Quality Information

Document: Road Safety Audit – Stage 1
Route Options – Preliminary Concept Design

Ref: DEV06/04-EN-MA-Road Safety Audit

Date: 21 November 2007

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Revision history

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<td>For issue</td>
<td>Richard Merrett</td>
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RTA acceptance

<table>
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<tr>
<th>Business Unit</th>
<th>Southern Operations and Engineering Services</th>
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<td>Project No.</td>
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Executive Summary

Background

The preliminary concept designs for the short listed routes have been subject to a Stage 1 Road Safety Audit. The objectives include the early identification of potential road safety issues inherent in the designs and the elimination or reduction of the incidence and severity of road accidents.

The short listed routes are as follows:

Table 1 Study area sections and selected routes

<table>
<thead>
<tr>
<th>Section</th>
<th>Route</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section A</td>
<td>Red route</td>
</tr>
<tr>
<td>Section B</td>
<td>Pink route</td>
</tr>
<tr>
<td></td>
<td>Green route</td>
</tr>
<tr>
<td></td>
<td>Yellow route</td>
</tr>
<tr>
<td>Section C</td>
<td>Blue route</td>
</tr>
<tr>
<td></td>
<td>Orange route</td>
</tr>
<tr>
<td>Section B/C</td>
<td>Brown route</td>
</tr>
<tr>
<td>Section D</td>
<td>Purple route</td>
</tr>
</tbody>
</table>

This section presents a summary of the audit findings. They have been grouped into general observation types and the route(s) to which they apply have been identified.

Summary of findings

Horizontal and vertical alignment

a) Extended lengths of straight flat alignments may contribute to (Yellow / Brown / Blue):
   - Potential for increased speeds;
   - Drivers having difficulty in maintaining concentration; and
   - Drivers being less prepared for horizontal curves and in selecting the appropriate negotiation speed.

b) Vertical alignment with grades exceeding six per cent are undesirable resulting in (Red / Pink / Green):
   - The speed differential for cars and trucks on uphill sections will increase the potential for lane changing type crashes; and
   - Merges located on steep upgrades particularly where trucks are a significant proportion of entering traffic, will increase the potential for rear-end and lane changing type crashes.

c) Combinations of steep grades and minimum radii horizontal curves, particularly where horizontal curves commence over crests, may reduce the driver’s ability to read the alignment and increase the likelihood of accidents (Red / Pink / Green).

d) Inappropriate coordination of horizontal and vertical design elements may lead to (all routes):
   - Sight distance issues; and
   - Reduced appreciation of approach geometry and conditions.
Cross section
a) Although a relatively narrow median width would result in headlight glare from oncoming vehicles at night, it is noted that this would be a significant improvement to the existing situation (especially as the proposal includes median barrier treatment) (all routes).

Interchanges and intersections
Interchanges and intersections are conceptual at this stage of the project and are therefore not included in this audit. Further audits as design development proceeds will consider these elements. General comments follow:

a) Some routes will include interchanges. Location and geometry must provide adequate provision for sight distance, deceleration and acceleration (Red / Blue / Orange).

b) Some routes will include intersections with local roads. A controlled access strategy will be applied including “left in”/ “left out” only arrangements, protected right turns and U-turn facilities. Intersections increase the amount of potential points of conflict and hence designs must provide adequate provision for sight distance, queuing, deceleration and acceleration (all routes).

Pavement drainage
a) Long flat sections of pavement may lead to aquaplaning if not drained appropriately (Red / Pink / Yellow / Brown).

Interface with existing highway
a) Inappropriate approach signage and/or geometry may not alert drivers to the changing road conditions from the upgrade to lower and/or different geometric standards and potentially lead to vehicle conflicts (Red / Purple).

Roller coaster grading
a) Vertical alignments with many crests and sags may lead to opposing vehicles going in and out of vision which may confuse drivers at night due to head light glare. Confusion may lead to vehicle conflict (Blue / Purple).

Sun glare
a) Potential exists for drivers exiting tunnels or driving on an easterly or westerly direction to be affected by sun glare (Green / Yellow).

Reduced cross section in tunnel
It is understood that the common practise of reducing the standard nearside shoulder widths may be applied in the proposed tunnels. Appropriate provision should be considered for dealing with safe vehicle breakdowns (i.e. safe refuge for drivers of broken down vehicle and appropriate indication of lane closures) and safe refuge and/or routes for drivers to evacuate the tunnels by foot (Green / Yellow).

Construction staging
a) Many different temporary tie-ins and sidetrack scenarios may be faced by drivers during construction. Treatments should be consistent and include appropriate speed control to ensure safe operation (all routes).
1.0 Background

Maunsell was engaged by the RTA in December 2006 to carry out an Options and Route Selection Study, Concept Development and Environmental Assessment (EA) for upgrading the Princes Highway between 42.6 km to 74.6 km south of Wollongong. Maunsell has engaged a number of prominent sub-consultants to contribute to the delivery of this project.

The work includes development of route options and concept development based on the identified preferred route, environmental assessment, public displays and handover period to allow for finalisation of all activities and reports following the announcement and display of the Preferred Route, the Environmental Assessment and the Conditions of Approval.

The project will provide a bypass of Berry. The northern extremity of the project is in the vicinity of the Mount Pleasant Lookout (north of Gerringong at the termination of the four lane configuration) and the southern extremity of the project is the intersection (roundabout) of the Princes Highway with Cambewarra and Moss Vale Roads at Bomaderry.

Community involvement is a key aspect of this project and will afford the broader community the opportunity to make a demonstrable input to the process and to ensure that the requirements and aspirations of the community are adequately and appropriately addressed. This is particularly relevant to:

a) Any potential impacts on rural and residential areas within the study area;
b) Social and economic impacts;
c) Accessibility of the road network for local and through traffic;
d) Potential impacts on water quality;
e) Potential impacts on wetlands;
f) Potential impact on flooding;
g) Potential impacts on land uses;
h) Threatened flora and fauna species;
i) Indigenous and non-indigenous heritage;
j) Visual impact;
k) Noise; and
l) Air quality.

Several studies have been undertaken since the early 1990s to identify a preferred route to upgrade sections of the Princes Highway between Kiama and Nowra including a bypass around the town of Berry.

These studies include:

m) The 1991 Gerringong to Berry Route Study;
n) 1998 North Street Berry Bypass Corridor; and
o) 2004/05 Quantm Study from Kiama to Nowra.

Sections of the highway between Gerringong and Bomaderry have a poor accident record and limited safe overtaking opportunities.

Due to the significant changes in traffic, land use and population since 1991, the NSW state government, in March 2006 committed to investigating an area where it is likely a preferred route would be located to upgrade the Princes Highway between Mount Pleasant at Gerringong and Moss Vale/Cambewarra Road at Bomaderry to meet current road standards.
2.0 Introduction

2.1 Background

The northern extremity of the project is in the vicinity of the Mount Pleasant Lookout (north of Gerringong at the termination of the four lane configuration) and the southern extremity of the project is the intersection (roundabout) of the Princes Highway with Cambewarra and Moss Vale Roads at Bomaderry. The study area in which options were to be investigated is illustrated in Figure 2.1.

The upgraded section will include four lanes with geometry to suit high travel speeds and provide improved road user safety and capacity between the existing dual carriageway alignments at either end of the study area. The project includes a bypass of Berry.
The existing highway alignment follows flat to undulating terrain at the base of the coastal escarpment. Sections of the highway between Gerringong and Bomaderry have a poor accident record and limited safe overtaking opportunities. An objective of the proposed upgrade is to improve road safety, with following aims:

a) The route must bypass Berry;  
b) Improve road alignment;  
c) Provide for separation of opposing traffic;  
d) Improve the safety of town accesses, and  
e) Eliminate narrow bridges.

During the route assessment and selection process, key assessment criteria were identified as:

f) Mixing of local and through traffic is minimised;  
g) Improve the road alignment and grades to minimise loss of control crashes;  
h) Improve the extent of clear-zone to minimise severity of impacts;  
i) Provide opportunity to rationalise access points;  
j) Provide opportunity for an appropriate truck parking area; and  
k) Narrow bridges are to be widened or eliminated.

### 2.2 Route options

The route options assessment process split the study area into four sections. A number of different routes were selected within the sections. The routes are listed below and shown in Figure 2.2. Each of the routes has been audited and the findings are presented in this audit report.

<table>
<thead>
<tr>
<th>Section</th>
<th>Route</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section A</td>
<td>Red route</td>
</tr>
</tbody>
</table>
| Section B | Pink route     
    | Green route    
    | Yellow route   |
| Section C | Blue route     
    | Orange route   |
| Section B/C | Brown route    |
| Section D | Purple route   |
Not used
2.3 Design criteria for the upgrade

This audit is a Stage 1 Road Safety Audit of preliminary concept designs. The objective is to identify potential road safety issues inherent in any of the designs so that the potential incidence and severity of road accidents can be eliminated or reduced during the design development.

Certain fundamental design criteria have been determined and further refinement and clarifications may occur in response to particular constraints, as design development proceeds.

Whilst this section outlines the main design criteria and access strategy to be adopted, the preliminary concept designs are not developed sufficiently to address all these issues. The audit findings are therefore limited to broad observations only.

It is understood that the RTA is reviewing its policy in respect to the adoption of 600 m radius curves for a 110 km/h design speed. Evidence indicates that this minimum radius may be in the range where drivers are mislead regarding the appropriate negotiation speed, i.e. the radii are deceptive to the approaching driver as it appears that they may be negotiated at higher speeds than is actually safe. The preliminary concept design parameters therefore include a desirable minimum radius of 750 m for all new / greenfield sections of the upgrade, whilst the upgraded sections of the existing highway have retained the minimum 600 m radius.

Initial criteria have been identified as follows:

2.3.1 Highway design

a) Posted speed limit- 100 km/h;
b) Design speed for horizontal alignment – 110 km/h;
c) Design speed for vertical alignment – 100 km/h;
d) Stopping sight distance – 210 m horizontal, 175 m vertical, based on 2.5s reaction time;
e) Maximum grade – desirable six per cent, absolute maximum eight per cent;
f) The typical cross section provides for two 3.5 m lanes in each direction with 2.5 m shoulders on the nearside (potential use for cyclists) and 0.5 m shoulder on the median side, with 0.5 m verge and 3.0 m depressed median with wire rope barrier;
g) Vertical clearances - 5.3 m to overhead structures for lanes and shoulder;
h) Vertical clearances - 6.05 m over railways (it has been assumed that the South Coast railway may be electrified in the future);
i) Consideration of bus stops, emergency stopping bays, incident management and traffic signals; and
j) Minimum horizontal curve radius of 600 m adopted generally for upgraded sections of the existing highway, and 750 m for sections of new alignment.

2.3.2 Local road connections / service roads:

a) Minimum 60 km/h horizontal alignment;
b) Minimum 60 km/h vertical alignment;
c) Lane widths, parking lanes, shoulders, and footpaths to be as per the RTA Road Design Guide;
d) Local / service roads to be designed to match the adjoining road conditions and topography, existing speed zoning and council requirements; and

e) Provision for cyclists wanting to join or travel along the highway.
2.3.3 **Interchanges**

a) Design for B-double movements where appropriate;
b) Provide for Level of service C of better for the 100\textsuperscript{th} highest hourly volume in design year 20 after opening; and
c) Entry and exit ramps to suit highway design speed of 110 km/h.

2.3.4 **Tunnels**

a) Separate bores for opposing flows;
b) Cross section - traffic lanes 3.5 m wide, minimum 0.5 m shoulder nearside and offside; and
c) Grade (vertical alignment) - heavy vehicles not required to slow by more than 20 km/h below the posted speed limit.

2.3.5 **Other design criteria**

**Road reserve:**
- Width requirements shall include consideration of short and long term requirements for carriageway widening, interchanges, local / service roads, property accesses, pedestrians, pedal cyclists, stock, environmental safeguards, and urban design / landscaping requirements.

**Pedestrians and cyclists:**
- Provision shall be made for pedal cyclists wanting to travel along and/or join the upgraded highway, or an alternative route made available. Pedestrian amenity shall be considered, particularly adjacent to urban areas.

**Traffic facilities:**
- Consideration of bus stops, emergency pull-over bays, incident management provisions (including consideration of a Variable Message Sign (VMS) strategy) and traffic signals.

**Roadside furniture**
- Items of roadside furniture erected to provide safety (including safety barriers) and the provision of all fencing and other security measures necessary to prevent either unlawful, or accidental access to the project

**Environmental mitigation measures:**
- Provision of environmental mitigation measures including fauna crossings, fauna fencing, noise amelioration and water management structures, as determined by detailed study and in consultation with relevant agencies.

**Stockpile sites:**
- Provision of three stockpile sites along the Preferred Route. Each stockpile site shall be approximately 3,500 m\textsuperscript{2} in area, with a minimum 40 m length on any side, with access addressed by an appropriate Vehicle Management Plan. One stockpile site shall be provided in each of the following locations:
  - Between Gerringong and the Kiama Municipal boundary.
  - Between the Kiama Municipal boundary and Berry
  - Between Berry and Bomaderry.
Public transport operations

- Any permanent infrastructure required to provide for the operations of public transport operators, utility and services agencies and emergency services agencies.

2.3.6 Access strategy

Two standards of design will apply to the upgrade:

1) Off-line sections of the upgrade (i.e. new or greenfield sections of highway) are to adopt an ‘M Class’ standard; and

2) Online sections of the upgrade (i.e. improvements to the existing highway, such as widening, duplication and realignment) are to adopt an ‘A Class’ standard.

The standards are defined in the Pacific Highway Design Guidelines (Issue 2.0) as follows.

1) ‘M Class’ projects are to be designed to 110 km/hr Freeway standard, and require alternative routes to be available for local traffic through the provision of service roads or local arterial road networks.

   Freeway: A special form of controlled access road specifically defined in the State Roads Act. Generally a divided road, with no access for traffic between interchanges and with grade separation at all intersections.

2) ‘A Class’ projects are to be designed as Controlled Access Roads, and must be developed with a strategy for conversion to ‘M Class’ standard in the future. Future conversion should not require changes to the alignments, although ‘A Class’ projects will generally be signposted at 100 km/hr.

   Controlled access roads: The special situation where the Deposited Plans of all properties adjoining the road reserve are annotated to describe the sections where access across the boundary is denied.

For this project there is no requirement for a strategy for future conversion of A Class to M Class.

In line with this strategy, the following principles have been identified for this project:

a) Grade separated interchanges will only be provided to service the towns of Gerringong and Berry. Where possible, these interchanges will be located such that they can also serve as connection points for local roads or service roads. A grade separated interchange will also be considered at Meroo Road.

b) Where the existing alignment is to be improved (on-line sections) and where appropriate and feasible, properties currently directly accessing the existing highway are to connect to a service road. The service road is to connect with the upgrade at either an at-grade seagull-type intersection, or a grade separated interchange where one is accessible for either Gerringong or Berry.

c) Where service roads are not appropriate or feasible, properties will continue to directly access the upgrade with left-in-left-out arrangements, protected right turn, and U-turn facilities provided. This is likely to be the case where residences are sparse.
d) Where the upgrade is located in “green-field” (off-line sections), and local roads are crossed, the local road is not to connect with the upgrade, but will cross the upgrade in under or over-pass as appropriate for the terrain. The local road will connect to the upgrade via the existing highway route. Adjustments will be made to affected properties to provide access to a local road.

e) Where the upgrade is not located on the existing alignment (off-line sections), the existing alignment will revert to a collector road, which will connect to the upgrade with at-grade seagull-type intersection or at a grade separated interchange where one is accessible for either Gerringong or Berry.

2.4 Existing road network characteristics

As background to this audit, a brief description of the existing road network characteristics is outlined in this section.

2.4.1 Key intersections

All the intersections within the study area on the Princes Highway are currently uncontrolled or priority intersections, except for a two lane roundabout at Cambewarra Road at the southern end of the study area.

Some of the key intersections along the existing Princes Highway are:

a) Fern Street (northern access to Gerringong);

b) Belinda Street (southern access to Gerringong);

c) Tannery Road (access to David Berry Hospital and to the Sandtrack);

d) Woodhill Mountain Road (access to North Street and Broughton Vale);

e) Prince Alfred Street (connection to Shoalhaven Heads);

f) Kangaroo Valley Road (access to Kangaroo Valley);

g) Meroo Road (access to Bomaderry); and

h) Cambewarra Road (access to Bomaderry and Moss Vale).

2.4.2 Existing traffic volumes

Mid-block tube counts along the Princes Highway were conducted for one week in February 2007, as summarised in Table 2.2 below.

<table>
<thead>
<tr>
<th>Location</th>
<th>February 2007 peak hour flow (veh/hr)</th>
<th>Estimated 2007 AADT (veh/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Northbound</td>
<td>Southbound</td>
</tr>
<tr>
<td>Princes Highway, north of Fern Street</td>
<td>700</td>
<td>900</td>
</tr>
<tr>
<td>Princes Highway, north of Tannery Road</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>Princes Highway, north of Cambewarra Road</td>
<td>450</td>
<td>400</td>
</tr>
</tbody>
</table>

AADT = Annual average daily traffic

Source: Automatic tube counts 12/02/07- 18/07/07, Maunsell estimate of AADT, 2007
2.4.3 Speed limits

The existing speed limit on the highway varies significantly, as follows:

a) Mount Pleasant Lookout to Fern Street – 80 km/h;

b) Fern Street to Foxground Road – 100 km/h;

c) Foxground Road to Tannery Road – 90 km/h;

d) Tannery Road to Albany Street (Berry) – 50 km/h;

e) Albany Street to Victoria Street (Berry) – 60 km/h; and

f) Victoria Street to 400 metres north of Cambewarra Road – 100 km/h (70 km/h on approach to the at-grade roundabout intersection with Cambewarra Road).

2.4.4 Travel speeds

Vehicle travel speeds have been extracted from the mid-block tube counts at various locations along the Princes Highway within the study area. The 85th percentile and average speeds at each location are summarised in Table 2.3.

<table>
<thead>
<tr>
<th>Location</th>
<th>85th percentile speed (km/h)</th>
<th>Average speed (km/h)</th>
<th>Speed limit (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Princes Highway, north of Fern Street</td>
<td>93.9</td>
<td>85.5</td>
<td>100</td>
</tr>
<tr>
<td>Princes Highway, north of Tannery Road</td>
<td>72.6</td>
<td>64.7</td>
<td>60</td>
</tr>
<tr>
<td>Princes Highway, north of Cambewarra Road</td>
<td>83.6</td>
<td>73.8</td>
<td>70</td>
</tr>
</tbody>
</table>

Source: Australasian Traffic Surveys, 2007

The average speeds on the Princes Highway at stations north of Tannery Road and north of Cambewarra Road are higher than the speed limits as the speeds were taken at locations immediately after a speed reduction from 90 km/h to 60 km/h and 100 km/h to 70 km/h respectively.

2.4.5 Freight transport

The Princes Highway is currently classified as a B-double route between Wollongong and Nowra. Further upgrades within the study area are expected to increase the attractiveness of the Princes Highway for freight transport.

2.4.6 Public transport

The study area is served by two modes of public transport – bus/coach services and train. Public transport accounts for less than 10 per cent of the mode share in Kiama and Shoalhaven Local Government Areas.

The bus and coach services that utilise the Princes Highway route comprise of local / regional services as well as catering for long distance travel, however services are however very limited.

The use of rail services is limited as the South Coast Railway terminates at Bomaderry north of the Shoalhaven River.
2.4.7 Overtaking opportunities

Overtaking lanes are important at locations where slower moving vehicles prevent other vehicles from travelling at their desired speed. Overtaking lanes are often found at windy or hilly sections of highways. There are eight overtaking opportunities when travelling along the Princes Highway within the study area. Details of the overtaking lanes on both directions of the Princes Highway are summarised in Table 2.4.

Table 2.4 Overtaking lanes on the Princes Highway

<table>
<thead>
<tr>
<th>Direction</th>
<th>Starting from</th>
<th>Finishing at</th>
<th>Length (metres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB</td>
<td>0.54 km south of Belinda Street</td>
<td>1.40 km south of Belinda Street</td>
<td>860</td>
</tr>
<tr>
<td>SB</td>
<td>2.79 km south of Belinda Street</td>
<td>3.92 km south of Belinda Street</td>
<td>1,130</td>
</tr>
<tr>
<td>SB</td>
<td>4.25 km south of Belinda Street</td>
<td>4.56 km south of Belinda Street</td>
<td>310</td>
</tr>
<tr>
<td>SB</td>
<td>3.02 km south of Kangaroo Valley Road</td>
<td>3.73 km south of Kangaroo Valley Road</td>
<td>710</td>
</tr>
<tr>
<td>SB</td>
<td>1.16 km south of Turners Lane</td>
<td>2.12 km south of Turners Lane</td>
<td>960</td>
</tr>
<tr>
<td>NB</td>
<td>0.05 km north of Meroo Road</td>
<td>0.73 km north of Meroo Road</td>
<td>680</td>
</tr>
<tr>
<td>NB</td>
<td>1.95 km north of Turners Lane</td>
<td>2.73 km north of Turners Lane</td>
<td>780</td>
</tr>
<tr>
<td>NB</td>
<td>2.60 km north of Foxground Road</td>
<td>3.71 km north of Foxground Road</td>
<td>1,110</td>
</tr>
</tbody>
</table>

Source: Maunsell, 2007
SB = southbound, NB = northbound

2.4.8 Walking and cycling modes

There are limited footpaths along the Princes Highway within the study area. Pedestrian volumes are generally low for the majority of the route with the exception in Berry. A 2002 pedestrian survey between Prince Alfred Street and Alexandra Street in Berry showed that there were approximately 1000 people crossing the highway in an hour on a Sunday afternoon. Pedestrian refuges are installed along the highway in Berry to assist pedestrians to cross the highway.

Within the Shoalhaven Local Government Area, there is provision for an unmarked on-road cycle route on the Princes Highway between Berry to Bomaderry. This route connects with on-road cycle routes in Bomaderry on Meroo Road and Bolong Road.
2.5 Crash history

While analysis of the crash history does not form part of the audit, the existing crash history for the extent of the project was analysed by the RTA Southern Region for a five year interval, between 1 October 2001 and 30 September 2006. The crash location by severity is plotted in Figure 2.3.

Figure 2.3 Location of crashes on the Princes Highway (2001-2005)

Source: RTA, 2006

2.5.1 Crash category

Crash data for the 5-year period (2001 to 2006) indicates that 261 crashes have occurred on the Princes Highway between Mount Pleasant Lookout and Cambewarra Road in Bomaderry. Of the total crashes, nine were fatal (3.4% of total) crashes that resulted in 10 fatalities. There were 119 injury crashes (44.1% of total) that resulted in 179 casualties and 167 non-injury (tow away) crashes (52.5% of total).

The six most common types of crashes account for some 80 per cent of all accidents within the study area. The type and number of crashes were:

a) Rear-end (56);
b) Off carriageway on curve, hit object (41);
c) Intersection, adjacent approaches (45);
d) Head-on (not overtaking) (27);
e) Off carriageway on straight, hit object (28);
f) Off road on curve (11).
Total Intersection: 86 (33%); and
Total Non-Intersection: 175 (67%).

Other characteristics were:

i) Vehicle type: cars were involved in 88.5% of crashes with the remainder involving light trucks (18%) and heavy vehicles (13.4%);

j) Single vehicle crashes: (37.2%);

k) Speed limit: 100 km/h (48.5%), 90 km/h 14.3% and 80 km/h (17.3%);

l) Lighting: Daylight (74.3%), darkness (20.7%) dawn (0.2%) and dusk (4.2%); and

m) Road surface: wet (33.3%) and dry (66.7%).

Contributing factors were identified as speed (24.5%), fatigue (7.3%) and alcohol (2.3%).
3.0 The audit process

3.1 Scope of this report

This audit comprises a Stage 1 preliminary concept design audit for the short-listed routes. The audit was conducted to ascertain potential road safety issues for all road users.

Given the current development of the options, the audit is limited to consideration of elements identifiable from the preliminary alignment plan and longitudinal sections. As design development proceeds, further design elements would be developed and be subject to a Stage 2 design road safety audit. Issues considered during the audit were:

a) Road alignment and cross-section;
b) General arrangement of interchanges;
c) Local and property access, where identifiable;
d) Provision for pedestrian and cycle movements, and;
e) Potential staging and construction issues.

Issues to be addressed in the Stage 2 audit may include:

f) Lighting;
g) Physical objects;
h) Drainage;
i) Road pavement;
j) Traffic control devices, and;
k) Roadside safety barriers.

The objective of the audit was to identify potential safety issues for all road users and to ensure that these are recognised and considered. The following matters were considered:

l) Have all of the permitted movements of all of the various road users been catered for in a safe way?
m) Are the appropriate operational and control mechanisms in place to promote safety?
n) Would the system operate to an acceptable level of safety in all situations, such as poor weather and during darkness? and;
o) Are there opportunities to reduce the occurrence or severity of crashes?

Although the audit reviewed and identified safety issues, the responsibility for assessing and implementing the recommendations remains with the designers, project managers and asset owners. It is not the role of the auditor to provide solutions to the identified safety issues; however identification of potential safety concerns may assist the designer in developing alternative remedial solutions.

3.2 Audit team

This road safety audit was undertaken by:

Bev Atkinson IPWEA Level 3 Auditor
Gillian McCartney IPWEA Level 1 Auditor
3.3 Information sources

The following documents have been referenced during the audit:

a) Accident Reduction Guide, Part 2: Road Safety Audits (RTA, August 2005);
b) Road Design Guide (RTA, 2000, various);
c) Road Safety Audit, Second Edition (AUSTROADS, 2002);
d) Guide to Traffic Engineering Practice, Part 14: Bicycles (AUSTROADS, 1999);
e) Guide to Traffic Engineering Practice, Part 13: Pedestrians (AUSTROADS, 1999); and
f) NSW Bicycle Guidelines (RTA, 2004).

There were no design reports supplied as part of the audit, although a brief summary of design criteria and the RTA accident analysis were provided during the audit.

The potential risk associated with the deficiencies identified has been based on a subjective assessment of the accident severity and crash frequency, as outlined in Section 4.

3.4 The audited plans

The audited plans comprise the preliminary concept design drawings (information documents) for Sections A, B, C, B/C and D, namely:

<table>
<thead>
<tr>
<th>Section</th>
<th>Route</th>
<th>Plan and profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section A</td>
<td>Red route</td>
<td>ID plan and profile – Route 1A_01</td>
</tr>
<tr>
<td>Section B</td>
<td>Pink route</td>
<td>ID plan and profile – Route 2A_01, Route 2A_02, Route 2A_03</td>
</tr>
<tr>
<td></td>
<td>Green route</td>
<td>ID plan and profile – Route 2B_01, Route 2B_02, Route 2B_03</td>
</tr>
<tr>
<td></td>
<td>Yellow route</td>
<td>ID plan and profile – Route 2E_01, Route 2E_02, Route 2E_03</td>
</tr>
<tr>
<td>Section C</td>
<td>Blue route</td>
<td>ID plan and profile – Route 3A_01, Route 3A_02</td>
</tr>
<tr>
<td></td>
<td>Orange route</td>
<td>ID plan and profile – Route 3C_01, Route 3C_02</td>
</tr>
<tr>
<td>Section B/C</td>
<td>Brown route</td>
<td>ID plan and profile – Route 2D_01, Route 2D_02, Route 2D_03, Route 2D_04</td>
</tr>
<tr>
<td>Section D</td>
<td>Purple route</td>
<td>ID plan and profile – Route 4A_01, Route 4A_02, Route 4A_03</td>
</tr>
</tbody>
</table>

Typical cross sections, ref 60021933-SK-0001 (02) and SK-0002 (03)

Any intersection and interchange arrangements shown on these plans are conceptual and indicative only and are not included in this audit. Subsequent design audits will consider the intersections and interchanges once details are available.
4.0 Risk classification methodology

4.1 Risk assessment system

The rating of the importance of the problem / deficiency has been undertaken in accordance with the RTA Accident Reduction Guide, Part 2: Road Safety Audits (August 2005). The following subsections describe the proposed methodology to be used in the risk analysis.

4.2 Crash frequency

The probable frequency of crash occurrence, resulting from each safety issue identified in the audit is assessed from the options presented in Table 4.1.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly probable</td>
<td>It is likely that a number of these crashes of this type could occur within one year.</td>
</tr>
<tr>
<td>Occasional</td>
<td>It is likely that one crash of this type could occur within one year.</td>
</tr>
<tr>
<td>Improbable</td>
<td>It is likely that one crash of this type could occur every three years.</td>
</tr>
</tbody>
</table>

4.3 Crash severity

The severity of the crash resulting from the identified safety issue is rated from the choices presented in Table 4.2.

<table>
<thead>
<tr>
<th>Severity</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major</td>
<td>The crash is likely to result in death or serious injuries</td>
<td>High / medium speed vehicle collision&lt;br&gt;High / medium speed collision with a fixed object&lt;br&gt;Pedestrian struck at high speed&lt;br&gt;Cyclist hit by car</td>
</tr>
<tr>
<td>Moderate</td>
<td>The crash is likely to result in minor injuries or large scale property damage</td>
<td>Some slow speed vehicle collisions&lt;br&gt;Cyclist falls&lt;br&gt;Rear end crashes</td>
</tr>
<tr>
<td>Minor</td>
<td>The crash is likely to result in minor property damage or many near miss crash events</td>
<td>Some slow speed collisions&lt;br&gt;Pedestrian walks into object (No head injury)&lt;br&gt;Car reverses into post</td>
</tr>
</tbody>
</table>
4.4 Level of risk

Deficiencies are then rated for their importance according to a three-tiered system, based on the following matrix, summarised in Table 4.3.

<table>
<thead>
<tr>
<th></th>
<th>Highly probable</th>
<th>Occasional</th>
<th>Improbable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Moderate</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Minor</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>
5.0 Audit statement

We, the undersigned, have undertaken Stage 1 Preliminary Concept Design Audit for the Gerringong to Bomaderry Princes Highway Upgrade. The audit was conducted in accordance with the RTA Accident Reduction Guide, Part 2: Road Safety Audits 2005, for the purpose of identifying any features, which that potentially impair road safety.

While every care and diligence has been taken to identify potential safety concerns, as detailed in this report, we do not warrant that every safety issue has been identified.

Bev Atkinson
Lead Auditor
Date: 29 October, 2007

Gillian McCartney
Auditor
6.0 Audit findings

The audit findings are presented below and are based on Sections A, B, C, B/C, and D. The chainages and descriptions are referenced from north to south. For uniformity the highway is assumed to be orientated north-south, irrespective of the actual orientation at a specific location. The findings are not presented in any order of relative importance.

The route options assessed are:

- **Section A**  Red route
- **Section B**  Pink, Green and Yellow routes
- **Section C**  Blue and Orange routes
- **Section B/C**  Brown route
- **Section D**  Purple route

Several features have not yet been developed as this is a preliminary concept design only. Findings in this audit related to local road and property access in particular, are indicative only and further design development would permit more detailed review in the preferred route phase. Similarly, findings related to the coordination of vertical and horizontal alignment are based on the current preliminary concept design, which is anticipated would be modified in further design development.

The general findings, which relate to all route options, in varying degrees, are

a) **Horizontal and vertical alignment**

- Extended lengths of straight, flat alignments may contribute to:
  - Potential for increased speeds;
  - Drivers having difficulty in maintaining concentration; and
  - Drivers being less prepared for horizontal curves and in selecting the appropriate negotiation speed.

- Vertical alignment with grades exceeding six per cent are undesirable, although the existing alignment may be a contributing factor, resulting in:
  - The speed differential for cars and trucks on uphill sections will increase the potential for lane changing type crashes; and
  - Merges located on steep upgrades particularly where trucks are a significant proportion of entering traffic will increase the potential for rear-end and lane changing type crashes.

- Combinations of steep grades and minimum radii horizontal curves, particularly where horizontal curves commence over crests may reduce the driver’s ability to read the alignment and increase the likelihood of accidents.

b) **Cross section**

- A relatively narrow median width (e.g. five metres), depending on the horizontal alignment would result in headlight glare from oncoming vehicles at night, affecting the drivers’ appreciation of the road alignment ahead. The proposed median however, represents an improvement over the existing undivided road configuration.

- The proposed road cross section provides for sufficient shoulder width (2.5 m) to permit use by cyclists. However the narrow shoulders (0.5 m) through tunnel sections will provide a significant constraint to cyclist use. It is noted that the routes which include tunnels are likely to involve continued use of the existing highway as a local access road which may also provide an alternative route for cyclists.
c) **Intersection treatments**

- Route options next to the rail line may introduce potential conflicts due to proximity of on-load and off-load ramps, intersections and interchanges from the highway to rail crossings. It is assumed that existing grade separated rail crossings of local roads would be retained, with local access maintained by connecting service roads. Given the potential for serious accidents at at-grade rail crossings, it is assumed that there would be no new at-grade crossings of the rail line of either the upgrade or local roads.

- Some routes will include intersections with local roads. A controlled access strategy will be applied including “left in” / “left out” only arrangements, protected right turns and U-turn facilities. Intersections increase the amount of potential points of conflict and hence designs must provide adequate provision for sight distance, queuing, deceleration and acceleration (all routes).

d) **Tunnels**

- The constrained width of cross section in the tunnels will increase the accident potential in the event of breakdown or incident.

- In the event of breakdown or incident, the narrow shoulders (0.5 m) will provide limited safe evacuation routes for pedestrians to emergency phones or exits, where moving traffic is adjacent to the shoulder.

- The constrained width of cross section in the tunnel would increase the severity of crashes.

The audit findings in relation to the individual routes are presented in the following sections.
6.1 Section A – Red route

The Red route follows the existing highway corridor.

6.1.1 Northern extremity – interface between the upgrade and existing highway

The northern tie-in occurs just to the south of a small radius horizontal curve, (estimated at approximately 120 m radius). The relationship of the horizontal curve to the crest vertical curve, some eight per cent upgrade, speed zone and relationship / compatibility to the upgraded section of the highway, particularly for northbound travel direction is not evident from the audited concept. However it is important that drivers accelerating on the upgrade appreciate the horizontal curve ahead and have adequate warning to adjust speed. Increased speeds in the southbound travel direction may occur due to the downgrade.

The RTA crash analysis (2002-2006) indicates a cluster of injury crashes in this section; however it is not feasible to identify whether the horizontal curve and grades are implicated.

Mount Pleasant Lookout access is located on the outside of the horizontal curve, some 170 m from the end of the proposed works. Right turn entry and exit movements at this junction may contribute to rear-end accident potential with stationary right turn vehicles and no passing opportunity or slow moving vehicles entering from the side road affecting the centre (fast) lane.

Frequency: Occasional
Severity: Major
Risk: High

6.1.2 Horizontal and vertical alignment between Ch 230 to 1150

The horizontal and vertical alignment has offset horizontal and vertical curves with a short section of straight separating horizontal curves. This may contribute to poor lane discipline and restrict drivers’ appreciation of the road alignment ahead.

An eight per cent upgrade is proposed for the northbound travel direction, which is considered at the upper limit for highway design. Due to the long length of the grade, the speed differential between northbound trucks and cars will increase substantially, with accident potential, as discussed in Section 6.1.3 following.

A 600 m radius curve (currently the minimum horizontal curve radius for a 110 km/h design speed) is located within the section of the upgrade. The relationship of the crest beyond the start of the works and southbound drivers’ view of the horizontal 600 m radius curve would be important to avoid run-off the road and head-on accident potential.

Frequency: Occasional
Severity: Moderate
Risk: Medium
6.1.3 Local road access at Ch 1400 (northbound)

Merge on upgrade

The northbound merge lane from the local road access is on an initial upgrade of some 4.2 per cent increasing to some eight per cent over the actual merge with highway traffic. The location of the merge on a relatively steep upgrade would potentially contribute to rear end or side swipe type accidents particularly due to slower moving trucks. The proportion of truck traffic on the side road junction is not known, however the effects of grade and vehicle type in combination with the upgrade should be taken into account during design development.

Frequency: Occasional  
Severity: Moderate  
Risk: Medium

6.1.4 Local road access at Ch 1400 (southbound)

It is not clear whether the proposed design will accommodate a local access / merge lane for traffic to join the highway southbound. Preliminary indications are that this movement would not be permitted, which would be desirable, due to potential conflicts at the ramp junctions.

However, two lanes (two-way) are proposed on the local access on the eastern side of the highway and to the south, which would generate vehicle conflicts with traffic on the exit ramp from the highway and turning traffic to and from the local road and the western side of the highway.

It is also likely that headlight glare at night from northbound traffic on the local road and southbound traffic on the off-load ramp may affect drivers’ appreciation of the road ahead, with drivers’ braking on the off-load ramp.

Frequency: Occasional  
Severity: Moderate  
Risk: Medium

6.1.5 Fern Street interchange

It is understood that the feasibility of providing an interchange at Fern Street is under review. The potential local access crosses the rail line at Ch 2220. Based on the highway grading, it is assumed that the rail crossing would be at-grade. The alignment of the access road approach is skewed, which would affect driver’s view of the rail line approaches and allow for increased speed at the crossing.

Frequency: Occasional  
Severity: Major  
Risk: High

6.1.6 Pavement drainage in section of flat grade

An extended length of very flat grade (longitudinal grade of 0 per cent) is proposed between approximately Ch 1750 and 2800. This coincides with a short section of horizontal curve. The design of pavement drainage must ensure that aquaplaning would be avoided.

Frequency: Occasional  
Severity: Moderate  
Risk: Medium
6.1.7 Construction staging

The proposed alignment follows the existing highway corridor which would require careful consideration of construction staging. Particular care would be required where the new works have significant level changes from existing.

Frequency: Occasional
Severity: Moderate
Risk: Medium
6.2 Section B – Pink route

The Pink route improves the horizontal alignment of the highway. Whilst it generally follows the existing corridor, the majority of the route is offline and crosses the existing highway at several locations.

6.2.1 Horizontal curve located over crest (Ch 932-1187)

Drivers’ appreciation of the road alignment will be restricted in the northbound travel direction, due to the location of a horizontal curve (600 m radius) over a crest vertical curve. The vertical curve at 600m radius and 900 m length is anticipated to provide acceptable stopping sight distance (SSD) (1.15 m to 0.2 m). The road would be in cutting in the vicinity of the crest and benching as indicated may assist in maximising sight lines.

Frequency: Occasional
Severity: Major
Risk: High

6.2.2 Property access near Ch 2000 (southbound)

A property access with an acute angle of approach to the highway is located on a six per cent downgrade and on the outside of a horizontal curve. The proposed treatment of property access is not indicated on the current design plan; however the alignment of the access, and the effects of grade and curve, will need to be taken into account, if highway access is retained.

Frequency: Improbable
Severity: Moderate
Risk: Low

6.2.3 Pavement drainage in section of flat grade

A section of very flat grade (longitudinal grade <1%) is proposed between Ch 2470 and 2830, and Ch 5600 to 6850. The design of pavement drainage must ensure that aquaplaning would be avoided.

Frequency: Occasional
Severity: Moderate
Risk: Medium

6.2.4 “Broken back” horizontal curves at Ch 3450

A short section of straight is proposed to separate two 600 m radius horizontal curves. The location with six per cent downgrade on the northern approach may contribute to poor lane discipline and reduce drivers’ appreciation of the alignment. Due to the two northbound lanes and divided carriageway, potential crashes would be limited to side-swipe type accidents.

Frequency: Improbable
Severity: Moderate
Risk: Low
6.2.5 Proposed alignment follows and crosses existing highway (Ch 4200, 5600-5900, 7200, 7500, 7700, 8000 and 8400).

The proposed alignment follows or crosses the existing highway at several locations. In the southernmost sections and near Ch 4300, there is a substantial level difference between the existing and proposed design levels which would contribute to difficulties in maintaining access during construction.

Staging would require careful consideration to maintain access at side road junctions to the existing highway which may otherwise be severed by the new road alignment.

The proposed alignment departs from the existing highway at approx Ch 4200. Whilst no detail of the junction treatment is provided, the substantial cutting to the south may influence the junction treatment and sight distances.

Frequency: Occasional
Severity: Major
Risk: High

6.2.6 Horizontal curve located at crest (Ch 4570-6480)

Drivers’ appreciation of the road alignment ahead would be restricted in the southbound travel direction, due to the horizontal curve commencing in the vicinity of the crest of the vertical curve. Once over the crest, the driver would see a large sweeping horizontal curve on a downgrade over an extended length, with the potential to encourage increased speeds. Lane discipline may be affected by the need to maintain a constant turning alignment for some 1.9 km, with potential for side swipe type accidents.

For drivers travelling in the northbound direction, to the north of the crest there would be a series of significantly smaller horizontal curves approaching the crest uphill (Radii decreasing from 1220 m approaching the crest uphill, to 750 m to 600 m on the downgrade on departure). Drivers accelerating on the downgrade may exceed desirable speeds for the 600 m radius horizontal curves. However, this radius meets the current minimum horizontal curve criteria for the 110 km/h design speed.

The road would be in cutting in the vicinity of the crest. Benching as indicated on the preliminary concept design may assist in maximising sight lines to assist drivers’ appreciation of the road alignment.

Frequency: Occasional
Severity: Major
Risk: High
6.3 Section B – Green route

The Green route follows the Pink route alignment between Ch 0 and 3100, and between Ch 6900 and 8900. Therefore findings relevant to these sections of the Pink route apply to the Green route. The Green route provides for a 350 m long section of tunnel between Ch 4514 and 4900.

6.3.1 Horizontal curve on northbound tunnel approach

The southbound exit from the tunnel is a 750 m radius horizontal curve commencing 78 m south of the tunnel portal and after the crest of a vertical curve. Southbound drivers would have limited appreciation of the road alignment due to the exit from the tunnel portal with the potential of changed light conditions, potential sun glare, and location of the start of the horizontal curve over crest.

For drivers travelling northbound, the proximity of the horizontal curve at the tunnel portal and the substantial cutting on the southern approach may restrict sight distance on the tunnel approach and contribute to drivers crossing the centreline or leaving the carriageway in the vicinity of the portal.

Frequency: Occasional  
Severity: Major  
Risk: High

6.3.2 Tunnel cross section

The tunnel cross section provides for two 3.5 m wide lanes and 0.5 m wide shoulders, with separate tunnels for each traffic direction. In the event of breakdown or accident within the tunnel there would be potential for rear-end accidents, with vehicles stopped in the traffic lane and absence of breakdown bays. Pedestrians walking on the shoulder to reach emergency phone or exit locations would be at risk due to the narrow shoulder / proximity to moving traffic.

Frequency: Occasional  
Severity: Major  
Risk: High

6.3.3 Coordination of horizontal and vertical alignment

The alignment provides for a combination of horizontal and vertical curves with offset start and end points (Ch 6150 to 6850) which would make the alignment less legible for drivers.

Frequency: Improbable  
Severity: Moderate  
Risk: Low

6.3.4 Proposed alignment follows and crosses existing highway (Ch 7700, 8100 and 8300)

The proposed alignment follows or crosses the existing highway at multiple locations where there are substantial level differences between the existing and proposed design levels which would contribute to difficulties in maintaining access during construction.

Staging would require careful consideration to maintain access at side road junctions to the existing highway which may otherwise be severed by the new road alignment.

Frequency: Occasional  
Severity: Moderate  
Risk: Medium
6.4 **Section B – Yellow route**

The Yellow route leaves the existing highway in the vicinity of Belinda Street (Ch 0) and runs parallel to the existing railway before leaving it at Ch 4200 and curving westward.

6.4.1 **Treatment of side road and property access junctions adjacent to the railway (Ch 1500, 2300, 3100, 3750, and 4200)**

The Yellow route follows the existing railway with 25 m to 35 m separation. The treatment of junctions to the upgraded highway is not indicated on the current preliminary concept design, however it is understood that some access and service roads will be provided in order to maintain local road access. It is assumed that all new crossings of the railway will be grade-separated due to the potential for major accidents at rail level crossings.

Design of junctions with the highway will need to take into account the proximity of grade-separated rail crossings and potential for steep grades.

- **Frequency:** Occasional
- **Severity:** Moderate-
- **Risk:** Medium

6.4.2 **Horizontal curve located after a long straight**

The alignment is relatively straight and flat (grade 0.06% - 1.0%) for the first 4 km as the route follows the railway. For southbound traffic a 750 m radius horizontal curve at Ch 4227 is proposed. The relatively long section of straight preceding this curve may contribute to increased approach speeds and drivers misjudging the negotiation speed of the curve.

- **Frequency:** Occasional
- **Severity:** Moderate
- **Risk:** Medium

6.4.3 **Tunnel cross section Ch 5750 to 6100**

The tunnel cross section provides for two 3.5 m wide lanes and 0.5 m wide shoulders, with separate tunnels for each traffic direction. In the event of breakdown or accident within the tunnel there would be potential for rear-end accidents, with vehicles stopped in the traffic lane and absence of breakdown bays. Pedestrians walking on the shoulder to reach emergency phone or exit locations would be at risk due to the narrow shoulder / proximity to moving traffic.

- **Frequency:** Occasional
- **Severity:** Moderate-Major
- **Risk:** Medium-High

6.4.4 **East-west alignment of tunnel**

Potential exists for drivers exiting the tunnel portals to be affected by sun glare due to the east-west alignment of this section of the Yellow route.

- **Frequency:** Occasional
- **Severity:** Moderate
- **Risk:** Medium
6.4.5 Horizontal curve Ch 6700 to 7850

A horizontal curve coincides with an area of substantial cutting between Ch7100 and 7500 with the crest of a vertical curve at Ch 7600. Appropriate sight distance would need to be provided and take account of the effects of the earthworks.

Frequency: Occasional
Severity: Moderate
Risk: Medium
6.5 Section C – Blue route

The Blue route extends over 6.5 km, with a relatively flat and gently undulating alignment. The proposed alignment departs from the existing alignment in the vicinity of Tindalls Lane. The alignment remains off-line before converging back to the existing highway in the vicinity of Kangaroo Valley Road. It then follows the existing highway corridor until the end of Section C at Croziers Road. It is understood there may be interchanges located at Ch 300 in the north and at Kangaroo Valley Road west of Berry.

6.5.1 Horizontal curve located at crest (Ch 0 – 500)

Northbound, drivers’ appreciation of the road alignment ahead would be affected by the location of a horizontal curve commencing in the vicinity of the crest of the vertical curve. Once over the crest, the horizontal alignment would be a reverse curve (1200 m radius and 900 m radius) with a short intervening straight on a downgrade encouraging increased speeds. The sag vertical curve to the north (on Pink, Green, and Yellow routes) is sufficient to hide vehicles, although the divided carriageway and barrier would mitigate opposing vehicle conflict.

The alignment for northbound drivers approaching this section can be described as “roller coaster” grading with long straight sections with a 730 m length of 3000 m radius curve intervening. “Roller coaster” grading is vertical alignment with may crests and sags which may lead to opposing vehicles going in and out of vision which may confuse drivers at night due to headlight glare. There is potential for increased speeds and reduced legibility of the alignment for drivers, particularly if considered in combination with any junctions or intersections.

Frequency: Occasional  
Severity: Moderate  
Risk: Medium

6.5.2 Treatment of side road and property access junctions – existing highway (Ch 300, 1950, 2350)

A junction with the highway may be proposed at Tindalls Lane (Ch 300). However the current location is within the area of reverse horizontal curves, level differences and where vertical alignment may affect sight distances; with potential for intersection accidents and rear-end accidents on approaches. Similar accident potential may occur for any junctions located at Ch 1950 and 2350.

Frequency: Occasional  
Severity: Moderate  
Risk: Medium

6.5.3 Access at southern Berry

The current preliminary concept plans do not indicate a southern town centre access / interchange. Should one be developed in the vicinity of Ch 4100 may suggest an overpass option, i.e. Kangaroo Valley Road over the upgrade. However any connecting on-load and off-load ramps in this vicinity would need to take into account the horizontal curve of 600 m radius at this location.

Frequency: Occasional  
Severity: Moderate  
Risk: Medium
6.5.4 Construction staging

In the northern section, there is a substantial level difference between the existing and proposed design levels, which would contribute to difficulties in maintaining access during construction.

Staging would require careful consideration to maintain access at side road junctions to the existing highway, which may otherwise be severed by the new road alignment.

Frequency: Occasional
Severity: Moderate
Risk: Medium

6.5.5 Horizontal curve located after long straight

The alignment is relatively straight for the last 2.6 km. In the northbound direction, the long section of straight precedes a curve, which may contribute to excessive speed and driver’s misjudging the negotiation speed for the curve. The alignment for southbound drivers approaching this section can also be described as “roller coaster” grading (refer Section 6.5.1). Potential for increased speeds and reduced legibility of the alignment for drivers, may contribute to poor lane discipline however, the new divided four lane carriageway will reduce the severity of any side-swipe type accidents.

Frequency: Occasional
Severity: Moderate
Risk: Medium
6.6 Section C – Orange route

The Orange route initially follows the existing highway with localised improvement to horizontal curves over the first three kilometres and crossing the existing highway at several locations, before diverting to a new alignment on the North Street corridor.

6.6.1 Coordination of Horizontal and Vertical Alignment

Horizontal curves starting in the vicinity of crest vertical curves reduce drivers’ appreciation of the road alignment ahead. In addition, the alignment can be described as “roller coaster” grading (refer to Section 6.5.1) over the initial three kilometres, which reduces drivers’ appreciation of the alignment, particularly with the series of 600 m radius curves in this section, and with potential for drivers to misjudge negotiation speeds at curves. At Ch 1317-1437 a short section (120 m) length of 600 m radius curve is indicated. A further short section of some 149 m length of 600 m radius curve is proposed between Ch 715 and Ch 864.

The coordination of vertical and horizontal curves provides for mismatched start / end points. The extent of cutting in the vicinity of the horizontal 600 m radius curve (Ch 300) and the crest vertical curve may reduce sight distance, with drivers’ appreciation of the road alignment reduced.

The depth of sag vertical curves between crest curves is sufficient to hide approaching vehicles. Approach and intersection sight distance requirements will affect the potential introduction of any at-grade access to the highway in this area.

Frequency: Occasional
Severity: Moderate
Risk: Medium

6.6.2 Proposed alignment follows and crosses existing highway at multiple locations

The proposed alignment follows or crosses the existing highway at multiple locations Ch 0, 500, 1100, 1700, 2350, 4200. Locations with substantial level differences between the existing and proposed design levels will contribute to difficulties in maintaining access during construction.

Staging will require careful consideration to maintain access at side road junctions to the existing highway, (which may otherwise be severed by the new road alignment).

Frequency: Occasional
Severity: Moderate
Risk: Medium

6.6.3 Access at northern Berry

Access / interchange solutions would require to meet appropriate design standards and be appropriate for the vehicle and journey types anticipated at this location.

6.6.4 Access at southern Berry

The current preliminary concept plans do not indicate a southern town centre access / interchange. Should one be developed here the topography in the vicinity of Ch 4100 may suggest an overpass option, i.e. Kangaroo Valley Road over the upgrade. However any connecting on-load and off-load ramps in this vicinity would need to take into account the horizontal curve of 600m radius at this location.

Frequency: Occasional
Severity: Moderate
Risk: Medium
6.7 Section B/C – Brown route

The Brown route leaves the existing highway in the vicinity of Belinda Street on the same alignment as the Yellow route. Where the Yellow route departs from the railway at Ch 4200, the Brown route continues to follow the railway alignment into Berry. The Brown route adopts the Orange route alignment along the North Street corridor.

The findings relevant to the Yellow route from Ch 0 to 4200 and the Orange route from Ch 2700 to 6600 also apply to the Brown route. The findings below relate to the Brown route between Ch 4200 and 11800.

6.7.1 Treatment of side road and property access junctions adjacent to the railway

The Brown route follows the existing railway with 25 m to 35 m separation. The treatment of junctions to the upgraded highway is not indicated on the current preliminary concept design, however it is understood that some access and service roads will be provided in order to maintain local access. Similarly existing at-grade crossings or grade separated crossing may be retained, where necessary, for local access.

Design of junctions with the highway will need to take into account the proximity of grade-separated rail crossings and potential for steep grades, due to the limited separation of road and rail. Steep grades may impact deceleration, acceleration and stopping times and therefore load to vehicle conflict.

Frequency: Occasional
Severity: Major
Risk: High

6.7.2 Horizontal curve after a long straight

The alignment is relatively straight and flat (grade 0.06 per cent - 1.0 per cent) for the first six kilometres as the route follows the railway. For southbound traffic a 750 m radius horizontal curve at Ch 6400 is proposed. The relatively long section of straight preceding this curve may contribute to increased approach speeds and drivers misjudging the negotiation speed of the curve.

Frequency: Occasional
Severity: Moderate-Major
Risk: Medium-High

6.7.3 Horizontal curves Ch 7900 – 8600

The proposed alignment between Ch 7900 and 8600 includes two horizontal curves with an intervening straight of 110 m. This combination may contribute to poor lane discipline, with drivers misjudging negotiation speeds and needing to adjust their travel path.

The horizontal curve between Ch 8334 and 8575 also coincides with an area of substantial cutting with the crest of a vertical curve at Ch 8482. The adequacy of sight distance should be confirmed taking into account the effects of earthworks.

Frequency: Occasional
Severity: Moderate
Risk: Medium
6.8  **Section D – Purple route**

The Purple route extends over 10 km following the existing highway corridor with a relatively flat and undulating alignment. The route generally follows the existing highway horizontal alignment with the vertical alignment improved. It has not been determined as yet whether widening would be symmetrical or parallel (or a combination of both).

6.8.1  **Construction staging**

The proposed alignment follows the existing highway. In some sections there is a substantial level difference between the existing and proposed design levels, which would contribute to difficulties in maintaining access during construction.

Staging would require careful consideration to maintain access at side road junctions to the existing highway which may otherwise be severed by the new road alignment.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Severity</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occasional</td>
<td>Moderate</td>
<td>Medium</td>
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</table>

6.8.2  **“Broken back” horizontal curves**

The proposed alignment between approximately Ch 3300 and 4200 provides for a series (3) of horizontal curves with intervening straights and a short section (87 m) of 600 m radius curve. This combination may contribute to poor lane discipline, with drivers misjudging negotiation speeds and needing to adjust their travel path.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Severity</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occasional</td>
<td>Moderate</td>
<td>Medium</td>
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</tbody>
</table>

6.8.3  **“Roller coaster” grading**

The vertical alignment creates “roller coaster” grading (refer Section 6.5.1) with sufficient height differences between crests and sags to obscure an oncoming vehicle from view. Depending on the horizontal alignment, drivers’ appreciation of the road alignment ahead would be affected particularly at night by the alternating appearance of headlights in particular between Ch 3800-5700.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Severity</th>
<th>Risk</th>
</tr>
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<tbody>
<tr>
<td>Improbable</td>
<td>Moderate</td>
<td>Low</td>
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6.8.4  **Coordination of Horizontal and Vertical Alignment**

Horizontal curves starting in the vicinity of crest vertical curves reduce driver’s appreciation of the road alignment ahead e.g. 760 m radius horizontal curve at northbound Ch 6500. Also, the co-ordination of vertical and horizontal curves provides for mismatched start / end points e.g. Ch 8594, with potential for drivers to misjudge the alignment and negotiation speeds.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Severity</th>
<th>Risk</th>
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<tbody>
<tr>
<td>Occasional</td>
<td>Moderate</td>
<td>Medium</td>
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</table>
6.8.5 Junction with existing roundabout at Bomaderry Ch 10000

The upgrade terminates at an existing roundabout. The approach alignment provides for a high speed left turn to the eastern exit. Increased approach speeds may occur due to the straight alignment of the approach and potential speed of the left turn. The speed of the approach and potential for high(er) turning speeds through the roundabout reduce the safety of the roundabout with drivers less likely to stop, or be able to stop, to give way.

Frequency: Occasional
Severity: Moderate
Risk: Medium

6.8.6 Treatment of side road and property access junctions – (Ch0, 950, 1900, 4900, 8500)

The treatment of junctions to the upgraded highway is not indicated. However, junctions with the highway will be required in order to maintain local access. The affects of horizontal and vertical alignment on sight distance should be considered in selecting junction locations, e.g.

a) Ch 0. the intersection treatment should account for the affects of cut embankment on sight distance;
b) Ch 950, junction would be located in sag, although safe intersection sight distance appears to be available;
c) Ch 1900 a potential junction would be located in the vicinity of a crest vertical curve and horizontal curve;
d) Ch 4900. junction would be located in a sag with potential for vehicles to be hidden by crest on southern approach; and
e) Ch 8500. junction would be located in a sag with potential for vehicles to be hidden by crests / sags in approach.

Frequency: Occasional
Severity: Moderate
Risk: Medium