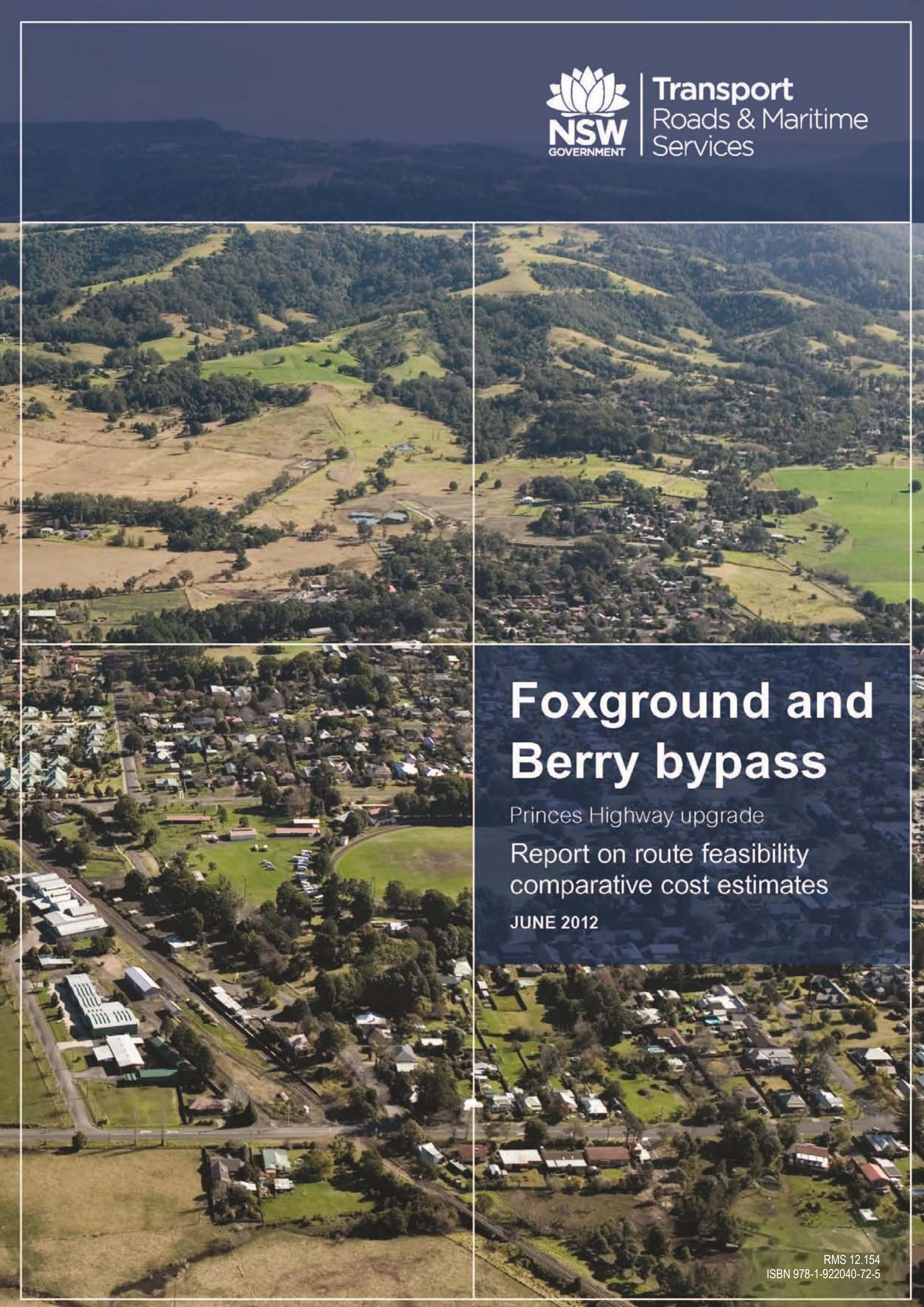

Transport
Roads & Maritime Services

Foxground and Berry bypass

Princes Highway upgrade

Report on route feasibility comparative cost estimates

JUNE 2012

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Quality information

Document	Foxground and Berry bypass Route Feasibility Comparative Cost Estimates Report
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RMS acceptance

Business unit	Southern Operations and Engineering Services
Project No.	DEV06/04
Approving Officer	Steve Arnold, General Manager Development Program
Reviewing Officer	Ron de Rooy, RMS Project Development Manager

Revision date	Details	Name / Position	Signature
June 2012	For Issue	Steve Arnold General Manager Development Program	
Version 2, 29 June 2012	Addenda 1 to 17	Geoff Cahill	

Prepared by

AECOM aurecon EVANS & PECK PETER STEWART CONSULTING P/L NSW GOVERNMENT Transport Roads & Maritime Services

LIST OF ADDENDA

The following minor changes have been made to the report since its publication on 8 June 2012:

(1) Page 3, Table 2:

- Replaced "Maximum cost if all discretionary items adopted" with "Maximum discretionary cost";
- Replaced "$573.1m" with "$566.1m".

(2) Page 3, second paragraph:

Replaced this paragraph with "The **provisional** sums, if the maximum discretionary cost was adopted would **increase** the potential cost of the northern route by **$20.7m** to **$566.1m**, but would have **no impact** on the southern route."

(3) Page 142, Section 7.3.3.9 Structures:

- Replaced $139.3m with $44.9m.

(4) Page 143, Section 7.3.3.13 Provisional items, paragraphs 2 and 3:

- Replaced "$25.9 million" with "$20.7 million".

(5) Page 2, paragraph 3:

- Replaced "$693m" with "$711m".

(6) Page 2, Table 1:

- Balance of construction costs, southern route – replaced "$98m" with "$118m";
- Balance of construction costs, difference – replaced "-$53m" with "-$33m";
- Project management and design, southern route – replaced "$89m" with "$86m";
- Project management and design, difference – replaced "$21m" with "$18m";
- Total, southern route – replaced "$693m" with "$711m";
- Total, difference – replaced "$148m" with "$166m".

(7) Page 3, Table 3:

- Total estimate, southern route – replaced "$693.3m" with "$710.7m";
- Maximum discretionary cost – replaced "$693.3m" with $710.7m".

(8) Page 3, paragraph 1:

- Inserted text "if the maximum amount was adopted would";
- Replaced "$68.6m" with "$51.2m";
- Repalced "$693.3m" with "$710.7m".

(9) Page 125, Table 7.1:

- Balance of construction costs, southern route – replaced "$98m" with "$118m";
- Balance of construction costs, difference – replaced "-$53m" with "-$33m";
- Project management and design, southern route – replaced "$89m" with "$86m";

- Project management and design, difference – replaced "$21m" with "$18m";
- Total, southern route – replaced "$693m" with "$711m";
- Total, difference – replaced "$148m" with "$166m".

(10) Page 135, Table 7.8:

- Concept development, sub-total, contingency amount – replaced "$802,562" with "$1,002,562";
- Total, contingency amount – replaced "$161,815,329" with "$162,015,329";
- Updated Note 3 – the word "where" was replaced with the word "because";
- Updated the date on the estimate summary sheet from "19/06/2012" to "27/06/2012".

(11) Page 136, Table 7.9:

- Concept development, sub-total, contingency amount – replaced "$930,200" with "$1,230,200";
- Total, contingency amount – replaced "$220,908,870" with "$221,208,870";
- Updated Note 3 – the word "where" was replaced with the word "because";
- Updated the date on the estimate summary sheet from "19/06/2012" to "27/06/2012";
- 1. Concept development, sub-total, % of total estimate – replaced "0.62%" with "0.61%";
- 2. Detail design & documentation, sub-total, % of total estimate – replaced "9.64%" with "9.40%";
- 3. Property acquisitions, sub-total, % of total estimate – replaced "3.28%" with "3.20%";
- 4. Utility adjustments, sub-total, % of total estimate – replaced "1.30%" with "1.27%";
- 5(d) Adjustment sums, base estimate (excluding contingency) – replaced "-$44,122,443" with "-$32,922,131";
- 5(d) Adjustment sums, contingency amount – replaced "-$24,429,488" with "-$18,228,156";
- 5(d) Adjustment sums, estimate (including contingency) – replaced "-$68,551,931" with "-$51,150,287";
- 5. Infrastructure construction, sub-total, base estimate (excluding contingency) – replaced "$383,324,390" with "$394,524,702";
- 5. Infrastructure construction, sub-total, contingency % – replaced "48%" with "49%";
- 5. Infrastructure construction, sub-total, contingency amount – replaced "$185,458,029" with "$191,659,360";
- 5. Infrastructure construction, sub-total, estimate (including contingency) – replaced "$568,782,419" with "$586,184,062";

- 5. Infrastructure construction, sub-total, % of total estimate – replaced "82.04%" with "82.48%";
- 6. Finalisation, sub-total, % of total estimate – replaced "3.12%" with "3.04%";
- Total, base estimate (excluding contingency) – replaced "$472,066,577" with "$483,266,889";
- Total, contingency amount – replaced "$221,208,870" with "$227,410,202";
- Total, estimate (including contingency) – replaced "$693,275,447" with "$710,677,091";
- Total project estimate – replaced "$694,000,000" with "$711,000,000";
- Cost per km, base cost – replaced "$36,880,201" with "$37,755,226";
- Cost per km, estimate with contingency – replaced "$54,162,144" with "$55,521,648";
- Cost per lane-km, base cost – replaced "$9,220,050" with "$9,438,806";
- Cost per lane-km, estimate with contingency – replaced "$13,540,536" with "$13,880,412".

(12) Page 137, Table 7.11:

- Earthworks, % amounts – replaced "34.3%" with "33.5%";
- Earthworks, % cumulative values – replaced "34%" with "33%";
- Structures, % amounts – replaced "26.5%" with "25.8%";
- Structures, % cumulative values – replaced "61%" with "59%";
- General, $ amounts – replaced "$108.0" with "$125.4";
- General, % amounts – replaced "15.6%" with "17.6%";
- General, $ cumulative values – replaced "$529.3" with $546.7";
- General, % cumulative values – replaced "76%" with "77%";
- Pavements, % amounts – replaced "9.1%" with "8.9%";
- Pavements, $ cumulative values – replaced "$592.4" with $609.8";
- Pavements, % cumulative values – replaced "85%" with "86%";
- Miscellaneous, % amounts – replaced "3.1%" with "3.0%";
- Miscellaneous, $ cumulative values – replaced "$614.0" with "$631.4";
- Drainage, % amounts – replaced "3.0%" with "2.9%";
- Drainage, $ cumulative values – replaced "$634.6" with "$652.0";
- Urban design & landscape, % amounts – replaced "2.9%" with "2.8%";
- Urban design & landscape, $ cumulative values – replaced "$654.5" with "671.9";
- Urban design & landscape, % cumulative values – replaced "94%" with "95%";
- Environmental, % amount – replaced "2.3%" with "2.2%";
- Environmental, $ cumulative values – replaced "$670.5" with "$687.9";

- Local roads, % amounts – replaced "1.7%" with "1.6%";
- Local roads, $ cumulative values – replaced "$681.9" with "$699.3";
- Public utility adjustments, % amounts – replaced "1.3%" with "1.2%";
- Public utility adjustments, $ cumulative values – replaced "$690.8" with "708.2";
- Noise mitigation, $ cumulative values – replaced "$693.1" with "$710.5";
- Flood mitigation, $ cumulative values – replaced "$693.3" with "$710.7";
- Total, $ amounts – replaced "$693.3" with "$710.7";
- Total, $ cumulative values – replaced "$554.6" with "$568.5".

(13) Page 140, Table 7.12:

- Total adjustment sums, southern route – replaced "-$68.6" with "-$51.2";
- Added Note 1 "Adjustment sums items HIGHLIGHTED are included in scope of item HIGHLIGHTED";
- Note 3 – inserted "refers to";
- Added Note 4 "The provisional sums of $15.8 million (split KVR interchange) and $5.2 million (off-ramp under interchange overbridge) are mutually exclusive."

(14) Page 143, Section 7.3.3.13, paragraph 1 last sentence:

- Replaced the sentence with "Some of the adjustment sums have common scopes. If the maximum Adjustment Sums are realised the result is a cost saving of $51.2 million to the southern route."

(15) Page 146:

- Replaced "$693m" with "$711m".

(16) Appendix H, northern route:

- Separated provisional items section from the cost estimate;
- Note 3 – corrected from 'amount from NOT incl' to 'amount not included';
- Note 3 – replaced 'where drevided' with 'because derived';
- Updated the date on the infrastructure construction estimate summary from "19/06/2012" to "27/06/2012";
- 5(d) Adjustment sums, comments/assumptions – inserted "Refer NOTE 1. below";
- Updated Note 1 to "1. Adjustment Sums items HIGHLIGHTED are included in scope of item HIGHLIGHTED";
- Inserted Note 2 "2. Provisional Sum amount NOT incl. in Project Estimate total because derived from a discretionary item currently under consideration";
- 5(e) provisional sums, comments/assumptions - replaced "Refer NOTE 1. above" with "Refer NOTE 2. above".

(17) Appendix H, southern route:

- Separated provisional items section from the cost estimate;

- Note 3 – corrected from ‘amount from NOT incl’ to ‘amount not included’;
- Note 3 – replaced ‘where drevided’ with ‘because derived’;
- Updated the date on the infrastructure construction estimate summary from “19/06/2012” to “27/06/2012”;
- 5(a) Base infrastructure, sub-total, % of total estimate – replaced “98.22%” with “95.14%”;
- 5(b) Environmental works, sub-total, % of total estimate – replaced “5.52%” with “5.34%”;
- 5(c) General activities, sub-total, % of total estimate – replaced “9.05%” with “8.76%”;
- 5(d) Adjustment sums, sub-total, base estimate (excluding contingency) – replaced “-$44,122,443”’ with “-$32,922,131”;
- 5(d) Adjustment sums, contingency amount – replaced “-$24,429,488” with “-$18,228,156”;
- 5(d) Adjustment sums, estimate (including contingency) – replaced “-$68,551,931” with “-$51,150,287”;
- 5(d) Adjustment sums, sub-total, % of total estimate – replaced “-12.79%” with “-9.24%”;
- 5(d) Adjustment sums, comments/assumptions – inserted “Refer NOTE 1. below”;
- Total, base estimate (excluding contingency) – replaced “$360,021,722” with “$371,222,034”;
- Total, contingency amount – replaced “$176,136,962” with “$182,338,293”;
- Total, estimate (including contingency) – replaced “$536,158,684” with “$553,560,328”;
- Total amount – replaced “$536,158,684” with “$553,560,328”;
- Updated Note 1 to “1. Adjustment Sums items HIGHLIGHTED are included in scope of item HIGHLIGHTED”;
- Inserted Note 2 “2. Provisional Sum amount NOT incl. in Project Estimate total because derived from a discretionary item currently under consideration”;
- 5(e) provisional sums, comments/assumptions - replaced “Refer NOTE 1. above” with “Refer NOTE 2. above”.

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LIST OF APPENDICES

Executive summary

The development of route options for the Princes Highway upgrade program began in March 2006, with a preferred 11.6km Foxground and Berry Bypass route including a bypass to the north of Berry, announced by Roads and Maritime Services (RMS) in December 2011. In February 2012 RMS was directed by the Minister for Roads and Ports to undertake a cost evaluation of a southern Berry bypass route following a suggestion submitted by a community member in December 2011.

The December 2011 community submission claimed to provide a cost saving of $23 million in direct costs and numerous qualitative benefits to Berry over the northern bypass route. The proposal claimed that the southern route is a true bypass as opposed to the northern route which divides the older part of Berry from the new development area to the northwest. In February 2012 this claim was expanded further stating a potential cost saving of up to $50 million could be achieved if the contractor costs and a full contingency were included.

RMS formed a group of technical experts to investigate a southern suggestion. RMS prepared two route feasibility cost estimates for the Foxground and Berry Bypass project, one incorporating a bypass to the north of Berry and one incorporating a bypass to the south, as shown in Figure 1. This report documents these investigations to develop the design of the southern route and perform technical and construction investigations to sufficiently undertake a like-for-like cost comparison with the northern route. The investigation process was carried out between February 2012 and June 2012. This work was witnessed and reviewed by an independent review team to ensure the process was thorough and impartial during the assessment of technical criteria and construction methodologies.

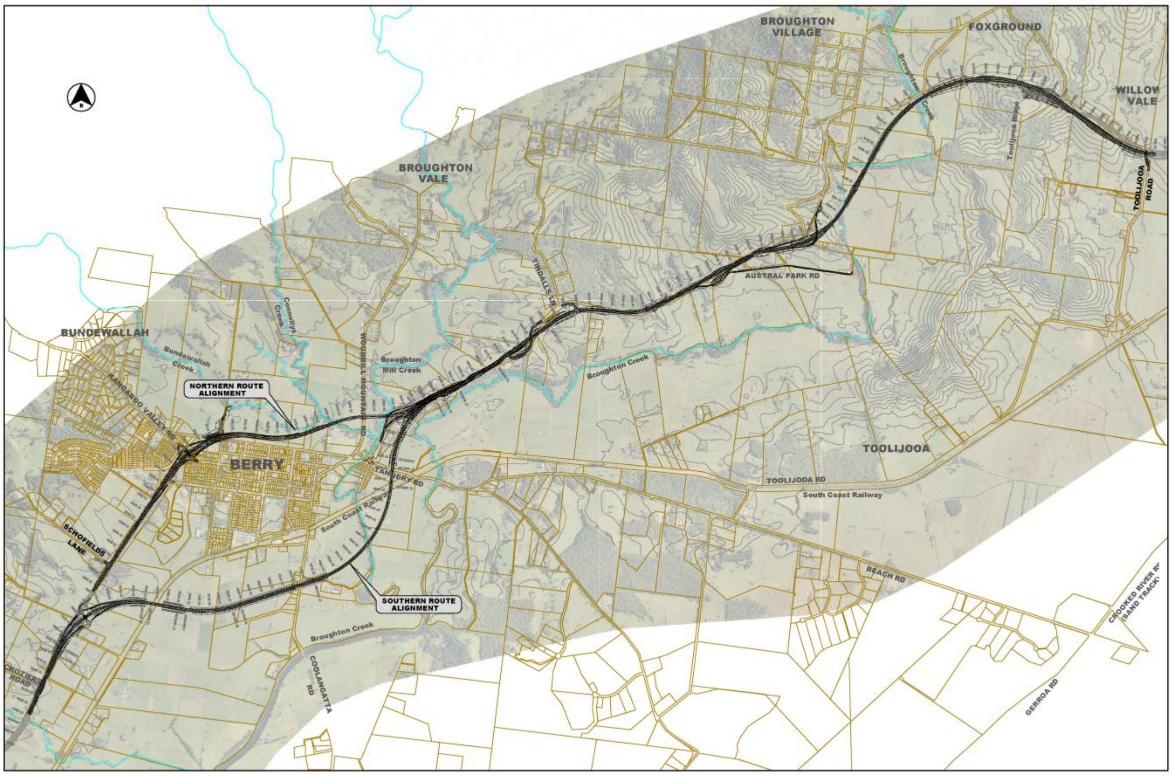


Figure 1 Northern route and southern route comparison

The investigation has produced two strategic cost estimates of the whole Foxground and Berry Bypass project cost, the first with the cost of the northern route and the second with the cost of the southern route. Incorporating the southern route requires that the overall length of the 11.6km Foxground and Berry Bypass section be extended by approximately 1.2km to 12.8km, re-joining the Princes Highway alignment at Croziers Road. To ensure like-for-like comparisons for the purposes of the investigation, the northern route is extended to the same end point.

Prior to this investigation the Foxground and Berry Bypass project, incorporating the bypass to the north of Berry, had been developed to concept design level. Therefore much of the investigation focused on preparing information for the southern route sufficient to a level comparable with the Foxground and Berry Bypass concept design, to produce a similar standard cost estimate.

The investigations produced a strategic cost estimate of $545m (May 2012) for the Foxground and Berry Bypass proposal incorporating the northern route. The cost estimate for the Foxground and Berry Bypass project incorporating the southern route suggestion is $711m (May 2012). The main variances between the cost estimates are summarised below in Table 1.

Table 1 Northern and southern cost estimate summaries

Item Description	Northern Route	Southern Route	Difference
Structures	$138m	$183m	$45m
Earthworks	$97m	$238m	$141m
Pavements	$67m	$63m	-$4m
Balance of construction costs	$151m	$118m	-$33m
Land acquisitions	$24m	$23m	-$1m
Project management and design	$68m	$86m	$18m
TOTAL	**$545m**	**$711m**	**$166m**

Note: Above amounts are inclusive of contingency allowances

Proposed amendments to the "base case" designs raised during the investigation process were included where feasible. In other cases these amendments were assessed as provisional items to allow for investigation and costing within the time available.

Provisional item costs addressed during the investigation process are summarised in Table 2, with details of the provisional items provided in Table 3. These items have been classed as either adjustment sums or provisional sums. Adjustment sums were calculated for items assessed as likely to be in the next stage of the design development and are included in the project estimate. Provisional sums were calculated for items that are discretionary, requiring more design development and further consideration and are not included in the project estimate.

Table 2 Northern and southern routes provisional cost items (rounded to $0.1m)

Item Description	Northern route	Southern route
Base estimate	$545.4m	$761.8m
Adjustment sums (required for further design development)		
Reroute alignment south of the sewage treatment plant		$9.6m
Island embankment		-$5.6m
Realignment of northern interchange		-$2.3m
Changes to vertical alignment to generate extra fill material		-$55.1m
Adjustment to southern interchange		-$15.1m
Total estimate	**$545.4m**	**$710.7m**
Provisional sums (discretionary)		
Additional pedestrian bridge	$4.5m	
Northbound offload ramp to Woodhill Mountain Road	$0.4m	
Adjustments to Kangaroo Valley Road interchange, split ramps	$15.8m	
Adjustments to Kangaroo Valley Road interchange, Northbound offload under Kangaroo Valley Road	$5.2m	
Maximum discretionary cost	**$566.1m**	**$710.7m**

The **adjustment** sums, if the maximum amount was adopted would **reduce** the total cost of the southern route by **$51.2m** to **$710.7m**, but have **no impact** on the **total cost** of the northern route.

The **provisional** sums, if the maximum discretionary cost was adopted would **increase** the potential cost of the northern route by **$20.7m** to **$566.1m**, but would have **no impact** on the southern route.

Table 3 Details of provisional items

Community input	Status: * (additional, provisional)	Why	Additional comments
Southern route			
Reroute alignment south of the sewage treatment plant	additional	Likely to be in the next stage of development	▪ Aims to minimise bridge length and impacts on local properties and provide flood relief for the sewage treatment plant
Island embankment	additional	Likely to be in the next stage of development	▪ Aims to reduce overall capital cost by increasing the length of embankment and reducing the length of bridges
Realignment of northern	additional	Likely to be in the next stage	▪ Aims to minimise property impacts on the heritage property “Mananga” and win additional fill

Community input	Status: * (additional, provisional)	Why	Additional comments
interchange		of development	material to address the earthworks imbalance
Changes to vertical alignment to generate extra fill material	additional	Likely to be in the next stage of development	▪ Aims to generate additional fill material to achieve balanced earthworks
Adjustment to southern interchange	additional	Likely to be in the next stage of development	▪ Aims to generate additional fill material by redesigning the southern interchange so that local roads pass over the upgraded highway rather than vice versa
Northern route			
Additional pedestrian bridge at North Street	provisional	Access for North St pedestrians can be provided over the nearby Kangaroo Valley Road bridge	▪ Restores severed access ▪ Would impact northern views ▪ Unlikely to attract the majority of pedestrian traffic ▪ Adds cost
Northbound offload ramp to Woodhill Mountain Road	provisional	Traffic predictions show no warrant for an additional ramp	▪ Would require construction in a flood plain and crosses Bundewallah Creek twice ▪ No value in acquiring land now
Adjustments to Kangaroo Valley Road interchange, relocation of south facing ramps	provisional	Requires more design development	▪ Reduces noise & visual impacts ▪ Preserves Mark Radium Park ▪ Reduces bridge & earthworks by one lane width, slight cost reduction ▪ Effectively relocates one of four ramps ▪ Increases highway footprint ▪ Bigger impact on some properties and impacts additional properties ▪ Requires an additional bridge and one kilometre of two way road, increases cost
(RMS input) Adjustments to Kangaroo Valley Road interchange, locate northbound offload ramp under Kangaroo Valley Road bridge	provisional	Requires more design development	▪ Reduces direct impacts on residences ▪ Intersection located on vacant RMS owned land ▪ No adjustment to Huntingdale Park Road required ▪ Reduces noise & visual impacts ▪ Allows roundabout at Huntingdale Park Rd and Kangaroo Valley Road to be constructed earlier ▪ Reduces or eliminates the need for a noise wall ▪ Requires a longer bridge at Kangaroo Valley Road

Community input	Status: * (additional, provisional)	Why	Additional comments
			▪ Potential greater visual impact of roundabouts ▪ Slightly increased land take from adjacent farms

* All these additional and provisional items with the exception of the one marked RMS input have been suggested by the community. All community suggestions have been accepted as valid except one item which was found to be non-compliant and no improvements or benefits to the existing southern route were able to be derived.

This investigation is to inform the community, RMS and the NSW Government of the cost feasibility of a southern bypass route. If a decision is made by the Minister for Roads and Ports to proceed further in consideration of the southern route, community consultation would continue through the formal environmental assessment planning process where all qualitative issues would be considered.

1 Introduction

The Princes Highway between Gerringong and Bomaderry is one of the remaining sections between Waterfall and Jervis Bay Road to be upgraded to four lanes. The proposed Foxground and Berry Bypass is approximately the middle third of the Princes Highway upgrade between Gerringong and Bomaderry, with the Gerringong section commencing construction later in 2012 and the section south of Bomaderry now in planning.

The development of route options for the Princes Highway upgrade program began in March 2006 and considered all three highway upgrade projects collectively between Gerringong and Bomaderry. The preferred route for the Berry bypass was announced by Roads and Maritime Services (RMS), formerly the Roads and Traffic Authority, in 2009, and included a bypass to the north of the Berry township. The concept design for the Foxground and Berry Bypass section was completed in early 2012 and included the preferred bypass route to the north of Berry.

In December 2011, members of the community submitted a proposal for a bypass route to the south of Berry. Following this submission, the Minister for Roads and Ports directed RMS to investigate the costs of a southern route and compare it to the costs of the current northern preferred route.

This report documents the RMS investigations of the preferred northern route and the southern route for the preparation of cost estimates of the two routes. RMS established a technical investigation group to prepare a design and information.

A technically compliant design based on the community member's submission for a southern bypass route between Tindalls Lane (CH14500) and Croziers Road (CH20400) was initially developed. The investigation then examined technical criteria and construction methodologies to develop an optimised design for a southern bypass route and to prepare a cost estimate. Several community suggestions to improve the design of both the northern preferred route and the southern route were included. Where necessary, further investigations were also undertaken for the northern bypass route. In line with the scope of the assessment, RMS focused on understanding the engineering constraints to best inform the cost comparison for both routes as closely as possible, on a like-for-like basis.

The investigation process was independently reviewed by construction industry professionals to test whether it was thorough, balanced and technically rigorous. The independent reviewers had access to all investigation activities and provided real-time feedback at regular progress and coordination meetings. The independent reviewers recorded their observations and assessment of the process in a separate report submitted to the RMS client representative outside of the southern region.

Chapters 3 and 4 of this report document the investigation and design development process to develop the southern bypass design and ensure the two bypass routes are comparable for the purposes of preparing cost estimates. Chapters 5 and 6 document the outcomes of the technical and construction investigations and the design and cost implications of those outcomes. Chapter 7 outlines the methodology used to develop the cost estimates for the two routes and provides the details of these estimates.

In summary a base case estimate was developed for each route. However not all the proposed design amendments suggested by the community could be incorporated into the base case designs without delaying the completion of the cost estimate. To address these amendments, provisional items were created to allow investigation and costing of these items within the time available. These items were not developed to the same extent as the "base case" design and their costs necessarily attracted a higher level of contingency. These costs have been shown separately in the estimates.

Base case estimates were developed for each route based on the time restraints in preparing the report. Therefore not all design amendments coming out of community consultation could be included. However these items were included as provisional items and cost estimates developed. These are shown separately in the estimates.

2 Project background

The Princes Highway between Gerringong and Bomaderry is one of the remaining sections between Waterfall and Jervis Bay Road to be upgraded to four lanes. The proposed Foxground and Berry bypass constitutes approximately the centre one third of the Princes Highway upgrade between Gerringong and Bomaderry, with the Gerringong section commencing construction later in 2012 and the section down to Bomaderry now in planning.

The proposed Foxground and Berry bypass would provide a four lane highway (two lanes in each direction with central median separation) for 11.6 kilometres, for the most part replacing the existing Princes Highway between Toolijooa Road and Schofields Lane. The bypassing of Berry would include interchanges immediately to the southwest and northeast of the town.

Route options for the Berry area were identified and evaluated as part of a broader route options process for the Princes Highway upgrade between Gerringong and Bomaderry. This process consulted the community on the key environmental, social and economic constraints associated with the study area.

The development of route options for the Princes Highway upgrade program began in March 2006 and considered three highway upgrade projects between Gerringong and Bomaderry. The Foxground to Berry bypass project as investigated by this report, forms part of the overall upgrade.

The preferred route for the Berry bypass was announced by Roads and Maritime Services (RMS) in 2009, and included a northern bypass of the Berry township. An RMS early 2011 concept design was developed for the preferred route.

In August 2011 RMS commenced consultation with the community to re-examine the Berry bypass preferred route. Community review group meetings and design workshops focused on reducing the visual and noise impacts of the proposed route as it crosses Berry Bridge and runs adjacent to North Street. A series of bypass options presented by members of the community were explored for contribution to an improved solution. The consultation process informed and assisted the development of the RMS northern bypass route which was presented to the community in December 2011.The outputs of this consultation are documented in the *Community Review Group Option Review Report* (Dec 2011).

In December 2011 members of the community submitted a proposal for an alternative route bypassing Berry to the south, referred to as a 'southern bypass route'. As a result of this submission, RMS was directed by the Minister for Roads and Ports to compare the costs of a southern Berry bypass route with the current northern bypass route.

In response RMS developed a cost comparison between the northern route and the southern route. The cost comparison was undertaken on a like-for-like basis with the preferred northern alignment. RMS established a group of RMS personnel, principal design and engineering consultants AECOM, infrastructure management consultants Evans & Peck, and engineering consultants Aurecon and Peter Stewart Consulting to work as a team on the project. In the first instance a technically compliant design was developed based on the community members' submission for the southern bypass route to a level of detail comparable with the existing concept design for the northern bypass route. To ensure the equal comparisons, the designs were prepared between CH14500 (Tindalls Lane) and CH20400 (Croziers Road) for the two bypass routes. This required the northern bypass route to be extended approximately 1.6km along the existing highway from the Kangaroo Valley Road interchange to coincide with the southern bypass route at CH20400.

2.1 Route development history summary

The key background studies carried out previously by RMS relating to the northern bypass route and other southern bypass routes are summarised below. It must be emphasised the descriptions below do not directly apply to the current suggested southern bypass route but to similar routes examined historically. In addition, the descriptions are a summary of the reported findings of the time, not the opinions, recommendations or findings of the current investigations which have not investigated qualitative issues (environmental and social impacts), but has been directed to assess technical and quantitative criteria only.

Route Options Development Report (2007)

The *Route Options Development Report* describes the consideration of a long list of options, with the subsequent determination of a shortlist. The report is available on the project website www.rta.nsw.gov.au/fbb. A list of route options between Gerringong and Bomaderry were identified including routes to the north and south of Berry.

The high level project objectives are listed below:

- Improve road safety;
- Improve efficiency of the Princes Highway between Gerringong and Bomaderry;
- Support regional and local economic development;
- Provide value for money;
- Enhance potential beneficial environmental effects and manage potential adverse environmental impacts; and
- Optimise the benefits and minimise adverse impacts on local social environment.

Route identification was based on desktop studies and preliminary assessments of environmental and functionality constraints to determine potentially feasible routes. A route options development workshop in 2007 established a set of project criteria against which the long list of route options were considered. Findings from the specialist preliminary assessments relating to the biophysical environment, social and cultural environment, land use and property, landscape and potential amenity impacts were used to inform this feasibility assessment. Engineering functionality and economic factors were also considered.

A route options value management workshop was held to develop key assessment criteria and evaluate the potential options. This workshop included government and community participants. The workshop assessed and weighted the options against the project objectives in addition to the following key criteria:

- Functional – focusing on design objectives as well as constructability, maintenance, safety and efficiency considerations;
- Socio-economic – including business and agricultural impacts, property severance, connectivity, road traveller experience, views and impacts on community facilities/amenity; and

- Environmental (natural and cultural) – including ecological, Aboriginal heritage, flooding, noise, groundwater and climate change impacts.

Six route options were identified including one option to the south of Berry that followed the South Coast Railway line from Gerringong before bypassing Berry to the south. The value management workshop recommended that the southern option should not be pursued further as it was considered deficient on constructability, environmental, functionality and socio-economic grounds. Specifically, the key limitations of that southern option were that it had the greatest impact on the following:

- The natural environment, including impacts on endangered ecological communities, wetlands, wildlife corridors and water quality;
- The cultural environment, specifically impacts on the David Berry Hospital, Broughton Mill and the heritage precinct at Pulman Street;
- The socio-economic environment, with significant impacts on agricultural properties and the associated flow on effects on productivity and viability resulting from land take and the exacerbation of property severance;
- Communities, with the route having a greater level of severance and land acquisition, impacting on community connectivity, accessibility and amenity (such as at Toolijooa and Harley Hill);
- Landscape, with poor integration with the natural landform and the introduction of new visual impacts.

The preferred option from that process included a bypass of Berry to the north was considered to provide the best outcome for the local environment and community. It performed best against the project objectives of providing value for money, supporting regional and local economic development, traffic efficiency and maximising benefits to the local social environment and road safety.

Route Optimisation Peer Review (Connell Wagner) 2008

A peer review of the route optimisation process was commissioned by RMS in response to community feedback and a request from the (then) Minister for Roads. In particular the Minister for Roads requested a review of the process used in selecting the short listed options and the rationale behind the removal of all options to the south of Berry. The independent report prepared by Connell Wagner as part of the review is on the project website www.rta.nsw.gov.au/fbb.

The peer review supported the assessment process but recommended that further work be carried out in relation to a southern bypass option. Specifically it was recommended that further evaluation of a route between Gerringong and Berry that included a southern bypass of Berry should be considered. The review advised that more robust cost estimates and project risk identification, consistent with the assessment undertaken for short list options, be the basis of the evaluation. It was suggested that an overall rating of this option be compared against the worst performing short listed option to determine its validity. The peer review noted that when only considering the Berry bypass section of a broader route, the cost of any southern route option is likely to be greater than a northern option given the extent of structures and the associated project risks.

Response to Peer Review (Maunsell / AECOM) 2008

The recommendations of the peer review were considered by the RMS project team. It was noted that in order to be comparable in cost, a southern bypass option would need to be combined with the 'brown route', which was the short listed route that ran between Gerringong and Berry adjacent to the railway line. However the brown route had been identified through the route optimisation process as not viable. A shorter southern bypass around Berry was not considered. A more detailed cost estimate for a southern option and further assessment of risks was prepared. It was concluded that the nominated southern bypass option of Berry was likely to be approximately double the cost than a northern bypass option and concluded that whilst not quantified, the project risks would likely result in an increase in cost. However, the difference in project risks between a northern and southern bypass option was not evaluated.

Preferred Option Report and Value Management Reports 2008

The *Preferred Option Report* provides the outcomes of the process undertaken to determine the selection of the shortlist of route options. The Value Management Reports document the comparative process and outcomes of the workshops carried out to select the preferred route. Both reports are on the project website www.rta.nsw.gov.au/fbb.

The weighted assessment criteria considered most important to the value management group included road safety, connectivity and impact on the Berry community, and impact on environment and heritage.

Community Review Group Option Review Report 2011

The *Community Review Group Option Review Report* documents the community review group process between 24 August 2011 and 30 November 2011, which explored and compared options to improve the design for the northern preferred option. The report describes the evolution of the northern route, which has been used to inform this current review. This report can be found on the project website www.rta.nsw.gov.au/fbb.

3 Investigation overview

3.1 Overview

RMS established a project team to prepare comparative cost estimates for the southern route and northern route for the Berry bypass. This review follows a request from the Minister for Roads and Ports to investigate the robustness of the estimates and assumptions which informed past decisions to discontinue planning investigations into a bypass to the south of Berry. The relative cost outcomes will inform the NSW Government on whether further investigations and consultation are necessary for a southern bypass route. If a decision is made by the Minister for Roads and Ports to proceed to investigate a southern route, community consultation would continue through the environmental assessment planning process.

The Berry Bypass route review process is outlined in the Figure 3.1 below.

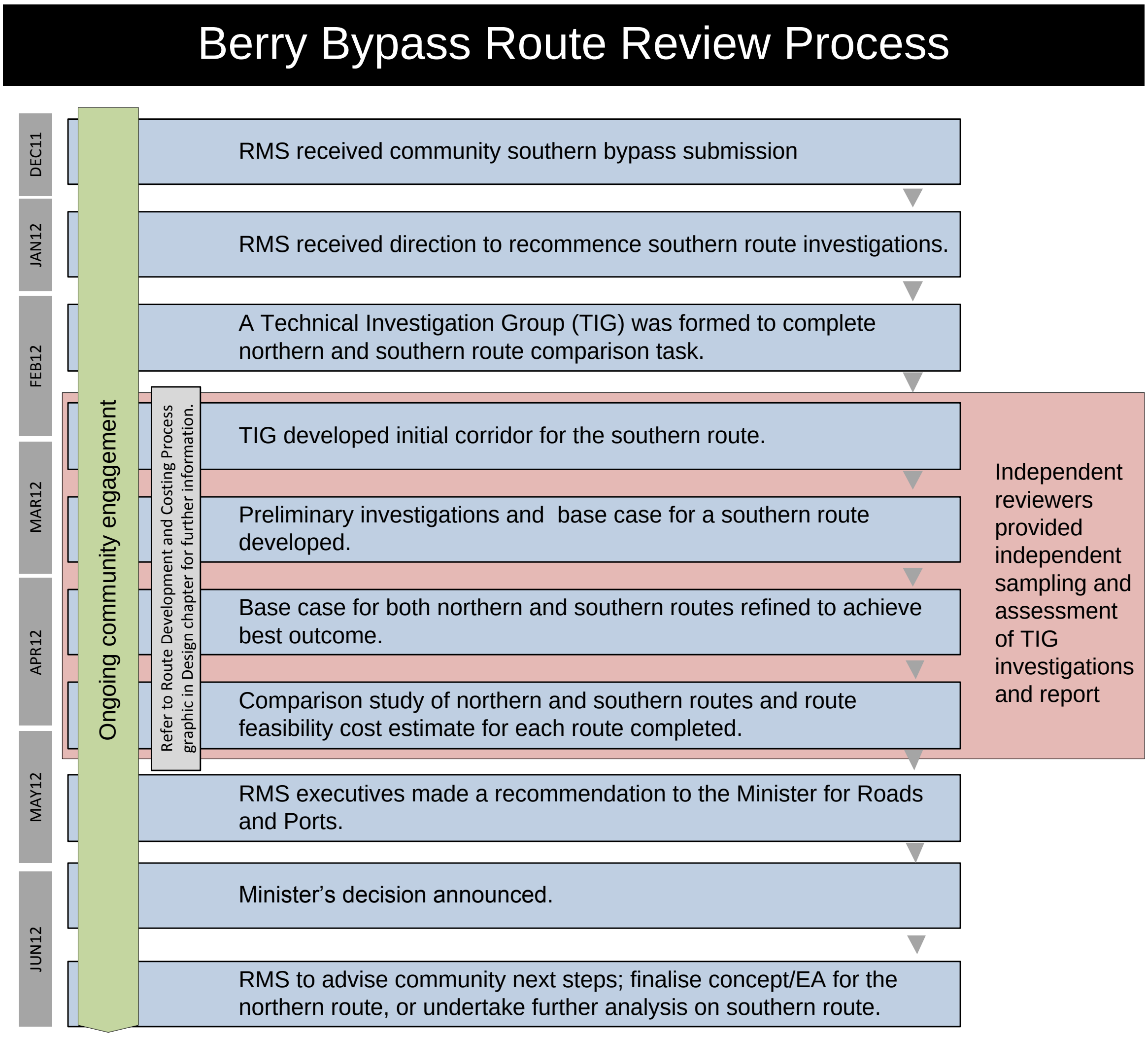


Figure 3.1 Berry Bypass route review process

3.2 Technical Investigation Group (TIG)

A project team known as the TIG was formed to carry out investigations into the suggested southern bypass route; apply improvements to the northern route where feasible; and enable the production of comparable route feasibility strategic cost estimates. The brief was to:

- develop an indicative route bypassing Berry to the south with sufficient information to produce a robust strategic cost estimate.
- use best endeavours to:
  - Optimise the southern route to minimise property impacts and land severance;
  - Engineer a cost effective southern route solution;
  - Apply any benefits found on the southern route to the northern route where applicable, and vice versa;
- complete investigations required for both the southern and northern routes to produce robust strategic cost estimate; and
- evaluate the feasibility of the routes by comparing the estimates within the context of the whole Foxground and Berry Bypass Princes Highway Upgrade.

The terms of reference for the group are provided in Appendix A1. It provides advice to RMS who advises the Minister on the study outcomes.

Technical inputs are dependent on the information held by RMS and AECOM and the knowledge base of their technical teams. The project team consisted of the members shown in Table 3.1 below. Qualifications of the group are included in Appendix A2.

Table 3.1 Technical investigation group members

TIG Member	Company	Role in TIG
Jon Williamson	AECOM, Principal Environmental Scientist	Project manager, AECOM design team
Glen Smith	AECOM, Principal Technical Officer – Roads/highways	Route design
Ben Noble	AECOM, Principal Engineer – Flood and Drainage	Flood investigations
David Kennewell	AECOM, Principal Engineer – Water Resources	Flood investigations
Henk Buys	AECOM, Technical Director – Ground Engineering	Geotechnical engineering
Ken O'Neill	Aurecon, Associate – Transport Services	Structures design
Peter Stewart	Peter Stewart Consulting Pty Ltd, Director	Construction methodology, earthworks, bridgeworks, estimating
Michael Moore	Evans & Peck, Principal	Advising on construction methodology, earthworks, bridgeworks
Philip Jorgensen	Evans & Peck, Senior Associate	Cost estimator
Steve Zhivanovich	RMS, Project Director	RMS representative

TIG Member	Company	Role in TIG
John Poposki	RMS, Lead designer (road)	RMS representative
Adam Berry	RMS, Project Development Manager	RMS representative
Ron de Rooy	RMS, Project Manager	RMS representative
Annabel Killen	Evans & Peck, Consultant	Coordination of technical documentation and report preparation
Gillian Goldsmith	Evans & Peck, Associate	Report preparation

The group has met at regular intervals throughout the process to coordinate the technical investigations and discuss and interrogate the results. The meeting notes are publicly available on the project website www.rta.nsw.gov.au/fbb.

3.3 Independent review

The integrity of the process has been cross examined by RMS appointing independent reviewers.

The principal objectives of the independent reviewers were to observe and record the nature of the process to ensure it had been thorough and even-handed when evaluating the strategic route feasibility cost estimate for the southern bypass, and support the technical inputs required to produce it.

The independent examination of the review aimed to achieve the above objectives by considering whether:

- The technical investigations were conducted in an unbiased and even-handed manner for both routes;
- The project team adequately questioned and challenged the scope of work and outputs;
- The scope of work and outputs were in line with community and RMS expectations;
- All reasonable measures were taken to ensure a like-for-like comparison of the two bypass routes;
- The best possible engineering solutions were applied to both routes;
- Applicable suggestions from the community and others were included in developing the route designs and construction methods;
- The proposed constructability methods were realistic and reasonable;
- Any innovations carrying a risk premium were understood and accounted for;
- The appropriate risk factors and contingencies were adopted and properly documented;
- The construction programme was realistic and production rates in line with construction industry norms; and
- The cost estimate was thorough and complete.

The independent review comprises a twofold check carried out by:

(18) An internal RMS review team as defined in Table 3.2 and totally separate from the project.

Table 3.2 Internal independent reviewers

Reviewer	Position	Review responsibilities
Basil Pazpinis	Estimating Manager, Project Management Office, Infrastructure Contracts	Cost estimation
Alan Thomas	Manager, Project Management Office	Investigation process

(19) An external independent reviewer as defined in Table 3.3 below.

Table 3.3 External reviewers

Reviewer	Organisation	Review responsibilities
Dan Reeve	General Manager, Transport at SMEC Australia Pty Ltd	Review director
Chris Masters	SMEC, NSW Manager Environment and Sustainability	Investigation process, engineering design
Derrick Hitchins	SMEC, National Sector Leader – Traffic and Transport Planning - Transport	Investigation process, engineering design
Brian Lyall	Lyall & Associates, Principal	Flooding investigations
Scott Button	Lyall & Associates, Principal	Flooding investigations

Refer to Appendix A3 for a more detailed profile of the independent reviewers.

The independent reviewers:

- Had access to all information sources used;
- Had the ability to request meetings with any members of the project team to investigate and potentially challenge assumptions made;
- Produced an independent report on the information contained in this report (for publication on the project website when available); and
- Attended TIG meetings, community meetings and any other meetings as required during the investigation process.

The independent reviewers have produced a report on the technical investigation process and these findings will be published on the RMS website.

The independent reviewers agreed on the content and format of their report which was not subject to RMS approval. The independent reviewers' report of their findings will be presented to the General Manager, Project Development without reference to the RMS project team.

3.4 Engagement with community

The objectives of the community consultation activities undertaken during the review of the southern Berry bypass route suggestion were to:

- Inform the community of the southern Berry bypass cost review;
- Contact the potentially affected property owners both along the preferred northern route and the southern bypass route;
- Ensure ongoing information on the southern Berry bypass cost review was broadly disseminated to the community;
- Update the community during the southern Berry bypass cost review; and
- Provide an avenue for community members to record their issues and provide feedback and input to the technical investigation group for consideration as part of the costing review.

Consultation activities, undertaken from early February until late May 2012, to engage the local community and stakeholders are detailed below.

Southern Berry bypass cost review community consultation

Consultation activities for the southern Berry bypass alignment review, aimed at providing the community with updates on the process, comprised:

- Three pre-announcement meetings between RMS and community members to discuss their southern bypass route suggestion.
- Telephone calls to advise on the southern bypass review were made to potentially directly affected property owners along both the preferred northern Berry bypass route and the southern bypass route in early February prior to the announcement of the investigation.
- Telephone calls were followed up with letter drops and door knocks to residents along the suggested southern alignment.
- Telephone calls to residents along the southern bypass route to request property access to conduct geotechnical investigations.
- E-mail to registered stakeholders sent on 6 February 2012 to advise RMS website update with regional manager’s statement on the southern bypass route review.
- The southern bypass route cost review was announced by Member for Kiama Gareth Ward during the community working group meeting on 8 February 2012.
- Letter to the householder sent on 22 February 2012 to residents along the southern bypass route to advise the schedule of southern bypass route Q&A sessions.
- Southern bypass route Q&A sessions were held on:
  - 16 February 2012
  - 1 March 2012
  - 19 March 2012
  - 30 April 2012

Southern Berry bypass cost review community consultation
Meeting notes were published on the project website following each Q&A session. ▪ Three post-announcement meetings between RMS and community members to discuss the southern bypass route. ▪ Newspaper advertisements were placed in the South Coast Register detailing the date, time and location of the southern bypass route Q&A sessions. ▪ Electronic message signs were placed at the northern and southern ends of Berry to advertise the date, time and location of the southern bypass route Q&A sessions. ▪ Newspaper advertisements providing updates on the southern bypass route review were placed in the March, April and May editions of the Berry Town Crier. ▪ Regular updates and latest information on the southern bypass route review were posted on the project website www.rta.nsw.gov.au/fbb. ▪ E-mails were sent to registered stakeholders following key information updates. ▪ Incoming emails were received via the dedicated project email address. Written responses were provided as applicable. ▪ Calls received on the 1800 project information line. ▪ Members of the project team were available every Friday from 10am to 5pm in the Berry project office, located in Broughton Court, Berry to discuss the project with the community.

Feedback was sought from the community through a series of community meetings held by RMS on 16 February, 1 March, 19 March and 30 April. Individual meetings were also held between members of the TIG and community members on an as-requested basis.

Written (letters and emails) and verbal (calls to the project information line and conversations undertaken at the Berry project office) submissions from the community have been recorded. Technical / cost issues raised in these submissions were forwarded to the TIG for consideration.

Issues raised by the community were tracked and responded to using a critical issues register which was updated and published as investigations proceeded. Weekly updates of the critical issues register were posted on the project website. This critical issues register, now known as the Issues, Actions and Outcomes register, is included as Appendix A4.

4 Design

Designs for the northern and southern bypass routes were developed and investigated to prepare comparative route feasibility cost estimates.

The investigation boundaries for both the northern route and southern route are CH7600 and CH20400. The design for the northern route was completed to concept design level for the entire Foxground and Berry Bypass project in early 2012. The design for the southern route was completed to preliminary concept design level. This design was produced to the level of detail required to allow preparation of the comparative route feasibility cost estimate.

This chapter provides a summary of the design development including details of the design development process undertaken for the southern route, and details of the southern route design. It concludes with an explanation of the approach taken for design amendments that were assessed as provisional items and as such not included in the base case route designs.

4.1 Summary of outcomes

The design outcomes are summarised in Table 4.1 below.

Table 4.1 Summary of design investigation

Design investigations	Northern route	Southern route
Design documentation developed	**Concept design** The northern route design was developed during the route optimisation process for concept design development. The section of this concept design between the investigation boundaries of CH7600 and CH20400 was used for this investigation.	**Preliminary concept design** A preliminary concept design was produced in this investigation. This design has been developed to the level required to prepare the comparative route feasibility cost estimate for the southern route. The emphasis in design development has been on the aspects of design with significant cost impacts.

The horizontal alignments of the two routes are compared in Figure 4.1, while Table 4.2 summarises the key characteristics of the two routes.

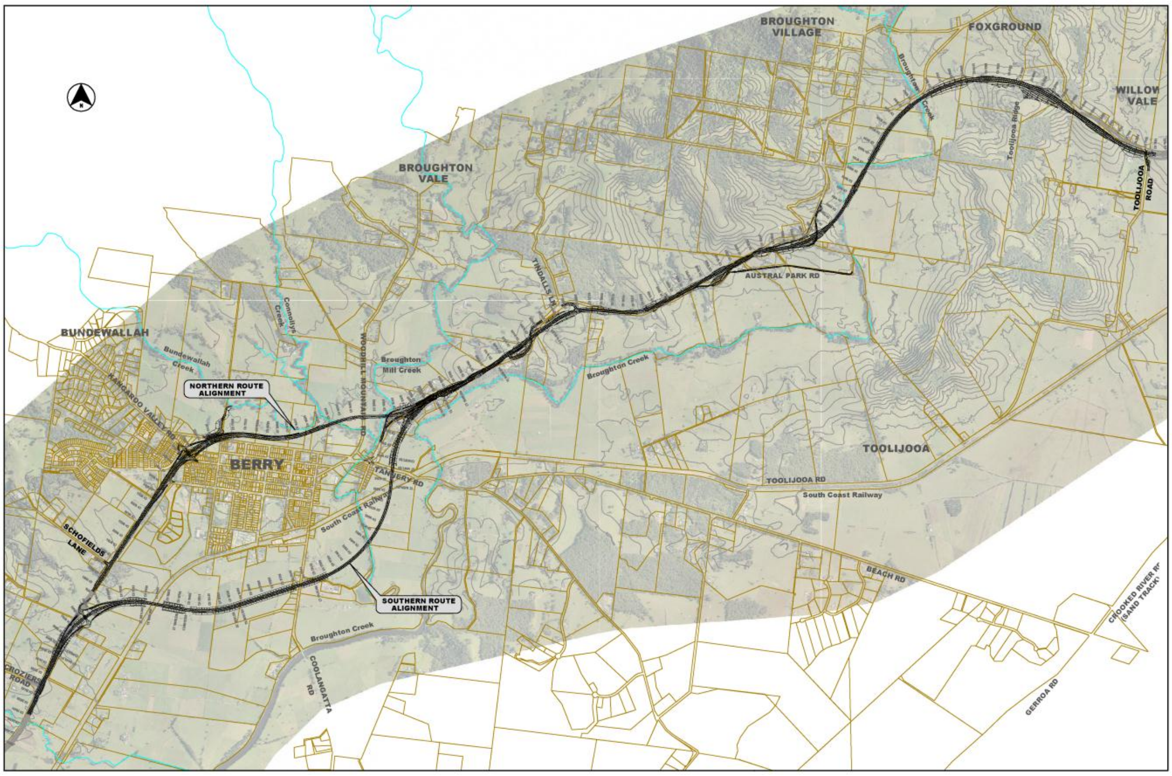


Figure 4.1 Northern route and southern route comparison

Table 4.2 Comparison of key route characteristics

Characteristic	Northern route	Southern route
Horizontal alignment	CH7600 to CH20400 Length of 12800m	CH7600 to CH20400 Length of 12800m
Vertical alignment	Maximum cutting depth approx. 7.5m Max fill / structure height approx. 11.8m	Maximum cutting depth approx. 14.2m Max fill / structure height approx. 12.3m
Structures	2 viaduct/bridge structures	9 viaduct/bridge structures
Provisional items (not included in base case estimate)	1. Addition of North Street pedestrian bridge 2. Land reserved for possible future provision of a second northbound off load ramp 3. Relocation of (Kangaroo Valley Road) southern interchange towards Schofields Lane	1. Diversion of the route south of the sewage treatment plant 2. Inclusion of an island embankment to replace part of the viaduct in the southern route 3. Alternative earthworks design for the northern interchange (Zone 1) to generate additional fill for an island embankment 4. Lowering the vertical alignment north of the Berry north interchange to generate additional fill for earthworks 5. Alternative alignment for southern intersection (Zone 3) to reduce embankment fill requirements 6. Diversion of Town Creek (information provided at Shoalhaven City Council's request)

4.2 Design development process

The focus of the design development process was developing and investigating a southern route design for preparation of the comparative cost estimates. The flow chart in Figure 4.2 details the design development process undertaken.

Minimal additional design development and investigation was required for the northern route as extensive information was available from the concept design development process for this route. In some cases further specific investigations were required for the northern route and this is identified where relevant.

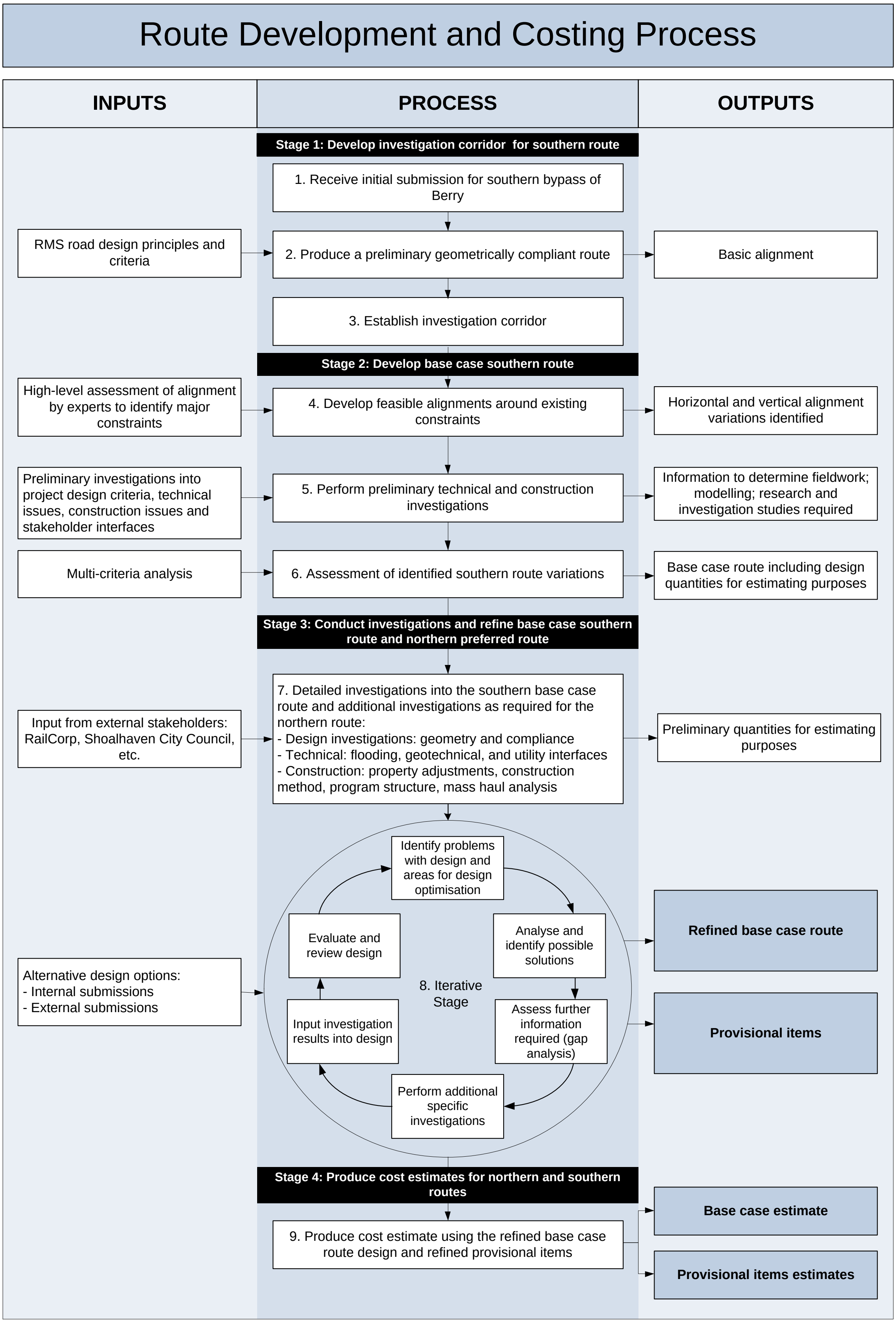


Figure 4.2 Route development and costing process

Stage 1: Develop investigation corridor for southern route

(1) Receive initial submission

The design submission received in December 2011 proposed a route to the south of Berry. The original submission in entirety is contained in Appendix B1.

(2) Produce preliminary route with geometrically compliant alignment

A preliminary route from this submission was developed and an initial alignment that was geometrically compliant with the design criteria was produced based on the submitted route. This route is shown in Figure 4.3 below.

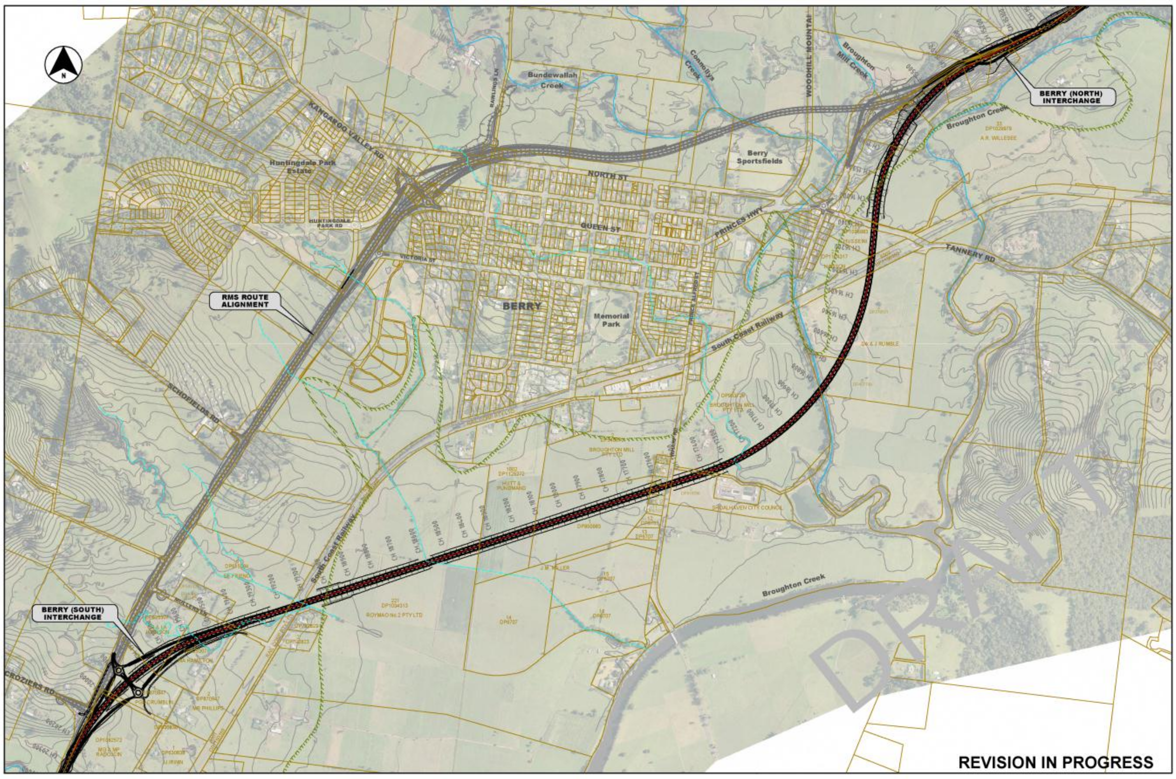


Figure 4.3 Southern route submission

(3) Establish investigation corridor

An investigation area was established by identifying a corridor through which routes would achieve the intent and objectives of the original submission for a southern route. This investigation area is depicted as the blue area in Figure 4.4.

Figure 4.4 Southern route study corridor

Stage 2: Develop base case southern route

(4) Develop three feasible alignments around existing constraints

Indicative alignments for three potential routes are shown in Figure 4.5 below. These routes primarily differ at the southern extent of the bypass in relation to the location of the interchange. Preliminary vertical alignments for the routes were also prepared to aid in assessment of the routes.

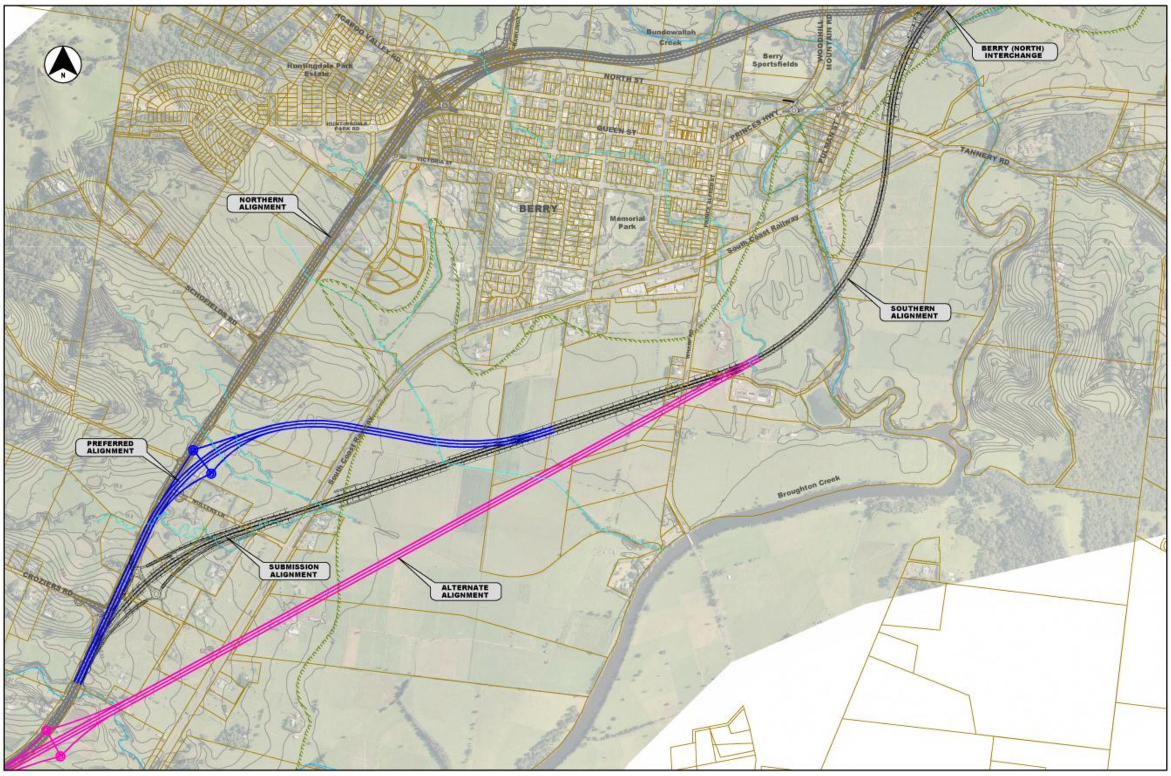


Figure 4.5 Preliminary southern route options

(5) Perform preliminary technical and construction investigations

A preliminary understanding of the different characteristics and impacts of the three routes was developed through a desktop review of existing information. The major considerations were identified in a workshop session and are described below in Table 4.3.

Table 4.3 Considerations in evaluating route options

Horizontal alignment considerations	Vertical alignment considerations
▪ Impact on communities. ▪ Compliance with the relevant design criteria referenced [Design criteria and Design criteria addendum, as provided in Appendix B2 and Appendix B3], such as minimum radii, curve lengths and straight lengths. ▪ Minimisation of skew across roads and railways to reduce structure lengths and thereby reduce costs. ▪ Coordination with the vertical geometry.	▪ Compliance with the relevant design criteria referenced [Design criteria and Design criteria addendum, as provided in Appendix B2 and Appendix B3], such as minimum sag or crest curve lengths, minimum longitudinal grades, maximum longitudinal grades and sight distance. ▪ Achieve clearance requirements over roads and railways. ▪ Minimisation of earthworks. ▪ Reduction of visual impacts where possible. ▪ Coordination with the horizontal geometry.

(6) Assessment of identified route variations

Assessment criteria were developed in a workshop session with the members of the TIG based on the project objectives and design criteria. These were given weightings based on the judgement of the group regarding their perceived impact on cost.

The relative performance of the three options shown in Figure 4.5 was then assessed ranked for each criterion. The weightings shown in Table 4.4 were applied to the rankings to provide the final outcome.

Table 4.4 Route assessment

Assessment criteria	Sub-criteria	Weighting	Black route		Blue route		Magenta route	
			Rank	Weighted rank	Rank	Weighted rank	Rank	Weighted rank
Structures	Flooding impacts	25	2	50	1	25	3	75
	Required bridge lengths	20	2	40	1	20	3	60
	Structures	24	2	48	1	24	3	72
Earthworks	Earthworks	7	1	7	2	14	3	21
	Risk of acid sulphate / soft soils	6	2	12	1	6	3	18
Pavement	Route length	8	2	16	1	8	3	24
Other considerations	Property adjustment requirements	1	2	2	1	1	3	3
	Road geometry	1	1	1	2	2	3	3
	Functionality	1	2	2	1	1	3	3
	Constructability	2	2	4	3	6	1	2
	Utility interfaces	2	3	6	2	4	1	2
	Future proofing	1	2	2	1	1	3	3
	Ease of maintenance	2	2	4	1	2	3	6
Total		100	25	194	18	114	35	292
Overall Ranking			**2**		**1**		**3**	

The "blue route" was ranked first in this assessment and was selected as the horizontal alignment for the purposes of this investigation.

Stage 3: Conduct investigations and refine base case southern route and northern preferred route

(7) Detailed technical and construction investigations

Extensive technical and construction investigations were undertaken to provide the information required to prepare the comparative cost estimates. As discussed above, considerable investigations had previously been undertaken for the northern preferred route. The investigations therefore focused primarily on developing information for the southern route. Specific additional investigations were undertaken for the northern route as required.

(8) Iterative stage of design development

As results were obtained from the technical and construction investigations the route designs were interrogated in detail. Problems with the designs such as conflicts with constraints or excessive exposure to risks were identified. Opportunities for design optimisation, including achieving cost savings, were identified.

Further specific investigations were undertaken directed at addressing these problems or opportunities for improvement. These investigations allowed design solutions to be developed and incorporated into the base case routes.

This process was iterative as it was necessary to then re-evaluate the amended base case with consideration to the impact of the changes on the route as a whole. This iterative process was undertaken within the time available until the quality and detail of design was considered appropriate for preparation of the comparative estimates.

In several cases, possible design amendments were identified and investigated however was not incorporated in the base case routes. These design amendments were then assessed as provisional items. This is explained further in Section 4.4.

Stage 4: Produce cost estimates for northern and southern routes

(9) Production of cost estimate

Comparative route feasibility cost estimates were produced for the base case northern and southern routes. The cost estimate were prepared on a like-for-like basis, employing the same estimating methodology. Cost estimate information was also prepared for the design amendments that were assessed as provision items.

The cost estimates are discussed in detail in Section 7.

4.3 Southern route design

This section provides the details of the base case southern route design developed. The details provided are the:

(1) Horizontal alignment;

(2) Vertical alignment; and

(3) Structures.

4.3.1 Horizontal alignment

An overview of the horizontal alignment is provided in Figure 4.6. Details of the northern and southern interchanges are provided in Figure 4.7 and Figure 4.8 respectively. A visualisation of the southern interchange is contained in Figure 4.9.

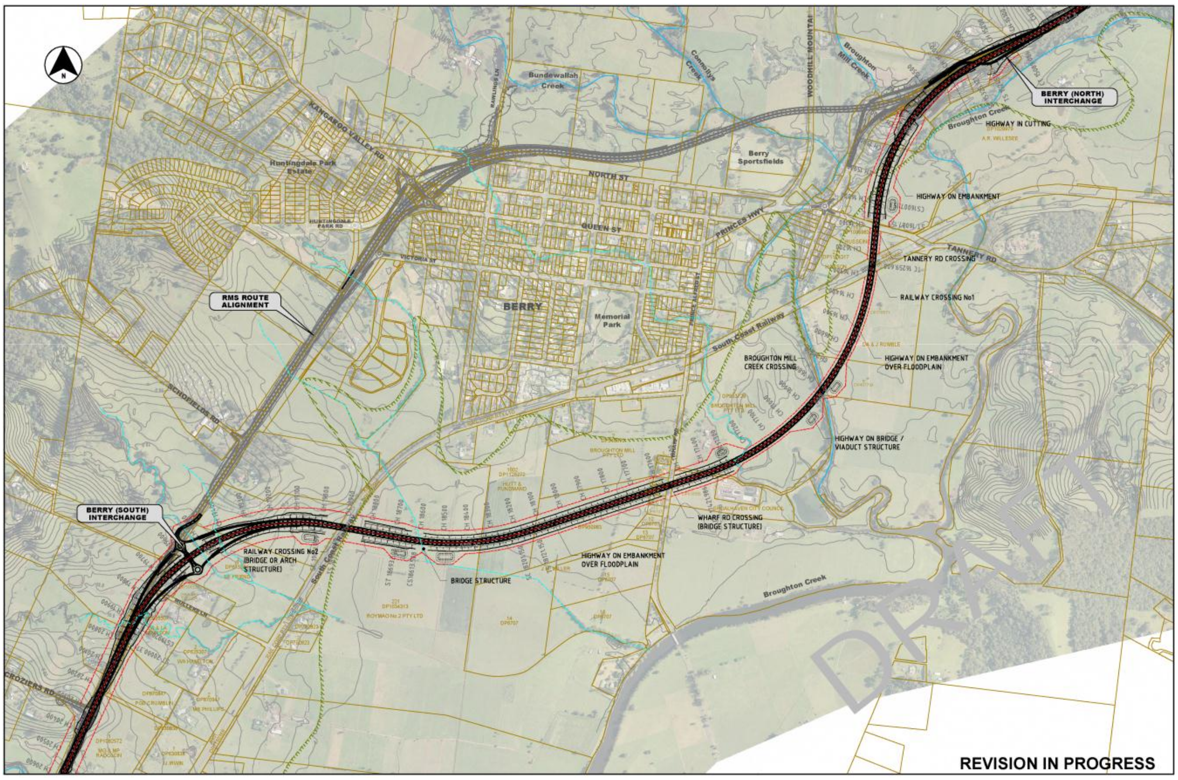


Figure 4.6 Southern route design

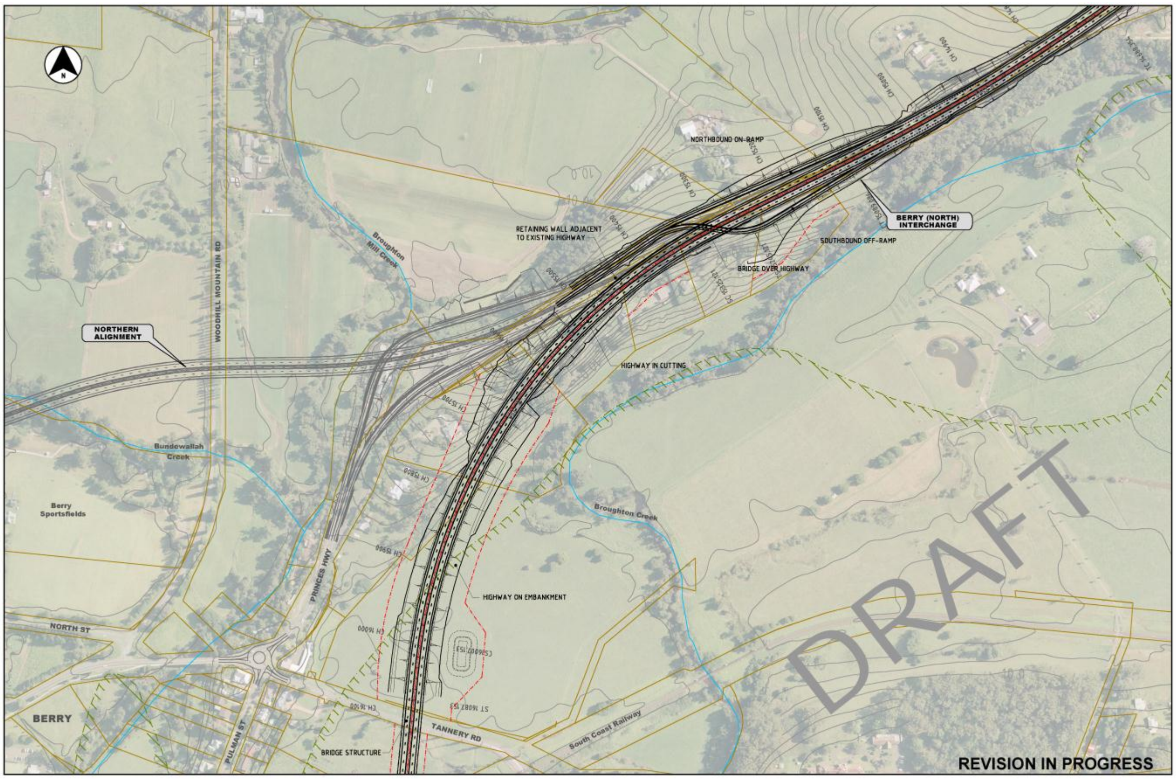


Figure 4.7 Northern interchange detail

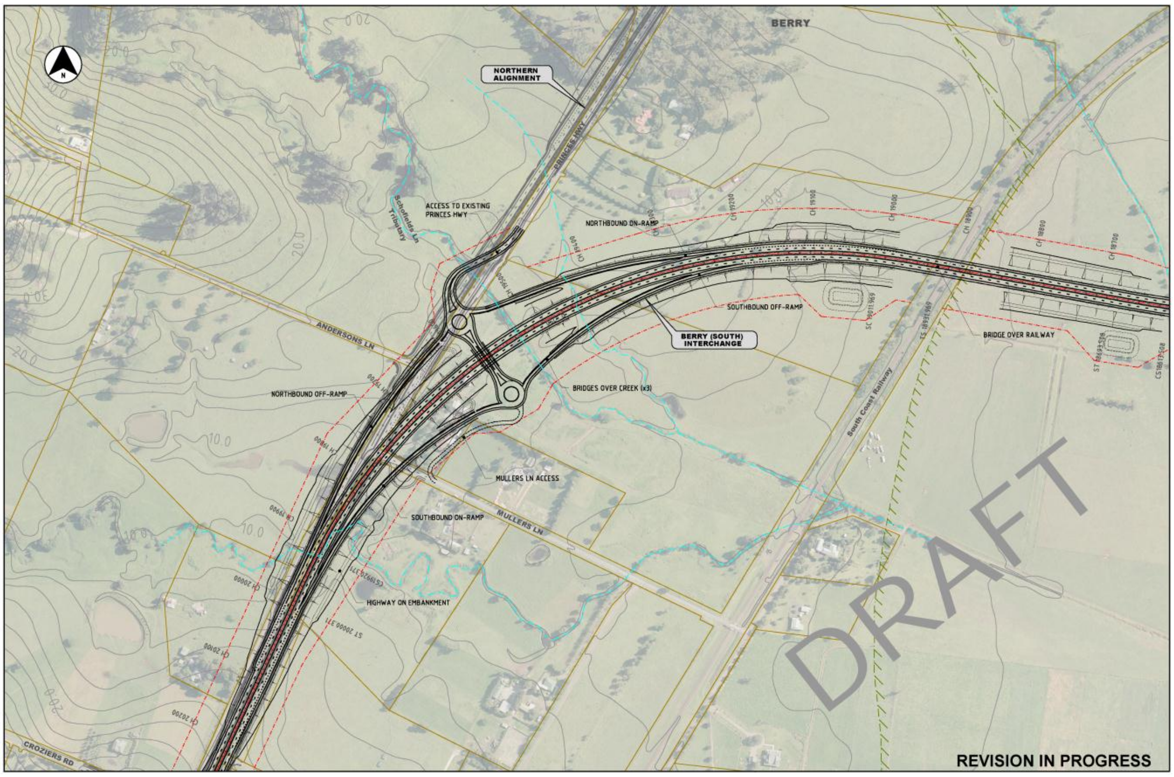


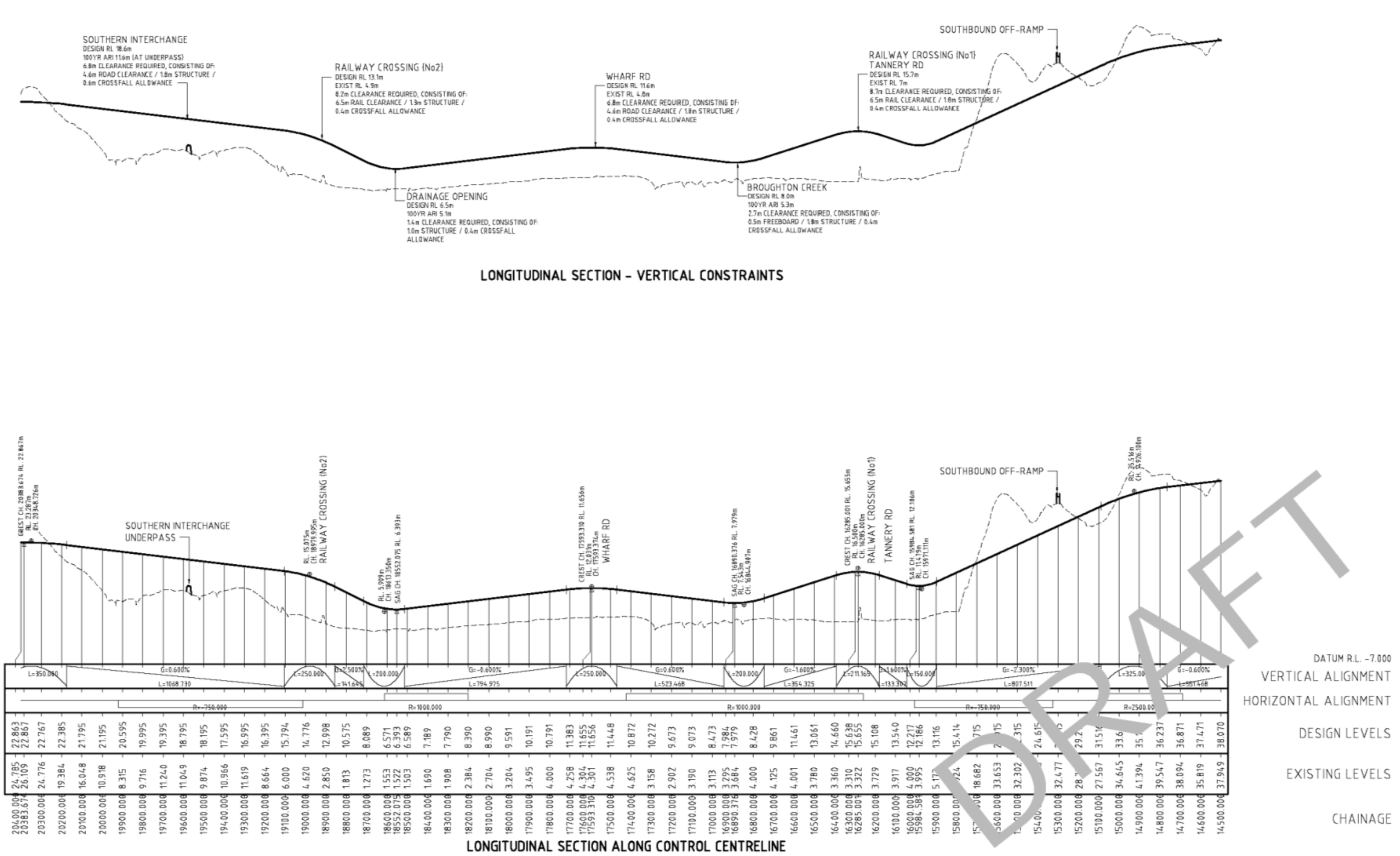
Figure 4.8 Southern interchange detail

Figure 4.9 Southern interchange visualisation

4.3.2 Vertical alignment

An indicative vertical alignment for the route was developed at the time of selection of the blue route as the horizontal alignment. The most cost effective vertical alignment design that is compliant with the relevant design standards was developed. The vertical alignment design was refined as the design constraints were investigated. In particular, the results of the flooding investigation were key determinants of the required vertical alignment of the roadway at several locations.

The final vertical alignment is provided as a long section in Figure 4.10. This long section is annotated with the constraints governing the vertical alignment at the critical points.



REVISION IN PROGRESS

Figure 4.10 Southern route vertical alignment

4.3.3 Structures

There are nine bridge structures in the current design for the southern route. The locations of these structures are shown in Figure 4.11.

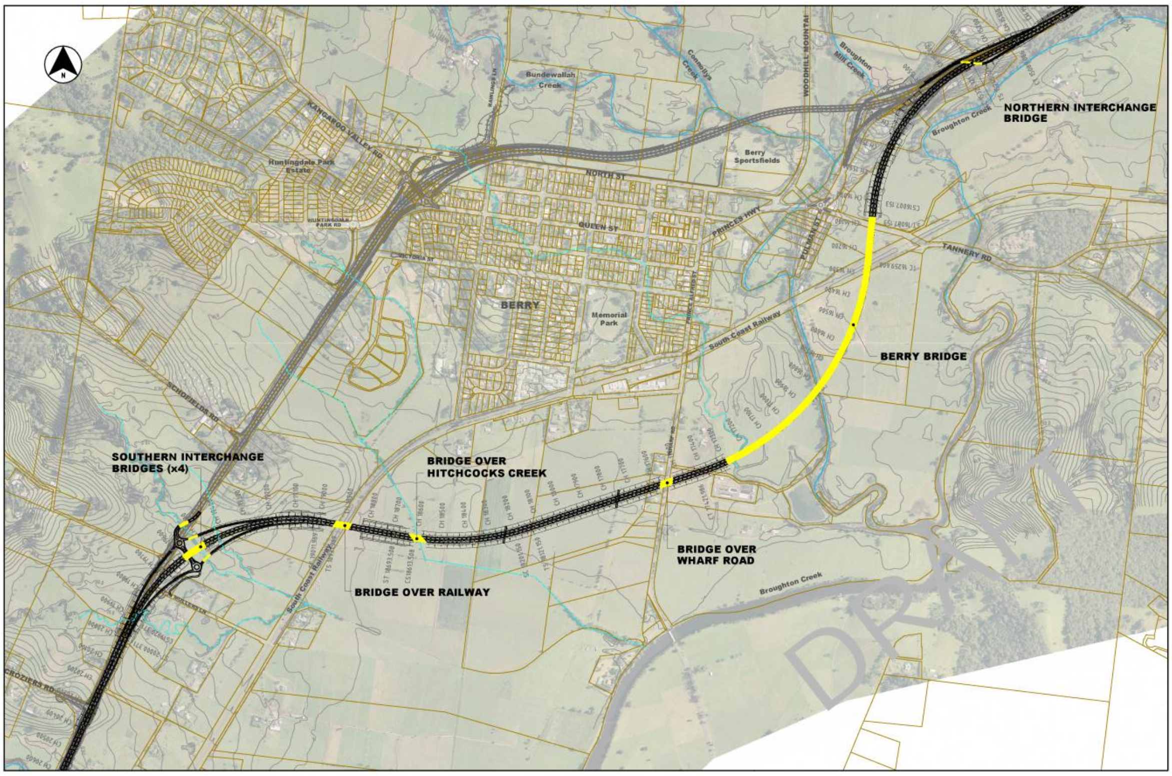


Figure 4.11 Plan of southern route identifying each bridge structure

Indicative designs for these structures allow preparation of the cost estimate. These indicative designs have been based on the same design constraints and principles for the both routes, to ensure that the cost estimate is based on like-for-like information. These constraints as relevant to the southern route are outlined in Table 4.5.

Table 4.5 Structure design constraints

Design constraint	Comments
Aesthetics	For the cost gateway exercise, a simple bridge form has been adopted on both the northern and southern routes for consistency. At the time of writing this report, a northern route community working group was in the process of developing a preferred bridge option with an overall bridge aesthetic sympathetic to the wishes of the community. These aesthetic considerations have not been included in the strategic cost estimate for both routes.
Bridge barriers	Bridge barriers are a requirement of the Bridge Design Code of practice. All bridge barriers for the Foxground and Berry Bypass Project will comprise a concrete barrier with two steel railings measuring a total height of 1.3 m from the road surface level of the bridge. The bridge barriers will extend down the outside of the bridge deck to conceal the drainage pipes that run underneath the bridge deck.
Railway requirements	Two bridges interface with the South Coast Railway. The TIG liaised with RailCorp during the options study to confirm RailCorp's requirements. Horizontal and vertical clearances as well as allowing for future

Design constraint	Comments
	duplication and electrification were confirmed by RailCorp.
Flooding requirements	The bridge structures have been set at a height above the 1 in 100 year flood event based on the findings from the flood modelling investigations. In some locations, the bridge height may be higher than the 1 in 100 year flood level to meet the road geometric criteria and where it crosses the South Coast Railway. This is detailed in Section 5.1.
Geotechnical requirements	Bridge structure foundations can vary depending on the geotechnical profile of the existing ground. Refer to Section 5.2 for more details.
Pre-cast concrete arches or Super-Ts	Based on the investigation, both arches and conventional beam type bridges comprising precast concrete beams (Super-T girders for example) are feasible for this project and the costs between the two structure types are similar. In an effort to reduce the heights of the embankments to reduce the amount of fill required, a conventional beam type bridge comprising Super-T girders was chosen for the South Coast Railway Underbridge and the Wharf Road Underbridge. The conventional beam type bridge has less overall structural depth compared with an arch and allows the embankment heights and ground treatments to be reduced and therefore results in a more cost effective solution.

Table 4.6 presents a summary of the key features of the indicative designs for the bridge structures on the southern option.

The design of these structures has been completed to a level appropriate for cost estimate preparation. Where relevant the design has employed the same assumptions and design guidelines as for the northern route to provide consistency for pricing purposes. The detailed final designs for the structures would be determined during detailed design development.

Table 4.6 Southern route bridges

Bridge Name	Overall length/width	Description
Northern interchange Bridge	60m / 12.9m	▪ Bridge is on a high skew and crosses over the Mainline. ▪ 3 no. bridge spans of varying length comprising post-tensioned concrete I-girders supporting a 0.23m thick cast in-situ concrete deck slab. ▪ 5.3m minimum clearance from Mainline road surface to underside of bridge.
Berry Bridge (refer to Figure 4.12)	1200m / 26m	▪ 36 no. bridge spans of 33m between pier centrelines. ▪ Superstructure comprises 1.5 m deep precast prestressed concrete Super-T girders supporting a 0.23m thick cast in-situ concrete deck slab. ▪ Bridge crosses the South Coast Railway with a clearance requirement from the underside of bridge to top of rail being 6.5m. ▪ Pier supports comprise 3 no. circular columns supporting a reinforced concrete headstock.
Bridge over Wharf Road (refer to Figure 4.12)	22m / 26m	▪ Single span of 20m. ▪ Superstructure comprises 1.2m deep Super-T girders supporting a 0.23m thick cast in-situ concrete deck slab. ▪ Reinforced soil abutments to retain the embankment on each side of Wharf Road.

Bridge Name	Overall length/width	Description
		▪ 4.6m minimum clearance from road surface to arch structure.
Drainage structure No. 1 (refer to Figure 4.13)	50m / 26m	▪ 3 no. bridge spans of 16.6m between pier centrelines. ▪ Superstructure comprises 0.7m deep precast prestressed concrete planks/beams supporting a 0.23m thick cast in-situ concrete deck slab. ▪ Pier supports comprise 3 no. circular columns supporting a reinforced concrete headstock.
South Coast Railway Underbridge (refer to Figure 4.14)	22m / 26m	▪ Single span comprising 1.0m deep precast prestressed concrete Super-T girders supporting a 0.23m thick cast in-situ concrete deck slab. ▪ Bridge crosses the South Coast Railway with a clearance requirement from the underside of bridge to top of rail being 6.5 m. ▪ Reinforced soil wall abutments to allow span length to be minimised.
Berry south interchange Overbridge	22m / 26m	▪ Single span comprising 1.0m deep precast prestressed concrete Super-T girders supporting a 0.23m thick cast in-situ concrete deck slab. ▪ 4.6m minimum clearance from road surface to underside of bridge. ▪ Reinforced soil wall abutments to allow span length to be minimised.

Visualisations of the indicative designs for the structures have been prepared and are contained in Figure 4.12 to Figure 4.14.

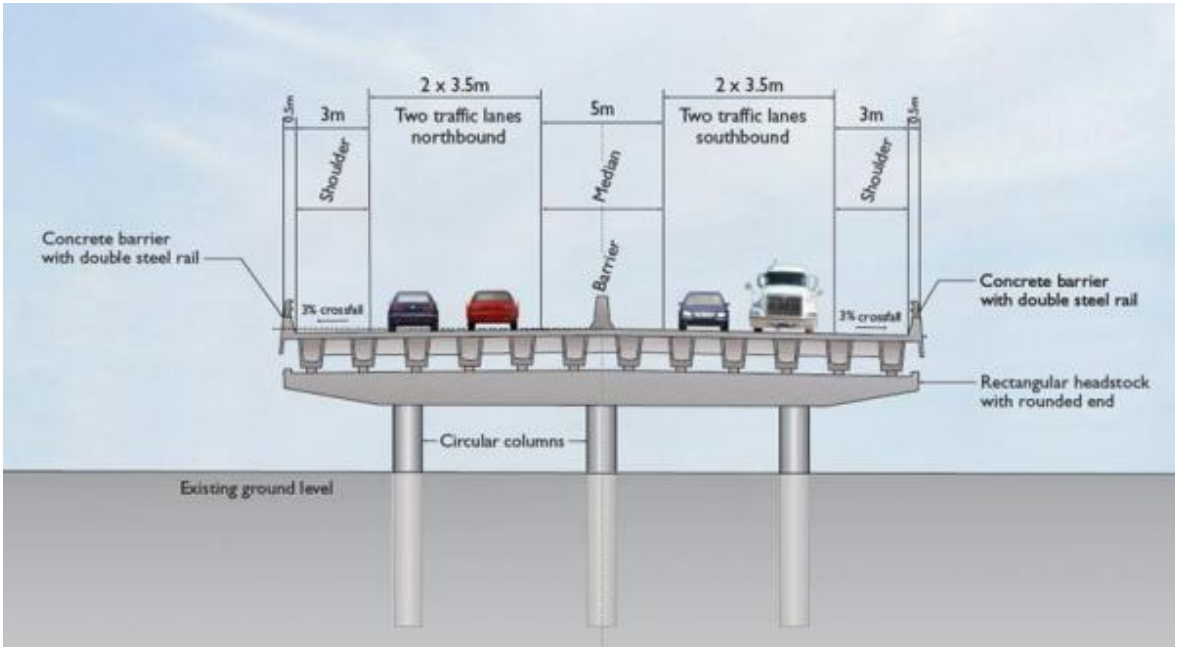


Figure 4.12 Indicative cross sections through Berry Bridge and Wharf Road Underbridge

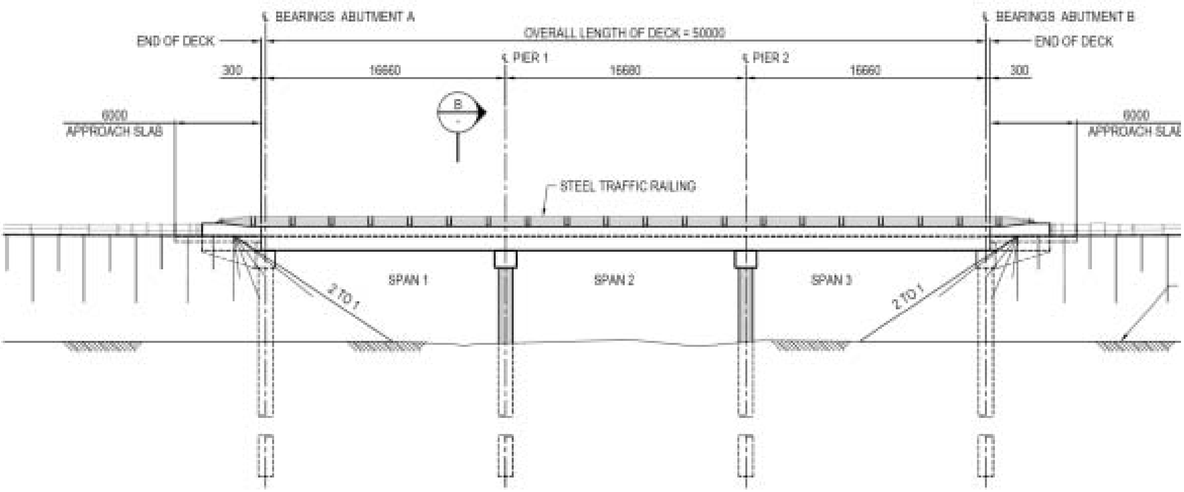


Figure 4.13 Elevation of drainage structure No. 1

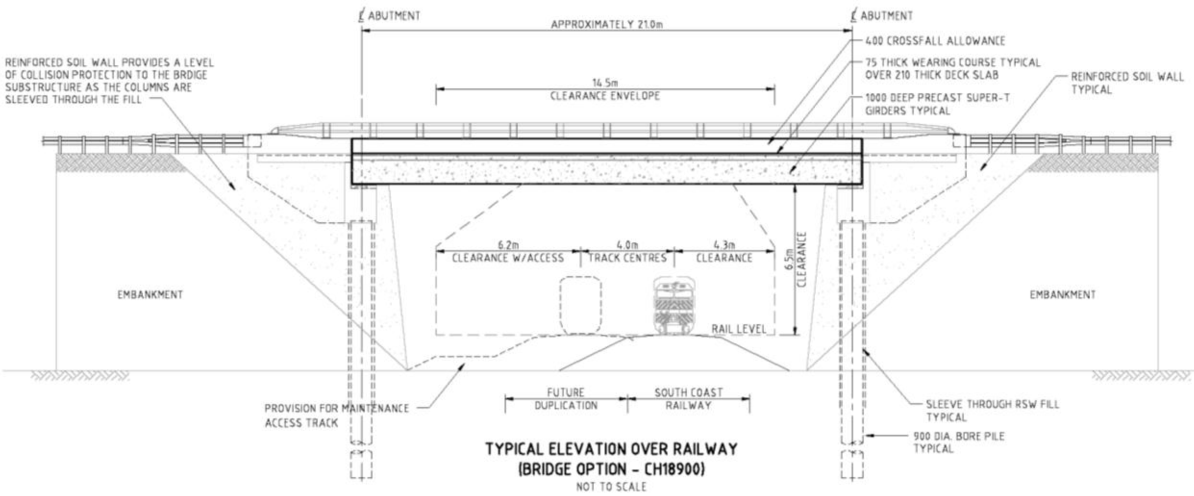


Figure 4.14 Annotated elevation of South Coast Railway underbridge

4.4 Provisional design items

Designs were prepared for a bypass to the south of Berry to enable a route feasibility strategic estimate to be prepared. The scope of this design was not to prepare a final design; rather the emphasis was on preparing a design of sufficient detail to provide parity when comparing its estimated cost with the preferred northern route.

During the investigation a number of design issues or potential design amendments were proposed by community members and the TIG. These design proposals were investigated by the TIG to assess whether they were feasible from an engineering perspective. Where these investigations suggested that the proposal was feasible, further investigations were undertaken to understand their impacts.

If the proposal was assessed by the group to be the best design solution, it was incorporated as the "base case" preliminary concept design for the cost estimate.

If the proposal was feasible but not the best design solution, the proposed design change was treated as a provisional item.

Relevant design information for each provisional item was prepared in order to assess the cost impact of the provisional item. These cost have been provided as "below the line" provisional items in the cost estimate.

This section provides a register of these design issues as shown in Table 4.7 and explains the investigations undertaken and the assessment of their cost impact.

Table 4.7 Summary of provisional items not included in the base case

Item	Northern route	Southern route
Provisional items (not included in base case estimate)	1. Addition of North Street pedestrian bridge 2. Land reserved for possible future provision of a second northbound off load ramp 3. Relocation of (Kangaroo Valley Road) Southern interchange south facing ramps towards Schofields Lane 4. Relocation of (Kangaroo Valley Road) Southern interchange northbound offload ramp under Kangaroo Valley Road bridge	1. Diversion of the route to the south of the sewage treatment plant 2. Inclusion of an island embankment to replace part of the viaduct in the southern route 3. Alternative earthworks design for the northern interchange (Zone 1) to generate additional fill for an island embankment 4. Lowering the vertical alignment north of the Berry north interchange to generate additional fill for earthworks 5. Alternative alignment for southern intersection (Zone 3) to reduce embankment fill requirements 6. Diversion of Town Creek (information provided at Shoalhaven City Council's request)

The following sections describe the various provisional items listed above and discuss the relative benefits and drawbacks of each. In line with the brief, environmental factors have not been considered and their respective potential benefits may not materialise. Subsequent issues may arise which are beyond the scope of this investigation.

4.4.1 Northern route

(1) Addition of North Street pedestrian bridge

The proposal is to maintain the current connectivity along North Street for recreational use. The cost and technical benefits are discussed in Table 4.8 and the drawbacks are discussed in Table 4.9.

Table 4.8 Addition of North Street pedestrian bridge: Benefits

Item	Benefits	Comments
1	To provide additional pedestrian connectivity along North Street alignment.	Connectivity under the northern route design is via the overbridge as part of the Southern Berry Interchange at Kangaroo Valley Road. This would be in addition and separate to that overbridge. Included as provisional item in the cost estimate for the northern route.
2	Separates some North Street to Kangaroo Valley Road pedestrian movements from the Kangaroo Valley Road Interchange.	This would be in addition and separate to the overbridge as part of the Southern Berry Interchange.

Table 4.9 Addition of North Street pedestrian bridge: Drawbacks

Item	Drawbacks	Comments
1	Bridge is approximately 200 metres from the Kangaroo Valley Road Interchange Bridge, which would accommodate pedestrian and cyclist movements.	The bridge is unlikely to service the majority of pedestrian "desire line" traffic movements due to its proximity to the Kangaroo Valley Road overbridge. Building two bridges so close together in these circumstances is unlikely to represent value for money. Further studies outside the scope of this investigation should be undertaken to assess the demand for this facility.
2	Extra cost	Would provide duplication of the same pedestrian amenity as the Kangaroo Valley Road overbridge, although in a different manner and location.
3	Urban design	Urban design requirements would need to be reviewed with likely impact on cost.

(2) Land reserved for possible future provision of a second northbound off load ramp

There is a desire from Shoalhaven City Council and the Berry Alliance for future provision of a second northbound off load ramp to relieve increased traffic on some local roads caused by the proposed interchange at Kangaroo Valley Road. The cost and technical benefits are discussed in Table 4.10 and the drawbacks are discussed in Table 4.11.

Table 4.10 Land reserved for future provision of a second northbound off load ramp: Benefits

Item	Benefits	Comments
1	Avoids further land acquisition when the need for a second northbound offload ramp arises.	This would ensure no further land acquisition is required for the foreseeable future.
2	Provides a second chance entry to Berry as is the case for southbound traffic.	This would provide similar entry provisions for both directions of traffic.
3	Restores west to east vehicle access from west to east.	This would provide a second east west access across Berry, replacing North Street which would be severed.

Table 4.11 Land reserved for future provision of a second northbound off load ramp: Drawbacks

Item	Drawbacks	Comments
1	Predicted utility is low.	Traffic studies indicate there is no warrant for a second northbound access. The second southbound access has been provided to provide a flood free access, not because of high traffic volumes.
2	An offload ramp connected to Woodhill Mountain Road would have to cross Bundewallah Creek twice and is located in the flood plain.	The ramp would need to be constructed close to ground level and with causeways so that flooding is not exacerbated. The ramp would be unavailable from time to time because of flooding.

(3) Relocation of Southern (Kangaroo Valley Road) interchange towards Schofields lane

There is a desire from some residents to move the two south facing ramps further south to Schofields Lane to reduce the impact at Kangaroo Valley Road. The cost and technical benefits are discussed in Table 4.12 and the drawbacks are discussed in Table 4.13.

Table 4.12 Relocation of Southern (Kangaroo Valley Road) interchange towards Schofields Lane: Benefits

Item	Benefits	Comments
1	Reduces noise and visual impacts at the Kangaroo Valley Road interchange.	The reduction is limited to the removal of one of the four ramps.
2	Preserves Mark Radium Park.	Retains the existing highway alignment without impacting Mark Radium Park. The preferred RMS interchange arrangement has a limited impact on Mark Radium Park.
3	Reduces the size of the bridge and excavation at Kangaroo Valley Road interchange by one lane width.	This would slightly reduce the cost of the excavation and the bridge at the Kangaroo Valley Road interchange.
4	Improves pedestrian safety across the northern side of Kangaroo Valley Road bridge.	Reduces the number of lanes crossed by one compared with the RMS preferred arrangement.

Table 4.13 Relocation of Southern (Kangaroo Valley Road) interchange towards Schofields Lane: Drawbacks

Item	Drawbacks	Comments
1	Requires an expanded footprint from Mark Radium Park to Schofields Lane.	This is to accommodate a two way service road connection back to Berry.
2	Requires an additional bridge and approximately one kilometre of two way service road.	This increases the cost of the interchange.
3	Increased impacts on adjacent properties.	Has bigger impacts on some properties already affected by the proposal and also impacts new properties.
4	Decreases pedestrian safety across the southern side of Kangaroo Valley Road bridge.	Reduces the number of lanes crossed by one compared with the RMS preferred arrangement.

(4) Relocation of (Kangaroo Valley Road) Southern interchange northbound offload ramp under Kangaroo Valley Road bridge

The intent of this modification from RMS is to reduce the property, noise and visual impacts in the vicinity of the southern interchange. The cost and technical benefits are discussed in Table 4.14 and the drawbacks are discussed in Table 4.15.

Table 4.14 Relocation of (Kangaroo Valley Road) Southern interchange northbound offload ramp under Kangaroo Valley Road bridge: Benefits

Item	Benefits	Comments
1	Reduces visual impacts	Moves the ramp away from Huntingdale Park Estate, eliminates the need to divert Huntingdale Park Road and keeps offloading traffic in the highway cutting under Kangaroo Valley Road bridge. Retains the current character of the Huntingdale Park Road junction.
2	Reduces noise impacts	Keeps offloading traffic in the highway cutting under Kangaroo Valley Road bridge and connects traffic to the local network further away from most residences. Reduces or eliminates the need for a noise wall.
3	Reduces direct property impacts	Eliminates the need to acquire two residences on Kangaroo Valley Road. Makes use of RMS owned vacant land.
4	Brings forward construction of Huntingdale Park Road roundabout	Allows early construction of a roundabout at the junction of Huntingdale Park and Kangaroo Valley Roads, required as part of the development consent for the Huntingdale Park Estate.
5	The ramp connects at the Huntingdale Park Road junction	No additional junction to be constructed on Kangaroo Valley Road
6	Provides a good heavy vehicle connection to Rawlings Lane	Rawlings Lane provides access to two dairy farms. Removes the need to negotiate acute angle junction of North St with Kangaroo Valley Rd.

Table 4.15 Relocation of (Kangaroo Valley Road) Southern interchange northbound offload ramp under Kangaroo Valley Road bridge: Drawbacks

Item	Drawbacks	Comments
1	Requires lengthening of the Kangaroo Valley Road bridge	Additional cost, a bridge similar to the Shellharbour Road interchange required.
2	Visual impact of roundabouts	Further work required to improve appearance of roundabouts. Potential to review intersection treatment in detailed design.
3	Requires larger land take	Roundabout requires more land. Potential for slightly increased land take from adjacent farms as the northbound onload ramp is moved further east to accommodate the southbound offload ramp connection.

4.4.2 Southern route

(1) Diversion of the route south of the sewage treatment plant

The intent of this route modification is to minimise bridge length and the impacts on local properties (such as severance) and provide added flood immunity to the sewage treatment plant (STP). The cost and technical benefits are discussed in Table 4.16 and the drawbacks are discussed in Table 4.17.

Table 4.16 Diversion of the route south of the sewage treatment plant: Benefits

Item	Benefits	Comments
1	Potential to reduce bridge viaduct length by replacing with cheaper earth embankment.	Being further south the route would span a greater extent of the Broughton Creek floodplain. This will most likely require a greater length of viaduct. An assessment of potential flood impacts and associated mitigation measures required has been undertaken.

Table 4.17 Diversion of the route south of the sewage treatment plant: Drawbacks

Item	Drawbacks	Comments
1	The route length will be longer by approx. 200m adding to the capital costs.	A preliminary estimate of this item is included in this report. An appropriate contingency is included.
2	Sewage plant operational impact due to flooding.	Levels given in previous Broughton Creek Flood Study by SMEC indicates the sewerage plant may be inundated in around the 1 in 10 year event. Having the alignment downstream of the STP could create greater potential for flood impacts. Therefore, this route would not provide a benefit to the STP in terms of reducing flooding.
3	Being further south the route would span a greater extent of the Broughton Creek floodplain.	This will most likely require a greater length of viaduct. An assessment of potential flood impacts and associated mitigation measures required has been undertaken. An appropriate contingency is included.
4	Being further south the route would more impacted by the existence of very soft soils and Acid Sulphate Soils.	An assessment of potential acid sulphate and soft soils and associated mitigation measures required has been undertaken. An appropriate contingency is included.
5	The additional work (extra 200m) and potential for preloading of soft soils on the floodplain may also extend the construction programme.	This may be significant if shown to be on the critical path. An appropriate contingency is included.
6	The additional length (extra 200m) of the alignment will increase demand for fill material.	There is a significant shortfall of suitable fill material for embankments for which alternative material sources have been examined.
7	This route may impact a residence on the southern side of the STP.	There appears to be insufficient width between the STP and the residence to fit the embankment.

(2) Inclusion of an island embankment to replace part of the viaduct in the southern route

The inclusion of an island embankment attempts to reduce the overall capital cost of the southern route recognising that general earthworks are typically cheaper to construct than bridges. The base case includes a 1200m long bridge from CH16075 to CH17300 and the island embankment option comprises two bridges with an island sandwiched in the middle. The corresponding lengths are: bridge 300m; embankment 350m; bridge 575m (=total 1225m). The embankment is an average height of 8.5m high and the height is fixed by the height of the bridges on either side and the grades leading up to those bridges. The cost and technical benefits are discussed in Table 4.18 and the drawbacks are discussed in Table 4.19.

Table 4.18 Inclusion of an island embankment: Benefits

Item	Benefits	Comments
1	Potential cost benefit by using embankments in lieu of bridges.	An estimate of this item is included in this report.

Table 4.19 Inclusion of an island embankment: Drawbacks

Item	Drawbacks	Comments
1	The southern suggestion base case earthworks are unbalanced before adding this feature and this adds to the quantity of imported fill unless an on-site source can be engineered.	This item adds significantly to the earthworks imbalance especially when unsuitable material and topsoil replacement are taken into account.
2	The embankment being on a flood plain may be overlying soft soils.	There is potential for soft soils and this will lead to settlement and there may be a need for removal of the unsuitable alluvial soils and replacement with an engineered fill. Maximum practical depth of removal would depend on site constraints, but would generally be limited to three metres depth. Preloading of the embankments may be required where unsuitable soils are greater than 3m depth.
3	The embankment being on a flood plain may have adverse flood impacts.	Flood analysis outcomes are included in the report. Initial indications are that this will lead to an increase in flood levels and velocities upstream of the embankment, which may have adverse impacts on the surrounding environment. Flood model results are currently being reviewed to determine the extent of any drainage structures and scour protection that may need to be included in the design to minimise impacts. An estimate of costs associated with these structures is included in this report.
4	The embankment construction will require an all-weather access road included that permits haulage by road trucks to the top of the embankment.	This will require import and removal of fill for the ramp including surfacing material to the access road up the embankment. Access road material will require double handling to remove it.
5	The potential for differential settlement adjacent to bridge abutments.	Treatments would need to be included to mitigate the potential for differential settlement in these areas. Ground

Item	Drawbacks	Comments
		improvement measures under the fill may include stone columns. An appropriate contingency is included.
6	The disruption to the construction cycles by having shorter lengths of bridges & pavement layers to construct between bridges.	This will result in lower productions for several activities when compared with long uninterrupted activities. This is reflected in the cost estimate.
7	The extra cost and time for the construction of the two extra bridge abutments over the base case piers.	For embankment stability reasons abutments designed as spill through may not be suitable and more conventional abutments may be required. This is reflected in the cost estimate and programme.
8	Access will be required via Wharf Rd and then along the alignment easement with temporary creek crossings.	The embankment is located between the railway corridor and Broughton Mill Creek, currently accessible only via Tannery Road and constrained by a low height bridge (3.3m clearance) under the railway. Earthmoving trucks hauling fill to this location require alternate access route via creek crossing or from the south. There will be more construction traffic on Wharf Road.
9	Scour protection will be required to prevent erosion of the embankments during floods.	The use of Reno mattresses or Gabion baskets needs to be confirmed. A preliminary estimate to cover both of these solutions is included in the cost estimate.

(3) Alternative earthworks design for the northern interchange (Zone 1) to generate additional fill for an island embankment

Re-design of northern interchange to minimise property impacts on the heritage "Mananga" property and win additional fill material. The cost and technical benefits are discussed in Table 4.20 and the drawbacks are discussed in Table 4.21.

Table 4.20 Alternative earthworks design for the northern interchange: Benefits

Item	Benefits	Comments
1	To generate extra fill which could be used in the island embankment and elsewhere as required by the mass haul analysis.	Early indications of this investigation show that it may be better to win extra material from Toolijooa Cut rather than adjust an optimum arrangement at the northern interchange. The use of Berry Siltstone as general fill would require further testing for degree of dispersion and slaking before confirming its suitability for earthworks or assessing the requirement for stabilisation and protection. Materials won from the Toolijooa cut may be used in embankment fill. The material from this source is probably unsuitable for use as base course or sub base due to its mineralogy, but could potentially be used as sub base when stabilised. Additional depth of cut at Toolijooa will require blasting.

Table 4.21 Alternative earthworks design for the northern interchange: Drawbacks

Item	Drawbacks	Comments
1	Constructability issues.	Level differences would require significant temporary works to maintain existing highway traffic during construction.
2	Extra cost of cut/fill earthworks.	This will be included in the southern route alignment cost estimate.

(4) Lowering the vertical alignment north of the Berry north interchange to generate additional fill for earthworks

Options include adjusting batter profiles where possible, i.e. flattening slopes of cuts or steepening slopes of fills. After detailed assessment it became apparent that adjusting the batter profiles at selected locations does not significantly reduce the amount of imported fill required for the southern route. These adjustments yield 42,000m^3 which is a small proportion of the large shortfall of 600,000m^3 on the base case. No issues associated with changing these batters have been identified in the scope of this study. Should this route be adopted further investigations should be undertaken to check the viability of this measure.

Major vertical realignments/adjustments:

In developing this alignment to concept design level there were a number of drivers/objectives that influenced the vertical geometry (in addition to balancing earthworks). Therefore there are limited opportunities to realign the vertical alignment to produce a significant generation of fill, without additional impacts on adjoining properties/land acquisition, vegetation and other environmental impacts such as visual impact, heritage significance and fauna connectivity, etc. However, a few examples of where this may be possible (subject to further consideration of these impacts) are as follows:

a) Toolijooa Ridge

The cost and technical benefits are discussed in Table 4.22 and the drawbacks are discussed in Table 4.23.

b) Austral Park Road South (CH12900 – CH13600)

The cost and technical benefits are discussed in Table 4.22 and the drawbacks are discussed in Table 4.24.

Table 4.22 Lowering the vertical alignment north of the Berry north interchange: Benefits

Item	Benefits	Comments
1	To generate extra fill from adjusted alignments which could be used in the island embankment and other fills towards the southern end of the southern suggestion.	Lowering the vertical crest curve at Toolijooa by 5m yields 280,000 m^3 and alternate design at Austral Park Road South yields 75,000m^3. These figures exclude removal of topsoil, unsuitable and compaction factors.
2	To reduce the haul distance from cut to fill and hence the cost of fill associated with the southern suggestion.	Whilst the approximate haul distance is the same as that assumed for importing fill, the source is known and can be priced with increased certainty.

Table 4.23 Lowering the vertical alignment north of the Berry north interchange (Toolijooa Ridge) : Drawbacks

Item	Drawbacks: Toolijooa	Comments
1	The Toolijooa cut alignment lowering may impact on the property boundaries by increasing its footprint.	Early indications are that for a 5m increase in depth the cutting footprint increases up to 30m in width.
2	Cost of winning material as this extra depth is in fresh latite which requires drilling & blasting.	An estimate of this item is included in this report.
3	Urban design due to cutting depth and size.	Urban design requirements will need to be reviewed with likely impact on cost. An appropriate contingency is included.
4	Proposed property and fauna underpass (approx. CH8400) impacted and would need to be relocated.	This underpass is currently located specifically to service property access and fauna movement along a fauna corridor and the functionality of this structure may be compromised if it is relocated. An appropriate contingency is included.
5	Batter interface/footprint encroaches onto existing Princes Highway (approx. CH8500).	Batter designs will need to be revisited to address this issue in conjunction with the proposed property and fauna underpass at approx. CH8400. An appropriate contingency is included.
6	Increased impact on dwellings at CH8550 and CH8700.	In the event this measure is required batter designs will need to be revisited. An appropriate contingency is included.
7	Batters will need to be adjusted to varying geotechnical conditions/strata.	In the event this measure is required batter designs will need to be revisited. An appropriate contingency is included.

Table 4.24 Lowering the vertical alignment north of the Berry north interchange (Austral Park Road South): Drawbacks

Item	Drawbacks: Austral Park Road South CH12900 – CH13600)	Comments
1	The alignment lowering may impact on the property boundaries, vegetation etc.	Early indications are that this alignment change will impact on boundaries due to increased footprint.
2	Fauna Crossings impacts.	There will be a cost impact on the fauna crossings as they will be significantly longer.

(5) Alternative alignment for southern intersection (Zone 3) to reduce embankment fill requirements

This involves the re-design of alignment to reduce embankment fill required for the southern interchange. The cost and technical benefits are discussed in Table 4.25 the drawbacks are discussed in Table 4.26.

Table 4.25 Alternative alignment for southern intersection: Benefits

Item	Benefits	Comments
1	To reduce embankment fill required for the southern interchange.	Interchange adjustment to lower the main carriageways and take the local roads over the highway.
2	Reduced imported fill will reduce cost of southern route.	An estimate of this item is included in this report.

Table 4.26 Alternative alignment for southern intersection: Drawbacks

Item	Drawbacks	Comments
1	Potential impacts from flooding.	Flood analysis outcomes will be included in the report.
2	Property impacts.	The increased embankments required to take the local roads over the highway would increase the footprint.
3	Urban design impacts.	Urban design requirements will need to be reviewed with likely impact on cost. An appropriate contingency is included.
4	Geometric Design.	Additional crest/sag introduced into the vertical alignment at undesirable locations (with regard to coordination of vertical and horizontal geometry).

(6) Diversion of Town Creek (information provided at Shoalhaven City Council's request)

To accommodate the lowered highway alongside North Street, it is proposed to divert Town Creek into Bundewallah Creek thereby diverting flows away from the town centre and reducing the flood risk that currently exists in town. This is an existing benefit of the northern route and information is provided at the request of Council should the southern route be developed further and the benefits of the northern route not be realised. The cost and technical benefits are discussed in Table 4.27 and the drawbacks are discussed in Table 4.28.

Table 4.27 Diversion of Town Creek: Benefits

Item	Benefits	Comments
1	Potential to provide greater flood protection for the town of Berry equivalent to that which would be provided by the northern route.	Flood flows in Town Creek would no longer be passed through town in storm events and flooding would be reduced.

Table 4.28 Diversion of Town Creek: Drawbacks

Item	Drawbacks	Comments
1	Extra cost of creek realignment.	This will be included in the southern route alignment.

5 Technical investigations

Technical investigations were undertaken to provide the information required to produce the comparative cost estimates. The results from the technical investigations were used to develop the route designs, as well as provide information on the construction methods.

The technical investigations undertaken covered flooding impacts, geotechnical conditions and utility interfaces.

5.1 Flooding investigation

The purpose of this investigation is to assess design and construction requirements from flooding impacts for the southern route.

The location of the highway with respect to the floodplain is an important consideration in the design and construction of the northern and southern routes. Flooding of the highway can restrict access, cause damage and pose a safety risk to users. The alignment and design considerations must manage the potential for flooding and its associated risks.

Flood modelling and assessment has previously been carried out for the northern route as part of the Foxground to Berry Bypass concept design development and environmental assessment. The impacts of flooding on the design of the northern route have been assessed as part of the concept design development for that route. For the southern route, flood modelling and assessment has been carried out to guide the design development to a level of detail suitable for the preparation of a strategic cost estimate. To enable a like-for-like comparison with the northern route, the flood modelling and assessment for the southern route has been carried out to a similar level of detail. Hydrologic and hydraulic modelling and assessment had been undertaken as part of the investigations.

This section outlines the modelling and assessment carried out for the southern route and the design implications details the flooding impacts on the investigation area.

5.1.1 Summary of outcomes

A summary of the results for the flooding investigations is provided in Table 5.1.

Table 5.1 Flood assessment summary

Design Development	Northern preferred route	Southern route
Flood immunity requirements	▪ Upgraded highway to be located above the 100 year Average Recurrence Interval (ARI) flood level. ▪ 100 year ARI flood immune access to be provided between upgraded highway and Berry. ▪ Investigations undertaken as part of concept design development.	▪ Upgraded highway to be located above the 100 year ARI flood level. ▪ 100 year ARI flood immune access to be provided between upgraded highway and Berry. ▪ Refer Section 5.1.4.
Hydrologic and hydraulic modelling	▪ Combination of Probabilistic Rational Method calculations and RAFTS rainfall runoff routing to quantify peak flows and runoff	▪ Combination of Probabilistic Rational Method calculations and RAFTS rainfall runoff routing to quantify peak flows and runoff

Design Development	Northern preferred route	Southern route
	behaviour. ▪ Hydraulic assessment carried out using a combination of HEC-RAS 1D, TUFLOW 2D and culvert hydraulic calculations to suit the size and nature of the respective waterway crossings. ▪ Investigations undertaken as part of concept design development.	behaviour. ▪ Hydraulic assessment carried out using a combination of HEC-RAS 1D, TUFLOW 2D and culvert hydraulic calculations to suit the size and nature of the respective waterway crossings. ▪ Refer Section 5.1.3.2.
Flood impacts	▪ Minimise changes to existing flood behaviour in the context of the nature and extent of existing and future development. ▪ Investigations undertaken as part of concept design development.	▪ Minimise changes to existing flood behaviour in the context of the nature and extent of existing and future development. ▪ Refer Section 5.1.5.
Climate change allowances	▪ Adopting a 6% increase in design rainfall intensities for design of transverse drainage structures for the Project; and ▪ Undertaking sensitivity analyses for increases in – rainfall intensity of 10, 20 and 30% – sea level rise of up to 0.4m and 0.9m in accordance with current NSW government policy and guidelines. ▪ Investigations undertaken as part of concept design development.	▪ Adopting a 6% increase in design rainfall intensities for design of transverse drainage structures for the Project; and ▪ Undertaking sensitivity analyses for increases in – rainfall intensity of 10, 20 and 30% – sea level rise of up to 0.4m and 0.9m in accordance with current NSW government policy and guidelines. ▪ Refer Section 5.1.4.2.
Design outcomes	▪ Design developed for vertical alignment and drainage. structures that achieves – Flood immunity for project. – Flood immune access to town. – Acceptable impacts on surrounding environment.	▪ Design developed for vertical alignment and drainage structures that achieves. – Flood immunity for project. – Flood immune access to town. – Acceptable impacts on surrounding environment.

5.1.2 Background Information

5.1.2.1 Standards and guidelines

Relevant standards and guidelines associated with the flood assessment include:

- Australian Rainfall and Runoff (Institute of Engineers Australia, 1987) (and updates);
- Floodplain Development Manual (NSW Government, 2005);
- Practical Consideration of Climate Change (Department of Environment and Climate Change, 2007);

- NSW Sea Level Rise Policy Statement (Department of Environment, Climate Change and Water, 2009); and
- RTA Bridge Waterway Manual.

5.1.2.2 Catchment description

The southern route crosses the floodplain of Broughton Creek and a number of its tributaries. Named creeks and tributaries in the vicinity of the project area are shown on Figure A1 in Appendix C1 and include (from west to east):

- Andersons Lane Creek;
- Hitchcocks Lane Creek;
- Town Creek;
- Broughton Mill Creek; and
- Broughton Creek.

Broughton Creek and its tributaries drain the hills of the Cambewarra Range that lie north of the township of Berry as well as the broad flat floodplain that lies to the south of Berry. Broughton Creek flows south from Berry for approximately 8km before joining the Shoalhaven River.

The catchment area of Broughton Creek at Coolangatta Road (south of Berry) is approximately 104 square kilometres (SMEC, 2008). Natural forest and cleared pasture are typical of the catchment, with varying levels of development around the townships of Berry, Bundewallah, Foxground, Broughton, Broughton Vale and Broughton Village.

The area traversed by the southern route is typically flat and low lying. Ground levels south of the railway line are typically between 1m and 4m Australian Height Datum (AHD). The terrain rises in the vicinity of the southern and northern connections to the existing highway.

5.1.2.3 Previous catchment studies

The southern route is influenced by flooding from Broughton Creek and its tributaries, as well as the Shoalhaven River. A number of studies have been carried out for the Broughton Creek and wider Shoalhaven River catchments. These studies provide useful background information to understanding the nature of flooding across the study area and include:

- Lower Shoalhaven River Flood Study (Public Works Department, 1990);
- Lower Shoalhaven River Floodplain Risk Management Study and Plan (Webb McKeown & Associates, 2008);
- Broughton Creek Flood Study (SMEC Australia Pty Ltd, 2008);
- Lower Shoalhaven River Floodplain Management Study & Plan: Climate Change Assessment (WMAwater, 2011); and
- Broughton Creek Floodplain Risk Management Study and Plan (Cardno, 2011).

5.1.3 Investigations

5.1.3.1 General

Hydrologic and hydraulic modelling and assessment has been carried out to better understand the flooding characteristics of the creeks and waterways crossed by the southern route under both existing and design conditions. This information has been used to make informed decisions on managing the flood risks to the project and users as well as impacts on the surrounding environment.

Hydrologic and hydraulic modelling is outlined in the Section 5.1.3.2. Flood risks to the project works are outlined in Section 5.1.4 including flood immunity standards adopted in the route design to manage these risks. Impacts on the surrounding environment and measures to manage these impacts are outlined in Section 5.1.5.

5.1.3.2 Hydrologic and hydraulic modelling

The flood assessment of the southern route has involved the development of a number of hydrologic and hydraulic modelling approaches to suit the nature and extent of the waterways traversed by the project.

The approach adopted is consistent with that adopted for the northern route. For the northern route the assessment of the major crossing of Broughton Mill Creek was carried out using the XP RAFTS and TUFLOW models developed for the Broughton Creek Floodplain Risk Management Study and Plan (Cardno, 2011). Other waterway crossings were assessed using PRM and a combination of HECRAS 1D modelling and culvert hydraulic calculations.

Hydrologic modelling

For the larger Broughton Creek catchment (including Hitchcocks Lane Tributary, Town Creek and Broughton Mill Creek) hydrologic modelling was carried out using the XP RAFTS rainfall runoff routing model to derive inflow hydrographs. For this purpose the XP RAFTS model constructed and used in the Broughton Creek Flood Study (SMEC, 2008) and the Broughton Creek Floodplain Risk Management Study and Plan (Cardno, 2011) was adopted. A subcatchment layout that forms the basis of this model is provided in Figure A2 in Appendix C1.

For the remaining waterway crossings the Probabilistic Rational Method (PRM) was used to estimate peak flows. The PRM is based on data from 308 gauged catchments and is applicable to small to medium rural catchments in eastern NSW. The PRM was therefore considered appropriate for application to the present assessment.

Hydraulic modelling

Flood levels, depths and velocities along the southern route were determined from a range of detailed hydraulic analyses.

For the Broughton Creek floodplain (including Hitchcocks Lane Tributary, Town Creek and Broughton Mill Creek) the TUFLOW 2D model established for the Broughton Creek Floodplain Risk Management Study and Plan (Cardno, 2011) was used as a basis. The Cardno TUFLOW model covers an area of approximately 8.95km^2 covering Berry and its immediate surrounds and is based on a 3m by 3m grid to define the ground topography. The downstream (southern) model limit is approximately 300m south of the railway line.

The Cardno TUFLOW model was extended further south to incorporate the area traversed by the southern route alignment. The ground terrain over the extended section of the model was defined using photogrammetry collected for the Gerringong to Bomaderry Upgrade project and also used in the design of the southern route. The original Cardno TUFLOW model was developed using a different ground data set based on Aerial Laser Survey. A review was made of the variability in levels across the model extension. In the context of the nature and depth of flooding across the model extension the relative differences are considered appropriate for the purposes of the current assessment. However, should the southern route be developed further through concept design then a consistent data set would need to be adopted for definition of the ground terrain in the TUFLOW model.

To assess the impacts of the proposed highway on flood behaviour, the base model representing existing conditions was modified by adding the road design to the ground definition. For the purposes of strategic design, the effects of bridges and viaduct piers have not been modelled. These are expected to have relatively minor and localised impacts on flood levels and velocities. These impacts would need to be considered in more detail in future projects stages.

Downstream model boundaries in the Cardno TUFLOW model were shifted to suit the extended model extent. A layout of the extended TUFLOW model is provided in Figure A3 in Appendix C1.

Inflow hydrographs derived from the XP RAFTS hydrological model were applied to the upstream extents of the TUFLOW model. Rainfall was also applied directly to the 2D grid over the TUFLOW model extent which is consistent with the approach adopted for the Broughton Creek Floodplain Risk Management Study and Plan (Cardno, 2011).

Fixed tailwater levels were adopted for the various modelled scenarios based on design flood levels obtained from the Shoalhaven River Flood Study (PWD, 1990). The study was based on a CELLS hydraulic model of the Shoalhaven River and its tributaries. The model layout, shown in Figure A4 in Appendix C1, extends up Broughton Creek to Coolangatta Road, just south of Berry.

Flooding in the Shoalhaven River has a critical duration of approximately 36 to 48 hours. This is considerably longer than the local catchment which has a critical duration of 1 to 2 hours for Town Creek and Broughton Mill Creek and 6 to 9 hours for Broughton Creek (Cardno, 2011). The rise and fall in flood levels in the Shoalhaven River over these shorter durations is such that a fixed level boundary was considered appropriate.

The remaining waterway crossings are located upstream of the railway line and therefore are less influenced by flooding on the Broughton Creek floodplain. Accordingly, these waterway crossings were modelled using either the HEC RAS 1D model, Bentley Culvertmaster or HY-8 depending on the size and complexity of the crossing.

Broughton Creek Floodplain Risk Management Study models

During the Broughton Creek Floodplain Risk Management Study and Plan (Cardno, 2011) the XP RAFTS and TUFLOW models were calibrated against the historical floods of 2002 and 2005. The models have been adopted by Shoalhaven Council and OEH as part of the Floodplain Risk Management process. For the purpose of a strategic design for cost comparison purposes no critique or examination has been carried out of the XP RAFTS and TUFLOW models. However, a comprehensive review of the model structure will need to be undertaken as part of the concept design of the preferred route.

5.1.4 Results: flood risk to the project

Flood standards and immunity requirements for the Berry Bypass project have been established based on RMS design standards, Gerringong to Bomaderry project objectives and standard practice in accordance with the *NSW Floodplain Development Manual* (2005). Requirements for the southern route assessment are consistent with those adopted for the northern route and include:

- 100 year ARI flood immunity to the highway when measured to the edge of the outer carriageway in accordance with project requirements;
- An appropriate clearance between the 100 year ARI flood level and the underside of the bridge or viaduct structures in accordance with the RMS Bridge Waterway Manual (technically referred to as freeboard). Freeboard to bridges and viaducts is generally recommended to be a minimum of 0.5m over the main flow channel. However, in some circumstances it may be feasible to provide a lesser value where flow velocities are relatively low (e.g. less than 1m/s) and/or the reduced freeboard occurs over a relatively short section of the overall waterway opening. In these cases a minimum value of say 0.3m may be appropriate;
- 100 year ARI flood immunity access between the highway and the township of Berry. This is an objective of the Gerringong to Bomaderry project which was also provided at Gerringong and for Berry under the northern route;
- In accordance with NSW Government guidelines, the design must consider potential impacts due to climate change.

The following sections provide an overview of the flood behaviour and design flood levels relevant to each section of the southern route, considerations of potential impacts due to climate change, and minimum design requirements for the highway.

5.1.4.1 Design flood levels

Southern route alignment CH15700 - CH19300

The southern alignment over this section spans the Broughton Creek floodplain, including the tributaries Hitchcocks Lane Creek, Town Creek and Broughton Mill Creek. The floodplain generally is flat and low-lying, with ground levels typically between 1m and 4m AHD. The prevailing ground topography results in ill-defined flow paths and complex interaction of flows between Broughton Creek and its tributaries, as well as Shoalhaven River.

Previous studies of the catchment have identified that the area is influenced by flooding from the Shoalhaven River. The *Shoalhaven Flood Study* (PWD, 1990) provides a 100 year ARI flood level at Berry of 5mAHD due to Shoalhaven River flooding.

To establish appropriate 100 year ARI design flood levels for the southern route it is necessary to consider the combination of Shoalhaven River flooding with flooding of Broughton Creek and its tributaries. For the *Broughton Creek Floodplain Risk Management Study* (Cardno, 2011) a 100 year ARI local flow from Broughton Creek coinciding with 100 year ARI Shoalhaven River flooding was adopted. While this approach may be appropriate in the context of broad scale planning purposes, it is potentially conservative for establishing design road levels.

Due to the relative size of the two catchments it is reasonable to expect that for most flood events, the local catchment would peak prior to peak flows in the Shoalhaven River. It is also possible that flooding of the local Broughton Creek and broader Shoalhaven River catchments could be caused by different storm patterns. The simultaneous peaking of 100 year ARI flows from the local catchment and Shoalhaven River would therefore have a probability significantly lower than a 1 in 100 year return period.

In light of the above, a flood envelope approach has been adopted to resolve the problem of coincident flooding. This has involved assessment of the following flooding combinations:

- 20 year ARI Shoalhaven River flooding coinciding with 100 year ARI Broughton Creek catchment flooding; and
- 100 year ARI Shoalhaven River flooding coinciding with 20 year ARI Broughton Creek catchment flooding.

Shoalhaven River flood levels were obtained from the Shoalhaven River Flood Study (PWD, 1990). The 20 year and 100 year ARI flood levels were 4.3mAHD and 5.0mAHD respectively.

Results of the flood modelling are summarised in Table 5.2. The greater flood level of the two scenarios was adopted as the 100 year ARI flood level for the design of the southern route. As can be seen, the dominant flood combination is the 100 year ARI Shoalhaven River flooding combined with a 20 year ARI local catchment flow. Flood mapping for the two scenarios are presented as Figures A5 and A6 in Appendix C1.

Table 5.2 Southern Route Alignment (CH15700 to CH19300) – envelope of peak flood levels (mAHD)

Location	Scenario	
	100 year ARI local flow / 20 year ARI Shoalhaven River flooding	20 year ARI local flow / 100 year ARI Shoalhaven River flooding
Hitchcocks Lane Tributary (CH18600SR[1])	4.3	5.0[2]
Town Creek (CH17200SR[1])	5.0	5.2[2]
Broughton Mill Creek (CH16700SR[1])	5.1	5.3[2]

Note

1. Chainages based on southern route alignment.
2. Adopted as 100 year ARI design flood level.

Southern interchange CH19300 - CH19800

The southern interchange for the southern route spans Anderson Lane Tributary approximately 450m upstream (west) of the railway line. The confluence of Anderson Lane Tributary and Broughton Creek is a further 1.4km downstream (east) of the railway line.

The railway line is at a level of approximately 5m AHD, compared with levels of the watercourse at the interchange of 7m to 11m AHD. The variation in ground levels is such that flooding at the southern interchange would not be influenced by Shoalhaven River/Broughton Creek flooding or any hydraulic control caused by the railway line. Flood modelling was carried out using the HECRAS 1D modelling software to estimate flood levels at the southern interchange. Results are summarised in Table 5.3.

Table 5.3 Southern interchange (CH19300 to CH19800) - peak flood levels (mAHD)

Location	100 year ARI Flood Level (mAHD)
Northern connection to existing highway	12.6
Northern on ramp	11.7
Main alignment	11.6
Southern off ramp	10.3

Access to Berry

A key project objective of the Gerringong to Bomaderry Upgrade based on consultation with Shoalhaven Council is to provide 100 year ARI flood immunity access to the townships of Gerringong and Berry. This requirement has been provided as part of the Gerringong Upgrade project and is also accommodated under the northern preferred route. For consistency this requirement has also been adopted in the evaluation of the southern route.

The southern route would involve two access routes into Berry, along the existing highway from the north and south interchanges (refer to Figure A1 in Appendix C1). Under existing conditions both of these access routes have less than 100 year ARI flood immunity and therefore, one of these routes would need to be upgraded.

The northern access route via the existing Princes Highway crosses Broughton Mill Creek immediately west of the Albert Street intersection. Flood modelling undertaken for the *Broughton Creek Floodplain Risk Management Study and Plan* (Cardno, 2011) shows that the Princes Highway is overtopped by Broughton Mill Creek in a 5 year ARI flood to a depth of 0.3m. In a 100 year ARI flood the depth of flooding is estimated to be 0.7m. To provide a 100 year ARI flood immune access the existing highway would need to be raised over a distance of 400m and the existing bridge crossing at Broughton Mill Creek substantially upgraded. This would require substantial property adjustments and would have significant impacts on the surrounding properties.

In comparison, the southern access route involves four waterway crossings. These crossings do not currently have 100 year ARI capacity and upgrading the route would involve localised works that would include amplifying the crossing size and localised raising of road levels. Based on the scope of works involved and extent of impacts on surrounding properties, this route is considered the more feasible for providing 100 year ARI flood immune access to Berry for the southern route alignment.

Hydraulic assessment was carried out for the four waterway crossings. A summary of design flood levels and proposed upgrade measures to provide 100 year ARI flood immunity are provided in Table 5.4.

At CH17850, flows in excess of the culvert capacity will travel south along the edge of the highway toward the larger waterway crossing at CH18100. Overflows occur in the 100 year; however flood levels are lower than the road level. At CH18100 and CH18550 the existing culverts have insufficient capacity to convey the 100 year ARI flow and overtopping of the highway would occur. At CH19160, flows in excess of the culvert capacity will travel south along the edge of the highway toward the larger Andersons Creek tributary at the southern interchange. Flows would encroach onto the highway as they travel south. 100 year ARI flood immunity at this location could therefore be achieved by some local reshaping works to increase the capacity of the overflow channel.

Table 5.4 Southern access to Berry – waterway crossing summary

Location	Existing			Design		
	Culvert Crossing Size	Road Level[1] (mAHD)	100 year ARI Flood Level (mAHD)	Culvert Crossing Size	Road Level (mAHD)	100 year ARI Flood Level (mAHD)
CH17850	450mm diameter pipe	11.8	11.4	No upgrade required	11.8	11.4
CH18100	3 x 1350mm diameter pipe	10.1	10.4	9x 1350mm diameter pipe (or equivalent)	10.1	9.9
CH18550	3 x 1350mm diameter pipe	6.8	7.1	8 x 1350mm diameter pipe (or equivalent)	6.8	6.8
CH19160	600mm Diameter pipe	14.8	15.0	Local reshaping of roadside swale to increase capacity	14.8	14.8

Note:

1. Road level measured to edge of carriageway.

5.1.4.2 Potential impacts due to climate change

Climate change has the potential to alter rainfall and sea level conditions that lead to flooding of the creeks and waterways traversed by the Foxground and Berry Bypass project.

Scientific research into the potential impacts of climate change has been rapidly evolving over recent years. Research indicates that climate change is likely to result in more frequent and intense storms, but lower average annual rainfall. This has the potential to increase rainfall intensities for storms leading to increases in the frequency and magnitude of flooding to catchments and waterways in the vicinity of the Berry Bypass project.

Research into sea level trends shows that over the period 1870 – 2001 global sea levels rose by 0.2m, with the current global rate of increase approximately twice the historical average (DECCW, 2009). Increased sea level rise has the potential to affect areas of the Project that are influenced by Shoalhaven River flooding.

The Floodplain Risk Management Guideline *Practical Consideration of Climate Change* (DECC, 2007) identifies that based on available research sea level rise could be between 0.18m and 0.91m by 2090. The DECC 2007 Guideline also provides estimated changes in rainfall intensities for the 1 in 40 year 1 day rainfall totals. With regard to the study area the predicted increase in rainfall intensity is +7% by 2030 and +5% by 2070. On this basis the RMS have established design criteria providing an allowance for 6% rainfall increase across the Gerringong to Bomaderry project.

While there is general consensus regarding the overall trend of increased rainfall intensities and sea level rise, there is fewer consensus on the extent of these increases. For this reason the

DECC 2007 Guideline recommends assessment of a range of rainfall and sea level scenarios to assess the sensitivity of the catchment to potential increases.

The *DECC 2007 guidelines* recommends consideration of the following:

- Ocean level rise by year 2090:
  - Low level ocean rise 0.18m
  - Medium level ocean rise 0.55m
  - High level ocean rise 0.91m
- Increase in peak rainfall and storm volume:
  - Low level rainfall increase 10%
  - Medium level rainfall increase 20%
  - High level rainfall increase 30%

It should be noted that under the *DECC 2007 Guidelines* a high level rainfall increase of 30% is recommended for consideration due to the level of uncertainty in rainfall projections and application of the "precautionary principle" as recommended under the *DECC 2007 Guidelines*. However, on the basis of current research it is generally acknowledged that a 30% rainfall increase is on the conservative side.

Subsequent to the issue of the *DECC 2007 Guideline*, the *NSW Sea Level Rise Policy Statement* (DECCW, 2009) advised that:

> *"The best national and international projections of sea level rise along the NSW coast are for a rise relative to 1990 mean sea levels of up to 40cm by 2050 and 90cm by 2100. There is no scientific evidence to suggest that sea levels will stop rising beyond 2100 or that the current trends will be reversed."*

In light of the above, the approach adopted to manage the potential impacts of climate change on flooding has involved:

- Adopting a 6% increase in design rainfall intensities for design of transverse drainage structures for the project; and
- Undertaking sensitivity analyses for increases in,
  - rainfall intensity of 10%, 20% and 30%;
  - sea level rise of 0.4m and 0.9m.

Potential increases in rainfall intensities and sea levels have been assessed as part of the hydrologic and hydraulic modelling carried out for the assessment and design of the southern route alignment. A summary of the implications on 100 year ARI flood levels under the range of scenarios is provided below.

Southern Route Alignment CH15700 - CH19300

As noted in Section 5.1.4.1, the southern alignment is influenced by flooding from the Broughton Creek floodplain as well as the Shoalhaven River. Potential impacts on flood levels in the Shoalhaven River due to climate change has been investigated and documented in the *Lower Shoalhaven River Floodplain Management Study and Plan Climate Change Assessment* (WMAwater, 2011).

Assessment of potential climate change impacts on design flood levels for the southern route between CH15700 to CH19300 was based on the adopted design scenario of 20 year ARI local catchment rainfall combined with 100 year ARI Shoalhaven River flooding.

Outcomes of the *Lower Shoalhaven River Floodplain Management Study and Plan Climate Change Assessment* (WMAwater, 2011) were used to define tailwater conditions from Shoalhaven River flooding for the various climate change scenarios considered. Shoalhaven River flood levels are provided in Table 5.5. Variations in rainfall on the local catchment were assessed by factoring the inflows to the TUFLOW model by 10%, 20% and 30% to reflect the respective increases in rainfall intensity on the local catchment.

Table 5.5 Shoalhaven River - potential climate change impacts (m)

Sea Level Rise	Increase in Rainfall Intensity				
	Base Case Flood Level (mAHD)	0%	10%	20%	30%
0m	5.00	-	0.16	0.31	0.48
0.4m		0.02	0.17	0.33	0.50
0.9m		0.05	0.20	0.38	0.57

Note

- Extracted from Figures 3 to 6 of the Lower Shoalhaven River Floodplain Management Study and Plan Climate Change Assessment (WMAwater, 2011).

There are 12 possible combinations of sea level rise and increase in rainfall intensity to consider. However, the results show that sea level rise alone would have a negligible effect on flood levels along the southern route alignment. A sea level rise of 0.9m would result in increases in flood level of up to 0.05m only, experienced at Hitchcocks Lane Tributary. For this reason, and to reduce the number of model runs, the assessment was limited to 0.9m sea level rise with increases in rainfall intensity of 10%, 20% and 30%.

Results of the various sea level and rainfall intensity scenarios assessed are shown in Table 5.6.

Table 5.6 Southern route alignment - potential climate change impacts (m)

Sea Level Rise	Increase in Rainfall Intensity				
	Base Case Flood Level (mAHD)	0%	10%	20%	30%
	Hitchcocks Lane Tributary – CH18600SR				
0.9m	5.01	0.05	0.19	0.37	0.56
	Town Creek – CH17200SR				
0.9m	5.22	0.01	0.03	0.21	0.40
	Broughton Mill Creek – CH16700SR				
0.9	5.25	0.00	0.03	0.19	0.38

The results show that for a 10% increase in rainfall, increases in flood level are less than 0.2m. The upper bound of the sensitivity analysis (30% increase in rainfall) would result in an increase in flood level of up to 0.56m.

The greatest increases in flood levels are experienced at Hitchcocks Creek Tributary. Relative increases tend to reduce as one moves further upstream (east) along the Broughton Creek floodplain as there is less influence from Shoalhaven River flooding.

In light of the above, the potential impacts due to climate change are at worst expected to reduce or eliminate at some point in the future the freeboard which would normally be available. More mid-range scenarios are likely to result in a reduction of freeboard from 0.5m to say 0.2 to 0.3m. On this basis no additional allowance for climate change is considered necessary.

Southern interchange CH19300 - CH19800

Flooding at this location is not influenced by Shoalhaven River/Broughton Creek flooding and is therefore not influenced by sea level rise. Flooding of the southern interchange was therefore assessed for potential increases in rainfall intensity only.

Variations in rainfall on the local catchment were assessed by factoring the inflows to the HECRAS model by 10%, 20% and 30% to reflect the respective increases in rainfall intensity on the local catchment.

Results of the various rainfall intensity scenarios assessed are summarised Table 5.7.

Table 5.7 Southern interchange - Potential Climate Change Impacts (m)

Location	Increase in Rainfall Intensity			
	Base Case Flood Level (mAHD)	10%	20%	30%
Northern connection to existing highway	12.6	0.03	0.10	0.16
Northern on ramp	11.7	0.03	0.11	0.19
Main alignment	11.6	0.03	0.11	0.19
Southern off ramp	10.3	0.03	0.11	0.19

The results show that an increase in 10% rainfall intensity would result in a relatively minor increase in flood level of 0.03m at each of the bridge crossings, with negligible reduction in freeboard. Even the upper bound of the sensitivity analysis (30% increase in rainfall intensity) would result in less than 0.2m increase in flood level, with a resulting reduction of freeboard to 0.3m. On this basis no additional allowance for climate change is considered necessary.

Access to Berry

Similar to the southern interchange, flooding of the waterway crossings along the southern access to Berry are not influenced by Shoalhaven River/Broughton Creek flooding and are therefore not influenced by sea level rise. Flooding of the crossings was therefore assessed for potential increases in rainfall intensity only.

Variations in rainfall on the local catchment were assessed by factoring the inflows to the HECRAS model by 10%, 20% and 30% to reflect the respective increases in rainfall intensity on the local catchment.

Results of the various rainfall intensity scenarios assessed are summarised Table 5.8.

Table 5.8 Southern access to Berry - potential climate change impacts (m)

Location	Increase in Rainfall Intensity			
	Base Case Flood Level (mAHD)	10%	20%	30%
CH17850NR1	11.4	0.01	0.03	0.04
CH18100NR1 Hitchcocks Lane Tributary	9.9	0.09	0.32	0.34
CH18550NR1 Hitchcocks Lane Creek	6.8	0.06	0.12	0.18
CH19160NR1	14.8	0.01	0.03	0.04

Note

1. Chainages are based on northern route alignment along the existing Princes Highway. Refer to Figure A1 for locations.

For the minor waterway crossings at CH17850 and CH19160 the results show that increasing rainfall would have negligible effect on peak flood levels. This is because flows in excess of the culvert capacity are diverted along the roadside swale to the adjacent, larger waterway crossing.

For the larger waterway crossings at CH18100 and CH18550, flood levels are more sensitive to increases in rainfall intensity. Increases in peak flood level are between 0.05m and 0.34m for the range of scenarios considered.

The results show that an increase of 10% rainfall intensity would result in a relative minor increase in flood level of up to 0.13m maximum at one of the culvert crossings. The upper bound of the sensitivity analysis (30% increase in rainfall intensity) would result in 0.34m increase in flood level.

The local works required to provide flood immunity are outlined in Section 5.1.4.3 and would involve amplifying culverts and where necessary raising the level of the road. Given the nature and extent of works it would be relatively straight forward to provide adaptive measures in the future to address any potential impacts due to climate change. This could involve raising the road by up to 0.2 to 0.3m and/or providing additional culvert capacity. Consequently, no additional allowance for climate change is considered necessary at this point in time.

Recommendations

On the basis of the preceding assessment, the recommended measures to manage potential impacts due to climate change would involve:

- For bridge waterway crossings potential impacts due to climate change can be accommodated through the provision of an appropriate freeboard of say 0.5m minimum;
- For upgrades to existing waterway crossings on Princes Highway potential impacts due to climate change can be accommodated (if required) through future local adaptive measures such as culvert amplification and/or lifting the level of the highway. The assessment has shown that impacts are not expected to be significant. Consequently, no additional measures are considered necessary at this point in time.

5.1.4.3 Summary of flood immunity requirements

A summary of 100 year ARI flood levels and associated minimum design requirements is provided in Table 5.9.

Table 5.9 Southern route alignment – summary of flood level requirements

Location	100 year ARI design flood level (mAHD)	Design/freeboard requirement
Southern route alignment (CH15700 – CH19300)		
CH18600SR1 Hitchcocks Lane Creek	5.0	0.5m clearance to underside of bridge
CH17200 SR1 Town Creek	5.2	0.5m clearance to underside of bridge
CH16700 SR1 Broughton Mill Creek	5.3	0.5m clearance to underside of bridge
Southern interchange (CH19300 – CH19700)		
Connection to existing highway	12.6	0.5m clearance to underside of bridge
Northern on ramp	11.7	0.5m clearance to underside of bridge
Main alignment	11.6	0.5m clearance to underside of bridge
Southern off ramp	10.3	0.5m clearance to underside of bridge
Access to Berry via Existing Princes Highway		
CH18100NR2 Hitchcocks Lane Tributary	11.4	Existing highway provides 100 year ARI flood immunity. No additional measures required.
CH18100NR2 Hitchcocks Lane Tributary	9.9	Amplify culverts and lift road to provide 100 year ARI flood immunity when measured to edge of road.
CH18550NR2 Hitchcocks Lane Creek	6.8	Amplify culverts to provide 100 year ARI flood immunity when measured to edge of road.
CH19160NR2	14.8	Existing highway provides 100 year ARI flood immunity. No additional measures required.

Note

1. Chainage is based on southern route alignment.
2. Chainage along existing Princes Highway is based on northern route alignment.

5.1.5 Results: flood risk due to impacts on the surrounding environment

The southern route design crosses a number of creeks and watercourses and their associated floodplains. Under the current design a range of works are required within these floodplains including embankments, bridge and viaduct piers /columns and abutments. Any works within the floodplain have the potential to change flood behaviour and adversely impact on the surrounding environment.

Detailed hydraulic modelling has been carried out to quantify flood behaviour in the 100 year ARI event under existing and proposed conditions. This modelling has provided a basis for assessing potential changes in flood levels, velocities and depths as a result of the proposed works.

No detailed hydraulic assessment has been carried out for flooding in excess of the 100 year ARI event, up to the PMF. However, qualitative assessment of potential impacts is provided, particularly in the context of impacts on critical infrastructure adjoining the project such as David Berry hospital.

The following sections provide an outline of the main waterways traversed or bordered by the project, the nature of works proposed, potential flood impacts on the surrounding environment and measures incorporated into the design to manage these impacts.

In accordance with the requirements of the *NSW Floodplain Development Manual* (2005) it is necessary to consider the consequences of flooding in excess of the 100 year ARI event, up to the Probable Maximum Flood (PMF). This is particularly relevant in the context of potential impacts on key infrastructure and significant increases in risk to life (due to increased flood depths and cutoff of flood evacuation routes).

For the purposes of providing a cost comparison between the northern and southern routes flood modelling and assessment of events in excess of the 100 year ARI design scenario has not been carried out in detail. However, a qualitative assessment particularly in the context of impacts on critical infrastructure adjoining the project such as David Berry Hospital has been carried out based on the proposed southern route design. Discussion is provided in the following sections.

5.1.5.1 Southern route alignment CH15700 - CH19300

Between CH15700 and CH19300 the southern route alignment traverses the broad floodplain of Broughton Creek including its tributaries Hitchcocks Lane Creek, Town Creek and Broughton Mill Creek (refer Figure A1). The creek lines of the larger watercourses of Broughton Creek, Broughton Mill and Town Creeks are moderate to deeply incised with well vegetated main channel and overbank areas. In comparison, Hitchcocks Lane Creek is highly modified, of relatively uniform shape and less than 1m deep.

The main southern railway line lies to the north of the proposed road alignment. Existing development along the proposed alignment is predominantly rural residential. The Berry Wastewater Treatment Plant lies immediately south of the road alignment, adjacent to Town Creek. David Berry Hospital is located west of the road alignment and the Broughton Creek floodplain.

The proposed road alignment in this area consists of a combination of embankment with bridges and viaduct spanning waterway crossings. Flood modelling has been undertaken to quantify potential changes in flood behaviour, in terms of changes in flood levels, depths and velocities. The outcomes of this modelling are outlined below.

As it was shown in Section 5.1.4, flooding in this area is influenced by a combination of Shoalhaven River flooding and runoff from the local catchment. In establishing design flood levels it was found that 100 year ARI Shoalhaven River flooding was the dominating factor. However, in consideration of potential changes in flood behaviour a lesser Shoalhaven River flood level in combination with 100 year ARI local catchment flows will be the dominating factor. This is because elevated Shoalhaven River levels will tend to drown out any influence the road embankment and structures will have on changing flood behaviour.

A range of tailwater conditions representing Shoalhaven River flood levels were assessed and it was found that for a tailwater level of 2mAHD or less, there was negligible change to flood levels at the road alignment. For this reason assessment of flood impacts has been undertaken based on 100 year ARI local catchment flows, in combination with a Shoalhaven River level of 2mAHD.

Results

Changes in flood levels and velocities are presented in Figures A7 and A10 in Appendix C1 respectively. A summary of potential flood impacts at key locations is provided below.

The results show that there would be increases in flood levels at Hitchcocks Lane Creek (CH18600 on Figure A7) of up to 0.3m upstream. There would also be increases in flood level along the embankment immediately east of Hitchcocks Lane Creek (CH17900 on Figure A7). The areas affected are low lying farm land (typically less than 2mAHD) and no development would be affected. However, the embankment will alter drainage patterns, redistribute flows and increase velocities. The results show increases in velocity of up to 1m/s along the embankment (between CH18100 and CH18700 on Figure A10).

To offset local drainage impacts it is recommended that culverts are provided at CH17900 and CH18400. For the purposes of the current assessment, and in the context of a strategic cost estimate, the equivalent of 3m x 3m box culverts should be provided at the two locations. Should further design development be undertaken for the southern route alignment then a more detailed assessment would be required that also considers a range of issues including potential for settlement and access for farming.

At Wharf Road (CH17500 on Figure A7) the model results show an increase in flood level of up to 0.1m. However, impacts are relatively localised and no development would be affected.

Due to the location of the road embankment with respect to the Wastewater Treatment Plant (CH17300 on Figure A7) there would be a slight reduction in flood levels. However, changes in flood level would be less than 0.02m and therefore this would provide negligible benefit to the plant.

The approach embankment for the northern abutment extends into the floodplain by approximately 400m (from CH 15700 to CH 16100 on Figure A7). This obstructs the breakout of flows from the Broughton Creek floodplain. As a result flood levels along Broughton Creek would increase by up to 0.15m. Conversely, flood levels west of the embankment would be reduced by up to 0.08m. Changes in flood level are relatively minor compared to flood depths, which are typically between 1.2m and 2.2m in this area. No existing development would be affected.

The potential changes in peak velocities resulting from the northern abutment are shown in Figure A10. The results show increases in velocity between the northern abutment (CH15700 to CH16100 on Figure A10) and the South Coast Railway Line. The modelling shows increases are typically less than 0.2m/s. There are localised increases in velocity around the northern abutment (CH16100 on Figure A10) of up to 1m/s. However, these increases could be addressed through the design and implementation of appropriate scour protection measures during future project stages.

David Berry Hospital is located to the east of the Broughton Creek floodplain and the southern route alignment (refer Figure A7). The hospital is at a level of 18mAHD which is over 5m above the adjacent road design level. Consequently, the southern route is not expected to have any adverse flood impacts on the hospital in the PMF event. Access to the hospital from Berry is via Tannery Road which is currently inundated at the railway underpass (CH16200 on Figure A7) to a depth of 1.9m in the 20 year ARI flood event (Cardno, 2011). The southern route would have negligible impact on the existing level of flood immunity, and relative depth of flooding at Tannery Road.

The main areas where there is potential for adverse impacts in the PMF are where significant extents of embankment are constructed across the floodplain. This is particularly relevant to the embankment between CH17300 and CH18800 (refer Figure A1). Based on the level of the road embankment there is the potential for adverse impacts on development along the southern side of the railway line, including Berry Railway Station (refer Figure A1).

5.1.5.2 Southern interchange CH19300 - CH19800

Anderson Lane Creek at the southern interchange has an upstream catchment area in the order of 220 hectares. The catchment is predominantly natural forest or rural residential. In the immediate vicinity of the southern interchange there are some rural residential properties on both sides of the existing Princes Highway.

Model results show that the existing highway overtops in a 100 year ARI flood to a depth of approximately 0.6m. Under the proposed design of the southern route the road alignment at this location is to be raised above the 100 year ARI flood level. The existing culvert crossing will need to be upgraded to offset potentially adverse flood impacts upstream due to the removal of the relief provided by overflows across the highway in a 100 year ARI flood. The proposed arrangement involves four bridge crossings for the southbound on ramp, main alignment, northbound on ramp and the connection to the existing highway. Each bridge will involve provide a total span of 40m.

Results

Flood model results for the 100 year ARI flood are summarised in Table 5.10. The results show that there would be an increase in flood level upstream of the northbound off ramp, main alignment and southbound on ramp bridges of between 0.35 and 0.9m. However, these increases would be confined to the road corridor. Upstream of the existing Princes Highway there would be a slight reduction in flood level in the 100 year ARI event.

Table 5.10 Andersons Lane Tributary – 100 year ARI relative impacts (m)

Location	100 year ARI Existing Flood Level (mAHD)	Proposed Conditions Relative Impact (m)[1]
Upstream of Existing Princes Highway	12.8	-0.17
Upstream of Northbound On Ramp	12.7	-1.00
Upstream of Main Alignment	10.6	+0.96
Upstream of Southbound Off Ramp	9.7	+0.61
Downstream of Southbound Off Ramp	9.3	+0.09

Note: A positive relative impact represents an increase in flood level under proposed conditions relative to existing conditions. A change in flood level within the range of +/-0.01m is considered to be within the limits of accuracy of the model.

The proposed works will result in no significant changes in flow distribution. Consequently, there is expected to be minimal changes in flow velocity outside the project corridor. Localised increases in velocity across the project corridor could be addressed through appropriate scour protection measures.

The southern interchange will create a potential barrier to flows in excess of the 100 year ARI event. However, the area upstream of the interchange is relatively steep and is currently undeveloped. Consequently, the extent of impacts would be confined to a relatively small area and no existing development would be adversely affected.

5.1.5.3 Access to Berry

As noted in Section 5.1.2.3, to provide 100 year ARI flood immunity access between the southern route and Berry, it would be necessary to upgrade the waterway crossings on the existing Princes Highway at CH18100 and CH18550. The design of these upgrades has been carried out with due consideration to potential impacts on the surrounding environment. The required waterway crossings are summarised in Table 5.11.

Table 5.11 Southern Access to Berry – Waterway crossing summary

Location	Existing			Design		
	Culvert Crossing Size	Road Level (mAHD)	100 year ARI Flood Level (mAHD)	Culvert Crossing Size	Road Level (mAHD)	100 year ARI Flood Level (mAHD)
CH18100 Hitchcocks Lane Tributary	3 x 1350mm diameter pipe	10.1	10.4	9x1350mm diameter pipe	10.1	9.9
CH18550 Hitchcocks Lane Creek	3 x 1350mm diameter pipe	6.8	7.1	8x1350mm diameter pipe	6.8	6.8

At CH18100 recent development has occurred downstream. Consideration has therefore been given to avoid a significant reduction in upstream flood storage by significantly augmenting waterway area and thereby reducing flood levels as this could result in an increase in flows through the downstream development. Under the current design there would be a reduction in flood level of 0.5m upstream of CH18100. Further design refinement during future design stages could reduce this reduction to 0.3m without the need for modifications to the existing road level. In the context of the broader floodplain, this is expected to have a minor impact on floodplain storage and changes in flows.

At CH18550 there is no development downstream. Therefore the potential increase in flows as a result of the reduction in flood storage is not expected to be significant. Augmentation of the existing culverts is proposed, with little change to the existing level of the highway required. Localised increases in flow velocity could be addressed by appropriate scour protection and energy dissipation measures.

The nature of the works at both of these crossings is not expected to result in any significant impacts on surrounding development for flooding in excess of the 100 year ARI event. At CH18100 upstream impacts would be confined to the area between the highway and Huntingdale Park Road, which consists of a wetland that drains the upstream development. The culvert augmentation works at CH18550 would result in negligible changes in flood behaviour in the PMF event.

5.1.5.4 Island Embankment CH16400 to CH16700

An alternative option of providing a 350m long island embankment immediately south of the railway line has been assessed. Flood modelling was carried out for the 100 year ARI design scenario using the TUFLOW model developed to assess the southern alignment.

Results

Changes in flood levels are presented in Figure A11. Peak velocities around the embankment are presented in Figure A12, with respective changes in velocity compared to existing conditions presented in Figure A13.

The results show that the island embankment would result in an increase in flood levels of up to 0.5m. At adjacent development along Broughton Mill Creek increases in flood level would be less than 0.02m.

Flows that currently overtop the railway line and travel through this area will be diverted north and south of the embankment. As a result, there would be an increase in flood levels of up to 0.5m. At adjacent development along Broughton Mill Creek increases in flood level would be less than 0.02m.

The diversion of flows would also result in an increase in velocities immediately north and south of the embankment. The results presented in Figure A13 show localised increases in velocities of up to 1.4m/s north of the abutment, with peak velocities typically be less than 2.5m/s. South of the embankment increases in velocities would be up to 1.0m/s, with resulting velocities typically less than 2.5m/s. Scour protection would be required around the northern and southern abutments.

The island embankment would also result in localised increases in velocity along the toe of the embankment. However, peak velocities would be less than 2.5m/s and could be addressed through appropriate lining of drainage swales that would be required along the toe of the embankment.

The island embankment traverses an existing drainage line at CH16650. The embankment has the potential to alter local drainage patterns. To offset these impacts it is recommended that a culvert is provided at CH16650. This culvert would also assist in offsetting any adverse flood impacts on the adjacent development. For the purposes of the current assessment, and in the context of a strategic cost estimate, the equivalent of a 3m x 3m box culvert should be provided. Should further design development be undertaken for the Southern Route alignment then a more detailed assessment would be required that also considers a range of issues including potential for settlement and access for farming.

5.2 Geotechnical investigation

The purpose of this investigation is to develop comparable geotechnical information for the northern and southern routes to inform the preparation of the cost estimates.

Ground conditions are critical determinants of the engineering design requirements for a project. An understanding of the geology within the corridor is essential to design and construct cost effective, aesthetic, low maintenance roads. Geotechnical investigations were carried out for the northern route as part of the concept design development process. The geotechnical investigations undertaken focused primarily on providing information about the geotechnical conditions within the corridor for the southern route. Limited further specific investigations were undertaken for the northern route where required to ensure an equivalent level of information. Geotechnical field investigations and the results of laboratory testing are presented in the Factual Geotechnical Investigation Report given in Appendix D2.

This chapter of the report describes the topography and geology of the area investigated and explains the desktop and field investigations performed. An analysis of the results provides information regarding the presence and extent of soft soils, acid sulphate soils (ASS) and the rock profile. The design implications of these results are then discussed.

5.2.1 Summary of outcomes

The investigations undertaken are summarised in Table 5.12 below and discussed in detail in Section 5.2.2 of this report.

Table 5.12 Summary of geotechnical investigations undertaken

Investigation	Northern route	Southern route
Desktop study	Review of relevant materials between 2007 and May 2012	Review of relevant materials in 2012 as part of this investigation
Geotechnical fieldwork	▪ Six boreholes and 9 test pits in 2009 ▪ Two boreholes in 2012 in this investigation ▪ Eight CPTs [2009]	▪ 22 boreholes in 2012 in this investigation ▪ 14 CPTs in 2012 in this investigation ▪

The results obtained from this investigation are summarised in Table 5.13 below and discussed in detail in Section 5.2.3 of this report.

Table 5.13 Summary of results

Results	Northern route	Southern route
Soft soils (The route has been categorised into three zones characterising the nature of the alluvium and described	Only Zone 1 materials encountered in the alluvial floodplain along this alignment. Material types are summarised below: ▪ CH16375 to CH17600: Up 2.7 m of alluvial stiff sandy clay ▪ CH17920 to CH18200: 2.5 m of very stiff alluvial sandy clay ▪ CH18480 to CH18840: Firm alluvium to a maximum depth of	The route has been categorised into three zones describing the extent of soft soils. ▪ Zone 1: Firm to hard clay overlying sandy/gravelly layers ▪ Zone 2: Soft clay layers within the alluvial profile up to a depth of 3m ▪ Zone 3: Soft clay layers within the alluvial profile up to a depth of 6m The extent of these zones is shown in

Results	Northern route	Southern route
in the sections that follow)	4.5m below ground level	Figure 5.6
Acid Sulphate Soils (ASS)	No acid sulphate soils were identified in previous investigations or in the additional boreholes in this investigation.	44 tests were undertaken. The results indicate that an acid sulphate soil management plan and treatment will be required in the region of the following boreholes: ▪ B19 ▪ B19 ▪ B9 ▪ B9 ▪ B23
Depth to rock	Results indicate that the weathered rock surface varies between approximately 5 metres and 9 metres below ground level.	Preliminary results indicate depth to rock varies between approximately 8 metres and 13 metres. A dyke has been identified at the South Berry Interchange.

The design implications of these results are summarised in Table 5.14 below.

Table 5.14 Summary of design implications

Results	Northern route	Southern route
Foundations	▪ Bridge foundations estimated to comprise bored piles socketed into rock below depths of 7 metres to 10 metres.	▪ Berry South Interchange: Presence of a dyke could have significant impact on bridge substructure. Interchange will need to be located to avoid dyke. If dyke can be avoided, piles can be founded below a depth of 6.5m. ▪ Railway Bridge: Piles estimated to be founded below a depth of approximately 13m. ▪ Flood plain: Piles estimated to below a depth of approximately 10m. ▪ Berry North Interchange: estimated that structures could be founded on shallow footings at approximately 2m depth
Embankments	▪ Zone 1 materials only encountered. ▪ Potential for differential settlement due to the nature of alluvial soils. Mitigation measures would be required in selected areas such as bridge abutments and in poorer soils. ▪ Options include removal of unsuitable fill and replacement with an engineered fill or preloading the embankments.	▪ Zone 1 materials to be treated as for Northern route. ▪ Ground improvement will be required for Zone 2 and Zone 3 soils. ▪ Current design assumes stone columns to a depth of 4m in the Zone 2 soils and 8m in the Zone 3 soils.

Results	Northern route	Southern route
Earthworks	▪ Excavation of extremely- to highly-weathered Berry Siltstone anticipated to be feasible using conventional earthmoving machinery. The use of this material for general fill would require further testing of its suitability. ▪ Excavation in the moderately weathered to fresh sandstone and siltstone anticipated to require hard ripping machinery or rock hammers. The excavated materials in this area should be suitable for use as general fill.	▪ Unsuitable materials expected in the floodplain. ▪ Material from Toolijooa cut expected to be suitable for subbase embankment fill when stabilised. ▪ Blasting expected to be required at Toolijooa cut.

The investigations carried out at present can be regarded as appropriate for cost estimating purposes, but not for detailed engineering design purposes. The design calculations that have been carried out, in particular in relation to embankment stability and settlement are not detailed calculations, but provide approximate solutions for costing purposes.

5.2.2 Investigations

5.2.2.1 Referenced Information

Desktop investigations were carried out to review and assess information available from previous investigations. Documents reviewed are listed in Table 5.15.

Table 5.15 Documentation reviewed in investigation

Document	Produced by and year of publication
Concept Design Report – Foxground and Berry Bypass Appendix A – Geotechnical Report	AECOM (2011)
"Geotechnical Factual Report for Preferred Option - Gerringong to Bomaderry Princes Highway Upgrade", Report No: GEOTWOLL02580AE-BD.	Coffey Geotechnics, (2010)
"Geotechnical Interpretive Report for Preferred Option - Gerringong to Bomaderry Princes Highway Upgrade", Report No: GEOTWOLL02580AE-BL.	Coffey Geotechnics, (2010)
"Preliminary Geotechnical Report - Gerringong to Bomaderry Princes Highway Upgrade".	Coffey Geotechnics, (2007)
"Additional Geotechnical Investigation – Factual Report", Princes Highway Upgrade – Gerringong to Bomaderry, Report No: 087622122.	Golder Associates Pty Ltd, (2008)
"Geotechnical Interpretive Report - Gerringong to Bomaderry Princes Highway Upgrade", Report No: DEV06/04-GE-MA.	Maunsell AECOM, (2009)

5.2.2.2 Topography

The Broughton Creek flood plain and tributary valley floor areas occupy a large portion of the proposed bypass route. Broughton Creek is the dominant watercourse in this area extending back to the escarpment slopes to the north and northeast in the areas of Broughton, Broughton Vale and Bundewallah, and Jaspers Brush and Meroo Meadow areas to the south and southeast of Berry. Broughton Creek flows across a broad floodplain in a southerly direction, flowing into the Shoalhaven River about 5km west of Shoalhaven Heads. The floodplain generally undulates between 4mRL and 7mRL.

The floodplain is bounded by two areas of higher ground at the location of the proposed northern interchange (CH14700 to CH15700, 41.4m AHD) and southern interchange (CH20000 to CH20400, 25m AHD).

The route traverses mainly open farmland, and crosses the Broughton Creek at CH16800; and the South Coast Railway at CH19000. Over the flood plain the alignment is to the south of the South Coast Railway, which hugs the edge of the floodplain.

5.2.2.3 Field investigations

Fieldwork was originally carried out for the northern route and the results of those investigations are documented in the reports listed in Table 5.12. Field investigations have now also been carried out for the southern route. Field investigations carried out for the southern route include 22 boreholes and 14 CPTs. In addition, two boreholes were drilled along the northern route to provide further information in the floodplain area to the north east of the alignment. Boreholes and CPTs were located to provide appropriate coverage of the various soil units anticipated, with some access limitations.

Boreholes

A total of 24 boreholes were completed as shown on Figure 5.1. The boreholes are distributed throughout the study area and not limited to locations on the current route alignments. Twenty two boreholes area were located in the area to the south of Berry and two boreholes were located to the north of Berry.

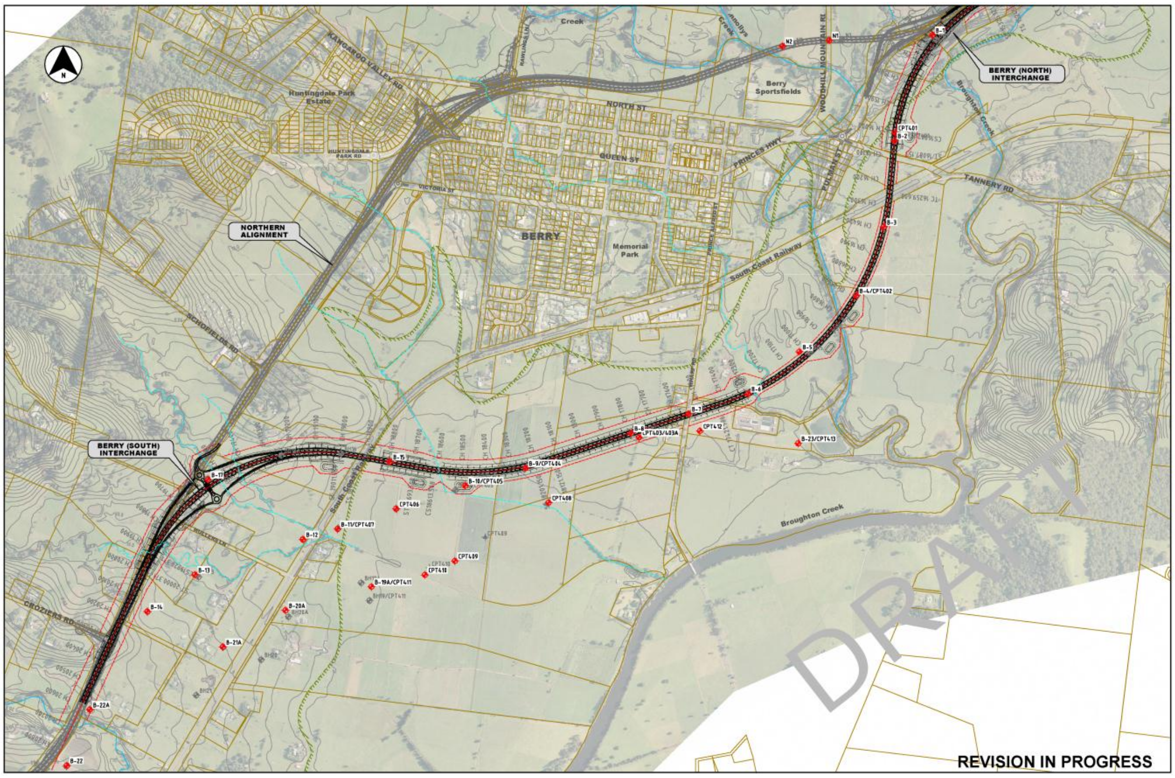


Figure 5.1 Exploratory hole location plan

Cone penetrometer testing

A total of 14 CPTs were completed in this investigation. The locations of these are shown on Figure 5.1, with more detailed maps given in Appendix D1.

Laboratory testing

Laboratory testing has been undertaken and a factual report has been prepared.

The Factual Geotechnical Report (ref D/00386/C/P1) is presented in Appendix D2.

5.2.2.4 General description of field investigation techniques

Borehole drilling

Boreholes provide undisturbed samples of solid, fractured or weathered rock formations. This allows properties such as the load bearing capacity, hydraulic conductivity, porosity and mineral or chemical content of the rock sample to be assessed. These rock properties have important implications for the design and construction methods through an area.

Borehole samples are obtained through coring. Coring is usually undertaken with truck- or track-mounted drilling rigs, as shown in Figure 5.2. A continuous rock core sample is obtained using a diamond-tipped core barrel, usually 50mm internal diameter for conventional investigations. This technique provides a generally reliable method of investigation when full core recovery is achieved. Full core recovery is not always possible in very weak rocks and granular soils.

Figure 5.2 Example of process to obtain boreholes

A core tube is used to retrieve the core samples. Once the core tube is removed from the hole, the core sample is then removed from the core tube and catalogued, as shown in Figure 5.3. The core is washed, measured, broken into smaller pieces using a hammer and placed into sample trays for analysis.

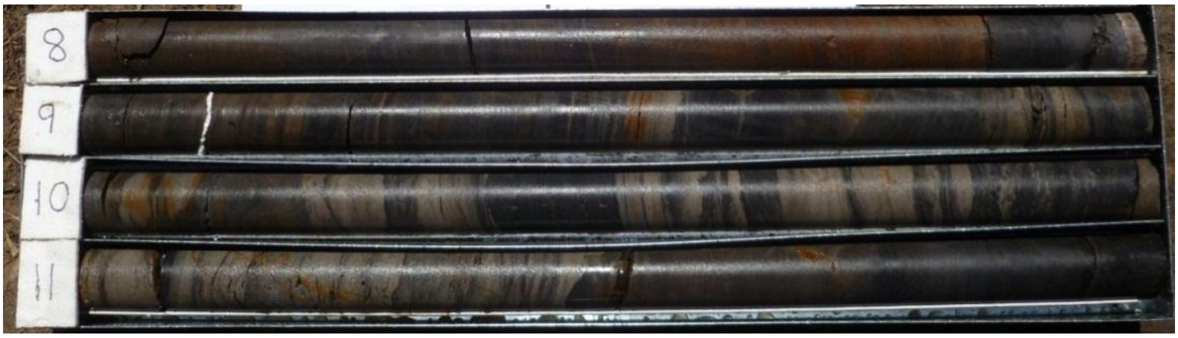


Figure 5.3 Example of bore samples

Borehole testing provides a sample of the soil to be extracted and further analysed. The analysis will demonstrate the composition of the subsurface, showing the presence and depth of different types of soil types such as top soil, soft soils, clays and hard rock. In addition, borehole testing will reveal the presence of soft soils, and whether they include acid sulphate soils.

Cone penetration testing

The cone penetration test (CPT) is carried out using an electrical friction cone penetrometer. The purpose of this test is to determine the geotechnical engineering properties of soils and the nature of the soil layering (stratigraphy) in the floodplain.

In the test, a 35 mm diameter rod with a cone-tipped end is pushed continuously into the soil. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck. As penetration proceeds, the transducers measure the geotechnical properties including the end bearing resistance and the friction resistance and transmit these measurements back to the control truck.

Penetration occurs at a rate of approximately 20 mm per second. Measurements are plotted and stored for further analysis. Figure 5.4 gives an example of the data presented from the CPT.

CPT testing provides a continuous profile of engineering properties of the soil at the test location from the surface to the ultimate test depth. These properties can be used to estimate geotechnical behaviour of the surrounding area during and following construction, such as the settlement of foundations.

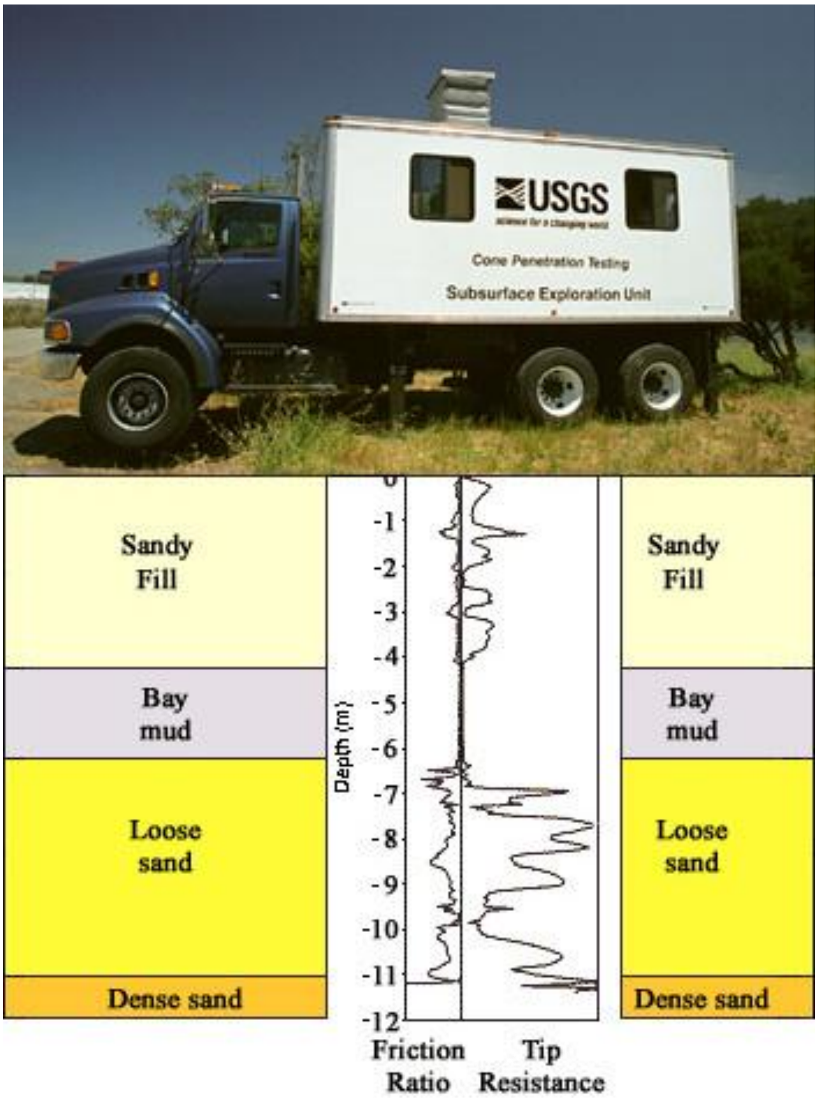


Figure 5.4 CPT example of result

5.2.2.5 Local geology

Except for the southern and northern interchanges, the southern route is constructed over the Broughton Creek floodplain. The floodplain comprises Quaternary undifferentiated floodplain and Pleistocene terrace deposits, and Berry siltstone.

The alluvial soils are generally described as soft to very stiff clays, silty clays and sands, with some hard zones, brown-grey, often mottled.

The residual soils are generally described as very stiff to hard clays and extremely weathered rock developed in units associated with the underlying rock.

Berry siltstone is generally described as a dark grey siltstone and fine sandstone with interbedded shale. Faults, shear zones and other structural defects have been encountered in Berry siltstone during previous ground investigations.

5.2.3 Results

The results obtained from the investigations provide information about the presence and extent of soft soils, the presence and extent of acid sulphate soils (ASS), and the rock profile.

The results of the field investigations are presented in the Factual Geotechnical Report in Appendix D2.

5.2.3.1 Ground conditions

The borehole and CPT test results have been used to characterise the materials and stratigraphy in the Broughton Creek floodplain. A simplified geological long section is presented in Figure 5.5 below, and a summary table of the ground conditions encountered is summarised in Table 5.16.

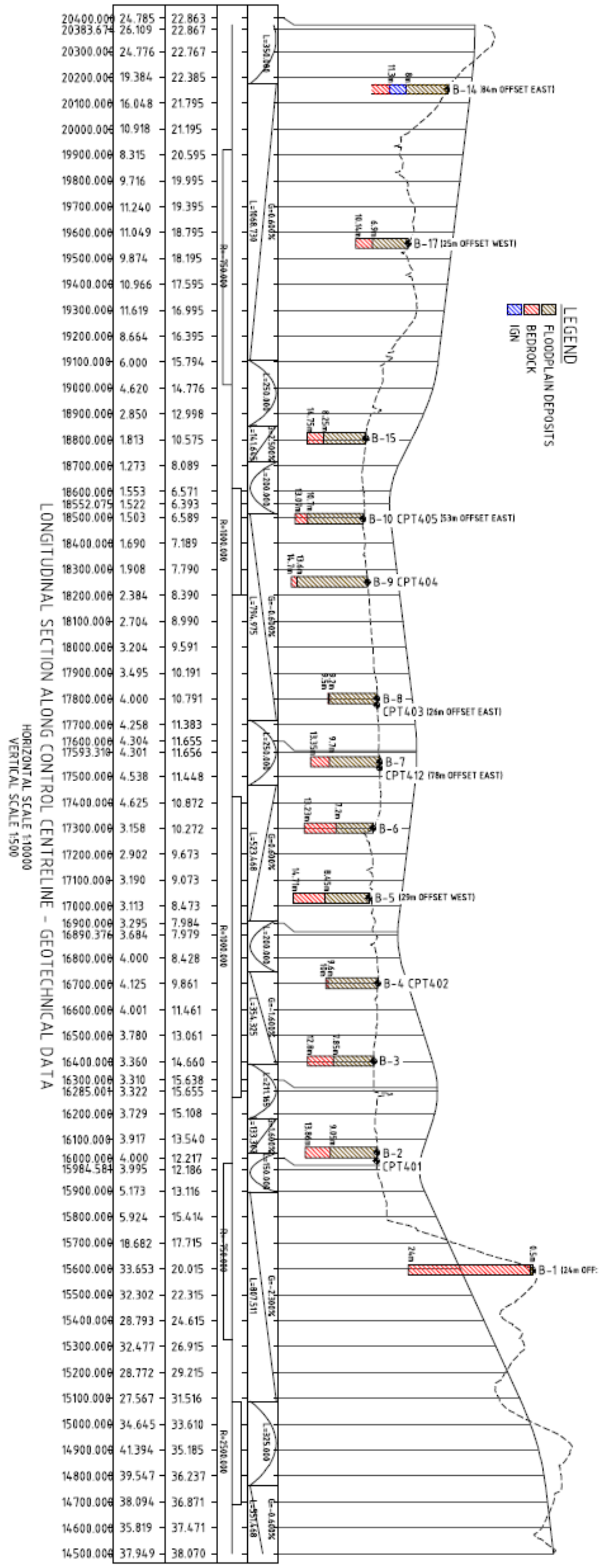


Figure 5.5 Simplified geological long section of southern alignment

Table 5.16 Summary of the ground conditions encountered along the southern route

Unit	Strata	Description	Thickness Range (m)
1	Floodplain deposits	Medium dense to dense sand/gravel and soft to stiff clays	8m to 13m
3	Residual soils	Very stiff to hard clays	0 to 1m
4	Berry siltstone	Siltstone and fine sandstone with interbedded shale	Not proved

The alluvial soils are generally underlain by Berry Siltstone at a depth of 8m to 13m, generally medium to high strength close to the rock head.

At the southern and northern ends of the alignment the floodplain gives way to an undulating landscape with depth to rock reducing to 6.5m at the southern end and approximately 2m at the northern end.

A dolerite dyke has been identified at borehole B14, south of the currently proposed southern interchange.

5.2.3.2 Acid sulphate soils

Northern route

No acid sulphate soils have been identified in the northern route.

Southern route

Test results indicate that a management plan will be required in the vicinity of BH9, BH19, and BH23. BH9 is on the alignment and BH19 and BH23 are to the south. The locations of these materials are in line with the published data.

The results of the acid sulphate soil laboratory analysis are presented in the Factual Geotechnical Report. Table 5.17 below is a summary of results exceeding the action criteria trigger value adopted in the Acid Sulphate Soil Management Advisory Committee (ASSMAC) manual[8].

Table 5.17 Southern route risks of ASS

Borehole	Depth (m)
B19	0.5 – 0.95
B19	2.5 – 2.95
B9	0.5 – 0.95
B9	1.5 – 1.95
B23	1.5 – 1.95

5.2.4 Geological interpretation

The following sections detail the interpreted ground conditions relative to the proposed alignments and geotechnical structures.

5.2.4.1 Alluvial floodplain

Soft soil zones

The area has then been delineated into three zones in terms of the depth of soft soils. These are described below:

Zone 1

- Including: BH1 to BH11, BH14, BH15, BH19, BH20A, BH21A, BH22, BH22A, BH23, N1, N2 and CPT401 to CPT405, CPT407, and CPT412.

Based on the currently available information, borehole B3 is the critical section in this zone for settlement and stability analysis. The profile at this borehole has therefore been adopted for preliminary settlement and stability assessments in this zone. A summarised profile at this borehole is presented in Table 5.18 below.

Table 5.18 Simplified preliminary ground model for Zone 1

Unit	Description	Thickness (m)
2	Firm to Stiff Clay	4
4	M. Dense to Dense sand/gravel	4
5	Bedrock	-

Zone 2

- Including: BH12, BH13, BH17, CPT406, CPT408, CPT410, and CPT411.

Tracings from CPT406 and 410 have been used establish the soil profile for this zone, with up to 3m of very soft, normally consolidated clay overlying up to 10m of firm to stiff clay. A summarised profile for this zone is presented in Table 5.19 below.

Table 5.19 Simplified preliminary ground model for Zone 2

Unit	Description	Thickness (m)
1	V. Soft to Soft Soil	3
2	Firm to Stiff Clay	10
5	Bedrock	-

Zone 3

- Including: CPT409.

Tracings from CPT409 have been used establish the soil profile for this zone, with up to 6m of very soft to soft, normally consolidated clay overlying up to 9m of firm to stiff clay. A summarised profile for this zone is presented in Table 5.20 below.

Table 5.20 Simplified preliminary ground model for Zone 3

Unit	Description	Thickness (m)
1	V. Soft to Soft Soil	6
2	Firm to Stiff Clay	9
5	Bedrock	-

5.2.4.2 Distribution of soft soils

The distribution of soft soils for the northern and southern routes is compared in Table 5.21.

Table 5.21 Soft soil description

Route	Soft Soils
Northern	Only Zone 1 materials were encountered in the northern route as shown in Figure 5.6. Table 5.18 summarises the characteristics of Zone 1 materials.
Southern	The route has been categorized into three zones as indicated below in Figure 5.6 based on the ground conditions observed in the boreholes and CPTs. It can be seen from the figure that the alignment is sensitive to the potential of encountering soft soils, with increasing risk of encountering soft soils as the alignment is moved south towards Broughton Creek. Zone 1, 2, and 3 materials can occur along this alignment depending on the final location (Table 5.22). The distribution of these materials is provided in Table 5.22.

The locations of the zones of soft soils are shown in Figure 5.6.

Figure 5.6 Zoned distribution of soft soils along southern route

The chainage boundaries for the locations of the soft soil zones for the southern route are summarised in Table 5.22 below.

Table 5.22 Distribution and general description of alluvial soils along southern route

Chainage	Summary of profile
CH16375 to CH17600	Up to 2.7 m of alluvial stiff sandy clay
CH17920 to CH18200	2.5 m of very stiff alluvial sandy clay
CH18480 to CH18840	Firm alluvium to 4.5 m bgl maximum depth

5.2.4.3 Bedrock

Bedrock largely comprises Berry Siltstone, and was encountered along the northern and southern routes as shown in Table 5.23 below. A dolerite dyke was encountered in the southern route at the South Berry Interchange.

Table 5.23 Rock profile information

Route	Details
Northern	Based on the borehole data to date the ground conditions encountered indicate weathered rock surface varies between approximately 5m and 9m below ground level.
Southern	Preliminary borehole data indicates depth to rock generally ranges between 8 and 13m in Zones 1 to 3. A dolerite dyke has been identified at the South Berry Interchange. Further investigations will be required to delineate and characterise this feature to properly assess its impact on foundations. Rock occurs within 2m of the surface at the northern interchange, and within 6.5m of the surface at the southern interchange, away from the dyke.

5.2.5 Design considerations

The following sections draw on the investigations undertaken as part of the concept design development for the Foxground and Berry Bypass and assessment of the information from the current investigations.

5.2.5.1 Embankments

Settlement has been assessed as a potential geotechnical issue at sections of the alignment underlain by alluvial soils where earthfill embankments are proposed. Differential settlement between the current highway formation and the proposed highway widening has also been assessed to be a potential issue.

The nature and degree of settlement of embankments constructed on the alluvial soils has been assessed on the basis on the soft soil zoning detailed in Section 5.2.4.

Northern route

Only Zone 1 materials were encountered in the northern route. However, some allowance for treatment at abutments and selected areas should be allowed for at this concept stage. For the current costing exercise an allowance of 66,000m (200m length of embankment) for wick drains and 300m length of preloading is be appropriate.

Southern route

The alluvial soils across the flood plain have been divided into three zones for treatment of settlement and stability issues. These zones are shown in Figure 5.7, Figure 5.8 and Figure 5.9 are plots showing predicted consolidation settlement against embankment height and Factor of Safety (FoS) against embankment height for the various zones. The zones are presented on the attached plan and are discussed below in Figure 5.7.

Zone 1 and Zone 2 materials occur along the alignment and, if the alignment is moved south, Zone 3 materials will be encountered as well.

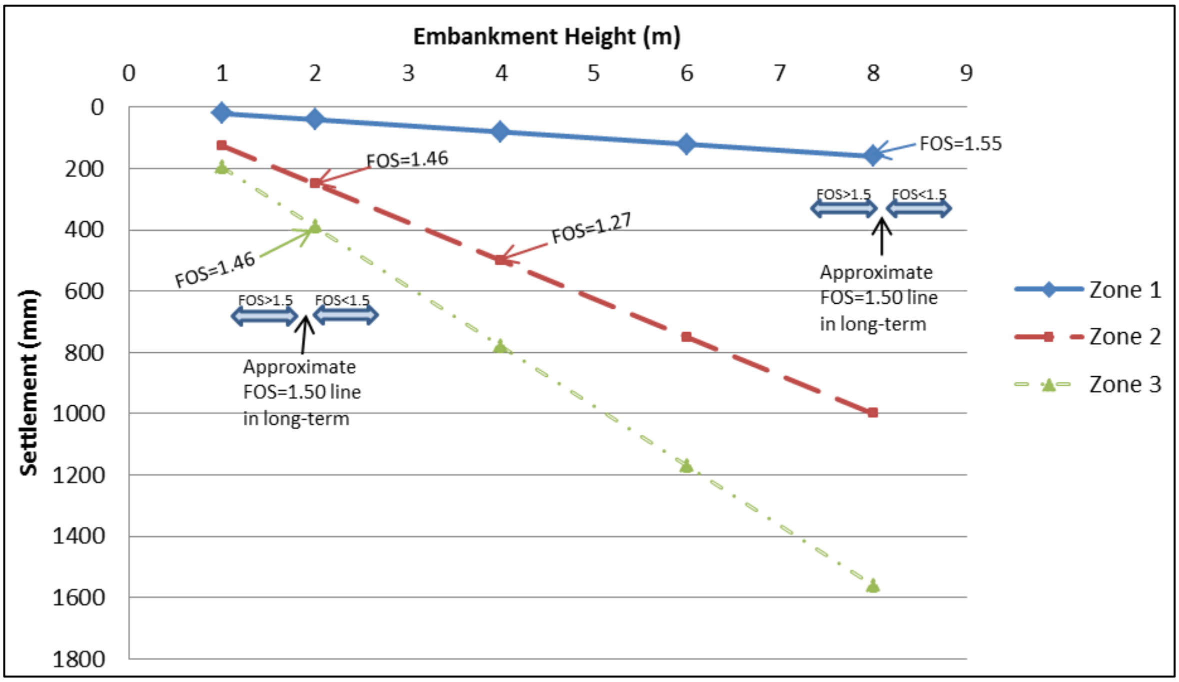


Figure 5.7 Preliminary predicted settlement values

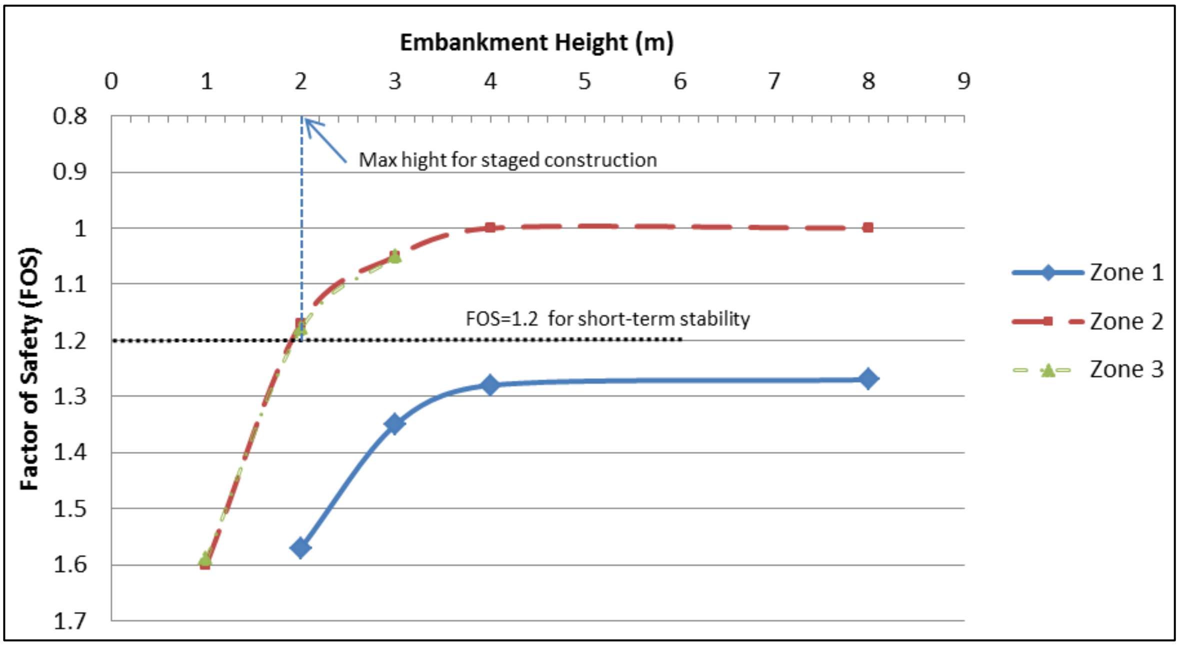


Figure 5.8 Preliminary Factor of Safety values for short term loading

Table 5.24 Southern route details of geotechnical zones

Zone	Relevant geotechnical information	Implications of results
Zone 1	▪ Generally limited depth of soft soil. Settlements can be expected to be less than 200mm. No soil improvement required.	▪ Embankments constructed over these soils can be expected to have long term factors of safety in excess of 1.5 in the long term and short term construction factors of safety in excess of 1.25. ▪ Piezometric pressures in the foundation soils must be allowed to dissipate adequately to maintain stability. A maximum lift of 2m for each stage has been assumed. No dissipation times have been estimated, but this can be expected to vary from 3 to 6 months depending on the fines content of the soil and the presence of drainage layer in the profile.
Zone 2	▪ Maximum depth of soft soil 3m.	▪ Embankments in this zone can be expected to undergo consolidation settlements in the order of 0.2m to 1.0m for embankment heights varying from 2m to 8m respectively. ▪ Long term factors of safety for embankments higher than 2m will be less than 1.5 and will require ground treatment.
Zone 3	▪ Maximum depth of soft soil 6m.	▪ Embankments in this zone can be expected to undergo consolidation settlements in the order of 0.2m to 1.5m for embankment heights varying from 2m to 8m respectively. ▪ Long term factors of safety for embankments higher than 2m will be less than 1.5 and will require ground treatment.

Some general comments regarding the above figures and Table 5.24 is provided below:

- Factors of safety for Zone 2 and Zone 3 embankments are essentially the same as the failure plane generally passes within the upper 3m of the soft soil unit;
- Factors of safety for embankment heights greater than 4m are generally the same, as the crest of the failure plane passes through the slope batter rather than the top of formation;
- Factors of safety depend on piezometric pressure dissipation. For all embankments, including embankments less than 2m in height, piezometric pressures must be allowed to dissipate. This may slow embankment construction and could have cost and program impacts;
- Settlement and lateral ground movements at bridge abutments need to be monitored to ensure that piles are installed only after these soil movements due to embankment construction have taken place. Bridge abutments are located in Zone 1 areas for the current proposal and substantial lateral soil movements are not anticipated;
- The settlement estimates allow for consolidation settlement only. An allowance of 20mm to 100mm should be made for elastic settlement;
- The above analyses are based on limited data and therefore no detailed assessment has been made of individual test results.

Ground treatment – southern alignment

- A number of ground treatment options are available. For this costing exercise stone columns have been adopted as they are a well-established technology, widely used and generally competitively priced.
- The stone columns need to be taken down to an adequate foundation to ensure that they do not punch through their foundations. For this preliminary exercise it can be assumed stone columns will be constructed to a depth of 4m in the Zone 2 soils and 8m in the Zone 3 soils.
- The diameter of the stone columns can vary depending on the column spacing, embankment height and the soil shear strength required. For simplicity the amount of improvement required has been calculated as an area of column per m^2 of plan area supporting the embankment. For 8m embankments the requirement is $0.3m^2$ columns per m^2 of soil and for 4m embankments the requirement is $0.13m^2/m^2$ for both Zone 2 and Zone 3 soils.
- It is recommended that an allowance be made for preloading the abutments for the railway crossing and the viaduct. It should be noted that monitoring of the railway and retamping of the track may be required if settlements are excessive. Allowance should be made for retamping. The allowance for preloading of 800m of embankment is appropriate in view of the greater extent of floodplain crossing for this option and the identified presence of soft soils on and near the alignment.
- The requirement for soil improvement at the southern interchange and preloading at the rail bridge and viaduct, will add complexity to the bridge construction, as any lateral soil movements will need to be dissipated before construction of the bridge piles at each of the three bridges can commence. This may lead to inefficiencies in construction programming, as the construction teams for the bridges may need to be mobilised separately for each bridge.
- A number of alignments have been put forward for the southern suggestion. Until the alignment is finalised, it is difficult to provide accurate information regarding founding conditions for embankments. However, the investigations do indicate that the further south this alignment is taken, the higher the risk of encountering soft soils and the more adverse the ground conditions.

5.2.5.2 Cuts

Rock Anchors

In general both alignments have been designed with relatively flat batters to allow reasonable land take and for urban design and maintenance considerations. Cuts should also be benched at approximately 7m height intervals for maintenance and safety. Hence for the batters adopted, a nominal allowance of 1 anchor per $1000m^2$ will suffice for both the northern route and the southern route. For the southern suggestion, an additional 5m cut is required at Toolijooa. Blasting will be required to extract this material, and hence due to the potential for localised fracturing of the rock or opening of joints resulting from blasting, an allowance of 1 anchor per $100m^2$ is recommended for the additional depth of cut.

Depth of cut at Toolijooa

Groundwater levels have been monitored a part of the geotechnical investigations at the Toolijooa cut by RMS. Geological cross sections and long section are shown in Figure 5.9 to Figure 5.13 (excerpt from RMS report ref D/00386/C/P/1) below. Monitored groundwater levels vary between 0.15m to 9m below ground level, with an average of 4m to 6m below ground level.

Groundwater flows are expected into the cuts from depths of 1m to 3m during wet weather. Surface drainage measures would be required to dispose of this water. In addition, a drainage blanket would be provided at the base of the cut to ensure the proper long term performance of the pavement.

These measures would locally reduce groundwater levels in the vicinity of the cut. A deeper cut can locally reduce groundwater levels further where groundwater flows through vertical joints

Materials

Cut material won from the extra 5m of cut at Toolijooa, is generally not suitable for use as pavement construction material on its own. However, when stabilised, the material may be suitable for use as subbase or in the select material zone (SMZ). The value of using this material in the subbase needs to be weighed against the higher cost of excavation, crushing, stockpiling and stabilisation.

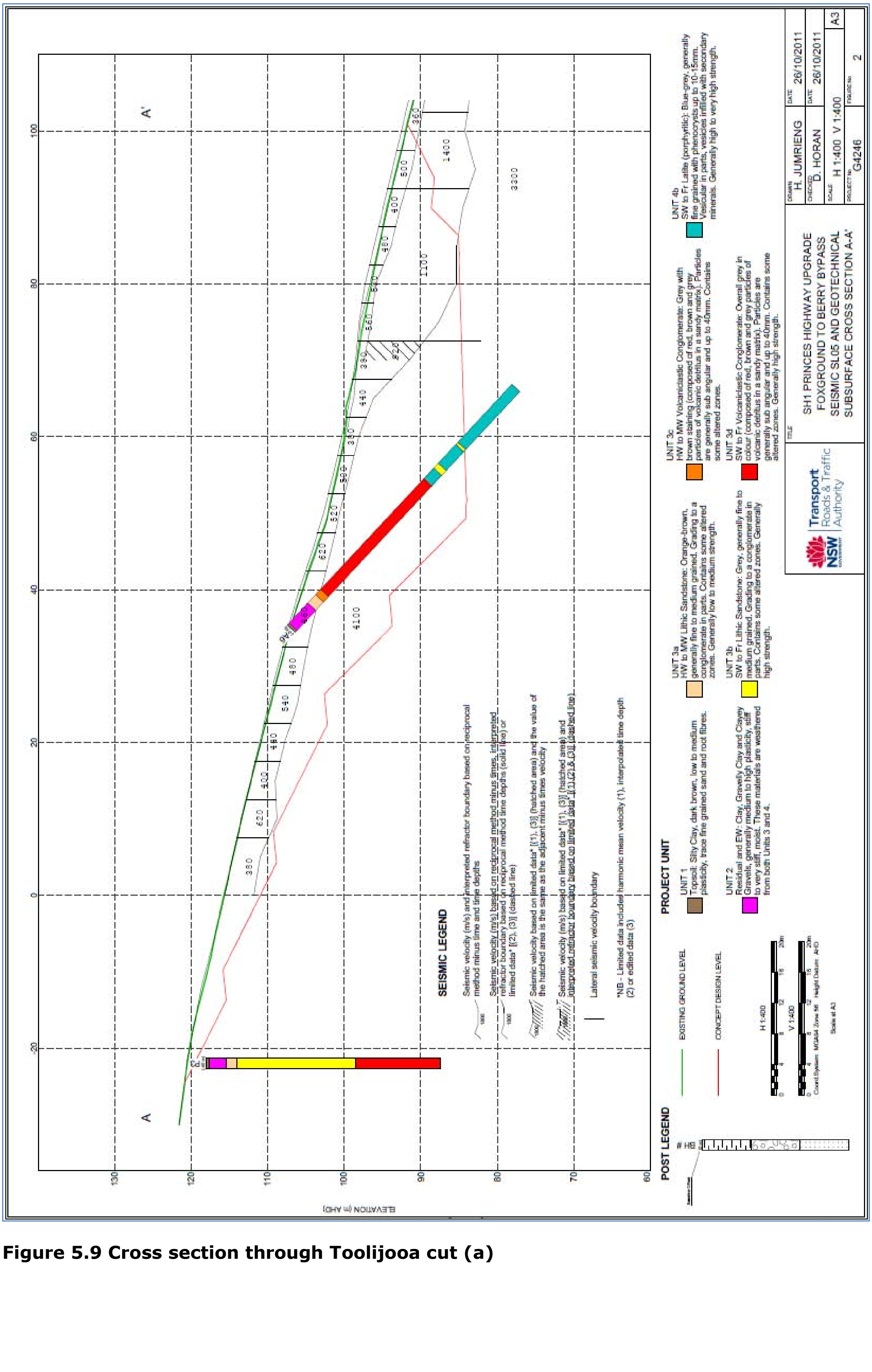


Figure 5.9 Cross section through Toolijooa cut (a)

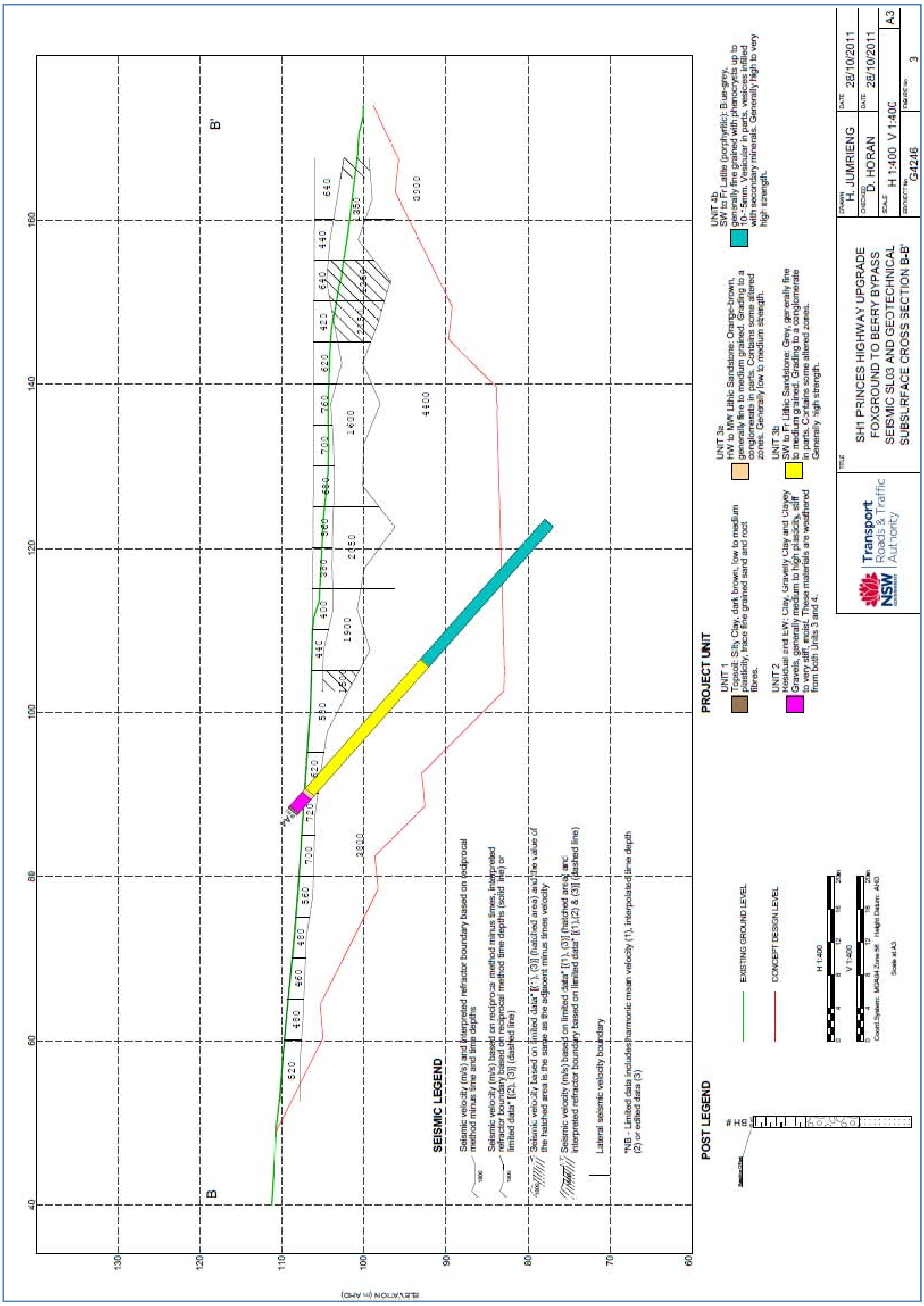


Figure 5.10 Cross section through Toolijooa cut (b)

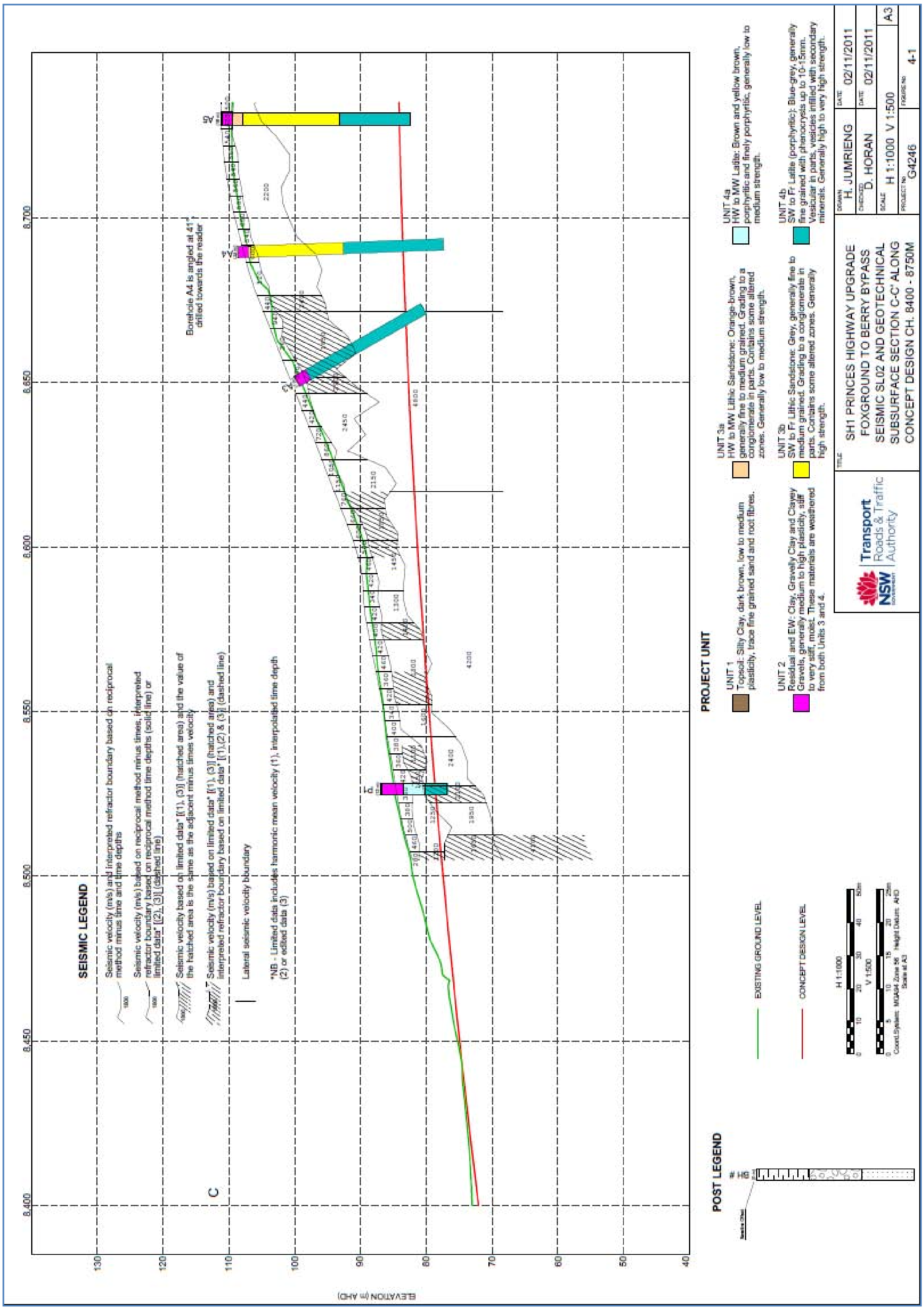


Figure 5.11 Long section through Toolijooa cut (a)

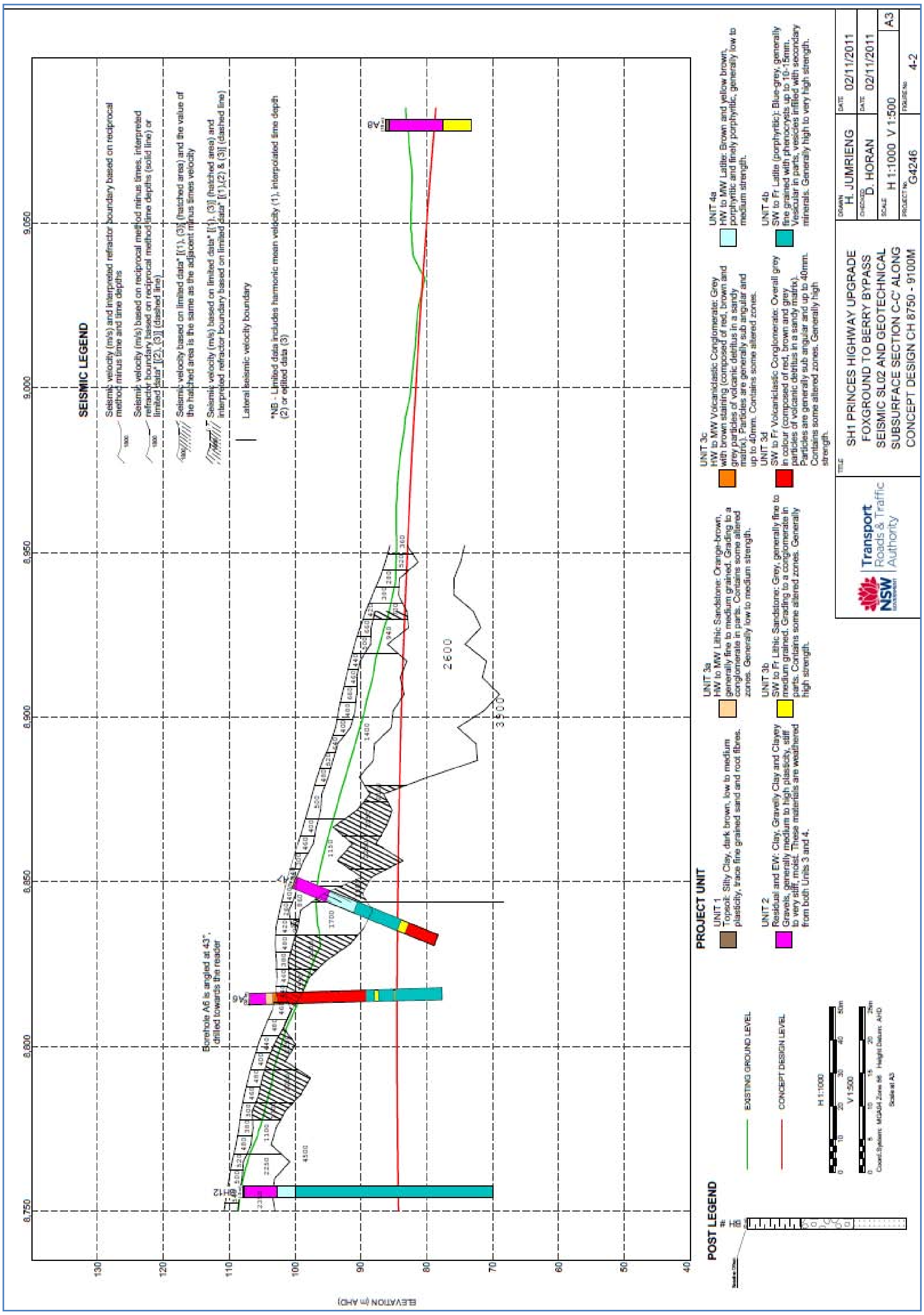


Figure 5.12 Long section through Toolijooa cut (b)

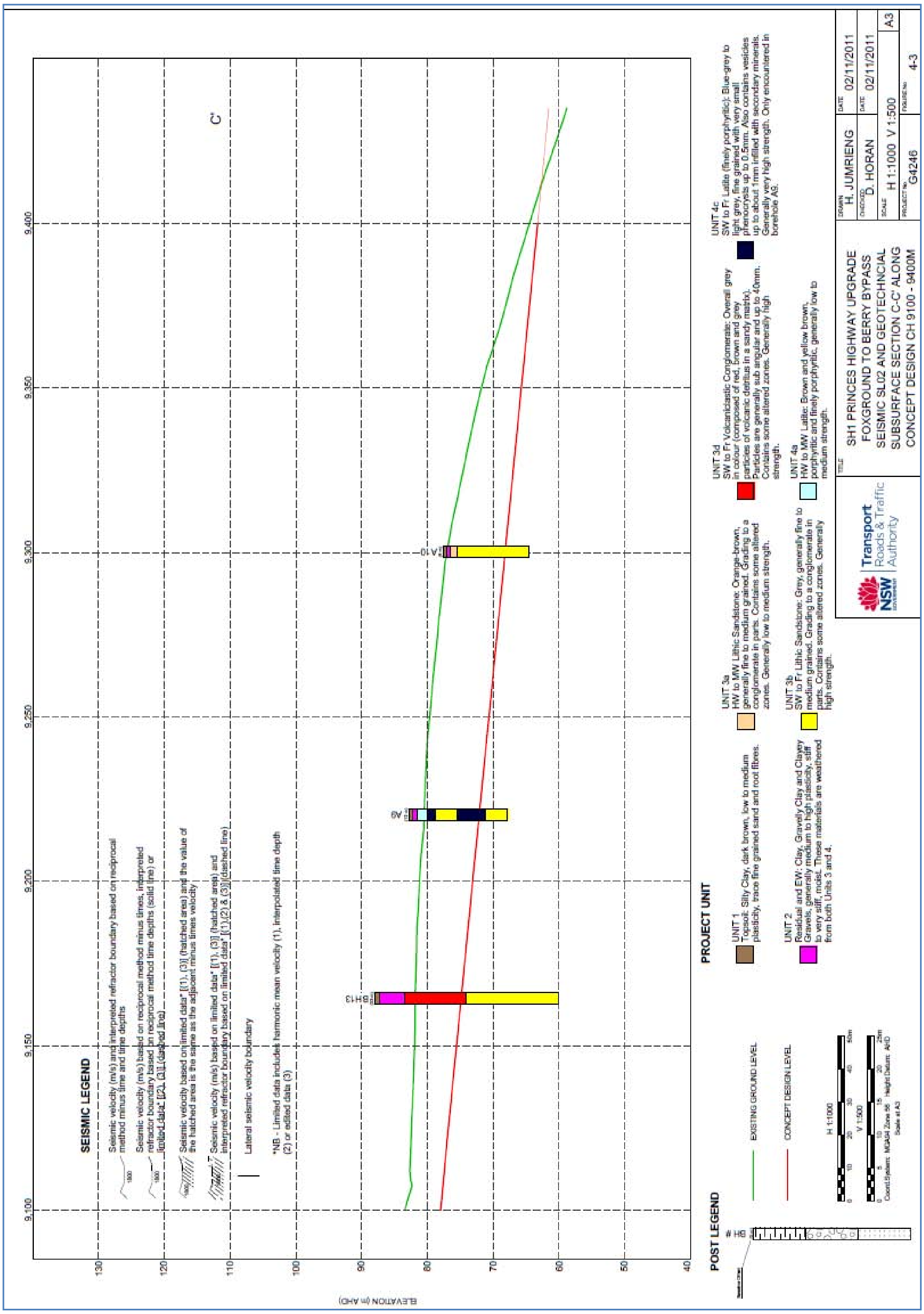


Figure 5.13 Long section through Toolijooa cut (c)

5.2.5.3 Acid sulphate soils

In order to assess the significance of the acid sulphate soil potential, the laboratory results are compared with action criteria in the *Acid Sulfate Soil Management Advisory Committee (ASSMAC) Manual 8.*

The ASSMAC action criteria trigger the need to prepare a management plan and obtain development consent. The action criteria are based on oxidisable sulphur concentrations for three differing soil textures. The manual provides different action levels depending on the quantity of acid sulphate soils that is to be disturbed. Based on the proposed works, the volume of acid sulphate soils to be disturbed would be greater than 1000 tonnes.

Northern route

In line with published information, no acid sulphate soils have been identified in the northern route, including at the new boreholes N1 and N2. However, as a precautionary approach at this concept stage allow for treatment of 1000m^3 of material.

Southern route

Test results indicate that a management plan would be required in the vicinity of BH9, BH19, and BH23. BH9 is on the alignment and BH19 and BH23 are to the south. The locations of these materials are in line with the published data. There is the possibility that this material extends into the Zone 2 area which requires soil improvement. Hence allow for treatment of 20,000m^3 of material. In line with the precautionary approach taken for the northern route an additional amount of 5,000m^3 should be allowed for, particularly as the published data indicates that there is a higher probability of intersecting these materials on the southern suggestion. Hence a total of 25,000m^3 should be allowed for. The further south the alignment is taken, the higher the risk of encountering acid sulphate soils.

5.2.5.4 Structure foundations

The results of the geotechnical fieldwork indicate that in general piled foundations would be required for the bridge structures. The exception to this is at Berry North interchange where shallow foundations are anticipated to be appropriate. This is described in Table 5.25.

Table 5.25 Southern route structure foundations

Location	Relevant boreholes	Implications of results
Berry (South) Interchange	Boreholes B14/B13	The bridge foundation requirements are sensitive to the location of the interchange. A number of locations have been assessed and two of these are discussed below. At B14 extremely weathered, extremely low strength rock was encountered at a depth of approximately 8m. The drilling intersected a possible dolerite dyke at this depth; siltstone is identified from a depth of approximately 10.5m. The siltstone is highly fractured, with a highly altered contact zone at the dyke. Away from the dyke (B13), medium to high strength siltstone can be anticipated from a depth of approximately 8m. The presence of the dyke presents a substantial cost risk for the bridge substructure, as piling depths will need to be increased due to the highly fractured nature of the rock at the contact. It is possible that foundations will need to be amended after detailed design to accommodate poorer ground conditions in the

Location	Relevant boreholes	Implications of results
	B17	vicinity of the dyke. Further detailed investigations will be required at this bridge location to locate and accommodate the dyke in the bridge design. This interchange has subsequently been moved north. The new location is in the vicinity of borehole B17. At this location rock occurs at a depth of 6.5m and piles will be socketed into the rock below this depth.
Railway Bridge	Borehole B12	The borehole log indicates the presence of siltstone rock at a depth of approximately 10.7m. Piles would be founded in the medium to high strength rock identified below a depth of approximately 13m.
Flood plain	Boreholes B3, B4, B5, B6	Siltstone is generally encountered from a depth of 7.5m to 10m. Piles are likely to be founded on the high strength rock below a depth of approximately 10m.
Berry North Interchange	Borehole B1	Medium to high strength sandstone was encountered from a depth of 2m, and the bridge structures could be founded at this level.

5.2.5.5 Risks

The geotechnical risks associated with the northern and southern routes are discussed in Table 5.26.

Table 5.26 Southern route geotechnical risks

Content	Risks – Northern alignment	Risks – Southern Alignment
Bridge foundations	▪ Depth to rock deeper than anticipated	▪ Depth to rock deeper than anticipated ▪ The requirement for soil improvement at the southern interchange and preloading at the rail bridge and viaduct, will add complexity to the bridge construction, as any lateral soil movements will need to be dissipated before construction of the bridge piles at each of the three bridges can commence. This may lead to inefficiencies in construction programming, as the construction teams for the bridges may need to be mobilised separately for each bridge. ▪ The direction and persistence of the dyke identified at borehole B14 is not known and may lead to substantially increased foundation costs if foundations need to be modified to accommodate this feature.
Embankments	▪ Soft soils requiring ground treatment	▪ Soft soils requiring ground treatment. This is a substantially greater risk for the southern route due to the greater length of alignment in the flood plain, the identification of soft soils along the alignment and its proximity to Broughton Creek. ▪ Program and cost delays due to

Content	Risks – Northern alignment	Risks – Southern Alignment
		embankment stability issues related piezometric pressure dissipation.
Additional depth of cutting at Toolijooa	▪ Not required	▪ Additional support required at base of deeper cutting. This risk can be offset by the possibility of using the material as subbase after stabilisation.
PASS/ASS	▪ Not identified to date	▪ Greater extent than identified to date. ▪ Acid sulphate soils map indicates greater potential risk along the southern alignment

5.2.6 Additional interpretive geotechnical report

Coffey Geotechnics consultants were engaged to provide an additional interpretive report based on the fieldwork investigations and factual report provided by RMS to compare with AECOM's findings and provide additional robustness to the technical investigations.

The Coffey report addresses the geotechnical conditions in the investigation corridor for the southern route and does not address geotechnical conditions along the northern route. The findings of the Coffey report are briefly outlined below and areas of difference with AECOM's findings are identified. The Coffey interpretive report is included in Appendix D3.

5.2.6.1 Subsurface conditions

The subsoil profile developed by Coffey to describe the subsurface conditions is similar to that characterised in this report, with scattered fill, topsoil, overlying alluvium, overlying Berry Siltstone. The major difference between the subsoil profiles developed by Coffey and AECOM is that Coffey further subdivide the alluvium into upper alluvium, alluvial clays and alluvial gravels.

5.2.6.2 Groundwater

Coffey have identified groundwater at depths ranging from 0.3m to 2.3m below ground level. They comment that groundwater levels are likely to fluctuate and that the area is prone flooding.

5.2.6.3 Soft soils and long term settlements

The Coffey and AECOM reports differ slightly in their assessment of the depth of soft soils along the southern route.

AECOM has assessed that the majority of the southern route is in Zone 1 material, with some sections of the route in areas of deeper soft soil described as Zone 2 material. The risk of encountering Zone 2 material increases to the south.

Coffey has assumed that the entire southern route would be in material similar to that described as Zone 1 material in this report. The Coffey report includes a comment that further analyses would be required in the vicinity of the rail corridor to assess the need for stabilisation of soft soils in that area.

The Coffey assessment of the risk of encountering soft soils is consistent AECOM's assessment with the risk of encountering Zone 2 material increasing to the south. The Coffey Report indicates a preference for the southern alignment to be moved as far north as possible to reduce this risk.

The conclusions reached by both consultants regarding the implications of these results for design and construction are generally consistent. Coffey's settlement calculations for construction in this material are similar to the calculations by AECOM. Coffey recommend that allowance should be made for ground improvement works given the likely settlement of soft soils. This is consistent with the recommendations in this report which identify that ground improvement would be required for construction in an area with these geotechnical conditions. The AECOM report has additionally provided the assessed length of route along which ground improvement would be required for cost estimation purposes.

5.2.6.4 Acid sulphate soils

Coffey indicate that the testing carried out to date does not constitute a comprehensive assessment of acid sulphate soils on site and that further testing would be required to check for the presence of these materials. They identify the presence of acid sulphate soils at one borehole location on the southern route and two further locations south of the base case southern route. This is consistent with the findings of the AECOM report.

Coffey do not provide recommendations on the appropriate allowances for acid sulphate soil materials. They do indicate that these areas may be present in other areas across the site. The AECOM report has recommended a limited allowance has for acid sulphate soils for cost estimation purposes.

5.3 Utility interfaces investigation

The purpose of this investigation is to identify the relevant utility interfaces for each route and assess the major design, construction and cost impacts of these interfaces.

Interfaces with utilities are a source of design and construction constraints for infrastructure projects. There may also be direct costs of dealing with the relevant utility agencies. An understanding of the impacts of utility interfaces is therefore important in preparing cost estimates for a project.

This section chapter provides the details the utility interfaces affecting the project and the allowances that have been made for these interfaces.

5.3.1 Summary of outcomes

The utility interfaces for the two routes are summarised in Table 5.27 below.

Table 5.27 Summary of major public utilities

Utility interfaces	Northern route	Southern route
RailCorp	▪ No rail crossings	▪ Allowance for two crossings of South Coast Railway ▪ Design constraints at rail crossing
Telstra fibre optic cable	▪ Allowance for unknown minor telecommunication services	▪ Allowance for the cost of four crossings of cable ▪ Allowance for unknown minor telecommunication services
Water main	▪ Allowance has been made for adjustment of service covers and valves / hydrants	▪ Allowance for water main crossing ▪ Allowance has been made for adjustment of service covers and valves / hydrants
Gas	▪ Allowance for crossing of 150mm Jemena gas line	▪ Allowance for crossing of 150mm Jemena gas line
Power	▪ Allowance for impacts on low voltage overhead power lines and poles	▪ Allowance for impacts on low voltage overhead power lines and poles
Minor infrastructure	▪ Allowance for minor infrastructure interfaces	▪ Allowance for minor infrastructure interfaces

5.3.2 Investigations

This investigation has involved the review of documentation prepared previously during project planning as well as consultation with relevant agencies.

Utility interfaces affecting the project were assessed in preparation of the Preferred Option Report (2008). This information was used to identify the relevant interfaces and assess whether there was potential for significant design or construction constraints.

These constraints were then identified through consultation with the relevant agencies.

5.3.3 Results

The locations of relevant utilities are displayed in Figure 5.14. The interface with the South Coast Railways was found to result in both cost impacts and design constraints. Other impacts were assessed to have cost impacts only.

Figure 5.14 Major public utilities

5.3.3.1 RailCorp interface

Bypass routes to the south of Berry include crossings of the South Coast Railway. The design of these crossings is subject to constraints imposed by RailCorp as detailed in Table 5.28. The documentation from RailCorp is provided in Appendix E1.

Table 5.28 Design constraints at RailCorp interface

Design Constraints
▪ Allow for future duplication (to the western side) ▪ Allow for access roads either side of the expanded tracks ▪ No provision for raising of railway for flooding required at this stage ▪ Standards / clearance envelopes to be in accordance with RailCorp Standard ESC215 ▪ Allow for electrification, (wiring not to be attached to bridge structures therefore 6.5m clearance required)

These constraints have design implications for the rail crossing at the location shown in Figure 5.14. An annotated cross-section of this crossing is provided in Figure 4.14 that illustrates the impact that the RailCorp constraints have on the design.

In addition, there is a cost involved to cover the design, approvals and coordination of the interface from RailCorp. RailCorp have indicated an indicative cost in the order of $100,000 to $150,000 which has been included in the estimate.

5.3.3.2 Other utility interfaces

The impacts of the other utility interfaces and the allowances made for these are identified in Table 5.29.

Table 5.29 Other utility interfaces

Interface	Details
Telstra fibre optic cable	There are four crossings of major Telstra fibre optic cables along the southern alignment. An allowance for the cost of four adjustments / protections of fibre optic services has been made covering permanent relocations and/or protections and temporary protection from construction activities. A further nominal cost allowance has been made for adjustment of unknown minor telecommunication services.
Water main	The water main supply to Berry crosses the southern alignment just west of the second railway crossing near Mullers Lane. A cost allowance has been made for encasement of this existing water main at that location. A further nominal cost allowance has been made for adjustment of service covers and valves / hydrants.
Gas	The 150 mm Jemena gas line crosses the upgraded highway north of Tindalls Lane. This crossing is common to both northern and southern alignments. A cost allowance has been made for protecting 150m of the Jemena gas main at this location.
Power	The high voltage, overhead 132KV electrical transmission line is not impacted by a southern alignment for the Berry bypass. A nominal cost allowance has been made for impacts on low voltage overhead power lines and poles.
Minor infrastructure interfaces	A cost allowance has been made for other minor infrastructure interfaces such as sewerage, stormwater, footpaths etc., for both alignments.

6 Construction investigations

6.1 Land acquisition

The land acquisition requirements for the northern and southern routes were investigated to provide information for the cost estimates prepared for the northern and southern routes.

The cost of land acquisition can be a significant component of the total cost of a project. RMS is responsible for the valuation of land to determine the net cost impact of acquisitions for the northern and southern routes. The same valuation principles have been applied to the northern and southern route property adjustment estimates, to achieve like-for-like outcomes.

This section outlines the RMS' land acquisition policy and describes the land acquisition valuation method for each route. The results present the net assessed land acquisition costs for the northern route and the southern route.

6.1.1 Summary of outcomes

The estimated costs of the land acquisitions for the two routes are summarised in Table 6.1.

Table 6.1 Estimated cost of required land acquisitions

Route	Net cost impact
Northern route	$22m
Southern route	$19m

6.1.2 Investigations

6.1.2.1 RMS Policy

The Roads and Maritime Services (RMS) land acquisition policy is governed by *the Land Acquisition (Just Terms Compensation) Act 1991* and the *Roads Act 1993*. The application of these acts is detailed in the *Land acquisition information guide February 2012* (available from the RMS website). These documents are summarised in Table 6.2.

Table 6.2 Documents governing RMS land acquisition

Document	Year
Land Acquisition (Just Terms Compensation) Act	1991
Roads Act	1993
Land acquisition information guide	2012

The RMS is responsible for maintaining and developing the road network in NSW. Land acquisitions are often required for RMS projects involving new or upgraded roads. Depending on the requirements for the proposed roadwork, it may be necessary to acquire the whole of a property or only part of a property. The RMS is not required to acquire more property than is necessary for the roadwork.

The RMS aims to undertake the land acquisition process in a collaborative and consultative manner to reach mutually acceptable agreements for purchases. When RMS needs to acquire property, it contacts the relevant landowners and initiates a process of consultation and negotiation. However, if agreement is not reached, the property may be acquired by compulsory acquisition. Entitlement to compensation is identical whether the property is purchased by agreement or compulsorily acquired.

The RMS recognises that planned future projects may impact on property owners. For example, some owners may experience difficulty in selling their property if part or the whole of the property is designated for future acquisition. If an owner is unsuccessful in attempting to sell this property and is experiencing some financial or personal hardship as a result of this, they can make a written application to RMS requesting acquisition under the 'hardship' provisions of the Act. Hardship acquisitions have been completed for some properties affected by the northern route since the identification of this corridor as the preferred upgrade corridor.

6.1.2.2 Design

The estimation of the costs of property adjustments was performed based on the designs for the northern and southern routes in Figure 6.1 and Figure 6.2 respectively. The design for the northern route has been developed to concept design level. The design for the southern route has been produced as a preliminary concept design during this investigation. Should the southern route be progressed for evaluation following this investigation, further design development would proceed in accordance with RMS policies and with community consultation. It is likely that this would result in change to the design, and therefore the property adjustments required.

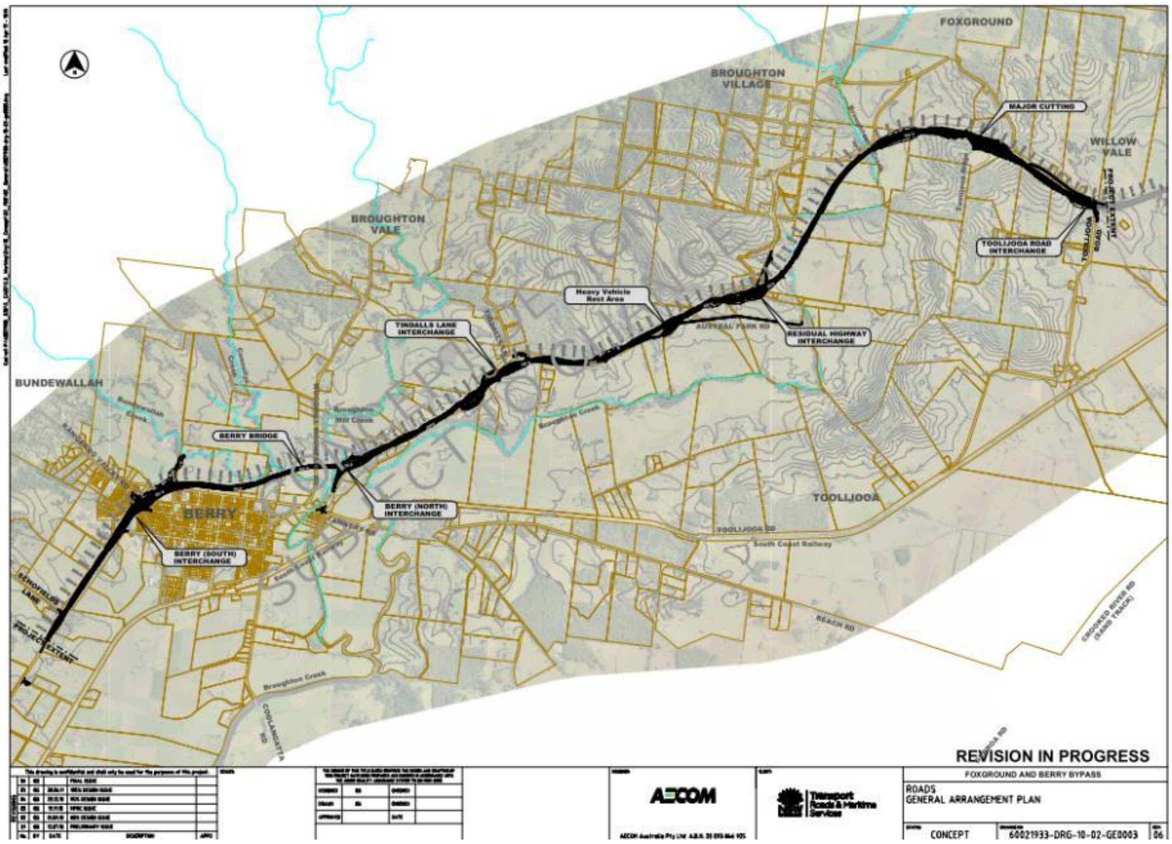


Figure 6.1 Northern route design

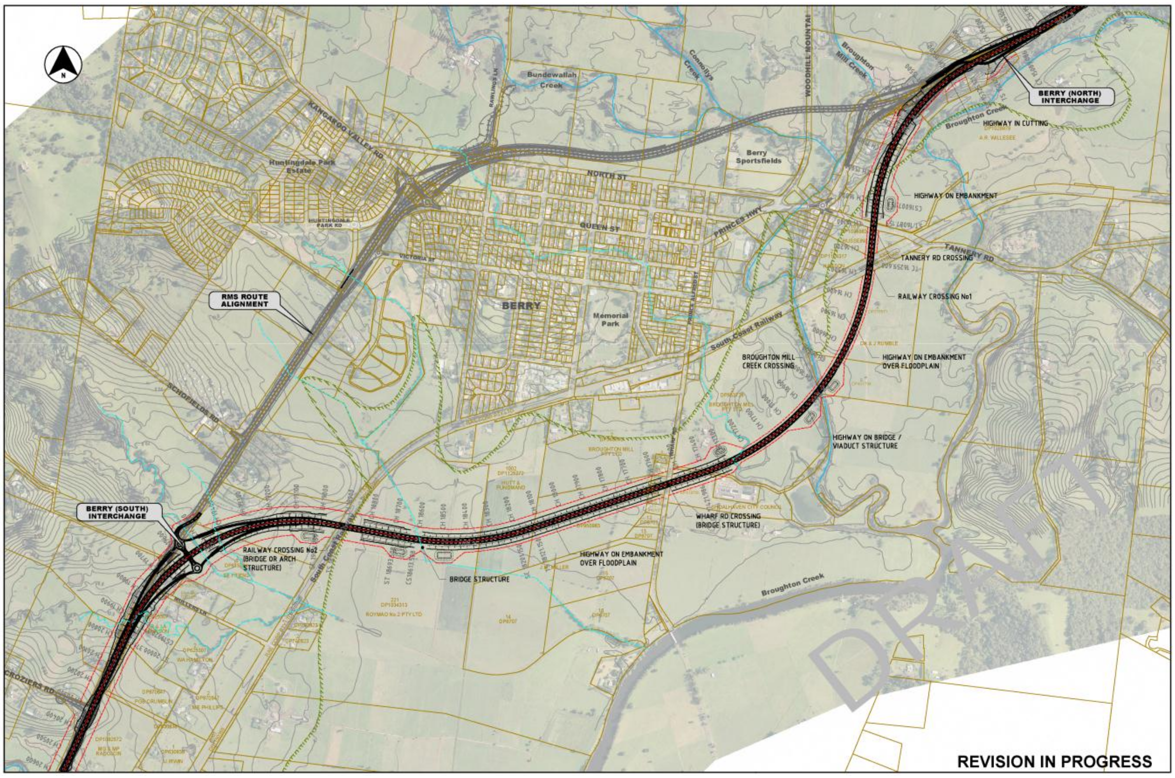


Figure 6.2 Southern route design

6.1.2.3 Valuation

The RMS performed a valuation of land acquisitions required given the northern and southern route design.

The valuation approaches for the northern route and the southern route are detailed in Table 6.3 and Table 6.4 respectively. The difference between the valuation approaches reflects that some land acquisitions have already been undertaken for the northern route whereas no land acquisitions have been undertaken for the southern route. The valuation principles are consistent for the two approaches.

Table 6.3 Land acquisition valuation method: Northern route

Quantity	Value	Details
Addition: Land acquisitions to date	Present value assessment of past purchases	Present value of the costs of all land acquisitions made by the RMS between 1961 and February 2012. The cost of these land acquisitions also includes compensation for the impact on businesses formerly conducted at the properties. A present value assessment was undertaken to bring the purchase price to today's levels.
Addition: Remaining land acquisitions	Estimate of current market value	The estimated value of the remaining land acquisitions RMS would need to make to construct the northern alignment. The cost of these land acquisitions includes estimated compensation for the impact on businesses currently conducted at the property with contingency applied for the uncertainty in

Quantity	Value	Details
		this estimate. This cost is an estimate of current market values with contingency applied for the uncertainty in this estimate.
Deduction: Resale of residual lands after project completion	Estimate of current market value	The estimated value of residual lands purchased by RMS to construct the northern alignment which would not be required following project completion and would be resold into the local real estate market at the completion of the project. This cost is an estimate of future market values with contingency applied for the uncertainty in this estimate.

Table 6.4 Land acquisition valuation method: Southern route

Southern Route	Value	Details
Addition: Land acquisitions to date	Present value assessment of past purchases.	Present value of the costs of all land acquisitions made by the RMS between 1961 and February 2012. The cost of these land acquisitions also includes compensation for the impact on businesses formerly conducted at the properties. A present value assessment was undertaken to bring the purchase price to today's value.
Addition: Land acquisitions required	Estimate of current market value	The estimated value of the land acquisitions RMS would need to make to construct the southern alignment. The cost of these land acquisitions includes estimated compensation for the impact on businesses currently conducted at the property. This cost is an estimate of current market values with contingency applied for the uncertainty in this estimate.
Deduction: Resale of residual lands after project completion	Estimate of future market value	The estimated value of residual lands purchased by RMS to construct the southern alignment which would not be required following project completion and would be resold into the local real estate market at the completion of the project. This cost is an estimate of future market values with contingency applied for the uncertainty in this estimate.
Deduction: Resale of lands currently owned by RMS for the northern route	Estimate of current market value	The estimated resale value of lands currently owned by RMS to construct the northern alignment, which would be resold into the local real estate market in their current conditions, in the event of the southern route proceeding in favour of the northern alignment. This cost is an estimate of future market values with contingency applied for the uncertainty in this estimate.

6.1.3 Results

The estimated costs for required property adjustments are provided in Table 6.5. These have been prepared based on current information. The RMS does not release information about values for individual properties as this is confidential and market sensitive.

Table 6.5 Net assessed land acquisition costs

Item	Northern route ($m)	Southern route ($m)
Purchased items	17.7	17.7
Future purchases	7.4	12.0
Sale Items	3.2	10.4
Net cost	**22**	**19**

6.2 Construction methodology

This investigation involved developing indicative information on potential construction methods for the northern and southern routes. This information has been used in the preparation of the cost estimates for each route.

The approach used and level of detail produced are the same for both the northern and southern routes to provide like-for-like information to the cost estimate.

Construction method statements have been prepared for the more complex construction activities that are the significant contributors to the cost of the project. These construction method statements have been developed based on the design documentation produced, the relevant site constraints and the results of the technical investigations undertaken. They have been developed to inform the cost estimates prepared for each routes and are not final construction method statements. The actual construction methods for the project would be determined by the contractor based on the final design developed for the route selected.

This section provides a summary of the construction method statements prepared for major construction activities, including the construction method for bridge construction and earthworks.

6.2.1 Summary of outcomes

Construction method statements have been prepared for the major construction activities for each route as summarised in Table 6.6.

Table 6.6 Construction method statements prepared

Investigation	Northern route	Southern route
Construction method statement - Bridgeworks	10910 Main Berry Bridge	Southern Berry Bridge
Construction method statements - Earthworks	Northern: Bulk Earthworks Ch7600 - Ch20600	Southern: Bulk Earthworks Ch7600 - Ch20600

Much of the detail in the construction method statements is common to both routes and as a result provides equivalent data in support of the cost estimate.

In general, the same assumptions and approaches have been applied to both routes. The major differences in construction methods between the routes are summarised in Table 6.7 below. These differences arise from differences in design, quantities, geotechnical impacts, access or other site-specific reasons.

Table 6.7 Summary of differences in construction methods

Differences in construction method	Northern route	Southern route
Structures – Berry Bridge	Major bridge: 10910 Main Berry Bridge ▪ Number of super-T girders: 240; ▪ Main access points: Woodhill Mountain Road, auxiliary	Major bridge: Southern Berry Bridge ▪ Number of super-T girders: 432; ▪ Main access points: Wharf Road.

Differences in construction method	Northern route	Southern route
	access from Princes Highway at northern interchange. Super-T girders may be procured from industry suppliers or manufactured on site, depending on the quantity and the availability of a precasting site.	The large number of Super-T girders warrants an on-site precasting facility.
Earthworks	▪ Balanced earthworks, no imported fill ▪ Preloading of embankment over floodplain for soft soil consolidation	Same as for Northern Route except for: ▪ Potential acid sulfate soils. ▪ Potential imported fill required; ▪ Ground improvement of soft soils required for part of southern embankment over floodplain. ▪ Preloading for consolidation required for part of southern embankment over floodplain.

6.2.2 Investigations

6.2.3 Bulk earthworks and mass haul

6.2.3.1 Purpose

Earthworks are one of the most significant costs in a major road project. A mass haul analysis aims at finding the most economic approach to construction of the earthworks. This is best achieved by minimising haul distances and the quantity of imported fill (if required).

6.2.3.2 Approach

The volumes of earthworks are determined from the design long section and cross sections. These are either cuts (excavated material) or fills (embankments). The amount of topsoil is determined and this is generally stockpiled for later reuse in landscaping the embankment batters. The amount of unsuitable material to be excavated is assessed from knowledge of the geotechnical conditions along the route and industry experience. The final mass haul then takes these factors into account in determining the earthworks balance (where the amount of cut equals the amount of fill consistent with the minimum of haul distance).

6.2.3.3 Constraints

Mass haul analysis takes into account material properties but also:

1. Geological properties of the excavated material and its suitability for the intended use;

2. Special issues such as the presence of soft soils, potential acid sulfate soils and embankment stability;
3. Material bulking and compaction factors;
4. Obstacles such as major rivers, roads, and railways which intercept the mass haul and hence impact the analysis;
5. Accommodation of existing highway traffic by means of staging or traffic switching;
6. Need to sequence work to optimise usage of plant and to achieve the shortest possible program.

6.2.4 Results

6.2.4.1 Construction method statements

Construction method statements were prepared for the construction activities summarised in Table 6.8.

Table 6.8 Construction method statements prepared

Construction Activity	Construction method statements	
	Northern route	Southern route
Structures	10910 Main Berry Bridge (refer to Berry Bridge Table 6.9 for details) The key features of the construction method statements for Berry Bridge are summarised below in Table 6.9 and Table 6.10 and contained in full in Appendix F1.	Southern Berry Bridge (refer to Table 6.10 for details)
Earthworks	Bulk earthworks (refer to Table 6.11 for details) The key features of the construction method statements for bulk earthworks are summarised below in Table 6.11 and Table 6.12 and contained in full in Appendix F2.	Bulk earthworks (refer to Table 6.12 for details)

6.2.4.2 Berry Bridge

The key features of the construction method statements for Berry Bridge are summarised below in Table 6.9 and Table 6.10 and contained in full in Appendix F1 and Appendix F2.

Table 6.9 10910 Main Berry Bridge

Assumptions	Major construction features
▪ Hard surface access is available to all pile locations. ▪ Main access point from Woodhill Mountain Road; auxiliary access from Princes Highway at	Pile installation: ▪ Bored piles installed. ▪ Anticipated resources: pile driving rig; drilling rig; bob cat loader; truck; 25t support crane.

Assumptions	Major construction features
northern interchange. ▪ Creek diversions or alternatives are in place to ensure construction is dry, although pumping may be required to keep the excavation dry. ▪ 3 no circular piers (uniform shape) extend upwards from 3 no same diameter piles. ▪ No pile caps are anticipated. ▪ Super-T girders: 32.250m span x 1.5m deep, weighing approx. 55t.	Pier construction: ▪ Anticipated resources: access tower; purpose-made steel forms (capable of doing 3 no piers simultaneously); 20t RT crane; concrete skip; hiab truck. Headstock construction (Headstocks may be precast or cast in situ): ▪ In situ headstocks anticipated resources: access tower (at each pier remains in place); walkways on the headstock; 20t crane. ▪ Precast headstocks anticipated resources: access tower (at each pier remains in place); walkways on the headstock; 200t crane. Super-T girder supply: ▪ Super-T's may be procured from a commercial source or manufactured on site. ▪ Anticipated resources for girder erection: horse and jinker haulage unit; 400t crane. Deck construction: ▪ Formwork and reinforcement needs to be put in place, and screed rails need to be established before concrete is poured for the deck. ▪ Anticipated resources for the deck construction: 50t rough terrain crane, concrete pump. ▪ Precast 6m parapet shells 6m long may be manufactured off-site or on-site and craned onto the bridge. Completion of the bridge involves: ▪ Conventional traffic barriers, hand railing, expansion joints, asphalting, line markings and signs.

Table 6.10 Southern Berry Bridge

Assumptions	Major construction features
▪ Hard surface access is available to all pile locations. ▪ Main access point is from Wharf Road with northern section accessed from Tannery Road (west of the railway bridge which only has a 3.3m clearance). ▪ Creek diversions or alternatives are in place to ensure construction is dry, although pumping may be required to keep the excavation dry. ▪ 3 no circular piers (uniform shape) extend upwards from 3 no same diameter piles. ▪ No pile caps anticipated. ▪ Super-T girders: 33m span x 1.5m deep, weighing approx.	Pile installation: ▪ Bored piles installed. ▪ Anticipated resources: pile driving rig; drilling rig; bob cat loader; truck; 25t support crane. Pier construction: ▪ Anticipated resources: access tower; purpose-made steel forms (capable of doing 3 no 1200 diameter piers simultaneously); 20t RT crane; concrete skip; hiab truck. Headstock construction(Headstocks may be precast or cast in situ): ▪ In situ headstocks anticipated resources: access tower (at each pier remains in place); walkways on the headstock; 20t crane. ▪ Precast headstocks anticipated resources: access tower (at each pier remains in place); walkways on the headstock; 200t crane. Super-T girder supply:

Assumptions	Major construction features
55t.	▪ Super tees may be procured from a commercial source or manufactured on site. ▪ Anticipated resources for girder erection: horse and jinker haulage unit; 400t crane. Deck construction: ▪ Formwork and reinforcement needs to be put in place, and screed rails need to be established before concrete is poured for the deck. ▪ Anticipated resources for the deck construction: 50t rough terrain crane, concrete pump. ▪ Precast parapet shells 6m long may be manufactured off-site or on-site and craned onto the bridge. Completion of the bridge involves: ▪ Conventional traffic barriers, hand railing, expansion joints, asphalting, line markings and signs.

6.2.4.3 Bulk earthworks

Northern route

Earthworks for the northern route were approximately balanced at time of analysis meaning all excavated material will be used on the project in embankments or to replace unsuitable material, as indicated in Figure 6.3.

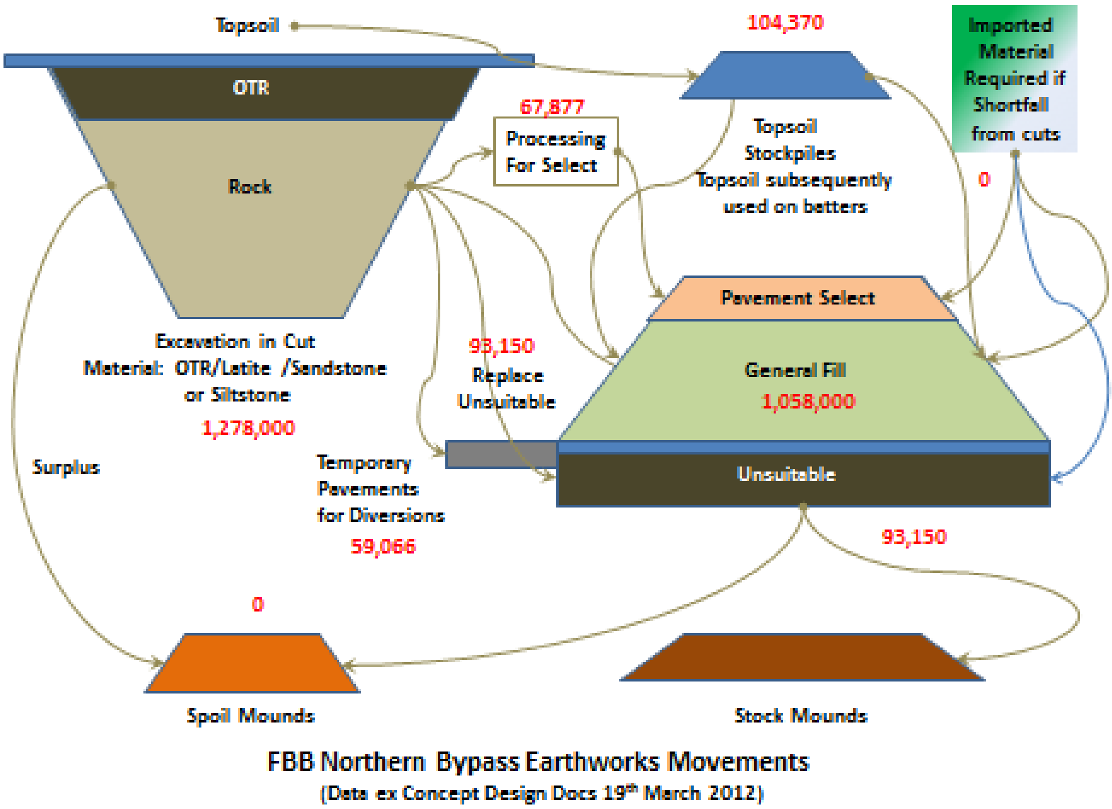


Figure 6.3 Northern route earthworks movements

Southern route

Initial mass haul analysis for the southern route revealed a requirement to import approximately 600,000m^3 of fill from sources unknown, as indicated in Figure 6.4.

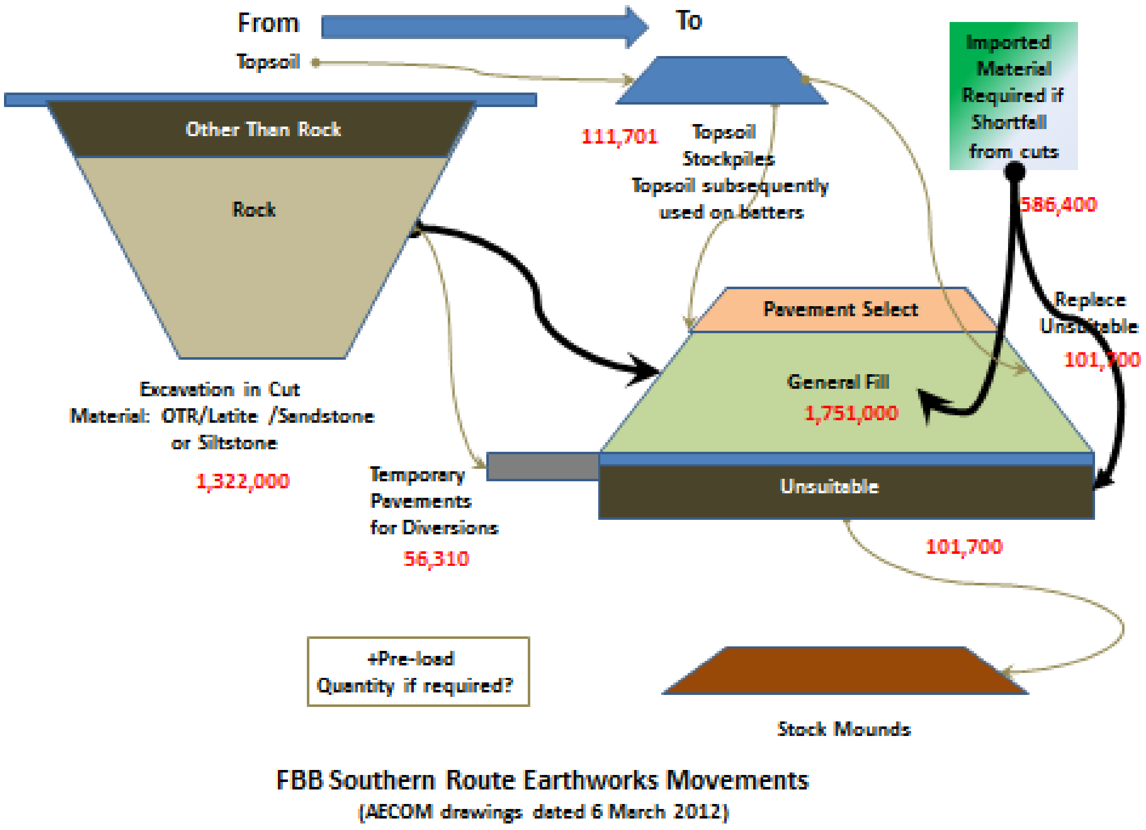


Figure 6.4 Southern route earthworks movements (March 2012)

Further analysis by the TIG after introducing some major horizontal and vertical realignment changes at Toolijooa Ridge, Austral Park Road South, northern interchange and southern interchange to win additional material from the project, brought the mass haul roughly into balance.

Any further alignment changes such as adopting the route south of the sewage treatment plant or the introduction of an island embankment will disrupt this earthworks balance and require fill material to be imported. Earthworks movements for the subsequent realignments up to May 2012 are indicated in Figure 6.6.

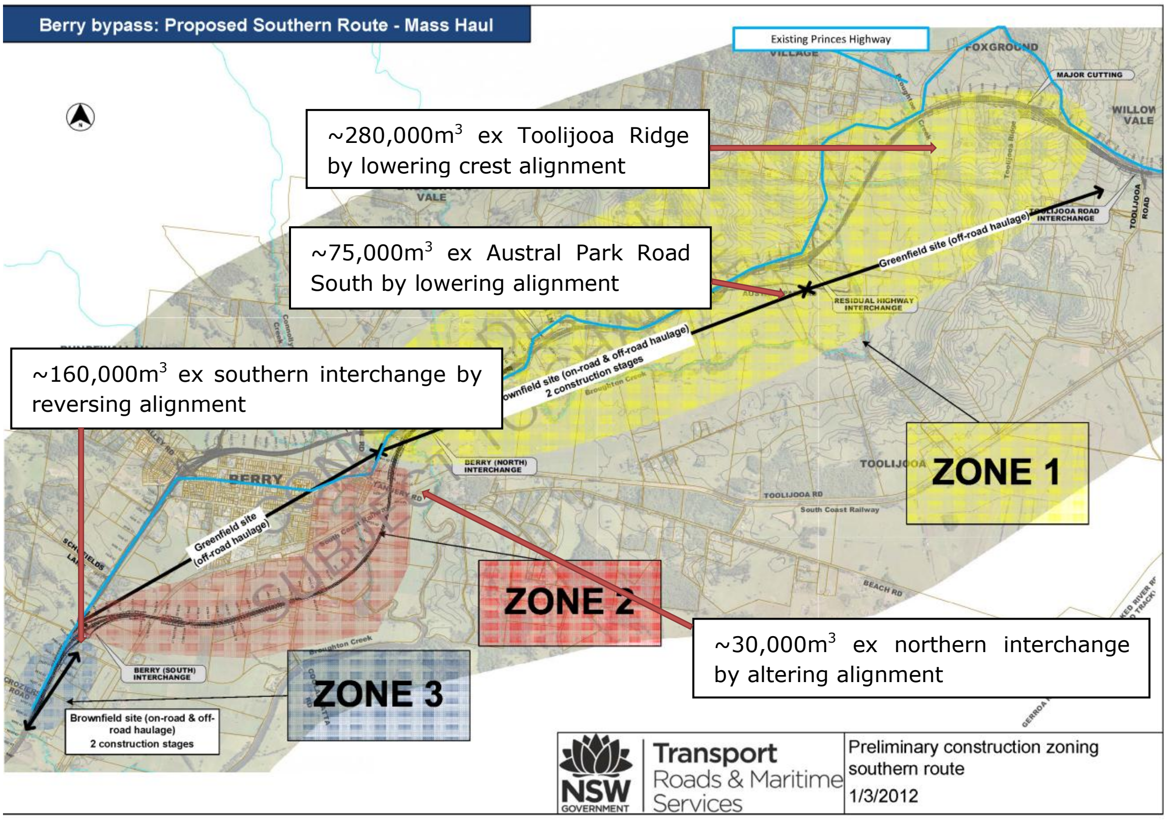


Figure 6.5 Southern Route - Mass haul changes arising from realignments

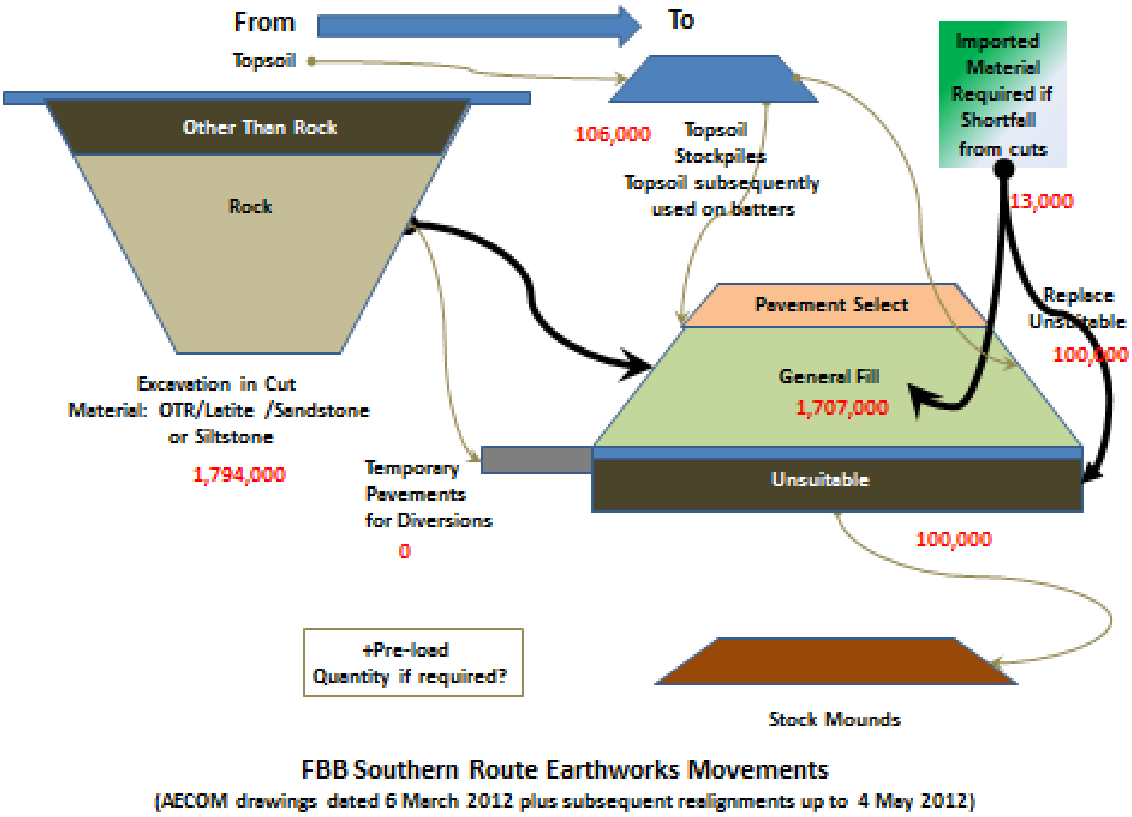


Figure 6.6 Southern route earthworks movements (May 2012)

The key features of the construction method statements for bulk earthworks are summarised below in Table 6.11 and Table 6.12 and contained in full in Appendix F1 and Appendix F2.

Table 6.11 Northern route: bulk earthworks

Assumptions	Major construction features
▪ Topsoil is assumed to be an average 150mm thick. ▪ Major cut is in latite. ▪ Other cuts in sandstone and stiff silty clays. ▪ Latite needs to be drilled and blasted. ▪ Sandstone cuts will be ripped. ▪ The latite is only suitable for general fill and not select material. ▪ All latite and sandstone cut batters will be presplit. ▪ Geotechnical report indicates the following bulking factors which affects the amount of material that has to be hauled. From this: - Allowed 1.1 for Other Than Rock (OTR); and - 1.3 for major cuts. ▪ Assumptions have been made for haulage of unsuitable material and its replacement material as the quantity and location are not yet determined. ▪ Short hauls (under 1.5km) are generally handled with motorised scrapers provided the material is not too abrasive. ▪ Latite is abrasive and generally unsuitable for scraper work. ▪ The latite rock is loaded into haul trucks and transported to the embankment fills; off-highway trucks are used where possible, e.g. on greenfield sites and in the first stage of the staged works. ▪ Highway trucks have to be used where material is required to be transported on public roads; this also applies to the second stage of the staged works. ▪ Where staged works are necessary in order to accommodate the existing traffic flows on the Princes Highway, it has been assumed that 60% of the works can be executed in the first stage and 40% in the second stage. ▪ In order to accommodate construction the existing highway will require a number of temporary diversions and cross over points. ▪ Cross over points are located at approximately CH11950, CH13800, CH14250 and CH15400. ▪ The quantity of unsuitable material is assumed based on experience.	Unsuitable and spoil Other Than Rock (OTR): ▪ Any unsuitable and spoil OTR is removed by scraper fleet, and hauled using a truck depending on the local of spoil dump and haul route and distance. ▪ Anticipated resources to remove spoil: CAT E35 excavator, haul with truck and dog (6no.), CAT D6H dozer, truck water cart 30kL, spotter. Latite material cut: ▪ Drilling and blasting of latite material will be undertaken by a specialist subcontractor (resources used determined by subcontractor). ▪ Anticipated resources to carry out cutting: load dump trucks with Komatsu PC1000 excavator or equivalent; 6 number CAT 773 50t rear dump trucks; grader CAT 14G; truck water cart 30kL; spotter. ▪ Anticipated resources for compaction of fill: CAT 825C (2no.), CA51 smooth drum roller, grader CAT14G, truck water cart 30kL 50%, spotter. Sandstone cuts: ▪ Sandstone to be ripped to win the material for general fill and also for select material. ▪ Anticipated resources: CAT E65 excavator, CAT D10R ripper, CAT773 Dry (5 no.), grader CAT 14G, truck water cart 30kL 50%, spotter. OTR and siltstone cuttings plus initial stages of staged construction: ▪ Anticipated resources: CAT651 scraper (3 no), CATD11D11R ripping, grader CAT14G, truck water cart 30kL 50%, spotter. OTR and siltstone cuttings plus final stages of staged construction: ▪ Excavate with CAT E35 excavator, CAT D10R dozer ripping, haul with truck and dog (4 no.), truck water cart 15kL 50%, spotter. Ripping of cutting floors: ▪ Anticipated resources: CAT D10R dozer ripping, truck water cart 30kL 50%, spotter. Temporary diversions: ▪ Side tracks to be constructed: cross section width 10m – 1.5m shoulders, two 3.5m lanes. ▪ Pavement specifications (typical pavement

Assumptions	Major construction features
	suggestion) for the side track: select material 300mm (150mm lime stabilised 3% - 150mm min CBR 15%), DGB20 200mm, 10mm sprayed seal, 50mm asphalt.

Table 6.12 Southern route: bulk earthworks

Assumptions	Major construction features
▪ Major cut is in latite. ▪ Other cuts in sandstone and stiff silty clays. ▪ Latite needs to be drilled and blasted. ▪ Sandstone cuts will be ripped. ▪ The latite is only suitable for general fill and not select material. ▪ All latite and sandstone cut batters will be presplit. ▪ Geotechnical report indicates the following bulking factors which affects the amount of material that has to be hauled. From this: - Allowed 1.1 for OTR; and - 1.3 for major cuts. ▪ Assumptions have been made for haulage of unsuitable material and its replacement material as the quantity and location are not yet determined. ▪ Assume that the source of the 600,000m^3 of imported fill is within 10km. ▪ Short hauls (under 1.5km) are generally handled with motorised scrapers provided the material is not too abrasive. ▪ Latite is abrasive and generally unsuitable for scraper work. ▪ The latite rock is loaded into haul trucks and transported to the embankment fills; off-highway trucks are used where possible, e.g. on greenfield sites and in the first stage of the staged works. ▪ Highway trucks have to be used where material is required to be transported on public roads; this also applies to the second stage of the staged works. ▪ Where staged works are necessary in order to accommodate the existing traffic flows on the Princes Highway, it has been assumed that 60% of the works can be executed in the first stage and 40% in the second stage. ▪ In order to accommodate construction the existing highway will require a number of temporary diversions and cross over points. ▪ Cross over points are located at approximately CH11950, CH13800,	Unsuitable and spoil OTR: ▪ Any unsuitable and spoil OTR is removed by scraper fleet, and hauled using a truck depending on the local of spoil dump and haul route and distance. ▪ Anticipated resources to remove spoil: CAT E35 excavator, haul with truck and dog (6no.), CAT D6H dozer, truck water cart 30kL, spotter. Latite material cut: ▪ Drilling and blasting of latite material will be undertaken by a specialist subcontractor (resources used determined by subcontractor). ▪ Anticipated resources to carry out cutting: load dump trucks with Komatsu PC1000 excavator or equivalent; 6 number CAT 773 50t rear dump trucks; grader CAT 14G; truck water cart 30kL; spotter. ▪ Anticipated resources for compaction of fill: CAT 825C (2no.), CA51 smooth drum roller, grader CAT14G, truck water cart 30kL 50%, spotter. Sandstone cuts: ▪ Sandstone to be ripped to win the material for general fill and also for select material. ▪ Anticipated resources: CAT E65 excavator, CAT D10R ripper, CAT773 Dry (5 no.), grader CAT 14G, truck water cart 30kL 50%, spotter. OTR and siltstone cuttings plus initial stages of staged construction: ▪ Anticipated resources: CAT651 scraper (3 no), CATD11D11R ripping, grader CAT14G, truck water cart 30kL 50%, spotter. OTR and siltstone cuttings plus final stages of staged construction: ▪ Excavate with CAT E35 excavator, CAT D10R dozer ripping, haul with truck and dog (4 no.), truck water cart 15kL 50%, spotter. Ripping of cutting floors: ▪ Anticipated resources: CAT D10R dozer

Assumptions	Major construction features
CH14250 and CH15400. ▪ The quantity of unsuitable material is assumed based on experience. ▪ Access is restricted at the Tannery Road Railway Bridge to 3.3m so material haulage to the southern section will be substantially into Berry and along Wharf Road to the site.	ripping, truck water cart 30kL 50%, spotter. Temporary diversions: ▪ Side tracks to be constructed: cross section width 10m – 1.5m shoulders, two 3.5m lanes. ▪ Pavement specifications (typical pavement suggestion) for the side track: select material 300mm (150mm lime stabilised 3% - 150mm min CBR 15%), DGB20 200mm, 10mm sprayed seal, 50mm asphalt.

6.2.4.4 Differences in construction methods

The differences between the construction methods required for the routes contribute to the differences between the estimated costs of the routes. The main differences between the construction methods for bridges and earthworks for the two routes are summarised in Table 6.13 and Table 6.14 respectively.

Table 6.13 Comparison of bridge construction method statements

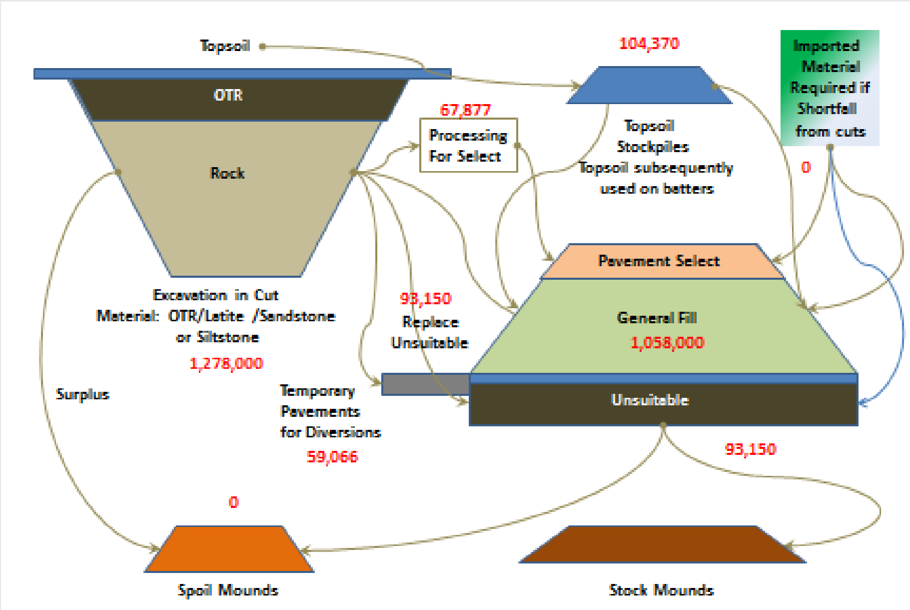
Differences in construction methods	Northern route (10910 Main Berry Bridge)	Southern route (Southern Berry Bridge)
Bridge construction method statements	▪ Main access points: Woodhill Mountain Road, auxiliary access from Princes Highway at northern interchange. ▪ Super-T girders may be procured from industry suppliers or manufactured on site, depending on the quantity and the availability of a precasting site.	▪ Main access points: Wharf Road ▪ The large number of Super-T girders warrants an on-site precasting facility.

Table 6.14 Comparison of earthworks construction method statements

Difference in construction methods	Northern route	Southern route
Earthworks balance	Earthworks are approximately balanced as at May 2012.	Earthworks are approximately balanced as at May 2012 after alignment changes. However, this excludes the island embankment and the alternative route south of the sewage treatment plant.
Soft soils on floodplain	There is some existence of soft soils. Preloading may be required for embankments over the floodplain which will impact material handling and timing.	There are significant areas and quantities of soft soils requiring treatment. Preloading may be required which will impact material handling and timing. Ground improvement of soft soils will be required for part of the southern embankment over the floodplain.

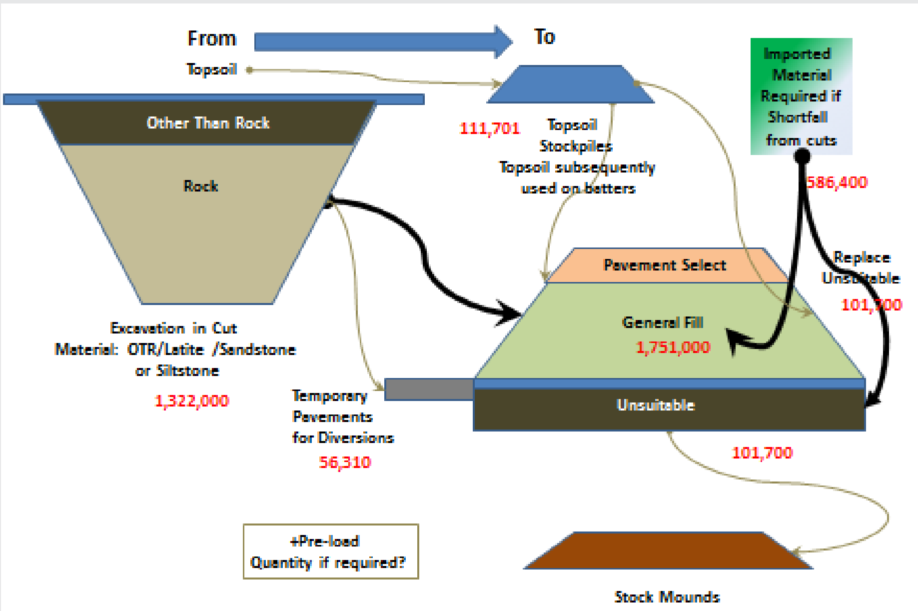
<table>
<tr><th>Difference in construction methods</th><th>Northern route</th><th>Southern route</th></tr>
<tr><td>Potential Acid Sulfate Soils (PASS)</td><td>There are no PASS identified on the northern route.</td><td>There is evidence of PASS on the southern route and this material is not available for use in embankments. This material is subject to a specific Materials Management Plan.</td></tr>
<tr><td>Bulk earthworks construction method statements</td><td colspan="2">

Northern route bulk earthworks



FBB Northern Bypass Earthworks Movements
(Data ex Concept Design Docs 19th March 2012)

Southern route bulk earthworks



FBB Southern Route Earthworks Movements
(AECOM drawings dated 6 March 2012)

</td></tr>
</table>

6.3 Design and Construction Program

Indicative design and construction programs were developed for the northern and southern routes based on the outcomes from the technical investigations and the design information available. These programs informed the cost estimates for each route, specifically the time-related components of the cost estimate such as site accommodation and project management costs.

The approach to developing the programs was to produce a similar level of detail for both routes to provide like-for-like information to input to the cost estimate. Whilst separate programs have been developed for each route, the programs are similar for the scope of work east of the Berry northern interchange since both routes have a similar design alignment over the 8km to Toolijooa Road.

The design and construction programs are preliminary to inform the cost estimates prepared for each routes and hence are not final design and construction programs. The actual design and construction program for the project would be determined by the successful D&C contractor based on the final design developed for the selected route.

This section outlines the construction sequence and assumptions for both routes that have been adopted to develop the D&C programs. A summary of the northern route and southern route programs are presented in the results.

6.3.1 Summary of outcomes

The key inputs to the program development were as follows:

- horizontal and vertical design alignment and cross-sections;
- structures and cross drainage designs;
- construction methods for major activities and staging requirements;
- traffic management plans to maintain traffic movements on the existing Princes Highway during construction;
- earthworks mass haul analysis;
- geotechnical investigations and flood modelling; and
- productivity rates used for estimating.

The major features of the design and construction programs for the northern and southern routes are summarised in Table 6.15.

Table 6.15 Construction program summary

Key D&C program features	Northern route	Southern route
Overall construction completion	Month 32 *	Month 41 *
Bypass opening milestone	Month 30 *	Month 37 *
Program critical path	Zone 1a earthworks & pavements (north of Austral Park Road)	Berry Bridge over Broughton Mill Creek

Key D&C program features	Northern route	Southern route
Allowance for soft soil consolidation &/or ground improvement	6 months (embankment west of Berry Bridge)	6 months (embankment over floodplain, between rail corridor and Broughton Mill Creek)
Berry Bridge construction	14 months	20 months
* Includes inclement weather provision		

6.3.2 Construction sequence

The construction sequence would be finalised once the construction contractor has been appointed. The programs developed for this report adopt a construction sequence for each section of the route generally as follows:

- Site establishment;
- Temporary site access including traffic controls;
- Clearing and grubbing, including sediment & erosion controls;
- Topsoil stripping, including establishment of stockpile areas;
- Cross drainage, including fauna crossings;
- Bulk earthworks cut to fill;
- Service roads and access roads;
- Bridge construction;
- Subgrade & pavement construction;
- Topsoil, revegetation and landscaping; and
- Line marking, signage & finishing works.

Construction zones for the northern route and the southern route are indicated in Figure 6.7 and Figure 6.8 respectively. The program structure is based on these three construction zones.

For the northern route, the bypass of Berry township would be opened to traffic on completion of the Berry Bridge and concurrent with the completion of the upgrade from the southern interchange through to Austral Park Road. The remainder of the upgrade through to Toolijooa Road would be opened some two months later.

For the southern route, the bypass of Berry township would be opened to traffic on completion of the embankments over the floodplain and the Berry Viaduct over Broughton Mill Creek. The remainder of the upgrade from the northern interchange to Toolijooa Road could be opened to traffic up to three months earlier. To avoid upgrading the existing highway under traffic, the flood immunity improvements to the existing highway north from Schofields Lane would be completed after traffic is diverted onto the bypass. These works extend the overall program duration by approximately four months.

The program for work in Zone 1 from Toolijooa Road to the residual highway interchange (Zone 1a) is based around the large earthworks cut to fill operation and completion of three bridge crossings of Broughton Creek to provide access for off-road haulage of fill material and for pavement works.

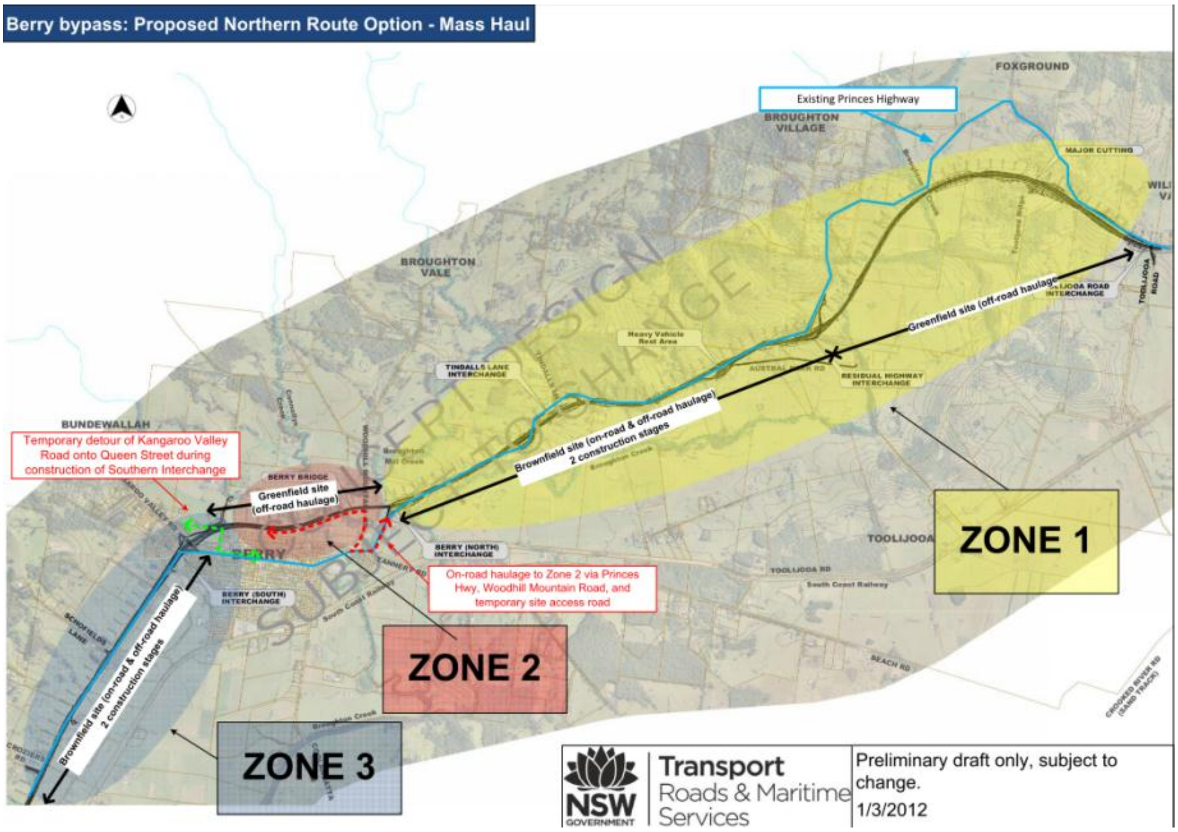


Figure 6.7 Northern route: Construction zones

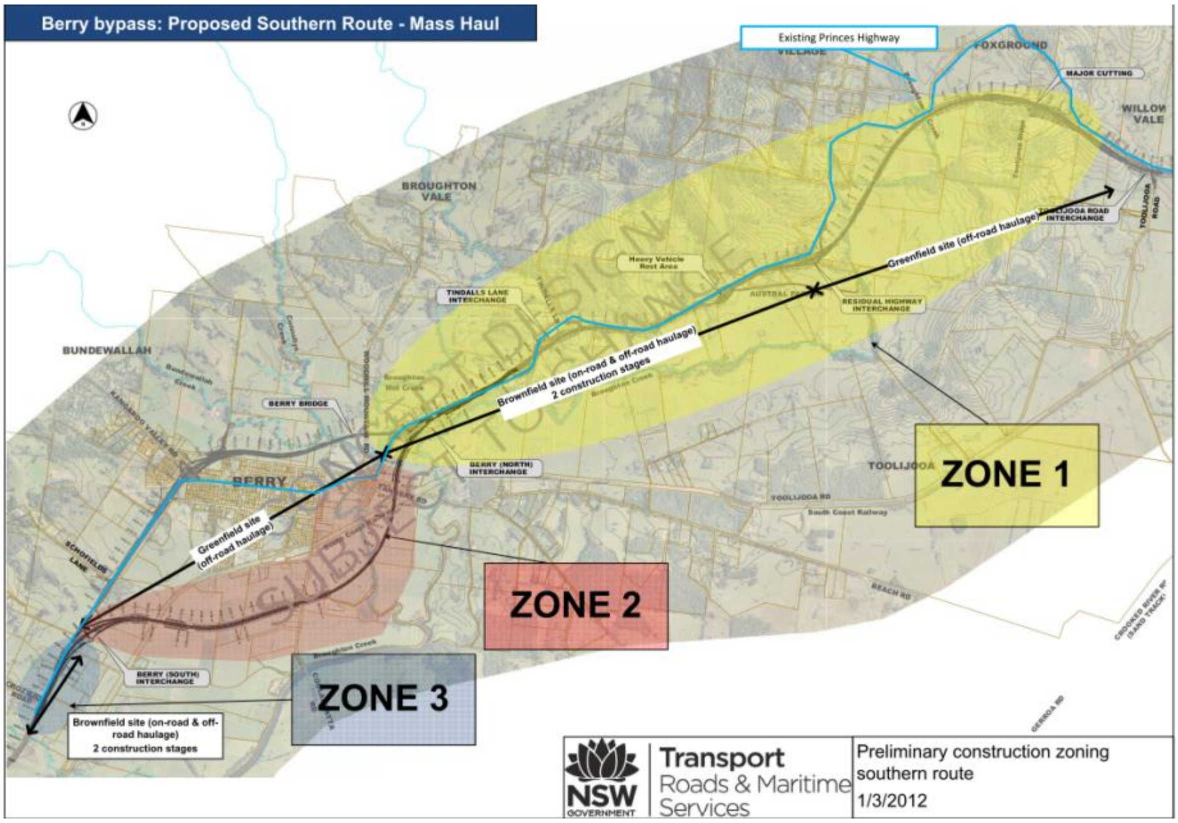
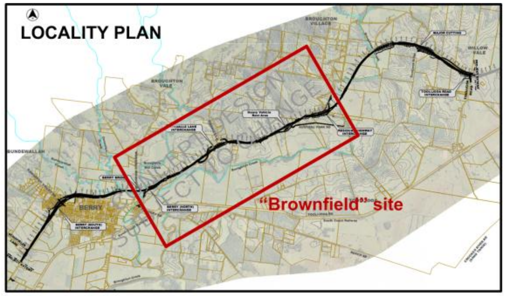
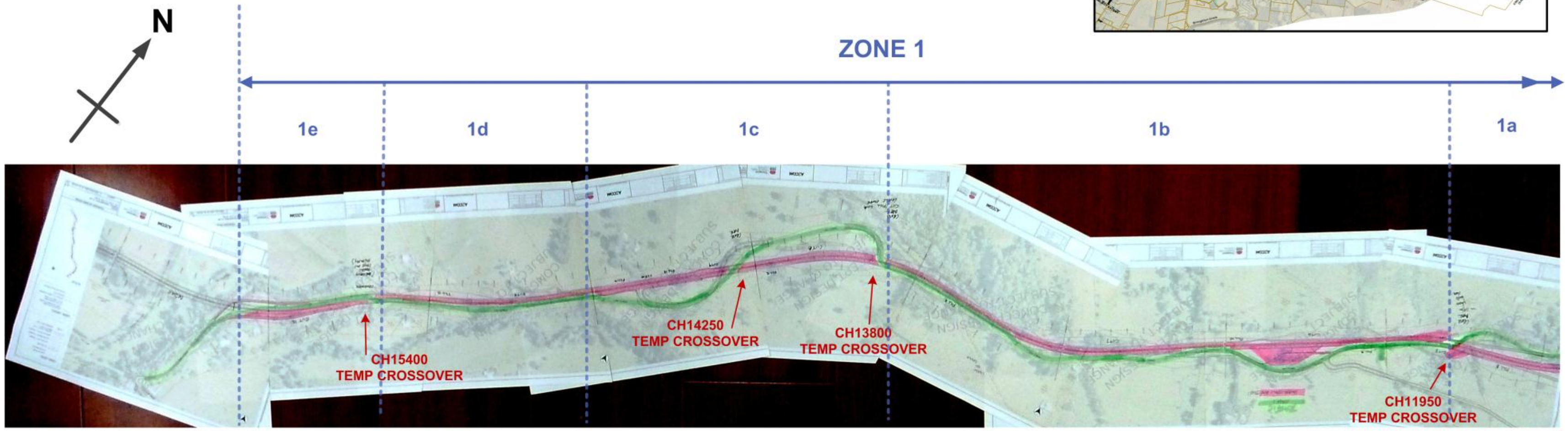


Figure 6.8 Southern route: Construction zones

ZONE 1 – CONSTRUCTION SEQUENCE: "BROWNFIELD" WORKS





Zone 1e

(i) Bulk earthworks SB ramp + mainline
(ii) Complete SB exit ramp
(iii) Complete NB + SB mainline
(iv) Switch Princes Hwy traffic to exit ramp (contraflow)
(v) NB on ramp earthworks + pavement
(vi) Complete NB + SB mainline
(vii) Open NB ramp to traffic

Zone 1d

(i) Temporary pavement widening SB exsiting highway
(ii) Construct NB carriageway
(iii) Switch traffic to NB (contraflow)
(iv) Construct SB carriageway

Zone 1c

(i) Construct NB + SB carriageway
(ii) Construct bridge over mainline (Tindalls Lane) + sidetrack at Ch13800
(iii) Switch Princes Hwy to new bridge
(iv) Complete NB + SB carriageway
(v) Switch Princes Hwy to NB (contraflow)
(vi) Complete connections + intersection with existing highway + complete NB at Ch13600
(vii) Open SB to traffic
(viii) Complete AC wearing course NB

Zone 1b

(i) Construct NB carriageway
(ii) Switch traffic to NB (contraflow)
(iii) Construct SB carriageway
(iv) Open SB to traffic

Zone 1a

(i) Mainline NB + SB, SB On Ramp bridge, + NB exit ramp from CH11950
(ii) Switch existing highway to NB ramp
(iii) Complete NB ramp from Ch12100
(iv) Open NB ramp
(v) Complete NB + SB mainline connection to Ch12100
(vi) Open mainline + complete NB ramp

Existing Princes Hwy

Princes Hwy Upgrade

Figure 6.9 Construction sequence

Further west in Zone 1b to 1e from the northern interchange to the residual highway interchange (east of Austral Park Road), the "brownfield" construction site requires a staged program of earthworks and pavements to maintain highway traffic movements as detailed in the construction sequence diagram in Figure 6.9.

The northern route program for the Berry Bridge in Zone 2 requires construction of temporary access across the floodplain to commence piling works and diversion of highway traffic to the new southbound exit ramp to construct the eastern abutment. The casting cycle for precast bridge girders is determined by the program demand for erection of the girders as the bridge superstructure is advanced, based on a continuous operation after mobilising a 400T crane to site. The embankment west of the bridge requires fill material hauled on-road and then via the bridge access road from the northern interchange earthworks early in the program, Allowance of 6 months for surcharging and settlement of the embankment expected from soft soil consolidation is included in the program.

The northern route program for mainline earthworks and pavements in Zone 3 at Kangaroo Valley Road interchange is staged around the completion of the overbridge works, to maintain continuous traffic access to Berry town centre. South of Kangaroo Valley Road interchange the upgrade requires staged construction of each carriageway sequentially to maintain traffic on the existing highway.

The southern route program for the Berry Bridge in Zone 2 requires construction of temporary access across the floodplain from Wharf Road and across the creek to commence piling works. Access for construction equipment from Tannery Road is restricted by low clearance under the railway bridge. The casting cycle for precast bridge girders is again determined by the program demand for erection of the girders as the bridge superstructure is advanced, based on a continuous operation after mobilising a 400T crane to site. Construction of the embankment across the floodplain to the rail corridor requires a temporary access road off Wharf Road for hauling imported fill to site early in the program. A portion of the required fill material will be hauled on-road from the northern interchange earthworks. The program includes an allowance of 9 months for surcharging and settlement of the embankment expected from soft soil consolidation.

6.3.2.1 Assumptions

This section outlines the assumptions used to prepare the design and construction programs for the northern route and the southern route, as follows:

- A standard 5-day working week is used, with 10 hour days;
- An allowance of two non-working weeks is included for the Christmas break;
- Public holidays and fixed RDOs are considered non-working days;
- Inclement weather allowance of 20% of the remaining work days during the site construction period is included;
- Program commencement is from contract award to the successful D&C contractor;
- Land acquisitions are assumed complete at contract award;
- Environmental assessment and approval is assumed complete at contract award;
- The project delivery method is assumed as a single design and construct contract for the whole of the works;

- Utility relocations are assumed complete at contract award; and
- Fill material for the southern embankment across the floodplain is assumed imported to achieve early commencement of earthworks in Zone 3.

Further assumptions specific to the activities are detailed in the sections below.

6.3.2.2 Bulk earthworks and drainage

The assumptions used to derive the durations for bulk earthworks and drainage are detailed in Table 6.16.

Table 6.16 Bulk earthworks and drainage program assumptions

Component	Assumptions
Fleets	▪ For the northern route, there are seven earthworks fleets allocated. ▪ For the southern route, there are six earthworks fleets allocated. ▪ The work for each fleet is split into component activities, and the duration of these activities used to develop the D&C program.
Activity	▪ The activity duration comprises the aggregate of bulk earthworks duration + duration for drainage installation for each section of carriageway.
Productivity	▪ Production rate for bulk earthworks is assumed to vary from 230 to 419 bcm/hr, except where scraper fleet used rate increases to 1,396 bcm/hr ▪ Average production rate for drainage installation is assumed at 0.7km/ week.
Bulk earthworks	▪ The duration of bulk earthworks for each fleet is calculated as: $Bulk\ earthworks\ (weeks) = \frac{Earthwork\ Quantity\ \ (bcm)}{Production\ rate\ \left(\frac{bcm}{hr}\right)\ x\ 50hrs/wk}$ ▪ The durations are further split into separate activity durations dependent on the length of the work section.
Drainage	▪ $Drainage\ (weeks) = Carriageway\ length\ (km) \times Drainage\ installation\ rate\ (km/week)$
Bulk earthworks and drainage overall duration	▪ $Bulk\ earthworks\ and\ drainage\ (weeks) = Bulk\ earthworks\ activity\ duration\ (weeks) + Duration\ allowance\ for\ drainage\ (weeks)$
Included works	▪ The scope of works assumed to be completed under bulk earthworks and drainage works includes: - removal and treatment of acid sulphate soils; - batter stabilisation; installation of drainage (not including pavement drainage); - reinforced concrete box culverts; - installation of drainage pits; - installation of rock-filled gabions and mattresses; - removal of existing highway pavement; and - reinforced soil walls.

6.3.2.3 Road pavement and finishing works

The assumptions used to derive the durations for road pavement and finishing works are detailed in Table 6.17.

Table 6.17 Road pavement and finishing works program assumptions

<table>
<tr><th>Component</th><th>Assumptions</th></tr>
<tr><td>Pavement layers</td><td>

The pavement layers required for construction of road pavements include: select fill layer, stabilised subbase layer, base course layer, and wearing course.
Paving production rates for each pavement layer is as follows:
<table>
<tr><th>Pavement layer</th><th>Rate</th></tr>
<tr><td>Select fill</td><td>250m²/hr</td></tr>
<tr><td>Stabilised subbase layer</td><td>250m²/hr</td></tr>
<tr><td>Base course (dense grade asphalt)</td><td>1,400T/day</td></tr>
</table>
The duration for each pavement layer is calculated as :
$Pavement\ layer\ (weeks) = Carriageway\ length\ (km) \times Paving\ rate\ (km/week)$
The stabilised subbase is assumed to commence after 50% of the select fill has been placed in each section.
The base course is assumed to commence after completion of the stabilised subbase.
The base course duration includes allowance for placing the AC wearing course where the upgrade is to be opened as dual carriageway.
Where temporary contraflow is required on new pavements, the AC wearing course is assumed to be placed after the temporary arrangements cease.
</td></tr>
<tr><td>Road pavement overall duration</td><td>

$Road\ pavement\ (weeks) = 0.5\ x\ Select\ fill\ duration + stabilised\ subbase\ duration + Base\ course\ duration$
</td></tr>
<tr><td>Finishing works</td><td>

A separate activity is allocated following the road pavement for each section of carriageway.
$Finishing\ works\ (weeks) = Carriageway\ length\ (km) \times Finishing\ works\ rate\ (weeks/km)$
Assumed completed at a rate of 3 weeks/km.
Scope of work includes line markings, sign installation, placing top soil, re-vegetation, barrier installation.
</td></tr>
</table>

6.3.2.4 Standard bridges

Bridges of up to six spans on both the northern and southern route programs are considered standard bridges. The assumptions used to derive the durations for standard bridges are detailed in Table 6.18.

Table 6.18 Standard bridges program assumptions

Component	Assumptions
Substructure	▪ Scope of works for bridge substructure includes civil works, construction of piles, piers and headstocks.
Superstructure	▪ Scope of works for bridge superstructure includes erection of precast girders, installation of deck joints, pouring deck slabs, construction of parapets and guard rails.
Productivity	▪ Production rates are assumed to be similar to those applied to the main Berry Bridge using additional resources.
Asphalting	▪ Asphalting of the bridge deck is assumed to be concurrent with the final mainline pavement works which occurs continuously along the length of the mainline. ▪ This activity is not allocated a separate duration for the standard bridges.
Staging	▪ For bridges of three spans or less, it is assumed that each stage of construction will be completed prior to commencing the following stage, to allow for the constraints of working on a smaller work site ▪ For bridges of more than three spans, certain construction stages are assumed to occur in parallel with one another: - For bridge substructure, the headstock for the first span is assumed to commence after the third span piers are complete. Construction of headstocks is assumed to follow the piers at a similar rate. In this way the overall construction period for each bridge is reduced and allows continuity of work for each trade on site; - Pouring of deck slabs and parapets share some resources and work activities. Casting of bridge parapets for the first span is assumed to commence after the third span deck slab is poured.

6.3.2.5 Berry Bridge northern route and southern route

Each of the major northern and southern route bridges consist of a long viaduct over the floodplain which require separate calculations for the design and construct program. The northern route bridge is 20 spans, while the southern route is 38 spans. The assumptions used to derive the durations for these long bridges are detailed in Table 6.19.

Table 6.19 Northern Bridge and southern bridge duration assumptions

Activity	Assumptions
Site preparation	▪ Assumed to commence after girder production has commenced.
Girder production	▪ Assumed casting yard is local but off-site. ▪ Assumed 3 girders cast each working day.
Girder cured and transported	▪ Assumed minimum period of 6 weeks for curing girders prior to transportation to site.
Piles	▪ Assumed piling works commence on completion of site preparation. ▪ Pile depth assumed 15m to sound rock. ▪ Piling rate assumed 5m/hr.

Activity	Assumptions
Piers	▪ Assumed one week for piling to progress prior to commencing pier construction.
Headstocks	▪ Assumed three weeks for the construction of piers to progress and cure prior to commencing headstocks.
Girder erection	▪ Assumed Super-T girders erected 6 per day. ▪ 12 girders erected per bridge span. ▪ Commencement of girder erection is scheduled such that the final girders are cast, cured and transported to site and the final headstock is cast and sufficiently cured when the erection crew is ready to install the final span of girders. That is, the final girders are planned to be erected four weeks after the final headstocks are poured.
Deck pouring	▪ Planned to commence a minimum of one week after commencement of girder erection to provide safe separation between work teams.
Parapets	▪ Planned to commence a minimum three weeks after the deck pours have started to allow for preparation, pouring and curing of the deck.
Steel rails	▪ Completion of guard rail installation has been planned to conclude three weeks after the final parapet is cast and stripped to allow for curing and separation of work faces.
Wearing Course	▪ Assumed AC paving is placed after completion of all of the above activities. ▪ Finishing works are also assumed to be included in this activity duration.

The integrated staging of scheduled activities for the Berry Bridge is illustrated graphically in Figure 6.10 and Figure 6.11 for the northern and southern route respectively.

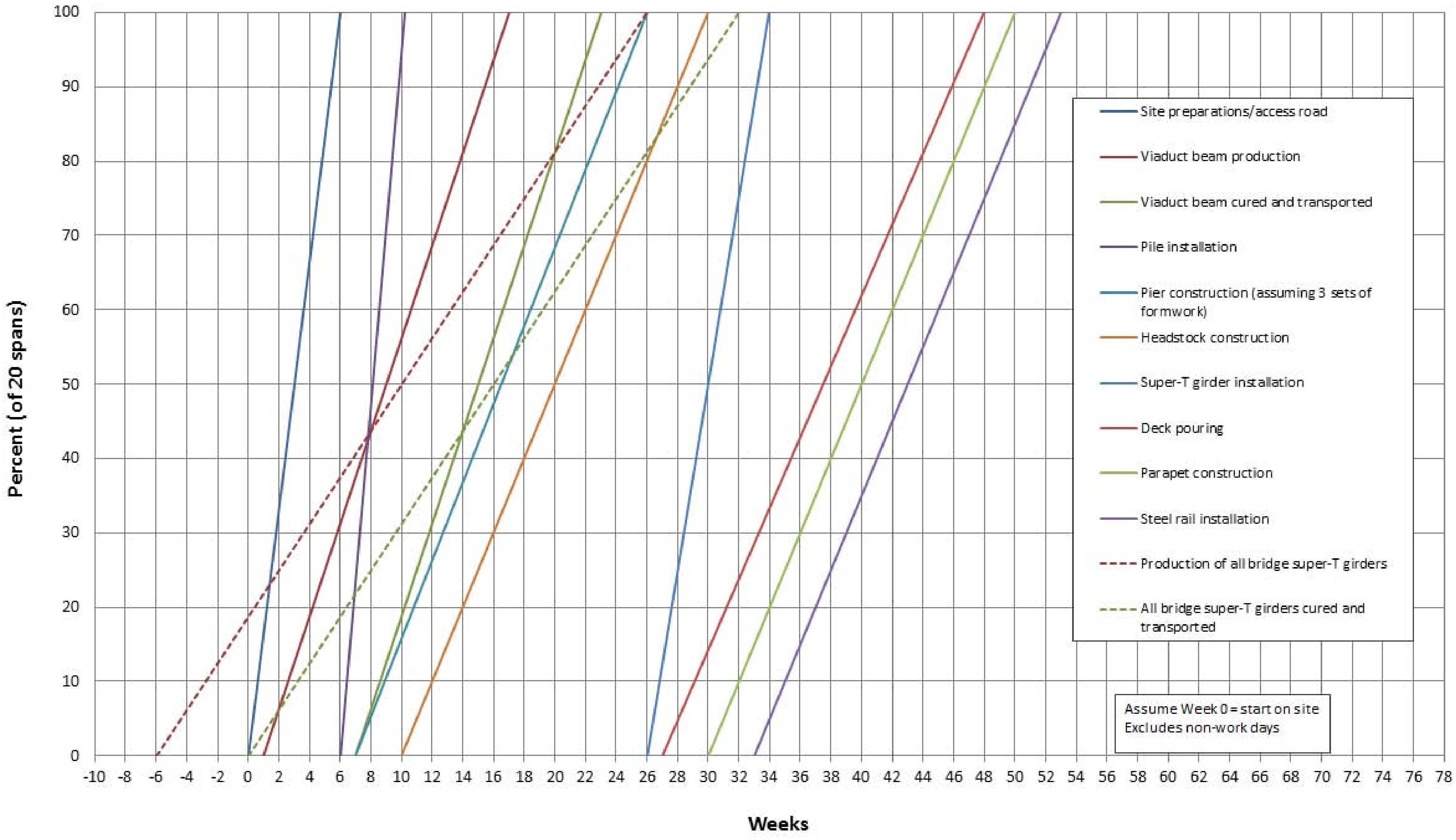


Figure 6.10 Bridge chart – Northern bridge

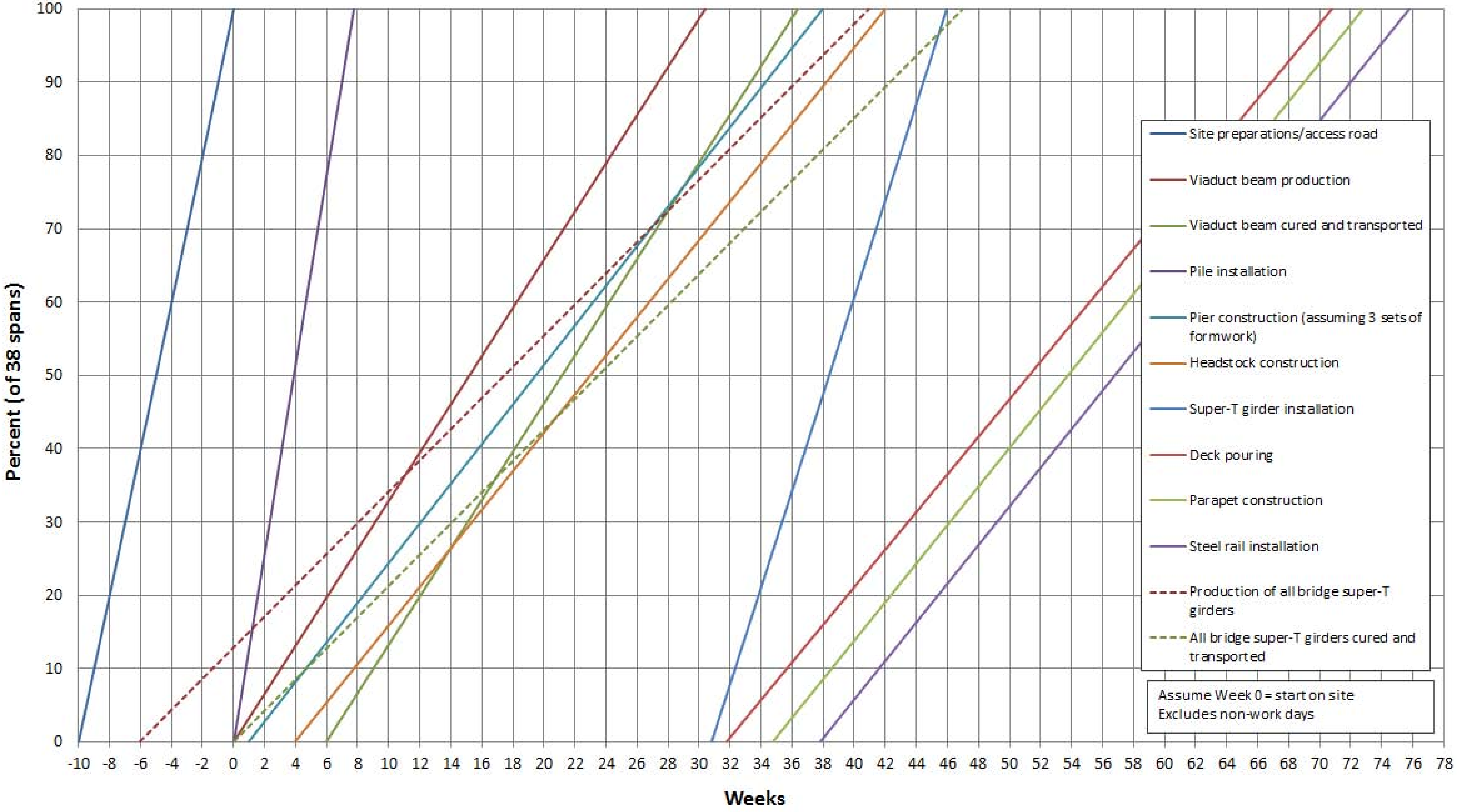


Figure 6.11 Bridge chart – Southern bridge

6.3.3 Results

The detailed construction programs prepared for the northern and southern routes are included in Appendix G1 and Appendix G2. The outline programs for the northern and southern routes are contained in Figure 6.12 and Figure 6.13 respectively.

As noted in the assumptions above, for comparative purposes the design and construction programs include only those activities which follow the award of a contract to a D&C contractor. Those activities which occur prior to award are likely to include environmental assessments, land acquisition, planning approvals, completion of a reference design, and further investigative studies such as flood analysis. It is possible the time required for these activities may differ for the two routes.

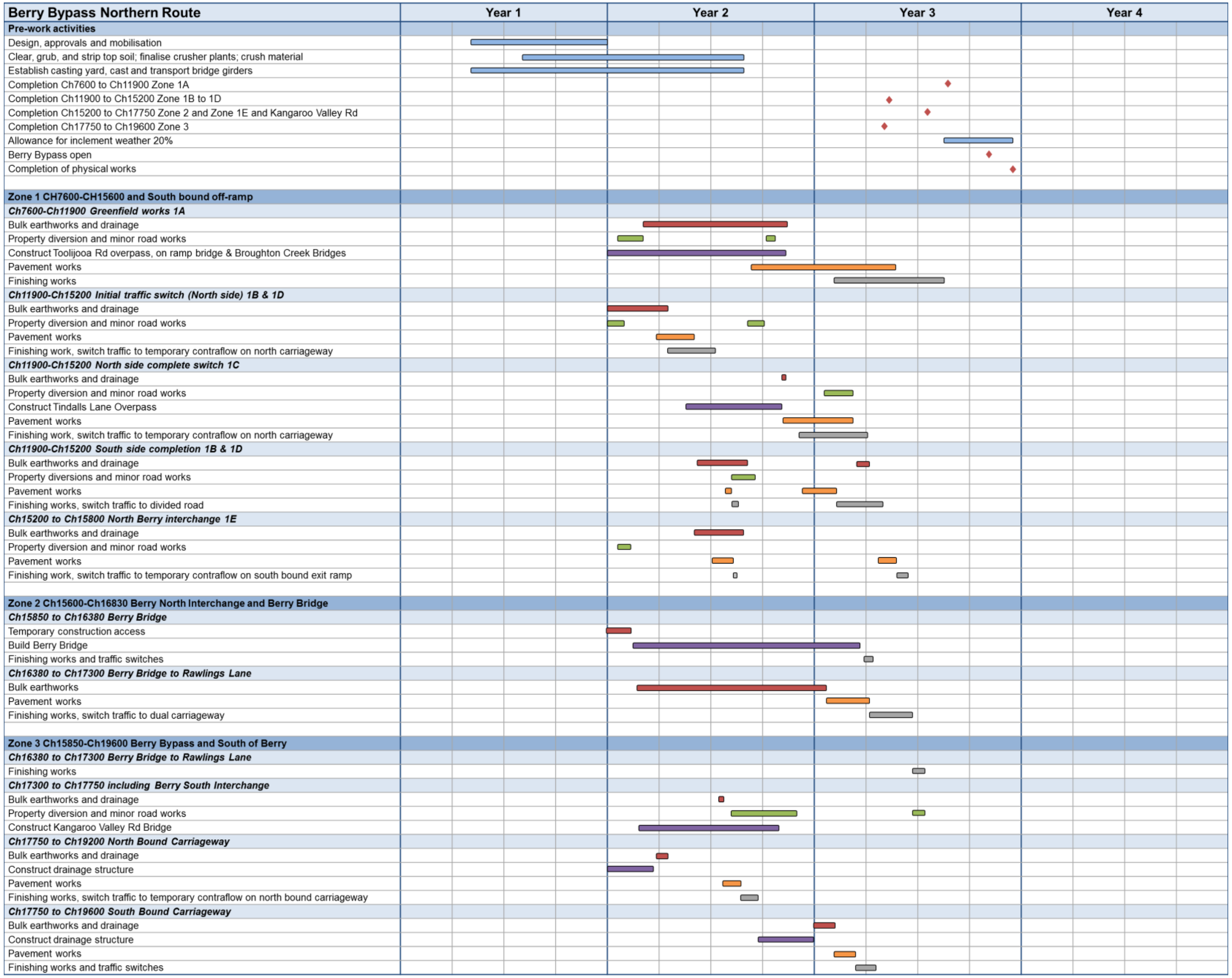


Figure 6.12 Berry Bypass northern route program summary

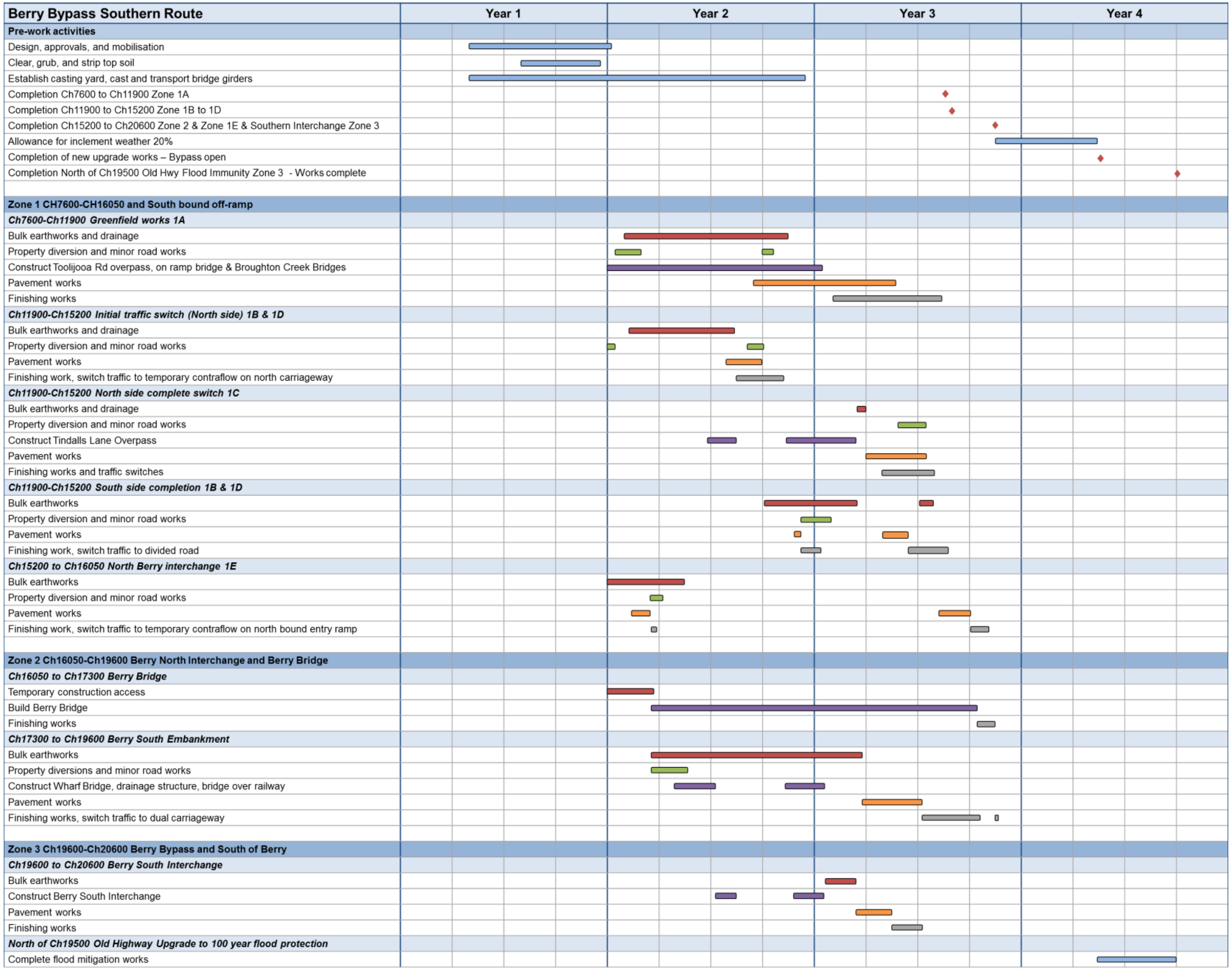


Figure 6.13 Berry Bypass southern route program summary

7 Cost estimate

The purpose of this investigation is to prepare route feasibility comparative cost estimates for evaluation of a southern Berry bypass route. The cost estimates for both routes have been prepared in the format of a strategic route feasibility level estimate. The TIG's investigations were undertaken to provide comparable design, technical and construction information for the two routes to develop these estimates. The consistency of the estimating method used and the comparable level of information ensures a like-for-like comparison.

This section of the report summarises the cost estimation approach taken. It describes the process for the preparation of estimates and gives a detailed breakdown of the estimate components. It outlines how the cost estimation method used complies with the estimation principles outlined in the RMS Project Estimating Manual (2008). A brief comparison of this method with the methods used by other road infrastructure agencies is also examined. A summary of the cost estimate results is provided, with commentary provided relating to major cost components, provisional items and the reasons for differences in cost between the two routes. The cost estimates obtained are also benchmarked against similar road projects for comparison purposes.

7.1 Summary of outcomes

A summary of the cost estimates for the northern and southern routes is provided in Table 7.1 below.

Table 7.1 High level summary of cost estimates

Item description	Northern route	Southern route	Difference	Comment
Structures	\$138m	\$183m	\$45m	Greater length of bridges and area of retaining walls in the southern route: Southern route: ▪ Total bridge deck 46,400m^2; and ▪ Total area of retaining walls 2,800m^2. Northern route: ▪ Total bridge deck area 31,200m^2; and ▪ Total area of retaining walls 1,400m^2.
Earthworks	\$97m	\$238m	\$141m	Greater volume of earthworks, further travelling time, imported fill. Southern route: ▪ Total volume of earthworks 1,984,000m^3. Northern route: ▪ Total volume of earthworks 1,301,000m^3.
Pavements	\$67m	\$63m	-\$4m	Reduction in pavement areas because of shorter length of embankments. Southern route: ▪ Total pavement area 243,000m^2.

Item description	Northern route	Southern route	Difference	Comment
				Northern route: ▪ Total pavement area 257,400m^2.
Balance of construction costs	$151m	$118m	-$33m	General reduction in scope for items such as noise walls, traffic control, drainage etc. for northern vs southern routes.
Land acquisitions	$24m	$23m	-$1m	
Project management and design	$68m	$86m	$18m	
TOTAL	**$545m**	**$711m**	**$166m**	

7.2 Investigations

This section provides the relevant information about RMS estimating guidelines and identifies how these estimates have been produced within these guidelines.

7.2.1 RMS cost estimating guidelines

RMS identifies reasons for compiling an estimate as follows:

- To provide information to decision makers;
- To provide the basis for a project budget; and
- To provide information for the comparison of project alternatives or options.

RMS follows a strict process for the development of cost estimates throughout the various stages of a project to ensure that the estimates produced are adequate for these purposes.

7.2.1.1 Project stages

This section identifies the stages at which estimates are prepared and the characteristics of these estimates, as given in Table 7.2. This information provides the context for understanding the route feasibility cost estimate produced in this investigation. These route feasibility cost estimates are generally strategic stage estimates prepared for the purpose of comparing routes. They are therefore preliminary in their nature.

Table 7.2 Project stages and cost estimation

Project Stage	Cost estimation	Target order of accuracy#
Strategic	▪ Strategic estimate: an estimate in current dollars prepared for a proposal. ▪ For the purpose of program management, comparing options, project feasibility, reporting, etc. ▪ Prepared in the absence of significant investigations, data gathering and when the scope is not clearly and fully defined. ▪ Possibly amended due to changes that affect the proposal cost.	+/- 30%

Project Stage	Cost estimation	Target order of accuracy#
	▪ Used to provide budgets for program management purposes. ▪ Used to compare various alternatives within a project.	
Concept	▪ Concept estimate: an estimate in current dollars prepared during the concept stage and the planning stage and finalised following the determination of the Environmental Impact Assessment and the finalisation of the project development. ▪ Must be reported in the project development proposal (PDP). ▪ Possibly amended during the concept or land acquisition stages due to changes that affect the proposal cost. ▪ Determines viability of projects through cost/benefit values. ▪ Used to monitor and compare costs in project-value engineering.	+/- 20%
Detailed	▪ Detailed estimate: the total estimate (in current dollars) of all project aspects prepared prior to commencement of construction. ▪ Based on final designs, detailed quantities, other costs. ▪ Must be reported in the project implementation report. ▪ Possibly amended during the detailed design, public utility adjustment or construction stages due to changes in project cost. ▪ Used to establish values for contracts. ▪ Used to establish cash flow and payment requirements.	+/- 10%
Construction	▪ Tender estimate: a subset of the detailed estimate and in most cases can be extracted directly from the detailed estimate. ▪ A contract estimate prepared before the tender box is opened to compare tender submissions. ▪ Reflection of the costs of work included in the advertised tender. ▪ Used to establish values for contract tender assessment.	+/- 10%

This is the target order of accuracy for infrastructure projects and is applicable to the total of quantity multiplied by the rate (before contingency). It does not account for risks (risks must be allowed in the contingency).

* If a tender estimate varies considerably (>5% or <90%) from the base cost of the equivalent portion of work in the detailed estimate, the detailed estimate must be reviewed, re-valued and submitted for concurrence (where applicable) and approval.

Source: RMS Project Estimating Manual v2.0, 2008

7.2.2 Estimation process

The route feasibility strategic estimates have been prepared according to the guidelines in the RMS Project Estimating Manual (2008) in particular Section 5 which details the requirements for strategic estimates.

Section 5.3.1 of the Manual states:

> *"The determination of the scope of the project is a very important requirement for a reliable estimate.*
>
> *Information such as the extent of the project, lane configuration, major structures, property issues, constraints, utilities and risks are ideally required in order to prepare a reasonable strategic estimate.*

The nature of strategic estimates is such that some if not all of this information will not be available and/or reliable at the strategic stage of the project proposal. In such instances, in order to complete the estimating process, the estimator must make appropriate assumptions that must be recorded."

The technical and construction investigations were undertaken in order to provide this required information. Other aspects of the project have not been defined in detail at this stage. Assumptions for these aspects have been applied consistently to the two routes to ensure comparability of the estimates.

7.2.2.1 Estimating process

Figure 7.1 summarises the process undertaken to develop a strategic cost estimate as outlined in the RMS Project Estimating Manual (2008) and applied in this investigation.

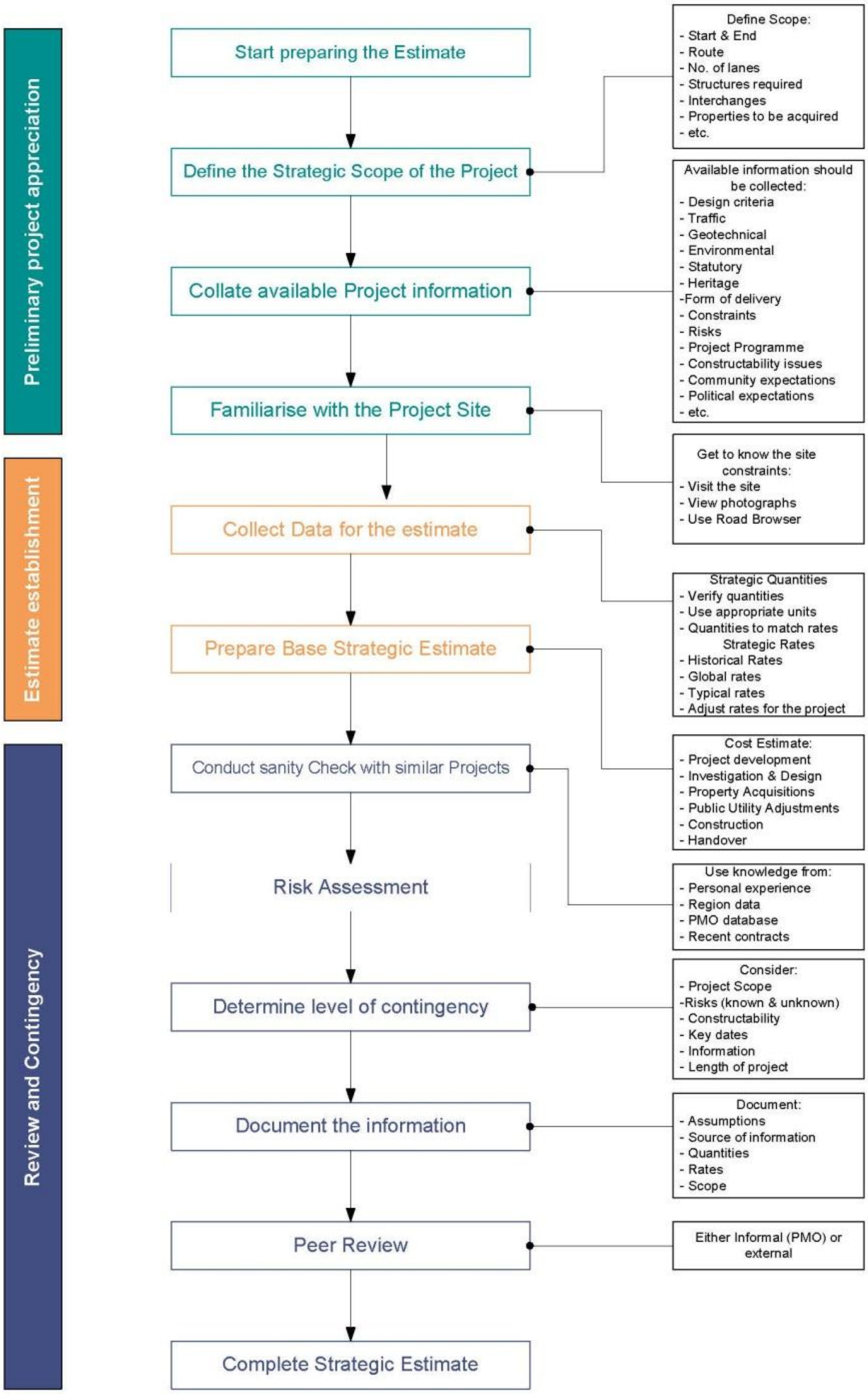


Figure 7.1 Strategic cost estimate flow chart

7.2.3 Estimate components

This section identifies the major components of an estimate and provides an explanation of their nature to aid understanding of the cost estimate process undertaken.

The overall cost of the project is calculated by estimating the values of a number of major components:

- Base estimate – The cost charged by a contractor to construct the physical scope of works of the project;
- Client costs – The amount required by the client (in this case RMS) to develop and manage the delivery of the project; and
- Contingency allowance – For a strategic estimate level, the average total contingency allowance is typically within the range of 40% to 70% of the total of the above amounts.

Shown below in Figure 7.2 is a diagrammatic representation of a typical project estimate build up, excluding contingency allowances.

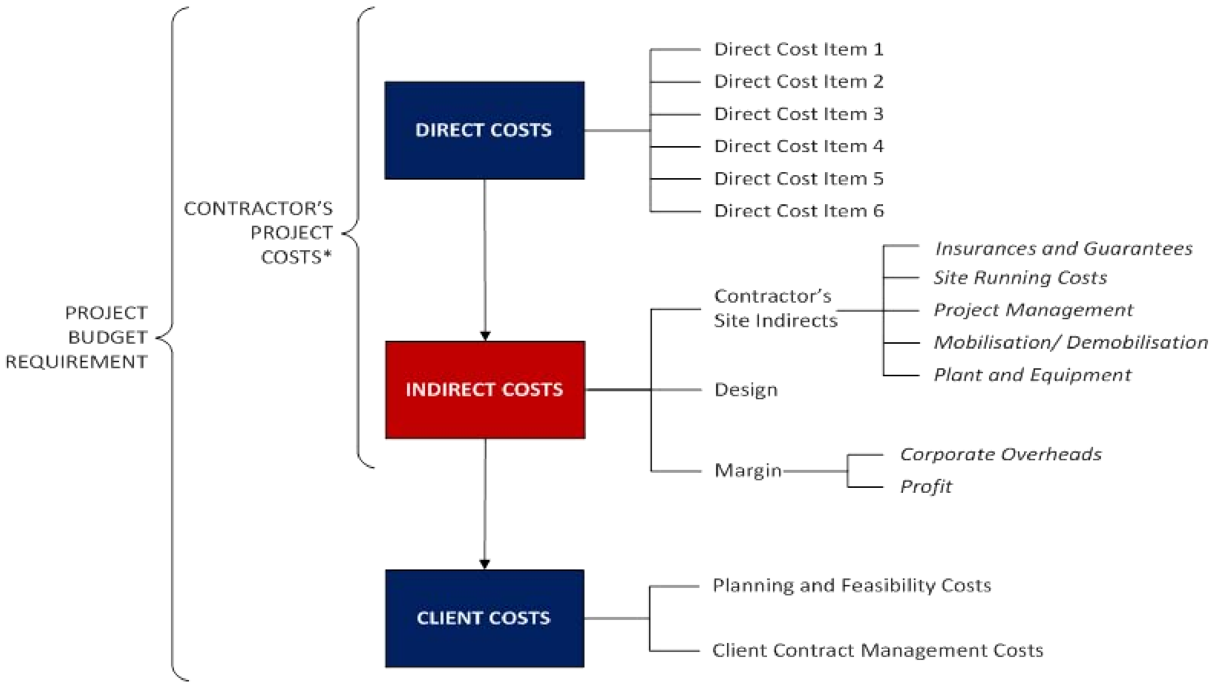


Figure 7.2 Typical estimate budget build-up

Base estimate (Contractor's project costs)

The base estimate consists of a number of sub components:

- Direct costs – The costs for the permanent works completed by a contractor required by the project scope. Determined by the summation of multiplying a scope item quantity against a unit rate to calculate an item amount;
- Indirect costs – The cost of the contractor's supervision and overheads to carry out the works required by the project scope;
- Design costs – The costs of any design by the contractor, over and above the initial concept design provided by the client, necessary for the project scope; and

- Contractors' margin

The first step in preparing the cost estimates involves defining the project scope for the northern route and the southern route. The Work Breakdown Structure (WBS) shown in Table 7.3 has been used to define the scope of the project. This was developed following the requirements of Section 5 of the RMS Project Estimating Manual (2008) and review of the physical constraints of each route, as described by the strategic concept designs.

Table 7.3 Typical Work Breakdown Structure (WBS)

Item	Description
10100	Public Utility Adjustments
10200	General
10300	Environmental
10400	Noise Mitigation
10500	Flood Mitigation
10600	Earthworks
10700	Drainage
10800	Pavements
10900	Structures
11000	Local Roads
11100	Urban Design & Landscaping
11200	Miscellaneous

Items that required specific consideration in the cost estimate include:

- Construction over soft ground;
- Construction over waterways / obstacles;
- Intersection and interchanges;
- Service roads; and
- Land acquisitions.

Other inputs used to compile the estimate include:

- Strategic concept design;
- Project program;
- Construction methods; and
- Proposed contract delivery method.

The practice of multiplying individual item quantities against unit rates to determine the total cost of that item is generically called "First Principles Estimating". This technique was used to calculate the value of each of the direct cost items listed above in Table 7.3. The other inputs listed above have an influence on the adopted unit rates for the items.

Client costs

The proposed elements for client costs were as follows:

- Project development;
- Investigation and design;
- Project management services for construction;

- Principal arranged insurances for construction;
- Acquisition costs;
- Client representation for construction; and
- Finalisation costs.

Allowances are generally made against the above items within the estimates. Value / percentage suggested in the RMS Project Estimating Manual have been adopted for these items suitable for the level of knowledge typical for a strategic estimate.

Contingency allowances

In line with the requirements of the RMS Project Estimating Manual, allowances for contingency have been included against major items of the estimate.

For estimating purposes, the RMS defines contingency as '*the sum of money allocated for dealing with unforeseen events*'. Contingency must take into consideration the confidence and reliability of the information used to prepare the estimate. It must also take the risks associated with the project into account. The higher the likelihood a risk will materialise and the higher the consequences of the residual risk, the higher the contingency.

A contingency allowance is applied to items based on certain assumptions during the cost estimating process. The contingency allowance determined is reviewed at each stage of the estimate and adjusted, if necessary, depending on the predicted probability and severity of the risk.

When preparing cost estimates, it is important to produce a high confidence estimate. The RMS' estimating policy requires that at each project stage the actual cost of a project must have a 90% probability of not exceeding the estimate prepared. When assessing contingencies, P90 values must be calculated.

Table 7.4 provides the RMS' appropriate levels of contingency for each project stage. Contingencies outside of the given ranges must be justified.

Table 7.4 Appropriate levels of contingency for each project stage

Stage	Estimate	Level of Contingency
Strategic	Strategic	40% - 70%
Concept	Concept	25% - 40%
Detailed	Detailed	15% - 25%
Construction	Tender	No allowance made – base cost only

Adopted contingency levels on Project

The contingencies factors applied to the P90 route feasibility strategic estimates are detailed below in Table 7.5 for both the northern and southern routes.

Table 7.5 Contingency allowances used in the cost estimate

Item Description	Contingency Allowance *		
	Northern Route	Southern Route	Comments
Public Utility Adjustments	100%	100%	Similar level of information
General	40%	40%	As above
Environmental	50%	50%	As above
Noise Mitigation	40%	50%	No noise study for Southern Route
Flood Mitigation	100%	100%	Similar level of information
Earthworks	60%	75%	Potential imbalance in Southern Route Mass Haul quantities
Drainage	60%	60%	Similar level of information
Pavements	40%	40%	As above
Structures	40%	40%	As above
Local Roads	50%	50%	As above
Urban Design & Landscaping	40%	40%	As above
Miscellaneous	40%	40%	As above
Contractor's Design Costs	50%	50%	As above
Contractor's Indirect time related costs	40%	40%	As above
Contractor's Margin	40%	40%	As above
Primary testing (RMS)	40%	40%	As above
Independent design verification (RMS)	40%	40%	As above
Handover (RMS) costs	40%	40%	As above
Property Acquistion (RMS) costs	11%	18%	Differences in certainty for purchase and sale values
Client (RMS) costs	40%	40%	Similar level of information

*These contingencies applied to individual line items for base estimate and client costs.

7.2.4 Comparison of RMS' approach to other Australian States

This section compares the RMS' approach to estimating against that adopted by road infrastructure agencies in other Australian States which identifies that the RMS approach is broadly consistent with that taken by other agencies. The agencies discussed here and the relevant manuals are:

- Government of South Australia Department of Planning, Transport and Infrastructure – Estimating Manual, Road and Rail Projects, March 2012;
- Queensland Government Department of Main Roads – Project Cost Estimating Manual Fourth Edition, July 2009.

The manuals examined all provide a similar approach to cost estimating. The manuals explain the principles of cost estimating, followed by a description of how to prepare estimates at different project stages and introducing a standard process to follow.

Table 7.6 lists the estimating stages for each State's manual. Although the number of estimate stages varies depending on the manual, an estimate is still provided for each stage of the project lifecycle – pre-project, concept, planning, implementation and finalisation.

Table 7.6 Comparison of project stages

NSW	QLD	SA
▪ Strategic ▪ Concept ▪ Detailed ▪ Tender	▪ Strategic ▪ Proposal ▪ Options analysis ▪ Business case ▪ Preliminary design ▪ Detailed design ▪ Procurement ▪ Implementation ▪ Finalisation	▪ Strategic ▪ Preliminary options ▪ Preliminary concept ▪ Concept ▪ Planning ▪ Detailed ▪ Pre-tender

Estimating policy - P90 values

A key difference in estimating policies is that RMS requires estimates at all project stages be prepared for a P90 confidence level. The manuals examined from Queensland and South Australia requires a confidence level of P90 to be calculated only on estimates after the preliminary options stage. The RMS policy is generally more rigorous than the requirements of those other manuals, and what is typically observed in the estimating industry. This policy is implemented by the RMS to ensure that the cost estimate is as accurate as possible using the available information.

Level of contingency

The level of contingency for each project stage shown in Table 7.7 is similar to those shown in the RMS estimating manual.

Table 7.7 Comparison of contingency levels

Stage	Estimate	Level of Contingency		
		NSW	**OLD**	**SA**
Strategic	Strategic	35% - 70%	40-70%	40-70%
Concept	Concept	25% - 40%	30-40%	0-40%
Detailed	Detailed	15% - 25%	10-30%	
Construction	Tender	No allowance made – base cost only	No allowance made – base cost only	No allowance made – base cost only

7.2.5 Peer reviews

As part of the strategic cost estimate process, peer reviews were conducted. Three reviews were undertaken – an initial review, intermediate review and final review. These were conducted progressively throughout the duration of the estimating process as the level of information and understanding increased. Participants in the reviews included TIG members and members of the independent review team (SMEC & PMO).

7.3 Results

This section provides the details of the route feasibility cost estimates prepared for the two routes. Table 7.8 and Table 7.9 summarise the cost estimates developed for the whole Foxground and Berry Bypass project, incorporating the northern route and the southern route for the Berry Bypass respectively. Appendix H1 provides additional detail of these cost estimate figures.

As required by the RMS Estimating Manual, the estimates have been prepared to a P90 confidence level, with an assessment of a 90 per cent probability that the cost would come in at or below the estimated costs given. Appropriate contingencies have been applied. The cost estimate results are presented in the standard format defined by the RMS to ensure consistency in the comparison of the two routes.

Table 7.8 Estimate summary sheet - northern route

Project: Berry Bypass, Strategic Route Feasibility, Northern Option

Estimate Prepared by: Evans & Peck (PJ)
Quantities Prepared by: Aecom
Design Prepared by: Aecom

Project No: D/00386 | Date: 27/06/2012 | Estimate Type: Strategic Route Feasibility

Item	Base Estimate (excluding contingency)	Contingency %	Contingency Amount	Estimate (including contingency)	% of Total Estimate	Comments/Assumptions
1. Concept Development						
1 (a) Route/Concept/EIS	$0	0%	$0	$0		Refer Note 1. below
1 (b) Project Management Services	$2,006,404	40%	$802,562	$2,808,966		
1 (c) Sponsor	$0	0%	$0	$0		Incl. in above item
1 (d) Community Liaison	$500,000	40%	$200,000	$700,000		Allowance RMS
Sub total	$2,506,404	40%	$1,002,562	$3,508,966	0.64%	
2. Detail Design & Documentation						
2 (a) Investigation and Design	$30,528,679	44%	$13,451,556	$43,980,235		Contractor's design costs + Primary Testing + Design IV
2 (b) Project Management Services	$1,221,147	40%	$488,459	$1,709,606		Allowance 4% of Investigation and design costs
2 (c) Sponsor	$0	0%	$0	$0		Incl. in above item
Sub total	$31,749,827	44%	$13,940,015	$45,689,841	8.38%	
3. Property Acquisitions						
3 (a) Acquire Property	$21,900,000	11%	$2,440,000	$24,340,000		Value provided by RMS
3 (b) Professional Services for Property	$0	0%	$0	$0		Incl. in above item
3 (c) Project Management Services	$0	0%	$0	$0		Incl. in above item
3 (d) Sponsor	$0	0%	$0	$0		Incl. in above item
Sub total	$21,900,000	11%	$2,440,000	$24,340,000	4.46%	
4. Utility Adjustments						
4 (a) Adjust Utilities	$3,681,542	82%	$3,032,617	$6,714,158		Refer to "RMS Infrastructure - Northern" worksheet for detail
4 (b) Project Management Services	$73,631	40%	$29,452	$103,083		Allowance 2% of Utilities costs
4 (c) Sponsor	$0	0%	$0	$0		Incl. in above item
Sub total	$3,755,172	82%	$3,062,069	$6,817,241	1.25%	
5. Infrastructure Construction						
5(a) - 5(c) Infrastructure	$295,550,200	44%	$129,861,248	$425,411,448		Refer to "RMS Infrastructure - Northern" worksheet for detail
5(d) Adjustment Sums (Including markup and contingency)	$0	0%	$0	$0		Additional items to base case scope
5(e) Provisional Sums (Including markup and contingency)	$17,307,083	50%	$8,648,110	$25,955,193		Refer to Note 3. below
5(f) Project Management Services	$11,822,008	40%	$4,728,803	$16,550,811		Allowance 4% of Construction costs
5(g) Sponsor	$0	0%	$0	$0		Incl. in above item
5(h) PA Insurance	$5,024,612	40%	$2,009,845	$7,034,456		PA Insurance allowed 1.0% of Project Costs
Sub total	$312,396,820	44%	$136,599,895	$448,996,715	82.32%	
6. Finalisation						
6 (a) Refurbish old route	$7,443,086	47%	$3,502,884	$10,945,970		Refer to "RMS Infrastructure - Northern" worksheet for detail
6 (b) Project data and post completion review.	$3,242,341	40%	$1,296,937	$4,539,278		Handover (RMS) Costs
6 (c) Project Management Services	$427,417	40%	$170,967	$598,384		Allowance 4% sum item 6(a) & 6(b) costs
6 (d) Sponsor	$0	0%	$0	$0		Incl. in above item
Sub total	$11,112,844	45%	$4,970,788	$16,083,632	2.95%	
TOTAL	**$383,421,068**	**42%**	**$162,015,329**	**$545,436,397**		

TOTAL PROJECT ESTIMATE: $546,000,000

Project Management:	$22,470,850	4.1%
Sponsor:	$0	0.00%

Length of the Project: 12.8 km
51.2 lane-km

Reality Costs:

	Base cost	Estimate with contingency
1. Cost per km	$29,954,771	$42,612,218
2. Cost per lane-km	$7,488,693	$10,653,055
3. Cost per m^2 of bridge deck area	$3,172	$4,441
4. Cost of earthworks /m^3	$37	$59
5. Cost of pavement /m^2	$186	$261
6. Cost of drainage /m	$584	$934

NOTE:
1. Costs for Route/Concept/EIS covered by Client Project Management Services (Item 1(b))
2. Sponsor costs NOT included in this estimate
3. Provisional Sum amount NOT incl. in Project Estimate total because derived from a discretionary item currently under consideration

Table 7.9 Estimate summary sheet - southern route

Project: Berry Bypass, Strategic Route Feasibility, Southern Option

Estimate Prepared by: Evans & Peck (PJ)
Quantities Prepared by: Aecom
Design Prepared by: Aecom

Project No: D/00386 | **Date:** 27/06/2012 | **Estimate Type: Strategic Route Feasibility**

Item	Base Estimate (excluding contingency)	Contingency %	Contingency Amount	Estimate (including contingency)	% of Total Estimate	Comments/Assumptions
1. Concept Development						
1 (a) Route/Concept/EIS	$0	0%	$0	$0		Refer Note 1. below
1 (b) Project Management Services	$2,325,499	40%	$930,200	$3,255,698		
1 (c) Sponsor	$0	0%	$0	$0		Incl. in above item
1 (d) Community Liaison	$750,000	40%	$300,000	$1,050,000		Allowance RMS
Sub total	$3,075,499	40%	$1,230,200	$4,305,698	0.61%	
2. Detail Design & Documentation						
2 (a) Investigation and Design	$44,591,758	44%	$19,744,610	$64,336,368		Contractor's design costs + Primary Testing + Design IV
2 (b) Project Management Services	$1,783,670	40%	$713,468	$2,497,138		Allowance 4% of Investigation and design costs
2 (c) Sponsor	$0	0%	$0	$0		Incl. in above item
Sub total	$46,375,429	44%	$20,458,078	$66,833,506	9.40%	
3. Property Acquisitions						
3 (a) Acquire Property	$19,300,000	18%	$3,440,000	$22,740,000		Value provided by RMS
3 (b) Professional Services for Property	$0	0%	$0	$0		Incl. in above item
3 (c) Project Management Services	$0	0%	$0	$0		Incl. in above item
3 (d) Sponsor	$0	0%	$0	$0		Incl. in above item
Sub total	$19,300,000	18%	$3,440,000	$22,740,000	3.20%	
4. Utility Adjustments						
4 (a) Adjust Utilities	$4,857,935	83%	$4,014,674	$8,872,609		Refer to "RMS Infrastructure - Southern" worksheet for detail
4 (b) Project Management Services	$97,159	40%	$38,863	$136,022		Allowance 2% of Utilities costs
4 (c) Sponsor	$0	0%	$0	$0		Incl. in above item
Sub total	$4,955,094	82%	$4,053,537	$9,008,631	1.27%	
5. Infrastructure Construction						
5(a) - 5(c) Infrastructure	$404,144,165	50%	$200,566,450	$604,710,615		Refer to "RMS Infrastructure - Southern" worksheet for detail
5(d) Adjustment Sums (Including markup and contingency)	-$32,922,131	55%	-$18,228,156	-$51,150,287		Additional items to base case scope
5(e) Provisional Sums (Including markup and contingency)	$0	0%	$0	$0		Refer to NOTE 3. below
5(f) Project Management Services	$16,165,767	40%	$6,466,307	$22,632,073		Allowance 4% of Construction costs
5(g) Sponsor	$0	0%	$0	$0		Incl. in above item
5(h) PA Insurance	$7,136,901	40%	$2,854,760	$9,991,661		PA Insurance allowed 1.0% of Project Costs
Sub total	$394,524,702	49%	$191,659,360	$586,184,062	82.48%	
6. Finalisation						
6 (a) Refurbish old route	$7,803,089	47%	$3,675,795	$11,478,884		Refer to "RMS Infrastructure - Southern" worksheet for detail
6 (b) Project data and post completion review.	$6,654,764	40%	$2,661,905	$9,316,669		Handover (RMS) Costs
6 (c) Project Management Services	$578,314	40%	$231,326	$809,640		Allowance 4% sum item 6(a) & 6(b) costs
6 (d) Sponsor	$0	0%	$0	$0		Incl. in above item
Sub total	$15,036,166	44%	$6,569,027	$21,605,193	3.04%	
TOTAL	**$483,266,889**	**47%**	**$227,410,202**	**$710,677,091**		

TOTAL PROJECT ESTIMATE: **$711,000,000**

Project Management:	$21,700,409	3.1%
Sponsor:	$0	0.00%

Length of the Project: 12.8 km
51.2 lane-km

Reality Costs:

	Base cost	Estimate with contingency
1. Cost per km	$37,755,226	$55,521,648
2. Cost per lane-km	$9,438,806	$13,880,412
3. Cost per m^2 of bridge deck area	$2,822	$3,950
4. Cost of earthworks /m^3	$55	$97
5. Cost of pavement /m^2	$186	$260
6. Cost of drainage /m	$605	$967

NOTE:
1. Costs for Route/Concept/EIS covered by Client Project Management Services (Item 1(b))
2. Sponsor costs NOT included in this estimate
3. Provisional Sum amount NOT incl. in Project Estimate total because derived from a discretionary item currently under consideration

7.3.1 Major cost components

This section identifies the major cost components for the two estimates. Table 7.10 and Table 7.11 identify the cost components and their relative contributions to the northern and southern route estimates.

These tables show that the majority of the cost for both estimates is contributed by a small number of cost items. This can be described in terms of the "Pareto Principle" or 80-20 rule, that "for many events, roughly 80% of the effects come from 20% of the causes." This principal has guided the investigations undertaken, with the greatest emphasis on the items contributing significant proportions of the estimate.

Table 7.10 Ranked major contributors - northern route

Rank	Description	Northern Option			
		Amounts		Cumulative values	
		$	%	$	%
1	General	$143.7	26.3%	$143.7	26%
2	Structures	$138.5	25.4%	$282.1	52%
3	Earthworks	$96.7	17.7%	$378.8	69%
4	Pavements	$66.8	12.3%	$445.7	82%
5	Miscellaneous	$22.2	4.1%	$467.9	86%
6	Drainage	$22.0	4.0%	$489.9	90%
7	Urban Design & Landscaping	$19.8	3.6%	$509.7	93%
8	Environmental	$12.2	2.2%	$521.9	96%
9	Local Roads	$10.9	2.0%	$532.8	98%
10	Public Utility Adjustments	$6.7	1.2%	$539.5	99%
11	Noise Mitigation	$5.7	1.1%	$545.3	100%
12	Flood Mitigation	$0.2	0.0%	$545.4	100%
	TOTAL	$545.4		$436.3	80% Value

Table 7.11 Ranked major contributors - southern route

Rank	Description	Southern Option			
		Amounts		Cumulative values	
		$	%	$	%
1	Earthworks	$238.0	33.5%	$238.0	33%
2	Structures	$183.4	25.8%	$421.4	59%
3	General	$125.4	17.6%	$546.7	77%
4	Pavements	$63.0	8.9%	$609.8	86%
5	Miscellaneous	$21.6	3.0%	$631.4	89%
6	Drainage	$20.6	2.9%	$652.0	92%
7	Urban Design & Landscaping	$19.9	2.8%	$671.9	95%
8	Environmental	$15.9	2.2%	$687.9	97%
9	Local Roads	$11.5	1.6%	$699.3	98%
10	Public Utility Adjustments	$8.9	1.2%	$708.2	100%
11	Noise Mitigation	$2.3	0.3%	$710.5	100%
12	Flood Mitigation	$0.2	0.0%	$710.7	100%
	TOTAL	$710.7		$568.5	80% Value

For both routes, the four items that together contribute over 80% of the cost estimate are:

(1) Earthworks;

(2) Structures;

(3) General; and

(4) Pavements.

The ‘General’ item consists predominately of client costs including concept development, detailed design & documentation, land acquisition and finalisation.

7.3.2 Provisional items

Design development for the Foxground and Berry Bypass project was ongoing through this investigation. The design for the project incorporated a northern route that was being refined in consultation with the community. The design for a southern route, produced as part of this investigation was developed and optimised as results from the technical and construction investigations became available, in order to achieve a cost effective and compliant design.

However for both routes, there were proposed design amendments during the investigation that could not have been incorporated into the base case route designs without delaying the completion of cost estimate preparation. Therefore during the investigation process, design changes to the initial “base case” routes were included where feasible. In other cases Provisional Items were created to allow investigation and costing of the items within the time available. These items were not developed to the same extent as the “base case” design and their costs necessarily attracted a higher level of contingency. These costs have been shown separately in the estimates.

The provisional items were identified, however they were not fully costed to the extent of the base case given the time restraints of developing this report.

The TIG prepared relevant design, technical and construction information for each of the provisional items in order to assess the cost impact. An assessment was made regarding the likelihood of the item being progressed to a greater level of detail and understanding in the next stage of design development. The result is a division of the provisional items into adjustment sums and provisional sums. This process is shown in Figure 7.3 as a flow chart.

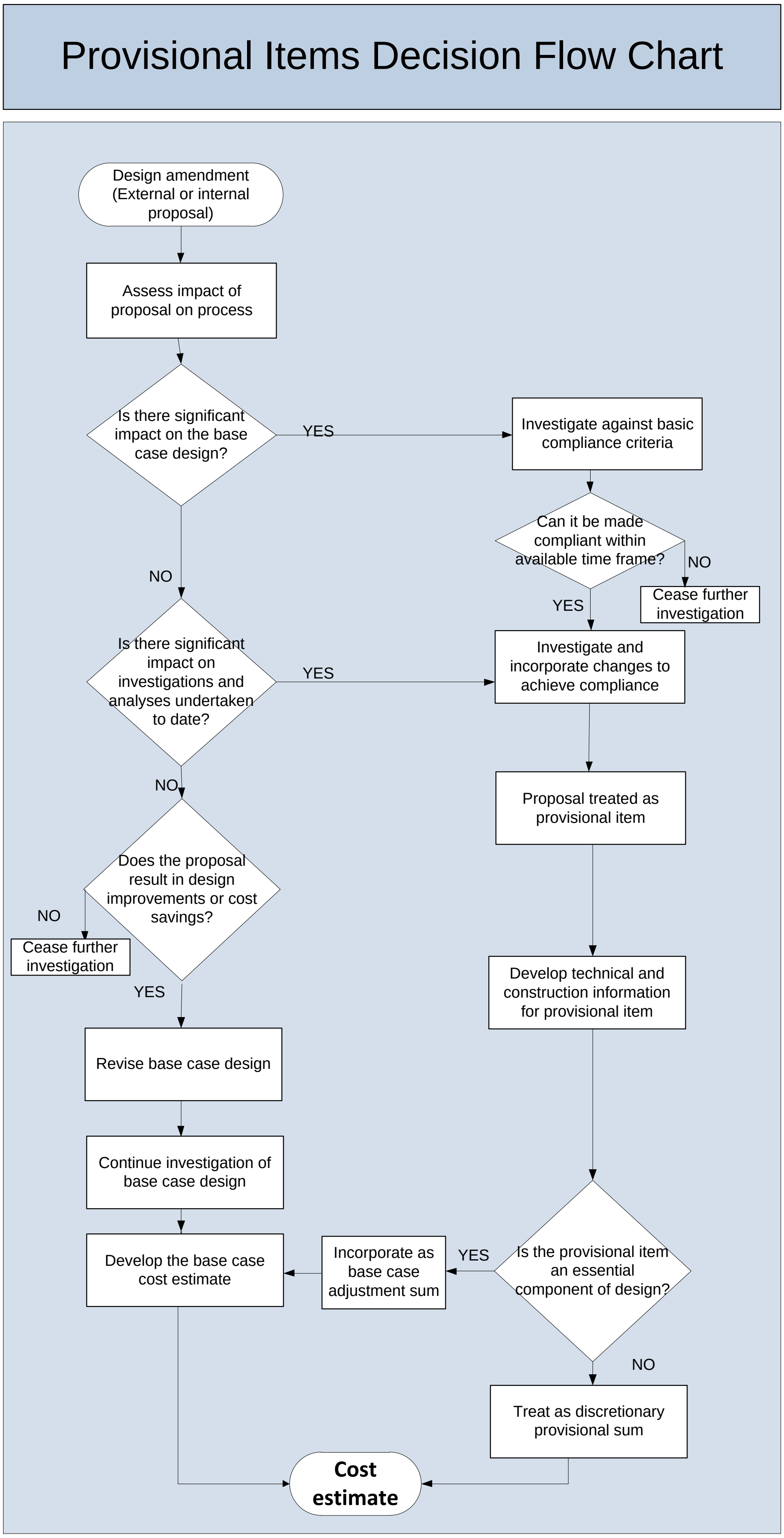


Figure 7.3 Provisional Items Decision Flow Chart

The adjustment sums are for provisional items assessed as likely to be in the next stage of design development. They have been included within the project estimate for the northern and southern routes in Table 7.8 and Table 7.9 at Item 5(d).

The provisional sums are those items that are discretionary requiring more design development and further consideration and do not contribute to the project estimate. The provisional sums are listed in Table 7.8 and Table 7.9 at Item 5(e).

The relative benefits and drawbacks of each provisional item are discussed in Section 4.4 of this report. The provisional items are summarised below in Table 7.12 as they apply to each of the northern and southern routes, and defined as either adjustment sums or provisional sums for the purpose of the project estimate.

Table 7.12 Provisional items – Adjustment sums (incorporated) and provisional sums (not incorporated)

Provisional Item Description	Amounts $m		Comments
ADJUSTMENT SUMS	**Northern Option**	**Southern Option**	
E/O Reroute alignment south of STP	$0.0	$9.6	Diversion of route south of sewerage treatment plant. Requires extra 200m length of road
E/O Island embankment	$0.0	-$5.6	Inclusion of an island embankment to replace part of the viaduct
E/O Realignment of Northern interchange	$0.0	-$2.3	Alternative earthworks design for northern interchange (Zone 1) to generate additional fill
E/O Changes to vertical alignment to generate extra fill material	$0.0	-$55.1	Balanced 'Mass Haul' for southern option
E/O Adjustment to Southern Interchange	$0.0	-$15.1	Alternative alignment for southern interchange (Zone 3) to reduce embankment fill requirements
TOTAL ADJUSTMENT SUMS	**$0.0**	**-$51.2**	
PROVISIONAL SUMS			
Additional pedestrian bridge	$4.5	$0.0	Addition of North Street pedestrian bridge cost
Northbound offload ramp to Woodhill Mountain Road	$0.4	$0.0	Second offload ramp to Woodhill Mountain Road land purchase cost
E/O Adjustments to Kangaroo Valley Road (KVR) Interchange	$15.8	$0.0	Split KVR interchange construction cost
E/O Adjustments to Kangaroo Valley Road (KVR) Interchange	$5.2	$0.0	Configuration of off-ramp under interchange overbridge

NOTE:
1. Adjustment Sums items HIGHLIGHTED are included in scope of item HIGHLIGHTED
2. Above amounts are inclusive of contingency allowances
3. E/O refers to "Extra / Over" base case estimate

7.3.3 Reasons for cost estimate differences

This section provides commentary on the differences in the cost estimates for the two routes. This commentary identifies the key differences in characteristics of the two routes and how this results in cost estimate differences.

7.3.3.1 Public utility adjustments

The estimate item consists of a further subdivision into seven (7) sub-items; Water, Sewerage, Stormwater, Power, Telecommunications, Gas and Other. Between the northern and southern routes, there are varying occurrences and associated costs for the various sub-items. The main difference in cost is a higher allowance for adjustments to existing telecommunications services on the southern route.

7.3.3.2 General

The estimate item consists of a further subdivision into four (4) sub-items; Mobilisation & Establishment, Community Liaison, Management Plans & Traffic Control. It is assumed that significantly more traffic control measures will be required for the northern route due to its proximity to the Berry township and impact on local traffic.

7.3.3.3 Environmental

The estimate item consists of a further subdivision into seven (7) sub-items; Building Condition Reports, Site Monitoring, Erosion & Sedimentation Control, Treat contaminated water & discharge water, Maintenance, Fauna Control Measures and Other Temporary Works. Minor plus and minuses exist between the two routes for the first six (6) sub-items; however the major difference is the allowance for temporary environmental works required for the southern route associated with the increased number and size of the bridge structures.

7.3.3.4 Noise mitigation

The estimate item consists of a further subdivision into three (3) sub-items; Properties, Noise Walls (Solid) and Noise Walls (Transparent). No allowance for transparent noise walls has been included in either route estimates currently. The major difference with this item is the allowance for treatments to affected properties and additional length of solid noise walls in the southern route.

7.3.3.5 Flood mitigation

The estimate item consists of a single sub-item. There is no difference between the northern and southern routes. The same number of houses is assumed to be affected in each. It is suggested that further studies may be necessary to confirm this assumption.

7.3.3.6 Earthworks

The estimate item consists of a further subdivision into ten (10) sub-items, Clearing & Grubbing, Topsoil, General Earthworks, Removal and Treatment of Acid Sulphate Soils, Temporary Access Roads, Select Material, Batter Stabilisation Works, Temporary Dewatering, Ground Improvements & Preloading. As noted in Section 6 – Construction Investigations, detailed mass haul calculations were carried out for both the northern and southern route designs to determine the scope, quantity and rate for the various earthworks activities. The result was a substantial difference in the overall earthworks rate between the northern and southern routes of $59/m^3 and $97/m^3 respectively. A separate mass haul was calculated on an amended vertical alignment for the southern route to achieve an earthworks balance, resulting in a substantial cost reduction ($55.1m) as shown in Table 7.12 above.

Differing soft ground treatments required for the northern and southern routes also contribute to the higher cost of earthworks on the southern route.

7.3.3.7 Drainage

The estimate item consists of a further subdivision into nine (9) sub-items; Excavation, Precast Reinforced Concrete Pipe (RCP), Reinforced Concrete Box Culverts (RCBC), Drainage Pits, Concrete Lined Catch Drains, Open Drains, Rock-filled Gabions & Mattresses, Diversion of Town Creek and Secondary Drainage Structure – Property Underpass. Apart from the Diversion of Town Creek which is only required for the northern route, the difference in rate for drainage works was predominately due to length of surface drainage required, i.e. the shorter structure for Berry bridge on the northern route and subsequent greater length of surface works results in a higher value for drainage works.

7.3.3.8 Pavements

The estimate item consists of a further subdivision into five (5) sub-items; Remove existing Princes Highway Pavements, Stabilised Base Layer 275mm, Asphalt, Cold Milling and Subgrade and Sub-pavement Drainage. This item has similar logic to the previous drainage item, i.e. longer lengths of surface works equates to a higher cost of pavements for the northern route. It should be noted that the scope for removal of the existing Princes Highway pavements is the same for both routes as it only covers the area in Zone 1 which is common to both. A separate item for the flood immunity works on the existing Princes Highway for the southern route is included under the Local Roads item below.

7.3.3.9 Structures

The estimate item consists of a further subdivision into two major sub-items; Bridge structures and Reinforced Soil Walls. For the northern and southern routes there are ten and eleven major structures respectively. The average rate for the bridge structures are $4,441 per m^2 and $3,950 per m2 of bridge deck area for the northern and southern routes respectively. The lower rate for the southern route is achieved by the 'economies of scale' generated by the longer 1,200 metre viaduct Berry bridge for the southern route compared to the shorter 600 metre Berry bridge for the northern route. However due to the greater quantum of bridge deck area required for the southern route, there is a $44.9 million difference in the cost of the structures for the two routes.

7.3.3.10 Local roads

The estimate item consists of a further subdivision into two (2) sub-items common to both routes; Local Roads – Pavement Type 1 and Local Road Repairs, and a third sub-item for the southern route; Existing Princes Highway Flooding Immunity. The additional sub-item is to allow for access to the township of Berry from the new bypass alignment proposed in the southern route during a flooding event. This additional sub-item is the primary cause of the cost difference for Local Roads between the two routes.

7.3.3.11 Urban design & landscaping

The estimate item consists of a further subdivision into three (3) sub-items; Urban Design, Landscaping and Vegetation. The difference in road corridor area requiring landscaping and revegetation is the cause of the cost difference between the two routes for this item, i.e. the higher and longer embankments on the southern route in Zone 2 and 3 across the floodplain increase the area of landscaping required.

7.3.3.12 Miscellaneous

The estimate item consists of a further subdivision into ten (10) sub-items; Demolition, Minor Concrete Works, UPVC Ducts, Guide Posts, Safety Barriers, Pavement Markings, Signposting, Street Lighting, Fencing, Property Adjustments, Heavy Vehicle Rest Area (HVRA) and Other. Minor pluses and minuses exist between the two routes for the ten sub-items. The cause of these differences is a similar logic to the previous drainage item – longer length of surface works equates to a greater cost for the northern route.

7.3.3.13 Provisional items

As noted above in Section 7.3.2 the provisional items are design changes to the initial "base case" routes which will require further design development to be properly evaluated (refer to process shown in Figure 7.3). They are not currently included in the cost estimate as it has not been determined if they are technically compliant. The Adjustment Sums all relate to amending issues in the base case southern route, i.e. community concerns about access, imbalances in the earthworks volumes as demonstrated by the mass haul calculations, and attempts to address these issues. Preliminary costing has been conducted on these items to determine their viability hence the inclusion within the Project Estimate amount. Some of the adjustment sums have common scopes. If the maximum Adjustment Sums are realised the result is a cost saving of $51.2 million to the southern route.

The provisional sums are discretionary items which could all be added to the base case northern route and relate to community requests to enhance interchanges and pedestrian access. Preliminary costing has been conducted on these items to determine their cost impact if adopted. The maximum cost of the provisional items is $20.7 million and all these items apply only to the northern route.

The provisional items are discretionary and relate to community requests for enhancing interchanges and pedestrian access. The maximum cost of these items is $20.7 million and only applies to the northern route.

7.3.4 Benchmarking against similar road projects

The cost estimates produced have been benchmarked against the costs of other RMS projects. This benchmarking has been performed on a relative basis using cost per lane km. This is a very high level benchmarking exercise intended to provide a context for the estimates produced. It does not go into a level of detail that includes the extent of structures required, ground conditions, or other factors that are key determinants of cost. The rates for the northern & southern routes and values from a selection of similar road projects are detailed in Table 7.13.

Table 7.13 Benchmarking

Item	Project Name	Road Name	Amount $m	Lane Km's	$m per lane km	Adjusted rate $ 2012
1	Coopernook to Herons Creek	Pacific Highway	$567.1	125.0	$4.5	$5.0
2	Oakflats to Dunmore	Princes Highway	$99.1	23.0	$4.3	$4.8
3	Conjola Mt	Princes Highway	$52.4	9.0	$5.8	$6.4
4	Berry Bypass - Northern Option	Princes Highway	$324.2	51.2	$6.3	$6.3
5	Berry Bypass - Southern Option	Princes Highway	$443.7	51.2	$8.7	$8.7

The data contained in the Table 7.13 has been analysed to calculate the following results, shown in Table 7.14.

Table 7.14 Summary of benchmarking results

Contract price $m per lane km	
Mean	$5.9
Median	$5.8
Highest Amount	$8.7
Lowest Amount	$4.3

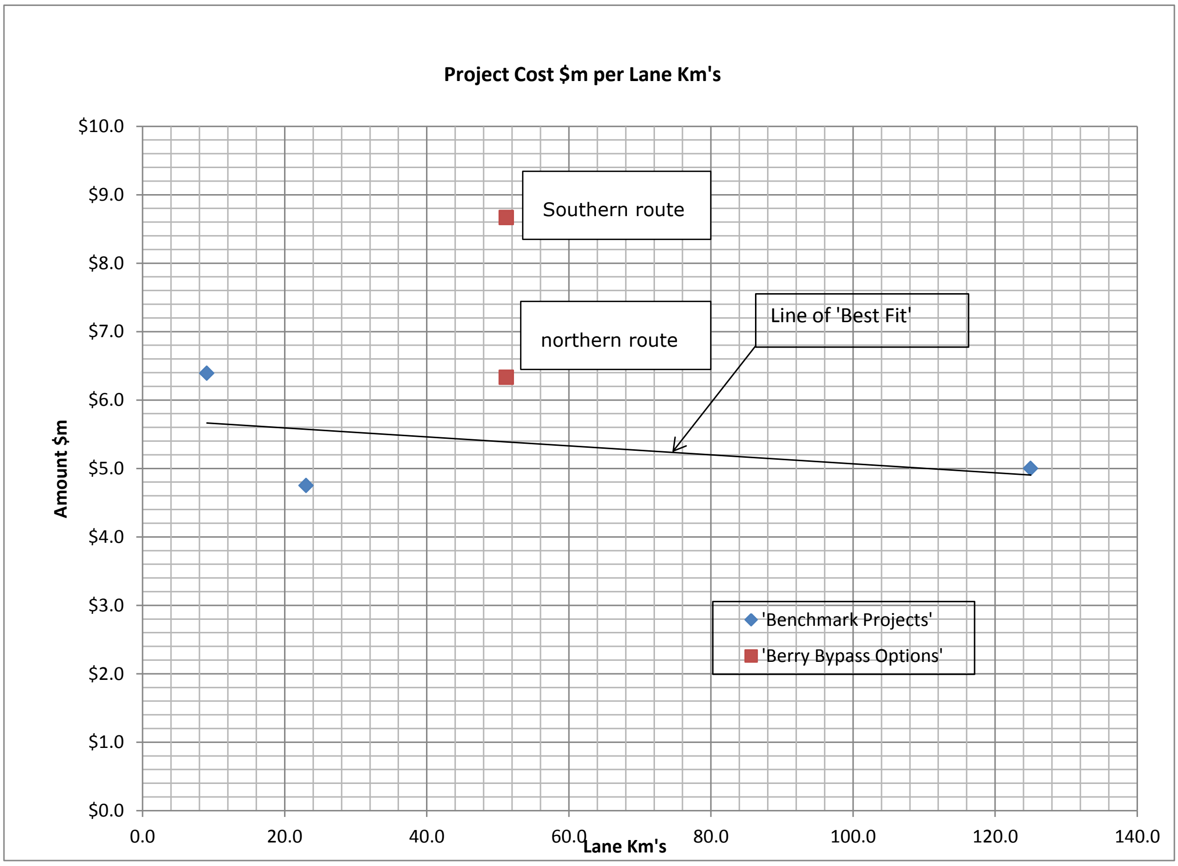


Figure 7.4 Graph of benchmarking data

The data used in the above table and Figure 7.4 are construction costs, i.e. contract prices, and exclude client costs for project management, and land acquisition. As shown in the graph the rate for the Foxground and Berry Bypass northern route and southern route are higher than average result of the three benchmarked projects, as represented by the 'Line of Best Fit' shown in Figure 7.4. This is assessed to be in part due to both the estimates being preliminary estimates with the associated higher levels of contingency applied, as compared to the actual construction costs. The value for the northern route at $6.3m per lane km is not significantly higher than mean value of the projects at $5.9m per lane km. For the southern route costing $8.7m per lane kilometre there is a significant difference to the mean value. Potential reasons for this difference could include the greater amounts of structures and earthworks required for the southern route.

8 Conclusion

The route feasibility comparison produced two strategic level cost estimates for the whole Foxground and Berry Bypass project cost, the first with the cost impact of the preferred northern route for the Berry Bypass and secondly the cost impact of the suggested southern route.

Incorporating the southern route requires that the overall length of the 11.6km Foxground and Berry Bypass section be extended by approximately 1.2km to 12.8km, with the bypass rejoining the Princes Highway alignment at Croziers Road. To ensure like-for-like comparisons for the purposes of the investigation, the same end point was applied for the estimate incorporating the northern route.

The strategic cost estimates for the Foxground and Berry Bypass project incorporating each route (and excluding provisional items) are:

- $545m for the preferred northern route; and
- $711m for the suggested southern route.

Prior to this investigation, the Foxground and Berry Bypass project incorporating the bypass to the north of Berry had been developed to concept design level. Therefore much of the TIG's investigations focused on preparing information for the southern route to a level comparable with the Foxground and Berry Bypass concept design. This report describes the development of the design for the southern route to establish a "base case" from which technical criteria could be investigated. Subsequent design revisions to the initial "base case" identified during the investigation process were included where feasible. In other cases provisional items were created to allow investigation and costing within the time available.

The technical investigations focused on the areas with significant cost impact. These areas were flooding impacts, geotechnical conditions and utility interfaces. Construction investigations were undertaken to develop equivalent indicative information for the two routes on the likely required land acquisitions, construction methods and the time taken to deliver them.

This report has been delivered to the RMS Director Infrastructure Development Division.

The integrity and quality of the group's investigations were assessed throughout by independent reviewers who were appointed to oversee the process and specific technical aspects of the investigation. The independent reviewers provided ongoing feedback during the investigation process, witnessing the TIG's meetings, participating in reviews and community meetings and ensuring the TIG addressed issues raised by the community. This report has been submitted to the independent review team which has scrutinised it to ensure the investigation process has been thorough and impartial. The findings of the independent review team will subsequently be advised to the RMS Executive through its sponsor, RMS General Manager Project Development, who will then make a recommendation about the way forward to the NSW Government.