New England Highway Muswellbrook Bypass

Options Report

Roads and Maritime Services | July 2018

NSW GOVERNMENT

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1. Executive summary

The New England Highway passes through the town centre of Muswellbrook, which is about 127 kilometres north-west of Newcastle with a population of around 13,000. The New England Highway forms part of the inland National Land Transport Network (NLTN) which is a key freight route between Sydney and Brisbane.

Currently highway traffic passes through six traffic lights, a roundabout, a school zone, under a narrow railway overpass, and through a flood prone section of the highway at Muscle Creek which all impact on travel time. The narrow railway underpass poses limitations for over-size over-mass (OSOM) vehicles which are required to use alternate routes around the town.

Taking these issues into consideration, the following objectives are specific to a bypass of Muswellbrook:

- Improve network efficiency on the New England Highway, particularly travel times for long haul freight movements
- Improve safety for all road users in the town centre, particularly relating to heavy and light vehicle interactions
- Improve amenity of Muswellbrook township.

The Australian Government announced a preferred option for the Muswellbrook bypass in 2005. Muswellbrook Shire Council included this preferred option as a corridor in their 2009 Local Environment Plan (LEP). After further consideration of project constraints and costs, this option is considered not economically viable.

Roads and Maritime has continued investigations to identify a more economically viable option for the bypass, including consideration of in-town routes.

1.1 Purpose of this document and scope of the study

This report meets the *New England Highway Draft Corridor Strategy's* short term goal to investigate options for a bypass of Muswellbrook[1]. The purpose and scope of this report is to:

- Document the need for a Muswellbrook bypass
- Review constraints which may affect bypass options
- Identify potential bypass options
- Analyse traffic benefits, economics and cost estimate of bypass options.

1.2 Study area

The study area for the Muswellbrook bypass starts about 500 metres south of the intersection of the New England Highway and Milpera Drive and ends about 1.5 kilometres north of its intersection with Sandy Creek Road. The study area includes the township of Muswellbrook and extends west from the urban area of Muswellbrook to the east of Skellatar Hill.

[1] NSW Government 2016, New England Highway Draft Corridor strategy (October 2016) http://www.rms.nsw.gov.au/projects/hunter/new-england-highway/corridor-strategy.html

1.3 Project need

The analysis identified the need for the project as:

- There is an increasing number of vehicles through the centre of Muswellbrook with heavy vehicle growth rates higher than total vehicle growth
- Projected travel times on the New England Highway through Muswellbrook (between Muscle Creek Road and Sandy Creek Road) are forecast to increase from between 10 and 11 minutes (during peak hours in 2016), to between 12.7 minutes and 16.2 minutes in the peak hours by 2044
- Between 29 and 35 per cent of traffic on the New England Highway in Muswellbrook is through traffic, with the majority of heavy vehicles passing through Muswellbrook using a bypass if provided
- Travel time and speed analysis found the average speeds in town (Bridge Street) reduced to 18km/h to 28km/h during peak hours, substantially lower than the 50km/h posted speed limit
- There are current restrictions to OSOM vehicles
- There were 77 casualty crashes on the New England Highway from 2011 to 2015 with heavy vehicles involved in more than 50 per cent of casualty crashes despite making up 14 per cent of total vehicles
- Heavy vehicles are slower, noisier and take up more space on the road. More local traffic and heavy vehicles can lead to delays, congestion, safety problems and decreased amenity.

1.4 Options development

Five options were considered and are highlighted in blue (updated version of the corridor outlined in Muswellbrook Shire Council's LEP), purple, yellow, green and orange in **Figure 1**.

In-town options were not assessed further due to potential amenity impact on local streets.

1.5 Constraints analysis

Key constraints in the study area are:

- Topographical constraints including Skellatar Hill
- Aboriginal heritage
- Endangered Ecological Communities (ECCs)
- Effects of mining operations
- Land ownership.

1.6 Options assessment

The five options were assessed by looking at:

- Traffic modelling: travel time savings for each option to the year 2044
- Economic analysis (if an option delivers value for money): This is a calculation called a benefit-cost ratio (BCR) which compares benefits and costs, with a higher number showing more value for money

The traffic modelling and BCR for each option is shown in **Table 1**. A project is generally considered economically viable when the BCR is greater than 1, which shows the value of the project exceeds the cost.

The blue option has the lowest cost and highest BCR of the five options with the second highest travel time saving.

1.7 Recommendation

The blue option is recommended as the preferred route option. It is a refinement of the previous corridor identified in the Muswellbrook bypass 2009 LEP, with changes that make it the most economically viable option.

Future planning will refine the corridor for the final route. We will continue to work with council to secure the refined corridor in the LEP.

Table 1 Muswellbrook Bypass Options Traffic and Economic Performance

Bypass Option	Blue	Purple	Yellow	Green	Orange
Option length	9.1 kilometres	7.9 kilometres	7.7 kilometres	7.1 kilometres	7 kilometres
2044 travel time saving (peak hours)	4.9 – 9.2 minutes	5 – 8.8 minutes	5.9 – 9.7 minutes	0.7 – 2.9 minutes	0.7 – 3.2 minutes
Out-turn Cost*	$285 million	$420 million	$415 million	$395 million	$425 million
Benefit Cost Ratio (BCR)	1.3	0.7	1	0.3	0.3

* All cost estimates are preliminary estimates for comparative purposes only.

Study area
Existing route
Named streams
Railway

Potential Bypass Options

Blue Option
Green Option
Orange Option
Purple Option
Yellow Option

Muswellbrook Bypass Options
Muswellbrook Bypass - Options Report
0 0.25 0.5 1 Kilometres

Dec 2017

Fig. 1

2. Introduction

2.1 Project overview

The New England Highway passes through the town centre of Muswellbrook, which is about 127 kilometres north-west of Newcastle with a population of around 13,000.

Currently highway traffic passes through six traffic lights, a roundabout, a school zone, under a narrow railway overpass, and through a flood prone section of the highway at Muscle Creek which all impact on travel time. The narrow railway underpass poses limitations for over-size over-mass (OSOM) vehicles which are required to use alternate routes around the town.

A bypass of the town centre would remove conflicts between local and through traffic, improve local amenity and improve the efficiency of heavy vehicle movements along the New England Highway.

The Australian Government announced a preferred option for the Muswellbrook bypass in 2005. Muswellbrook Shire Council reserved the road corridor of the preferred option in their 2009 Local Environment Plan (LEP). After further consideration of project constraints and costs, the 2005 preferred option is not considered economically viable.

Roads and Maritime has continued identifying a more economically viable option for a bypass including consideration of in-town routes and refinements on the 2005 preferred option.

2.2 Project objectives

The objectives of the Muswellbrook bypass are to:

- Improve network efficiency on the New England Highway, particularly travel times for long haul freight movements
- Improve safety for all road users in the town centre, particularly relating to heavy and light vehicle interactions
- Improve amenity of Muswellbrook township.

2.3 Purpose of this document

This report summarises investigations of an economically viable option for a Muswellbrook bypass. The report meets the short term goal of *New England Highway Draft Corridor Strategy* [2] to investigate options for a bypass of Muswellbrook.

The purpose of this report is to:

- Document the need for a Muswellbrook bypass
- Summarise constraints which may affect bypass options
- Describe potential bypass options
- Analyse traffic benefits, economics and cost estimate of bypass options.

[2] NSW Government (2016), New England Highway Draft Corridor strategy (October 2016) http://www.rms.nsw.gov.au/projects/hunter/new-england-highway/corridor-strategy.html

2.4 Study area

The study area for the Muswellbrook bypass starts about 500 metres south of the intersection of the New England Highway and Milpera Drive and ends about 1.5 kilometres north of its intersection with Sandy Creek Road. The study area includes the township of Muswellbrook and extends west from the urban area of Muswellbrook to the east of Skellatar Hill.

The study area is in the federal division of Hunter, the state electorate of Upper Hunter and in the local government area of Muswellbrook Shire Council.

In Muswellbrook, the largest employment sector is coal mining followed by the service (cafes, restaurants and takeaway food) and education sectors. Being close to coal mines means Muswellbrook is also one of New South Wales' largest power generation centres.

The Hunter River lies west of Muswellbrook, with Muscle Creek (a tributary of the Hunter River) flowing through the town from the east. Agricultural land is located on the western banks of the Hunter River and north of the town. There are mines to the south, west and east of Muswellbrook, including the large Muswellbrook Coal Mine north-east of the township. The Main North rail line splits Muswellbrook in half.

The New England Highway route through Muswellbrook includes six sets of traffic signals and a roundabout, a school zone, a width restricted railway overpass and a section with low flood immunity. The highway is four lanes for the majority of the route through Muswellbrook, with a two-lane section between Denman Road (Sydney Street), and the Market Street roundabout at the rail underpass.

The study area is shown in **Figure 2.**


N
HUNTER RIVER
New England Hwy
Burtons Ln
Sandy Creek Rd
KEEVERS QUARY
SANDY CREEK
Aberdeen St
SUB STATION
MUSWELLBROOK COAL COMPANY LTD
MUSWELLBROOK
WASTE DEPOT
Coal Rd
Bridge St
SKELLATAR HILL
Sydney St
Maitland St
Bell St
Golf Course
Main Northern Railway
MUSCLE CREEK
New England Hwy
Muscle Creek Rd
Study area
Existing route
Named streams
Railway
Muswellbrook Bypass Study Area
Muswellbrook Bypass - Options Report
0 0.25 0.5 1 Kilometres
Dec 2017
Fig. 2

2.5 Strategic context

The project is consistent with the strategic plans outlined in this section.

National Land Transport Network

The New England Highway through Muswellbrook forms part of the inland Sydney-Brisbane Corridor of the National Land Transport Network (NLTN). This transport network is funded by the Australian, State and Territory governments and is recognised for its strategic importance to national and regional economic growth, development and connectivity. The New England Highway is recognised as a major freight and commuter route in this network. As a result, the Muswellbrook bypass is consistent with Australian and State government priorities.

New England Highway Draft Corridor Strategy (2016)

Roads and Maritime publicly displayed a draft corridor strategy for the New England Highway in October 2016. The corridor strategy identifies a range of short, medium and long term priority actions to address the challenges on the New England Highway over the next 20 years.

Priorities related to the Muswellbrook bypass include:

- Investigate options for a bypass, including a review of the existing preserved corridor and other shorter alignments to improve the safety and efficiency of the New England Highway
- Identify a preferred option for a bypass of the town centre of Muswellbrook
- Start implementing the preferred option for Muswellbrook bypass.

Investigating options for a bypass of Muswellbrook bypass is one of a number of projects in the draft corridor strategy as shown in **Figure 3**.

Draft Future Transport Strategy 2056

The Draft Future Transport Strategy is a vision for how transport can support growth and the economy of New South Wales over the next 40 years. This strategy is underpinned by the Draft Regional Services and Infrastructure Plan and the Draft Greater Sydney Services and Infrastructure Plan as well as a number of supporting plans including Road Safety and Tourism.

Draft Regional NSW Services and Infrastructure Plan

The Draft Regional Services and Infrastructure Plan sets a 40 year vision for transport in Regional New South Wales to support liveable communities and productive economies. The plan has a committed initiative (0 – 10 years) for the planning of a bypass of Muswellbrook.

State and Premier's Priorities (2015)

The Muswellbrook bypass aligns to the following State and Premier's priorities including:

- Reduce road fatalities by 30 per cent from 2011 levels by 2021
- Improve road travel reliability.

Hunter Regional Plan (2016)

The Hunter Regional Plan identifies the New England Highway as one of several national freight networks linking the Hunter Region to global gateways like the Port of Newcastle. The plan outlines actions to enhance the efficiency of these networks to support economic growth and diversification of regional NSW.

State Infrastructure Strategy (2014 update)

The strategy recognises the role of the New England Highway as a critical freight corridor for the movement of freight to the Port of Newcastle. It recommends investment priorities for the New England Highway corridor are guided by freight productivity needs.

The strategy also identifies a role for the NSW Government to improve roads to support coal mining in the Hunter Valley and Gunnedah basins. The New England Highway is a critical enabler to the Hunter Valley Coal Chain.

NSW Freight and Ports Strategy (2013)

The NSW Freight and Ports Strategy aims to create a transport network where goods move efficiently to their markets. The Muswellbrook bypass aligns with the goals of the freight and port strategy to help create a competitive and productive NSW economy.

NSW Road Safety Strategy (2012)

The NSW Road Safety Strategy 2012-2021 sets the direction of road safety in NSW for the next 10 years. The NSW Government is committed to at least a 30 per cent reduction in fatalities and serious injuries by 2021. The proposed Muswellbrook bypass would reduce the crash rate along this section of the corridor, particularly as heavy vehicles are over-represented in crashes within the Muswellbrook urban area.

Hunter Regional Transport Plan (2014)

The Hunter Regional Transport Plan identifies the need to progressively provide upgrades along the New England Highway to address safety and congestion issues. This includes reducing the impact of freight movements on the urban centre of Muswellbrook.

Hunter Economic Infrastructure Plan (2013)

Regional Development Australia (Hunter) and Infrastructure NSW prepared the Hunter Economic Infrastructure Plan to assist the Hunter in preparing an integrated infrastructure plan to help mining communities improve export capacity and support the region's future economic growth.

The plan identifies the Muswellbrook bypass as one of 13 key road infrastructure projects in the region to support freight movements and the mining sector.

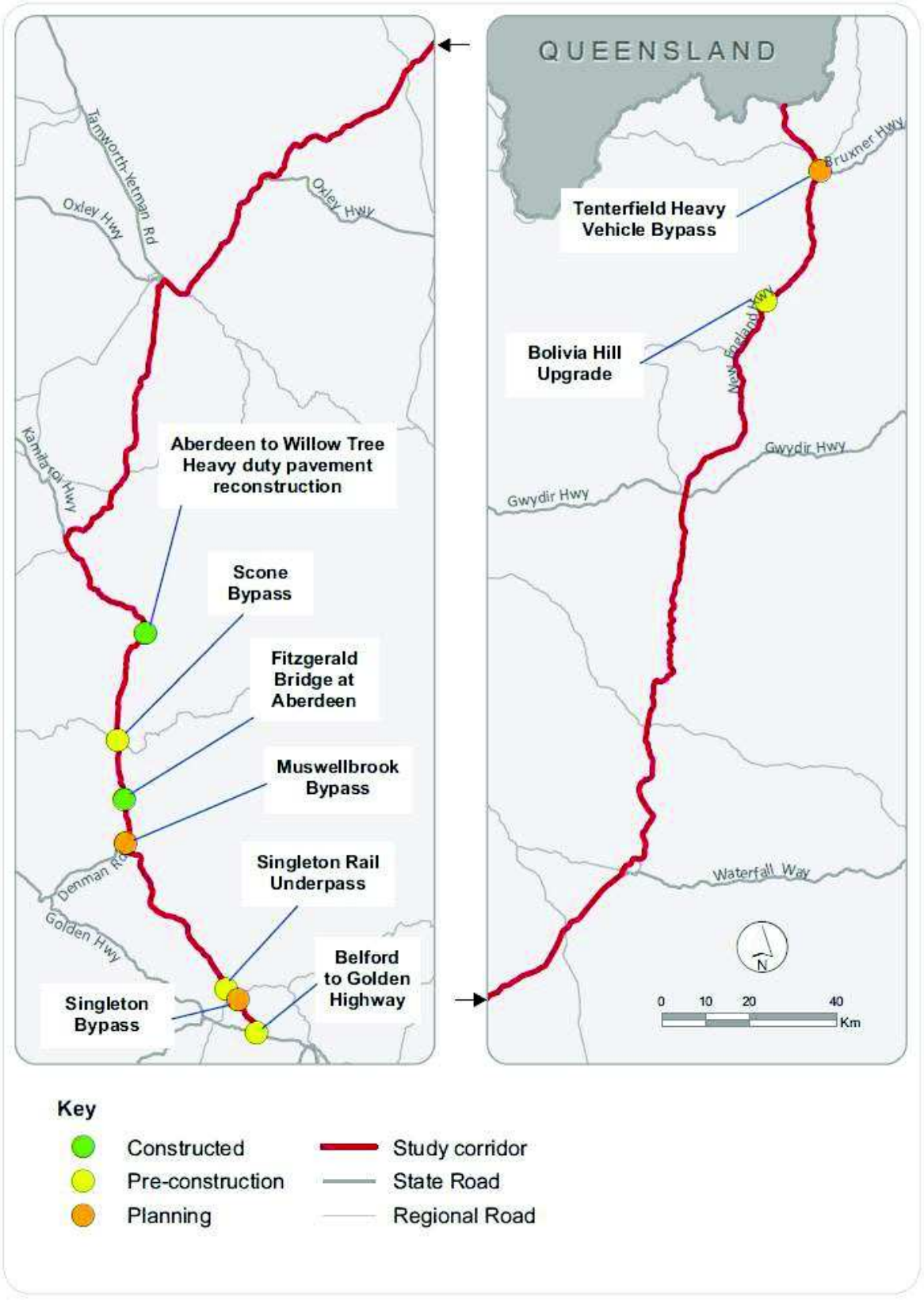


Figure 3 New England Highway Corridor and Road Projects (as at October 2016)

3. Project need

To identify and determine the need for a Muswellbrook bypass we have to understand current and future traffic performance, safety, traffic conditions and amenity. This section outlines the review of these factors.

3.1 Traffic performance

Traffic performance looks at what can affect traffic on the New England Highway through Muswellbrook. This includes the number of vehicles on the road (traffic volumes), where vehicles are travelling to (local and through traffic), travel times and speeds, and the mix of light and heavy vehicles.

3.1.1 Surveyed traffic volumes

Traffic surveys of light and heavy vehicles were carried out in July and November 2016 which showed:

- Volumes of 9600 to 19,500 vehicles per day on an average weekday depending on the location
- Up to 10 per cent higher traffic volumes on a Friday
- About 20 per cent lower traffic volumes on the weekend.

Daily traffic volumes on nearby local roads such as Sandy Creek Road, Common Road and Coal Road were relatively low.

Daily traffic on the New England Highway through Muswellbrook varied significantly, with 9600 vehicles per day south of Muscle Creek Road increasing to about 19,500 vehicles per day through the Muswellbrook town centre, south of Brook Street due to local traffic. The results of traffic surveys are shown in **Figure 4**.

Some OSOM vehicles use Bell Street as an alternative route to the New England Highway. However, the surveys showed most of the 7200 vehicles on Bell Street on an average weekday were light vehicles on local trips (school, employment or shopping).

The traffic surveys showed heavy vehicle traffic:

- Varied between 1600 and 2700 vehicles per day
- Was about 24 per cent of total traffic south of Muswellbrook
- Was about 14 per cent of total traffic north of Muswellbrook.

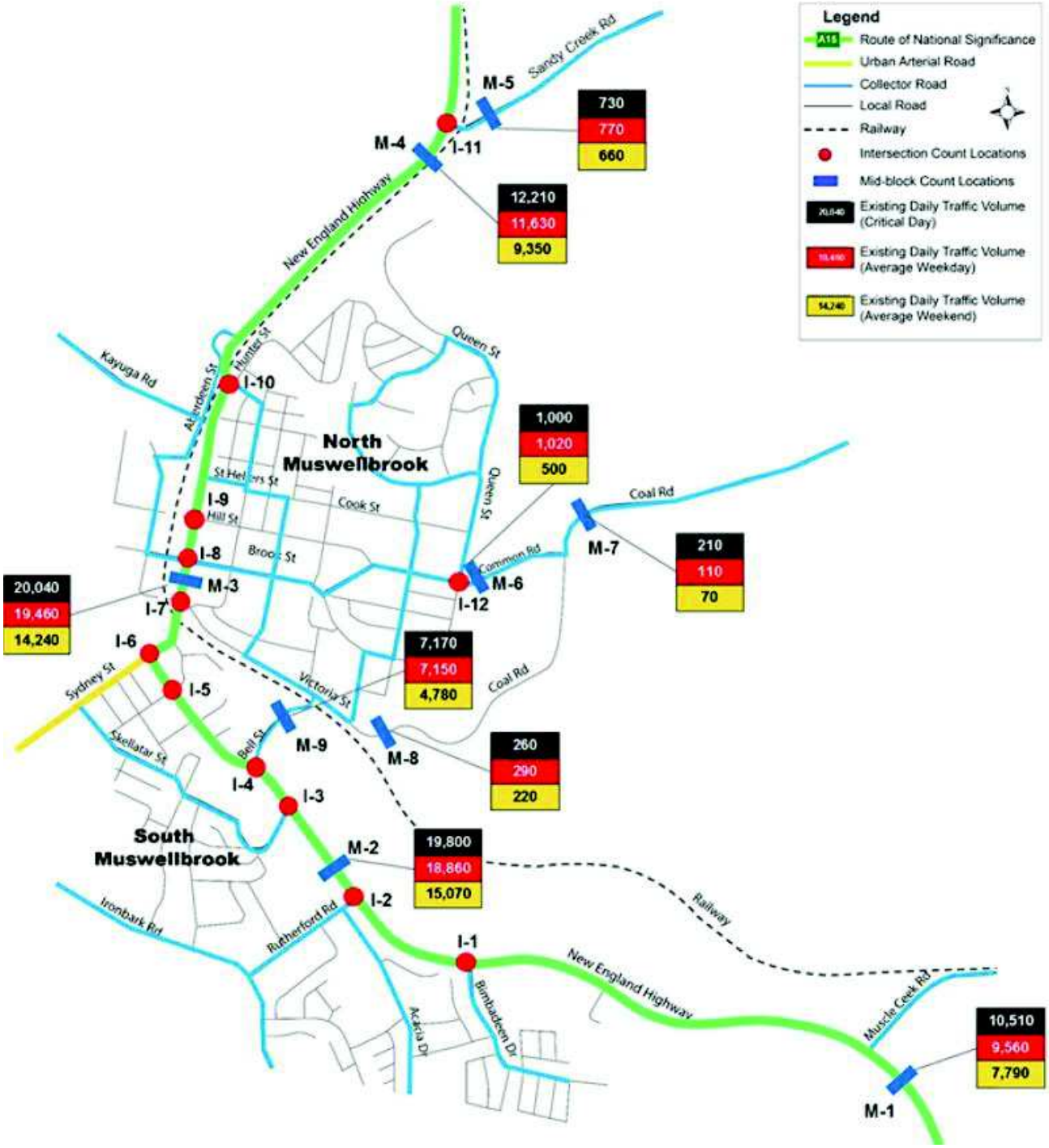


Figure 4 Muswellbrook 2016 daily traffic volumes (vehicles per day)

3.1.2 Origin-destination surveys

Origin-destination (OD) surveys on the New England Highway approaches to Muswellbrook in 2016 showed that for all traffic (heavy and light vehicles):

- About 35 per cent northbound (56 per cent of heavy vehicles) were travelling through
- About 29 per cent southbound (59 per cent of heavy vehicles) were travelling through
- Between 65 per cent and 71 per cent local.

Of the total 1966 daily heavy vehicles recorded on the day of the OD survey on the New England Highway, the majority would use the bypass if it were provided (see **Figure 5**).

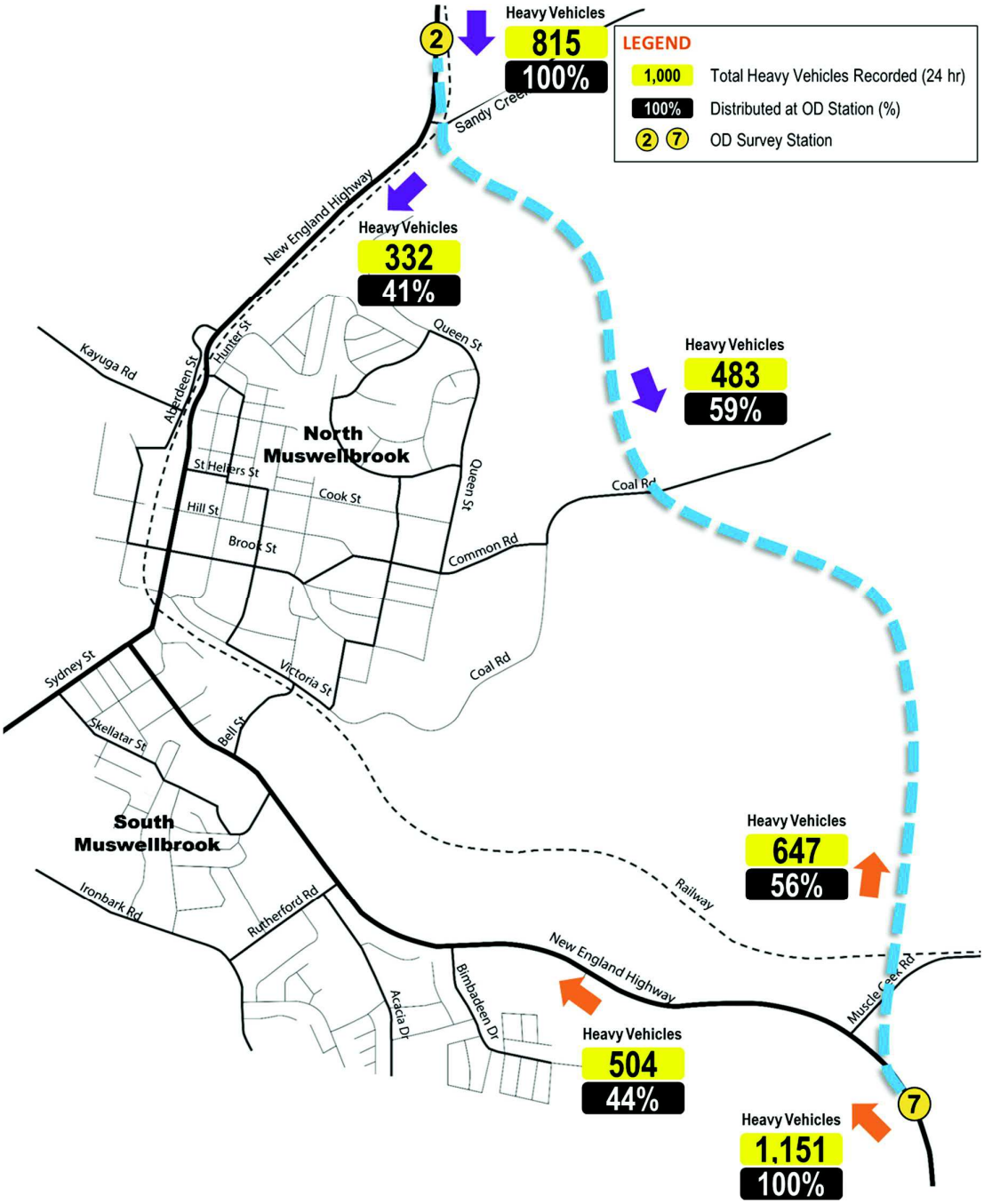


Figure 5 Heavy vehicle through volumes (as measured in 2016)

3.1.3 Travel times and speeds

We analysed travel times and found vehicles took between 10 and 11 minutes to travel the 8.3 kilometres on the New England Highway between Muscle Creek Road and Sandy Creek Road. The average travel speed was between 47km/h and 51km/h which is below the posted speeds of 50km/h and 60km/h in urban areas, and 100km/h on the urban fringe.

Through the town centre (Bridge Street), average speeds reduced to between 18km/h and 28km/h during peak hours. This is substantially lower than the 50km/h posted speed limit.

Travel times for vehicles moving through Muswellbrook will worsen as heavy vehicle numbers grow and more traffic lights are installed on the New England Highway.

3.1.4 Road freight

The NSW Strategic Freight Model explains types of freight transported, volumes of each freight type, mode used, origin and destination. The model also provides a forecast of future freight volumes. The forecasts show significant growth in the proportion of freight volumes along the New England Highway carried by heavy vehicles.

About half of all heavy vehicle movements through Muswellbrook are articulated (semi-trailers or B-Doubles), and most of these are through traffic.

Vehicles larger than those generally permitted to operate on any particular road are known as Higher Productivity Vehicles (HPV). These are vehicles larger than 19 metre long semi-trailer or 19 metre long B-Doubles. More productive freight movements can be achieved through the use of vehicles carrying greater loads. The vision for the New England Highway is to provide access for vehicles up to 30 metres long.

Heavy vehicles are slower, noisier and take up more space on the road. More heavy vehicles can lead to delays, congestion, safety problems and decreased amenity.

Over-size over-mass vehicles

Over-size over-mass (OSOM) vehicles exceed the generally allowable size or weight limits. They are allowed restricted access to parts of the road network. The New England Highway is a key OSOM route.

Several OSOM loads travel along the New England Highway through Muswellbrook each day. These OSOM vehicles have trouble negotiating the urban environment and this impacts on traffic and travel times.

Figure 6 OSOM load Sydney Street and New England Highway intersection, Muswellbrook

Figure 7 Intersection of the New England Highway (Bridge Street) and Market Street with OSOM vehicle

The existing rail bridge over the New England Highway has width and height restrictions which require some OSOM vehicles to use a local road detour of Bell, Victoria and Market streets (see **Figure 8**). This lessens road freight efficiency and creates traffic and safety issues for the local roads.

Figure 8 New England Highway rail underpass of the Main North rail line

3.2 Future traffic conditions

Future traffic conditions also help us to determine the need for the project. This is assessed by looking at projecting traffic in the area for 2024, 2034 and 2044 based on population and traffic growth rates. We also look at how the current route ('do minimum' option) would perform under these conditions if a bypass was not built.

3.2.1 Growth rates

The average annual growth rate for population in the Muswellbrook local government area (LGA) is anticipated to be 0.9 per cent a year from 2011 to 2031. As a comparison, the Singleton LGA area to the south of Muswellbrook has an average annual growth rate of 0.8 per cent. The Upper Hunter LGA to the north of Muswellbrook has an average annual growth rate of 0.5 per cent.[3]

Increased traffic on the New England Highway, especially in the Lower Hunter, is a likely consequence of the forecast population growth. The highway corridor between Belford and Scone already experiences a relatively high rate of traffic growth which will reduce safety and traffic efficiency.

3.2.2 Traffic growth rates

The number of vehicles moving through the centre of Muswellbrook on the highway is increasing. Traffic on the New England Highway has grown about 1.3 per cent each year from 2007 as shown in **Table 2**.

Table 2 New England Highway all vehicle growth rates (2007 – 2016)

Site ID	Location on New England Highway	Average weekday traffic volumes			Traffic growth per year 2007 - 2016 (8.5 years)
		November 2007	June 2013	July 2016	
M-1	South of Muscle Creek Road	8900	9600	9560	0.8%
M-2	West of Rutherford Road	15,300	16,900	18,860	2.5%
M-3	South of Brook St	18,200	18,000	19,460	0.8%
M-4	South of Sandy Creek Road	10,900	12,100	11,630	0.8%
Average for all locations		**13,330**	**14,150**	**14,880**	**1.3%**

3.2.3 Future traffic growth and volumes

For the purpose of traffic projections (and modelling), we assumed future traffic growth rates by vehicle type. We determined these growth rates using a mixture of:

- Historical growth rates (discussed in the previous section)
- Growth rates considering background population growth in urban areas and higher growth rates from heavy vehicle through traffic.

Future growth rates for all vehicles are assumed to be 1.1 per cent between 2024 and 2034 (0 to 10 years after assumed opening date) then by 1 per cent per annum between 2034 and 2044 (10 to 20 years after assumed opening date).

Using the future growth rates, we were able to project daily total traffic and heavy traffic volumes from 2016 to 2044. Traffic volumes for all vehicles are shown in **Table 3**. This table shows total daily traffic volumes along the New England Highway growing 35 per cent at Brook Street.

[3] NSW Government (2016), *New England Highway Draft Corridor strategy* (October 2016) http://www.rms.nsw.gov.au/projects/hunter/new-england-highway/corridor-strategy.html

Table 3 Actual (2016) and forecast daily traffic volumes (all vehicles)

Road / Location	2016	2024	2034	2044
New England Highway, South of Muscle Creek Road	9600	10,400	11,600	12,900
New England Highway, West of Rutherford Road	18,600	20,200	22,500	24,900
New England Highway (Bridge Street), South of Brook Street	19,400	21,200	23,500	26,000
New England Highway, South of Sandy Creek Road	11,100	12,100	13,500	15,000
Bell Street, South of Victoria Street	7,500	8,200	9,000	10,000

3.2.4 Future Road Network: "Do Minimum"

The future "do minimum" road network assumes a number of intersection upgrades including new traffic lights at Bimbadeen Drive, Thompson Street, Heydon Street/Lorne Street, and a new signalised pedestrian crossing on Bridge Street north of Brook Street. The "do minimum" is shown in **Figure 9**.

The additional traffic lights may be required due to a mixture of development, safety and pedestrian activity across the highway. The lights are assumed to be in place by 2024. This would result in 10 traffic lights on the New England Highway through Muswellbrook, between Muscle Creek Road and Sandy Creek Road.

Modelling of the "do minimum" scenario shows that delays and travel times on the New England highway will increase. Projected travel times for this scenario are forecast to increase from between 10 and 11 minutes (during peak hours in 2016), to between 12.7 minutes and 16.2 minutes in the peak hours by 2044. Heavy vehicle numbers are expected to increase by the year 2044. Amenity and safety in the town centre would deteriorate.

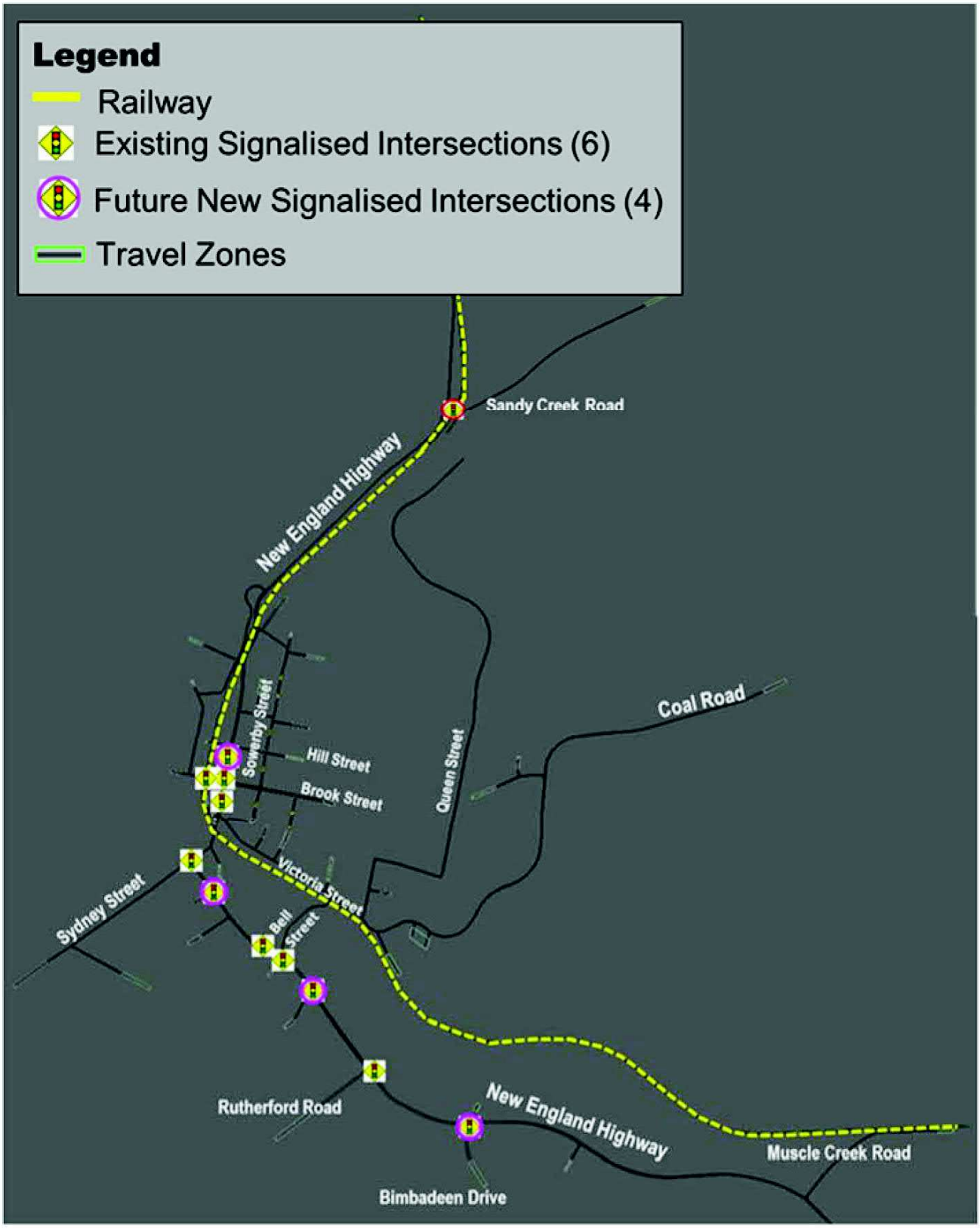


Figure 9 "Do minimum" traffic network for the New England Highway in Muswellbrook

3.3 Road safety

We carried out a detailed analysis of crashes in the study area from January 2011 to December 2015. Mixing heavy vehicles with local traffic in the town centre has contributed to casualty crashes.

3.3.1 Crash location

There were 77 reported crashes on the New England Highway between Muscle Creek Road and Sandy Creek Road. Of the 77 crashes on the New England Highway:

- 45 were at intersections
- 16 were on road sections with no medians (undivided)
- 16 were on road sections with medians (divided).

There were four reported crashes on Victoria Street. There were no reported crashes on Coal Road.

3.3.2 Crash severity

Of the 77 crashes on the New England Highway, crash severity included:

- One fatal crash about one kilometre south of Sandy Creek Road
- 35 injury crashes with 46 people injured in these crashes
- 40 non casualty (tow-away) crashes.

Of the four crashes on Victoria Road all were non-casualty.

The severity is shown in **Table 4**.

Table 4 Location and Severity of Crashes (2011 to 2015)

Road	Section	Fatal	Injury	Non Casualty (tow away)	Total
New England Highway	(Muscle Creek Road to Sandy Creek Road)	1 (1%) 1 person killed	34 (44%) 46 people injured	42 (55%)	77
Victoria Street	Coal Road to Market Street	0 (0%)	0 (0%)	4 (100%)	4
Total		**1**	**34**	**46**	**81**

3.3.3 Crashes by vehicle type

While they make up only 14 per cent of the total vehicles in the study area, heavy vehicles were involved in 54 per cent of the casualty crashes (19 of 35). Heavy vehicles are most likely involved in one out of every two casualty crashes because they have difficulty stopping suddenly and manoeuvring in busy streets, like the Muswellbrook town centre.

3.4 Amenity

The Bridge Street section of the New England Highway serves as Muswellbrook's town centre and as a through heavy vehicle route. This can create conflict with vehicles (light and heavy), traffic (local and through) and vulnerable road users such as pedestrians and cyclists. There are conflicting demands between light vehicles undertaking local trips (shopping, employment and school), and long distance heavy vehicle trips.

A bypass of the town centre would improve local amenity. It would remove conflicts between local and through vehicles and reduce the number of heavy vehicles moving through the town centre on Bridge Street. This would reduce noise, improve the visual appeal, and improve local commuter and pedestrian safety in the town centre.

Figure 10 Heavy Vehicle travelling through Muswellbrook on New England Highway

4. Bypass options

4.1 Option development

The Australian Government announced a preferred option for the Muswellbrook bypass in 2005. Muswellbrook Shire Council included this preferred option as a corridor in their 2009 Local Environment Plan (LEP).

The NSW Government announced funding for the Muswellbrook bypass in March 2015. After further consideration we found the option in the Muswellbrook LEP was no longer economically viable with current construction costs.

The draft corridor strategy for the New England Highway was released for public display in October 2016. The draft corridor strategy recommended investigating options to remove through traffic and improve conditions for the main street. This included reviewing the existing full bypass corridor (preserved in the Muswellbrook LEP) and identifying other options which may be economically viable.

We developed five options: blue (updated version of the corridor outlined in Muswellbrook Shire Council's LEP), purple, yellow, green and orange. These options are described in section 4.3. We also looked at in-town heavy vehicle bypass options. However, we did not assess in-town options because of their potential amenity impact on local streets.

4.2 Design criteria

Road geometry for the development of the preferred option has been designed in accordance with Austroads Guide to Road Design (2010) and, where applicable, Road and Maritime supplements. The design criteria adopted for the bypass are summarised in **Table 5**.

Table 5 Bypass design criteria

Design element	Blue, Purple, Yellow, Green and Orange 100-110km/h sections	Green and Orange Local road 50-70km/h sections
Lane widths	3.5 metres	3.5 metres
Shoulder widths	2.5 metres	2 metres
Central median width	1 metre	Nil on low speed (50-70km/h design speeds sections. 1 metre on high speed bypass section.
Sight distance (100km/h)	245 metres	115 metres
Super-elevation	3%	3%
Minimum horizontal curve radius	750 metres	180-250 metres
Maximum grade	8%	6% (Orange) 9% (Green)
Vertical (bridge) clearance	7.3 metres (road), 9.3 metres (rail)	7.3 metres (road), 9.3 metres (rail)
Posted speed (high-speed bypass sections)	100km/h	100km/h
Design speed (high-speed bypass sections)	110km/h	110km/h
Posted speed (local road sections)	N/A	Green 50-60km/h. Orange, Bell Street to Victoria Street, 50-60 km/h. Orange, new section from Victoria Street to start of high speed bypass section, 60-70km/h
Design speed (local road - speed bypass sections)	N/A	60-70km/h (depending on option)
Design vehicle	PBS 2B vehicle (30 metre Super B-Double)	PBS 2B vehicle (30 metre Super B-Double)

4.3 Description of bypass options

A summary of the bypass options and key design features is provided in **Table 6**.

Table 6 Bypass options and key design features

Key design feature	Blue	Purple	Yellow	Green	Orange
Option length	9.1 kilometres	7.9 kilometres	7.7 kilometres	7.1 kilometres	7 kilometres
Maximum Grade	8%	5%	5%	9%	6%
Southern access point	Split seagull	Split seagull	Split seagull	N/A	N/A
Southern access point to Bell Street	N/A	N/A	N/A	N/A	N/A
Bell Street / New England Highway	N/A	N/A	N/A	Upgrade of Bell Street to provide double right into Bell Street	Upgrade of Bell Street to provide double right into Bell Street
Bell Street	N/A	N/A	N/A	Re-construction of pavement 3.5 metre lanes with variable shoulders	Re-construction of pavement 3.5 metre lanes with variable shoulders
Bell Street / Victoria Street intersection	N/A	N/A	N/A	Signal controlled (staggered T)	Re-aligned (squared) intersection requiring new rail bridge
Victoria Street	N/A	N/A	N/A	Reconstruction of pavement	Reconstruction of pavement
Coal Road (Victoria Street to 100km/h bypass)	N/A	N/A	N/A	Widening to allow 60km/h design speed (posted at 50km/h), pavement reconstruction 3.5 metre lanes, 2.5 metre shoulders	Re-alignment of Coal Road to 70km/h design speed (posted at 60km/h) with 3.5 metre lanes, 2.5 metre shoulders
Coal Road access roads	Potential connection to Coal Road	New access roads to Council requirements	N/A	New access point to industrial areas south of Coal Road overpass	New access point to industrial areas south of Coal Road overpass
Northern access point	Partial movement interchange	Partial movement interchange	Partial movement interchange	Partial movement interchange	Partial movement interchange

4.3.1 Blue option

The blue option is about 9.1 kilometres long. The route departs the New England Highway near its intersection with Milpera Drive. The route heads north on new bridges crossing Muscle Creek Road and the Main North rail line and another bridge further north crossing Muscle Creek.

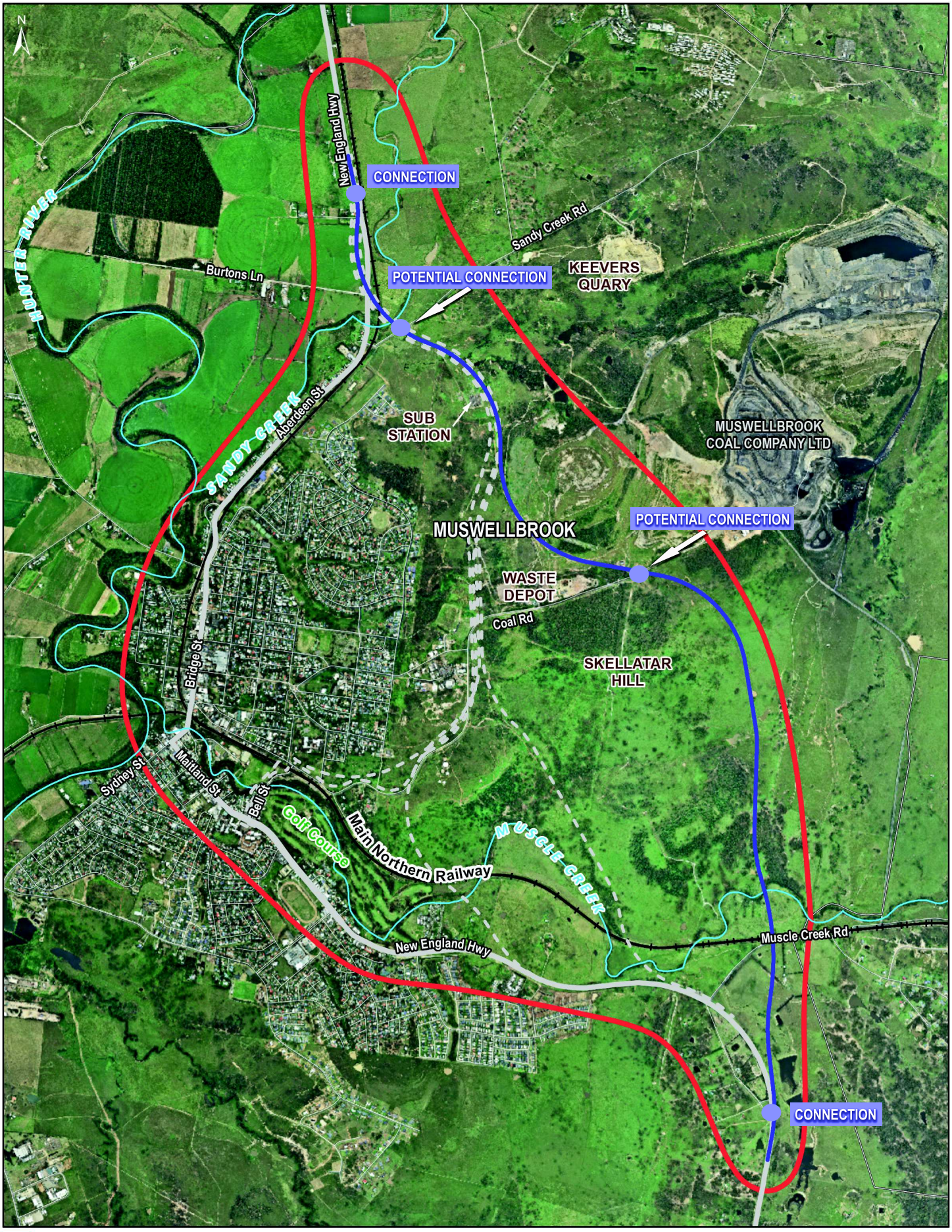
The route continues north on the east side of Skellatar Hill before curving north-west and crossing Coal Road between the Muswellbrook Waste Facility and the Muswellbrook Coal Mine. The option includes a potential connection to Coal Road.

The route then continues north on new crossings of Sandy Creek Road, Sandy Creek and the Main North rail line. It then overpasses and connects with the New England Highway about 1.2 kilometres north of Sandy Creek Road.

The blue option is an updated version of the corridor outlined in Muswellbrook Shire Council's LEP with amendments to improve the economic viability of the option. The main differences between the blue option and the corridor in the LEP are:

- Where the bypass crosses over Muscle Creek Road and the Main North rail line, the route has been moved to the east which reduces the new bridge length and the amount of road work required on Muscle Creek Road
- At the Muswellbrook Waste Management Facility on Coal Road, the route has been moved further to the east. This reduces some of the potential constraints such as underground mine workings
- At the Ausgrid electrical sub-station site the route has been moved further to the east. This reduces the impact on services and the amount of potential power line relocations
- Along Sandy Creek Road the route has been moved further to the west which simplifies the bridge design over Sandy Creek Road, Sandy Creek, the Main North rail line and the current New England Highway.

The corridor for this option would be further refined considering the results of geotechnical investigations carried out for future planning and any requirements of the rail authority.



Study area
Existing route
Named streams
Railway

Blue Option
Muswellbrook Bypass - Options Report
0 0.25 0.5 1 Kilometres

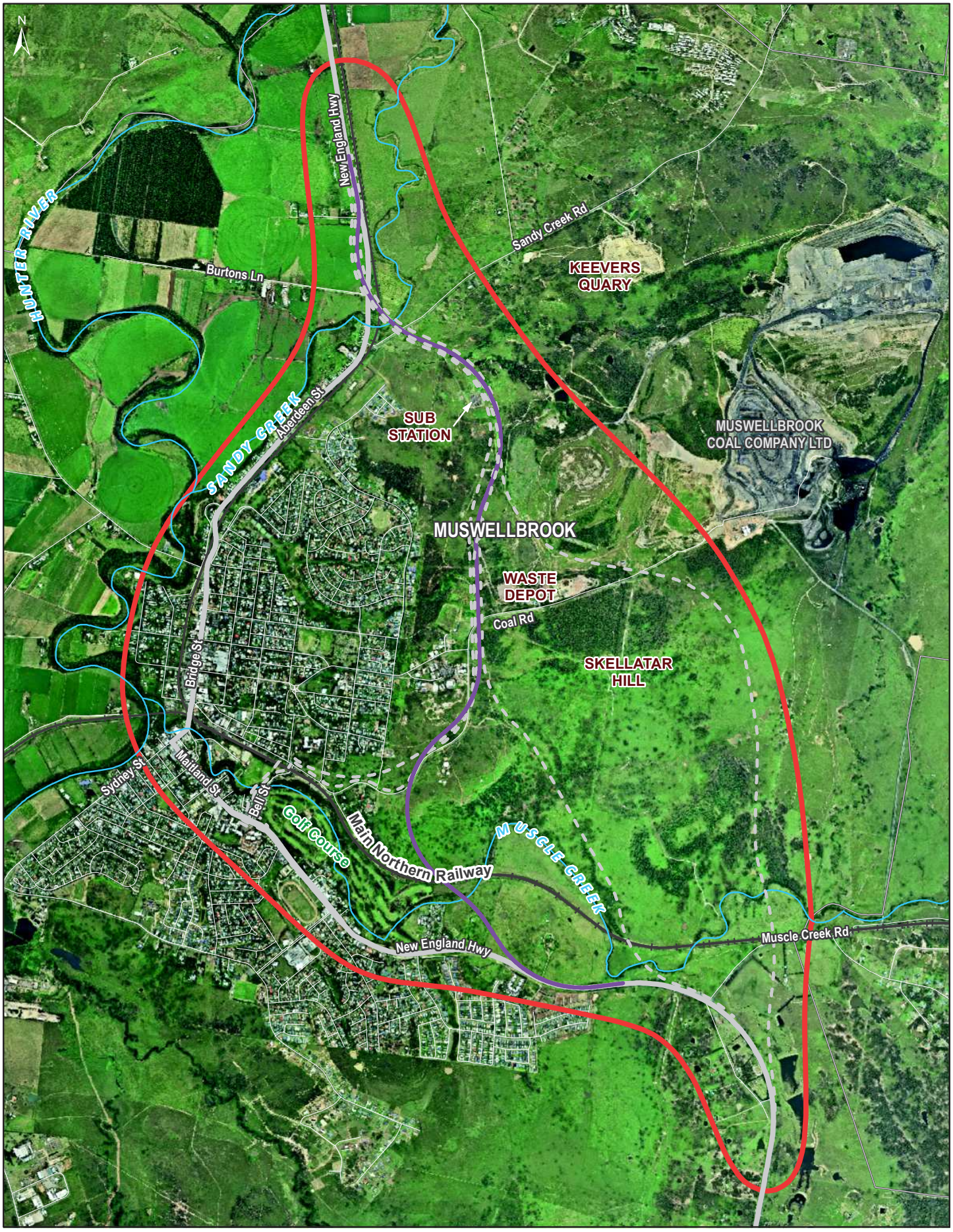
Dec 2017

Fig. 11

4.3.2 Purple option

The purple option is about 7.9 kilometres long. The route departs the New England Highway about 800 metres east of Bimbadeen Drive. It heads north-west on a new bridge crossing Muscle Creek on the eastern boundary of the Muswellbrook Golf Course and the Main North rail line. The route then runs parallel to Coal Road and continues north on a new bridge crossing Coal Road between Weeraman Fields and Muswellbrook Waste Facility.

The route continues on new bridges crossing Sandy Creek Road, Sandy Creek and the Main North rail line. It then overpasses the existing highway and connects with the New England Highway about 1.2 kilometres north of Sandy Creek Road.



Study area
Existing route
Named streams
Railway

Purple Option
Muswellbrook Bypass - Options Report

0 0.25 0.5 1 Kilometres

Dec 2017

Fig. **12**

4.3.3 Yellow option

The yellow option is about 7.7 kilometres long. The route departs the New England Highway about 300 metres west of the intersection of the New England Highway and Muscle Creek Road. The route heads north on a new bridge crossing the Main North rail line, before heading north-west towards Muswellbrook.

The route then heads north, parallel to Coal Road, before crossing Coal Road on a new bridge between Weeraman Fields and Muswellbrook Waste Facility. It continues north passing west of the Ausgrid Sub-station and on new bridges over Sandy Creek Road, Sandy Creek and the Main North rail line. The route then overpasses the existing highway and connects with the New England Highway about 1.2 kilometres north of Sandy Creek Road.

Study area
Existing route
Named streams
Railway

Yellow Option
Muswellbrook Bypass - Options Report

0 0.25 0.5 1 Kilometres

Dec 2017

Fig. 13

4.3.4 Orange and green options

Green option

The green option is about 7.1 kilometres long and uses new and existing roads.

The route starts at the intersection of Bell Street and the New England Highway. The route heads north on Bell Street which is an existing OSOM heavy vehicle route. This option requires an upgrade of the intersection of Bell Street and the New England Highway.

After Bell Street, the route continues east along Victoria Street before joining Coal Road. Coal Road would need minor alignment improvements to reduce the current grade (steepness) of 14 per cent to meet minimum heavy vehicle design standards.

The alignment leaves Coal Road on a new road section, and heads north between Weeraman Fields and Muswellbrook Waste Facility. It runs north and crosses new bridges over Sandy Creek Road, Sandy Creek and the Main North rail line. The route then overpasses the existing highway and connects with the New England Highway about 1.2 kilometres north of Sandy Creek Road.

Orange option

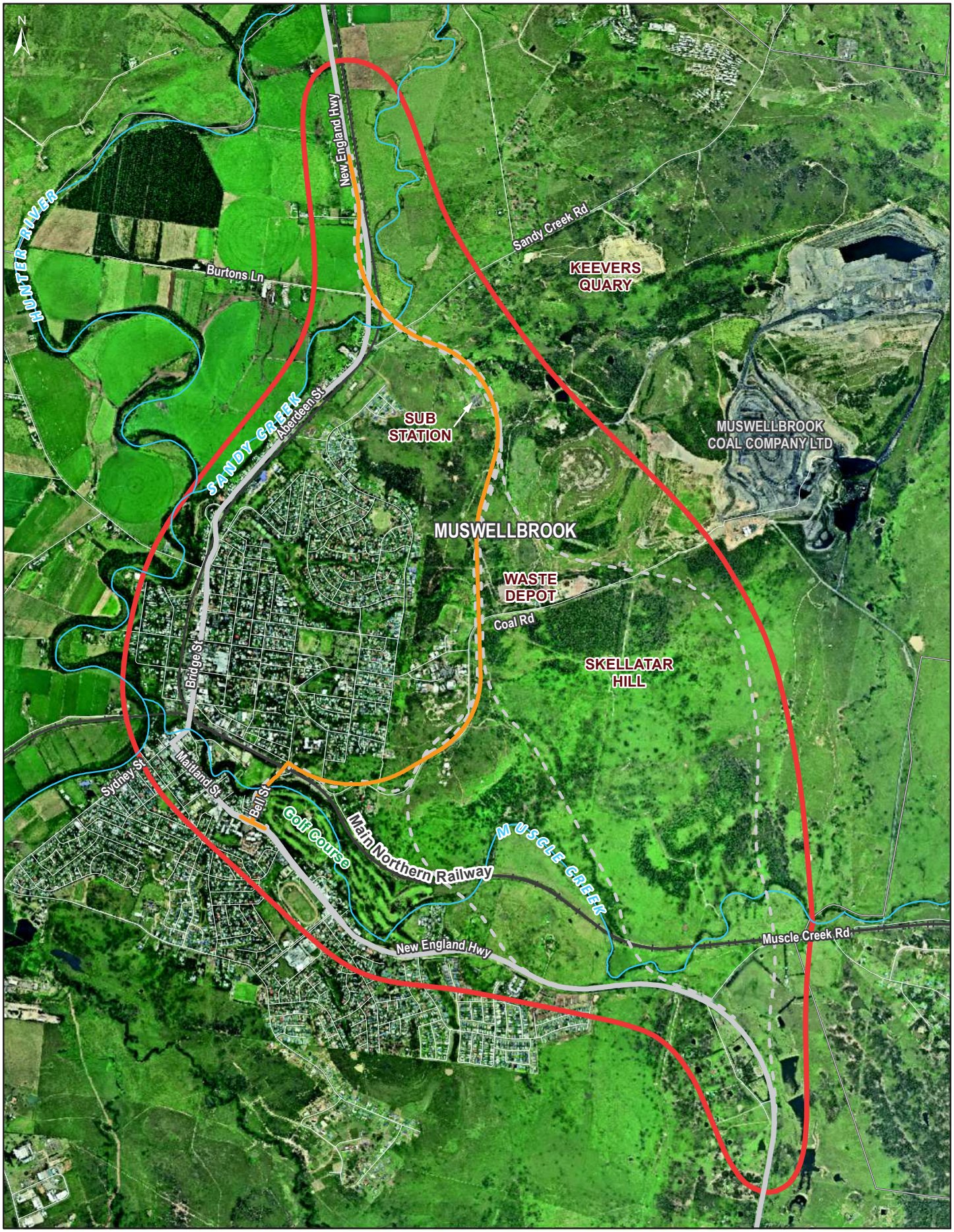
The orange option is about seven kilometres long. It follows the same alignment as the green option but would require more changes to the existing road network. These changes would include a new bridge on Bell Street over the Main North rail line and a realigned section of Coal Street.

Study area
Existing route
Named streams
Railway

Green Option
Muswellbrook Bypass - Options Report
0 0.25 0.5 1 Kilometres

Dec 2017

Fig. **14**



Study area
Existing route
Named streams
Railway

Orange Option
Muswellbrook Bypass - Options Report

0 0.25 0.5 1 Kilometres

Dec 2017

Fig. 15

5. Constraints

Roads and Maritime identified potential environmental constraints and opportunities for the Muswellbrook bypass options. We reviewed:

- Databases including Office of Environment and Heritage (OEH) and Environment Protection Authority (EPA)
- Environmental and planning publications
- Muswellbrook Council's LEP
- Land ownership
- Mining operations
- Available constraints maps.

The constraint information in this report is preliminary. We need to carry out further constraint investigations in the next stage of planning.

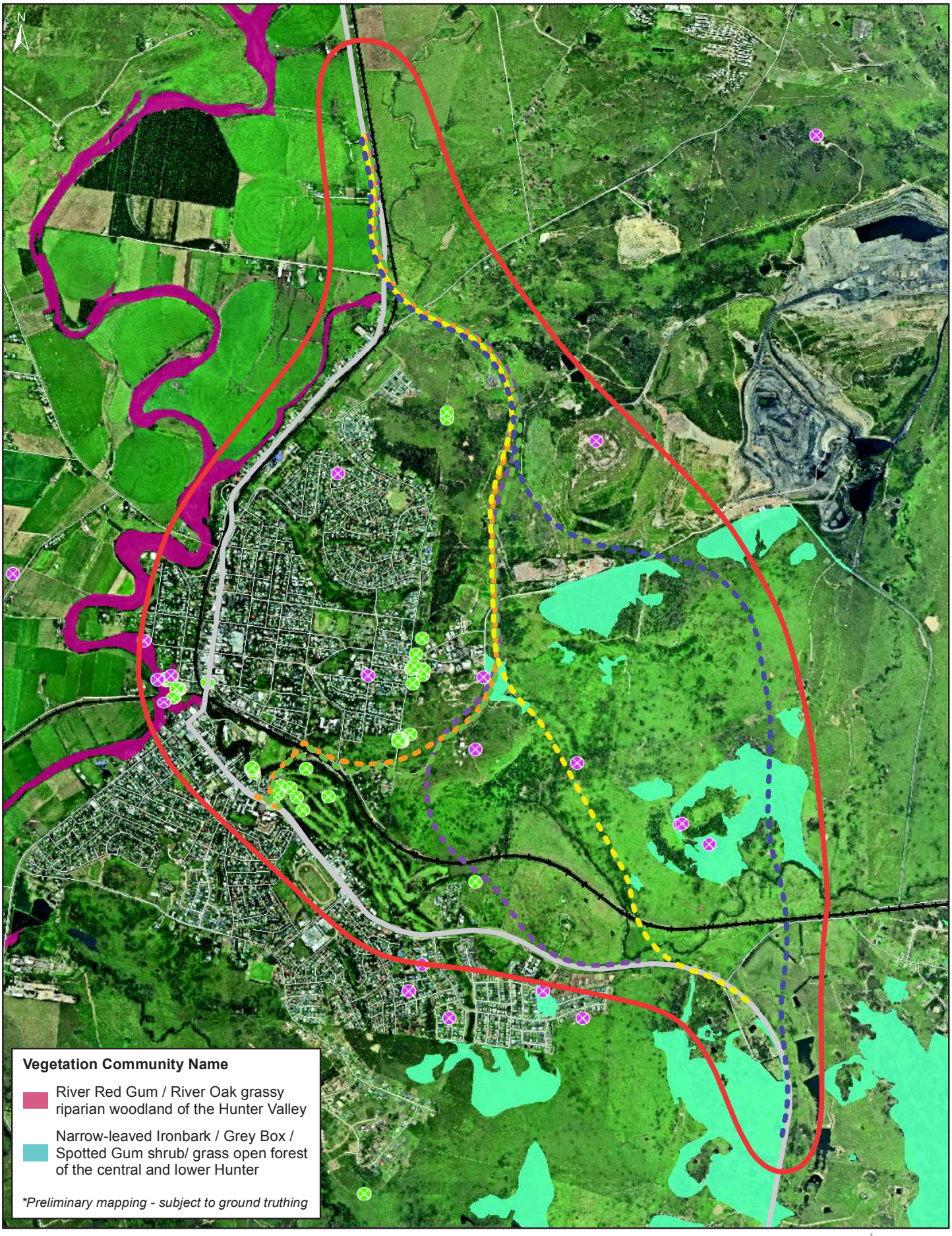
5.1 Biodiversity

The presence of threatened species and Endangered Ecological Communities (EECs) is a potential constraint to all bypass options. Threatened species and EECs are protected under state legislation and federal in some instances.

Our desktop searches of threatened species databases identified:

- Four threatened flora records
- Sixteen threatened fauna records
- Two potential EECs.

The results of the database searches are shown in **Figure 16.** While database searches show there could potentially be threatened species and communities in the study area, we will need more investigations to determine accurate locations.


N
Vegetation Community Name
River Red Gum / River Oak grassy riparian woodland of the Hunter Valley
Narrow-leaved Ironbark / Grey Box / Spotted Gum shrub/ grass open forest of the central and lower Hunter
*Preliminary mapping - subject to ground truthing
Study area
Existing route
Threatened Fauna
Threatened Flora
Railway
Threatened flora and fauna records
Muswellbrook Bypass - Options Report
0 0.25 0.5 1
Kilometres
Dec 2017
Fig. 16

5.2 Surface water and flooding

The study area is in the upper section of the Hunter River Catchment. This catchment is the largest coastal catchment in NSW, covering about 22,000 square kilometres. The Hunter River is the largest water course and the two secondary watercourses are Sandy Creek in the north and Muscle Creek in the south. There are also several other minor watercourses and drainage lines.

All bypass options would cross waterways and require bridges, culverts and cross drainage structures. There has been recorded flooding on the existing New England Highway (Bridge Street) at the rail underpass in Muswellbrook. Flooding is a risk for low lying areas near the Hunter River, and where Muscle Creek and Sandy Creek join with the Hunter River. Higher areas to the east of Muswellbrook are outside predicted flood risk areas. Surface water and flooding are not constraints for the bypass options on higher ground to the east of Muswellbrook.

We will further consider water quality and flooding of creeks and drainage lines in future planning of a Muswellbrook bypass.

5.3 Geotechnical constraints

Geotechnical studies assess the ground to better understand ground stability and the potential for contaminants that can pollute water and soil.

Ground stability looks at the risk of settling and subsidence:

- Settling: Soils of different physical, chemical and compaction properties can be used in backfilling former mines. These soils can then settle at different depths and rates.
- Subsidence: This occurs when the surface slip downwards. This can happen in areas where there are voids underneath the ground surface like old underground mines.

Settling and subsidence can cause uneven ground surfaces which can pose a safety hazard on road surfaces. Areas where there are high risks of settling and subsidence mean there could be increased costs associated with treating these geotechnical risks to prevent settling and subsidence.

5.3.1 Mining

Subsidence from underground mines potentially affects all options. The risk depends on the depth of the mine. The treatment of underground mine workings will affect the cost of the bypass. The green, orange, purple and yellow options cross about a 400 metre area of underground mine. The blue option crosses only about 50 metres of identified underground mine. The locations of mining operations including underground and open cut mines, and approved mining boundaries are shown in **Figure 17**.

The blue option is in an identified active mine area. However the Muswellbrook Coal Mining Company has indicated that mining activities in the vicinity of the proposed bypass are winding down. This means mining may be finished before the potential delivery of a bypass.

We will consult with the mining sector as part of further planning.

5.3.2 Landfills

Current and former landfill sites pose a range of issues including settlement and subsidence. The location of Muswellbrook Waste Management Facility is shown in **Figure 17**. All options avoid the current active work area within the existing waste facility.

We will carry out a review of other landfill sites, such as former dump sites, as part of further planning.

5.3.3 Spontaneous Combustible Material

Spontaneous combustible material (SCM) is material that contains carbon material such as coal. It can ignite under certain conditions. SCM may be present in underground and open cut mines.

The combustion of SCM can lead to the formation of underground voids and settlement of the ground. Fire, smoke and fumes from SCM may also create unsafe driving conditions. The location of material that may contain SCM is shown in **Figure 17**. SCM is a potential constraint to all options.

We would do further investigations of SCM as part of further planning.

5.3.4 Acidic leachate

When water passes through a solid it can sometimes leach out some of the solid it has passed through. This is called a leachate. Acidic leachate can occur when soil layers that contain iron compounds are exposed to air. This can happen in former mining areas where the underlying soil layers have been disturbed.

While the Coal Measures can contain pyrite, our desktop studies have not identified the conditions for acidic leachate. Acidic leachate is an unlikely risk on areas that have not been mined including the green, orange, yellow and purple options. We would need to further assess acidic leachate risk as part of further planning.

Study area
Site constraints
Existing route
Named streams
Cadastre
Potential mine activity affected area
Historical underground workings
Muswellbrook Coal - Project area
Coal titles
Railway

Mining areas and geotechnical constraints
Muswellbrook Bypass - Options Report

0 0.25 0.5 1 Kilometres

Dec 2017

Fig. 17

5.4 Topography

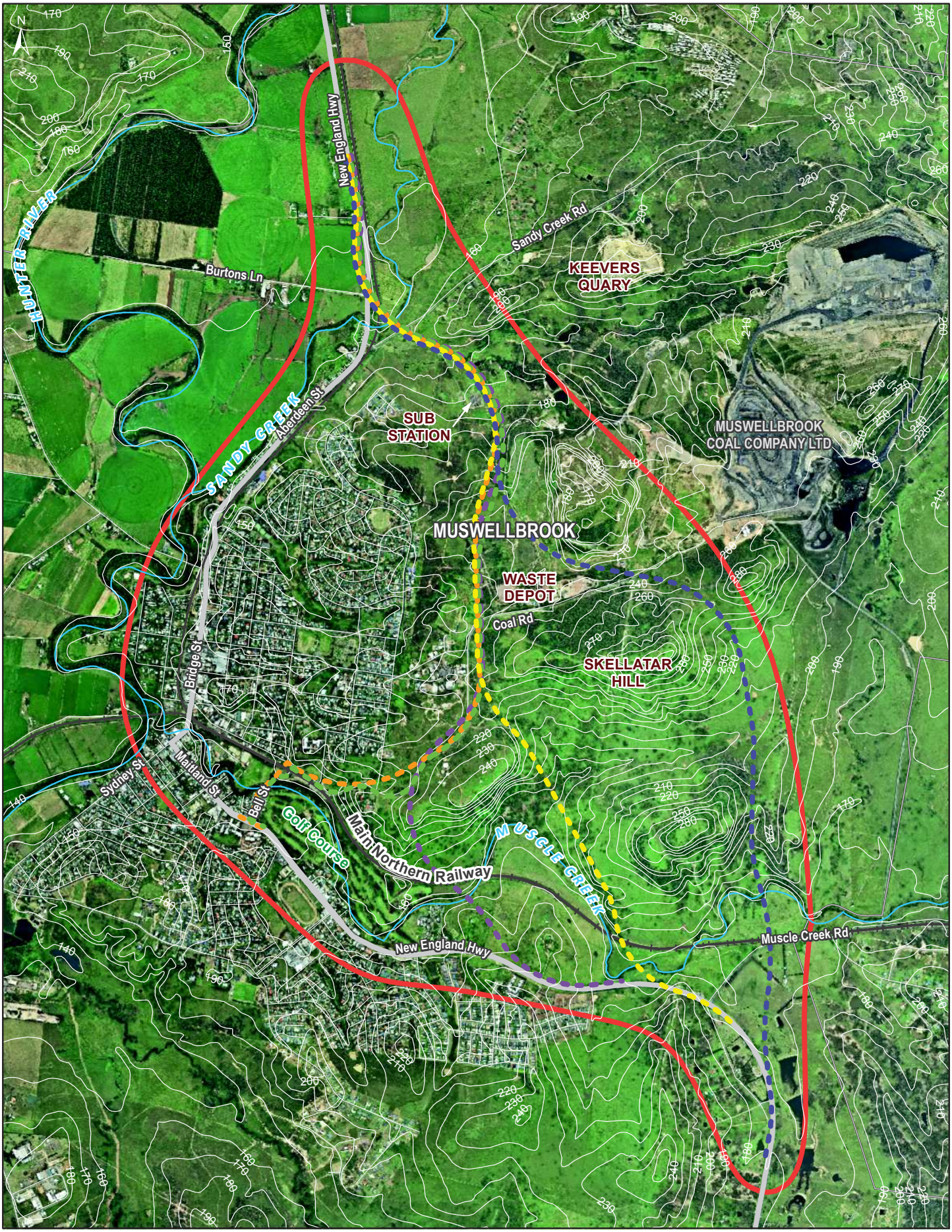
Topography can affect road design, safety and travel time. Hilly terrain can lead to steep road grades which can increase the risk of crashes, slow down heavy vehicles and increase travel times. It can also increase construction costs with more earthwork needed to reduce slopes. Steep terrain can slow heavy vehicles resulting in longer travel times. Options with longer travel times are less attractive to road users and will result in less traffic using the bypass.

Skellatar Hill is the major topographical feature that constrains options east of the Muswellbrook township. Skellatar Hill has an elevation of 320 metres and is connected by adjoining hills and ridgelines. The blue option skirts to the east of Skellatar Hill while the yellow and purple options lie to the west (**Figure 18)**.

The *New England Highway Draft Corridor Strategy* has a vertical grade target of 6 per cent. The blue option has maximum grades of 8 per cent as it hugs Skellatar Hill and avoids another hill to the immediate north-east of Skellatar Hill. The yellow and purple options have grades of up to 6 per cent.

Green and orange options avoid Skellatar Hill, however, the existing Coal Road alignment exhibits maximum grades of up to 14 per cent. The options have sought to reduce the current 14 per cent grade on Coal Road to a maximum 9 per cent (Green option) and 6 per cent (Orange option).

Road grades and the potential need for overtaking lanes would be considered as part of further planning.



Study area
Existing route
Named streams
Railway

Muswellbrook bypass options and topography
Muswellbrook Bypass - Options Report
0 0.25 0.5 1 Kilometres

Dec 2017

Fig. 18

5.5 Heritage

5.5.1 Aboriginal heritage

Aboriginal heritage is a potential constraint to all options because of the high number of recorded sites and landscape features such as water and drainage lines in the study area.

Roads and Maritime searched the OEH Aboriginal Heritage Information Management System (AHIMs) in 2016 and identified more than 50 registered sites.

We have not assessed cultural heritage values as part of the preliminary investigation. We will consult with Office of Environment and Heritage (OEH), Local Aboriginal Land Councils and representatives of the local Aboriginal community as part of any future planning.

5.5.2 Non-Aboriginal heritage

We searched databases for items of local, state and federal non-Aboriginal heritage. The search identified 65 items with heritage significance and two heritage conservation areas. There were 10 items listed on the state heritage register. State listed heritage places are protected under the Heritage Act and Environmental Planning & Assessment Act.

The results of the searches are in **Figure 19**.

Study area
Named streams
Existing route
Railway

Non-aboriginal heritage
Local Heritage
Local Conservation Area
State Heritage

Muswellbrook bypass options and non-Aboriginal heritage
Muswellbrook Bypass - Options Report
0 0.25 0.5 1 Kilometres

Dec 2017

Fig. 19

5.6 Noise and vibration

Noise levels increase during construction from earth moving and road construction equipment. When the road is operational the noise levels adjacent to the bypass would increase with traffic and heavy vehicles. Noise and vibration may be a constraint on the purple, green and yellow options, particularly where they are near residential zoned land. Noise and vibration does not appear to be a constraint for the blue option, which is further away from residences.

Vibration is a potential constraint for all options during construction. Vibration standards and controls will apply to all bridge construction near rail lines, waterway crossings and road overpasses. The orange option has a new bridge at Bell Street. This may mean vibration impacts especially for Muswellbrook High School.

5.7 Air quality

Air quality is a potential issue during construction and operation. Dust from roadwork and emissions from machinery can impact local air quality during construction. When a road is operating vehicle exhaust fumes can affect air quality.

Sections of the green and orange options are in urban areas. These options pose more of risk of air quality impacts than the yellow, purple and blue options. We need to further investigate construction and operational air quality impacts in the next stage of planning.

5.8 Visual amenity

New roads and structures such as bridges, road cuttings and embankments can impact on the visual settings and character of a place, such as areas characterised by an undisturbed rural setting. Increases in vehicle volumes and additional heavy vehicles can also impact visual amenity, particularly areas characterised by low traffic volumes with little to no heavy vehicle movements.

5.9 Contamination

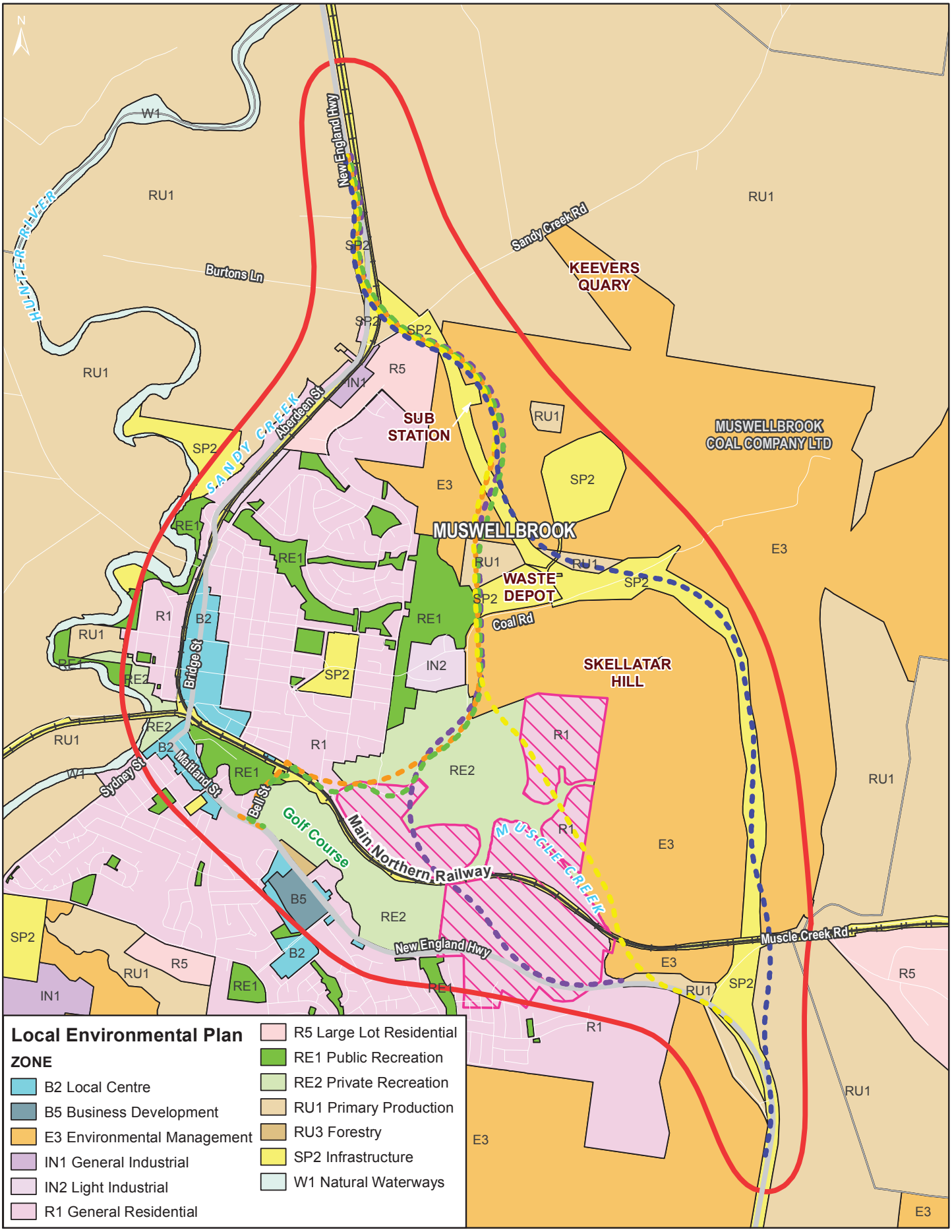
Current and historical land uses like landfill, mining, agricultural, industrial and commercial land use could result in contamination. Contamination on a route can increase investigation, sampling, mitigation, remediation, mitigation and management costs.

Roads and Maritime searched the NSW EPA databases in December 2016. While there were no recorded contaminated sites, future bypass planning would incorporate land use activities and contamination risk investigation.

5.10 Property and land use

The extent of land acquisition for a new bypass can increase cost and have social impacts. The bypass location can impact nearby current and future land uses. We have reviewed property ownership, current and future land uses in the study area. Some of the current land ownership constraints include:

- Residential zoned land and release areas shown in **Figure 20**
- Privately owned property and Crown Lands, mining companies and land vested under the Aboriginal Lands Rights Act shown in **Figure 21**
- Muswellbrook Golf Course
- Muswellbrook Waste Management Facility and future facility shown in **Figure 21**
- Ausgrid substation site and
- Main North Rail Line.


N
W1
RU1
HUNTER RIVER
New England Hwy
Burtons Ln
Sandy Creek Rd
KEEVERS QUARRY
SP2
R5
IN1
SUB STATION
SANDY CREEK
Aberdeen St
MUSWELLBROOK COAL COMPANY LTD
E3
MUSWELLBROOK
RE1
WASTE DEPOT
Coal Rd
R1
B2
Bridge St
IN2
SKELLATAR HILL
RE2
Sydney St
Maitland St
Bell St
Golf Course
Main Northern Railway
MUSCLE CREEK
B5
Muscle Creek Rd
Local Environmental Plan
ZONE
B2 Local Centre
B5 Business Development
E3 Environmental Management
IN1 General Industrial
IN2 Light Industrial
R1 General Residential
R5 Large Lot Residential
RE1 Public Recreation
RE2 Private Recreation
RU1 Primary Production
RU3 Forestry
SP2 Infrastructure
W1 Natural Waterways
Study area
Existing route
Railway
Future residential
Muswellbrook Local Environmental Plan
Muswellbrook Bypass - Options Report
0 0.25 0.5 1 Kilometres
Dec 2017
Fig. 20

Study area
Future residential
Crown Land Parcels
Land Constraint
Site Constraints
Existing route
Named streams
Cadastre
Coal titles
Railway

Options showing land constraints
Muswellbrook Bypass - Options Report
0 0.25 0.5 1 Kilometres

Dec 2017

Fig. 21

5.11 Infrastructure and utilities

5.11.1 Main North rail line

The Main North rail line enters Muswellbrook from the east and runs parallel to the New England Highway, before continuing north towards Aberdeen. A spur line (the Ulan line) continues west across Muscle Creek and the Hunter River. The Main North rail line overpass on Bridge Street has width restrictions that limit over-size vehicles (**Figure 8**). These over-size vehicles instead travel along Bell, Victoria and Market streets.

The Main North rail line is a constraint on all bypass options. Road and bridge work in and near the rail corridor would be subject to additional vibration assessment and design standards. Construction in the rail corridor is also restricted with limited rail possessions per year due to disruption to the Hunter Valley Coal Chain.

Blue, purple and yellow options would require two bridges over the Main North rail line: one on the southern approach to Muswellbrook, and one near the intersection of Sandy Creek Road and the New England Highway.

5.11.2 Utilities

Utility constraints in the study area include:

- Fibre optic and telecommunication cables on the New England Highway
- Telecommunication cables on Muscle Creek Road, Coal Road and Sandy Creek Road
- Water mains on Coal Road and Sandy Creek Road
- Water reservoir on Coal Road
- Electricity sub-station north-east of Muswellbrook.

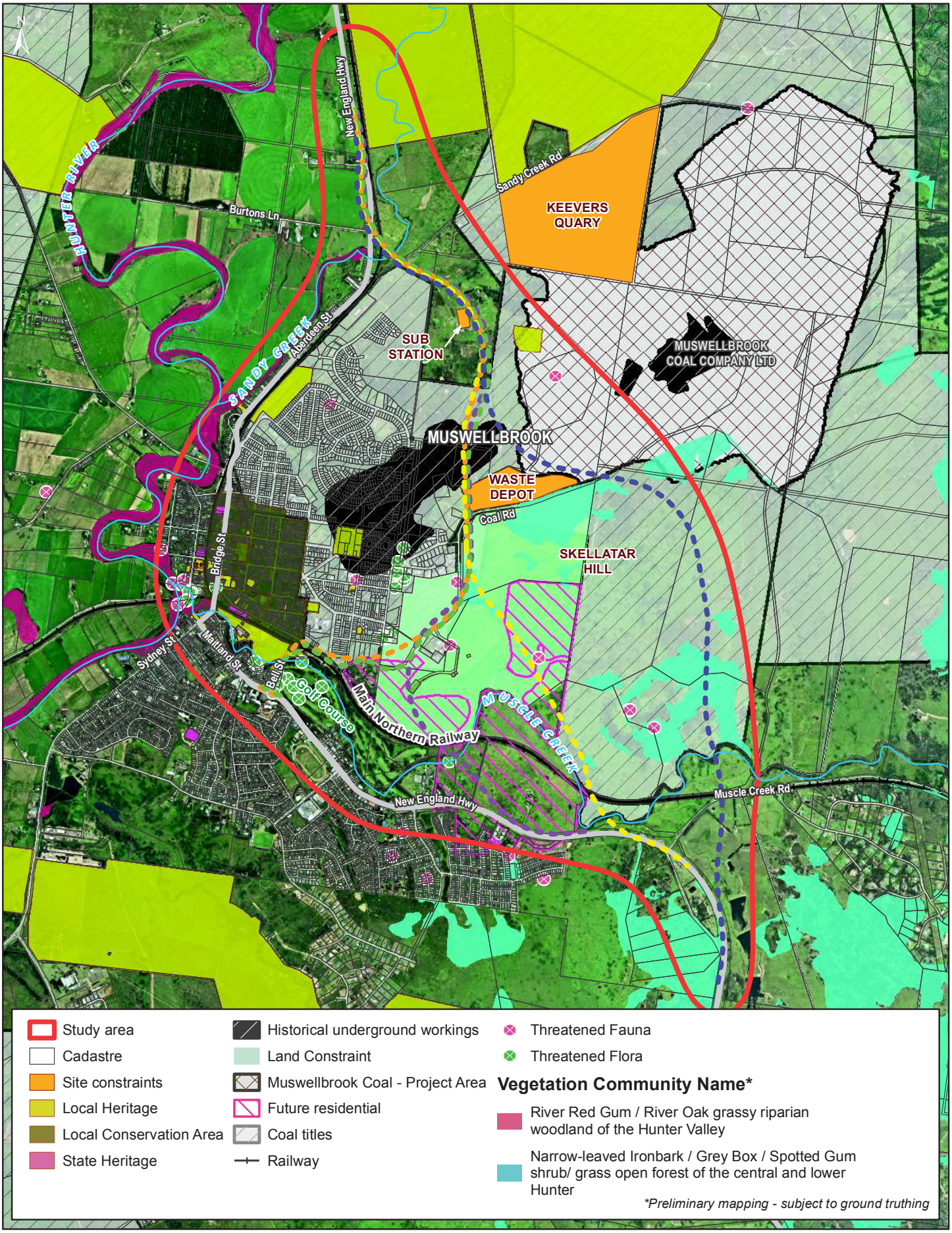
We will consult with utility owners in the next stage of investigations of a Muswellbrook bypass.

5.12 Summary

A summary of potential constraints for each bypass option is in **Table 7**. A cross shows we identified that constraint in preliminary studies for that option.

Table 7 Summary of potential bypass option constraints

Constraints	Blue	Purple	Yellow	Green	Orange
Biodiversity	X	X	X	X	X
Surface water and flooding					
Geotechnical	X	X	X	X	X
Topographical	X	X	X	X	X
Heritage Aboriginal	X	X	X	X	X
Heritage Non-aboriginal				X	X
Noise and vibration		X	X	X	X
Air quality				X	X
Visual amenity					
Contamination					
Property		X	X	X	X
Land use	X	X	X	X	X
Infrastructure and utilities	X	X	X	X	X



Preliminary environmental constraints
Muswellbrook Bypass - Options Report

0 0.25 0.5 1 Kilometres

Dec 2017

Fig. **22**

6. Option assessment

6.1 Travel time saving

We determined the travel time saving of each bypass option for the year 2044 using a traffic model. The travel time saving is the time for a vehicle travelling using a new bypass option compared against the "do minimum" described in section **3.2.4**. This comparison is in **Table 8**.

The yellow option has the highest travel time saving of 5.9 minutes to 9.7 minutes, depending on the direction of travel and the morning or afternoon peak period. The blue option has the second highest travel time saving of 4.9 to 9.2 minutes.

Orange and green do not perform as well. Green has travel time saving of 0.7 to 3.2 minutes and Orange 0.7 to 2.6 minutes.

Table 8 Forecast travel times for "do minimum" and bypass options (2044)

Travel time using	Trip distance[1]	Forecast 2044 travel times (minutes) AM Peak		Forecast 2044 travel times (minutes) PM Peak	
		North Bound	South bound	North Bound	South bound
Do minimum	10.1 kilometres	14.4	13.1	16.2	12.7
Blue	8.7 kilometres	7.3	7.8	7.0	7.8
Travel time saving (min)		7.1▼	5.3▼	9.2▼	4.9▼
Purple	9.4 kilometres	7.6	7.6	7.4	7.7
Travel time saving (min)		6.9▼	5.5▼	8.8▼	5.0▼
Yellow	8.3 kilometres	6.7	7.0	6.4	6.8
Travel time saving (min)		7.7▼	6.1▼	9.7▼	5.9▼
Green	11.6 kilometres	11.8	12.2	13.0	12.0
Travel time saving (min)		2.6▼	0.9▼	3.2▼	0.7▼
Orange	11.5 kilometres	12.6	12.4	13.6	11.8
Travel time saving (min)		1.9▼	0.7▼	2.6▼	0.9▼

[1] The trip distance for the purpose of the modelling is taken from the intersection of Muscle Creek Road with the existing New England Highway in the south, to the intersection of the existing New England Highway with Sandy Creek Road to the north. The "trip distance" is not necessarily the option length, but allows a consistent comparison of options by using consistent trip end points to the north and south of Muswellbrook.

6.2 Cost estimates

We prepared cost estimates for each bypass option. All cost estimates are preliminary estimates for comparative purposes. Costs estimates will be revised as part of further planning.

Out-turn cost estimates are used to plan future spending. They are used in conjunction with project cost benefit analysis to compare various options. Out-turn costs take into account further project planning and construction. They incorporate factors such as wages and materials cost increases over a future time period.

Out-turn costs for the Muswellbrook bypass were prepared in 2016$ and are based on an escalation rate of 7% in accordance with Roads and Maritime Service's Estimating Manual (2008) and an assumed construction start in 2021 and opening in 2024. Actual start and opening dates are subject to finding an economically viable option, State and Australian Government funding and planning approvals.

The blue option is the least cost bypass option for Muswellbrook, with an out-turn cost of $285M. The next cheapest option is green with an out-turn cost of $395 million. This is $110million greater than the out-turn cost of the blue option.

The biggest cost variation for the purple, yellow, green and orange options is costs associated with geotechnical risk from underground mines. The ground will need to be treated in areas that have been affected by mining activities which will increase the cost. Other costs associated with green and orange include road upgrade costs to accommodate bypass traffic. This includes pavement reconstruction, intersection upgrades and road geometry improvements.

Out-turn costs for the bypass options are shown in **Table 9**.

Table 9 Bypass cost estimates (out-turn)

Option	Out-turn estimate ($M)*
Blue	285
Purple	420
Yellow	415
Green	395
Orange	425

* All cost estimates are preliminary estimates for comparative purposes only.

6.3 Economic analysis

We assessed the economic viability of bypass options by calculating a BCR for each option. A BCR is the ratio of the option's benefits compared to the option's costs. A BCR of one or greater indicates that the benefits of a project exceed total project construction costs. The results of the cost benefit analysis of bypass options are presented in **Table 10.**

The total project construction cost includes the capital as well as the operation and maintenance costs. The project benefits include travel time savings, vehicle operating cost savings, reduction in crash costs, environmental externality costs and the residual value of the (bypass) asset. Cost and benefits are calculated over a 30 year period. The options are compared against the costs and operational performance of the 'do minimum' scenario described in section 3.2.4.

Table 10 Economic analysis of bypass options

Input to BCR	Blue	Purple	Yellow	Green	Orange
Benefit Cost Ratio (BCR)	1.3	0.7	1	0.3	0.3

7. Conclusion

Blue

The blue option performs well compared to the other options.

Blue has the lowest costs of $285 million. It is approximately $110 million less than the next option (green of $395 million).

Blue is the most economically viable bypass option, with a BCR of 1.3, with the second greatest traffic travel time reduction rate of 9.2 minutes by 2044 (northbound afternoon peak).

Blue performs the best against the identified constraints. It has reduced property impacts. It is further away from residential areas and future land releases. It performs more favourable on amenity grounds such as noise, vibration and air pollution during construction and operational phases.

This option is the least exposed to identified geological risks from underground mine workings. It crosses about 50 metres of underground mine workings. Purple, yellow, green and orange options cross about 400 metres.

Purple

The purple option does not perform as well as blue and yellow. However this option does perform better than green and orange.

Purple has a higher cost ($420 million) than blue and yellow. It has a lower BCR (0.7) and lesser savings in travel times than blue and yellow. Purple does however have a higher BCR and greater travel time savings than options orange and yellow.

Purple has a number of constraints that can increase project cost and delivery timeframes in comparison with blue. It has greater potential property impacts compared with blue. The route is closer to residential properties on the east of Muswellbrook and future land release areas. Amenity may be affected during construction and operational phases for noise, vibration and air pollution. Purple passes through about 400 metres of underground mine workings.

These constraints may further affect the economic viability of the option.

Yellow

The yellow option has a BCR of one. Yellow provides the shortest travel distance (about 8.3 kilometres) and highest maximum travel time saving of 9.7 minutes (in the peak hour) by 2044.

Yellow has higher costs when compared with blue of $415 million as compared with $285 million for blue.

Yellow has a number of constraints that can increase project cost and delivery timeframes in comparison with blue. It has greater potential property impacts compared with blue. The route is closer to residential properties on the east of Muswellbrook and future land release areas. Amenity may be affected during construction and operational phases for noise, vibration and air pollution. Yellow passes through about 400 metres of underground mine workings.

These constraints may further affect the economic viability of the option.

Green and Orange option

The green and orange options do not perform as well as the other options.

Orange is the most expensive option of all options considered at $425 million. Green has $395 million. These costs are far higher than the blue option at $285 million.

Both options have a BCR of 0.3. Travel time savings are 0.7 to 2.9 minutes for green and 0.7 to 3.2 minutes for orange depending on the direction of flow and peak. By comparison blue has travel time savings of 4.9 to 9.2 minutes depending on the direction of flow and peak.

Green and orange has a number of constraints which could increase project cost and delivery timeframes in comparison with blue. Green and orange both have greater potential property impacts compared with blue. Both routes are closer to residential properties on the east of Muswellbrook and future land release areas. Amenity may be affected during construction and operational phases for noise, vibration and air pollution. Green and orange passes through about 400 metres of underground mine workings.

These constraints may further affect the economic viability of the option.

Table 11 Muswellbrook bypass options and traffic and economic performance

Bypass Option	Blue	Purple	Yellow	Green	Orange
Option length	9.1 kilometres	7.9 kilometres	7.7 kilometres	7.1 kilometres	7 kilometres
2044 travel time saving (peak hours)	4.9 – 9.2 minutes	5 – 8.8 minutes	5.9 – 9.7 minutes	0.7 – 2.9 minutes	0.7 – 3.2 minutes
Out-turn Cost*	$285 million	$420 million	$415 million	$395 million	$425 million
BCR	1.3	0.7	1	0.3	0.3

* All cost estimates are preliminary estimates for comparative purposes only.

7.1 Recommendation

The blue option is recommended as the preferred route option.

The blue option is the most economically viable. This reconfirms the corridor identified in previous planning studies. The blue option has minor route changes from the Muswellbrook bypass 2009 LEP corridor. These changes have improved the economic viability of the route option.

Future planning will refine the corridor for the final route. We will continue to work with council to secure the refined corridor in the LEP.

8. Glossary

The following table contains a glossary of terms.

Table 12 Glossary of terms.

Term	Meaning
AADT	Annual average daily traffic. The total volume of traffic passing a roadside observation point over a period of a year, divided by the number of days per year
Aboriginal heritage	The tangible (objects) and intangible (dreaming stories, songlines, places) cultural practices and traditions associated with past and present day Aboriginal communities
AEP	Annual exceedance probability
AHD	Australian height datum
Alignment	The geometric layout (eg of a road) in plan (horizontal) and elevation (vertical)
Amenity	The look and feel of a place, or its attractiveness
Arterial road	A high capacity road connecting towns and cities and/or within urban areas
ATD	Average daily traffic
BCR	Benefit cost ratio. The ratio of the monetary benefits to the costs of a project as a measure of worth to the community
Biodiversity	The variety of life forms, including flora and fauna, the genes they contain and the ecosystems in which they live
Capacity	The nominal maximum number of vehicles that can travel along a road in a given time
Carriageway	The portion of a roadway used by vehicles including shoulders and auxiliary lanes
Catchment	The area from which a surface watercourse or a groundwater system derives its water
Constraint	Something that limits or restricts the project design, development or construction
Constructability	Refers to the ease in which a project can be built
Culvert	One or more adjacent enclosed channels for conveying a stream below formation level
Cut	The material excavated from a cutting
Design speed	A nominal speed which determines the geometric design features of a road
Earthworks	All operations involved in loosening, excavating, placing, shaping and compacting soil or rock
Ecology	The relationship between living things and the environment
Economic analysis	An economic based approach that considers the merits of a project from the viewpoint of the community at large rather than that of the organisation responsible for the project
Embankment	An earthen structure where the road sub grade level is above the natural surface
Endangered ecological community (EEC)	An ecological community identified by relevant legislation that is likely to become extinct or is in immediate danger of extinction
Environment	All aspects of the surroundings of humans, whether affecting any human as an individual or in his or her social groupings (from EP&A Act)
Environmental assessment (process)	Process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of proposals prior to major decisions being taken and commitments made
Fauna	Animals
Fill	The material placed in an embankment
Flood immunity	Flood immunity measures whether the surface of a section of road will be above the flood height for a specific flood event. A section of road with low flood immunity will have water over the road more often than one with a high flood immunity.
Flora	Plants

Term	Meaning
Footprint	The extent (or area in plan) of a development on the land
Grade	The rate of longitudinal rise (or fall) with respect to the horizontal expressed as a percentage or ratio
Grade separated	The separations of road, rail or other traffic so that crossing movements at intersections are at different levels
Habitat	The place where a species, population or ecological community lives (whether permanently, periodically or occasionally). Habitats are measurable and can be described by their flora and physical components.
Heavy vehicle	A heavy vehicle is classified as a Class 3 vehicle (a two axle truck) or larger, in accordance with the Austroads Vehicle Classification System
Hydrology	The study of rainfall and surface water runoff processes
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment
Interchange	A grade-separated junction between roads where a road passes over or under the highway via a bridge or underpass structure with one or more interconnecting roadways
Landscape	A tract of land. Also a prospect or piece of scenery or land which may include villages, towns, cities and infrastructure
Landscape character	The aggregate of built, natural and cultural aspects that make up an area and provide a sense of place. Includes all aspects of a tract of land – built, planted and natural topographical and ecological features
Leachate or acid leachate.	Water that has percolated through a solid and leached out some of the constituents. Acid leachate can occur when water moves through material containing pyrite (iron sulphide). Sulfuric acid can form.
LEP	Local environmental plan
LGA	Local government area
Local road	Roads that have a low speed limit, have a small footprint, serve local communities and that are generally conducive to walking and cycling. A road or street used primarily for access to abutting properties.
MCA	Multi Criteria Analysis
Merge	The converging of separate streams of traffic into a single stream
Origin-Destination (OD survey)	An origin-destination (OD) study is used to determine where and how much traffic is travelling during a typical day for a particular road network. Trips are defined as one-way movement, from where a trip starts (origin) to where the trip is going (destination).
Out-turn Dollars	Is the estimated dollar value for which the project would be completed assuming a given delivery period. Out-turn dollars are calculated by escalating the estimated project cash flow for each year of the project to represent the actual project costs in future year dollars.
Preloading	Placing a mound of earth over an area and allowing it settle before building
Property	In the context of the project, property acquisition refers to purchasing property from owners to provide land for the project
PV	Present value
Sensitive receiver	Premises sensitive to noise. These can include residential dwellings, schools, hospitals, nursing homes and places of worship.
Settlement	Settlement is a process where there is a reduction in the volume of soil.
SMVU	Survey of Motor Vehicle Use
Spontaneous Combustible Material (SCM)	SCM is material that contains coal. It can ignite under certain conditions.
Staged Bypass	A staged bypass is a bypass that is constructed and opened to traffic in two or more stages. Each stage connects to an existing road at the start and end point. There may be a number of years between the opening of the first stage of bypass and subsequent stages.

Term	Meaning
Stakeholder	Organisations, parties and/or special interest groups likely to have an interest in the proposal
Study area	The study area encompasses the proposal area and the area that may be indirectly impacted by the proposal
Subsidence / Mine subsidence	When material is removed from underground mine the overlying earth can sink. This is mine subsidence.
Threatened	As defined under the NSW Threatened Species Conservation Act 1995. A species, population or ecological community that is likely to become extinct or is in immediate danger of extinction.
Topography	The physical appearance of the natural features of an area of land, especially the shape of its surface.
Urban design	The process and product of designing human settlements and their supporting infrastructure, in urban and rural environments.
VHT	Vehicle Hours Travelled
Viaduct	A bridge with several spans
VKT	Vehicle Kilometres Travelled
Vulnerable	As defined under the Threatened Species Conservation Act 1995, a species that is likely to become endangered unless the circumstances and factors threatening its survival or evolutionary development cease to operate.

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