Bolivia Hill Upgrade - Assessment of Route Options

APPENDIX J

INTERNAL TECHNICAL WORKSHOP REPORT

Cardno
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Internal Technical Workshop Report

Bolivia Hill Upgrade – Assessment of Route Options

NA89913018

Prepared for
Roads and Maritime Services

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Appendices

1 Introduction

1.1 Background

Roads and Maritime Services (RMS) engaged Cardno September 2012 to carry out an options and route assessment study and preliminary environmental assessment for upgrading approximately three kilometres of the New England Highway at Bolivia Hill between Glen Innes and Tenterfield.

The New England Highway passes through the Bolivia Range about 55km north of Glen Innes in NSW. The Bolivia Range runs east west and connects with the Great Dividing Range to the east and Deepwater River passes around the range to the west. Bolivia Hill (1225m) and Little Bolivia (1100m) are hills within the Range. Both the New England Highway (1025m) and the Great Northern Railway line (disused) pass through gaps in the range just to the west of Bolivia Hill.

Bolivia Hill has poor horizontal alignment (curves with 75km/h advisory speeds) and steep grades (up to 9.0%) and a poor crash history with respect to fatalities and injuries. It has narrow or no road shoulders with a rock face to the east and steep drop to the west. Traffic at Bolivia Hill is relatively low with little or no growth over recent years.

1.2 The study area

The study area identified for the proposed upgrade covers an area that starts at the top of Bolivia Hill and descends to the valley floor to the north, ending at Pyes Creek bridge (refer to **Figure 1.1**). The area is approximately three kilometres long and approximately 0.75 kilometres wide on either side of the existing highway.

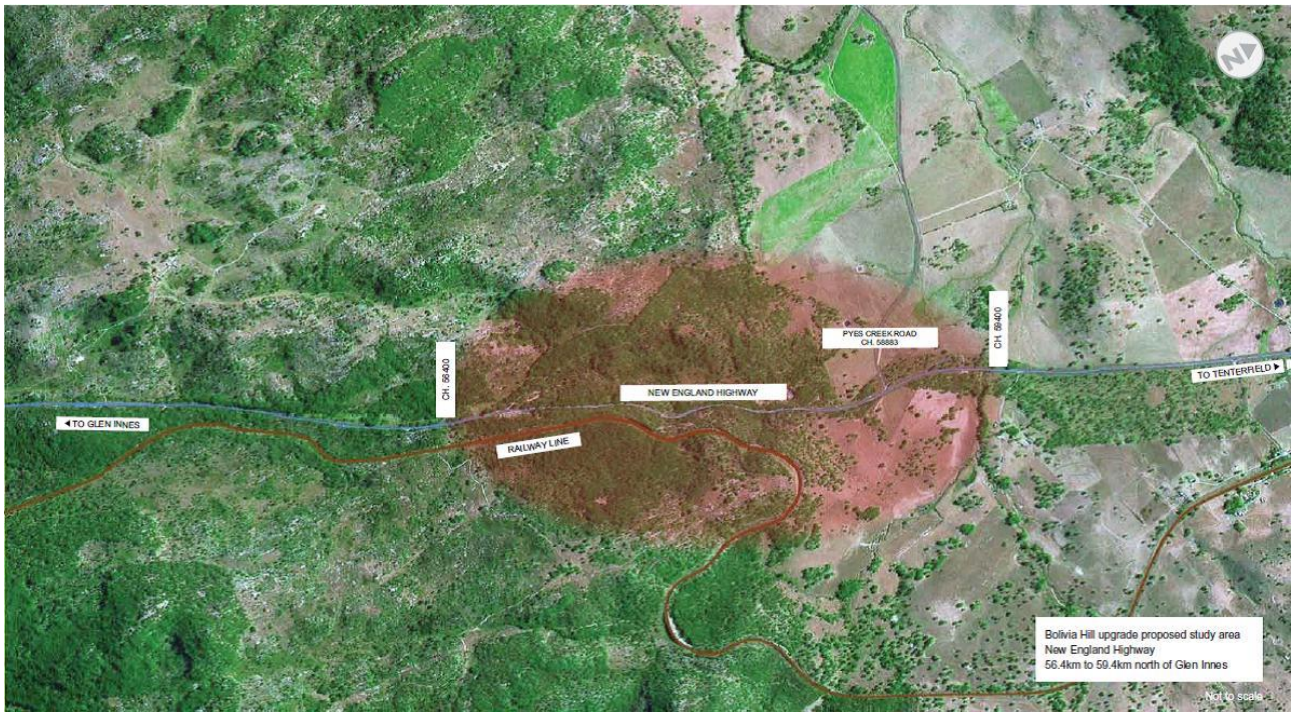


Figure 1.1 Study area

For the purpose of this initial stage of the study, Chainage 0.0 has been established at the southern end of the study area, corresponding to Chainage 56400 shown in **Figure 1.1**.

Significant constraints which influence the location and design of the route options include:

- The existing highway corridor
- Sub-standard road geometry of the existing highway

- Very steep terrain
- Floodplain located in the north of the study area
- The Main Northern railway (disused)
- Indigenous and non-Indigenous cultural heritage at various locations across the study area
- Colonies of Endangered Ecological Community and threatened plant species.

1.3 Project objectives

The aim of the project is to determine a preferred New England Highway corridor route at Bolivia Hill. RMS determined the objectives for this project as follows:

i. Improve road safety.

ii. Improve road transport productivity, efficiency and reliability of travel.

iii. Minimise the impact on the natural, cultural and built environment.

iv. Provide value for money.

The highway will be upgraded by improving horizontal alignment and vertical grades. Upgrade options will consider an overtaking lane for southbound traffic and possibly a dual lane carriageway separated by wire rope.

1.4 Workshop purpose

The Internal Technical Workshop (ITW) was held on 21 November 2012. The purpose of the workshop was to provide a forum for discussion on the potential options and the constraints around them with input from stakeholders including RMS and Transport for NSW (TfNSW).

The process leading to the workshop was as follows:

- Desktop studies were carried out (refer to Section 2) and constraints mapped
- A range of preliminary route options were developed using MX 3D road design software (refer to Section 3)
- Criteria for assessing the preliminary route options were developed in consultation with RMS (refer to Section 4)
- The process proposed for the ITW was developed in consultation with RMS (refer to Section 4).

The workshop used a Multi Criteria Decision Analysis (MCDA) approach to refine options from eleven to four that will be carried into the next phase of the project for further investigation and design.

A copy of the workshop agenda is included in **Appendix A.**

1.5 This report

This report has been prepared to be included as **Appendix A** of the **Preliminary Route Options Report**.

The report presents the findings of the preliminary route options internal technical workshop process. The process is described in **Chapter 7** of the main report.

2 Specialist studies

2.1 Overview

A number of key environmental, engineering and economic issues influence the location and design of route options and ultimately the preferred route. Preliminary investigations were carried out, including reviews of studies from previous investigations into the upgrade.

The investigations comprised a review of existing background data and analysis to provide a preliminary understanding of the physical, environmental, social and economic aspects of the study area. Specialist studies conducted during the preliminary route options development phase included:

- Geotechnical
- Topography, geology and soils
- Visual amenity
- Traffic, transport
- Public utilities and services
- Social-economic
- Flora and fauna (terrestrial and aquatic)
- Cultural heritage (Indigenous and non-Indigenous)
- Flooding and drainage
- Land use and planning.

The results of these studies were summarised in the *Internal Technical Workshop Background Paper*, *November 2012* (ITW Background Paper) that was provided to workshop participants two weeks prior to the workshop.

In fulfilling a commitment to the community, this project also includes a comprehensive community engagement program to facilitate community engagement in the route options development process.

2.2 Constraints maps

Constraints identified in the studies were entered into a GIS database and the following constraints maps produced:

- Crown Land, Flora and Fauna
- Geotechnical
- Utilities
- Hydrology
- Biodiversity
- Aboriginal Heritage
- Non-aboriginal Heritage.

The constraints maps were included in the ITW Background Paper that was provided to workshop participants.

3 Preliminary route options

3.1 Overview

A number of preliminary route options were developed using MX road design software. The centrelines of the options are shown on the plan included in **Appendix B**. Descriptions of the options and the alignment plan were provided in the ITW Background Paper that was provided to workshop participants two weeks prior to the workshop.

The horizontal and vertical alignments were developed to conform to the following design criteria:

- Design speed 110km/h
- Absolute minimum horizontal curve radius.460m
- Vertical alignment grade no greater than 6%.

Note that Option 7 was developed to eliminate the existing nonconforming horizontal alignment and to tie into the existing roadway as quickly as possible. The vertical alignment has grades up to 9% and is therefore nonconforming.

Note that the cross section used to produce the preliminary options is a 'worst case' with 4 x 3.5m lanes protected by wire rope in the centre, with embankments and cuttings at 2H : 1V benched every 10m in height

The Preliminary Geotechnical Report suggests that steeper batters may be possible as cuts become deeper. The batter slopes in the design will be refined in the next stage of the project following field investigations along the short listed alignments.

The specialists charged with assessment of the options (refer to **Section 4.2**) had access to the MX design longitudinal sections and footprints for the options. These footprints show the extent of cut and fill batters.

A very brief and broad description of each of the options follows. The lengths for cuts, fills, bridges and tunnels in the descriptions following are approximate only and will be refined in the next stage of the investigation.

3.2 Preliminary route options

3.2.1 General

The descriptions of the options start at the southern end of the project area. Apart from Option 7, all options start at assumed Chainage 0 at the southern end of the project area.

The reconnection of Pyes Creek Road to the proposed alignments is not described in the options below as it is a minor cost in the scheme of the project at this preliminary stage. Treatments may include a new alignment and intersection for Pyes Creek Road or a bridge/arch over Pyes Creek Road and a new intersection.

3.2.2 Option 1

- Option 1 is 3450m long
- The first 1000m consists of minor cut and fill plus a bridge 130m long over the watercourse in the gully to the west of the existing highway
- The alignment moves into a major cut through the ridge at the western extent of the study area. The cut is 700-800m long and up to 65m deep. A tunnel option (450m in length) through this section will be assessed on cost and constructability comparison
- The alignment then moves into extensive fill up to 15m high as it grades down to the Brickyard Creek floodplain. Extensive retaining walls may be required. A bridge up to 150m long will be required across the watercourse to the west of the existing highway just south of Pyes Creek Road

- To the north of the bridge the alignment is in minor fill with the last 200m being an upgrade of the existing highway.

3.2.3 Option 2

- Option 2 is 3200m long
- The first 1050m consists of minor cut and fill plus a bridge 150m long over the watercourse in the gully to the west of the existing highway
- The alignment moves into a major cut through the ridge at the western extent of the study area. The cut is 600m long and up to 25m deep. The majority of the cut is on the western side of the alignment into the ridgeline
- The alignment then moves into extensive fill up to 20m high as it grades down to the Brickyard Creek floodplain. Extensive retaining walls and or bridges may be required. A bridge up to 200m long will be required across the watercourse to the west of the existing highway just south of Pyes Creek Road
- The high fill continues over Pyes Creek Road and grades down with the last 200m being an upgrade of the existing highway.

3.2.4 Option 3

- Option 3 is 3120m long
- The first 750m consists of minor cut and fill
- The alignment crosses the watercourse in the gully to the west of the existing highway then follows the line of the gully to the west of the waterway. A major bridge/viaduct up to 1500m long is required to keep roadway out of creek line
- The viaduct ends before Pyes Creek Road. High fill then grades down with the last 200m being an upgrade of the existing highway.

3.2.5 Option 4

- Option 4 is 3100m long
- The first 800m consists of minor cut and fill
- The next 200m requires extensive fill up to 20m high possibly requiring extensive retaining walls
- The alignment then follows the line of the gully to the west of the highway on the eastern side of the waterway. A major bridge/viaduct up to 1000m long is required to keep roadway out of creek line
- The viaduct ends before Pyes Creek Road. High fill then grades down with the last 200m being an upgrade of the existing highway.

3.2.6 Option 5a

- Option 5a is 3200m long
- The first 400m is an upgrade the existing highway in minor cut and fill
- The alignment then goes into cut for 300m to a tunnel portal west of the railway line
- Tunnel under the rail reserve for 1400m (open cut produces extensive batters into the Bolivia Hill Nature Reserve)
- Fill then grades down for 700m to the existing highway
- The last 400m is an upgrade of the existing highway.

3.2.7 Option 5b

- Option 5b is 2500m long
- This is a variation on Option 5a, shortening the total length

- The first 400m is an upgrade the existing highway in minor cut and fill
- The alignment then goes into cut for 300m to a tunnel portal west of the railway line
- Tunnel under the rail reserve for 1300m (open cut produces extensive batters into the Bolivia Hill Nature Reserve)
- The alignment is then in cut up to 20m deep for 350m until it joins the existing highway alignment
- The last 150m is an upgrade of the existing highway to the Pyes Creek Road intersection.

3.2.8 Option 6

- Option 6 is 2850m long
- The first 300m consists of minor cut and fill
- The next 600m goes into cut up to 25m deep
- The alignment then follows the line of the gully to the west of the highway on the eastern side of the waterway. A major bridge/viaduct up to 1000m long is required to keep roadway out of creek line
- From the end of the viaduct, fill up to 15m high tapers back to the existing highway over approximately 250m. The last 400m to just past Pyes Creek Road intersection is an upgrade of the existing highway.

3.2.9 Option 7

- Option 7 is 1150m long
- This option was developed to demonstrate a minimalist treatment of straightening out the bends in the steepest part of the highway. It has non-conforming grades up to 9.0% in order to shorten the length and starts approximately 900m north of the other options
- The first 200m will require extensive retaining walls to keep the fill out of the creek line
- A major bridge up to 550m long will then be required to keep the road out of the creek line
- From the northern abutment at about 8m high, fill tapers back 400m to the existing highway.

3.2.10 Option 8

- Option 8 is 3000m long
- This option was developed to demonstrate an alignment through areas not covered by other alignments to the west of the existing highway
- The first 650m consists of minor cut and fill with a bridge over the watercourse in the gully 50m long
- The alignment moves into a major cut through the ridge at the western extent of the study area. The cut is 1300m long and up to 82m deep (or a tunnel approximately 1000m long)
- The alignment then moves into extensive fill up to 30m high for 500m as it grades down to the Brickyard Creek floodplain. Extensive retaining walls and or bridges may be required. A bridge up to 300m long will be required across the watercourse to the west of the existing highway
- The last 450m to just past Pyes Creek Road intersection is an upgrade of the existing highway.

3.2.11 Option 9

- Option 9 is 3200m long
- The first 250m consists of minor cut and fill
- It is assumed at this stage that the existing railway line must remain therefore the alignment goes into cut and then tunnel under the line. 2 x 2 lane tunnels 1700m long will be required under the Bolivia Hill Nature Reserve
- From the northern portal of the tunnel, the alignment goes into extensive fill up to 22m high for 800m possibly requiring extensive retaining walls

- The last 300m is an upgrade of the existing highway.

3.2.12 Option 10

- Option 10 is 2950m long. The option is a variation on Option 3 attempting to reduce the length of the viaduct
- The first 300m is in minor cut and fill
- The alignment then moves into extensive cut 650m long and up to 25m deep
- A major bridge/viaduct up to 900m long to is then required to keep the road out of the creek line
- The alignment then moves into extensive fill up to 15m high for 1000m possibly requiring extensive retaining walls. A bridge up to 150m long will be required across the watercourse to the west of the existing highway
- The last 300m is an upgrade of the existing highway.

3.2.13 Stakeholder options

Two submissions were received from the community with suggested alignments marked up on project information leaflets. Copies of these submissions are included in **Appendix C. Figure C1** in **Appendix C** shows a western alignment along the old western road corridor and an eastern alignment through the Bolivia Hill Nature Reserve. **Figure C2** in **Appendix C** shows an alignment along the existing highway that straightens out the substandard curves.

An option adopting the current alignment for uphill (southbound) lanes and new alignment for a downhill (northbound) lane was suggested at a community drop-in session.

3.3 Strategic cost estimates

Strategic cost estimates were prepared for each option. The estimates were prepared in accordance with the requirements of the RMS Estimating Manual and include investigation, design and project management costs.

The estimates were developed based on the worst case scenario of having two lanes both directions as noted in Section 3.1.

Estimated strategic costs are as follows:

Option 1	$584 million
Option 2	$316 million
Option 3	$445 million
Option 4	$430 million
Option 5a	$374 million
Option 5b	$693 million
Option 6	$278 million
Option 7	$129 million
Option 8	$1,073 million
Option 9	$890 million
Option 10	$362 million

4 Assessment of options

4.1 Assessment criteria

Table 1 sets out the assessment criteria. At this preliminary assessment stage, some of the studies relevant to the Critical Criteria have yet to be carried out and therefore could not be assessed.

Each option was scored against the criteria based on a semi subjective 1 to 4 scale as follows:

4 fully meets the criteria

3 significantly meets the criteria

2 partially meets the criteria

1 mostly does not meet the criteria

0 non-negotiable => discard

4.2 Initial assessments

The potentially feasible routes ("long list") were assessed by individual specialists from Cardno independent from other influences in advance of the workshop process to ensure the optimum efficiency of the workshop.

The preparatory assessments included:

- Assessment against the project objectives (this involved a detailed assessment of the routes against the objectives and the constraints)
- Identification of preliminary "negotiable" and "non-negotiable" issues
- Identification of preliminary discards of route options
- Identification of preliminary route preferences.

The specialist investigations categories comprised:

Design

- Alignment, staging and access
- Constructability
- Flooding and drainage
- Cost.

Geotechnical

- Ground conditions.

Biodiversity

- Terrestrial and aquatic ecology.

Heritage

- Indigenous and non-indigenous heritage.

Table 1 Assessment criteria

Project Objectives	Critical Criteria*[1]	Description of criteria that can be assessed
Improve road safety	• Reduced crash rate and injuries • Improved road safety standards – improved geometry standard • Minimise conflict points on the highway (intersections) • Constructability • Work Health and safety in construction and maintenance.	• Provide for an overtaking lane for southbound traffic and possibly a dual lane carriageway separated by wire rope • Maintain at least one lane of the highway open during construction of the upgrade • Minimise work health and safety risk in construction and maintenance.
Improve road transport productivity efficiency and reliability of travel	• Reduced road freight user costs • Reduced travel time • Target a route level of service of A • Increase road network capacity.	• Provide appropriate horizontal and vertical road geometry.
Minimise the impact on the natural, cultural and built environment	• Impact on fauna habitat including threatened species • Impact on flora including threatened species • Water quality • Air quality • Noise and vibration impact • Aboriginal and Europe heritage • Stormwater and drainage • Residential and commercial properties impacted • Ecological sustainability • Visual impact and amenity.	• Minimise adverse impacts on native vegetation • Minimise adverse impacts on sensitive habitats • Minimise adverse impacts on Endangered Ecological Communities • Minimise adverse impacts on surface water quality • Minimise adverse impacts on known European heritage sites, values and areas of archaeological potential • Minimise adverse impacts on known Aboriginal heritage sites, values and areas of archaeological potential • Potential to use recycled or waste materials.
Provide value for money	• Cost benefit ratios • NPV over 30 years • Road user costs and benefits • Infrastructure operating costs (including maintenance). • Comparative project costs.	• Minimise project cost.

Note *1 – Feasible routes must conform with critical criteria

4.3 Workshop

4.3.1 Specialist summaries

At the workshop, the specialists summarised their preparatory work which included:

- An explanation of the category
- An explanation of features of a route which would be beneficial and undesirable relative to that category
- A preliminary assessment of what are the critical issues, ie those which fundamentally influence the choice of route
- An explanation of study area relative to that category.

This provided an opportunity for participants to appreciate issues arising from the specialist categories resulting in a balanced assessment between specialist areas and issues.

4.3.2 Process for assessment of options

Each option was then described in detail and the pre-workshop scoring presented. For each objective, some specialist categories were combined, ie a route may have attracted a different outcome for each specialist category for a specific objective. The workshop included debate on each of these scenarios and determined a collective result for that category overall. This included identification of routes which failed to meet critical objectives and were therefore discarded.

Although Option 7 did not fully comply with the design criteria (in that it the vertical alignment exceeded 6% slope), participants agreed that it should not be eliminated from the assessment as:

- Minor upgrades of the existing alignment should be an option for consideration
- Upgrading of the existing alignment was suggested by many community stakeholders.

The workshop scoring is presented in **Table D1** in **Appendix D**. The rationale behind the scoring is detailed in **Section 4.4**.

4.3.3 Consideration of community options

Options suggested by the community were also assessed.

1. Refer to **Figure C1** in **Appendix C** – the western alignment was assessed by participants to be similar to Option 1. The eastern alignment passes through the Bolivia Hill Nature Reserve and would also require either very deep cuttings or a tunnel similar to Option 9 resulting in unacceptably high cost.
2. Refer to **Figure C2** in **Appendix C** – this option was assessed by participants to be similar to Option 7.
3. The option adopting the current alignment for uphill (southbound) lanes and new alignment for a downhill (northbound) lane was assessed by participants. The following was agreed:
    - The substandard curves on the current alignment would need to be rectified. The road would need to be widened to provide acceptable shoulder widths. These works are similar to Option 7 which is assessed in detail in **Section 4.4**.
    - The provision of a single lane (with appropriate shoulders) downhill will cost significantly more than one quarter of the cost of a four lane option such as Option 6 or Option 10. As such, the construction of a single downhill lane at a high cost was not considered to provide value for money. If a new alignment is to be considered, it would be more cost effective to build multiple lanes (say three lanes – see **Section 4.3.5** following). This would then negate the need to upgrade the existing alignment.
    - In summary, the cost effective solution is to either upgrade the existing alignment to cater for all traffic (such as Option 7) **or** to build a new alignment to cater for all traffic (such as Option 6 or 10).

4.3.4 Ranking of options

The options were initially ranked 1 (best) to 11 (worst) against the total score for each option.

To test the validity of this ranking, the following methods were also used:

- Equally weight each objective.
  - Calculate the average score for Road Safety, Efficiency, Environment and Value for Money
  - Add each average score to obtain a score out of 16
- Rank each objective on total score for the objective and then sum the rankings. The option with the lowest score ranks best.

The rankings showed consistency over the three methods.

Following the initial ranking, the options were reviewed and it was agreed that Options 3 and 4 were variations of Options 10 and 6 respectively. These variations can be explored during refinement of the shortlisted options during the preliminary concept design stage of the project.

Final confirmation of the ranking was carried out by removing the discarded options (1, 5b, 8 and 9) and the variations (3 and 4). Details of the final ranking are shown in **Table D2** in **Appendix D**.

The shortlisted options to be investigated in more detail are as follows:

Option 6 Rank 1

Option 10 Rank 2

Option 7 Rank 3

Option 2 Rank 4

Option 5a was ranked fifth and will not be further considered.

4.4 Rationale behind workshop scoring

Table 2 details the rationale behind the workshop scoring.

Table 2 Rationale behind workshop scoring

Option 1

Description

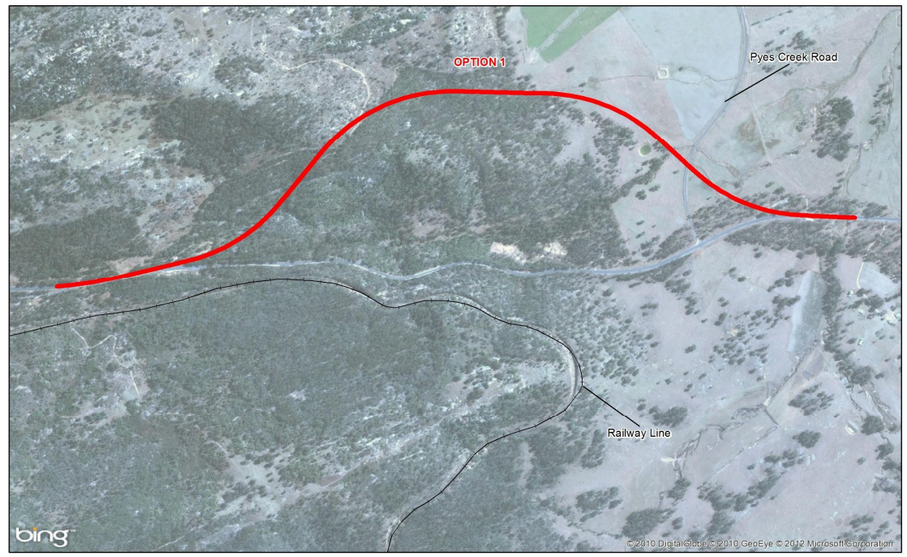
- Option 1 is 3450m long.
- The first 1000m consists of minor cut and fill plus a bridge 130m long over the watercourse in the gully to the west of the existing highway
- The alignment moves into a major cut through the ridge at the western extent of the study area. The cut is 700-800m long and up to 65m deep. A tunnel option (450m in length) through this section will be assessed on cost and constructability comparison
- The alignment then moves into extensive fill up to 15m high as it grades down to the Brickyard Creek floodplain. Extensive retaining walls may be required. A bridge up to 150m long will be required across the watercourse to the west of the existing highway just south of Pyes Creek Road
- To the north of the bridge the alignment is in minor fill with the last 200m being an upgrade of the existing highway.

Workshop conclusion

Option 1 scored poorly for constructability due to the long and deep cutting in very hard rock. The variable nature of the hard rock presents high risk and construction difficulties which are reflected in the high cost. Option 1 also scored poorly against the environmental objectives. The deep cut and high fills leave a very large footprint and have a considerable impact on flora and fauna and create a significant visual impact. The cut would also require a large amount of rock to be transported away from site.

Overall, Option 1 scored very poorly against all the objectives and was not shortlisted to be taken forward for further investigation and design.

Note – Overall Ranking Against Objective – 1 equals best, 11 equals worst

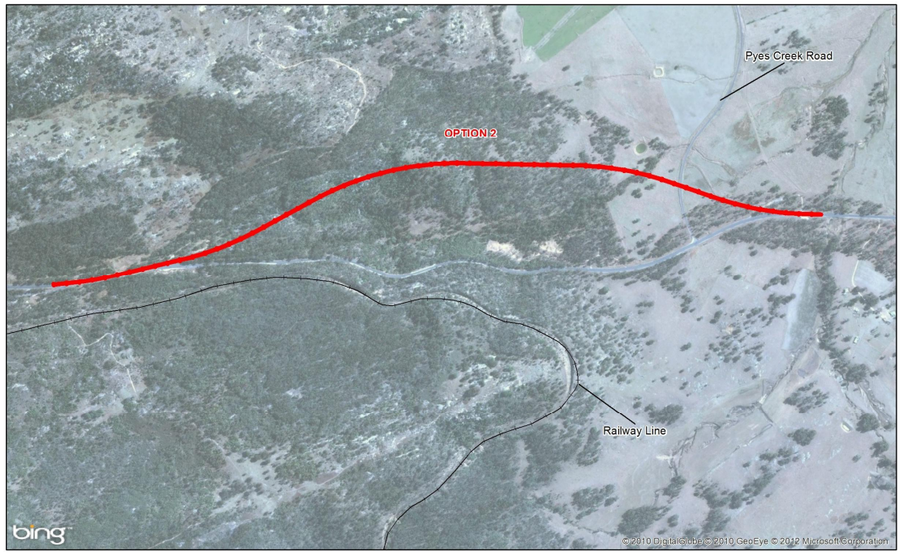


Project Objectives	Critical Criteria	Overall Ranking Against Objective	Comment
Improve road safety	• Reduced crash rate and injuries • Improved road safety standards – improved geometry standard • Minimise conflict points on the highway (intersections) • Constructability • Work Health and safety in construction and maintenance.	6 (equal)	• Road safety will be improved with the vertical and horizontal alignment to improved geometry standards • Scores poorly for constructability and work health and safety in construction and maintenance due to the long and deep cutting in very hard rock
Improve road transport productivity efficiency and reliability of travel	• Reduced road freight user costs • Reduced travel time • Target a route level of service of A • Increase road network capacity.	5 (equal)	• Although the alignment has conforming horizontal and vertical geometry, scores lower in comparison with other options due to the use of minimum radius curves.
Minimise the impact on the natural, cultural and built environment	• Impact on fauna habitat including threatened species • Impact on flora including threatened species • Water quality • Air quality • Noise and vibration impact • Aboriginal and Europe heritage • Stormwater and drainage • Residential and commercial properties impacted • Ecological sustainability • Visual impact and amenity.	9 (equal)	• Scores poorly on impact to flora and fauna habitat due to the long, deep cut that leaves a very large footprint • Scores well for non-Aboriginal impacts as it avoids most of the sensitive areas, only a small portion in Bolivia Station would be affected by the route • Scores poorly for Aboriginal heritage as the route passes through areas of high and moderate Aboriginal heritage sensitivity • Scores poorly in relation to surface water quality due to interference with existing floodplain and creek realignment • Significant interference due to two proposed creek crossings results in a poor score for flooding and drainage • Scores poorly on potential to use recycled or waste material due to the large amount of rock excavated from the large cutting that would need to be transported away from site • Scores poorly on visual impact with a large footprint due to the large cuts and fills.
Provide value for money	• Cost benefit ratios • NPV over 30 years • Road user costs and benefits • Infrastructure operating costs (including maintenance). • Comparative project costs.	8 (equal)	• Cost $584 M • $455 M more than lowest cost option mainly due to the very large quantity of cut through hard rock • Cost is considered excessive.

Option 2

Description

- Option 2 is 3200m long
- The first 1050m consists of minor cut and fill plus a bridge 150m long over the watercourse in the gully to the west of the existing highway
- The alignment moves into a major cut through the ridge at the western extent of the study area. The cut is 600m long and up to 25m deep. The majority of the cut is on the western side of the alignment into the ridgeline
- The alignment then moves into extensive fill up to 20m high as it grades down to the Brickyard Creek floodplain. Extensive retaining walls and or bridges may be required. A bridge up to 200m long will be required across the watercourse to the west of the existing highway just south of Pyes Creek Road
- The high fill continues over Pyes Creek Road and grades down with the last 200m being an upgrade of the existing highway.



Workshop conclusion

Option 2 scored poorly for constructability due to the long and deep cutting in very hard rock. The variable nature of the hard rock presents high risk and construction difficulties which are reflected in the high cost. Option 2 also scored poorly against the environmental objectives. The deep cut and high fills leave a large footprint and have a considerable impact on flora and fauna and create a significant visual impact although the impacts are not as significant as in Option 1.

Overall Option 2 did not score well against the objectives. However, as the workshop participants agreed that Options 3 and 4 were variations of Options 10 and 6 respectively (these variations can be explored during refinement of the shortlisted options during the preliminary concept design stage of the project), the overall ranking of Option 2 was enough for the option to be investigated in the next stage of design.

Note – Overall Ranking Against Objective – 1 equals best, 11 equals worst

Project Objectives	Critical Criteria	Overall Ranking Against Objective	Comment
Improve road safety	• Reduced crash rate and injuries • Improved road safety standards – improved geometry standard • Minimise conflict points on the highway (intersections) • Constructability • Work Health and safety in construction and maintenance.	5	• Road safety will be improved with the vertical and horizontal alignment to improved geometry standards • Scores poorly for constructability and work health and safety in construction and maintenance due to the long and deep cutting in very hard rock
Improve road transport productivity efficiency and reliability of travel	• Reduced road freight user costs • Reduced travel time • Target a route level of service of A • Increase road network capacity.	5 (equal)	• Although the alignment has conforming horizontal and vertical geometry, scores poorly in comparison with other options due to the use of minimum radius curves.
Minimise the impact on the natural, cultural and built environment	• Impact on fauna habitat including threatened species • Impact on flora including threatened species • Water quality • Air quality • Noise and vibration impact • Aboriginal and Europe heritage • Stormwater and drainage • Residential and commercial properties impacted • Ecological sustainability • Visual impact and amenity.	6	• Scores well on the impact to flora and fauna as it avoids the Bolivia Hill Nature Reserve and has a smaller area of cut in comparison to other options, but the route will still require removal of some vegetation • Scores well for non-Aboriginal impacts as it avoids most of the sensitive areas, only a small portion in Bolivia Station would be affected by the route • Scores poorly for Aboriginal heritage as the route passes through areas of high and moderate Aboriginal heritage sensitivity • Scores poorly in relation to surface water quality due to interference with existing floodplain and creek realignment • Significant interference due to two proposed creek crossings results in a poor score for flooding and drainage • Scores poorly on potential to use recycled or waste material due to the large amount of rock excavated from the large cutting that would need to be transported away from site • Scores poorly on visual impact with a large footprint due to the large cuts and fills.
Provide value for money	• Cost benefit ratios • NPV over 30 years • Road user costs and benefits • Infrastructure operating costs (including maintenance). • Comparative project costs.	3 (equal)	• Cost $316 M • $187 M more than lowest cost option mainly due to the large quantity of cut through hard rock • Ranked equal third on cost

Option 3

Description

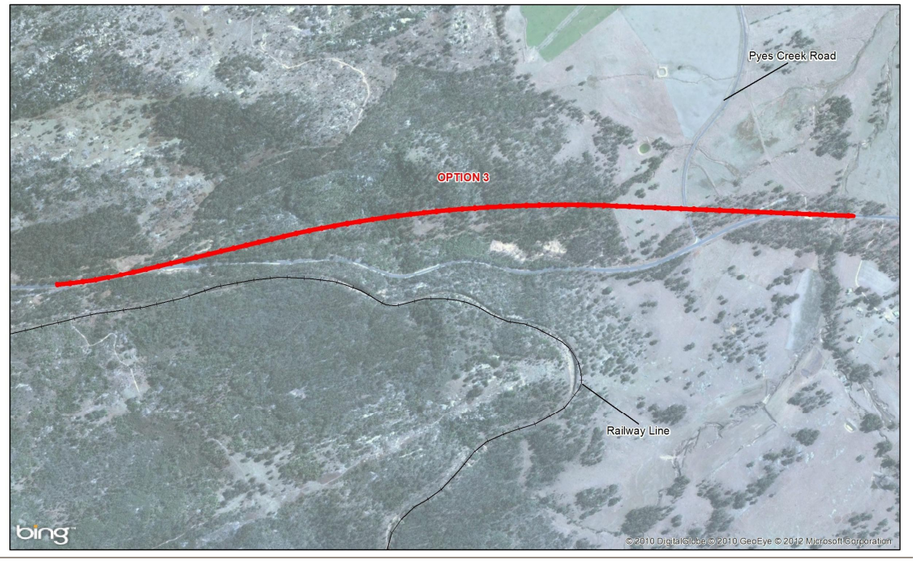
- Option 3 is 3120m long
- The first 750m consists of minor cut and fill
- The alignment crosses the watercourse in the gully to the west of the existing highway then follows the line of the gully to the west of the waterway. A major bridge/viaduct up to 1500m long is required to keep roadway out of creek line
- The viaduct ends before Pyes Creek Road. High fill then grades down with the last 200m being an upgrade of the existing highway.

Workshop conclusion

Option 3 scored well for constructability due to minimal cutting in very hard rock. Option 3 scored reasonably well against the environmental objectives due to its smaller footprint having a smaller impact on flora and fauna. The cost of the option was large due to the requirement for a very long bridge/viaduct required to minimise the impact on the creek to the west of the existing highway.

Overall Option 3 scored well against the majority of the objectives, however, workshop participants considered the alignment to be similar to Option 10. Option 3 was therefore considered as a variation to Option 10 (which had a better overall ranking than Option 3) which can be explored during refinement of the shortlisted options during the preliminary concept design stage of the project.

Note – Overall Ranking Against Objective – 1 equals best, 11 equals worst



Project Objectives	Critical Criteria	Overall Ranking Against Objective	Comment
Improve road safety	• Reduced crash rate and injuries • Improved road safety standards – improved geometry standard • Minimise conflict points on the highway (intersections) • Constructability • Work Health and safety in construction and maintenance.	1 (equal)	• Road safety will be improved with the vertical and horizontal alignment to improved geometry standards • Acceptable score for constructability and work health and safety in construction and maintenance due to no major cut in hard rock.
Improve road transport productivity efficiency and reliability of travel	• Reduced road freight user costs • Reduced travel time • Target a route level of service of A • Increase road network capacity.	1 (equal)	• The alignment has conforming horizontal and vertical geometry. Scores higher than other conforming alignments with minimum radius curves.
Minimise the impact on the natural, cultural and built environment	• Impact on fauna habitat including threatened species • Impact on flora including threatened species • Water quality • Air quality • Noise and vibration impact • Aboriginal and Europe heritage • Stormwater and drainage • Residential and commercial properties impacted • Ecological sustainability • Visual impact and amenity.	3	• Scores well on the impact to flora and fauna as it avoids the Bolivia Hill Nature Reserve and has a smaller area of cut in comparison to other options, but the route will still require removal of some vegetation • Scores well for non-Aboriginal impacts as it avoids most of the sensitive areas, only a small portion in Bolivia Station would be affected by the route • Scores poorly for Aboriginal heritage as the route passes through a large area of high Aboriginal sensitivity along the 100yr ARI floodline • A large viaduct/bridge is proposed which may minimise the creek realignment required • The proposed viaduct would result in a poor score for flooding and drainage due to the potential for piers and foundations which may impact on existing hydrology • Scores well for recycling of waste material as the rock cut can be used in fill on site.
Provide value for money	• Cost benefit ratios • NPV over 30 years • Road user costs and benefits • Infrastructure operating costs (including maintenance). • Comparative project costs.	6 (equal)	• Cost $445 M • $216 M more than lowest cost option mainly due to the very long bridge/viaduct • Ranked equal sixth on cost

Option 4

Description

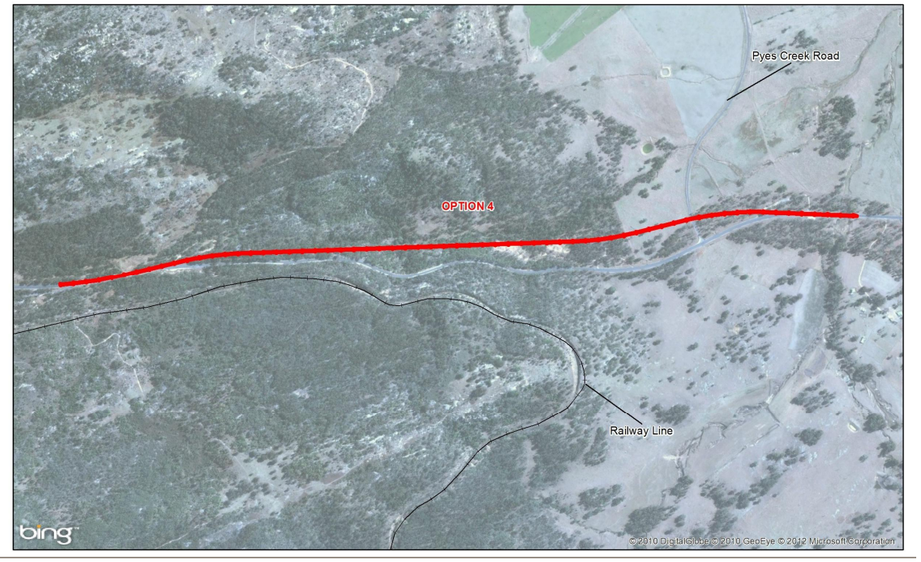
- Option 4 is 3100m long.
- The first 800m consists of minor cut and fill
- The next 200m requires extensive fill up to 20m high possibly requiring extensive retaining walls
- The alignment then follows the line of the gully to the west of the highway on the eastern side of the waterway. A major bridge/viaduct up to 1000m long is required to keep roadway out of creek line
- The viaduct ends before Pyes Creek Road. High fill then grades down with the last 200m being an upgrade of the existing highway.

Workshop conclusion

Option 4 scored well for constructability due to minimal cutting in very hard rock. Option 4 scored reasonably well against the environmental objectives due to its smaller footprint having a smaller impact on flora and fauna. The cost of the option was large due to the requirement for a very long bridge/viaduct required to minimise the impact on the creek to the west of the existing highway.

Overall Option 4 scored well against the majority of the objectives, however, workshop participants considered the alignment to be similar to Option 6. Option 4 was therefore considered as a variation to Option 6 (which had a better overall ranking than Option 4) which can be explored during refinement of the shortlisted options during the preliminary concept design stage of the project.

Note – Overall Ranking Against Objective – 1 equals best, 11 equals worst



Project Objectives	Critical Criteria	Overall Ranking Against Objective	Comment
Improve road safety	• Reduced crash rate and injuries • Improved road safety standards – improved geometry standard • Minimise conflict points on the highway (intersections) • Constructability • Work Health and safety in construction and maintenance.	1 (equal)	• Road safety will be improved with the vertical and horizontal alignment to improved geometry standards • Acceptable score for constructability and work health and safety in construction and maintenance due to no major cut in hard rock.
Improve road transport productivity efficiency and reliability of travel	• Reduced road freight user costs • Reduced travel time • Target a route level of service of A • Increase road network capacity.	1 (equal)	• The alignment has conforming horizontal and vertical geometry. Scores higher than other conforming alignments with minimum radius curves.
Minimise the impact on the natural, cultural and built environment	• Impact on fauna habitat including threatened species • Impact on flora including threatened species • Water quality • Air quality • Noise and vibration impact • Aboriginal and Europe heritage • Stormwater and drainage • Residential and commercial properties impacted • Ecological sustainability • Visual impact and amenity.	4	• Scores well on the impact to flora and fauna as it avoids the Bolivia Hill Nature Reserve and has a smaller area of cut in comparison to other options, but the route will still require removal of some vegetation • Scores well for non-Aboriginal impacts as it avoids most of the sensitive areas, only a small portion in Bolivia Station would be affected by the route • Scores poorly for Aboriginal heritage as the route passes through a large area of high Aboriginal sensitivity along the 100yr ARI floodline • A large viaduct/bridge is proposed which may minimise the creek realignment required and interference with the floodplain • The proposed viaduct, while shorter than Option 3, would result in a poor score for flooding and drainage due to the potential for piers and foundations to impact on existing hydrology
Provide value for money	• Cost benefit ratios • NPV over 30 years • Road user costs and benefits • Infrastructure operating costs (including maintenance). • Comparative project costs.	6 (equal)	• Cost $430 M • $301 M more than lowest cost option due to the major bridge/viaduct. • Ranked equal sixth on cost

Option 5a

Description

- Option 5a is 3200m long
- The first 400m is an upgrade the existing highway in minor cut and fill
- The alignment then goes into cut for 300m to a tunnel portal west of the railway line
- Tunnel under the rail reserve for 1400m (open cut produces extensive batters into the Bolivia Hill Nature Reserve)
- Fill then grades down for 700m to the existing highway
- The last 400m is an upgrade of the existing highway.

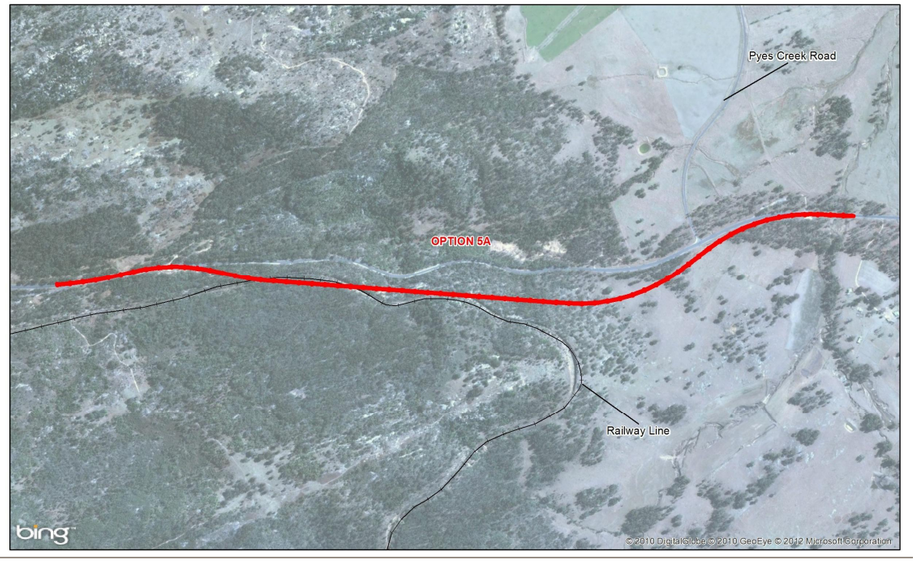
Workshop conclusion

Option 5a scored poorly for constructability due to tunnelling required in very hard rock. Tunnelling has additional design, safety and maintenance requirements that are technically challenging in this terrain. The variable nature of the hard rock presents high risk and construction difficulties which are reflected in the cost.

Option 5a scores poorly against the environmental objectives due to the large amount of rock excavated from the tunnel that would need to be transported away from site. Tunnelling also requires a large amount of water and therefore tunnelling activities may impact on surface water quality due to the requirement for extensive wastewater ponds.

Overall, Option 5a scored poorly against the majority of the objectives and was not shortlisted to be taken forward for further investigation and design.

Note – Overall Ranking Against Objective – 1 equals best, 11 equals worst

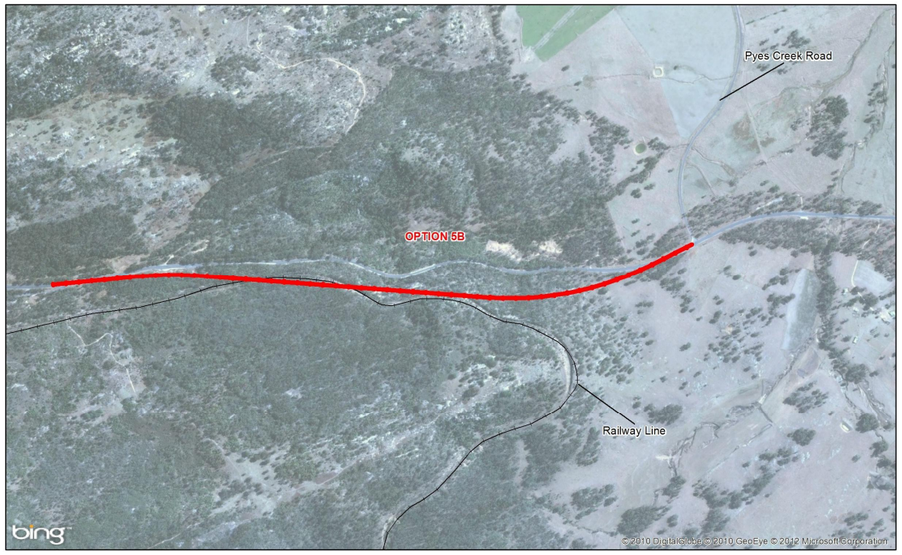


Project Objectives	Critical Criteria	Overall Ranking Against Objective	Comment
Improve road safety	• Reduced crash rate and injuries • Improved road safety standards – improved geometry standard • Minimise conflict points on the highway (intersections) • Constructability • Work Health and safety in construction and maintenance.	6 (equal)	• Road safety will be improved with the vertical and horizontal alignment to improved geometry standards • Scores poorly for constructability and work health and safety in construction and maintenance due to tunnelling in hard rock.
Improve road transport productivity efficiency and reliability of travel	• Reduced road freight user costs • Reduced travel time • Target a route level of service of A • Increase road network capacity.	5 (equal)	• Although the alignment has conforming horizontal and vertical geometry, scores poorly in comparison with other options due to the use of minimum radius curves.
Minimise the impact on the natural, cultural and built environment	• Impact on fauna habitat including threatened species • Impact on flora including threatened species • Water quality • Air quality • Noise and vibration impact • Aboriginal and Europe heritage • Stormwater and drainage • Residential and commercial properties impacted • Ecological sustainability • Visual impact and amenity.	9 (equal)	• Scores poorly for impacts to flora and fauna as the route passes through the Bolivia Hill Nature Reserve • Scores poorly for impacts to non-Aboriginal heritage as the route passes through a large area of highly sensitive heritage land • Scores well for Aboriginal heritage as it avoids highly sensitive land and only impacts a small portion of moderate sensitivity • Scores well in regard to surface water quality as it avoids the existing hydrology constraints however construction activities may impact on surface water quality • Scores well as this option avoids the existing watercourse • Scores poorly on potential to use recycled or waste material due to the large amount of rock excavated from the tunnel that would need to be transported away from site
Provide value for money	• Cost benefit ratios • NPV over 30 years • Road user costs and benefits • Infrastructure operating costs (including maintenance). • Comparative project costs.	3 (equal)	• Cost $374 M • $245 M more than lowest cost option due to the very high cost of tunnelling through hard rock • Ranked equal third on cost

Option 5b

Description

- Option 5b is 2500m long
- This is a variation on Option 5a, shortening the total length
- The first 400m is an upgrade the existing highway in minor cut and fill
- The alignment then goes into cut for 300m to a tunnel portal west of the railway line
- Tunnel under the rail reserve for 1300m (open cut produces extensive batters into the Bolivia Hill Nature Reserve)
- The alignment is then in cut up to 20m deep for 350m until it joins the existing highway alignment
- The last 150m is an upgrade of the existing highway to the Pyes Creek Road intersection.



Workshop conclusion

Option 5b scored poorly for constructability due to tunnelling required in very hard rock. Tunnelling has additional design, safety and maintenance requirements that are technically challenging in this terrain. The variable nature of the hard rock presents high risk and construction difficulties which are reflected in the cost.

Option 5b scores poorly against the environmental objectives due to the large amount of rock excavated from the tunnel that would need to be transported away from site. Tunnelling also requires a large amount of water and therefore tunnelling activities may impact on surface water quality due to the requirement for extensive wastewater ponds.

Overall, Option 5b scored poorly against the majority of the objectives and was not shortlisted to be taken forward for further investigation and design.

Note – Overall Ranking Against Objective – 1 equals best, 11 equals worst

Project Objectives	Critical Criteria	Overall Ranking Against Objective	Comment
Improve road safety	• Reduced crash rate and injuries • Improved road safety standards – improved geometry standard • Minimise conflict points on the highway (intersections) • Constructability • Work Health and safety in construction and maintenance.	6 (equal)	• Road safety will be improved with the vertical and horizontal alignment to improved geometry standards • Scores poorly for constructability and work health and safety in construction and maintenance due to tunnelling in hard rock.
Improve road transport productivity efficiency and reliability of travel	• Reduced road freight user costs • Reduced travel time • Target a route level of service of A • Increase road network capacity.	1 (equal)	• The alignment has conforming horizontal and vertical geometry. Scores higher than other conforming alignments with minimum radius curves.
Minimise the impact on the natural, cultural and built environment	• Impact on fauna habitat including threatened species • Impact on flora including threatened species • Water quality • Air quality • Noise and vibration impact • Aboriginal and Europe heritage • Stormwater and drainage • Residential and commercial properties impacted • Ecological sustainability • Visual impact and amenity.	9 (equal)	• Scores poorly for impacts to flora and fauna as the route passes through the Bolivia Hill Nature Reserve • Scores poorly for impacts to non-Aboriginal heritage as the route passes through a large area of highly sensitive heritage land • Scores well for Aboriginal heritage as it avoids highly sensitive land and only impacts a small portion of moderate sensitivity • Scores well in regard to surface water quality as it avoids the existing hydrology constraints however construction activities may impact on surface water quality • Scores well as this option avoids the existing watercourse • Scores poorly on potential to use recycled or waste material due to the large amount of rock excavated from the tunnel that would need to be transported away from site.
Provide value for money	• Cost benefit ratios • NPV over 30 years • Road user costs and benefits • Infrastructure operating costs (including maintenance) • Comparative project costs.	8 (equal)	• Cost $693 M • $564 M more than lowest cost option due to the very high cost of tunnelling through hard rock • Cost is considered excessive.

Option 6

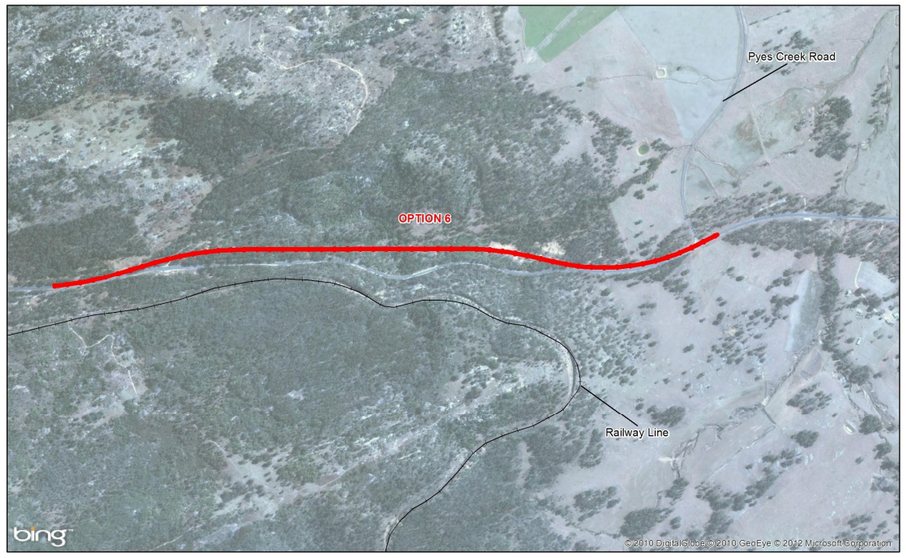
Description

- Option 6 is 2850m long
- The first 300m consists of minor cut and fill
- The next 600m goes into cut up to 25m deep
- The alignment then follows the line of the gully to the west of the highway on the eastern side of the waterway. A major bridge/viaduct up to 1000m long is required to keep roadway out of creek line
- From the end of the viaduct, fill up to 15m high tapers back to the existing highway over approximately 250m. The last 400m to just past Pyes Creek Road intersection is an upgrade of the existing highway.

Workshop conclusion

Option 6 scored well for constructability due to minimal cutting in very hard rock. Option 6 also scored well against the environmental objectives due to its smaller footprint having a smaller impact on flora and fauna. Although the option requires a long bridge/viaduct to minimise the impact on the creek to the west of the existing highway, it is shorter than some other options and the overall cost of the option is therefore reduced.

Overall, Option 6 scored well against the majority of the objectives and the workshop participants considered that it should be investigated in the next stage of design.



Note – Overall Ranking Against Objective – 1 equals best, 11 equals worst

Project Objectives	Critical Criteria	Overall Ranking Against Objective	Comment
Improve road safety	• Reduced crash rate and injuries • Improved road safety standards – improved geometry standard • Minimise conflict points on the highway (intersections) • Constructability • Work Health and safety in construction and maintenance.	1 (equal)	• Road safety will be improved with the vertical and horizontal alignment to improved geometry standards • Acceptable score for constructability and work health and safety in construction and maintenance due to no major cut in hard rock.
Improve road transport productivity efficiency and reliability of travel	• Reduced road freight user costs • Reduced travel time • Target a route level of service of A • Increase road network capacity.	5 (equal)	• Although the alignment has conforming horizontal and vertical geometry, scores poorly in comparison with other options due to the use of minimum radius curves.
Minimise the impact on the natural, cultural and built environment	• Impact on fauna habitat including threatened species • Impact on flora including threatened species • Water quality • Air quality • Noise and vibration impact • Aboriginal and Europe heritage • Stormwater and drainage • Residential and commercial properties impacted • Ecological sustainability • Visual impact and amenity.	2	• Scores well on the impact to flora and fauna as it avoids the Bolivia Hill Nature Reserve and has a smaller area of cut in comparison to other options, but the route will still require removal of some vegetation • Scores high for non-Aboriginal heritage as it avoids all areas of sensitivity • Scores poorly for Aboriginal heritage as the route passes through a large area of high Aboriginal sensitivity along the 100yr ARI floodline (but less off an impact than Option 3) • A large viaduct/bridge is proposed which may minimise the creek realignment for the main watercourse and interference with the floodplain • The proposed viaduct, while shorter than Option 3, would result in a poor score for flooding and drainage due to the potential for numerous piers and foundations to impact on existing hydrology and minor watercourse realignment • Scores well for recycling of waste material as the rock cut can be used in fill on site.
Provide value for money	• Cost benefit ratios • NPV over 30 years • Road user costs and benefits • Infrastructure operating costs (including maintenance). • Comparative project costs.	2	• Cost $278 M • $149 M more than lowest cost option mainly due to the major bridge/viaduct.

Option 7

Description

- Option 7 is 1150m long
- This option was developed to demonstrate a minimalist treatment of straightening out the bends in the steepest part of the highway. It has non-conforming grades up to 9.0% in order to shorten the length and starts approximately 900m north of the other options
- The first 200m will require extensive retaining walls to keep the fill out of the creek line
- A major bridge up to 550m long will then be required to keep the road out of the creek line
- From the northern abutment at about 8m high, fill tapers back 400m to the existing highway.

Workshop conclusion

Option 7 scores poorly against other options on constructability and work health and safety in construction and maintenance as the majority of the length will be constructed under traffic control next to existing highway traffic. It also ranks last against the objective of improving road transport productivity efficiency and reliability of travel due to the 9% grade compared to 6% maximum of the other options. Option 7 does, however, score will against the environmental objective, with a small area of disturbance of flora and fauna. Option 7 ranks as the lowest cost option, being $149 M less than the next lowest cost option.

Although Option 7 did not fully comply with the design criteria (in that it the vertical alignment exceeded 6% slope), participants agreed that it should not be eliminated from the assessment as:

- Minor upgrade of the existing alignment should be an option for consideration
- Upgrading of the existing alignment was suggested by many community stakeholders.

Overall, Option 7 scored well and the workshop participants considered that it should be investigated in the next stage of design.

Note – Overall Ranking Against Objective – 1 equals best, 11 equals worst

Project Objectives	Critical Criteria	Overall Ranking Against Objective	Comment
Improve road safety	• Reduced crash rate and injuries • Improved road safety standards – improved geometry standard • Minimise conflict points on the highway (intersections) • Constructability • Work Health and safety in construction and maintenance.	11	• Although not unsafe, ranks last against improved geometry standard due to the vertical geometry containing a 9% grade where all other options have a conforming 6% maximum grade • Scores poorly against other options on constructability and work health and safety in construction and maintenance as the majority of the length will be constructed under traffic control next to highway traffic
Improve road transport productivity efficiency and reliability of travel	• Reduced road freight user costs • Reduced travel time • Target a route level of service of A • Increase road network capacity.	11	• Ranks last due to the 9% grade compared to 6% maximum of the other options
Minimise the impact on the natural, cultural and built environment	• Impact on fauna habitat including threatened species • Impact on flora including threatened species • Water quality • Air quality • Noise and vibration impact • Aboriginal and Europe heritage • Stormwater and drainage • Residential and commercial properties impacted • Ecological sustainability • Visual impact and amenity.	1	• Scores well on the impact to flora and fauna as it avoids the Bolivia Hill Nature Reserve and has a smaller area of cut in comparison to other options, but the route will still require removal of some vegetation • Scores well for non-Aboriginal heritage as it avoids most areas of sensitivity (small impact in a small area along the rail line) • Scores poorly for Aboriginal heritage as the route passes through a large area of high Aboriginal sensitivity along the 100yr ARI floodline (but less off an impact than Option 3) • Scores poorly in relation to surface water quality due to interference with minor tributaries and resulting realignment required • Significant interference due to two proposed culvert crossings and large viaduct/bridge required results in a poor score for flooding and drainage • Scores well for recycling of waste material as the rock cut can be used in fill on site.
Provide value for money	• Cost benefit ratios • NPV over 30 years • Road user costs and benefits • Infrastructure operating costs (including maintenance). • Comparative project costs.	1	• Cost $129 M • Lowest cost option.

Option 8

Description

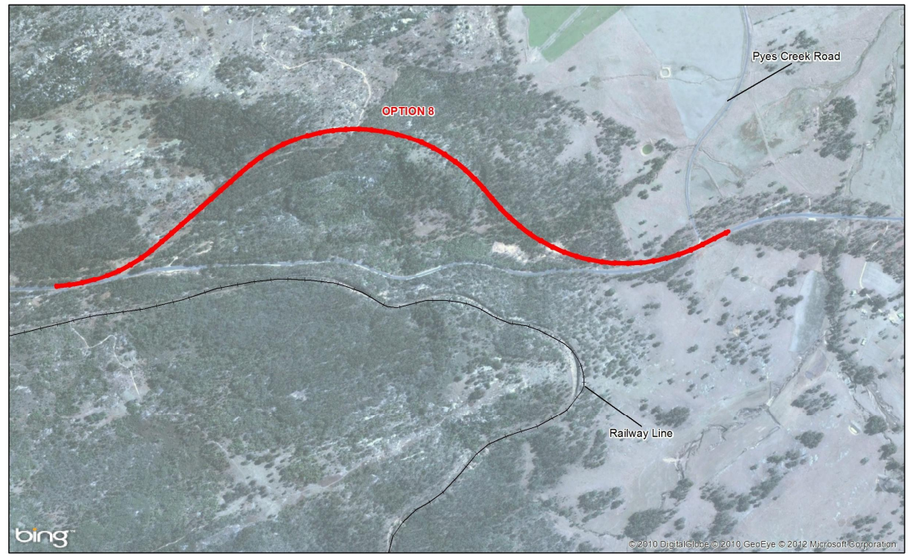
- Option 8 is 3000m long
- This option was developed to demonstrate an alignment through areas not covered by other alignments to the west of the existing highway
- The first 650m consists of minor cut and fill with a bridge over the watercourse in the gully 50m long
- The alignment moves into a major cut through the ridge at the western extent of the study area. The cut is 1300m long and up to 82m deep (or a tunnel approximately 1000m long)
- The alignment then moves into extensive fill up to 30m high for 500m as it grades down to the Brickyard Creek floodplain. Extensive retaining walls and or bridges may be required. A bridge up to 300m long will be required across the watercourse to the west of the existing highway
- The last 450m to just past Pyes Creek Road intersection is an upgrade of the existing highway.

Workshop conclusion

Option 8 scored poorly for constructability due to the long and deep cutting in very hard rock. The variable nature of the hard rock presents high risk and construction difficulties which are reflected in the high cost. Option 8 also scored poorly against the environmental objectives. The deep cut and high fills leave a very large footprint and have a considerable impact on flora and fauna and create a significant visual impact. The cut would also require a large amount of rock to be transported away from site.

Overall, Option 8 scored very poorly against all the objectives and was not shortlisted to be taken forward for further investigation and design.

Note – Overall Ranking Against Objective – 1 equals best, 11 equals worst



Project Objectives	Critical Criteria	Overall Ranking Against Objective	Comment
Improve road safety	• Reduced crash rate and injuries • Improved road safety standards – improved geometry standard • Minimise conflict points on the highway (intersections) • Constructability • Work Health and safety in construction and maintenance.	6 (equal)	• Road safety will be improved with the vertical and horizontal alignment to improved geometry standards • Scores poorly for constructability and work health and safety in construction and maintenance due to the long and deep cutting in very hard rock
Improve road transport productivity efficiency and reliability of travel	• Reduced road freight user costs • Reduced travel time • Target a route level of service of A • Increase road network capacity.	5 (equal)	• Although the alignment has conforming horizontal and vertical geometry, scores poorly in comparison with other options due to the use of minimum radius curves.
Minimise the impact on the natural, cultural and built environment	• Impact on fauna habitat including threatened species • Impact on flora including threatened species • Water quality • Air quality • Noise and vibration impact • Aboriginal and Europe heritage • Stormwater and drainage • Residential and commercial properties impacted • Ecological sustainability • Visual impact and amenity.	7 (equal)	• Scores poorly on impact on flora and fauna habitat due to the long, deep cut that leaves a very large footprint • Scores high for non-Aboriginal heritage as it avoids all areas of sensitivity • Scores poorly for Aboriginal heritage as the route passes through large areas of high and moderate Aboriginal heritage sensitivity • Scores poorly in relation to surface water quality due to significant interference with existing watercourse alignment • Significant interference on flooding and drainage due to realignment and large bridge required over floodplain • Scores poorly on potential to use recycled or waste material due to the large amount of rock excavated from the large cutting that would need to be transported away from site • Scores poorly on visual impact with a large footprint due to the large cuts and fills.
Provide value for money	• Cost benefit ratios • NPV over 30 years • Road user costs and benefits • Infrastructure operating costs (including maintenance). • Comparative project costs.	8 (equal)	• Cost $1,073 M • $944 M more than lowest cost option due to the excessive amount of cut through hard rock. • Cost is considered excessive.

Option 9

Description

- Option 9 is 3200m long
- The first 250m consists of minor cut and fill
- It is assumed at this stage that the existing railway line must remain therefore the alignment goes into cut and then tunnel under the line. 2 x 2 lane tunnels 1700m long will be required under the Bolivia Hill Nature Reserve
- From the northern portal of the tunnel, the alignment goes into extensive fill up to 22m high for 800m possibly requiring extensive retaining walls
- The last 300m is an upgrade of the existing highway.

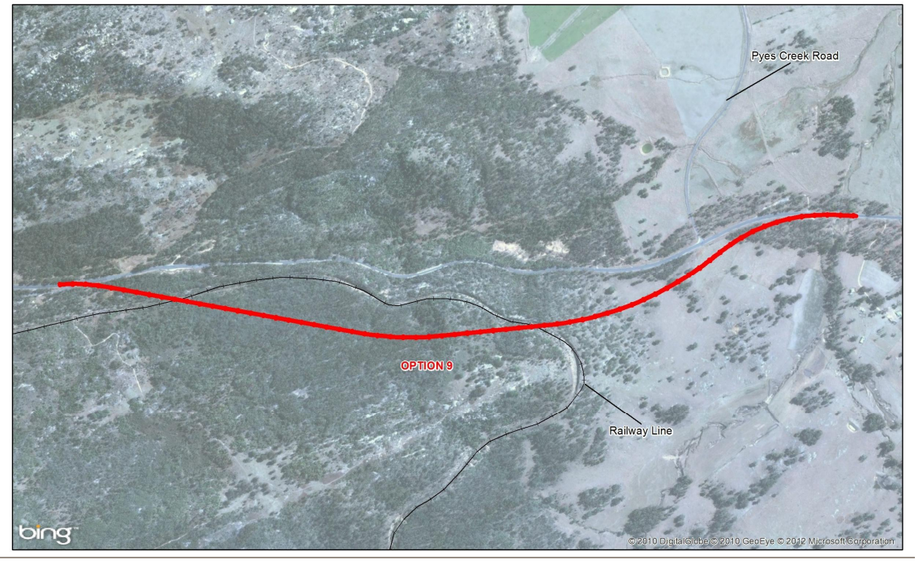
Workshop conclusion

Option 9 scored poorly for constructability due to tunnelling required in very hard rock. Tunnelling has additional design, safety and maintenance requirements that are technically challenging in this terrain. The variable nature of the hard rock presents high risk and construction difficulties which are reflected in the very high cost.

Option 9 scores poorly against the environmental objectives due to the large amount of rock excavated from the tunnel that would need to be transported away from site. Tunnelling also requires a large amount of water and therefore tunnelling activities may impact on surface water quality due to the requirement for extensive wastewater ponds.

Overall, Option 9 scored poorly against the majority of the objectives and was not shortlisted to be taken forward for further investigation and design.

Note – Overall Ranking Against Objective – 1 equals best, 11 equals worst



Project Objectives	Critical Criteria	Overall Ranking Against Objective	Comment
Improve road safety	• Reduced crash rate and injuries • Improved road safety standards – improved geometry standard • Minimise conflict points on the highway (intersections) • Constructability • Work Health and safety in construction and maintenance.	6 (equal)	• Road safety will be improved with the vertical and horizontal alignment to improved geometry standards • Scores poorly for constructability and work health and safety in construction and maintenance due to tunnelling in hard rock.
Improve road transport productivity efficiency and reliability of travel	• Reduced road freight user costs • Reduced travel time • Target a route level of service of A • Increase road network capacity.	1 (equal)	• The alignment has conforming horizontal and vertical geometry. Scores higher than other conforming alignments with minimum radius curves.
Minimise the impact on the natural, cultural and built environment	• Impact on fauna habitat including threatened species • Impact on flora including threatened species • Water quality • Air quality • Noise and vibration impact • Aboriginal and Europe heritage • Stormwater and drainage • Residential and commercial properties impacted • Ecological sustainability • Visual impact and amenity.	7 (equal)	• Scores poorly for impacts to flora and fauna as the route passes through the Bolivia Hill Nature Reserve • Scores well for non-Aboriginal heritage as it avoids most areas of sensitivity (small impact in a small area along the rail line) • Scores well for Aboriginal heritage as it avoids highly sensitive land and only impacts a small portion of moderate sensitivity • Scores well in regard to surface water quality as it avoids the existing hydrology constraints however construction activities may impact on surface water quality • Scores well as this option avoids the existing watercourse • Scores poorly on potential to use recycled or waste material due to the large amount of rock excavated from the tunnel that would need to be transported away from site
Provide value for money	• Cost benefit ratios • NPV over 30 years • Road user costs and benefits • Infrastructure operating costs (including maintenance). • Comparative project costs.	8 (equal)	• Cost $890 M • $761 M more than lowest cost option due to the very high cost of tunnelling through hard rock • Cost is considered excessive.

Option 10

Description

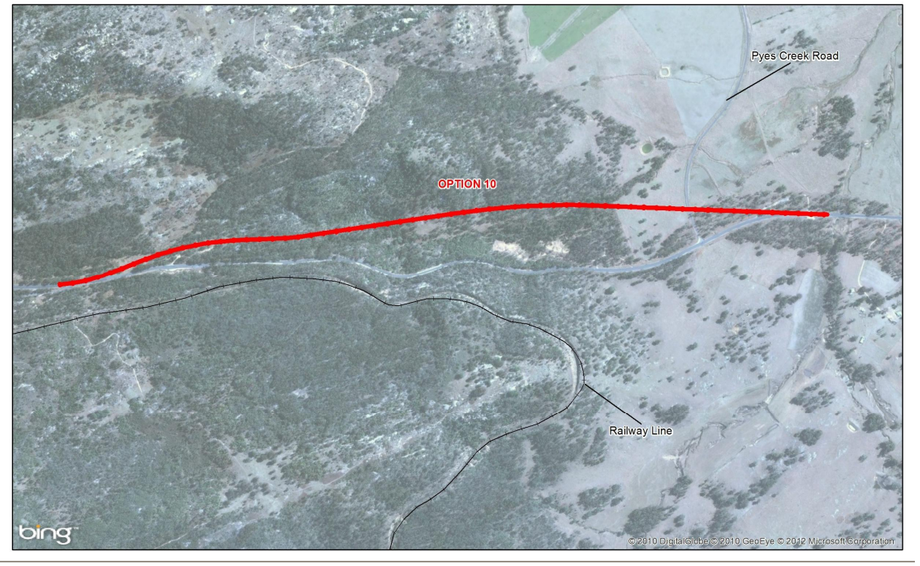
- Option 10 is 2950m long. The option is a variation on Option 3 attempting to reduce the length of the viaduct
- The first 300m is in minor cut and fill
- The alignment then moves into extensive cut 650m long and up to 25m deep
- A major bridge/viaduct up to 900m long to is then required to keep the road out of the creek line
- The alignment then moves into extensive fill up to 15m high for 1000m possibly requiring extensive retaining walls. A bridge up to 150m long will be required across the watercourse to the west of the existing highway
- The last 300m is an upgrade of the existing highway.

Workshop conclusion

Option 10 has an acceptable score for constructability due to a shallower cutting in very hard rock compared to other options with large cuts. Option 10 scored reasonably well against the environmental objectives due to its smaller footprint having a smaller impact on flora and fauna. The cost of the option was large due to the requirement for a very long bridge/viaduct required to minimise the impact on the creek to the west of the existing highway.

Overall, Option 10 scored well against the majority of the objectives and the workshop participants considered that it should be investigated in the next stage of design.

Note – Overall Ranking Against Objective – 1 equals best, 11 equals worst



Project Objectives	Critical Criteria	Overall Ranking Against Objective	Comment
Improve road safety	• Reduced crash rate and injuries • Improved road safety standards – improved geometry standard • Minimise conflict points on the highway (intersections) • Constructability • Work Health and safety in construction and maintenance.	1 (equal)	• Road safety will be improved with the vertical and horizontal alignment to improved geometry standards • Acceptable score for constructability and work health and safety in construction and maintenance due to no major cut in hard rock.
Improve road transport productivity efficiency and reliability of travel	• Reduced road freight user costs • Reduced travel time • Target a route level of service of A • Increase road network capacity.	5 (equal)	• Although the alignment has conforming horizontal and vertical geometry, scores poorly in comparison with other options due to the use of minimum radius curves.
Minimise the impact on the natural, cultural and built environment	• Impact on fauna habitat including threatened species • Impact on flora including threatened species • Water quality • Air quality • Noise and vibration impact • Aboriginal and Europe heritage • Stormwater and drainage • Residential and commercial properties impacted • Ecological sustainability • Visual impact and amenity.	5	• Scores well on the impact to flora and fauna as it avoids the Bolivia Hill Nature Reserve and has a smaller area of cut in comparison to other options, but the route will still require removal of some vegetation • Scores well for non-Aboriginal impacts as it avoids most of the sensitive areas, only a small portion in Bolivia Station would be affected by the route • Scores poorly for Aboriginal heritage as the route passes through a large area of high Aboriginal sensitivity along the 100yr ARI floodline • Scores poorly in relation to surface water quality due to interference with existing creek alignment and floodplain • The proposed viaduct would result in a poor score for flooding and drainage due to the potential for piers and foundations to impact on existing hydrology • Scores well for recycling of waste material as the rock cut can be used in fill on site. •
Provide value for money	• Cost benefit ratios • NPV over 30 years • Road user costs and benefits • Infrastructure operating costs (including maintenance). • Comparative project costs.	3 (equal)	• Cost $362 M • $233 M more than lowest cost option mainly due to the major bridge/viaduct.

4.5 Further discussions

Following agreement on the ranking of options, participants expressed concern at the high cost of the shortlisted options.

Based on the requirements of the RMS document *Network Performance Measures and Network Planning Targets, July 2010* it was established that there is no warrant for a northbound overtaking lane at Bolivia Hill. Further development of the shortlisted options will therefore be based on a three lane cross section.

Participants agreed that consideration should be given to varying some of the design criteria set out by the network planning target to make this route more consistent with the usage of the topography.

Conclusions reached were as follows:

- Costs will be reduced when a three lane cross section is adopted
- Costs would be substantially reduced if a steeper vertical alignment was adopted – say 7-8%. This would lower the grade line resulting in substantially shorter bridges, smaller retaining walls and smaller fills.
- This project should be related to similar projects such as Devils Pinch on the New England Highway south of Glen Innes to refine the criteria and get approval from the federal government.

RMS participants agreed that approval for the adoption of relaxed design criteria should be sought.

5 Conclusions

5.1 Shortlist of options for further investigation

The shortlisted options to be investigated in more detail are as follows:

Option 6 Rank 1

Option 10 Rank 2

Option 7 Rank 3

Option 2 Rank 4

5.2 Revised design criteria

RMS will seek approval to revised design criteria to make this route more consistent with the usage of the topography.

Following approval of the revised criteria, Cardno will modify the shortlisted options and re-estimate the cost of each.

Bolivia Hill Upgrade – Assessment of Route Options

APPENDIX A
WORKSHOP AGENDA

Cardno
Shaping the Future

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Bolivia Hill Upgrade

Internal Technical Workshop

Date: 21 November 2012

Time: 9.00am - 5.00pm

Venue: Cardno
Level 9
203 Pacific Highway
St Leonards

Attendees:

RMS

- Colin Nunn
- Brett Butcher
- Cameron Adam
- Damien Sartori
- Gurjit Singh
- Nick McTeigue
- Anita Kemp
- Geoff Kearns
- Kirsty Sutherland
- Steve Brailsford

Transport for NSW

- Viv Manwaring
- Joann Tulett

Cardno

- John Rayment
- Kester Boardman
- Jay Hodson
- Craig Stoddart
- Paul Lambert
- Devinda Kumarasinghe
- Larissa Miller
- Caroline Bathje
- Kieran Geraghty
- Boon Quah

AGENDA

8.30 – 9.00	Tea / coffee	
9.00 – 9.20	Introductions and workshop overview	John Rayment
9.20 – 9.30	RMS overview	Gurjit Singh
9.30 – 9.45	Traffic and transport background	Devinda Kumarasinghe
9.45 – 10.30	Specialist presentations (see Note 1)	Cardno
10.30 – 10.45	Morning tea	
10.45 – 12.30	Specialist presentations (continued)	Cardno

12.30 – 1.45	Lunch	
1.45 – 3.30	Discussion – agreement on rating and ranking of route options	All
3.30 – 3.45	Afternoon tea	
3.45 – 4.30	Further discussion (if required)	All
4.30 – 5.00	Wrap up and action plan	All

Note 1 Refer to Section 5 of the Internal Technical Workshop Background Paper

Bolivia Hill Upgrade – Assessment of Route Options

APPENDIX B
PRELIMINARY ROUTE OPTIONS

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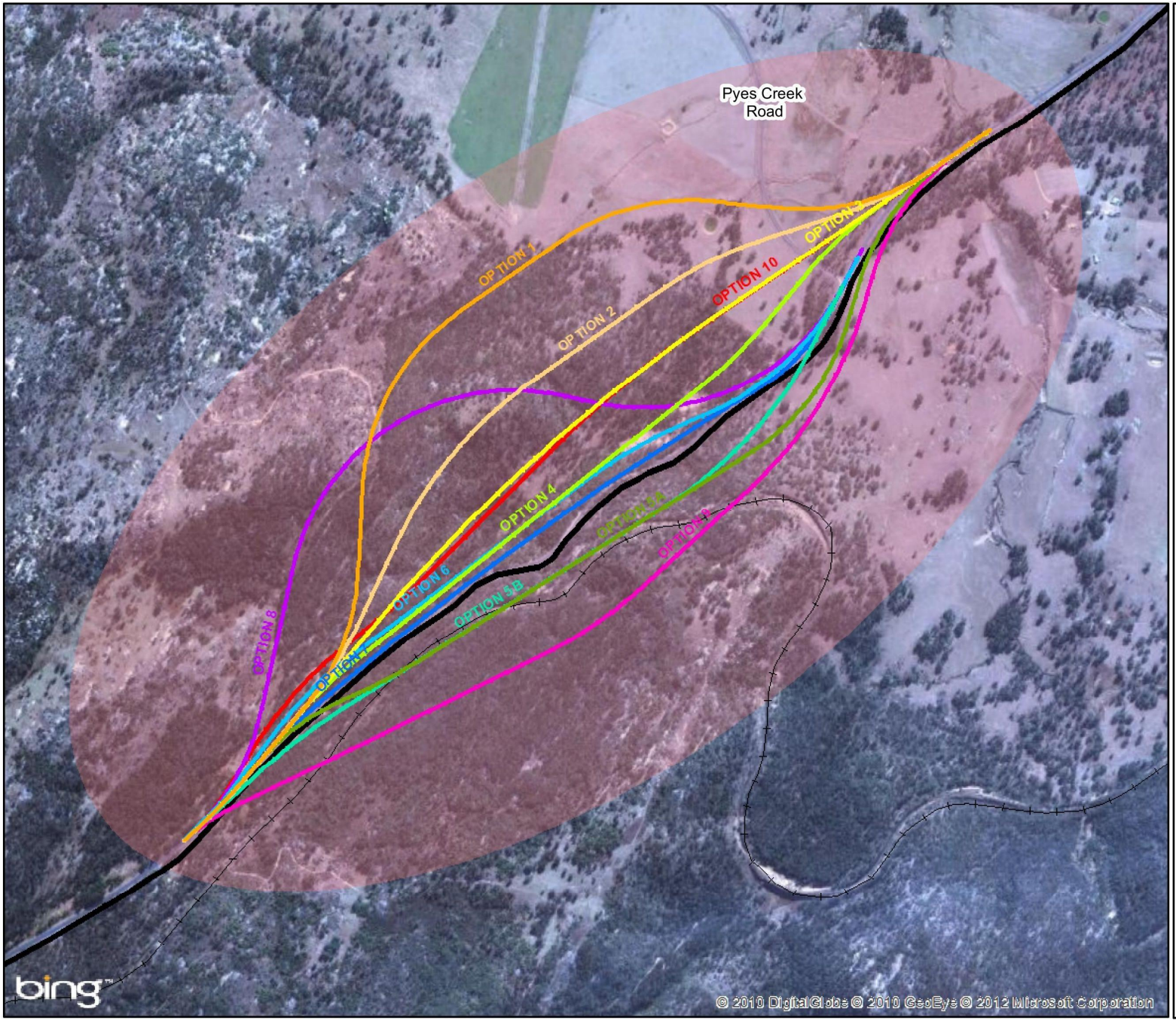

NSW GOVERNMENT Transport Roads & Maritime Services

Alignment Options

HW9 BOLIVIA HILL UPGRADE

Legend

- Study Area
- Option 1
- Option 2
- Option 3
- Option 4
- Option 5A
- Option 5B
- Option 6
- Option 7
- Option 8
- Option 9
- Option 10
- Railway Line
- New England Highway

N W E S

1:15,000 Scale at A4

Metres
0 50 100 200 300 400

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2012-12-21
Coordinate System: GDA 1994 MGA Zone 56
Project: NA89913018-04
Map: G4019_RouteOptions_combined.mxd 01
Data Sources: NSW Land and Property Information (LPI)

Bolivia Hill Upgrade – Assessment of Route Options

APPENDIX C
COMMUNITY ROUTE OPTIONS

Cardno
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New England Highway
Bolivia Hill upgrade

Australian Government
Nation Building Program

NSW GOVERNMENT Transport Roads & Maritime Services

SEPTEMBER 2012

The Australian Government has committed $6 million for planning of safety works at Bolivia Hill and a future Tenterfield heavy vehicle bypass as part of the Nation Building Program.

The New England Highway is a major link from the Hunter Region to the New England area and beyond.

Bolivia Hill is a steep winding section of the New England Highway between Glen Innes and Tenterfield. The existing highway corridor is narrow with a rock face to the east and steep drop to the west.

Initial investigations for the project will include:

- Meeting with adjacent landowners and other stakeholders.
- Mapping environmental constraints.
- Investigating technical and engineering issues.
- Developing route options.

Current status

Roads and Maritime Services (RMS) has engaged Cardno to help develop route options. Investigations are now underway. Initial discussions have been held with key stakeholders and property owners to identify local constraints and issues.

Study area

Investigations will focus within a proposed study area, indicated on the opposite plan.

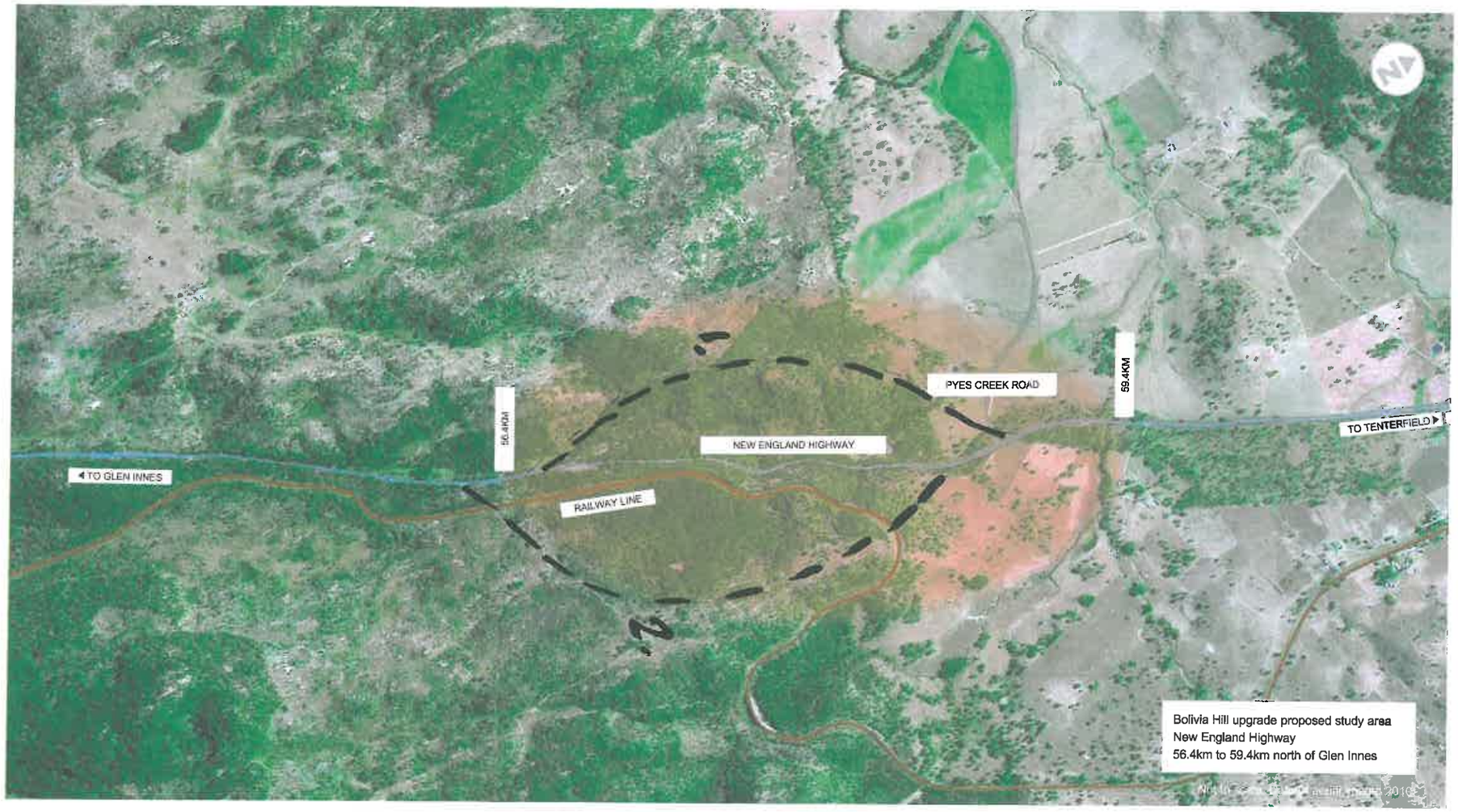
The aim of the investigations is to determine a preferred New England Highway corridor route at Bolivia Hill. The preferred route will meet the following objectives:

- Improve road safety.
- Improve road transport productivity, efficiency and reliability of travel.
- Minimise the impact on the natural, cultural and built environment.
- Provide value for money.

More Information

If you would like to be kept up to date with the project's progress, please contact the Bolivia Hill Upgrade project team by calling 1800 024 535 or emailing boliviahill@cardno.com.au

Figure C1 - Community Option



Bolivia Hill upgrade proposed study area
New England Highway
56.4km to 59.4km north of Glen Innes

The existing route features steep and winding curves

View of Bolivia Hill approaching from the north

The existing route is bounded by a steep rock face to the east

Figure C2 - Community Option

Bolivia Hill Upgrade – Assessment of Route Options

APPENDIX D
SUMMARY OF SCORES

Cardno
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Table D1 - Summary of initial assessment of long list of options against project objectives and assessment criteria

	Project Objectives	Critical Criteria*1	Description of criteria that can be assessed	1	2	3	4	5a	5b	6	7	8	9	10
	Improve road safety	> Reduced crash rate and injuries. > Improved road safety standards – improved geometry standard. > Minimise conflict points on the highway (intersections). > Constructability. > Work Health and safety in construction and maintenance.	Provide for an overtaking lane for southbound traffic and possibly a dual lane carriageway separated by wire rope.	4	4	4	4	4	4	4	3	4	4	4
			Provide an alignment that minimises problems in construction.	1	2	3	3	1	1	3	1	1	1	3
			Maintain at least one lane of the highway open during construction of the upgrade.	4	4	4	4	4	4	4	3	4	4	4
			Minimise work health and safety risk in construction and maintenance.	2	3	3	3	2	2	3	1	2	2	3
1			AVE FOR ROAD SAFETY	2.75	3.25	3.5	3.5	2.75	2.75	3.5	2	2.75	2.75	3.5
2			TOTAL FOR ROAD SAFETY	11	13	14	14	11	11	14	8	11	11	14
3			RANK FOR ROAD SAFETY	6	5	1	1	6	6	1	11	6	6	1
4	Improve road transport productivity efficiency and reliability of travel	> Reduced road freight user costs. > Reduced travel time. > Target a route level of service of A. > Increase road network capacity.	Provide appropriate horizontal and vertical road geometry.	2	2	2	3	2	3	2	1	2	3	3
5			RANK FOR EFFICIENCY	5	5	5	1	5	1	5	11	5	1	1
	Minimise the impact on the natural, cultural and built environment	> Impact on fauna habitat including threatened species. > Impact on flora including threatened species. > Water quality > Air quality > Noise and vibration impact. > Aboriginal and Europe heritage. > Stormwater and drainage. > Residential and commercial properties impacted. > Ecological sustainability. > Visual impact and amenity.	Minimise adverse impacts on native vegetation.	2	3	3	3	1	1	3	3	2	1	3
			Minimise adverse impacts on sensitive habitats.	2	3	3	3	1	1	3	3	2	1	3
			Minimise adverse impacts on surface water quality.	2	2	3	3	3	3	3	3	2	3	2
			Minimise adverse impacts on flooding and drainage	2	2	2	3	3	3	2	3	2	3	2
			Minimise adverse impacts on known European heritage sites, values and areas of archaeological potential.	2	2	1	2	4	4	3	3	2	4	1
			Minimise adverse impacts on known Aboriginal heritage sites, values and areas of archaeological potential.	3	3	3	3	2	2	4	3	4	3	3
			Potential to use recycled or waste materials.	1	1	4	2	1	1	3	4	1	1	3
6			AVE FOR ENVIRONMENT	2.0	2.3	2.7	2.7	2.1	2.1	3.0	3.1	2.1	2.3	2.4
7			TOTAL FOR ENVIRONMENT	14	16	19	19	15	15	21	22	15	16	17
8			RANK FOR ENVIRONMENT	11	6	3	3	8	8	2	1	8	6	5
	Provide value for money	> Cost benefit ratios. > NPV over 30 years. > Road user costs and benefits. > Infrastructure operating costs (incl maintenance). > Comparative project costs.	Minimise project cost.	$584 M	$316 M	$445 M	$430 M	$374 M	$693 M	$278 M	$129 M	$ 1,073 M	$890 M	$362 M
9				0	2	1	1	2	0	3	4	0	0	2
10			RANK VALUE FOR MONEY	8	3	6	6	3	8	2	1	8	8	3
	Note *1 – Feasible routes must conform to critical criteria		**Total Score (2+4+7+9)**	27	33	36	37	30	29	40	35	28	30	36
			Score out of 16 (equal weighting of 4 categories) (1+4+6+9)	6.8	9.5	9.2	10.2	8.9	7.9	11.5	10.1	6.9	8.0	10.9
			Sum of ranks (3+5+8+10)	30.0	19.0	15.0	11.0	22.0	23.0	10.0	24.0	27.0	21.0	10.0
	Key													
	Eliminated due to fatal flaw		**Initial Rank (on Total Score)**	11	6	3	2	7	9	1	5	10	7	3
	Variation of another option		**Rank with equal weighting**	11	5	6	3	7	9	1	4	10	8	2
			Best ranked	11	5	4	3	7	8	1	9	10	6	1
						Var of 10	Var of 6							
			Final Shortlist		4					1	3			2

Table D2 - Summary of initial assessment of long list of options against project objectives and assessment criteria (culled)

	Project Objectives	Critical Criteria*[1]	Description of criteria that can be assessed	2	5a	6	7	10
	Improve road safety	> Reduced crash rate and injuries. > Improved road safety standards – improved geometry standard. > Minimise conflict points on the highway (intersections). > Constructability. > Work Health and safety in construction and maintenance.	Provide for an overtaking lane for southbound traffic and possibly a dual lane carriageway separated by wire rope.	4	4	4	3	4
			Provide an alignment that minimises problems in construction.	2	1	3	1	3
			Maintain at least one lane of the highway open during construction of the upgrade.	4	4	4	3	4
			Minimise work health and safety risk in construction and maintenance.	3	2	3	1	3
1			AVE FOR ROAD SAFETY	3.25	2.75	3.5	2	3.5
2			TOTAL FOR ROAD SAFETY	13	11	14	8	14
3			RANK FOR ROAD SAFETY	3	4	1	5	1
4	Improve road transport productivity efficiency and reliability of travel	> Reduced road freight user costs. > Reduced travel time. > Target a route level of service of A. > Increase road network capacity.	Provide appropriate horizontal and vertical road geometry.	2	2	2	1	3
5			RANK FOR EFFICIENCY	2	2	2	5	1
	Minimise the impact on the natural, cultural and built environment	> Impact on fauna habitat including threatened species. > Impact on flora including threatened species. > Water quality > Air quality > Noise and vibration impact. > Aboriginal and Europe heritage. > Stormwater and drainage. > Residential and commercial properties impacted. > Ecological sustainability. > Visual impact and amenity.	Minimise adverse impacts on native vegetation.	3	1	3	3	3
			Minimise adverse impacts on sensitive habitats.	3	1	3	3	3
			Minimise adverse impacts on surface water quality.	2	3	3	3	2
			Minimise adverse impacts on flooding and drainage	2	3	2	3	2
			Minimise adverse impacts on known European heritage sites, values and areas of archaeological potential.	2	4	3	3	1
			Minimise adverse impacts on known Aboriginal heritage sites, values and areas of archaeological potential.	3	2	4	3	3
			Potential to use recycled or waste materials.	1	1	3	4	3
6			AVE FOR ENVIRONMENT	2.3	2.1	3.0	3.1	2.4
7			TOTAL FOR ENVIRONMENT	16.0	15.0	21.0	22.0	17.0
8			RANK FOR ENVIRONMENT	4	5	2	1	3
	Provide value for money	> Cost benefit ratios. > NPV over 30 years. > Road user costs and benefits. > Infrastructure operating costs (incl maintenance). > Comparative project costs.	Minimise project cost.	$316 M	$374 M	$278 M	$129 M	$362 M
9				2	2	3	4	2
10			RANK VALUE FOR MONEY	3	3	2	1	3

Note *1 – Feasible routes must conform to critical criteria

Total Score (2+4+7+9)	33	30	40	35	36
Score out of 16 (equal weighting of 4 categories) (1+4+6+9)	9.5	8.9	11.5	10.1	10.9
Sum of ranks (3+5+8+10)	12.0	14.0	7.0	12.0	8.0
Initial Rank (on Total Score)	4	5	1	3	2
Rank with equal weighting	4	5	1	3	2
Best ranked	3	5	1	3	2
Final Shortlist	4		1	3	2