual impacts	<ul style="list-style-type: none"> If cut-off drains or swales are required as a permanent fixture, their location, size and treatment would be finalised during detailed design so that they blend into the landform and landscape character. 	Roads and Maritime	Detailed design
CG1	Climate change	<ul style="list-style-type: none"> Design would consider the potential effects of climate change on the proposal, including drainage requirements. 	Roads and Maritime	Detailed design
CG2	Energy efficiency	<ul style="list-style-type: none"> The selection process for vehicle and plant would consider energy efficiency and related carbon emissions. 	Construction contractor	Pre-construction and construction
CG3	Energy efficiency	<ul style="list-style-type: none"> Equipment would be serviced frequently to ensure it is operating efficiently. 	Construction contractor	Construction
CG4	Energy efficiency	<ul style="list-style-type: none"> Machinery would be operated efficiently to ensure optimal performance, minimise down time and improve fuel efficiency. 	Construction contractor	Construction
WM1	Increases in production of waste materials	<ul style="list-style-type: none"> A Resource and Waste Management Plan (RWPM) would be developed as a component of the CEMP, which would include: <ul style="list-style-type: none"> The type and volume of all materials Destinations for each resource/waste type either for on-site reuse or recycling, off-site reuse or recycling, or disposal at a licensed waste facility 	Construction contractor	Pre-construction and construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		<ul style="list-style-type: none"> - Quantity and classification of excavated material generated as a result of the proposal - Disposal strategies for each type of material - Details of how waste would be stored and treated on site - Identification of all non-recyclable waste - Identification of strategies to 'avoid', 'reduce', 're-use', and 'recycle' - Identification of available recycling facilities on and off site - Identification of suitable methods and routes to transport waste - Procedures and disposal arrangements for unsuitable excavated material or contaminated material - Site clean-up for each stage. 		
WM2	Increases in production of waste materials	<ul style="list-style-type: none"> • Waste management measures developed in accordance with the waste hierarchy established under the WARR Act for the proposal would be included in the CEMP. 	Construction contractor	Pre-construction and construction
WM3	Increases in production of waste materials	<ul style="list-style-type: none"> • Training in waste management principles would be included in site inductions for the workforce. 	Construction contractor	Pre-construction and construction
WM4	Increases in production of waste materials	<ul style="list-style-type: none"> • Types of waste collected, amounts, date/time and details of disposal shall be recorded in a waste register. 	Construction contractor	Pre-construction and construction
WM5	Sourcing of recycled materials	<ul style="list-style-type: none"> • Roads and Maritime contractors would be required to propose recycled-content materials where they are cost and performance competitive. 	Construction contractor	Construction

No.	Impact	Environmental safeguards	Responsibility	Timing
WM6	Reuse and recycling of materials	<ul style="list-style-type: none"> Workspaces would be maintained, kept free of rubbish and cleaned up at the end of each working day. 	Construction contractor	Construction
WM7	Waste disposal	<ul style="list-style-type: none"> Solid and liquid wastes, as well as fuels, lubricants and chemical containers would be disposed of in accordance with OEH requirements. 	Construction contractor	Construction
WM8	Waste disposal	<ul style="list-style-type: none"> Suitable waste disposal locations would be identified and used to dispose of litter and other wastes on-site. Suitable containers would be provided for waste collection. 	Construction contractor	Construction
WM9	Waste disposal	<ul style="list-style-type: none"> Material identified for recycling would be stockpiled in an adequately bunded area (in accordance with the <i>Roads and Maritime Stockpile Site Management Guidelines, 2011</i>). 	Construction contractor	Construction
WM10	Waste disposal	<ul style="list-style-type: none"> Fuel and chemical storage areas would be appropriately sized and imperviously bunded. 	Construction contractor	Construction
WM11	Procurement	<ul style="list-style-type: none"> Procurement would endeavour to use materials and products with a recycled content and low carbon footprint where it is cost and performance effective to do so. 	Construction contractor	Pre-construction and construction
WM12	Waste management	<ul style="list-style-type: none"> All wastes would be managed in accordance with the <i>Protection of the Environment Operations Act 1997</i>. 	Construction contractor	Construction
WM13	Waste management	<ul style="list-style-type: none"> A dedicated concrete washout facility would be provided during construction so that runoff from the washing of concrete machinery and equipment could be collected and disposed of at an appropriate waste facility. 	Construction contractor	Construction
CU1	Cumulative impact during	<ul style="list-style-type: none"> Cumulative impact would be considered in the CEMP, addressing any cumulative traffic, noise and vibration and 	Contractor	Pre-construction

No.	Impact	Environmental safeguards	Responsibility	Timing
	construction	air quality impact as required.		and construction
CU2	Cumulative impact during construction	<ul style="list-style-type: none"> Work would be staged to minimise impact along the entire length of the proposal area, where possible. 	Contractor	Construction
CU3	Cumulative impact during construction	<ul style="list-style-type: none"> Cumulative impact management measures within the CEMP would be reviewed in response to any complaints received. 	Contractor	Construction

7.3 Licensing and approvals

Table 7-2 lists all of the relevant licenses, permits, notifications and/or approvals needed to construct/operate the proposal.

Table 7-2: Summary of licensing and approval required.

Requirement	Timing
<p>The proposal would be a scheduled activity under the <i>Protection of the Environment Operations Act 1997</i>. An environment protection license would be required under Section 48 of this Act to authorise the carrying out of scheduled development work. For the purposes of section 48, any activity that is declared by this Part to be a scheduled activity is taken to be an activity for which a license is required for the premises at which it is carried out (the activity is 'premises-based').</p>	<p>This would be required prior to undertaking the proposed work. Each period of 12 months (commencing from the issue of a license) is a license fee period for a license. The administrative fee for any license fee period of a license must be paid not later than 60 days after the beginning of that license fee period.</p>
<p>In accordance with Section 199 of the <i>Fisheries Management Act 1994</i>, Roads and Maritime would have to give the Minister written notice and consider any matters raised by the Minister in order to carry out any dredging and reclamation activities within a waterway.</p> <p>Section 220 of this Act requires written notice to be provided to the Minister for blocking of fish passage. As noted within section 6.5.3 this is not considered likely to be required. This would only be applicable at Strangers Creek as it is the only waterway within the proposal which is mapped as key fish habitat.</p> <p>If required, notification would be given to the Minister and any matters raised by the Minister would be considered within 28 days after the giving of the notice.</p>	<p>This would be obtained prior to any dredging and reclamation being undertaken.</p>

8 Conclusion

This chapter provides the justification for the proposal taking into account its biophysical, social and economic impact, the suitability of the site and whether or not the proposal is in the public interest. The proposal is also considered in the context of the objectives of the EP&A Act, including the principles of ecologically sustainable development as defined in Schedule 2 of the *Environmental Planning and Assessment Regulation 2000*.

8.1 Justification

The need to upgrade Memorial Avenue was first highlighted in 2005, when the Burns Road – Memorial Avenue, Kellyville, Route Strategy was developed by the Roads and Traffic Authority (RTA, now Roads and Maritime). The strategy concluded that an upgrade of Burns Road – Memorial Avenue could bring significant benefits to the proposal corridor and road users.

The impending development of the nearby Balmoral Road Release Area – which would significantly increase traffic in the road corridor – has underscored the importance of developing the upgrade. Traffic volumes along Memorial Avenue are forecast to almost double between 2014 and 2036, from 25000 annual average daily traffic (AADT) to 45,000 AADT.

The *Memorial Avenue Upgrade Traffic and Transport Assessment* (Hyder Consulting 2014) identified the Old Windsor Road/Memorial Avenue/Sunnyholt Road intersection is over capacity in both the morning and afternoon peak periods, and the Windsor Road/Memorial Avenue intersection is nearing capacity. Other intersections along Memorial Avenue are either satisfactory or near capacity, but congestion based on predicted traffic flows is expected to increase without upgrades.

The proposal is expected to result in a number of benefits. These include:

- Providing capacity to support projected traffic volumes on Memorial Avenue between Windsor Road and Old Windsor Road, including at the intersections with these arterial roads
- Improving travel times within the proposal area
- Providing facilities for walking and cycling as well as efficient bus movement within the proposal area
- Enhancing urban design and visual variety within the proposal area, to complement the changing landscape of the Balmoral Road Release Area
- Improving the drainage system, particularly at identified low points along Memorial Avenue so that the road is serviceable during one in 100-year floods
- Improving safety by providing a new road design and intersection upgrades compliant with current safety standards.

8.2 Objects of the EP&A Act

This section demonstrates how the proposal is consistent with the objectives of the EP&A Act. Table 8-1 explains how the proposal performs against the objects of the Act, and references earlier sections of this REF where greater detail is provided.

Table 8-1: How the proposal is consistent with the objectives of the EP&A Act

Object	Comment
5(a)(i) To encourage the proper management, development and conservation of natural and artificial resources, including agricultural land, natural areas, forests, minerals, water, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment.	The proposal would contribute to the continued management of traffic and facilitation of development of the Balmoral Road Release Area, and other local developments, by ensuring that Memorial Avenue and connections to Old Windsor Road and Windsor Road provide an acceptable level of service (refer to Section 6.3.2). The upgrade would be designed and built to maintain the environmental values of the surrounding area (refer to Chapter 6).
5(a)(ii) To encourage the promotion and co-ordination of the orderly economic use and development of land.	The proposal would facilitate more efficient transport along Memorial Avenue and connections to Old Windsor Road and Windsor Road. Benefits would include faster travel times and less crashes. The upgraded road corridor would reflect its function as a transit arterial, consistent with The Hills Shire Council's planning for the area, including the Balmoral Road Release Area.
5(a)(iii) To encourage the protection, provision and co-ordination of communication and utility services.	A strategic assessment of utilities has identified utility services within the proposal area, including: Sydney Water, Telstra, Optus, Jemena Gas, Endeavour Energy and PipeNetworks (TPG Telecom). Potential impacts on these utilities have been identified, including relocations, adjustments and protection work (Section 3.6). These would be considered further during detailed design.
5(a)(iv) To encourage the provision of land for public purposes.	This proposal includes the upgrade of a main road and provision of a shared path for cyclists and pedestrians.
5(a)(v) To encourage the provision and co-ordination of community services and facilities.	Not relevant to the proposal.
5(a)(vi) To encourage the protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats.	The proposal has been assessed against relevant environmental legislation that protects and conserves native animals and plants, including threatened species, populations and ecological communities, and their habitats (refer to Section 6.5).
5(a)(vii) To encourage ecologically sustainable development.	Ecologically sustainable development is considered in Sections 8.2.1 – 8.2.4.

5(a)(viii) To encourage the provision and maintenance of affordable housing.	Not relevant to the project.
5(b) To promote the sharing of the responsibility for environmental planning between different levels of government in the State.	Not relevant to the project.
5(c) To provide increased opportunity for public involvement and participation in environmental planning and assessment.	To date, consultation has included the Aboriginal community, with respect to Aboriginal heritage; and The Hills Shire Council with respect to ISEPP and development of the concept design. Ongoing consultation would involve obtaining community comments, feedback and suggestions on the proposal, particularly during the public exhibition of this REF.

The principles of ecologically sustainable development (ESD) as defined under Section 6(2) of the *Protection of the Environment Administration Act 1991*, were incorporated in the concept design and considered as part of the environmental assessment of the proposal. These principles are addressed below.

8.2.1 The precautionary principle

The precautionary principle requires evaluation of the threat of serious or irreversible harm to biodiversity.

As part of the assessment process, options were considered and assessed with the purpose of reducing the risk of serious and permanent impacts on the environment. Specialist studies were undertaken for the following issues to provide accurate and impartial information for the evaluation of options and development of the proposal:

- Aboriginal heritage
- Non-Aboriginal heritage
- Biodiversity
- Hydrology and flooding
- Noise and vibration
- Traffic and transport
- Urban design and visual impact.

These specialist studies did not identify any issues that may cause serious and irreversible environmental damage as a result of the proposal. In addition, best available technical information, environmental standards and measures were used to minimise environmental risks.

8.2.2 Intergenerational equity

The intergenerational equity principle is concerned with ensuring that the current generation preserves natural and built assets so that wellbeing and productivity are not compromised for future generations.

As part of the assessment process, a preferred route alignment and design were

chosen that would:

- Minimise environmental impacts (such as vegetation clearance)
- Improve flooding immunity to ensure that the road is serviceable for future generations
- Provide for the future predicted traffic increases associated with residential and commercial development in the proposal area
- Improve road safety.

Should the proposal not proceed, the principle of intergenerational equity may be compromised as:

- Future generations would inherit a road with a lower level of service, and a lower level of safety
- Memorial Road would continue to be affected by flooding during 100-year storm events.

8.2.3 Conservation of biological diversity and ecological integrity

This principle reinforces the previous two principles in requiring that the diversity of genes, species and communities, as well as the ecosystems and habitats to which they belong, be maintained and improved to ensure their survival.

As part of the assessment process, a comprehensive assessment of the existing local environment has been carried out to recognise and manage any potential impacts of the proposal on local biodiversity. It was found that the proposal would not significantly impact biological diversity or ecological integrity. An ecological assessment and appropriate site-specific safeguards are provided in Section 6.5 and Appendix G of this REF.

8.2.4 Improved valuation, pricing and incentive mechanisms

This principle requires that costs to the environment are incorporated or internalised within the overall project costs.

This REF has examined the environmental consequences of the proposal and identified mitigation measures for areas that may possibly experience adverse impacts. Implementation of these mitigation measures would increase both the capital and operating costs of the proposal. This shows that environmental resources were valued in economic terms during concept design.

In addition, the concept design was developed with an objective of minimising potential impacts on the surrounding environment, thereby minimising costs to the environment.

In summary, the proposal is generally in accord with the principles of ESD. The proposal would improve traffic movement and would provide a sustainable balance between environmental and economic objectives. It would also provide better facilities for pedestrians, cyclists and buses.

8.3 Conclusion

The proposed upgrade of Memorial Avenue at Kellyville is subject to assessment

under Part 5 of the EP&A Act. The REF has examined and taken into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the proposed activity. This has included consideration of conservation agreements and plans of management under the NPW Act, joint management and biobanking agreements under the TSC Act, wilderness areas, critical habitat, impacts on threatened species, populations and ecological communities and their habitats and other protected fauna and native plants.

A number of potential environmental impacts from the proposal have been avoided or reduced during the concept design development and options assessment. The proposal as described in the REF best meets the project objectives but would still result in some impacts on property, biodiversity, construction traffic and noise. There is also a moderate risk of encountering contamination associated with two former service stations at the corner of Memorial Avenue and Windsor Road and on Windsor Road opposite Wrights Road. Mitigation measures as detailed in this REF would ameliorate or minimise these expected impacts. The proposal would also have a range of benefits including improved road safety; traffic conditions; bus, cyclist and pedestrian facilities; access to and from local roads; drainage and flood immunity. On balance the proposal is considered justified.

The environmental impacts of the proposal are not likely to be significant and therefore it is not necessary for an environmental impact statement to be prepared and approval to be sought for the proposal from the Minister for Planning under Part 5.1 of the EP&A Act. The proposal is unlikely to affect threatened species, populations or ecological communities or their habitats, within the meaning of the *Threatened Species Conservation Act 1995* or *Fisheries Management Act 1994* and therefore a Species Impact Statement is not required. The proposal is also unlikely to affect Commonwealth land or have an impact on any matters of national environmental significance.

9 Certification

This review of environmental factors provides a true and fair review of the proposal in relation to its potential effects on the environment. It addresses to the fullest extent possible all matters affecting or likely to affect the environment as a result of the proposal.



Kate Wiggins
Senior Environmental Consultant
Hyder Consulting Pty Ltd
Date: 16 October 2014

I have examined this review of environmental factors and the certification by **insert name from above and company name** and accept the review of environmental factors on behalf of Roads and Maritime Services.

Insert name
Position title, eg Project Manager
Insert relevant Roads and Maritime Services region/area
Date:

10 References

ANZECC 2000, *Australia and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian and New Zealand Environment and Conservation Council 2000.

Australian Transport Council, 2011. *National Road Safety Strategy 2011–2020*

Bannerman, S.M. and Hazelton, P.A. 1990, Soil Landscapes of the Penrith 1:100,000 Map Sheet, *Soil Conservation Service NSW, Sydney*.

Baulkham Hills Shire Council, 2003. *Draft Balmoral Road Release Area Structure Plan*.

Baulkham Hills Shire Council, 2008. *The Hills 2026 Community Strategic Direction*.

BoM, Bureau of Meteorology, 2014, Seasonal Rainfall Outlook Archive. Available online at:

<http://www.bom.gov.au/climate/ahead/archive/rainfall/index.shtml>.

Department of Minerals and Energy (NSW) , 2014. Geological Series Sheet 9030 – Penrith 1991, Geological Survey of NSW, www.asris.csiro.com.au, searched on 31st January 2014.

Department of Environment, Climate Change and Water (NSW), 2009. Interim Construction Noise Guideline, available at www.environment.nsw.gov.au/noise/constructnoise.htm.

Department of Environment, Climate Change and Water (NSW). 2008. *Managing Urban Stormwater: Soils and Construction: Volume 2D Main road construction*, DECCW and Sydney Metropolitan Catchment Management Authority, Sydney.

Department of Environment, Climate Change and Water (NSW).2001. *NSW Road Noise Policy*

Department of Environment, Climate Change and Water (NSW), 2007. *Threatened Species Assessment Guidelines: the assessment of significance*. Department of Environment and Climate Change NSW, August 2007.

Department of Environment and Conservation (NSW), 2006. *Assessing Vibration: A Technical Guideline*

Department of Environment and Conservation (NSW), 2007. *Guidelines for the Assessment and Management of Groundwater Contamination*.

Department of Environment and Conservation (NSW) 2005, *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, NSW Department of Environment and Heritage.

Department of Environment and Conservation (NSW), 2004. *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities* (Working draft).

Department of Planning (NSW), 2010. *Metropolitan Plan for Sydney 2036*

Department of Planning (NSW), 2007. *North West Subregional Strategy (draft)*.

Department of Planning and Environment (NSW), 2013. *Draft Metropolitan Strategy for Sydney*

Department of Urban Affairs and Planning (NSW), 1999. *Is an EIS required?* DUAP, Department of Urban Affairs and Planning.

Fairfull, S. and Witheridge, G. 2003. *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterways Crossings*. New South Wales Fisheries, Cronulla.

Landcom, 2004. *Managing Urban Stormwater – Soils and Construction – Volume 1*.

Livengood Consulting, 2010, *Anabat Techniques Workshop Course Manual*

New South Wales (NSW) Government, 2011. *NSW 2021: A Plan to Make NSW Number One*

New South Wales (NSW) Government, 2012. *State Infrastructure Strategy*

New South Wales (NSW) Government, 2013. *North West Rail Link (NWRL) Corridor strategy*.

Office of Environment and Heritage, 2011. *Sustainable Mountain Biking Strategy*, Sydney.

Office of Environment and Heritage, Search Atlas (*Groundwater Dependent Ecosystems*), available at http://www.environment.nsw.gov.au/atlaspublicapp/UI_Modules/ATLAS_/AtlasSearch.aspx

Office of Environment and Heritage, 2011. *Contaminated Sites – Guidelines for Consultants Reporting on Contaminated Sites*.

Pennay, M., Law, B., and Reinhold, L. 2004. *Bat Calls of NSW: region based guide to the echolocation calls of Microchiropteran bats*. NSW Dept. Environment and Conservation, Hurstville.

Roads and Maritime Services, 2011, *Community Engagement and Communications Resources Manual*

Roads and Maritime Services, 2012. *Foxground and Berry Bypass – Technical paper: Air quality*.

Roads and Maritime Services, 2012. *Land Acquisition Information Guide*.

Roads and Maritime Services, 2011. *Community Engagement and Communications Resources Manual*.

Roads and Maritime Services, 2011. *Standard Management Procedure – Aboriginal cultural heritage consultation and investigation (PACHCI)*, Transport NSW.

Roads and Maritime Services, 2011. *Roads and Maritime Technical Guidelines – Temporary Stormwater Drainage for Road Construction*.

- Roads and Maritime Services 2011, *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects*, Transport NSW.
- Roads and Maritime Services, 2011, *Standard Management Procedure – Unexpected Threatened Species Finds*, Transport NSW.
- Roads and Maritime Services, 2011, *Stockpile Site Management Guidelines*, Transport NSW.
- Roads and Maritime Services 2011, *EIA Guidelines – Environmental assessment procedure, Project review of environmental factors, EIA-P05-2*, Transport NSW.
- Roads and Maritime Services 2011, *EIA Guidelines – Environmental assessment procedure, Addressing ecologically sustainable development practice note, EIA-N02*, Transport NSW.
- Roads and Maritime Services, 2010. *Code of Practice for Water Management*.
- Roads and Maritime, 2013. *Guideline for Landscape Character and Visual Impact Assessment*.
- Roads and Traffic Authority, 2005. *Burns Road – Memorial Avenue, Kellyville, Route Strategy*
- Roads and Traffic Authority, 2006. *Preliminary Environmental Investigation – Memorial Avenue Upgrade*
- Roads and Traffic Authority and Department of Environment, Climate Change and Water (NSW), 2010. *NSW Bike Plan*
- Roads and Traffic Authority, 2010. *Traffic Control at Work Sites*.
- Roads and Traffic Authority, 2008. *Roads and Maritime Erosion and Sedimentation Procedure*.
- Roads and Traffic Authority, 2001. *Environmental Noise Management Manual 2001, Practice Note vii – Roadworks Outside of Normal Working Hours*.
- Transport for NSW, 2012. *NSW Long Term Transport Master Plan*
- Tozer, M. 2003. The native vegetation of the Cumberland Plain, western Sydney: systematic classification and field identification of communities. *Cunninghamia*, 8(1), 1-75.

Terms and acronyms used in this REF

Provide a list of the technical terms and acronyms used in the REF and their definitions.

AADT	Average annual daily traffic
AHIMS	Aboriginal Heritage Information System
AHIP	Aboriginal Heritage Impact Permit
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
ANZECC	Australia and New Zealand Environment and Conservation Council
ARI	Average Rainfall Recurrence Interval
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).
BRRRA	Balmoral Road Release Area
CEMP	Construction environmental management plan
CPW	Cumberland Plain Woodland
Decibel [dB]	The units that sound is measured in.
dB(A)	A-weighted decibels. The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
DLALC	Deerubbin Local Aboriginal Land Council
EPA	Environment Protection Authority
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i> (NSW). Provides the legislative framework for land use planning and development assessment in NSW
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Commonwealth). Provides for the protection of the environment, especially matters of national environmental significance, and provides a national assessment and approvals process.
ESCP	Erosion and Sedimentation Control Plan
ESD	Ecologically sustainable development. Development which uses, conserves and enhances the resources of the community so that ecological processes on which life depends, are maintained and the total quality of life, now and in the future, can be increased
FM Act	<i>Fisheries Management Act 1994</i> (NSW)
Heritage Act	<i>Heritage Act 1977</i> (NSW)
ISEPP	State Environmental Planning Policy (Infrastructure) 2007
KTP	Key Threatening Processes
L _{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
L _{Max}	The maximum sound pressure level measured over a given period.

LALC	Local Aboriginal Land Council
LEP	Local Environmental Plan. A type of planning instrument made under Part 3 of the EP&A Act.
LGA	Local Government Area
LoS	Level of Service. A qualitative measure describing operational conditions within a traffic stream and their perception by motorists and/or passengers.
NES	Matters of national environmental significance under the Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i> .
Noxious Weeds Act	<i>Noxious Weeds Act 1993 (NSW)</i>
NPW Act	<i>National Parks and Wildlife Act 1974 (NSW)</i>
NWRL	North West Rail Link
OEH	NSW Office of Environment and Heritage
PACHCI	Roads and Maritime Procedure for Aboriginal Cultural Heritage Consultation and Investigation
PAD site	Potential Aboriginal deposit site
PAHs	Polycyclic aromatic hydrocarbons
PEI	Preliminary Environmental Investigation
PoEO Act	<i>Protection of the Environment Operations Act 1997</i>
REF	Review of Environmental Factors
SEPP	State Environmental Planning Policy. A type of planning instrument made under Part 3 of the EP&A Act.
SHR	State Heritage Register
SoHI	Statement of Heritage Impact
SoHI	Statement of Heritage Impact
SWMP	Soil and Water Management Plan
THSC	The Hills Shire Council
TMP	Traffic management plan
TfNSW	Transport for New South Wales
TSC Act	<i>Threatened Species Conservation Act 1995 (NSW)</i>
T-way	Transitway – comprises bus lanes on existing roads and bus-only roadways

Appendix A

Consideration of clause 228(2) factors and matters of national environmental significance

Factor	Impact
<p>c. Any environmental impact on the ecosystems of the locality?</p> <p>The proposal would involve the loss of native vegetation, including threatened ecological communities. A total of 0.65 hectares of native vegetation would be directly impacted within the proposal area. The areas to be cleared consist predominantly of disturbed native regrowth. The proposal may result in the expansion of edge effects associated with the new road edge, including weed invasion, altered hydrology and increased sedimentation and runoff.</p> <p>The proposal would result in loss of flora and fauna habitat, including potential habitat for threatened flora and fauna species. Vegetation removal would result in potential impacts on nesting, roosting and foraging habitat for birds, mammals, reptiles and frogs that occur in disturbed and urban landscapes.</p> <p>Measures, as outlined in Section 6.5.4 of this REF, would be implemented to minimise impacts on the ecosystems associated with the proposal.</p>	<p>Long-term minor negative impacts</p>
<p>d. Any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality?</p> <p>There would be a minor reduction in the aesthetic quality of the locality due to the removal of vegetation, increase in road width and changes to intersections and property boundaries. Mitigation measures would be implemented to reduce impacts and detailed design would be undertaken in line with the urban design objectives of the proposal. These include revegetation and landscaping of the road corridor and retention of vegetation where possible (see Section 6.5.4).</p>	<p>Long-term negligible negative impacts</p>
<p>e. Any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations?</p> <p>There would be no impacts on any locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations.</p>	<p>Nil</p>

Factor	Impact
<p>f. Any impact on the habitat of protected fauna (within the meaning of the <i>National Parks and Wildlife Act 1974</i>)?</p> <p>All native fauna species fall within the meaning of protected fauna under the <i>National Parks and Wildlife Act 1974</i>. A total of 27 native fauna species, including 16 bird species, 9 mammal species, 1 amphibian species, 1 reptile species and 1 invertebrate species were recorded in the study area.</p> <p>The proposal would result in removal of fauna habitats, including remnant and planted street trees, landscaped vegetation, riparian habitat and modified fauna habitats in disturbed and developed areas. The removal of vegetation in potential impacts on nesting, roosting and foraging habitat for birds, mammals, reptiles and frogs that occur in disturbed and urban landscapes. The proposal may impact on one potential hollow-bearing tree. Removal of this tree could impact arboreal fauna roosting/nesting in hollows</p> <p>Safeguards recommended in Section 6.5.4 would minimise impacts.</p>	<p>Long term minor negative</p>
<p>g. Any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air?</p> <p>The proposal is unlikely to have a significant impact on any threatened species, population or community listed under the TSC Act or EPBC Act</p> <p>The proposal would result in the removal of about 0.190 hectares of disturbed Cumberland Plain Woodland and about 0.067 hectares of disturbed Swamp Oak Floodplain Forest, listed as Endangered Ecological Communities under the TSC Act.</p> <p>Assessments of significance under the TSC Act and Significant Impact Assessments under the EPBC Act were undertaken for all threatened species, populations and communities recorded or considered to have a high to moderate likelihood of occurrence in non-certified areas. The assessments concluded that the proposal would not have a significant impact on any of the threatened species, populations or communities considered.</p> <p>Safeguards recommended in Section 6.5.4 would minimise impacts on threatened species and communities.</p>	<p>Nil</p>

Factor	Impact
<p>h. Any long-term effects on the environment?</p> <p>The proposal would result in short-term environmental impacts, largely restricted to the construction period. These include traffic, noise and air.</p> <p>Long-term impacts include clearing of vegetation, including about 0.190 hectares of disturbed Cumberland Plain Woodland and about 0.067 hectares of disturbed Swamp Oak Floodplain Forest (endangered ecological communities). The removal of this vegetation is considered not significant in the context of the transitional nature of the proposal area from rural residential to higher density residential and commercial development. The vegetation to be removed has been previously disturbed.</p> <p>Visual impacts shall be minimised through application of urban design principles.</p>	<p>Long term positive and negative impacts</p>
<p>i. Any degradation of the quality of the environment?</p> <p>The proposed upgrade has the potential to degrade the quality of the environment through noise, visual, water, air, erosion and sedimentation pollution, as well as accidental spills during construction. These potential impacts would be managed using a suite of safeguards and mitigation measures. The construction footprint would be reduced as far as practicable and the site would be rehabilitated as work progresses to minimise impacts. Removal of vegetation would be kept to a minimum and appropriate mitigation incorporated to minimise impacts on native flora and fauna.</p> <p>In the long-term, the project would provide a range of benefits including improved traffic conditions; bus, cyclist and pedestrian facilities and drainage and flood immunity.</p>	<p>Short-term negative</p> <p>Long-term positive</p>
<p>j. Any risk to the safety of the environment?</p> <p>The proposal is likely to reduce safety along the road during construction. This would be managed through appropriate signage and a traffic management plan.</p> <p>The proposal would provide a shared pedestrian and bicycle path and signalise intersections. This would improve road user safety.</p>	<p>Short-term negative</p> <p>Long-term positive</p>

Factor	Impact
<p>k. Any reduction in the range of beneficial uses of the environment?</p> <p>The proposal would result in traffic impacts during construction which would include an increase in the volume of heavy vehicles, interruption of traffic flow and speeds, and temporary impacts to access. These traffic impacts would reduce the beneficial use of Memorial Avenue during the construction phase.</p> <p>In the long-term, the proposal would be consistent with future uses and there would be no reduction in the range of beneficial uses of the environment.</p>	<p>Short-term negative</p> <p>Nil</p>
<p>l. Any pollution of the environment?</p> <p>There would be some potential noise, visual, air, water, erosion and sedimentation impacts associated with construction of the proposed upgrade. Construction activities would be carefully managed with numerous safeguard for protection of the environment from pollution (refer to Chapter 7).</p>	<p>Short-term negative</p>
<p>m. Any environmental problems associated with the disposal of waste?</p> <p>Waste would be generated across a number of waste streams during construction. These streams would be managed in accordance with Roads and Maritime specification, the <i>Waste Avoidance and Resource Recovery Act 2001</i> and recycled where possible.</p> <p>It is not anticipated that there would be any issues associated with the disposal of waste during the operation of the proposal.</p>	<p>Short-term negative</p> <p>Nil</p>
<p>n. Any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply?</p> <p>None of the resources required to effect this proposal are, or are likely to become, in short supply.</p>	<p>Nil</p>

Factor	Impact
<p>o. Any cumulative environmental effect with other existing or likely future activities?</p> <p>The proposal would likely be effected at the same time as the development associated with the Balmoral Road Release Area, the NWRL and other commercial developments such as a Woolworth's supermarket. Cumulative noise, traffic, visual and air quality impacts may result during construction. These would be short-term and manageable.</p> <p>All cumulative impacts are considered justifiable by the long-term positive impacts of the proposal.</p>	<p>Short-term negative</p> <p>Long-term positive</p>
<p>p. Any impact on coastal processes and coastal hazards, including those under projected climate change conditions?</p> <p>Proposed works are located in western Sydney outside of the coastal zone and would not impact coastal processes or coastal hazards.</p>	<p>Nil</p>

Matters of National Environmental Significance

Under the environmental assessment provisions of the *Environment Protection and Biodiversity Conservation Act 1999*, the following matters of national environmental significance and impacts on Commonwealth land are required to be considered to assist in determining whether the proposal should be referred to the Australian Government Department of Sustainability, Environment, Water, Population and Communities.

Factor	Impact
<p>a. Any impact on a World Heritage property?</p> <p>The proposal would not impact on a World Heritage property. No sites in or near the proposal area are included on the World Heritage List.</p>	<p>Nil</p>
<p>b. Any impact on a National Heritage place?</p> <p>The proposal would not impact on a National Heritage property. No sites in or near the proposal area are included on the National Heritage List.</p>	<p>Nil</p>
<p>c. Any impact on a wetland of international importance?</p> <p>The proposal would not impact on a wetland of international importance. There are no wetlands of international importance (listed under the Ramsar Convention) in or near the proposal area.</p>	<p>Nil</p>
<p>d. Any impact on a listed threatened species or communities?</p> <p>The proposal is unlikely to have a significant impact on any threatened species, population or community listed under the TSC Act or EPBC Act</p> <p>The proposal would result in the removal of about 0.190 hectares of disturbed Cumberland Plain Woodland and about 0.067 hectares of disturbed Swamp Oak Floodplain Forest, listed as Endangered Ecological Communities under the TSC Act.</p> <p>Assessments of significance under the TSC Act and Significant Impact Assessments under the EPBC Act were undertaken for all threatened species, populations and communities recorded or considered to have a high to moderate likelihood of occurrence in non-certified areas. The assessments concluded that the proposal would not have a significant impact on any of the threatened species, populations or communities considered.</p> <p>Safeguards recommended in Section 6.5.4 would minimise impacts on threatened species and communities.</p>	<p>Minor</p>

Factor	Impact
<p>e. Any impacts on listed migratory species?</p> <p>A search of the DoE Protected Matters Search Tool found 12 migratory species listed under the EPBC Act known or likely to occur within 10 kilometres of the study area. The likelihood of each threatened species occurring in the study area was assessed (Appendix G). All migratory species identified in the search were assessed to have a low likelihood of occurrence in the study area.</p>	<p>Nil</p>
<p>f. Any impact on a Commonwealth marine area?</p> <p>The proposal would not impact on a Commonwealth marine area. There are no Commonwealth marine areas in or near the proposal area.</p>	<p>Nil</p>
<p>g. Does the proposal involve a nuclear action (including uranium mining)?</p> <p>The proposal would not involve a nuclear action.</p>	<p>Nil</p>
<p>Additionally, any impact (direct or indirect) on Commonwealth land?</p> <p>Additionally, any impact (direct or indirect) on Commonwealth land? The proposal would not impact (either directly or indirectly) on Commonwealth land.</p>	<p>Nil</p>
