Transport
Roads & Maritime Services

NSW GOVERNMENT

Foxground and Berry bypass

Princes Highway upgrade

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NOVEMBER 2012

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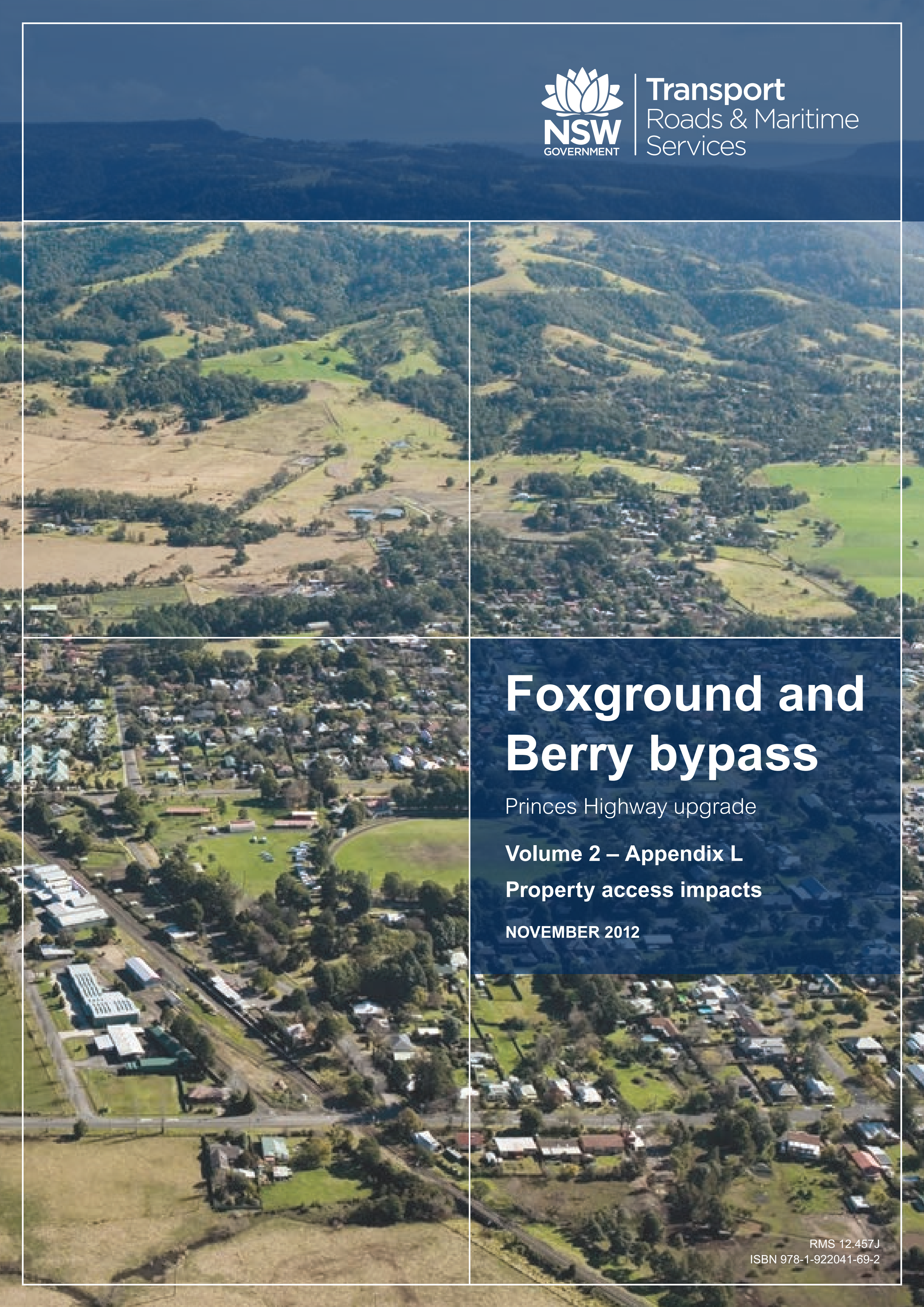

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Volume 2 – Appendix L

Property access impacts

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Appendix L – Property access changes

The purpose of this appendix is to provide detail on the internal and external access impacts of the project. This appendix should be read in conjunction with **Figure L-1**, **Figure L-2** and **Section 7.9**. This appendix does not include properties that have no physical access changes or direct impacts to the property as a result of the project. For example, properties located along the existing highway between Toolijooa Road interchange and Austral Park Road interchange would need to travel to these interchanges to access the upgrade. However, no physical change would be undertaken at these individual properties (unless specified in **Table L–1**).

Table L–1 Details of internal and external access impacts of the project

Lot number or property reference*	Internal access impacts	External Access Impacts
1	No impact.	Loss of direct highway access and replaced with a new access onto Toolijooa Road. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound. RMS owned.
A	No impact.	Direct access to existing Princes Highway unchanged without the need to use the u-turn facility provided at chainage 7850 as part of the Gerringong upgrade. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
B	No impact.	Access to existing Princes Highway unchanged with modified driveway provided as part of the Gerringong upgrade. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
C	No impact.	Access to existing Princes Highway unchanged with modified driveway provided as part of the Gerringong upgrade. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
2	No impact.	Access to Millers Lane unchanged. Opportunity for a new access via an underpass to existing Princes Highway at chainage 8400 would be considered during detailed design. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
3	No impact.	Access via new underpass to existing Princes Highway at chainage 8400. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
4	Property severed, no internal access between severed portions provided in design.	Access to existing Princes Highway unchanged for northern portion. No external access to southern portion and would require property amalgamation. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound. RMS owned.
5	No impact.	No impact.
6	No impact.	No impact.
7	Property severed, no internal access between severed portions provided in design.	Access via new underpass to existing Princes Highway at chainage 9470. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound. RMS owned.

Lot number or property reference*	Internal access impacts	External Access Impacts
8	Property severed, no internal access between severed portions provided in design.	Access to existing Princes Highway unchanged for western portion. No external access to eastern portion and would require property amalgamation. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound. RMS owned.
9	Property severed, internal access between severed portions under Broughton Creek bridge number two.	No physical change to external access arrangements with access to existing Princes Highway unchanged. No external access to eastern portion and would require property amalgamation. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound. RMS owned.
10	Property severed, internal access between severed portions under Broughton Creek bridge number two.	No physical change to external access arrangements with access to existing Princes Highway unchanged. Access via right of way maintained through Austral Park Road extension and lot 11 (common owner). Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
11	Property severed, internal access between severed portions under Broughton Creek bridge number three. Extended cattle pass.	No physical change to external access arrangements with access to existing Princes Highway unchanged. Access via right of way maintained through Austral Park Road extension. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
D	No impact.	Modified driveway access to existing Princes Highway. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
12	No impact.	Loss of direct highway access. Replaced with modified driveway access to via a service road to existing Princes Highway. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
13	No impact.	Loss of direct highway access via private road passing through property E (common owner). Replaced with modified driveway and access via a right of way and Austral Park Road extension to Austral Park Road interchange. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
E	No impact.	Loss of direct highway access via private road passing through lot 13 (common owner). Replaced with modified driveway and access via a right of way and Austral Park Road extension to Austral Park Road interchange. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.

Lot number or property reference*	Internal access impacts	External Access Impacts
14	No impact.	Loss of direct highway access via private road which also has right of way provisions for several nearby properties. Replaced with access via Austral Park Road extension to Austral Park Road interchange. The current right of way provisions would no longer be required, however, right of way provisions would be required for property 13 and property E. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
15	No impact.	Modified driveway access to Austral Park Road. Access via Austral Park Road extension to Austral Park Road interchange. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound. RMS owned.
16	No impact.	Loss of direct highway access via private road and replaced with access via Austral Park Road extension to Austral Park Road interchange. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
F	No impact.	Modified driveway access to Austral Park Road. Access via Austral Park Road extension to Austral Park Road interchange. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
17	No impact.	Modified driveway and access to the project via Austral Park Road extension to Austral Park Road interchange. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound. RMS owned.
18	No impact.	Loss of direct highway access with modified driveway and access to the project via Austral Park Road extension to Austral Park Road interchange. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
19	No impact.	Loss of direct highway access. Modified driveway access to via a service road to existing Princes Highway. Access to project via Toolijooa Road interchange northbound and Austral Park Road interchange southbound.
20	No impact.	Modified driveway access with left in / left out direct access to the project northbound. Southbound access via the Austral Park Road interchange.
21	No impact.	Modified driveway access with left in / left out direct access to the project southbound. Northbound access via the Austral Park Road interchange. RMS owned.

Lot number or property reference*	Internal access impacts	External Access Impacts
G	No impact.	Existing access to Gembrook Lane unchanged. Gembrook Lane extended and intersection with project restricted to left in / left out access to the project southbound. Northbound access via the Austral Park Road interchange.
H	No impact.	Existing access to Gembrook Lane unchanged. Gembrook Lane extended and intersection with project restricted to left in / left out access to the project southbound. Northbound access via the Austral Park Road interchange.
I	No impact.	Existing access to Gembrook Lane unchanged. Gembrook Lane extended and intersection with project restricted to left in / left out access to the project southbound. Northbound access via the Austral Park Road interchange.
22	No impact.	Loss of direct highway access with modified driveway access to Tindalls Lane interchange (via the existing right of way through property 24). The opportunity to provide access via the Gembrook Lane extension, which would be explored during detailed design. Access to project northbound and southbound via Tindalls Lane interchange.
23	100 per cent impact to lot by project.	The property is 100 per cent impacted by the project and would become part of the road reserve.
24	No impact.	Loss of direct highway access with modified driveway access to Tindalls Lane interchange. Access to project northbound and southbound via Tindalls Lane interchange. RMS owned.
25	No impact.	Primary access on the eastern side of the property is not impacted by the project. For the quarry, modified driveway access at new location and access to project northbound and southbound via Tindalls Lane interchange. On the western boundary, loss of direct highway access for secondary access. Replaced with modified driveway and new access road connecting to the northern interchange for Berry.
26	No impact.	Loss of direct highway access with modified driveway access to Tindalls Lane interchange. Access to project northbound and southbound via Tindalls Lane interchange.

Lot number or property reference*	Internal access impacts	External Access Impacts
27	No impact.	Modified driveway access with left in / left out direct access to the project northbound. Access to the project southbound via Tindalls Lane interchange. Southbound access to the property from the project via northern interchange for Berry and u-turn at the roundabout at the junction of the existing Princes Highway and Woodhill Mountain Road. RMS owned.
J	No impact.	Modified driveway access with left in / left out direct access to the project northbound. Southbound access to the property from the project via northern interchange for Berry and u-turn at the roundabout at the junction of the existing Princes Highway and Woodhill Mountain Road.
28	No impact.	Loss of direct highway access and replaced with modified driveway, new access road and underpass at chainage 15100 connecting to the existing highway near ‘Mananga’. Northbound access to and from the project via the northern interchange for Berry and southbound access through Berry via the southern interchange for Berry.
29	No impact.	Loss of direct highway access and replaced with modified driveway, new access road and underpass at chainage 15100 connecting to the existing highway near ‘Mananga’. Northbound access to and from the project via the northern interchange for Berry and southbound access through Berry via the southern interchange for Berry.
30	No impact.	Loss of direct highway access and replaced with modified driveway, new access road and underpass at chainage 15100 connecting to the existing highway near ‘Mananga’. Northbound access to and from the project via the northern interchange for Berry and southbound access through Berry via the southern interchange for Berry.
31	Lot severed. Internal access between severed portions provided under the bridge at Berry.	No impact to the primary access to the lot via Woodhill Mountain Road. Loss of direct highway for secondary access on the eastern edge of the property. Replaced with modified driveway, new access road and underpass at chainage15100 connecting to the existing highway near ‘Mananga’. Access to and from the project for the main access via the northern and southern interchanges for Berry. Northbound access to and from the project for the secondary access via the northern interchange for Berry and southbound access through Berry via the southern interchange for Berry
32	No impact.	Loss of direct highway access. Replaced with modified driveway and new access road connecting to the northern interchange for Berry. Northbound access to and from the project via the northern interchange for Berry and southbound access through Berry via the southern interchange for Berry.

Lot number or property reference*	Internal access impacts	External Access Impacts
33	No impact.	Loss of direct highway access. Replaced with modified driveway and new access road connecting to the northern interchange for Berry. Northbound access to and from the project via the northern interchange for Berry and southbound access through Berry via the southern interchange for Berry.
34	No impact.	Loss of direct highway access. Replaced with modified driveway and new access road connecting to the northern interchange for Berry. Northbound access to and from the project via the northern interchange for Berry and southbound access through Berry via the southern interchange for Berry.
35	No impact.	Loss of direct highway access. Replaced with modified driveway and new access road connecting to the northern interchange for Berry. Northbound access to and from the project via the northern interchange for Berry and southbound access through Berry via the southern interchange for Berry.
36	No impact.	Loss of direct highway access. Replaced with modified driveway and new access road connecting to the northern interchange for Berry. Northbound access to and from the project via the northern interchange for Berry and southbound access through Berry via the southern interchange for Berry.
37	100 per cent impact to lot by project	Existing road reserve lot and is 100 per cent impacted by the project. RMS owned.
38	100 per cent impact to lot by project	The lot is 100 per cent impacted by the project and would become part of the road reserve. RMS owned.
39	Property severed, no internal access between severed portions provided in design.	No impact.
K	No impact	Slightly modified intersection of access road and existing highway, but existing access provisions unchanged.
40	Lot severed, no internal access between severed portions provided in design..	No impact.
41	Lot severed. Internal access between severed portions provided under the bridge at Berry.	No impact. RMS owned.

Lot number or property reference*	Internal access impacts	External Access Impacts
42	Lot severed, no internal access between severed portions provided in design.	No impact. RMS would acquire directly impacted land, and would investigate potential to acquire the entire lot.
43, 46 and 47	No impact.	Loss of access to North Street and replaced with modified driveway access to Rawlings Lane. Rawlings Lane modified to connect to North Street and southern interchange for Berry.
K	No impact.	Modified driveway access to be provided to connect to the North Street cul-de-sac.
44	No impact.	Access to lot via North Street lost and not replaced in design.
45 and 48	No impact.	Modified driveway access to be provided to connect to the North Street cul-de-sac.
49, 50 and 51	100 per cent impact to lot by project.	Each lot is 100 per cent impacted by the project. All are RMS owned.
52	No impact.	Existing access to Rawlings Lane unchanged. Rawlings Lane modified to connect to North Street and southern interchange for Berry.
53	Residual land is not viable.	No longer a viable lot and requires amalgamation. RMS owned.
54, 55 56	Residual land is not viable.	No longer a viable lot (lot 55 and 56 are 100 per cent impacted). RMS owned.
57	No impact.	No impact.
58	Residual land is not viable.	Residual land is not viable. Would be subject to acquisition.
59	100 per cent impact to lots by project.	Each lot is 100 per cent impacted by the project and would become part of the road reserve.. Both lots are RMS owned.
60	Residual land is not viable.	No longer a viable lot. RMS owned.
61, 62 and 63	100 per cent impact to lot by project.	Each lot is 100 per cent impacted by the project and would become part of the road reserve. Both lots are RMS owned.
64 and 65	100 per cent impact to lot by project.	Each lot is 100 per cent impacted by the project and would become part of the road reserve. Both lots are RMS owned.

Lot number or property reference*	Internal access impacts	External Access Impacts
66	100 per cent impact to lot by project.	The lot is 100 per cent impact by the project and would become part of the road reserve. Would be subject to acquisition.
67 and 68	Residual land is not viable.	Each lot is no longer a viable lot and would require amalgamation. RMS owned.
69, 70, 71, 72, 73 and 74	100 per cent impact to lot by project.	Each lot is 100 per cent impacted by the project and would become part of the road reserve. All are RMS owned.
75	100 per cent impact to lot by project.	The lot is 100 per cent impact by the project and would become part of the road reserve. Would be subject to acquisition.
76 and 78	100 per cent impact to lot by project.	Each lot is 100 per cent impacted by the project and would become part of the road reserve. All are RMS owned.
77	No impact.	Loss of direct access to highway via Hitchcocks Lane, and replaced with modified Hitchcocks Lane connecting to Huntingdale Park Road. Northbound and southbound access to the project via southern interchange for Berry.
L	No impact.	Loss of direct access to highway via Hitchcocks Lane, and replaced with modified Hitchcocks Lane connecting to Huntingdale Park Road. Northbound and southbound access to the project via southern interchange for Berry.
79	No impact.	Loss of access to the highway via Victoria St. Replaced with access via Victoria, George and Queen streets. Northbound and southbound access to the project via southern interchange for Berry.
80	No impact.	Loss of direct access to highway via Hitchcocks Lane, and replaced with modified Hitchcocks Lane connecting to Huntingdale Park Road. Northbound and southbound access to the project via southern interchange for Berry.
81	No impact.	Loss of direct access to highway via Hitchcocks Lane, and replaced with modified Hitchcocks Lane connecting to Huntingdale Park Road. Northbound and southbound access to the project via southern interchange for Berry.
82	100 per cent impact to property by project	The lot is 100 per cent impact by the project and would become part of the road reserve. Would be subject to acquisition.
83	No impact (road corridor).	Owned by Shoalhaven City Council (road corridor for Schofields Lane). The potential for full acquisition would be investigated.

Lot number or property reference*	Internal access impacts	External Access Impacts
84	No impact.	Left in / left out northbound access to and from the project via the modified Schofields Lane junction. Southbound access to the project via the southern interchange for Berry. Southbound access from the project via the Mullers Lane u-turn facility.
M	No impact.	Left in / left out northbound access to and from the project via the modified Schofields Lane junction. Southbound access to the project via the southern interchange for Berry. Southbound access from the project via the Mullers Lane u-turn facility.
85	No impact.	Left in / left out northbound access to and from the project via the modified Schofields Lane junction. Southbound access to the project via the southern interchange for Berry. Southbound access from the project via the Mullers Lane u-turn facility.
86	No impact.	No impact.
87	No impact.	Modified driveway access with left in / left out direct access to and from the project. Northbound access to the project via the Mullers Lane u-turn facility. Northbound access from the project to the property via the southern interchange for Berry.
88	No impact	Modified driveway access (requiring a deep cutting to connect to internal driveway) with left in / left out direct access to and from the project. Northbound access to the project via the Mullers Lane u-turn facility. Northbound access from the project to the property via the southern interchange for Berry.
89	No impact.	No impact with existing access via George Street, Berry.
90	No impact.	Loss of direct access to highway and replaced with new access road connecting to the cul-de-sac at the western end of Victoria Street. Northbound and southbound access to the project via the southern interchange for Berry.

** Property numbers are assigned to properties directly impacted by the project and are consistent with the lot references in Section 7.9. References A ,B and so on have used for additional properties.*

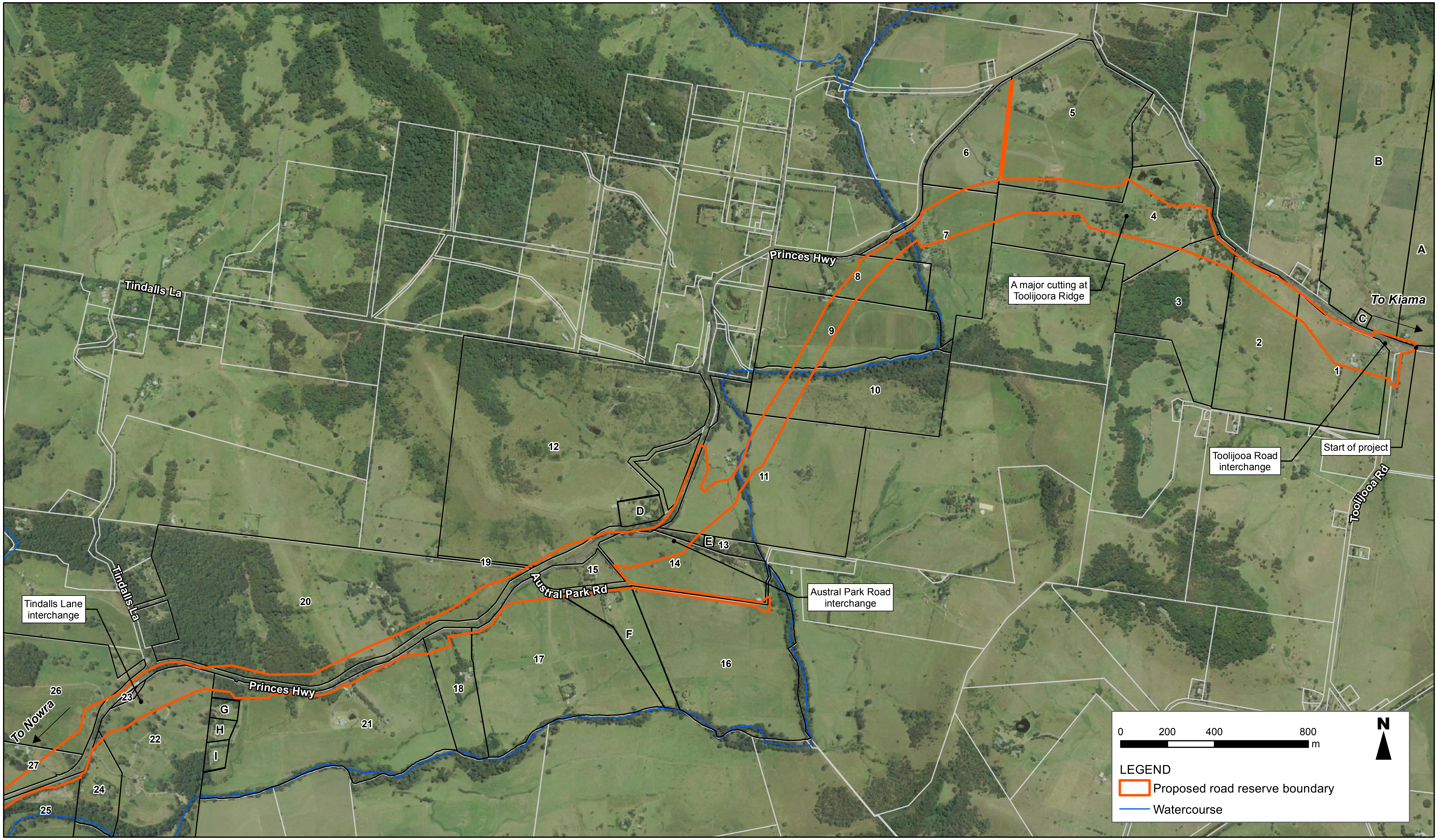


Figure L-1 Properties impacted by internal or external property access changes (Toolijooa Road interchange to Tindalls Lane interchange)

Note: Lot numbers refer to Table L - 1

Source: AECOM (2012)

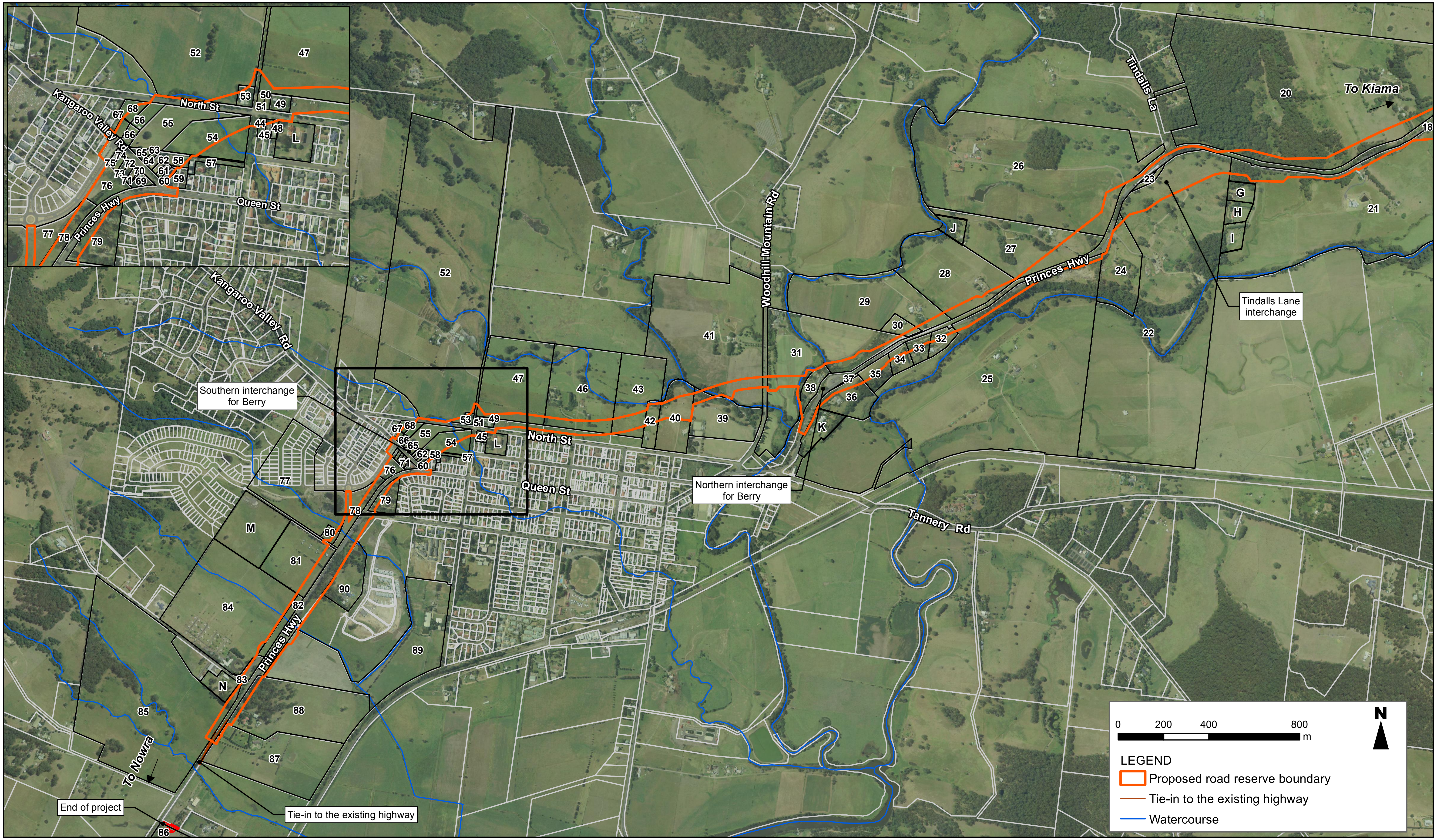
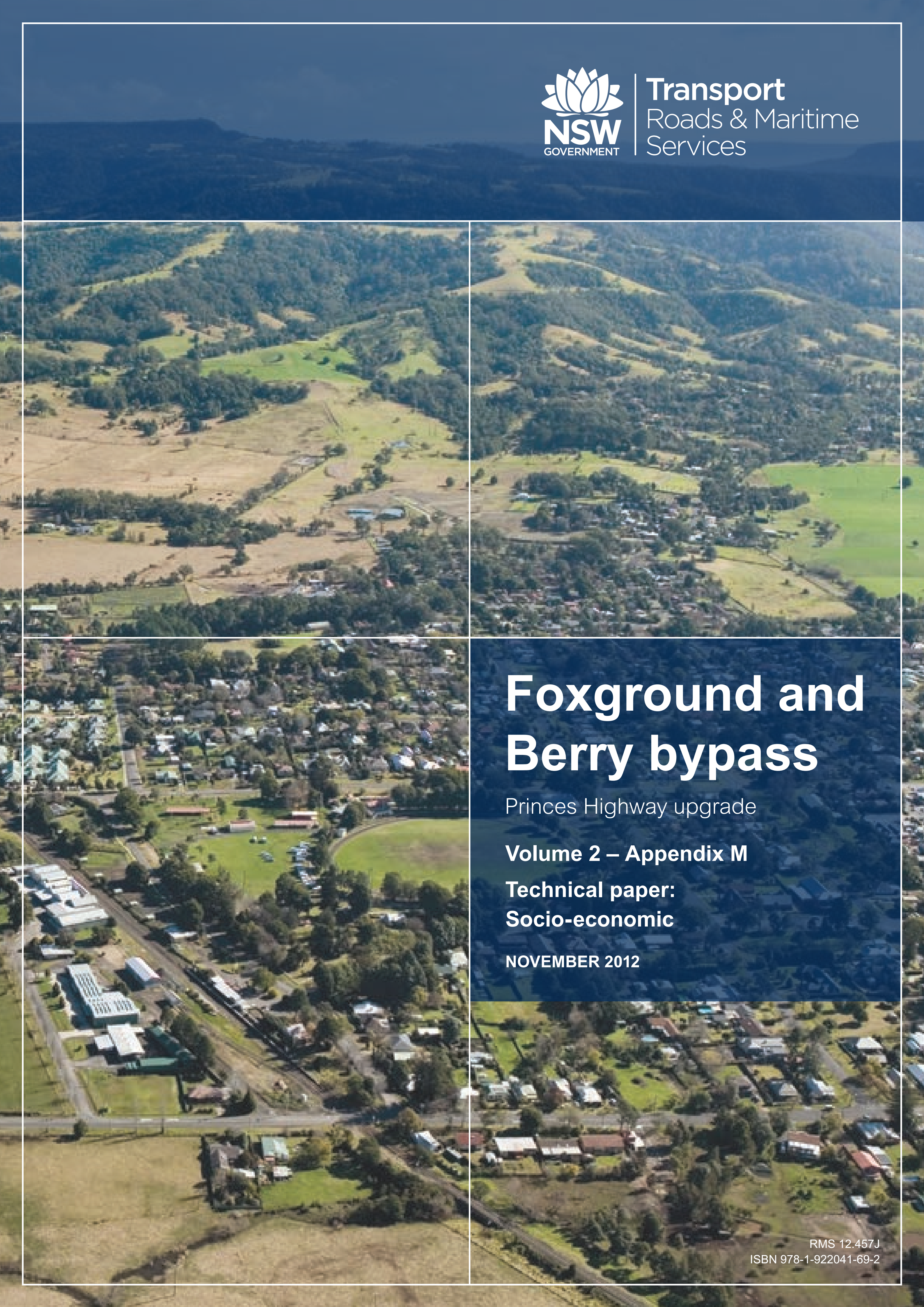


Figure L-2 Properties impacted by internal or external property access changes (Tindalls Lane interchange to Schofields Road junction)

Note: Lot numbers refer to Table L - 1

Source: AECOM (2012)



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Volume 2 – Appendix M

Technical paper: Socio-economic

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Foxground and Berry bypass

Prepared for

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November 2012

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Executive summary

Roads and Maritime Services (RMS) propose to upgrade 11.6 kilometres of the Princes Highway between Toolijooa Road north of Foxground and Schofields Lane south of Berry, in New South Wales (NSW) (the project), to achieve a four lane divided highway (two lanes in each direction) with median separation. The project includes bypasses of Foxground and Berry and would provide increased road safety and traffic efficiency in the south coast region.

The project objectives are to:

- Improve road safety.
- Improve efficiency of the Princes Highway between Toolijooa Road (north of Foxground) and Schofields Lane (south of Berry).
- Support regional and local economic development.
- Provide value for money.
- Enhance potential beneficial environmental effects and manage potential adverse environmental impacts.
- Optimise the benefits and minimise adverse impacts on the local social environment.

The purpose of this report is to assess the socio-economic impacts of the project. This study has been undertaken by AECOM in association with RM Planning.

The Director-General of the NSW Department of Planning and Infrastructure required that the study address a number of matters relating to affected properties; agricultural sector impacts; local community socio-economic impacts relating to access, land use, property and amenity related changes; impacts on businesses in Berry; and impacts on recreational fishing. The report has addressed these and other relevant socio-economic issues.

The study area for the purpose of this report includes the road corridor as well as the land immediately adjacent, and the wider catchment as it relates to current usage of the Princes Highway.

The methodology for this study relies on the description of the existing context, analysis of key stakeholder issues, review of case studies on the impacts of bypassed towns, and assessment of impacts and mitigation measures. The methodology uses quantitative as well as qualitative data.

The region is defined both by its agricultural history and a more recent focus on tourism. Since the 1970s, the town of Berry has assumed increasing importance as a tourist destination as well as a location for ‘tree changers’, or people choosing to move from the city for a rural lifestyle.

The population in the region is stable, with only modest growth expected between 2011 and 2036. Some new development is occurring in Berry, but nothing is planned for other villages in the study area. An ageing population is manifest in the region, and particularly in the town of Berry. The decline of agriculture as an employment sector has been accompanied by a rise in employment in service sector industries that target both resident and visitor populations, in particular, in retail, health care, accommodation and food service.

In community consultation undertaken as part of the project, the local community has indicated that it values the high quality and intrinsic beauty of the surrounding rural environment and considers it an economic asset, being a draw for tourists as well as being productive agricultural land. Significant value is also placed on the existing community, recreation and open space facilities in Berry. Accessibility is a key driver of the community cohesion that currently exists in Berry. These elements contribute to the lifestyle qualities that have attracted people to the region in the first instance.

Key stakeholder issues to emerge during consultation for the project included access arrangements, agricultural land and farming activities, business and the local Berry economy, impacts on commercial operations, properties, amenity and heritage, uncertainty, and community impacts. These issues, including the project design response, are discussed at Chapter 3 of the report.

A review of case studies of town bypasses was conducted to ascertain relevance for the project. A number of key issues were identified as influencers of post bypass socio-economic conditions, including distance of the bypass from a town; town size; extent of reliance of businesses on highway trade; length of impact; and the role and characteristics of the town. This discussion is at Chapter 4 of the report.

Assessment of impacts has taken into account both construction phase and operational impacts. The nature of anticipated impacts is discussed in detail at Chapter 5 of this report.

The project would be likely to create both positive and negative impacts on the region and its community.

The project would result in improved amenity for the greater part of Berry. Amenity impacts on residents of Huntingdale Park and North Street include increased noise and loss of views. These impacts have been mitigated by moving the highway further away from the Berry urban area and through the provision of noise barriers and visual treatment.

Social interaction and identity may be strengthened as a result of the project. Uncertainty is an impact that would be felt mostly before and during the construction stage but can be managed through continuing consultation. Community severance may be experienced by a small number of residents in the vicinity of North Street, Berry.

The project would impact the economic contribution of the agriculture sector in the study area, although with resale of productive land to neighbouring properties, there would be opportunities to minimise this impact. The project would not be expected to affect the viability of the dairy industry.

Although some highway-reliant businesses in Berry may experience a decrease in turnover as a result of the bypass, the town as a whole would be expected to benefit from an improvement to amenity within the main commercial area of Queen Street and Alexandra Street.

Access to recreational fishing sites is not expected to be significantly affected as a result of the project, since existing access to the Broughton Creek bridge would be unaffected by the construction works. Opportunities for fishing in the local area would increase as access would be available at four new bridge crossings provided as part of the project. Parking bays for bridge maintenance workers would be provided where possible along the project and these would be available for use by fishers wishing to access the river bank in the vicinity of the bridge.

The study recommends a number of mitigation measures that are intended to minimise any impacts that would be associated with the construction and operation of the project. These are detailed at Chapter 5 of this report.

On balance, it is considered that the overall impact of the project would be positive for the region.

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1 Introduction

The Roads and Maritime Services (RMS) is seeking approval under Part 3A of the *Environmental Planning and Assessment Act 1979* for the upgrade of 11.6 kilometres of the Princes Highway, to achieve a four lane divided highway (two lanes in each direction) highway with median separation between Toolijooa Road north of Foxground and Schofields Lane, south of Berry (the project). The project would include bypasses of Foxground and Berry.

The project objectives are to:

- Improve road safety.
- Improve efficiency of the Princes Highway between Toolijooa Road (north of Foxground) and Schofields Lane (south of Berry).
- Support regional and local economic development.
- Provide value for money.
- Enhance potential beneficial environmental effects and manage potential adverse environmental impacts.
- Optimise the benefits and minimise adverse impacts on the local social environment.

The purpose of this report is to assess the socio-economic impacts of the project. The study has been undertaken by AECOM in association with RM Planning.

The Director-General of the NSW Department of Planning and Infrastructure required that the socio-economic impact assessment address a number of matters. These are outlined in **Table 1-1** and cross referenced to the relevant sections in the report. Impact on land use and future development are considered in Section 7.9 of the environmental assessment.

Table 1-1: Director-General's requirements

DGR reference	Report section
Directly affected properties and land uses adjacent to the project including: impacts to land use viability and future development potential; and property allotment, land sterilisation and severance impacts.	Sections 5.2.2, 5.2.5 Section 7.9.2 of the environmental assessment
Agricultural sector, taking into account the fragmentation and potential loss of agricultural and farm viability, including internal and external farm access arrangements during construction and operation.	Sections 5.1.5, 5.2.3
Local community socio-economic impacts associated with access, land use, property and amenity related changes.	Sections 5.1.1, 5.1.2, 5.1.3, 5.2.1, 5.2.2, 5.2.4
Business impacts including the overall viability, profitability, productivity and sustainability of businesses in the Berry township associated with the changes to the route alignment in Berry.	Sections 5.1.4, 5.2.5
Recreational fishing impacts on access and opportunities in Broughton Creek, Broughton Mill Creek and Bundewallah Creek.	Sections 5.1.6, 5.2.6

Sections 5.1.9 and 5.2.8 address mitigation measures for construction and operational impacts respectively across the above areas of consideration.

1.1 Overview of the proposed works

The project is one of a series of upgrades to sections of the Princes Highway which aims to provide a four lane divided highway between Waterfall and Jervis Bay Road, Falls Creek. This would improve road safety and traffic efficiency, including for freight, on the NSW south coast.

The project comprises the following key features:

- Construction of a four lane divided highway (two lanes in each direction) with median separation (wire rope barriers or concrete barriers where space is constrained, such as at bridge locations).
- Bypasses of the Foxground bends and the Berry township.
- Construction of around 6.6 kilometres of new highway where the project deviates from the existing highway alignment at Toolijooa Ridge, the Foxground bends and the Berry township.
- Provision for the possible widening of the highway (if required in the future) to six lanes within the road corridor and, in some areas, construction of the road formation to accommodate future additional lanes where safety considerations, traffic disruption and sub-optimal construction practices are to be avoided.
- Grade-separated interchanges at:
  - Toolijooa Road.
  - Austral Park Road.
  - Tindalls Lane.
  - East of Berry at the existing Princes Highway, referred to as the northern interchange for Berry.
  - West of Berry at Kangaroo Valley Road, referred to as the southern interchange for Berry.
- A major cutting at Toolijooa Ridge (around 900 metres long and up to 26 metres deep).
- Six lanes (two lanes plus a climbing lane in each direction) through the cutting at Toolijooa Ridge for a distance of 1.5 kilometres.
- Four new highway bridges:
  - Broughton Creek bridge 1, a four span concrete structure around 170 metres in length and nine metres in height.
  - Broughton Creek bridge 2, a three span concrete structure around 75 metres in length and eight metres in height.
  - Broughton Creek bridge 3, a six span concrete structure around190 metres long and 13 metres in height.
  - A bridge at Berry, an 18 span concrete structure around 600 metres long and up to 12 metres in height.
- Three highway overbridges:
  - Austral Park Road interchange, providing southbound access to the highway.
  - Tindalls Lane interchange, providing southbound access to and from the highway.
  - Southern interchange for Berry, providing connectivity over the highway for Kangaroo Valley Road along its existing alignment.

Eight underpasses including roads, drainage structures and fauna underpasses:

  - Toolijooa Road interchange, linking Toolijooa Road to the existing highway and providing northbound access to the upgrade.
  - Property access and fauna underpass in the vicinity of Toolijooa Ridge at chainage 8400.
  - Dedicated fauna underpass in the vicinity of Toolijooa Ridge at chainage 8450.
  - Property access underpass between Toolijooa Ridge and Broughton Creek at chainage 9475.
  - Combined drainage and fauna underpass in the vicinity of Austral Park Road at chainage 12770.
  - Combined drainage and fauna underpass in the vicinity of Tindalls Lane at chainage 13320.
  - Dedicated fauna underpass in the vicinity of Tindalls Lane at chainage 13700.
  - Property access underpass between the Tindalls Lane interchange and the northern interchange for Berry in the vicinity of at chainage 15100.

- Modifications to local roads, including Toolijooa Road, Austral Park Road, Gembrook Road, Tindalls Lane, North Street, Queen Street, Kangaroo Valley Road, Hitchcocks Lane and Schofields Lane.
- Diversion of Town Creek into Bundewallah Creek upstream of its confluence with Connollys Creek and to the north of the project at Berry.
- Modification to about 47 existing property accesses.
- Provision of a bus stop at Toolijooa Road and retention of the existing bus stop at Tindalls Lane.
- Dedicated u-turn facilities at Mullers Lane, the existing highway at the Austral Park Road interchange, the extension to Austral Park Road and Rawlings Lane.
- Roundabouts at the southern interchange for Berry and the Woodhill Mountain Road junction with the exiting Princes Highway.
- Two culs-de-sac on North Street and the western end of Victoria Street in Berry.
- Tie-in with the existing highway about 75 metres north of Toolijooa Road and about 440 metres south of Schofields Lane.
- Left in/left out only provisions for direct property accesses to the upgraded highway.
- Dedicated public space with shared pedestrian/cycle facilities along the southern side of the upgraded highway from the playing fields on North Street to Kangaroo Valley Road.
- Ancillary operational facilities, including permanent detention basins, stormwater treatment facilities and a permanent ancillary facility site for general road maintenance.

Modifications to local roads include:

- Relocation of the entrance to Toolijooa Road.
- Addition of two roundabouts to Kangaroo Valley Road, of which one forms the intersection with Queen Street, the other with Huntingdale Park Road.
- Realignment and extension of Austral Park Road.
- Severance of North Street.
- Closure of Victoria Street.
- Connection of Hitchcocks Lane to Huntingdale Park Road.

The project and the key features of the project are shown in **Figure 1-1**.

1.2 Definition of study area

The study area includes the road corridor itself, as well as those lands immediately adjacent to it, and the wider catchment as it relates to current usage of the Princes Highway. Most of the study area lies within the Shoalhaven Local Government Area (LGA). Around one third of the study area between Toolijooa Road and Broughton Creek bridge 3 is in the Kiama LGA.

The regional context of the project is shown in **Figure 1-2**.

1.3 Methodology

The methodology for this study has been developed to address the Director-General's requirements for the environmental assessment. It relies on the description of the existing social and economic context, analysis of key stakeholder issues, review of case studies on the impacts of bypassed towns, and assessment of impacts and mitigation measures.

The methodology relies on quantitative as well as qualitative data. The analysis of key stakeholder issues and community values identified during project consultation also draws on recent data from interviews with property owners and a survey of local businesses.

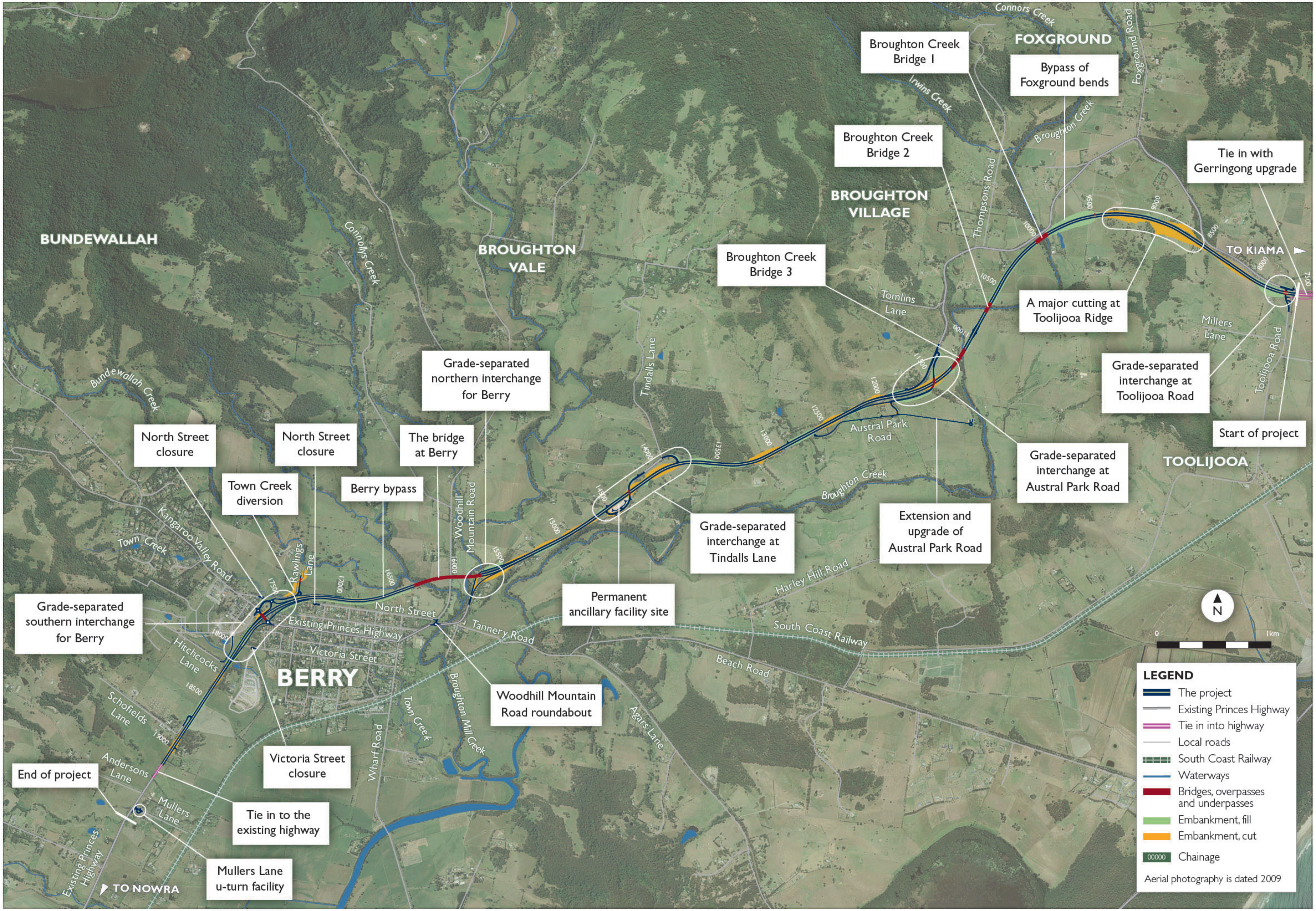

Figure 1-1: Foxground and Berry bypass project area

Figure 1-2 Regional context of the project

2 Context

2.1 Historical background

The study area was largely owned by the Berry family from around the 1820s, with dairying being the primary purpose for the original land acquisition. For the next 100 years, land was subdivided for small scale dairy farming. The consolidation of the dairy industry into larger, more mechanised businesses, coming at a time when non-manual labour was becoming more attractive, resulted in a decline in the number of dairy farms in the region. Where once there may have been several hundred farms, by 2009 there were only around 12 (*Non-Aboriginal (Historic) Heritage technical paper*, Navin Officer, 2009, Appendix K of the environmental assessment).

Timber harvesting and sawmilling flourished from the early nineteenth century and persisted through the housing boom of the mid 1900s. This industry has now disappeared.

In the early and middle part of the twentieth century, Foxground and Broughton Village were small but active communities, including community facilities such as schools, churches and community halls and milk co-operatives. Berry was also a small settlement during this period.

From the 1970s, Berry started to become attractive as a tourist destination as well as a location for city residents seeking alternative lifestyles. These two factors contributed to Berry's increased dominance in the region. As Berry continued to grow and flourish, villages such as Foxground and Broughton Village entered a period of decline as people moved away. This decline saw the closure of community facilities, churches and schools, for which there was no longer sufficient demand. The Toolijooa community has become stronger in recent years but is still a minor settlement.

Berry has become the dominant urban centre in the study area. While some connections remain in the rural villages, these are no longer identifiable as urban communities (Navin Officer, 2009).

2.2 Existing context

2.2.1 Socio demographic indicators

Data for socio-demographic indicators is from the 2006 Census[1], unless otherwise stated. Demographic tables are provided at Appendix A.

The study area has been profiled by examining the data for the Census Collection Districts (CCDs) of Broughton Vale, Broughton Village, Jaspers Brush and Rose Valley. The CCDs which comprise the study area are 1180508, 1180504, 1180812, 1180306, 1180314, 1180801[2], 1180502, 1180503 and 1180506. The geographical areas of comparison are therefore NSW, Shoalhaven LGA, the study area and Berry urban centre. As only a very small section of the study area is contained within the Kiama LGA, no reference is made to Census data for this LGA.

Berry is in the Shoalhaven LGA and is defined for the purposes of statistical profiling as the Berry urban centre, as illustrated in **Figure 2-1**.

[1] *A complete set of Census 2011 data was not available at the time this report was prepared.*

[2] *There was a boundary adjustment to this CCD at the 2006 Census which reduced its size. As much of what was previously included is forest area, this adjustment is unlikely to have had a significant effect on data comparison between the 2001 and 2006 Census.*

Figure 2-1: Berry Urban Centre

Source: ABS (2006), RTA (2011), LPMA (2011)

Key socio-demographic characteristics are as follows:

- Population growth: The population of the study area, as well as that of Berry, declined between 2001 and 2006, whereas there was a marginal increase in the Shoalhaven LGA. Population forecasts for the Shoalhaven LGA show modest growth between 2011 and 2036 (NSW Department of Planning and Infrastructure, 2010).
- Median age: The median age of Berry's population was 49 in 2006, whereas it ranged between 45 and 51 in the rest of the study area. The median age was 44 in the Shoalhaven LGA and 37 in NSW. Median age increased in the study area, Berry and Shoalhaven between 2001 and 2006.
- Population aged 65 and over: Both the study area and Berry had a high proportion of population in this category (29.2 per cent and 28.3 per cent respectively), compared with Shoalhaven LGA (21.2 per cent), and 13.8 per cent in NSW.
- Indigenous population: Indigenous population in the study area is comparatively low in 2006 (0.7 per cent) and declining since 2001. This trend is similar for Berry which has a low percentage of indigenous population in 2006 (0.8 per cent) compared with Shoalhaven LGA (3.7 per cent) and NSW (2.1 per cent).
- Ethnicity: The study area, Berry, and the Shoalhaven region are largely homogeneous with more than 90 per cent of the population speaking English at home, compared to 74 per cent in NSW.
- Employment status: 49 per cent of the study area's workforce was employed in full time occupations in 2006, compared to 53 per cent of the Berry workforce, 51 per cent in Shoalhaven LGA and 61 per cent in NSW. Over a third (35 per cent) of the study area's workforce was employed in part time occupations, compared to 38 per cent in Berry. These proportions are higher compared to Shoalhaven LGA (34 per cent) and NSW (27 per cent). The study area's unemployment rate was four per cent compared to five per cent in Berry. This is low when compared to the rate of nine per cent in Shoalhaven LGA and six per cent in NSW.
- Employment by industry sector: 40 per cent of Berry's jobs are concentrated in the retail, health care, accommodation and food services sectors. Comparable figures for the study area, Shoalhaven LGA and NSW are 32 per cent, 35 per cent and 28 per cent respectively. Employment in the study area is not concentrated in any one or group of sectors. The most common industry of employment is the retail and health care sectors, each of which employs 12 per cent of the workforce.
- Employment: 628 persons were employed within the Berry urban area at the 2006 Census, of whom 398 persons were employed in the retail, healthcare, accommodation and food services, education, construction and manufacturing sectors. This represents 63 per cent of the Berry workforce and 43 per cent of the study area workforce respectively. Much of this employment is related to servicing the tourist sector, while the prominence of the healthcare and social assistance services sector, coupled with an ageing population, suggests a link to the retiree market.
- Median weekly household income in Berry was $789 compared to $659 in Shoalhaven LGA and $1036 in NSW. The study area range is $700 to $1266.
- Journey to work: The vast majority of the study area's population uses a car to go to work, as is the case with residents of Shoalhaven LGA. For example, of those persons using one method of travelling to work, 86 per cent of the study area population uses a car, compared to 85 per cent of Berry residents, with comparable figures for Shoalhaven and NSW residents being 88 per cent and 78 per cent respectively.

Some expansion of the Berry urban area has recently occurred around the southern part of Kangaroo Valley Road (west Berry) and in Victoria Street. The area around Huntingdale Park continues to develop for the family housing market, whereas the following two retirement villages in Victoria Street will add significantly to the amount of available housing stock for the retiree market:

- The Arbour, comprising 52 self-care dwellings and housing for the aged, adjacent to the Princes Highway but accessed from Victoria Street. More than 50 per cent of the dwellings have been constructed, with the remainder expected to be completed mid 2013 subject to demand (Michael Sullivan, The Arbour, personal communication 5 October 2011).
- 'The Grange', comprising 37 self-care dwellings, a community centre and recreational facilities accessed from Victoria Street. This development has been operational for a few years, with 14 villas still to be constructed.

In summary, the study area has a homogenous and ageing population. Recent development of almost 100 aged persons housing units has responded to a significant proportion of population in the over 65 age group. The study area enjoys a lower than average unemployment rate, with the most common industry of employment in the retail and health care sectors and the bulk of jobs located in Berry. The study area population is heavily dependent on motor vehicles for transport.

2.2.2 Community character

The study area is predominantly rural in character, consisting mainly of large lot agricultural holdings. Agriculture has traditionally been dominated by the dairy industry, but more recently wineries and equestrian activities have become more prominent in the sector.

The historically active towns of Broughton Village and Foxground are today an agglomeration of rural residential allotments.

Berry is the first non-coastal country town located along the Princes Highway when heading south from Sydney. It is located around 130 kilometres, or two hours drive time, from Sydney.

The northern and southern boundaries to the Berry urban area are North Street and the South Coast railway, respectively. Within Berry, the Princes Highway is known as Queen Street, and is the main street of the town.

Berry's physical qualities are defined by both the built and the natural environment. The town contains a number of historic buildings, well established gardens and vegetation, and is set against the dramatic scenic backdrop of the Cambewarra range located to the north and west.

Berry's community infrastructure consists of several educational facilities, health services, places of worship, community centres, arts and entertainment facilities, emergency services, open space, sporting and recreation facilities, and clubs. An inventory of facilities associated with these land uses is provided at Appendix B. These facilities are important not only in servicing the needs of the town and its hinterland, but also in creating a sense of community cohesion and wellbeing. See also Section 2.2.6.

Community values

In community consultation undertaken over the past five years during the route selection process and planning for the project, the local community has indicated that it values the high quality and intrinsic beauty of the surrounding rural environment and considers it an economic asset, as it is a draw for tourists as well as being productive agricultural land. The community also highly values the existing community, recreation and open space facilities in the town. These elements make up the lifestyle qualities that have attracted people to the region.

Existing physical connections and linkages between the different parts of Berry are instrumental in shaping current community cohesion. Existing paths of travel by vehicle, bicycle and on foot are seen as critical to maintaining this current community cohesion. This also contributes to the community character of the town.

These community values are summarised in **Table 2-1** (AECOM, 2008).

Table 2-1: Community values

Category	What the community value about living in the area
Functional	• Location – business and transport links to Sydney. • Location – easy drive to and from Sydney, the coast and surrounding districts for locals and tourists. • Safety for cyclists, pedestrians and vehicles.
Environment	• Climate and rainfall provides highly productive agricultural land. • Quiet, pristine rural and natural environment (flora and fauna). • Long agricultural history still alive in working farms. • Connection of European and Indigenous heritage with the environment.
Economic	• Productive land of national significance. • Tourist destination, not just a thoroughfare. • Market, employment and business opportunities. • Potential for economic and population growth.
Social	• Strength of enduring sense of belonging and networks of support and cohesion. • Family, generational and emotional connection to the landscape, environment and the region. • Aesthetic appeal – unique combination of hills and escarpment, rainforest, agricultural land and the coast. • Lifestyle and associated emotional and health benefits – small, safe town and rural communities with access to facilities and services, and the countryside eg scenic vistas, cycling, slow roads. • Active community with strong social and interest group networks.

2.2.3 Economic/business environment

The economy of the study area is based on rural as well as urban activities.

Agricultural businesses

Agricultural land within the study area is used for dairy and beef production, viticulture, goat rearing, livestock feed (grasses) and agistment, with the largest economic contributions being from the dairy and beef industries. Dairy farms within the study area supply the Berry Rural Cooperative, which employs a total of 28 people across the organisation[3].

[3] *Number of employees sourced from the Berry Rural Co-operative Society website. www.southcoastdairy.com.au, viewed October 2011.*

The dairy industry is one of Australia's major rural industries, third most important in terms of the value of production, behind the beef and wheat industries (Dairy Australia, 2011). The dairy industry in Australia is concentrated in the south east of the country where the conditions are favourable and eight per cent of Australia's milk production comes from NSW (Dairy Australia, 2011).

The majority of the land in the study area is classified as high value in terms of land capability. The project area is largely made up of land classified as Class 2 as classified by the former Soil Conservation Service of NSW. This classification refers to land that is suitable for regular cultivation and a wide variety of agricultural uses. In particular this land has a high potential for production of crops. The NSW Department of Primary Industries Agricultural Land Classification indicates this land as Agricultural Class 2 or 3. The department describes Class 2 Agricultural land as arable land suitable for regular cultivation for crops but not suited to continuous cultivation and Class 3 Agricultural land is identified as grazing land or land well suited to pasture improvement. **Figure 2-2** and **Figure 2-3** illustrate land classifications in the study area.

Around Broughton Village the study area includes land of lower Agricultural Classes 4 and 5. This land is classified as suitable for grazing but not for cultivation or as land unsuitable for agriculture or best suited only to light grazing.

Of the 58 potentially directly affected rural properties, 24 are classified as having agricultural uses. These involve dairy (including Berry Rural Cooperative suppliers) and beef cattle farming, as well as horse agistment, goat rearing, turf production and silage.

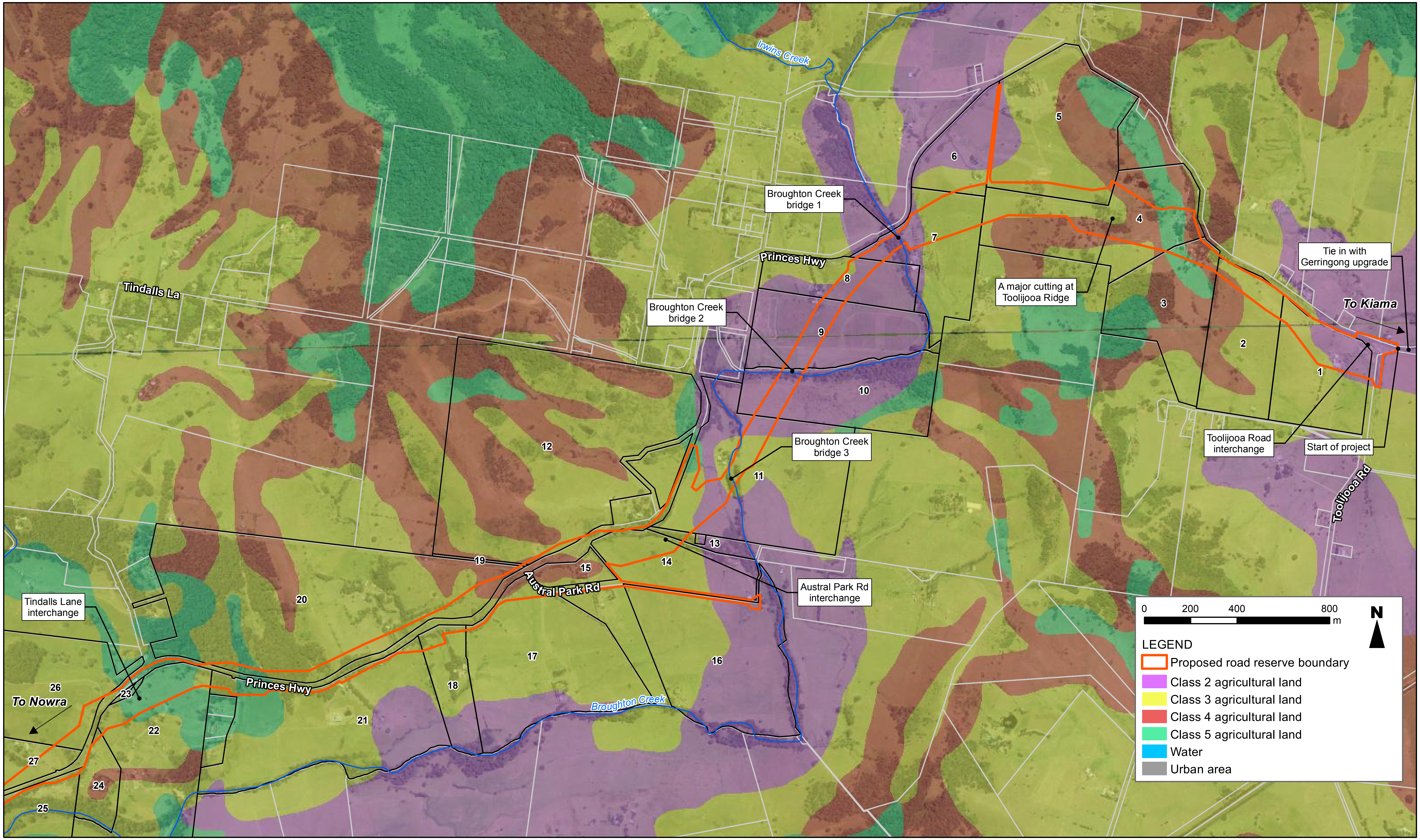

Figure 2-2 Land capability within study area (AECOM, 2011)

Source: DPI (2012)

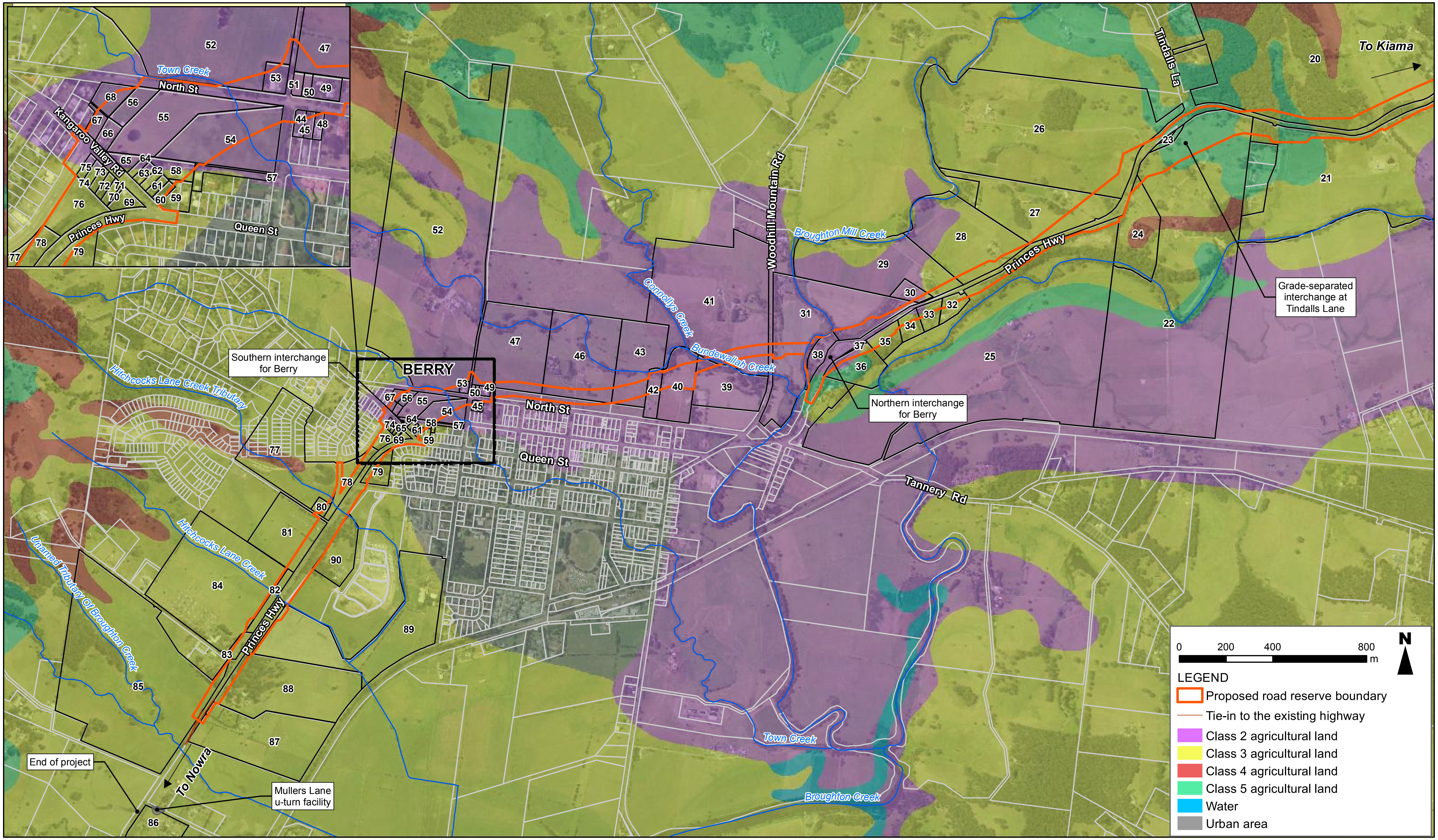

Figure 2-3 Land capability within study area (AECOM, 2011)

Source: DPI (2012)

Berry businesses

Berry is within an easy days drive or train ride from Sydney[4] and, coupled with its natural and built form attractions, the town represents an ideal stopping point for through traffic as well as being a destination in itself. It attracts a significant number of day trippers who visit the town for its amenity.

A survey in 2008 of 15 food outlets, gift stores and clothes shops in Berry revealed that business from outside the town was generated by:

- People driving through the town and stopping for a short period.
- Tourists staying in the town and surrounding area.
- People travelling to the town as a destination.

In particular:

- Gift shops such as home wares, jewellery, china and furniture had a high level of trade from outside the local area, generally around 70-90 per cent.
- Cafés and food shops also had a high level of external trade, generally around 70-90 per cent.
- Clothes shops had around 50-60 per cent of external trade and specialised shops (ie antique shops) also had a high turnover from external trade (up to 90 per cent).

In general:

- Customers came primarily from the north (Wollongong and Sydney) but some shops reported a smaller number of customers coming from the south.
- Berry is a destination town and many people travel there for shopping, food and browsing.
- People who come to Berry as a destination tend to stay longer in the town, often on a day trip, and spend more than people who stop briefly on their way through the town.
- More people visit and pass through Berry on weekends than weekdays.
- ‘Long haul’ highway travellers were not often mentioned, indicating that the bulk of trade was from people with a destination in the region (SGS Economics and Planning, 2008).

Business activity in Berry is mainly concentrated along Queen Street, between Albert and Alexandra Streets, as depicted in **Figure 2-4**.

[4] *And about an hour from Wollongong.*

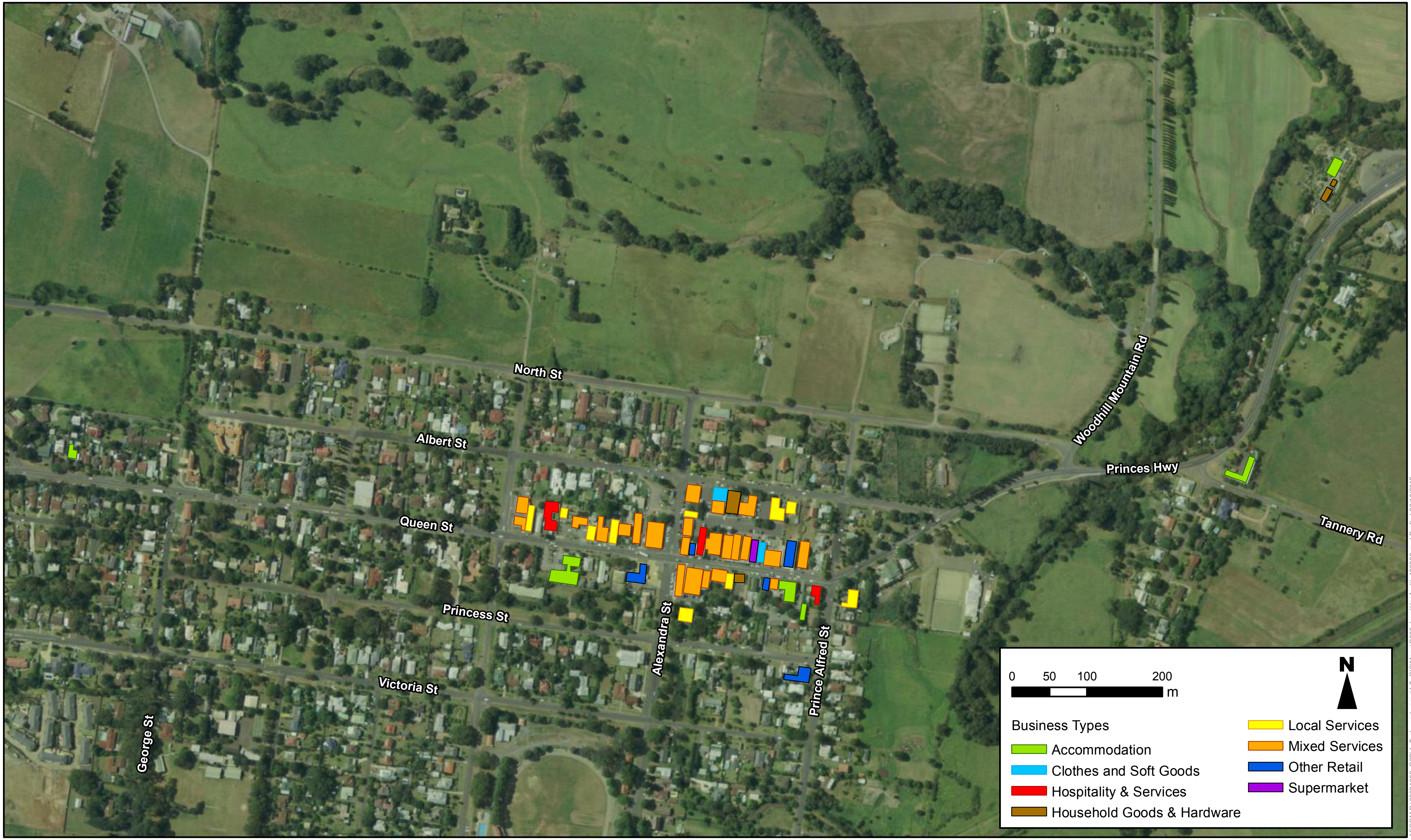

Figure 2-4: Business types within Berry (SGS Economics and Planning, 2008)

Source: SGS Economics and Planning, 2008

Berry has a number of businesses that cater both to the tourist and local markets. The SGS report (2008) identified 105 businesses in Berry of which 34 (32 per cent) were likely to cater to locals only and the remaining 71 businesses (68 per cent) were those that would serve both locals, as well as tourists and motorists passing through the town. Further surveys by AECOM in 2008 and 2011 of businesses catering to passing motorists, tourists and locals, confirmed these proportions. The AECOM survey (2008)[5] showed that retail businesses, representing the majority of Berry businesses, considered that less than 15 per cent of their turnover resulted from through traffic. Businesses most reliant on this form of trade were petrol stations, with 70 to 75 per cent of their turnover earned from this source. Accommodation businesses and food and beverage businesses considered that 24 per cent and 20 per cent respectively of their turnover resulted from through traffic.

2.2.4 Tourism

The study area is a popular tourist destination, with an abundance of natural attractions such as beaches, waterways, national parks and state forests, but also containing more formal attractions such as historic villages and buildings, for example Coolangatta historic village, and recreation areas and Seven Mile Beach National Park.

The significance of tourism to the South Coast Region is reflected in the percentage of businesses that serve this sector; ie 24.2 per cent of all businesses compared to the national benchmark of 20.2 per cent at June 2009. Employing businesses comprise 54.8 per cent of all tourism businesses in the region, compared to the national benchmark of 39.7 per cent.[6]

Despite the global downturn and high value of the Australian dollar, visitation to the South Coast continues to increase. In the year ending 30 September 2011, international visitation to the area increased by 13 per cent, with expenditure in excess of $190 million by foreign visitors. Domestic overnight and day visitors to the area injected $617 million into the local economy, supporting 6000 jobs.[7]

On a national scale, the Shoalhaven area, in which most of the study area is located, ranks as the third most visited LGA behind the Gold Coast and Sunshine Coast.

In the year ending June 2011, the Shoalhaven LGA received 1.2 million domestic visitors and 421,700 visitor nights, an increase of 11 per cent over the previous year. By comparison, the South Coast Region (from Helensburgh to the Victorian border) recorded 2.9 million visitors, while NSW recorded 24.1 million visitors during this period.[8]

Accommodation data[9] is available for hotels and resorts, motels, private hotels and guest houses, and serviced apartments, all of which have 15 or more rooms and where the stay is shorter than two months. Key indicators for the year ending June 2011 for the Kiama and Shoalhaven B Statistical Local Areas, within which the study area is located, are as follows:

- There were 18 establishments in Shoalhaven and nine in Kiama, offering 419 and 328 rooms respectively, and 1440 and 945 bed spaces respectively.
- These establishments employed 233 persons in Shoalhaven and 188 in Kiama.
- Shoalhaven room occupancy rates were 50.6 per cent while those in Kiama were 53.3 per cent.

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[5] *Unpublished background research.*
[6] *Economic Importance of Tourism in Australia's Regions Tourism Research Australia August 2011, p6.*
[7] *Tourism Research Australia data, viewed at www.southcoastregister.com.au/news/...tourist.../2397162.aspx.*
[8] *Shoalhaven Tourism 29 September 2011 www.scpromotions.com.au/shoalhaven-tourism-statistics.*
[9] *ABS Catalogue 8635155001DO001_201106 Tourist Accommodation, Small Area Data, New South Wales, Jun 2011.*

There were 89,281 guest arrivals in Shoalhaven while there were 63,834 in Kiama.

- Average length of stay in Shoalhaven was 1.7 days while this was two days in Kiama.
- Revenue from this form of accommodation was $12.4 million in Shoalhaven and $10.0 million in Kiama.

The tourism sector is therefore significant to the study area both in terms of economic activity and job creation. No tourism statistics are available for Berry but a survey in 2008 identified eight accommodation providers in the town.

2.2.5 Travel patterns

The Princes Highway is the major route for road traffic between Sydney and the South Coast. Since the Highway passes through Berry, all through traffic, including heavy vehicles[10], must pass through this town. This means that between 70-75 per cent of traffic passing through Berry does not stop (AECOM, 2011b).

Private vehicles are the predominant mode of transport in the study area, which is reflected in high levels of household vehicle ownership in the Kiama and Shoalhaven LGAs. The levels are 1.73 and 1.69 respectively, which are higher than the average of 1.47 in the Sydney greater metropolitan area. The 2007 Household Travel Survey Summary Report (NSW Department of Transport and Infrastructure, 2009) shows that around 85 per cent of total trips on a typical weekday made in Kiama and Shoalhaven are car-based, compared to an average of 72 per cent in the Sydney Greater Metropolitan Area (AECOM, 2011b).

Local and regional bus and coach services use the Princes Highway in the project area, although the number of routes and frequency of services available to the general public are limited, resulting in fewer buses being used when compared to other forms of travel (AECOM 2011b). School services between Gerringong, Berry and Bomaderry frequent the route during term time.

Rail passengers represent one per cent of average weekday travel mode share in the project area. This is due in part to the South Coast line terminating in Bomaderry and the absence of direct rail services from Berry to Sydney (AECOM 2011b).[11]

There are no formal cycle specific facilities in Berry but Shoalhaven Council does promote various cycle routes to and from Berry utilising the Princes Highway and other local and regional roads (for example Berry to Seven Mile Beach via the Princes Highway, Tannery Road and Beach Road, and Berry to Kangaroo Valley via Berry Mountain) (AECOM 2011b).

A proposed 1400 kilometre coastal cycleway stretching from the Queensland border to the Victorian border includes a section within the study area that follows the route of the 'Sandtrack'. This connects to the Berry to Seven Mile Beach route described above. The purpose of the cycleway program is to deliver more sustainable transport choices, increase tourism, provide better coastal recreation access and grow bicycle-tourism industries. It is largely funded by RMS and implemented by local government, and has already resulted in over 330 kilometres of the route being constructed or committed, in the form of shared pedestrian/cycle paths or on-road cycle lanes along local streets.[12] There are opportunities for Shoalhaven and Kiama Councils to apply for grants to improve the route for cyclists. There is also the opportunity to expand the cycling network beyond the coastal cycleway.

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[10] *There is an alternative route along the 'Sandtrack', but heavy vehicles are not permitted to use this route (AECOM 2011b).*

[11] *There is a train service from Berry to Sydney, but passengers are required to change at Kiama.*

[12] *www.planning.nsw.gov.au viewed on 17 January 2012.*

Other than within Berry, there are limited opportunities for pedestrian movement along the Princes Highway within the project area due to significant travel distances between towns coupled with the high speed limits along the highway.

2.2.6 Recreation/community facilities

Berry has a wide range of community facilities and assets, ranging from places of worship to sporting grounds, recreational, educational and essential facilities and services. Many of these facilities were provided when the town was first established, including the old court house, hospital, post office and police station. An inventory of facilities and services, prepared using maps of the area and supplemented by a site visit, is at Appendix B.

The Berry Community Activities Centre was established in the 1970s and played a pivotal role in reviving the town as a tourist and residential destination. A number of activities are coordinated from this Centre, including the Berry School of Arts, Berry Community Cottage, and the Berry Country Fair.

The Berry Showground is used by Shoalhaven residents and visitors, and has been identified in consultations as a key focal point for community interaction. The showground is the location for local community activities such as the annual Berry Agricultural Show, monthly Berry Country Fair, equestrian events and football.

The Berry Sports and Recreation Centre is a popular and integral part of town life, providing facilities for sporting activities such as swimming, cricket, netball and tennis, on-site accommodation and conference space, picnic and BBQ facilities.

The Berry Riding Club and a number of other equestrian clubs including the Woodhill Mountain Pony Club and the Shoalhaven Show jumping Club operate from a property owned by Shoalhaven City Council on North Street, adjacent to the sportsground.

Local residents enjoy using North Street as a quiet and scenic route for recreational walking, jogging and cycling. It is also a pleasant alternative route to Queen Street for other trips on foot and by bike. Local residents have also cited the importance of North Street as a pedestrian connector with other parts of Berry (see **Figure 2-5**).[13] The study area affords many opportunities for passive recreation, with an abundance of natural features, as well as parks, rest stops and lookouts.

Another recreational pastime in the area is fishing. Fishers at local creeks mostly fish for Australian Bass in the spring and summer months. Broughton Creek has been used as a brood stock location for fish stocking. Feedback from the local fishing community suggests that the number of fishers accessing local creeks is low but those that do mainly visit Broughton Creek, which they access from the road bridge. Fishers also visit Bundewallah, Connelly's and Broughton Mill Creeks, which are also accessed from road bridges. Legal access to the bed and bank of the creek areas is currently only available from existing road crossings of the creeks, unless prior agreed access has been arranged across private lands. RMS has been advised by some landowners that they experience unauthorised access by fishers to their land.

Figure 2-5 illustrates the location of the growth areas described in Section 2.2.1 and shows how the North Street corridor provides an alternative route between the established area of Berry and the growth area at west Berry. It also shows how North Street provides a connection from west Berry to community assets, including the Berry sportsground and the Pullman Street heritage precinct.

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[13] *Personal communication, Berry Project Office, 6 December and 12 December 2011.*

Summary

The study area is strongly defined by physical, economic and social characteristics.

The physical qualities of the rural environment derive from their agricultural capability as well as their scenic qualities. These physical qualities have become a draw for tourists as well as an economic asset for the study area, and on which the local community places high value.

The majority of land in the study area has high value land capability, with favourable conditions for dairying. The dairy industry in the study area is the third most important nationally in terms of value of production.

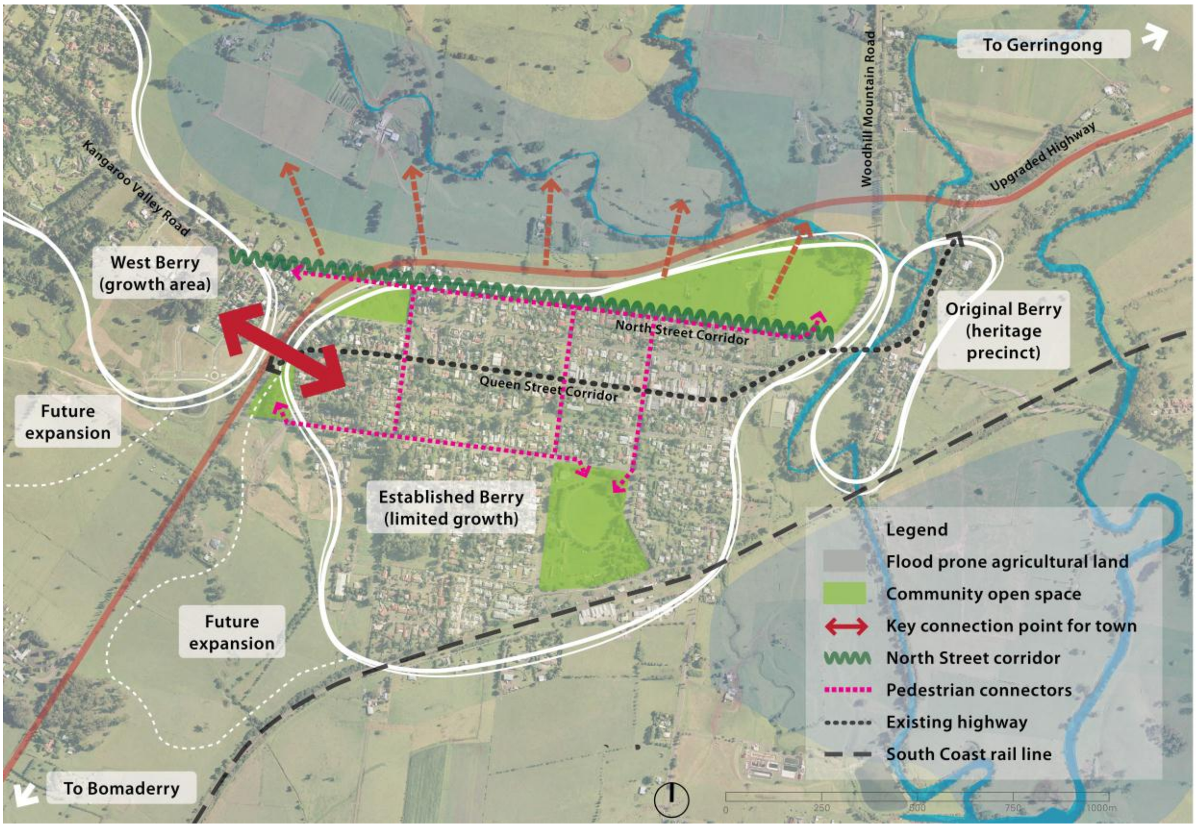

Figure 2-5: Pedestrian routes to key community assets within Berry (Source: AECOM, 2012)

Note: The orange arrows pointing away from North Street represent views from Berry across rural vistas to the escarpment.

Nestling in the escarpment of the Cambewarra range, Berry's historic buildings, well established landscaped areas and community facilities, have forged particular lifestyle qualities that have made it an attractive place in which to live. Berry's proximity to Sydney and Wollongong has also made it an ideal stopping point for through traffic as well as being a destination in itself. Berry attracts a significant number of day trippers who visit the town for its amenity.

While a number of Berry's businesses target the tourist market, they also serve residents' needs. A survey by AECOM in 2008 found that less than 15 per cent of business turnover is considered to be dependent on highway related trade.

Private vehicles are the predominant mode of transport throughout the study area, with higher than average levels of vehicle ownership. There is limited public transport availability, and limited opportunities for cycling and pedestrian movement, other than within Berry.

The study area affords many opportunities for both passive and active recreation, with an abundance of natural features, parks, rest stops and lookouts. Fishing from local creeks is an established pastime. Many of Berry’s community and recreational facilities were provided when the town was first established, and together with those that have developed more recently, have become important aspects of residents’ lives.

2 Consultation and key stakeholder issues

RMS has undertaken a comprehensive program of community consultation with potentially affected property owners, interest groups, government and private agencies and the broader community since March 2006.

The consultation process has allowed the community to raise issues and themes that have been considered in the project design. The community expressed values about living in the area, which are set out in **Table 2-1** and are summarised as follows (RTA, 2008):

- Economic: productive land of national significance; tourist destination, not just a thoroughfare; market, employment and business opportunities; potential for economic and population growth.
- Social: strength of enduring community spirit and networks of support and cohesion; family, generational, emotional and spiritual connection to the landscape, environment and region; visual beauty; lifestyle and associated emotional and health benefits.

The economic and social issues that emerged during consultation on route options (RTA, 2008) are summarised in **Table 3-1**. The third column to the table identifies where the issue is addressed in this report or in other documents.

Table 3-1: Economic and social issues

Issue	Detail	Report section
Economic issues		
Access arrangements	• The upgrade must ensure that access and connectivity are maintained to protect business viability. • Design of interchanges must provide easy access in/out of Berry.	• 5.1.3 and 5.2.4. • Princes Highway Upgrade – Foxground and Berry Bypass, Traffic and Transport Assessment (AECOM, 2011b).
Agricultural land and farming activities	• The preferred route option should minimise impacts to agricultural land and farming business: impacts include land fragmentation, severance of high value agricultural land, impacts to viability of long established dairy farms. • Prime crop, dairy and agricultural land needs to be preserved and recognised as a valuable resource.	• 5.1.5 and 5.2.3. • Section 7.9 of the environmental assessment.
Business and the local economy	• The preferred route option should minimise impacts to business and local economy, including tourist industry. • Job losses from decrease in passing trade, impacts of delays during construction and flow on effects of reduced visitation to the area, if tourist related businesses close, should be considered. • The proposed upgrade/bypass has potential to have a positive impact on local economy, including tourism.	• 5.1.4 and 5.2.5. • Princes Highway Upgrade: Economic Appraisal of Berry and Gerringong town access arrangement (SGS Economics and Planning, 2008).

Issue	Detail	Report section
	• Options that divert traffic away from Berry, but still maintain a visual link with the town are preferred. • The Berry bypass would improve amenity, improve business and increase tourism potential.	
Impact on commercial operations	• The upgrade may impact on the viability of the Berry Rural Co-operative Society. There may be an impact to individual dairy farms, reduced business from local residents and supply of agistment from local rural land.	• 5.1.5 and 5.2.3.
Impact to properties	• The preferred route option should minimise loss of property.	• 5.2.2. • Section 7.9 of the environmental assessment.
Social issues		
Social amenity	• Potential impacts to village character/heritage qualities, sporting/recreational and other community facilities, tourism potential, severance of significant views, quiet enjoyment of the area. • Benefits of Berry bypass include traffic reduction and noise reduction which would enhance tourist potential and town amenity. • Need to maintain integrity (cohesion) of the area. • The upgrade needs to protect the natural and built amenity of Toolijooa. • The North Street option has potential to impact on noise, air quality, scenic vistas, and to isolate sporting facilities. • The preferred route option should be located parallel to North Street to minimise impacts.	• Table 3-2, 5.1.1, 5.1.6, 5.2.1, 5.2.2 and 5.2.6. • Princes Highway Upgrade – Foxground and Berry Bypass, Noise and Vibration Impact Assessment (AECOM, 2011a). • Air Quality Impact Assessment (PAE Holmes, 2011).
Heritage	• Berry's historic qualities need to be protected. • The North Street option is incompatible with Berry's historic context.	• Table 3-2, 5.2.6.
Uncertainty	• Uncertainty about impacts on property and livelihood is difficult, particularly for the elderly.	• 5.1.2.
Impacts to property	• Social costs associated with property loss include loss of home, lifestyle, sense of belonging, fragmentation of land, devalued property, etc.	• 5.2.2. • Section 7.9 of the environmental assessment.

Issue	Detail	Report section
Impacts to community	• The project needs to consider the community's needs, including impacts on existing community facilities and amenities. • The sporting complex is an important part of (Berry) town life, its facilities are important for maintaining community wellbeing. • The process (of investigations into the highway upgrade) has caused division within the community.	• 5.1.2, 5.1.6 and 5.2.2.

Feedback during the route options phase of the project highlighted the importance to the community of the access arrangements for Berry. As a result, RMS committed to undertaking community consultation on access options for Berry and a value management study to assist the development and selection of the Berry access arrangements.

Ongoing consultation since then has included discussions with residents who would be affected by construction noise and with recreational fishers, who were contacted through local fishing clubs. The community is also kept informed of the project through regular updates and by having weekly access to a project office in Berry. A community review group met seven times between August 2011 and November 2011 to discuss alternative alignment options to the north of North Street.

Members of this group raised the issues that are summarised in **Table 3-2**. The third column to the table outlines the ways in which the design of the project and the planning process has responded to these issues. A public meeting was held in December 2011 to present a new alignment for the Berry bypass.

Table 3-2: Issues raised by members of the Berry bypass community review group

Group	Issue	Design response
North Street residents	• Residents along North Street have expressed concern about impacts on lifestyle quality resulting in particular from the close proximity of the project to residences along North Street and the inclusion of noise attenuation measures up to five metres high along the southern side of the upgrade. • Concerns include security (North St would become a dark dead end street), amenity and loss of rural outlook (noise, visual) and health (perceived loss of sunlight and air quality) impacts. • Residents are also concerned about the effects on property values as a result of these potential impacts.	• The highway has been moved further away from North Street, creating a 40 metre buffer between the highway and North Street between Alexandra and Edward Streets. The highway has been lowered by up to two metres in the vicinity of North Street. Noise barriers have been reduced in height from five to four metres. • The heights of road and noise barriers have been reduced and highway moved further away from North Street. This would reduce noise and visual impacts as well as preserve views to the escarpment. • The design is unable to respond to changes in property values.

Group	Issue	Design response
Dairy farmers north of North Street	• The viability and future plans for expansion of two farms is in question due to further loss of land, Berry Co-op relies on these farms for its viability. • The farms create the pastoral landscape character for which Berry is known. • Retain preferred alignment.	• The revised alignment seeks to minimise impacts on productive agricultural land while addressing the amenity concerns of the community.
Dairy Farmers Co-operative	• Support for current preferred alignment as it minimises land take affecting dairy farms and subsequently its viability and future plans for expansion.	• The revised alignment seeks to minimise impacts on productive agricultural land while addressing the amenity concerns of the community.
Chamber of Commerce	• Support a bypass and accept the preferred route if the design would be appropriate and would not spoil Berry. • Believe that height of the bridge at Berry would create an 'eyesore' and change the existing rural 'feel' of Berry for local residents and visitors. This would discourage visitors and therefore affect business operations.	• The bridge at Berry has been moved 95 metres to the north at Woodhill Mountain Road, and its height over Woodhill Mountain Road has reduced from 13.1 metres to 6.7 metres.
Berry Alliance	• Reduce height of bridge and move away from North Street to reduce the environmental impact of the upgrade, particularly the associated noise and visual impacts of the elevated bridge and embankment to the north of North Street.	• The bridge height has been reduced and the highway moved further away from North Street – see points above.
Residents north of Berry	• Support existing alignment as it reduces the potential impact on rural agricultural land north of Berry, but RMS should seek to reduce potential noise and visual impacts by reducing the height of the bridge and embankment to the north of North Street.	• The bridge height has been reduced from 13.1 metres to 6.7 metres.

3 Review of case studies of town bypasses

This socio-economic impact assessment for the project draws on evidence of reported socio-economic impacts experienced by bypassed towns as follows:

- Bureau of Transport and Communications Economics 1994, Working Paper 11. The Effects on Small Towns of Being Bypassed by a Highway: A Case Study of Berrima and Mittagong.
- Urban Regional Planning Program, University of Sydney 2005, The Karuah Highway Bypass, Economic and Social Impacts: The 1 Year Report.
- Urban Regional Planning Program, University of Sydney 2009, The Karuah Highway Bypass, Economic and Social Impacts: The 5 Year Report.
- NSW RTA and University of Sydney, 1996, Evaluation of the Economic Impacts of Bypass Roads on Country Towns: Final Report.
- NSW RTA and University of NSW 2011, Economic Evaluation of Town Bypasses: Review of Literature.

This chapter summarises the findings of this review.

4.1 What were key issues affecting these towns?

The *Economic Evaluation of Town Bypasses study* (RTA and UNSW 2011) identified the following key indicators of change post bypass:

- Small towns (less than 2500 in size) are generally at more risk of adverse economic impacts from a highway bypass, yet they continue to survive.
- Towns with a higher level of dependence on highway trade may experience greater economic impact than towns with a lower level of such dependence.
- Highway dependent businesses seen as vulnerable to impacts from a bypass included service stations and restaurants. Studies of highway bypass impacts in NSW show similar findings, with service stations, food and beverage outlets being the most affected businesses, with accommodation establishments being less affected.
- In some cases, being close to a large centre was seen to be detrimental to post bypass recovery as motorists could use the bypass to quickly access the larger centre for highway related services.
- Distance to the town from the bypass was seen to have some bearing on impacts, for example, the greater the distance from the bypass, the less likely traffic would be to stop in the town.
- The social impacts of a highway bypass on towns are generally very positive, with the perception of improved quality of life and environmental amenity. Residents benefit from significant reductions in traffic flows through their main streets and town centres, with access and parking becoming easier, more pleasant and safer.

Before being bypassed, each of the towns described below was defined by a certain set of characteristics which influenced the extent to which impacts were felt after the bypass had been constructed. For example:

- Berrima: The main industry in this historic village was tourism and retailing, with Berrima's heritage character being a prime reason to visit, notwithstanding the amenity impacts caused by the Highway bisecting the town.
- Mittagong: While this town also had a tourism and retailing base, its appeal as a tourist destination was less important compared to Berrima. It also served as a convenient stopping place for long distance and regional traffic of which a number of businesses were associated.
- Karuah: This small town had few major linkages to industries in the area, limited amenity, a population with a high level of disadvantage, and a large proportion of businesses that were either totally or partially reliant on highway trade. Forty one per cent of businesses in the food, petrol, restaurant/takeaway and accommodation sectors were identified as being dependent on business from highway traffic (University of Sydney, 2005).
- Goulburn: This established regional town serviced the needs of a large resident population as well as its rural hinterland; a proportion of businesses were, however, reliant on highway trade. The town contains a number of heritage precincts and buildings of heritage significance.
- Yass: Part of Canberra's dormitory zone, Yass was an important centre servicing motorists' needs, and the most important truck stop between Melbourne and Sydney. The town's amenity was significantly impacted by the highway.
- Studies of highway bypass impacts in NSW have shown that the most affected businesses are those directly serving the needs of the motorist: motor vehicle services, particularly service stations, food and beverage outlets and, to a lesser extent, accommodation establishments.

Goulburn, Mittagong and Yass all had populations of more than 2500 prior to being bypassed, while Berrima and Karuah had fewer than this number. Berry had a population of 1484 at the 2006 Census.

In each case, the bypass was some distance from the affected town. Impacts of the respective bypasses varied as follows:

- Berrima: The resulting reduction in traffic and elimination of heavy vehicles from the main street improved the town's amenity and increased Berrima's tourist appeal. There were medium term benefits for tourism and retailing businesses and employment. The bypass resulted in an increase in the number of tourism related businesses.
- Mittagong: There were short term adverse impacts on tourist and retail sales and employment, with take away food shops, service stations, budget priced motels being the most seriously affected.
- Karuah: The town's economy was adversely affected with 48 job losses in one year after the bypass opened, reducing to 35 job losses at the five year mark. Businesses most seriously affected were service stations, takeaway food outlets/cafes/restaurants. By contrast, there was an improvement to Karuah's amenity, quality of life and safety. There was also a feeling that the bypass had indirectly assisted in forging community cohesion, by removing the barrier that had previously split the town in half. In the medium term, some businesses had repositioned themselves, including a service station, and businesses were reporting less of an impact than was felt immediately after the bypass had opened (University of Sydney, 2005; 2009).

- Goulburn: Economic impacts were not significant, with job losses corresponding to less than one per cent of total employment. There were significant improvements to main street amenity through the removal of heavy vehicles and reduction in traffic, coupled with a main street improvement program promoted by Goulburn City Council (RTA and University of Sydney, 1996).
- Yass: This town experienced a significant reduction in employment attributable to the bypass (93 jobs at 18 businesses), but significant benefits to main street amenity through the removal of heavy vehicles and reduction in traffic. The subsequent development of highway service centres close to the Yass turn-off compensated in considerable part for job losses sustained by businesses dependent on highway related trade (RTA and University of Sydney, 1996).

4.2 Relevance for Berry and other settlements that would be bypassed

The primary interest for this assessment is in how the project would affect Berry. While there are other settlements along the route, including Foxground and Broughton Village, the project is not anticipated to generate adverse impacts for those communities. If anything, it is likely to enhance their amenity and reinforce the sense of community cohesion by moving the highway further away, with the exception of the Toolijooa community which would still be in relative proximity to the highway. In addition, these settlements support little to no business activity, thus impacts from loss of highway related trade would not arise. Some individual residences would be closer to the highway as a result of the project.

The following key issues emerge from the case studies on bypassed towns:

- Being able to see the town from the bypass is not necessarily a critical factor in determining the ongoing viability of the bypassed town. For example, Berrima and Goulburn have flourished post bypass.
- Town size alone does not predispose a locality to adverse impacts eg. Berrima's population at the 2006 Census was 868 persons.
- Towns whose businesses relied heavily on highway trade were more affected by the bypass. Service stations, some retailing, takeaway food and restaurants were most affected.
- Businesses that serviced a resident community and hinterland were not adversely affected.
- A number of vulnerable businesses such as service stations, over time, repositioned themselves to survive the post bypass environment.
- While economic impacts can be severe in the short term, this severity appeared to become less marked in the medium term.
- Towns that were destinations in themselves eg Berrima, performed better post bypass than those whose role in the region was less well defined eg Mittagong.
- There was a universal improvement in amenity and lifestyle quality as a result of removing heavy traffic from the towns' main streets.

This experience appears to suggest that the economic impacts on Berry would be restricted to those businesses that are extremely dependent on highway trade (see also discussion at 5.2.5), but that Queen Street and the streets adjoining it would benefit significantly from improved amenity.

Most of the case studies analysed during the literature review do not discuss mitigation measures in any great detail.

Mitigation measures implemented to minimise and manage the impacts of these bypasses range from signage, upgrading of tourist and recreation facilities, conversion of redundant land uses for community use, and main street improvements.

In the case of Karuah, Port Stephens Council took a proactive role in trying to promote improvements to the town’s facilities and services. The then Department of Planning required, as a condition of approval, that an economic recovery plan be funded by RMS and monitoring of impacts be made at 12 months and five years after the bypass had been built. Features of the plan included marketing of the town, increasing local community social infrastructure, main street improvements and enhancement of tourism potential through facility upgrades (RTA and UNSW 2011). A project co-ordinator was appointed to oversee implementation of the mitigation measures. These initiatives have had mixed outcomes.

Goulburn City Council implemented a Main Street Program that reduced the two lanes in each direction through the town, to one lane in each direction. This allowed for increased parking capacity and improvements to main street amenity.

5 Assessment of impact

5.1 Construction phase impacts

5.1.1 Amenity impacts

Amenity refers to the quality of a place, its appearance, feel and sound, and the way its community experiences the place. Aesthetic qualities are an important part of amenity, but the broader concept of amenity is determined also by the physical design of a place and the human activity that takes place within it. A place that has 'amenity' is regarded as pleasant and attractive, as well as convenient and comfortable.[14]

Amenity impacts include any factors that affect the ability of a resident, visitor or business owner to enjoy their home and daily activities, for example, noise, vibration, detrimental changes to views or changes to air quality. A project could improve amenity in some locations while being reduced in others. Residents or road users could experience construction fatigue during a lengthy construction phase.

Amenity impacts during construction of the project are discussed in detail in Sections 7.2 (noise and vibration), 7.6 (landscape character and visual amenity) and 8.2 (air quality) of the environmental assessment.

Most of the construction activities would take place from 7am-6pm, Monday to Friday and 8am-1pm Saturday, with no work on Sunday or public holidays. However, certain activities would need to take place outside of these hours due to technical considerations, such as the need to meet particular quality specifications for placement of concrete pavement; safety and traffic management considerations; and/or due to climatic factors (cold winters and hot summers)[15]. Construction hours are further detailed in the *Foxground and Berry Bypass, Noise and Vibration Impact Assessment* (AECOM, 2011a) which is provided at Appendix E of the environmental assessment.

A noise and vibration assessment of construction activities, based on a worst case 15 minute period[16], found that noise management levels would be exceeded if no mitigation measures were put in place. Some residents would be 'highly noise affected' by some activities, including earthworks and impact piling. Those residents affected would be notified before particularly noisy activities were to take place and activities would be organised so that there are respite periods from high levels of noise.

Blasting would be required along the Toolijooa Ridge to produce a cutting to accommodate the project. Appropriate blasting criteria in accordance with the relevant guidelines have been recommended. Higher limits have also been proposed contingent on the approval of the affected residents, and the employment of safe work practices. The aim of the higher blasting limits is to reduce the number of blasts and the overall construction timeframe and consequent impacts on the community.

[14] *Handy, S Amenity and Severance 2002.*
[15] *This occurred on the Hume Highway Duplication Project during hot weather periods.*
[16] *Which is not representative of the entire construction period.*

An extension to working hours has been proposed as part of the project. To date, a proposal to extend working hours by one hour at the start and end of the working day during the period of daylight saving, for activities between Toolijooa Road and Tindalls Lane has been discussed with directly affected residents. These activities would be limited to the following times and locations:

- Between 6am and 7pm Monday to Friday for the Toolijooa cut, Broughton Creek floodplain and major bridge works (outside Berry township).
- Between 7am and 4pm on Saturdays for the Toolijooa cut, Broughton Creek floodplain and major bridge works (outside Berry township).
- Outside of known likely major traffic peaks (such as the Friday evening prior to a public holiday long weekend).

No consultation has been undertaken with residents in Berry as only standard working hours would be apply to the town precinct.

Generally, affected residents support extended working hours since they could mean that the overall construction period is shorter. Mitigation measures would reduce the impacts of extended working hours (refer to **Table 5-1**).

The temporary partial or full closure of Kangaroo Valley Road to enable construction of the overbridge would increase local traffic along North Street which would increase traffic noise. However the duration of the closure and whether it would be a full or partial closure of Kangaroo Valley Road, would depend on the detailed design and construction methodology.

Dust would be generated from earthworks associated with the construction of the project and the total amount of dust would depend on the silt and moisture content in the soil and the types of activities being carried out. The main sources of dust would be from blasting and crushing, the use of excavators, front-end loaders and dump trucks as well as wind erosion from exposed areas (PAE Holmes, 2011). This would be addressed by mitigation measures as described in **Table 5-2**.

The construction phase would also create visual impacts to road users and to residents of rural properties in the vicinity and in Berry, from not only road works but associated materials stockpiles adjacent to the corridor.

In summary, the main amenity impacts during construction are expected to arise from noise, dust and visual effects.

5.1.2 Community cohesion and severance

There is no agreed definition of community or social cohesion, with most of the discussion around intangible concepts such as a sense of belonging, attachment to a group, willingness to participate in activities and to share in outcomes.

A recent report into the mapping of social cohesion found three common elements to the concept:

- Shared vision: Social cohesion requires a set of universal values, mutual respect and common aspirations or identity shared by their members.
- A property or group or community: Social cohesion describes a well-functioning core group or community in which there are shared goals and responsibilities and a readiness to work with other members.
- Process: Social cohesion is generally not seen as an outcome, but as a continuous and ongoing process of achieving social harmony.[17]

Another view suggests that community cohesion is a ‘state of togetherness and unity across diverse people in the community with social engagement, participation and shared values. A cohesive and integrated community is characterised by equality of opportunity, citizen awareness of rights and responsibilities, and high levels of trust in each other and local institutions.’ Social connectedness is an indicator of community cohesion. It comprises ‘the social interactions, relationships and networks that people have with others and the benefits that these relationships can bring to the individual as well as to society.’[18]

In a cohesive community, residents have a sense of belonging and feel a strong attachment to the community and their neighbours. The physical environment, including transport infrastructure, plays an important role in fostering or obstructing community cohesion by either creating borders that help to define the community, barriers that divide a community, or by creating gathering spots that foster community interaction. Streets within the community are important public spaces and can provide areas for residents to gather and interact. This is the traditional role of the main street in an urban setting. Bicycle and pedestrian facilities can also foster interaction. The degree to which transport infrastructure would serve as borders, barriers or gathering places would depend in part on how residents perceive and react to this infrastructure.[19]

Community severance occurs when people are separated from the facilities, services and social networks they wish to use within their community. This can be due to modified travel patterns or psychological barriers created by transport infrastructure eg highways or bridges, and can manifest in outcomes such as trip delays, diversions and traffic noise. Severance also arises where there are changes in the comfort and the attractiveness of areas.[20]

While much of the literature focuses on the negative consequences of road infrastructure on community cohesion, the potential for changed transport arrangements to have a beneficial impact on community cohesion should not be overlooked. This is particularly the case where existing traffic conditions may be dividing the community for example, congested or heavily trafficked main roads.

Existing physical connections and linkages in the study area, and particularly within Berry, are instrumental in shaping current community cohesion. Existing paths of travel by vehicle, bicycle and foot are seen by the local community as critical to maintaining this current community cohesion, which also contributes to the community character of the town. There are currently two road accesses from west Berry to Berry: via North Street and via the Kangaroo Valley Road/Queen Street intersection. Access to existing community infrastructure (educational facilities, health services, places of worship, etc) is also seen as fundamental to creating and maintaining a sense of community cohesion and wellbeing.

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[17] *Mapping Social Inclusion, 2011. Scanlon Foundation Surveys Summary Report, Monash University*
[18] *Quigley and Watts, 2011 Ltd Literature Review on Community Cohesion and Community Severance: definitions and indicators for transport planning and monitoring.*
[19] *Handy, S Amenity and Severance 2002*
[20] *Quigley and Watts, 2011*

The ongoing impact of the proposed upgrade on community cohesion is discussed in detail at Section 5.2.2.

Construction of the project has the potential to impact on community cohesion if it results in physically alienating sections of the community, even on a temporary basis, and particularly in the case of Berry. Consultation activities to date, including community information sessions, forums and workshops have allowed participants to express diverse opinions within a supportive environment.

Early consultation with those people who might be affected by change has reduced uncertainty by providing them with relevant information and an opportunity to become aware of, suggest improvements to, and adjust to the changes.

Construction of the project does not include any major works within the centre of Berry. The most significant modification to the town’s road network would occur at the new Kangaroo Valley Road interchange, which would require a temporary road closure. The alternative route between Berry and west Berry would be via North Street. The majority of works in the vicinity of Berry would be constructed offline and although it is likely that there would be some adverse effects where the offline sections connect with the active road network, these occurrences would only last for short periods of time (AECOM, 2011b).

5.1.3 Traffic and access arrangements

Due to the off-line construction of the Berry bypass, the local road network and Berry intersections would still perform adequately during the construction period. During construction, temporary accesses to some properties may be required but there are not expected to be significantly different impacts to the operations phase. As described in Section 5.1.2, a temporary road closure of Kangaroo Valley Road would be required and access between west Berry and Berry would be via North Street.

The traffic and transport impact assessment prepared for the project describes in detail potential changes to conditions for road users as a result of project construction. Although RMS is aiming to maintain an 80 kilometres per hour construction speed zone, construction activities would inevitably impact traffic efficiency (in order to maintain road and workplace safety) for both local and regional commuters due to a short term reduction in travel speeds through construction zones and potential delays caused by temporary road closures/detours. In the unlikely event that the average speed along the whole route were to fall from 80 kilometres per hour to 50 kilometres per hour, a driver travelling the entire 11.6 kilometre distance may experience a delay of around six minutes. A detailed Traffic Management Plan (TMP) would be prepared as part of the Construction Environmental Management Plan (CEMP) (refer to **Table 3-2**).

5.1.4 Business impacts

The project, including the northern and southern interchanges for Berry, would be constructed in a way that would allow existing traffic arrangements to continue until the new interchanges are operational. Access to businesses and therefore highway trade would not be directly affected during construction.

In the order of 500 direct jobs would be created during the construction phase assuming a construction period of about three years. Construction worker expenditure during the three year construction period would benefit local services in the vicinity of the highway, such as cafes and takeaways, service stations, trades and services suppliers and potentially some accommodation providers. The expenditure would have flow on effects to other businesses in the area.

Construction works north of Berry may encourage a small proportion of drivers to divert to the ‘Sandtrack’, which could reduce highway trade, but this is not expected to be a significant impact. Potential visitors to the area may perceive that construction works would create an impact on their enjoyment of their stay, which may discourage them to visit the area. This would impact local businesses in the tourism sector.

5.1.5 Agricultural sector impacts

Some temporary losses of productive agricultural land are anticipated where sites adjacent to the project would be required for ancillary uses, such as the storage of materials. Potential sites have been identified by RMS and are located on land that has been acquired, would be acquired or leased as part of the project or is already owned by RMS. **Figure 5-1** and **Figure 5-2** illustrate the location of the ancillary sites.

As described in Section 5.2.3, land acquired that lies outside of the highway corridor would be repackaged and sold on completion of the project. Therefore, once rehabilitated and if practicable, there would be potential for the ancillary sites to be returned to their previous use once the project is complete.

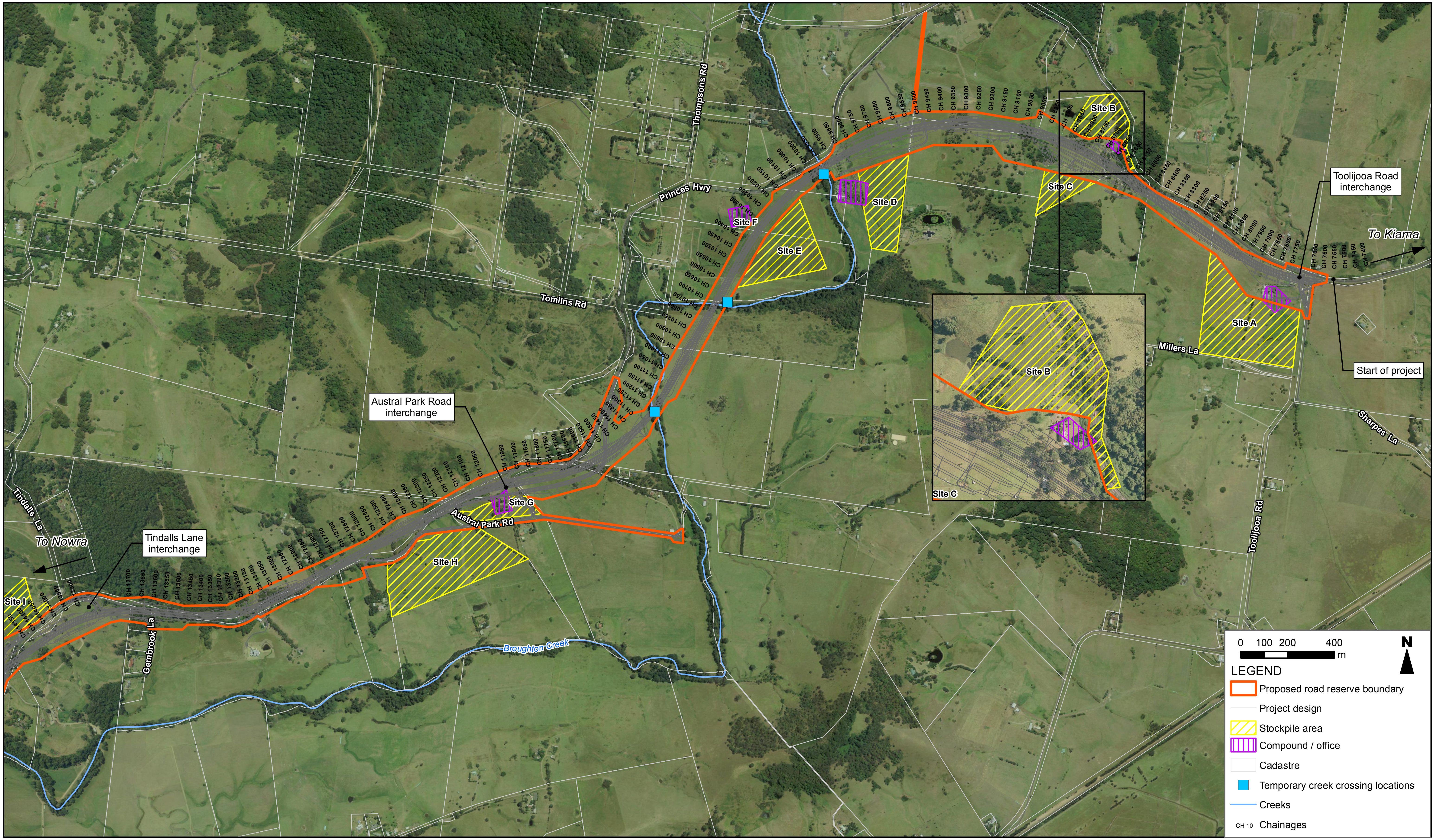

Figure 5-1 Ancillary sites map 1

Source: Fugro (2007), Dept. of Lands (2007), RTA (2011)

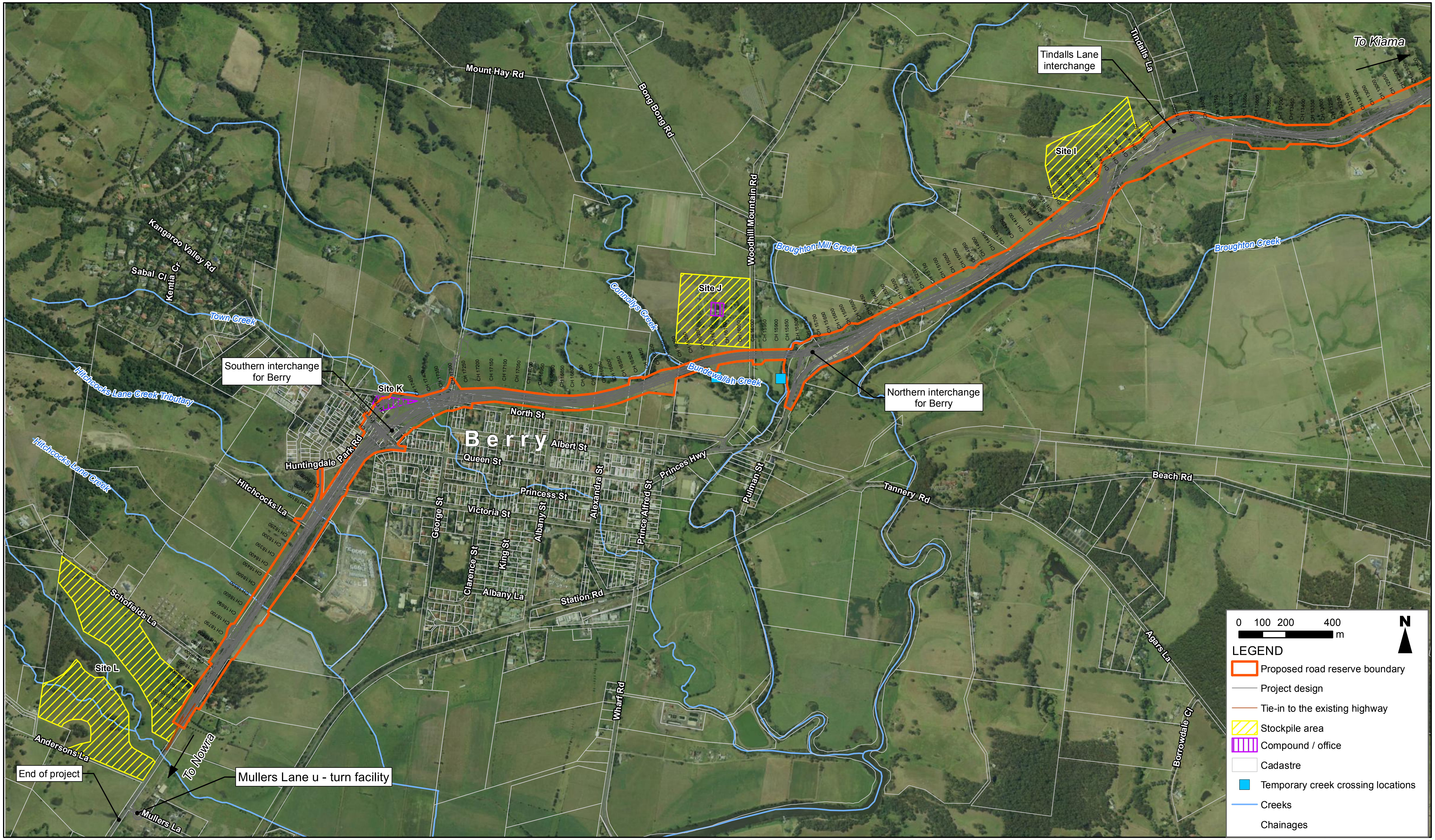

Figure 5-2 Ancillary sites map 2

Source: Fugro (2007), Dept. of Lands (2007), RTA (2011)

5.1.6 Recreational impacts

Access to recreational fishing sites is not expected to be greatly affected as a result of the project, since existing access to the Broughton Creek bridge would be unaffected by the construction works. However, construction works may restrict movement along the creek bank in the immediate vicinity of the project to fishing sites near Broughton Creek (crossing 1) and near the Berry sportsground. See **Figure 5-7**. The main impacts would be downstream of the existing Broughton Creek Bridge. Access upstream is not likely to be impeded except where traffic control or other temporary safety works restrict roadside parking or access.

The construction of the project has the potential to impact the riparian and aquatic habitat in the vicinity of new bridges as sediment enters the water and the banks are altered to accommodate the structure. An *Aquatic Ecology and Water Quality Management Assessment* (Cardno Ecology Lab, 2012) has been prepared for the project (refer Section 7.3 and Appendix G of the environmental assessment). The assessment identifies potential risks to fish stocks including impediments to fish passage, sedimentation and pollution, which may be experienced during the construction phase and includes mitigation measures to minimise the impacts.

The following recreational impacts may also occur during the construction phase of the project:

- Minor disruption to the Berry sportsground due to small amount of land take (0.3 hectares), which should not disrupt sporting activities or passive recreational activities.
- Relocation of the Berry Riding Club located adjacent to the sportsground during construction to an alternative site in the study area. The site also accommodates two other small riding clubs.
- Disruption to passive recreational space at Mark Radium Park, due to land take associated with the southern interchange.
- Disruption to the use of North Street as an existing recreational route.[21]
- Traffic disruption for vehicles travelling from outside of Berry to access recreational facilities or clubs within town. Access within Berry to recreational sites would not change.

Apart from the relocation of the Berry Riding Club, impacts on recreational activities during construction are not expected to be significant.

5.1.7 Location specific impacts

In the Berry area, the construction phase of the project may have the following location specific impacts:

- Around the southern interchange for Berry, in particular, the Huntingdale Park area would experience elevated noise levels, visual impacts as well as disruptions to traffic movements during the realignment of Huntingdale Park Road.
- As described in Section 5.1.2, construction of the Kangaroo Valley Road interchange would require a temporary and/or partial road closure and diversion via North Street subject to detailed design and construction methods.

Consultation with directly affected residents is underway and would continue during construction.

[21] *Used for walking, cycling and jogging.*

5.1.8 Construction phase implications

During construction temporary accesses to some properties may be required but the impact is not expected to differ greatly between the construction and operations phases. A temporary road closure of Kangaroo Valley Road may be required and access between west Berry and Berry would then be via an alternative route such as North Street.

Although RMS is aiming to maintain an 80 kilometres per hour construction speed zone, in the unlikely event that the average speed along the whole route were to fall to 50 kilometres per hour, a driver travelling the entire 11.6 kilometre distance may experience a delay of around six minutes.

5.1.9 Mitigation measures for construction

Mitigation measures for construction impacts are summarised in **Table 5-1**.

Table 5-1: Mitigation measures

Mitigation measure
Amenity impacts
General: • Through implementation of a Community Involvement Plan, provide timely, regular and transparent information about changes to access and traffic conditions, details of future work programs and general construction progress throughout the construction phase of the project. Provide information in a variety of ways including letter box drops, media releases, an internet site and variable message signs. Set up a 24 hour hotline and complaints management process. Noise and vibration: • Implementation of a construction, noise and vibration management plan (CNVMP). The CNVMP would detail the “best practice” construction methods to be used, presenting a reasonable and feasible approach. The CNVMP would also detail the community engagement activities that are planned, which would include prior notification for particularly noisy activities. An extension to working hours between Toolijooa Road and Tindalls Lane has been agreed with directly affected residents. Air quality: • Implementation of an air quality management plan in accordance with the recommendation of the air quality impact assessment for the project) (PAE Holmes, 2011). Visual: • Reduce vegetation clearance where possible and progressively revegetate and landscape cleared areas as works are completed. Refer also to Landscape and visual amenity measures in Section 7.6. Construction fatigue: • Implementation of measures in the CNVMP to reduce the length of the construction phase and to provide respite periods from particularly noisy activities.

Mitigation measure
Community cohesion
By keeping the local community informed, as well as targeting affected groups with mitigation measures described in this table, the risk for community cohesion impacts is minimised. Community and stakeholder consultation would continue during the detailed design and construction phases of the project to encourage public participation in the design and to aid understanding of the project details and processes. RMS would also continue to provide timely, regular and transparent information and updates to residents and property owners such as: • Letter box drops, media releases, and/or community updates. • An internet site established and maintained for the duration of the project. • Variable message signs. • Targeted consultation with affected individuals or groups. • A 24 hour telephone hotline and complaints management process maintained throughout the construction of the project. Using the tools above, information would be provided to the community including: • Changes to access and traffic conditions. • Details of future work programs. • General construction progress.
Traffic and access arrangements
Through the community information plan, residents and road users would be advised in a timely manner before any changes to road access arrangements were implemented. Where feasible and appropriate, a variable message sign would be used to communicate road changes to road users. Should temporary or alternative property access be required, this would be provided in consultation with the affected landowner(s). Work would not be carried out on public holidays or over the Christmas and New Year holiday period. Traffic Control Plans would address peak tourist/holiday traffic such as Friday and Sunday afternoons and days immediately prior to and following public holidays. A Traffic Management Plan would be prepared and implemented and would ensure: • Construction methods and staging would be designed to minimise road closures, subject to other project constraints and ensure that disruptions to existing traffic are within acceptable levels. • Where feasible, the provision of an 80 km/h construction speed zone for highway traffic. • Continuous access to local roads and properties. • Road occupancy licences would be obtained for all work that impacts traffic on the existing highway. • The continuing performance of the local road network in Berry during the proposed closure of Kangaroo Valley Road (AECOM 2011b).
Business impacts
Potential visitors to the area would be provided with information on the RMS website about access and timing of works. Continue discussions with Shoalhaven City Council about strategies to encourage trade (refer to operational phase mitigation in **Table 5-2**) and inclusion of information on tourism websites to encourage visitors.

Mitigation measure
Agricultural sector impacts
Ancillary sites used for stockpiling materials would be located on acquired land. This land would be rehabilitated, repackaged and sold on completion of the project so that the sites can be returned to their original uses.
Recreational impacts
Adopt recommendations of Aquatic Ecology and Water Quality Management Assessment (Cardno Ecology Lab, 2012) to manage impacts on fish stocks, sedimentation and pollution. Relocate the Berry Riding Club facilities to a nearby site agreed by the Club for the period that safe access cannot be provided to the grounds. Undertake works in the area of the Club as early as practicable in the construction program.
Location specific impacts
Refer to amenity and access mitigation measures.
Phasing implications
The Traffic Management Plan would include the guidelines, general requirements and procedures to be used when activities or areas of work have a potential impact on existing traffic arrangements. The TMP would be submitted in stages to reflect the progress of work and would: • Include a framework to accommodate the different phases of the project, which would be developed by the contractor. • Identify the traffic management requirements during construction, including any changes to road safety on the 'Sandtrack' as a result of the highway construction works. • Describe the general approach and procedures to be adopted when producing specific traffic control plans. • Ensure the continuous, safe and efficient movement of traffic for both the public (for all modes of transport) and construction workers. • Produce Traffic Control Plans for all changes to existing traffic conditions, including but not limited to: sign posting, linemarking, temporary barriers, temporary traffic control devices (such as temporary traffic signals), variable message signs and a community information plan.

5.2 Operational phase impacts

5.2.1 Amenity impacts

In other cases where a town has been bypassed and heavy traffic removed from its main street, the result has been an improvement in amenity and lifestyle quality for the town concerned. In the case of Berry, the bypass would improve amenity at properties and businesses on and in the vicinity of Queen Street, by reducing noise levels, improving air quality and by diverting heavy vehicles to the upgrade.

The air quality not only in Berry but throughout the study area is expected to improve as the result of the project. Predicted ground-level carbon monoxide, nitrogen dioxide and particulate matter concentrations for the project area in 2017 and 2027 would generally be lower than those for the existing alignment in future years if the project was not constructed (refer to Appendix M to the environmental assessment for further detail).

However, residents in those areas closest to the bypass have raised concerns relating to noise and disturbed views, especially views to the escarpment which are seen to add to the attractive pastoral character of the area. In particular, the Berry community was very concerned about the impact on amenity given the proximity of the bypass to North Street and Huntingdale Park, as well as the height and location of the bridge at Berry, as described in **Table 3-2** in Chapter 3. The installation of measures to mitigate noise impacts adjacent to the upgrade such as walls and mounds, would also have implications for visual amenity.

The alignment of the bypass and the bridge has been improved in response to community concerns about noise and visual impacts as follows:

- The highway has been moved about 40 metres further away from residences most affected by the bypass (along North Street).
- The proposed highway in the vicinity of North Street has been reduced in height by up to two metres and noise barriers reduced from five to four metres.
- The bridge has been moved approximately 95 metres further away from Berry as it crosses Woodhill Mountain Road.
- The bridge has been lowered by up to 6.4 metres.
- At the southern interchange to Berry, the northbound off-ramp has been re-aligned to avoid Huntingdale Park Road.
- Vegetative screening would be provided between potential noise barriers and properties to reduce visual impacts. This mitigation would also be appropriate for the visual impacts to rural and Berry residences of other structures, such as bridges.

These features would reduce noise and visual impacts for residents closest to the bypass, as well as preserve views to the escarpment (refer to Chapter 4 of the environmental assessment for further details).

The closure of Victoria Street creates a cul-de-sac at its western end. Traffic wishing to access the highway would divert to Queen Street via local roads such as George Street, Edward Street and Albany Street, which would increase noise levels at properties in these streets, although not significantly, as the diverted traffic would be spread across a number of local roads. Noise levels on Victoria Street from local traffic may decrease so on balance, there is not expected to be a change in amenity for residents in the south of Berry.

Notwithstanding the reduced noise impact of the proposal, a total of 114 receivers are eligible to be considered for noise mitigation, such as noise barriers and architectural treatments. The design of noise mitigation measures, particularly in the Berry area, would be developed in consultation with the community and potential location specific treatments are described in Section 5.2.7.

The potential for adverse amenity impacts are mostly location specific, and so are also discussed in Sections 5.1.7 and 5.2.7 of this technical paper.

5.2.2 Community cohesion and severance

The project has the potential to impact community cohesion in both positive and negative ways. In a positive way, it has the ability to bring communities closer together through removal of physical barriers to movement in some locations although in other locations it may interrupt access to facilities and the ability of individuals or groups to interact with each other.

The route alignment has been designed to minimise impacts on the community identity of Berry and smaller localities within the study area.

Localities such as Broughton Village and Foxground are no longer active communities, although some friendships remain between farming families that settled in the area generations ago. The project would not sever these communities, and the community members are not concerned that the project would interfere with their ability to continue to interact with each other.[22] While the Toolijooa community has become stronger in recent years, the route of the project is close to the existing alignment and would not affect the integrity of this community.

Implications of changed access at Berry

There are currently two road accesses from west Berry to Berry: one via North Street and the other via the Kangaroo Valley Road/Queen Street intersection. The upgrade would sever the link via North Street to Berry and convert North Street into a cul-de-sac on both sides of the project.

The removal of the North Street link is not expected to affect access from within Berry by car to North Street destinations. However, this would increase the distance that residents in west Berry would have to walk to destinations on North Street, such as the Berry Riding Club and Berry sportsground by about 150 metres. This could create a perception of increased isolation or severance amongst these residents, particularly in the event of an incident at the southern interchange for Berry, which could result in west Berry residents being temporarily denied access to other parts of Berry or the Princes Highway, especially by vehicle. An incident on the southern interchange would require vehicles travelling to and from west Berry, including emergency vehicles, to divert via the grade-separated Tindalls Lane interchange or the at-grade Mullers Lane u-turn facility.

To improve pedestrian connectivity, the design includes a proposed pedestrian link that would be provided adjacent to the southbound carriageway. This would primarily be developed as a recreational route and would connect North Street to the intersection of Queen Street and Kangaroo Valley Road.

The current access via the Kangaroo Valley Road/Queen Street intersection would be altered to accommodate the proposed southern interchange for Berry. Initial community concerns over changes to this route, including concerns about reduced connectivity between existing and newly developing areas, have been addressed by bridging Kangaroo Valley Road over the upgrade. This bridge would be sufficiently wide to provide for off road pedestrian/cycle access adjacent to, but separated from, the carriageway and would maintain the existing connection between the main township of Berry and developing areas to the north-west. The design retains the existing alignment and level of Kangaroo Valley Road and incorporates formal pedestrian and cyclist access to reinforce connectivity between the existing urban area and newly developing areas. The Kangaroo Valley Road bridge is illustrated in **Figure 5-3**.

Pedestrians and cyclists using the shared path would be required to cross two roundabouts to move between Berry and west Berry. However the inclusion of pedestrian refuges at each leg of the roundabout means that shared path users would only be required to cross one lane of traffic at a time. The provision of a shared path and the refuges would improve pedestrian and cyclist facilities at this location.

The potential for severance between the existing and newer areas of Berry is further mitigated by maintaining the visual connection along Kangaroo Valley Road which would be designed to remain at around the same height post construction. It is expected that residents at one property west of the proposed bypass that currently access Berry across North Street would lose this direct connection as a result of the project. Alternative access arrangements to Berry via Kangaroo Valley Road would be provided to mitigate this effect. **Figure 5-6** illustrates the design of the bypass at this location.

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[22] *This theme has emerged in consultations with these communities.*

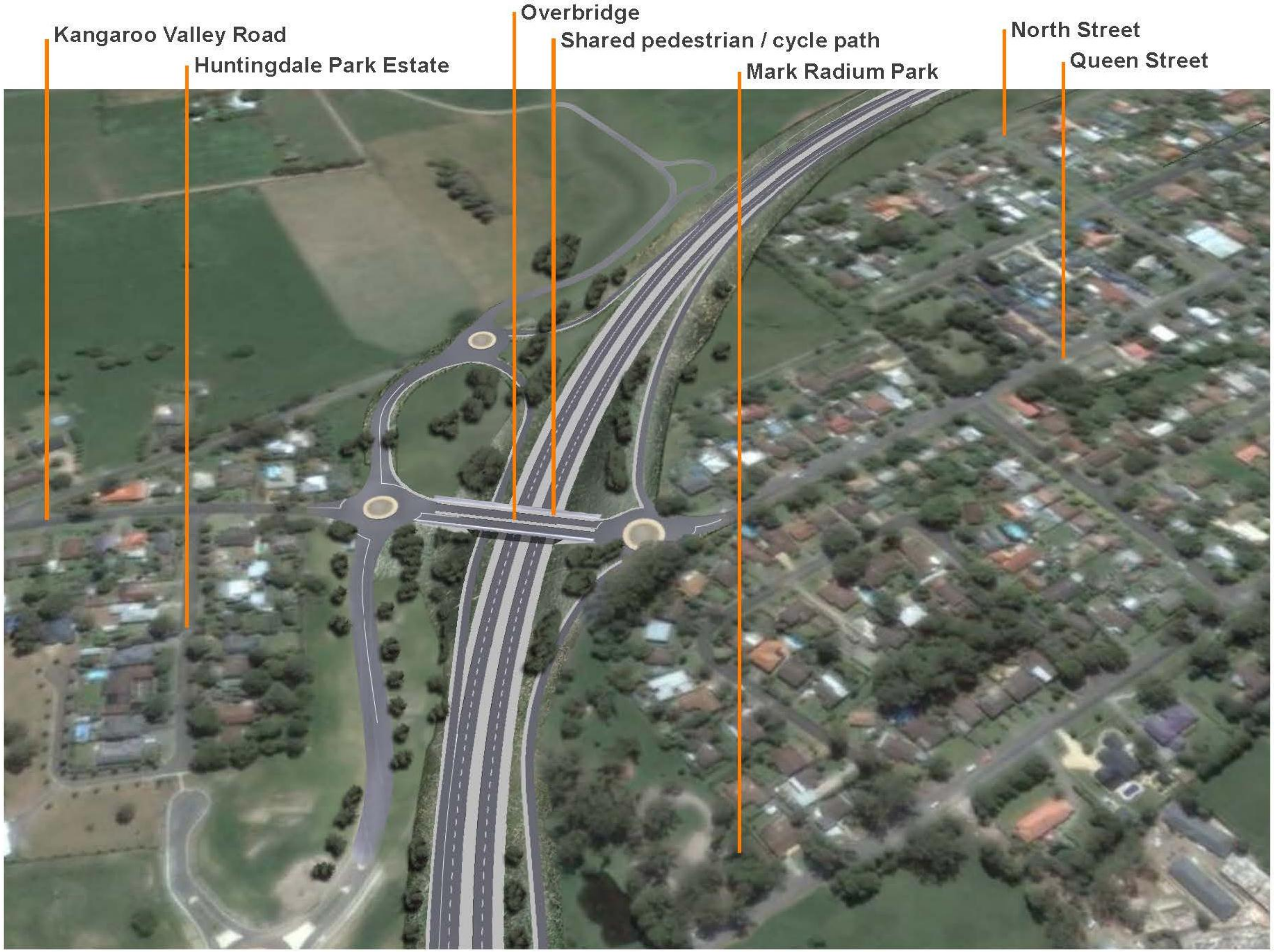

Figure 5-3: The Kangaroo Valley Road bridge at the southern Berry interchange

While the design of the upgrade has been unable to overcome the removal of an access point for west Berry residents, the trade-off following the bypass is expected to be improved safety for pedestrians and cyclists and the strengthening of Berry's identity as a destination town. The diversion of through traffic and heavy vehicles from Queen Street would not only improve the amenity of this area, the improved quality of the urban environment for businesses and the local community would reinforce a sense of community identity and community wellbeing. The amenity of Queen Street, in particular, is expected to improve significantly with the removal of heavy traffic, creating a more pedestrian friendly environment that would also reinforce community cohesion. This has been shown to be the case in other towns that were bypassed eg Berrima, Karuah, Yass, and it is likely that Berry can expect the same outcome.

Impacts of property acquisition

Properties that are located within the road corridor in the project area are described as 'potentially directly affected' by the project[23]. Such properties would be considered for partial or full acquisition by RMS, and discussions have commenced with affected owners. Where only a part of a property is required for the project, RMS would seek to acquire only that part needed for the road.

Wherever possible, the proposed road alignment has been sited such that direct impact on dwellings would be avoided. However, the road boundaries for the concept design would require acquisition of around 112 hectares of land, affecting 90 properties. This impact would be experienced prior to and during the construction phase and would be a permanent impact through the operation phase. Of the 90 properties, 39 properties have already been acquired in full by RMS, totalling around 308 hectares. In total, 14 dwellings plus additional outbuildings across the study area would be acquired and demolished prior to construction. Some of the dwellings are already owned by RMS and occupied by tenants. **Figure 5-4** and **Figure 5-5** illustrate the location of the land that would be acquired.

The majority of land that would be acquired is currently used for rural purposes, including general, residential and agriculture purposes. Within Berry, nine residential properties would need to be acquired and 18 would be affected by partial acquisition. A further nine properties zoned under the *Shoalhaven Local Environment Plan 1985* as Rural (General) would be acquired. These properties are used for a variety of activities, including agriculture. Two of these lots are prime agricultural land. The effect on dairy and other agricultural businesses is considered in Section 5.2.3 of this report.

Section 7.9 of the environmental assessment describes the property impacts of land acquisition in more detail.

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[23] *The impact of the project on land uses of properties in the vicinity of the corridor is considered in Section 7.10 of the environmental assessment.*

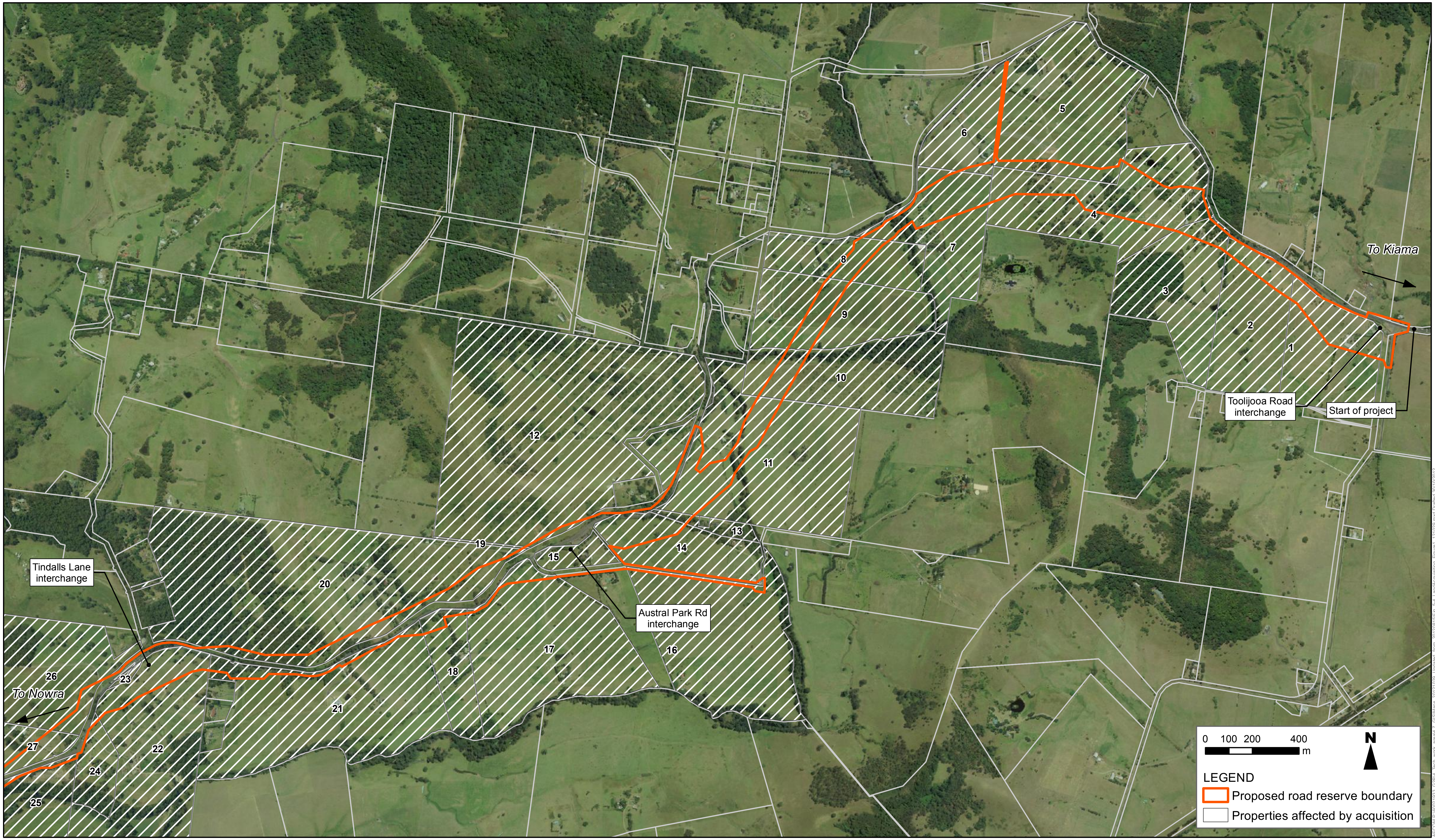


Figure 5-4 Land acquisition map 1

Source: Fugro (2007), Dept. of Lands (2007), RTA (2011)

Figure 5-5 Land acquisition map 2

Source: Fugro (2007), Dept. of Lands (2007), RTA (2011)

Land acquisition may create social impacts, as it brings major changes to the lives of those affected such as anxiety and uncertainty, a loss of amenity, financial costs and isolation.

Those residents whose property would be acquired as a result of the project would relocate to an alternative location. RMS would compensate owners for land acquisition in accordance with the Land Acquisition (Just Terms Compensation) Act 1991.

In summary:

- The bypass would remove the North Street access to Berry for west Berry residents. While these residents would have access to other parts of Berry via the Kangaroo Valley Road/Queen Street intersection, there may be an increase in the distance travelled for some residents to destinations along North Street, such as the Berry Sportsground.
- Maintenance of the existing height of Kangaroo Valley Road is expected to retain the visual connection with other parts of Berry.
- Improved amenity in Berry is expected to reinforce a sense of community identity and wellbeing which, in turn, is expected to have positive outcomes for community cohesion.
- RMS would compensate owners for land acquisition in accordance with the Just Terms Compensation Act.

5.2.3 Agricultural sector viability

Where the project requires acquisition of agricultural land, it has the potential to impact on the economic productivity and the viability of agricultural businesses. Where the alignment would pass across greenfield locations there is also the potential to fragment rural properties and therefore restrict agricultural operations.

Specifically, the productivity of agricultural businesses could be affected by:

- Loss of productive land.
- Changes to the size and shape of paddocks (through strip acquisitions, severance or fragmentation of properties).
- Changes to farming conditions as a result of the road development affecting flooding behaviour and water supply.
- Changes to access between different parts of the property.

Any one of, or a combination of, these factors could result in a loss of revenue to the owner and, if significant, could affect the viability of the business.

Where possible, the orientation of property boundaries has been considered during the design of the highway so that the impact on farms would be minimised. Where a property would be fragmented, a suitable, safe and economically justifiable means of restoring internal access by connecting the portions of land has been considered and discussed with the property owner.

Figure 5-4 and **Figure 5-5** in Section 5.2.2 illustrate the location of the land that would be acquired. Each potentially directly affected lot has been considered individually to determine:

- The land acquired as a percentage of the lot and the residual area.
- The capability of the land affected in relation to the quality of other land on the property.
- Changes to external and internal access, including the impacts of fragmentation and severance.
- Any impact on dams, outbuildings etc, necessary for a farm to operate.
- How the above may affect profits/ productivity?
- How the above may affect viability of the business?

Seven rural operators have said that their businesses would no longer be viable as a result of the proposal and these properties have been acquired in full by RMS. Of the seven properties, two were used for grazing beef cattle, two for silage[24], one for horse agistment, one as a mixed hobby farm and one for goat farming. The acquired properties are currently leased to tenants and are being used for similar operations, with the exception of the goat farm, which is now used for horse agistment.

There are 16 other agricultural businesses which would be affected by land acquisition and, while they may experience a decrease in productivity, their viability is not expected to be affected. Dairy farms supplying the Berry Rural Cooperative would be affected by partial acquisition, but again this is not expected to reduce the scale of the Cooperative's operation, turnover or workforce. Consultation with agricultural business owners would continue throughout the detailed design and construction phases of the project with the aim of minimising impacts on the viability of the farms and the Cooperative where feasible. Appendix C contains a property by property analysis of agricultural business impacts.

The economic impact of the project on the agriculture sector as a whole has been determined by estimating the change to 'value added', or the contribution by a business to the gross regional product. The resulting estimates of reduction in value added during the construction and operation phases are considered reliable as indicators of the impact of the project. However, they should be used with caution when assessing the absolute impacts as they are not necessarily reflective of local value, being derived in part from national or other level data.

The estimates of the gross direct economic impact (excluding any resale potential described above) of the project as well as the number of impacted agricultural businesses is contained in **Table 5-2**[25].

[24] *Fermented fodder made from grass crops.*
[25] *The number of impact businesses includes those acquired in full.*

Table 5-2: Economic impact: agriculture sector

Potential loss of value added ($)		Economic activity of potentially directly affected agricultural businesses	No. of businesses impacted	No. of businesses acquired in full
Annual	Long-term			
385,100	8,801,900	Dairy cattle farming	3	0
		Beef cattle farming	13	2
		Silage, hay and turf farming	3	2
		Agistment	1	1
		Goat farming	1	1
		Other	2	1

Note a: Present value of annual loss of value added over 50 years discounted at seven per cent real discount rate (in discounting to present value, 50 years is a reasonable period to represent permanent). Other businesses include a hobby farm and a maze.

The loss of productive agricultural land could also impact on the contribution of agriculture to the regional economy, with flow on effects to other sectors. For instance, the operation of a dairy farm requires inputs and services from other suppliers, and the processing and transport of dairy products creates further economic benefit.

There are opportunities for fragmented land parcels to be amalgamated into large lots with access provisions and resold, potentially to neighbouring property owners thereby adding back to the stock of agricultural land. Although there would be an initial reduction in rural and agricultural land use in the study area, the reduction in agricultural land use in the long-term could be minimal if this were to occur.

In summary, the project would have impacts on the economic contribution of the agriculture sector in the study area, in that seven operators would no longer be viable and their properties have now been fully acquired by RMS and partial acquisition is necessary from 16 other properties. The viability of the dairy industry is not expected to be affected by the proposal since the extent of acquisition or its location at the edge of a property would not affect business operations of the individual properties nor of the Berry Rural Cooperative Society Ltd. The opportunity for resale of productive land to neighbouring properties has the potential to reduce the impact on the agricultural sector.

5.2.4 Access arrangements

Detailed changes to local access arrangements and traffic movements are described in the *Traffic and Transport Impact Assessment* prepared for the project (AECOM 2011b) and provided at Appendix D to the environmental assessment.

Reduced traffic volumes within Berry would increase ease of access and connectivity for local road users, including cyclists and pedestrians.

Initial community concerns over access between west Berry and Berry have been addressed by bridging Kangaroo Valley Road over the upgrade as part of the southern interchange for Berry. This bridge would be sufficiently wide to provide for off road pedestrian/cycle access adjacent to, but separated from the carriageway. This design element retains the existing alignment and level of Kangaroo Valley Road and incorporates formal pedestrian and cyclist access to maintain connectivity between the main township of Berry and developing areas to the northwest. The additional roundabouts on Kangaroo Valley Road to the west of Berry could be restrictive for pedestrians and cyclists but, as described in Section 5.2.2, the provision of pedestrian refuges at each leg of the roundabout and a shared path within the design improves pedestrian and cyclist facilities over the existing situation at this location.

The closure of North Street creates a cul-de-sac at its western end in the vicinity of George Street from which a private access would be constructed for one residence, as illustrated by **Figure 5-6**. Rawlings Lane currently provides access for one property to George Street, North Street and Berry. This link would be closed as a result of the project and alternative access provided via Kangaroo Valley Road and a new roundabout constructed as part of the southern interchange for Berry.[26]

As described in Section 5.2.1, the closure of Victoria Street also creates a cul-de-sac at its western end. Traffic wishing to access the highway would divert to Queen Street via local roads but the diversion is not expected to increase travel times for vehicular traffic and pedestrian accessibility would not be affected.

Direct access to Hitchcocks Lane would not be available from the highway. A link would be provided as part of the project from Huntingdale Park Road.

The introduction of median fencing would provide significant improvements in road safety, including the elimination of traffic turning to and from minor roads across fast-moving two-way traffic. However, this would also mean that access to adjoining properties with frontage to the highway must be restricted to left-in left-out movements only or be provided with an access road, adding up to four minutes of additional travel time to affected properties. There are 12 properties where access to the highway would be restricted to left-in left-out movements as a result of the project.

U-turn provisions would be via the grade-separated interchanges at Toolijooa Road, Austral Park Road, Tindalls Lane, the northern interchange for Berry and the southern interchange for Berry. Because a number of the interchanges would not include provision for all traffic movements, additional u-turn facilities would be provided on the existing highway north of Austral Park Road and south of Schofields Lane at Mullers Lane. u-turn manoeuvres would be facilitated via a new roundabout at the junction of Woodhill Mountain Road with the existing Princes Highway in Berry.

[26] *There are no changes in access for Huntingdale Park residents.*

Figure 5-6 North Street closure

Source: RTA (2011), LPMA (2011)

5.2.5 Business impacts

Regional economic impacts

In terms of the regional economic effects, improved connectivity to the NSW south coast would enhance business opportunities in the area and support the existing tourism industry including Jervis Bay, Batemans Bay and Ulladulla. In addition, industries in the Nowra area would benefit from improved accessibility to markets and raw materials in the Sydney and Wollongong areas due to reduced travel times and increased road safety.

When people make decisions about whether or not to work, where to work and how much to work, they take into account many things, including not only the wages on offer but also the costs associated with each option such as time forsaken, commuting costs and stress. This means that high commuting costs can lead workers to work less or in less productive and lower paid jobs than they otherwise would. Reducing travel time and costs along the Princes Highway may cause people to enter the labour market or move to more productive jobs as a result.

Tourism and other non-highway reliant businesses

The experience at other bypassed towns shows that increased amenity in the commercial precinct of Berry, resulting from lower traffic volumes and noise and improved air quality, is likely to increase turnover at non-highway reliant businesses. These businesses cater to locals and tourists and help to form the destination feel of the town. This impact could lead to an overall increase in economic activity within the town that, in turn, could expand business activity and employment in the area.

The upgraded highway and Berry interchange would become a part of the view from businesses such as bed and breakfast establishments in the Jaspers Brush area. The impact on views created by the bridge is not expected to impact the viability of these businesses since it is balanced by safer road access for guests, and they would retain views to the Cambewarra Range and escarpment. The bypass to the north of Berry provides the closest freeway access to the town centre which would enhance access to accommodation in Berry.

Highway reliant businesses

Completion of the highway upgrade may result in the diversion of traffic from the ‘Sandtrack’, with indirect impacts for Gerringong businesses, particularly those reliant on through traffic. This could potentially reduce the volume of passing trade for these businesses leading to decreased turnover and decreased employment at affected businesses. However, the percentage of businesses in Gerringong and Gerroa that are reliant on highway trade is low (SGS Economics and Planning, 2008).

While the Berry bypass would improve the amenity of the town, reduced traffic volumes can negatively impact those businesses that are reliant on passing trade from the highway. The design of the bypass means that Berry would be visible from the bypass and from the southern Berry interchange, which would encourage through traffic to continue to stop in the town. Studies of highway bypass impacts in NSW have shown that the most affected businesses are those directly serving the needs of the motorist such as motor vehicle services, particularly service stations, food and beverage outlets and, to a lesser extent, accommodation establishments.

An assessment of the impact on businesses has been undertaken in accordance with the *A Guide to Good Practice - Evaluation of the Economic Impacts of Bypass Roads on Country Towns* (RTA, 1966). This publication provides guidance around the assessment of the impact on the highway related sector of a town economy resulting from the diversion of through traffic from the town after the opening of a bypass. Following this approach, all estimates of changes in the value of highway generated trade are based on changes in the volume of through traffic stopping in the town. The approach required the collection of the following information:

- Extent of employment in highway related businesses.
- Gross annual turnover associated with highway related activities.
- Extent to which businesses are dependent on highway generated trade.

The assessment estimates the direct loss of jobs and turnover after the opening of the bypass. It is a worst case assessment in so far as it does not take account of an increase in turnover as businesses adapt to the conditions. The linkages with other businesses supplying goods and services to those businesses directly impacted were not quantified. These would be the indirect or second round impacts on employment and turnover resulting from the diversion of through traffic from the town. However, the *A Guide to Good Practice - Evaluation of the Economic Impacts of Bypass Roads on Country Towns* (RMS, 1966) states that "in the case of smaller settlements the multiplier effect has been shown to be very small and can safely be ignored in calculating changes in employment and turnover."

Business owners may be considerably uncertain about the extent of impact the project would have on through traffic and trade. To address this uncertainty, this assessment has examined the economic and business effects at highway reliant businesses only as a result of three traffic diversion scenarios. A central traffic diversion scenario is consistent with the traffic assessment, which estimates that 78 per cent of traffic would divert from Berry to the bypass. Under this scenario, the assessment assumes that highway reliant trade would reduce by 78 per cent upon opening of the upgraded highway. A high scenario of diverted traffic was assumed to be 100 per cent (worst case) and a low scenario 50 per cent (best case).

The business effects assessed are the potential change in employment and turnover at highway reliant businesses. The potential change in economic contribution of each business to the study area was indicated by value added per employed person[27]. The value added by a particular business represents the contribution by a business to the gross regional product.

The **Table 5-3** summarises the estimated impacts on employment, turnover and value added as a result of the three traffic scenarios.

[27] *Derived from ABS National Accounts data on industry value added and employment.*

Table 5-3: Economic impact on highway-reliant businesses

	Low			Central			High		
	Decrease in FTE jobs	**Decrease in turnover**	**Loss in value added (annual)**	**Decrease in FTE jobs**	**Decrease in turnover**	**Loss in value added (annual)**	**Decrease in FTE jobs**	**Decrease in turnover**	**Loss in value added (annual)**
Motor vehicle services	3	419,226	146,930	6	838,452	293,861	12	1,676,904	587,721
Food and beverage	4	181,903	136,955	8	363,806	273,909	17	727,611	547,819
Other retail	1	109,065	47,176	3	218,130	94,352	6	436,260	188,703
Total	**8**	**710,194**	**331,061**	**17**	**1,420,388**	**662,122**	**35**	**2,840,775**	**1,324,243**

Notes: FTE - Full time equivalent
Totals include rounding

Under the central scenario, there is potentially a loss of up to 17 full time equivalent jobs as a result of the project and a decrease in turnover equivalent to two per cent of total Berry turnover[28].

While the above analysis indicates that some businesses would experience a decrease in turnover and reduced employment at least in the short term, the evidence from bypassed towns indicates that some highway dependent businesses have been able to reposition themselves and become sustainable in the longer term.

The overall effect on business in Berry following the bypass is expected to be as follows:

- Improved amenity is likely to create new business development opportunities for both local and tourist trade.
- New business activity would lessen the overall effect of reduced turnover and employment in highway affected businesses.

This view is strengthened by evidence of bypassed towns that were established destination towns pre-bypass, which was reviewed in Section 4. Post bypass, their business sectors generally all performed well.

[28] *Based on the estimate of total Berry turnover calculated by SGS (2008).*

5.2.6 Recreational impacts

Community assets

Community assets used for recreation have a role in promoting cohesion and interaction among community members and are therefore an important social impact.

The buffer zone of varying width but around 40 metres between North Street and the upgrade would be made available for community uses, such as open space. This would create the potential for adding to the stock of community assets in an accessible location. Uses would be developed in consultation with and to respond to the community's needs. Similarly, a parcel of vacant land on the corner of George Street and Albert Street could be added to the community assets in the area, which is a benefit of the project. As described in Section 5.2.2, a recreational pedestrian link would be provided across this parcel of land and adjacent to the southbound carriageway, connecting North Street to the intersection of Queen Street and Kangaroo Valley Road.

As described in section 5.2.1, the closure of Victoria Street also creates a cul-de-sac at its western end. The unused road space could be used as an extension to the parking area for Mark Radium Park, which would improve the amenity and useability of the facility and is another benefit of the project. The design of this space would be developed in consultation with the community.

Feedback from the community during earlier stages of the project highlighted concerns relating to the impact of the bypass on the Berry sportsground, Camp Quality memorial park and the Pullman Street and Tannery Road European heritage precinct. As a result, the alignment was modified during the concept design phase of the project to avoid these areas. Although some land acquisition would be required on the western edge of the sportsground, access would be maintained.

The Berry Riding Club (pony club) and two other smaller clubs would not be able to operate on the existing site following the acquisition of land for construction and would require relocation. RMS is in discussions with the Berry Riding Club and Council to establish a new configuration for the club using land from the neighbouring property, which would be been acquired and that has direct access to North Street. This would retain the Clubs in the local area with comparable facilities to their current facilities including car parking.

Recreational fishing

The project would cross a number of creeks that are or could in the future be, accessed for recreational fishing, including Broughton Creek, Broughton Mill Creek, Connelly's Creek and Bundewallah Creek. The existing bridge over Broughton Creek is understood to be currently used as the main access point for fishers, and this bridge would remain following construction of the project.

RMS recognises the opportunity to reduce conflict between fishers wishing to access creeks and the owners of private land adjacent to creeks through the project. Four potential future access points are illustrated in **Figure 5-7**, including a bridge over Bundewallah Creek and Broughton Mill Creek and two new bridges over Broughton Creek. RMS has indicated that it would liaise with the NSW Department of Primary Industries (DPI) Fisheries on appropriate angler access signage and access infrastructure such as fence stiles.

Parking bays for bridge maintenance workers would be provided where possible along the route and these would be available for use by fishers wishing to access the river bank in the vicinity of the four new bridges shown in **Figure 5-7**. The existing access point at Broughton Creek bridge would be bypassed by the highway and would therefore become safer for fishers to use on completion of the upgrade.

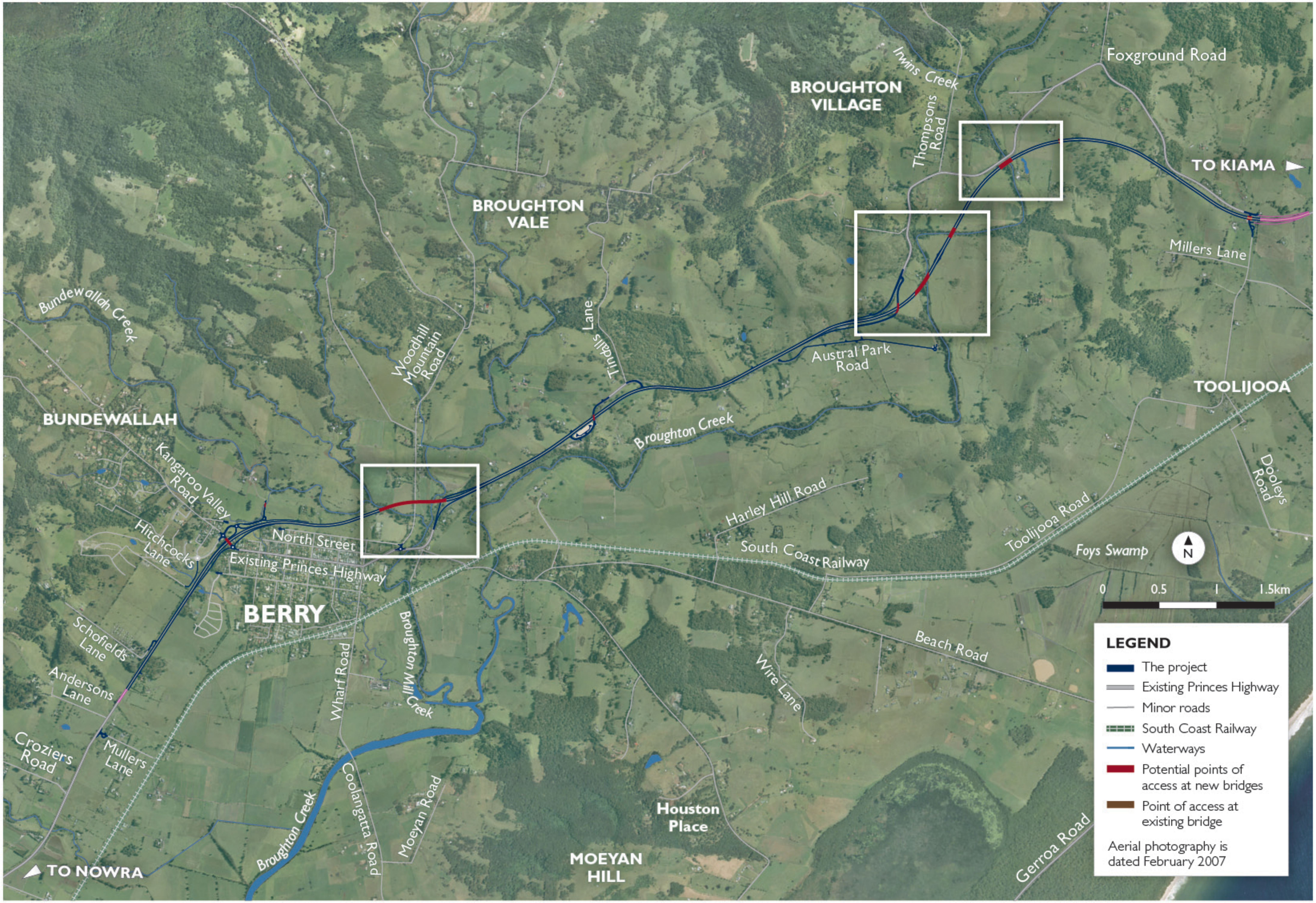


Figure 5-7 Fishing opportunities at Broughton Creek, Broughton Mill Creek and Bundewallah Creek in the vicinity of the Princes Highway (AECOM, 2011)

5.2.7 Location specific impacts

The upgrade is anticipated to have the following location specific impacts:

- Removal from Queen Street of highway traffic and heavy vehicles in particular, would significantly improve the amenity of Berry, and its attraction as a tourist destination and residential area. Although some highway reliant businesses may experience a decrease in turnover and employment, improved amenity is expected to have benefits for Berry's commercial precinct.
- Berry residents would benefit from the opportunity to zone the buffer area between North Street and the new highway upgrade for community uses.
- Impacts to dwellings[29] concentrated along the western section of North Street are expected to include increased noise levels and visual impacts of the new alignment, and interrupted views to the escarpment from noise mitigation structures. Community consultation would continue around the design of noise mitigation measures. The creation of a buffer area between North Street and the upgrade permits one potential solution to be a 'ha-ha', a type of sloping embankment, which is illustrated by **Figure 5-8.** Architectural treatments such as double glazing would be considered for those who would still be affected by noise following construction of noise mitigation measures.
- The properties on Huntingdale Park Road, Kangaroo Valley Road would also be affected by increased noise levels and visual impacts of the road alignment, noise mitigation structures and interchange ramps. The noise and vibration assessment recommends construction of noise barriers four metres in height (AECOM, 2011a). Community consultation would continue around the design of noise mitigation measures.
- The upgrade would involve changed access (particularly for pedestrians and cyclists) between west Berry and other parts of Berry. The closure of North Street means that access between west Berry and the rest of Berry would be via Queen Street, at the intersection of Kangaroo Valley Road and involve crossing of two roundabouts, although overall pedestrian facilities would be improved at this location.
- A 600 metre long bridge structure spanning Woodhill Mountain Road, Broughton Mill Creek and Bundewallah Creek, would be visible from Berry and rural properties north of Berry. Potential view impacts have been moderated by lowering the bridge by up to 6.4 metres and by moving it 95 metres away from Berry. Vegetative screening may be used to mitigate loss of view to affected properties.

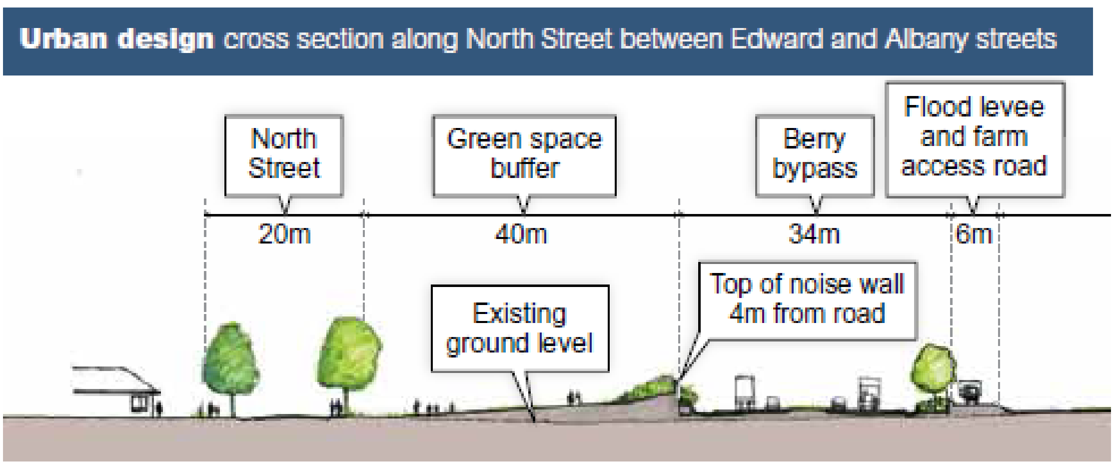


Figure 5-8: Potential design of noise mitigation measure, North Street (RMS, 2011)

[29] *Residents of 28 properties are expected to be affected.*

Elsewhere within the study area, the project would have the following location specific impacts:

- Noise impacts would be experienced by residents of nine isolated rural properties outside Berry. As it would not be feasible to construct noise mitigation structures at such locations, these properties would be considered for architectural treatments.
- There would be potential visual impacts from selected viewpoints along the project route. For example, significant cuttings would be required at Toolijooa Ridge and Austral Park Road. Bridges, interchanges and intersection structures would be visible from Berry and rural residences in other locations, especially those in the vicinity of Austral Park Road and Tindalls Lane, but are screened in part by existing vegetation.

5.2.8 Mitigation measures - operation

Mitigation measures for operational impacts are summarised in **Table 5-4**.

Table 5-4: Mitigation measures

Mitigation measure
Amenity
• The noise and vibration assessment (refer to Section 7.2 and Appendix E of the environmental assessment) recommends mitigation through a combination of low-noise pavement, noise barriers at North Street and Huntingdale Park Road and consideration of architectural treatments to 20 properties. Architectural treatments are the most suitable mitigation measure for nine isolated rural properties and may also be necessary where noise barriers or similar measures do not completely mitigate the noise impact. • Community consultation would continue around the amenity impact and design of noise mitigation measures.
Community cohesion
• Continue community consultation to provide a means of achieving outcomes that maximise benefits for the community as a whole. • RMS would continue to consult with residents, the community and stakeholders to develop a plan for providing pedestrian access and cycle links over the proposed highway connecting the east and west sides of town. This would include the consultation about the design of crossings near the proposed roundabouts to ensure adequate access for pedestrians and cyclists is maintained. Any design would aim to support and complement the Pedestrian Access and Mobility Plan (SCC, 2006) developed by Shoalhaven City Council for Berry. • Property acquisition would be carried out in accordance with the RMS Land Acquisition Information Guide (RTA, 2011) and under the terms of the Land Acquisition (Just Terms Compensation) Act 1991.
Agricultural sector viability
• Continue consultation with agricultural business owners to address the impacts of land acquisition on the viability of farm operations and the Berry Dairy Cooperative. • Repackage lots and sell parcels of acquired land to new owners or neighbouring owners. • Provide sign posting to encourage highway traffic to visit Berry for a rest stop and as a tourist destination.

Mitigation measure
Access arrangements
• Continue consultation with affected property owners during the detailed design process to ensure functional and safe access is provided. • Provide interchanges with opportunities for local drivers to perform a u-turn to reach their destination. • RMS would investigate ways of maintaining access to Berry via the Kangaroo Valley Road bridge during incidents that may involve a full or partial closure of the bridge.
Business impacts
• Provide sign posting and traffic management to encourage highway traffic to visit Berry for a rest stop. • Continue discussions with Shoalhaven City Council to offer technical advice in developing strategies to encourage the ongoing viability of businesses in the town and to encourage new businesses, for example, programs to enhance community areas and streetscapes.
Recreational impacts
• Provide parking bays for bridge maintenance workers where possible along the project that would be available for use by fishers wishing to access the river bank in the vicinity of bridges. • Continue discussions with the Berry Riding Club and Council to establish a new configuration for the club using land from the neighbouring property which would be acquired.
Location specific impacts
• Mitigation of noise to residents near North Street would be by way of a low-noise pavement, noise barriers along North Street, and architectural treatments to six properties to achieve compliance with the applicable noise goals. • Construction of a four metre high noise barrier between Huntingdale Park Road and the project and the consideration of architectural treatments to three properties on Kangaroo Valley Road and North Street to achieve compliance with the applicable noise goals. • Community consultation would continue around the design of noise mitigation measures at North Street and Huntingdale Park Road. At North Street, noise mitigation could include a ‘ha-ha’, a type of sloping embankment that would be constructed in place of a noise barrier. Vegetative screening between potential noise attenuation measures and affected properties would reduce visual impact. This measure would also be appropriate to mitigate the visual impacts to rural and Berry residences of other structures, such as bridges.

6 Conclusion

The report has identified and assessed the potential socio-economic impacts associated with the project. The report has had regard to the existing context of the proposal, the experience of other towns that have been bypassed, ongoing community consultation, and adoption of appropriate mitigation measures.

The project has aimed to minimise potential impacts through the project design.

The proposed road alignment has been sited to avoid direct impact on dwellings and minimise impacts on property boundaries. It has also been designed to limit property acquisition to one side of the existing highway where possible. RMS would compensate owners for land acquisition.

The upgrade is expected to make significant improvements to amenity, in particular within the Berry commercial and retail precinct. Community concerns about the proximity of the bypass to North Street and associated amenity impacts have been addressed by reducing the height of the bypass in this vicinity and moving it further away from North Street.

The closure of North Street would reduce access between west Berry and other parts of Berry. It is acknowledged that a single access has a heightened risk of severing these communities in the case of a traffic incident. In this case it is considered that any incident would be manageable with limited duration due to the low speed environment and width that would enable vehicles to pass the incident in most cases. The trade-off of this reduced access is improved amenity in Berry which, in turn, is expected to have benefits for community cohesion.

The project has caused seven agricultural businesses to cease operating. The acquired properties are currently leased to tenants and are being used for similar operations, with the exception of the goat farm, which is now used for horse agistment. The potential for the resale of productive land that has been acquired by RMS to neighbouring properties, also presents an opportunity to minimise the impact of acquisition. The upgrade is not expected to affect the viability of the dairy industry.

Reduced traffic volumes within Berry would increase ease of access and connectivity for local road users, including cyclists and pedestrians. Introduction of median fencing would improve road safety and eliminate traffic turning to and from minor roads across fast moving two-way traffic. However, this would increase travel times to and from 12 properties for which access would be restricted to left in/left out movements.

Improved connectivity is expected to benefit the tourism industry in the study area and support local businesses through reduced travel times to major markets in Sydney and Wollongong. Improved amenity for Berry is likely to have flow on effects for business and employment, both for the local and tourist trade. The proposal is expected, however, to have an impact on highway related businesses in Berry, with up to 17 jobs lost and a two per cent decrease in the town’s turnover. From the experience of other towns that have been bypassed, this impact may be moderated in the medium to longer term as businesses reposition themselves and as new businesses establish in response to improved amenity.

The impacts on the community as a whole are not expected to be significant. Uncertainty is an impact that would be felt mostly before and during the construction stage but can be eased by providing updates and continuing consultation.

The project has been sited to minimise impacts on community assets. The buffer zone between North Street and the project would create opportunities for expanding community uses.

Access to recreational fishing sites is not expected to be significantly affected as a result of the project, since existing access to the Broughton Creek bridge would be unaffected by construction works. Opportunities for fishing in the local area would increase as access would be available at four new bridge crossings provided as part of the project. Parking bays for bridge maintenance workers would be provided where possible along the project and these would be available for use by fishers wishing to access the river bank in the vicinity of the bridge. Appropriate signage and fences would be installed.

In the vicinity of Berry, the project has the potential to affect the amenity of properties through increased noise and loss of views, as well as visual impacts from noise attenuation measures. North Street and west Berry (along Huntingdale Park Road) are two residential localities that would be particularly affected. Dwellings on North Street would be impacted by increased noise levels, traffic volumes and visual impacts of the new alignment that would replace rural and escarpment views. West Berry residents would be affected by a combination of, increased noise levels and visual impacts of the road alignment and interchange ramps. Noise and visual mitigation measures are recommended to ameliorate these impacts.

Where necessary, mitigation measures are recommended to address negative impacts of the upgrade, at Chapter 5 of this report.

Overall, the social and economic benefit of the proposal is expected to outweigh any negative impacts that cannot be satisfactorily mitigated.

7 References

AECOM (2008). *Gerringong to Bomaderry Route Options Submissions Report*.

AECOM (2011a). *Princes Highway Upgrade – Foxground and Berry Bypass, Noise and Vibration Impact Assessment*.

AECOM (2011b). *Princes Highway Upgrade – Foxground and Berry Bypass, Traffic and Transport Assessment*.

Australian Bureau of Statistics (June 2011) *Catalogue 8635155001DO001_201106 Tourist Accommodation*, Small Area Data, New South Wales.

Cardno Ecology Lab (2011). *Princes Highway Upgrade – Foxground and Berry Bypass, Aquatic Ecology and Water Quality Management Assessment.*

Bureau of Transport and Communication Economics (1996) *Employment Effects of Road Construction. Working Paper 29.* December 1996.

Dairy Australia (2011). Industry Overview http://www.dairyaustralia.com.au/Industry-overview.aspx

Handy, S (2002). *Amenity and Severance*

Monash University (2011). *Mapping Social Inclusion*, Scanlon Foundation Surveys Summary Report.

Navin Officer (2009). *Gerringong to Bomaderry Princes Highway Oral History Recording*.

NSW Department of Planning and Infrastructure (2010). *Projected population by sex, SLAs in NSW, 2006-2036*

NSW Department of Transport and Infrastructure (2009). *2007 Household Travel Survey Summary Report.* Sydney.

NSW Roads and Maritime Services (6 December 2011) *Princes Highway Upgrade Berry Bypass Community Review Group Option Review*

NSW RTA (1966) *A Guide to Good Practice - Evaluation of the Economic Impacts of Bypass Roads on Country Towns*

NSW RTA (2001). *RTA Environmental Noise Management Manual.*

NSW RTA (2008). *Route Options Submissions Report*.

NSW RTA and University of Sydney (1996). *Evaluation of the Economic Impacts of Bypass Roads on Country Towns: Final Report*.

NSW RTA and University of New South Wales (UNSW) (2011). *Economic Evaluation of Town Bypasses: Review of Literature.*

NSW Office of Environment and Heritage (2011) NSW Road Noise Policy

PAE Holmes (2011). *Air Quality Impact Assessment*.

Quigley and Watts (2011). *Literature Review on Community Cohesion and Community Severance: definitions and indicators for transport planning and monitoring*.

SGS Economics and Planning (2008). *Princes Highway Upgrade: Economic Appraisal of Berry and Gerringong town access arrangements*

Shoalhaven Tourism 29 September 2011 www.scpromotions.com.au/shoalhaven-tourism-statistics

Tourism Research Australia (2011). *Economic Importance of Tourism in Australia's Regions*

Tourism Research Australia data, viewed at /www.southcoastregister.com.au/news/...tourist.../2397162.aspx

UK Department for Transport (2006). *Transport, Wider Economic Benefits, and Impacts on GDP*.

University of Sydney (2005). *Urban Regional Planning Program. The Karuah Highway Bypass, Economic and Social Impacts: The 1 Year Report*.

University of Sydney (2009). *Urban Regional Planning Program. The Karuah Highway Bypass, Economic and Social Impacts: The 5 Year Report*.

Appendix A

Demographic tables

Demographic tables

Figure A-1 and **Figure A-2** illustrate the Census Collection District (CCD) boundaries within the study area at 2001 and 2006. The CCDs which comprise the study area are 1180508, 1180504, 1180812, 1180306, 1180314, 1180801, 1180502, 1180503, 1180506. There was a boundary adjustment to CCD 1180801at the 2006 Census which reduced its size.

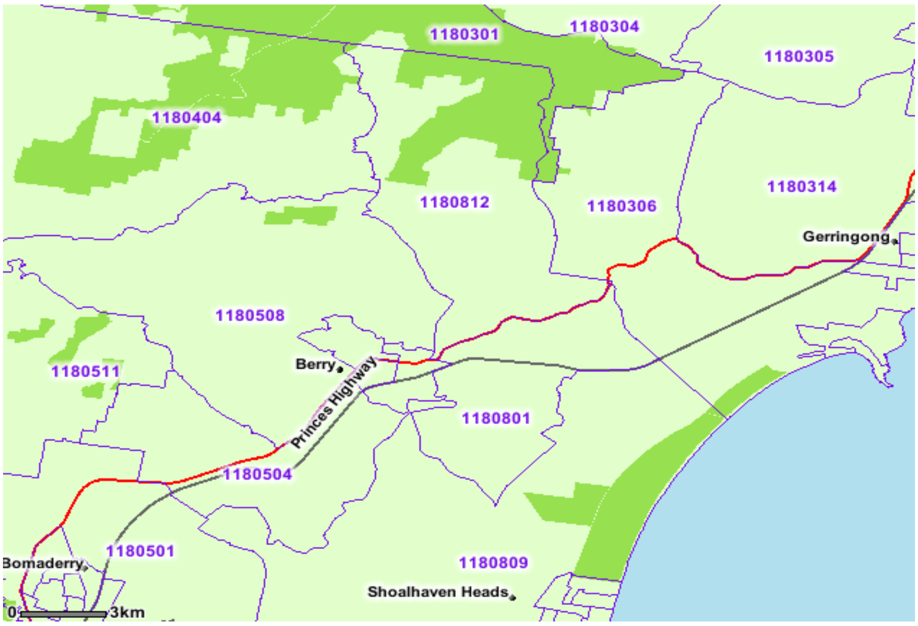


Figure A-1: CCD boundaries within the study area: 2001

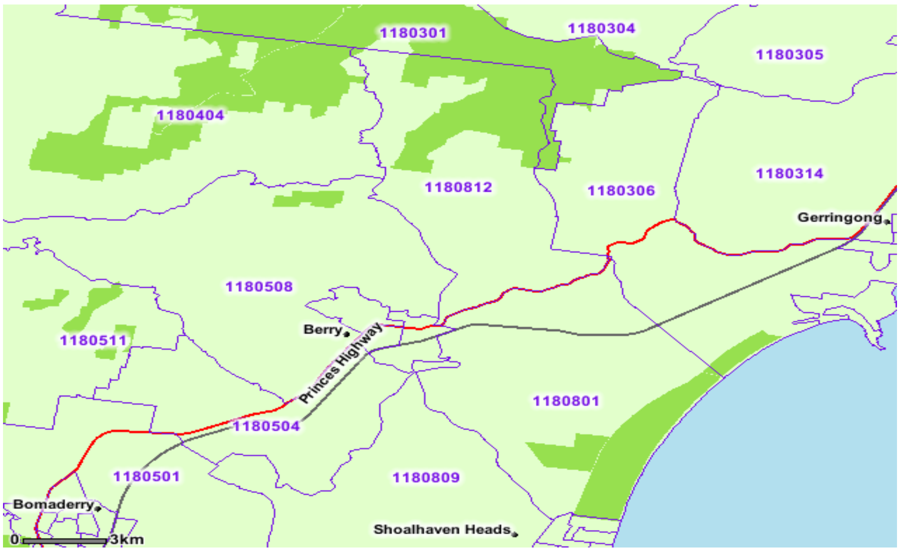


Figure A-2: CCD boundaries within the study area: 2006

Data is from the 2001 and 2006 Census (Australian Bureau of Statistics) unless otherwise stated.

Table A-1: Key demographic characteristics of the study area: 2001 and 2006

Key demographic statistics	Study area		Berry		Shoalhaven LGA		NSW	
	2001	2006	2001	2006	2001	2006	2001	2006
Median age*	38-49	45-51	42	49	41	44	35	37
Total pop	3657	3563	1597	1484	83,548	88,405	6,371,745	65,49,177
Pop aged 15+	2852	2963	1267	1258	65,354	71,374	5,052,247	5,250,261
%	77.99%	83.16%	79.34%	84.77%	78.22%	80.74%	79.29%	80.17%
Pop aged 65+	657	1040	353	420	15945	18702	833,419	905,778
%	17.97%	29.19%	22.10%	28.30%	19.08%	21.15%	13.08%	13.83%
Unemployment rate	5.48%	3.56%	5.9	4.80%	11.1	9.20%	7.20%	5.90%
Indigenous pop	37	24	23	12	3002	3311	119,865	138,506
%	1.01%	0.67%	1.44%	0.81%	3.59%	3.75%	1.88%	2.11%
Speaks a language other than English at home	80	102	33	100	2592	6982	1,196,204	1,702,884
%	2.19%	2.86%	2.07%	6.74%	3.10%	7.90%	18.77%	26.00%

**Median ranges available only for study area*

Table A-2: Population projections

Year	Kiama LGA	Shoalhaven LGA
2006	20,000	92,300
2011	20,600	98,500
2016	21,100	105,100
2021	22,100	111,700
2026	23,300	117,900
2031	24,100	123,600
2036	24,900	129,100

(Source: Projected population by sex, SLAs in NSW, 2006-2036, NSW Department of Planning and Infrastructure 2010)

Table A-3: Labour force characteristics 2006

Labour force statistics Population 15+	Study area	Berry	Shoalhaven	NSW
Total labour force	1634	662	34,479	3,092,603
Employed FT	796	349	17,451	1,879,628
%	48.71%	52.72%	50.61%	60.78%
Employed PT	572	253	11,691	842,713
%	35.01%	38.22%	33.91%	27.25%
Employed away from work*	39	18	1306	103,525
%	2.39%	2.72%	3.79%	3.35%
Employed hours not stated	55	13	845	83578
%	3.37%	1.96%	2.45%	2.70%
Unemployed	61	29	3186	183,159

During the week of the census these respondents did not spend any time at work and so could not be classified as full-time or part-time workers

Table A-4: Employment by industry 2006

	Study area		Berry		Shoalhaven		NSW	
	No. persons	%	No. persons	%	No. persons	%	No. persons	%
Agriculture, forestry and fishing	116	7.33	21	3.34	715	2.29	78,661	2.70
Mining	4	0.25	3	0.48	119	0.38	20,318	0.70
Manufacturing	108	6.82	35	5.57	2611	8.34	277,986	9.55
Electricity, gas, water and waste services	25	1.58	6	0.96	329	1.05	29,184	1.00
Construction	130	8.21	48	7.64	3116	9.96	212,729	7.31
Wholesale trade	31	1.96	25	3.98	672	2.15	136,761	4.70
Retail trade	196	12.38	97	15.45	4459	14.25	323,929	11.13
Accommodation and food services	124	7.83	65	10.35	2741	8.76	190,454	6.55
Transport, postal and warehousing	61	3.85	18	2.87	1142	3.65	145,518	5.00
Information media and telecommunications	16	1.01	3	0.48	387	1.24	68,976	2.37
Financial and insurance services	31	1.96	15	2.39	538	1.72	144,867	4.98
Rental, hiring and real estate services	27	1.71	11	1.75	585	1.87	50,588	1.74
Professional, scientific and technical services	99	6.25	33	5.25	1307	4.18	213,247	7.33
Administrative and support services	53	3.35	14	2.23	974	3.11	90,431	3.11
Public administration and safety	79	4.99	31	4.94	2959	9.46	174,915	6.01
Education and training	170	10.74	60	9.55	2444	7.81	219,679	7.55
Health care and social assistance	191	12.07	93	14.81	3678	11.75	304,335	10.46
Arts and recreation services	35	2.21	12	1.91%	487	1.56	39,574	1.36
Other services	44	2.78	20	3.18	1316	4.21	110,094	3.78
Inadequately described/not stated	43	2.72	18	2.87	712	2.28	77,194	2.65
Total	**1583**		**628**		**31,291**		**2,909,440**	

Table A-5: Journey to work (single method only) 2006

	Study area		Berry		Shoalhaven		NSW	
	No. persons	%	No. persons	%	No. persons	%	No. persons	**%**
Train	10	0.91	0	0.00	80	0.33	158,000	6.86
Bus	3	0.27	0	0.00	116	0.48	100,058	4.34
Ferry	0	0.00	*0*	0.00	0	0.00	6004	0.26
Tram (includes light rail)	0	0.00	0	0.00	3	0.01	1051	0.05
Taxi	0	0.00	0	0.00	42	0.17	8219	0.36
Car, as driver	872	78.99	350	75.59	19,359	79.30	1,639,528	71.16
Car, as passenger	82	7.43	44	9.50	2106	8.63	166,871	7.24
Truck	22	1.99	10	2.16	688	2.82	45,953	1.99
Motorbike/ scooter	20	1.81	3	0.65	235	0.96	16,495	0.72
Bicycle	6	0.54	7	1.51	260	1.07	19,274	0.84
Other	9	0.82	3	0.65	231	0.95	14,951	0.65
Walked only	80	7.25	46	9.94	1293	5.30	127,446	5.53
Total one method	1104		463		24,413		2,303,850	

Appendix B

Inventory of community and recreational facilities

Inventory of community and recreational facilities

Churches

- Berry Gateway Uniting Church, 69 Albert Street.
- St Lukes Anglican Church, 66-68A Princess Street.
- Berry Presbyterian Church, 81 Victoria Street.
- Berry Community Church, 34 Alexandra Street.
- St Patricks Catholic Church, 80 North Street.

Schools, childcare and other educational facilities

- Berry Primary School, 42 Victoria Street.
- Berry School of Arts, 19 Princess Street (Berry Community Activities Centre).
- Berry Preschool Inc, 20-24 Edward Street.
- Scouts Hall, Wharf Road.

Aged care facilities

- Accommodation for Aged and Disabled Persons, 10 Albany Lane.
- Berry Masonic Village (Aged Care facility), 41 Albany Street.

Services

- David Berry Hospital, 85 Tannery Road.
- Fire Brigade, 26 Prince Alfred Street.
- Broughton Vale Berry Rural Fire Brigade, 82 Albert Street.
- Police Station, 28 Victoria Street.
- Post Office, Princes Highway.
- Service Station, Alexandra Street.
- Court House, 58 Victoria Street.
- Berry General Cemetery, Kangaroo Valley Road.
- Berry Sewerage Treatment Works, off Wharf Road.
- Harley Hills Cemetery, Beach Road.
- Waste Depot, 175 Agars Lane.

Open spaces, recreational facilities and clubs

- Berry Showground, Station Road.
- Camp Quality memorial park, North Street.
- Berry Memorial Park, Gilliam Street.
- Anzac Memorial Park, Alexandra Street.
- Mark Radium Park, Princes Highway.
- Apex Park, Albert Street.
- Oval (adjoining Berry Primary).
- Berry Swimming Pool, Berry Showground (Hazel and David Berry Parks).
- Berry Bowling Club, 140 Princes Highway.
- Berry Sporting Complex, North Street.
- Berry Riding Club, 445 Coolangatta Road.
- Berry Tennis Club Ltd, North Street.
- Berry RSL Sub-Branch, 26 Alexander Street.

Appendix C

Agricultural business impacts

Agricultural business impacts

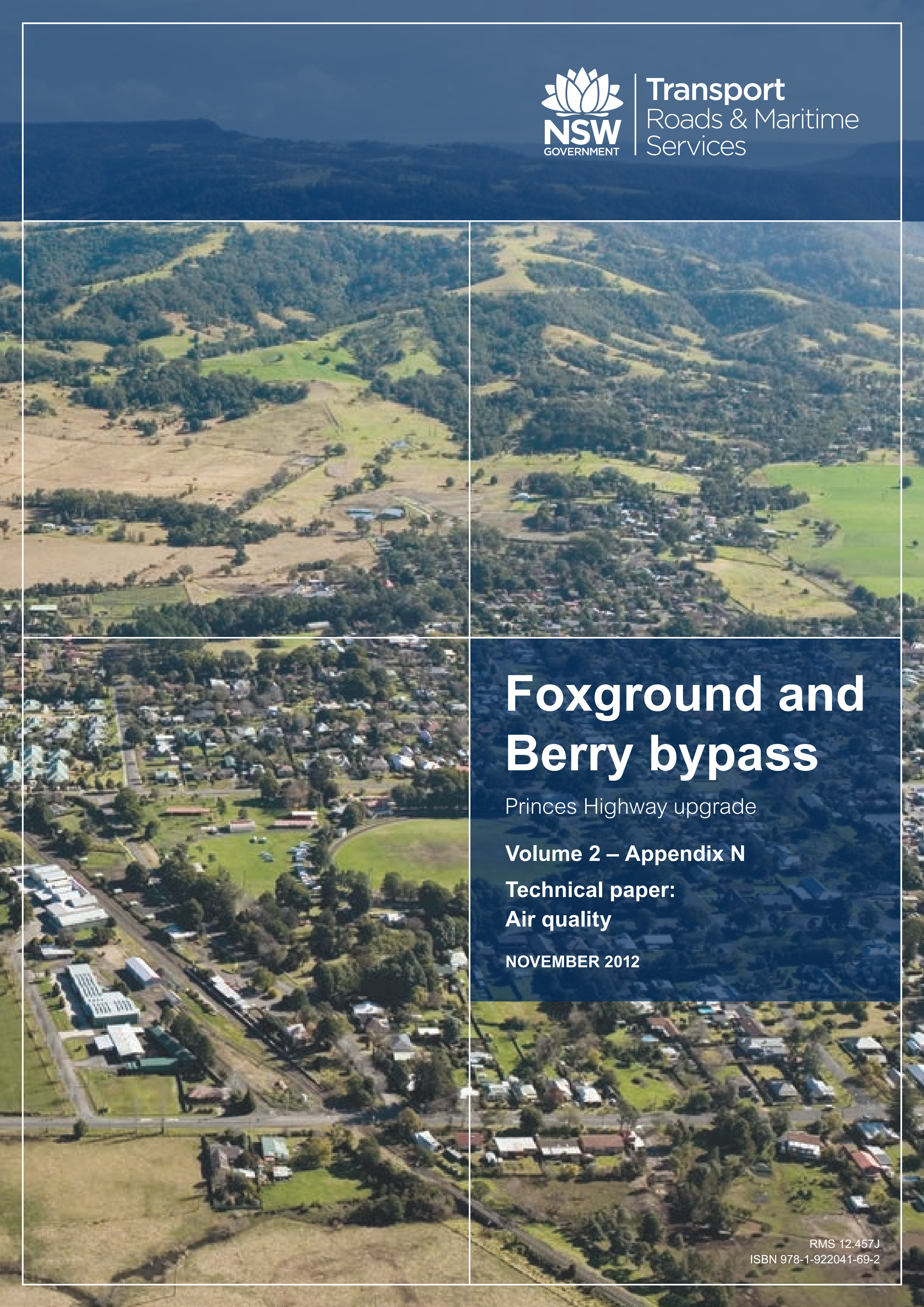
Ref no.[30]	Current Land use/zoning	Total property area	Area of impact	Remaining area	% total property affected	Description of impacts	Proposed mitigation measures
1	Rural (Agricultural Production)	183,392	58,880	124,513	32%	• Partially impacted on northern boundary through cleared land. • Land impacted is of land capability classification 3 and is identified as suitable for regular cultivation. • Remaining land is of agricultural land capability classifications 1 and 3 and is identified as suitable for regular cultivation. • Dwelling directly impacted and all outbuildings directly impacted. • Loss of direct access to the highway. • Proposal would affect the profitability of property. • Proposal would impact viability of property.	• RMS has already acquired property. • Access to be reinstated from relocated Toolijooa Rd.
2	Rural (Agricultural Production)	187,408	28,553	158,855	15%	• Partially impacted on northern boundary through cleared land. • Land impacted is of highest land capability classification 1. The remaining property is of lower land capability classifications 3 and 6. • Loss of access to property. • Proposal would affect the profitability of property. • Proposal would not impact the viability of property.	• Acquisition of affected land. • Compensation for acquired land. • Relocation of property access through proposed property underpass.
3	Rural (Agricultural Production)	205,910	16,183	189,727	8%	• Partially impacted through timbered land on north eastern boundary. • Land impacted is of agricultural land capability classification 6 and is suitable for grazing with no cultivation. • Land remaining is of similar or higher land capability. • Dwelling directly impacted. • Outbuildings directly impacted. • Remaining land suitable for new dwelling. • Loss of direct access to highway. • The proposed route impacts the profitability and viability of the business.	• Acquisition of affected land. • Compensation • Relocation of property access through proposed property underpass.
4	Rural (Agricultural Production)	289,872	130,218	159,653	45%	• Property severed through cleared and timbered land. • Land impacted is of highest agricultural land capability classification and is identified as suitable for regular cultivation. • Remaining agricultural land is of similar land capability. • Outbuildings directly impacted. • Access to northern part of the property severed. • Impact would not affect the viability of property.	• RMS has already acquired property. • Access to northern part of the property to be reinstated from the new highway. • Southern part of the property still accessible from the Princes Highway. • Remaining property could be sold to neighbouring land owners or repackaged and sold.
5	Rural (Agricultural Production)	315,548	38,300	277,248	12%	• Partially impacted along southern boundary through partially cleared land. • Land impacted is of highest agricultural land capability classification and is identified as suitable for regular cultivation. • Remaining land is of agricultural land capability classifications 1 and 3 and is identified as suitable for regular cultivation. • Proposal would not impact viability or profitability of the property.	• Acquisition of affected land. • Compensation for acquired land.
6	Rural (Agricultural Production)	102,688	4,713	97,975	5%	• Partially impacted along south eastern boundary through cleared land. • Land impacted is of agricultural land capability classification 3 and is identified as suitable for regular cultivation. • Remaining land is of similar agricultural land capability.	• Acquisition of affected land. • Compensation for acquired land.
7	Rural	184,053	65,221	118,831	35%	• Property severed through cleared land.	• RMS has already acquired property.

[30] Reference numbers refer to **Figure 5-4** and **Figure 5-5**. Only impacts to agricultural businesses are described in **Appendix C**.

Ref no.[30]	Current Land use/zoning	Total property area	Area of impact	Remaining area	% total property affected	Description of impacts	Proposed mitigation measures
	(Agricultural Production)					• Land impacted is of agricultural land capability classification 3 and is identified as suitable for regular cultivation. • Remaining land is of similar or higher agricultural land capability. • Loss of access to northern part of the property. • Access to western part of the property severed. • Dwelling not directly impacted. • Loss of direct access to highway. • Proposal would affect the profitability of property. • Proposal would impact viability of the land.	• Remaining property could be sold to neighbouring land owner or repackaged and sold. • Access to be reinstated.
9	Rural (Agricultural Production)	207,191	30,577	176,614	15%		
8	Rural (Agricultural Production)	122,987	19,410	103,577	16%	• Property severed through cleared and timbered land. • Land impacted is of agricultural land capability classification 3 and is identified as suitable for regular cultivation. • Remaining land is of similar or higher agricultural land capability. • Proposal would not affect the profitability of the property. • Proposal would impact viability of the property.	• RMS has already acquired property. • Remaining property could be sold to neighbouring land owners or repackaged and sold.
10	Rural (Agricultural Production)	225,891	21,636	204,255	10%	• Property severed through cleared and timbered land. • Land impacted is of land capability classification 3 and is identified as suitable for regular cultivation. • Remaining land is of agricultural land capability classifications 1, 3 and 6 and is identified as unsuitable for cultivation in some areas. • Access to western part of the property severed. • Dwelling not directly impacted. • Proposal would affect the profitability of property. • Proposal could potentially impact viability of the land.	• Acquisition of affected land, with consideration of total acquisition. • Compensation for acquired land. • Access to western part of the property to be reinstated.
11	Rural (Arterial and Main Road Protection)	436,573	79,557	357,016	18%		
12	Rural (Arterial and Main Road Protection)	776,413	4,444	771,970	1%	• Partially impacted along southern boundary through cleared land. • Land impacted is of highest agricultural land capability classification and is identified as suitable for regular cultivation. • Remaining land is of agricultural land capability of similar or lower land capability. • Dwelling not directly affected. • Loss of access to highway. • Proposal would not impact viability or profitability of the property.	• Acquisition of affected land. • Compensation for acquired land. • Access to be reinstated to highway.
14	Rural (Arterial and Main Road Protection)	135,200	41,326	93,873	31%	• Partially impacted along northern boundary through cleared and timbered land. • Land impacted is of agricultural land capability classification 3 and is identified as suitable for regular cultivation. • Remaining land is of similar or higher agricultural land capability. • Access from highway impacted. • Proposal would not impact the profitability or viability of the property.	• Acquisition of affected land. • Compensation for acquired land. • Access would be restored via service road.
17	Rural (Arterial and Main Road Protection)	358,957	15,215	343,742	4%	• Partially impacted along northern boundary through cleared land. • Land impacted is of agricultural land capability classification 3 and is identified as suitable for regular cultivation. • Remaining land is of similar or higher agricultural land capability. • Dwelling not directly affected. • Impact would affect the viability of property.	• RMS has already acquired property. • Remaining property could be sold to neighbouring land owners or repackaged and sold.
20	Rural (Arterial and Main Road Protection)	414,404	66592.29	629,623	10%	• Partially impacted along southern boundary through mainly timbered land. • Remaining land is of similar or higher agricultural land capability. • Dwelling not directly affected. • Impact would affect the viability or profitability of the property.	• Acquisition of affected land. • Compensation for acquired land.

Ref no.[30]	Current Land use/zoning	Total property area	Area of impact	Remaining area	% total property affected	Description of impacts	Proposed mitigation measures
21	Rural (Arterial and Main Road Protection)	414,404	31,915	382,490	8%	• Partially impacted along northern boundary. • Land impacted is of agricultural land capability classification 3 and is identified as suitable for regular cultivation. • Remaining land is of similar or higher agricultural land capability. • Dwelling not directly impacted. • Outbuilding directly impacted by new proposal. • Loss of direct access to highway. • Proposal would affect the profitability of property. • Proposal would not impact viability of property.	• Acquisition of affected land. • Compensation for acquired land. • Access to be provided to highway.
22	Rural (Arterial and Main Road Protection)	609,230	58,362	550,868	10%	• Partially impacted along northern boundary through partially cleared land. • Land impacted is of highest agricultural land capability classification and is identified as suitable for regular cultivation. • Remaining land is of agricultural land capability classifications 1 and 3 and is identified as suitable for regular cultivation. • Dwelling not directly impacted. • Direct access to the highway severed. • Proposal would not impact viability of property.	• Acquisition of affected land. • Compensation for acquired land. • Access would be reinstated from the rear of the property.
26	Rural (Arterial and Main Road Protection)	423,075	15,742	407,333	4%	• Partially impacted along south eastern boundary through partially cleared land. • Land impacted is of highest agricultural land capability classification and is identified as suitable for regular cultivation. • Remaining land is of agricultural land capability classifications 1 and 3 and is identified as suitable for regular cultivation. • Loss of direct access to highway. • Proposal would affect the profitability of property • Proposal would impact viability of property.	• RMS has already acquired property. • Remaining property could be sold to neighbouring landowner or repackaged and sold. • Access to be reinstated via Princes Highway service road.
27	Rural (Arterial and Main Road Protection)	109,409	24,859	84,551	23%	• Partially impacted along south eastern boundary. • Land impacted is of land capability classification 1. The remaining land is also of the highest land capability classification. • Loss of direct access to highway • Proposal would affect the profitability of property • Proposal would not impact the viability of property	• Acquisition of affected land. • Compensation for acquired land. • Access to be reinstated from highway.
28	Rural (Arterial and Main Road Protection)	118,082	10,953	107,129	9%	• Partially impacted along south-eastern boundary through partially cleared land. • Land impacted is of highest agricultural land capability classification and is identified as suitable for regular cultivation. • Remaining land is of agricultural land capability classifications 1 and 3 and is identified as suitable for regular cultivation. • Dwelling not directly affected. • Outbuilding directly impacted by new proposal. • Loss of direct access to highway. • Impact would not affect the viability of the property.	• Acquisition of affected land. • Compensation for acquired land. • Access to be provided via an underpass to an access road that connects to the existing highway.
29	Rural (Arterial and Main Road Protection)	128,693	5,169	123,524	4%	• Partially impacted along south eastern boundary. • Land impacted is of highest agricultural land capability classification and is identified as suitable for regular cultivation. • Remaining land is of agricultural land capability classifications 1 and 3 and is identified as suitable for regular cultivation. • Dwelling not directly impacted.	• Acquisition of affected land. • Compensation for acquired land. • Access to be provided via an underpass to an access road that connects to the existing highway.

Ref no.[30]	Current Land use/zoning	Total property area	Area of impact	Remaining area	% total property affected	Description of impacts	Proposed mitigation measures
						• Loss of direct access to highway. • Proposal would not impact profitability of the property. • Proposal would not impact the viability of the property.	
31	Rural (Flood Liable)	169,090	25,339	143,751	15%	• Property severed through cleared and timbered land. • Land impacted is of agricultural land capability classifications 1 and 3 and is identified as suitable for regular cultivation. • Remaining land is of similar or higher agricultural land capability. • Access to southern part of the property severed. • Proposal would not impact the viability of the property.	• Acquisition of affected land, with consideration of total acquisition. • Compensation for acquired land.
41	Rural (Flood Liable)	249,682	12,809	236,873	5%	• Partially impacted along southern boundary through partially cleared land • Land impacted is of agricultural land capability classification 3 and is identified as suitable for regular cultivation. • Remaining land is of similar or higher agricultural land capability. • Proposal would affect viability of the property.	• RMS has already acquired property. • Remaining property could be sold to neighbouring land owners or repackaged and sold.
43	Special Uses (Proposed Arterial Roads Preservation and Widening of Existing Arterial Roads Reservation)	62,469	7,784	54,685	12%	• Property severed through cleared land. • Access to southern part of the property severed. • Land impacted is of agricultural land capability classification 3 and is identified as suitable for regular cultivation. • Remaining land is of similar or higher agricultural land capability. • Proposal would impact profitability of the property. • Proposal would not impact the viability of the property. • Loss of access to North Street.	• Acquisition of affected land. • Compensation for acquired land. • Access to be provided to Rawlings Lane.
46	Special Uses (Proposed Arterial Roads Preservation and Widening of Existing Arterial Roads Reservation)$$ $	108,141	12,768	95,373	12%		
47	Special Uses (Proposed Arterial Roads Preservation and Widening of Existing Arterial Roads Reservation)	106,478	8,988	97,490	8%		
52	Special Uses (Proposed Arterial Roads Preservation and Widening of Existing Arterial Roads Reservation)	569,476	1,528	567,948	0%	• Partially impacted along southern boundary through uncleared land. • Land impacted is of agricultural land capability classification 3 and is identified as suitable for regular cultivation. • Remaining land is of similar or higher agricultural land capability. • Acquired land is classified as Agricultural Class 1 land. • Dwelling not directly impacted. • Proposal would not impact profitability or viability of the property.	• Acquisition of affected land. • Compensation for acquired land.



Transport
Roads & Maritime
Services

Foxground and Berry bypass

Princes Highway upgrade

Volume 2 – Appendix N

Technical paper:
Air quality

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Foxground and Berry bypass

Prepared for

Roads and Maritime Services

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November 2012

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Glossary of terms and abbreviations

Abbreviation	Meaning
CO	Carbon Monoxide
$\mu g/m^3$	Microgram per cubed metre
ABS	Australian Bureau of Statistics
AQMP	Air Quality Management Plan
CAL3QHCR	Software model used for predicting air pollution concentrations of carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter (PM), and other inert gases from idle or moving motor vehicles
Caline, CALINE3/4	Software models which estimate dispersion of vehicle exhaust based on a Gaussian diffusion equation
CALRoads	An air dispersion modelling software package for predicting air quality impacts of pollutants near roadways.
Carboxyhaemoglobin	A stable complex of carbon monoxide and haemoglobin that forms in red blood cells when carbon monoxide is inhaled or produced in normal metabolism
CEMP	Construction Environmental Management Plan
DEC	NSW Department of Environment and Conservation. (now OEH)
DECCW	NSW Department of Environment, Climate Change and Water
DEH	Department of Environment and Heritage
EPA	NSW Environment Protection Authority (formerly part of DECCW)
Expectorating	To cough up and spit out phlegm, thus clearing the bronchial passages
Gaussian Model	A way of calculating concentrations of polluting chemicals from stationary industrial sources. The substance goes downwind and disperses (gets weaker) as it travels, according to Gaussian mathematics.
GLC	Ground level concentration
HC	Hydrocarbons
HGVs	Heavy Goods Vehicles
ISCMOD	Industrial Source Complex model
Lassitude	A state of weariness accompanied by listlessness or apathy
NEMP	National Environment Protection Measures.
NEPC	National Environment Protection Council of Australia
NEPC	National Environmental Protection Council
NHMRC	National Health and Medical Research Council of Australia
NO_2	Nitrogen dioxide

Abbreviation	Meaning
NO_X	Nitrogen oxides
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
EPA	NSW Environment Protection Authority
Photochemical	Relating to, or caused by the chemical action of light.
PIARC	Permanent International Association of Road Congresses
PM_{10}	Particulate matter < 10 µm
POEO	*Protection of the Environment Operations Act 1997*
Ppm	Parts per million
RAN	Royal Australian Navy
RMS	Roads and Maritime Services of New South Wales
RTA	Roads and Traffics Authority of NSW (now RMS)
SO_2	Sulphur dioxide
TOEM	Tapered Element Oscillating Microbalance (PM_{10} Monitor)
TSP	Total suspended particulates
TSP	Total Suspended Particulates
USEPA	United States Environmental Protection Agency
WHO	World Health Organisation
Windrose	A graphic tool used by meteorologists to give a succinct view of how wind speed and direction are typically distributed at a particular location

1 Introduction

The Roads and Maritime Services (RMS) (formerly the Roads and Traffic Authority of NSW (RTA)) is seeking approval under Part 3A of the *Environmental Planning and Assessment Act 1979* to upgrade 11.6 kilometres of the Princes Highway between Toolijooa Road north of Foxground and Schofields Lane south of Berry, in New South Wales (NSW) (the project), to achieve a four lane divided highway (two lanes in each direction) with median separation. The project includes bypasses of Foxground and Berry.

The project would form part of the Princes Highway upgrade which aims to provide a four lane divided highway between Waterfall and Jervis Bay Road, Falls Creek. The upgrade of the Princes Highway would improve road safety and traffic efficiency, including for freight, on the NSW south coast.

The report comprises the following components:

- Project description.
- Regional meteorology and air quality issues.
- Local air quality and dispersion conditions.
- Impacts of the existing highway alignment.
- Estimation of emissions based on traffic volumes and vehicle mix.
- Assessment of construction impacts.
- Assessment of air quality impacts associated with the project in two representative years following completion – 2017 and 2027.
- Identification of mitigation and management measures.

1.1 Study area

The project is located west of Gerringong, between the junctions of the Princes Highway with Toolijooa Road (north of Foxground) and Schofields Lane (south of Berry). South of Schofields Lane, a u-turn facility would be provided at Mullers Lane.

The study area is shown in **Figure 1-1**.

From north-east to south-west, the project traverses Toolijooa Ridge, bypasses the Foxground bends, crosses Broughton Creek in three locations and bypasses the town of Berry. An illustration of local terrain features in the study area is shown in **Figure 1-2**.

The project study area mainly comprises the existing road reserve, privately owned rural agricultural, rural residential and suburban (Berry) properties. The main agricultural land use in the study area is cattle grazing.

The project deviates from the existing Princes Highway corridor in two locations:

- Across Toolijooa Ridge and the Broughton Creek floodplain between Toolijooa Road and east of Austral Park Road.
- A northern bypass of Berry from the ridgeline to the east of Woodhill Mountain Road to the south of Berry, rejoining the existing route south-west of Kangaroo Valley Road.

Remaining portions of the project follow the existing route of the Princes Highway where potential impacts would typically affect isolated rural residences and properties fronting the existing highway.

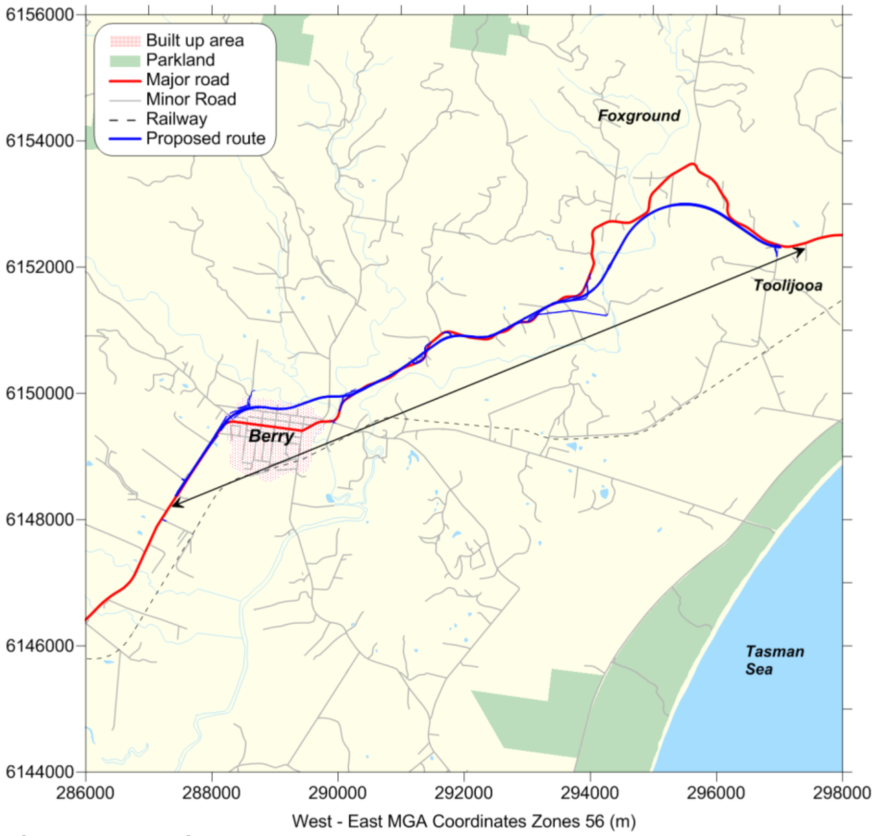

Figure 1-1: Study area

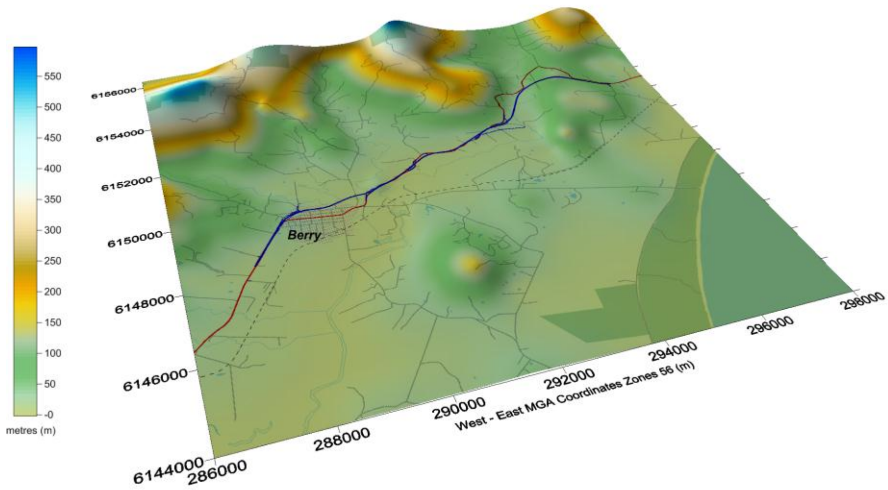

Figure 1-2: Local terrain features in the study area

2 Project description

Roads and Maritime Services (RMS) propose to upgrade 11.6 kilometres of the Princes Highway between Toolijooa Road north of Foxground and Schofields Lane south of Berry, in New South Wales (NSW) (the project), to achieve a four lane divided highway (two lanes in each direction) with median separation. The project includes bypasses of Foxground and Berry.

The project comprises the following key features:

- Construction of a four lane divided highway (two lanes in each direction) with median separation (wire rope barriers or concrete barriers where space is constrained, such as at bridge locations).
- Bypasses of the Foxground bends and the Berry township.
- Construction of around 6.6 kilometres of new highway where the project deviates from the existing highway alignment at Toolijooa Ridge, the Foxground bends and the Berry township.
- Provision for the possible widening of the highway (if required in the future) to six lanes within the road corridor and, in some areas, construction of the road formation to accommodate future additional lanes where safety considerations, traffic disruption and sub-optimal construction practices are to be avoided.
- Grade-separated interchanges at:
  - Toolijooa Road.
  - Austral Park Road.
  - Tindalls Lane.
  - East of Berry at the existing Princes Highway, referred to as the northern interchange for Berry.
  - West of Berry at Kangaroo Valley Road, referred to as the southern interchange for Berry.
- A major cutting at Toolijooa Ridge (around 900 metres long and up to 26 metres deep).
- Six lanes (two lanes plus a climbing lane in each direction) through the cutting at Toolijooa Ridge for a distance of 1.5 kilometres.
- Four new highway bridges:
  - Broughton Creek bridge 1, a four span concrete structure around 170 metres in length and nine metres in height.
  - Broughton Creek bridge 2, a three span concrete structure around 75 metres in length and eight metres in height.
  - Broughton Creek bridge 3, a six span concrete structure around 190 metres long and 13 metres in height.
  - A bridge at Berry, an 18 span concrete structure around 600 metres long and up to 12 metres in height.

- Three highway overbridges:
  - Austral Park Road interchange, providing southbound access to the highway.
  - Tindalls Lane interchange, providing southbound access to and from the highway.
  - Southern interchange for Berry, providing connectivity over the highway for Kangaroo Valley Road along its existing alignment.
- Eight underpasses including roads, drainage structures and fauna underpasses:
  - Toolijooa Road interchange, linking Toolijooa Road to the existing highway and providing northbound access to the upgrade.
  - Property access and fauna underpass in the vicinity of Toolijooa Ridge at chainage 8400.
  - Dedicated fauna underpass in the vicinity of Toolijooa Ridge at chainage 8450.
  - Property access underpass between Toolijooa Ridge and Broughton Creek at chainage 9475.
  - Combined drainage and fauna underpass in the vicinity of Austral Park Road at chainage 12770.
  - Combined drainage and fauna underpass in the vicinity of Tindalls Lane at chainage 13320.
  - Dedicated fauna underpass in the vicinity of Tindalls Lane at chainage 13700.
  - Property access underpass between the Tindalls Lane interchange and the northern interchange for Berry in the vicinity of at chainage 15100.
- Modifications to local roads, including Toolijooa Road, Austral Park Road, Gembrook Road, Tindalls Lane, North Street, Queen Street, Kangaroo Valley Road, Hitchcocks Lane and Schofields Lane.
- Diversion of Town Creek into Bundewallah Creek upstream of its confluence with Connollys Creek and to the north of the project at Berry.
- Modification to about 47 existing property accesses.
- Provision of a bus stop at Toolijooa Road and retention of the existing bus stop at Tindalls Lane.
- Dedicated u-turn facilities at Mullers Lane, the existing highway at the Austral Park Road interchange, the extension to Austral Park Road and Rawlings Lane.
- Roundabouts at the southern interchange for Berry and the Woodhill Mountain Road junction with the exiting Princes Highway.
- Two culs-de-sac on North Street and the western end of Victoria Street in Berry.
- Tie-in with the existing highway about 75 metres north of Toolijooa Road and about 440 metres south of Schofields Lane.
- Left in/left out only provisions for direct property accesses to the upgraded highway.
- Dedicated public space with shared pedestrian/cycle facilities along the southern side of the upgraded highway from the playing fields on North Street to Kangaroo Valley Road.
- Ancillary operational facilities, including permanent detention basins, stormwater treatment facilities and a permanent stockpiling site for general road maintenance.

Construction activities as part of the project would include the following:

- Site preparation and establishment works.
- Temporary construction facilities, including construction compounds, stockpile sites, creek crossings, sediment control basins and haulage roads.
- Temporary works, including relocation/protection of services, tie-ins, traffic facilities and side tracks.
- Earthworks and bridge construction.
- Pavement construction.
- Drainage construction.
- Road furniture installation.
- Site restoration.

The project and the key features of the project are shown in **Figure 2-1**.

During the detailed design phase of the project, refinements could be made to the design features and construction methods.

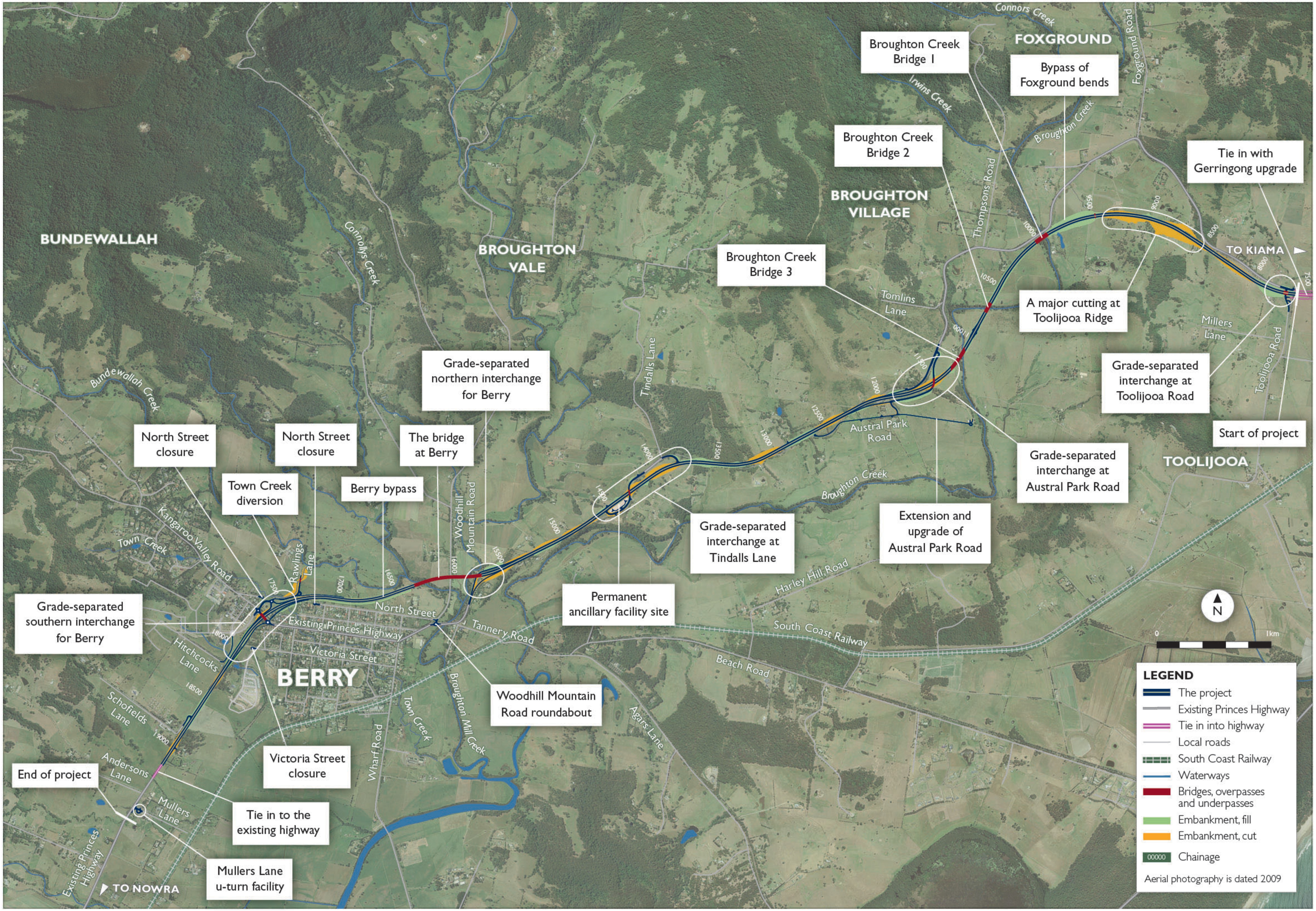

Figure 2-1: Key features of the project

3 Air quality criteria

Motor vehicles emit a number of pollutants that are known to be potentially harmful to human health. These pollutants are carbon monoxide (CO), nitrogen oxides (NO_x), hydrocarbons (HC, including benzene), sulphur dioxide (SO_2) and particulate matter. Each of these pollutants has the capacity to adversely affect health if the concentration is too great over a particular exposure period. Emissions of SO_2 are minor and are not considered further in this assessment.

The NSW Environmental Protection Authority[1] (EPA) (formerly included in the Department of Environment, Climate Change and Water, DECCW) has historically noted air quality goals determined by the World Health Organisation (WHO), the United States Environmental Protection Agency (US EPA) and the National Health and Medical Research Council of Australia (NHMRC).

In 1998, the National Environment Protection Council of Australia (NEPC) determined a set of air quality goals for adoption at a national level, which are part of the National Environment Protection Measures (NEPM). New air quality goals for nitrogen dioxide and particulate matter were adopted by the EPA in its publication "*Action for Air*" (NSW EPA, 1998).

The EPA specifies ground-level concentration (glc) criteria for criteria pollutants (NSW Department of Environment and Conservation (DEC), 2005), as listed in **Table 3-1**. The basis of these air quality goals and, where relevant, the safety margins which they provide are outlined in the following sections.

Table 3-1: EPA air quality assessment criteria

Pollutant	Goal	Averaging period	Source
Carbon monoxide	30 mg/m^3 10 mg/m^3	1-hour 8-hour	WHO (2000) NEPC (1998)
Nitrogen dioxide	246 $\mu g/m^3$ 62 $\mu g/m^3$	1-hour Annual	NEPC (1998) NEPC (1998)
Particulate matter < 10 µm (PM_{10})	50 $\mu g/m^3$ 30 $\mu g/m^3$	24-hour Annual	NEPC (1998) EPA (1998)

mg/m^3 – milligrams per cubic metre
ppm – parts per million
$\mu g/m^3$ – micrograms per cubic metre

3.1 Carbon monoxide

Carbon monoxide is produced from incomplete combustion of fuels, where carbon is only partially oxidised instead of being fully oxidised to form carbon dioxide.

Carbon monoxide can be harmful to humans because of its affinity for haemoglobin, which is more than 200 times greater than that of oxygen. When it is inhaled it is taken up by the blood and therefore reduces the capacity of the blood to transport oxygen. This process is reversible and reducing the exposure will lead to the establishment of a new equilibrium. A period of three hours is the approximate time required to reach 50 per cent of the equilibrium value.

[1] OEH was previously part of the Department of Environment, Climate Change and Water (DECCW). The DECCW was also recently known as the Department of Environment and Climate Change (DECC), and prior to that the Department of Environment and Conservation (DEC). The terms NSW OEH, DECCW, DECC and DEC are used interchangeably in this report.

Symptoms of carbon monoxide intoxication are lassitude and headaches. These symptoms are not however generally reported until the concentration of carboxyhaemoglobin in the blood is in excess of 10 per cent of saturation. This is about the equilibrium value achieved with an ambient atmospheric concentration of 70 milligrams per cubic metre for a person engaged in light activity. Further, there is evidence of an increased risk for individuals with cardiovascular disease once carboxyhaemoglobin concentration reaches four per cent, and the WHO recommends that ambient concentrations be kept to values which would protect individuals from exceeding the four per cent level.

The 15 minute, one hour and eight hour goals noted by the EPA provide a significant margin for safety in protecting the community, including the very young and elderly. The 15 minute, one hour and eight hour goals are 100 milligrams per cubic metre, 30 milligrams per cubic metre and 10 milligrams per cubic metre respectively.

3.2 Oxides of nitrogen

Oxides of nitrogen are produced by motor vehicles when nitrogen from the air is oxidised at high temperature and pressure in the combustion chamber.

Nitrogen oxides emitted by motor vehicles are comprised mainly of nitric oxide (approximately 95 per cent at the point of emission) and nitrogen dioxide (approximately five per cent at the point of emission). Nitric oxide is much less harmful to humans than nitrogen dioxide and is not generally considered a pollutant at the concentrations normally found in urban environments. Monitoring data collected in Sydney (RTA, 1997) indicates that close to roadways, nitrogen dioxide makes up between five to 20 per cent by weight of the total oxides of nitrogen.

Concern with nitric oxide is related to its transformation to nitrogen dioxide and its role in the formation of photochemical smog. Nitrogen dioxide has been reported as having an effect on respiratory function, although evidence concerning the effects has been mixed and conflicting.

The EPA has not set any air quality goals for nitric oxide, however it has adopted the NEPM standard one hour and annual average goals for nitrogen dioxide as shown in **Table 3-1**.

3.3 Particulate matter

Particulate matter is emitted by motor vehicles and results from incomplete combustion of fuels, additives in fuels and lubricants, worn material that accumulates in the engine lubricant, and brake and tyre wear.

The presence of particulate matter in the atmosphere can have an adverse effect on health and amenity. Larger particles, that is, those greater than 10 microns, generally adhere to mucus in the nose, mouth, pharynx and larger bronchi, and from there are removed by either swallowing or expectorating. Finer particles can enter bronchial and pulmonary regions of the respiratory tract, with increased deposition during mouth breathing, which increases during exercise. The health effects of particulate matter are further complicated by the chemical nature of the particles and by the possibility of synergistic effects with other air pollutants such as sulfur dioxide.

The current project will be assessed using the NEPM standards for particulate matter shown in **Table 3-1**, adopted by the EPA.

3.4 Vehicle emissions and photochemical smog

Motor vehicle emissions have the potential to contribute significantly to photochemical smog in an urban environment. Photochemical smog is formed from a reaction between nitrogen oxides and reactive hydrocarbons in the presence of sunlight. Models for the formation of photochemical smog envisage hydrocarbon emissions resulting predominately from motor cars, facilities for the storage of hydrocarbons or spray painting operations, mixing with nitrogen oxides from either industrial sources or motor cars. The mixture of pollution from these sources then reacts photochemically to form photochemical smog comprising mainly of ozone, but also including other oxidants. At concentrations of 0.1 parts per million and above, the smog can affect the eyes and respiratory system and can adversely affect plants and building materials.

Ozone is not emitted directly from motor vehicles but results from photochemical reactions that take some time to occur. Concentrations close to roadways are low because fresh emissions of nitric oxide titrate takes the place of any ozone that may be present.

4 Existing air quality

4.1 Monitoring data

Air quality standards and goals refer to pollutant levels resulting from a combination of both the project and existing sources. To fully assess impacts against all the relevant air quality standards and goals (detailed in Section 3 and listed in **Table 3-1**) it is therefore necessary to have information or estimates on existing background pollutant concentrations for the area in which the project is likely to contribute to these levels.

The closest EPA monitoring station was located at Croom Road in Albion Park, approximately 15 kilometres north of Gerringong. This site was however decommissioned in early 2005 and a new station was commissioned at Terry Reserve (Albion Park South) in December 2005. **Table 4-1** presents a summary of air monitoring data from both sites from 1997 to 2007, which includes the most recent available data[2]. Pollutants monitored at these sites were nitrogen dioxide, ozone, sulphur dioxide and PM_{10}. The data is taken from the *National Ambient Air Quality Status and Trends Report, 1991 – 2001* (DEH, 2004) and the EPA quarterly air quality reports (NSW DECCW, 2002 - 2007).

Maximum one hour average and annual average nitrogen dioxide concentrations are well below the EPA air quality criteria. The maximum measured one hour average nitrogen dioxide concentration over the 11 year monitoring period was 166 micrograms per cubic metre in 1998. The maximum annual average was measured at 31 micrograms per cubic metre in 2003, with an average over the whole monitoring period of 11 micrograms per cubic metre.

The maximum one hour and four hour ozone air quality goals were regularly exceeded during the monitoring period. These exceedances can be attributed, in part, to variability in meteorological conditions and often occurred in the warmer summer months when sunlight hours are higher. Bushfires are also known to cause elevated ozone concentrations.

Maximum PM_{10} concentrations were on occasions above the 24 hour goal of 50 micrograms per cubic metre. For example, in 2003 the maximum recorded 24 hour average concentration recorded was 281 micrograms per cubic metre. The EPA *Annual Compliance Report* (NSW DEC, 2004) notes that dust storms occurred on the day this value was recorded. Particle pollution is affected by environmental factors such as bushfires and dust storms and some of the other high levels may also be attributed to these factors. Annual average concentrations of PM_{10} are below the EPA air quality goal of 30 micrograms per cubic metre, except in 2003. Exceedances in that year were likely to be the result of dust storms.

4.2 Modelled existing alignment

In 2007, PAEHolmes (then Holmes Air Sciences) conducted a modelling study, *Air Quality Impact Assessment – Gerringong to Bomaderry Princes Highway Upgrade* (Holmes Air Sciences, 2007), which investigated air quality impacts of the existing highway alignment in the study area. The results of this modelling are provided in **Table 4-2** and show all predicted concentrations as well below their respective air quality goals. The nearest residences through the township of Berry are about 10 metres from the kerb. Levels at this distance due to existing traffic volumes are very low and well below air quality criteria.

[2] *Data from 2008 – 2010 is not available in this format at this time.*

Table 4-1: Summary of monitoring data from 1997 to 2007

	NO_2		O_3		TEOM PM_{10}		$CO^{(d)}$	
Year	**Maximum 1 hour average**	**Annual average**	**Maximum 1 hour average**	**Maximum 4 hour average**	**Maximum 24 hour average**	**Annual average**	**Maximum 1 hour average**	**Maximum 8 hour average**
Goal	**246 (µg/m^3)**	**62 (µg/m^3)**	**214 (µg/m^3)**	**171 (µg/m^3)**	**50 (µg/m^3)**	**30 (µg/m^3)**	**30 (mg/m^3)**	**10 (mg/m^3)**
1997[(a)]	90	8	308	265	62	18*	ND	ND
1998[(a)]	166	8	300	248	64	15	5.5	2.8
1999[(a)]	100	8	193	173	49	13	5.1	3.0
2000[(a)]	113	10	227	178	63	15	5.6	3.0
2001[(a)]	105	8	188	175	59	16	10.6	5.3
2002[(b)]	98	10	201	178	88	20	4.8	2.9
2003[(b)]	113	31	278	235	281	40	4.1	2.6
2004[(b)]	90	8	235	197	195	18	4.0	2.6
2005	ND	ND	ND	ND	ND	ND	3.5	2.3
2006[(c)]	104	9	205	167	60	18	3.4	1.9
2007[(c)]	92	9	197	171	54	16	3.2	1.6
Median	102	9	216	178	63	17	4.5	2.7
Maximum	166	31	308	265	281	40	10.6	5.3

ND = No data available
TOEM = Tapered Element Oscillating Microbalance (PM_{10} Monitor)
** one or more quarters of the year had data availability less than 75 per cent*
(a) DEH (2004)
(b) EPA (2002-2007)
(c) Monitoring site now located at Albion Park Reserve
(d) Wollongong monitoring site

Table 4-2: Predicted maximum ground level concentrations for existing alignment

Direction of traffic flow	**Distance from kerb (m)**	**CO**		**NO_2**		**PM_{10}**	
		1 hour average	**8 hour average**	**1 hour average**	**Annual average**	**24 hour average**	**Annual average**
		EPA assessment criteria					
		30 (mg/m^3)	**10 (mg/m^3)**	**246 (µg/m^3)**	**62 (µg/m^3)**	**50 (µg/m^3)**	**30 (µg/m^3)**
Northbound	0	0.9	0.2	231	6.1	10.8	3.6
	10	0.4	0.1	158	1.9	4.0	1.1
	30	0.2	0.1	94	0.9	2.1	0.5
	50	0.2	0.0	37	0.6	1.5	0.3
Southbound	0	0.9	0.2	297	6.2	9.2	3.7
	10	0.6	0.1	171	1.9	3.3	1.1
	30	0.3	0.1	88	0.9	1.8	0.5
	50	0.2	0.1	66	0.7	1.3	0.4

Note: The values for the NO_2 annual averages in the Holmes Air Sciences (2007) document were incorrect by a factor of 10. They have been corrected for this table.

5 Dispersion meteorology and climate

The dispersion model used for this assessment, CAL3QHCR, requires information about the dispersion characteristics of the area. In particular, data is required on wind speed, wind direction, temperature, atmospheric stability class[3] and mixing height[4].

5.1 Wind speed and direction

Meteorological data is available from two sites in the vicinity of the project. The data collected in 2000 was collected from a site located at Gerroa Tip, which is approximately five kilometres to the south-west of Gerringong. Data was also collected in 2001 from a site on Beirnfels Lane, approximately three kilometres to the south-west of Gerringong. The data was collected by the PAEHolmes (formerly Holmes Air Sciences) on behalf of Veolia Water. Permission has been granted by Veolia Water to use this data.

The Beirnfels data has an unusually high percentage of calms (wind speed of 0.5 metres per second or less) which have been attributed to some equipment malfunction during spring and early summer. For this reason data from Gerroa Tip was used in the air quality impact assessment. The data consists of hourly records of wind speed, wind direction and temperature and is presented in a format suitable for dispersion modelling. Windroses prepared from these data are shown in **Figure 5-1**.

On an annual basis, the most common winds were recorded from the west, west-north-west and north-east. During the summer the predominant winds were recorded from the north-east, while in spring they were recorded from the west, west-north-west and north-east. In autumn and winter the winds were mainly from the west and west-north-west. In autumn there were also winds from the north-east. The annual average speed recorded at the Gerroa Tip was 2.4 metres per second.

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[3] In dispersion modelling stability class is used to categorise the rate at which a plume would disperse. In the Pasquill-Gifford stability class assignment scheme, as used in this study, there are six stability classes A through to F. Class A relates to unstable conditions such as might be found on a sunny day with light winds. In such conditions plumes would spread rapidly. Class F relates to stable conditions, such as occur when the sky is clear, the winds are light and an inversion is present. Plume spreading is slow in these circumstances. The intermediate classes B, C, D and E relate to intermediate dispersion conditions.

[4] The term mixing height refers to the height of the turbulent layer of air near the earth's surface into which ground-level emissions would be rapidly mixed. A plume emitted above the mixed-layer would remain isolated from the ground until such time as the mixed-layer reaches the height of the plume. The height of the mixed-layer is controlled mainly by convection (resulting from solar heating of the ground) and by mechanically generated turbulence as the wind blows over the rough ground.

Figure 5-1: Annual and seasonal windroses for Gerroa Tip

5.2 Atmospheric stability

For the Gerroa Tip dataset, a stability class was assigned to each hour of the meteorological data using concurrent cloud cover information and the method of Turner (Turner, 1970). **Table 5-1** shows the frequency of occurrence of the stability categories expected in the area. The most common stability occurrences were calculated to be D class stabilities (21 per cent) suggesting that emissions would disperse quickly for a significant proportion of the time. For 40 per cent of the time conditions are stable (E and F class), indicating poor dispersion at those times.

Mixing height was determined using a scheme defined by Powell (1976) for daytime conditions and an approach described by Venkatram (1980) for night-time conditions. These two methods provide a good estimate of mixing height in the absence of upper air data.

Joint wind speed, wind direction and stability class frequency tables for the Gerroa Tip dataset are presented in Appendix A.

Table 5-1: Frequency of occurrence of stability classes at Gerroa tip

Stability class	Frequency of occurrence (per cent)
A	18.2
B	14.1
C	7.8
D	21.1
E	19.7
F	19.1
Total	100.0

5.3 Climate data

Table 5-2 presents the temperature, humidity and rainfall data from the Nowra Royal Australian Navy (RAN) automatic weather station (Bureau of Meteorology, 2011). Temperature and humidity data consist of monthly averages of 9am and 3pm readings. Also presented are monthly averages of maximum and minimum temperatures, and mean monthly rainfall data.

The annual average maximum and minimum temperatures experienced at Nowra RAN are 21.3 degrees Celsius and 11.3 degrees Celsius respectively. On average, January and February are the hottest months with an average maximum temperature of 25.8 degrees Celsius. July is the coldest month, with average minimum temperature of 6.2 degrees Celsius.

The annual average humidity reading collected at 9am is 70 per cent, and at 3pm the annual average is 58 per cent. The month with the highest humidity on average is February with a 9am average of 76 per cent, and the lowest humidity is in August and September with a 3pm average of 52 per cent.

Rainfall data collected shows that February is the wettest month, with an average rainfall of 120.0 millimetres. The average annual rainfall is 1110 millimetres.

Table 5-2: Temperature, humidity and rainfall data for Nowra RAN

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
9am mean dry-bulb and wet-bulb temperatures (^oC) and relative humidity (%)													
Dry-bulb	20.8	20.6	19.6	17.1	13.8	11.1	10.0	11.6	14.4	17.0	18.3	19.9	16.2
Wet-bulb	17.6	17.9	16.8	14.1	11.4	9.0	7.8	8.8	10.9	13.1	14.6	16.2	13.2
Humidity	72	76	74	71	74	75	72	68	63	63	66	68	70
3pm mean dry-bulb and wet-bulb temperatures (^oC) and relative humidity (%)													
Dry-bulb	24.1	24.3	23.0	20.8	18.0	15.4	14.8	15.9	17.8	19.5	21.3	23.0	19.8
Wet-bulb	19.0	19.3	18.3	15.9	13.5	11.4	10.4	11.0	12.5	14.4	16.0	17.7	15.0
Humidity	62	63	62	59	59	59	54	52	52	57	58	59	58
Daily maximum temperature (^oC)													
Mean	25.8	25.8	24.5	22.1	19.0	16.4	15.8	17.1	19.3	21.5	23.1	24.8	21.3
Daily minimum temperature (^oC)													
Mean	15.9	16.3	14.8	12.1	9.7	7.6	6.2	6.7	8.3	10.7	12.6	14.6	11.3
Rainfall (mm)													
Mean	88.4	120.0	24.4	97.1	90.5	104.8	56.5	75.8	65.6	107.5	98.1	80.5	1110

Station number 068076; Commenced: 1942, Last record: 2000; Latitude (deg S): - 34.94; Longitude (deg E): 150.55; Elevation: 190 metres
Source: Bureau of Meteorology (2011)

6 Approach to assessment

6.1 Introduction

This chapter provides a description of the methods used to model the emissions from the proposed upgrade following completion of the project. Three sections of the project were modelled, namely:

- Princes Highway, between Toolijooa Road interchange and Berry North interchange.
- Princes Highway, between Berry North interchange and Berry South interchange.
- Princes Highway, between Berry South interchange and Schofields Lane.

6.2 Caline

The Caline series of dispersion models has been used to estimate the concentration of oxides of nitrogen, carbon monoxide and particulate matter that are likely to occur in the vicinity of the existing Princes Highway. The CALINE4 model is widely used in roadway studies throughout Australia and was validated for Australian conditions in a study undertaken in Sydney by Williams et. al. (1994).

This model is an upgrade of CALINE3, the most recently US EPA approved model. It is a steady state Gaussian model which can determine concentrations at receptor locations downwind of ’at grade’, ‘fill’, ‘bridges’ and ‘cut section’ highways located in relatively uncomplicated terrain. The model is applicable for any wind direction, highway orientation and receptor location.

For this study, the CALRoads package was used to assess the impacts. This package incorporates CALINE4 as well as CAL3QHCR, which is an enhanced version of CALINE3 able to process up to a year of meteorological data.

Information needed as input to the model includes:

- Meteorological conditions.
- Traffic volumes.
- Emissions information.
- Receptor location information.

The following sections discuss each of the input requirements.

6.2.1 Meteorological conditions

As discussed in **Chapter 5**, meteorological data from Gerroa Tip for the year 2000 was the closest data to the project site that was available and was deemed to be appropriate for use in the assessment.

6.2.2 Traffic volumes

AECOM provided hourly traffic volumes for each section of highway for both years being assessed. **Table 6-1, Table 6-2** and **Table 6-3** present a summary of this data, as well as the percentage of heavy vehicles for each hour, for the years 2017 and 2027.

Table 6-1: Hourly traffic volumes (vehicles/hour) – Toolijooa Road interchange to Berry north interchange

Hour	2017				2027			
	Northbound		Southbound		Northbound		Southbound	
	Total	% Heavy vehicles	Total	% Heavy vehicles	Total	% Heavy vehicles	Total	% Heavy vehicles
1*	20	30	44	26	30	24	70	21
2	17	44	29	36	25	37	45	29
3	20	54	21	53	29	47	30	45
4	28	45	18	47	42	38	27	39
5	63	37	35	53	95	30	52	45
6	113	21	84	33	180	17	131	27
7	226	16	218	24	363	13	346	18
8	366	12	328	18	595	9	531	14
9	437	12	449	11	711	10	739	9
10	449	12	458	12	729	10	753	9
11	500	10	530	12	817	8	872	9
12	556	9	549	11	912	7	905	8
13	579	10	544	9	949	7	901	7
14	584	9	494	10	957	7	818	7
15	676	9	500	10	1110	7	827	7
16	704	7	544	9	1162	5	903	7
17	673	7	578	8	1112	5	961	6
18	577	6	503	6	955	4	840	4
19	327	6	371	7	540	5	619	5
20	167	7	252	7	276	5	420	5
21	107	10	194	8	176	8	321	6
22	77	14	148	8	124	11	246	6
23	52	19	98	10	84	15	161	8
24	33	27	61	14	51	21	100	10

**1 represents the first hour of the day, between midnight and 1 am*

Table 6-2: Hourly traffic volumes (vehicles/hour) – Berry north interchange to Berry south interchange

Hour	2017				2027			
	Northbound		Southbound		Northbound		Southbound	
	Total	% Heavy vehicles	Total	% Heavy vehicles	Total	% Heavy vehicles	Total	% Heavy vehicles
1*	20	24	41	26	31	21	63	23
2	16	40	27	36	24	36	42	31
3	17	50	19	53	25	45	28	48
4	25	43	17	47	37	38	25	42
5	54	37	33	53	82	33	48	48
6	97	22	78	33	150	19	120	29
7	208	19	201	24	323	16	314	20
8	321	16	303	18	502	14	479	15
9	392	13	414	11	615	11	663	10
10	469	11	423	12	740	9	675	10
11	492	10	489	12	778	8	782	10
12	544	9	507	11	860	8	811	9
13	551	9	502	9	872	8	806	8
14	539	10	456	10	852	8	732	8
15	566	9	462	10	895	8	740	8
16	614	7	502	9	974	6	807	7
17	615	7	533	8	977	6	859	7
18	543	6	464	6	864	5	749	5
19	302	6	343	7	480	5	552	6
20	164	6	233	7	261	5	375	6
21	102	10	179	8	161	9	287	7
22	82	11	137	8	129	10	220	7
23	57	15	90	11	89	13	144	9
24	35	22	56	14	54	19	90	12

**1 represents the first hour of the day, between midnight and 1 am*

Table 6-3: Hourly traffic volumes (vehicles/hour) – Berry south interchange to Schofields Lane

Hour	2017				2027			
	Northbound		Southbound		Northbound		Southbound	
	Total	% Heavy vehicles	Total	% Heavy vehicles	Total	% Heavy vehicles	Total	% Heavy vehicles
1*	26	24	48	26	37	21	68	22
2	20	40	34	35	28	36	48	31
3	22	50	25	49	29	45	34	44
4	32	43	20	38	44	38	28	34
5	68	37	37	42	95	33	52	37
6	121	22	84	33	174	19	120	28
7	261	19	236	22	377	16	341	19
8	403	16	400	16	585	14	586	14
9	492	13	598	10	717	11	886	9
10	589	11	540	11	862	9	798	9
11	618	10	565	14	906	8	832	11
12	683	9	610	13	1002	8	899	11
13	692	9	616	11	1017	8	911	9
14	677	10	606	11	993	8	896	9
15	710	9	636	10	1043	8	942	9
16	770	7	689	9	1135	6	1022	8
17	772	7	690	8	1138	6	1025	7
18	681	6	593	6	1007	5	886	5
19	379	6	404	7	560	5	601	6
20	206	6	265	7	304	5	394	6
21	128	10	190	9	187	9	282	7
22	103	11	155	8	151	10	230	7
23	72	15	107	10	104	13	159	9
24	44	22	71	14	63	19	104	11

**1 represents the first hour of the day, between midnight and 1 am*

6.2.3 Vehicle emission rates

This section provides a brief description of the methods used to calculate the emissions of carbon monoxide, nitrogen oxides and PM_{10} from vehicles.

Vehicle emission data from the Permanent International Association of Road Congresses (PIARC) (PIARC, 2004) was adjusted to reflect the NSW vehicle fleet. The modified tables include emissions of carbon monoxide, nitrogen oxides and PM_{10} by age and type of vehicle. The ages of vehicles are categorised into seven periods which correspond to the introduction of emission standards. The types of vehicle are categorised into light and heavy vehicle groups.

Proportions of traffic within each age category for 2017 and 2027 have been extrapolated from the proportions of traffic within each age category using NSW traffic registration data from the Australian Bureau of Statistics (ABS) Motor Vehicle Census (ABS, 2005). No future improvements in vehicle technology or fuel standards have been included in the emission estimates. The data collected by Australasian Traffic Surveys showed that the proportion of the fleet that is heavy-goods vehicles (HGVs) varies throughout the day. It was assumed that five per cent of the passenger vehicles are diesel and 95 per cent are petrol.

The CAL3QHCR model requires emission factors in units of grams per vehicle mile. The emission factors along each section of road have been calculated from the traffic flow, vehicle mix and the emission rate per vehicle derived from the PIARC tables. Due to the variability of the light and heavy vehicle traffic mix, the emission factors would be different for each hour. **Table 6-4, Table 6-5**, and **Table 6-6** present the estimated carbon monoxide, nitrogen oxide and PM_{10} emission rates for 2017 and 2027, along each section of the highway.

Table 6-4: Estimated vehicle emission rates – Toolijooa Road interchange to Berry north interchange (g/veh-mile)

Hour	Northbound						Southbound					
	CO		NO_2		CO		NO_2		CO		NO_2	
	2017	2027	2017	2027	2017	2027	2017	2027	2017	2027	2017	2027
1*	4.38	3.83	2.97	1.95	0.18	0.10	4.42	3.89	2.72	1.79	0.16	0.09
2	4.19	3.59	3.94	2.59	0.24	0.14	4.29	3.73	3.37	2.20	0.20	0.12
3	4.05	3.40	4.64	3.08	0.29	0.17	4.07	3.43	4.53	3.00	0.28	0.17
4	4.18	3.57	4.01	2.64	0.25	0.15	4.14	3.53	4.15	2.72	0.26	0.15
5	4.28	3.71	3.46	2.27	0.21	0.12	4.07	3.42	4.57	3.01	0.29	0.17
6	4.48	3.97	2.38	1.60	0.14	0.08	4.33	3.78	3.20	2.09	0.19	0.11
7	4.55	4.05	2.05	1.40	0.11	0.07	4.46	3.93	2.54	1.69	0.15	0.09
8	4.61	4.11	1.76	1.23	0.09	0.06	4.53	4.03	2.15	1.45	0.12	0.07
9	4.61	4.11	1.78	1.24	0.09	0.06	4.62	4.13	1.70	1.19	0.09	0.05
10	4.61	4.11	1.78	1.24	0.09	0.06	4.61	4.11	1.76	1.23	0.09	0.06
11	4.63	4.14	1.63	1.16	0.08	0.05	4.61	4.12	1.74	1.22	0.09	0.06
12	4.65	4.16	1.56	1.12	0.08	0.05	4.62	4.13	1.69	1.19	0.09	0.05
13	4.64	4.15	1.58	1.14	0.08	0.05	4.65	4.15	1.57	1.12	0.08	0.05
14	4.64	4.15	1.57	1.13	0.08	0.05	4.64	4.15	1.60	1.13	0.08	0.05
15	4.66	4.17	1.52	1.10	0.08	0.05	4.64	4.15	1.61	1.15	0.08	0.05
16	4.68	4.19	1.40	1.03	0.07	0.04	4.65	4.16	1.54	1.10	0.08	0.05
17	4.68	4.19	1.38	1.02	0.07	0.04	4.67	4.18	1.47	1.07	0.07	0.05
18	4.69	4.20	1.32	0.99	0.06	0.04	4.69	4.20	1.34	0.99	0.06	0.04
19	4.68	4.20	1.36	1.01	0.06	0.04	4.68	4.19	1.41	1.04	0.07	0.04
20	4.67	4.19	1.41	1.04	0.07	0.05	4.67	4.19	1.42	1.04	0.07	0.05
21	4.64	4.14	1.62	1.15	0.08	0.05	4.66	4.17	1.50	1.09	0.07	0.05
22	4.58	4.08	1.87	1.30	0.10	0.06	4.66	4.17	1.50	1.09	0.07	0.05
23	4.52	4.01	2.22	1.50	0.12	0.07	4.63	4.14	1.65	1.17	0.08	0.05
24	4.42	3.88	2.76	1.82	0.16	0.09	4.59	4.09	1.86	1.29	0.10	0.06

g/veh-mile – grams per vehicle mile
**1 represents the first hour of the day, between midnight and 1 am*

Table 6-5: Estimated vehicle emission rates – Berry north interchange to Berry south interchange (g/veh-mile)

Hour	Northbound						Southbound					
	CO		NO_2		CO		NO_2		CO		NO_2	
	2017	2027	2017	2027	2017	2027	2017	2027	2017	2027	2017	2027
1*	4.46	3.89	2.55	1.79	0.15	0.09	4.42	3.86	2.73	1.90	0.16	0.10
2	4.23	3.60	3.69	2.55	0.22	0.14	4.30	3.69	3.38	2.33	0.20	0.13
3	4.11	3.42	4.35	3.02	0.27	0.17	4.07	3.37	4.55	3.14	0.28	0.18
4	4.20	3.55	3.87	2.68	0.24	0.15	4.15	3.47	4.16	2.87	0.26	0.16
5	4.28	3.66	3.45	2.39	0.21	0.13	4.06	3.36	4.57	3.17	0.29	0.18
6	4.48	3.92	2.46	1.73	0.14	0.09	4.33	3.73	3.20	2.21	0.19	0.12
7	4.52	3.98	2.20	1.56	0.12	0.08	4.45	3.90	2.55	1.78	0.15	0.09
8	4.56	4.03	2.02	1.44	0.11	0.07	4.53	3.99	2.16	1.53	0.12	0.08
9	4.59	4.07	1.85	1.34	0.10	0.06	4.62	4.11	1.71	1.25	0.09	0.06
10	4.63	4.11	1.68	1.23	0.09	0.06	4.61	4.09	1.77	1.28	0.09	0.06
11	4.64	4.13	1.59	1.18	0.08	0.05	4.61	4.10	1.75	1.27	0.09	0.06
12	4.64	4.14	1.56	1.17	0.08	0.05	4.62	4.11	1.69	1.23	0.09	0.06
13	4.65	4.14	1.55	1.16	0.08	0.05	4.64	4.14	1.57	1.17	0.08	0.05
14	4.64	4.14	1.59	1.18	0.08	0.05	4.64	4.13	1.60	1.18	0.08	0.05
15	4.65	4.15	1.53	1.15	0.08	0.05	4.64	4.13	1.62	1.19	0.08	0.05
16	4.67	4.17	1.42	1.08	0.07	0.05	4.65	4.14	1.53	1.14	0.08	0.05
17	4.68	4.18	1.38	1.06	0.07	0.05	4.67	4.16	1.47	1.10	0.07	0.05
18	4.69	4.20	1.31	1.01	0.06	0.04	4.69	4.20	1.34	1.02	0.06	0.04
19	4.69	4.20	1.32	1.02	0.06	0.04	4.68	4.18	1.41	1.07	0.07	0.05
20	4.69	4.19	1.35	1.03	0.06	0.04	4.67	4.17	1.42	1.08	0.07	0.05
21	4.64	4.13	1.62	1.19	0.08	0.05	4.66	4.16	1.51	1.13	0.07	0.05
22	4.61	4.10	1.71	1.25	0.09	0.06	4.66	4.15	1.50	1.12	0.07	0.05
23	4.57	4.04	1.97	1.42	0.11	0.07	4.63	4.12	1.64	1.21	0.08	0.06
24	4.48	3.94	2.41	1.70	0.14	0.09	4.58	4.07	1.86	1.35	0.10	0.06

g/veh-mile – grams per vehicle mile
**1 represents the first hour of the day, between midnight and 1 am*

Table 6-6: Estimated vehicle emission rates – Berry south interchange to Schofields Lane (g/veh-mile)

Hour	Northbound						Southbound					
	CO		NO_2		PM_{10}		CO		NO_2		PM_{10}	
	2017	2027	2017	2027	2017	2027	2017	2027	2017	2027	2017	2027
1*	4.46	3.89	2.55	1.79	0.15	0.09	4.43	3.86	2.69	1.87	0.16	0.10
2	4.23	3.60	3.69	2.55	0.22	0.14	4.31	3.70	3.33	2.29	0.20	0.12
3	4.11	3.42	4.35	3.02	0.27	0.17	4.12	3.44	4.31	2.98	0.27	0.17
4	4.20	3.55	3.87	2.68	0.24	0.15	4.26	3.64	3.54	2.43	0.21	0.13
5	4.28	3.66	3.45	2.39	0.21	0.13	4.22	3.57	3.79	2.61	0.23	0.14
6	4.48	3.92	2.46	1.73	0.14	0.09	4.34	3.74	3.16	2.18	0.19	0.12
7	4.52	3.98	2.20	1.56	0.12	0.08	4.48	3.93	2.44	1.71	0.14	0.09
8	4.56	4.03	2.02	1.44	0.11	0.07	4.56	4.03	2.03	1.45	0.11	0.07
9	4.59	4.07	1.85	1.34	0.10	0.06	4.63	4.12	1.63	1.20	0.08	0.06
10	4.63	4.11	1.68	1.23	0.09	0.06	4.62	4.11	1.69	1.24	0.09	0.06
11	4.64	4.13	1.59	1.18	0.08	0.05	4.59	4.07	1.85	1.34	0.10	0.06
12	4.64	4.14	1.56	1.17	0.08	0.05	4.60	4.08	1.79	1.30	0.09	0.06
13	4.65	4.14	1.55	1.16	0.08	0.05	4.63	4.12	1.66	1.22	0.09	0.06
14	4.64	4.14	1.59	1.18	0.08	0.05	4.62	4.11	1.67	1.22	0.09	0.06
15	4.65	4.15	1.53	1.15	0.08	0.05	4.63	4.12	1.63	1.20	0.08	0.06
16	4.67	4.17	1.42	1.08	0.07	0.05	4.65	4.14	1.56	1.15	0.08	0.05
17	4.68	4.18	1.38	1.06	0.07	0.05	4.66	4.15	1.50	1.12	0.07	0.05
18	4.69	4.20	1.31	1.01	0.06	0.04	4.69	4.20	1.32	1.01	0.06	0.04
19	4.69	4.20	1.32	1.02	0.06	0.04	4.67	4.18	1.43	1.08	0.07	0.05
20	4.69	4.19	1.35	1.03	0.06	0.04	4.68	4.18	1.39	1.05	0.07	0.05
21	4.64	4.13	1.62	1.19	0.08	0.05	4.66	4.15	1.52	1.13	0.08	0.05
22	4.61	4.10	1.71	1.25	0.09	0.06	4.66	4.15	1.50	1.12	0.07	0.05
23	4.57	4.04	1.97	1.42	0.11	0.07	4.63	4.12	1.64	1.20	0.08	0.06
24	4.48	3.94	2.41	1.70	0.14	0.09	4.59	4.07	1.86	1.34	0.10	0.06

g/veh-mile – grams per vehicle mile
**1 represents the first hour of the day, between midnight and 1 am*

6.2.4 Receptor locations

Receptors were positioned at the nearest residential receptors along the proposed alignment. **Figure 6-1** shows the locations of residences, as well as the ancillary construction facilities, which would include stockpile compounds that would be used during construction as assessed in Section 8.2. The 69 receptors used for the operational modelling represent those closest to the proposed roadway alignment. An additional number of receptors were chosen for the modelling of wind erosion from stockpiles at the ancillary facilities (discussed in Section 8.2), and those are also shown in **Figure 6-1**.

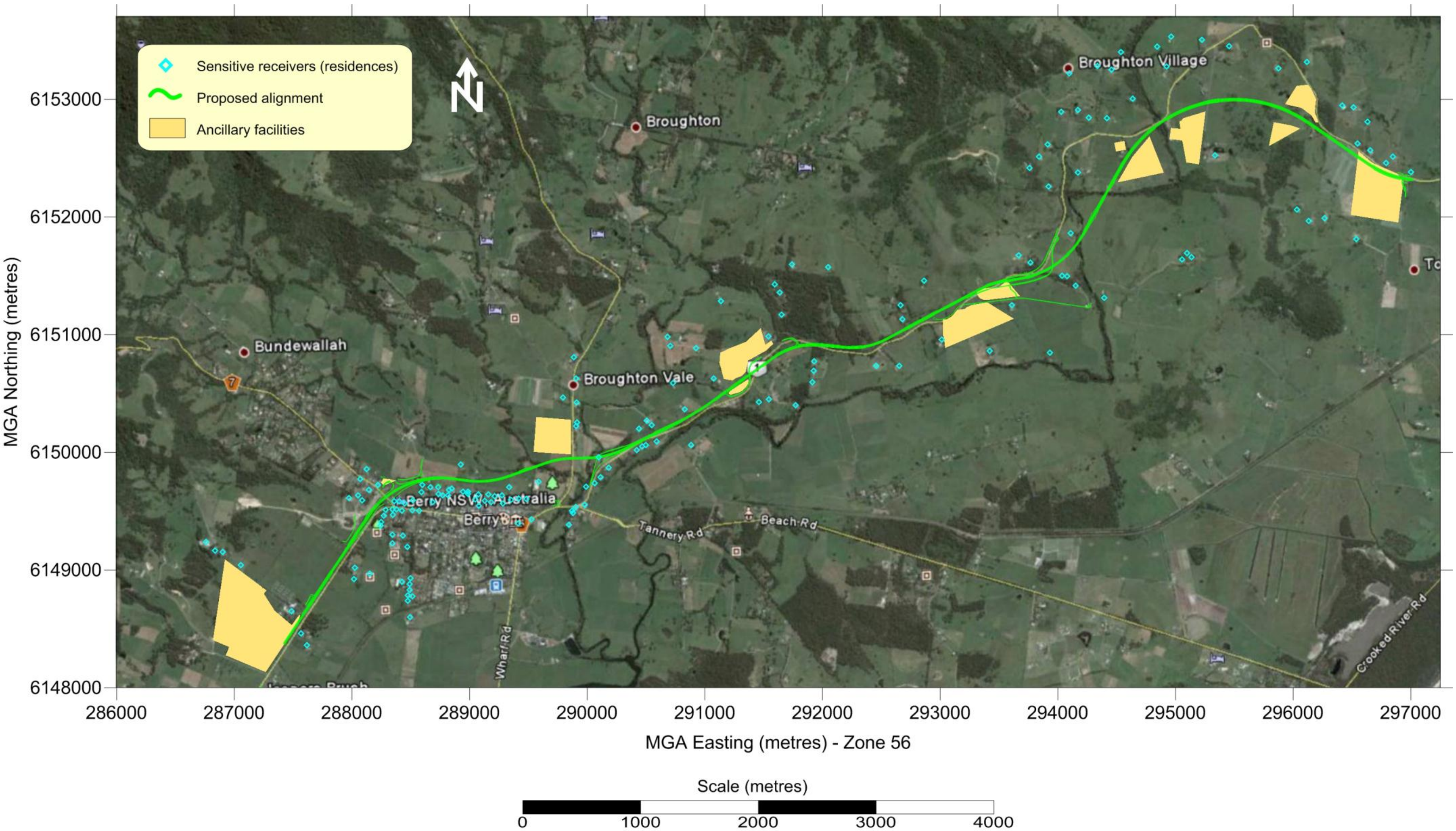


Figure 6-1: Location of sensitive receptors (residences) and potential ancillary facilities locations along the proposed alignment

7 Assessment of impacts

7.1 Introduction

This chapter assesses the predicted local air quality impacts due to emissions from the project. The maximum predicted concentrations for 2017 and 2027 at 69 of the closest receptors are shown in **Table 7-1** and **Table 7-2** respectively.

Table 7-1 Predicted maximum ground-level concentrations in 2017

	EPA criteria					
	CO		NO_2		PM_{10}	
Receptors	30 (mg/m^3)	10 (mg/m^3)	246 ($\mu g/m^3$)	62 ($\mu g/m^3$)	50 ($\mu g/m^3$)	30 ($\mu g/m^3$)
1	0.16	0.05	4.1	0.04	0.17	0.01
2	0.15	0.04	4.2	0.23	0.18	0.03
3	0.11	0.03	3.0	0.16	0.27	0.04
4	0.16	0.03	4.7	0.10	0.20	0.02
5	0.16	0.03	4.4	0.09	0.18	0.02
6	0.17	0.03	4.7	0.10	0.17	0.02
7	0.16	0.03	4.5	0.09	0.17	0.02
8	0.16	0.03	4.6	0.09	0.17	0.02
9	0.16	0.03	4.6	0.09	0.19	0.01
10	0.17	0.04	4.8	0.09	0.18	0.01
11	0.17	0.03	4.7	0.08	0.14	0.01
12	0.28	0.05	7.8	0.13	0.23	0.02
13	0.24	0.04	6.7	0.10	0.20	0.02
14	0.25	0.04	6.9	0.09	0.20	0.01
15	0.21	0.04	5.9	0.08	0.17	0.01
16	0.21	0.04	5.9	0.08	0.17	0.01
17	0.14	0.03	3.9	0.06	0.12	0.01
18	0.12	0.03	3.5	0.16	0.15	0.02
19	0.10	0.03	2.9	0.13	0.14	0.01
20	0.17	0.05	4.8	0.24	0.25	0.04
21	0.16	0.04	4.5	0.23	0.22	0.03
22	0.19	0.06	5.3	0.36	0.35	0.07
23	0.25	0.05	7.1	0.10	0.20	0.02
24	0.21	0.04	5.9	0.08	0.10	0.01
25	0.23	0.04	6.4	0.08	0.18	0.01
26	0.12	0.02	3.3	0.05	0.11	0.01
27	0.11	0.02	3.3	0.07	0.09	0.01
28	0.27	0.05	6.9	0.28	0.26	0.04
29	0.14	0.03	3.3	0.17	0.15	0.02
30	0.16	0.03	4.1	0.15	0.14	0.02
31	0.20	0.06	5.9	0.25	0.29	0.05
32	0.20	0.05	5.7	0.21	0.22	0.04

Receptors	EPA criteria					
	CO		NO_2		PM_{10}	
	30 (mg/m^3)	10 (mg/m^3)	246 (µg/m^3)	62 (µg/m^3)	50 (µg/m^3)	30 (µg/m^3)
33	0.21	0.05	5.9	0.21	0.25	0.04
34	0.23	0.06	6.3	0.23	0.28	0.04
35	0.27	0.05	7.6	0.19	0.24	0.04
36	0.28	0.05	7.7	0.18	0.26	0.04
37	0.29	0.05	8.0	0.19	0.31	0.04
38	0.20	0.04	5.3	0.16	0.21	0.03
39	0.32	0.06	8.9	0.24	0.38	0.05
40	0.21	0.04	5.8	0.18	0.23	0.03
41	0.21	0.04	6.2	0.20	0.31	0.04
42	0.23	0.04	6.7	0.21	0.31	0.04
43	0.18	0.04	5.4	0.16	0.22	0.02
44	0.21	0.04	6.2	0.20	0.26	0.03
45	0.19	0.05	5.6	0.20	0.28	0.04
46	0.17	0.05	5.1	0.21	0.30	0.04
47	0.13	0.05	3.8	0.20	0.26	0.03
48	0.13	0.05	3.6	0.17	0.24	0.03
49	0.13	0.05	3.6	0.18	0.23	0.03
50	0.13	0.05	3.6	0.18	0.25	0.03
51	0.11	0.04	3.3	0.15	0.20	0.02
52	0.12	0.04	3.5	0.15	0.19	0.02
53	0.13	0.04	3.7	0.15	0.19	0.02
54	0.13	0.04	3.7	0.15	0.20	0.02
55	0.12	0.04	3.6	0.14	0.17	0.02
56	0.12	0.04	3.6	0.13	0.17	0.02
57	0.12	0.03	3.5	0.11	0.13	0.01
58	0.15	0.04	4.1	0.18	0.20	0.02
59	0.22	0.07	5.7	0.38	0.33	0.08
60	0.13	0.05	3.5	0.18	0.18	0.03
61	0.39	0.10	10.8	0.44	0.55	0.14
62	0.37	0.10	10.7	0.40	0.48	0.11
63	0.33	0.09	9.4	0.00	0.40	0.00
64	0.24	0.07	6.3	0.30	0.36	0.06
65	0.12	0.04	3.5	0.11	0.13	0.02
66	0.10	0.02	2.7	0.10	0.12	0.01
67	0.20	0.04	5.6	0.14	0.13	0.02
68	0.12	0.03	3.1	0.09	0.16	0.02
69	0.19	0.04	5.7	0.13	0.18	0.03

Table 7-2: Predicted maximum ground-level concentrations in 2027

Receptors	EPA criteria					
	CO		NO_2		PM_{10}	
	30 (mg/m^3)	10 (mg/m^3)	246 (µg/m^3)	62 (µg/m^3)	50 (µg/m^3)	30 (µg/m^3)
1	0.21	0.06	4.6	0.05	0.18	0.01
2	0.20	0.05	4.7	0.24	0.18	0.03
3	0.15	0.05	3.4	0.17	0.27	0.04
4	0.21	0.05	5.1	0.11	0.18	0.02
5	0.21	0.05	4.9	0.10	0.18	0.02
6	0.22	0.05	5.2	0.11	0.17	0.02
7	0.21	0.05	5.1	0.10	0.17	0.02
8	0.22	0.05	5.1	0.10	0.17	0.02
9	0.22	0.05	5.1	0.10	0.21	0.01
10	0.22	0.05	5.4	0.10	0.18	0.01
11	0.22	0.04	5.3	0.09	0.15	0.01
12	0.37	0.07	8.7	0.14	0.24	0.02
13	0.32	0.06	7.6	0.11	0.20	0.02
14	0.33	0.06	7.7	0.10	0.20	0.01
15	0.28	0.05	6.6	0.09	0.18	0.01
16	0.28	0.05	6.7	0.09	0.17	0.01
17	0.19	0.04	4.4	0.07	0.12	0.01
18	0.16	0.04	3.9	0.18	0.15	0.02
19	0.14	0.04	3.2	0.14	0.14	0.01
20	0.22	0.06	5.4	0.26	0.24	0.04
21	0.21	0.06	5.1	0.24	0.21	0.03
22	0.25	0.08	5.9	0.39	0.36	0.07
23	0.33	0.06	7.9	0.11	0.20	0.02
24	0.28	0.05	6.6	0.09	0.18	0.01
25	0.30	0.05	7.2	0.09	0.18	0.01
26	0.16	0.03	3.7	0.05	0.10	0.01
27	0.17	0.03	4.0	0.08	0.10	0.01
28	0.38	0.07	8.5	0.33	0.27	0.05
29	0.18	0.04	4.0	0.20	0.17	0.02
30	0.23	0.04	5.1	0.18	0.14	0.02
31	0.28	0.09	7.1	0.30	0.30	0.06
32	0.29	0.08	6.8	0.26	0.24	0.05
33	0.30	0.08	7.2	0.26	0.25	0.04
34	0.32	0.08	7.7	0.27	0.28	0.05

Receptors	EPA criteria					
	CO		NO_2		PM_{10}	
	30 (mg/m^3)	**10 (mg/m^3)**	**246 ($\mu g/m^3$)**	**62 ($\mu g/m^3$)**	**50 ($\mu g/m^3$)**	**30 ($\mu g/m^3$)**
35	0.38	0.07	9.1	0.23	0.27	0.04
36	0.40	0.07	9.3	0.22	0.31	0.04
37	0.41	0.07	9.7	0.23	0.33	0.05
38	0.27	0.05	6.5	0.20	0.23	0.03
39	0.46	0.08	10.7	0.29	0.43	0.06
40	0.29	0.06	7.1	0.22	0.27	0.03
41	0.31	0.06	7.5	0.25	0.34	0.04
42	0.33	0.06	8.1	0.26	0.30	0.04
43	0.27	0.05	6.5	0.20	0.22	0.03
44	0.30	0.06	7.4	0.24	0.30	0.04
45	0.27	0.07	6.8	0.25	0.28	0.04
46	0.25	0.07	6.2	0.26	0.31	0.05
47	0.19	0.07	4.6	0.24	0.29	0.04
48	0.18	0.07	4.4	0.21	0.26	0.03
49	0.18	0.07	4.4	0.21	0.25	0.03
50	0.18	0.07	4.3	0.21	0.25	0.03
51	0.16	0.06	4.0	0.18	0.20	0.02
52	0.17	0.06	4.2	0.19	0.20	0.02
53	0.18	0.06	4.4	0.19	0.20	0.02
54	0.19	0.06	4.5	0.18	0.22	0.02
55	0.18	0.05	4.3	0.17	0.18	0.02
56	0.18	0.06	4.3	0.16	0.19	0.02
57	0.19	0.05	4.3	0.13	0.14	0.01
58	0.22	0.06	5.0	0.21	0.20	0.02
59	0.32	0.10	7.0	0.44	0.33	0.08
60	0.19	0.07	4.2	0.21	0.20	0.03
61	0.57	0.15	13.0	0.51	0.58	0.15
62	0.55	0.14	12.8	0.47	0.53	0.12
63	0.49	0.13	11.4	0.43	0.45	0.10
64	0.36	0.10	7.8	0.35	0.38	0.06
65	0.18	0.05	4.2	0.13	0.14	0.02
66	0.15	0.03	3.3	0.12	0.11	0.01
67	0.30	0.06	6.7	0.16	0.15	0.02
68	0.18	0.05	3.9	0.11	0.16	0.02
69	0.30	0.06	6.8	0.15	0.20	0.03

7.2 Carbon monoxide

7.2.1 Predicted impacts

Table 7-1 and **Table 7-2** show that the highest predicted one hour average carbon monoxide concentrations along the proposed highway are 0.39 milligrams per cubic metre and 0.57 milligrams per cubic metre in 2017 and 2027, respectively. Both these concentrations occurred at residences to the east of Berry. The maximum predicted eight hour average carbon monoxide concentration is approximately 0.10 milligrams per cubic metre and 0.15 milligrams per cubic metre in 2017 and 2027 respectively. These values are well below their respective EPA criteria of 30 milligrams per cubic metre (one hour) and 10 micrograms per cubic metre (eight hour).

These results are of the same order as those presented for the existing alignment in **Table 4-2** for distances 30 metres from the highway. This is not surprising given that even though traffic volumes have increased, the vehicles are spread further across four lane widths instead of two. Also, although no specific future improvements in emissions technology have been incorporated in the modelling, the vehicle mix is considered and in 2017 and 2027, the vehicle fleet would have a lower percentage of older, more inefficient vehicles.

7.2.2 Cumulative impacts

Based on the data presented in **Table 4-1**, the maximum one hour average carbon monoxide concentration is 10.6 milligrams per cubic metre. Therefore, the cumulative impact with the maximum predicted one hour average concentration of 0.39 milligrams per cubic metre at the most affected residence, is 11 milligrams per cubic metre. The cumulative eight hour average carbon monoxide concentration is estimated to be 5.4 milligrams per cubic metre [5.3 milligrams per cubic metre + 0.1 milligrams per cubic metre]. It is therefore unlikely that the EPA one hour average impact assessment criteria of 30 milligrams per cubic metre would be exceeded due to emissions from the proposed highway. Concentrations at residences further from the highway would be lower.

It should be noted, that the existing air quality data presented in **Table 4-1** includes emissions from the current sources in the area including the existing highway. Therefore, simply summing the maximum modelled concentration and maximum measured background concentration would result in a very conservative assessment of cumulative impacts. However, it has been shown that even this conservative approach does not result in an exceedance of the EPA criteria.

7.3 Oxides of nitrogen

7.3.1 Introduction

Estimating nitrogen dioxide concentrations is more complicated than estimating carbon monoxide concentrations. As discussed in Section 3.2, nitrogen oxides are initially emitted as a mixture of nitric oxide and other oxides of nitrogen, which are oxidised to nitrogen dioxide. At the point of emission the mixture is generally about five per cent nitrogen dioxide by mass. However, while the maximum concentrations of total oxides of nitrogen generally occur during peak hour, this is not necessarily the case for nitrogen dioxide. The monitoring program undertaken by RMS (RTA, 1997) indicates that during peak hour the percentage nitrogen dioxide at 10 metres from the highway edge is likely to be about five per cent. The conversion rate from nitric oxide to nitrogen dioxide at other times of the day may be significantly higher than this although the total oxides of nitrogen levels may be significantly lower than peak hour levels. It is therefore necessary to assume some intermediate value for a worst-case assessment.

Data from the air quality monitoring program (RTA, 1997) indicates that at 10 metres from the highway, a conversion rate of 15 per cent by weight is conservative (ie an overestimate). At distances of between 20 metres and 60 metres from the kerbside, the 20 per cent conversion rate appears to be appropriate. There are no monitoring data for the kerbside location in the present study, but it is considered that a 15 per cent conversion rate at 10 metres is likely to still be conservative. Given that the nearest residences are 20-30 metres or more from the highway, a rate of 20 per cent would be appropriate. However, for this study a 100 per cent conversion rate has been used to show that, even at this rate, levels would remain below the air quality criteria.

7.3.2 Predicted impacts

Table 7-1 and **Table 7-2** show that the highest predicted one hour and annual average concentrations of nitrogen dioxide, are 10.8 micrograms per cubic metre and 0.4 micrograms per cubic metre (2017) and 13.0 micrograms per cubic metre and 0.5 micrograms per cubic metre (2027), respectively. These are well within the EPA assessment criteria and are also lower than those predicted for the existing alignment, for reasons already discussed in Section 7.2.1.

7.3.3 Cumulative impacts

As summarised in **Table 4-1** the maximum measured nitrogen dioxide concentrations in the area were 166 micrograms per cubic metre (one hour average) and 31 micrograms per cubic metre (annual average). It should be remembered that these were maximum values over an 11 year monitoring period and most values were much lower, so adding model predictions to these is a very conservative method of assessment. However, even when using this conservative method, the nitrogen dioxide values remain below EPA criteria.

7.4 Particulate matter

7.4.1 Predicted impacts

Table 7-1 and **Table 7-2** show that the highest predicted 24 hour average PM_{10} concentrations contributed by emissions from the project alone are 0.55 micrograms per cubic metre and 0.58 micrograms per cubic metre in 2017 and 2027, respectively, at the nearest residential receptor. The maximum predicted annual average concentrations contributed by emissions from the project alone are approximately 0.14 micrograms per cubic metre and 0.15 micrograms per cubic metre in 2017 and 2027 respectively. These values are well below their respective EPA criteria of 50 micrograms per cubic metre and 30 micrograms per cubic metre respectively. These predicted PM_{10} concentrations are not significant increases to the emission levels from the existing highway and are not likely to result in adverse impacts on air quality at residences.

When comparing these PM_{10} results with those for the existing alignment, as shown in **Table 4-2**, it can be seen that PM_{10} values are predicted to be lower following completion of the project. Given the extremely variable nature of 24 hour PM_{10} measurements due to local sources, these increases are unlikely to be detectable.

7.4.2 Cumulative impacts

In the case of particulate matter, there would be exceedances of the 24 hour assessment criteria from time to time, as background levels on occasions are already close to or in exceedance of the goal (as can be seen from the data presented in **Table 4-1**). This is due to the fact that 24 hour levels can be greatly affected by local dust generating activities near the monitor, and may be quite high when levels not far away are much lower. These measurements can also be influenced by more regional phenomenon such as dust storms which is indeed the case for some of the excessive levels.

Also, the 24 hour average values presented in **Table 4-1** are the maximum values over the whole year, and may have occurred on a single day while the majority of readings were well below these.

If the logic that there should be no exceedances of impact assessment criteria is followed, no project could be approved on the basis of particulate emissions given that the goals are already exceeded on occasion. In the case of a relatively rural area such as for this project, these exceedances are often caused by local dust generating activities and are usually short lived. In these circumstances it is useful to consider the degree to which the project on its own compromises the impact assessment criteria.

The approach adopted in this report has been to consider first the case of adding the maximum predicted to the median background. If this approach shows exceedances, the degree to which the predicted concentrations of pollutants make up the relevant impact assessment criteria has been considered.

Based on the data presented in **Table 4-1**, the median 24 hour average PM_{10} concentration is 63 micrograms per cubic metre. This exceeds the EPA impact assessment criteria of 50 micrograms per cubic metre without the inclusion of the predicted concentrations due to the project. The maximum predicted 24 hour average concentration of 0.55 micrograms per cubic metre represents less than one per cent of the EPA assessment criteria. This percentage is approximately the same in 2027. It is therefore unlikely that the goal would be exceeded due to the small contribution from the proposed upgrade.

Based on the data presented in **Table 4-1**, the median annual PM_{10} concentration is 17 micrograms per cubic metre. Therefore, the cumulative impact with the maximum predicted annual average concentration of 0.15 micrograms per cubic metre is 17.2 micrograms per cubic metre at the nearest residences. This is well below the EPA annual average criteria of 30 micrograms per cubic metre.

8 Construction impacts

Dust would be generated from earthworks associated with the construction of the proposed highway and the total amount of dust would depend on the silt and moisture content in the soil and the types of activities being carried out.

There are a number of activities involved in the construction process but the main sources would be blasting, the use of excavators, front-end loaders and dump trucks, as well as wind erosion from exposed areas.

8.1 Earth moving operations

In order to estimate what emissions may be expected in an area where drilling and blasting would occur, emissions have been calculated on information provided by AECOM and are summarised in **Table 8-1**. It has been assumed that the construction would occur over a 39 month period. Blasting, however, has been assumed to occur only at the beginning of construction for the first 24 months.

There would be other sources of dust such as vehicle movement on unsealed roads (an estimate for which has been made in **Table 8-1**), but these are not as easily quantifiable due to the highly variable distances travelled. The use of a water cart would assist to substantially reduce these emissions.

Table 8-1: Estimated dust emissions due to earthworks

Source/activity	Intensity	Emission factor[5]	Total dust emissions
Site setup and excavation (Time period – 39 months)			
Blasting	300 blasts	14 kg/blast[6]	4200 kg
Excavators on material	441,100 t[7]	0.0022 kg/t	970 kg
Front-end loaders moving material	441,100 t	0.0022 kg/t	970 kg
Haulage	441,100 t	0.0139 kg/t[8]	6130 kg
Surface area exposed to wind erosion	8 ha	0.4 kg/ha/h	91,100 kg
Total (over a 39 month period)			103,370 kg
Average annual emission			31,800 kg/y

t = tonne
kg = kilogram
kg/t = kilogram per tonne
kg/blast = kilogram per blast
kg/y = kilogram per year
kg/ha/h = kilogram per hectare per hour

[5] *Using equations from US EPA, 1995 and updates.*

[6] *Assuming 1600 square metres blasts and 150 blasts per year (300 total blasts over construction period).*

[7] *Assuming a density of 2.3 tonnes per bank cubic metre (used to convert cubic metres into tonnes for use with emission factors). Bank cubic metre refers to the amount of material when it is in the ground.) for the 192,000 cubic metres of rock to be excavated through Toolijooa Ridge.*

[8] *This assumes a truck capacity of about 36 tonne, travelling approximately 500 metres on unsealed/watered roads.*

Dust emissions of this scale are unlikely to cause any adverse impacts at the nearest residential areas. As a comparison, there are major dust producing industries such as quarries which emit dust at rates significantly greater than this and still comply with both health and nuisance long-term criteria. There may be short-term nuisance impacts at locations adjacent to the construction site and these would generally occur on days where wind speeds are elevated.

8.2 Wind erosion from proposed ancillary facilities

A simple modelling study was undertaken to estimate the impacts of wind erosion emissions from proposed ancillary facilities on sensitive receptors. It was assumed that all sites would be stockpile compounds and that all stockpiles were 50 per cent exposed at all times over a 12 month period, and subject to wind erosion 24 hours per day. This is a conservative (ie worst case) estimate as it is more likely that construction would occur in phases and therefore not all stockpiles would be active simultaneously for the whole year.

Predictions were made using a modified version of the United States Environment Protection Agency (USEPA) Industrial Source Complex model, namely ISCMOD[9], at sensitive receptors (residences) along the proposed route. Both maximum 24 hour and annual average PM_{10} concentrations were predicted as well as annual average total suspended particulates (TSP) concentrations and dust deposition levels. As discussed in Section 3.3, the maximum 24 hour and annual average PM_{10} criteria are 50 micrograms per cubic metre and 30 micrograms per cubic metre, respectively, and the annual average criterion for TSP is 90 micrograms per cubic metre.

In addition to this, airborne dust also has the potential to cause nuisance effects by depositing on surfaces, and deposition criteria are set to protect against these nuisance impacts (NSW DEC, 2005). The maximum acceptable increase in dust deposition over the existing dust levels from an amenity perspective is two grams per square metre per month. So for the project alone, the incremental criterion is two grams per square metre per month and for total deposition (including background) is four grams per square metre per month.

Modelling results for both concentration and deposition are shown in contour plots from **Figures 8-1** to **Figure 8-4**, and show that none of these annual concentration criteria are predicted to be exceeded due to wind erosion from the stockpile compounds along the alignment route. The highest predicted annual average PM_{10} level at any of the sensitive receptors was estimated to be approximately six micrograms per cubic metre, while the maximum predicted annual average TSP concentration at these receptors was 12 micrograms per cubic metre. These predictions are both well below their respective goals of 30 micrograms per cubic metre and 90 micrograms per cubic metre and are likely to remain so even when adding in a conservative background level.

Dust deposition predictions at a single residence (indicated as a red cross) showed an annual average level of three grams per square metre per month as a result of the project. This is an exceedance of the incremental criterion. However, this is unlikely to occur in reality given the conservative assumptions made about the wind erosion occurring from all stockpile compounds simultaneously for the entire year. Also, and perhaps more importantly, it should be noted that no dust mitigation measures (discussed in Section 9) have been incorporated into the modelling. With these measures in place, particularly at times of elevated wind speeds, emissions are likely to be lower than those modelled and within the criterion. Predictions at all other sensitive receptors remained well below the incremental criterion of two grams per square metre per month. It is also unlikely that the cumulative criterion would be exceeded at this receiver.

[9] *ISCMOD has been accepted for use in NSW by the EPA*

Predictions of 24 hour PM_{10} concentrations at almost all of the sensitive receptors were below 10 micrograms per cubic metre. One residence (identified with a red cross on **Figure 8-1)** is predicted to experience a maximum 24 hour PM_{10} concentration of 38 micrograms per cubic metre, which is below 50 micrograms per cubic metre criteria. Further review of results at that particular residence showed that there were only two days in the year where predictions were above 20 micrograms per cubic metre, and that the 90th percentile 24 hour average PM_{10} level was very low at four micrograms per cubic metre.

This low 90th percentile indicates that these higher values are infrequent and likely to be the result of winds blowing directly from the stockpile towards that particular receptor for a number of hours within the 24 hour period. Again, it should also be noted that mitigation measures have not been incorporated into the modelling, and on a 24 hour basis these can reduce ground level concentrations significantly. The implementation of the standard and best practice mitigation measures, discussed further in Section 9 is more than likely to be able to manage both the long-term deposition and short-term PM_{10} impacts.

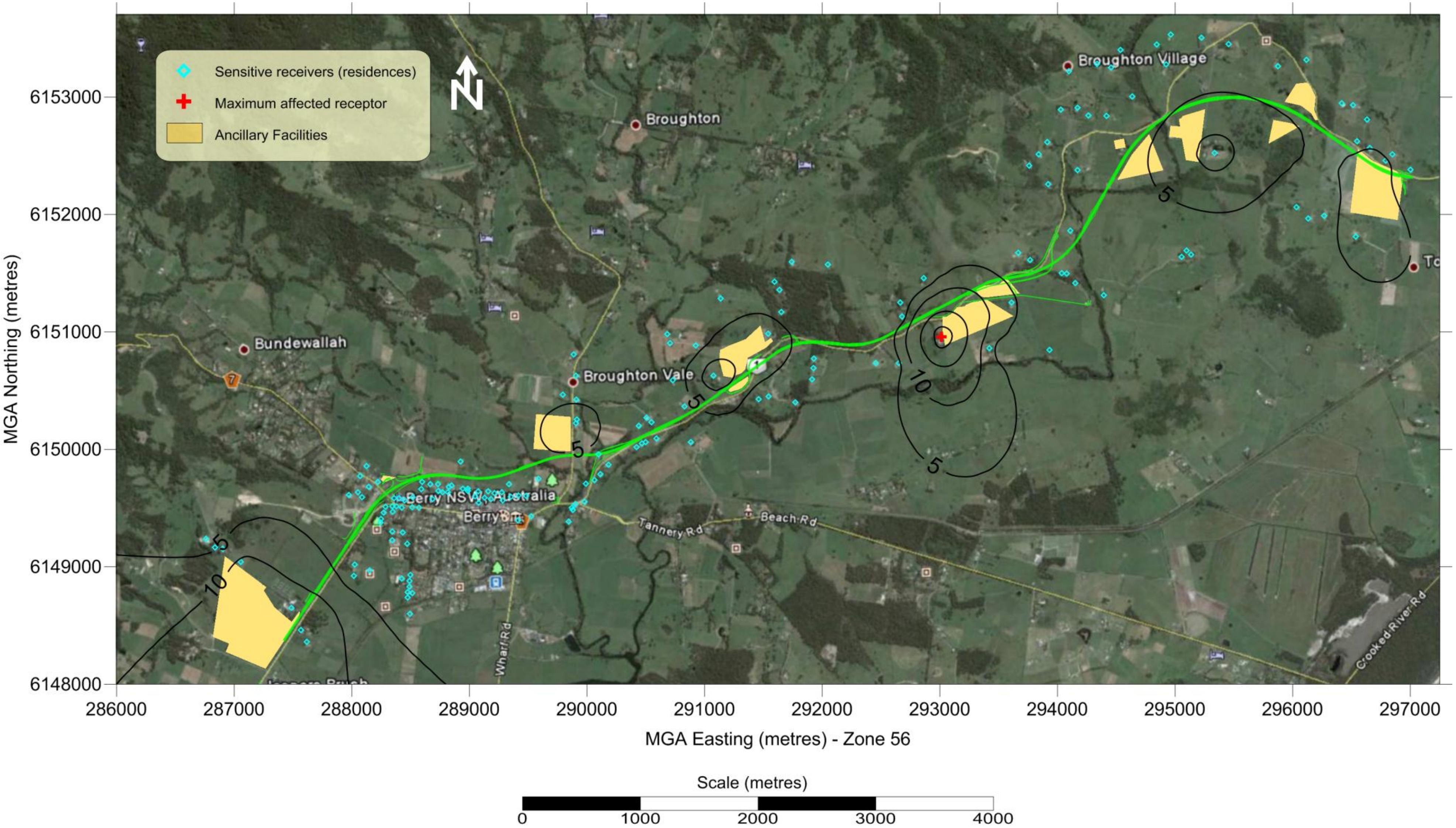


Figure 8-1: Predicted maximum 24 hour average PM10 concentrations (unmitigated) due to wind erosion from the potential ancillary facilities locations (µg/m3)

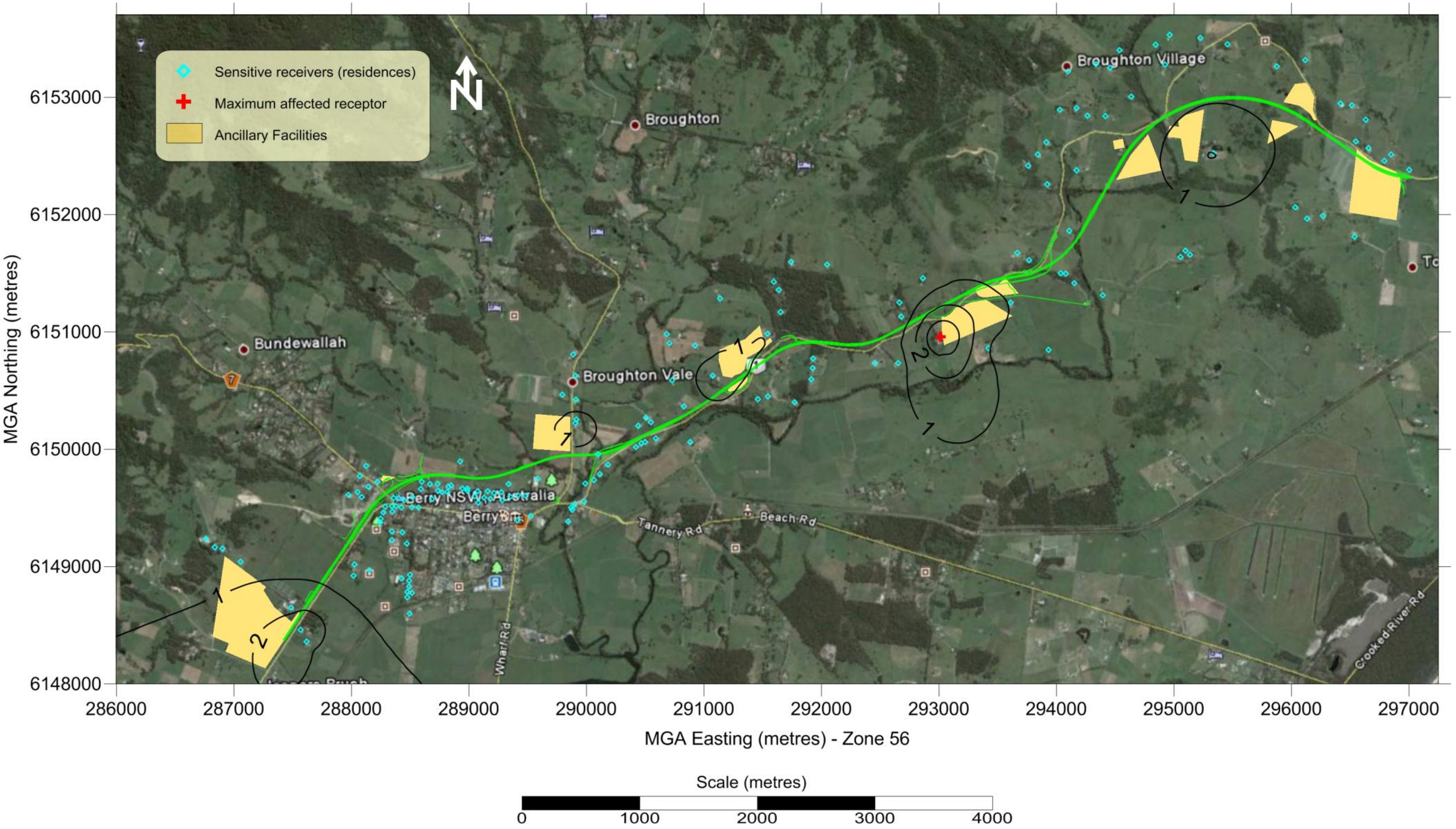


Figure 8-2: Predicted annual average PM10 concentrations (unmitigated) due to wind erosion from the potential ancillary facilities locations (µg/m3)

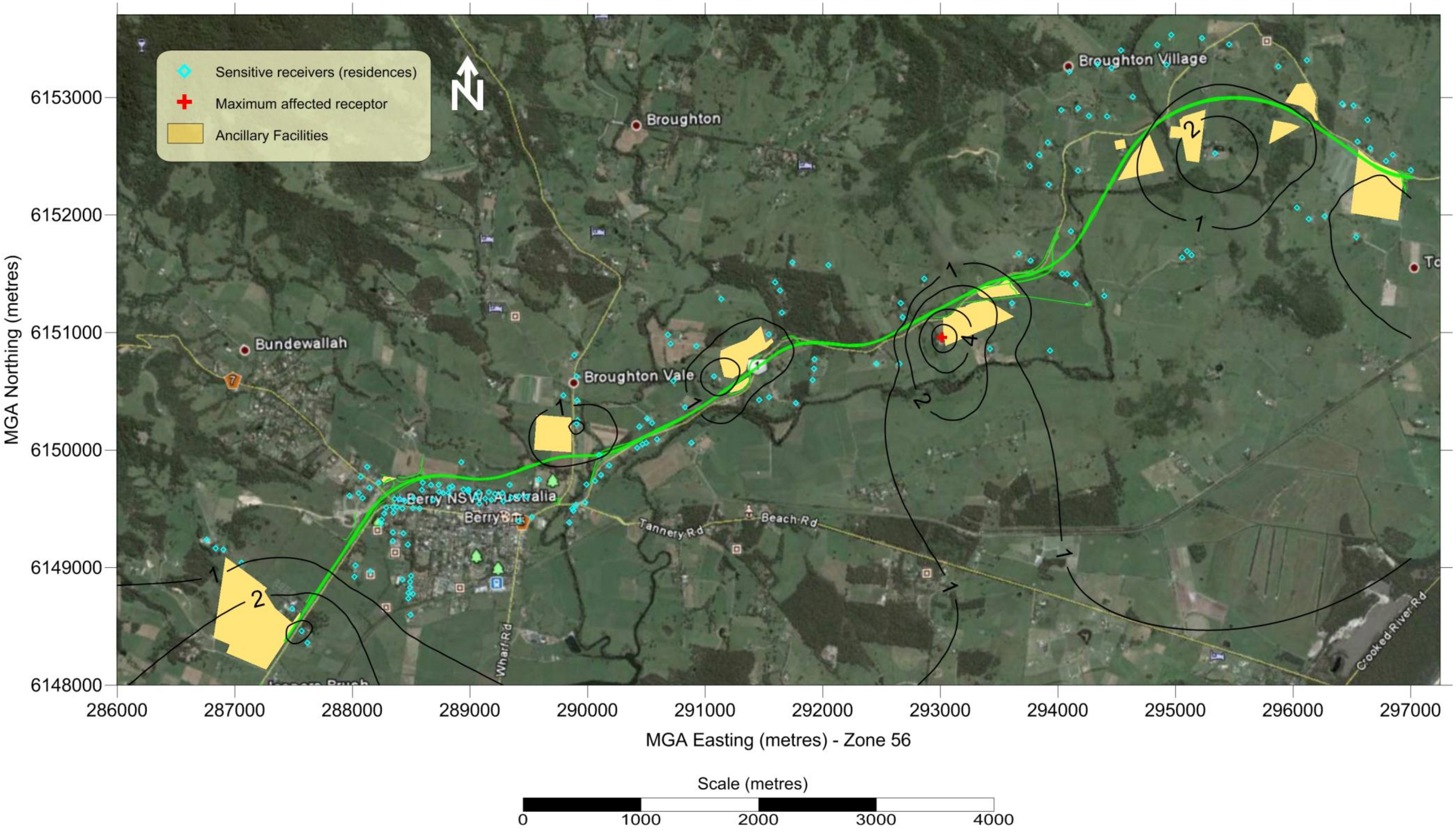


Figure 8-3: Predicted annual average TSP concentrations (unmitigated) due to wind erosion from the potential ancillary facilities locations (µg/m3)

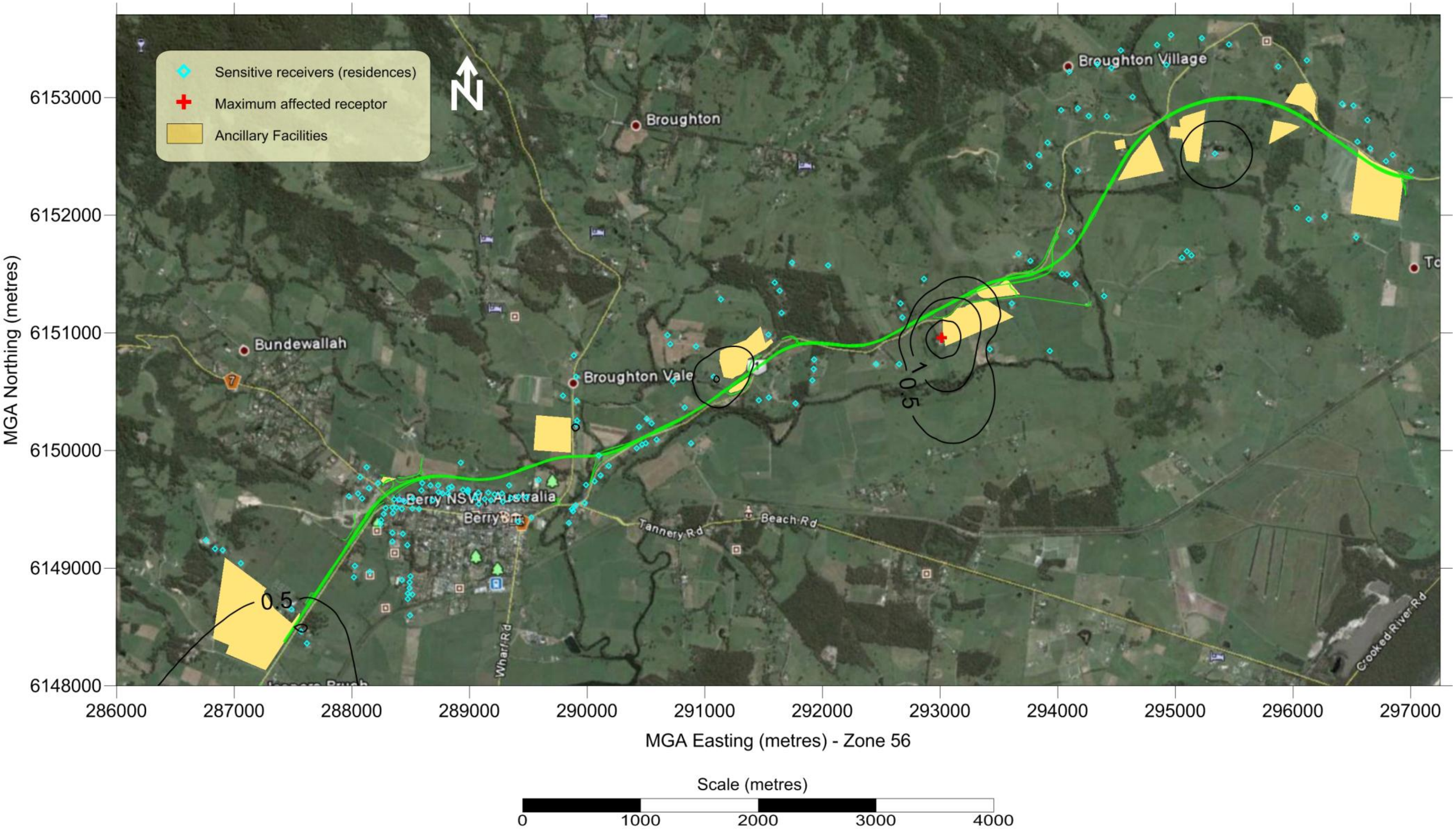


Figure 8-4: Predicted annual average dust deposition (unmitigated) due to wind erosion from the potential ancillary facilities locations (g/m2/month)

9 Dust mitigation and management

The EPA has reviewed the environmental hazards associated with construction/excavation sites and prepared a general document containing safeguards to protect the environment during such activities. Many of these safeguards relate to controlling water pollution and runoff. However, these procedures frequently assist in the control of air pollution. The recommendations of the EPA include mitigation measures such as:

- Watering of haul roads and sealing of roads, where possible.
- Maintenance of all trucks entering and leaving the site in accordance with the manufacturer's specification to comply with all relevant regulations. Fines may be imposed on vehicles that do not comply with smoke emission standards.
- Truck movement controlled on-site and restricted to designated roadways.
- Truck wheel washes or other dust removal procedures installed to minimise transport of dust off-site.
- If necessary, modification of construction activities during periods of high wind.
- Watering / revegetating of stockpiles and exposed areas.

It may be necessary to carry out dust monitoring at sensitive receptors during construction to determine compliance with dust deposition goals currently noted by the EPA and summarised in **Table 9-1** below. The interpretation of these goals is that the maximum total dust deposited should be no more than four grams per square metre per month over a twelve-month period. This total includes ambient levels already present in the area. The project alone should not contribute more than an additional two grams per square metre per month to this total, as indicated by the maximum increase listed in **Table 9-1**.

Table 9-1: EPA criteria for dust fallout

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

An air quality management plan (AQMP) for the proposed works is also recommended as part of an overall construction environmental management plan. The general principles of the AQMP are listed below.

- All disturbed areas would be stabilised as soon as practicable to prevent or minimise windblown dust.
- All unsealed trafficable areas would be kept sufficiently damp during working hours to minimise windblown or traffic generated dust emissions.
- Water sprays, sprinklers and water carts would be employed if needed to adequately dampen stockpiles, work areas and exposed soils to prevent the emission of dust from the site.
- Stockpiles and handling areas would be maintained in a condition that minimises windblown or traffic generated dust. Areas that may be inaccessible by water carts would be kept in a condition which minimises windblown or traffic generated dust using other means, such as alternative soil treatment or reduction of wind through use of windbreaks.

- All equipment for dust control would be kept in good operating condition. The equipment would be operable at all times with the exception of shutdowns required for maintenance. Construction equipment would be properly maintained to ensure exhaust emissions comply with the *Protection of the Environment Operations Act 1997*.
- Silt would be removed from behind filter fences and other erosion control structures on a regular basis, so that collected silt would not become a source of dust.
- Any dust, soil or mud deposited on public roads by subcontractors construction activities and vehicle movements would be removed immediately and disposed of appropriately.

10 Conclusions

The Caline series of dispersion models was used to predict concentrations of carbon monoxide, nitrogen dioxide and PM_{10} due to emissions from the project. The model was used to predict pollutant concentrations from vehicle emissions at the nearest residential receptors.

Predictions of ground-level concentrations from the existing alignment were also used to determine the potential changes due to the project. It was determined that the predictions for the project in 2017 and 2027 were generally lower than those for the existing alignment. The predicted concentrations of carbon monoxide, nitrogen dioxide, and PM_{10}, were found to be within the relevant EPA air quality standards.

Dust impacts associated with construction were also analysed using both qualitative and quantitative techniques. Emissions for drilling and blasting areas were calculated and determined to be minimal and not likely to result in adverse concentration or deposition impacts. Some preliminary modelling was undertaken for wind erosion emissions from stockpile compounds and assumed that all stockpile compounds are fully exposed simultaneously and all year. These were conservative assumptions and the modelling determined that there were unlikely to be any long-term PM_{10} or TSP adverse impacts at any of the sensitive receptors along the proposed alignment.

Dust deposition and short-term PM_{10} predictions indicated that although there may be impacts at one residence, these are unlikely and could be avoided or controlled by implementing standard and best practice management and mitigation measures as outlined in Section 9.

11 References

ABS (2005) “Motor Vehicle Census 2005”, Australian Bureau of Statistics.

Bureau of Meteorology (2011) Climatic Averages on the Australian Bureau of Meteorology Internet Site, URL: http://www.bom.gov.au/climate/averages/

Holmes Air Sciences (2007) “Air Quality Impact Assessment – Gerringong to Bomaderry Princes Highway Upgrade”.

NSW DEC (2004) Annual Compliance Report

NSW DEH (2004) “National Ambient Air Quality Status and Trends Report, 1991 – 2001”. Department of the Environment and Heritage, April 2004. ISBN 0 642 54990 7.

NSW DEC (2004) “National Environmental Protection Measure - New South Wales Annual Compliance Report” Department of Environment and Conservation, NSW.

NSW DEC (2005) “Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in New South Wales“, Department of Environment and Conservation, NSW.

NSW DECCW (2002-2007) “Quarterly Air Quality Monitoring Report” prepared by NSW DEC available from http://www.environment.nsw.gov.au/air/datareports.htm#quarterlies

NSW EPA (1998) "Action for Air", the NSW Government's 25-Year Air Quality Management Plan.

PIARC (2004) “Road Tunnels: Vehicle Emissions and Air Demand for Ventilation”, PIARC Technical Committee on Road Tunnels Operation (C5).

Powell D C (1976) "A Formulation of Time-varying Depths of Daytime Mixed Layer and Night time Stable Layer for use in Air Pollution Assessment Models", Annual Report for 1976 Part 3, Battelle PNL Atmospheric Sciences, 185-189.

RTA (1997) "RTA Air Quality Monitoring Program” prepared for the RTA by Holmes Air Sciences, January 1997.

Turner, D.B. (1970) "Workbook of Atmospheric Dispersion Estimates", United States Environmental Protection Agency, Office of Air Programs, Research Triangle Park, North Carolina, Revised 1970, Office of Air Programs Publication Number AP-26.

Venkatram (1980) "Estimating the Monin-Obukhov Length in the Stable Boundary Layer for Dispersion Calculations", Boundary-Layer Meteorology, Volume 19, 481-485.

Appendix A

Joint wind speed, wind direction and stability class frequency tables for the Gerroa Tip - 2000

STATISTICS FOR FILE: C:\Jobs\G2B\Met\Ger00_rev1.AUS
MONTHS: All
HOURS : All
OPTION: Frequency

PASQUILL STABILITY CLASS 'A'
Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000343	0.002862	0.001603	0.000114	0.000000	0.000000	0.000000	0.000000	0.004922
NE	0.001717	0.003320	0.002633	0.000572	0.000000	0.000000	0.000000	0.000000	0.008242
ENE	0.000916	0.001717	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.002862
E	0.001030	0.001030	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.002518
ESE	0.001145	0.000916	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.002175
SE	0.001030	0.003892	0.000916	0.000000	0.000000	0.000000	0.000000	0.000000	0.005838
SSE	0.002976	0.007784	0.002976	0.000458	0.000000	0.000000	0.000000	0.000000	0.014194
S	0.002633	0.006296	0.004235	0.001717	0.000000	0.000000	0.000000	0.000000	0.014881
SSW	0.002060	0.009272	0.006410	0.001832	0.000000	0.000000	0.000000	0.000000	0.019574
SW	0.003434	0.008585	0.004579	0.001259	0.000000	0.000000	0.000000	0.000000	0.017857
WSW	0.002976	0.011103	0.005266	0.000916	0.000000	0.000000	0.000000	0.000000	0.020261
W	0.004922	0.011905	0.010417	0.006410	0.000000	0.000000	0.000000	0.000000	0.033654
WNW	0.002060	0.006868	0.006983	0.004808	0.000000	0.000000	0.000000	0.000000	0.020719
NW	0.001946	0.002633	0.000687	0.000000	0.000000	0.000000	0.000000	0.000000	0.005266
NNW	0.000801	0.001145	0.000572	0.000229	0.000000	0.000000	0.000000	0.000000	0.002747
N	0.001145	0.001259	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.002518
CALM									0.003434
TOTAL	0.031136	0.080586	0.048191	0.018315	0.000000	0.000000	0.000000	0.000000	0.181662

MEAN WIND SPEED (m/s) = 2.74
NUMBER OF OBSERVATIONS = 1587

PASQUILL STABILITY CLASS 'B'
Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000687	0.001832	0.001946	0.000458	0.000000	0.000000	0.000000	0.000000	0.004922
NE	0.000687	0.005723	0.016598	0.014423	0.000000	0.000000	0.000000	0.000000	0.037431
ENE	0.000572	0.003205	0.007326	0.006181	0.000000	0.000000	0.000000	0.000000	0.017285
E	0.000229	0.001145	0.001488	0.000458	0.000000	0.000000	0.000000	0.000000	0.003320
ESE	0.000572	0.001374	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.002404
SE	0.001717	0.006181	0.001145	0.000000	0.000000	0.000000	0.000000	0.000000	0.009043
SSE	0.002633	0.003663	0.000687	0.000229	0.000000	0.000000	0.000000	0.000000	0.007212
S	0.001030	0.006067	0.002175	0.000458	0.000000	0.000000	0.000000	0.000000	0.009730
SSW	0.001717	0.001946	0.000916	0.000000	0.000000	0.000000	0.000000	0.000000	0.004579
SW	0.000801	0.001374	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.002289
WSW	0.002862	0.005037	0.000343	0.000114	0.000000	0.000000	0.000000	0.000000	0.008356
W	0.004006	0.013851	0.002060	0.000343	0.000000	0.000000	0.000000	0.000000	0.020261
WNW	0.001488	0.003205	0.003892	0.000916	0.000000	0.000000	0.000000	0.000000	0.009501
NW	0.000458	0.000687	0.000343	0.000114	0.000000	0.000000	0.000000	0.000000	0.001603
NNW	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000343
N	0.000458	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000916
CALM									0.001374
TOTAL	0.020261	0.055746	0.039492	0.023695	0.000000	0.000000	0.000000	0.000000	0.140568

MEAN WIND SPEED (m/s) = 3.02
NUMBER OF OBSERVATIONS = 1228

PASQUILL STABILITY CLASS 'C'
Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000114	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000343
NE	0.000114	0.003320	0.004579	0.003434	0.000000	0.000000	0.000000	0.000000	0.011447
ENE	0.000343	0.003205	0.004006	0.004579	0.000000	0.000000	0.000000	0.000000	0.012134
E	0.000458	0.003892	0.004121	0.001488	0.000000	0.000000	0.000000	0.000000	0.009959
ESE	0.000801	0.008242	0.004121	0.000229	0.000000	0.000000	0.000000	0.000000	0.013393
SE	0.001488	0.003320	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.004922
SSE	0.001259	0.000801	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.002633
S	0.000229	0.000687	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000916
SSW	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000229
SW	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000229
WSW	0.000916	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001145
W	0.003549	0.006754	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.010531
WNW	0.003434	0.002747	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.006296
NW	0.000916	0.000229	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.001259
NNW	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000343
N	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
CALM									0.001946
TOTAL	0.014423	0.033768	0.017972	0.009730	0.000000	0.000000	0.000000	0.000000	0.077839

MEAN WIND SPEED (m/s) = 2.71
NUMBER OF OBSERVATIONS = 680

PASQUILL STABILITY CLASS 'D'
Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000916	0.000572	0.005037	0.000916	0.000114	0.000000	0.000000	0.000000	0.007555
NE	0.001832	0.003091	0.016827	0.006410	0.007212	0.000229	0.000000	0.000000	0.035600
ENE	0.001603	0.001145	0.001946	0.001145	0.000458	0.000000	0.000000	0.000000	0.006296
E	0.000458	0.000801	0.000916	0.000000	0.000572	0.000000	0.000000	0.000000	0.002747
ESE	0.000343	0.000572	0.001374	0.000000	0.000114	0.000000	0.000000	0.000000	0.002404
SE	0.000229	0.000114	0.000687	0.000000	0.000000	0.000000	0.000000	0.000000	0.001030
SSE	0.000114	0.000000	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.000343
S	0.000000	0.000000	0.002747	0.001259	0.000114	0.000000	0.000000	0.000000	0.004121
SSW	0.000000	0.000000	0.002747	0.001374	0.000114	0.000000	0.000000	0.000000	0.004235
SW	0.000114	0.000000	0.001832	0.001030	0.000000	0.000000	0.000000	0.000000	0.002976
WSW	0.000458	0.000114	0.003549	0.001145	0.000000	0.000000	0.000000	0.000000	0.005266
W	0.009615	0.013851	0.014766	0.009158	0.004464	0.000343	0.000114	0.000000	0.052312
WNW	0.027816	0.020604	0.005838	0.003434	0.002289	0.000114	0.000114	0.000000	0.060211
NW	0.008814	0.001374	0.000801	0.000114	0.000114	0.000000	0.000000	0.000000	0.011218
NNW	0.004808	0.000114	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.005151
N	0.002747	0.000114	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.003205
CALM									0.006525
TOTAL	0.059867	0.042468	0.059867	0.025984	0.015568	0.000687	0.000229	0.000000	0.211195

MEAN WIND SPEED (m/s) = 2.96
NUMBER OF OBSERVATIONS = 1845

PASQUILL STABILITY CLASS 'E'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.004006	0.004006	0.001488	0.000000	0.000000	0.000000	0.000000	0.000000	0.009501
NE	0.004464	0.011790	0.000801	0.000000	0.000000	0.000000	0.000000	0.000000	0.017056
ENE	0.001603	0.003777	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.005495
E	0.001145	0.001030	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002175
ESE	0.000343	0.001145	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001488
SE	0.000000	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000343
SSE	0.000343	0.000458	0.000801	0.000000	0.000000	0.000000	0.000000	0.000000	0.001603
S	0.000114	0.000343	0.001145	0.000000	0.000000	0.000000	0.000000	0.000000	0.001603
SSW	0.000229	0.000916	0.002289	0.000000	0.000000	0.000000	0.000000	0.000000	0.003434
SW	0.000229	0.001374	0.001374	0.000000	0.000000	0.000000	0.000000	0.000000	0.002976
WSW	0.003320	0.005151	0.002633	0.000000	0.000000	0.000000	0.000000	0.000000	0.011103
W	0.015797	0.048077	0.003320	0.000000	0.000000	0.000000	0.000000	0.000000	0.067193
WNW	0.021864	0.018086	0.000916	0.000000	0.000000	0.000000	0.000000	0.000000	0.040865
NW	0.012134	0.001832	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.014080
NNW	0.004350	0.000916	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.005380
N	0.004235	0.000687	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.005151
CALM									0.007898
TOTAL	0.074176	0.099931	0.015339	0.000000	0.000000	0.000000	0.000000	0.000000	0.197344

MEAN WIND SPEED (m/s) = 1.79

NUMBER OF OBSERVATIONS = 1724

PASQUILL STABILITY CLASS 'F'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.005266	0.008814	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.014080
NE	0.006525	0.009730	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.016255
ENE	0.002633	0.001717	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004350
E	0.001603	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002175
ESE	0.002289	0.002289	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004579
SE	0.001717	0.001946	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003663
SSE	0.001603	0.002633	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004235
S	0.001145	0.001374	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002518
SSW	0.002747	0.004693	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007440
SW	0.004235	0.007440	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.011676
WSW	0.006410	0.014995	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.021406
W	0.010646	0.019918	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.030563
WNW	0.012935	0.008585	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.021520
NW	0.011447	0.002747	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.014194
NNW	0.005952	0.001374	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007326
N	0.008013	0.003892	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.011905
CALM									0.013507
TOTAL	0.085165	0.092720	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.191392

MEAN WIND SPEED (m/s) = 1.54

NUMBER OF OBSERVATIONS = 1672

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)

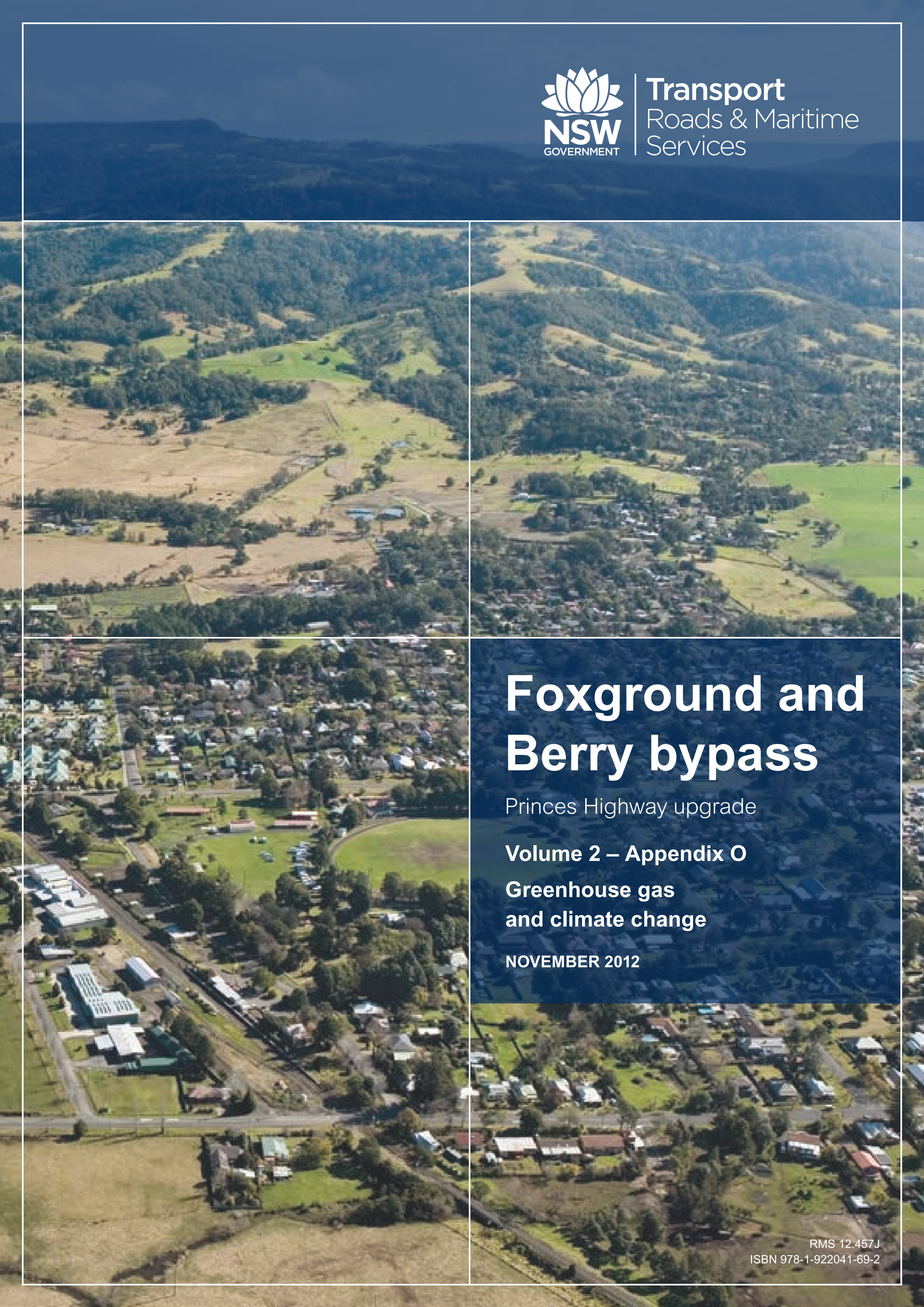
WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.011332	0.018315	0.010073	0.001488	0.000114	0.000000	0.000000	0.000000	0.041323
NE	0.015339	0.036973	0.041438	0.024840	0.007212	0.000229	0.000000	0.000000	0.126030
ENE	0.007669	0.014766	0.013622	0.011905	0.000458	0.000000	0.000000	0.000000	0.048420
E	0.004922	0.008471	0.006983	0.001946	0.000572	0.000000	0.000000	0.000000	0.022894
ESE	0.005495	0.014538	0.006067	0.000229	0.000114	0.000000	0.000000	0.000000	0.026442
SE	0.006181	0.015797	0.002862	0.000000	0.000000	0.000000	0.000000	0.000000	0.024840
SSE	0.008929	0.015339	0.005266	0.000687	0.000000	0.000000	0.000000	0.000000	0.030220
S	0.005151	0.014766	0.010302	0.003434	0.000114	0.000000	0.000000	0.000000	0.033768
SSW	0.006983	0.016827	0.012363	0.003205	0.000114	0.000000	0.000000	0.000000	0.039492
SW	0.009043	0.018773	0.007898	0.002289	0.000000	0.000000	0.000000	0.000000	0.038004
WSW	0.016941	0.036630	0.011790	0.002175	0.000000	0.000000	0.000000	0.000000	0.067537
W	0.048535	0.114354	0.030792	0.015911	0.004464	0.000343	0.000114	0.000000	0.214515
WNW	0.069597	0.060096	0.017743	0.009158	0.002289	0.000114	0.000114	0.000000	0.159112
NW	0.035714	0.009501	0.002060	0.000229	0.000114	0.000000	0.000000	0.000000	0.047619
NNW	0.016598	0.003549	0.000916	0.000229	0.000000	0.000000	0.000000	0.000000	0.021291
N	0.016598	0.006525	0.000687	0.000000	0.000000	0.000000	0.000000	0.000000	0.023810
CALM									0.034684
TOTAL	0.285027	0.405220	0.180861	0.077724	0.015568	0.000687	0.000229	0.000000	1.000000

MEAN WIND SPEED (m/s) = 2.40

NUMBER OF OBSERVATIONS = 8736

FREQUENCY OF OCCURENCE OF STABILITY CLASSES

- A : 18.2%
- B : 14.1%
- C : 7.8%
- D : 21.1%
- E : 19.7%
- F : 19.1%



NSW GOVERNMENT | Transport Roads & Maritime Services

Foxground and Berry bypass

Princes Highway upgrade

Volume 2 – Appendix O

Greenhouse gas and climate change

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Appendix O: Detailed GHG assessment results, GHG emissions activity data and calculation methodology

Detailed GHG assessment results

Table O-1 gives the Greenhouse gas (GHG) assessment results for the GHG emissions estimated to occur during construction of the project, reported according to Scope 1, Scope 2, Scope 3 and total emissions.

Table O-1: Detailed construction GHG emissions assessment results

Emission source category	Emission source	Quantity	Unit	GHG emissions (t CO_2-e)				
				Scope 1	Scope 2	Scope 3	Total	% Total
Fuel - diesel	Mobile equipment	17,315.1	kilolitres (kL)	46,658.4	0.0	3,542.3	**50,200.7**	**50.41**
	Transport - site vehicles	489.6	kilolitres (kL)	1,319.3	0.0	100.2	**1,419.5**	**1.43**
	Transport - material delivery	463.1	kilolitres (kL)	0.0	0.0	1,342.8	**1,342.8**	**1.35**
	Transport - equipment delivery	1.5	kilolitres (kL)	0.0	0.0	4.2	**4.2**	**0.00**
	Transport - earthworks	364.0	kilolitres (kL)	980.9	0.0	74.5	**1,055.4**	**1.06**
	Transport - spoil removal	191.1	kilolitres (kL)	0.0	0.0	554.0	**554.0**	**0.56**
	Transport - vegetation removal	4.9	kilolitres (kL)	0.0	0.0	14.1	**14.1**	**0.01**
Materials	Pavement - aggregate	214,414.0	tonnes (t)	0.0	0.0	857.7	**857.7**	**0.86**
	Concrete	107,886.6	tonnes (t)	0.0	0.0	13,701.6	**13,701.6**	**13.76**
	Pavement - cement	6,304.2	tonnes (t)	0.0	0.0	5,169.4	**5,169.4**	**5.19**
	Sand	45,740.0	tonnes (t)	0.0	0.0	137.2	**137.2**	**0.14**
	Structural Steel	14,726.3	tonnes (t)	0.0	0.0	15,462.6	**15,462.6**	**15.53**
	Pavement - hot mix asphalt	113,032.8	tonnes (t)	0.0	0.0	6,555.9	**6,555.9**	**6.58**
	Pavement - bitumen	525.2	tonnes (t)	0.0	0.0	330.8	**330.8**	**0.33**
	Pavement - lime	2,547.7	tonnes (t)	0.0	0.0	2,777.0	**2,777.0**	**2.79**
	Gravel	600.0	tonnes (t)	0.0	0.0	2.6	**2.6**	**0.00**
Totals				**48,958.6**	**0.0**	**50,626.9**	**99,585.5**	**100**
% Total				**49.2**	**0.0**	**50.8**	**100.0**	

Table O-2 gives the GHG emissions associated with the use of electricity in site offices and the clearing of vegetation. These emissions sources were removed from the GHG assessment boundary, based on materiality criteria. Table 3.3 in the Supporting Document for the *Greenhouse Gas Assessment Workbook for Road projects* (the Workbook) (Transport Authorities Greenhouse Group (TAGG), 2011) lists vegetation removal as an emission source that may be insignificant and removed from the GHG assessment boundary on a project specific basis. Additionally, Table 3.3 of the Supporting document recommends excluding the use of electricity in site offices from the GHG assessment boundary, as it would generally be insignificant to the assessment. The GHG emissions associated with these activities are listed below for information purposes, however they do not form part of the GHG assessment boundary of GHG emissions associated with construction of the project, as when calculated, these emission source categories represented less than five per cent of the GHG inventory.

Table O-2: Construction GHG emissions assessment results – immaterial emissions

Emission source category	Emission source	Quantity	Unit	GHG emissions (t CO_2-e)			
				Scope 1	Scope 2	Scope 3	Total
Electricity	Site offices	87,600	kWh	0.0	78.0	14.9	**92.9**
Land use Change	Vegetation removal - undisturbed	26.0	hectares (ha)	12.7	0.0	0.0	**12.7**
Land use Change	Vegetation removal - disturbed	86.4	hectares (ha)	7.8	0.0	0.0	**7.8**

Greenhouse gas emissions activity data

This section details the quantification of the GHG emission source data used for estimating the GHG emissions associated with construction, operation and maintenance of the project, including the sources of information used and assumptions made.

Table O-3 to **Table O-7** details the GHG emission source data used in the GHG assessment, including assumptions and information sources.

Table O-3: GHG emission source data used in the GHG assessment

Emission source category	Emission source	Quantity	Unit	Source	Assumptions
Fuel – diesel (construction)	Mobile equipment	17,315.1	kL	Equipment types and hours of operation: Cost Estimate (Risk Summary Rev D dated January 2012) Equipment Rate of Fuel Consumption: Workbook and California EPA OFFROAD inventory database	Refer to **Table O-3** below: Emission Source Data: Diesel Fuel Use
	Transport - site vehicles	489.6	kL	Workbook Table 5.3 Default Quantity Factors - Site offices and vehicles	Large project with 4 sites along road, each with 10 hilux utes, all diesel operated, over 36 construction months
	Transport - material delivery	463.1	kL	Vehicle capacity, haulage quantity, number of trips: FBB Traffic and Transport Assessment November 2011	Refer to **Table O-4** below: Emission Source Data: Transport Fuel Use
	Transport - equipment delivery	1.5	kL	Equipment Types: Cost Estimate (Risk Summary Rev D dated January 2012)	Refer to **Table O-4** below: Emission Source Data: Transport Fuel Use
	Transport - earthworks	364.0	kL	Vehicle capacity : FBB Traffic and Transport Assessment November 2011 Haulage Quantity: Cost Estimate (Risk Summary Rev D dated January 2012) and AECOM Quantity estimate update_120706_pavement and earthworks	Refer to **Table O-4** below: Emission Source Data: Transport Fuel Use
	Transport - spoil removal	191.1	kL	Excess earthworks material: Cost Estimate (Risk Summary Rev D dated January 2012) and AECOM Quantity estimate update_120706_pavement and earthworks	Refer to **Table O-4** below: Emission Source Data: Transport Fuel Use
	Transport - vegetation removal	4.9	kL	Vegetation removal quantity: email from Brett Morrisey, Biosis Research, dated 12 January 2012	Refer to **Table O-4** below: Emission Source Data: Transport Fuel Use
Electricity consumption	Site offices	87,600.0	kWh	-	Five houses used as site offices, with an average electricity consumption of 7300kWh (NSW Government Power Use in NSW accessed 19/01/2012 http://www.savepower.nsw.gov.au/get-the-facts/power-use-in-nsw.aspx), over a period of 2.4 years per house.

Emission source category	Emission source	Quantity	Unit	Source	Assumptions
Vegetation Removal	Vegetation removal - undisturbed	26.0	ha	Vegetation removal quantity: email from Brett Morrisey, Biosis Research, dated 12 January 2012	-
Vegetation Removal	Vegetation removal - disturbed	86.4	ha	Vegetation removal quantity: email from Brett Morrisey, Biosis Research, dated 12 January 2012	-
Materials usage - construction	Pavement - aggregate	214,414.0	t	Cost Estimate (Risk Summary Rev D dated January 2012) and AECOM Quantity estimate update_120706_pavement and earthworks Bridge steel and concrete quantities sourced from AECOM	Refer to **Table O-5** below: Emission Source Data: Materials
	Concrete	107,886.6	t		
	Pavement - cement	6,304.2	t		
	Sand	45,740.0	t		
	Structural steel	14,726.3	t		
	Pavement - hot mix asphalt	113,032.8	t		
	Pavement - bitumen	525.2	t		
	Pavement - lime	2,547.7	t		
	Gravel	600.0	t		
Electricity consumption	Street lighting	59,130.0	kWh	Wattage of lamps: Workbook, Table 6.3, for freeway ramps and arterial roads Number of lights: AECOM design	250 Watt lamps 54 lights 12 hours of operation per day, 365 days per year
	Variable message sign	10,512.0	kWh	Wattage of variable message sign: Workbook, Table 6.3 Number of variable message signs: Cost Estimate (Risk Summary Rev D dated January 2012)	1200 Watt 1 variable message sign 24 hours of operation per day, 365 days per year
Fuel combustion – diesel – operation and maintenance	Mobile equipment	2,576.2	kL	Workbook default quantity factor for maintenance activities Table 7.3	One major rehabilitation with top 150mm replaced - once every 50 years and 5% of road replaced every 50 years for patching/repair (TAGG, 2011)
	Transport - material delivery	516.5	kL	-	10 tonne Articulated truck, with fuel efficiency of 54.6 L/100km, average return trip distance of 70km.

Emission source category	Emission source	Quantity	Unit	Source	Assumptions
Materials usage - maintenance	Pavement - aggregate	38,368.9	t	Based on construction material quantities	One major rehabilitation with top 150mm replaced - once every 50 years and 5% of road replaced every 50 years for patching/repair (TAGG 2011)
	Pavement - cement	315.2	t		
	Pavement - hot mix asphalt	95,773.0	t		
	Pavement - bitumen	551.4	t		
	Pavement - lime	127.4	t		

Table O-4: Emission source data: diesel fuel use

Emission Activity	Quantity	Unit	Equipment	Equipment Category	Duration of operation	Unit	Months of operation	Rate of fuel use (kL/UOM)	UOM	Quantity of Diesel Used (kL)	Assumptions
SMZ layer	70,000.0	m^3	140 grader	Grader	1,795.1	hr	6.0	5.1	Months	30.5	Class 110, Medium application, 300 hours/month (TAGG 2011)
Cut to fill	1,000,000.0	m^3	14G grader		16,666.4	hr	55.6	5.1	Months	283.3	
SMZ layer	70,000.0	m^3	14G grader		2,333.2	hr	7.8	5.1	Months	39.7	
Surcharge loading	30,000.0	m^3	14G grader		429	hr	1.4	5.1	Months	7.3	
Rip floor, trim and compact	116,125.0	m^2	Grader		774	hr	2.6	5.1	Months	13.2	
250mm DGS 40	53,983.7	m^2	Grader		540	hr	1.8	5.1	Months	9.2	
250mm DGS 40	53,983.7	m^2	Grader		416	hr	1.4	5.1	Months	7.1	
150mm DGB 20	51,413.6	m^2	Grader		386	hr	1.3	5.1	Months	6.6	
150mm DGB 20	51,413.6	m^2	Grader		428	hr	1.4	5.1	Months	7.3	
275mm heavily bound base	262,577.9	m^2	Grader		4814	hr	16.0	5.1	Months	81.8	
275mm heavily bound base	262,577.9	m^2	Grader		2387	hr	8.0	5.1	Months	40.6	
300mm DGB 20	10,500.0	m^2	Grader		79	hr	0.3	5.1	Months	1.3	
300mm DGB 20	10,500.0	m^2	Grader		88	hr	0.3	5.1	Months	1.5	
Cut to fill	1,000,000.0	m^3	25t artic dumps	-	149,999.7	hr		0.06	hr	9000.0	Assumed average rate of fuel consumption of 60L/hr
Cut to fill	1,000,000.0	m^3	825 compactor		16,666.4	hr		0.06	hr	1000.0	Assumed average rate of fuel consumption of 60L/hr
Surcharge loading	30,000.0	m^3	825 compactor		429	hr	-	0.06	hr	25.7	Assumed average rate of fuel consumption of 60L/hr

Emission Activity	Quantity	Unit	Equipment	Equipment Category	Duration of operation	Unit	Months of operation	Rate of fuel use (kL/UOM)	UOM	Quantity of Diesel Used (kL)	Assumptions
Hay bales	1,368.0	No	Backhoe	Backhoe loader (backhoe)	45.6	hr	0.2	3	Months	0.5	4WD Class 2 to Class 5, medium application, 300 hours/month (TAGG 2011)
Subsoil drains	45,600.0	m	Backhoe		4560	hr	15.2	3	Months	45.6	
500mm drainage layer	20,000.0	m^2	CA30 roller	Vibrating Roller (asphalt, soil)	167	hr	0.6	4.8	Months	2.7	Class VR35, Medium application, 300 hours/month (TAGG 2011)
SMZ layer	70,000.0	m^3	CA30 roller 50%		1,167.1	hr	3.9	4.8	Months	18.7	
Cut to fill	1,000,000.0	m^3	CA30 roller dry		8,333.6	hr	27.8	4.8	Months	133.3	
Sediment basins	16.0	No	Roller		600.0	hr	2.0	4.8	Months	9.6	
SMZ layer	70,000.0	m^3	Roller		2,333.2	hr	7.8	4.8	Months	37.3	
SMZ layer	70,000.0	m^3	Roller		1,795.1	hr	6.0	4.8	Months	28.7	
Excavate and dispose on site to Preload area	150,000.0	m^3	Roller		2,999.9	hr	10.0	4.8	Months	48.0	
Rip floor, trim and compact	116,125.0	m^2	Roller		774	hr	2.6	4.8	Months	12.4	
250mm DGS 40	53,983.7	m^2	Roller		539.6	hr	1.8	4.8	Months	8.6	
250mm DGS 40	53,983.7	m^2	Roller		415.5	hr	1.4	4.8	Months	6.6	
150mm DGB 20	51,413.6	m^2	Roller		386	hr	1.3	4.8	Months	6.2	
150mm DGB 20	51,413.6	m^2	Roller		428	hr	1.4	4.8	Months	6.8	
275mm heavily bound base	262,577.9	m^2	Roller		4814	hr	16.0	4.8	Months	77.0	
275mm heavily bound base	262,577.9	m^2	Roller		2387	hr	8.0	4.8	Months	38.2	
300mm DGB 20	10,500.0	m^2	Roller		79	hr	0.3	4.8	Months	1.3	
300mm DGB 20	10,500.0	m^2	Roller		88	hr	0.3	4.8	Months	1.4	

Emission Activity	Quantity	Unit	Equipment	Equipment Category	Duration of operation	Unit	Months of operation	Rate of fuel use (kL/UOM)	UOM	Quantity of Diesel Used (kL)	Assumptions
Rock-extra over	103,830.0	m^3	D10150m³/ hr	Tractor Dozer	277.0	hr	0.9	12.9	Months	11.9	Class 300C (D9 size) Medium application, 300 hours/month (TAGG 2011)
Rock-extra over	103,830.0	m^3	D10 to push		311.0	hr	1.0	12.9	Months	13.4	
Cut to fill	1,000,000.0	m^3	D6 dozer		16,666.4	hr	55.6	12.9	Months	716.7	
Surcharge loading	30,000.0	m^3	D6 dozer		429	hr	1.4	12.9	Months	18.4	
Sediment basins	16.0	No	Dozer @ 40m³/hr		600.0	hr	2.0	12.9	Months	25.8	
Rip floor, trim and compact	116,125.0	m^2	Dozer D10		774	hr	2.6	12.9	Months	33.3	
Clear and grubb	3.0	ha	Dozer D6		14.0	hr	0.0	12.9	Months	0.6	
Excavate and dispose on site to preload area	150,000.0	m^3	Dozer D6 @ 50m³/hr		2,999.9	hr	10.0	12.9	Months	129.0	
Clear and grubb	3.0	ha	Dozer D8		10.0	hr	0.0	12.9	Months	0.4	
Remove and stockpile topsoil	108,634.0	m^3	Dozer push up		1,358.0	hr	4.5	12.9	Months	58.4	
Clear and grubb	3.0	ha	Exc + grab	Excavator (digger, trackhoe)	48.0	hr	0.2	5.1	Months	0.8	Crawler class 100, medium application, 300 hours/month (TAGG 2011)
Clear and grubb	3.0	ha	Exc + grab		8.0	hr	0.0	5.1	Months	0.1	
Revetment	12,000.0	m^2	Excavation		3600	m^3	12.0	5.1	Months	61.2	
Transverse RCBC	60.0	m	Excavation		1380	m^3	4.6	5.1	Months	23.5	
Transverse RCBC	10.0	m	Excavation		300	m^3	1.0	5.1	Months	5.1	
Transverse RCBC	80.0	m	Excavation		672	m^3	2.2	5.1	Months	11.4	
Truck cleaning facilities	6.0	No	Excavator		48.0	hr	0.2	5.1	Months	0.8	
Sediment basins	16.0	No	Excavator		600.0	hr	2.0	5.1	Months	10.2	
Headwalls	44.0	No	Excavator		88	hr	0.3	5.1	Months	1.5	

Emission Activity	Quantity	Unit	Equipment	Equipment Category	Duration of operation	Unit	Months of operation	Rate of fuel use (kL/UOM)	UOM	Quantity of Diesel Used (kL)	Assumptions
Remove and stockpile topsoil	108,634.0	m^3	Excavator @ 80m^3/hr		1,358.0	hr	4.5	5.1	Months	23.1	
Excavate and dispose on site to Preload area	150,000.0	m^3	Excavator @50m3/hr		2,999.9	hr	10.0	5.1	Months	51.0	
Cut to fill	1,000,000.0	m^3	Excavator PC300 @ 60m^3/hr		16,666.4	hr	55.6	5.1	Months	283.3	
500mm drainage layer	20,000.0	m^2	Loader	Loader - wheeled	167	hr	0.6	4.5	Months	2.5	Class 50WL, Medium application, 300 hours/month (TAGG 2011)
Silt fence	19,950.0	m	Loader/ dozer with rip		456.0	hr	1.5	4.5	Months	6.8	
Remove and stockpile topsoil	108,634.0	m^3	Moxies x 20min hauls		4,074.0	hr	-	0.06	hr	244.4	Assumed average rate of fuel consumption of 60L/hr
Clear and grubb	3.0	ha	S/Plant		32.0	hr	-	0.06	hr	1.9	Assumed average rate of fuel consumption of 60L/hr
Clear and grubb	3.0	ha	S/Plant		40.0	hr	-	0.06	hr	2.4	Assumed average rate of fuel consumption of 60L/hr
Cut to fill	1,000,000.0	m^3	Spotter	Spotter	8,333.6	hr		0.06	hr	500.0	Assumed average rate of fuel consumption of 60L/hr
SMZ layer	70,000.0	m^3	Spotter		2,333.2	hr		0.06	hr	140.0	
500mm drainage layer	20,000.0	m^2	Spotter		167	hr	-	0.06	hr	10.0	
Surcharge loading	30,000.0	m^3	Spotter		429	hr	-	0.06	hr	25.7	

Emission Activity	Quantity	Unit	Equipment	Equipment Category	Duration of operation	Unit	Months of operation	Rate of fuel use (kL/UOM)	UOM	Quantity of Diesel Used (kL)	Assumptions
Truck cleaning facilities	6.0	No	Truck	Truck	48.0	hr	-	0.0995		4.8	Fuel consumption for 'off-highway trucks' sourced from the California EPA OFFROAD inventory database, for 500HP (average) truck
Clear and grubb	3.0	ha	Truck		192.0	hr	-	0.0995	-	19.1	
Clear and grubb	3.0	ha	Truck		32.0	hr	-	0.0995	-	3.2	
Cut to fill	1,175,242.0	m^3	Truck haul		1,175,242.0	m^3	-	-	-	-	Already accounted for
Clear and grubb	3.0	ha	Tub grinder	Tub grinder	48.0	hr	-	0.07	hr	3.4	Fuel consumption for 'chippers/stump grinders' sourced from the California EPA OFFROAD inventory database, for 500HP (average)
Clear and grubb	3.0	ha	Tub grinder		8.0	hr	-	0.07	hr	0.6	
Sediment basins	16.0	No	Water cart	Water cart	600.0	hr	-	0.045	hr	27.0	Fuel consumption for 'hydrant truck' sourced from the California EPA OFFROAD inventory database
Cut to fill	1,000,000.0	m^3	Water cart		66,667.1	hr		0.045	hr	3000.0	
SMZ layer	70,000.0	t	Water cart		2,333.2	hr		0.045	hr	105.0	
SMZ layer	70,000.0	t	Water cart		1,795.1	hr		0.045	hr	80.8	
Excavate and dispose on site to Preload area	150,000.0	m^3	Water cart		2,999.9	hr		0.045	hr	135.0	
Rip floor, trim and compact	116,125.0	m^2	Water cart		774	hr	-	0.045	hr	34.8	
Surcharge loading	30,000.0	m^3	Water cart		857	hr	-	0.045	hr	38.6	
250mm DGS 40	53,983.7	m^2	Water cart		540	hr	-	0.045	hr	24.3	
250mm DGS 40	53,983.7	m^2	Water cart		416	hr	-	0.045	hr	18.7	
150mm DGB 20	51,413.6	m^2	Water cart		386	hr	-	-0.045	hr	17.4	

Emission Activity	Quantity	Unit	Equipment	Equipment Category	Duration of operation	Unit	Months of operation	Rate of fuel use (kL/UOM)	UOM	Quantity of Diesel Used (kL)	Assumptions
150mm DGB 20	51,413.6	m^2	Water cart		428	hr	-	0.045	hr	19.3	
275mm heavily bound base	262,577.9	m^2	Water cart		4814	hr	-	0.045	hr	216.6	
275mm heavily bound base	262,577.9	m^2	Water cart		2387	hr	-	-0.045	hr	107.4	
300mm DGB 20	10,500.0	m^2	Water cart		79	hr	-	0.045	hr	3.6	
300mm DGB 20	10,500.0	m^2	Water cart		88	hr	-	0.045	hr	4.0	
TOTAL										**17,315.1**	kL

Table O-5: Emission source data: transport fuel use

Transport category	Fuel type	Vehicle type	Vehicle load	Unit	Vehicle rate of fuel use* (L/100km)	Average trip distance (km)	Total haulage quantity	Unit	Number of trips	Total distance (km)	Fuel used (kL)	Assumptions/ source
Site vehicles	Diesel	LCV	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	489.6	GHG Assessment Workbook for Road Projects(June 2011) Table 5.3 Default Quantity Factors - Site offices and vehicles, assuming large project with 4 sites along road, each with 10 hilux utes, all diesel operated, over 36 construction months
Material delivery - dry bulk materials	Diesel	Articulated truck	30	m^3	54.6	70	330,000.0	m^3	11,000.0	770,000.0	420.4	*FBB Traffic and Transport Assessment* (AECOM 2012): Vehicle capacity, haulage quantity, number of trips
Material delivery - reinforcing steel	Diesel	Articulated truck	10	tonnes	54.6	70	5,320.0	t	532.0	37,240.0	20.3	*FBB Traffic and Transport Assessment* (AECOM 2012): Vehicle capacity, haulage quantity, number of trips

Transport category	Fuel type	Vehicle type	Vehicle load	Unit	Vehicle rate of fuel use* (L/100km)	Average trip distance (km)	Total haulage quantity	Unit	Number of trips	Total distance (km)	Fuel used (kL)	*Assumptions/ source*
Material delivery - pre-fabricated units	Diesel	Articulated truck	1	unit	54.6	200	205.0	units	205.0	41,000.0	22.4	*FBB Traffic and Transport Assessment* (AECOM 2012): Vehicle capacity, haulage quantity, number of trips
Equipment delivery	Diesel	Articulated truck	1	unit	54.6	70	38.0	units	38.0	2660.0	1.5	One return trip per equipment unit, by articulated truck
Earthworks	Diesel	Articulated truck	30	m^3	54.6	20	1,000,000.0	m3	33,333.3	666,666.7	364.0	*FBB Traffic and Transport Assessment* (AECOM 2012): Vehicle capacity, AECOM Quantity estimate update_120706_pavement and earthworks: haulage quantity
Spoil removal	Diesel	Articulated truck	30	m^3	54.6	70	150,000.0	m3	5,000.0	350,000.0	191.1	AECOM Quantity estimate update_120706_pavement and earthworks: Excess earthworks material
Veg removal	Diesel	Truck	10	tonnes	54.6	70	1270.6	t	127.1	8893.9	4.9	-

Table O-6: Emission source data: materials used in construction

Emission activity	Quantity	Unit	Material	Quantity	Unit
250 mm DGS40	53983.7	m^2	Aggregate	29,960.9	tonnes
150mm DGB20	51413.6	m^2	Aggregate	17,120.7	tonnes
275mm stabilised base	262,577.9	m^2	Aggregate	151,300.4	tonnes
7mm seal	262,577.9	m^2	Aggregate	8,139.9	tonnes
300mm DGB20	10,500.0	m^2	Aggregate	6,993.0	tonnes
300mm selected material zone	243,715.0	m^2	Aggregate	Sourced within project	-
Concrete medians and paths - 120mm DGS 20	2,500.0	m^2	Aggregate	666.0	tonnes
Truck stops - 300mm DGB 20	350.0	m^2	Aggregate	233.1	tonnes
7mm seal	262,577.9	m^2	Bitumen	525.2	tonnes
275mm stabilised base	266,088.0	m^2	Cement	6,304.2	tonnes
Pipework 1200 RCP C16	1,100.0	m	Concrete	701.7	m^3
525mm headwalls	44.0	No	Concrete	9.0	m^3
Noise barriers 4m	6,400.0	m^2	Concrete	83.6	m^3
Pits	518.0	No	Concrete	311.0	m^3
Pits - assume 900x900 type E (up to 525∅)	518.0	No	Concrete	234.2	m^3
Open drains	18,800.0	m	Concrete	780.0	m^3
Open drains	18,800.0	m	Concrete	4,032.0	m^3
Kerbing	14,400.0	m	Concrete	2,289.0	m^3
Kerbing	14,400.0	m	Concrete	566.0	m^3
3/3.0m x 2.4m RCBC - units	60.0	m	Concrete	100.2	m^3
3/3.0m x 2.4m RCBC - base slab 300mm	420.0	m^2	Concrete	126.0	m^3
5 cells @ 2.1h*2.4w RCBC - units	10.0	m	Concrete	64.7	m^3

Emission activity	Quantity	Unit	Material	Quantity	Unit
5 cells @ 2.1h*2.4w RCBC - base slab 250mm	70.0	m^2	Concrete	17.5	m^3
2/2.4m x 1.5m RCBC - units	80.0	m	Concrete	78.3	m^3
2/2.4m x 1.5m RCBC - base slab 250mm	448.0	m^2	Concrete	112.0	m^3
Headwalls	6.0	No	Concrete	6.0	m^3
Bridge B1 (short span<20m, 10.5m wide plank) and Bridge B2 (Medium span <35m, 10.5m wide Super T)	-	m^2	Concrete	29,850.0	m^3
Concrete medians and paths	2,500.0	m^2	Concrete	315.0	m^3
Type F barrier	400.0	m	Concrete	274.8	m^3
Wire rope barrier	21,300.0	m	Concrete	1,446.3	m^3
3m x 3m culvert	100.0	m	Concrete	216.0	m^3
Longitudinal pipework - 525mm RCP (average size) pipe class 3	22,800.0	m	Concrete	2,214.2	m^3
RSS wall (approx 5m height)	1,400.0	m^2	Concrete	280.0	m^3
Truck cleaning facilities	6.0	No	Gravel	600.0	tonnes
50mm AC	48965	m^2	Hot mix asphalt	5,631.0	tonnes
135mm AC20	247,714.6	m^2	Hot mix asphalt	76,915.4	tonnes
50mm AC	240,500.0	m^2	Hot mix asphalt	27,657.5	tonnes
50mm AC Overlay	1,593.0	tonnes	Hot mix asphalt	1,593.0	tonnes
50mm AC	10,000.0	m^2	Hot mix asphalt	1,150.0	tonnes
Truck stops - 100mm AC	86.0	tonnes	Hot mix asphalt	86.0	tonnes
300mmm selected material zone	266,088.0	m^2	Lime	2,547.7	tonnes
Longitudinal pipework - 525mm RCP (average size)	22,800.0	m	Sand	18,240.0	tonnes
Pipework	1,100.0	m	Sand	5,500.0	tonnes
500mm drainage layer	20,000.0	m^2	Sand	22,000.0	tonnes
Guardrail and barriers - Armco Guardrail	8,500.0	m	Steel	198.1	tonnes

Emission activity	Quantity	Unit	Material	Quantity	Unit
pipework 1200 RCP C16	1,100.0	m	Steel	70.2	tonnes
525mm headwalls	44.0	No	Steel	0.9	tonnes
Longitudinal pipework - 525mm RCP (average size) pipe class 3	22,800.0	m	Steel	221.4	tonnes
RSS wall (approx 5m height)	1,400.0	m^2	Steel	28.0	tonnes
3/3.0m x 2.4m RCBC - units	60.0	m	Steel	10.0	tonnes
3/3.0m x 2.4m RCBC - base slab 300mm	420.0	m^2	Steel	12.6	tonnes
5 cells @ 2.1h*2.4w RCBC - units	10.0	m	Steel	6.5	tonnes
5 cells @ 2.1h*2.4w RCBC - base slab 250mm	70.0	m^2	Steel	1.8	tonnes
2/2.4m x 1.5m RCBC - units	80.0	m	Steel	7.8	tonnes
2/2.4m x 1.5m RCBC - base slab 250mm	448.0	m^2	Steel	11.2	tonnes
3m x 3m culvert	100.0	m	steel	21.6	tonnes
Concrete medians and paths - steel mesh	2,500.0	m^2	Steel reinforcement	5.5	tonnes
Type F barrier	400.0	m	Steel reinforcement	5.0	tonnes
Wire rope barrier	21,300.0	m	steel	225.8	tonnes
Bridge B1 (short span<20m, 10.5m wide plank) and Bridge B2 (medium span <35m, 10.5m wide Super T)	-	m^2	Steel structural	13,900.0	tonnes

Table O-7: Emission source data: materials used in maintenance

Pavement type	Pavement area (m^2)	Material	Material component	Thickness (mm)	Component material quantity (tonnes)	Assumption
Pavement Type 1 - local roads	48,965.0	50mm AC wearing course	Hot mix asphalt	50	5,631.0	One major rehabilitation with top 150mm replaced, once every 50 years
Pavement Type 1 - local roads	51,413.6	150 mm DGB20 Base	Aggregate	100	11,413.8	
Pavement Type 2 - flexible	240,500.0	50mm AC wearing course	Hot mix asphalt	50	27,657.5	
Pavement Type 2 - flexible	247,714.6	135mm AC20	Hot mix asphalt	100	56,974.3	
Pavement Type 2 - flexible	262,577.9	2 coat, spray seal	Aggregate	N/A	8139.913768	
Pavement Type 2 - flexible	262,577.9	2 coat, spray seal	Bitumen	N/A	525.155727	
Truck stops - 300mm DGB 20	350.0	300mm DGB 20	Aggregate	150	116.55	
Concrete medians and paths	2,500.0	120mm DGS 20	Aggregate	120	666	
50mm AC wearing course	2,448.3	50mm AC wearing course	Hot mix asphalt	50	281.5	5% of road replaced over 50 year period for patching/repair
150mm DGB20 base	2,570.7	150mm DGB20 Base	Aggregate	150	856.0	
250 mm DGS40 sub-base	2,699.2	250 mm DGS40 sub-base	Aggregate	250	1498.0	
50mm AC wearing course	12,025.0	50mm AC wearing course	Hot mix asphalt	50	1382.9	
135mm AC20	12,385.7	135mm AC20	Hot mix asphalt	135	3845.8	
275mm stabilised base	13,128.9	275mm stabilised base	Cement	275	315.2	
275mm stabilised base	13,128.9	275mm stabilised base	Aggregate	275	7565.0	
300mm selected material zone	13,128.9	300mm selected material zone	Lime	300	127.4	
300mm selected material zone	12,025.0	300mm selected material zone	Aggregate	300	7661.6	

Pavement type	Pavement area (m^2)	Material	Material component	Thickness (mm)	Component material quantity (tonnes)	Assumption
2 coat, spray seal	13,128.9	2 coat, spray seal	Aggregate	N/A	407.0	
2 coat, spray seal	13,128.9	2 coat, spray seal	Bitumen	N/A	26.3	
300mm DGB 20	17.5	300mm DGB 20	Aggregate	300	11.7	
120mm DGS 20	125.0	120mm DGS 20	Aggregate	120	33.3	

GHG calculation methodology

The following steps were taken in estimating the GHG emissions associated with the construction and operation of the project (as per the procedure outlined in **Figure 8-6** of the environmental assessment):

- The GHG emissions relevant to the stages of project construction, operation and maintenance were identified.
- The GHG inventory boundary was determined, which defines the emissions sources to be considered in the assessment and those to be excluded (as given in **Tables 8-1** and **8-2** in the environmental assessment).
- The emissions sources were quantified (as detailed in the section above).
- For the different emissions sources and sinks, emissions factors were established and the emissions calculated. This section provides the methodology used for calculating GHG emissions from fuel use, electricity use, vegetation removal, material use and from the use of the road by traffic post construction.
- Opportunities for mitigation were identified, as detailed in Section 8.5.4 of the environmental assessment.

Fuel

The method used to calculate the Scope 1 GHG emissions from the combustion of liquid fuels, for transport energy purposes is given by the formula below, as given by the *National Greenhouse Accounts* (*NGA) Factors 2011*:

GHG emissions (t CO_2-e) = ((Q x ECF) / 1000) x (EF_{CO2} + EF_{CH4} + EF_{N2O})

Where: Q is the quantity of fuel (in kL).

ECF is the relevant energy content factor (in GJ/kL).

EF_{CO2} is the relevant Carbon dioxide (CO_2) emission factor (in kg $CO_{2\text{-}e}$/GJ).

EF_{CH4} is the relevant Methane (CH_4) emission factor (in kg $CO_{2\text{-}e}$/GJ).

EF_{N2O} is the relevant Nitrous oxide (N_2O) emission factor (in kg $CO_{2\text{-}e}$/GJ).

The method used for calculating the Scope 3 GHG emissions from the combustion of liquid fuels, for transport energy purposes is given by the formula below, as given by the *NGA Factors 2011*:

GHG emissions (t CO_2-e) = (Q x ECF x $EF_{for\ scope\ 3}$) / 1000

Where: Q is the quantity of fuel (in kL).

ECF is the relevant energy content factor (in GJ/kL).

$EF_{for\ scope\ 3}$ is the relevant emission factor (in kg $CO_{2\text{-}e}$/GJ).

The Scope 1 and Scope 3 emission factors for diesel (post 2004 vehicles) are given in **Table O-8**.

Table O-8: Scope 1 and Scope 3 emission factors for diesel (post 2004 vehicles) (Source: NGA Factors 2011 Tables 4 and 38)

Fuel	Energy content factor (GJ per kL)	Scope 1 emission factor (kg CO_2-e/GJ)			Scope 3 emission factor (kg CO_2-e/GJ)	Emissions per unit quantity (t CO2-e per kL)		
		CO_2	CH_4	N_2O		Scope 1	Scope 2	Scope 3
Diesel - transport - post 2004 vehicles	38.6	69.2	0.01	0.6	5.3	2.6947	0	0.2046

Electricity

The method used to calculate the Scope 1 and Scope 3 GHG emissions from the consumption of purchased electricity is given by the formula below, as given by the *NGA Factors 2011*:

GHG emissions (t CO_2-e) = Q x ($EF_{for\ scope}$ /1000)

Where: Q is the quantity of purchased electricity (in kWh).
$EF_{for\ scope}$ is the scope 2 or 3 emissions factor for NSW (in kg CO_2-e/kWh).

The emission factors for the consumption of purchased electricity are given in **Table O-9**.

Table O-9: Scope 2 and Scope 3 emission factors for the use of purchased electricity (Source: NGA Factors 2011 Table 39)

Fuel	Emissions per unit quantity		Units
	Scope 2	Scope 3	
Electricity	0.00089	0.00017	t CO_2-e per kWh

Vegetation removal

The GHG emissions associated with the loss of CO_2 sequestration potential through the removal of vegetation were calculated according to the default method given in the Workbook. The simple method given therein is for use in cases where relevant local data is not available. The method has been established based on the National Carbon Accounting System (NCAS) and FullCAM model. The method involved the following steps:

The mean annual rainfall (mm) for the road project was identified using the Bureau of Meteorology website and is presented in **Table O-10**.

1. The total area of vegetation to be removed that has not been disturbed by human activity and the total area of vegetation to be removed that has been previously disturbed by human activity were determined.
2. Estimated the t CO_2 per hectare sequestered in the vegetation by:
    a. Multiplying the mean annual rainfall (millimetres) by 0.49 if the vegetation has not previously been disturbed by human activity.
    b. Multiplying the mean annual rainfall (millimetres) by 0.09 if the vegetation has previously been disturbed by human activity.
3. The GHG emissions associated with the loss of CO_2 sequestration potential were estimated by multiplying the area of vegetation to be cleared (hectare) by the relevant emission factor (t CO_2 per hectare) to determine.

Table O-10: Mean rainfall (at Bureau of Meteorology station 068003 Berry Masonic Village, statistics calculated over all years of data) (mm)

Month	Rainfall (mm)
January	135.8
February	154.2
March	156.8
April	133.9
May	126.6
June	135.4
July	97
August	84.1
September	79.7
October	103.4
November	102.5
December	111.5
Total annual	**1420.9**

Materials

Indirect Scope 3 GHG emissions from the use of materials have been calculated according to the formula below:

GHG emissions (t CO_2-e) = Q (t) x EF (tCO_2-e/t)

Where: Q is the quantity of material (in tonnes).
EF is the relevant Emission Factor (in t CO_2-e per tonne of material).

Material emission factors have been sourced from the Workbook and are given in **Table O-11**.

Table O-11: Material Emission Factors (TAGG 2011)

Material	Emission factor (t CO_2-e/t)
Aggregate (crushed rock)	0.004
Concrete (30 MPa concrete 1:2:4)[1]	0.127
Portland cement	0.82
Sand	0.003
Structural steel	1.05
Hot mix asphalt (400MJ/t)	0.058
Bitumen	0.63
Lime	1.09

[1] *Note that all concrete has been assumed to be 30MPa (1:2:4), in the absence of information on concrete types for the different structural elements – to be refined if more information on concrete types can be made available*

Road use

To assess the Indirect Scope 3 GHG emissions from traffic use of the project post construction, road use in two scenarios was considered:

1. Do nothing - No upgrade of the Princes Highway between Gerringong and Bomaderry. This represents the consequence of no action environmental assessment measure.
2. Do minimum - Construction of only the Gerringong upgrade and Foxground and Berry bypass. This represents the operational impacts environmental assessment measure.

The analysis is based on the Vehicle Kilometres Travelled (VKT) and average speed values in the opening year 2017 and the design year 2037, for the traffic impact footprint and involved the following steps:

1. Average speed by road type

   For both scenarios, for the opening year (2017) and the design year (2037), the average speed by road type was sourced from the Traffic *and Transport Assessment Technical Paper* (AECOM, 2012), for the traffic impact footprint. **Table O-12** gives the projected average speeds for the different road sections within the traffic impact footprint, including respective road section lengths.

Table O-12 Average speeds and section length estimates

Route	Section start	Section end	Length (km) 'Do nothing'	Length (km) 'Do something'	Average speed (km/h) 'Do nothing'	Average speed (km/h) 'Do something'
Princes Highway	Rose Valley Road	Belinda Street	3.8	3.8	77.8	97.5
	Belinda Street	Toolijooa Road	3.2	3.0	77.8	97.5
	Toolijooa Road	East of Berry	9.5	8.1	51.9	98.5
	East of Berry	Kangaroo Valley Road	2.0	1.9	51.9	98.5
	Kangaroo Valley Road	Schofields Lane	1.1	1.2	51.9	98.5
	Schofields Lane	Bolong Road	13.6	13.6	64.0	68.9
The 'Sandtrack'	Princes Highway | Rose Valley Road	Crooked River Road | Dooley's Road	8.7	8.7	50.3	50.5
	Crooked River Road | Dooley's Road	Bolong Road | Shoalhaven Heads Road	9.9	9.9	78.2	79.0
	Bolong Road | Shoalhaven Heads Road	Princes Highway | Bolong Road	13.8	13.8	71.2	72.4

2. Vehicle kilometres travelled

   For both scenarios, for the opening year (2017) and the design year (2037), the Average Annual Daily Traffic (AADT) and vehicle kilometres travelled (VKT), for light and heavy vehicles, were sourced from the Traffic *and Transport Assessment Technical Paper* (AECOM, 2012) , for the traffic impact footprint, as given in **Table O-13** below.

Table O-13: AADT Estimates (LV = Light Vehicles, HV = Heavy Vehicles)

			'Do Nothing'				'Do Something'			
			2017 Opening Year AADT		2037 Design Year AADT		2017 Opening Year AADT		2037 Design Year AADT	
Route	Section Start	Section End	LV, 2-way	HV, 2-way	LV, 2-way	HV, 2-way	LV, 2-way	HV, 2-way	LV, 2-way	HV, 2-way
Princes Highway	Rose Valley Road	Belinda Street	13,057	1,680	19,710	2,537	15,229	1,707	31,631	2,774
	Belinda Street	Toolijooa Road	11,528	1,605	17,420	2,425	13,373	1,605	30,088	2,650
	Toolijooa Road	East of Berry	11,150	1,552	16,850	2,345	12,862	1,543	28,938	2,549
	East of Berry	Kangaroo Valley Road	12,563	1,680	18,933	2,532	11,895	1,436	25,632	2,552
	Kangaroo Valley Road	Schofields Lane	13,976	1,808	21,015	2,719	14,981	1,808	29,781	2,965
	Schofields Lane	Bolong Road	13,976	1,808	21,015	2,719	14,981	1,808	29,781	2,965
The 'Sandtrack'	Princes Highway | Rose Valley Road	Crooked River Road | Dooley's Road	10,401	346	15,371	511	8,451	346	5,463	553
	Crooked River Road | Dooley's Road	Bolong Road | Shoalhaven Heads Road	10,078	384	14,845	565	7,823	384	4,759	610
	Bolong Road | Shoalhaven Heads Road	Princes Highway | Bolong Road	9,754	421	14,319	618	7,195	421	4,055	667

Table O-14: VKT Estimates (LV = Light Vehicles, HV = Heavy Vehicles)

			'Do Nothing'				'Do Something'			
			2017 Opening Year VKT		2037 Design Year VKT		2017 Opening Year VKT		2037 Design Year VKT	
Route	Section Start	Section End	LV, 2-way	HV, 2-way	LV, 2-way	HV, 2-way	LV, 2-way	HV, 2-way	LV, 2-way	HV, 2-way
Princes Highway	Rose Valley Road	Belinda Street	18,110,059	2,330,160	27,337,770	3,518,819	21,122,623	2,367,609	43,872,197	3,847,538
	Belinda Street	Toolijooa Road	13,464,704	1,874,640	20,346,560	2,832,400	14,643,435	1,757,475	32,946,360	2,901,750
	Toolijooa Road	East of Berry	38,662,625	5,381,560	58,427,375	8,131,288	38,026,503	4,561,880	85,555,197	7,536,119
	East of Berry	Kangaroo Valley Road	9,170,990	1,226,400	13,820,725	1,848,360	8,249,183	995,866	17,775,792	1,769,812
	Kangaroo Valley Road	Schofields Lane	5,611,364	725,912	8,437,523	1,091,679	6,561,678	791,904	13,044,078	1,298,670
	Schofields Lane	Bolong Road	69,376,864	8,974,912	104,318,460	13,497,116	74,365,684	8,974,912	147,832,884	14,718,260
The 'Sandtrack'	Princes Highway | Rose Valley Road	Crooked River Road | Dooley's Road	33,028,376	1,098,723	48,810,611	1,622,681	26,836,151	1,098,723	17,347,757	1,756,052
	Crooked River Road | Dooley's Road	Bolong Road | Shoalhaven Heads Road	36,415,046	1,385,777	53,642,408	2,039,821	28,268,411	1,385,777	17,196,647	2,204,235
	Bolong Road | Shoalhaven Heads Road	Princes Highway | Bolong Road	49,130,898	2,120,577	72,124,803	3,112,866	36,241,215	2,120,577	20,425,035	3,359,679

3. Rate of fuel consumption

The rate of fuel consumption was calculated for each road type within the traffic impact footprint, using the basic fuel-speed formula given below (Equation 1 in Austroads Guide to Project Evaluation Part 4: Project Evaluation Data part 6):

Fuel Consumption (L/100km) = A+ (B/V) + (CxV) + (DxV²)

$$\text{Fuel Consumption (L/100km)} = A + (B/V) + (C \times V) + (D \times V^2)$$

Where: A, B, C and D are the Fuel consumption parameter values given in **Table O-15**.
V is the all day average link speed in km/h

Table O-15: Fuel consumption parameter values on freeways - litres/100 km (Austroads Guide to Project Evaluation Part 4: Project Evaluation Data Table 6.3)

Vehicle type	A	B	C	D
Cars	-18.433	1306.02	0.15477	0.0003203
Light commercial vehicle (LCV)	-27.456	2060.5	0.1911	0.000851
Rigid trucks	-65.056	4156.75	0.49681	0.0006798
Articulated vehicles	-80	6342.8	0.48496	0.0020895
Buses	-80	5131.63	0.60539	0.0015775

As the GHG emissions from road use were assessed for two vehicle categories, light vehicles and heavy vehicles, weighted average fuel consumption parameters were applied for each vehicle category, according to the likely proportional makeup of vehicle types within each category, based on Australian Bureau of Statistics NSW Registration vehicle type data for the year 2011 (given in **Table O-16**). The likely proportional makeup of cars and LCV's within the category of 'light vehicles' and the likely proportional makeup of rigid trucks, articulated vehicles and buses within the category 'heavy vehicles' are given in **Table O-17**. The weighted average fuel consumption parameters applied for calculation of the fuel consumption rate of light and heavy vehicles are given in **Table O-18**.

Table O-16: Australian Bureau of Statistics NSW Registration vehicle type data for calculating weighted average fuel consumption parameters for light and heavy vehicles

Category	2011 NSW registrations	Proportion total	Heavy/ Light	Sub-classification according to fuel consumption parameters	Proportion heavy/light
Articulated trucks	18578	0.39%	H	Articulated vehicles	0.11
Buses	23390	0.49%	H	Buses	0.14
Heavy rigid trucks	84401	1.77%	H	Rigid trucks	0.50
Light rigid trucks	39460	0.83%	H	Rigid trucks	0.23
Non-freight carrying trucks	3320	0.07%	H	Rigid trucks	0.02
Total	**169149**				1.00
Campervans	10537	0.22%	L	Cars	0.00
Light commercial vehicles	675152	14.13%	L	LCV	0.15
Motor cycles	181107	3.79%	L	Cars	0.04
Passenger vehicles	3742476	78.32%	L	Cars	0.81
Total	**4609272**				1.00

Table O-17: Estimated proportional makeup of light and heavy vehicles according to vehicle type

Category	Cars	LCV	Rigid Trucks	Articulated vehicles	Buses
Light Vehicles	0.85	0.15	0	0	0
Heavy Vehicles	0	0	0.75	0.11	0.14

Table O-18: Fuel consumption parameter values on freeways for light and heavy vehicles - litres/100 km (adapted from Austroads Guide to Project Evaluation Part 4: Project Evaluation Data Table 6.3)

Vehicle category	A	B	C	D
Light	-19.7546613	1416.5339122	0.1600915	0.0003980
Heavy	-68.7637949	4531.6554390	0.5105230	0.0009588

Rates of fuel consumption calculated according to Equation 1 are applicable at the year of 2008 (year of publication of Austroads Guide to Project Evaluation). Annual rates of fuel efficiency improvement were applied to calculate rates of fuel consumption, for light and heavy vehicles, in the years 2017 and 2037, according to road transport fuel intensity projections by vehicle type, given by SKM (2011) in Australian Transport Emissions Projections to 2050 (**Table O-19**), as follows:

- Rates of fuel consumption for the years 2017 and 2020 were calculated by applying the annual percentage change in fuel intensity for 2008-2020, given in **Table O-19**, to the rate of fuel consumption in the year 2008.
- Rates of fuel consumption in the year 2037 were calculated by applying the annual percentage change in fuel intensity for 2020-2030, given in **Table O-19**, to the rate of fuel consumption in the year 2020.

Table O-19: Estimated fuel intensity projections by road type

Vehicle Type	Annual % Fuel Intensity Change (2008-2020)[1]	Annual % Fuel Intensity Change (2020-2030)[1]	Heavy/Light	Annual % Fuel Intensity Change (2008-2020) (based on vehicle proportions)	Annual % Fuel Intensity Change (2020-2030) (based on vehicle proportions)
Passenger	-1.1	-1.4	Light	-0.97	-1.37
Motorcycles	1	-0.8			
LCV	0.2	-1.2			
Buses	0.4	0.3	Heavy	-0.40	-0.53
Rigid	-0.5	-0.6			
Articulated	-0.7	-1.1			

SKM (2011) Australian transport emissions projections to 2050

4. Total fuel quantity combusted

   For both scenarios, for the opening year (2017) and the design year (2037), VKT was factored by the rate of fuel consumption, for each road type to determine the total quantity of fuel consumed in each scenario.

5. Fuel quantity combusted by fuel type

   The analysis considered three fuels, petrol, diesel and LPG. The total quantity of fuel combusted in each scenario, for the opening year (2017) and the design year (2037), was apportioned according to fuel type, based on Australian Bureau of Statistics Survey of Motor Vehicle Use for 12 Months to 31 October 2010. Estimates of the proportional makeup of light and heavy vehicles, by fuel type, are given in **Table O-20** below.

Table O-20: Fuel type proportions for light and heavy vehicles (calculated from data in ABS Survey of Motor Vehicle Use 9208.0 for the 12 months ending 31 October 2010)

Vehicle category	Fuel type	Estimated proportion
Light Vehicles	Petrol	84.1
	Diesel	8.4
	LPG/CNG/dual fuel/hybrid (assume LPG)	7.5
Heavy Vehicles	Petrol	0.8
	Diesel	97.3
	LPG/CNG/dual fuel/hybrid (assume LPG)	1.9

The estimated total quantities of each fuel type used in each scenario, for the opening year (2017) and the design year (2037) are given in **Table O-21** below.

Table O-21: Fuel quantity estimates by fuel type

Route	Section Start	Section End	'Do Nothing' 2017 – Fuel Quantities (kL)			'Do Nothing' 2037 – Fuel Quantities (kL)			'Do Something' 2017 – Fuel Quantities (kL)			'Do Something' 2037 – Fuel Quantities (kL)		
			Petrol	Diesel	LPG	Petrol	Diesel	LPG	Petrol	Diesel	LPG	Petrol	Diesel	LPG
Princes Highway	Rose Valley Road	Belinda Street	1864.2	951.3	181.2	2162.8	1259.0	213.2	2311.8	1043.7	222.1	3687.4	1560.6	352.3
	Belinda Street	Toolijooa Road	1386.4	754.0	135.6	1610.2	1000.4	159.9	1603.0	763.4	154.8	2769.2	1175.8	264.6
	Toolijooa Road	East of Berry	5058.9	2909.3	498.0	5876.2	3865.8	587.7	4189.4	1994.2	404.5	7236.9	3072.6	691.6
	East of Berry	Kangaroo Valley Road	1199.8	667.7	117.7	1389.8	884.1	138.4	908.8	434.8	87.8	1504.1	702.1	145.0
	Kangaroo Valley Road	Schofields Lane	734.0	397.6	71.8	848.3	524.9	84.2	722.9	345.7	69.8	1103.7	515.2	106.4
	Schofields Lane	Bolong Road	7645.0	4016.3	745.3	8835.1	5298.2	873.8	7887.7	3879.8	763.9	12,043.0	5780.1	1163.6
The 'Sandtrack'	Princes Highway / Rose Valley Road	Crooked River Road / Dooley Road	4453.1	954.7	407.7	5055.7	1184.8	464.8	3600.5	866.5	331.4	1791.6	910.4	174.1
	Crooked River Road / Dooley Road	Bolong Road / Shoalhaven Heads Road	3738.6	827.9	342.8	4230.9	1026.5	389.6	2901.8	743.6	268.0	1359.4	787.4	133.9
	Bolong Road / Shoalhaven Heads Road	Princes / Bolong Road	5137.1	1230.8	472.8	5793.7	1529.7	535.9	3771.5	1088.9	350.6	1638.4	1182.4	165.9

6. The GHG emission calculation

The Scope 3 GHG emissions associated with the use of petrol, diesel and LPG, in both scenarios, for the opening year (2017) and the design year (2037) were calculated according to the formula below, as given by the *NGA Factors 2011*:

$$GHG\ emissions\ (t\ CO_2\text{-}e) = (Q \times EF_{full\ fuel\ cycle}) / 1000$$

Where: Q is the quantity of fuel (in kL).
$EF_{full\ fuel\ cycle}$ is the relevant emission factor (in kg $CO_{2\text{-}e}$/kL).

The emission factor applied represents the full fuel cycle, which is the sum of Scope 1 and Scope 3 emissions. The emission factors for petrol, diesel and LPG are given in **Table O-22**.

Table O-22: Scope 1, Scope 3 and full fuel cycle emission factors for (post 2004 vehicles) (Source: NGA Factors 2011 Tables 4 and 38)

Fuel	Energy content factor (GJ per kL)	Scope 1 emission factor (kg CO_2-e/GJ)			Scope 3 emission factor (kg CO_2-e/GJ)	Emissions per unit quantity (t CO_2-e per kL)			Full fuel cycle (t CO_2-e per kL)
		CO_2	CH_4	N_2O		Scope 1	Scope 2	Scope 3	
Petrol - gasoline	34.2	66.7	0.6	2.3	5.3	2.38032	-	0.18126	2.56158
Diesel oil	38.6	69.2	0.2	0.5	5.3	2.69814	-	0.20458	2.90272
Liquid petroleum gas (LPG)	26.2	59.6	0.6	0.6	5	1.59296	-	0.131	1.72396

The estimated GHG emissions from the use of fuel in each scenario, for the opening year (2017) and the design year (2037) are given in **Table O-23** below.

Table O-23: GHG emission estimates

Route	Section Start	Section End	'Do Nothing' GHG Emissions (t CO2-e)- opening year 2017	'Do Nothing' GHG Emissions (t CO2-e)- design year 2037	'Do Something' GHG Emissions (t CO2-e)- opening year 2017	'Do Something' GHG Emissions (t CO2-e)- design year 2037	Difference 'Do Something' – 'Do Nothing' GHG Emissions (t CO2-e)- opening year 2017	Difference 'Do Something' – 'Do Nothing' GHG Emissions (t CO2-e)- design year 2037
Princes Highway	Rose Valley Road	Belinda Street	7849.1	9562.2	9334.4	14,583.0	1485.4	5020.8
	Belinda Street	Toolijooa Road	5973.9	7304.1	6589.2	10,962.7	615.2	3658.6
	Toolijooa Road	East of Berry	22,262.1	27,287.0	17,217.4	28,649.3	-5044.8	1362.3
	East of Berry	Kangaroo Valley Road	5214.4	6365.0	3741.4	6140.8	-1473.0	-224.3
	Kangaroo Valley Road	Schofields Lane	3158.1	3842.0	2975.8	4506.1	-182.4	664.2
	Schofields Lane	Bolong Road	32,526.4	39,517.4	32,783.9	49,632.9	257.5	10,115.5
The 'Sandtrack'	Princes Highway/ Rose Valley Road	Crooked River Road/| Dooley Road	14,880.9	17,190.9	12,309.4	7531.9	-2571.5	-9659.0
	Crooked River Road/| Dooley Road	Bolong Road/ Shoalhaven Heads Road	12,570.7	14,489.1	10,053.5	5998.7	-2517.2	-8490.3
	Bolong Road/ Shoalhaven Heads Road	Princes Highway/ Bolong Road	17,546.6	20,205.2	13,426.4	7914.9	-4120.3	-12,290.3
		Totals	121,982.2	145,763.0	108,431.3	135,920.4	**-13,550.9**	**-9,842.6**