Appendix C Hyder Report into East Muswellbrook Bypass

9/305.15 Vol 7
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HW9 NEW ENGLAND HIGHWAY
MUSWELLBROOK BYPASS - TRAFFIC STUDY

Dear Neil,

Please find attached for your records, a copy of the final traffic study report for the proposed Muswellbrook Bypass.

Should you wish to discuss the project or require further information, please contact Matthew Mate, Project Development Manager, on 4924 0646.

Yours sincerely

C W Nunn
Infrastructure Development Manager
Hunter Region

Roads and Traffic Authority

RTA

HW9 New England Highway Detailed Traffic Study and Modelling of Proposed Muswellbrook Bypass

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1 Introduction

1.1 Background

The New England Highway is part of the AusLink National Network between Sydney and Brisbane, extending from the Pacific Highway at Hexham, via Muswellbrook and Tamworth, to the Queensland border near Tenterfield.

The New England Highway through Muswellbrook passes through four sets of traffic signals, one roundabout, and under a narrow and height restricted railway overpass. The highway is four lanes for a majority of the route through Muswellbrook, but includes a two-lane section crossing Muscle Creek and passing under the Main Northern Railway. The highway has created some undesirable impacts through Muswellbrook town centre including conflict between light and heavy vehicles serving both the coal industry and long-distance freight haulage.

The Roads and Traffic Authority (RTA) engaged Hyder Consulting to prepare a detailed traffic study for the proposed Muswellbrook Bypass by undertaking refinement of the Muswellbrook local area traffic model. In 2007 Parsons Brinckerhoff (PB) developed a local area traffic model using TransCAD software for Muswellbrook Shire Council. In a broad sense, the Muswellbrook traffic model was an extension of the Lower Hunter Traffic Model owned and maintained by the RTA. The Muswellbrook traffic model was calibrated for 2007 for the AM peak 2 hour period consistent with the Lower Hunter Traffic Model. The forecast traffic volumes were prepared for future years 2020 and 2037 as per land use data contained in Muswellbrook Shire Council's local area traffic model.

The modelling of the proposed bypass was based on modified option E being the preferred route approved in June 2005 by the then Department of Transport and Regional Services (DOTARS), now Department of Infrastructure, Transport, Regional Development and Local Government (DOI). The preliminary concept design for the preferred route consists of a two-lane single carriageway bypass to the east of Muswellbrook approximately 8.8 km long and comprising the following elements:

- Three partial interchanges and one full interchange within the project length.
- Two bridge crossings over the Main Northern Railway line;
- Two bridges over Muscle Creek and Sandy Creek; and
- Provision of overtaking lanes in both directions.

The original Muswellbrook traffic model was developed during 2007 and included the results of the previous origin destination survey that the RTA conducted during its bypass route alignment study (2002). This was supplemented by further 2007 traffic counts on the New England Highway provided by Council. In developing the bypass model augmentation process, the traffic data and modelling assumptions from previous reports were reviewed.

The reports are:

- Muswellbrook Bypass, Preliminary Traffic Report, Roads and Traffic Authority, Parsons Brinckerhoff, October 2007; and
- Muswellbrook Traffic Study and Plan, Muswellbrook Shire Council, Parsons Brinckerhoff, January 2008.

Both reports provided background information including existing traffic numbers and level of service of key intersections on the New England Highway.

Following the completion of the preliminary traffic study on the proposed bypass, the RTA conducted a new 24 hour origin destination (OD) survey, supplementary traffic counts on local roads, and travel time data on key routes along the bypass corridor. This new data improved the traffic model parameters and forecasting results, and therefore formed the basis of the model augmentation and detailed bypass traffic study.

1.2 Study area

Figure 1-1 shows the proposed New England Highway bypass route and its relationship with the existing road network. The road hierarchy was used to define the function of the network and is also shown in Figure 1-1. Broadly, the study area network is composed of rural arterial, sub arterial, urban arterial, collector and local roads. The New England Highway (HW9) is the main arterial road running predominantly north-south. It provides an important connection with a number of local areas including south Muswellbrook, North Muswellbrook and the town centre. To the north, the model extends to McCullys Gap Road and to the south to Bimbadeen Drive. The study area network was refined in sufficient detail to capture travel patterns from land use changes proposed in both north and south Muswellbrook.

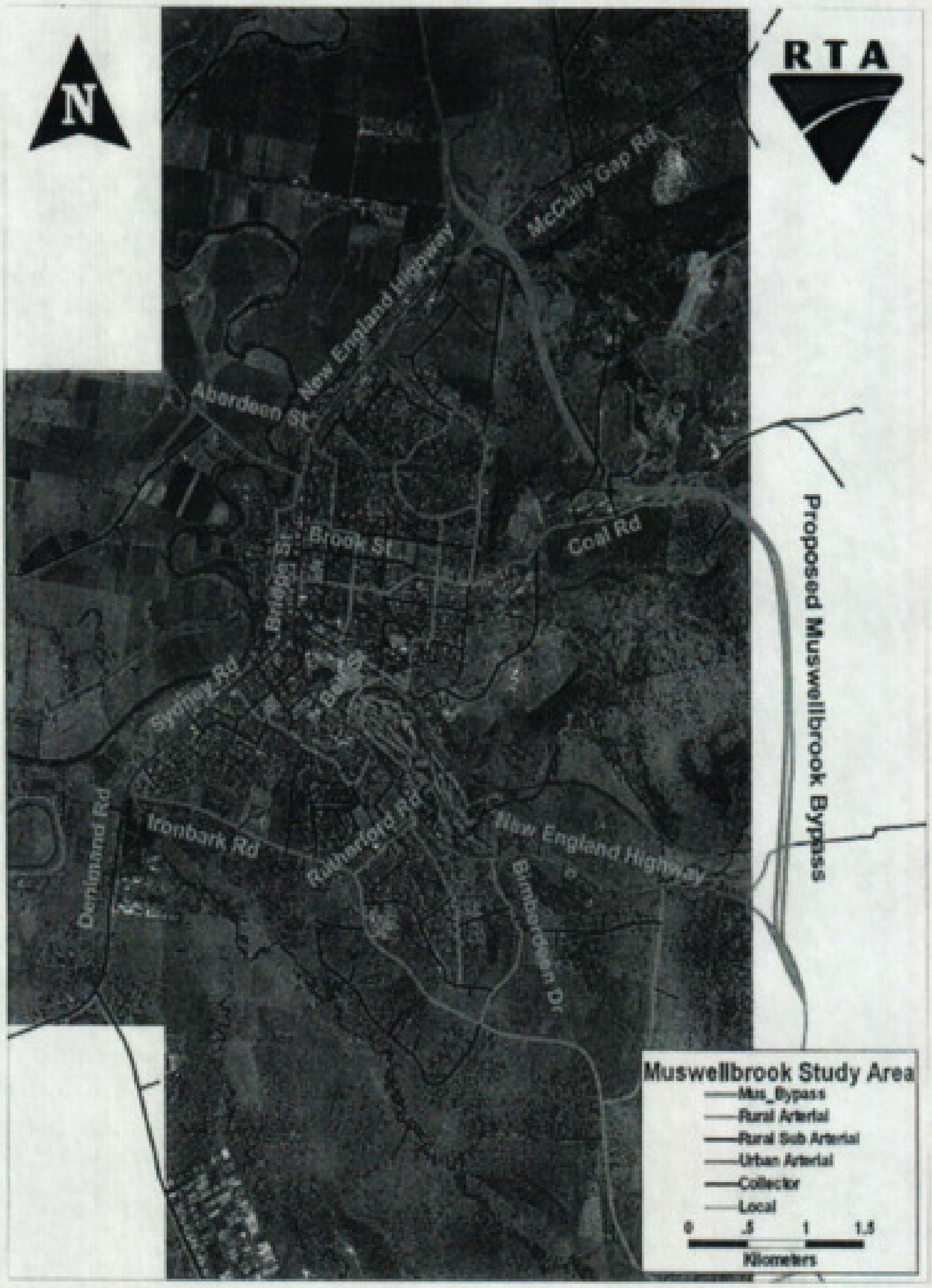

Figure 1-1 Muswellbrook Study Area

1.3 Study objectives, methodology and process

The purpose of this study is to prepare traffic forecasts on the proposed Muswellbrook Bypass and associated interchanges using the 24 hour origin destination survey conducted by the RTA in 2007. In preparing the traffic forecasts the origin destination survey was analysed in a number of ways to confirm through and stopping traffic distribution. Results of the traffic distribution, in conjunction with updated travel times on the New England Highway, were used to augment the preliminary AM peak period model. Key objectives of the detailed traffic investigation are as follows:

- Analyse through and stopping traffic patterns on the New England Highway on the basis of the 24 hour OD survey conducted in 2007;
- Analyse supplementary mid-block counts, intersection counts and travel time data at key roads and intersections used to refine the 2007 calibration and validation on the New England Highway;
- Assess the crash patterns on the New England Highway using the most current five year historical data;
- Update the road network along the Coal Road and Common Road in the vicinity of the proposed central interchange;
- Augment the preliminary AM peak period model using OD, traffic counts and travel time data;
- Update traffic forecasts on the bypass and New England Highway for 2020 and 2037;
- Estimate travel time saving from the bypass compared to the "no build" case;
- Prepare traffic input data for noise, air quality and socio economic assessments as required for a future environmental assessment of the bypass;
- Estimate vehicle km and vehicle hours for the bypass and "no build" cases for input to the economic assessment; and
- Undertake a preliminary economic analysis of the bypass in accordance with the RTA's Economic Analysis Manual.

A three phase study methodology was developed to achieve the above objectives. Broadly the approach involved reviewing data sources, analysing OD data, supplementary traffic counts and travel time data; augment base and future year models; prepare traffic forecasts; and estimate the benefit cost ratio (BCR) of the bypass. The overview of tasks in each phase and expected outcomes are presented in Figure 1-2. Figure 1-2 also shows the detailed subtasks in each phase and their relationship with the preceding tasks.

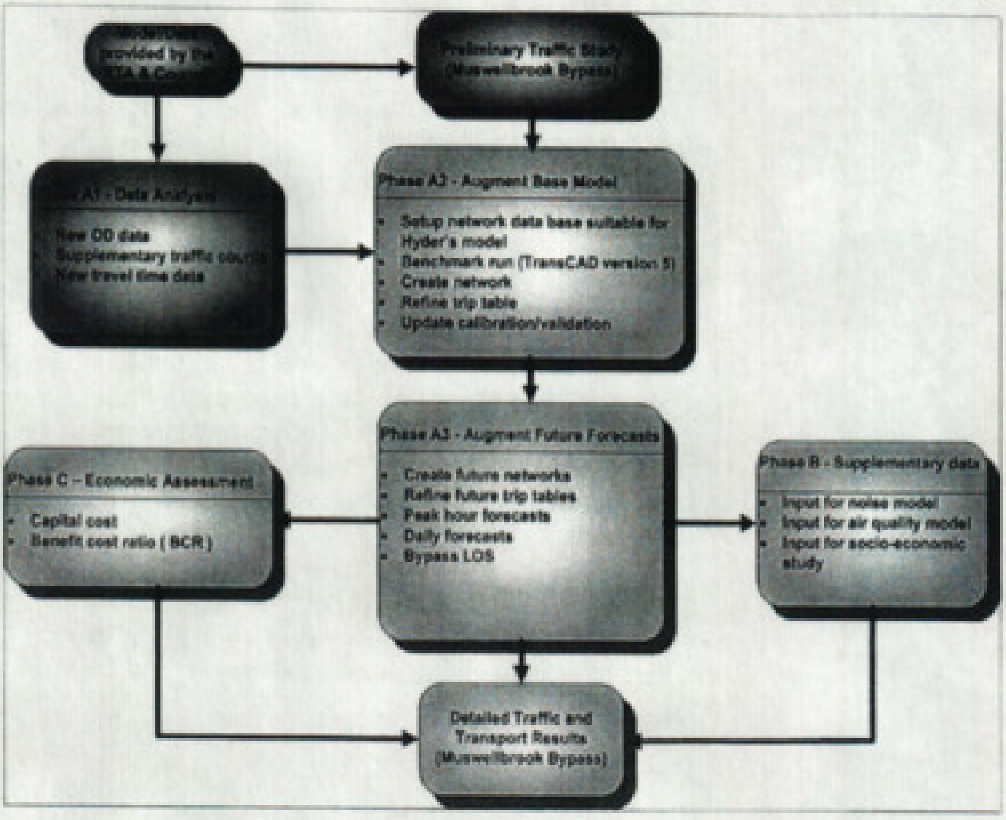

Figure 1-2 Overview of Hyder's Modelling Approach

Below is a brief summary of the three phase traffic and modelling methodology.

Phase A

This phase involved reviewing data resources used for preparing the preliminary bypass traffic model, augmentation of base and future year traffic models, new data analysis and revised forecasts for the proposed bypass. Tasks from Phase A were further categorised into three broad sub phases as follows:

Sub Phase A1

This phase involved analysing the new OD data, supplementary traffic counts and travel time data. During October and November 2007, the RTA conducted new OD survey at six locations on the New England Highway for a 24 hour period. The OD data formed the basis of the model augmentation. The tasks undertaken during sub phase A1 included:

- Develop existing (2007) traffic patterns from OD survey;
- Determine 24 hour OD patterns for cars, trucks and B-Doubles separately;
- Determine stopped traffic patterns for cars, trucks and B-Doubles separately;

- Estimate anticipated traffic patterns following the opening of the proposed bypass;
- Analyse supplementary counts data on local roads parallel to the New England Highway; and
- Analyse travel time data on the New England Highway and other local roads.

Sub Phase A2

This phase involved refining the base year 2007 model on the basis of the OD survey, traffic counts and travel time results from previous sub phase A1. The preliminary Muswellbrook Bypass traffic model was developed using TransCAD version 4.7. The model was augmented using TransCAD version 5. A new data base system was set up that facilitated data transfer including the road network and trip tables into TransCAD version 5. Key modelling tasks were:

- Benchmark model run by using TransCAD version 5;
- Create new network and update network in and around Coal Road (near the proposed Coal Road interchange);
- Refine trip tables for revised through and stopping traffic distributions;
- New traffic assignment 2007 base model; and
- Refine or update 2007 model calibration and validation.

A key output from this phase was the revised base year 2007 model reflecting new OD patterns and travel time on the New England Highway.

Sub Phase A3

This phase involved the future model augmentation for 2020 and 2037 by applying revised calibration and validation factors and parameters obtained from the preceding sub phase A2. Key modelling tasks in this sub phase were:

- Create new future networks with and without bypass;
- Refine future trip tables;
- New traffic assignment for future years models;
- Prepare peak hour forecasts for future years;
- Prepare daily forecasts for future years;
- Assess impact on key surface roads following the opening of the proposed bypass;
- Analyse level of service (LOS) of the proposed bypass and associated interchanges, and
- Prepare a traffic band and volume to capacity (v/c) ratios map for all future years.

A key output from this sub phase was the revised forecasts on the bypass. aaSIDRA models were developed for surface roads at each of the three interchanges.

Phase B

As part of the broader environmental assessment of the proposed Muswellbrook Bypass, specialist studies would need to be conducted to assess potential noise and air quality impacts. A key input to these studies is future traffic forecasts not only on the bypass itself but also on the competing New England Highway. Another important aspect of environmental assessment would be a socio economic study, where the current and future stopping pattern of highway traffic passing through Muswellbrook town centre would be assessed. Traffic data was prepared for these future specialist studies in the following areas:

- Current and future traffic data for noise and air quality analysis-15 hrs, 9 hrs (light and heavy vehicles); and
- Current and future traffic data for socio economic input, stopping traffic pattern, and anticipated traffic reduction on the New England Highway.

Section 2.3.1 discussed the stopping traffic patterns of the through traffic from the OD survey. Appendix A summarises 2007 traffic on the New England Highway and 2037 forecasts for the bypass, classified by 15 hours and 9 hours, suitable for noise and air quality analysis.

Phase C

An economic analysis was undertaken to determine the economic benefits of the proposed bypass by using the RTA's Economic Analysis Manual. The economic evaluation was undertaken using 2007 updated parameter values from the RTA Economic Analysis Manual. Chapter 5 describes the results of the benefit cost ratio (BCR) analysis of the proposed bypass.

1.4 Structure of the report

The report summarises the findings of the investigations into the following chapters:

- Chapter One: Introduction chapter describes the study area, objectives and scope of the report. It also discusses methods being considered in each phase of the study;
- Chapter Two: This is the most comprehensive chapter and includes the survey methods adopted for collecting new traffic data including OD, midblock, turning counts and travel time. Results from the traffic data are also summarised in this chapter;
- Chapter Three: This section describes the augmenting of the base year model. This section describes the model augmentation, calibration and validation process;

- Chapter Four: This chapter summarises the revised traffic forecasts on the proposed bypass for the years 2020 and 2037. The impact on the New England Highway is also discussed for the no build and full build with bypass cases;
- Chapter Five: This chapter describes the economic analysis results for the proposed bypass; and
- Chapter Six: Summary of findings from this investigation.

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2 Traffic data

2.1 Review of traffic data and models

RTA made available the following traffic data, reports and models:

- Muswellbrook origin and destination survey, Austraffic, October/November 2007;
- Supplementary intersections and midblock counts, Austraffic, October/November 2007;
- Supplementary travel time survey along the bypass corridor, Austraffic October/November 2007;
- AM peak period models supplied by the RTA and Muswellbrook Shire Council;
- Muswellbrook Bypass, Preliminary Traffic Report, Roads and Traffic Authority, Parsons Brinckerhoff, October 2007; and
- Muswellbrook Traffic Study and Plan, Muswellbrook Shire Council, Parsons Brinckerhoff, January 2008.

The above data sources and reports formed the basis of the detailed traffic study and model augmentation of the Muswellbrook Bypass. The following section summarises the new traffic surveys (October/November 2007), locations and method used to collect OD and supplementary traffic data.

2.2 Overview of new traffic surveys

Following the completion of the preliminary traffic study (PB, 2007), Austraffic were engaged to conduct a series of new traffic surveys on the New England Highway and associated key roads along the proposed bypass corridor. Four types of surveys were conducted including:

- A 24 hour Origin and Destination survey;
- Supplementary intersection turning movement counts at local roads with the New England Highway;
- Supplementary mid-block counts on Coal Road; and
- Supplementary travel time surveys on the New England Highway and key local roads forming competitive route to the proposed bypass.

Figure 2-1 showed overview of survey locations.

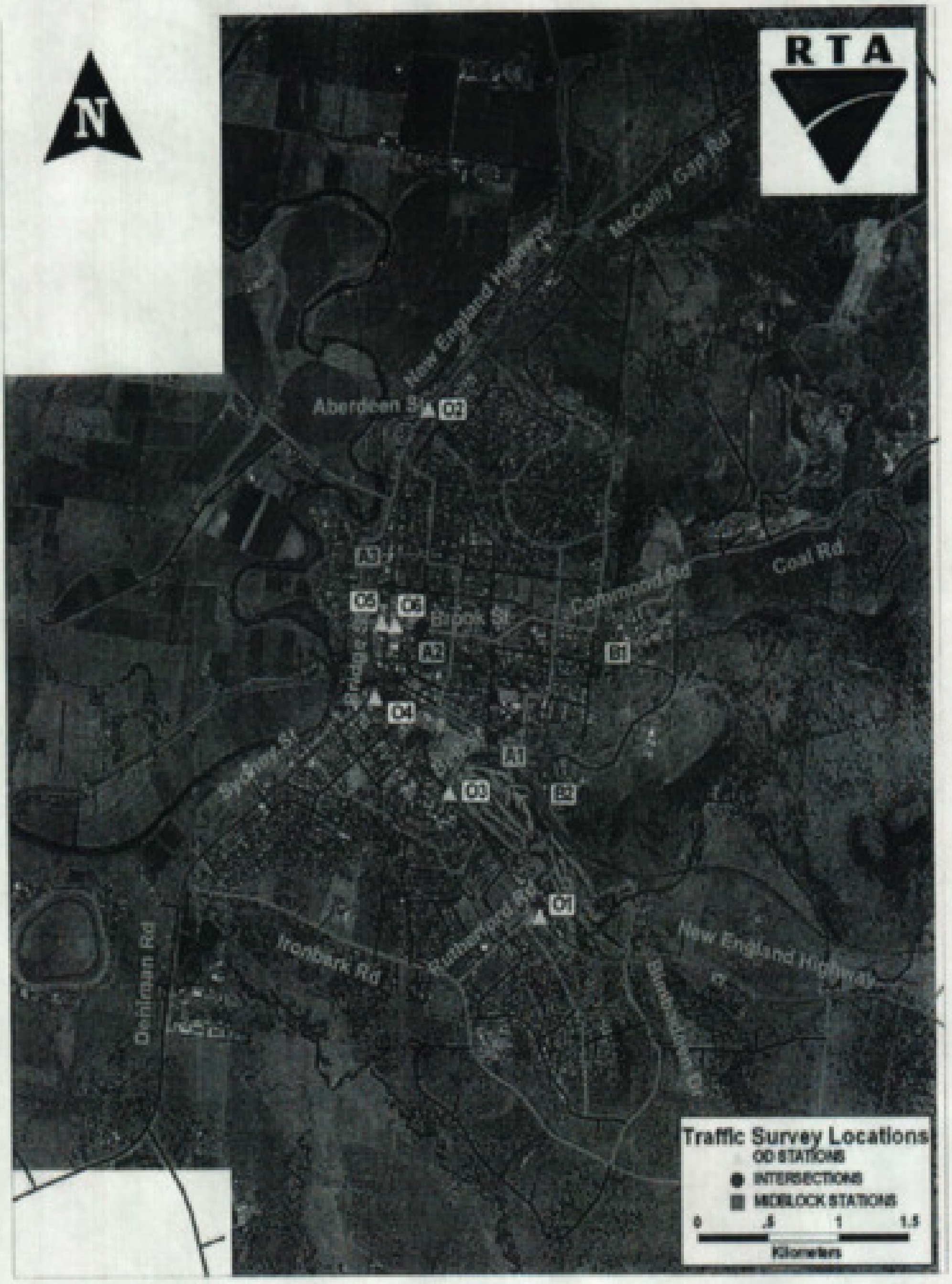

Figure 2-1 Traffic Survey Locations

2.2.1 Origin destination (OD) survey

The origin destination survey was conducted for 24 hours using video camera technology for matching vehicle number plates. Six (6) bi-directional locations were selected on the New England Highway that could potentially capture 100% of through traffic. OD survey locations were:

- O1 - New England Highway, East of Rutherford Road;
- O2 - New England Highway, North of Aberdeen Street;
- O3 - Bell Street, North of New England Highway;
- O4 - Bridge Street, South of Railway over Bridge;
- O5 - Brook Street, East of Bridge Street; and
- O6 - Brook Street, West of Bridge Street.

The OD survey was conducted between 31st October and 1st of November 2007 using three vehicle categories including light vehicles, heavy vehicles and B-doubles. Figure 2-2 shows the location of the OD stations in the study area. Table 2-1 summarised the sampling capture rate at each station. The capture rate at key stations 1 and 2 was more than 95%.

Table 2-1 Capture Rate from 24 Hours OD Survey

OD	Road	Dir	Description	Total	Light Vehicle	Heavy Vehicle	B-Double	Capture Rate
1E	NEH	East	East of Rutherford Rd	4,847	4,105	601	141	95%
1W	NEH	West	East of Rutherford Rd	4,773	4,062	541	170	96%
2N	NEH	North	North of Aberdeen St	5,174	4,433	578	163	95%
2S	NEH	South	North of Aberdeen St	5,280	4,494	642	144	95%
3S	Bell St	South	Bell St, North of NEH	3,104	3,024	80	0	96%
3N	Bell St	North	Bell St, North of NEH	2,959	2,876	82	1	93%
4S	Bridge St	South	Bridge St, South of Railway overbridge	10,116	9,206	768	142	88%
4N	Bridge St	North	Bridge St, South of Railway overbridge	10,234	9,352	717	165	96%
5E	Brook St	East	At Brook St, East of Bridge St	3,731	3,618	113	0	77%
5W	Brook St	West	At Brook St, East of Bridge St	2,095	2,018	76	1	62%
6E	Brook St	East	At Brook St, West of Bridge St	2,091	1,967	123	1	94%
6W	Brook St	West	At Brook St, West of Bridge St	2,294	2,189	102	3	96%

Figure 2-2 Detailed OD Stations

2.2.2 Intersection turning movements

The following three key intersections were selected for the supplementary turning traffic movement counts. These were:

- A1 - Bell Street, Victoria street and Dolahenty Street;
- A2 - Brook Street and Sowerby Street; and
- A3 - Bridge Street and Hill Street.

The survey was conducted on Tuesday, 15th November 2007 during the morning peak between 7 am and 10 am and evening peak between 3 pm and 6 pm, consistent with Council's previous survey schedule.

2.2.3 Mid-block counts

Two supplementary mid-block counts were undertaken at the following locations, which are likely to be impacted by the proposed bypass interchange at Coal Road:

- B1 - Common Road, East of Queen street; and
- B2 - Coal Road, East of Victoria Street.

These counts were used to refine traffic distribution to and from Coal Road. The survey was undertaken for one week between the 14th November and 20th November, 2007 inclusive.

2.2.4 Travel time

Travel time data was a key input to the AM peak period traffic models. The preliminary bypass study considered travel time data from a limited number of runs for the AM peak period (7-9). The new travel time data captured average travel speed on the New England Highway and associated local roads for three time periods including:

- AM peak period between 6 and 9 am;
- Midday period between 11 am and 2 pm; and
- PM peak period between 3 pm and 6 pm.

The travel time data was collected using GPS on four routes. A total of 9 runs were performed to confirm any travel time variations that could occur during the above time periods. The survey was undertaken on Thursday, 22nd November 2007 for the following four routes:

- Route 1 New England Highway (between Muscle Creek Road and McCullys Gap Road);
- Route 2 Coal Road, Common Road and Rutherford Road (between Rutherford Road and Coal Road);
- Route 3 Bell Street, Victoria Street, Carl Street, Hunter Street (between Bell Street and Hunter Street); and

- Route 4 Victoria Street, Market Street, William Street, Sowerby Street, Hunter Street (between Victoria Street and Hunter Street).

Figure 2-3 shows the travel time survey routes.

Figure 2-3 Travel Time Survey Routes

2.3 Traffic results

This section summarises traffic results from OD, intersection turning movements, mid-block counts and travel time surveys described in the previous Section 2.2. This provides a context for determining through, local and stopping traffic on the New England Highway being used in the model augmentation. Results from the travel time survey also provided a basis of further model refinement along the bypass corridor.

2.3.1 Traffic pattern from OD

Traffic on the New England Highway is a mixture of through and local movements. In determining the potential use of the new bypass, both types of traffic must be quantified and current travel patterns for through trip makers must be understood. The OD patterns on the New England Highway were separated into vehicle classes to determine distribution patterns including:

- Table 2-2 shows traffic distribution for all vehicles;
- Table 2-3 shows traffic distribution for light vehicles;
- Table 2-4 shows traffic distribution for heavy vehicles; and
- Table 2-5 shows traffic distribution for B-doubles.

Table 2-2 Traffic Distribution for Light and Heavy Vehicles (Total)

		Matched									
O/D	Description	1E	2N	3N	3S	4N	4S	5E	5W	6W	Total (Count)
1W	NEH, E of Rutherford Rd	0 0%	2,250 47%	1,042 22%	0 0%	3,345 70%	0 0%	502 11%	0 0%	455 10%	4,773
2S	NEH, N of Aberdeen St	2,321 44%	0 0%	369 7%	486 9%	0 0%	3730 71%	638 12%	0 0%	410 8%	5,280
3N	Bell St, North of NEH	0 0%	424 14%	0 0%	0 0%	0 0%	0 0%	0 0%	293 10%	343 12%	2,959
3S	Bell St, North of NEH	1,022 33%	370 12%	0 0%	0 0%	1202 39%	0 0%	382 12%	0 0%	293 9%	3,104
4N	Bridge St, S of Railway over Bridge	0 0%	3962 39%	0 0%	0 0%	0 0%	0 0%	2044 20%	0 0%	1517 15%	10,234
4S	Bridge St, S of Railway over Bridge	3,159 31%	0 0%	1,095 11%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	10,116
5E	Brook Street, E	0	0	0	747	0	0	0	0	0	3,731

OD	Description	1E	2N	3N	3S	4N	4S	5E	5W	6W	Total (Count)
		Matched									
	of Bridge St	0%	0%	0%	20%	0%	0%	0%	0%	0%	
5W	Brook Street, E of Bridge St	239	548	228	0	0	766	0	0	618	2,095
		11%	26%	11%	0%	0%	37%	0%	0%	29%	
6E	Brook Street, W of Bridge St	365	356	221	282	0	1,271	654	0	0	2,091
		17%	17%	11%	13%	0%	61%	31%	0%	0%	

Key daily travel patterns from Table 2-2 showed:

- Through traffic on the New England Highway was between 44% and 47% being higher than previous 2002 OD results;
- The 2002 OD results showed the through traffic proportion on the New England Highway was between 25% and 32% (refer to Table 3.2 of Muswellbrook Bypass Preliminary Traffic Report, PB, Oct 2007);
- The 2002 OD survey was based on a 12 hour period (between 6 am and 6pm). Comparing results for a similar time frame showed that the new OD data captured a significantly higher proportion of through traffic between 41% and 45% on the New England Highway.
- There could be number of reasons for such anomalies including:
  - previous OD data only captured 20% sampling and was undertaken manually;
  - The probability of error in manual OD survey is always higher and can be regarded a critical limitation of the previous OD technology;
  - The new OD data collection is an improved technique that captures almost 95% of traffic travelling north and south on the New England Highway through Muswellbrook;
- Matching OD between stations 1 and 3 indicated that about 22% to 33% traffic travelled between the New England Highway (south of Rutherford Road) and possibly north of the Muswellbrook town centre used Bell Street. This also captured high heavy vehicles which currently use Bell Street as a diversion route;
- Matching OD between stations 1 and 5, 1 and 6 (or vice versa) indicated that about 10% to 17% of traffic using the New England Highway had a possible destination in the Muswellbrook town centre;
- Matching OD between stations 1 and 4 and 2 and 4 indicated about 70% of traffic using the New England Highway had a possible origin or destination in the town centre, or passed without stopping in the town centre. This indicated that about 30% of local traffic at station 4 possibly had an origin or destination in the south and north of Muswellbrook.

Table 2-3 shows the OD distribution for light vehicles. As expected, the light vehicle distribution was similar to total vehicles but with a slightly lower magnitude. The OD distribution trend for light vehicles was plausible. It represented about 85% of the total traffic on the New England Highway, the remaining 15% was heavy vehicles which includes B-doubles (see Table 2.12).

Table 2-3 Traffic Distribution for Light Vehicles

		Matched									
O\D	Description	1E	2N	3N	3S	4N	4S	5E	5W	6W	Total (Count)
1W	NEH, E of Rutherford Rd	0	1,697	985	0	2,736	0	464	0	427	4,062
		0%	42%	24%	0%	67%	0%	11%	0%	11%	
2S	NEH, N of Aberdeen St	1,733	0	356	460	0	3,066	612	0	397	4,494
		39%	0%	8%	10%	0%	68%	14%	0%	9%	
3N	Bell St, North of NEH	0	389	0	0	0	0	0	280	325	2,876
		0%	14%	0%	0%	0%	0%	0%	10%	11%	
3S	Bell St, North of NEH	979	349	0	0	1170	0	369	0	281	3,024
		32%	12%	0%	0%	39%	0%	12%	0%	9%	
4N	Bridge St, S of Railway over Bridge	0	3,273	0	0	0	0	1,962	0	1,439	9,352
		0%	35%	0%	0%	0%	0%	21%	0%	15%	
4S	Bridge St, S of Railway over Bridge	2,578	0	1056	0	0	0	0	0	0	9,206
		28%	0%	11%	0%	0%	0%	0%	0%	0%	
5E	Brook Street, E of Bridge St	0	0	0	728	0	0	0	0	0	3,618
		0%	0%	0%	20%	0%	0%	0%	0%	0%	
5W	Brook Street, E of Bridge St	219	517	218	0	0	708	0	0	599	2,018
		11%	26%	11%	0%	0%	35%	0%	0%	30%	
6E	Brook Street, W of Bridge St	333	328	199	271	0	1,180	611	0	0	1,967
		17%	17%	10%	14%	0%	60%	31%	0%	0%	

The OD patterns for heavy vehicles and B-double are shown separately to confirm if the proposed bypass will attract the majority of heavy vehicles from the existing New England Highway. Table 2-4 and Table 2-5 show OD distributions for heavy vehicles and B-doubles on the New England Highway respectively.

Table 2-4 Traffic Distributions for Heavy Vehicles

		Matched									
O\D	Description	1E	2N	3N	3S	4N	4S	5E	5W	6W	Total (Count)
1W	NEH, E of Rutherford Rd	0 0%	392 72%	56 10%	0 0%	453 84%	0 0%	38 7%	0 0%	26 5%	541
2S	NEH, N of Aberdeen St	457 71%	0 0%	13 2%	26 4%	0 0%	545 85%	26 4%	0 0%	13 2%	642
3N	Bell St, North of NEH	0 0%	34 6%	0 0%	0 0%	0 0%	0 0%	0 0%	13 2%	18 3%	82
3S	Bell St, North of NEH	43 52%	21 26%	0 0%	0 0%	32 39%	0 0%	13 16%	0 0%	12 15%	80
4N	Bridge St, S of Railway over Bridge	0 0%	518 72%	0 0%	0 0%	0 0%	0 0%	82 11%	0 0%	76 11%	717
4S	Bridge St, S of Railway over Bridge	467 61%	0 0%	39 5%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	768
5E	Brook Street, E of Bridge St	0 0%	0 0%	0 0%	19 17%	0 0%	0 0%	0 0%	0 0%	0 0%	113
5W	Brook Street, E of Bridge St	20 26%	31 41%	10 13%	0 0%	0 0%	58 76%	0 0%	0 0%	19 25%	76
6E	Brook Street, W of Bridge St	31 25%	27 22%	22 18%	11 9%	0 0%	91 74%	43 35%	0 0%	0 0%	123

Table 2-5 Traffic Distribution for B-double Vehicles

		Matched									
O/D	Description	1E	2N	3N	3S	4N	4S	5E	5W	6W	Total (Count)
1W	NEH, E of Rutherford Rd	0 0%	161 95%	1 1%	0 0%	156 92%	0 0%	0 0%	0 0%	2 1%	170
2S	NEH, N of Aberdeen St	131 91%	0 0%	0 0%	0 0%	0 0%	119 83%	0 0%	0 0%	0 0%	144
3N	Bell St, North of NEH	0 0%	1 100%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	1
3S	Bell St, North of NEH	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0
4N	Bridge St, S of Railway over Bridge	0 0%	161 98%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	2 1%	165
4S	Bridge St, S of Railway over Bridge	114 80%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	142
5E	Brook Street, E of Bridge St	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0
5W	Brook Street, E of Bridge St	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	1
6E	Brook Street, W of Bridge St	1 100%	1 100%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	1

The results from Table 2-4 and Table 2-5 show a number of interesting findings as follows:

- About 72% of heavy vehicles on the New England Highway pass through Muswellbrook having an origin or destination outside the study area. Of the 1500 heavy vehicles counted on the New England Highway, the majority of heavy vehicles could use bypass if it was built; and
- The through patterns of B-doubles were even higher than other heavy vehicles. Data indicated about 90% to 95% of B-doubles travelled the New England Highway with potential origin or destination outside of study area.

Another important aspect of the OD survey was to identify stopping patterns of through traffic on the New England Highway. In defining stopping traffic, two criteria were considered:

- Travel time greater than 1.25 of median travel time or
- Travel time greater than median travel time plus 5 minutes, whichever is greater.

The average travel time on the New England Highway between Muscle Creek Road and McCullys Gap Road is about 10 minutes. In general if vehicles took more than 10 minutes to travel the New England Highway between OD stations 1 and 2 then it was defined as stopping traffic. Table 2-6 showed stopping traffic patterns between OD pairs. Results indicated that approximately 26% to 28% of matched through traffic stopped at town centre while travelling from north to south or vice versa.

Table 2-6 Stopping Traffic Patterns (Total Vehicles)

	O/D	1E	2N	3N	3S	4N	4S	5E	5W	6W
1W	Stopped Vehicles	0	638	281	0	877	0	211	0	198
	Total Matched	0	2,250	1042	0	3345	0	502	0	455
		0%	28%	27%	0%	26%	0%	42%	0%	44%
2S	Stopped Vehicles	598	0	140	203	0	745	284	0	179
	Total Matched	2,321	0	369	486	0	3,730	638	0	410
		26%	0%	38%	42%	0%	20%	45%	0%	44%
3N	Stopped Vehicles	0	171	0	0	0	0	0	112	139
	Total Matched	0	424	0	0	0	0	0	293	343
		0%	40%	0%	0%	0%	0%	0%	38%	41%
3S	Stopped Vehicles	268	147	0	0	505	0	158	0	115
	Total Matched	1,022	370	0	0	1,202	0	382	0	293
		26%	40%	0%	0%	42%	0%	41%	0%	39%
4N	Stopped Vehicles	0	947	0	0	0	0	710	0	639
	Total Matched	0	3952	0	0	0	0	2,044	0	1517
		0%	24%	0%	0%	0%	0%	35%	0%	42%
4S	Stopped Vehicles	829	0	422	0	0	0	0	0	0
	Total Matched	3,159	0	1,095	0	0	0	0	0	0
		26%	0%	39%	0%	0%	0%	0%	0%	0%
5E	Stopped Vehicles	0	0	0	300	0	0	0	0	0
	Total Matched	0	0	0	747	0	0	0	0	0
		0%	0%	0%	40%	0%	0%	0%	0%	0%
5W	Stopped Vehicles	85	187	83	0	0	300	0	0	115
	Total Matched	239	548	228	0	0	766	0	0	618
		36%	34%	36%	0%	0%	39%	0%	0%	19%
6E	Stopped Vehicles	157	152	84	106	0	500	233	0	0
	Total Matched	365	356	221	282	0	1271	654	0	0
		43%	43%	38%	38%	0%	39%	36%	0%	0%

The above analysis demonstrates that OD stations 1 and 2 provide more meaningful results for through traffic distribution on the New England Highway. Further OD analysis was undertaken showing temporal distribution of through traffic by trip time. Through traffic on the New England Highway was categorised at 5 minute intervals. Results on through traffic trip distribution was summarised for light vehicles, heavy vehicles (excluding B doubles) and B-doubles separately as follows:

- Table 2-7 shows trip length distribution of through trips for light vehicles (LV);
- Table 2-8 shows trip length distribution of through trips for heavy vehicles excluding B-doubles (HV);
- Table 2-9 shows trip length distribution of through trips for B-doubles (BD); and
- Figure 2-4 shows graphically the trip length distribution for combined light and heavy vehicles including B-doubles.

To estimate stopping traffic pattern on the New England Highway, travel time threshold of more than 10 minutes was used.

Table 2-7 Through Trips on the New England Highway for LV by Duration of Trip Times,

Direction	Description	5 Mins	10 mins	15 Mins	20 Mins	25 Mins	30 Mins	> 30 Mins	Total
Northbound	Number of trips	377	671	126	80	44	39	354	1,691
	Percentage of Total	22%	40%	7%	5%	3%	2%	21%	
	Cumulative of Total	22%	62%	69%	74%	77%	79%	100%	
Southbound	Number of trips	374	723	145	60	34	50	323	1,709
	Percentage of Total	22%	42%	9%	4%	2%	3%	19%	
	Cumulative of Total	22%	64%	73%	76%	78%	81%	100%	

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Table 2-8 Through Trips on the New England Highway for HV by Duration of Trip Times

Direction	Description	5 Mins	10 mins	15 Mins	20 Mins	25 Mins	30 Mins	> 30 Mins	Total
Northbound	Number of trips	111	229	10	5	9	4	45	413
	Percentage of Total	27%	55%	2%	1%	2%	1%	11%	
	Cumulative of Total	27%	82%	85%	86%	88%	89%	100%	
Southbound	Number of trips	118	272	14	8	12	7	37	467
	Percentage of Total	25%	58%	3%	2%	3%	1%	8%	
	Cumulative of Total	25%	83%	86%	88%	91%	92%	100%	

Table 2-9 Through Trips on the New England Highway for BD by Duration of Trip Times

Direction	Description	5 Mins	10 mins	15 Mins	20 Mins	25 Mins	30 Mins	> 30 Mins	Total
Northbound	Number of trips	45	89	0	3	2	1	5	146
	Percentage of Total	31%	61%	0%	2%	2%	1%	4%	
	Cumulative of Total	31%	92%	92%	94%	95%	96%	100%	
Southbound	Number of trips	37	101	1	1	2	0	2	144
	Percentage of Total	25%	70%	1%	1%	2%	0%	2%	
	Cumulative of Total	25%	95%	96%	97%	98%	98%	100%	

The results from Table 2-7 to Table 2-9 show the following temporal distribution:

- Of the through traffic, about 62% of light vehicles travel time on the New England Highway was less than 10 minutes, and thus they did not stop at the town centre;
- About 38% of light vehicles took more than 10 minutes time travelling on the New England Highway indicating that they stopped at the town centre; and

- Heavy vehicles (which includes B-doubles) rarely stopped at the town centre while travelling from north to south on the New England Highway or vice versa. Data indicates that 80% to 90% of heavy vehicles did not stop at the town centre.

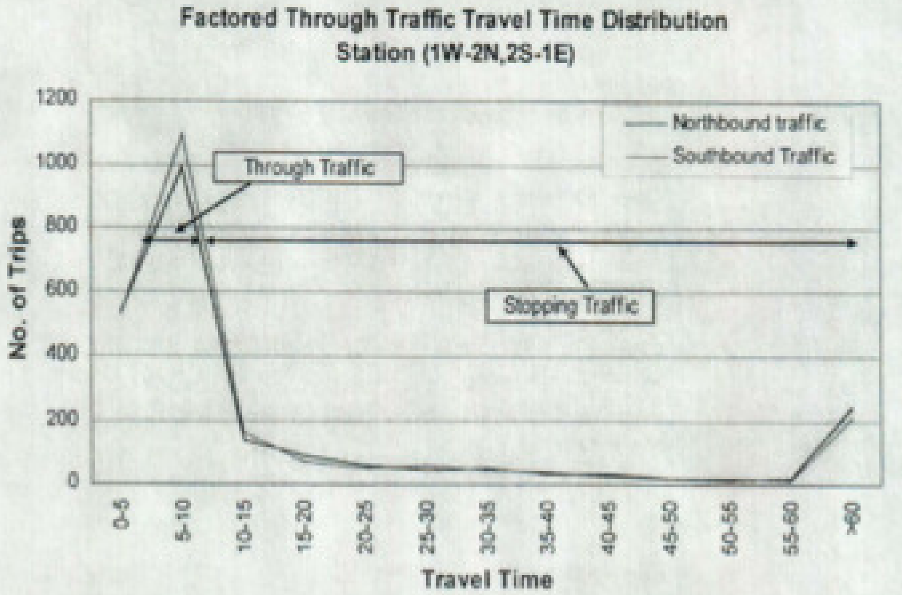


Figure 2-4 Through Traffic Trip Length Distribution

In a summary,

- Between 44% and 47% of vehicles can be regarded as through traffic, travelling either from a southern origin point (Singleton, Maitland, Cessnock) to a northern destination (Murrurundi, Scone or further north) or vice versa;
- Of the through traffic, approximately 72% to 74% was non stopping traffic while travelling north or south through the town. This means approximately 33% of the total traffic is through non stopping traffic;
- Of the through traffic between 26% and 28% of traffic stopped at Muswellbrook for more than 10 minutes while travelling north to south or vice versa; and
- For heavy vehicles including B-doubles, about 82% of vehicles did not stop while travelling north to south or vice versa.

Hourly Variations of Through Traffic

Figure 2-5 and Figure 2-6 show the hourly variation of through traffic classified by light, heavy vehicles (excluding B-doubles) and B-doubles on the New England Highway for northbound and southbound travel respectively. The main objective of both graphs is to compare hour by hour through traffic matched with total traffic counted on the New England Highway to understand temporal distribution of light and heavy vehicles.

For instance, the graph provides a better understanding of which time period showed the highest through traffic on the New England Highway. The following observations are noted from Figure 2-5 and Figure 2-6:

- A similar traffic distribution was observed on the New England Highway for northbound and southbound directions;
- During early morning and midnight (between 12 am and 4 am and between 9 pm and 12 am) light vehicles on the New England Highway are predominantly through traffic;
- As expected, between 5 am and 7pm local traffic is dominant on the New England Highway, with possibly a higher proportion of mine related traffic in the early morning. In other words, the level of service of key intersections on the New England Highway is triggered by the magnitude of local traffic;
- Through heavy vehicles dominate during the early morning and late at night. A higher proportion of heavy vehicles during the middle of the day are local, with origin or destination at the town centre or elsewhere;
- B-doubles travelling on the New England Highway are prodominantly through traffic from south to north or vice versa; and
- The traffic trend on the New England Highway implies that the proposed bypass could be effective in removing the majority of heavy vehicles from the New England Highway. Currently between 1400 and 1500 heavy vehicles (including B-doubles) travel on the New England Highway daily.

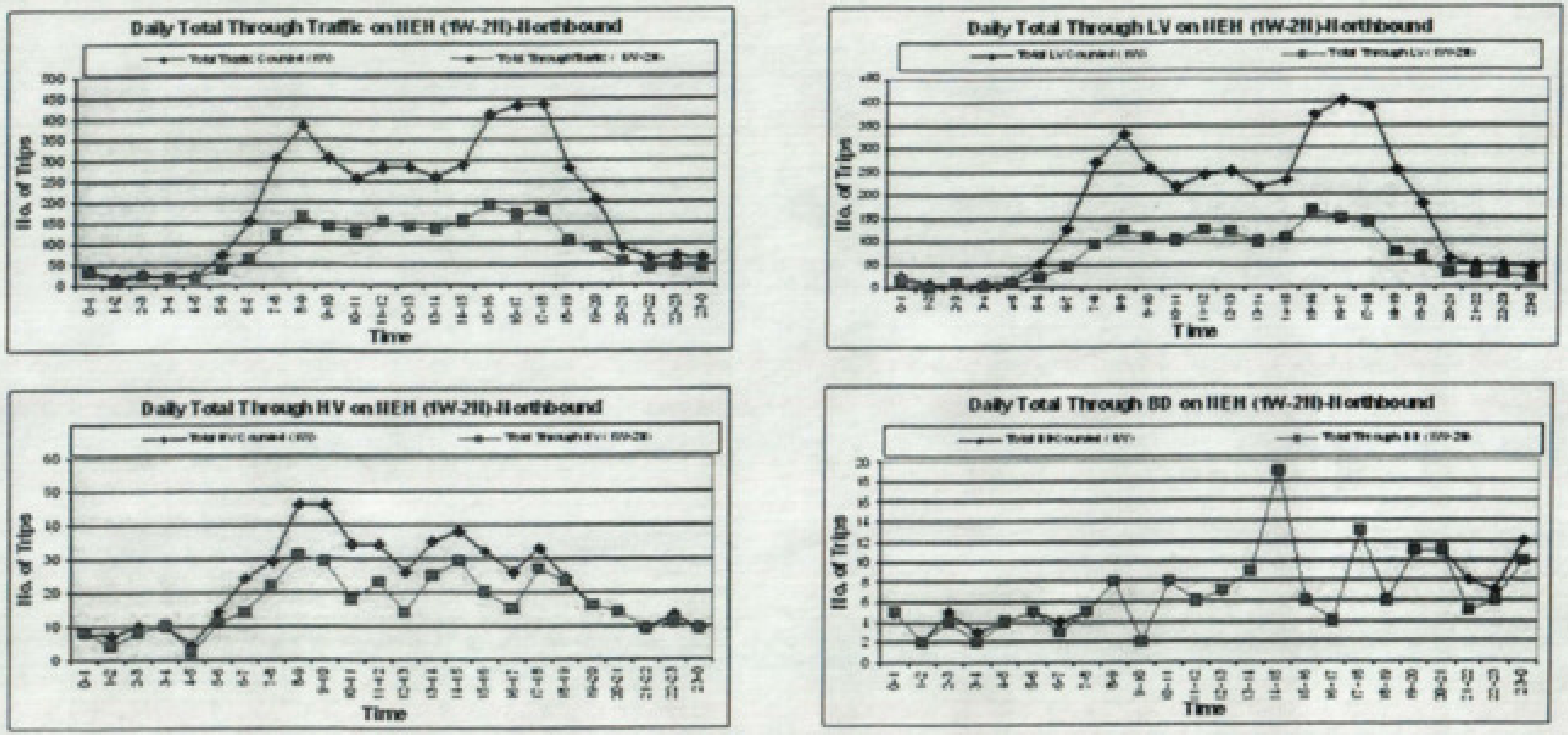


Figure 2-5 Daily Through Traffic Distribution 1W-2N

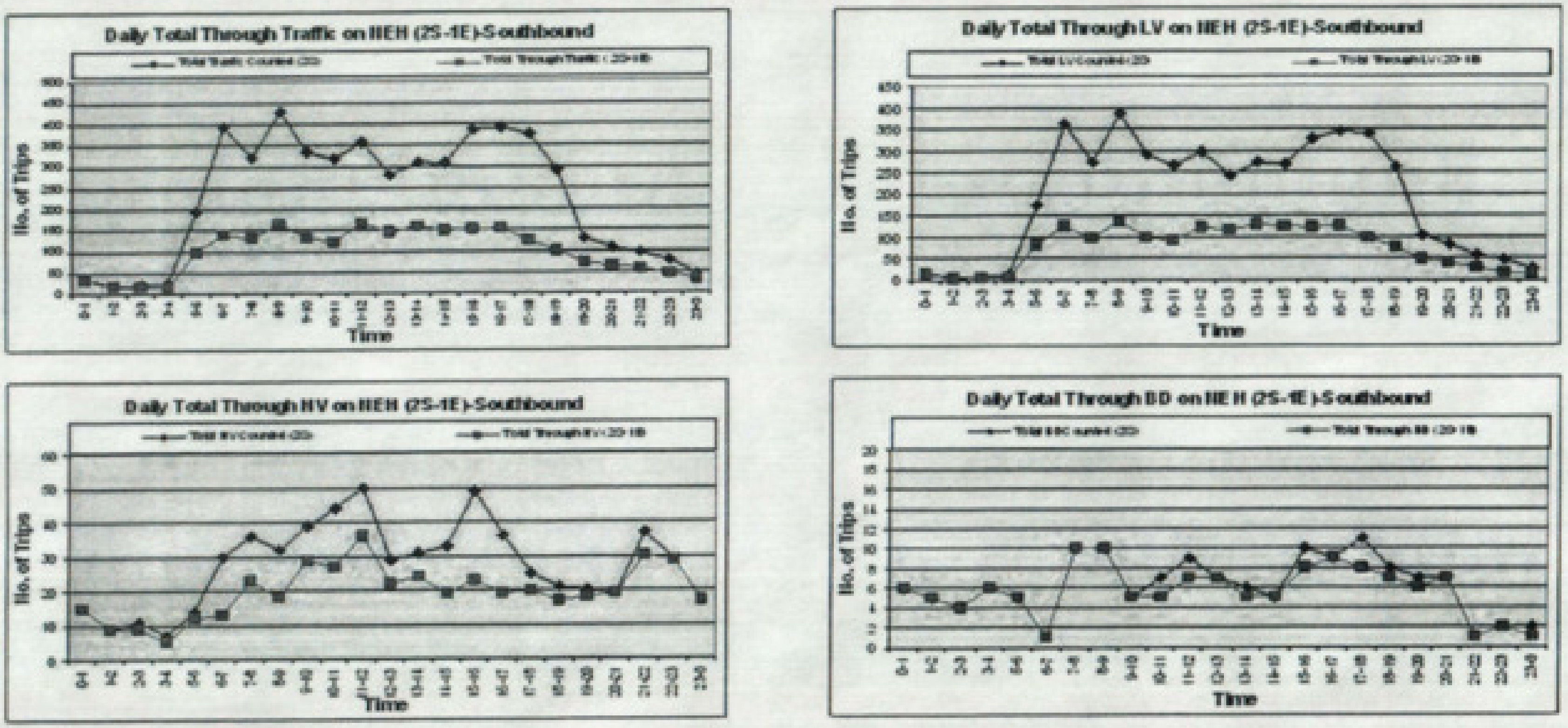


Figure 2-6 Daily Through Traffic Distribution 2S-1E

2.3.2 Mid block traffic counts

The 24 hour mid block count survey was conducted at the same six locations concurrently with OD survey. This enabled a comparison of traffic changes on the New England Highway with previous mid block counts conducted during April 2007. For a consistent comparison daily traffic for a typical Wednesday at three locations on the New England Highway were reviewed. Table 2-10 shows daily traffic comparison on the New England Highway between April and October 2007. Notable traffic changes were:

- New England Highway, north of Aberdeen St showed minor differences as traffic at this location is primarily influenced by through traffic alone; and
- Some traffic differences on the New England Highway between April and October are noticeable. Traffic on the New England Highway south of Rutherford or Bridge St (New England Highway) is influenced by both through and local traffic. It is plausible to assume that local traffic patterns change from time to time subject to local network constraints and motorists choosing different routes offered by local roads. However, for through traffic, route choice on the New England Highway is largely unaffected.

Table 2-10 Comparison of Mid-Block Traffic

Source	Site ID (PB)	Site ID (Hyder)	Description	Total Vehicle				Heavy Vehicle			
				Wed, 2nd Apr, 07	Wed, 31st Oct, 07	Abs diff	% diff	Wed, 2nd April, 07	Wed, 31st Oct, 07	Abs diff	% diff
RTA	M1	1	NEH, South of Rutherford Road	8,582	9,620	1038	11%	1,633	1,453	-180	-12%
RTA	M4	2	NEH, North of Aberdeen St	10,652	10,454	-198	-2%	1,685	1,527	-158	-10%
RTA	M3	4	BRIDGE ST, South of Railway over Bridge	17,825	20,350	2525	12%	1,771	1,792	21	1%

Concurrently with New England Highway survey, traffic was also counted on Common Road and Coal Road in the vicinity of the proposed central interchange. Traffic was counted over a period of a week on Common Road and Coal Road. Table 2-11 and Table 2-12 summarises the traffic count results at eight locations from the October 2007 counts for typical Wednesday traffic conditions. Summarised are the results of key traffic profiles on the New England Highway, Coal Road and Common Road in terms of:

- Directional distribution;
- AM and PM peak hour travel; and

- Daily and peak hour profiles for heavy vehicles, B-doubles and total vehicles separately.

Results from Table 2-11 and Table 2-12 show that:

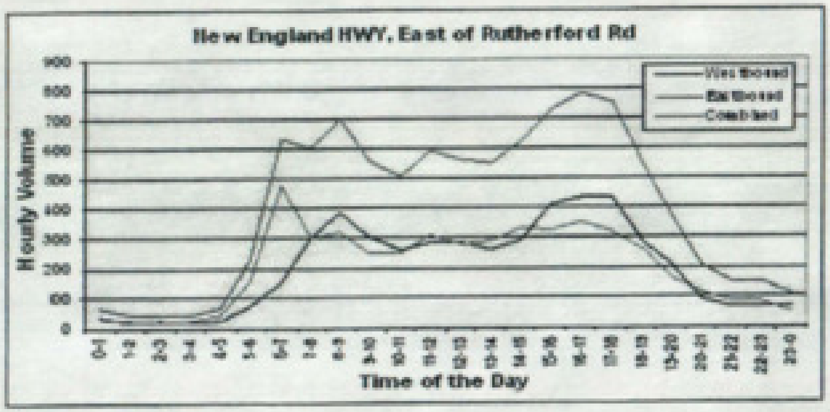
- As expected New England Highway carried about 50% traffic on the Northbound and 50% on the southbound direction;
- New England Highway east of Rutherford Road carried about 10,000 vehicles per day;
- Daily traffic on the Bridge St increased to about 20,000 vehicles with more than 50% were local traffic;
- The New England Highway north of Aberdeen St carried about 10500 per day, similar to traffic flows recorded east of Rutherford Road;
- This implies that capacity at critical intersections with the New England Highway between Rutherford Road and Aberdeen St is driven by the local traffic influence rather than through traffic alone;
- The number of heavy vehicles recorded on the New England Highway varied between 1450 and 1800 vehicles per day. This represented about 15% heavy vehicles either on the south or north of the town centre. The proportion of heavy vehicles is reduced on Bridge St to comprise about 9% of total traffic. The lower proportion of heavy vehicles results from a high proportion of local light vehicles at Bridge St;
- About 160 heavy vehicles were recorded on Bell St, which is a high vehicle bypass route;
- Daily traffic recorded on Common Road and Coal Road was relatively low with 1000 vehicles per day on Common Road and 300 vehicles per day on Coal Road;
- Directional peak volumes on the New England Highway were between 500 vehicles and 1000 vehicles per hour, significantly lower than the midblock capacity of the New England Highway. The notional peak hour capacity could be between 1200 and 1400 vehicles per hour per lane depending on capacity at key intersections. During the peak hour, the estimated LoS on the New England Highway is between LoS A and B/C. The LoS B/C is plausible on Bridge St largely due to local traffic; and
- In general, PM peak traffic is marginally higher (2% to 3%) than the AM peak, largely due to shift work and school travel (see Figure 2-7, Figure 2-8 to Figure 2-11).

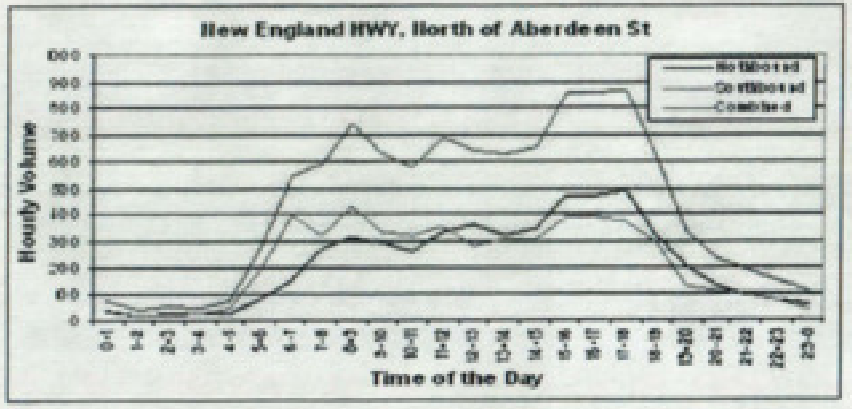
Table 2-11 Traffic Volume on the New England Highway at Each Station (Wed 31 Oct 2007)

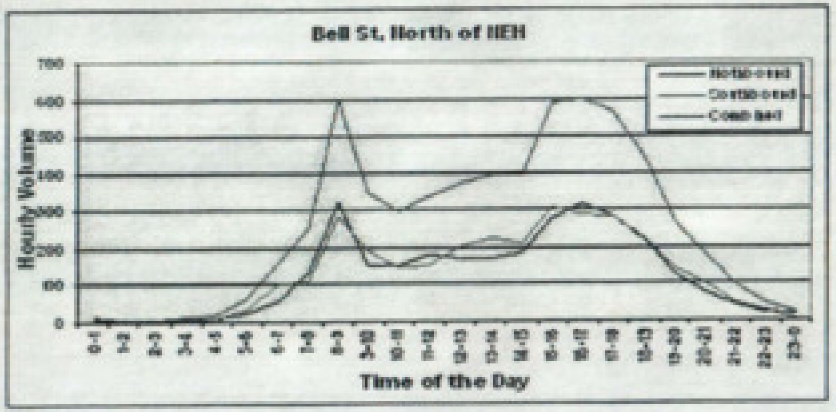
Site ID	Description	Daily			AM (8-9 AM)			PM (3-4 PM)		
		NB/WB	SB/EB	Total (2Way)	NB/WB	SB/EB	Total (2Way)	NB/WB	SB/EB	Total (2Way)
1	NEH, East of Rutherford Rd	4,773 50%	4,847 50%	9,620	384 55%	318 45%	702	409 56%	324 44%	733
2	NEH, North of Aberdeen St	5,174 49%	5,280 51%	10,454	311 42%	429 58%	740	469 55%	386 45%	855
3	Bell St. North of NEH	2,959 49%	3,104 51%	6,063	319 53%	280 47%	599	279 48%	308 52%	587
4	BRIDGE ST, South of Railway over Bridge	10,34 50%	10,116 50%	20,350	671 55%	557 45%	1228	963 58%	694 42%	1,657
5	At Brook St, East of Bridge St	2,095 36%	3,731 64%	5,826	103 27%	272 73%	375	150 31%	337 69%	487
6	At Brook St. West of Bridge St	2,294 52%	2,091 48%	4,385	141 46%	163 54%	304	217 55%	175 45%	392
7	Common Rd, East of Queen St	554 50%	555 50%	1109	32 41%	46 59%	78	63 55%	51 45%	114
8	Coal Rd. East of Victoria St	137 47%	154 53%	291	10 56%	8 44%	18	12 43%	16 57%	28

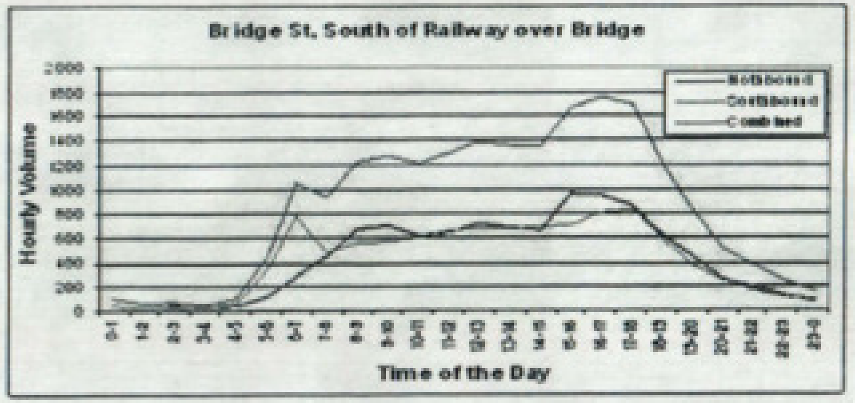
Table 2-12 HV Volume at Each Station (Wed 31 Oct 2007)

Site ID	Description	Daily			AM (8-9 AM)			PM (3-4 PM)		
		NB/WB	SB/EB	Total (2Way)	NB/WB	SB/EB	Total (2Way)	NB/WB	SB/EB	Total (2Way)
1	NEH, East of Rutherford Rd	711	742	1453	54	47	101	38	46	84
		15%	15%	15%	14%	15%	14%	9%	14%	11%
2	NEH, North of Aberdeen St	741	786	1527	47	42	89	43	59	102
		14%	15%	15%	15%	10%	12%	9%	15%	12%
3	Bell St, North of NEH	83	80	163	7	11	18	6	7	13
		3%	3%	3%	2%	4%	3%	2%	2%	2%
4	BRIDGE ST, South of Railway over Bridge	882	910	1792	68	59	127	56	67	123
		9%	9%	9%	10%	11%	10%	6%	10%	7%
5	At Brook St, East of Bridge St	77	113	190	4	7	11	2	8	10
		4%	3%	3%	4%	3%	3%	1%	2%	2%
6	At Brook St, West of Bridge St	105	124	229	11	13	24	11	9	20
		5%	6%	5%	8%	8%	8%	5%	5%	5%
7	Common Rd, East of Queen St	59	58	117	4	3	7	10	7	17
		11%	10%	11%	13%	7%	9%	16%	14%	15%
8	Coal Rd, East of Victoria St	23	21	44	1	2	3	1	2	3
		17%	14%	15%	10%	25%	17%	8%	13%	11%


New England HWY, East of Rutherford Rd
Hourly Volume
Time of the Day
Westbound
Eastbound
Combined


New England HWY, North of Aberdeen St
Hourly Volume
Time of the Day
Northbound
Southbound
Combined


Bell St, North of NEH
Hourly Volume
Time of the Day
Northbound
Southbound
Combined


Bridge St, South of Railway over Bridge
Hourly Volume
Time of the Day
Northbound
Southbound
Combined

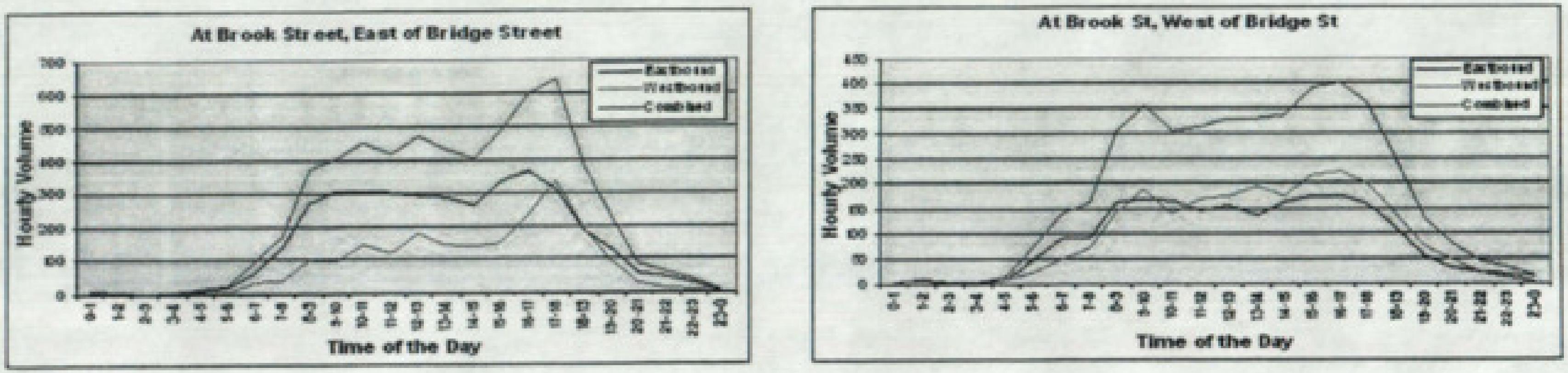


Figure 2-7 Hourly Traffic Variation

appropriate locations. The travel time was slightly adjusted on the New England Highway and parallel competing routes from new travel time data. (see Section 2.3.4).

3.3.2 Trip table

The 2007 OD survey provided the basis for updating trip tables particularly through traffic distribution. During the trip table adjustment, a series of select link models were run on the New England Highway and competing local roads to identify possible origin and destination pairs. Through an iterative process trip table was adjusted. This provided a new trip distribution that matched surveyed OD patterns. Table 3-1 shows the comparison of trip distribution by trip purpose.

Table 3-1 Demand of the Trip Purposed for AM Peak Two Hours (2007 base model)

Trip Purpose	Preliminary Model (PB)	Revised Model (Hyder)	Diff.	%Diff.
External to external (EE)	958	1,223	265	27.6%
External to internal (EI)	1,473	1,473	0	0.0%
Internal to external (IE)	1,178	1,080	-98	-8.3%
Internal to internal (II)	4,207	4,034	-174	-4.1%
Total	7,817	7,811	-6	-0.1%

The 2007 base model trip distribution was presented as "desire lines" confirming a similarity with the preliminary traffic distribution, particularly for local trips. Figure 3-1 shows sector by sector trip distribution from the revised base 2007 model.

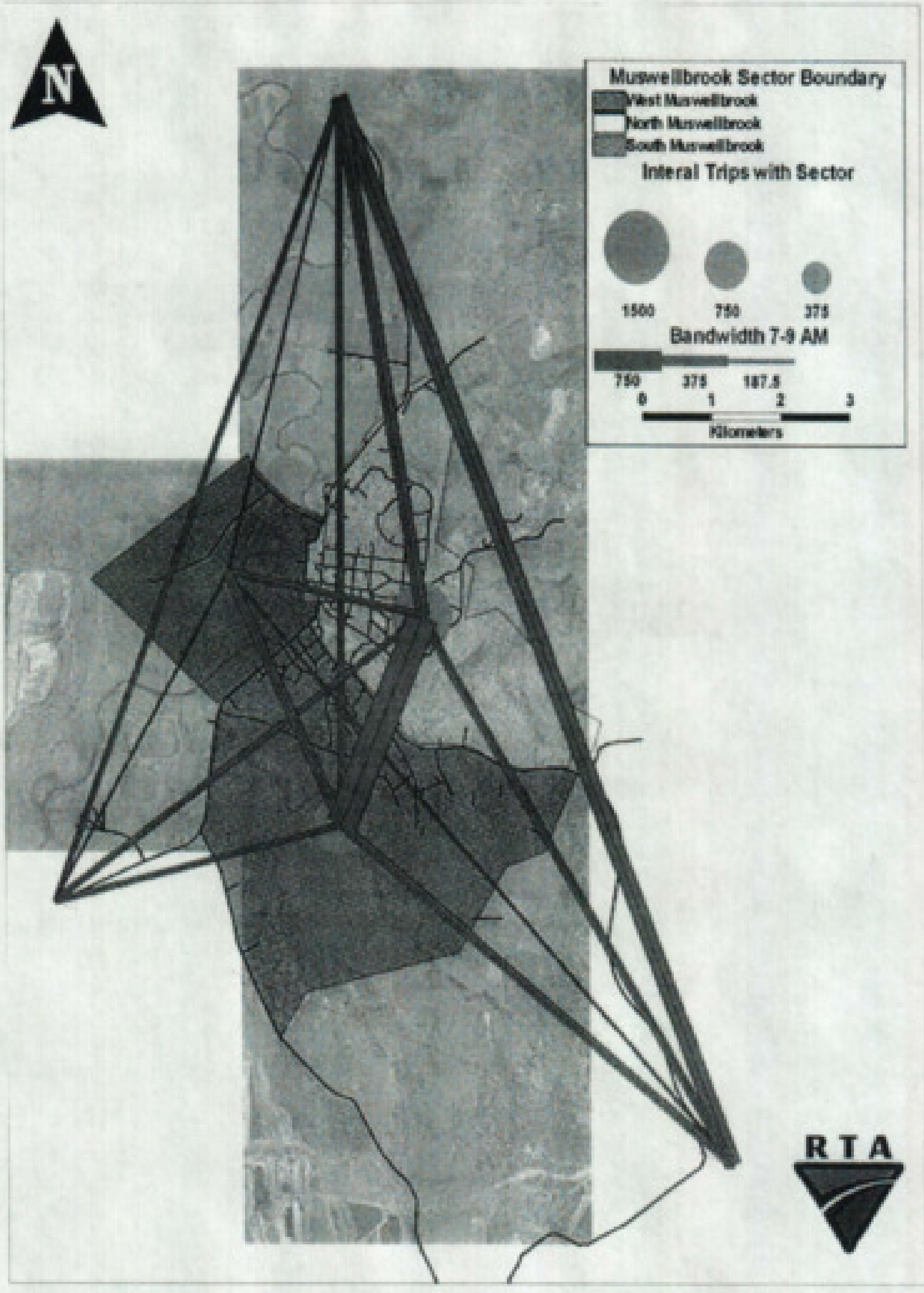


Figure 3-1 Revised Traffic Distribution for Base 2007 Model

3.4 Refinement of model calibration

One important consideration in the revised modelling approach was to check whether the network and trip table adjustment conformed to the calibration criteria as set out in Table 3-2. The revised model was calibrated against a comprehensive set of traffic counts undertaken during May 2007, and supplementary counts undertaken in November 2007. For the revised model a similar calibration criteria to the preliminary model was adopted. Model calibration and validation criteria were based on the US Federal Highway Administration (FHWA) requirements and the "Model Reasonableness and Checking Manual" as described below:

- The correlation coefficient, R^2 for region wide observed traffic counts versus estimated volumes should be greater that 0.88 (see Figure 3-2);
- Observed vs. modelled travel time should replicate closely observed patterns (see Section 3.5); and
- GEH statistics comply (see Table 3-2).

Table 3-2 summarises the calibration target and revised model compliance with industry standard values.

Table 3-2 Calibration Targets and results for 2007 (7-9AM)

Calibration Objective	Calibration Target	Revised Model Compliance
Road traffic characteristic leading to realistic route choice	For links: $R^2 > 0.9$ % difference within ± 15% = 85% of sites GEH statistic < 5 – required in 60% of cases <10 – required in 95% of cases <12 – required in 100% of cases	For links: (162 sites) $R^2 > 0.98$ % difference within ± 15% = 82% of sites GEH statistic < 5 – required in 94% of cases <10 – required in 99% of cases <12 – required in 100% of cases

Within the study area, model volumes were compared with traffic counts for 162 uni-directional sites. Intersection turning movement counts were converted to link counts and these were also included in the calibration process. The Figure 3-2 showed R^2 values of 0.98 indicated a close match between counts and model volumes.

In summary, the revised 2007 base peak period model complies with calibration targets set out in Table 3-2.

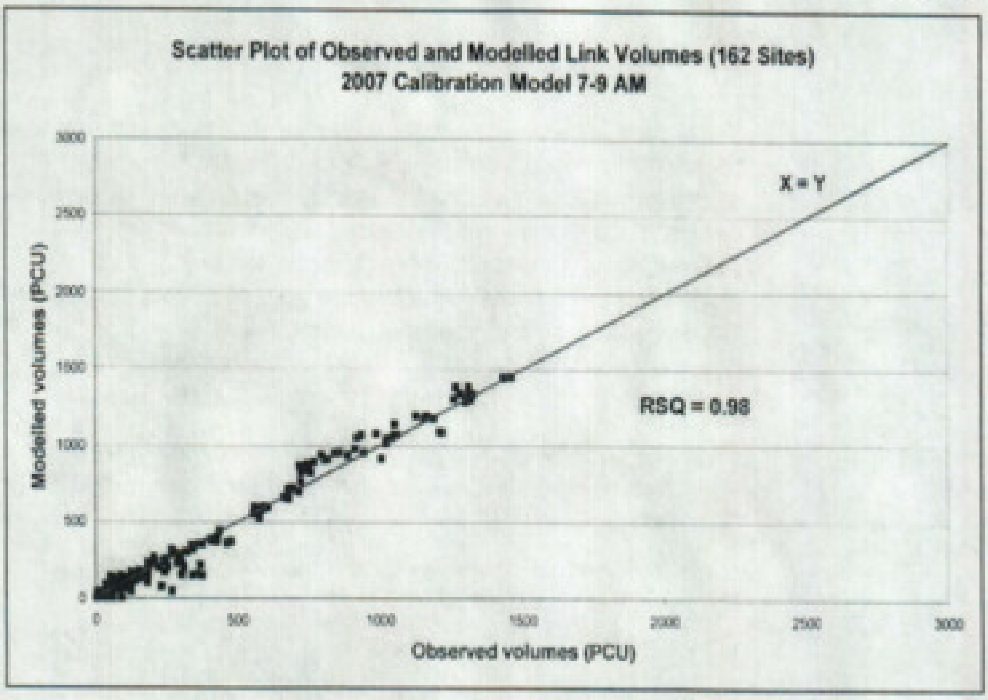


Figure 3-2 Scatter Plot of Observed and Modelled Link Volumes (2007 7-9AM, PCU)

3.5 Model revalidation

Using a similar calibration process described in Section 3.4, model validation against travel time was undertaken for four routes involving New England Highway and competing parallel routes along the proposed bypass corridor. Table 3-3 compares travel time data between the survey and model. The model travel time was compared with average survey data. Figure 2-14 also showed a comparison of model travel time with survey data for the four routes. Model revalidation results from Table 3-3 indicated:

- On the New England Highway the modelled travel time matched with survey data ; and
- Model travel times also closely matched the times for the other three routes with differences between 2 % and 4%.

Table 3-3 Comparison of Surveyed and Modelled Travel Time on Key Routes (minutes)

Route ID	Route	Section	Direction	Observed	Modelled	Diff.	%Diff.
1	New England Hwy	Between Muscle Creek Rd and McCullys Gap Rd	NB	9.6	9.6	0.0	0%
			SB	9.7	9.7	0.0	0%
2	Coal Rd/Common Road etc	Between Rutherford Rd and Coal Rd	NB	7.1	7.2	0.1	2%
			SB	6.5	6.3	-0.2	-3%

Route ID	Route	Section	Direction	Observed	Modelled	Diff.	%Diff.
3	Bell St/Victoria St etc	Between Bell St and Hunter St	NB	4.7	4.7	0.0	0%
			SB	4.5	4.4	-0.1	-3%
4	Victoria St/Market St etc	Between Victoria St and Hunter St	NB	3.7	3.8	0.1	2%
			SB	3.7	3.9	0.2	4%

Note: Distance of Route 1 is 10.1 km, route 2 is 5.7 km, route 3 is 2.8 km and route 4 is 2.4 km.

To supplement the base model results, a flow plot showing AM peak period volumes and volume capacity ratios (v/c) was prepared for the study area network. Figure 3-3 presents the TransCAD generated traffic bands and congestion index (expressed as v/c ratios) for 2007. Overall the Muswellbrook network does not show link congestion during the AM peak period as notional volume capacity ratios (v/c) are less than <0.50.

Figure 3-3 AM peak period Volume and V/C Ratio for 2007

4 Augmented future forecasts

4.1 Overview

The revised forecasts on the Muswellbrook road network were prepared for the years 2020 and 2037 assuming similar land use projections to the preliminary bypass model. Our revised forecasts assumed trip generation from an additional 3954 lots and 35,100m^2 of commercial development being planned by Muswellbrook Shire Council. Regional traffic growth on the New England Highway was assumed to be 1.45% per annum between 2007 and 2020 followed by 1% until 2037, as derived in the Preliminary Traffic Report, PB (2007). In the following sections the revised model results on the proposed bypass are summarised. The impact of the new bypass on the New England Highway is also discussed.

4.2 Traffic flows on proposed bypass

Table 4-1 and Table 4-2 summarises the revised forecasts on the proposed bypass for the years 2020 and 2037. The peak one hour to daily expansion factors were derived from traffic count data on the New England Highway (see Table 2-11). Daily traffic was counted on the New England Highway between 9600 and 10,400 vehicles. AM and PM peak traffic was between 700 and 850 vehicles per one hour. The peak one hour to daily expansion factors are between 12 and 14. On average a factor of 13 was used being consistent with the earlier traffic study.

Table 4-1 and Table 4-2 also show the results from the preliminary model thus enabling a comparison of forecasts from both models. The traffic forecast results are in terms of passenger car unit (PCU). Results from the revised model indicated:

- Traffic was forecast on the bypass between 5,000 and 5,700 vehicles per day in 2020;
- Traffic was forecast on the bypass between 5,800 and 6,600 vehicles per day in 2037. This was an increase of 800 to 900 vehicles compared to 2020 forecasts;
- The revised forecasts were higher by about 32% to 43% than the preliminary forecasts. This resulted from new through traffic distribution data from OD survey and improved travel time data on the New England Highway;
- The southern section of the new bypass was forecast to carry about 12% more traffic than the northern section;
- Traffic on Coal Road was forecast at about 1,100 vehicles per day. This was an increase of about 800 vehicles per day, primarily attributed by the proposed bypass. Current traffic on the Coal Road is about 300 vehicles per day; and

- The revised bypass model indicated a minor traffic reduction on Coal Road compared to the preliminary model. This was due to network refinement along the Coal Road.

Table 4-1 Traffic Forecasts on the Proposed Bypass in 2020 (2 way)

Road Section	Preliminary Model (PB)		Revised Model (Hyder)		Change		%Change	
	Peak Hour	Daily	Peak Hour	Daily	Peak Hour	Daily	Peak Hour	Daily
Muswellbrook Bypass, between New England Highway and Coal Road	310	4,000	430	5,700	120	1,700	39%	43%
Muswellbrook Bypass, between Coal Road and Sandy Creek Road	270	3,600	380	5,000	110	1,400	41%	39%
Coal Road, west of Muswellbrook Bypass	90	1,200	80	1,100	-10	-100	-11%	-8%

Table 4-2 Traffic Forecasts on the Proposed Bypass in 2037 (2 way)

Road Section	Preliminary Model (PB)		Revised Model (Hyder)		Diff.		%Diff.	
	Peak Hour	Daily	Peak Hour	Daily	Peak Hour	Daily	Peak Hour	Daily
Muswellbrook Bypass, between New England Highway and Coal Road	370	4,800	510	6,600	140	1,800	38%	38%
Muswellbrook Bypass, between Coal Road and Sandy Creek Road	330	4,400	440	5,800	110	1,400	33%	32%
Coal Road, west of Muswellbrook Bypass	90	1,200	90	1,100	0	-100	0%	-8%

Figure 4-1 and Figure 4-2 show graphically the impact of the proposed bypass on the Muswellbrook network in 2020 and 2037 respectively. The green colour indicates traffic reduction and red indicates a traffic increase. As expected, the highest traffic reduction was forecast on the New England Highway. Some traffic reduction is likely to occur on Bell St and local roads in North Muswellbrook. Coal Road is forecast to increase traffic from its current level as it provides a direct connection between the proposed central interchange and the town centre.

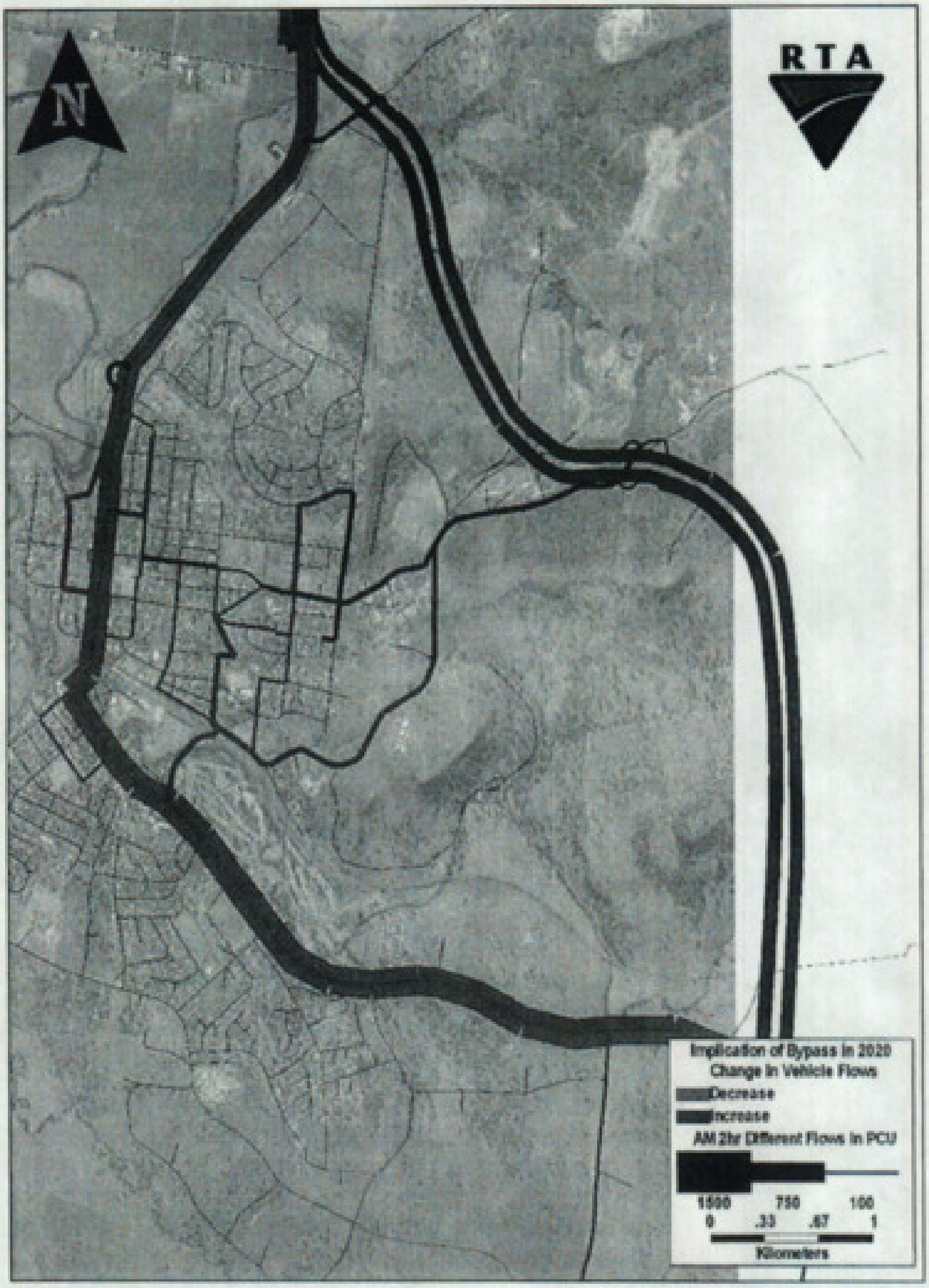


Figure 4-1 Implication of Bypass in 2020 (Flow Difference between No Bypass and Bypass Option)

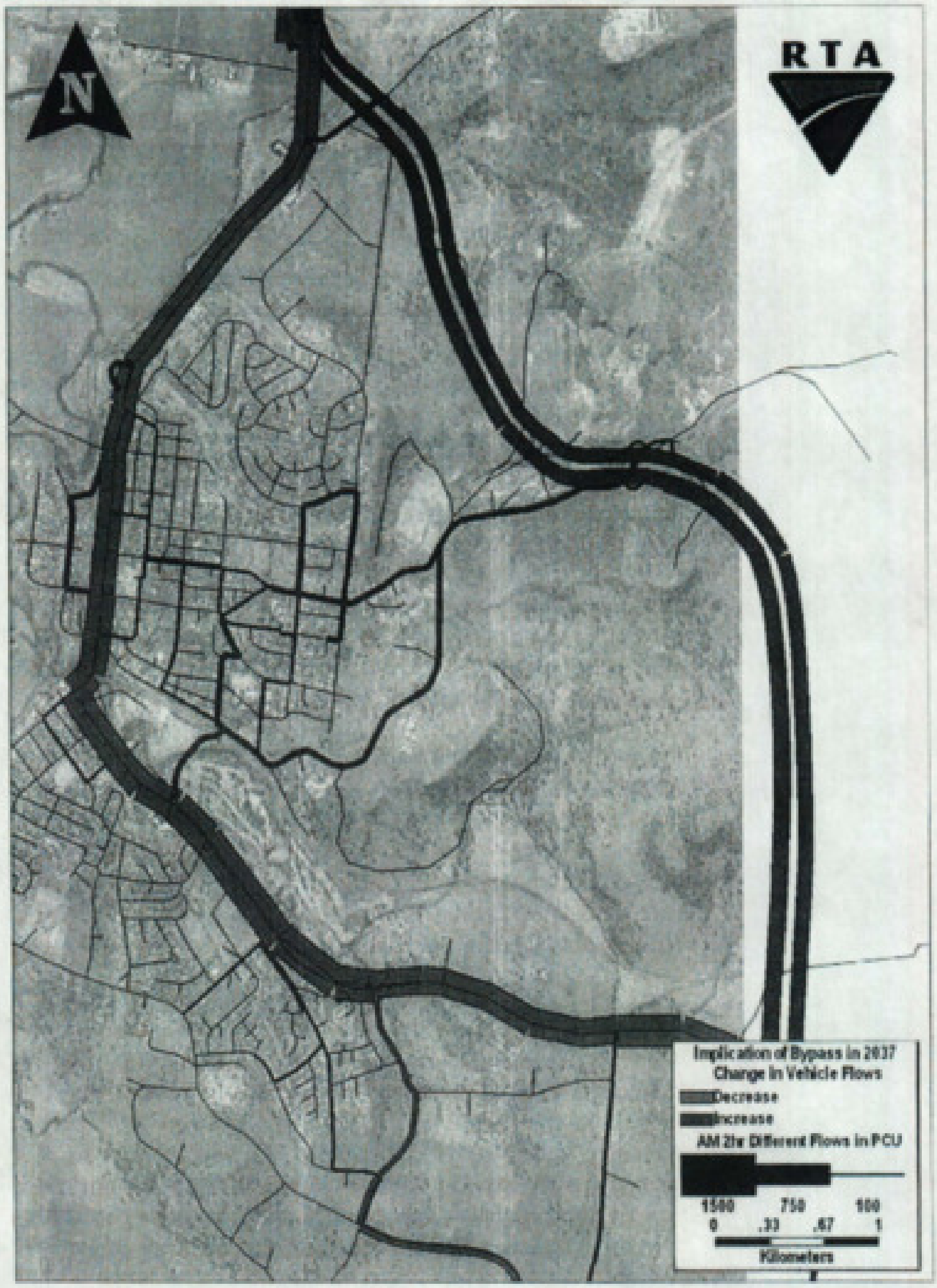


Figure 4-2 Implication of Bypass in 2037 (Flow Difference between No Bypass and Bypass Option)

4.3 Impact on the New England Highway

Following the completion of the proposed bypass, the traffic patterns within Muswellbrook will depend on a number of factors including:

- Local traffic growth as a result of predicted land use changes in Muswellbrook particularly at the southern part of the town; and
- Stopping traffic patterns which could be influenced by the location of ramps and their connection with the town centre network.

The impact of bypasses on urban traffic is discussed in Evaluation of Economic Impacts of Bypass Roads on Country Towns — Final Project Report (Roads and Traffic Authority 1996) and Evaluation of Economic Impacts of Bypass Roads on Country Towns — A Guide to Good Practice (Roads and Traffic Authority 1996). The reports suggest that the impact is affected by factors such as the size of the town, distance from major cities, ease of access to the town, visibility, facilities in the town, inherent attractions, and the location of other service towns or service centres. A comparison of four bypassed towns by the RTA showed that traffic in each town was significantly reduced after the bypass was opened (35–96 percent fewer vehicles). The factors outlined above can account for the variations in changed traffic volumes.

The traffic forecasts for the New England Highway have been summarised at four key locations. Tables 4.3 to 4.7 show forecasts on the New England Highway for the years 2020 and 2037 respectively. The bypass would be effective in reducing traffic flows by an average of between 5,000 to 5,500 vehicles per day on the New England Highway over the next 30 years. This represents a traffic reduction between 24% and 34% on the New England Highway after the bypass is built.

Under the no build case, the revised model forecasts a further 3% to 10% increase in traffic on the New England Highway compared to the preliminary model. This is mainly attributable to improved through traffic distribution. Without the proposed bypass, the New England Highway was forecast to carry between 13,000 and 21,000 vehicles per day in 2020, increasing to between 15,000 and 27,000 vehicles per day in 2037. With the bypass, the revised forecast shows marginal traffic reductions on the New England Highway between 2% and 7% compared to the preliminary forecasts. This is plausible as additional capacity is available from the through traffic reduction which is expected to be taken up by local traffic growth.

Table 4-3 Traffic forecast on New England Highway (Daily 2020)

Road section	Preliminary Model (PB) Without Bypass	Preliminary Model (PB) With Bypass	Revised Model(Hyder) Without Bypass	Revised Model(Hyder) With Bypass	%Change Without Bypass	%Change With Bypass
New England Highway, east of Bimbadeen Drive	16,000	12,100	17,300	11,500	8%	-5%
New England Highway, west of Rutherford Road	20,300	16,300	21,200	15,400	4%	-6%
Bridge Street, south of Brook Street	19,900	16,700	20,400	15,500	3%	-7%
New England Highway, south of McCullys Gap Road	11,900	9,500	13,100	9,400	10%	-1%

Table 4-4 Traffic forecast on New England Highway (Daily 2037)

Road section	Preliminary Model (PB) Without Bypass	Preliminary Model (PB) With Bypass	Revised Model(Hyder) Without Bypass	Revised Model(Hyder) With Bypass	%Change Without Bypass	%Change With Bypass
New England Highway, east of Bimbadeen Drive	23,100	18,800	24,800	19,500	7%	4%
New England Highway, west of Rutherford Road	26,500	21,900	27,200	20,600	3%	-6%
Bridge Street, south of Brook Street	22,900	18,800	23,400	17,600	2%	-6%
New England Highway, south of McCullys Gap Road	13,600	10,400	14,800	10,200	9%	-2%

Table 4-5 Traffic forecast on New England Highway (Peak Hour 2020)

Road section	Preliminary Model (PB)		Revised Model(Hyder)		%Change	
	Without Bypass	With Bypass	Without Bypass	With Bypass	Without Bypass	With Bypass
New England Highway, east of Bimbadeen Drive	1,230	930	1,320	890	7%	-4%
New England Highway, west of Rutherford Road	1,550	1,260	1,630	1,190	5%	-6%
Bridge Street, south of Brook Street	1,540	1,280	1,560	1,190	1%	-7%
New England Highway, south of McCullys Gap Road	920	730	1,010	720	10%	-1%

Table 4-6 Traffic forecast on New England Highway (Peak Hour 2037)

Road section	Preliminary Model (PB)		Revised Model(Hyder)		%Change	
	Without Bypass	With Bypass	Without Bypass	With Bypass	Without Bypass	With Bypass
New England Highway, east of Bimbadeen Drive	1,780	1,450	1,910	1,500	7%	3%
New England Highway, west of Rutherford Road	2,050	1,690	2,090	1,580	2%	-7%
Bridge Street, south of Brook Street	1,760	1,450	1,790	1,350	2%	-7%
New England Highway, south of McCullys Gap Road	1,050	800	1,130	790	8%	-1%

The overall network impact from the proposed bypass is shown in Figures 4.3 to 4.6. The impact is shown as volume capacity ratios (notionally defined as a congestion index) for the no build and build cases. The AM peak TransCAD plots shows:

- Figure 4-3 network plots without bypass in 2020;
- Figure 4-4 network plots with bypass in 2020;
- Figure 4-5 network plots without bypass in 2037; and
- Figure 4-6 network plots with bypass in 2037.

Figure 4-3 Network plot in 2020 without Bypass

Hyder
Consulting

Figure 4-4 Network plots in 2020 with Bypass

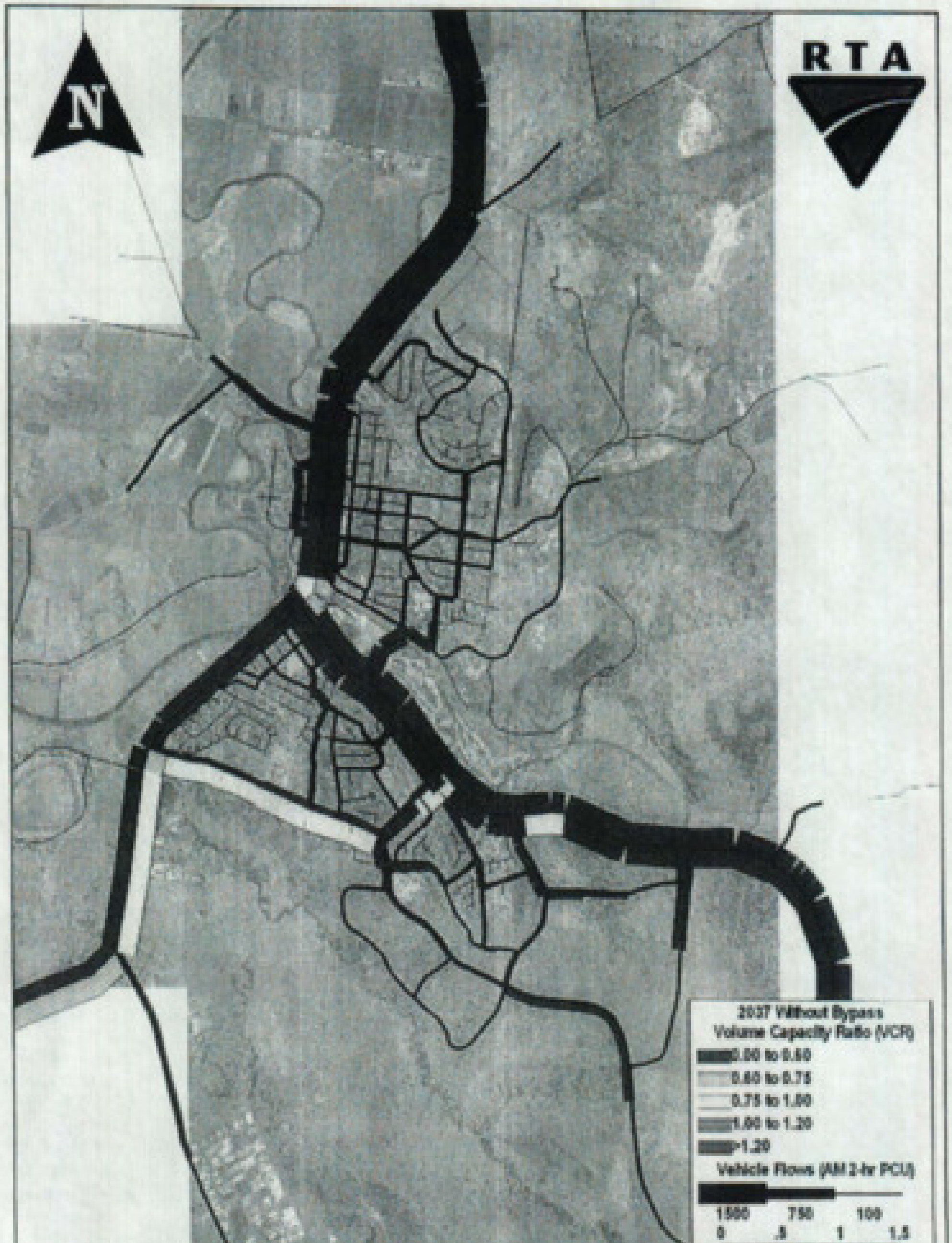


Figure 4-5 Network plot in 2037 without Bypass

Figure 4-6 Network plot in 2037 with Bypass

Interpreting the results from Figures 4.3 to 4.6 indicates some notable traffic changes as follows:

- The predominant local traffic growth from the planned residential development at South Muswellbrook would increase vehicle movements at key intersections with the New England Highway particularly at Rutherford Road and Bimbadeen Drive;
- Traffic on the New England Highway under the railway bridge would have highest impact as it is a critical pinch point;
- The proposed bypass would be effective in removing through traffic from the town centre; and
- The extent of through traffic reduction is unlikely to reduce delays of local traffic accessing the New England Highway. In the future, local traffic growth will dominate the traffic performance of key intersections within Muswellbrook Town Centre, even if the bypass is built.

4.4 Impact on operational performance

The overall operational performance of the bypass can be described in terms of the predicted average travel speed, effectively a measure of the level of service offered by the network configurations. The overall average speed of all trafficable roads in the study area is presented in Figure 4-7. Without the bypass, the average speed for the entire network is projected to reduce from 66 kilometres per hour in 2007 to approximately 64 kilometres per hour by 2037. In the long term, the bypass would marginally improve entire network average speeds by about 3 kilometres per hour.

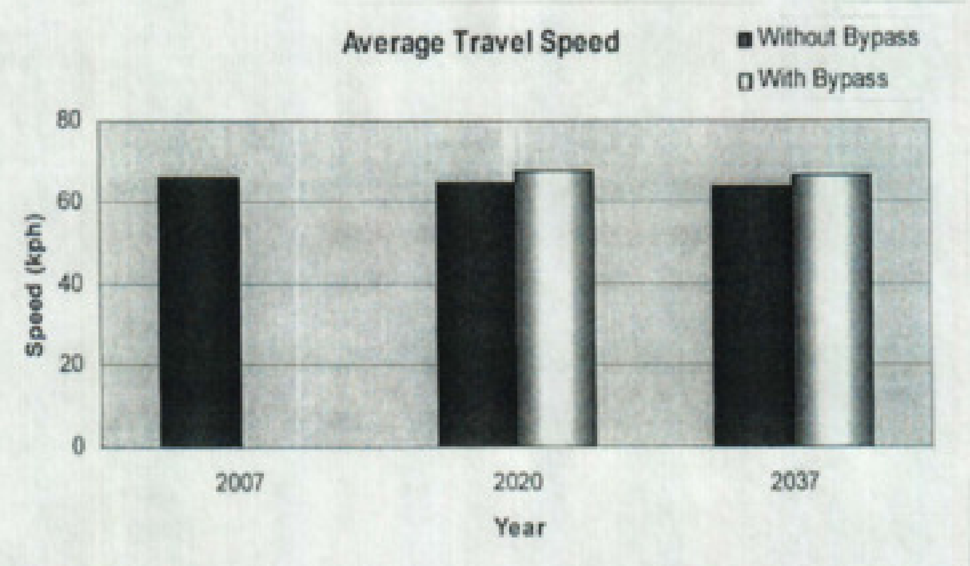


Figure 4-7 Comparison of Average Travel Speed

Table 4-7 and Table 4-8 summarises daily and annual vehicle kilometres (VKT) and vehicle hours (VHT) respectively. Daily to annual factor was derived from an analysis of representative permanent counter sites on the New England Highway. It reflects a combination of commuter characteristics and more regional travel patterns. The daily to annual factor was about 340. Appendix A includes traffic data used to derive the annualisation factor.

The daily VKT saving can be in the order of 6500 being marginal (about 2% saving) compared to the no build case. The VHT saving of the bypass is about 5%. The VHT growth between 2007 and 2037 is unlikely to reduce travel speed significantly should the bypass not proceed. The net VHT benefit offered by the bypass is therefore likely to be lower.

To examine the future congestion effect on the New England Highway, a separate model scenario for 2037 was undertaken assuming a higher passenger car unit (PCU) factor for heavy vehicles. The analysis assumed "no build" case network to examine the congestion impact from a higher heavy vehicle PCU factor which was increased from 3 to 6. The model suggested, with a heavy vehicle PCU factor of 6, the v/c ratios through the New England Highway were forecast similar to v/c ratios using a heavy vehicle PCU of 3 (see Figure 4-5, for v/c ratio, PCU of 3). The resultant vehicle km and vehicle hour saving from a higher heavy vehicle PCU factor showed marginal differences. For the no build case, the level of congestion of the New England Highway through Muswellbrook is not high enough to influence the travel time from using a higher heavy vehicle PCU factor.

Figure 4-8 and Figure 4-9 showed VKT and VHT growth between 2007 and 2037 being used to estimate the economic benefit of the bypass.

Table 4-7 Daily VKT, VHT and Average Travel Speed for the Overall Network

Network Statistics	Year	Preliminary Model				Revised Hyder Model			
		Without Bypass	With Bypass	Saving	Saving (%)	Without Bypass	With Bypass	Saving	Saving (%)
Daily VKT	2007	232,579				249,795			
	2020	411,065	406,225	4,840	1%	428,844	422,361	6,482	2%
	2037	516,313	511,929	4,384	1%	534,141	528,620	5,520	1%
Daily VHT	2007	3,503				3,917			
	2020	6,364	6,149	216	3%	6,911	6,544	367	5%
	2037	8,134	7,876	258	3%	8,778	8,354	424	5%
Avg speed (kph)	2007	69				66			
	2020	68	70			65	68		
	2037	67	69			64	67		

Table 4-8 Annually VKT and VHT (x1,000) for the Overall Network

Network Statistics	Year	Preliminary Model (VKT & VHTx1000)				Revised Hyder Model (VKT & VHTx1000)			
		Without Bypass	With Bypass	Saving	Saving (%)	Without Bypass	With Bypass	Saving	Saving (%)
Daily VKT	2007	79,077				84,930			
	2020	139,762	138,117	1645	1%	145,807	143,603	2204	2%
	2037	175,546	174,056	1,490	1%	181,608	179,731	1,877	1%
Daily VHT	2007	1,191				1,332			
	2020	2,164	2,091	73	3%	2,350	2,225	125	5%
	2037	2,766	2,678	88	3%	2,985	2,840	144	5%

Note: A factor of 340 was assumed for daily to annual

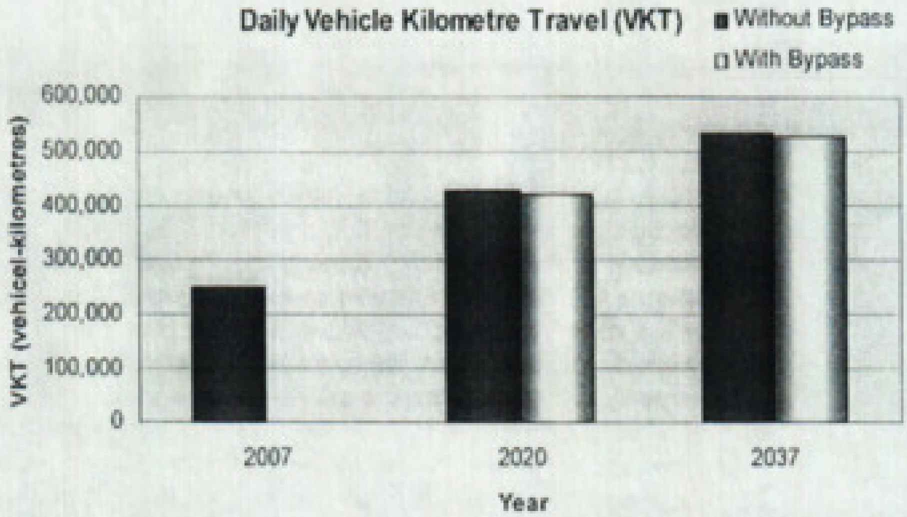


Figure 4-8 Comparison of Vehicle Kilometre Travel (VKT)

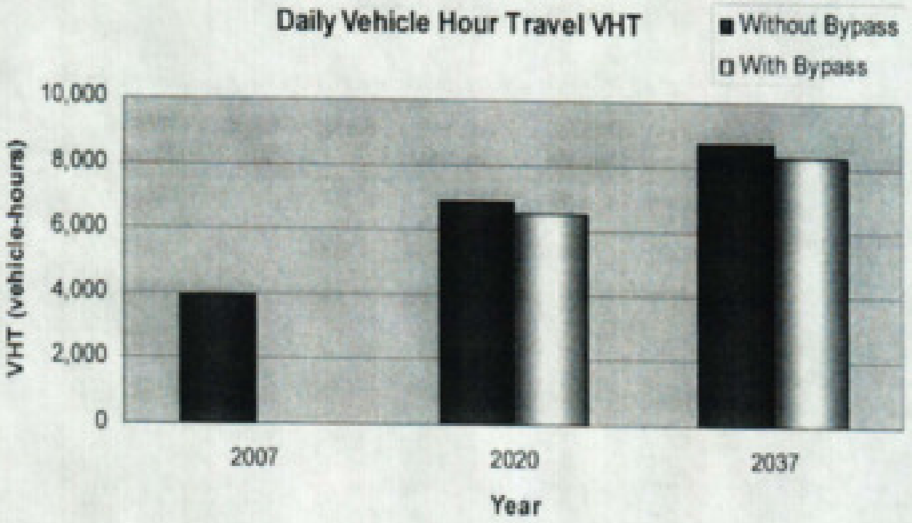


Figure 4-9 Comparison of Vehicle Hour Travel (VHT)

4.4.1 Travel time saving

Table 4-9 summarises forecast travel time on the New England Highway and the proposed bypass in 2020 and 2037. The net travel time saving was forecast at about 5 minutes between the no build and with bypass cases (Figure 4-10 showed measured travel time routes). The travel time saving is not considered significant and is plausible given that the New England Highway (under current configuration) would have sufficient mid block capacity to cope with future growth. From comparison of Figure 3-3 (2007 AM peak condition) and Figure 4-5 (2037 AM peak condition, without the bypass), the notional volume to capacity ratios (v/c) on the New England Highway is less than 0.60 for both 2007 and 2037 without the bypass. The AM peak network plot showed few congestion issues on the New England Highway except sections under the railway bridge and near Bimbadeen Drive. The marginal through traffic growth on the New England Highway (1.45% between 2007 and 2020 and 1% until 2037) is unlikely to reduce speeds significantly under the no build case. In addition local traffic growth at South Muswellbrook would increase mining traffic demand via Skellatar Stock Route and Denman Road, and v/c ratios on both roads would increase (see Figure 4-5). The analysis therefore does not suggest significant mid block capacity issues on the New England Highway from both local and through traffic growth. The key benefit from the bypass would be eliminating heavy vehicles from the New England Highway through the Muswellbrook town centre.

Table 4-9 Travel Time Saving of the Bypass (minutes) from AM peak model

	Preliminary Model (PB)			Revised Model (Hyder)		
Year	On the New England Hwy (Without Bypass)	On the Bypass	Savings	On the New England Hwy (Without Bypass)	On the Bypass	Savings
2007	8.9			9.6		
2020	9	5	4	10	5	5
2037	9	5	4	10	5	5

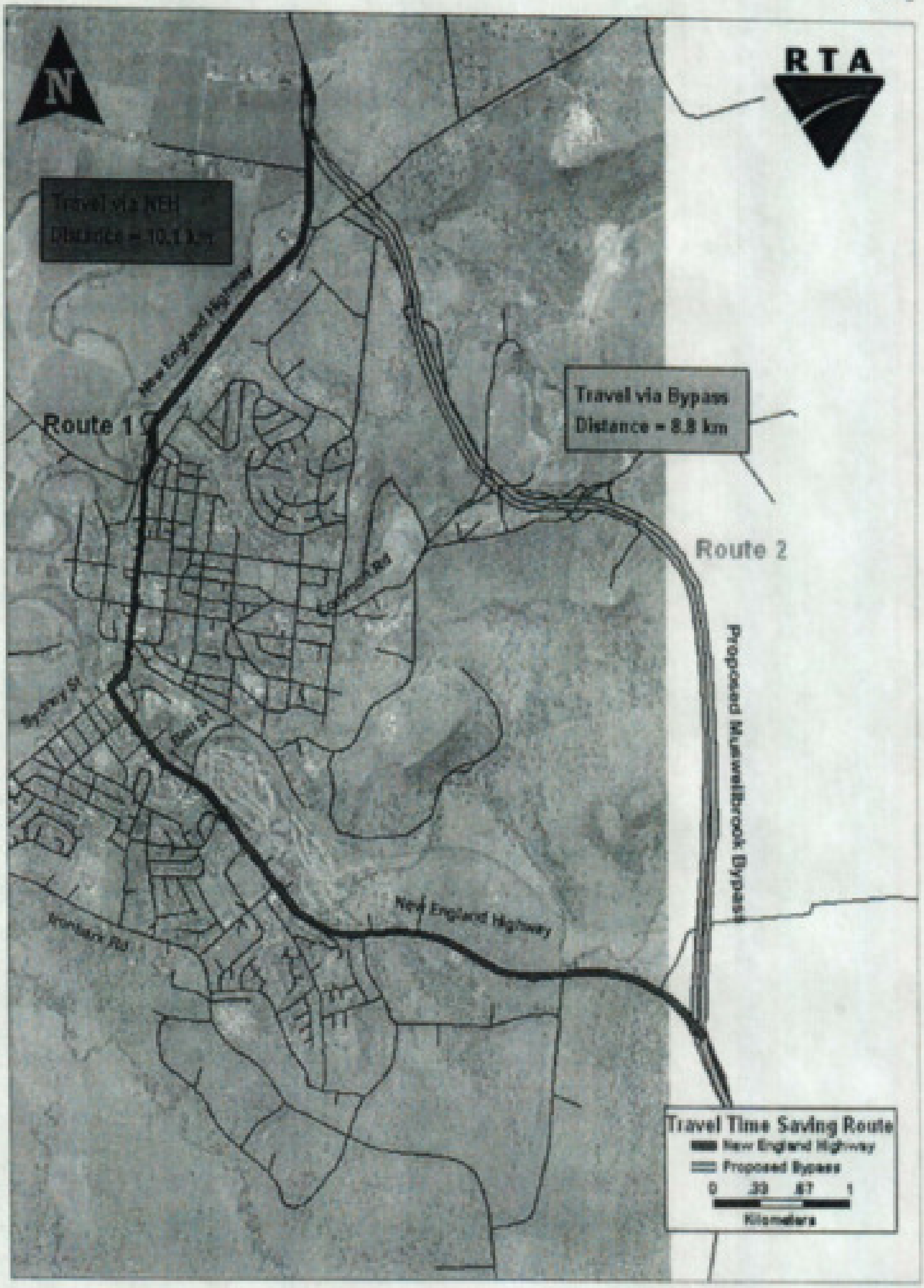


Figure 4-10 Travel Time Routes

4.5 Capacity and LoS of proposed bypass

Level of service (LoS) calculations of the proposed bypass have been based on the Austroads Guide to Traffic Engineering Practice Part 2 Roadway Capacity (Austroads 1988). In estimating LoS of the main carriageway, the following bypass parameters were adopted:

- Two lane single carriageway;
- Overtaking lanes in both directions; and
- Posted travel speed 100km/h.

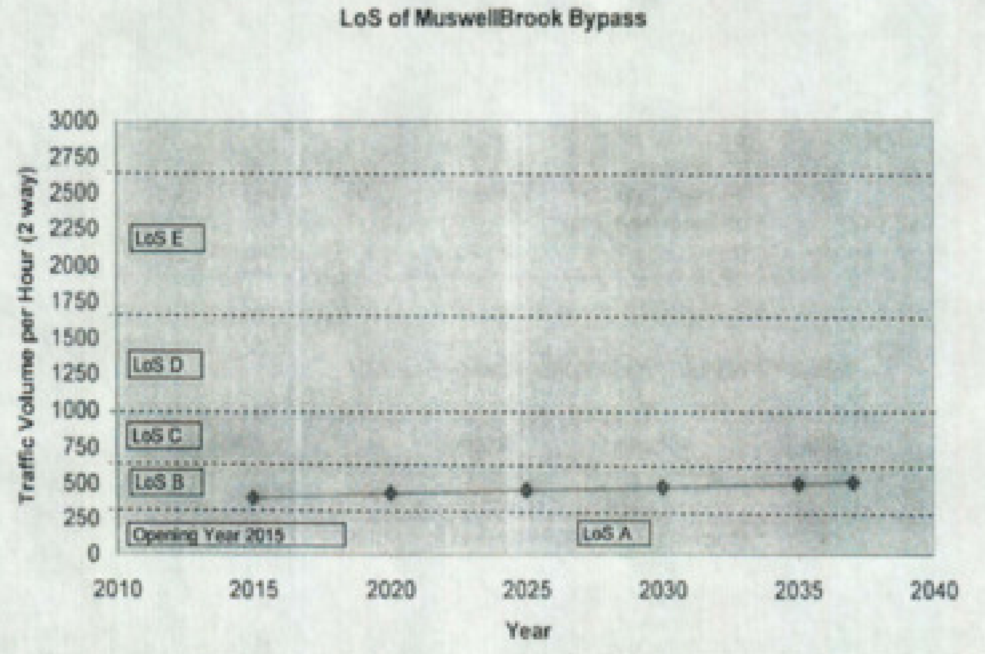


Figure 4-11 LoS of Proposed Bypass

As shown in Figure 4-11 the bypass would operate at level of service B on opening in 2015 and level of service B in 2035, twenty years after the opening of bypass.

The capacity of the single lane on and off ramps were analysed with reference to Section 5.3 of the Austroads Guide to Traffic Engineering Practice Part 2 Roadway Capacity (Austroads 1988). The analysis indicated that single lane on and off ramps would provide adequate capacity with a level of service A/B until 2035.

Four local at-grade intersections which would be affected by the bypass interchanges were analysed for their level of service in 2037: The aaSIDRA (Signalised and Unsignalised Design and Research Aid) intersection model was used to assess delay and level of service at each intersection. The results are shown in Tables 4.10 and 4.11 for AM and PM peak hour respectively. All intersections are projected to operate at LoS A, 20 years after the opening of the bypass.

Table 4-10 AM Peak (1 hour) SIDRA output for year 2037

Site ID	Location	Control	AM Peak				Comments
			DoS	Delays	Los	Queue (m)	
BP-1	Muswellbrook BP off ramp and McCullys Gap Rd	Give way	0.05	10	A	2	No Capacity issue
BP-2	Muswellbrook BP on ramp and McCullys Gap Rd	Give way	0.05	11	A	2	No Capacity issue
BP-3	Muswellbrook BP off ramp and Coal Rd	Give way	0.01	11	A	0	No Capacity issue
BP-4	Muswellbrook BP on ramp and Coal Rd	Give way	0.03	11	A	1	No Capacity issue

Table 4-11 PM Peak (1 Hour) SIDRA output for year 2037

Site ID	Location	Control	PM Peak				Comments
			DoS	Delays	Los	Queue (m)	
BP-1	Muswellbrook BP off ramp and McCullys Gap Rd	Give way	0.06	10	A	2	No Capacity issue
BP-2	Muswellbrook BP on ramp and McCullys Gap Rd	Give way	0.06	11	A	3	No Capacity issue
BP-3	Muswellbrook BP off ramp and Coal Rd	Give way	0.01	11	A	0	No Capacity issue
BP-4	Muswellbrook BP on ramp and Coal Rd	Give way	0.04	11	A	1	No Capacity issue

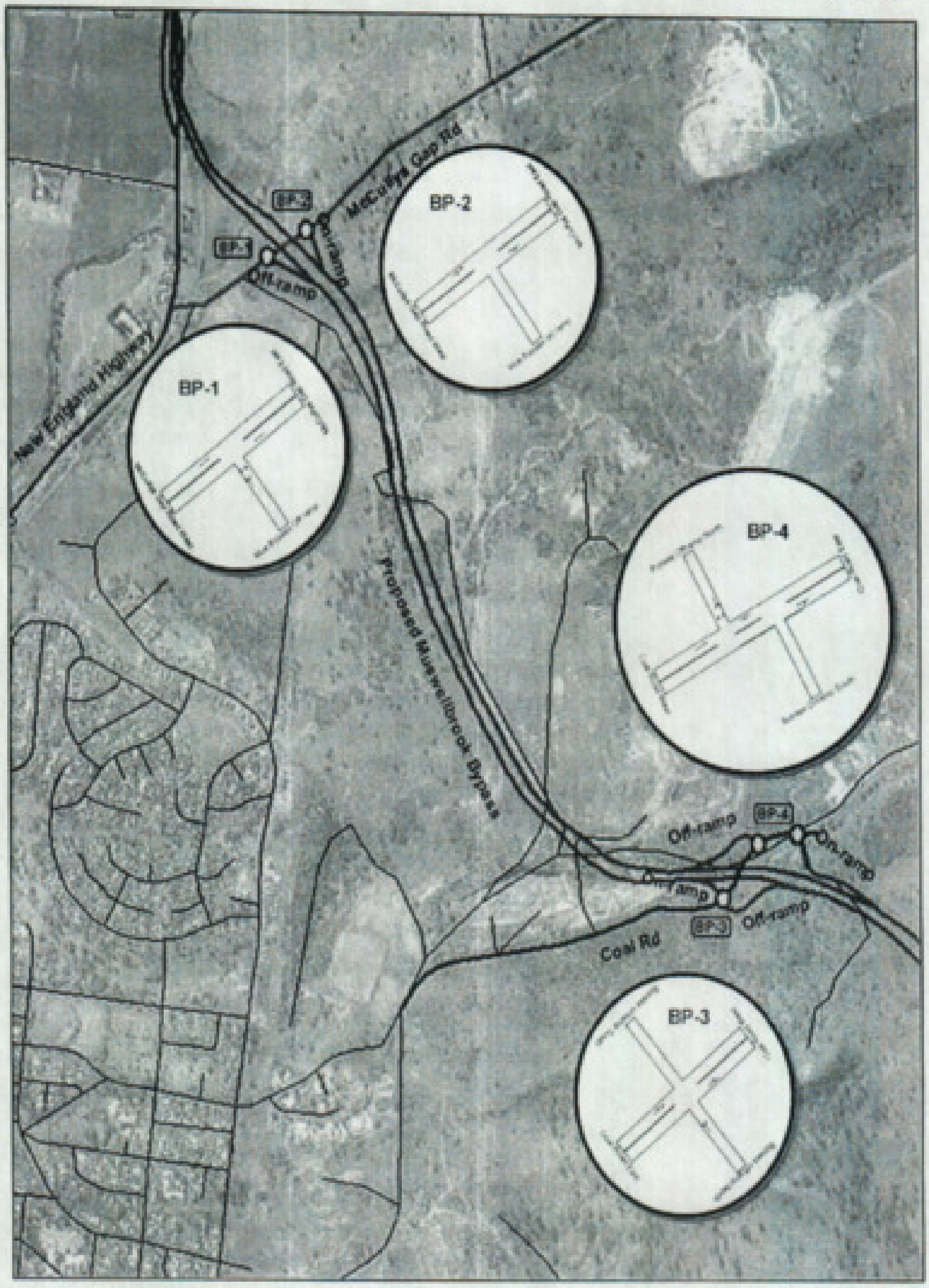


Figure 4-12 Proposed intersections

5 Economic assessment of the bypass

This section outlines the method and results of the road user cost-benefit analysis of the proposed Muswellbrook Bypass. The cost-benefit analysis compares the existing New England Highway (NEH) with the proposed bypass route.

5.1 Methodology

A cost-benefit analysis (CBA) determines the impact from investing funds in a proposed project against a base case, which for the Muswellbrook Bypass is the maintenance of the existing New England Highway route through Muswellbrook; i.e. a continuation of the status quo.

Of interest are the differences between the base case and the preferred bypass option. Those factors that are common have no bearing on choosing the most worthwhile option. CBA is a tool for measuring the relative economic worth of project options and provides a guide to decision making.

The cost-benefit analysis follows the Roads and Traffic Authority Economic Analysis Manual (December, 2007) and uses a seven percent discount rate, as recommended in the NSW Treasury Guidelines for economic appraisal. Sensitivity analysis was also performed using a four percent and ten percent discount rate.

The following assumptions were made for the purpose of the economic analysis:

- Evaluation Period: 2011-2045,
- Construction period: June 2013 –June 2015;
- Open to traffic: June 2015;
- Finalisation/handover: June 2016; and
- Price year for analysis: costs 2008, benefits 2007.

5.2 Traffic forecast

Traffic forecasts are used to estimate benefits such as changes in vehicle operating costs, travel time and accident costs. Aspects of the forecasts that are of significance to the cost-benefit analysis include the following:

- Three broad road types are used, the existing NEH, the proposed bypass and other roads in Muswellbrook and its vicinity;
- Heavy vehicles comprise 15 percent of vehicles on the existing NEH and the bypass, while they are only 3 percent of the traffic flow on other roads;
- The bypass is forecast to reduce distance and time travelled on the NEH by about 28 percent over the evaluation period. There will be

significant increases in travel speeds for through traffic using the bypass. The traffic model predicts speed on the existing NEH is about 58 km/h while speed on the bypass is forecast in the order of 99 km/h in 2037.

Road user costs and benefits are linearly interpolated between forecast years, and assumed to remain constant after the last forecast year (2037).

5.3 Costs and benefits

5.3.1 Capital cost

The estimated capital cost to build the Muswellbrook Bypass is $185 million ($2008), comprising $178.8 million for construction and $6.2 million for property acquisition, as shown in the last column of Table 5-1.

Some amendments to the capital costs are required for their use in a cost-benefit analysis. Expenditure to date that cannot be recovered if the bypass does not proceed is excluded, a total of $1.3 million ('project development', 'investigation and design' and 'property services'). This exclusion results in a capital cost for construction of $177.5 million. Expenditure on property to date is not excluded as property can be sold and the expenditure recouped if the project does not proceed. This results in capital costs of $6.2 million for property acquisition.

The last row of Table 5-1 shows an amount of $9.3 million for rehabilitation costs or costs for capital items that need to be replaced during the evaluation period. These costs are discussed in Sections 5.3.2 and 5.3.3.

Table 5-1 Capital Cost of the Muswellbrook Bypass ($'000)

Cost Component	Expended	To Spend	Total
Project Development	1,215	2,068	3,283
Investigation and Design		7,824	7,824
Property services	42	410	452
Utilities		2,291	2,291
Environmental		4,421	4,421
Traffic Control		2,277	2,277
Earthworks & Drainage		57,220	57,220
Pavements		35,429	35,429
Bridges & Structures		32,227	32,227
Fences & Lights		9,274	9,274
Noise Attenuation		971	971
Retaining Walls		2,149	2,149
Miscellaneous		7,014	7,014

Cost Component	Expended	To Spend	Total
Project Management, etc		13,705	13,705
Finalisation		234	234
Sub-total Construction Costs	1,257	177,514	178,771
Property Costs	447	5,782	6,229
Total Project Costs	1,704	183,296	185,000
Costs for use in cost-benefit analysis (excluding sunk costs)			
Construction costs		177,514	
Property costs		6,229	
Rehabilitation costs (repeat capital)		9,274	

The costs are allocated to the years in which they are expected to be incurred, as shown in Table 5-2. The basis of these costs is as follows:

- Expenditures prior to the start of construction ('project development' and 'property services') are distributed evenly between December 2011 to the start of the construction in June 2013;
- Other construction costs (other than 'finalisation') are distributed evenly over the construction period from June 2013 to June 2015;
- 'Finalisation' costs are allocated to the year after the bypass is open to traffic (June 2015); and
- The costs of property already acquired enter the analysis in the first year (2011) while the costs of property to be acquired are spread evenly over the two years prior to the start of construction (2011 and 2012).

Table 5-2 Capital Cost by Year ($'000)

Year	Construction	Acquisitions	Total
2011	2,575	3,338	5,913
2012	5,151	2,891	8,042
2013	44,320		44,320
2014	83,489		83,489
2015	41,745		41,745
2016	234		234
Total =	177,514	6,229	183,743

5.3.2 Residual value

A residual value is included in the last year of the evaluation period (2045) to represent the unused portions of assets that have economic lives beyond the evaluation period (see Table 5-3).

Four of the asset classes in the table have lives greater than the evaluation period ('earthworks & drainage', 'pavements', 'bridges & structures' and 'retaining walls). Their remaining value on a straight line depreciation basis is included. One asset class ('fences & lights') has a 20 year life so will need to be replaced during the evaluation period and will then have a remaining value at the end of the evaluation period.

Table 5-3 Construction Costs and Residual Values, 2045

Cost Component	Capital Cost ($'000)	Asset Life	Residual Value ($'000)
Earthworks & Drainage	57,220	40	14,305
Pavements	35,429	40	8,857
Bridges & Structures	32,227	100	22,559
Fences & Lights	9,274	20	4,637
Noise Attenuation	971	50	388
Retaining Walls	2,149	100	5,551
Total	**137,270**		**57,721**

At the end of the evaluation period, the residual value is estimated to total almost $58 million on an initial capital cost of just over $137 million. After discounting at the seven percent rate, the residual value reduces to $5.2 million.

5.3.3 Road maintenance costs

Road maintenance costs are estimated as annual costs and periodic rehabilitation costs. The annual maintenance costs of this project are estimated from the length of routes and a unit cost of $10,000 per km, resulting in a cost of $88,000 per annum. The unit cost is considered suitable for a two lane single carriageway.

Rehabilitation costs are estimated as capital replacement costs for assets that have lives less than the evaluation period (see Table 5-3). 'Fences & Lights' has a life of 20 years and will need to be replaced to continue to provide service during the evaluation period. The costs of $9.3 million enter the cost-benefit analysis 20 years after the bypass is opened to traffic (2035).

Maintenance costs or rehabilitation costs for roads other than the proposed bypass are not included. This assumes that there are no roads that will be closed and that changes in traffic flow on existing roads will have no effect on these costs, i.e. the costs will be the same whether the proposed bypass proceeds or not.

5.3.4 Vehicle operating costs

The distance travelled from the traffic forecasts and unit vehicle operating costs are used to estimate changes in vehicle operating costs (VOCs). The unit costs for the base case and the preferred bypass option are derived from the RTA Economic Analysis Manual. VOCs are estimated separately for cars and trucks.

The unit costs recognise the nature of existing roads and the proposed bypass, and are based on the following assumptions:

- The New England Highway is an urban road as it passes through the town of Muswellbrook;
- The new bypass is a rural arterial of very good condition (S5); and
- Other roads are rural arterials of average condition (S3). This is a simplification as many of these roads are in the Muswellbrook township.

Table 5-4 shows the reductions in VOCs for the bypass option. Reductions are estimated to occur in both forecast years for both cars and trucks.

Table 5-4 Vehicle Operating Cost Savings relative to the Base Case ($'000)

Year	Car	Truck	Total
2020	634	178	812
2037	581	141	722

5.3.5 Travel times

Travel time from the traffic forecasts and unit values are used to estimate savings in travel time. The unit values of time are calculated differently for vehicle and road types as follows:

- The default rural traffic composition in the RTA Economic Analysis Manual is used to calculate the value of the time for cars on all roads at $31.35 per hour;
- The default rural traffic composition is also used to calculate the value of time for commercial vehicles using other roads. The value of $30.43 per hour applies to commercial vehicles which comprise three percent of the traffic flow on these roads; and
- The composition of the heavy vehicle traffic stream on the existing NEH and the proposed bypass are determined from traffic count data, giving 48%, 37%, and 15% for light, medium and heavy vehicles respectively. The value of time of $38.09 per hour is considerably

higher than on other roads because there are more vehicles at the heavier end than in the default values.

Table 5-5 shows the savings in travel time relative to the base case for the proposed bypass. Savings are estimated to occur in both forecast years for both cars and trucks.

Table 5-5 Travel Time Savings relative to the Base Case($'000)

Year	Car	Truck	Total
2020	3,321	683	4004
2037	3,842	787	4629

5.3.6 Accident costs

Unit accident costs used in the evaluation are derived from analysis of the accident history of the NEH through Muswellbrook and the default values in the RTA Economic Analysis Manual.

There were 132 accidents on the NEH between Bimbadeen Drive and McCullys Gap Road from December 2002 to March 2008. The average annual cost of these accidents is $2.6 million (using values from the RTA Manual). This cost represents a rate of $84,465 per mvkt[1]. Default values for arterial road from the RTA Economic Analysis Manual were used for the bypass and local/sub-arterial road cost value was used for other roads.

The resulting accident costs and savings are shown in Table 5-6. The savings are relatively small, reflecting the small change in the forecast kilometres of travel if the bypass proceeds.

Table 5-6 Accident Costs and Savings relative to the Base Case ($000)

Year	Base Case Costs	Bypass Costs	Savings
2020	10,194	9,482	712
2037	12,680	11,913	768

5.3.7 Environmental costs

Environmental costs were sourced from the RTA Economic Analysis Manual, which includes the following seven components of environmental costs:

- Noise – impacts on housing comfort, tourism and recreation, and industry and production;

1 mvkt = million vehicle kilometres of travel.

- Air pollution – impacts on human health, flora, fauna, buildings and structures;
- Water pollution – indirect costs of transport including energy production, vehicle production and maintenance, and infrastructure construction and maintenance;
- Greenhouse gas emissions – refers to long term global warming effects;
- Nature and landscape – impacts to biodiversity, loss of natural land area, reduction in the quality of landscape and land pollution;
- Urban separation – costs associated with constraints on mobility of pedestrians and community severance; and
- Upstream and downstream effects of energy generation, vehicle production and maintenance, and road construction and maintenance.

Upstream and downstream effects are the largest component of the environmental cost representing 35 percent for all vehicle types in urban areas, and 57 to 77 percent in rural areas, depending on vehicle type. Cost-benefit analysis is marginal in nature so it is inappropriate to include the costs of upstream and downstream effects which are most unlikely to be affected by the marginal nature of the travel and changes in travel if the Muswellbrook Bypass proceeds.

The unit costs used are as shown in Table 5-7. Urban costs are used for the New England Highway and rural costs for the other two road types. This is a simplification for 'other roads', but is consistent with the estimation approach used for vehicle operating costs.

Table 5-7 Unit Costs of Environmental Effects (Cents per kilometre)

Road Type	Cars	Trucks
NEH	6.5	41.6
Bypass	2.6	12.3
Other roads	2.6	6.7

There are savings estimated as a result of the proposed bypass because of the reduction of vehicle kilometres travelled. The savings shown in Table 5-8 indicate that the truck savings are higher than for cars even though they comprise less than 15 percent of the traffic flow. This can be explained by the significantly higher unit costs.

Table 5-8 Savings in Environmental Costs relative to the Base Case ($'000)

Year	Car	Truck	Total
2020	543	679	1222
2037	593	746	1339

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5.4 BCR results

The results of the cost-benefit analysis are given in terms of the following five decision criteria:

- Net present value (NPV), which is equal to the discounted benefits minus the discounted costs or the overall economic worth of the project. This is the decision criterion that the NSW Treasury Guidelines recommend when projects are mutually exclusive;
- NPV per $ of capital invested, which measures the return on investment, explicitly taking capital constraints into account. It is the method recommended in the NSW Treasury Guidelines for ranking of projects;
- BCR - RTA is the discounted benefits divided by the discounted costs (capital and maintenance). This is the method recommended in the RTA Economic Analysis Manual. The inclusion of maintenance costs in the discounted costs implies that there is some restriction on the availability of both capital and recurrent funds for roads;
- BCR - Auslink is the net benefits (discounted benefits minus the discounted costs except capital costs) divided by the discounted capital costs. This method of calculation is used in both the NSW Treasury and Auslink Guidelines and gives a return on investment; and
- First year rate of return (FYRR), which is the net benefits in the first full year of operation divided by the discounted capital costs. The Auslink Guidelines state that it provides an indication of the project's optimal implementation time (past or future) and whether a deferral is warranted.

Appendix B includes the economic analysis results.

Table 5-9 Cost-Benefit Analysis Results by discount rate

Criteria	7%	4%	10%
Present value of investment costs	-152,305	-164,719	-141,236
Present value of benefits and other costs	65,045	108,329	42,192
NPV ($'000)	-87,260	-56,391	-99,044
NPV per $ invested	-0.6	-0.3	-0.7
BCR – RTA	0.4	0.7	0.3
BCR – Auslink	0.4	0.7	0.3
FYRR (%)	2.2	2.4	2.0

At the preferred discount rate of seven percent, the proposed Muswellbrook Bypass has a negative economic worth, with costs exceeding benefits by over $87 million. The BCR is less than 1, using either method of calculation, and the FYRR is less than the discount rate.

The economic results of the proposed bypass improve at the more favourable four percent discount rate, although the economic worth remains negative.

As can be seen from Table 5-10, construction costs dominate the results. The most significant benefit of the bypass would be travel time savings, but they are well below the capital costs. Maintenance and rehabilitation costs are relatively small, which is why there is no measurable difference in the value of the BCR no matter which of the two methods of calculating the benefit-cost ratio is used (reported in Table 5-9).

Table 5-10 Present Values of Cost and Benefits, discounted at 7 percent

Cost/Benefit	Present Value ($'000)
Property	-6,040
Construction	-146,266
Rehabilitation	-1,828
Maintenance	-833
Car VOC	5,499
Truck VOC	1,468
Car travel time	31,475
Truck travel time	6,136
Accidents	6,561
Car environment	5,028
Truck environment	6,304
Residual	5,237
Net Present Value	-87,260

6 Summary of findings

The Roads and Traffic Authority (RTA) engaged Hyder Consulting to prepare a detailed traffic study for the proposed Muswellbrook Bypass by undertaking a refinement of the Muswellbrook local area traffic model.

The modelling of the proposed bypass was based on modified option E being the preferred route approved in June 2005 by the then Department of Transport and Regional Services (DOTARS), now Department of Infrastructure, Transport, Regional Development and Local Government (DOI). The preliminary concept design for the preferred route consists of a two-lane single carriageway bypass to the east of Muswellbrook. It is approximately 8.8 km long, with three partial interchanges and one full interchange within the project length.

To assist with the process of refining the traffic model, additional traffic data was collected which included a new 24 hour origin destination (OD) survey, supplementary traffic counts on local roads, and travel time data on key routes along the bypass corridor. This new data improved the traffic model parameters and forecasting results, and therefore formed the basis of the model augmentation and detailed bypass traffic study.

A three phase study methodology was developed to achieve the study objectives. Broadly the approach involved reviewing data sources; analysing OD data, supplementary traffic counts and travel time data; augmenting base and future year models; preparing traffic forecasts; and estimating the benefit cost ratio (BCR) of the bypass.

Traffic on the New England Highway is a mixture of through and local movements and results from the traffic survey data show that:

- New England Highway east of Rutherford Road carried about 10,000 vehicles per day (vpd);
- Daily traffic on Bridge Street increased to about 20,000 vpd with more than 50% being local traffic;
- The New England Highway north of Aberdeen Street carried about 10,500 vpd, similar to traffic flows recorded east of Rutherford Road. This indicates that capacity at critical intersections with the New England Highway between Rutherford Road and Aberdeen Street is driven by the local traffic influence rather than by through traffic alone;
- The number of heavy vehicles recorded on the New England Highway varied between 1,450 and 1,800 vpd, and about 15% of all vehicles both south and north of the town centre. The daily number of B-Doubles were between 140 and 170;
- The proportion of heavy vehicles is reduced on Bridge Street to comprise about 9% of total traffic. The lower proportion of heavy vehicles results from a high proportion of local light vehicles at Bridge Street. About 160 heavy vehicles were recorded on Bell Street per day, which is a high vehicle bypass route; and

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- Daily traffic recorded on Common Road and Coal Road was relatively low with 1000 vehicles per day on Common Road and 300 vehicles per day on Coal Road.

Results from the Origin-Destination (OD) survey indicated that:

- Through traffic on the New England Highway was between 44% and 47% of all traffic. This is higher than the previous OD results of 25% to 32% (undertaken in May 2002);
- Of the through traffic, 72% to 74% did not stop, while travelling north or south through the town. This means approximately 33% of the total traffic is through non stopping traffic;
- Between 26% and 28% of through traffic stopped at Muswellbrook while travelling north to south or vice versa; and
- For heavy vehicles including B-doubles, about 82% of vehicles did not stop while travelling north to south or vice versa.

The temporal distribution of OD data showed:

- Between 12 am and 4 am, and between 9 pm and midnight, light vehicles on the New England Highway are predominantly through traffic;
- Between 5 am and 7pm local traffic is dominant on the New England Highway, with possibly a higher proportion of mine related traffic in the early morning;
- Through heavy vehicles dominate during the early morning and late at night. A higher proportion of heavy vehicles during the middle of the day are local, with origin or destination at and around the town centre ; and
- All B-doubles travelling on the New England Highway are through traffic from south to north or vice versa. Currently between 1400 and 1500 heavy vehicles (including B-doubles) travel on the New England Highway per day.

Results from the revised traffic model indicated:

- Without the proposed bypass, the New England Highway was forecast to carry 13,000 to 21,000 vehicles per day in 2020, increasing to between 15,000 and 27,000 vehicles per day in 2037; and
- With the bypass, the revised forecast shows marginal traffic reductions on the New England Highway of between 2% and 7% compared to the preliminary forecasts. This is plausible as additional capacity is available from the through traffic reduction which is expected to be taken up by local traffic growth.
- Traffic was forecast on the bypass between 5,000 and 5,700 vehicles per day in 2020;
- In 2037, model forecasts bypass traffic between 5,800 and 6,600 vehicles per day. This was an increase of 800 to 900 vehicles compared to 2020 forecasts;

- The southern section of the new bypass was forecast to carry about 12% more traffic than the northern section;
- The bypass would be effective in reducing traffic flows by an average of between 5,000 and 5,500 vehicles per day on the New England Highway over the next 30 years. This represents a traffic reduction of between 24% and 34% on the New England Highway after the bypass is built; and
- The bypass will save approximately 5 minutes travel time.

The cost-benefit analysis followed the Roads and Traffic Authority Economic Analysis Manual (December, 2007) and uses a seven percent discount rate, as recommended in the NSW Treasury Guidelines for economic appraisal. Sensitivity analysis was also performed using a four percent and ten percent discount rate. The estimated capital cost to build the Muswellbrook Bypass is $185 million (2008 values), comprising $178.8 million for construction and $6.2 million for property acquisition. The estimated benefit cost ratios (BCR) of bypass is summarised in Table 6-1.

Table 6-1 Estimated Benefit Cost Ratios (BCR) of bypass by discount rate

Criteria	7%	4%	10%
Present value of investment costs	-152,305	-164,719	-141,236
Present value of benefits and other costs	65,045	108,329	42,192
NPV ($'000)	-87,260	-56,391	-99,044
NPV per $ invested	-0.6	-0.3	-0.7
BCR – RTA	0.4	0.7	0.3
BCR – Auslink	0.4	0.7	0.3
FYRR (%)	2.2	2.4	2.0

At the preferred discount rate of seven percent, the bypass has a negative economic worth, with costs exceeding benefits by over $87 million. The BCR is less than 1. The economic results of the proposed bypass improve at the more favourable four percent discount rate, although the economic worth remains negative. The most significant benefits from the bypass would be travel time savings, but they are well below the capital costs.

7 References

Austraffic, "*3147-PB-Muswellbrook Origin Destination Survey*", October / November 2007;

Parsons Brinckerhoff, "*Muswellbrook Bypass Preliminary Traffic Report*," October 2007;

Parsons Brinckerhoff, "*Muswellbrook Traffic Study & Roadworks Plan*," January 2008;

Austroads, "*Guide to Traffic Engineering Practice Part 2 Roadway Capacity*," 1988;

Roads and Traffic Authority, "*Economic Analysis Manual*," December, 2007;

Department for Transport (UK), "Design Manual for Road and Bridges (DMRB)," Volume 12, Section 2, 1996;

FHWA (USA) ,"Model Calibration and Checking Manual," 1997; and

Transfund New Zealand, "State of the Environment Report," 2001.

Appendix A

Traffic Data for Noise Assessment and Derivation of Annualisation Factor

Table A1 Traffic Data for Noise Assessment –Light Vehicles (2- way)

Light Vehicles (2-way)

Time	2007				2007 (without bypass)				2007 (with bypass)					
Road Sections	NEH, East of Bimbadeen Dr	NEH, West of Rutherford Road	Bridge street, South of Brook Street	NEH,South of Mc Cullys Gap Road	NEH, East of Bimbadeen Dr	NEH, West of Rutherford Road	Bridge street, South of Brook Street	NEH,South of Mc Cullys Gap Road	NEH, East of Bimbadeen Dr	NEH, West of Rutherford Road	Bridge street, South of Brook Street	NEH,South of Mc Cullys Gap Road	Muswellbrook Bypass, between NEH and Coal Road	Muswellbrook Bypass, between Coal Road and Sandy Creek Road
15-Hours	6383	10973	13052	7817	17786	19507	16782	10614	15962	16862	14407	8349	4733	4160
9 Hours	1259	2164	2574	1542	3508	3847	3310	2093	3148	3326	2841	1647	934	820
Total	7642	13137	15627	9359	21293	23354	20091	12707	19110	20188	17248	9996	5667	4980

Table A2 Traffic Data for Noise Assessment –Heavy Vehicles (2- way)

Derivation of Annulisation Factors on the New England Highway

TRAFFIC COUNTS 2001

Station	Location	Direction	AADT	AAWT	Annualisation Factor
06.140	New England Hwy, East Maitland-N of MR102	East	21025	22990	336
		West	21963	23840	336
06.003	New England Hwy, Singleton-7.9km E of MR128	North	5675	5931	343
		South	5746	6004	349
06.150	Maitland Rd, Raymond Terrace-W of Irrawang Bridge	East	3327	3501	347
		West	3360	3524	348
06.066	New England Hwy, Hexham-N of SH10, Pacific Hwy	North	22665	24009	345
		South	23118	25064	337
06.096	Sydney-Newcastle Fwy, W W'snd-F3 O/BR NB George Booth Dr.	North	1036	1116	339
		South	918	983	341
06.196	Cessnock Rd, Brunkvl'e-1.6km N of MR392, M'Set Rd	North	3880	3932	369
		South	4130	3978	379
06.194	Cessnock Rd, Neath at Rly Xing	North	6149	6658	337
		South	6097	6603	337
				Min	336
				Max	379
				Median	342
				Average	346

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Appendix B

Economic Analysis

Undiscounted Costs and Benefits by Year ($'000)

Year	Land	Constn	Rehab	Mtce	VOC Benefits		Travel Time Benefits		Accident	Environ Benefits		Residual
	Costs	Costs	Costs	Costs	Car	Truck	Car	Truck	Benefits	Car	Truck	Value
2011	3,338	2,575	0	0	0	0	0	0	0	0	0	0
2012	2,891	5,151	0	0	0	0	0	0	0	0	0	0
2013	0	44,320	0	0	0	0	0	0	0	0	0	0
2014	0	83,489	0	0	0	0	0	0	0	0	0	0
2015	0	41,745	0	0	0	0	0	0	0	0	0	0
2016	0	234	0	88	439	123	2,299	473	493	376	470	0
2017	0	0	0	88	488	137	2,555	526	548	418	522	0
2018	0	0	0	88	537	150	2,810	578	602	459	575	0
2019	0	0	0	88	585	164	3,066	631	657	501	627	0
2020	0	0	0	88	634	178	3,321	683	712	543	679	0
2021	0	0	0	88	631	176	3,352	689	715	546	683	0
2022	0	0	0	88	628	173	3,382	695	719	549	687	0
2023	0	0	0	88	625	171	3,413	702	722	552	691	0
2024	0	0	0	88	622	169	3,444	708	725	555	695	0
2025	0	0	0	88	618	167	3,474	714	728	558	699	0
2026	0	0	0	88	615	165	3,505	720	732	561	703	0
2027	0	0	0	88	612	162	3,535	726	735	563	707	0
2028	0	0	0	88	609	160	3,566	732	738	566	711	0
2029	0	0	0	88	606	158	3,597	738	741	569	715	0
2030	0	0	0	88	603	156	3,627	744	745	572	719	0

Year	Land	Constn	Rehab	Mtce	VOC Benefits		Travel Time Benefits		Accident	Environ Benefits		Residual
	Costs	Costs	Costs	Costs	Car	Truck	Car	Truck	Benefits	Car	Truck	Value
2031	0	0	0	88	600	154	3,658	750	748	575	723	0
2032	0	0	0	88	596	152	3,689	756	751	578	726	0
2033	0	0	0	88	593	149	3,719	762	755	581	730	0
2034	0	0	0	88	590	147	3,750	769	758	584	734	0
2035	0	0	9,274	88	587	145	3,780	775	761	587	738	0
2036	0	0	0	88	584	143	3,811	781	764	590	742	0
2037	0	0	0	88	581	141	3,842	787	768	593	746	0
2038	0	0	0	88	581	141	3,842	468	768	593	746	0
2039	0	0	0	88	581	141	3,842	468	768	593	746	0
2040	0	0	0	88	581	141	3,842	468	768	593	746	0
2041	0	0	0	88	581	141	3,842	468	768	593	746	0
2042	0	0	0	88	581	141	3,842	468	768	593	746	0
2043	0	0	0	88	581	141	3,842	468	768	593	746	0
2044	0	0	0	88	581	141	3,842	468	768	593	746	0
2045	0	0	0	88	581	141	3,842	468	768	593	746	52,251

Discounted Costs and Benefits by Year ($'000), 7 per cent discount rate

Year	Land Costs	Constn Costs	Rehab Costs	Mtce Costs	VOC Benefits		Travel Time Benefits		Accident Benefits	Environ Benefits		Residual Value	Benefits-Costs
					Car	Truck	Car	Truck		Car	Truck		
2011	-3,338	-2,575	0	0	0	0	0	0	0	0	0	0	-5,913
2012	-2,702	-4,814	0	0	0	0	0	0	0	0	0	0	-7,516
2013	0	-38,711	0	0	0	0	0	0	0	0	0	0	-38,711
2014	0	-68,152	0	0	0	0	0	0	0	0	0	0	-68,152
2015	0	-31,847	0	0	0	0	0	0	0	0	0	0	-31,847
2016	0	-167	0	-63	313	88	1,639	337	351	268	335	0	3,102
2017	0	0	0	-59	325	91	1,702	350	365	278	348	0	3,401
2018	0	0	0	-55	334	94	1,750	360	375	286	358	0	3,502
2019	0	0	0	-51	341	95	1,784	367	382	292	365	0	3,575
2020	0	0	0	-48	345	97	1,807	372	387	295	369	0	3,624
2021	0	0	0	-45	321	89	1,704	350	364	278	347	0	3,408
2022	0	0	0	-42	298	82	1,607	330	341	261	326	0	3,205
2023	0	0	0	-39	277	76	1,515	311	320	245	307	0	3,014
2024	0	0	0	-37	258	70	1,429	294	301	230	288	0	2,834
2025	0	0	0	-34	240	65	1,347	277	282	216	271	0	2,664
2026	0	0	0	-32	223	60	1,270	261	265	203	255	0	2,505
2027	0	0	0	-30	207	55	1,198	246	249	191	239	0	2,355
2028	0	0	0	-28	193	51	1,129	232	234	179	225	0	2,214
2029	0	0	0	-26	179	47	1,064	218	219	168	211	0	2,082
2030	0	0	0	-24	167	43	1,003	206	206	158	199	0	1,957

Year	Land	Constn	Rehab	Mtce	VOC Benefits		Travel Time Benefits		Accident	Environ Benefits		Residual	Benefits-
	Costs	Costs	Costs	Costs	Car	Truck	Car	Truck	Benefits	Car	Truck	Value	Costs
2031	0	0	0	-23	155	40	945	194	193	149	187	0	1,840
2032	0	0	0	-21	144	37	891	183	181	140	175	0	1,729
2033	0	0	0	-20	134	34	839	172	170	131	165	0	1,626
2034	0	0	0	-19	124	31	791	162	160	123	155	0	1,528
2035	0	0	-1,828	-17	116	29	745	153	150	116	146	0	-392
2036	0	0	0	-16	108	26	702	144	141	109	137	0	1,350
2037	0	0	0	-15	100	24	662	135	132	102	129	0	1,269
2038	0	0	0	-14	93	23	618	75	124	95	120	0	1,134
2039	0	0	0	-13	87	21	578	70	115	89	112	0	1,060
2040	0	0	0	-12	82	20	540	66	108	83	105	0	991
2041	0	0	0	-12	76	18	505	61	101	78	98	0	926
2042	0	0	0	-11	71	17	472	57	94	73	92	0	865
2043	0	0	0	-10	67	16	441	54	88	68	86	0	809
2044	0	0	0	-9	62	15	412	50	82	64	80	0	756
2045	0	0	0	-9	58	14	385	47	77	59	75	5,237	5,943
Total	-6,040	-146,266	-1,828	-833	5,499	1,468	31,475	6,136	6,561	5,028	6,304	5,237	-87,260

Cost of Accidents on the New England Highway, December 2002 to March 2008:

Accident Type	Number	Cost/Accident ($)	Total Costs ($'000)
Towaway	63	7,540	475
Injury	69	192,007	13,248
Total	**132**		**13,724**
Number of years		5.25	
Cost per year ($'000)		2,614	
Mvkt		30.9	
Cost/mvkt ($)		**84,465**	

mvkt = millions of vehicle kilometres of travel