RTA

Woodburn to Ballina upgrade

Upgrading the Pacific Highway

CONCEPT DESIGN REPORT

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Glossary of terms and abbreviations

The following are a list of terms or abbreviations that may be used in this report:

Term	Description
100 year ARI flood event	Refers to the flood event which occurs, on average, once every 100 years. Also known as the 100 year Average Recurrence Interval of a flood. These events are of a random nature. It is possible for there to be two 100 year floods in successive years; similarly the 100 year flood may not occur for 200 years and the 100 year flood may not be the largest flood in the last 100 years. This is similar for 5 year ARI flood events and 20 year ARI flood events.
AADT	Annual Average Daily Traffic is the yearly two way traffic volume divided by 365, expressed as vehicles per day.
Afflux	The change in water level in a hydraulic system (such as normal river flow or in a flood) caused by the addition of a hydraulic structure (such as a bridge, culvert or highway embankment).
AHD	Australian Height Datum.
AHIMS	Aboriginal Heritage Information Management System.
ALS	Aerial Laser Survey.
ARI	Average Recurrence Interval – used to denote the different magnitudes of flood events. The ARI is the average time period that the described flood event occurs at. E.g. a 5 year ARI flood event occurs, on average, every five years. The larger the magnitude of flood event, the less often it occurs on average.
ARR	Australian Rainfall and Runoff.
ASS	Acid Sulphate Soils - naturally acid clays, mud and other sediments usually found in swamps and estuaries. They may become extremely acidic when drained and exposed to oxygen, and may produce acidic leachate and run-off which can pollute receiving waters and liberate toxins. ASS are classified as materials which are above the groundwater, are undergoing oxidation and have a ph of less than 4.0.
Auslink	The Australian Government's policy for planning and development of Australia's land transport infrastructure. It is supported by a $12.7 billion program of Australian Government investment over the five year period 2004-05 to 2008-09 together with partnering funding from State and Territory Governments and the private sector.
Average daily traffic	Average daily traffic based on survey counts and not adjusted as for AADT.

Term	Description
Background noise level	The ambient sound pressure level in the absence of the sound under investigation exceeded for 90 percent of the measurement period. Normally equated to the average minimum A-weighted sound pressure level. Symbol LA90 (unit:dba).
Biosis	Biosis Research Pty Ltd. – project ecologist.
Brown	Brown Consulting Pty Ltd – project hydraulics and hydrology consultant.
CLG	Community Liaison Group.
Coffee rock	Sandy soil lightly cemented by organic material to form layers of dark brown cemented sand.
Coffey	Coffey Geosciences Pty Ltd – project geotechnical consultant.
Cube	Traffic modelling software suite.
DA	Development Application.
Dba	Decibels using the ‘A’ weighted scale, measured according to the frequency of the human ear.
DECC	The Department of Environment and Climate Change – NSW (formerly the Department of Environment and Conservation – DEC -created in September 2003 from a number of separate agencies including the Environment Protection Authority (EPA), National Parks and Wildlife Service (NPWS), Botanic Gardens Trust and Resource NSW.
DEM	Digital Elevation Model.
DEWR	Department of the Environment and Water Resources - Commonwealth (formerly the Department of Environment and Heritage - DEH).
DMR	Department of Main Roads – NSW (the predecessor to the Roads and Traffic Authority – RTA).
DNR	Department of Natural Resources – QLD.
Dop	Department of Planning – NSW (formerly Department of Infrastructure Planning and Natural Resources DIPNR).
DOTARS	Department of Transport and Regional Services – Commonwealth.
DPI	Department of Primary Industries – NSW.
DRAINS	Drainage design software.
DTM	Digital Terrain Model.
Ecologically sustainable development (ESD)	Undertaking development in such a way that it uses, conserves and enhances the community’s resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.
Ecosense	Ecosense Consulting Pty Ltd – project ecologist.
ECRTN	Environmental Criteria for Road Traffic Noise.

Term	Description
Environmental assessment (EA)	An environmental assessment of a major infrastructure development prepared in accordance with Part 3A of the *EP&A Act 1979.*
Environmental impact statement (EIS)	An environmental assessment document prepared in accordance with Part 5 of the *EP&A Act 1979.*
EP&A Act	Environmental Planning & Assessment Act 1979.
EP&AA Act	Environmental Planning and Assessment Amendment [Infrastructure and Other Planning Reform] Act 2005.
EP&A Regulation	Environmental Planning & Assessment Regulation 2000.
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth).
FPDM	Floodplain Development Manual.
FPL	Flood Planning Level.
FPMM	Floodplain Management Manual.
FPRMS	Floodplain Risk Management Study.
FSL	Flood Surface Level.
GAF	Government Agency Forum.
GDR	Geotechnical Design Report.
Geolink	Geolink Environmental management and design – project community local consultation consultant.
Geolyse	Geolyse Pty Ltd. – project ecologist.
GIR	Geotechnical Investigation Report.
GIS	Geographical Information System.
Ha	Hectare/s.
HBO+EMTB	HBO+EMTB Pty Ltd. – project Urban and Landscape Design Consultant.
Hyder	Hyder Consulting Pty Ltd.
Interchange	A grade separated junction between roads where the local road passes above or beneath the highway via a bridge or underpass structure. Traffic joins and leaves the highway using exit and entry ramps. Traffic on both the local road and the proposed upgrade can move freely without interrupting traffic on the other road.
Intersection	A junction between roads where the connection is made at the same level (grade). Traffic on the connecting road has to wait for a gap in the through road to join or cross that road. These are the types of junctions that exist between local roads and the existing Pacific Highway.
IR2W	Iluka Road to Woodburn Project.

Term	Description
Km	Kilometre/s.
LALC	Local Aboriginal Land Council.
L_{A1}	The noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the LA1 level for 99% of the time.
L_{A10}	The noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the LA10 level for 90% of the time. The LA10 is a common noise descriptor for environmental noise and road traffic noise.
L_{A50}	The noise level which is exceeded for 50% of the sample period. During the sample period, the noise level is below the LA50 level for 50% of the time.
L_{A90}	The noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the LA90 level for 10% of the time. This measure is commonly referred to as the background noise level.
Laeq	The equivalent continuous sound level. This is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.
LEP	Local Environmental Plan (prepared under the Environmental Planning & Assessment Act 1979).
LGA	Local Government Area.
LOS	Level of Service.
m	Metre/s.
mm	Millimetre/s.
m^2	Square Metre/s.
m^3	Cubic Metre/s.
m/s	Metres per second.
m^3/s	Cubic metres per second.
MGA	Map Grid Australia.
MUSIC	Model for Urban Stormwater Improvement Conceptualisation.
MVKT	Million Vehicle Kilometres Travelled.
NCREP	North Coast Regional Environmental Plan.
NP&W Act	NSW National Parks and Wildlife Act 1974.
NPWS	NSW National Parks and Wildlife Service (now part of the Department of Environment and Climate Change).
PASS	Potential Acid Sulphate Soils (see ASS above).

Term	Description
PATN analysis	Process to undertake manipulation, analysis and display of patterns in multivariate biological data.
Pc/h	Passenger cars per hour.
Ph	Ph is a measure of the hydrogen ion concentration in soil and relates to the levels of acidity and alkalinity.
PMF	Probable Maximum Flood.
PMP	Probable Maximum Precipitation.
POEO Act	Protection of the Environment Operations Act 1997.
RCP	Reinforced Concrete Pipe.
RCBC	Reinforced Concrete Box Culvert.
REP	Regional Environmental Plan (prepared under the *Environmental Planning & Assessment Act 1979).*
RDG	RTA's Road Design Guide.
RTA	Roads and Traffic Authority NSW.
SEPP 14	State Environmental Planning Policy Number 14 – Policy prepared under the *Environmental Planning & Assessment Act 1979* for the protection of identified coastal wetlands in NSW.
SEPP 26	State Environmental Planning Policy Number 26 – Policy prepared under the *Environmental Planning & Assessment Act 1979* for the protection of identified littoral rainforest in NSW.
SEPP 58	State Environmental Planning Policy Number 58 – Policy prepared under the *Environmental Planning & Assessment Act 1979* for the protection of Sydney's drinking water catchments.
SIDRA	Intersection traffic analysis software.
SOBEK	Hydraulic modelling software.
Stn	Design station in metres north of Grafton.
TIN	Triangular Irregular Network.
TRIPS	Part of the Cube suite of traffic modelling software (see Cube above).
TSC Act	NSW Threatened Species Conservation Act 1995.
TUFLOW	Hydraulic modelling software.
Proposed upgrade	Woodburn to Ballina concept design of the Pacific Highway.
UPHDG	Upgrading the Pacific Highway Design Guidelines (Issue 2.0, March 2005).
VERM	Value Engineering and Risk Management workshop.
VMW	Value Management Workshop.
W2B	Woodburn to Ballina Project.
WBM	WBM Pty Limited (member of the BMT group of companies).

Executive summary

Completing the upgrade of the pacific highway

Currently 263 of a total 677 kilometres are now double lane divided road. A further 91 kilometres are under construction or have had a construction contract awarded. The remaining kilometres are either approved for construction or have had a preferred route identified. The Pacific Highway is part of the AusLink National Network. By mid-2009 the New South Wales Government will have spent $2.3 billion and the Australian Government $1.3 billion towards the upgrade of the Pacific Highway.

The RTA has engaged Hyder Consulting Pty Ltd to undertake route option investigations and concept development for the upgrading of the Pacific Highway between Woodburn and Ballina on the North Coast of NSW.

Route options for this project were announced in May 2005 and reported in the *Woodburn to Ballina Route Options Development Report* (RTA 2005a).

The preferred route for this project was announced in November 2005 and reported in the *Woodburn to Ballina Preferred Route Report* (RTA 2005b).

Concept design

Development of the Woodburn to Ballina concept design commenced in October 2005 immediately prior to the preferred route display in November 2005. The concept design development considers:

- Community feedback from the preferred route display.
- Ongoing consultation with key stakeholders (affected landowners, government agencies and local authorities).
- Preferred route field investigations (geotechnical, ground survey, heritage and ecology).
- Traffic modelling.
- Hydraulic modelling of the Richmond River floodplain, Duck Creek and Emigrant Creek floodplain and other smaller local catchments.
- Value engineering.

The resulting concept design is a 36 km dual carriageway upgrade of the Pacific Highway connecting from the existing highway 3 km south of Woodburn to the Ballina bypass at the Bruxner Highway intersection. The proposed upgrade has a minimum flood immunity of a 20 year average recurrence interval flood and has been developed to allow for future widening to three lanes when needed. It comprises the following key features:

- 6 local road overpasses.
- 5 major watercourse crossings.
- 8 flood alleviation viaducts and cross drainage bridges.
- 3 fauna overpasses.

- 2 frog/small mammal underpasses.
- 2 glider/possum rope overpasses.
- 1 NSW Sugar conveyor overpass.
- 4 local road diversions.
- 2 service roads.
- Half interchange at Woodburn with south facing ramps.
- Half interchange at Broadwater with north facing ramps.
- Full interchange at Wardell.
- Numerous cross drainage and flood alleviation culverts, many of which would also act as fauna underpasses.

1 Introduction

1.1 Preamble

As a part of the Roads and Traffic Authority's (RTA) ongoing program of works to upgrade the Pacific Highway, the RTA commissioned Hyder Consulting Pty Ltd to undertake route option investigations and concept development for the upgrading of the Pacific Highway between Woodburn and Ballina on the North Coast of NSW (refer to **Figure 1-1**).

Route options for this project were announced in May 2005 and reported in the *Woodburn to Ballina Route Options Development Report* (RTA 2005a).

The preferred route for this project was announced in November 2005 and reported in the *Woodburn to Ballina Preferred Route Report* (RTA 2005b).

The concept design has been developed and is reported here. The concept design is based on current standards applicable to the Pacific Highway Upgrade and the information available at this time. Further investigations at the environmental assessment stage may result in changes to this design.

The environmental assessment will take place closer to the construction phase of the project.

1.2 Report purpose

This report summarises the development of the concept design. It provides an overview of:

- Issues arising since the announcement of the preferred route.
- Key decisions taken in the development of the concept design.
- Issues/decisions yet to be resolved in the development of the concept design.
- Criteria used in the technical development of the concept design.

The intention of the concept design is to:

- Provide a level of certainty for property requirements for the proposed upgrade and assist in future planning for the region.
- Provide a basis to quantify the project and plan for future funding.

Figure 1-1 Location of Woodburn to Ballina upgrade section of the Pacific Highway

1.3 Development process

The preferred route was placed on public display from November 2005 to January 2006 to obtain further feedback from the community and other stakeholders.

The development process to refine the concept design involved collection and interpretation of community and stakeholder, environmental, socio-economic and engineering inputs. The extent and detail of information at the commencement of the concept design stage included detailed route investigations where specific potential impacts of the preferred route could be identified.

1.4 Community and stakeholder involvement

The involvement of the community and stakeholders during the development of route options and the preferred route has continued during the development of the concept design.

Submissions received during the public display of the preferred route have been responded to in the *Woodburn to Ballina Preferred Route Submissions Report* (RTA 2008a).

Directly affected landowners have been involved in ongoing consultation which has enabled the project team to, where possible, address their concerns and refine the design.

Feedback on the preferred route was also sought from government agency representatives, regional and local organisations including local councils, businesses and co-operatives (refer to **Figure 1-2**).

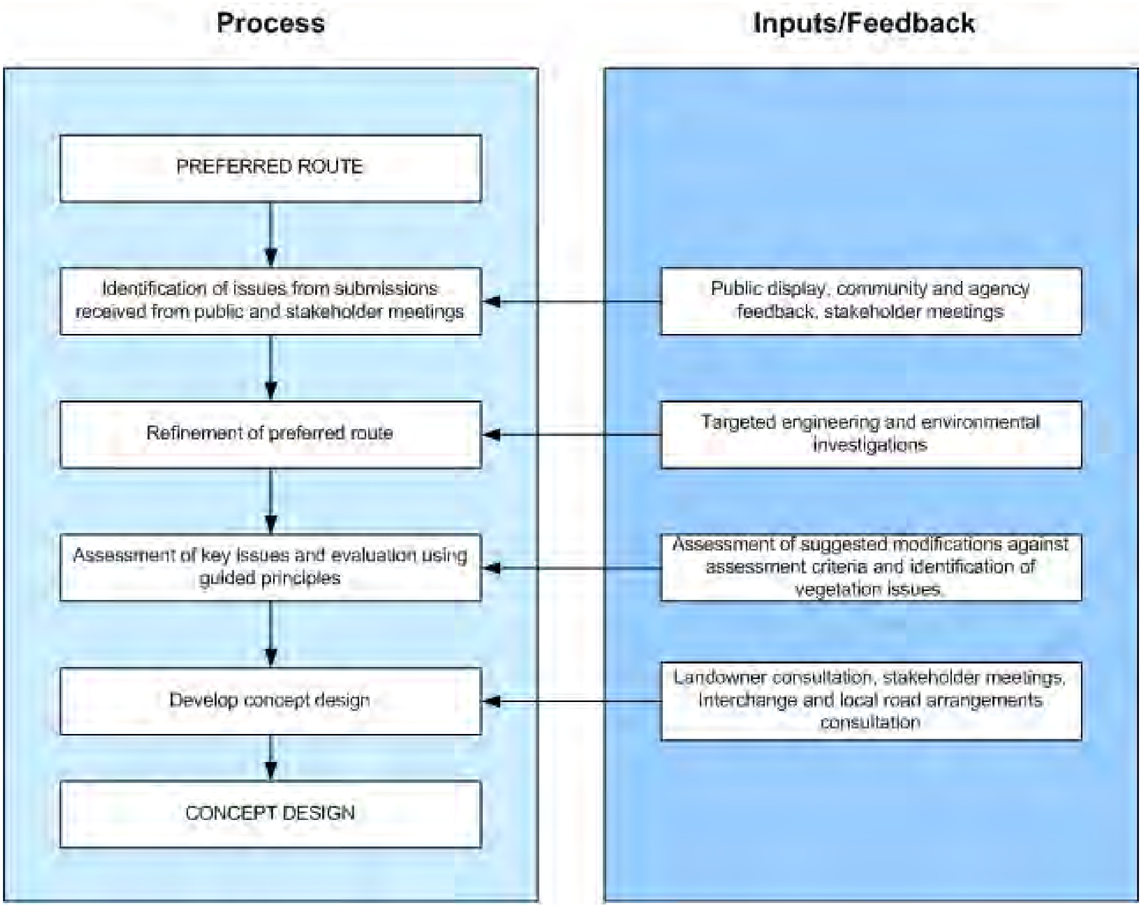

Figure 1-2 Stakeholder input

A summary of key stakeholder milestones following the announcement of the preferred route is presented in **Table 1-1**.

Table 1-1 Key stakeholder milestones

Date	Milestone
November 2005	Preferred route announced.
November 2005 to January 2006	Preferred route displayed at various locations within the study area.
December 2005	Aboriginal focus group meeting number 5 held (meeting numbers 3 and 4 had limited attendee's).
December 2005	Community liaison group meeting number 10 held. The meeting outlined: ▪ An overview of the preferred route. ▪ High and low level animations of the route. ▪ Community issues with the route. ▪ What happens next.
March 2006	Meetings held with Ballina Shire and Richmond Valley councils.

Date	Milestone
March 2006	Meeting with Jali Local Aboriginal Land Council.
March 2006	Aboriginal Focus Group meeting number 6 held.
March 2006	Meeting with the Department of Environment and Climate Change (DECC).
March 2006	Meeting with the NSW Sugar Association.
March 2006	Meeting with the Woodburn Chamber of Commerce.
April 2006	Meetings with Ballina Shire and Richmond Valley councils.
August 2006	Meeting with Department of Primary Industries (Fisheries) regarding the oxleyan pygmy perch.
October 2006	Distribution of interchange and local road arrangements leaflet to local community and stakeholders.
November 2006	Community information centre open day for community liaison regarding the interchange and local road arrangements leaflet.
December 2006	Meeting with DECC regarding the Broadwater National Park corridor.
December 2006	Meeting with Jali Local Aboriginal Land Council representatives.
April 2007	Consultation with Ballina Shire Council regarding local road arrangements.
September 2007	Meeting with DECC regarding the Broadwater National Park corridor.

1.4.1 Stakeholder response to the ecology component of the preferred route selection process

During the preferred route display submissions were received from a number of stakeholders, including Ballina Shire Council and the Department of Environment and Climate Change, regarding the robustness of the ecological assessment of route options and therefore selection of the preferred route.

Details of these government agency submissions, and issues raised in community stakeholder submissions can be found in the *Woodburn to Ballina Preferred Route Submissions Report* (RTA 2008a).

Further to subsequent meetings between the project team and government agencies, the RTA commissioned Ecosense Pty Ltd (Ecosense) to carry out an independent peer review of the ecology reporting undertaken for the assessment of route options.

This independent peer review identified a number of issues with the ecology reporting, including:

- Lack of transparency in the ecological assessment due to poor report structure and organisation.
- In some cases, the data was available but not examined robustly.

- Data necessary to compare routes objectively was not collected or analysed.
- Perceived errors in judgement.
- Data not assessed adequately within a regional or local context.

To address these issues Ecosense recommended that the following major tasks were undertaken:

- Terrestrial vegetation mapping for the entire study area using Aerial Photo Interpretation, ground-truthing and existing mapping.
- Identification and mapping of endangered ecological communities and regionally significant vegetation communities.
- Terrestrial fauna habitat mapping and identification of important habitat features for the entire study area.
- Reassessment of potential habitat for the oxleyan pygmy perch in section 2.
- Consideration of all available data including regionally significant species, Rare or Threatened Australian Plants (ROTAPs), invertebrates and nomadic and migratory fauna species.
- Reanalysis of the ecological impacts of route options on vegetation communities, fauna habitat, threatened terrestrial species and oxleyan pygmy perch habitat.
- Reassessment of the ecological impacts associated with route options based on accurate vegetation mapping and reanalysis of all available data.
- Ranking of route options based on reanalysis and reassessment of all available data.

The RTA commissioned Ecosense to carry out a review of the ecological assessment of the route options in line with the above recommendations.

This review involved analysis and assessment of all available data, and additional field investigations, to input into the independent ecology review of the route options. Details of the *Independent Ecological Review of Route Options* (Ecosense, 2008), are contained in **Appendix B**.

Overall, Ecosense found that the route options with the least ecological impacts comprised option 1A in section 1 and option 2F in section 2, although they found that route option 3B had slightly greater impacts than option 3A in section 3.

In section 2, Ecosense also found that route options 2A to 2E had significantly higher ecological impacts than route option 2F. Although the route options 2A to 2E were ecologically similar, trends were discernable. Options 2B and 2D performed similarly but had less overall ecological impacts than options 2A and 2E, which also performed similarly. Option 2C had higher ecological impacts than the other options in section 2.

Based on the results of the independent ecological assessment, the project team reviewed whether the outcomes affected the selection of the preferred route, as environment forms one of six assessed objectives in the route selection process. There were eight objectives for the project, listed below. Objectives 3 and 8 were not assessed as these are process objectives. The project team carried out a review of the assessment process, taking into consideration Ecosense's results for objective 4 rather than the original project team environmental assessment results.

Project Objective 1 -	Improve the efficiency of state, regional and local travel, safety and accessibility.
Project Objective 2 -	Provide a flowing road alignment responsive to and integrated with the landscape; optimising views, elegant design and planting opportunities.
Project Objective 3 -	Engage with the community and be informed by their views and experience (not assessed).
Project Objective 4 -	Identify and enhance potential beneficial environmental effects, and mitigate potential adverse environmental effects.
Project Objective 5 -	Minimise adverse socio-economic effects on the local community and maximise socio-economic benefits arising from the project.
Project Objective 6 -	Achieve high quality design and constructability.
Project Objective 7 -	Value for money.
Project Objective 8 -	Apply a sustainability framework to all stages of the project (not assessed).

Although the revised environmental ranking showed route option 2C as having a higher ecological impact than the other options, it still came out as the best performing overall option in section 2 when the assessment of performance against all of the project objectives was undertaken. Therefore the project team concluded that the selection of the preferred route was robust as it is still comprised of the best performing option in each section, and the design should proceed with the selected preferred route.

A summary of the independent reporting and subsequent review by the project team is contained in the *Technical Review of the Ecological Investigations for the Route Selection Process* (Hyder, 2008) in **Appendix B**.

For an overview of the ecology review process, refer to **Figure 1-3**.

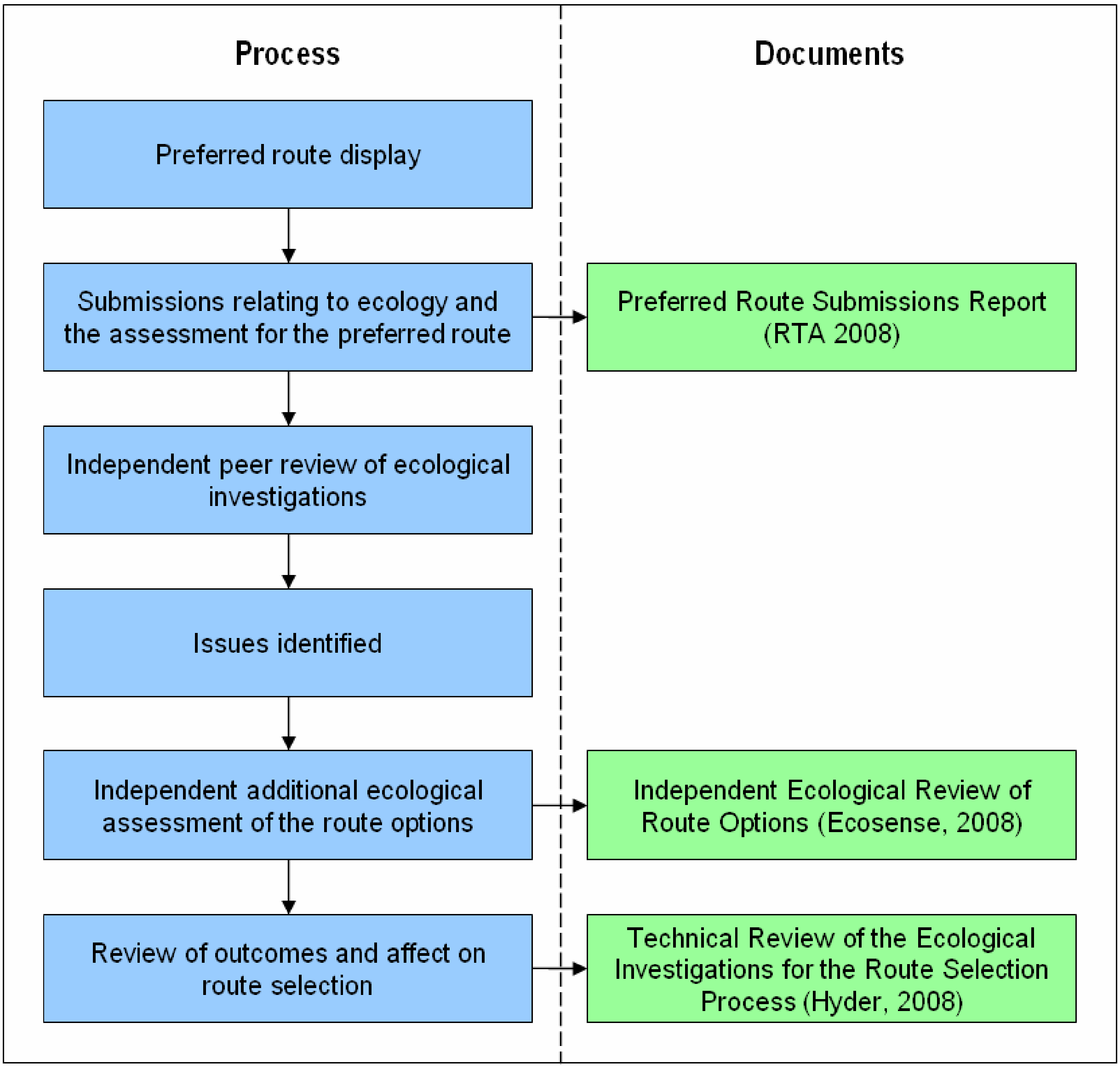

Figure 1-3 Ecological investigations review process

1.5 Concept design chronology

From the time the preferred route was selected a number of events occurred which required investigations and changes to aspects of the route. A timeline of these events is outlined in. **Table 1-2**

Table 1-2 Concept design chronology of key events

<table>
<tr><th>Month Year</th><th colspan="2">Event</th></tr>
<tr><td>Nov 2005</td><td rowspan="2">Preferred route public display</td><td></td></tr>
<tr><td>Jan 2006</td><td rowspan="2">Preferred route geotechnical investigations</td></tr>
<tr><td>Feb 2006</td><td></td></tr>
<tr><td>Apr 2006</td><td colspan="2">Preferred route modifications workshop</td></tr>
<tr><td>May 2006</td><td colspan="2">Concept design workshop</td></tr>
<tr><td>Aug 2006</td><td rowspan="2">Affected landowner consultation</td><td></td></tr>
<tr><td>Sep 2006</td><td></td></tr>
<tr><td>Nov 2006</td><td>Interchanges public display</td><td>Value engineering and risk management workshop</td></tr>
<tr><td>Dec 2006</td><td>Consultation with DECC</td><td></td></tr>
<tr><td>Apr 2007</td><td colspan="2">Consultation with Ballina Shire Council</td></tr>
<tr><td>May 2007</td><td colspan="2">Concept design arrangement finalised</td></tr>
<tr><td>June 2007</td><td colspan="2" rowspan="2">Concept design documented</td></tr>
<tr><td>July 2007</td></tr>
<tr><td>Sept 2007</td><td colspan="2" rowspan="4">Consultation with key stakeholders regarding concept design outcomes</td></tr>
<tr><td>Oct 2007</td></tr>
<tr><td>Nov 2007</td></tr>
<tr><td>Dec 2007</td></tr>
</table>

2 Design refinements to the preferred route

The preferred route was announced in November 2005 and formed the basis of the concept design. Since then the concept design has been refined based on community and stakeholder feedback, ecological investigations and engineering investigations.

Community and stakeholder input to the refinements of the concept design occurred through:

- Feedback from the preferred route display. A summary of this feedback and the project team responses are contained in the *Woodburn to Ballina Preferred Route Submissions Report* (RTA 2008a).
- Feedback from the interchanges and local road arrangements public display.
- Discussions with affected land owners and other stakeholders.

Further geotechnical, hydraulic, environmental and engineering investigations combined with risk and value engineering studies also contributed to the design refinements to the preferred route.

A summary of all of the potential refinements considered in the concept design are summarised in **Section 2.1**.

All proposed refinements were assessed against guiding principles established during the selection of the preferred route which were:

- Risk reduction: including the application of the precautionary principle.
- Cost: capital and road user cost.
- Ability to mitigate: possibility of redressing adverse impacts.
- Intergenerational equity: including consideration of high ecological impacts relating to impacts or imposts on future generations.

Design refinements were adopted if the proposed change demonstrated an improvement when assessed against the guiding principles.

This section summarises the outcomes from these inputs and discusses changes to the route and other significant refinements.

For ease of reporting the alignment has been subdivided into sections A, B, C and D. The preferred route corridor and the concept design refinements that were incorporated into the concept design are illustrated in **Figure 2-2** (section A), **Figure 2-3** (section B), **Figure 2-4** (section C) and **Figure 2-5** (section D). These adopted design refinements are summarised in **Table 2-1** and described in **Section 2.2**.

Table 2-1 Preferred route design refinements incorporated into the concept design.

No.	Description	Section
1	Provide south facing ramps south of Woodburn in the Iluka Road to Woodburn (IR2W) proposed upgrade and not provide ramps at Woodburn Evans Head Road, refer to **Figure 2-2.**	Now part of Iluka Road to Woodburn upgrade
2	Proposed upgrade level set to provide immunity from the 20 year ARI flood through the Richmond River floodplain rather than the 100 year ARI flood as adopted at the preferred route stage, refer to **Figure 2-2**.	A
3	Reduce the median width in the Richmond River floodplain south of the Broadwater National Park from the standard 12 m to five metres, with any future widening to six lanes to take place on the outside, refer to **Figure 2-2**.	A
4	Re-alignment of the proposed upgrade from 700 m southwest of Woodburn Evans Head Road to 2 km northeast of Woodburn Evans Head Road by up to 250 m to the north west from the preferred route corridor, refer to **Figure 2-2**.	A
5	Re-align the proposed upgrade, from the Langs Hill cutting to where the proposed upgrade joins the alignment of the existing Pacific Highway at the southern boundary of the national park by up to 270 m west, refer to **Figure 2-2**.	A/B
6	Lower the proposed upgrade close to natural surface through the Broadwater National Park and provide two fauna overpasses, refer **to Figure 2-3.** This option requires the acquisition of national park land for the proposed upgrade and fauna overpasses, which requires an act of parliament.	B
7	Provide a service road on the western side of the highway through the Broadwater National Park to connect to the existing highway at both ends of the national park corridor, refer to **Figure 2-3**. This option requires the acquisition of national park land for the proposed upgrade and fauna overpasses, which requires an act of parliament.	B
8	Provide north facing ramps at Broadwater Evans Head Road, refer to **Figure 2-3**.	B
9	A truck and light vehicle rest area and a heavy vehicle inspection area were added to the proposed upgrade to the south of Old Bagotville Road, refer to **Figure 2-4.**	C
10	Move the alignment through the private property just north of Old Bagotville Road by approximately 170 m to the east, refer to **Figure 2-4**.	C
11	Provide a diversion track to connect the western side of Thurgates Lane to Wardell Road rather than an overpass across the proposed upgrade at Thurgates Lane, refer to **Figure 2-4**.	C
12	Remove the overpass crossing the proposed upgrade at Lumleys Lane and provide diversion tracks adjacent to the proposed upgrade, refer to **Figure 2-4**.	C

No.	Description	Section
13	Add a fauna overpass near Meridian Heights between Lumleys Lane and Coolgardie Road, refer to **Figure 2-5**. (A fauna underpass may be considered in the future if this is found to be more suitable.)	D
14	Add a full interchange at Coolgardie Road, refer to **Figure 2-5.**	D
15	The existing Pacific highway between Coolgardie Road and Whytes Lane would be used as a service road. Pimlico Road between Whytes Lane and Duck Creek would be used as a service road. A new bridge across Duck and Emigrant creeks to connect Pimlico Road to Smith Drive. Smith Drive north of Emigrant Creek would be used as a service road. This design refinement is shown **in Figure 2-5.**	D
16	Provide an overpass at Whytes Lane/McAndrews Lane across the proposed upgrade, refer to **Figure 2-5**.	D

2.1 Design refinements considered

Proposed design refinements to the preferred route originated from a number of sources. This section identifies the origin of proposed refinements and summarises how they relate to the concept design.

2.1.1 Preferred route public display

The preferred route was displayed on 30 November 2005. The display period ended on 31 January 2006

80 written submissions and seven form letters were received from individuals and organisations.

During the public display in written submissions and in discussions with community members, several alignment change suggestions were made, refer to **Table 2-2**.

Table 2-2 Preferred route display community suggested alignment changes

No.	Location	Description
A	South east of Lang Hill	Move the route further east towards the Broadwater National Park boundary more off the agricultural property and into the vegetation in the adjacent property. Reduces the impact on the agricultural land.
B	North east of Lang Hill	Move route towards the Broadwater National Park boundary. Reduces impact on private property.
C	North of the Broadwater National Park	Suggested modified alignment leaves the existing highway in the Broadwater National Park, heads through the national park towards Cooks Hill, keeping out of the cleared private land. Reduces impact on property owners' potential subdivision (Land not zoned for subdivision and no DA approved).
D	Banks of the Richmond River	Move bridge crossing further northeast by approximately 100 m, reducing impact on agricultural land.
E	North of Old Bagotville Road on the west side of the Wardell heath	Move route to edge of Wardell heath, would create some impact on native title land. Reduces impact on agricultural property.
F	Wardell Road to Lumleys Lane	From Wardell Road move the route in a straight diagonal line to the existing Pacific Highway, reduces impact on Lumleys Lane properties.
G	Thurgates Lane	Use property at 36 Thurgates Lane for the upgrade as it cannot be developed or farmed due to local council zoning.
H	Woodburn Evans Head Road	Requested that the upgrade should be realigned to not disturb any soil within 100 m of the Rous Water bores off Woodburn Evans Head Road.

These suggestions were assessed against the guiding principles (as outlined at the start of **Section 2**) for the project and it was concluded that suggestions A, B, D, F and G would have unacceptable impacts against one or more of these guiding principles. These suggestions were not considered further.

Alignment change suggestion C was considered feasible and investigated further. An alignment change was suggested to the affected landowner, however this was not adopted due to the lack of improvement for the landowner.

A revised form of alignment change suggestion E was adopted (see design refinement 10, **Section 2.2.10**) and suggestion H was investigated further (see design refinement 4, **Section 2.2.4**).

2.1.2 Value engineering

A value engineering review of the preferred route alignment identified possible refinements to the design. The investigations identified cost savings or design improvements which would not compromise risk, ability to mitigate and intergenerational equity. The value engineering refinements investigated, assessed and adopted were:

- 20 year ARI flood immunity in the floodplain (design refinement 2, refer **Section 2.2.2**).
- Narrow median in the floodplain with widening for future six lanes on the outside (design refinement 3, refer **Section 2.2.3**).
- Lower the proposed upgrade through Broadwater National Park and provide fauna overpasses (design refinement 6, refer **Section 2.2.6**).
- Provide a rest area south of Old Bagotville Road (design refinement 9, refer **Section 2.2.9**.

2.1.3 Environmental investigations

Since the announcement of the preferred route in November 2005, particular emphasis had been placed on:

- Undertaking further scheduled ecological surveys.
- Reviewing proposed design refinements from the preferred route to establish whether it may be feasible to modify the alignment at particular locations and ensure there was no increase in adverse environmental impacts.
- Investigating potential fauna crossings and other ecological mitigation measures.

Biosis and Geolyse, the project ecologists, undertook targeted investigations within the preferred route corridor and also undertook investigations outside the footprint of the preferred route where design refinements were being investigated. Biosis then provided ecological advice on the potential ecological impact of the refinements to the preferred route.

Proposed design refinements investigated by broad walk-throughs by the project ecologists were:

- The Broadwater National Park corridor – to investigate the opportunity to locate a service road on either the eastern or western sides of the Pacific Highway with the least ecological impact (see design refinement 7, **Section 2.2.7**).
- The road corridor north of Wardell – to investigate which side of the Pacific Highway to widen or to provide a service road with the least ecological impact (see design refinement 15, **Section 2.2.15**).
- South western edge of Wardell heath – to investigate moving the alignment east to minimise impact on some farms (see design refinement 10, **Section 2.2.10**).

2.1.4 Land owner consultation

Following display of the preferred route the project team offered interviews to all directly impacted landowners. During the interviews, suggestions were made on modifying local access arrangements at Thurgates Lane, Lumleys Lane and Whytes Lane. These suggestions were investigated, assessed and those that provided benefits without compromising the project guiding principles were adopted (see design refinements10, 11, 12 and 16, **Sections 2.2.10, 2.2.11, 2.2.12 and 2.2.16** respectively).

2.1.5 Interchange and local road arrangements display

In October 2006 an interchange and local road arrangements brochure and questionnaire was distributed in the study area in conjunction with a public display. The brochure identified interchange and local road arrangements at Woodburn, Broadwater and Wardell, refer to **Figure 2-1**. The responses from the questionnaire were an input into an RTA value engineering and risk management workshop where agreement was reached on the interchange arrangements at Woodburn, Broadwater and Wardell.

The overall strategy was to provide access to the proposed upgrade and on local roads to accommodate the predominant traffic movements in the area.

As no interchange arrangements were proposed in the preferred route announcement, all interchange arrangements have been treated as a design refinement (see design refinements 1, 7, 8, 11, 12, 14, 15 and 16, **Sections 2.2.1, 2.2.7, 2.2.8, 2.2.11, 2.2.12, 2.2.14, 2.2.15 and 2.2.16** respectively).

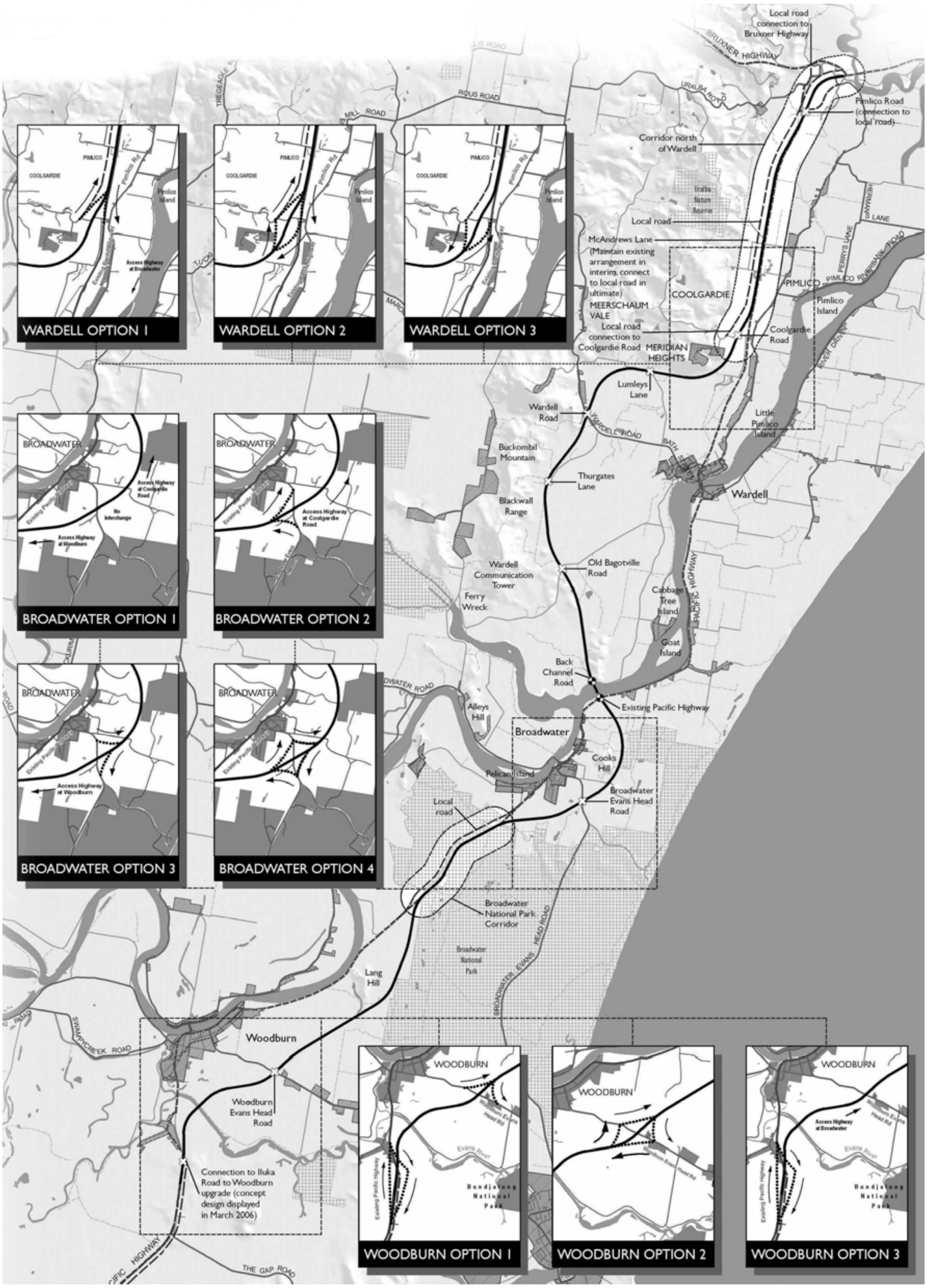

Figure 2-1 Interchange arrangement options

2.2 Adopted design refinements

This section expands on the adopted design refinements identified in **Table 2-1** and marked on **Figure 2-2**, **Figure 2-3**, **Figure 2-4** and **Figure 2-5**.

2.2.1 Design refinement 1 – Woodburn south facing ramps

Design refinement: Provide south facing ramps south of Woodburn in the Iluka Road to Woodburn (IR2W) proposed upgrade and not provide ramps at Woodburn Evans Head Road, refer to **Figure 2-2.**

Reasons for investigation:

Interchange arrangements needed to be finalised as part of the concept design. The following was taken into account in the investigation of this refinement:

- Feedback from the interchange and local road arrangements display indicated that 28 of 88 feedback form responses supported a full interchange at Woodburn.
- The study team presented options for the Woodburn interchange to the Woodburn Chamber of Commerce seeking feedback. Options discussed were a full interchange at Woodburn Evans Head Road or a split interchange with south facing ramps south of Woodburn and north facing ramps at Woodburn Evans Head Road. There was no formal response from this group.
- Rous Water had made a written submission requesting any road construction be kept at least 100 m from their water supply bores. Providing north facing ramps at Woodburn Evans Head Road would require construction works within this zone.

Reasons for adoption:

- Encourages Evans Head traffic to pass through Woodburn thereby retaining Woodburn's function as a service town.
- Locates interchange to utilise high topography which would provide additional cut material and reduce project fill demand.
- Improves integration with the adjoining Iluka Road to Woodburn proposed upgrade.
- It would minimise construction in the floodplain.

This design refinement assumed that land acquisition for the service road through Broadwater National Park is possible. This service road would provide northbound motorists from Woodburn and Coraki access to the proposed upgrade at Broadwater. If land acquisition from the Broadwater National Park is not possible then the interchange arrangements in this area would be reassessed.

2.2.2 Design refinement 2 - 20 year ARI flood immunity in the floodplain

Design refinement: Proposed upgrade level set to provide immunity from the 20 year ARI flood through the Richmond River floodplain rather than the 100 year ARI flood as adopted at the preferred route stage, refer to **Figure 2-2**.

Reasons for investigation:

This is a value engineering option to reduce project cost by lowering fill embankments and reducing viaduct lengths. Providing 100 year flood immunity requires embankments of up to four metres in height through the floodplain, as well as up to 800 m of viaduct to limit flooding afflux to no more than 50 mm in urban areas and 100 mm in rural areas. This approach is consistent with the immunity adopted on the adjoining Ballina bypass and several other Pacific Highway projects within major floodplains.

Reasons for adoption:

Adoption of 20 year flood immunity reduces embankment heights, ground improvement works and viaduct lengths. This design refinement would still limit flooding afflux to no more than 50 mm in urban areas and 100 mm in rural areas during a 100 year ARI flood event.

The 20 year ARI flood event immunity is the minimum standard for the Pacific Highway upgrade program, and is used on other projects with similar constraints such as the Ballina bypass. Immunity to a 20 year ARI flood event represents an improvement in flood immunity over significant lengths of the existing highway which are regularly inundated in 5 year ARI flood events, or less.

2.2.3 Design refinement 3 - Narrow median in the floodplain

Design refinement: Reduce the median width in the Richmond River floodplain south of the Broadwater National Park from the standard 12 m to five metres, with any future widening to six lanes to take place on the outside, refer to **Figure 2-2**.

Reasons for investigation:

A value engineering option to reduce project costs by reducing the fill requirement. The preferred route footprint was based on a standard 12 m wide median which allows for widening in the median for a future third lane. A narrow five metre wide median in this location would reduce the initial demand for fill. Any future widening to six lanes would be achieved with the addition of one lane on the outside of the carriageway in each direction.

Reasons for adoption:

A five metre wide median in the Richmond River valley floodplain south of the Broadwater National Park was adopted because of the reduced imported fill required for initial construction. Future widening can occur by allowing a sufficient corridor width for widening on the outside of the upgrade.

2.2.4 Design refinement 4 – Realignment around Woodburn Evans Head Road

Design refinement: Re-alignment of the proposed upgrade from 700 m southwest of Woodburn Evans Head Road to 2 km northeast of Woodburn Evans Head Road by up to 250 m to the north west from the preferred route corridor, refer to **Figure 2-2**.

Reasons for investigation:

- The preferred route corridor was within Rous Water's requested 100 m exclusion zone from it's water supply bores (located on the northern side of Woodburn Evans Head Road, either side of the preferred route).
- Ecological studies by Biosis showed that there was a high impact on swamp sclerophyll forest endangered ecological community to the north of the borefields.
- At the value engineering and risk management workshop it was agreed to investigate a reduction to the impact on the swamp sclerophyll forest endangered ecological community and the Rous Water borefield's zone of influence.

Reasons for adoption:

- Geotechnical investigations indicated that there is a generally impermeable surface layer of about one metre thickness underlying the area. However there may be a risk that this surface layer could crack during dry periods, which may enable road generated contaminants to enter the aquifer.
- A review identified that relocating the alignment approximately halfway between the two bores would minimise any risks to the water supply.
- Reduction of impact on the swamp sclerophyll forest endangered ecological community was in line with the project guiding principles.

2.2.5 Design refinement 5 – Realignment at McDonalds Creek

Design refinement: Re-align the proposed upgrade, from the Langs Hill cutting to where the proposed upgrade joins the alignment of the existing Pacific Highway at the southern boundary of the national park by up to 270 m west, refer to **Figure 2-2**.

Reasons for investigation:

During the preferred route ecological investigations the endangered oxleyan pygmy perch fish species were found in and around the 100 m preferred route corridor in McDonalds Creek, just south of the Broadwater

National Park (for locations of the oxleyan pygmy perch populations in and around Broadwater National Park, refer to **Figure 2-2)**.

Due to this finding several options have been investigated to select an alignment that would reduce the impacts on this threatened species to a level that would be acceptable under a seven part test.

Reasons for adoption:

The preferred route alignment was considered to have a high impact on the oxleyan pygmy perch habitat. This was discussed and confirmed with a representative from the Department of Primary Industries (Fisheries). Following this the project team assessed that the impact of the preferred route was unacceptable, and that the proposed design refinement was appropriate mitigation to reduce the impact on the oxleyan pygmy perch.

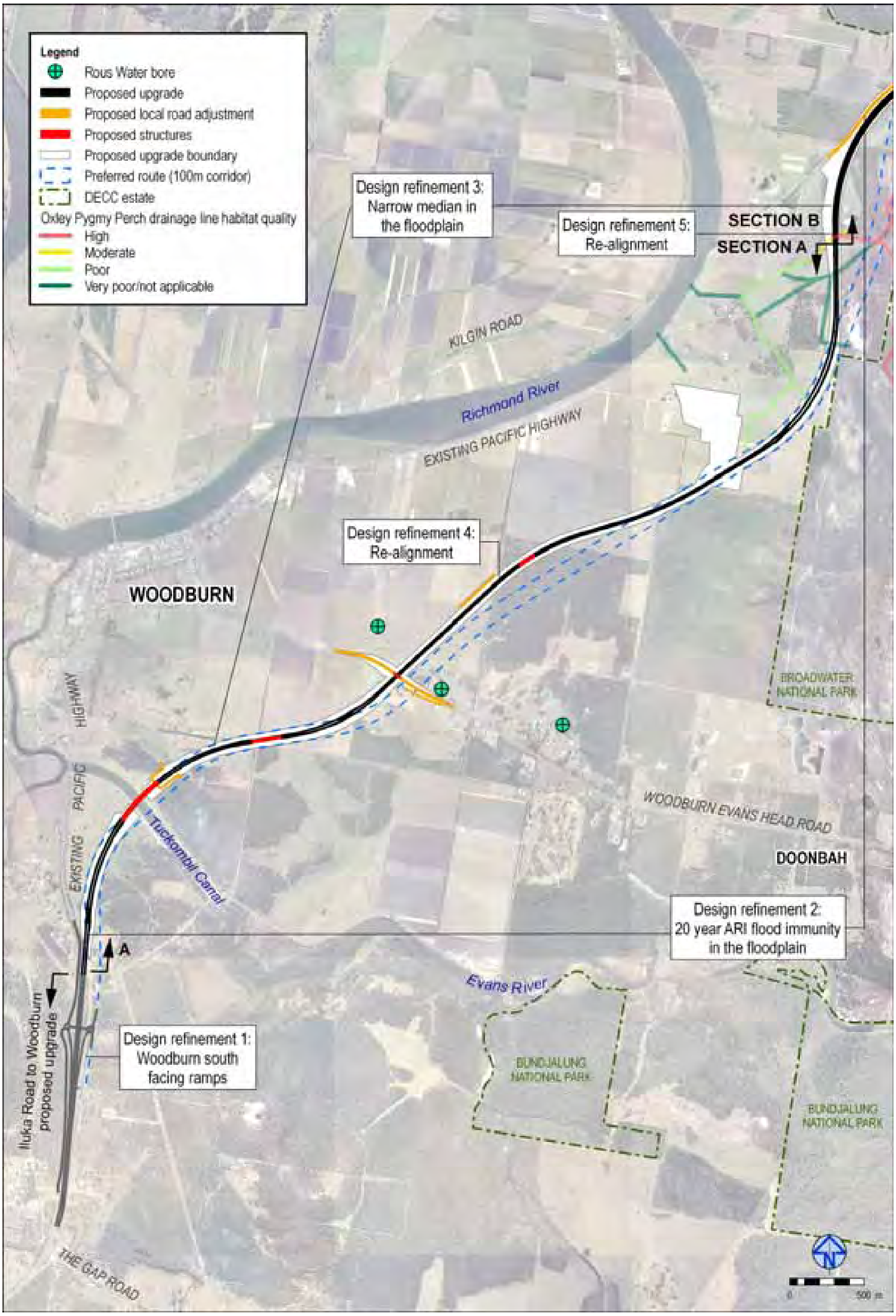

Figure 2-2 Section A design refinements

2.2.6 Design refinement 6 – Upgrade lowered through the Broadwater National Park

Design refinement: Lower the proposed upgrade close to natural surface through the Broadwater National Park and provide two fauna overpasses, refer to **Figure 2-3**. This option requires the acquisition of national park land for the proposed upgrade and fauna overpasses, which requires an act of parliament.

Reasons for investigation:

To avoid the need to acquire national park land, the preferred route proposed the following through the Broadwater National Park:

- A narrow cross section which did not allow for future widening or a service road (refer design refinement 7, **Section 2.2.7**).
- A lower than desirable minimum standard horizontal alignment which may have required reductions in speed limits
- Large fauna underpasses beneath the upgrade which requires raising the alignment over the underpasses. This would require 6 m high retaining walls through the Broadwater National Park corridor which would have a high cost and undesirable visual impact.

As part of the value engineering process, options were investigated to reduce the visual impact, fill demand, extent of retaining walls and cost.

Reasons for adoption:

- This design refinement does not require any major retaining walls along the park and would significantly reduce the quantity of imported fill required for construction, both reducing cost and visual impact.
- This allows for future widening within the standard 12 m median through the national park.

The arrangement of the proposed upgrade and overpasses through the Broadwater National Park is part of ongoing discussions with DECC.

2.2.7 Design refinement 7 – Broadwater service road

Design refinement: Provide a service road on the western side of the highway through the Broadwater National Park to connect to the existing highway at both ends of the national park corridor, refer to **Figure 2-3**. This option requires the acquisition of national park land for the proposed upgrade and fauna overpasses, which requires an act of parliament.

Reasons for investigation:

- At both the preferred route and interchange and local road arrangements displays there were numerous submissions requesting a service road through the national park to provide connectivity for local traffic between Woodburn and Broadwater. These included submissions from the Broadwater Sugar Mill and Richmond Valley Council

- An RTA Pacific Highway objective is to provide an alternative route to the proposed upgrade for local traffic.
- The RTA recognises that acquisition of national park land is a very involved process requiring extensive ongoing consultation with DECC and culminates in an act of parliament

Reasons for adoption:

At the value engineering and risk management workshop it was agreed to proceed with acquisition of land from the Broadwater National Park to provide a service road adjacent to the proposed upgrade between Woodburn and Broadwater to satisfy the RTA's Pacific Highway Objectives.

The project ecologists advised that based on the summer ecology surveys it would be preferable to widen the road onto the west/north side of the existing highway through the national park because it would not cause a significant impact on endangered ecological communities. Refer to **Table 13-1** for more information.

2.2.8 Design refinement 8 – Broadwater north facing ramps

Design refinement: Provide north facing ramps at Broadwater Evans Head Road, refer to **Figure 2-3**.

Reasons for investigation:

Interchange arrangements needed to be finalised as part of the concept design. The following was taken into account in the investigation of this design refinement:

- Feedback from the interchange and local road arrangement display indicated that 32 of 88 feedback from responses supported a full interchange at Broadwater.
- Discussions were held with the Broadwater Sugar Mill on access arrangements to the mill. They made a formal submission opposing a Broadwater interchange and keeping the existing link between Woodburn and Broadwater for sugar cane haulage so that economics of the enterprise and community impacts were not altered.

Reasons for adoption: At the value engineering and risk management workshop north facing ramps were agreed at Broadwater Evans Head Road. This arrangement had a balanced outcome for maintaining existing Pacific Highway access to the Broadwater Sugar Mill, tourism and Evans Head residents accessing Ballina via a flood free route. Rejecting south facing ramps at Broadwater improved the service town opportunities for Woodburn because Broadwater residents heading south would access the proposed upgrade via Woodburn.

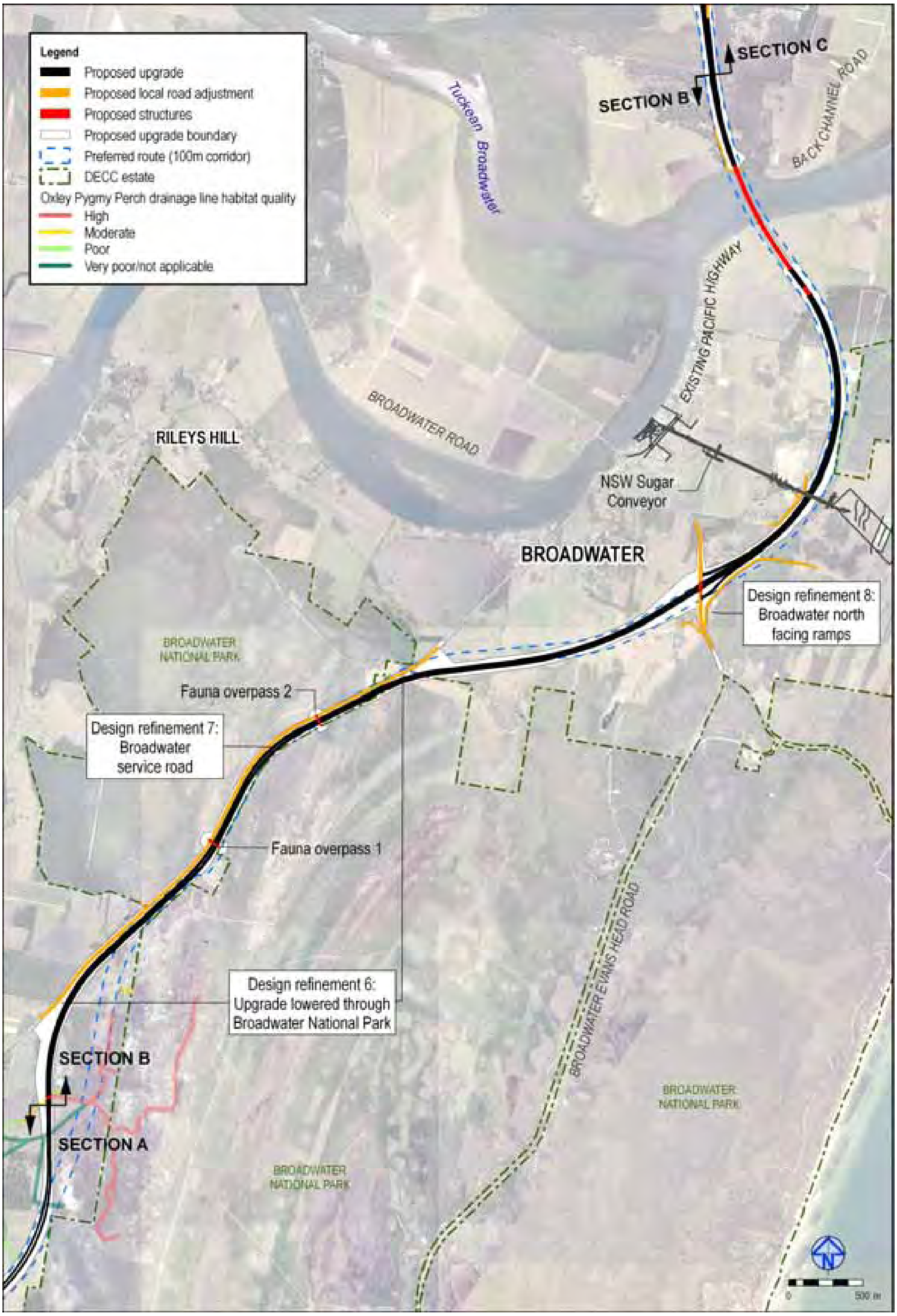

Figure 2-3 Section B design refinements

2.2.9 Design refinement 9 - Rest area and heavy vehicle inspection bay

Design refinement: A truck and light vehicle rest area and a heavy vehicle inspection area were added to the proposed upgrade to the south of Old Bagotville Road, refer to **Figure 2-4.**

Reasons for investigation:

A strategic review by the RTA during the concept design phase identified the need to provide both a truck rest area and a heavy vehicle inspection area in both northbound and southbound directions for the Woodburn to Ballina section of the Pacific Highway.

Issues considered for the location of the truck stop were to minimise urban design impacts, be remote from residents to minimise noise and visual impacts and to maximise material for won from earthworks.

Reasons for adoption:

The project team identified that the rest area was best located south of Old Bagotville Road, and would also best meet the need to minimise the urban design and noise impacts. North of the Richmond River there was a significant earthworks shortfall. This location also would enable material to be sourced for earthworks where the terrain was most suitable.

2.2.10 Design refinement 10 - Property realignment

Design refinement: Move the alignment through the private property just north of Old Bagotville Road by approximately 170 m to the east, refer to **Figure 2-4**.

Reasons for investigation:

The property owner proposed an alignment change during the preferred route public display to reduce the impacts on his property.

Reasons for adoption:

- The refinement reduces the impact on agricultural land without compromising the project's guiding principles.
- The refinement maintains the existing agricultural drainage system.

2.2.11 Design refinement 11 - Thurgates Lane diversion

Design refinement: Provide a diversion track to connect the western side of Thurgates Lane to Wardell Road rather than an overpass across the proposed upgrade at Thurgates Lane, refer to **Figure 2-4**.

Reason for investigation:

The preferred route included an overpass at Thurgates Lane to maintain access to properties across the proposed upgrade. In the meetings with landowners in September and October 2006, owners adjacent to this overpass suggested that the overpass should be removed and access to properties west of the proposed upgrade could be provided via a local access road from Wardell Road.

Reasons for adoption:

This option was adopted because:

- It provides a cost effective solution.
- It reduces the impacts on adjacent properties.

2.2.12 Design refinement 12 - Lumleys Lane diversion

Design refinement: Remove the overpass crossing the proposed upgrade at Lumleys Lane and provide diversion tracks adjacent to the proposed upgrade, refer to **Figure 2-4**.

Reasons for investigation:

- The interchange and local road arrangements brochure included an overpass at Lumleys Lane which maintained local access across the upgrade. This was provided because at the preferred route display there was concern from local landowners that their access would be impaired.
- In the meetings with landowners in September and October 2006, owners adjacent to this proposed overpass suggested that the overpass should be deleted if suitable safe alternative access could be provided.
- The existing junction between the western end of Lumleys lane and Wardell Road is unsafe and unsuitable for use by sugar cane trucks.

Reasons for adoption:

A Lumleys Lane diversion, linking the western side of Lumleys Lane to Wardell Road adjacent to the Wardell Road overpass was adopted because it was cost effective and in aligned with local landowners' opinions.

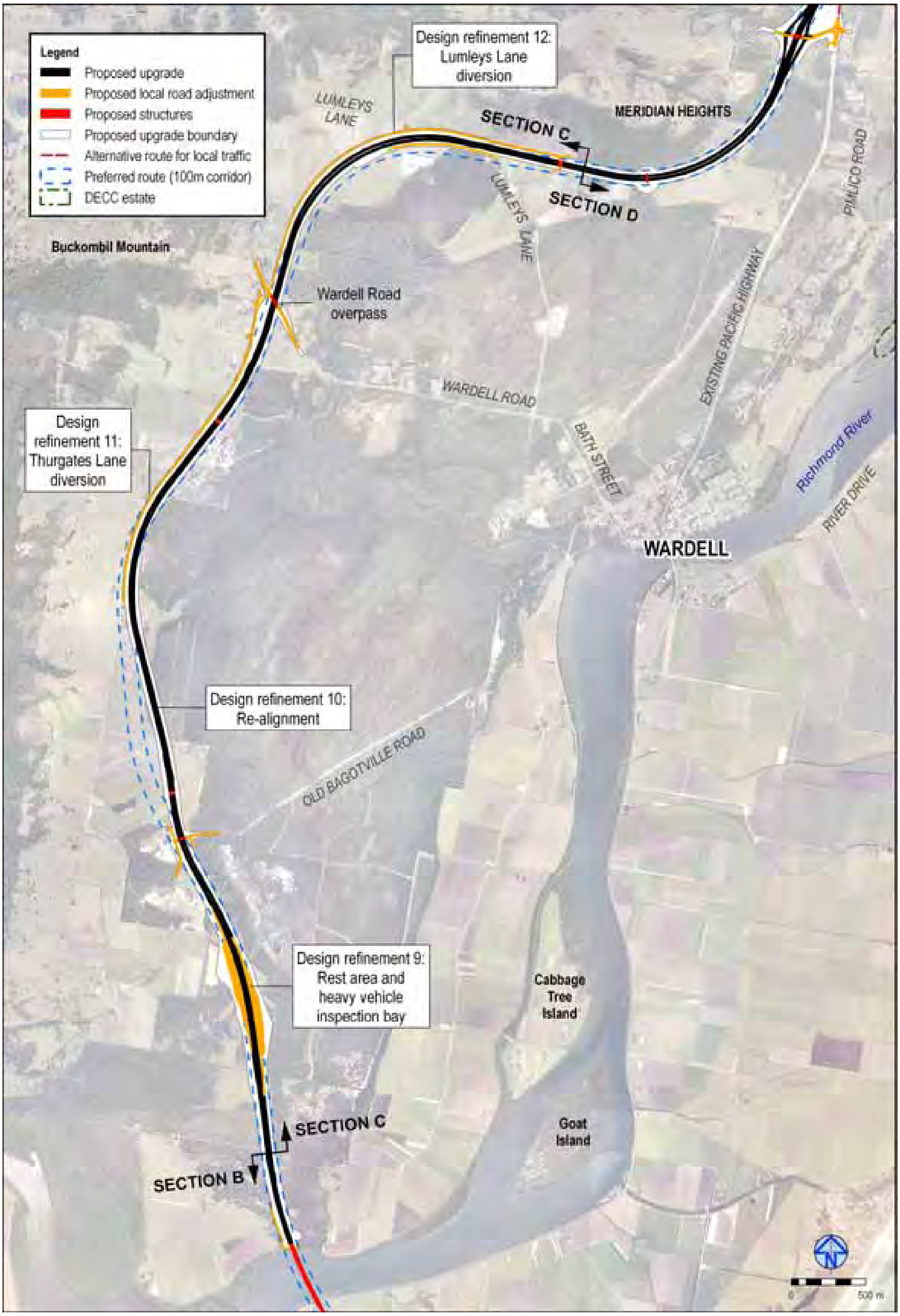

Figure 2-4 Section C design refinements

2.2.13 Design refinement 13 – Coolgardie scrub fauna overpass

Design refinement: Add a fauna overpass near Meridian Heights between Lumleys Lane and Coolgardie Road, refer to **Figure 2-5**. (A fauna underpass may be considered in the future if this is found to be more suitable.)

Reasons for investigation:

During the ecological surveys following the announcement of the preferred route, the project ecologist identified that there should be a fauna crossing to enable movements across the proposed upgrade from Wardell heath to the Coolgardie scrub in the vicinity of Meridian Heights

Reason for adoption:

A fauna overpass was adopted as it best suited the ecological requirements and local topography, however a fauna underpass may be considered in future if this is found to be more suitable, refer to **Table 13-1** for further details.

2.2.14 Design refinement 14 – Wardell north and south facing ramps

Design refinement: Add a full interchange at Coolgardie Road, refer to **Figure 2-5**.

Reason for investigation: Interchange arrangements needed to be finalised as part of the concept design. The following was taken into account in the investigation of this refinement:

- Feedback from the interchange and local road arrangement display indicated that 30 of 88 feedback form responses supported a full interchange at Wardell.
- The most suitable northern location where access could be provided is north of Wardell at Coolgardie Road just before the proposed upgrade joins the existing Pacific Highway.

Reason for adoption: The project team assessed that locating a full interchange at Wardell provided the full transport connectivity for the northern third of the project.

2.2.15 Design refinement 15 - Wardell service road

Design refinement:

A revised service road strategy north of Wardell:

- The existing Pacific highway between Coolgardie Road and Whytes Lane would be used as a service road.
- Pimlico Road between Whytes Lane and Duck Creek would be used as a service road.

- A new bridge across Duck and Emigrant creeks to connect Pimlico Road to Smith Drive.
- Smith Drive north of Emigrant Creek would be used as a service road.

This design refinement is shown in **Figure 2-5.**

Reasons for investigation:

The existing highway north of Coolgardie Road has two at-grade junctions with local roads at Whytes Lane and Pimlico Road. Road safety considerations require that the Pimlico Road and Whytes Lane junctions with the Pacific Highway be closed when this project is built.

The resolution of local access between Wardell and the Ballina bypass project needed to consider a service road on:

- The east of the proposed upgrade as shown in the preferred route display.
- The west of the proposed upgrade as shown at the interchange and local road arrangements display.
- An alternative considered after the brochure's publication was the option of connecting Pimlico Road to Smith Drive via a bridge across Duck and Emigrant creeks.

Reasons for adoption:

After detailed assessments of flooding impacts, deep soft soils, costs and consultation with Ballina Shire Council the project team adopted to use the existing highway between Coolgardie Road and Whytes Lane, Pimlico Road between Whytes lane and Duck Creek and Smith Drive between Emigrant Creek and Ballina as the local service Road, refer to **Figure 2-5**.

- The service road could use the existing highway and local road pavement for cost effectiveness.
- The proposal reduces the impacts on the western farm drainage canal running parallel to the Pacific Highway.
- The proposal reduced Duck Creek flooding impacts by avoiding a crossing of the Duck Creek floodplain upstream of the proposed upgrade.
- Predominant local traffic patterns would be maintained.

2.2.16 Design refinement 16 - Whytes Lane overpass

Design refinement: Provide an overpass at Whytes Lane/McAndrews Lane across the proposed upgrade, refer to **Figure 2-5**.

Reason for investigation:

The interchange and local road arrangements brochure did not indicate any access across the proposed upgrade at Whytes Lane.

Advice from local land owners indicated that a number of sugar cane farmers in the area operate farms on both sides of the proposed upgrade. The farmers frequently cross the existing Pacific Highway at Whytes Lane with harvesters and other agricultural equipment. Their viability would be significantly affected if the Whytes Lane crossing was severed.

Reason for adoption:

The Whytes Lane overpass has been included to mitigate adverse travel impacts on affected sugar cane farmers.

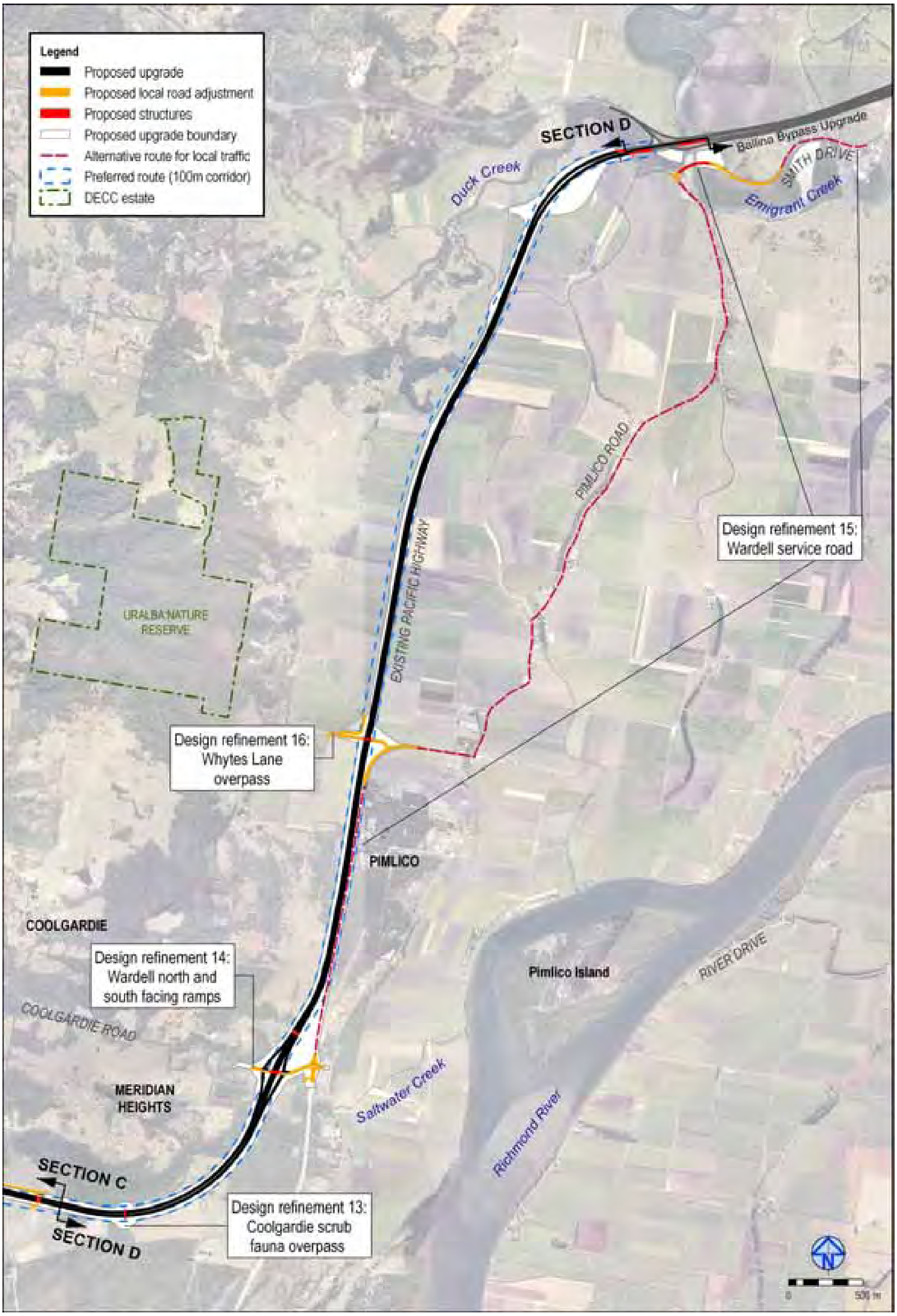

Figure 2-5 Section D design refinements

3 Traffic and transport

A traffic and transportation study has been undertaken for this project, broken into two phases:

1 Preliminary Traffic & Transportation Study.

2 Detailed Traffic and Transportation Study.

The preliminary study provided traffic input into the selection of the preferred route. It included, but was not limited to:

- A detailed desktop study of all existing modes of transport in the study area.
- Study area historic accident data.
- Traffic counts of key routes in the study area.
- Origin and destination surveys in the study area.
- Assessed historical traffic growth and predicted traffic growth.
- Assessment of the traffic performance for the route options.

Following the selection of the preferred route in November 2005, additional traffic modelling was carried out on various interchange arrangement combinations. The results of these assessments were used together with the outcomes of the interchange and local road arrangements consultation in November 2006 to select the final interchange configuration for the proposed upgrade.

The detailed traffic and transportation study built upon the work in the preliminary study with further traffic and intersection modelling of the concept design and is summarised in this section.

3.1 Existing Pacific Highway

An assessment of the existing Pacific Highway and other transport modes is detailed below. Generally, between Woodburn and Ballina, the existing Pacific Highway:

- Is an undivided two lane two way road with sealed shoulders.
- Has a 100 km/h posted speed limit between the townships.
- Has a 50 km/h posted speed limit within the townships of Woodburn and Broadwater (except in south Woodburn, where a 40 km/h speed limit is operational during school drop off and pickup times).
- Has an overtaking lane in each direction between the townships of Woodburn, Broadwater, Wardell and Ballina (south of Bruxner Highway).

The study area is served by three modes of public transport:

- Bus / coach with four routes and 1 or 2 movements per day.

- Train with stations at Grafton with 6 movements per day and Casino with 4 movements per day (whilst a long way from the study area, these are the closest rail links).
- Air services with airports at Ballina and Lismore.

The NSW Coastline Cycleway (NSWCC) (a project driven by NSW Department of Planning [DoP] and funded equally between DoP and local councils) has identified a cycle route running along Broadwater Evans Head Road – Pacific Highway between Broadwater and Wardell – River Drive to Ballina.

Pedestrian facilities are minimal throughout the study area.

3.1.1 Existing Pacific Highway traffic volumes

Existing traffic volume data for the study area is shown in **Figure 3-1**. This was derived from three sources, namely:

- RTA permanent counter site 04.264 – Pacific Highway, south of Bruxner Highway;
- Classification counts undertaken by Australasian Traffic Surveys (ATS) during week commencing Monday 22 November 2004 at the following locations:
    1 South Woodburn.
    2 North Woodburn.
    3 Between Broadwater and Wardell.
    4 South of Bruxner Highway.
- Classification counts undertaken by the RTA.

Table 3-1 Average weekday and 7 day average traffic volumes along Pacific Highway (2004)

ATS Site No.	Average Weekday Volume	7 Day Average Volume
1	7,910	7,810
2	7,190	7,000
3	8,230	8,200
4	9,120	9,010

3.1.2 Traffic patterns

An origin - destination (OD) survey was undertaken on Thursday 25 November 2004 between 7am and 7pm. **Figure 3-1** identifies the existing Pacific Highway and the location of the OD survey stations. The estimated 2004 all vehicle matrices for the study area are shown in **Table 3-2**, with the associated local movements in **Table 3-3**.

Figure 3-1 Origin destination survey stations

Note: The origin destination survey site numbers do not correspond to the ATS Classification site numbers.

Table 3-2 Estimated 2004 all vehicle matrix (7am to 7pm) with movement definition

Matrix					
Origin Station	Destination Station				Total
	1	2	3	4	
1	0	205	235	2091	2530
2	174	0	128	353	655
3	229	108	0	129	466
4	2191	396	126	0	2713
Total	2593	709	488	2573	6363

Table 3-3 Estimated 2004 local movements through OD stations (7am to 7pm) with movement definition

Station	Northbound Local	Southbound local
1	126	126
2	129	128
3	185	190
4	941	916

Table 3-4 links the colours in **Table 3-2** and **Table 3-3** to the following movement definitions:

- External to external – through traffic.
- Internal to external (& vice versa) – local traffic that originates within the study area and has a destination outside of the study area.
- Internal to internal – local traffic movements that begin and end within the study area.

Table 3-4 movement definition key

Colour	Movement definition
	External to external movements
	Internal to external and external to internal
	Internal to internal

Based on the above data, it can be seen that between 7am and 7pm:

- A high proportion of movements are external to external, or through traffic, with over 2,000 vehicles observed in each direction (movement 1 to 4 and vice versa).
- Internal to internal traffic (yellow) comprise a very small proportion of all traffic on the Pacific Highway – approximately 10% of all traffic.
- The internal to external movements are very high and are biased by the major traffic movement between Wardell (and Pimlico, south Ballina etc) and Ballina. Across the day, around 1,850 vehicles travel between these towns and use the Pacific Highway.

The major movement between Wardell and Ballina is the dominant reason why traffic volumes on the existing Pacific Highway are significantly higher in the northern section of the study area.

The performance of the existing pacific highway is summarised in **Table 3-5**.

Table 3-5 Pacific Highway 100th highest hourly volumes and LOS (2004)

Section	2004 100th Highest Hourly Flow (veh/h)			
	NB	LOS	SB	LOS
Woodburn to Broadwater	445	B	450	B
Broadwater to Wardell	500	B	520	B
Wardell to Bruxner Highway	560	C	580	C

Heavy vehicles

The heavy vehicle composition along the Pacific Highway is relatively high, particularly during weekdays, and overnight.

The permanent site located just south of Bruxner Highway (Site 04.264) recorded around 16% heavy vehicles for 2004.

- During weekdays, between 20 to 24% of all vehicles are heavy vehicles.
- On weekends, between 10 to 15% of all vehicles are heavy vehicles.
- The proportion of trucks is substantially higher overnight (7am to 7pm) when compared with the day (7am to 7pm).
- On average, the number of trucks on a weekday is around 1.5 to 2.1 higher than on the weekend.

3.1.3 Traffic accidents

The RTA provided 5 years of crash data covering the period July 1999 to June 2004. During this period, there were 195 reported crashes. The severity of these crashes is summarised in **Table 3-6**.

Table 3-6 Crash severity along Pacific Highway between 1999 and 2004

Severity	Number of Crashes	Percentage	Comments
Fatal	3	1.5%	3 persons killed
Injury	81	41.5%	148 persons injured
Towaway	111	57.0%	Non casualty
Total	195	100%	

3.1.4 Adopted traffic growth rates

Based on the review of the available historical data, a linear growth rate of +2.3% per annum has been adopted, with a base year of 2005. This growth rate was used to estimate the 2035 AM and PM peak hour traffic demand. For the purposes of analysis, a predicted opening year of 2015 has been used. It should be noted however that this is a planning date and the actual year of opening would be dependent on the availability of funding.

3.2 Detailed transport assessment

3.2.1 Traffic volumes on proposed road network

The detailed traffic assessment has been carried out on the configuration shown in **Figure 3-2**. The locations referenced in the following tables are the locations shown on **Figure 3-2**.

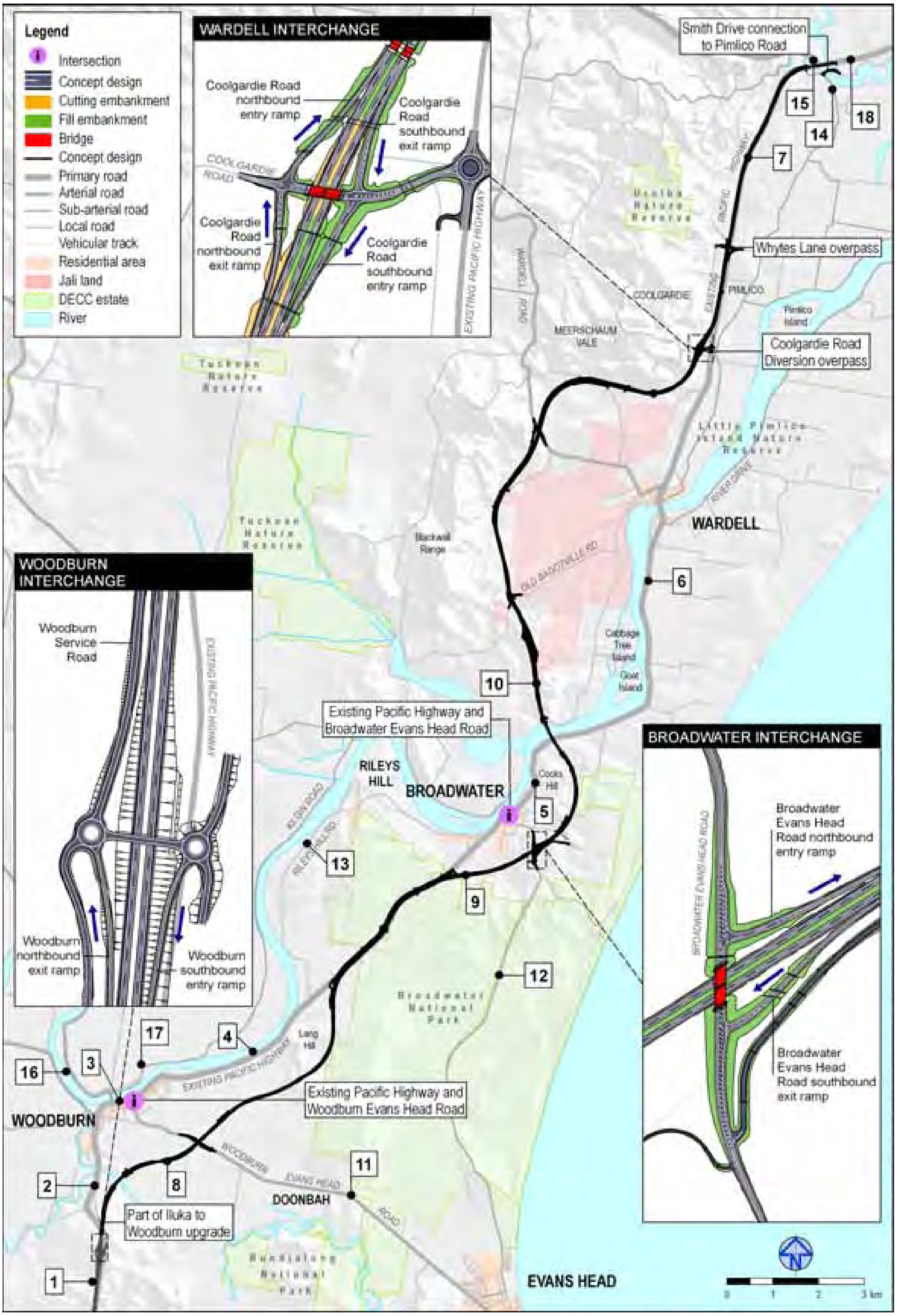

Figure 3-2 Concept design traffic network

Future traffic volumes have been forecast for the predicted opening year (2015) and assessment year (20 years after opening - 2035).

Table 3-7, **Table 3-8** and **Table 3-9** summarise the projected traffic volumes for key locations along the existing Pacific Highway, the proposed upgrade and local roads respectively, under the no upgrade and upgrade scenarios. The traffic volumes on the existing Pacific Highway are anticipated to decrease by around 60% through Woodburn and up to 90% between Broadwater and Wardell. The considerable decrease in traffic between Broadwater and Wardell is due to the north facing ramps at Broadwater. Based on the selection of the fastest route, a majority of traffic travelling north from Woodburn would access the proposed upgrade at Broadwater, rather than continuing along the existing Pacific Highway to Wardell.

Table 3-7 Projected traffic volumes (AADT) on the existing Pacific Highway, with and without the proposed upgrade.

No	Location	2015			2035		
		Without proposed upgrade	With proposed upgrade	% Change	Without proposed upgrade	With proposed upgrade	% Change
1	South of Woodburn (in IR2W project to the south)	9,800	9,800	0%	13,400	13,400	0%
2	South of Coraki Woodburn Road	9,800	3,900	-60%	13,400	5,400	-60%
3	Woodburn (between Cedar & Alfred)	11,300	5,500	-51%	15,500	7,500	-52%
4	North of Woodburn (south of Rileys Hill Road)	8,900	3,000	-66%	12,100	4,100	-66%
5	North Broadwater (north of Coraki Broadwater Road)	10,500	1,000	-90%	14,300	1,400	-90%
6	South of Wardell	10,900	1,500	-86%	14,900	2,000	-87%
7	North of Wardell	11,200	0*	-	15,300	0	-

No	Location	2015			2035		
		Without proposed upgrade	With proposed upgrade	% Change	Without proposed upgrade	With proposed upgrade	% Change
18†	North of Bruxner Highway Intersection (in Ballina bypass project)	26,300	26,300	0%	36,000	36,000	0%

* This section of the existing Pacific Highway is reclaimed as part of the proposed upgrade.

† The projected traffic volumes on this section of the highway are from modelling undertaken for this project only, and may not correspond to projected traffic volumes for the Ballina bypass project.

Table 3-8 Projected traffic volumes (AADT) on Pacific Highway upgrade

No	Location	2015	2035
8	South Woodburn (south of Woodburn Evans Head Road)	5,800	8,000
9	Woodburn to Broadwater	5,800	8,000
10	Broadwater to Wardell	9,400	12,900
7	Wardell to Bruxner Highway	11,400	15,600

Table 3-9 Projected traffic volumes (AADT) on local roads

No	Road	Location	2015		2035	
			Without upgrade	With proposed upgrade	Without upgrade	With proposed upgrade
11	Woodburn Evans Head Road	East of upgrade	3,100	3,100	4,200	4,200
12	Broadwater Evans Head Road	Evans Head to Broadwater	1,400	1,400	2,000	2,000
13	Rileys Hill Road	Mid-block	<50	<50	<50	<50
14	Pimlico Road	South of Pacific Highway / Smith Drive bridge	500	500	700	600
15	Bruxner Highway	North of Pacific Highway	16,400	16,400	22,400	22,400
16	Coraki Woodburn	West of Pacific	2,700	2,700	3,700	3,700

No	Road	Location	2015		2035	
			Without upgrade	With proposed upgrade	Without upgrade	With proposed upgrade
	Road	Highway				
17	Bank Street, Woodburn	East of bridge over the Richmond River at Woodburn	2,900	2,900	4,000	4,000

3.2.2 Junction performance

The interchange intersections, ramp merges and local roads were analysed using SIDRA intersection analysis software.

Under the proposed scheme, by 2035 the existing Pacific Highway is expected to operate at level of service B for both directions between Woodburn and Broadwater, and level of service A between Broadwater and Wardell.

By 2035 the proposed upgrade is expected to operate at level of service A. The scheme meets the criteria for the project, which is to operate at a level of service C or better 20 years after opening (2035).

The Coolgardie Road northbound entry ramp is expected to experience level of service B while all other merges and diverges experience level of service A.

Under the 60/40 tidal split with the greater numbers of vehicles heading south, the Wardell interchange southbound entry ramp is expected to experience level of service B while all other merges and diverges are expected to experience level of service A.

Under all tested conditions the merges and diverges meet the criteria for the project, an expected level of service C or greater 20 years after opening.

3.2.3 Accident reduction

An analysis to calculate the estimated accident numbers was undertaken to gauge the potential safety improvements the proposed upgrade could deliver. This analysis compared the predicted accident numbers with the proposed upgrade scenario and without the proposed upgrade[1] scenario.

Analysis shows that the accident rate for the existing highway is 48 accidents per 100 million vehicles kilometres travelled. Based upon the standard of upgrade proposed, an accident rate of 6.6 accidents per 100

[1] Accident rate for the existing highway was calculated using 1999 to 2004 accident records, which is prior to the installation of median wire rope safety barrier between Wardell and Whytes Lane.

million vehicle kilometres travelled has been adopted for the proposed upgrade.

These accident rates have been applied to the projected traffic volumes to produce an estimated number of accidents per year.

Table 3-10 shows the estimated number of accidents per year for both the without upgrade scenario and the with upgrade scenario. The analysis suggests that there is a potential to reduce the total number of accidents by just over 69% from the without proposed upgrade scenario.

Table 3-10 Estimated accident numbers per section

	Location	2005	2015	2035
Without proposed upgrade				
Existing highway	North of Woodburn (south of Rileys Hill Road)	13	16	22
	North Broadwater (north of Coraki Broadwater Road)	20	25	34
	North of Wardell	12	14	20
	TOTAL	45	55	76
With proposed upgrade				
Existing highway	North of Woodburn (south of Rileys Hill Road)	5	6	8
	North Broadwater (north of Coraki Broadwater Road)	2	2	3
	North of Wardell	1	1	1
Proposed upgrade	Woodburn to Broadwater	2	2	3
	Broadwater to Wardell	3	4	5
	Wardell to Bruxner Highway	2	2	3
	TOTAL	14	17	23

4 Highway design

This section describes the concept design incorporating the changes and refinements outlined in **Section 2**. It outlines the constituent elements of the concept design and the criteria that have been met or adopted in its development. For design references, refer to **Section 18.1**.

The concept design has been developed and is reported here. The concept design is based on current standards and the information available at this time. Further investigations at the environmental assessment stage may result in changes to this design. Any major changes would be made public as they arise.

4.1 Survey

The ground survey was comprised of four main components:

- An airborne laser scan (ALS) topographical survey.
- A ground survey of specific features (bridge abutments, watercourse spot heights, existing highway road levels).
- A hydrographic survey of the Richmond River bed.
- A cadastral survey of affected land parcels.

This survey work increased the accuracy of the ground survey model to +/- 0.15 m from the 2 m contour model that was available at the preferred route stage.

The more accurate topography and surrounding watercourses level data within the study area was used for:

- Improved highway design accuracy.
- Hydrological modelling of the Richmond River flood events.
- Modelling of catchments for cross drainage.

4.2 Standards

4.2.1 Highway

The design has been developed using the standards listed in **Section 18.1**. Where longitudinal grades are flatter than 0.5%, cross falls and superelevation have been increased to 4% to improve pavement drainage. This would not affect motorist comfort or safety.

4.2.2 Local roads and accesses

The following are the criteria adopted where alterations to local roads are required, either by realignment or in the provision of a crossing.

The reasons for the adoption of the standards noted are based upon the engineering and traffic assessments of the existing roads in relation to the standards noted in **Section 4.2.1** These standards, refer to **Table 4-1**, would be subject to discussion and agreement with the relevant local authorities.

Table 4-1 Adopted local road design criteria for the purpose of concept design*

Road	Design Speed km/h	No/Lane Width m	Shoulder Width m	Verge Width m	Pedestrian Width m[2]
Woodburn Evans Head Road	100	2/3.5	2	2.2	3
Broadwater Service Road	100	2/3.5	2	2.2	-
Broadwater Evans Head Road	80	2/3.5	2	2.2	3
Broadwater Quarry Road Diversion	60	2/3.5	-	1	-
Existing Pacific Highway	90	2/3.5	2	1.5	-
Back Channel Road	30[3]	1/4	-	1	-
Old Bagotville Road	60	2/3	1	1	1.5
Thurgates Lane diversion[1]	60	1/4	-	1	-
Wardell Road	80	2/3.5	2	2.2	3
Lumleys Lane Northern Diversion[1]	60	1/4	-	1	-
Lumleys Lane Southern Diversion[1]	60	1/4	-	1	-
Coolgardie Road	60	2/3.5	2	2.2	3
Whytes Lane	60	2/3.5	2	2.2	1.5
Pimlico Road - Smith Drive	60	2/3.5	2	2.2	1.5

1. Thurgates Lane and Lumleys Lane diversions would also have localised passing bays at 200 m centres.

2. This denotes the width of a pedestrian footpath provided only on bridges, not a constant footpath along the road.

3. The diversion to Back Channel Road provides property access to a single property, therefore 30 km/h design speed has been adopted.

* Subject to final design and agreement with local councils

4.3 Description

The concept design is described in four sections – section A (refer to **Figure 4-1**), section B (refer to **Figure 4-2**), section C (refer to **Figure 4-3**) and section D (refer **Figure 4-4**) from south to north.

An aerial photo-mosaic of the concept design in plan and profile is included in **Appendix A**.

4.3.1 Section A – Iluka Road to Woodburn tie-in to Broadwater National Park

The southern tie-in to the Iluka Road to Woodburn section of the Pacific Highway upgrade occurs approximately 89.7 km north of Grafton. The

Woodburn interchange is located about 360 m south of the tie-in with the Iluka Road to Woodburn project. Concept design of the Woodburn interchange and service roads appears in the *Iluka Road to Woodburn Preferred Concept Design Report* (RTA 2007b). The Woodburn service road connects to a proposed service road on the western side of the Iluka Road to Woodburn upgrade.

At the northern section of the Iluka Road to Woodburn project there is a cutting through the hill where the Woodburn interchange is located. This cutting would be a source of material (approximately 470,000 m^3 of fill) for the proposed Woodburn to Ballina upgrade further to the north.

At the tie-in with the adjoining project the proposed upgrade is west of the existing Pacific Highway. The upgrade crosses the existing highway and heads northeast to cross the Tuckombil Canal on two long curved bridges about 350 m long. The bridge soffits are set at 0.3 m above the 100 year flood level (RL 4.46 m) to meet the minimum hydraulic requirements.

From the Tuckombil Canal the proposed upgrade heads northeast to the Broadwater National Park across the Richmond River floodplain. The need for imported fill has been reduced by adopting a five metre wide median with a wire rope barrier. Future widening to three lanes would occur on the outside of the embankments. The height of the road has been set so that the edge line of the outer lane is set at the 20 year flood level (RL 3.5 m). Median widening on the smaller radii curves (less than 1,150 m) is provided to maintain stopping sight distances. A future third lane would be constructed on the outside and would be below the 20 year ARI flood level in the floodplain.

Elsewhere the median width would be 12 m to allow for inner widening to three lanes.

Viaduct 1, a straight bridge approximately 200 m long (minimum hydraulic opening), is located at the Woodburn drain. Viaduct 1 would be submerged during 100 year floods (RL 4.5 m) and would have about 2.3 m clearance for low vehicle access.

The Woodburn Evans Head Road passes over the proposed upgrade with a minimum clearance of 5.3 m. Providing an overpass minimises potential impacts to the floodplain compared with the proposed upgrade passing over Woodburn Evans Head Road and is also more cost effective. The overpass bridge has two spans with a total length of approximately 50 m.

The proposed upgrade is approximately 250 m west, and Woodburn Evans Head Road overpass is 100 m south, of Rous Water's nearest water bore. A hydrogeological investigation has assessed there would be minimal impact on the Rous Water infrastructure due to the construction and operation of the proposed upgrade.

Between Woodburn Evans Head Road and Broadwater National Park (5.6 km) the proposed upgrade heads north east on embankment set at the 20 year flood level (RL 3.5 m). Approximately 900 m northeast of Woodburn Evans Head Road the alignment cuts the northwest corner of the vegetated private property to minimise the impacts on the swamp sclerophyll forest endangered ecological community.

Viaduct 2, about 180 m north of Woodburn Evans Head Road, crosses a local drain. It is a bridge about 120 m long sized for hydraulic conveyance and is set at the 20 year flood level, meaning it would be submerged in a 100 year ARI flood (RL 4.4 m).

The proposed upgrade cuts through the spur of Lang Hill. The RTA intends to expand this cutting back into the Lang Hill spur, excavating down to an RL of five metres AHD (above the 1 in 100 ARI flood) to win approximately 495,000 m^3 for use as general fill material. The water tanks on the hill would be avoided and visual impacts of the remaining main hill would be minimised, where possible, with appropriate landscaping.

Immediately south of the Broadwater National Park the alignment skirts the western edge of the high and medium quality oxleyan pygmy perch habitat and endangered ecological community areas to the east. McDonalds Creek is crossed by two single bridges, approximately 12 m long (two carriageways), to avoid construction within the waterway and impacts on fish habitat.

The two cross drainage culverts in this area (A10 and A11) for waterways that could be used by oxleyan pygmy perch may be replaced with arch structures to maintain the stream's soil bed if required. The openings of the bridge and cross drainage structures also ensure the maximum 5 year ARI flood velocities would be 0.65 m/s. The project ecologists have advised that a velocity of 1.0 m/s is a limit for safe passage of the oxleyan pygmy perch.

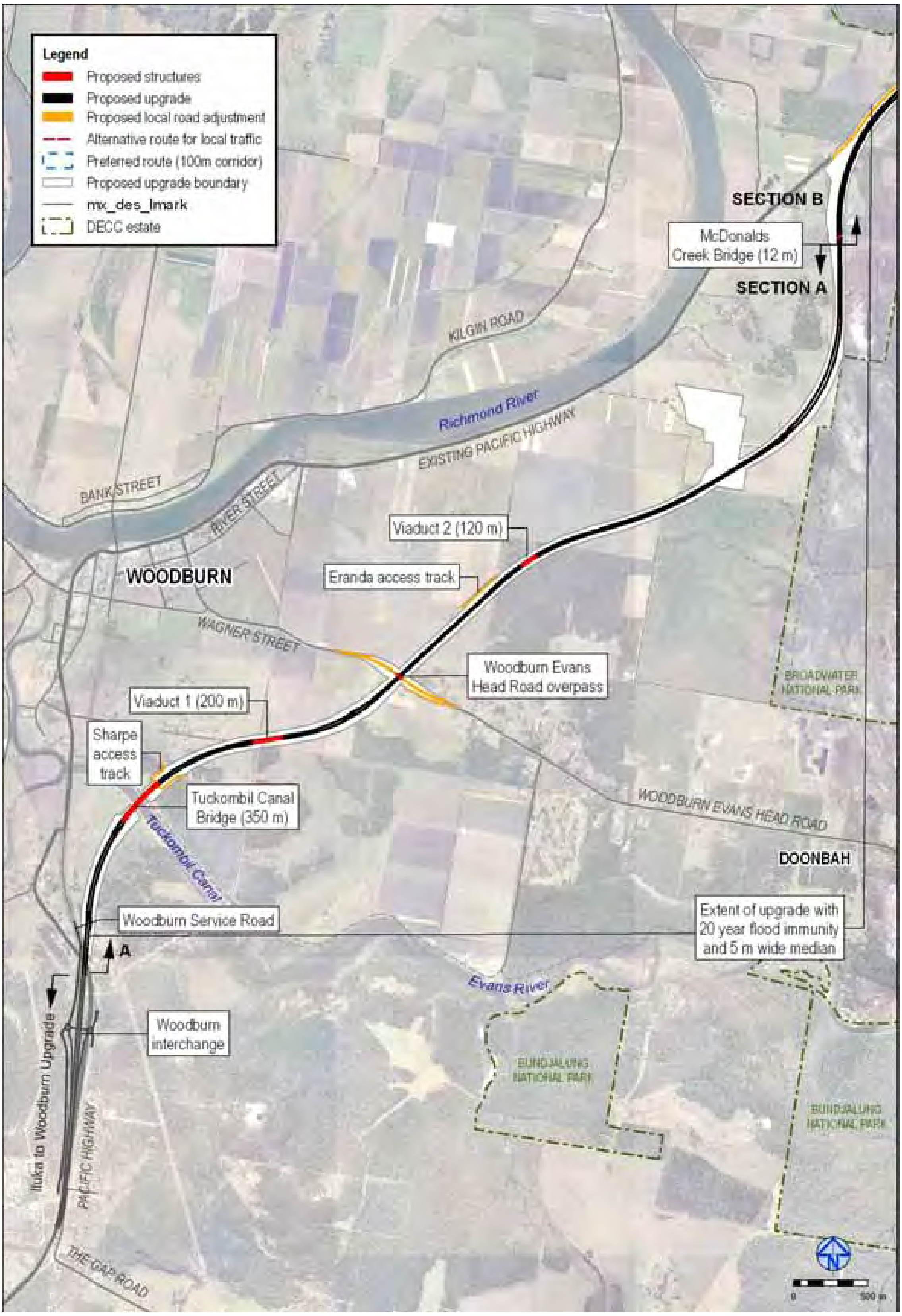

Figure 4-1 The concept design - Section A

4.3.2 Section B - Broadwater National Park to the Richmond River

Broadwater National Park

The alignment utilises the existing Pacific Highway reservation and requires the acquisition of land on the western side of the highway through the Broadwater National Park. The cross section allows for:

- Future widening of the proposed upgrade to three lanes within the median.
- A two way Broadwater service road connecting Woodburn and Broadwater on the western side of the proposed upgrade.

The existing road reserve through the Broadwater National Park is approximately 40 m wide. The proposed upgrade through the national park corridor includes:

- Dual two lane carriageways separated by a 12 m wide median.
- A two lane service road, one lane in each direction, which provides a connection between Broadwater and Woodburn for local traffic.

This cannot be achieved within the existing road reserve and would require acquisition of land from the Broadwater National Park. An Act of Parliament is needed to acquire national park land.

Based on ecological advice and providing value for money the proposed upgrade through the Broadwater National Park comprises:

- Land acquisition for a road corridor approximately 50 - 70 m wide (approximately 14 ha total) from the Broadwater National Park predominantly on the western side of the existing alignment as the vegetation was assessed as being more disturbed from sand mining or clearing than the eastern side.
- Two fauna overpasses of approximately 10 m in width, with approach earthworks (approximately 1.5 ha of the total 14 ha) constructed within the national park.
- Two frog and small mammal underpasses (1.2 m wide by 0.9 m high) near to paperbark swamp and wetland vegetation.
- A possum/glider rope overpass at the northern end of the national park corridor near to vegetation.
- Collection and discharge of proposed upgrade runoff clear of the national park.
- Wetlands at the northern and southern ends of the national park road corridor to treat the proposed upgrade runoff prior to discharge into natural watercourses.
- Vertical grade to be close to existing grade to minimise visual impact on the national park.
- Continuous floppy top and frog fauna fencing to minimise roadkill.

Through the Broadwater National Park the proposed upgrade utilises the existing 2.6 km long road reserve, avoids the former Council night soil depot and higher value endangered ecological community on the eastern side of the existing highway and the Council clay capped landfill site on the western side. The road level generally is elevated to enable cross drainage and disposal of stormwater runoff from the proposed upgrade.

Through Broadwater National Park the road grading has been set close to natural grade to avoid lowering the ground water through cuttings thus reducing the risk of affecting surrounding vegetation. Clay lined swales would collect road run-off and discharge to water quality structures before discharging into areas outside the park.

Two approximately 10 m wide vegetated overpasses are proposed for fauna. The fauna overpasses are located such that the longest distance travelled to cross the upgrade is about 600 m. Fauna overpass 1, is located just to the north of Richmond Valley Council's former night soil depot (600 m north of the Broadwater National Park southern boundary). Fauna overpass 2 is located about 1100 m north of fauna overpass 1 and 700 m south of the Broadwater National Park northern boundary. The extent and location of approach embankments and walls is being negotiated with Department of Environment and Climate Change (DECC).

Two frog and small mammal underpass culverts would provide crossings for frogs and other small fauna. These would be provided where the highway alignment can pass over the underpass structure, are close to suitable habitats and minimise the migration across the proposed upgrade of mosquito fish which are predators of the endangered oxleyan pygmy perch.

Frangible planting would be provided between the proposed upgrade and service road to reduce the problem of headlight glare. Through the Broadwater National Park suitable species for frangible planting include *banksia oblongifolia*, *leptospermum liversidgei*, *lomandra longifolia*, *aotus ericoides* and *baeckea frutescens*.

Broadwater Evans Head Road

North of the Broadwater National Park the proposed upgrade turns northeast on embankment with the edge line of the outer lane set at the 20 year flood level (RL 3.0 m) with a 12 m median. Immediately south of the Broadwater Evans Head Road the proposed upgrade leaves the floodplain and sits generally at grade with a 12 m median. Geotechnical investigations in this area revealed a high water table and pockets of coffee rock which is a potential acid sulphate soil (PASS). The level of the proposed upgrade in this area has been set to avoid exposing coffee rock. If coffee rock were exposed there would be a high risk of affecting surrounding vegetation due to run-off from exposed PASS. This limits the opportunity to lower the proposed upgrade to win fill material from this area.

Broadwater Evans Head Road would pass over the proposed upgrade with a minimum 5.3 m clearance. North facing ramps provide access to the proposed upgrade forming the Broadwater interchange.

The Broadwater Quarry Road diversion, to the east of the proposed upgrade, links Broadwater Evans Head Road to the eastern severed section of Broadwater Quarry Road. The diversion road maximised the use of the cleared land between the property landparcels. Frangible planting would be provided between the proposed upgrade and Broadwater Quarry Road diversion to reduce the problem of headlight glare.

North of Broadwater Quarry Road the proposed upgrade swings around to the east of Cooks Hill avoiding the national park to the east. The road grade has been set above the aquifer to avoid any impacts on the adjacent Broadwater National Park vegetation. Piezometers were installed and monitored to establish the seasonal ground water fluctuations.

Adjacent to Cooks Hill the proposed upgrade threads through the supporting legs of the existing NSW Sugar's conveyor. At this location the conveyor sits on a truss 10 m above existing ground level with columns spaced at 45 m. The proposed upgrade has been located to pass through the 45 m clear span without modifications to the conveyor. At the crossing the conveyor would be encompassed by an overpass structure without median columns. The overpass is to protect the proposed upgrade from conveyor debris and to enable maintenance access without the need to impact operation of the proposed upgrade. The overpass does not connect to or provide support for the conveyor.

North of Cooks Hill the proposed upgrade heads northwest over Viaduct 3, a hydraulically sized bridge approximately 60 m in length, located to reduce localised afflux in a major flood event. Embankment construction extends into the flood plain to the southern abutment of the Richmond River bridge. This abutment was located on Woodburn sand immediately south of the interface with the soft Pimlico clay. The bridge has approximately 10 m clearance over the existing highway on the river's south bank.

Richmond River

The proposed bridge over the Richmond River would be a single structure approximately 25 m wide and about 785 m long. The length of the bridge has been selected to keep the abutments out of the floodplain and soft soils. The width provides for:

- An initial two lane each way arrangement consisting of a 3.0 m outer shoulder, two 3.5 m lanes and a 1.5 m inner shoulder.
- A future three lane each way arrangement consisting of a 0.5 m outer shoulder, three 3.5 m lanes and a 0.5 m inner shoulder.

In the future three lane configuration cyclists would be directed to use the existing Pacific Highway between Broadwater and Wardell.

The Richmond River bridge vertical alignment provides a 15 m navigational clearance over the Mean High Water Springs tide (RL 0.433 m) which was requested by NSW Maritime. This, together with urban design considerations, requires a more complex structure type than the other bridges.

The actual bridge arrangements would be dependent on the construction techniques of the contractor and would comply with a request from NSW Maritime for either one 60 m opening or two 35 m openings over the navigable channel.

The northern abutment of the Richmond River bridge is located on the western side of Laws Hill and has approximately seven metres clearance over Back Channel Road. The abutment has been set back from Back Channel Road to allow fauna access beneath the bridge.

Figure 4-2 The concept design - Section B

4.3.3 Section C - Richmond River to Coolgardie Road

From the Richmond River to Old Bagotville Road the proposed upgrade is aligned to the north west as it descends from Laws Hill. Approximately 350 m north of the Richmond River a cross drainage culvert has been set to three metres in height to provide for movement of large fauna across the proposed upgrade. The height of the culvert controls the vertical grading of the proposed upgrade in this area.

In this section, two rest areas are proposed, one in each direction. Each would have toilets and rest facilities with parking allowed for about 12 B-Double trucks and 26 cars. The rest area footprint and layout is based on the project team's urban designer's draft concept design.

The proposed upgrade, as it passes beneath Old Bagotville Road, avoids Jali Local Aboriginal Land Council land to the west and east and is close to existing surface. Old Bagotville Road would pass over the proposed upgrade with a minimum 5.3 m clearance. A T-junction is proposed to minimise property impacts, with vehicles using Old Bagotville Road required to stop and turn through 90 degrees. Appropriate signposting at the T-intersection would be required to meet the safety requirements for these changed traffic conditions.

North of Old Bagotville Road the proposed upgrade heads east and north towards Thurgates Lane and is located on the western edge of the Wardell heath. To reduce impacts on private properties in this location the proposed upgrade has been aligned as far east as possible without significantly affecting the Wardell heath.

Approximately two kilometres north of Old Bagotville Road, the proposed upgrade is sited on the existing Thurgates Lane for about 500 m. Thurgates Lane would be terminated where it is crossed by the proposed upgrade. Access to properties west of the proposed upgrade that would be severed by the termination of Thurgates Lane would be provided via a parallel service road that connects to Wardell Road, via a re-aligned Hillside Lane. Frangible planting would be provided between the proposed upgrade and the service road to reduce headlight glare

From Thurgates Lane to Wardell Road the proposed upgrade travels generally to the north. An overpass is proposed at Wardell Road with 5.3 m clearance above the upgrade. The realigned Hillside Lane would connect to the Wardell Road diversion north of the Wardell Road overpass.

From Wardell Road to Lumleys Lane the proposed upgrade arcs northeast towards Lumleys Lane. Through this section the proposed upgrade would be on an embankment to allow for numerous drainage crossings beneath the roadway. This allows for local flood water movements from the Blackwall Range to pass beneath the proposed upgrade and enter the Wardell heath.

It is proposed to terminate Lumleys Lane where it would be crossed by the proposed upgrade. A diversion of Lumleys Lane would be provided adjacent to the proposed upgrade on the western side and connects

Lumleys Lane to Wardell Road adjacent to the Wardell Road overpass. The Lumleys Lane diversion provides a safe alternative for cane trucks and farm equipment to access Wardell Road in-lieu of the current unsafe intersection between the western end of Lumleys Lane and Wardell Road. Frangible planting would be provided between the proposed upgrade and Lumleys Lane diversion to reduce the headlight glare.

The alignment of the proposed upgrade as it crosses Lumleys Lane has been selected to avoid an existing land slip to the north and to reduce impacts on vegetation of high ecological value to the south. A 35 m buffer has been allowed between the proposed upgrade and the land slip. On the southern side the terminated Lumleys Lane could be extended west to connect to the severed properties east of the proposed upgrade.

From Lumleys Lane the proposed upgrade skirts the Blackwall Range as it swings around to the north. An approximately 10 m wide fauna overpass is proposed just east of an outcrop of native vegetation. This would maintain a fauna corridor between the Wardell heath to the south and the Coolgardie scrub to the north. The location of the fauna overpass has been selected to:

- Be as close as practical to the established fauna crossing whilst minimising the impact on native vegetation.
- Make use of the elevated land to the north to reduce the footprint of the overpass.

As the proposed upgrade turns to the north it has been located on cleared land as far as is practical to minimise ecological impacts. Cross drainage culverts minimum heights of 1.2 m have been specified in this location to provide a connection for small fauna beneath the proposed upgrade.

Figure 4-3 The concept design - Section C

4.3.4 Section D – Coolgardie Road to Ballina bypass tie in

The proposed upgrade heads north beneath a diversion of Coolgardie Road with a vertical clearance of 5.3 m. North and south facing ramps connect to Coolgardie Road forming the full Wardell interchange. The existing Pacific Highway between Coolgardie Road and Whytes Lane consists of two southbound lanes separated by wire rope barrier from a northbound lane. It is intended to decommission the existing northbound lane and utilise the southbound lanes as a local service road north of Wardell.

From Coolgardie Road to Whytes lane the proposed upgrade would sit as close as possible to the Wardell service road to minimise the impact on vegetation to the west. Approximately 150 m north of Whytes Lane the proposed upgrade rejoins the alignment of the existing Pacific Highway, with the existing pavement to be incorporated into the southbound carriageway of the proposed upgrade. The northbound carriageway would be constructed to the west of the existing highway. The proposed upgrade would be approximately the same level as the existing highway and would be set above the 100 year flood level from Coolgardie Road to Whytes Lane. North of Whytes Lane the proposed upgrade would be raised above the surrounding land to avoid excavation of PASS and would be set no lower than the 20 year ARI flood level.

An overpass is proposed at Whytes Lane.

Connection to the Ballina bypass[2]

The proposed upgrade would connect into the Ballina bypass at the southern abutment of the northbound Duck Creek bridge, and the northern abutment of the southbound Emigrant Creek bridge.

The existing eight metre wide highway bridges over Duck Creek and Emigrant Creek, which are not being replaced as part of the Ballina bypass, would be replaced when this project is constructed. By this stage it is assumed that these bridges would be nearing the end of their design life. The new bridges would be 10.5 m wide and longer than the existing bridges. This lengthening is required to minimise flooding impacts from the raising of the highway as it connects to the Duck Creek bridges. The new southbound Duck Creek bridge would be about 160 m long. The new southbound Emigrant Creek bridge would be about 195 m long.

The northbound bridge over Duck Creek that would be constructed as part of the Ballina bypass would be lengthened by about 50 m at its western end

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[2] Connection to the Ballina bypass described here is based on the Ballina bypass improved concept design displayed in June 2007. The bypass project is subject to refinement as part of detailed design currently being undertaken. Refinements in this area could affect the connection to the Woodburn to Ballina project. Any refinements to the Ballina bypass would be made available to the public once they have been finalised.

to minimise flooding impacts from the raising of the highway as it connects to the Duck Creek bridges.

The at-grade connection between Pimlico Road and the Pacific Highway would be closed. Pimlico Road would be connected to Smith Drive by a new bridge approximately 220 m long across Duck and Emigrant creeks. This bridge would provide alternative local access from Wardell to Ballina.

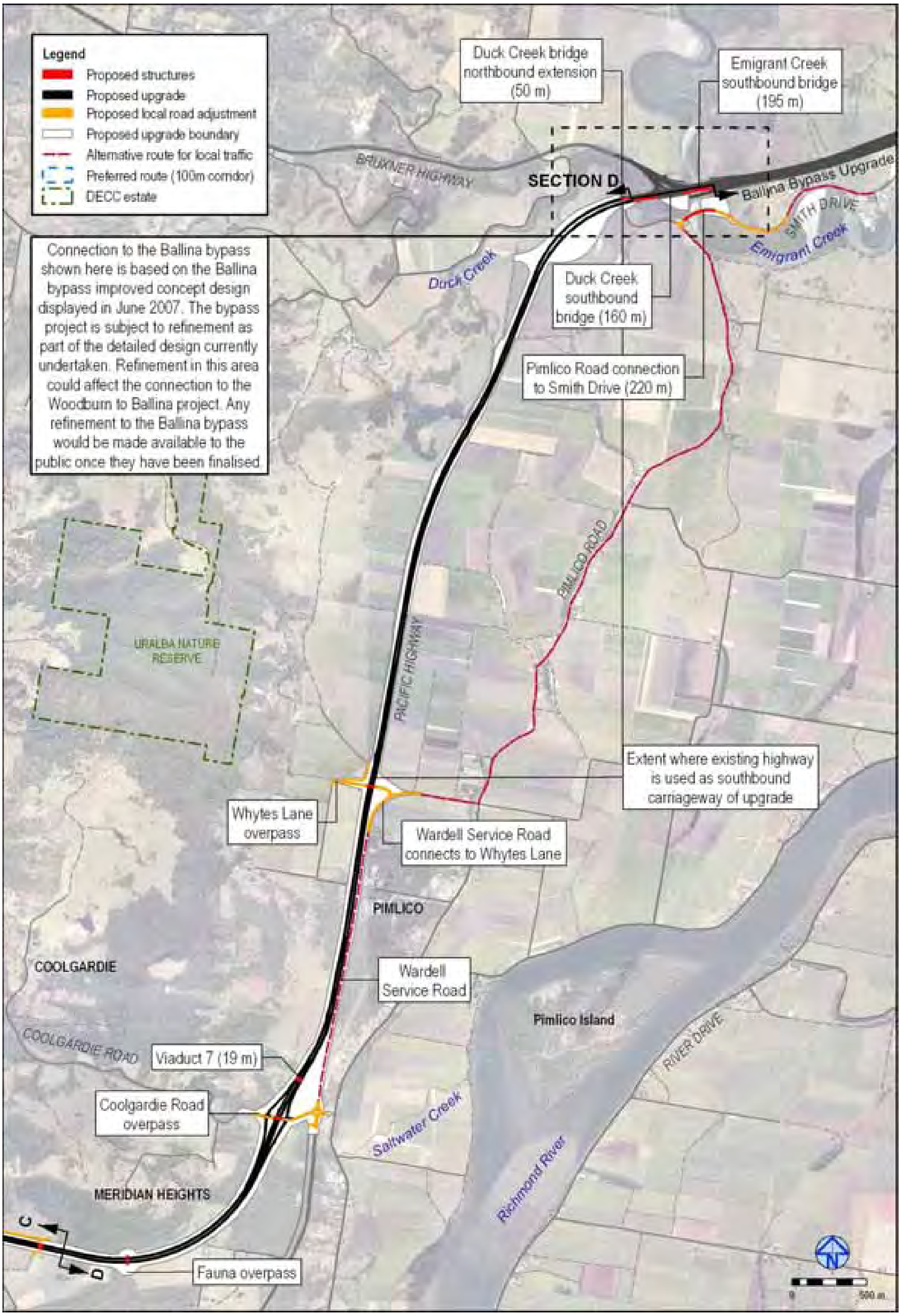

Figure 4-4 The concept design - Section D

4.4 Safety barriers

Safety barriers have been located in accordance with the following documents:

- Upgrading the Pacific Highway Design Guidelines (UPHDG, 2005).
- RTA Road Design Guide (RDG).
- RTA Standard Drawings.

In general, preference has been given to wire rope barriers in place of W-beam guardrails as they provide a similar safety outcome but are cheaper to install and maintain.

General principles for the location and use of safety barriers are set out below:

- Where the median width is less than 11.0 m a wire rope barrier would be used, located generally at one side of the median rather than down the centre, and shifted to suit sight distance requirements where necessary on curves. The wire rope barrier would be located a minimum of 1.7 m from the through lane in accordance with UPHDG Figure 5.
- Where an embankment batter slope is 1 in 4 or flatter, no safety barrier has been used at the top of the embankment as the embankment batter is assumed to be traversable.
- On the approach to bridges where safety barriers are not required to protect vehicles from an unsafe embankment slope, and in cuttings, guardrails would be connected to the bridge parapet to protect vehicles from the leading edge of the bridge parapet.
- Where an embankment batter slope is steeper than 1 in 4, a wire rope barrier has been used at the top of the embankment.
  - On the approach to bridges where wire rope barriers are used at the top of embankments, the bridge barrier would be extended out from the bridge and the wire rope barrier terminates in front of the Type F barrier with an appropriate amount of overlap.
  - Similarly, on departure from bridges, the bridge barrier would be extended out beyond the bridge and the wire rope barrier starts from behind the Type F barrier.
  - Recent experience of the RTA and preference from an urban design point of view has dictated that the interfaces between wire rope barriers and bridge barriers described above are the current preferred arrangements.
- W-beam guardrails would be used to protect bridge piers, with leading terminals, a section of straight guardrail, and then a trailing terminal on the departure side of the bridge pier.

- Where guardrail is required on bridge approaches and fill embankments, the RTA have specified that a maximum shoulder width of 3.0 m should be adopted

5 Hydrology

Hydrology investigations have been undertaken in two phases:

- The Richmond River floodplain.
- The Duck Creek and Emigrant Creek floodplain.

The investigations were separated because the connection of this project with the Ballina bypass relied upon flood investigation modelling undertaken for the Ballina bypass.

5.1 Richmond River floodplain

The proposed upgrade for Woodburn to Ballina incorporates significant capital works that would be required to mitigate the impact of the proposed upgrade on flooding within the Richmond River floodplain. These would include:

- Viaducts and culverts to allow flood water to pass beneath the proposed upgrade to link the different zones of the floodplain. This would reduce the possible loss of flood storage.
- Bridges across Tuckombil Canal, the Richmond River and other minor creeks.

The floodplain modelling for the proposed upgrade has used a more detailed terrain surface digital elevation model (DEM) than that used for the development of the route options, and includes additional survey sources. The additional data has improved flood modelling when compared to the prior modelling and provides a more accurate base from which to optimise the flood mitigation measures for the proposed upgrade.

Overall, the concept design achieves a 20 year average recurrence interval (ARI) flood immunity. The route alignment also meets the allowable afflux design criteria for the Pacific Highway Upgrade Program and does not extend inundation times within surrounding low-lying areas for both small and large ARI storms.

5.1.1 Design criteria

The design criteria for the concept design are:

- Limit afflux in the 100 year ARI as a result of the Pacific Highway upgrade to a maximum of 50 mm in towns and 100 mm in rural areas.
- Provide a minimum flood immunity of the 20 year ARI on both carriageways.
- Ensure inundation times are not significantly extended for floods.
- Minimise alteration to existing flooding behaviour and river tidal regimes.

5.1.2 Data sources

- A variety of data sources were used in assembling the hydraulic model, these are listed in **Section 18.3**.

Digital elevation model

A digital elevation model (DEM) of the Richmond River floodplain and surrounds was produced to model the effect of the proposed upgrade on flooding.

For the concept design a 60 m DEM grid size was utilised, which better resolved the key hydraulic features such as major roads and the proposed upgrade alignment, whilst providing manageable model run-times given the large number of iterations. This is particularly critical around Woodburn, where the route crosses the floodplain.

5.1.3 Proposed floodplain works

The stormwater management mitigation capital works included in the proposed upgrade within the Richmond River floodplain are shown in **Figure 5-1** and **Figure 5-2**, and include:

Woodburn

- 350 m bridge across Tuckombil Canal.
- 200 m viaduct at the Woodburn drain.
- 120 m of viaduct approximately 1.1 km north of the Evans Head Road overpass in an existing low lying area to allow connectivity to flood storage areas.
- Two 3.6 m wide x 1.5 m high box culverts north of Tuckombil Canal, but south of the Woodburn drain.
- Three 3.3 m wide x 0.9 m high box culverts south of the Woodburn Evans Head Road.

Broadwater

- 60 m viaduct prior to crossing the Richmond River across existing drain.
- 785 m bridge across Richmond River[3].

West of Wardell

- Various cross drainage structures allow surface flows from the Blackwall Range to cross beneath the proposed upgrade into the

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[3] This is greater then the minimum hydraulic requirement of 750 m due to the soft soil conditions on the south bank of the Richmond River.

Wardell heath to the southeast, and also allow rising floodwater in the Richmond River to flow from the river in the east to the western side of the proposed upgrade.

North of Wardell

- The proposed upgrade follows the existing Pacific Highway alignment in this area. As such, all cross drainage provided would be as per existing conditions.

Refer to **Section 5.2** for details of structures in the Duck Creek and Emigrant Creek catchments.

The above list refers to cross drainage elements that form part of the flood alleviation and management works on the project. There are numerous other elements to provide cross drainage for local farm drains and minor creeks that are not listed here.

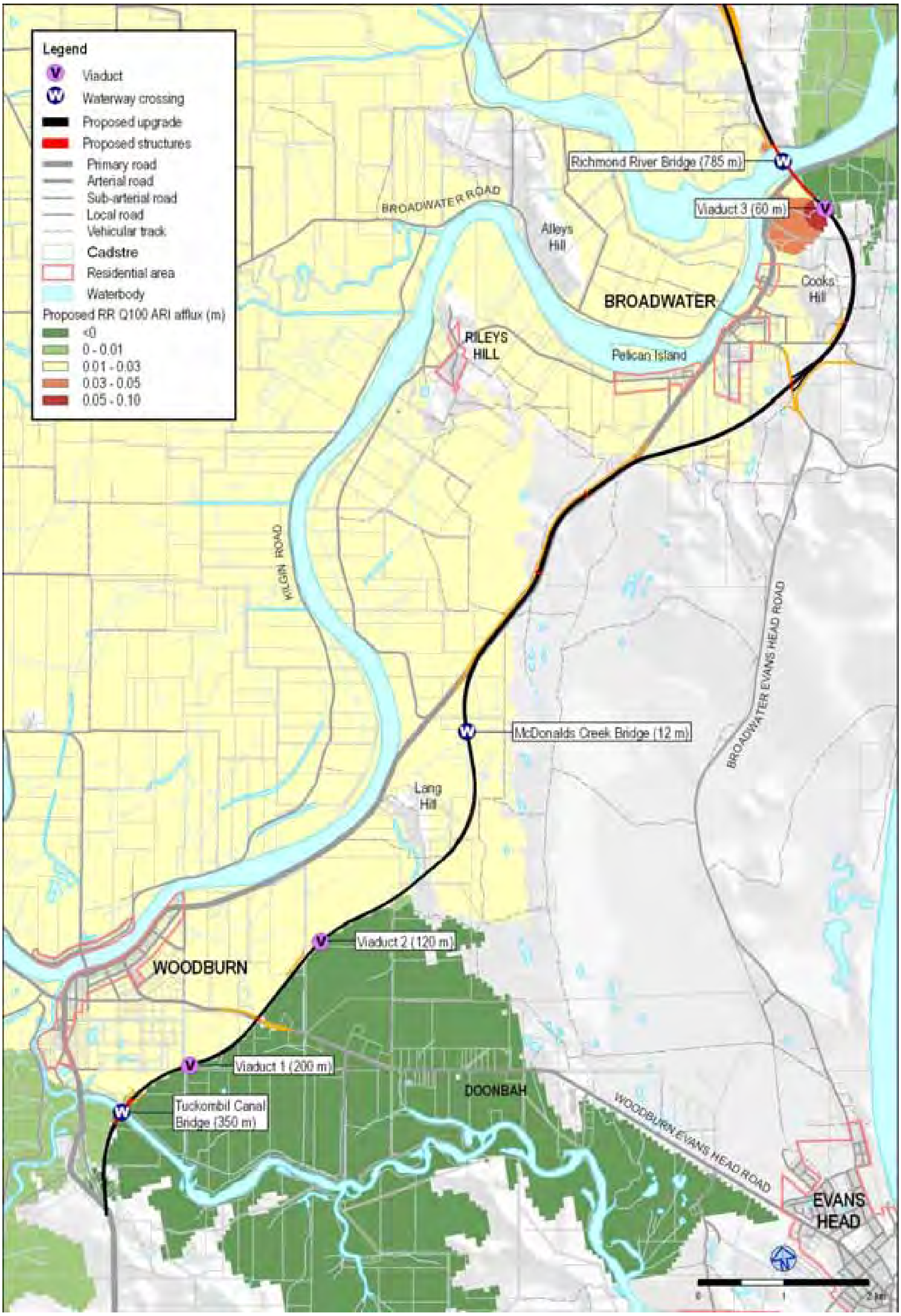

Figure 5-1 South of Richmond River afflux and flood mitigation structures

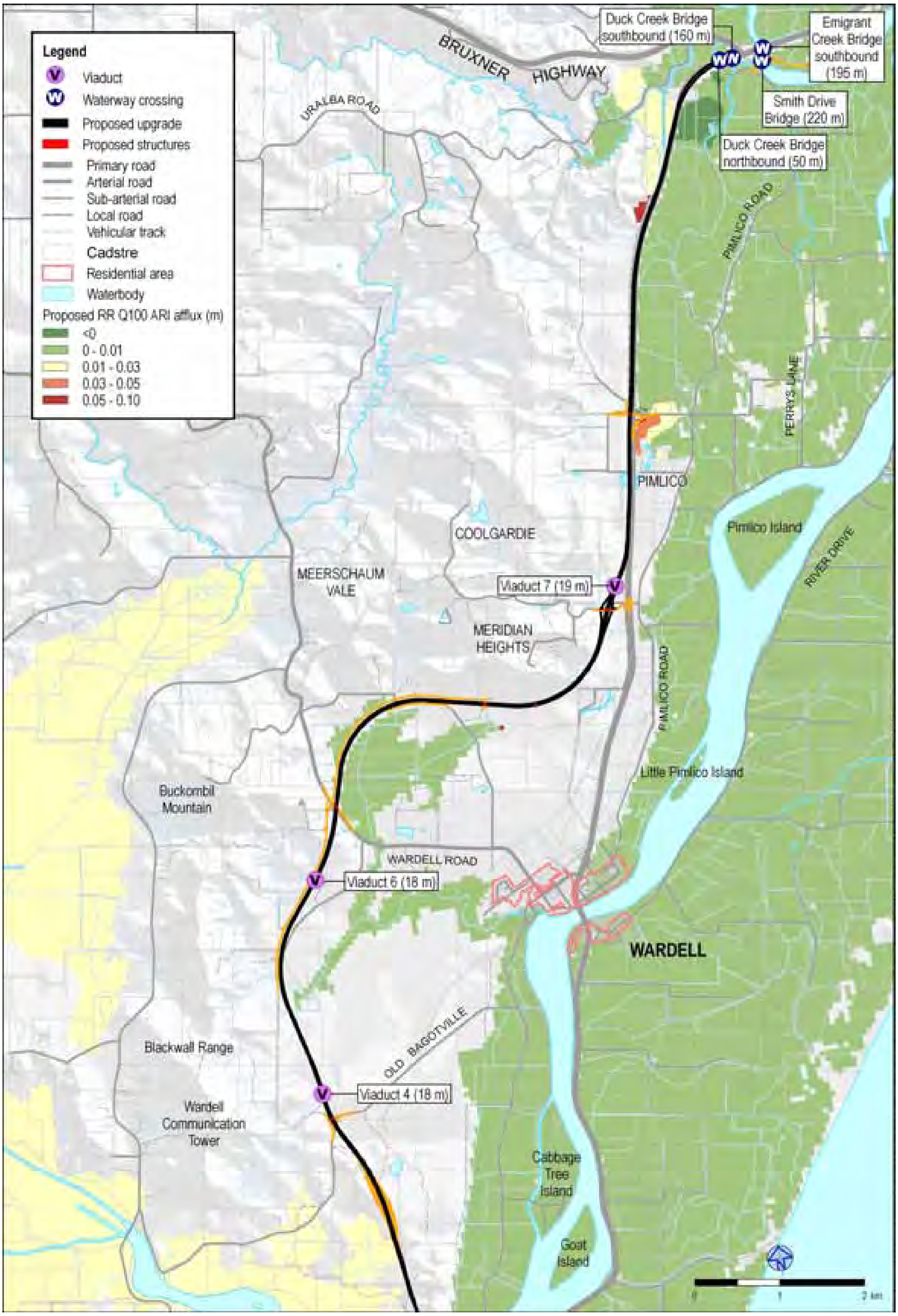

Figure 5-2 North of Richmond River afflux and flood mitigation structures

5.1.4 Hydraulic modelling results

Peak flood level differences

Flood level differences resulting from the concept design for the 5, 20 and 100 year ARI 72 hour duration storm were investigated. From the investigation it was found that the expected afflux is minimal for all storms, with the 20 year ARI flood having the highest resulting afflux at Woodburn, this being 40 mm. In the 100 year ARI flood, the impacts at Woodburn are restricted to 20 mm. All afflux estimated by the modelling is within the 50 mm allowable afflux criteria for urban areas.

Near the Richmond River bridge crossing at Broadwater a localised area would experience flood level increases of up to 75 mm in the 100 year ARI flood. This is not in an urban area and therefore meets the 100 mm afflux design criteria for non-urban areas. Except for this single localised impact, the afflux in non-urban areas would be 50mm or less.

The SOBEK modelling estimated that the highest afflux impacts occur for the 20 year ARI flood, but these impacts remain within the project design criteria. This is expected, given that during larger storms the proposed upgrade provides weir flow in addition to conveyance through viaducts and culverts. While for the 20 year ARI, flow would be constricted through the available openings in the proposed upgrade (e.g. viaducts, culverts and bridges).

For the 5 year ARI flood impacts are minimal, being generally less than 10 mm at Woodburn and less than 1 mm at other locations in the floodplain.

Flow velocity & influence on floodplain behaviour

Due to the overtopping of the proposed upgrade during the 100 year ARI flood there would be little impact on floodplain velocities. Most of the proposed upgrade adjacent to Woodburn would experience a maximum flow velocity of <0.5 m/s. A higher velocity of 1.55 m/s would be experienced adjacent to the eastern embankment of the proposed Tuckombil Canal bridge, which is considered an acceptable velocity that would not cause scour.

Floodplain inundation time

Particular consideration was given to the effect of inundation on sugar cane crops, which can have their quality affected in low ARI flood events with long inundation times, when combined with high temperature.

Existing inundation times vary in different parts of the floodplain, with inundation times upstream generally being greater than those downstream. The approximate 100 year ARI flood (for the existing floodplain, i.e. without the proposed upgrade) inundation times for Coraki, Woodburn, Broadwater and Wardell are 120 hours, 65 hours, 55 hours and 35 hours respectively.

A number of history stations were created in the flood model at various locations throughout the floodplain. These history stations are points in a flood model that record the water level at regular intervals during a modelling cycle. These were used to plot water depth against duration for the 100 and 5 year ARI floods.

The results from the modelling show that differences in duration of flooding are minimal when compared to existing conditions. Generally, the difference in inundation time is a matter of a few hours and the maximum equates to less than 5% of the overall inundation time. It is therefore considered the proposed upgrade would have no appreciable difference to the existing flood inundation regime.

Viaduct hydraulics

Within the Richmond River floodplain the viaducts have been designed to provide the proposed upgrade with flood immunity for the 20 year ARI flood and allow the 100 year ARI flood to overtop the highway. The soffits of the viaducts are located below the 20 year ARI flood level. All existing terrain under the viaduct areas would be excavated to achieve the minimum clearance level required from the hydraulic modelling. An additional 300 mm of excavation would allow for sediment and debris accumulation over time.

Impact on urban areas

As part of the flood study, dwelling floor heights from the towns of Woodburn, Broadwater, Cabbage Tree Island and Wardell have been obtained from local authorities and additional survey of homesteads in rural areas for this study. **Table 5-1** shows the number of dwellings expected to be inundated above habitable floor level in a 100 year ARI flood for existing conditions and for the proposed upgrade.

In total, 390 dwellings are expected to be inundated above habitable floor level in a 100 year ARI flood. A total of five additional dwellings would be flooded above floor level as a result of the proposed upgrade. Two of those dwellings in Wardell would already be classified as being at the flood level, as the residual flood level (i.e. the difference between the flood level and floor level) was only increased 1-4 mm at those locations. In Broadwater the residual increase was 12 mm and in Woodburn 18 mm. In all four cases wave action is likely to inundate the dwellings for existing conditions.

Table 5-1 Numbers of dwellings subject to inundation

Location	No. of dwellings surveyed	No. subject to over-floor flooding in existing 100Y ARI	No subject to over-floor flooding in proposed upgrade
Woodburn	274	100	101
Broadwater	166	99	100
Cabbage Tree Island	32	7	7
Wardell	121	33	35
Rural properties	453	151	152

Environmental issues associated with flooding

The proposed upgrade does not adversely affect flow regimes throughout the Richmond River. Tidal flows and conveyance during small storms would not be restricted. In addition, there is little change in inundation times on the floodplain and in flood inundation depth. Soil erosion potential within the river and floodplain is unlikely to change significantly as a result of the proposed upgrade. However, some localised increases in velocity are expected around structures, which could be mitigated by utilising appropriate stabilisation works at the inlet and outlet of those structures.

5.2 The Duck Creek and Emigrant Creek floodplain

A two-dimensional hydraulic model of the Richmond River floodplain between Pimlico Island in the south and Ross Lane in the north has been developed. This two-dimensional model is nested within a broader one-dimensional model, which extends south to Broadwater. The hydraulic model comprises one-dimensional representations of local creeks and channels coupled with a two-dimensional grid representation of the Richmond River and associated floodplain. Flooding has been simulated using the hydraulic package TUFLOW.

Only the 100 year ARI local catchment dominated flood event has been investigated. This event has a critical duration of 12 hours.

Rainfall input and ocean storm surge boundary conditions remain unchanged from those used for the Ballina bypass.

5.2.1 Hydraulic modelling results

The adopted model for the Ballina bypass improved concept design (as displayed in June 2007) has been used, with the addition of the components comprising the proposed Woodburn to Ballina upgrade. A series of simulations were then undertaken to optimise the size and efficiency of the bridges and culverts to ensure the design criteria were satisfied, refer to **Table 5-2** for details of the structures.

Culvert locations were selected to coincide with drainage canals where the highest flow magnitudes cross the existing Pacific Highway. These locations also coincide with the alignment of existing drainage canals. The bottom 200 mm of all culverts is assumed blocked to account for siltation.

Note that all impacts shown are combined Ballina bypass and Woodburn to Ballina impacts.

This investigation has shown that with the provision of appropriate drainage infrastructure, adverse flooding impacts can be kept within the design criteria as outlined in **Section 5.1.1** The inclusion of the proposed Woodburn to Ballina upgrade into the Ballina bypass flood modelling, with drainage structures listed in **Table 5-2**, does not adversely impact on the Ballina bypass flood levels, refer to **Figure 5-3**. In addition, this investigation has shown that the design criterion of a maximum increase in flooding of 50 mm, regardless of land-use, can be achieved throughout the this section of the proposed upgrade.

Table 5-2 Waterway openings around the Duck and Emigrant Creek catchments

Road	Start station m	End station m	Bridge length m	Culvert details	Approx invert upstream m AHD	Approx invert downstream m AHD	Assumed minimum obvert m AHD	Comments
Proposed upgrade	125,495	125,690	195		-4.00		3.70 (Above FL)	New bridge adjacent existing Emigrant Creek South bridge.
Proposed upgrade	125,050	125,258	208 (N) 160 (S)		-2.40		2.4 (Above FL)	Total length (being extended west 50 m from the 158 m and 110 m specified for Ballina bypass) with floodplain excavation to 0.75 m AHD under new construction only.
Proposed upgrade	124,860	124,860		7/2.1W x 0.9H	0.00	0.00		Increased size and raised inverts since Ballina bypass scheme.
Proposed upgrade	124,650	124,650		11/2.7W x 0.9H	0.00	0.00		Increased size and raised inverts since Ballina bypass scheme.
Proposed upgrade	124,100	124,100		11/1.2W x 0.9H	0.00	0.00		New culverts.
Proposed upgrade	123,780	123,780		5/1.05 Dia	-0.60	-0.45		Remove floodgates on existing culverts and lengthen to suit new carriageway.
Pimlico Road - Smith Drive			220				> 100yr ARI	

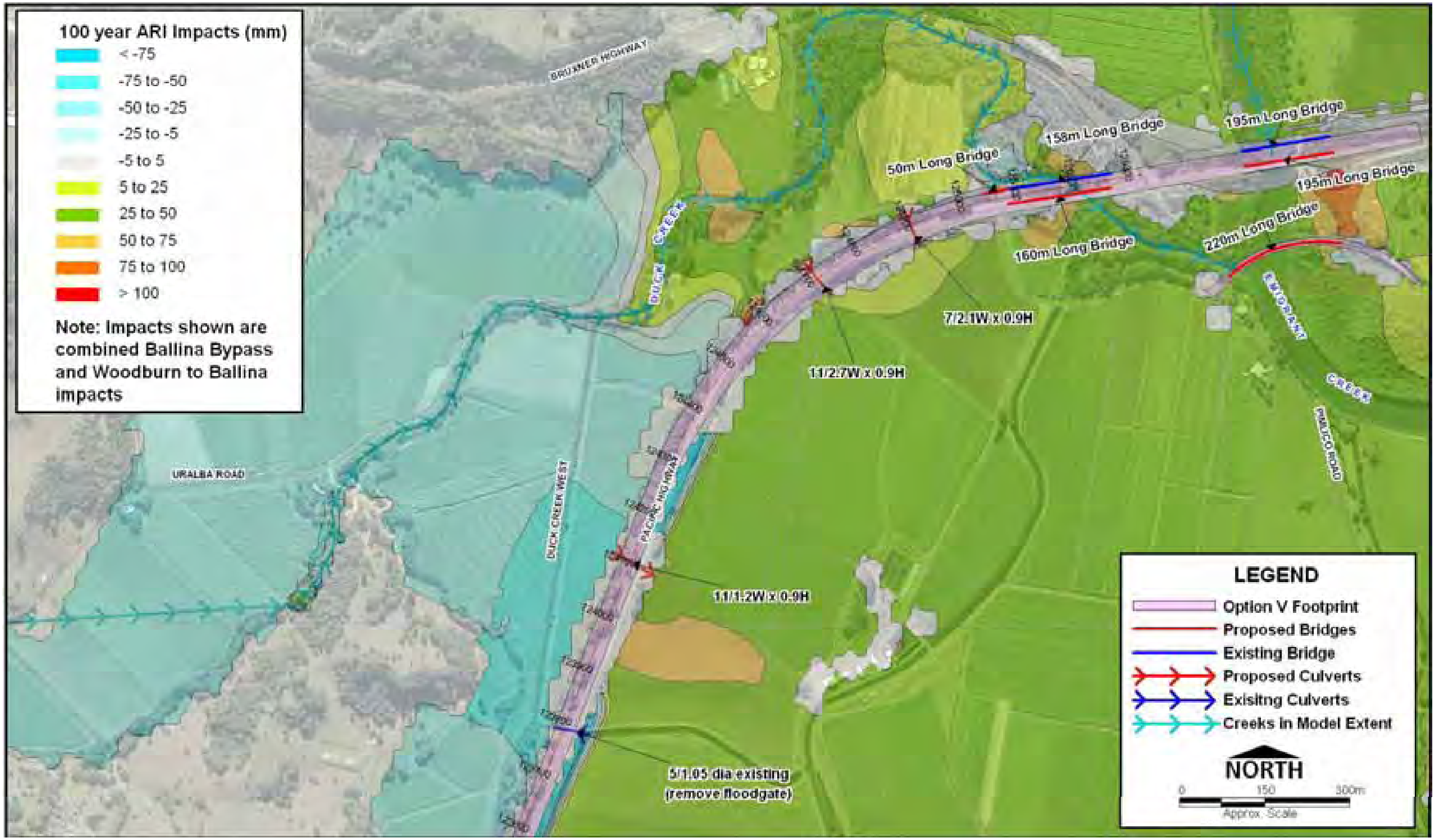

Figure 5-3 Duck Creek hydraulic model results 100 year ARI peak flood impacts (mm)

6 Drainage

6.1 Context

The proposed upgrade drainage has been adopted in response to local features and topography.

South of Woodburn Evans Head Road the proposed upgrade crosses the major floodway of the Tuckombil Canal. The Richmond River floodplain is very flat and traversed by numerous farm drains. The proposed upgrade has a flat longitudinal grade in the floodplain to act as a weir, with openings to pass major flood flows. In flood events greater than a 20 year ARI flood the proposed upgrade would be overtopped.

Adjacent to Woodburn Evans Head Road the proposed upgrade passes close to Rous Water drinking water supply borefields, which require protection from pollutants.

South of the Broadwater National Park at McDonalds Creek, the proposed upgrade abuts the habitat of the endangered oxleyan pygmy perch which needs protection from surface runoff.

Through the Broadwater National Park drainage design has been driven by the need to drain surface runoff out of the park to the south and the north. Further north around the west of Cooks Hill, the drainage accommodates numerous watercourses crossing the proposed upgrade.

North of the Richmond River the topography is higher and more varied, with a substantial number of drainage lines, creeks and local floodways crossing the line of the proposed upgrade. To the west and south of the proposed upgrade in this area the Wardell heath is a substantial area of vegetation that is sensitive to hydrogeological changes.

To the north of Wardell the route rejoins the line of the existing highway. North of Whytes Lane substantial farm drainage canals run parallel to the existing highway, requiring protection from surface runoff and spills.

6.2 Design considerations

Drainage features for the proposed upgrade have been developed considering:

- Pavement drainage (see **Section 6.3**).
- Water quality (see **Section 6.4**)
- Cross drainage. (see **Section 6.5**)
- Subsurface drainage (see **Section 6.6**)
- Temporary drainage (see **Section 6.7**)
- Erosion and sediment control (see **Section 6.8**)

- Scour protection (see **Section 6.9**)

Design has been carried out in accordance with the documents listed in **Section 18.8**.

6.3 Pavement drainage

The pavement drainage system consists of series of swales, pits, pipes etc to convey water away from the road pavement to be discharged into existing drainage channels adjacent to the proposed upgrade.

The design criteria adopted for pavement drainage and water quality are from *Upgrading the Pacific Highway Design Guidelines* (UPHDG 2005)

Design assumptions for the pavement drainage include:

- 50 % blockage for all sag pits, for the 10 year ARI pavement design. This was adopted from the RTA RDG Section 7.17.3.5 (7).
- Adoption of a 30% blockage for all on-grade pits.
- Pit inlet capacities are based on the approach flow or depth of ponding.
- 5 minute time of concentration for each road catchment.
- 1 minute overland flow time for gutter flow between each pit.
- 0.1% minimum grade on overland flow paths.
- The road pavement catchments (including proposed upgrade pavements, medians and berms) are 90% impervious.

6.3.1 Pavement drainage system

The pavement drainage has been provided in the form of traditional pits, pipes, gutters, and swales. The general pavement drainage design has been undertaken to ensure that pavement drainage is separated from the cross drainage to facilitate stormwater treatment.

Where possible the pavement drainage design consists of a kerb-less drainage system. In fill areas, runoff from traffic lanes would be allowed to sheet flow from the pavement across the verge and down the batter slopes, into swales that convey the runoff to the nearest cross drainage water quality treatment point. Runoff from grassed median areas would be collected by a pit and pipe system and directed to swales via pipes crossing under the roadway.

In fill areas where the road grade is greater than 0.5%, overland flows in the median would flow to a downstream sag point, where stormwater would pond and enter the pipe drainage system. The drainage system at these sags is designed to a 100 year ARI standard. In areas of zero longitudinal grade, all median pits would be sag pits with localised low points every 100 m.

In cut areas, SO kerb and SO type pits would be used, with longitudinal pipe lines to convey runoff from the cutting to the nearest discharge point. Depending on the length of the cut, a water quality/spill basin may be provided where the drainage system discharges from the cutting.

6.4 Water quality

Water quality modelling has been carried out to assess impacts on discharged and receiving water quality due to the proposed upgrade. Water quality treatment systems are used to manage stormwater discharge quality.

Pollutant generation and treatment efficiencies were modelled using the MUSIC package developed by the Cooperative Research Council for Catchment Hydrology. The model was developed using default source node pollutant generation, along with treatment devices such as buffer strips, swales, and bio-retention ponds.

Design assumptions adopted were:

- The rainfall record from Coffs Harbour MO Station 59040 was chosen rather than that from Ballina or Broadwater Sugar Mill, as the period of record at both these locations was too short. The Bureau of Meteorology records show that the average annual rainfall for Coffs Harbour MO is 1677 mm, for Ballina is 1654 mm and for Broadwater is 1483 mm. There is therefore a strong correlation between the average rainfall at Coffs Harbour and Ballina. Where MUSIC was used to model water quality improvement, rainfall from Coffs Harbour Station 59040 was used, from 1970 to 1993 at a 6 hour interval (mean annual rainfall 1539 mm). This mean annual rainfall is between that of Ballina and Broadwater, and is therefore representative of the catchment as a whole.

  The use of a longer record rather than the use of a single average year offers the advantage of modelling years with higher and lower than average rainfall. Sensitivity tests undertaken in MUSIC on pollutant removal efficiency for different periods of rainfall for Coffs Harbour showed that there was a negligible difference between modelling using the 1960-1993 with a 6-minute time step and using the 1970-1993 with a 6-hour time step, so the record 1970-1993 was used to keep model run time manageable.
- Monthly evaporation from Coffs Harbour was used.
- No blockage factor for the design of stormwater quality treatment devices, i.e. 1 year ARI.
- Actual impervious percentage was used rather than effective impervious percentage, resulting in conservative outcomes for pond sizing and removal efficiencies.

6.4.1 Design approach

Where required to protect sensitive environments, the downstream end of swales required for the pavement drainage would be formed into a small water quality basin. This would provide final treatment of the runoff and spill management before the water is discharged. These buffer areas and swales form an integral part of the water treatment train. The buffers and swales strip nutrients and suspended solids from the runoff, and the swales provide conveyance area for flows and storage area and treatment for spills.

6.4.2 Existing agricultural drains north of Wardell

There are two existing agricultural drainage channels running on the east and west sides of the proposed upgrade from Whytes Lane to Duck Creek. It is proposed the channels would remain in their current locations. Both channels would receive pavement runoff that has passed across a buffer strip created by the batters, and has been conveyed through swales at the base of each batter to water quality basins prior to discharge to the drains.

6.4.3 Pavement drainage and water quality in the Broadwater National Park

The existing Pacific Highway does not have any runoff treatment controls. All pavement runoff drains directly into the Broadwater National Park.

The proposed upgrade follows essentially the same corridor through the national park as the existing highway, but would initially include a four lane highway upgrade plus a two lane service road on the western side of the upgrade. The design would include an allowance for future widening of the highway from four to six lanes in the median. As a result of this increase in area of the proposed upgrade's footprint, a larger volume of runoff would be produced as well as a greater pollutant load.

The objectives for the drainage and water quality of the proposed upgrade in this area are to:

- Maintain post upgrade peak flow rates to levels below or equal to the peak flow rates from the existing highway.
- Provide neutral or beneficial effect on the runoff water quality when compared to the existing highway.

Modelling of both the existing highway and the proposed upgrade was undertaken to model pollutant loads and stormwater runoff flow rates.

Typically, the pollutants that are likely to be present in highway drainage are: sediments; hydrocarbons; metals; microbials; and other contaminants. Event mean concentration values of nutrients and suspended solids have been developed for Australian roads and these values have been used to assess the quality of runoff from the proposed upgrade.

The pollutants modelled include total suspended solids, total nitrogen, and total phosphorus. Other road pollutants such as metals were not modelled due to insufficient data on event mean concentrations. Instead reliance is made on the removal effectiveness of total suspended solids to indicate how the proposed treatment measures would perform for other road pollutants. The suspended solids load would contain most of the other pollutants found in road runoff through a binding process to the soil particles that make up the suspended solids load.

6.4.4 Broadwater National Park strategy

A swale and wetland strategy was developed for the drainage and water quality through the Broadwater National Park corridor. This strategy was assessed in terms of its performance against:

- Providing a neutral or beneficial effect on Broadwater National Park and McDonalds Creek water quality.
- Minimising required land impact on the Broadwater National Park.
- Providing spill containment.
- Maximising the use of natural drainage and treatment strategies.
- Protecting the oxleyan pygmy perch population in the watercourses to the south of the Broadwater National Park.
- Value for money.

The use of swales instead of a piped system allows pavement runoff to be drained to each end of the Broadwater National Park without requiring an excessively raised highway.

The swales drain to wetlands at either end of the park which, together with the swales, provides treatment and spill containment for the pavement runoff before it enters natural watercourses. In addition to reducing pollutants, the wetlands also provide on-site detention storage for stormwater runoff.

6.5 Cross drainage

The cross drainage structures include all bridges, box culverts and concrete pipes that drain existing catchments and discharge points that would naturally cross the proposed upgrade. The sizes of these structures have been determined considering:

- Hydraulic performance.
- Requirements for fauna crossings.
- NSW DPI Fisheries requirements for fish friendly structures.

The design criteria in “Upgrading the Pacific Highway beyond 2006: Design Guidelines” (UPHDG 2005) were adopted for cross drainage elements.

6.5.1 Culverts and bridges blockage factors

The size of each structure was determined in accordance with UPHDG and using a 50% blockage factor (current industry standard). With the blockage, each structure was sized such that ponding was allowed to occur to the road shoulder (approximately 600 mm above the culverts obvert in the 100 year ARI flood).

Where possible the culvert sizes have been optimised to ensure exit velocities do not exceed 2.5 m/s during the 100 year ARI design storm.

A minimum debris clearance of 0.3 m from the 100 year ARI flood level to the underside of bridges across the main channel was allowed for all bridges except Viaduct 1 and 2 which would be submerged in a 100 year ARI flood.

6.5.2 McDonalds Creek and oxleyan pygmy perch

The physical impact of the proposed upgrade on the habitat of the oxleyan pygmy perch in McDonalds Creek was mitigated by the alignment change from the preferred route described in **Section 2.2.5.** In addition, the project ecologists advised that oxleyan pygmy perch cannot swim against flow velocities greater than 1.0 m/s. Therefore it was necessary to ensure the proposed upgrade did not result in increased flow velocities in McDonalds Creek in regular storm events otherwise the oxleyan pygmy perch would be swept downstream to the Richmond River where they cannot survive.

At McDonalds Creek the 5 year ARI storm was modelled with the proposed upgrade to assess the impact on the oxleyan pygmy perch.

The major crossing of McDonalds Creek consists of a 10 m wide plank bridge. For a 5 year ARI, storm velocities of up to 0.65 m/s were estimated for this structure, which is considered acceptable for the protection of the oxleyan pygmy perch. Refer to **Figure 6-1** for flow velocities.

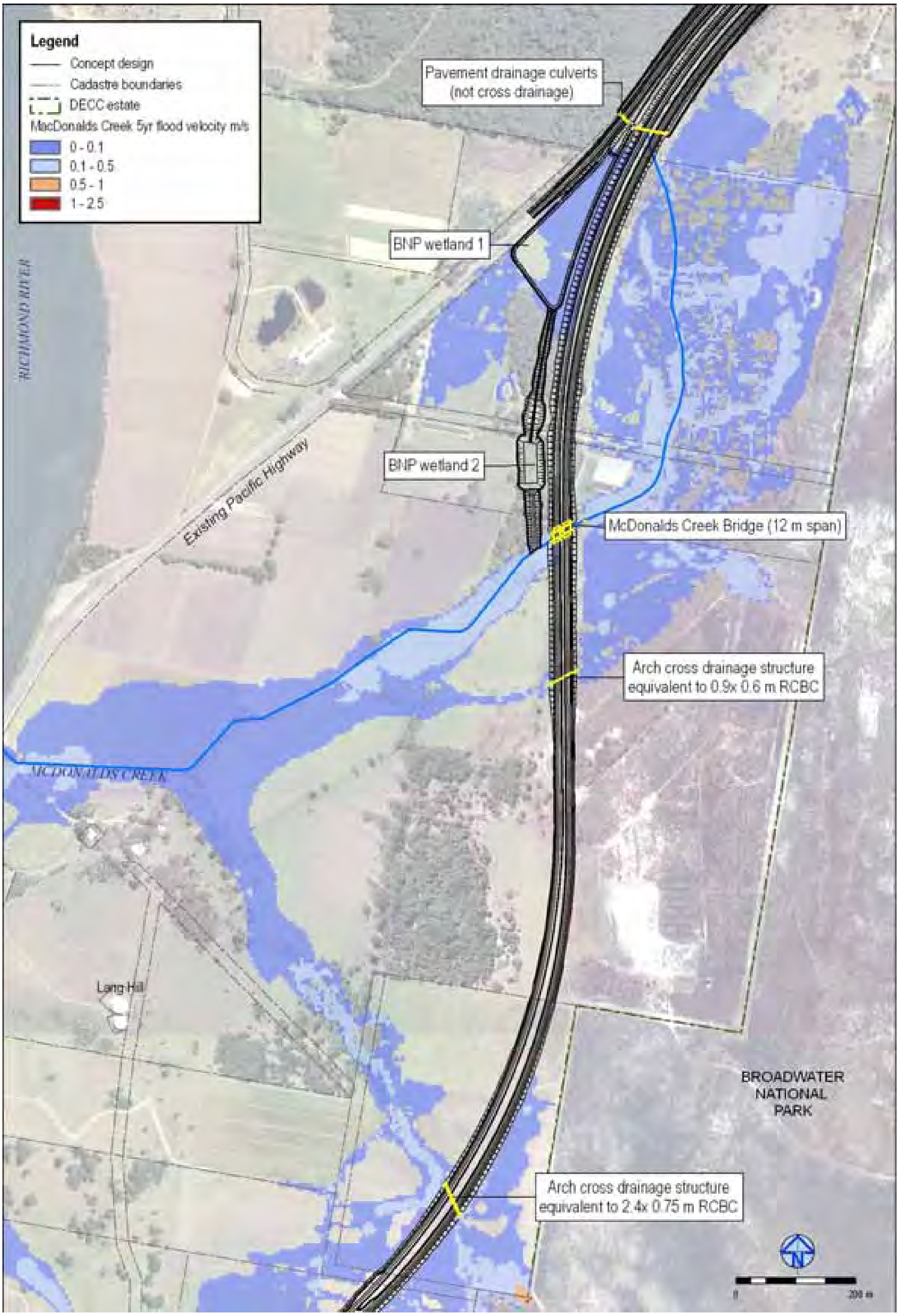

Figure 6-1 McDonalds Creek flow velocities

6.5.3 Fauna movement provisions

Proposed fauna corridors within the study area were optimised for cross drainage. Where fish passage issues were considered appropriate, the design considered the *Policy and Guidelines for Fish Friendly Water Crossings* (NSW Fisheries, 2003), and *Why do fish need to cross the road? Passage Requirements for Waterway Crossing* (NSW Fisheries, 2003).

Generally, all major cross drainage structures utilise plank bridges or box culverts which facilitate fauna movement.

6.6 Subsurface drainage

The design criteria in *Upgrading the Pacific Highway Design Guidelines* (UPHDG 2005) has been adopted for the subsurface drainage elements.

6.7 Temporary drainage

Temporary drainage systems used for the highway must be designed to the same criteria as mentioned above, but for a minimum 2 year average recurrence interval. The temporary drainage system must satisfy the requirements of all relevant authorities. Concept design of temporary drainage has not been undertaken for the concept design.

6.8 Erosion and sediment control

Sediment control basins are proposed to be constructed within the same locations as the future water quality and spill control ponds. The sediment control basins have been sized in accordance with the Managing Urban Stormwater – Soils and Construction (the “Blue Book”) as type D category sediment retention basins.

6.9 Scour protection

The detail design would include scour protection for all areas susceptible to scouring, including batters and bridge abutments. Scour protection would be designed in consultation with the relevant authorities for a minimum maintenance free life of 50 years. Scour protection for waterway areas would include fauna access and low flow fish friendly requirements.

Scour protection would be provided at all points where transverse pipes in fill areas and SO kerbs in cuttings discharge to swales. Scour protection may not be required where swales discharge to waterways, as the swales would be configured to encourage ponding before discharge, which would reduce flow velocities.

7 Pavements

Pavement designs were carried out in accordance with the documents listed in **Section 18.6**.

Pavement designs for the proposed upgrade have been carried out in response to the geotechnical conditions and predicted traffic volumes and would be heavy duty, low maintenance pavements, designed for a 40 year life.

For most of the route plain concrete pavements are proposed to provide a cost effective solution. In areas of deep soft soils, ground treatments are proposed to limit settlements to less than 100 mm, 40 years after construction (refer to **Section 9.2.1**), making plain concrete pavements viable.

North of Whytes Lane it is proposed to re-use the existing highway as the southbound carriageway with an asphalt or plain concrete overlay on the existing pavement.

Pavement designs for intersections and the local access roads may differ depending on traffic loads, and would be designed for a 20 year life.

8 Structures

Only sufficient design has been done to provide ‘Proof of Concept’ for the structures, and many of the details of the proposed upgrade structures may change after closer examination during the detailed design phase. The types and configurations of structures have been chosen on the basis of reasonable cost effective solutions, and no detailed examination of alternatives has been undertaken at this stage.

In general, scour has not been addressed for those structures spanning waterways. It is understood that flood velocities are likely to be low, but it would be necessary during detailed design to determine if any scour protection is required. Specific details regarding access requirements to maintain the structures have not been addressed, but would be necessary during the detailed design stage.

This section of the report describes the structures within the concept design. The bridge structures, excluding major culvers, are shown on **Figure 8-1** and listed in **Table 8-1**.

8.1 Design input

Bridge structures have been designed in accordance with the documents listed in **Section 18.7**.

Input has been obtained from the geotechnical design report; hydrology and hydraulics assessment; and the urban and landscape designers, to establish site constraints and design requirements.

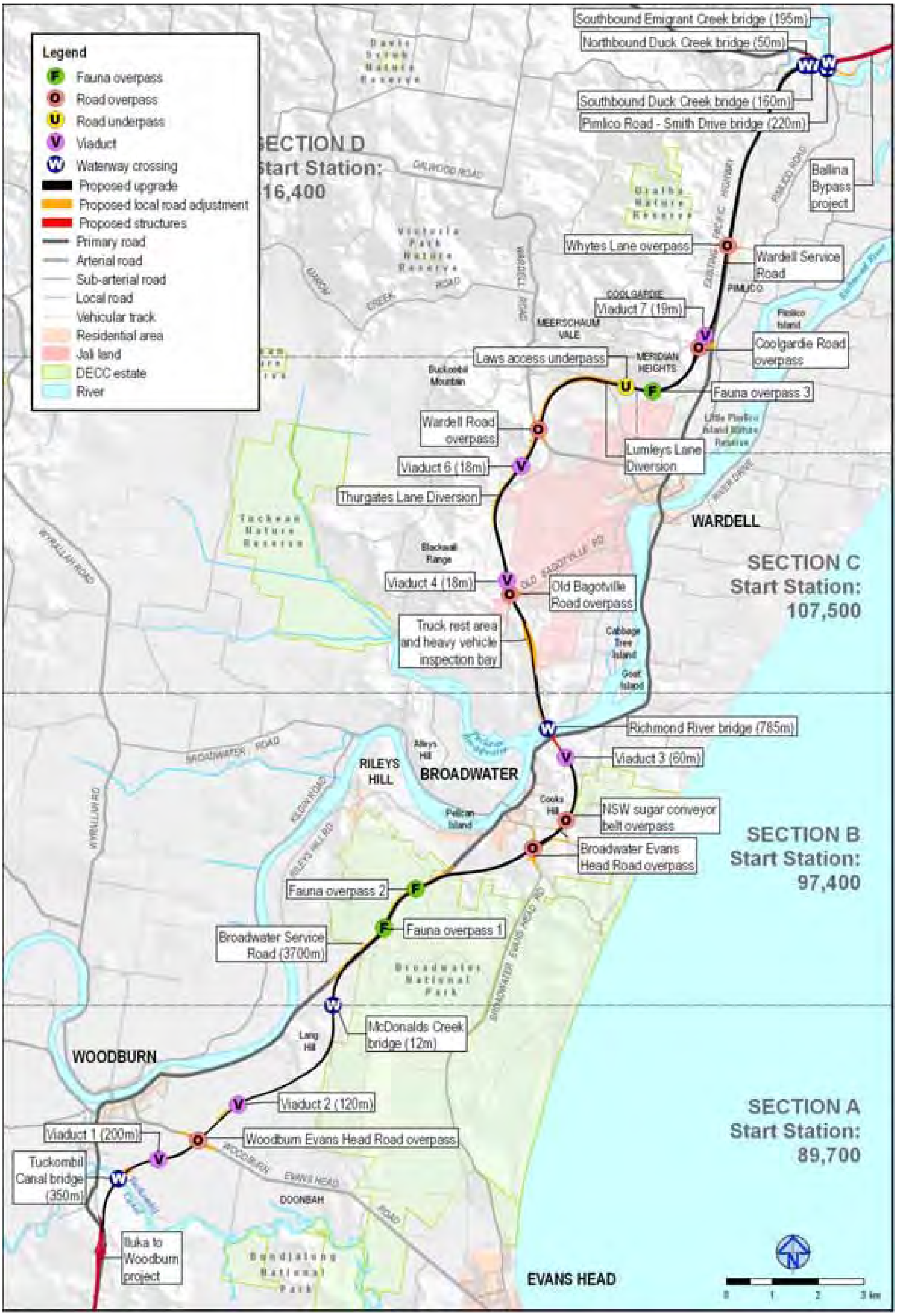

Figure 8-1 Structure locations

Table 8-1 Structures schedule

Name	Station m	Length† m	Width m	Spans	Bridge Crossing
Tuckombil Canal bridge	90,975	350	1 x 10.5 1 x 12.5	14	Watercourse
Viaduct 1	91,945	200	2 x 10.5	10	Floodway
Woodburn Evans Head Road overpass	92,944	50	1 x 14.0	2	Upgrade
Viaduct 2	94,115	120	2 x 10.5	8	Floodway
McDonalds Creek bridge	97,440	12	2 x 11.0	1	Watercourse
Fauna overpass 1	99,564	92	1 x 10.0	4	Upgrade
Fauna overpass 2	100,691	83	1 x 10.0	3	Upgrade
Broadwater Evans Head Road overpass	103,450	66	1 x 17.9	2	Upgrade
NSW Sugar conveyor overpass	104,415	38	1 x 4.4	1	Upgrade
Viaduct 3	105,858	60	2 x 10.5	4	Floodway
Richmond River bridge	106,600	785	2 x 11.5	11	Richmond River
Old Bagotville Road overpass	109,715	55	1 x 9.5	2	Upgrade
Viaduct 4	110,025	19	2 x 11.0	2	Floodway
Viaduct 6*	112,730	19	2 x 11.0	2	Floodway
Wardell Road diversion overpass	113,641	80	1 x 14.0	2	Upgrade
Laws access underpass	116,207	13	1 x 11.0	2	Upgrade
Fauna overpass 3	116,834	62	1 x 10	2	Upgrade
Coolgardie Road diversion overpass	118,314	57	1 x 17.9	2	Upgrade
Viaduct 7	118,605	20	1 x varies 1 x varies	2	Floodway
Whytes Lane overpass	120,662	55	1 x 12.5	2	Upgrade
Emigrant Creek bridge southbound	125,545	195	1 x 10.5	10	Watercourse
Duck Creek bridge northbound (extension to the south)	125,107	50	1 x Varies	4	Watercourse
Duck Creek bridge southbound	125,180	160	1 x 10.5	9	Watercourse
Pimlico Road - Smith Drive bridge	-	220	1 x 12.5	5	Watercourse

* Viaduct 6 follows Viaduct 4 as Viaduct 5 was deleted and replaced with a bank of five culverts

† Final lengths of bridge structures will be determined in detailed design.

8.1.1 Urban and landscape design

All bridge structures along the proposed upgrade have been reviewed by the urban and landscape designers to ensure that a consistent appearance is achieved (see **Section 10** of this report) in accordance with the principles for structures to be adopted from the Pacific Highway Urban Design Framework Plan.

8.1.2 Construction

All bridge structures are designed and configured to follow industry accepted construction practices. Aside from the Richmond River bridge and Wardell Road overpass, bridge structures commonly use precast members. This would reduce the risks associated with working at heights and provides a safe working platform for deck construction.

8.1.3 Geotechnical considerations

The majority of bridge structures are designed to use driven piles, which are beneficial in minimising in-situ construction and environmental impacts.

It should be noted that geotechnical data was based on the preferred route. In some areas, the alignment of the proposed upgrade deviates from the preferred route. Therefore some foundation systems are designed based on geotechnical information of up to 400 m from the proposed upgrade.

Further geotechnical investigations would need to be carried out to ascertain ground conditions and foundation design parameters.

8.1.4 Road user delay management

All bridge structures are designed for an economic design life of 100 years, in accordance with UPHDG 2005 and Australian Standards 5100 Part 1.

Elements such as bearings, expansion joints and protection screens would require maintenance or replacement over the structure’s design life.

The proposed maintenance strategy to gain access to any form of bridge maintenance work would involve taking possession of the 2.5 m wide outside shoulder. This would reduce the closure of traffic lanes, but may still require traffic control which would result in some delays if reduced speed limits are required.

The replacement of bearings can be carried out from the bridge deck via the use of hydraulic boom-lifts that can extend below the bridge superstructure.

8.2 Structure types

8.2.1 Overpasses

Overpasses carry local traffic or fauna across the proposed upgrade. The overpasses are typically two span bridges, however additional spans have been added to clear the width of the proposed upgrade where necessary.

Road and fauna overpasses provide a 5.3 m minimum vertical clearance to the bridge underside. The span lengths would allow for future widening of the proposed upgrade to three lanes.

Wire rope safety barriers are proposed at all overpass pier and abutments in the initial two lane upgrade (refer to **Figure 8-2**). Rigid traffic barriers (Type F) are proposed for the possible future three lane upgrade.

Overpass piers are designed to allow for a minimum working width in a possible future three lane upgrade of 0.8 m between face-of-barrier (three lane Type F barrier) and face-of-pier where there is 3-4% crossfall. Working widths have been selected based on Table 3.11-4 in the RDG.

Tapered piers and headstocks have been adopted to reduce visual intrusion. The maximum allowable pier width is 1.4 m at the top of the tapered headstock. This pier width is based on the future third lane configuration where the median is reduced to 5 m (from the initial 12 m). This is based on future Type F barriers protecting a pier as shown in **Figure 8-3.**

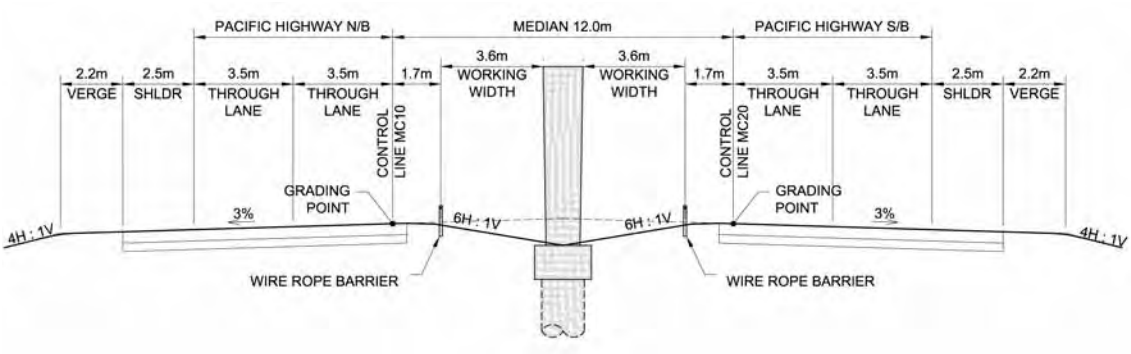

Figure 8-2 Central pier protection in proposed two lane upgrade

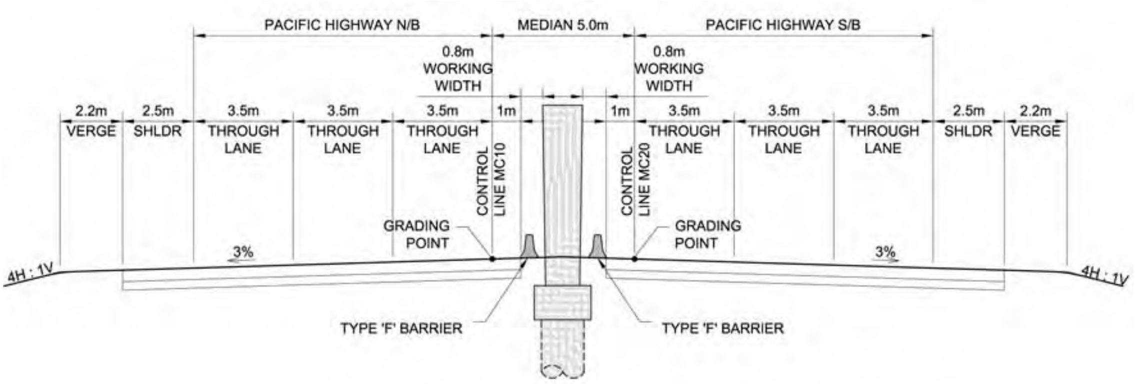

Figure 8-3 Central pier protection in possible future three lane upgrade

8.2.2 Richmond River bridge

The Richmond River bridge should meet the following requirements:

- Carry northbound and southbound traffic along the proposed upgrade over Richmond River.
- Be clear of the 100 year flood level (RL 3.742 m AHD) for flood alleviation.
- Provide a minimum waterway opening of 750 m for flood alleviation.
- Provide a minimum clearance of 5.3 m to Back Channel Road and the existing Pacific Highway.
- Provide a minimum navigational channel of 15 m height from mean high water mark to underside of structure and either one 60 m opening or two 35 m openings.
- Provide sufficient cross section (11.5 m) to allow for future widening of the proposed upgrade to three lanes without the need to widen the bridge structure (as allowed for in UPHDG Section 4.1 (a), Table 1).

A 785 m long bridge has been adopted. The southern abutment is situated at the transition from sand to deep soft soil (this occurs at approximately 400 m south of the south bank of the Richmond River) to avoid construction of high embankments on deep soft soil.

8.2.3 Flood alleviation structures

Structure lengths and minimum vertical clearances from ground level to the underside of the bridge appear in **Table 8-2**. This table details bridge structures. For details of culverts, which also contribute to flood alleviation, refer to **Section 6.5**.

Table 8-2 Flood alleviation requirements

Flood alleviation structure	Minimum Vertical Clearance m	Minimum Waterway Opening m
Tuckombil Canal bridge	Q100 – RL 4.45+0.5 m freeboard	350
Viaduct 1	2.3	200
Viaduct 2	1.5	120
Viaduct 3	1.5	60
Richmond River bridge	Q100 – RL 3.742+0.5 m freeboard	750
Viaduct 4	1.8	18
Viaduct 6	1.7	18
Viaduct 7	1.8	19
Northbound Duck Creek bridge	Q100 – RL 0.960	48 extension to Ballina bypass bridge
Southbound Duck Creek bridge	Q100 – RL 0.960	160
Southbound Emigrant Creek bridge	Q100 – RL 2.780 4.6 m to MHWL	195
Smith Drive Bridge	Q100 – RL 2.780 4.6 m to MHWL	220

The viaduct spans are designed to minimise impacts on sensitive environments including SEPP14 wetland and areas containing potential/actual acid sulphate soils.

Viaducts have been designed with shallow superstructures to minimise the height of the proposed upgrade, usually consisting of standard RTA planks.

8.2.4 Reconstructed bridges

The existing Pacific Highway bridges across Duck Creek and Emigrant Creek would need to be demolished and reconstructed as part of the proposed upgrade. These bridges are currently only eight metres wide and nearing the end of their design life.

Spans, lengths and pier locations have been nominated to coincide with the spans of the adjacent bridges in the Ballina bypass. These Ballina bypass bridges would be constructed before the Woodburn to Ballina bridges.

Southbound Duck Creek bridge

The replacement bridge is designed to meet the minimum waterway opening width of 160 m and a minimum vertical clearance of 0.96 m to minimise flooding impacts.

Southbound Emigrant Creek bridge

The replacement bridge is designed to meet the minimum waterway opening of 160 m and minimum vertical clearance of 2.8 m. This bridge crosses a navigable waterway and as such the underside of the bridge must be no lower than the underside of the existing bridge it is replacing which is 4.725 m AHD.

Northbound Duck Creek bridge

This bridge, to be built as part of the Ballina bypass, would be extended from the western abutment by approximately 50 m. The 12 m spans of the extension match the last span of the adjacent Ballina bypass bridge. The floodplain would be excavated to 0.75 m AHD under the new construction.

8.2.5 Special structures

Fauna overpasses

Three fauna overpasses are proposed to mitigate barrier effects of the proposed upgrade. Two are located in the Broadwater National Park corridor and the third is located near Meridian Heights. Each proposed fauna overpass would be 10 m wide. Fauna fencing is provided on either side of the overpass to direct fauna movements.

Frog and small mammal underpasses

Frog and small mammal crossings provide passageways between habitats either side of the proposed upgrade. The crossings have regular spaced grated openings to encourage use, a gravel invert would provide refuge and protection and the crowned invert stops transverse water flows thus preventing migration of mosquito fish. Crossings would have a minimum internal width and height clearances of 1.2 m and 1.2 m, and would be backfilled with 0.3 m soil to give a natural ground surface and internal vertical clearance of 0.9 m.

Natural lighting would penetrate the underground structures at approximately 10 m intervals.

NSW Sugar conveyor overpass

The NSW Sugar conveyor crosses the proposed upgrade just east of Cooks Hill. The conveyor has a 45 m span steel truss set 10 m above existing ground at the point it would cross the proposed upgrade. The NSW Sugar conveyor overpass would be above the proposed upgrade and below the conveyor truss where the conveyor truss crosses the proposed upgrade. Concrete upstanding walls and mesh protection screens are proposed to prevent debris or maintenance equipment from falling onto the proposed upgrade.

The structure is not designed to carry loads from the conveyor truss; however the structure would provide access for the maintenance of the bridge protection screens. Hydraulic boom-lifts are proposed to access the maintenance platforms if access cannot be gained from the NSW sugar conveyor walkway.

To avoid the need to modify the existing conveyor truss, the substructure would be designed to be jacked into position from below the conveyor truss.

9 Geotechnical

9.1 Field investigations and results

Following the announcement of the preferred route a series of geotechnical field investigations, together with detailed ground and cadastral survey were carried out to:

- Improve field data along the route.
- Investigate specific issues arising from the route options and preferred route public displays and submissions.

This section summarises these investigations and any key findings.

The geotechnical investigations into the preferred route corridor commenced in January 2006 and were largely completed by June 2006, however additional investigations continued throughout 2006 and early 2007 in response to specific issues raised in project investigations. The investigations comprised:

- 50 boreholes with piezometers installed in each.
- 46 test pits.
- 19 CPT (peizocone) probes.
- Seismic refraction survey (four sites with total length of 1125 m).
- Underwater seismic refraction survey in Richmond River (three lines with total length of 450 m).
- 4 over water boreholes at proposed pier locations in the Richmond River.
- 15 shallow hand auger holes in vicinity of Woodburn to Evans Head Road.
- Laboratory testing – geotechnical and environmental.
- Monitoring of standing water levels in boreholes.

Of the above investigations, the following were added to the original scope of work during the course of the investigations:

- Underwater seismic refraction survey in the Richmond River for an earlier and fuller picture of subsurface ground conditions across the Richmond River.
- Six shallow boreholes (piezometers) with data loggers in two boreholes, to the east of Cooks Hill for determination of ground water levels and their impact on national park vegetation.
- 10 shallow hand auger holes near the Woodburn to Evans Head Road as part of hydrogeological assessment of impacts on Rous Water's borefield.
- 4 shallow test pits in the landslip to the north of Lumleys Lane.

Based on results of the geotechnical investigations, 14 broad geotechnical units were identified. These are detailed in **Table 9-1** below.

Table 9-1 Broad geotechnical units

Label	Description
Unit 1	Fill
Units 2a & 2b	Recent Alluvium & Colluvium
Units 3a & 3b	Pimlico Clay
Unit 4a & 4b	Woodburn Sand & Coffee Rock
Units 5a & 5b	Pleistocene Sediments
Units 6a, 6b & 6c	Bundamba Group Rocks
Units 7a & 7b	Neranleigh-Fernvale Group Rocks

9.2 Concept design

The geotechnical units presented in **Table 9-1**, were used in the preparation of geotechnical models for areas of soft soil, for all major bridge structures, and for all cuts greater than approximately 3 m in depth.

9.2.1 Embankment settlements

Estimates of preload thicknesses required to achieve post construction settlement limits of 100 mm and 300 mm for embankments located on areas of soft soils have been determined. The estimates were based on the assumption of a 2 year construction period. Indicative settlements during preloading are:

- Approximately 1.2 m would take place on the northern side of Tuckombil Canal (near Stn 91,150).
- Near Duck Creek settlements in the order of 3.3 m.
- For the majority of the northern portion of the proposed upgrade, between Whytes Lane and the Ballina bypass (Stn 120,800 to 124,700), settlements of 0.25 to 1 m are estimated.

Where appropriate, recommendations on preload staging, tensile fabric strength and wick drain spacing have also been prepared.

9.2.2 Cuttings

For proposed cuttings greater than approximately 3 m in depth, site specific geotechnical models have been prepared, together with recommendations for permanent batter slope angles, anticipated excavation conditions, and bulking factors. These are summarised in **Table 9-2**.

Table 9-2 Summary of batter slope angles and excavation conditions

Geotechnical Unit	Recommended Permanent Batter Slope Angles	Anticipated Excavation Conditions	Bulking Factors
2b	2H:1V	Light ripping, dozing.	0.9
4a	3H:1V	Dozing, possible high water table.	1.0
6a	2H:1V	Light ripping, dozing	0.9
6b	2H:1V	Heavy ripping (blasting may be more economical)	1.1
6c	0.25H:1V or steeper	Blasting	1.2
7a	2H:1V	Light ripping	0.9
7b	2H:1V	Medium to heavy ripping, some localised blasting.	1.1

9.2.3 Structure foundations

To assist in the selection and design of footing systems for each of the major bridge structures, typical ultimate geotechnical design parameters for each of the geotechnical units were prepared. Recommendations for piled and shallow foundation systems, and a preliminary assessment of possible foundation systems for each of the major structures has also been prepared. The assessment includes the probability of encountering acid sulphate soils at major bridge structures.

9.2.4 Possible acid sulphate soils

Laboratory testing of soils indicate the presence of actual and potential acid sulphate soils at a number of locations along the preferred route corridor. For those areas where possible acid sulphate soils are likely to be disturbed, recommendations on appropriate liming rates for such soils have been made.

9.2.5 Contaminated soils

Field investigations, environmental sampling and subsequent laboratory testing did not identify any obvious signs of soil contamination along the preferred route corridor. In addition, no exceedances of the contaminant threshold concentrations for open space land use or the contaminant provisional phytotoxicity threshold concentrations were encountered.

9.2.6 Quarries

For existing quarries located adjacent to the proposed upgrade a preliminary assessment has been made of the potential impact of quarry blasting operations on roadway users. Possible impacts include:

- Flyrock - rock(s) propelled from a blast area by the force of an explosion.
- Ground vibrations.
- Airblast (or overpressure) noise.

Under the existing extraction rates from these quarries, blasting occurs on a very limited basis. Specific assessments for each quarry that affects the proposed upgrade would be carried out at the environmental assessment stage of the project. Assessments would take into account quarry material reserves, approved material extraction rates and material extraction methods predicted at the time of opening of the proposed upgrade.

Where it is assessed that the extents of these impacts would be unsafe for road users, mitigations measures such as those listed below may be required:

- Blast screens to protect the highway (where topography is appropriate).
- Cooperation to schedule highway closures at blasting times (where the number of blasts are very limited).

9.3 The extent of soft soil on the south bank of the Richmond River

The investigations in this area showed that the extent of soft soil was less than anticipated in the route development investigations. The transition point from relatively dense sand to soft soil was determined to be approximately 100 m closer to the river bank than previously assumed. The Richmond River bridge abutment has been shifted closer to the river bank to coincide with the transition from sand to deep soft soil.

9.4 Lumleys Lane landslip

A landslip to the north of Lumleys Lane was investigated in March of 2007 to assess if the proximity of the historical landslip posed a risk to the proposed upgrade. Through geological mapping and test pitting on and adjacent to the landslip it was assessed that the risk of the landslip remobilising and causing damage to the highway was low. In addition there are likely to be several relatively minor mitigation measures that can be adopted to either reduce the risk of a landslip or contain a landslip if it occurs. Further geotechnical investigation of this landslip area would be required during detail design stage studies to confirm the assumed geotechnical model, the assessed risk of slope instability, and likely slope remediation measures.

9.5 Main borrow sites

Large fill quantities are required in the Richmond River valley floodplain around Woodburn and between Wardell and the northern tie-in to the Ballina bypass, with the majority of materials to be possibly sourced from three main borrow areas:

- Woodburn interchange borrow site.
- Lang Hill borrow site.
- Existing quarries.

For each of the above main borrow areas, preliminary assessments were provided on likely material types, excavation methods and bulking factors. These assessments were based on extrapolation of results from nearby route investigations.

As no site specific geotechnical investigations were undertaken as part of the preferred route investigations of these main borrow sites detailed site specific investigations would need to be carried at these locations out as part of detailed design.

10 Urban and landscape design

10.1 Design activities

Urban and landscape design activities completed for the concept design include:

- A preliminary landscape concept design.
- A concept design of the truck stop and rest area.
- Inputs to the design of the bridges, in particular the Richmond River bridge and the fauna overpasses in Broadwater National Park.

These inputs were primarily a desktop exercise and were produced to establish a basis for cost estimating purposes only. These would need to be developed further in future stages of the project.

10.2 Aims of the urban and landscape design

Key aspects of the urban and landscape design strategy are:

- To maintain and reinforce the rural and natural character of the area by responding to the distinctive setting of the road corridor.
- To provide designs in accordance with the Pacific Highway Urban Design Framework objectives.

The design proposes to both enhance and clarify the different landscape characters through appropriate planting strategies. In the floodplain, low shrubs and native grasses allow views out over the cane fields. In the pastureland areas, scattered trees and shrubs/ grasses match the existing character and provide filtered views. In the heath woodland areas, dense woodland plantings match the existing woodland character with views confined to the highway corridor.

At the base of the Blackwall Range, woodland planting is proposed on the eastern edge only allowing views to the Blackwall Range and foothills to the west. However, property owners on the western side of proposed upgrade in the vicinity of the Wardell heath may expect to see dense woodland planting to screen the highway from their dwellings. This conflict would be addressed in the environmental assessment mitigation process.

At creek and river crossings, riparian plantings would enhance the existing character and provide a buffer to the important SEPP 14 areas. Fauna overpasses in the Broadwater National Park have been designed to provide a continuation of the coastal banksia heath habitat.

Another key aspect of the urban and landscape design strategy is to address and mitigate the visual impacts of the proposed upgrade, in particular from publicly accessible locations. Tall shrubs and grasses would be used in select locations in the median and highway edges to reduce headlight glare on curves and/or screen adjacent properties. Embankments at a 4H:1V slope would allow for better visual mitigation. The truck stop and rest area has been located to provide the minimum visual impact on residential areas and to provide opportunities to visually mitigate the existing quarry landscapes.

View opportunities are also an important consideration to create a memorable visual experience and sense of place. Individual locations such as interchanges, waterway crossings or places would be clarified and enhanced. At interchanges there is a change in the landscape treatment to reflect the points of arrival and departure from the main highway route. Views to cultural and natural landmarks would be carefully managed in the choice and location of planting treatments to add diversity to the travel experience and orient the traveller.

Bridges would be designed to be part of a suite (or family) of unified elements to strengthen the overall identity of the Pacific Highway as a single artefact. The project includes overbridges, highway bridges, fauna overpasses, refer to **Figure 10-1**, and a major structure over the Richmond River, refer to **Figure 10-2**. The designs reflect careful consideration of their specific locations within the project and are consistent with the overall urban and landscape design strategy established. The Richmond River bridge has been identified as being an important and distinctive bridge element.

Figure 10-1 Artist's perspective sketch of fauna overpass 1 in the Broadwater National Park

Figure 10-2 Artist's perspective sketch of Richmond River bridge

11 Utilities

11.1 Investigation process

The proposed upgrade affects utilities belonging to Rous Water, Optus, Country Energy, Telstra, Richmond Valley Council, Ballina Council and Lismore Council. In the route options stage of the project all authorities were requested to provide details of their assets throughout the area.

Each of these authorities has provided all known information on their assets. Due to the size of the initial study area the information provided by each authority was in electronic format, which has now been documented using both GIS and CAD formats.

11.2 Concept design

This section outlines the proposed mitigation measures for the utilities affected by the proposed upgrade. The services drawings indicate locations of potential impacts on the public utilities. Following the confirmation of the concept design and further consultation with the authorities during detail design, final utility relocation and or protection would be detailed.

11.2.1 Power

Country Energy's overhead power lines and power poles cross the proposed upgrade at multiple locations. Due to the raised alignment of the proposed upgrade to provide flood immunity and allow for cross drainage, the existing electrical network would not meet the required typical clearance of 5.5 m for low voltage power lines over freeways or arterial roads. The design approach has been to divert all points of conflict into the ground when crossing the proposed upgrade and relocate to services easements when installed adjacent to the proposed upgrade.

11.2.2 Water

The main impact the proposed upgrade has on water assets are:

- The crossing of Rous Water's 600 mm trunk mains in section A and section B.
- The close proximity to the water supply bore holes located adjacent to the Woodburn Evans Head Road in section A.

It is proposed to provide a protective reinforced concrete slab with piers for protection of the large water mains at the points of conflict. Other smaller water mains ranging from 100 mm – 200 mm would be provided with similar protection.

Investigations into the possible affects the proposed upgrade has on the water supply boreholes has been assessed as minimal. The hydrogeological investigations indicate the location of the proposed upgrade in this area should not produce a negative impact on the Rous Water borefields.

11.2.3 Communication

Telstra fibre optic and copper cable assets would generally be protected, using similar methods to the protection of water mains, where conflicts with the proposed upgrade occur. The main impact the proposed upgrade has is on the Sydney to Brisbane fibre optic cable by the proposed service road/northbound carriageway in section D. This would result in the relocation of approximately three kilometres of the fibre optic cable.

11.2.4 Other assets

Richmond Valley Council, Lismore Council, Ballina Council and Optus assets are generally not affected by the proposed upgrade. Where impacts may occur, minor relocation or protection of the utilities is proposed using similar methods as stated above for power and water assets.

11.2.5 Additional assets

In addition to the relocation or protection of the public utilities, a concept for the supply of utilities to the truck rest areas has been considered. The proposed location of the truck rest area has a nearby power source for general lighting and power supply. There is a lack of water supply near the proposed truck rest area and recycled rain water and or water supply boreholes are proposed. It is also proposed that the waste water and effluent from the toilets would be discharged onsite through a septic tank system and absorption trenches or through a bio-treatment system with landscape irrigation disposal.

11.2.6 Street lighting

The lighting concept for the proposed upgrade would be in accordance with the standards listed in **Section 18.9**.

Roadway lighting would be provided in the following areas:

- Interchanges (Category V3).
- Ramps (Category V3).
- Intersections (Category V3).
- Truck rest bays.
- Local roads where existing lighting exists.

The lighting design for the proposed upgrade would include high pressure sodium lamps. All lighting would be automatically controlled via either remote or integrated photocells and all control gears to be low loss type.

Country Energy would provide power supply to all the street lighting via several supply connection points. The street lighting would be supplied from local feeder distribution boards and control equipment in weatherproof housings.

The roadway lighting's cabling and reticulation would be designed in accordance with the AS/NZS 3000, Country Energy and RTA standards.

12 Noise

Preliminary noise calculations were undertaken to identify existing residential properties along the proposed upgrade where road traffic noise levels could exceed the guidelines recommended in the Department of Environment and Climate Change (DECC) Environmental Criteria for Road Traffic Noise (ECRTN) and RTA Environmental Noise Management Manual (ENMM).

Conceptual noise control measures were identified for the purpose of project cost estimation. As the majority of the residential properties are scattered along the road alignments and a number of properties located well above the road, noise controls in the form of building treatments would be more cost effective.

As the road alignments are conceptual and forecast traffic data are preliminary at this time, detailed calculations and the extent of noise control would be determined during the environmental assessment phase of the project.

13 Ecology

13.1 Introduction

Since the announcement of the preferred route in November 2005, further investigations have been undertaken to provide input into the refinement of the design, with particular emphasis placed on:

- Undertaking further ecological surveys.
- Reviewing proposed design refinements to the preferred route to establish whether it is feasible to modify the route at particular locations and ensure there was no increase in adverse impacts.
- Investigating potential fauna crossings and other ecological mitigation measures.
- Investigation and response to concerns raised regarding the ecology investigations carried out as part of the route selection process (see **Section 1.4.1** for further information)

13.2 Seasonal targeted surveys

Biosis Research (Biosis) was engaged to undertake more detailed ecological investigations along the preferred route to assess its potential impacts on biodiversity. In particular, Biosis was required to undertake seasonal targeted surveys for threatened flora (terrestrial and aquatic) and aquatic fauna species identified as being likely to occur along the preferred route in the previous ecological assessments. Geolyse were responsible for undertaking seasonal targeted surveys for threatened terrestrial fauna species. The seasonal surveys were conducted in February 2006 (summer), July 2006 (winter) and November 2006 (spring).

13.3 Ecological investigations for potential design refinements to the preferred route

In addition to surveys along the preferred route, Biosis was requested to provide ecological advice as to the potential ecological impact with regard to design refinements to the preferred route. Biosis undertook surveys outside the footprint of the preferred route where there have been submissions requesting design refinements to the preferred route.

The investigations involved walk-throughs of identified areas but don't include detailed assessments at this stage. The surveys involved a brief assessment of plant communities, condition of the habitats and the presence of habitat for threatened species. The surveys were by design brief and no trapping for fauna or quadrats for flora were undertaken.

Following the field investigations, Biosis provided advice regarding the ecological impacts of the proposed design refinements. The key survey findings and their input into the refinement of the concept design are summarised in **Table 13-1** below.

The design refinement numbers refer to the design refinements described in **Section 2**, **Table 2-1**. The suggested alignment change letters refer to the suggested alignment changes in **Section 2.1.1**, **Table 2-2**. All proposed design refinements were reviewed to assess whether further investigations were required prior to acceptance.

Table 13-1 Ecological investigations for potential design refinements to the preferred route

Design refinement 1 – Woodburn south facing ramps	
Issue	Move alignment to the west to accommodate the Woodburn interchange layout.
Location	Southern end of the alignment, south of the township of Woodburn.
Results	Swamp sclerophyll forest (an endangered ecological community on the NSW *Threatened Species Conservation Act 1995* [TSC Act]) was recorded on the western side of the existing Pacific Highway in low lying areas and swales forming natural drainages channels flowing to the west. The swamp sclerophyll forest in this location was assessed as being in a poor to moderate condition.
Outcomes	Alignment moved to the west to accommodate the selected Woodburn interchange layout.
Design refinement 4 – realignment around Woodburn Evans Head Road	
Issue	Move alignment to the north to reduce impacts on a large patch of endangered ecological community swamp sclerophyll forest and avoid the Rous Water borefield influence zones.
Location	On the vegetated property to the east of the Woodburn township, north of Woodburn Evans Head Road.
Results	The vegetation recorded on site was confirmed to be representative of the swamp sclerophyll forest endangered ecological community. The majority of the area was considered to be in good condition, whilst the northern section of the vegetated area was considered to be in poor condition.
Outcomes	The alignment was moved northwest to reduce fragmentation impacts on the area of swamp sclerophyll forest in good condition.
Suggested alignment change A - west of Broadwater National Park, southeast of Lang Hill	
Issue	Move alignment further east towards the Broadwater National Park boundary and into the native vegetation to the southeast of Lang Hill to reduce agricultural impacts.
Location	On the vegetated property to the southeast of Lang Hill.
Results	The proposed alignment change would fragment a relatively intact area supporting swamp sclerophyll forest endangered ecological community in good condition and threatened fauna. The proposed alignment change moves the project closer to Broadwater National Park and would also increase impacts on oxleyan pygmy perch occurring to the north.
Outcomes	The alignment was not altered in this location due to the potential increase in ecological impacts.
Design refinement 5 and suggested alignment change B – realignment at McDonalds Creek	
Issue	Move alignment to the west to reduce impacts on habitat for threatened species oxleyan pygmy perch.
Location	The properties, to the west of Broadwater National Park and east of the existing highway.

Results	Oxleyan pygmy perch were recorded in a number of water bodies within the McDonalds Creek catchment. The permanent, semi permanent and intermittent tributaries of McDonalds Creek form important connection habitat during floods and important local breeding habitat during non-drought periods. The lower sections of McDonalds Creek appear to contain small numbers of oxleyan pygmy perch in degraded habitats. Although the best habitat for this species was predominantly located along the western border of Broadwater National Park, oxleyan pygmy perch were found scattered along most sections of McDonalds Creek.
Outcomes	The alignment has been moved west to reduce impacts on oxleyan pygmy perch in the McDonalds Creek area.
Design refinement 7 - Broadwater Service Road	
Issue	Alignment widened through Broadwater National Park to provide for a service road in the corridor through the national park.
Location	Adjoining the existing road reserve along the existing Pacific Highway as it traverses Broadwater National Park south of the township of Broadwater.
Results	Parts of the western side of the existing Pacific Highway have been previously disturbed by sand mining, resulting in a low species diversity and simple plant community structure. However, endangered ecological community swamp sclerophyll forest borders the road in some locations and a small freshwater wetland (an endangered ecological community on the TSC Act) occurs on the west/north side of the existing Pacific Highway. However, the swamp sclerophyll forest on the southern side is more extensive and all vegetation communities on the eastern side are in better condition than the western side. The eastern side of the existing Pacific Highway through Broadwater National Park is therefore considered to have higher conservation value than the western side. Oxleyan pygmy perch are known to occur within Broadwater National Park on both sides of the existing Pacific Highway, however there is no suitable habitat adjacent to the existing highway itself, and oxleyan pygmy perch were not recorded under the proposed route in this location.
Outcomes	The alignment was widened through Broadwater National Park to: ▪ Acquire land approximately 50 - 70 m wide (approximately 14 ha) from the Broadwater National Park on the western side of the existing alignment. ▪ Incorporate two 10 m wide fauna overpasses with approach earthworks constructed within the national park. ▪ Incorporate two frog and small mammal underpasses near to paperbark swamp and wetlands. ▪ One glider crossing at the northern end of the Broadwater National Park corridor. ▪ Fauna exclusion fencing (including frog fencing) through the entire length of the national park. ▪ Collect and discharge runoff from the proposed upgrade clear of the national park. ▪ The new roads to be close to existing grades to minimise visual impact on the national park.

Suggested alignment change C - North of Broadwater National Park	
Issue	Suggested design refinement to move alignment to the south between where it exits Broadwater National Park and crosses Broadwater Evans Head Road, reducing impacts on the private properties.
Location	Properties to the south of the township of Broadwater that abut the northern boundary of the Broadwater National Park.
Results	The proposed alignment change would increase impacts on endangered ecological community swamp sclerophyll forest and would directly impact Broadwater National Park.
Outcomes	The alignment was not moved due to the potential ecological impacts on the endangered ecological community swamp sclerophyll forest.
Design refinement 9 - rest area and heavy vehicle inspection bay	
Issue	Alignment widened to provide for rest area and heavy vehicle inspection area.
Location	South of Old Bagotville Road.
Results	The area was highly disturbed by recent and historical quarrying activities. Areas had been revegetated, with artificial landforms planted with *eucalyptus pilularis* and *lophostemon confertus.* Areas of swamp sclerophyll forest (endangered ecological community) occur nearby.
Outcomes	The proposed widening in this area only result in limited additional ecological impacts, therefore the design was widened.
Design refinement 10 - property realignment	
Issue	Move proposed upgrade further east to reduce impacts on private property.
Location	Between Old Bagotville Road and Thurgates Lane and west of the Wardell heath.
Results	The area surveyed was the western edge of a large, intact area of bushland known as the Wardell heath. This area was considered to be in good condition, supporting a high diversity of native species, good plant community structure and very few weed species. The area also provides important aquatic habitat and potential habitat for the oxleyan pygmy perch.
Outcomes	The proposed upgrade was moved approximately 170 m towards the east. This reduced impacts on private property without increasing impacts on the ecological values of the Wardell heath.
North West of Wardell heath	
Issue	Move alignment of concept design to the west by a few metres to reduce impact on population of *oberonia titania* (a threatened tree orchid listed on the TSC Act).
Location	On the western fringe of the Wardell heath to the north of the proposed Wardell Road overpass
Results	*Oberonia titania* was recorded on the edge of a large patch of swamp sclerophyll forest (ecologically endangered community)
Outcomes	The alignment was moved slightly to the west and outside the swamp scleropyll forest to reduce the impacts on the population of *oberonia titania*. This was still within the preferred route corridor and not identified as a design refinement.

Design refinement 12 - Lumleys Lane diversion	
Issue	Adjust alignment in a straight northeast line between where it intersects Wardell Road and where Lumleys Lane first exits the vegetation at the northern edge of the Wardell heath to reduce impacts to private properties along Lumleys Lane.
Location	South of Lumleys Lane, northern edge of Wardell heath.
Results	The proposed alignment change would increase fragmentation of the vegetation within Wardell heath. The alignment change would also increase clearing of endangered ecological community swamp sclerophyll forest and increase impacts on numerous threatened plant and animal species, including *oberonia titania.*
Outcomes	The alignment was not altered in this location due to the potential increase in ecological impacts it would cause.
Design refinement 15 - Wardell service road (around existing highway north of Wardell)	
Issue	Corridor widening to upgrade existing highway or provide service road.
Location	The existing Pacific Highway Road corridor to the north of Wardell.
Results	Thin strips of endangered ecological community swamp sclerophyll forest in poor condition occur along the existing Pacific Highway in this area, with more extensive forest on the eastern side of the existing highway south of Whytes lane.
Outcomes	Widening of the proposed upgrade could occur to the west of the existing Pacific Highway to reduce impacts on the endangered ecological community swamp sclerophyll forest.
Design refinement 15 - Wardell service road (around proposed bridge connection between Pimlico Road and Smith Drive)	
Issue	Bridge to provide connection to Ballina for local traffic.
Location	The northern end of the route near Pimlico Road.
Results	There are three endangered ecological communities that would be impacted by the proposed bridge: subtropical coastal floodplain forest, swamp oak floodplain forest and a small area of coastal saltmarsh. The subtropical coastal floodplain forest and swamp oak floodplain forest were regrowth forest in poor condition in the impact area. Only the edge of the coastal saltmarsh would be impacted by the proposed bridge. An area supporting mangroves would also be impacted. Where possible, impacts to the endangered ecological communities should be minimised. The proposed bridge would impact on SEPP 14 wetlands. However, these wetlands are already highly disturbed and fragmented by existing roads and power line easements, and as such, the impacts would only be increased slightly.
Outcomes	The proposed bridge is acceptable as the ecological impacts are likely to be minor. However, it is important that the abutments of the bridge on the western side are located out of Emigrant Creek and as far back from the waters edge as possible to minimise impacts to aquatic and riparian habitat and to allow for fauna movement along the riparian corridor.

13.4 Ecological mitigation

Mitigation measures have been developed as part of the refinement of the proposed upgrade. Detailed investigations into potential fauna crossings and other ecological mitigation measures have been undertaken. The mitigation measures incorporated into the proposed upgrade are described below.

13.4.1 Fauna crossings

Fauna overpasses and underpasses have been included in the proposed upgrade to:

- Reduce impacts of habitat fragmentation.
- Provide means for fauna to safely move across the highway.
- Provide connectivity between the eastern and western sections of Broadwater National Park.

The type of fauna crossings included in the proposed upgrade have been selected based on the most cost effective solution to provide appropriate crossing facilities for the fauna in the local area.

The design of fauna crossings would be consistent with designs implemented on other Pacific Highway projects that have performed well. The major crossings are discussed below. Refer to **Figure 13-1** and **Figure 13-2** for locations of the proposed fauna crossings.

Fauna overpasses

Two vegetated 10 m wide fauna overpasses with flared approach earthworks, intended to provide safe passage for medium to large animals across the highway, would be constructed at equal spacings at approximately one-third and two third points along the Broadwater National Park frontage. These would be situated at locations with suitable adjacent vegetation to connect the national park on either side of the proposed upgrade.

Structures such as fauna exclusion fences and refuge poles have been proposed to increase the effectiveness of ground level fauna overpasses.

Establishing plant communities across ground level overpasses to simulate the continuation of vegetation communities either side of the proposed upgrade may encourage their use by fauna. Accordingly, the majority of the width would be vegetated with up to 1 m depth of soil. A cleared strip covered with 300 mm of mulch would provide passage for large fauna such as emus, and may enable maintenance and fire access across the proposed upgrade.

A third similar fauna overpass would be provided between Lumleys Lane and Coolgardie Road to connect the Coolgardie scrub to the north with the Wardell heath to the south.

Frog and small mammal underpasses

Two underpass culverts would provide crossings for frogs and other small mammals, particularly the eastern chestnut mouse, within Broadwater National Park near to the paperbark swamp and wetlands. The underpasses would be designed to ensure that the oxleyan pygmy perch habitat is protected from predatory mosquito fish by keeping the drainage across the upgrade unconnected during the majority of flood events.

The inclusion of forest substrate in underpasses, such as soil, leaf and branch litter, to simulate conditions of the forest floor, may increase the effectiveness of underpasses for target fauna. The crossings should also aim to provide dry passage for fauna either through the inclusion of a raised walkway within existing culverts or through the positioning of new cells.

Glider crossings

A glider crossing is proposed at the northern end of the Broadwater National Park with two separate connecting overpasses proposed to cover both the proposed upgrade and the Broadwater service road. Another glider crossing is proposed to the north of the Richmond River bridge. These crossing sites were chosen because arboreal mammals have been recorded at these locations and they are at the narrowest part of the proposed upgrade through these sections with connecting habitat on either side.

The overpasses would allow the movement of possums and gliders, important for threatened species such as the squirrel glider which is unlikely to use underpasses. The type of structure proposed would consist of a woven rope tube supported by cables strung between support poles located either side of the proposed upgrade.

Fauna fencing

Fauna exclusion fencing would be required along some sections of the upgrade. All fauna crossing structures would require at least 200 m of fauna fencing extending along the highway on either side of the crossing. Elsewhere, fauna exclusion fencing would be required where vegetation exists adjacent to the proposed upgrade. This is to ensure fauna cannot enter the upgrade from the vegetation. The fauna fencing would consist of a combination of regular wire mesh fencing, floppy top fencing and frog fencing.

Floppy top and frog proof fencing is proposed through the entire length of the Broadwater National Park to reduce road kill and encourage fauna to use the overpasses/underpasses. Frog proof fencing would also be effective in protecting small mammals such as the eastern chestnut mouse and common planigale.

The Department of Environment and Climate Change has identified that fencing along roads can cause problems for emus. They have trouble seeing fences and are prone to injury from colliding with the fence.

The exact location, design and extents of the fauna fencing for the proposed upgrade would be determined during the environmental assessment phase of the project.

Bridges / viaducts and drainage culverts

Allowance has been made for fauna crossing beneath seven bridges / viaducts and numerous other drainage structures have been refined for suitability as dual use drainage and fauna crossing points. These include:

- The drainage openings between the southern tie-in and the Broadwater National Park which include:
  - The Tuckombil Canal bridge (350 m).
  - Viaduct 1 (200 m).
  - Viaduct 2 (120 m).
- Access beneath the Richmond River bridge at both abutments for fauna, in particular along the northern bank which is a valuable ecological area. Access at the southern abutment would be approximately 300 m in length and ranging from 3 m to 10 m in height. Access at the northern abutment would be approximately 50 m in length and 7 m high at the highest point.
- Four viaducts approximately 20 m long between the Richmond River and Coolgardie Road.
- Nine drainage culverts over 1.2 m high between the Richmond River and Coolgardie Road (with a further six culverts over 0.9 m high).
- A 1 m high cross drainage culvert to link the vegetation either side of the proposed upgrade to the north of the Coolgardie Road overpass.

Figure 13-1 Fauna crossing locations (south)

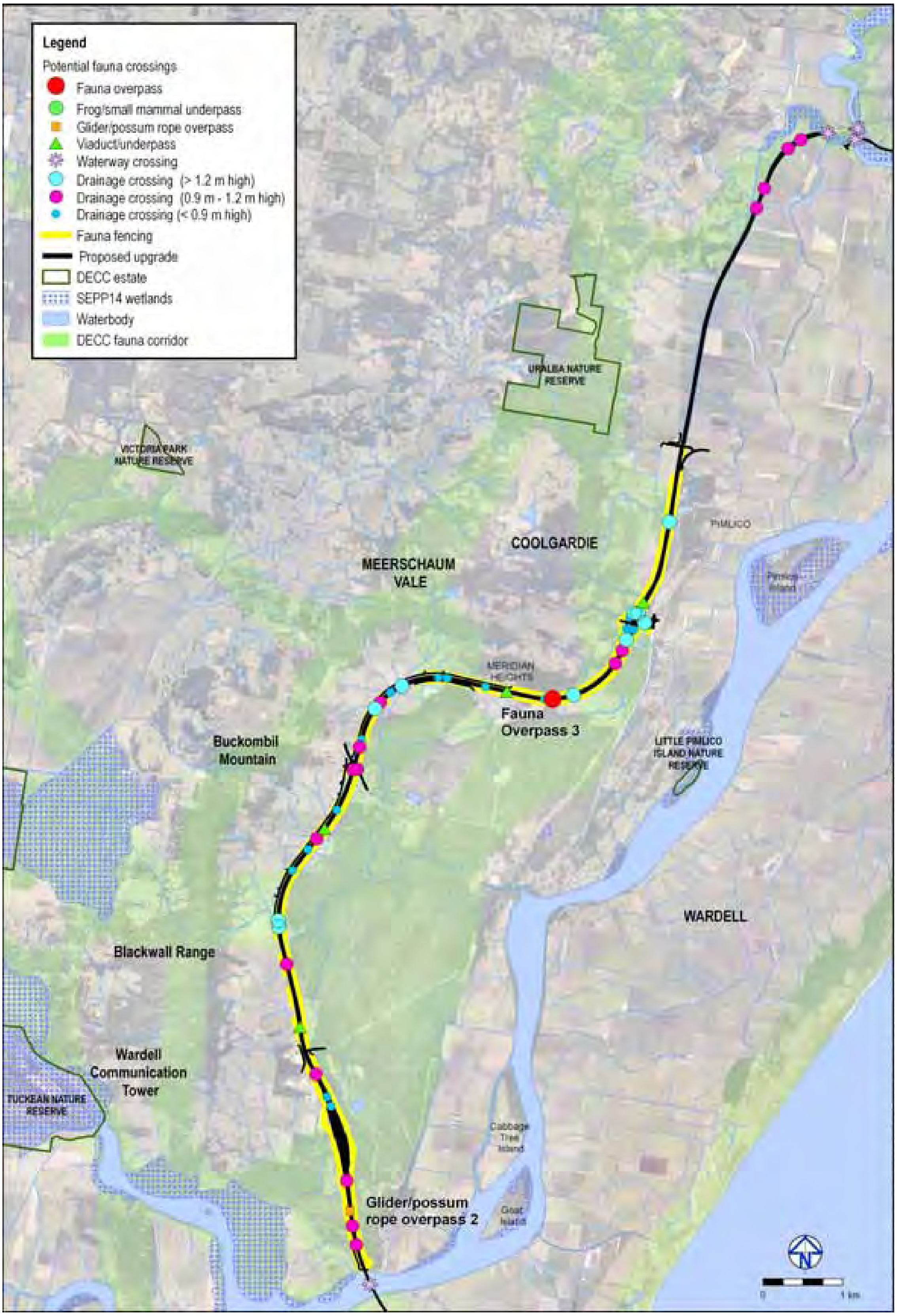

Figure 13-2 Fauna crossing locations (north)

14 Construction and future maintenance

14.1 Potential project staging

This project may be constructed in separate stages, depending on availability of funding and traffic needs. For example, staging could include an initial bypass of Woodburn and Broadwater, followed by a second stage upgrading from north of Broadwater to the Ballina bypass.

No decisions have yet been made on project staging, and this concept design is based on the upgrade being constructed as a single project.

14.2 Construction staging and impacts on the road network

The construction staging has been developed based on Pacific Highway and local traffic flows in combination with possible on/off road earthworks haulage. Traffic control detail is limited, at this stage, due to the uncertainty associated with the ultimate contractor’s work methods. The construction sequencing and any temporary works identified are based on minimising user delay whilst providing sufficient flexibility for the contractor to efficiently plan the construction.

Staging sketches were developed for southern tie-in interchange, Woodburn Evans Head Road overpass, Broadwater Evans Head Road overpass, Old Bagotville Road overpass, Wardell Road overpass, Wardell interchange and Ballina bypass tie-in.

Other locations such as existing Pacific Highway diversion at Broadwater National Park, Richmond River crossing, Thurgates Lane diversion, Lumleys Lane diversions and closure of Lumleys Lane, Whytes Lane overpass and upgrade north of Whytes Lane were not investigated because of the staging simplicity.

14.3 Haulage of earthworks, constituent materials and consumables

Materials requiring haulage within, and from outside, the project corridor included earthworks, constituent materials for concrete and asphalt pavement construction, i.e. select fill and lean mix concrete, consumables such as water, fuels and oils, manufactured items such as pre-cast concrete elements and other construction materials.

Consideration has been given to sourcing earthworks material from locations immediately adjacent to the project alignment to maximise off-road haulage. Some on-road haulage of earthworks may be required for material sourced from Woodburn interchange. However, if the new bridge over Tuckombil Canal was constructed early in the program, it may be possible to haul off-road from Woodburn interchange along the formation and over Tuckombil Canal.

14.4 Road user delay and impacts on the community during construction

A road user delay assessment was undertaken for the proposed upgrade. The assessment considered geometric requirements, pavements deterioration, vehicle restrictions, environmental impacts and local authority requirements and restrictions.

The assessment indicated that construction would not adversely impact upon Pacific Highway or local traffic, provided temporary works at haul crossings are provided with traffic control of haul vehicles.

14.5 Project demand for construction materials

Construction materials are either incorporated in the completed project, or consumed in the construction of the project. Significant materials incorporated in the project include general earthworks and select fill, concrete and asphalt pavement materials, and concrete for major structures. Significant materials consumed include water and fuels.

Construction material demand was determined by calculating the earthworks cut / fill balance, the quantities of select fill, concrete pavement, asphalt pavement, and concrete in major structures. These quantities were further broken down into constituent material quantities such as cement, bitumen, sand, and aggregate.

The Richmond River physically severs the construction of the project and hinders the movement of construction materials. It was therefore important to separate the construction material quantities on each side of the Richmond River.

The earthworks cut / fill imbalance is a significant issue for the project. South of the Richmond River, a fill imbalance of approximately 130,000 m^3 exists due to a need to elevate the road above the floodplain. North of the Richmond River there was more opportunity to balance the cut and fill.

14.6 Haulage and batching of site-batched construction materials

In terms of batching and haulage of materials, it is proposed that concrete and asphalt batching plants be established on both sides of the Richmond River.

Batch plants were located such that raw materials can be delivered either via the existing highway, or via local roads. The batch plants have direct access to the project alignment such that concrete and asphalt can be hauled off-road to the construction site.

14.7 Potential temporary construction sites and impacts

Potential sites have been identified for site compounds, stockpile sites, batching plants, casting yards, and crushing plants.

Sites were located such that they were close to major work sites, had access to the local road network, and satisfied environmental constraints.

As the Richmond River effectively severs the project, two administration compounds would be required – one south and one north of the river. Administration compound sites would have full access to utilities, local roads, and the construction site.

Construction compounds have been located adjacent to the major work sites and would also have direct access to the work site.

Topsoil stockpile sites have been located along the length of the project to minimise haulage and use residual parcels of land.

15 Occupational health and safety and operational hazards and risks plans

The occupational health and safety (OH&S) development plan identified potential OH&S hazards that arose during preparation of the concept design, and set the framework for identification of OH&S hazards that may arise during detailed design, construction, operation and maintenance phases of the project. The OH&S development plan also set out minimum site safety rules, health and safety goals, and objectives and generic hazards associated with the project.

The OH&S development plan detailed issues and control measures for areas of potential hazard and risk including existing traffic, construction traffic and personnel, work at heights, working over water, blasting, cut and fill earthworks, flooding, underground and overhead utilities, work in confined spaces and hazardous (dangerous) goods, and explained the value engineering and risk management workshop and the issues, risk and opportunities register.

The operational hazards and risks plan identified hazards and risks associated with the project during design and during construction, with emphasis on hazards and risks associated with the transport of hazardous (dangerous) goods. The plan provides an overview of operational and construction aspects of the project, an overview of associated risks and hazards and assessment of specific risk using standard likelihood/consequence methodology.

The plan assessed risks associated with flooding, rain, fog, safety in design, storage of maintenance materials, inadequate maintenance, objects adjacent to road, access for maintenance, and transport of each of the nine classes of hazardous (dangerous) materials. Measures were recommended in each case.

16 The next steps

Following the display of the concept design, the RTA will consider issues raised in any comments received and re-examine the design. Once this process is finalised, the relevant local council will be approached to have the corridor formally reserved in its local environmental plan.

The boundaries of the corridor will be based on the final concept design. Detailed environmental assessment will commence and formal planning approval sought closer to construction. Timing of construction will depend on funding availability. Once this is determined, the detailed environmental assessment will commence and planning approval will be sought to allow construction to commence.

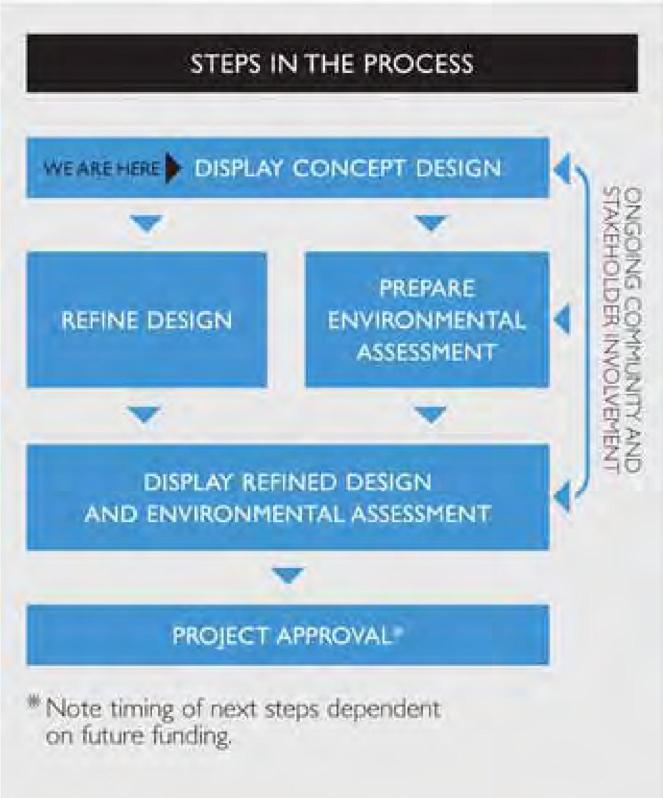

Figure 16-1 The approval process

17 Acknowledgements

Hyder Consulting would like to acknowledge the members of the study team that have contributed to this report, including:

- Roads and Traffic Authority – project management and property acquisitions.
- Hyder Consulting – options, traffic study, highway design, pavements design, structures design, construction staging, resource materials, temporary infrastructure, delay management, street lighting, services and environmental.
- Coffey Geosciences – Soft soil and hill side investigations and design of ground improvements.
- Brown Consulting – hydrology of Richmond River and minor streams excluding Duck and Emigrant creeks, minor cross drainage, pavement drainage, erosion and sedimentation control and water quality.
- WBM (member of the BMT group of companies) – hydrology study of the Duck Creek and Emigrant Creek catchments.
- Biosis Research – Flora and aquatic ecology.
- Ecosense Consulting – Ecology review.
- Geolyse – Fauna ecology.
- PPM Consultants – Social impact and community consultation strategy.
- Adise – Aboriginal heritage.
- Heritage Concepts – Non-Aboriginal heritage.
- HBO+EMTB – Urban design and landscaping

18 References

18.1 General references

The following documents were used in the compilation of this concept design report:

- Woodburn to Ballina Route Options Development Report (RTA 2005a).
- Woodburn to Ballina Preferred Route Report (RTA 2005b).
- Iluka Road to Woodburn Concept Design Report (RTA 2006a)
- Woodburn to Ballina Preferred Route Submissions Report (RTA 2008a).

18.2 Traffic design references

The traffic reporting built upon work from the following documents:

- Safer Roads: A Guide to Road Safety Engineering (Ken Ogden, Monash University, Melbourne, Victoria, Australia. 1996).
- Preliminary Traffic and Transportation Study (Hyder 2005).
- NSW Coastline Cycleway (NSWCC).

18.3 Hydraulic design references

A variety of data sources were used in assembling the hydraulic model:

- Mid Richmond River Flood Study (WBM 1999) - Mike 11 cross sections.
- Mid Richmond River Flood Study (WBM 1999) – Survey points of major hydraulic controls such as road crests and spot levels through the Tuckean Swamp.
- Cabbage Tree Island Flood Study (Patterson Britton 2004) photogrammetry.
- Ballina photogrammetry 2005 provided by DoP.
- River Bathymetry 2004 provided by DoP.
- Photogrammetry from Tuckombil Canal hydraulic assessment 2005 DoP.
- Additional ground survey undertaken as part of this study (source: Hyder Consulting 2005).
- Aerial Laser Survey – Only used in areas where photogrammetry was considered poor (i.e. west of Wardell) and used for extraction of additional drainage channel cross sections.

- 25 m DEM from 1 in 25,000 aerial photography (source: Hyder Consulting).
- 10 m contours of region (source: Hyder Consulting).

18.4 Highway design references

The following standards, in order of precedence, have been used in the development of the highway concept design:

- RTA (2005) DRAFT Upgrading the Pacific Highway Upgrading Program beyond 2006: Design Guidelines (UPHDG, Issue 2.0 March 2005).
- Woodburn to Ballina SWTC Appendix 16 – Technical Requirements.
- RTA Road Design Guide (RDG).
- Pacific Highway Urban Design Framework (UDF).
- AUSTROADS.
- Australian Standards.
- AUS-SPEC-1(Northern Rivers Local Council Design Standards, September 2003).

18.5 Signage and line marking references

- Department of Main Roads NSW Interim Guide to Signs and Markings (June 1981).
- Australian Standard AS1742-1990 Manual of uniform traffic control devices (Parts 1 to 13).

18.6 Pavement design references

Pavement designs were carried out in accordance with the following reference documents, listed in order of precedence:

- RTA Supplement to the AUSTROADS Guide to the Structural Design of Road Pavements DRAFT August 2006 Version 16.
- RTA (2005) DRAFT Upgrading the Pacific Highway Upgrading Program beyond 2006: Design Guidelines (UPHDG, Issue 2.0 March 2005).
- CIRCLY – Geomechanics computer program version 5.0.
- RTA Concrete Pavement Manual Design and Construction Edition 2 (1991).
- AUSTROADS (2004) A Guide to the Structural Design of Road Pavements.

18.7 Structures design references

Bridge structures have been designed in accordance with:

- Woodburn to Ballina SWTC Appendix 16 – Technical Requirements, Bridges.
- Section 8 - RTA (2005) DRAFT Upgrading the Pacific Highway Upgrading Program beyond 2006: Design Guidelines (UPHDG, Issue 2.0 March 2005).
- Australian Standard AS5100 – Bridge Design.
- Australian Bridge Design Code.
- RTA – Bridge Policy Manuals.
- RTA – Structural Drafting Manual.

18.8 Drainage design references

The following have been used in the development of the concept drainage design:

- RTA (2005) DRAFT Upgrading the Pacific Highway Upgrading Program beyond 2006: Design Guidelines (UPHDG, Issue 2.0 March 2005).
- RTA (2004) Quality Assurance Specifications & Guides to QA Specifications – R11.
- AUSTROADS (1994) Guide to Hydraulic Design of Bridges, Culverts and Floodways.
- RTA (1997) RDG - Section 7 Stormwater Management and Drainage Design.
- RTA (1994) Bridge Waterway Manual.
- AUST ROADS (2003) Guidelines for Treatment of Stormwater Runoff from the Road Infrastructures.
- The Institute of Engineers (2001) Australian Rainfall and Runoff – A Guide to Flood Estimation.
- NSW Fisheries (2003) Fish Note – Policy and Guidelines for Fish Friendly Water Crossings.
- NSW Fisheries (2003) Why do fish need to cross the road? Passage Requirements for Waterway Crossing.
- DoP Stormwater Outlet Structures to Streams (for pipes, culverts and spillways) – Version 1.
- DoP Draft Guidelines – Watercourse Crossing Design and Construction - Version 3.
- Department of Housing and Landcom (1998) Managing Urban Stormwater – Soils and Construction.

- Department of Main Roads NSW (1979) – Model Analysis to Determine Hydraulic Capacities of Kerb Inlets and Gully Pit Gratings.
- Relevant Council standards – for local infrastructure.

18.9 Street lighting design references

The lighting concept for the proposed upgrade would be in accordance with the following standards:

- Aus Road – Guide to Traffic Engineering Practices, Part 12 - Roadway Lighting.
- AS/NZS 1158 series.
- RTA reference standards and drawings.
- Relevant council standards.

18.10 Noise design references

The following documents were used in the acoustic component of the concept design:

- Department of Environment and Climate Change (DECC) Environmental Criteria for Road Traffic Noise (ECRTN).
- RTA Environmental Noise Management Manual (ENMM).

Appendix A

Aerial photography mosaic of the proposed upgrade

G515-NS02500-NSK-P4 Concept Design (27 sheet 1:5,000 map book)

Appendix B

Technical review of the ecological investigations for the route selection process

Technical Review of the Ecological Investigations for the Route Selection Process (Hyder, 2008)