Appendix C

Traffic modelling and economic appraisal

FINAL REPORT

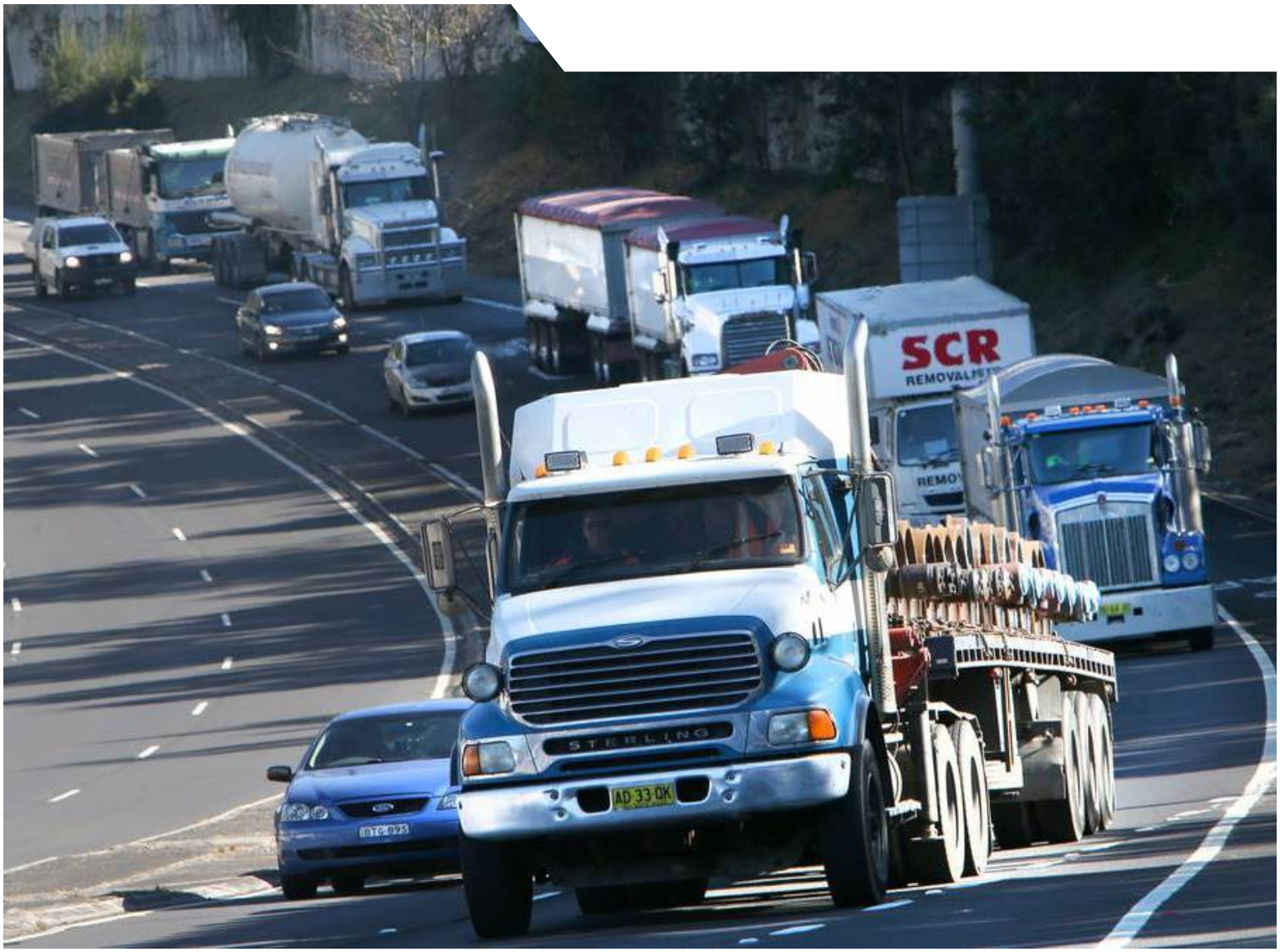
Hyder

M1 Princes Motorway – Offline Upgrade from Bellambi Creek and Picton Road

Traffic Modelling and Economic Appraisal

Prepared for

Roads and Maritime Services



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Roads and Maritime Services

M1 Princes Motorway – Offline Upgrade between Bellambi Creek and Picton Road

Traffic Modelling and Economic Appraisal

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Revisions

Revision	Date	Description	Prepared By	Approved By
A	8 Dec 14	Internal Review	SM, KN	
B	11 Dec 14	Draft for RMS review	MR	MR
C	16 Dec 14	Draft Final Report incorporating RMS ‘s comments	MR	MR
D	4 Feb 15	Final Report	MR	MR

CONTENTS

APPENDICES

Abbreviations

BCR	Benefit Cost Ratio
FYRR	First Year Rate of Return
NPV	Net Present Value
NPVI	Net Present Value per Dollar of Investment
PV	Present Value
RMS	Roads and Maritime Services (Roads and Maritime)
TfNSW	Transport for New South Wales
Tkm	Tonne-kilometer
VHT	Vehicle Hours Travelled
VKT	Vehicle kilometres travelled
VOC	Vehicle Operating Cost
VOTT	Value of Travel Time

1 Introduction

1.1 Report Purpose

The following document is a Traffic Modelling and Economic Appraisal Report (hereafter referred to as 'the Study') of the M1 Princes Motorway Offline upgrade option between Bellambi Creek and Picton Road ('the study area').

The purpose of this Study is two-folds:

- Undertake traffic modelling of the M1 Princes Motorway Offline upgrade option between Bellambi Creek and Picton Road. The modelling has been undertaken using micro-simulation Paramics software.
- Undertake economic merit of the Offline upgrade option. This involves estimating the net economic benefit, benefit cost ratio (BCR) and net present value (NPV) of the Offline upgrade option.

This report presents the methodology, assumptions and results of the traffic modelling and economic appraisal of the Offline upgrade option.

1.2 Background

The M1 Princes Motorway is a key strategic corridor and the only B-Double-capable route, linking Sydney with the Illawarra region and NSW South Coast. The section from south of Picton Road to Bulli Tops is currently constrained to two lanes in each direction. Adjoining sections of the M1 Princes Motorway are mostly configured with three lanes in each direction. Through the study area, the M1 Princes Motorway carries around 37,000 vehicles per day. The constrained road space in the section of the road, together with the undulating topography generates the need for vehicle weaving between slow, heavily-laden freight vehicles and unladen heavy vehicles and lighter passenger vehicles on that section of the M1 Princes Motorway.

Roads and Maritime (Roads and Maritime Services, RMS) has developed a strategic concept design for an 'offline' road upgrade and realignment of the M1 Princes Motorway southern section between Bellambi Creek and Picton Road ('Offline upgrade') to provide greater traffic efficiency and safety.

Road and Maritime commissioned Hyder Consulting Pty Ltd (Hyder) to undertake a traffic modelling and economic appraisal of the Offline upgrade.

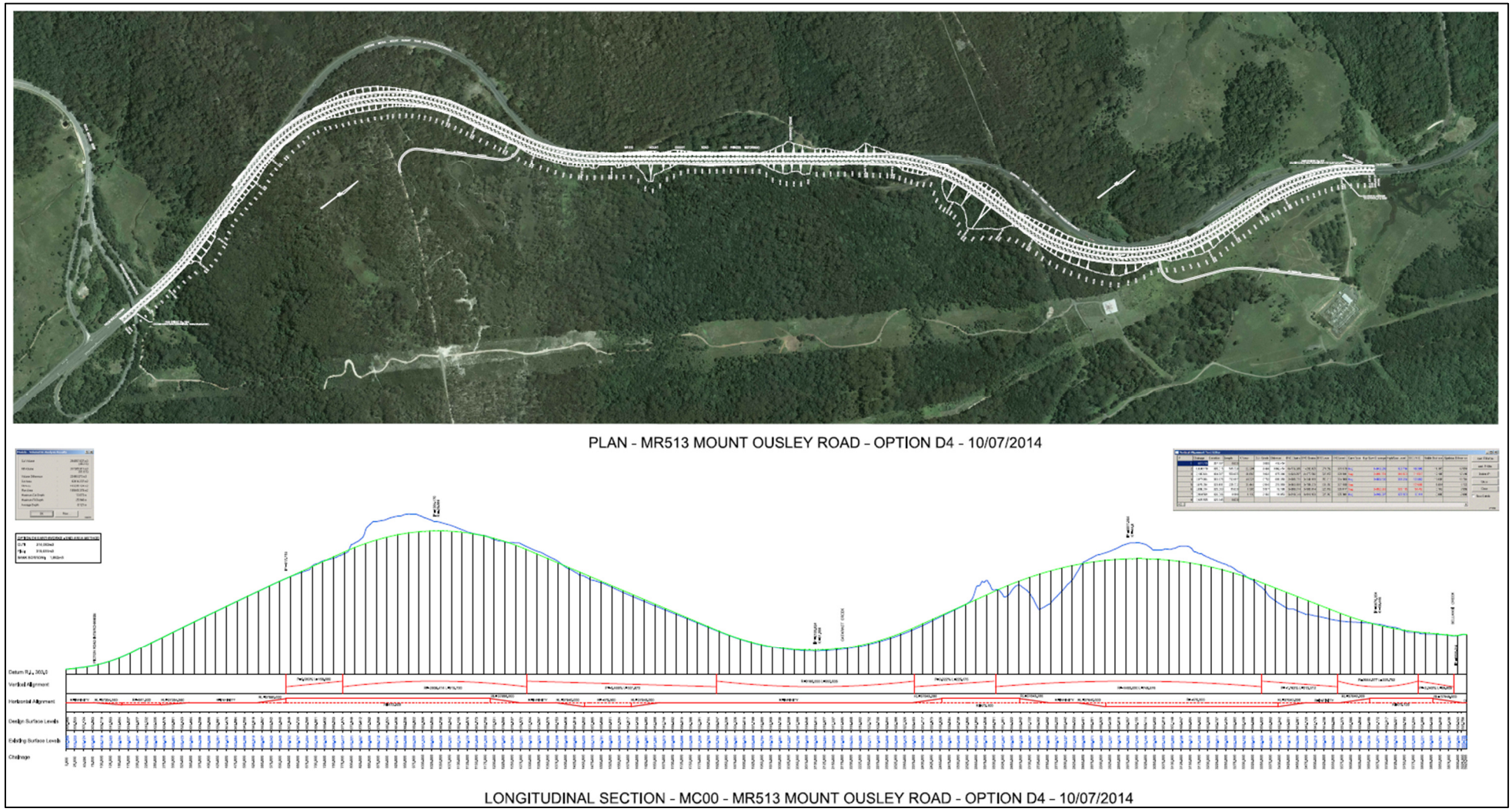
A consultation process involving Roads and Maritime constituted an important element of the study. This includes one modelling presentation to Roads and Maritime's staff. Feedback from RMS staff has been incorporated in the Study where relevant.

Through this report, the M1 Prince Motorway Offline Upgrade option between Bellambi Creek and Picton Road is referred to as the 'Offline upgrade'.

1.3 Offline Upgrade

The Offline upgrade involves road widening (3 lanes in each direction) and realignment of a 3.5 kilometres of the M1 Princes Motorway between Bellambi Creek and Picton Road.

Figure 1-1 shows the strategic concept design of the Offline upgrade.



Source: RMS, Option D4 dated 10/07/2014

Figure 1-1 Strategic Concept Design of Offline Upgrade

2 Traffic Modelling

2.1 Reference Traffic Data and Model

For the purpose of this Study, traffic and modelling data have been sourced from the RMS's Paramics model built for the Mouth Ousley Road/Southern Freeway project[1]. Hyder augmented the Paramics model for exiting 2014 traffic conditions. The updated Paramics model for existing base case includes the recently completed northbound overtaking lane to the north of Bulli Tops and a northbound acceleration lane from Picton Road onto the M1.

New traffic surveys were undertaken to satisfy the need and purpose of the traffic study. This includes intersection classified turning movement counts (car and heavy vehicles) and travel time surveys. The traffic survey was undertaken by Skyhigh in November 2014.

2.2 Modelling Study Area

Figure 2-1 shows the broader modelling study area. The study area includes the 8.3 kilometres section of the M1 Princes Motorway between Bulli Tops and Picton Road. The section currently a four lane divided road (two lanes in each direction) with speed limits of 100 km/h. Currently the M1 Princes Motorway within the study area carries about 37,000 vehicles per day.

[1] *Mouth Ousley Road/Southern Freeway Traffic Modelling, Bitzios Consulting, January 2010.*

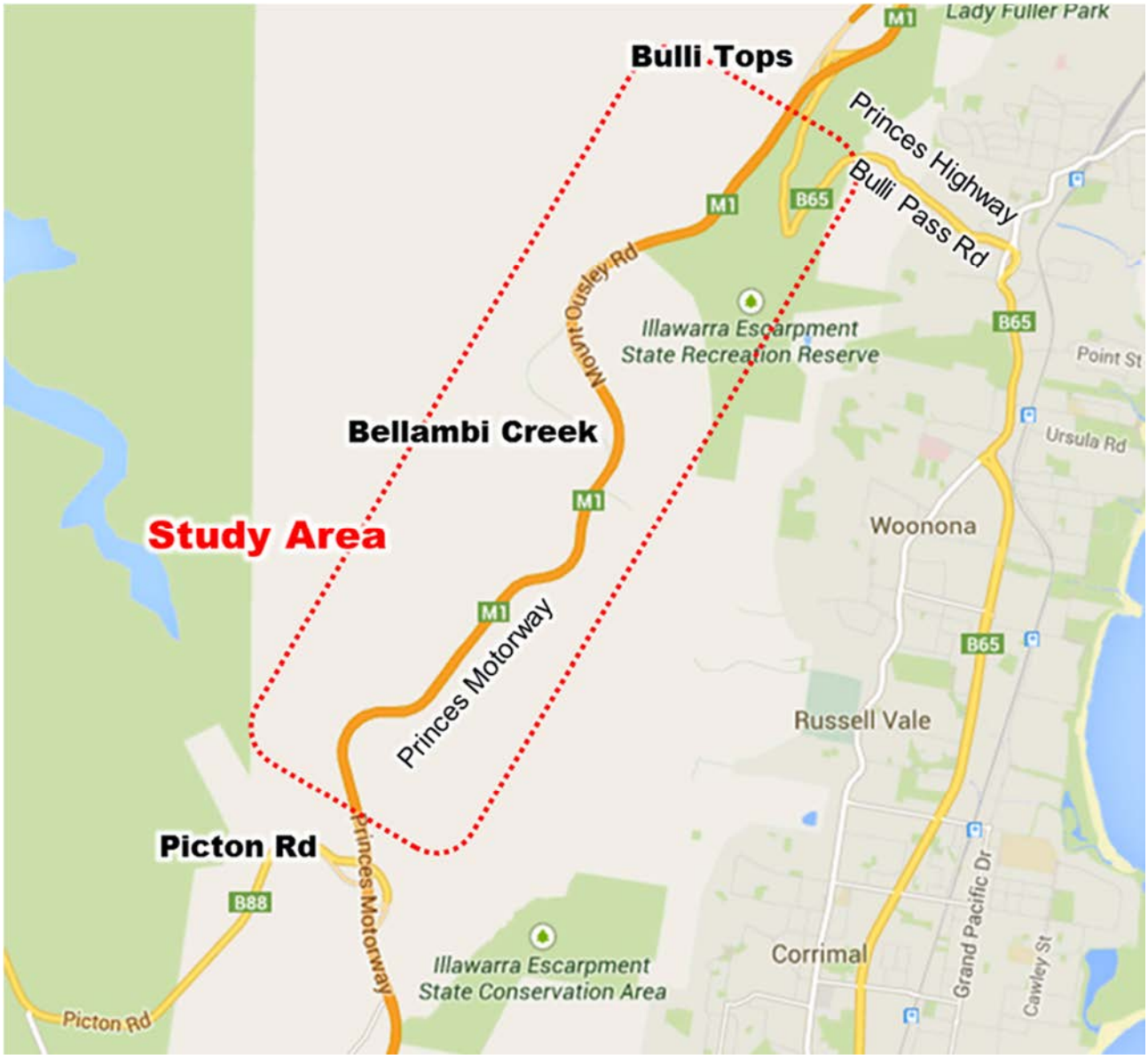


Figure 2-1 Study Area

2.3 Exiting Traffic Conditions

The M1 Princes Motorway, Picton Road and Appin Road, form the major freight and B-Double-links between the Sydney urban area and Wollongong, Port Kembla and the Illawarra. Whilst the proportion of heavy vehicles using the route is high (about 13% on a daily basis) those vehicles compete with general traffic for the available road space.

2.3.1 Traffic Volumes on the M1 Princes Motorway

In 2014 M1 Princes Motorway, between Bulli Tops and Picton Road carried about 37,000 vehicles per day. The heavy vehicle proportion was about 13% of the total traffic. The northbound hourly flow on the M1 was about 1,800 vehicles in the morning peak. The southbound hourly flow on the M1 was found slightly less than 1,800 vehicles in the afternoon peak. In the morning and afternoon peak, heavy vehicles comprised about 8-9% of peak hour traffic being lower than the daily heavy vehicles proportion. Of particular concerns are traffic issues generated by the laden heavy vehicles climbing and descending the steep grades of the motorway. Whilst the majority of heavy vehicles use the kerbside lane there are frequent occasions when the right lane is required by other heavy vehicles to pass. This has a 'knock-on' effect for general traffic, generating the need for weaving manoeuvres. Such manoeuvres are more able to be undertaken on the existing three lane carriageways south of the Picton Road. However, to the north, the existing two lanes significantly reduce the capacity for heavy vehicle overtaking. This potential weaving on the M1 results in increased travel times for all vehicles and the potential for more vehicle crashes.

Table 2-1 below summarise existing (2014) traffic on the M1 Princes Motorway between Bulli Tops and Picton Road.

Table 2-1 Traffic Volumes on M1 Princes Motorway between Bulli Tops and Picton Road

	Existing (2014) Traffic
Daily volumes (ADT)	37,000 vehicles (two way)
Heavy vehicles	13% are heavy vehicles and 87% are light vehicles.
Morning peak hour volumes	
Light vehicle	NB:1700 / SB:1000
Heavy vehicle	NB:120 / SB:120
All vehicle	NB:1800 / SB:1100

Source: Existing (2014) volumes are sourced from traffic counts.
Note: NB-Northbound towards Sydney, SB-Southbound towards Wollongong

2.3.2 Travel Speed and Travel time on the M1 Princes Motorway

Table 2-2 below shows average travel speed and travel time on the M1 Princes Motorway between Bulli Tops and Picton Road for light and heavy vehicles. The data indicates that travel speed for heavy vehicles are substantially lower than posted speed. In peak period, the travel speed is about 80-90 km/h for light vehicles and about 50-60 km/h for heavy vehicles. The average travel speeds on the motorway section are approximately 20%-25% lower that the posted speed limited of 100 km/h.

Table 2-2 Existing Travel Speed and travel time on the M1 Prince Motorway between Bulli Tops and Picton Road

Vehicle Type	Travel Speeds (km/h)		Travel Times (minutes)	
	Northbound	Southbound	Northbound	Southbound
Light Vehicles	86	89	5.8	5.6
Heavy Vehicles	54	62	8.9	7.7

Source: Paramics traffic model based on 2009 and 2014 traffic surveys

2.3.3 Crash Data

Recorded crash data from August 2009 to October 2013 (a period of 5 years) were obtained from Roads and Maritime. The crash data for the 3.5 kilometres section on the M1 Princes Motorway between Bellambi Creek and Picton (the study area) was analysed.

Table 2-3 summarises historical crashes recorded on the M1. In the five year period between 1 August 2009 and 31 October 2013, a total of 112 crashed were recorded. These crashes included two fatal crashes and 27 injury crashes. The historical crash data indicates that a high number of crashes are run-off road, rear-end and lane change type of crashes.

The crash rate on the M1 section per 100 million vehicle kilometres travelled (100 MVKM) is shown in Table 2-4. The crash data shows that average fatality rate on the subject section of the M1 Prince Motorway is 0.6 per 100 MVKM.

Table 2-5 summarises the crash costs for the subject sections M1 Princes Motorway between Bellambi Creek and Picton Road. The crash costs were estimated based on costs by accident type using 'willingness to pay' approach. The average crash costs based on definitions for coding accidents (DCA) are sourced from TfNSW's *Principles and Guideline of Economic Appraisal of Transport Investment and Investigation, March 2013*.

The crashes on the M1 Princes Motorway between Bellambi Creek and Picton Road between August 2009 and August 2013 cost an estimated total of $22.23 million based on 2012/13 willingness to pay rates approach. The average cost on the M1 per annum was about $4.45 million or about $0.84 million per kilometre.

Table 2-3 Crash History (1 August 2009 to October 2013)

Section Length (km)	Total Crash	Crash by Severity		
		Fatal Crash	Injury Crashes	Non-injury Crashes
5.31	112	2	27	83

Source: RMS crash data recorded between 1 August 2009 and October 2013.

Table 2-4 Crash Rate per 100 MVKM

Section Length (km)	2014 ADT	Crash Rate per 100 MVKM(1)			
		Total Crash	Fatal Crash	Injury Crashes	Non-injury Crashes
5.31	37,000	31.2	0.6	7.5	23.1

Note: (1) Crash rate per 100 MVKM = (total crashes x 100,000,000) / (no. of years x 365 x length (km) x AADT).

Table 2-5 Total and Average Annual Crash Cost

Section Length (km)	Total Cost (1) (5 years, 1 August 2009 to October 2013)		Average Annual Cost (per year)	
	Total Cost ($M)	Cost per Km ($M)	Total Cost ($M)	Cost per Km ($M)
5.31	22.23	4.19	4.45	0.84

Note: (1) Costs per crash sourced from Table 45 (Page 257) of TfNSW's Principles and Guideline of Economic Appraisal of Transport Investment and Investigation, March 2013

2.4 Traffic Forecasts

The traffic forecasts used in the economic evaluation are prepared by Hyder using Q-Paramics, a micro simulation traffic model. In agreement with RMS, traffic growth assumptions were used in future year models.

2.4.1 Historical Traffic Growth

Historical growth from 1996 to 2014 have been analysed for the section of M1 Pacific Motorway north of Appin Road. A regression model has been developed using long time historical data. The analysis showed that traffic on the M1 Pacific Motorway has grown consistently in the order of 2% per annum. The historical growth trends on M1 Pacific Motorway north of Appin Road are shown by Blue line in Figure 2-2 below.

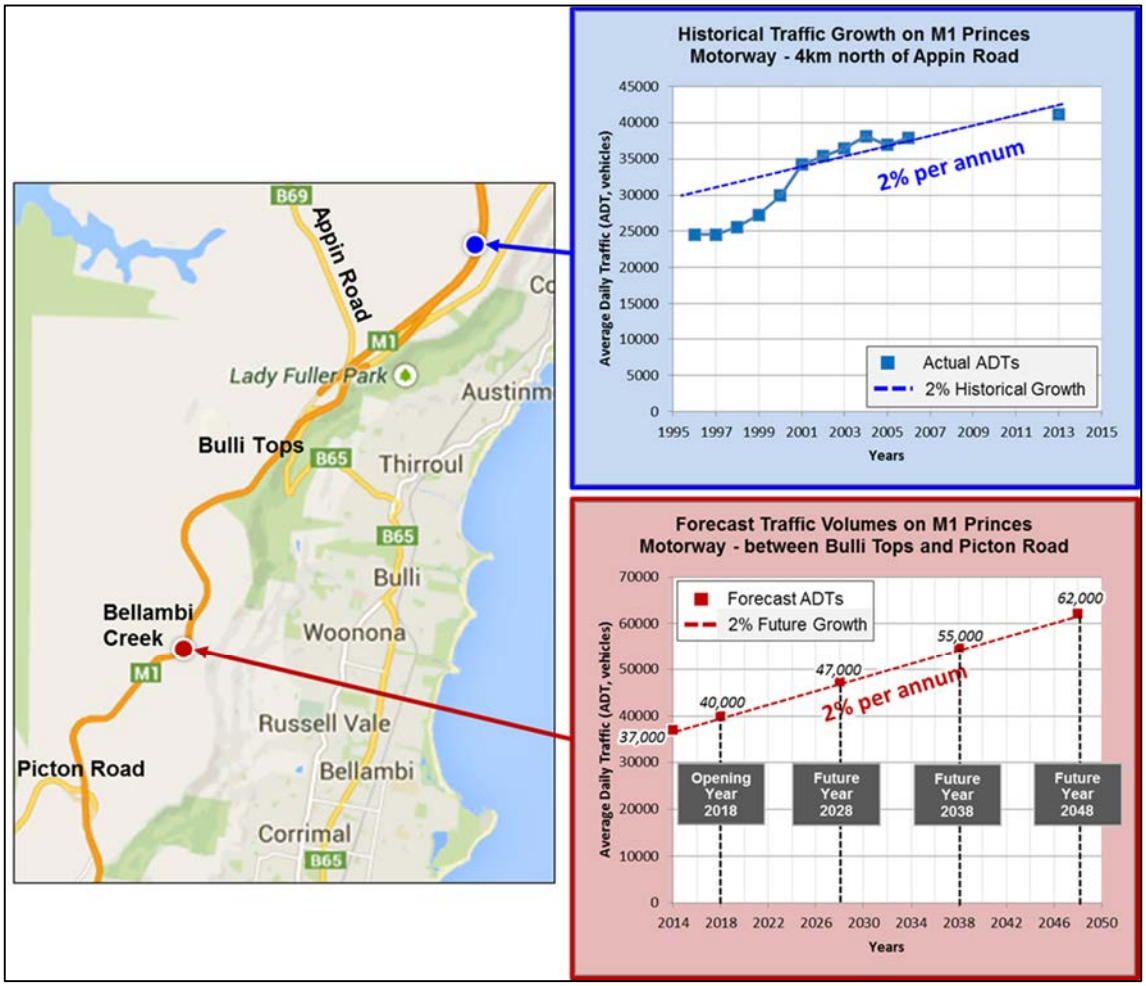


Figure 2-2 Historical Traffic Growth and Forecasts on the M1 Princes Motorway between Bulli Tops and Picton Road

2.4.2 Future Traffic Growth

The assessment assumed future traffic growth on the M1 Motorway for light and heavy vehicles separately, 2% per annum for light vehicles and 4% per annum for heavy vehicles. The growth assumption for this study was consistent with previous studies undertaken on the same route[2]. The underlying factors that would contribute the future growth:

- A projected growth of 38,000 new households in the Illawarra to 2036, primarily to the south of Wollongong (including the proposed West Dapto development), to include 17,000 new households. Whilst it could be expected that movements from this development will particularly impact local roads and the M1 together with the rail network, there will inevitably be some increase in car commuting to eastern and western Sydney along the Motorway north of Picton Road from these developments.
- Further development of the Port Kembla car import terminal. Current flows of 847,000 vehicles per annum from this terminal to, mainly, diverse locations in western and eastern Sydney are expected to rise to 1.3 million by 2036.
- Upgrading of coal infrastructure at Port Kembla such that capacity is expected to increase by about 40%. The M1 Princes Motorway is the primary route for the transport of coal by road from surrounding mines to the port.
- Expansion of the University of Wollongong, including its Innovation Campus.

In agreement with RMS, this study assumed a growth rate of 2% per annum for light vehicles and 4% per annum for heavy vehicles on the M1 section until 2038. Between 2038 and 2048, the growth is predicted to reduce to 1% per annum for light vehicles and 2% per annum for heavy vehicles. The reduced growth in the longer term (between 2038 and 2048) was adopted due to significant congestion predicted on this section of the M1 (2 lanes in each direction).

[2] *Mouth Ousley Road/Southern Freeway Traffic Modelling, Bitzios Consulting, January 2010.*

2.4.3 Traffic Forecasts

Table 2-8 below shows traffic forecasts on the M1 Princes Motorway between Bulli Tops and Picton Road for opening year 2018, 2028 (10 years after opening) and 2028 (20 years after opening). At opening year 2018, traffic on the M1 Princes Motorway is forecast in the order of 40,000 vehicles per day. In 2038 (20 years after opening), traffic on the M1 Princes Motorway is forecast in the order of 55,000 vehicles per day. In the future heavy vehicles proportions are retained in line with the current trend (i.e. 13% heavy and remaining 87% light vehicles).

Table 2-6 Traffic Forecasts on the M1 Princes Motorway between Bulli Tops and Picton Road

Traffic Forecasts	Traffic Forecast on the M1 Princes Motorway between Bulli Tops and Picton Road		
	2018 (opening year)	2028 (10 years after opening)	2038 (20 years after opening)
Forecast average daily volumes	40,000	47,000	55,000
Heavy vehicles	13% are heavy vehicles and 87% are light vehicles.		
AM peak hour volumes:			
Light vehicles	NB:1800 / SB:1200	NB:2000 / SB:1300	NB:2300 / SB:1600
Heavy vehicles	NB:140 / SB:140	NB:190 / SB:190	NB:240 / SB:240
All vehicles	NB:1900 / SB:1300	NB:2200 / SB:1500	NB:2500 / SB:1800

Source: Hyder's estimate

2.5 Traffic Performance of the Offline Upgrade

Traffic performance of the Offline upgrade was assessed for future years 2018, 2028 and 2038. Key traffic criteria used to assess the performance of the offline upgrade are:

- Motorway performance – Key objective of the Offline upgrade is to improve travel time and efficiency on the M1 Princes Motorway for both freight and commuter movements by providing additional lane capacity. This has been quantified in term of average travel times and travel speeds on the motorway in both travel directions.
- Motorway level of service – The Offline upgrade is proposed to increase reliability of the motorway and to support future traffic growth. This has been quantified in term of midblock level of service of the motorway for year 2038 (20 years after opening).

For traffic modelling purpose, the midblock level of service index has been developed based on the Highway Capacity Manual[3] and Austroads Guidelines[4]. The average travel speed is used assessing the operational performance against level of service as index. Following level service index used in the Paramics model. The level of service represents for 'all vehicles'.

Colour Code	Midblock Level of Service	Average Travel Speed (km/h)
	LoS A	More than 90 km/h
	LoS B	81 – 90 km/h
	LoS C	71 – 80 km/h
	LoS D	61 – 70 km/h
	LoS E	50 – 60 km/h
	LoS F	Less than 50 km/h

Source: Hyder's analysis

The base case represents the 'do nothing' case and includes the completion northbound acceleration lane from Bulli Pass and northbound acceleration lane from Picton Road onto the M1 Princes Motorway.

Quantitative measures are identified as being available to assist in the assessment of the performance of offline upgrade (refer to Table 2-7).

[3] Exhibit 23-2 LoS criteria for basic freeway segments, Highway Capacity Manual, 2010.

[4] Austroads Guideline to Traffic Management, Part 3: Traffic Studies and Analysis, 2009

Table 2-7 Quantitative measures against key traffic criteria

ID	Key criteria	Measures
1	Ability to improve travel time on the M1 northbound between Picton Road and Bulli Tops(1).	Measured average travel time (minute) for all vehicles.
2	Ability to improve travel time on the M1 southbound between Bulli Tops and Picton Road.	Measured average travel time (minute) for all vehicles.
3	Ability to improve northbound traffic flows on the M1 section between Bellambi Creek and Picton Road(2).	Measured average travel speed (km/h) by light and heavy vehicles.
4	Ability to improve southbound traffic flows on the M1 section between Bellambi Creek and Picton Road.	Measured average travel speed (km/h) by light and heavy vehicles.
5	Vehicle Kilometres Travelled, VKT – on t the M1 section between Bellambi Creek and Picton Road.	Vehicle Kilometres Travelled, VKT
6	Vehicle Hours Travelled, VHT - on t the M1 section between Bellambi Creek and Picton Road.	Vehicle Hours Travelled, VHT

Note:
(1) The 8.3 km section of the M1 between Picton Road and Bulli Tops.
(2) The 3.5 km upgrade section between Bellambi Creek and Picton Road.

Table 2-8 below summarises performance of Offline upgrade against key traffic criteria for AM peak traffic condition. The following points are noted from the results shown in Table 2-8 where compared with base case (do nothing):

- The Offline upgrade would improve travel time on the M1 Princes Motorway between Bulli Tops and Picton Road (measured for the entire 8.3 km section). In opening year 2018, travel time saving on the M1 is forecast up to 1 minute per vehicle (or 14%) in the northbound direction (towards Sydney). The travel time saving is forecast up to 1.3 minutes per vehicle (or 21%) in the southbound direction (towards Wollongong). In 2038 (20 years after opening), the travel time saving on the M1 is predicted up to 1.2 minutes (or 17%) in the northbound direction and about 2 minutes (or 27%) in the southbound direction.
- Model predicted substantial improvements on the M1 Princes Motorway section between Bellambi Creek and Picton Road (3.5 km) due to the proposed widening (three lanes in each direction).
- At opening year 2018, the average travel speed for light vehicles on the M1 improved by 40% from about 74-78 km/h (do nothing) to about 96-100 km/h (with offline). In 2038, model predicted travel speed improvement from about 63-72 km/h (do nothing) to 89-92 km/h (off line).

  The offline upgrade would substantially improve heavy vehicles travel speed. In 2018 model predicted speed improvement up to 30% from about 44-49 km/h (do nothing) to about 56-57 km/h (off line). In 2038 model predicted speed improvement up to 33% from about 43-48 km/h (do nothing) to about 55-57 km/h (off line).

Figure 2-3 graphically shows level of service (LoS) on the M1 for 2038 for AM peak with and without Offline upgrade. Colour codes are used to represent level of service based on travel speed changes on the motorway. The Paramics model indicated that without proposed Offline upgrade, level of service on the M1 would be low with LoS E/F (coloured in Red) for the majority of section between Bellambi Creek and Picton Road. The proposed Offline upgrade would substantially improve level of service on the M1 with LoS A/B (coloured in Green).

Table 2-8 Traffic Performance of Offline Upgrade

Offline Upgrade (Option D4)

Offline Upgrade (Option D4) involves:

- 'Offline' road upgrade and realignment of the M1 Princes Motorway (formerly Mount Ousley Road) between Picton Road interchange and Bellambi Creek.
- Widening of the M1 Princes Motorway between Picton Road interchange and Bellambi Creek from current two (2/2) to three (3/3) lanes in each direction.

Source: RMS's Plan – MR513 Mount Ousley Road – Option D4 – 10/07/2014

Traffic Performance

Table 1 Future Traffic Forecasts on the M1 Princes Motorway between Bulli Tops and Picton Road

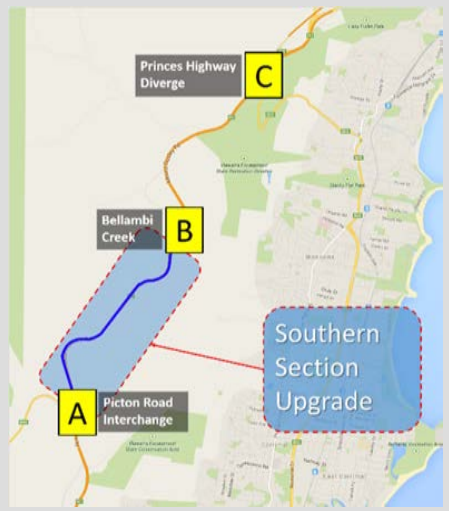
Traffic Forecast	2014[1] (Base Year)			2018 (Opening Year)			2028 (10 years after opening)			2038 (20 years after opening)		
	Light Vehicles	Heavy Vehicle	All Vehicles	Light Vehicles	Heavy Vehicle	All Vehicles	Light Vehicles	Heavy Vehicle	All Vehicles	Light Vehicles	Heavy Vehicle	All Vehicles
Forecast Average Daily Volumes	37,000 vehicles per day			40,000 vehicles per day			47,000 vehicles per day			55,000 vehicles per day		
Heavy Vehicles	13% are heavy vehicles and 87% are light vehicles.			Heavy vehicle proportions are maintained in all future years (ie.13% HV).								
Forecast AM Peak Hour Volumes	2,700	240	2,900	3,000	280	3,200	3,300	380	3,700	3,900	480	4,300
	NB:1700 / SB:1000	NB:120 / SB:120	NB:1800 / SB:1100	NB:1800 / SB:1200	NB:140 / SB:140	NB:1900 / SB:1300	NB:2000 / SB:1300	NB:190 / SB:190	NB:2200 / SB:1500	NB:2300 / SB:1600	NB:240 / SB:240	NB:2500 / SB:1800
Traffic Growth	The 1996 to 2013 historical traffic data on M1 Princes Motorway (4km north of Appin Road) shows an average growth of 2% per annum.			The historical growth trend of 2% per annum are used for future years traffic volumes on M1 section between Bulli Tops and Picton Road (refer to traffic growth figure prepared for M1 section)								

Table 2 Traffic Performance of Offline Upgrade (Option D4) in AM Peak

Traffic Criteria	Vehicle Type	2018 (Opening Year)			2028 (10 years after opening)			2038 (20 years after opening)		
		Base Case[2]	Option D4[3]	Improvement by Option D4 (%)	Base Case[2]	Option D4[3]	Improvement by Option D4 (%)	Base Case[2]	Option D4[3]	Improvement by Option D4 (%)
1. Ability to improve travel time on the M1 northbound between Picton Road and Bulli Tops (A to C). 2. Measured average travel time (minute)[4]:	All vehicles	6.2 mins	5.3 mins	0.9 mins (-14%) ▼	6.7 mins	5.7 mins	1.0 mins (-15%) ▼	7.1 mins	5.9 mins	1.2 mins (-17%) ▼
3. Ability to improve travel time on the M1 southbound between Bulli Tops and Picton Road (C to A). 4. Measured average travel time (minute)[5]	All vehicles	6.3 mins	5.0 mins	1.3 mins (-21%) ▼	6.9 mins	5.2 mins	1.7 mins (-24%) ▼	7.4 mins	5.4 mins	2.0 mins (-27%) ▼
5. Ability to improve northbound traffic flows on the M1 between Picton Road and Bellambi Creek (A to B). 6. Measured average travel speed (km/h)[6]	Light vehicle	78 km/h	100 km/h	22 km/h (+28%) ▲	73 km/h	95 km/h	22 km/h (+30%) ▲	72 km/h	92 km/h	20 km/h (+28%) ▲
	Heavy vehicle	49 km/h	56 km/h	7 km/h (+14%) ▲	48 km/h	56 km/h	8 km/h (+14%) ▲	48 km/h	55 km/h	7 km/h (+15%) ▲
7. Ability to improve southbound traffic flows on the M1 between Bellambi Creek and Picton Road (B to A). 8. Measured average travel speed (km/h)[7]	Light vehicle	74 km/h	96 km/h	22km/h (+30%) ▲	68 km/h	93 km/h	25 km/h (+37%) ▲	63 km/h	89 km/h	26 km/h (+41%) ▲
	Heavy vehicle	44 km/h	57 km/h	13 km/h (+30%) ▲	43 km/h	57 km/h	14 km/h (+33%) ▲	43 km/h	57 km/h	14 km/h (+33%) ▲
9. Vehicle Kilometres Travelled, VKT – section between Bellambi Creek and Picton (A to B).	All vehicles[8]	10703	10,413	3% ▼	12,633	12,282	3% ▼	14,321	13,916	3% ▼
10. Vehicle Hours Travelled, VHT - section between Bellambi Creek and Picton (A to B).	All vehicles[8]	157	116	26% ▼	199	144	28% ▼	240	168	30% ▼

Note:

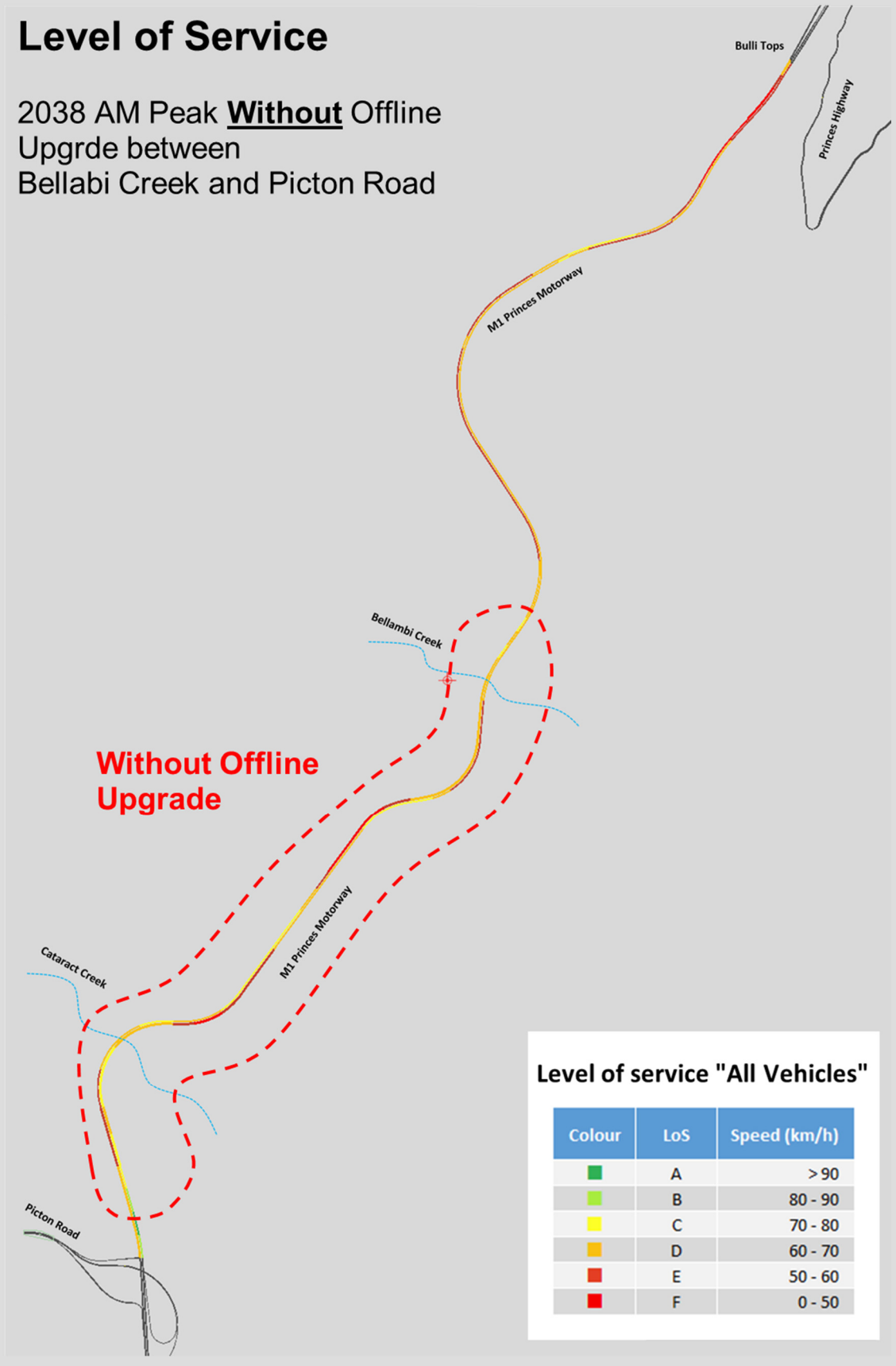
1. The 2014 traffic volume is estimated from Paramics traffic model.
2. Base Case means forecast traffic conditions in 2018, 2028 and 2038. Base Case network assumes a northbound acceleration lane from Picton Road onto the M1 (Lane 1) is completed.
3. Offline Upgrade is sourced from RMS's MR513 Mount Ousley Road – Option D4 – 10/07/2014
4. Average travel time on M1 northbound between Picton Road and Bulli Tops (A to C). The section length is about 8.3 km.
5. Average travel time on M1 southbound between Bulli Tops and Picton Road (C to A). The section length is about 8.3 km.
6. Average speed on M1 northbound between Picton Road and Bellambi Creek (A to B). The section length is about 4 km.
7. Average speed on M1 southbound between Bellambi Creek and Picton Road (B to A). The section length is about 4 km.
8. VKT and VHT values have been estimated and normalised for the Option D4 upgrade section (A to B). The Offline scheme (Option D4) proposes alignment changes on the M1 between Bellambi Creek and Picton Road which results in vehicle kilometres travelled saving.
9. Number of stops is not relevant for this study area.



*** Relative performance compared to Base Case**

	Improvement
	Slight Improvement
	No Change / Minor Change
	Slightly Worse
	Worse

Forecast Level of Service for 2038 AM Peak without the Offline Upgrade	Forecast Level of Service for 2038 AM Peak with Offline Upgrade



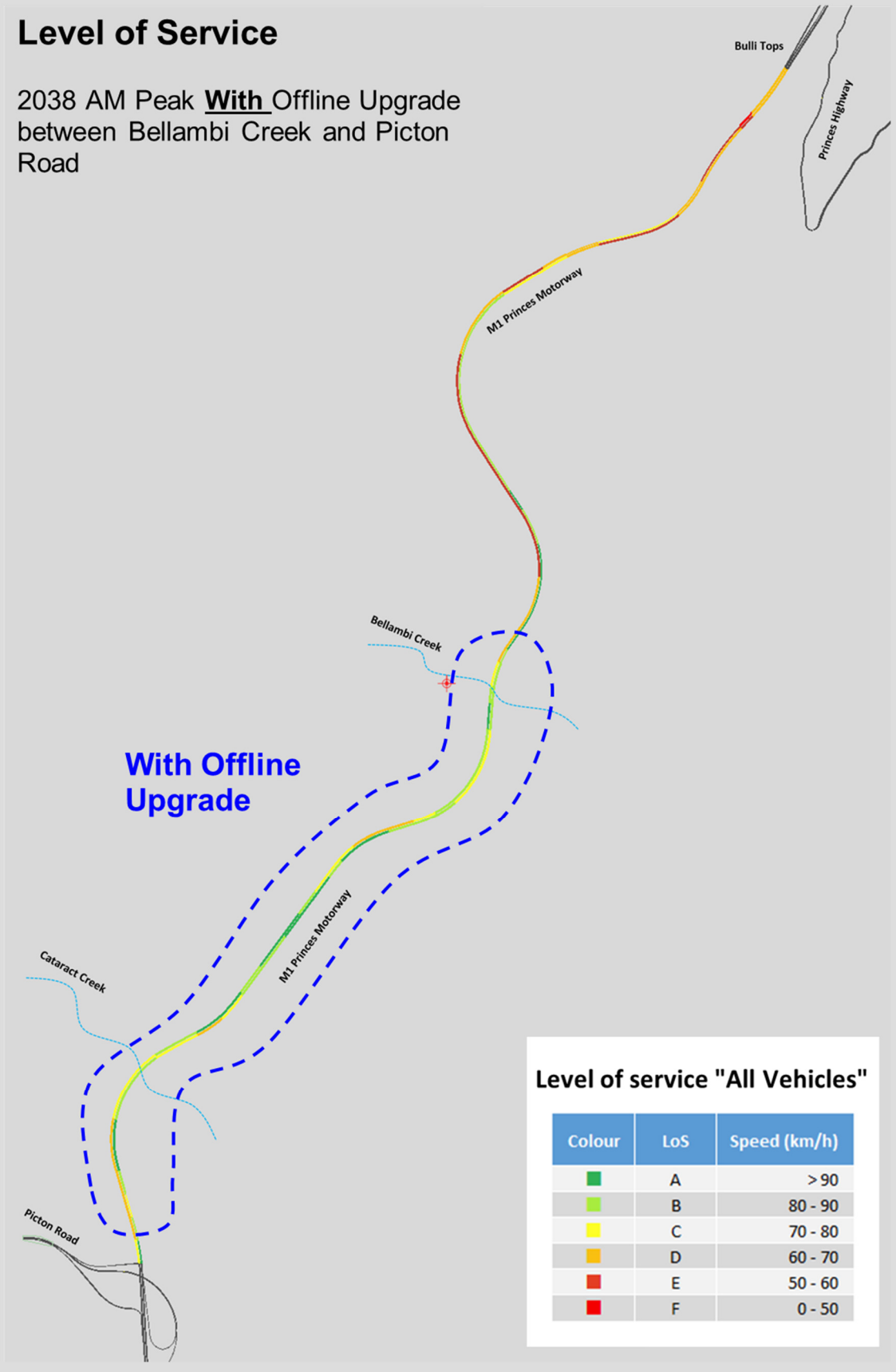


Figure 2-3 Forecast Level of Service for 2038 AM Peak with and without Offline Upgrade

2.6 Traffic Input to Economic Appraisals

The vehicle kilometres travelled (VKT) and vehicle hours travelled (VHT) for do nothing and offline line upgrade were used in the economic benefits of the M1 Offline upgrade. The numbers of stops data were not relevant for this motorway upgrade. The peak hour traffic forecasts formed the basis of vehicle operating costs and road user travel times attributable to Offline upgrade. The Paramics model produced peak period weekday traffic forecasts for year 2014, 2018 (at opening), 2028 (10 years after opening), 2038 (20 years after opening) and 2048 (30 years after opening). The Paramics models represented the AM peak (7:00 to 9:00 am) traffic conditions for the study area network. One hour warm up and one hour cool down period was used in Paramics. The decision of the model time period was based on the heavy vehicles which has the greatest impact on the M1 capacity within the study area network. The 2014 counts suggested higher proportion of heavy vehicles on the M1 in the morning peak than afternoon peak. In the morning peak, heavy vehicles proportion was found 8%-9% of total traffic compared to afternoon peak which was 4%-5% of total traffic. The AM peak period modelling results therefore formed the basis of the economic appraisals.

The TfNSW Guidelines for a rural road indicates an annual expansion factor of 3773 (1 hour peak to annual) and used for this Offline upgrade. Table 2-9 below shows traffic forecasts from Paramics for 2018, 2028, 2038 and 2048, in terms of the annual vehicle kilometres travelled (distance) and vehicle hours travelled (hours) incremental to the base case. The positive values represent less vehicle kilometres travelled (distance) or vehicle hours travelled (hours) in the offline upgrade (i.e. saving attributable to the offline upgrade).

Table 2-9 Annual Network Statistics of Offline Upgrade (Incremental VKT and VHT to Base Case, reported in '000)

	2018 (at opening)	2028 (10 years)	2038 (20 years)	2048 (30 years)
Offline Upgrade (Incremental to Base Case)				
Vehicle kilometres travelled (VKT)	1,141	1,018	1,780	1,671
Vehicle hours travelled (VHT)	157	206	269	332

Note: Number of stops was not relevant for Motorway upgrade.
Source: Hyder analysis, F:\AA007521\D-Calculations\BCR Analysis\ BCRAssessment_Offline Option_RevG.xls

3 Economic Appraisal Methodology

This economic appraisal has been carried out in accordance with the NSW Government guidelines. These guidelines are provided by the *Transport for NSW Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives, March 2013,* hereinafter referred to in this report as TfNSW Guidelines*.* This section of the report presents the appraisal framework and key assumptions that form the economic appraisal.

3.1 Appraisal Framework

The economic appraisal framework used to appraise the economic viability and based on the generalised road user cost benefit analysis methodology. The methodology appraises the options on an incremental basis by comparing the Offline upgrade to a 'base case'. The base case defined for evaluation was effectively a 'do nothing' option.

The appraisal is undertaken in the context of the following parameters:

- Capital costs;
- Project maintenance costs;
- Vehicle operating costs;
- Road user travel time costs;
- Crash costs; and
- External Cost.

The measures of economic performance include:

- Net present value (NPV) – the difference between the present value (PV) of total incremental benefits and the present value of the total incremental costs.

  The upgrade options that yield a positive Net Present Value (NPV>0) indicate the benefits exceed the costs over the evaluation period and the proposed option is considered economic. The proposed option with the highest modelled NPV is considered the most economic.

- Benefit Cost Ratio (BCR) – ratio of the PV of total incremental benefits over the PV of total incremental costs.

  The BCR is the most commonly used evaluation criteria. The BCR measures the return received per dollar of costs. The upgrade options with a Benefit Cost Ratio greater than 1 would be considered economically viable.

- First Year Rate of Return (FYRR) – measure of the PV of benefits achieved in the first full year of a project's operation divided by the PV of capital costs to achieve this.

  A First Year Rate of Return below the discount rate indicates implementation of the scheme can be deferred until it either equals or exceeds the discount rate.

- Net Present Value per Dollar of Investment (NPVI) – measure with the highest modelled NPVI being the most economically viable option as the return on a dollar of investment calculated by dividing the net present value by the present value of investment. The upgrade options with a positive NPVI (NPVI>0) would be considered economically viable.

The BCR and NPVI measures provide an indicative scale in which to compare the relative attractiveness of the different strategic design options where the level of expenditure varies between options. Each performance measure has its limitations in the interpretation of the

economic viability. The TfNSW Guidelines suggest a range of economic performance measures be considered to appraise a project.

3.2 Economic Parameters

The key parameters used in this economic appraisal are as follows:

- Discount Rate

Future net benefits are discounted to the base year using a real discount rate of 7%. The appraisal also undertakes sensitivity tests at the discount rates of 4% and 10%.

- Price Year

All costs and benefits in the evaluation are presented in 2014 prices. Appendix 4 of the TfNSW Guidelines, *Appendix 4 Economic Parameters Values and Valuation Methodologies, November 2013* present parameter values in 2012/13 dollars. The appraisal assumes the parameter values presented in Appendix 4.

- Evaluation Period

The evaluation period starts from conclusion of construction and ends on a 30 year horizon after opening to traffic. This is in line with the Guidelines on standard practice for project evaluation which require that projects are evaluated over a 30 year period from the first year of full operation of the upgrade option.

The construction and development period for the offline scheme is four (4) years from 2014 to 2017, and full scheme operation commencement is assumed to be year 2018.

3.3 Description of Appraisal Upgrade Option

This section appraises the economic viability of the offline upgrade on the M1 Princes Motorway with a “do nothing” base case.

Base Case

- The Base Case – “do nothing” base case represents the existing traffic network within the study area as of 2014. The base case assumes no capital costs for upgrading the section of the M1 Princes Motorway between Bellambi Creek and Picton Road.
- The Base Case network includes recently completed northbound overtaking lane to the north of Bulli Tops and a northbound acceleration lane from Picton Road onto the M1.

Offline Upgrade

The Offline upgrade involves road widening and realignment of 3.5 kilometres of the M1 Princes Motorway between Bellambi Creek and Picton Road. The upgrade would provide a six-lane divided motorway (three lanes in each direction) with median separation.

4 Costs and Benefits

This section defines the economic costs and benefits that are contained in the analysis, and presents the cost and benefits profile of the Offline upgrade.

4.1 Economic Costs

4.1.1 Capital Costs

The capital cost of the Base Case is zero as it is a “do-nothing” case.

The capital cost of the project is estimated in 2014 dollars. The capital costs account for the following items:

- Cost comparison;
- Project Development;
- Investigation and Design;
- Property Acquisitions;
- Construction; and
- Finalisation.

The costs estimates are at a strategic stage (P90) and provided by the RMS. They include an average contingency allowance up to 62%.

The estimated cost for completion of the offline scheme is $76M in 2014 dollars ($86.7M out-turn costs)[5] with the proposed timing and breakdown shown in Table 4-1.

Table 4-1 Capital Expenditure ($000)

Offline Scheme	2014	2015	2016	2017	Total
Current cost	$4,145	$6,045	$57,000	$8,810	$76,000
Out-turn cost	$4,145	$6,469	$65,259	$10,792	$86,700

Source: RMS, F:\AA007308\Data as received\20141016_Strategic Cost Estimates

[5] The out-turn value is equivalent to current costs inflated to future years when expenditure is expected to occur.

4.1.2 Maintenance Costs

The maintenance costs are estimated using unit maintenance rates for works associated with existing and new pavements. Table 4-2 shows the assumed maintenance unit rates applied. The unit rates were provided by the RMS.

Table 4-2 Maintenance Unit Rates

Maintenance Work Item	Routine Frequency	Unit Rate
Existing Pavement		
Flush reseal	Every 5 years	$7.31 per m^2
Rehabilitation	Every 10 years	$73 per m^2
New Pavement		
AC re-sheet	Every 10 years	$27.50 per m^2
Rehabilitation	Every 20 years	$94.00 per m^2

Source: RMS, F:\AA007308\Data as received\20141103_Pavement Areas for BCR

RMS provided pavement areas associated with base case and the Offline upgrade. The Offline upgrade comprised of existing pavement areas retained from the current pavement and new pavement areas constructed as part of the upgrade for inclusion in calculating maintenance costs. Table 4-3 summarises the pavement areas included in the analysis.

Table 4-3 Pavement Areas for Maintenance (m^2)

	Base case	Offline Upgrade
Existing Pavement	84,473	
Existing Pavement to be Retained with Upgrade		29,982
New Pavement		72394

Source: RMS, F:\AA007308\Data as received\2014-07-16_Cost Estimates

Maintenance costs were calculated for the base case and for the Offline upgrade scheme. The net maintenance costs are the difference between the base case maintenance cost and the offline upgrade scheme maintenance cost. A positive net maintenance cost reflects savings in maintenance costs while a negative net maintenance cost indicates an increase in maintenance costs over base case.

4.1.3 Vehicle Operating Costs per kilometre travelled

The vehicle operating cost (VOC) parameters used in the analysis was sourced from the *TfNSW Guidelines. Appendix 4, Table 16* reported VOC by vehicle type, and proportion of vehicle fleet. Based on the vehicle compositions, the weighted VOC per kilometre travelled was found approximately $0.68/VKT (vehicle km travelled).

4.1.4 Travel Time Costs

This entails the estimation of travel time costs based on the hourly value of travel time (VOTT) multiplied by the vehicle hours travelled for base case and the Offline upgrade. The hourly value of travel time was sourced from the *TfNSW Guidelines. Appendix 4, Table 9* reported VOTT by vehicle type, proportion of vehicle fleet, occupancy. The value for travel time for heavy vehicles is also considered in the assessment.

The VOTT used in this analysis reflects value of travel time for a non-urban (rural) condition of the project. This takes into account the impact of higher speed limits and speeds of travel generally observed in non-urban conditions.

A weighted average value of travel time was calculated using of observed composition of vehicle fleet on the M1 Princes Highway section between Picton Road and Bulli Tops. The resulting average VOTT used for the analysis is presented in Table 4-4.

Table 4-4 Weighted Average VOTT ($/VHT)

Vehicle Type	% Vehicle[1]	$/VHT
Light vehicle (Car and LCV)	87.0%	$33.17[2]
Heavy vehicle (HCV)	13.0%	$47.93[2]
Overall average		$35.18

Source:

(1) Vehicle composition based Mount Ousley Road/Southern Freeway Traffic Modelling Final Report, Bitzios Consulting, January 2010, page 8.

(2) TfNSW Guidelines, Appendix 4, Table 15

4.1.5 Crash Costs

One of the key objectives of the Offline upgrade is to improve road safety on the motorway. Analysis of crashes that have recently occurred on the Princes Motorway between Bellambi Creek and Picton Road is provided in the previous Section 2.3.3.

The proposed upgrade is expected to substantially improve road safety along and adjacent to the study area. Crash analysis has been undertaken by comparing existing and proposed conditions to determine estimated crash reduction statistics based on historical data between 1 August 2008 and 31 October 2013, using the RMS's Crash Reduction Guide, August 2005. Average crash costs by accident type are based on 'willingness to pay' approach sourced from TfNSW's Principles and Guideline for Economic Appraisal of Transport Investment and Investigation, March 2013.

The analysis assumed the following road safety improvements are implemented on the Princes Motorway between Bellambi Creek and Picton Road:

- Improved road alignment; and
- Additional lanes.

An improvement in road safety is estimated using RMS's *Crash Reduction Guide*, which includes typical percentage reductions in crashes by definitions for coding accidents (DCA) codes based on proposed midblock treatments. The existing crash data in the study area was analysed to determine if any crashes could have been prevented, or consequences minimised as a result of the construction of the proposed Offline upgrade.

The results presented in Table 4-5 indicate that total crashes on the Princes Motorway between Bellambi Creek and Picton Road would be reduced by 74% under the upgraded condition.

Table 4-6 shows that annual crash rate would reduce from 22.5 existing to 5.8 under upgrade condition with potential to eliminate all fatal crashes. The crashes per 100 million vehicle kilometres also experience a large reduction, falling from 31 to 8.

The annual cost of crashes under the new road alignment is estimated as $0.26 million, which is saving of $4.19 million per year or $0.79 million per kilometre based on 2012/13 willingness to pay rates.

Detailed crash reduction analysis is documented in **Appendix A**.

Table 4-5 Existing and Proposed Crash Statistics Based on Estimated Safety Improve

Scenario	Length (km)	Crash by Collision Type / DCA Code [2]											
		Rear end	Lane change	Hit parked vehicle	Pedestrian, crossing carriageway	Permanent obstruction on carriageway	Hit animal	Off carriageway, hit object	Out of control on straight	Off carriageway, on curve	Off carriageway, hit object	Out of control on curve	Total
		301-303	305-307	601	001-008; 901-902	605	609	703-704	705; 502	801; 802	803-804	805	
(1) Existing conditions (without Offline Upgrade)	5.31	22	11	4	2	4	4	7	9	5	43	1	112
(2) Proposed conditions (with Offline upgrade)	5.15	6	2	0	0	0	2	2	3	0	14	0	29
Change in Conditions	-0.16▼	-16▼	-9▼	-4▼	-2▼	-4▼	-2▼	-5▼	-6▼	-5▼	-29▼	-1▼	-83▼
Change in Conditions %	-3%▼	-73%▼	-82%▼	-100%▼	-100%▼	-100%▼	-50%▼	-71%▼	-67%▼	-100%▼	-67%▼	-100%▼	-74%▼

Note:
(1) RMS crash data recorded between 1 August 2009 and October 2013
(2) Potential crash reduction rates were estimated using the RMS' Accident Reduction Guide, August 2005.

Table 4-6 Existing and Proposed Crash Statistics Based on Estimated Safety Improve, Annual Average

Scenario	Length (km)	Total Crashes	Number of Crashes by Severity			Total Crash Per 100 MVKM [3]	Crash Severity Index [4]	Crash Cost per Year ($M)	
			Fatal Crashes	Injury Crashes	Non-injury Crashes			Total Cost [5]	Cost per Km
(1) Existing conditions (without Offline Upgrade)	5.31	22.4	0.4	5.4	16.6	31	1.16	4.45	0.84
(2) Proposed conditions (with Offline upgrade)	5.15	5.8	0	1.0	4.8	8	1.09	0.26	0.05
Change in Conditions	-0.16▼	-16.6▼	-0.4▼	-4.4▼	-11.8▼	-23▼	-0.07▼	-4.19▼	-0.79▼
Change in Conditions (%)	-3%▼	-74%▼	-100%▼	-81%▼	-71%▼	-74%▼	-6%▼	-94%▼	-94%▼

Note:
(1) RMS crash data recorded between 1 August 2009 and October 2013
(2) Potential crash reduction rates were estimated using the RMS' Accident Reduction Guide, August 2005.
(3) Crash rate per 100 MVKM = (total crashes x 100,000,000) / (no. of years x 365 x length (km) x AADT).
(4) Crash severity index = [(fatal crashes x 3.0)+(injury crashes x 1.5)+(non-injury crashes)]/total crashes.
(5) Costs per crash sourced from Table 45 (Page 257) of TfNSW's Principles and Guideline of Economic Appraisal of Transport Investment and Investigation, March 2013.

4.1.6 External Costs

Road use produces external costs on society in terms of the economic costs of environmental impacts. Environmental costs are determined by applying externality values per VKT based on vehicle composition form the traffic analysis.

The TfNSW Guidelines, Appendix 4, Tables 52 and 53 provides parameter values for environmental externality costs in urban and rural areas. These parameter values include:

- Noise pollution;
- Air pollution;
- Water pollution;
- Greenhouse gas emissions;
- Nature and landscape;
- Urban separation; and
- Upstream and downstream.

Light Vehicles

Environmental unit costs for passenger vehicles are expressed in cents per VKT. The unit costs are directly applied to the change in VKT to estimate the change in environmental costs. The average external costs per VKT used primarily for light vehicles in the analysis are summarised in Table 4-7.

Table 4-7 Environmental Externality Costs

Environmental Externality	Passenger Car	Light goods vehicle		Total light vehicles	Heavy vehicles	
	($/km)[1]	$/1000 tonne-km[1]	$/km[2]	($/km[3]	$/1,000 tonne-km[1]	$/km[4]
Noise pollution	$0.00	$0.00	$0.00	$0.00	$0.42	$0.01
Air pollution	$0.00	$0.00	$0.00	$0.00	$0.25	$0.01
Water pollution	$0.00	$0.28	$0.00	$0.00	$1.49	$0.04
Greenhouse gas emissions	$0.02	$57.88	$0.02	$0.02	$5.51	$0.15
Nature and landscape	$0.01	$0.21	$0.00	$0.01	$4.14	$0.11
Urban separation	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Upstream and downstream	$0.04	$192.91	$0.08	$0.05	$22.05	$0.61
Total	$0.07	$251.28	$0.10	$0.08	$33.86	$0.94

Source: TfNSW Guidelines Table 52 and Table 53.

(1) TfNSW Guidelines, Table 52

(2) Based on average load carried of 389 kg for light commercial vehicles (ABS Survey of Motor Vehicle Usage 2012, Table 16)

(3) Weighted average of cars and light commercial vehicles using the percentage composition in Table 5-4

(4) 4 Based on an average load carried of 27.7 tonnes for heavy vehicles (ABS Survey of Motor Vehicle Usage 2012, Table 16)

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In order to convert the environmental cost parameters into annual environmental costs, the passenger vehicle costs per VKT are applied to the annual VKT.

Heavy Vehicles

For heavy vehicles the environmental unit costs are expressed in dollars per 1000 tonne kilometre (tkm) travelled. The tkm unit costs are converted to dollars per VKT using NSW average tonne kilometres and average VKT for the two truck types taken from the latest Australian Bureau of Statistics "Survey of Motor Vehicle Use".

4.2 Economic Benefits

The benefits of the Offline upgrade related to savings in road user costs due to the reduction in vehicle hours and vehicle kilometres compared with the base case, as well as the residual value of assets remaining at the end of the analysis period. The benefits include:

- Road User cost savings:
  - Savings in vehicle operating costs;
  - Savings in travel time costs; and
  - Savings in crash costs
- Residual Value of Assets

In order to quantify the savings, a comparison is made for each parameter relative to base case and unit cost values are applied.

4.2.1 Vehicle Operating Costs Savings

The unit VOC is applied to the VKTs in base case and the Offline upgrade to calculate the incremental VOC for VKT for the analysis period. The savings in vehicle operating costs for the Offline upgrade are estimated by combining the incremental (relative to the base case) vehicle kilometres (VKTs) with the unit vehicle operating costs.

4.2.2 Travel Time Costs Savings

The difference in the travel time from the traffic forecasts are used to estimate savings in travel time cost for the Offline upgrade relative to base case.

4.2.3 Crash Cost Savings

Appendix C of the *RMS Accident Reduction Guide, August 2005,* provides a standard list of treatments for a particular crash type and suggests a percentage reduction in accidents for intersection and mid-block treatments for low speed and high speed environments. The Guide notes that the accident reduction parameters have been derived by consideration of before and after studies conducted both in Australia and overseas. Where information was not available for a particular treatment, the assessment of benefits has been derived by an assessment of the likely impact of the treatment on risk at the site. It is also noted that the assumed reduction parameters do not specifically account for combinations of treatments at a site.

The crash types were derived from the crash data and a target reduction factor was assigned for each crash type using the accident reduction factors provided in *Appendix C of the RMS Guide*. Crash costs were calculated for base case and the Offline upgrade using the *TfNSW Guidelines, Appendix 4, Table 9*. The difference in the annual crash costs of base case minus the Offline upgrade reflects the estimated crash cost savings (safety benefits).

4.2.4 Externality Cost Savings

The savings in externality costs will accrue as a result of a decrease in VKT from base case and the Offline upgrade. Externality costs are calculated by applying the externality unit costs on the VKT and the differential with the improved case is used to estimate savings in externality costs.

4.2.5 Residual Values

The economic appraisal includes the residual values of the road assets. The residual value reflects that fact that some infrastructure assets may have economic lives which extend beyond the evaluation period. Residual values are entered in the last year of the evaluation period to represent the unused portion of the asset that has lives greater than the evaluation period. The assumed economic life of the asset was sourced from *TfNSW Guidelines, Appendix 4, Table 66.* For this analysis, the road pavement asset was assumed to have an economic life of 60 years.

4.3 Summary of Benefits and Costs

Table 4-7 below provides a summary of the costs and benefits for the Offline upgrade in a similar format required by the Strategic Business Case.

Table 4-7 Discounted Costs and Benefits by Offline Upgrade ($M)

	Cost Comparison (in 2014 constant dollars, $million unless otherwise indicated)	
	Base Case	**Offline Upgrade**
Project Development		$0.93
Investigation and Design		$2.23
Property Acquisitions		$0.86
Utility Adjustments		$7.46
Construction		$63.02
Finalisation		$1.50
Total Project Development Costs [1]		$76.00
Ongoing **Operating** Costs (Borne by users, over 30 years, discounted @ 7%)		n/a
Ongoing **Maintenance** Costs (Borne by RMS, over 30 years, discounted @ 7%) ***[Net Maintenance Costs]***	$4.82	$4.02
Total Ongoing Costs (Discounted at 7% over 30 years) [PV of Costs]	$4.82	$4.02
Total **Cost** [2] (Discounted at 7% over 30 years) [PV of Costs]		$71.82
Total Financial Benefits		n/a
Total User and Non-User **Benefits** ***[PV of Benefits]***		$121.34
Total Benefits [3]		$121.34

[1] Total asset related costs (purchase and/or building of asset/solution) plus other project costs to be included in the Capital Budget

[2] Total of above amounts

[3] Difference between all economic costs in the improved case and in the base case

Source: Roads and Maritime Data / Hyder Economic Analysis *(F:\AA007521\D-Calculations\BCR%20Analysis\BCRAssessment_Offline%20Option_RevG.xls)*

Table 4-8 below provides a summary of the discounted benefits by road users for the offline upgrade assessed.

Table 4-8 Benefits Breakdown for Offline Upgrade ($million)

Discounted Benefits	Offline Scheme	Percent to Total Savings
Savings in Travel Time	$69.76	57%
Savings in Vehicle Operating Costs	$5.33	4%
Savings in Crash Costs	$39.63	33%
Externality Costs Savings	$2.27	2%
Residual Value	$4.34	4%
Total PV of Benefits	**$121.34**	**100%**

Source: Hyder Economic Analysis
(F:\AA007521\D-Calculations\BCR%20Analysis\BCRAssessment_Offline%20Option_RevG.xls)

The results from Table 4-8 indicates that offline upgrade will provide significant road user benefit. The analysis has identified travel time savings up to 57% of total benefit. The safety benefit comprised about 33% of total benefit.

Detailed discounted benefits and costs of Offline upgrade (incremental to base case) are included in **Appendix B.**

5 Evaluation Results

The economic appraisal results are presented in terms of three decision criteria as follows:

- Net present value (NPV);
- Benefit Cost Ratio (BCR); and
- Net Present Value per Dollar of Investment (NPVI).

The first year rate of return (FYRR), internal rate of return (IRR) are also presented for the Offline upgrade. The results of the economic appraisal for the Offline upgrade is summarised in Table 5-1.

Table 5-1 Summary of Economic Appraisal for the Offline Upgrade (7% discount rate)

	Offline Upgrade
PV Cost ($M)	$71.82
PV Benefit ($M)	$121.34
NPV ($M)	$49.52
BCR	1.7
NPVI	0.7
FYRR	10.4%
IRR	11.8%

Source: Hyder Economic Analysis
(F:\AA007521\D-Calculations\BCR%20Analysis\BCRAssessment_Offline%20Option_RevG.xls)

The results from Table 5-1 show that:

- The road user benefit for proposed upgrade would exceed the capital cost, therefore the proposed offline upgrade is economically viable.
- The BCR for the offline upgrade was found 1.7.
- The total road user benefit would be $121.3 million with a capital cost of $71.8 million. The NPV of the proposed upgrade was found to be $49.5 million.

Detailed economic appraisal results are included in **Appendix B**.

5.1 Sensitivity Analyses

Sensitivity analyse was undertaken as part of the economic appraisal. The economic analysis tests sensitivity of the results on discount rates and on estimation of costs and benefits.

5.1.1 Sensitivity on Discount Rates

The sensitivity analysis was undertaken for 4% and 10% discount rates. The results of the sensitivity analysis on discount rates are shown in Table 5-2.

Table 5-2 Sensitivity Analyses Results (On Discount Rates)

Discount Rate		Offline Upgrade
4%	NPV ($M)	$121.89
	BCR	2.6
	NPVI	1.6
	FYRR	11.0%
10%	NPV ($M)	$12.97
	BCR	1.2
	NPVI	0.2
	FYRR	9.8%

Source: Hyder Economic Analysis
(F:\AA007521\D-Calculations\BCR%20Analysis\BCRAssessment_Offline%20Option_RevG.xls)

5.1.2 Sensitivity on Costs and Benefits

The results of the sensitivity analyses on the estimation of costs and benefits are provided in Table 5-3. The tables provide the resulting economic parameters for a +/- 20% deviation on the cost estimates and the benefits streams, as well as the effect of a delayed delivery by one year.

Table 5-3 Sensitivity Analyses (On Estimation of Costs and Benefits)

Offline Upgrade	BCR	NPV ($M)	IRR	NPVI
Cost Estimate +20%	1.4	$37	10.1%	0.4
Cost Estimate -20%	2.2	$65	14.5%	1.2
Benefits +20%	2.1	$76	14.1%	1.1
Benefits – 20%	1.4	$27	9.8%	0.4
Delay in delivery by one year	1.7	$48	12.0%	0.7

Source: Hyder Economic Analysis
(F:\AA007521\D-Calculations\BCR%20Analysis\BCRAssessment_Offline%20Option_RevG.xls)

6 Summary of Findings

Overview

The M1 Princes Motorway is a key strategic corridor and the only B-Double-capable route, linking Sydney with the Illawarra region and NSW South Coast. The section from south of Picton Road to Bulli Tops is currently constrained to two lanes in each direction. Adjoining sections of the M1 Princes Motorway are mostly configured with three lanes in each direction. The constrained road space in the section of the road, together with the undulating topography generates the need for vehicle weaving between slow, heavily-laden freight vehicles and unladen heavy vehicles and lighter passenger vehicles on that section of the M1 Princes Motorway.

Roads and Maritime (Roads and Maritime Services, RMS) has developed a strategic concept design for an 'offline' road upgrade and realignment of the M1 Princes Motorway southern section between Bellambi Creek and Picton Road ('Offline upgrade') to provide greater traffic efficiency and safety.

The purpose of this Study is two-folds:

- Undertake traffic modelling of the M1 Princes Motorway Offline upgrade option between Bellambi Creek and Picton Road. The modelling has been undertaken using micro-simulation Paramics software.
- Undertake economic merit of the Offline upgrade option. This involves estimating the net economic benefit, benefit cost ratio (BCR) and net present value (NPV) of the Offline upgrade option.

Traffic Growth

In agreement with RMS, the assessment assumed traffic growth of 2% per annum for light vehicles and 4% per annum for heavy vehicles on this M1 section until 2038. Between 2038 and 2048, the growth is predicted to reduce to 1% per annum for light vehicles and 2% per annum for heavy vehicles. The reduced growth in the longer term (between 2038 and 2048) was adopted due to significant congestion predicted on this section (2/2) of the M1 Princes Motorway.

Traffic Volumes on the M1 Princes Motorway

In 2014 M1 Princes Motorway, between Bulli Tops and Picton Road carried about 37,000 vehicles per day. The heavy vehicles proportion was about 13% of the total traffic. At opening year 2018, traffic on the M1 Princes Motorway is forecast in the order of 40,000 vehicles per day. In 2038 (20 years after opening), traffic on the M1 Princes Motorway is forecast in the order of 55,000 vehicles per day. In the future heavy vehicles proportions are retained in line with the current trend (i.e. 13% heavy vehicles and remaining 87% light vehicles).

Offline Upgrade

The Offline upgrade involves road widening (3 lanes in each direction) and realignment of a 3.5 kilometres of the M1 Princes Motorway between Bellambi Creek and Picton Road. Figure 1-1 in this report shows an indicative Offline upgrade on the M1 Princes Motorway.

Performance of Offline Upgrade

For the purpose of traffic assessment, 2018 was assumed to be the opening year of the Offline upgrade. Traffic performance of the Offline upgrade was assessed for 2018 (at opening), 2028 (10 years after opening) and 2038 (20 years after opening).

Hyder's analysis found that:

- The Offline upgrade would improve travel time on the M1 Princes Motorway between Bulli Tops and Picton Road (measured for the entire 8.3 km section). In opening year 2018, travel time saving on the M1 is forecast up to 1 minute per vehicle (or 14%) in the northbound direction (towards Sydney). The travel time saving is forecast up to 1.3 minutes per vehicle (or 21%) in the southbound direction (towards Wollongong). In 2038 (20 years after opening), the travel time saving on the M1 is predicted up to 1.2 minutes (or 17%) in the northbound direction and about 2 minutes (or 27%) in the southbound direction.
- Model predicted substantial improvements on the M1 Princes Motorway section between Bellambi Creek and Picton Road (3.5 km) due to the proposed widening (three lanes in each direction).
- At opening year 2018, the average travel speed for light vehicles on the M1 would improve by 40% from about 74-78 km/h (do nothing) to about 96-100 km/h (with offline). In 2038, model predicted travel speed improvement from about 63-72 km/h (do nothing) to 89-92 km/h (off line).
- The offline upgrade would substantially improve heavy vehicles travel speed. In 2018 model predicted speed improvement up to 30% from about 44-49 km/h (do nothing) to about 56-57 km/h (off line). In 2038 model predicted speed improvement up to 33% from about 43-48 km/h (do nothing) to about 55-57 km/h (off line).
- Total crashes on the Princes Motorway between Bellambi Creek and Picton Road would be reduced by 74% under the upgraded condition. Annual crash rate would reduce from 22.5 (existing) to 5.8 (upgrade condition) with potential to eliminate all fatal crashes.

Economic Appraisal

This economic appraisal has been carried out in accordance with the NSW Government guidelines. These guidelines are provided by the *Transport for NSW Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives, March 2013.*

The economic assessment for the Offline upgrade returns a BCR of 1.7 and NPV of $49.52 million (using discount rate of 7% in 2014 dollars) with capital expenditure of approximately $76 million. The assessment identified significant road user benefit over the 30 year period from 2018 to 2048 with travel time benefit of $697.7 million and safety benefit of $39.6 million (2014 dollars).

As sensitivity analysis undertaken on the assumed discount rate as well as on the benefits and costs items resulted in a BCR range of 1.2 (discount rate of 10%) to 2.6 (discount rate of 4%).

In line with Strategic Business Case requirements, the economic appraisal for Offline upgrade is summarised as follows:

M1 Princes Motorway – Offline Upgrade between Bellambi Creek and Picton Road		
A	Offline Upgrade between Bellambi Creek and Picton Road	30 year economic evaluation Road user benefits Bellambi Creek to Picton Road (3.5 kilometres) Offline upgrade considered as standalone project
B1	Summary of Evaluation Results Cost Benefit Analysis (CBA)	Base Case - existing two lane formation with general traffic lanes Project Type: An 'offline' road upgrade (additional traffic lane) and realignment Local evaluation
B2	Evaluation Assumptions	Cost of Offline upgrade (at P90), $76 million. Travel time, VOC and accident cost as per Economic Appraisal Guidelines
C	Summary of Evaluation Results Sensitivity Results	7% discount rate At P90 Benefit/Cost Ratio - 1.7 At 4% discount rate, P90 Benefit/Cost Ratio - 2.6

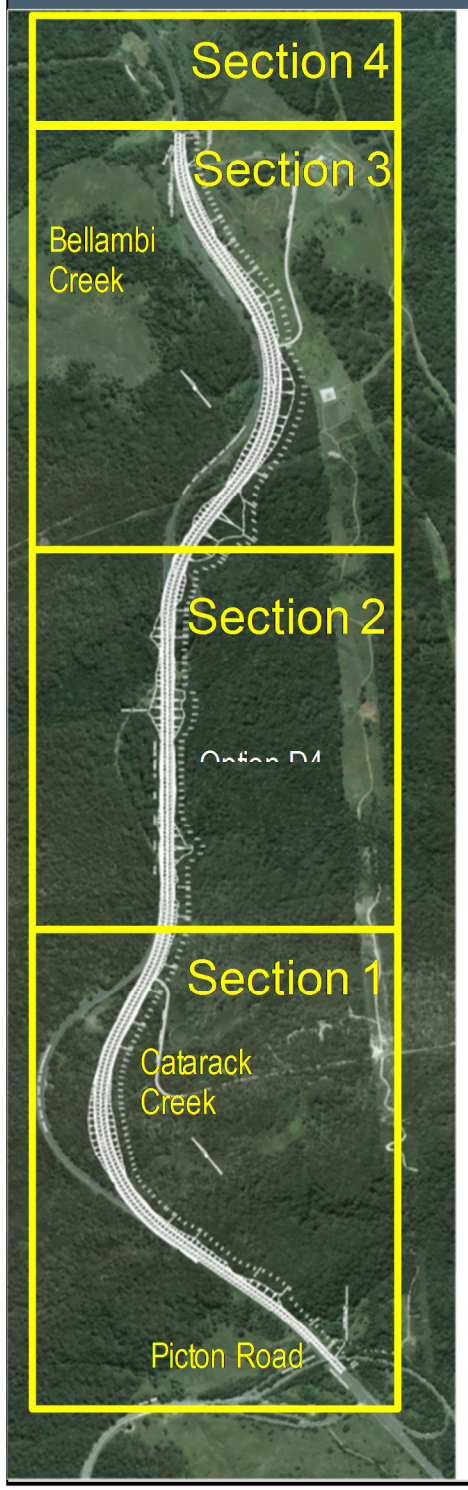
APPENDIX A

CRASH REDUCTION ANALYSIS

M1 Princes Motorway Upgrade - Offline Upgrade between Bellambi Creek and Picton Road (Option D4)

Accident Reduction Summary

Analysis period: 5 years

Road Section	Vehicle Accidents (Note 4)	DCA Code* (Note 4)	RUM Code* (Note 5)	Crash Description (Note 4)	Number of of Crashes recorded in analysis period (Note 1)				Potential Accident Reductions by the Offline Upgrade (Note 4)				$ Cost Savings per year (Note 5)
					Total	Fatal	Injury	Non-casualty (towaway)	Fatal	Injury	Non-casualty (towaway)	Total	
	**Two Vehicle Accidents**	**101-109**	**10,11 - 19**	Intersection, from adjacent approaches									
		201-501	**20, 50**	Head-on									
		202-206	**22 - 29**	Opposing vehicles; turning									
		207-304	**40**	U-turn									
		301-303	**30 - 32**	Rear end	22		3	19		3	13	16	$ 153,651
		305-307	**33 - 35**	Lane change	11		5	6		4	5	9	$ 181,955
		308-309	**36 - 37**	Parallel lanes; turning									
		401-409	**42, 47, 48**	Vehicle leaving driveway									
		503-506	**51, 52, 54**	Overtaking, same direction									
		601	**41, 60 – 63, 94**	Hit parked vehicle	4		2	2		2	2	4	$ 90,048
		903		Hit railway train									
	Single Vehicle Accidents	**001-008; 901-902**	**00 - 09**	Pedestrian, crossing carriageway	2	2			2			2	$ 3,127,019
		605	**64 – 66, 91**	Permanent obstruction on carriageway	4			4			4	4	$ 7,431
		609	**67**	Hit animal	4			4			2	2	$ 3,716
		701-702; 502; 706-709	**70, 72**	Off carriageway, on straight									
		703-704	**71, 73**	Off carriageway, hit object	7		1	6		1	4	5	$ 50,598
		705; 502	**74**	Out of control on straight	9		1	8		1	5	6	$ 52,455
		801; 802	**80, 82, 84, 86**	Off carriageway, on curve	5		1	4		1	4	5	$ 50,598
		803-804	**81, 83, 85, 87**	Off carriageway, hit object	43		14	29		10	19	29	$ 466,962
		805	**88**	Out of control on curve	1			1			1	1	$ 1,858
Total					**112**	**2**	**27**	**83**	**2**	**22**	**59**	**83**	**$ 4,186,290**

*** DCA - Definitions for Coding Accidents, RUM - Road User Movement**

Note:

1. The crash analysis has been undertaken using crash data provided by Roads and Maritime (RMS) for a five year period from 1 August 2008 and 31 October 2013.
2. Crash data for the subject M1 Princes Motorway Section between Picton Road and Bellambi Creek were used in the analysis.
3. Potential accident reduction rates were estimated using the RMS' Accident Reduction Guide, August 2005.
4. Table C4 - Percentage reduction in accidents for midblock treatments: High speed environment was applied.
5. Costs per crash sourced from Table 45 (Page 257) of TfNSW's Principles and Guideline of Economic Appraisal of Transport Investment and Investigation, March 2013.
6. The analysis assumed the proposed M1 Princes Motorway Upgrade Option D4 (Offline Scheme) involves realignment of the horizontal curves and will also improve driver visibility.
7. The analysis assumed the proposed upgrade Option D4 (Offline Scheme) have a new pavement overlay for entire upgrade section between Picton Road and Bellambi Creek. This in conjunction with realignment of the horizontal curves will further reduce the amount of loss of control crashes occurring in wet weather.

Source: Hyder analysis, F:\AA007521\D-Calculations\Crash Analysis\Offline Scheme Crash data\Accident Reduction_Offline Scheme_RevE_Willingness to Pay.xlsx

Road Section	Vehicle Accidents	DCA Code *	RUM Code *	Crash Description	Number of of Crashes recorded in period (Note 1)						Percentage reduction in accidents for midblock treatments: High speed environment (Note 4)				Proposed percentage reduction applied for the Offline Upgrade (%)	Justification	Potential Accident Reductions by the Offline Upgrade				$ Cost Savings per year (Note 5)			$ Cost Savings per year
					Total	Northbound	Southbound	Fatal	Injury	Non-casualty (towaway)	89. Duplicated Road	91. Accident Reduction Rate (Climbing Lanes)	92. Accident Reduction Rate (Horizontal Alignment)	94. Alignment - Change Horizontal & Vert.			Fatal	Injury	Non-casualty (towaway)	Total	Fatal	Injury	Non-casualty (towaway)	
	(Note 4)	(Note 4)	(Note 5)	(Notes 4 and 5)																				
Section 1 - between Picton Road and Cataract Creek	**Two Vehicle Accidents**	**101-109**	**10,11 - 19**	Intersection, from adjacent approaches							30%				30%		0	0	0	0				$ -
		201-501	**20, 50**	Head-on							100%	25%	30%	60%	90%	A 90% reduction is suggested.	0	0	0	0				$ -
		202-206	**22 - 29**	Opposing vehicles;													0	0	0	0				$ -
		207-304	**40**	U-turn							30%		30%	60%	60%		0	0	0	0				$ -
		301-303	**30 - 32**	Rear end	7	7			1	6	30%		30%	60%	60%	Rear-end crashes are mostly in NB direction for this section. The sharp curvature in conjunction with the steepness of the slope leads to speed differentials between light and heavy vehicles along the main traffic lane; thus inducing rear-end crashes. The proposed 'offline upgrade' which will realign the curve and remove the aforementioned merge on M1 will potentially reduce this rear-end crash type on the subject road section up to 60%.	0	1	4	5				$ 50,598
		305-307	**33 - 35**	Lane change	4	4			3	1					60%	The 'offline upgrade' of M1 will reduce lane changing manoeuvres of vehicles, north of Picton Rd. The likelihood of side-swipe crashes will also reduce between heavy vehicles and light vehicles as there is a designated third lane provided for heavy vehicles. The proposed 'offline upgrade' on M1 will potentially reduce the tendency of vehicles undertaking lane changing manoeuvres by 60%.	0	2	1	3				$ 88,191
		308-309	**36 - 37**	Parallel lanes; turning													0	0	0	0				$ -
		401-409	**42, 47, 48**	Vehicle leaving driveway							50%				50%		0	0	0	0				$ -
		503-506	**51, 52, 54**	Overtaking, same direction							50%	40%	30%	60%	60%		0	0	0	0	$ 7,817,548	$215,832	$9,289	$ -
		601	**41, 60 – 63, 94**	Hit parked vehicle	2	2			1	1	15%				15%		0	1	1	2				$ 45,024
		903	**903**	Hit railway train									30%	60%	60%		0	0	0	0				$ -
	Single Vehicle Accidents	**001-008; 901-902**	**00 - 09**	Pedestrian, crossing carriageway	1	1		1			50%		30%	60%	20%	A 20% reduction is suggested.	1	0	0	1				$ 1,563,510
		605	**64 – 66, 91**	Permanent obstruction on carriageway	2		2			2				60%	60%		0	0	2	2				$ 3,716
		609	**67**	Hit animal	2	1	1			2					20%	A 20% reduction is suggested.	0	0	1	1				$ 1,858
		701-702; 706-709	**70, 72**	Off carriageway, on							10%	30%		45%	45%		0	0	0	0				$ -
		703-704	**71, 73**	Off carriageway, hit object							10%	30%		45%	60%	Off-straight crashes were previously due to the sharp transition from the horizontal curve, north of Picton Rd to the straight section of road. Majority of these crashes are observed to be located immediately after the curve. As the 'offline upgrade' will smoothen this transition, off-straight crashes can potentially be reduced by 60%.	0	0	0	0				$ -
		705; 502	**74**	Out of control on straight	9	9			1	8	10%	30%		45%	60%	The majority of the loss of control crashes were located within the sharp horizontal curve, north of Picton Rd. As the 'offline upgrade' will reduce the curvature of this curve, loss of control crashes are likely to be reduced by 60%.	0	1	5	6				$ 52,455
		801; 802	**80, 82, 84, 86**	Off carriageway, on	1		1			1	10%	20%	30%	60%	60%		0	0	1	1				$ 1,858
		803-804	**81, 83, 85, 87**	Off carriageway, hit	14	13	1		4	10	10%	20%	30%	60%	60%		0	3	6	9				$ 140,646
		805	**88**	Out of control on curve							10%	20%	30%	60%	60%		0	0	0	0				$ -
	Total				**42**	**37**	**5**	**1**	**10**	**31**							**1**	**8**	**21**	**30**				**$ 1,947,855**

*** DCA - Definitions for Coding Accidents, RUM - Road User Movement**

Note:

1. The crash analysis has been undertaken using crash data provided by Roads and Maritime (RMS) for a five year period from 1 August 2008 and 31 October 2013.
2. Crash data for the subject M1 Princes Motorway Section between Picton Road and Bellambi Creek were used in the analysis.
3. Potential accident reduction rates were estimated using the RMS' Accident Reduction Guide, August 2005.
4. Table C4 - Percentage reduction in accidents for midblock treatments: High speed environment was applied.
5. Costs per crash sourced from Table 45 (Page 257) of TfNSW's Principles and Guideline of Economic Appraisal of Transport Investment and Investigation, March 2013.
6. The analysis assumed the proposed M1 Princes Motorway Upgrade Option D4 (Offline Scheme) involves realignment of the horizontal curves and will also improve driver visibility.
7. The analysis assumed the proposed upgrade Option D4 (Offline Scheme) have a new pavement overlay for entire upgrade section between Picton Road and Bellambi Creek. This in conjunction with realignment of the horizontal curves will further reduce the amount of loss of control crashes occurring in wet weather.

F:\AA007521\D-Calculations\Crash Analysis\Offline Scheme Crash data\[Accident Reduction_Offline Scheme_RevE_Willingness to Pay.xlsx]Accident Reduction_Section 1

Road Section	Vehicle Accidents	DCA Code *	RUM Code *	Crash Description	Number of of Crashes recorded in period (Note 1)						Percentage reduction in accidents for midblock treatments: High speed environment (Note 4)				Proposed percentage reduction applied for the Offline Upgrade (%)	Justification	Potential Accident Reductions by the Offline Upgrade				$ Cost Savings per year (Note 5)			$ Cost Savings per year
					Total	Northbound	Southbound	Fatal	Injury	Non-casualty (towaway)	89. Duplicated Road	91. Accident Reduction Rate (Climbing Lanes)	92. Accident Reduction Rate (Horizontal Alignment)	94. Alignment - Change Horizontal & Vert.			Fatal	Injury	Non-casualty (towaway)	Total	Fatal	Injury	Non-casualty (towaway)	
	(Note 4)	(Note 4)	(Note 5)	(Notes 4 and 5)																				
Section 2 - Straight section between Catarack Creek and Bellambi Creek	**Two Vehicle Accidents**	**101-109**	**10,11 - 19**	Intersection, from adjacent approaches							30%				30%		0	0	0	0.0				$ -
		201-501	**20, 50**	Head-on							100%	25%	30%	60%	90%	A 90% reduction is suggested.	0	0	0	0.0				$ -
		202-206	**22 - 29**	Opposing vehicles; turning													0	0	0	0.0				$ -
		207-304	**40**	U-turn							30%		30%	60%	60%		0	0	0	0.0				$ -
		301-303	**30 - 32**	Rear end	4	1	3			4	30%		30%	60%	60%	The steepness of the slope in this section of the road leads to heavy vehicles having to slow down on approach to the steep grade. This further affects the speed of light vehicles in the main traffic lane, leading to rear-end crashes. The addition of a third climbing lane in the 'offline upgrade' will mean heavy vehicles using the left-most lane and light vehicles using the adjacent traffic lanes. As such, there is less likelihood to be conflict between these vehicle types, hence reducing the occurrence of rear-end crashes. It is expected that rear-end crashes in this section will reduce by 60%..	0	0	3	3.0				$ 5,573
		305-307	**33 - 35**	Lane change	2	1	1		1	1					60%	The third climbing lane in the 'offline upgrade' provided for heavy vehicles will reduce the tendency of lane changing manoeuvres by light vehicles in order to overtake slow moving heavy vehicles. This crash type will reduce by 60%.	0	1	1	2.0				$ 45,024
		308-309	**36 - 37**	Parallel lanes; turning													0	0	0	0.0				$ -
		401-409	**42, 47, 48**	Vehicle leaving driveway							50%				50%		0	0	0	0.0				$ -
		503-506	**51, 52, 54**	Overtaking, same direction							50%	40%	30%	60%	60%		0	0	0	0.0				$ -
		601	**41, 60 – 63, 94**	Hit parked vehicle	2	2			1	1	15%				15%		0	1	1	2.0	$ 7,817,548	$215,832	$9,289	$ 45,024
		903	**903**	Hit railway train									30%	60%	60%		0	0	0	0.0				$ -
	Single Vehicle Accidents	**001-008; 901-902**	**00 - 09**	Pedestrian, crossing carriageway							50%		30%	60%	20%	A 20% reduction is suggested.	0	0	0	0.0				$ -
		605	**64 – 66, 91**	Permanent obstruction on carriageway										60%	60%		0	0	0	0.0				$ -
		609	**67**	Hit animal											20%	A 20% reduction is suggested.	0	0	0	0.0				$ -
		701-702; 502; 706-709	**70, 72**	Off carriageway, on straight							10%	30%		45%	45%		0	0	0	0.0				$ -
		703-704	**71, 73**	Off carriageway, hit object	5	4	1			5	10%	30%		45%	60%	Off-straight crashes are concentrated in the SB direction. This implies that vehicles had lost control upon exiting the curve south of Bellambi Ck. This is due to a sharp transition from the curve to the straight section of the road. As the 'offline upgrade' will smoothen this curve-to-straight transition, off-straight crashes can potentially be reduced by 60%.	0	0	3	3.0				$ 5,573
		705; 502	**74**	Out of control on straight							10%	30%		45%	60%		0	0	0	0.0				$ -
		801; 802	**80, 82, 84, 86**	Off carriageway, on curve	2	2				2	10%	20%	30%	60%	60%	The majority of the loss of control crashes were on approach to the reverse curve, north of Catarack Ck. These curves will be realigned and will reduce loss of control crashes by 60%.	0	0	2	2.0				$ 3,716
		803-804	**81, 83, 85, 87**	Off carriageway, hit object	6	1	5		3	3	10%	20%	30%	60%	60%		0	2	2	4.0				$ 90,048
		805	**88**	Out of control on curve							10%	20%	30%	60%	60%		0	0	0	0.0				$ -
	Total				**21**	**11**	**10**	**0**	**5**	**16**							**0**	**4**	**12**	**16**				**$ 194,959**

*** DCA - Definitions for Coding Accidents, RUM - Road User Movement**

Note:

1. The crash analysis has been undertaken using crash data provided by Roads and Maritime (RMS) for a five year period from 1 August 2008 and 31 October 2013.
2. Crash data for the subject M1 Princes Motorway Section between Picton Road and Bellambi Creek were used in the analysis.
3. Potential accident reduction rates were estimated using the RMS' Accident Reduction Guide, August 2005.
4. Table C4 - Percentage reduction in accidents for midblock treatments: High speed environment was applied.
5. Costs per crash sourced from Table 45 (Page 257) of TfNSW's Principles and Guideline of Economic Appraisal of Transport Investment and Investigation, March 2013.
6. The analysis assumed the proposed M1 Princes Motorway Upgrade Option D4 (Offline Scheme) involves realignment of the horizontal curves and will also improve driver visibility.
7. The analysis assumed the proposed upgrade Option D4 (Offline Scheme) have a new pavement overlay for entire upgrade section between Picton Road and Bellambi Creek. This in conjunction with realignment of the horizontal curves will further reduce the amount of loss of control crashes occurring in wet weather.

F:\AA007521\D-Calculations\Crash Analysis\Offline Scheme Crash data\[Accident Reduction_Offline Scheme_RevE_Willingness to Pay.xlsx]Accident Reduction Section 2

Road Section	Vehicle Accidents	DCA Code *	RUM Code *	Crash Description	Number of of Crashes recorded in period (Note 1)						Percentage reduction in accidents for midblock treatments: High speed environment (Note 4)				Proposed percentage reduction applied for the Offline Upgrade (%)	Justification	Potential Accident Reductions by the Offline Upgrade				$ Cost Savings per year (Note 5)			$ Cost Savings per year
					Total	Northbound	Southbound	Fatal	Injury	Non-casualty (towaway)	89. Duplicated Road	91. Accident Reduction Rate (Climbing Lanes)	92. Accident Reduction Rate (Horizontal Alignment)	94. Alignment - Change Horizontal & Vert.			Fatal	Injury	Non-casualty (towaway)	Total	Fatal	Injury	Non-casualty (towaway)	
	(Note 4)	(Note 4)	(Note 5)	(Notes 4 and 5)																				
Section 3 - Curve section south of Bellambi Creek	**Two Vehicle Accidents**	**101-109**	**10,11 - 19**	Intersection, from adjacent approaches							30%				30%		0	0	0	0.0				$ -
		201-501	**20, 50**	Head-on							100%	25%	30%	60%	90%	A 90% reduction is suggested.	0	0	0	0.0				$ -
		202-206	**22 - 29**	Opposing vehicles; turning													0	0	0	0.0				$ -
		207-304	**40**	U-turn							30%		30%	60%	60%		0	0	0	0.0				$ -
		301-303	**30 - 32**	Rear end	6	4	2			6	30%		30%	60%	60%	Rear-end crashes are caused by the sharp curvature and steepness of the slope, south of Bellambi Ck leading to differentials in speed between light and heavy vehicles along the main traffic lane. The proposed 'offline upgrade' on M1 will potentially reduce this rear-end crash type as light vehicles and heavy vehicles will use separate lanes. Rear-end crash types are predicted to be reduced by 60%.	0	0	4	4.0				$ 7,431
		305-307	**33 - 35**	Lane change	4	2	2		1	3					60%	The third climbing lane in the 'offline upgrade' provided for heavy vehicles will reduce the tendency of lane changing manoeuvres by light vehicles in order to overtake slow moving vehicles. This will further reduce the likelihood of lane side-swipe crashes between heavy and light vehicles. This crash type will reduce by 60%.	0	1	2	3.0				$ 46,882
		308-309	**36 - 37**	Parallel lanes; turning													0	0	0	0.0				$ -
		401-409	**42, 47, 48**	Vehicle leaving driveway							50%				50%		0	0	0	0.0				$ -
		503-506	**51, 52, 54**	Overtaking, same direction							50%	40%	30%	60%	60%		0	0	0	0.0				$ -
		601	**41, 60 – 63, 94**	Hit parked vehicle							15%				15%		0	0	0	0.0	$ 7,817,548	$215,832	$9,289	$ -
		903	**903**	Hit railway train									30%	60%	60%		0	0	0	0.0				$ -
	Single Vehicle Accidents	**001-008; 901-902**	**00 - 09**	Pedestrian, crossing carriageway	1	1		1			50%		30%	60%	20%	A 20% reduction is suggested.	1	0	0	1.0				$ 1,563,510
		605	**64 – 66, 91**	Permanent obstruction on carriageway	2		2			2				60%	60%		0	0	2	2.0				$ 3,716
		609	**67**	Hit animal											20%	A 20% reduction is suggested.	0	0	0	0.0				$ -
		701-702; 502; 706-709	**70, 72**	Off carriageway, on straight							10%	30%		45%	45%		0	0	0	0.0				$ -
		703-704	**71, 73**	Off carriageway, hit object	2	1	1		1	1	10%	30%		45%	60%	Off-straight crashes were previously due to the sharp transition from the horizontal curve, south of Bellambi Ck to the straight section of road. As the 'offline upgrade' will smoothen this transition, off-straight crashes can potentially be reduced by 60%.	0	1	1	2.0				$ 45,024
		705; 502	**74**	Out of control on straight							10%	30%		45%	60%		0	0	0	0.0				$ -
		801; 802	**80, 82, 84, 86**	Off carriageway, on curve	2	1	1		1	1	10%	20%	30%	60%	60%	The majority of the loss of control crashes were on approach to the reverse curve, south of Bellambi Ck. These curves are realigned and will reduce loss of control crashes by 60%.	0	1	1	2.0				$ 45,024
		803-804	**81, 83, 85, 87**	Off carriageway, hit object	18	11	7		6	12	10%	20%	30%	60%	60%		0	4	8	12.0				$ 187,528
		805	**88**	Out of control on curve							10%	20%	30%	60%	60%		0	0	0	0.0				$ -
	Total				**35**	**20**	**15**	**1**	**9**	**25**							**1**	**7**	**18**	**26**				**$ 1,899,115**

*** DCA - Definitions for Coding Accidents, RUM - Road User Movement**

Note:

1. The crash analysis has been undertaken using crash data provided by Roads and Maritime (RMS) for a five year period from 1 August 2008 and 31 October 2013.
2. Crash data for the subject M1 Princes Motorway Section between Picton Road and Bellambi Creek were used in the analysis.
3. Potential accident reduction rates were estimated using the RMS' Accident Reduction Guide, August 2005.
4. Table C4 - Percentage reduction in accidents for midblock treatments: High speed environment was applied.
5. Costs per crash sourced from Table 45 (Page 257) of TfNSW's Principles and Guideline of Economic Appraisal of Transport Investment and Investigation, March 2013.
6. The analysis assumed the proposed M1 Princes Motorway Upgrade Option D4 (Offline Scheme) involves realignment of the horizontal curves and will also improve driver visibility.
7. The analysis assumed the proposed upgrade Option D4 (Offline Scheme) have a new pavement overlay for entire upgrade section between Picton Road and Bellambi Creek. This in conjunction with realignment of the horizontal curves will further reduce the amount of loss of control crashes occurring in wet weather.

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Road Section	Vehicle Accidents	DCA Code *	RUM Code *	Crash Description	Number of of Crashes recorded in period (Note 1)						Percentage reduction in accidents for midblock treatments: High speed environment (Note 4)				Proposed percentage reduction applied for the Offline Upgrade (%)	Justification	Potential Accident Reductions by the Offline Upgrade				$ Cost Savings per year (Note 5)			$ Cost Savings per year
					Total	Northbound	Southbound	Fatal	Injury	Non-casualty (towaway)	89. Duplicated Road	91. Accident Reduction Rate (Climbing Lanes)	92. Accident Reduction Rate (Horizontal Alignment)	94. Alignment - Change Horizontal & Vert.			Fatal	Injury	Non-casualty (towaway)	Total	Fatal	Injury	Non-casualty (towaway)	
	(Note 4)	(Note 4)	(Note 5)	(Notes 4 and 5)																				
Section 4 - north of Bellambi Creek	**Two Vehicle Accidents**	**101-109**	**10,11 - 19**	Intersection, from adjacent approaches							30%				30%		0	0	0	0.0				$ -
		201-501	**20, 50**	Head-on							100%	25%	30%	60%	90%	A 90% reduction is suggested.	0	0	0	0.0				$ -
		202-206	**22 - 29**	Opposing vehicles; turning													0	0	0	0.0				$ -
		207-304	**40**	U-turn							30%		30%	60%	60%		0	0	0	0.0				$ -
		301-303	**30 - 32**	Rear end	5	5			2	3	30%		30%	60%	60%	The proposed 'offline upgrade' is likely to improve travel speed the subject M1 section between Picton Rd and Bulli Tops. With this improvement in travel speed, there will be a better flow of vehicles in the main traffic lane, thus reducing the likelihood of rear-end crashes by 60%.	0	2	2	4.0				$ 90,048
		305-307	**33 - 35**	Lane change	1	1				1					20%	A 20% reduction is suggested.	0	0	1	1.0				$ 1,858
		308-309	**36 - 37**	Parallel lanes; turning													0	0	0	0.0				$ -
		401-409	**42, 47, 48**	Vehicle leaving driveway							50%				50%		0	0	0	0.0				$ -
		503-506	**51, 52, 54**	Overtaking, same direction							50%	40%	30%	60%	60%		0	0	0	0.0				$ -
		601	**41, 60 – 63, 94**	Hit parked vehicle							15%				15%		0	0	0	0.0				$ -
		903	**903**	Hit railway train									30%	60%	60%		0	0	0	0.0				$ -
	Single Vehicle Accidents	**001-008; 901-902**	**00 - 09**	Pedestrian, crossing carriageway							50%		30%	60%	20%	A 20% reduction is suggested.	0	0	0	0.0	$ 7,817,548	$215,832	$9,289	$ -
		605	**64 – 66, 91**	Permanent obstruction on carriageway										60%	60%		0	0	0	0.0				$ -
		609	**67**	Hit animal	2	1	1			2					20%	A 20% reduction is suggested.	0	0	1	1.0				$ 1,858
		701-702; 502; 706-709	**70, 72**	Off carriageway, on straight							10%	30%		45%	45%		0	0	0	0.0				$ -
		703-704	**71, 73**	Off carriageway, hit object							10%	30%		45%	45%		0	0	0	0.0				$ -
		705; 502	**74**	Out of control on straight							10%	30%		45%	45%		0	0	0	0.0				$ -
		801; 802	**80, 82, 84, 86**	Off carriageway, on curve							10%	20%	30%	60%	60%		0	0	0	0.0				$ -
		803-804	**81, 83, 85, 87**	Off carriageway, hit object	5	4	1		1	4	10%	20%	30%	60%	60%		0	1	3	4.0				$ 48,740
		805	**88**	Out of control on curve	1		1			1	10%	20%	30%	60%	60%		0	0	1	1.0				$ 1,858
	Total				**14**	**11**	**3**	**0**	**3**	**11**							**0**	**3**	**8**	**11**				**$ 144,362**

*** DCA - Definitions for Coding Accidents, RUM - Road User Movement**

Note:

1. The crash analysis has been undertaken using crash data provided by Roads and Maritime (RMS) for a five year period from 1 August 2008 and 31 October 2013.
2. Crash data for the subject M1 Princes Motorway Section between Picton Road and Bellambi Creek were used in the analysis.
3. Potential accident reduction rates were estimated using the RMS' Accident Reduction Guide, August 2005.
4. Table C4 - Percentage reduction in accidents for midblock treatments: High speed environment was applied.
5. Costs per crash sourced from Table 45 (Page 257) of TfNSW's Principles and Guideline of Economic Appraisal of Transport Investment and Investigation, March 2013.
6. The analysis assumed the proposed M1 Princes Motorway Upgrade Option D4 (Offline Scheme) involves realignment of the horizontal curves and will also improve driver visibility.
7. The analysis assumed the proposed upgrade Option D4 (Offline Scheme) have a new pavement overlay for entire upgrade section between Picton Road and Bellambi Creek. This in conjunction with realignment of the horizontal curves will further reduce the amount of loss of control crashes occurring in wet weather.

F:\AA007521\D-Calculations\Crash Analysis\Offline Scheme Crash data\[Accident Reduction_Offline Scheme_RevE_Willingness to Pay.xlsx]Accident Reduction Section 4

APPENDIX B

ANNUAL COSTS AND BENEFITS

M1 Princes Motorway - Offline Upgrade between Bellambi Creek and Picton Road (Option D4)
Summary Calculations

Base Year	2014	
Opening Year	2018	
Analysis Period	30	years
Economic Life	60	

Analysis Period	Year	Costs			Benefits						Net Benefit (Cost)	First Year Benefit
		Construction Costs	Net Maintenance Costs	Total Costs	Annual Veh-Hr Savings	Annual Veh-Km Savings	Crash Reduction	Externality	Residual Value	Total Benefits		
Base Year	2014	$ 4,145,455	0	$4,145,455	$0	$0	$0	$0	$0	$0	-$4,145,455	$0
1	2015	$ 6,468,637	$0	$6,468,637	$0	$0	$0	$0	$0	$0	-$6,468,637	$0
2	2016	$ 65,259,300	$0	$65,259,300	$0	$0	$0	$0	$0	$0	-$65,259,300	$0
3	2017	$ 10,791,514	$0	$10,791,514	$0	$0	$0	$0	$0	$0	-$10,791,514	$0
4	2018	$ -	$0	$0	$5,527,128	$513,313	$4,186,290	$218,834	$0	$10,445,565	$10,445,565	$10,445,565
5	2019	$ -	$0	$0	$5,700,428	$507,760	$4,186,290	$216,467	$0	$10,610,945	$10,610,945	$0
6	2020	$ -	$0	$0	$5,873,727	$502,208	$4,186,290	$214,100	$0	$10,776,325	$10,776,325	$0
7	2021	$ -	$0	$0	$6,047,027	$496,656	$4,186,290	$211,733	$0	$10,941,706	$10,941,706	$0
8	2022	$ -	$398,329	$398,329	$6,220,326	$491,104	$4,186,290	$209,366	$0	$11,107,086	$10,708,757	$0
9	2023	$ -	$0	$0	$6,393,626	$485,552	$4,186,290	$206,999	$0	$11,272,466	$11,272,466	$0
10	2024	$ -	$0	$0	$6,566,925	$479,999	$4,186,290	$204,632	$0	$11,437,847	$11,437,847	$0
11	2025	$ -	$0	$0	$6,740,225	$474,447	$4,186,290	$202,265	$0	$11,603,227	$11,603,227	$0
12	2026	$ -	$0	$0	$6,913,524	$468,895	$4,186,290	$199,898	$0	$11,768,607	$11,768,607	$0
13	2027	$ -	$1,987,008	$1,987,008	$7,086,824	$463,343	$4,186,290	$197,531	$0	$11,933,988	$9,946,980	$0
14	2028	$ -	$0	$0	$7,260,123	$457,791	$4,186,290	$195,164	$0	$12,099,368	$12,099,368	$0
15	2029	$ -	$0	$0	$7,481,150	$492,101	$4,186,290	$209,791	$0	$12,369,332	$12,369,332	$0
16	2030	$ -	$0	$0	$7,702,176	$526,412	$4,186,290	$224,418	$0	$12,639,297	$12,639,297	$0
17	2031	$ -	$0	$0	$7,923,203	$560,723	$4,186,290	$239,046	$0	$12,909,261	$12,909,261	$0
18	2032	$ -	$398,329	$398,329	$8,144,229	$595,033	$4,186,290	$253,673	$0	$13,179,225	$12,780,896	$0
19	2033	$ -	$0	$0	$8,365,255	$629,344	$4,186,290	$268,300	$0	$13,449,189	$13,449,189	$0
20	2034	$ -	$0	$0	$8,586,282	$663,655	$4,186,290	$282,927	$0	$13,719,154	$13,719,154	$0
21	2035	$ -	$0	$0	$8,807,308	$697,965	$4,186,290	$297,554	$0	$13,989,118	$13,989,118	$0
22	2036	$ -	$0	$0	$9,028,335	$732,276	$4,186,290	$312,182	$0	$14,259,082	$14,259,082	$0
23	2037	$ -	-$2,827,193	-$2,827,193	$9,249,361	$766,587	$4,186,290	$326,809	$0	$14,529,047	$17,356,240	$0
24	2038	$ -	$0	$0	$9,470,387	$800,897	$4,186,290	$341,436	$0	$14,799,011	$14,799,011	$0
25	2039	$ -	$0	$0	$9,692,054	$795,984	$4,186,290	$339,341	$0	$15,013,669	$15,013,669	$0
26	2040	$ -	$0	$0	$9,913,721	$791,070	$4,186,290	$337,247	$0	$15,228,328	$15,228,328	$0
27	2041	$ -	$0	$0	$10,135,388	$786,156	$4,186,290	$335,152	$0	$15,442,986	$15,442,986	$0
28	2042	$ -	$398,329	$398,329	$10,357,055	$781,243	$4,186,290	$333,057	$0	$15,657,645	$15,259,315	$0
29	2043	$ -	$0	$0	$10,578,721	$776,329	$4,186,290	$330,962	$0	$15,872,303	$15,872,303	$0
30	2044	$ -	$0	$0	$10,800,388	$771,415	$4,186,290	$328,868	$0	$16,086,961	$16,086,961	$0
31	2045	$ -	$0	$0	$11,022,055	$766,502	$4,186,290	$326,773	$0	$16,301,620	$16,301,620	$0
32	2046	$ -	$0	$0	$11,243,722	$761,588	$4,186,290	$324,678	$0	$16,516,278	$16,516,278	$0
33	2047	$ -	$1,987,008	$1,987,008	$11,465,389	$756,674	$4,186,290	$322,583	$43,332,453	$60,063,389	$58,076,381	$0

Discount Rate	Capital Costs	Net Maintenance Costs	PV of Costs	PV of Benefits	NPV	BCR	First Year Benefit	FYRR
4%	$ 77,206,544	$1,164,829	$78,371,373	$200,249,962.48	$121,878,590	2.6	$8,585,492.72	11.0%
7%	$ 71,028,037	$795,157	$71,823,195	$121,333,091.29	$49,509,897	1.7	$7,447,543.22	10.4%
10%	$ 65,515,604	$573,156	$66,088,760	$79,055,819.97	$12,967,060	1.2	$6,485,873.81	9.8%

IRR	11.8%