Appendix C

Traffic modelling and economic appraisal

FINAL REPORT



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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This report has been prepared for Roads and Maritime Services in accordance with the terms and conditions of appointment for M1 Princes Motorway – Offline Upgrade dated October 2014. Hyder Consulting Pty Ltd (ABN 76 104 485 289) cannot accept any responsibility for any use of or reliance on the contents of this report by any third party.

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APPENDICES

Appendix A Crash Reduction Analysis

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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 microsimulation 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.



Figure 1-1 Strategic Concept Design of Offline Upgrade

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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 project¹. 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

Exiting Traffic Conditions 2.3

The M1 Princes Motorway, Picton Road and Appin Road, form the major freight and B-Doublelinks 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.

2.3.1Traffic 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.

Existing (2014) Trainc	
37,000 vehicles (two way)	
13% are heavy vehicles and 87% are light vehicles.	
NB:1700 / SB:1000	
NB:120 / SB:120	
NB:1800 / SB:1100	

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

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 2-3summarises historical crashes recorded on the M1. In the five year period between 1August 2009 and 31 October 2013, a total of 112 crashed were recorded. These crashesincluded two fatal crashes and 27 injury crashes. The historical crash data indicates that a highnumber 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	Total	Crash by Severity			
Length (km)	Crash	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	e per 100 MVKM			
Section	2014	Crash Rate per 100 MVKM ⁽¹⁾			
Length AE	ADT	Total	Fatal	Injury	Non-injury
(km)		Crash	Crash	Crashes	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 route². 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 Manual³ and Austroads Guidelines⁴. 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
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ID	Key criteria	Measures
1	Ability to improve travel time on the M1 <u>northbound</u> between Picton Road and Bulli Tops ⁽¹⁾ .	Measured average travel time (minute) for all vehicles.
2	Ability to improve travel time on the M1 <u>southbound</u> between Bulli Tops and Picton Road.	Measured average travel time (minute) for all vehicles.
3	Ability to improve <u>northbound</u> 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 <u>southbound</u> 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).

Traffic Performance

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

Traffic Forecast		:014 ⁽¹⁾ (Base Year)		201	18 (Opening Year		2028 (1	0 years after op	sening)	2038 (2	0 years after op	ening)
	Light Vehicles	Heavy Vehicle	AII Vehicles	Light Vehicles	Heavy Vehicle	All Vehicles	Light Vehicles	Heavy Vehicle	AII Vehicles	Light Vehicles	Heavy Vehicle	All Vehicles
Forecast Average Daily Volumes	37,	000 vehicles per di	ау	40,0	100 vehicles per dá	ĄŁ	47,0)00 vehicles per	day	55,0	00 vehicles per o	day
Heavy Vehicles	13% are he	avy vehicles and 87 vehicles.	7% are light			Heavy vehic	le proportions are	maintained in all	future years (ie.13	3% 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 201 Princes Motorwa shows an averag	3 historical traffic d y (4km north of Apl e growth of 2% pel	ata on M1 pin Road) r annum.	The historical grow	rth trend of 2% per	annum are used fr	or future years traf figure pre	fic volumes on N pared for M1 sec	/1 section betweer :tion)	Bulli Tops and Pi	cton Road (refer	to traffic growth
Table 2 Traffic Performance	of Offline Upo	rade (Option	D4) in AM Pe	k								

Traffic Criteria	Vehicle Type		2018 (Opening	Year)	3)28 (10 years aft	er opening)	2	038 (20 years aft	er 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 (%)
 Ability to improve travel time on the M1 <u>northbound</u> between Picton Road and Bulli Tops (A to C). 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%) ▼
 Ability to improve travel time on the M1 <u>southbound</u> between Bulli Tops and Picton Road (C to A). 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%) V	7.4 mins	5.4 mins	2.0 mins (-27%)
5. Ability to improve northbound traffic flows on the M1	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%) 🔺
between Picton Koad and beliampi Ureek (A to b). 6. Measured average travel speed (km/h) ⁽⁶⁾	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 <u>southbound</u> traffic flows on the M1	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%) 🔺
between beliambli Creek and Ficton Koad (b to A). 8. Measured average travel speed $(km/h)^{(7)}$	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%) 🔺
 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:

- The 2014 traffic volume is estimated from Paramics traffic model. .сi
- 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.
 - Offline Upgrade is sourced from RMS's MR513 Mount Ousley Road Option D4 10/07/2014
- Average travel time on M1 northbound between Picton Road and Bulli Tops (A to C). The section length ы. 4
 - Average travel time on M1 southbound between Bulli Tops and Picton Road (C to A). The section is about 8.3 km. 5.
- Average speed on M1 northbound between Picton Road and Bellambi Creek (A to B). The section length is about 8.3 km. ю.
- Average speed on M1 southbound between Bellambi Creek and Picton Road (B to A). The section length is about 4 km.
 - length is about 4 km. ۲.
- 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 αċ
 - Picton Road which results in vehicle kilometres travelled saving. Number of stops is not relevant for this study area.

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Traffic Performance of Offline Upgrade Table 2-8

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 _
- Road interchange and Bellambi Creek from current two Widening of the M1 Princes Motorway between Picton (2/2) to three (3/3) lanes in each direction.



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



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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 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 outturn costs)⁵ with the proposed timing and breakdown shown in Table 4-1.

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)
Table 4-5	ravement	Aleas IUI	Maintenance	()

	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 Weighte	ed Average VOTT (\$/VH	IT)
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 4-6shows that annual crash rate would reduce from 22.5 existing to 5.8 under upgradecondition with potential to eliminate all fatal crashes. The crashes per 100 million vehiclekilometres 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 Scenario	Existin	ig and Pro	posed Cras	sh Statistics	Based on Esti	mated Safety II Gras	mprove sh bv Collis	sion Tvpe / DC/	A Code ⁽²⁾	I	I		
	(km)	Rear end	Lane change	Hit parked vehicle	Pedestrian, crossing carriageway	Permanent obstruction on carriageway	Hitanimal	Off 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) Existingconditions(withoutOfflineUpgrade)	5.31	52	÷	4	2	4	4	7	o	Ω	43	~	112
(2) Proposed conditions (with Offline upgrade)	5.15	9	2	0	0	0	2	3	ę	0	14	0	29
Change in Conditions	-0.16	-16	▲6-	-4	-2	-4	-2	-5	9-	-5	-29	► L-	-83
Change in Conditions %	-3%	-73%	-82%	-100%	-100%	-100%	-50%	-71%	-67%	-100%	-67%	-100%	-74%
Noto:													

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.

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Table 4-6 Existir	ig and Proposed	Crash Statistic:	s Based on Es	timated Safety	Improve, Annua	I Average			
Scenario	Length (km)	Total Crashes	Number	of Crashes by	/ Severity	Total Crash Per 100	Crash Severity Index ⁽⁴⁾	Crash Cost (\$N	per Year 1)
			Fatal Crashes	Injury Crashes	Non-injury Crashes	MVKM (3)		Total Cost ⁽⁵⁾	Cost per Km
(1) Existingconditions(without OfflineUpgrade)	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	σ	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%	-9%9-	-94%	-94%
Note: (1) DMS crash data reco	vrded hetween 1 Aug	net 2000 and Octo	ober 2013						

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

f:)aa007521/I-report/report/offline upgrade/final report_feb15/m1_offline upgrade_traffic modelling and economic appraisal_revd.docx M1 Princes Motorway – Offline Upgrade—Traffic Modelling and Economic Appraisal Hyder Consulting Pty Ltd-ABN 76 104 485 289

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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.

Environmental	Passenger Car	Light goods	s vehicle	Total light vehicles	Heavy v	vehicles
Externality	(\$/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

 Table 4-7
 Environmental Externality Costs

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.

Summary of Benefits and Costs 4.3

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.

		s (\$)
	Cost	Comparison
	(in 2014 constant otherw	dollars, \$million unless ise 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

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

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%200ption_RevG.xls)

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

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%

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

Source: Hyder Economic Analysis

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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

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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 3-2 Selfsiti	Vity Analyses Results (on Discount Rates)
Discount Rate		Offline Upgrade
	NPV (\$M)	\$121.89
40/	BCR	2.6
4%	NPVI	1.6
	FYRR	11.0%
	NPV (\$M)	\$12.97
4.00/	BCR	1.2
10%	NPVI	0.2
	FYRR	9.8%

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

Source: Hyder Economic Analysis

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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.

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

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

Source: Hyder Economic Analysis

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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 microsimulation 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 Pr	inces Motorway – Offline Upgra	de between Bellambi Creek and Picton Road
А	Offline Upgrade between	30 year economic evaluation
	Bellambi Creek and Picton Road	Road user benefits
		Bellambi Creek to Picton Road (3.5 kilometres)
		Offline upgrade considered as standalone project
B1	Summary of Evaluation Results	Base Case - existing two lane formation with general traffic lanes
	Cost Benefit Analysis (CBA)	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
С	Summary of Evaluation	7% discount rate
	Results	At P90
		Benefit/Cost Ratio - 1.7
	Sensitivity Results	At 4% discount rate, P90
		Benefit/Cost Ratio - 2.6

APPENDIX A

CRASH REDUCTION ANALYSIS

C ę Ċ 5 -E 0 3 ~ j

n		ycars										
Accidents	DCA Code*	RUM Code*	Crash Description	Numb recorde	ber of of d in anal (Note	Crashes lysis period	Red	⁹ otentia uctions Uporade	I Acciden by the Off e (Note 4)	t fline	\$ Cos per yea	t Savings ar <mark>(Note 5</mark>)
	(Note 4)	(Note 5)	(Note 4)	Total Fat	al Injury	Non- casualty (towawav)	Fatal	Injury (t	Non- casualty owawav)	Total		
hicle	101-109	10,11 - 19	Intersection, from adjacent approaches									
nts	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	ю	19		e	13	16	ф	153,651
	305-307	33 - 35	Lane change	7	5	9		4	5	ი	Ь	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	ф	90,048
	903		Hit railway train									
Vehicle	001-008; 901-902	60 - 00	Pedestrian, crossing carriageway	2			2			2	ക	3,127,019
nts	605	64 – 66, 91	Permanent obstruction on carriageway	4		4			4	4	Ь	7,431
	609	67	Hit animal	4		4			N	2	φ	3,716
	701-702; 502; 706- 709	70, 72	Off carriageway, on straight									
	703-704	71, 73	Off carriageway, hit object	7	-	9		. 	4	5	Ь	50,598
	705; 502	74	Out of control on straight	ი	-	ω		-	5	9	ф	52,455
	801; 802	80, 82, 84, 86	Off carriageway, on curve	2	-	4			4	5	ф	50,598
	803-804	81, 83, 85, 87	Off carriageway, hit object	43	14	29		10	19	29	Ь	466,962
	805	88	Out of control on curve	-		-			.	~	ф	1,858
				112 2	27	83	2	52	59	83	\$	1,186,290
Definition	s for Coding Accide	nts, RUM - Road User Moveme	nt Roads and Maritime (RMS) for a five year p	eriod from	1 Audu	st 2008 and	31 Octo	bher 201	<u>m</u>			
rasiration analysis	ie subject <u>M1 Princes</u>	Motorway Section between Pictu	on Road and Bellambi Creek were used in t	the analys	is.	st 2000 allu			<u>.</u>			
ntial accide	nt reduction rates were	e estimated using the RMS' Acci	dent Reduction Guide, August 2005.									
C4 - Perce	entage reduction in ac	cidents for midblock treatments:	High speed environment was applied.			:	:					
s per crash nalysis ass	sourced from Table 4: sumed the proposed N	5 (Page 257) of TħNSW's Principle 11 Princes Motorway Upgrade Op	es and Guideline of Economic Appraisal of btion D4 (Offline Scheme) involves realignm	Transport ent of the	Investm horizont	ent and Inve al curves an	stigatio d will al	л, Marcl so impre	h 2013. ove driver	visibilit	y.	
Inalysis as This in conji	sumed the proposed u unction with realignme	pgrade Option D4 (Offline Schem ent of the horizontal curves will fu	ie) have a new pavement overlay for entire uther reduce the amount of loss of control c	upgrade se rashes o	ection be ccurring	etween Picto in wet weath	n Road ler.	and Bel	llambi			



Road Section	Vehicle 1	DCA Code *	RUM Code *	Crash	Numbe	r of of Crashes recorded in	n period (Note 1)	Per	centade reductio	n in accidents for midb	lock treatments: h	Hiah speed Pr	posed	Justification	Potential Accid	ent Reduction	s by the \$ Cost Savings	per vear (Note 5)	S Cost Savings
	Accidents			Description						environment (Note	4)		centage		Offli	ne Upgrade			per year
					Total Northbound	l Southbound Fat	al Injury n c c ((on- 89. asualty ow away)	. Duplicated R Road (C	91. Accident 92. / eduction Rate Reduu limbing Lanes) Alig	Accident 94. A stion Rate C rizontal Horizo jnment)	lignment - appli thange Offlin ntal & Vert.	ed for the e Upgrade (%)		Fatal Injury	Non-casualty (towaway)	Total Fatal Inju	ry Non- casualty (towaway)	
Section 1 - between Picton Road and Cataract Creek	Two Vehicle Accidents	101-10 9	(voce 5) 10,11 - 19	Intersection, from adjacent					30%				30%		•	0	0		ı ج
		201-501	20, 50	Head-on					100%	25%	30%	60%	90% A 5	30% reduction is suggested.	0	0	0		ı ج
		202-206	22 - 29	Opposing											0	0	0		ı ج
		207-304	40	Vellicies, U-tum					30%		30%	60%	60%		0	0	0		ı ج
Belamb		301-303	30 - 32	Rear end	-		~	ω	30%		30%	60%	60% Rei cur thu rea pot to 6	ar-end crashes are mostly in NB direction for this section. The sharp nature in conjunction with the steepness of the stope leads to speed erentials between light and heavy whicles along the main traffic lane; is inducing rear-end crashes. The proposed "offline upgrade" which will algor the curve and remove the abrementioned merge on M1 will tentially reduce this rear-end crash type on the subject road section up 20%.	-	4	ų		\$
		305-307	33 - 35	Lane change	4		m						50% The red thir will ma	 offline upgrade of M1 will reduce lane changing manoeuvres of nicles, north of Picton Rd. The likelihood of side-swipe crashes will also tuce between heavy vahicles and light vahicles as there is a designated rd lane provided for heavy vehicles. The proposed 'offline upgrade' on M1 potentially reduce the tendency of vehicles undertaking lane changing noeuvres by 60%. 	0	-	m		\$ 88,191
Opt D4		308-309	36 - 37	Parallel lanes; tuming											0	0	0		، ج
//20/01 -		401-409	42, 47, 48	Vehicle leaving drivewav					50%				50%		0	0	0		، ج
PO NOL		503-506	51, 52, 54	Overtaking, same direction					50%	40%	30%	60%	60%		0	0	0 \$ 7.817.548 \$2	5.832 \$9.289	י ج
LdO - 00		601	41, 60 – 63, 94	 Hit parked 	2 2		~	-	15%				15%		0	-	7		\$ 45,024
AOR	0	903	903	Hit railway train							30%	60%	60%		0	0	0		ı ج
	Single Vehicle Accidents	001-008; 901- 902	60 - 00	Pedestrian, crossing carriageway			_		50%		30%	60%	20% A 2	20% reduction is suggested.	1	0	~		\$ 1,563,510
		605	64 - 66, 91	Permanent obstruction on carriageway	2	2		5				60%	60%		0	7	N		\$ 3,716
<u>қ</u> а	•	609	67	Hit animal	2	-		2					20% A 2	20% reduction is suggested.	0	-	~		\$ 1,858
Tel		701-702; 502; 706-709	70, 72	Off carriageway, or	F				10%	30%		45%	45%		0	0	0		۰ ب
Section 1		703-704	71, 73	Off carriageway, hi object	-				10%	30%		45%	60% Office of the office of the potential pote	Actraight crashes were previously due to the sharp transition from the rizontal curve, north of Piction Rd to the straight section of road. Majority these crashes are observed to be located immediately after the curve. As to efficient upgrade will smoothen this transition, off-straight crashes can entially be reduced by 60%.	0	0	o		۰ ب
Cataract		705; 502	74	Out of control on straight	6 6		~	œ	10%	30%		45%	60% The hor	e majority of the loss of control crashes were located within the sharp rizontal curve. north of Picton Rd. As the offline upgrade will reduce the	0	5	9		\$ 52,455
		801; 802	80, 82, 84, 86	Off carriadeway or	-	~		-	10%	20%	30%	60%	60% cur	hature of this curve, loss of control crashes are likely to be reduced by	0	-	.		\$ 1,858
	~	803-804	81, 83, 85, 87	Off Carriadeway, o carriadeway, bi	14 13	~	4	10	10%	20%	30%	60%	60%		ю 0	9	თ		\$ 140,646
	-	805	88	Out of control on curve					10%	20%	30%	60%	60%		0	0	0		، ج
	* DCA - Definitio	ins for Coding	Accidents, RU	JM - Road User	42 37 Movement	ι.	9	£							∞ 	м	ę		\$ 1,947,855
Proton Road	Note: 1. The crash anal 2. Crash data for 3. Potential accid 4. Table C4 - Perr 5. Costs per crash 6. The analysis as	lysis has been the subject <u>M1</u> lent reduction <i>r</i> centage reducti h sourced from ssumed the pro	undertaken usi, <u>1 Princes Motor</u> ates were estim ion in accidents Table 45 (Page sposed M1 Princ	ing crash data proving crash data proving section betward using the F s for midblock tree e 257) of ThNSW: ces Motorway Up	wided by Roads and reen Picton Road ar MS' Accident Redu atments: High speet atments Principles and Gu ograde Option D4 (C	Maritime (RMS) for a five id Bellambi Creek vere us titon Guida August 2005. I environment vas applied deline of Economic Appria filine Scheme) involves res	/ear period from ed in the analysi sal of Transport I lignment of the h	1 August 2008 a s. nvestment and 1 orizontal curves	and 31 October 2 nvestigation, Mar and will also imj	013. ch 2013. prove driver visibility.									
	7. The analysis a horizontal curves	ssumed the pr will further redu	oposed upgrade uce the amount	e Option D4 (Offli	ne Scheme) have a r crashes occurring	iew pavement overlay for e in wet weather.	ntire upgrade se	tion between Pi	icton Road and E	sellambi Creek. This in	conjunction with	realignment of the							
	F:\AA007521\D-0	Calculations/C	Trash Analysis	Offline Scheme	Crash data\[Accide	nt Reduction_Offline Scl	neme_RevE_Wi	lingness to Pay	xlsx]Accident I	Reduction Section 1									

culations\Crash Analy F:\AA007521\D-Cal

M1 Princes Motorway – Offline Upgrade—Traffic Modelling and Economic Appraisal Hyder Consulting Pty Ltd-ABN 76 104 485 289 f:\aa007521\/-report/report/offline upgrade\final report_feb15\m1_offline upgrade_traffic modelling and economic appraisal_revd.docx

Road Section	Vehicle Accidents	DCA Code *	RUM Code *	Crash	Number of o	of Crashes recorded i	n period (Note 1)	Percentage rec	duction in accidents	s for midblock treat	ments: High speed	Proposed	Justification	Potential Accide	ent Reductions t	by the \$ Cost Si	avings per year (Note 5	\$ Cost Saving
												reduction			-			
					Total Northbo	und Southbound Fat	al Injury Non- casualty (towaway	89. Duplicated Road)	91. Accident Reduction Rate (Climbing Lanes	92. Accident Reduction Rate (Horizontal Alignment)	94. Alignment - Change Horizontal & Vert	applied for the Offline Upgrade		Fatal Injury	Non-casualty (towaway)	Total Fatal	Injury Non- casualty (towawa:	
Section 2 - Straight section between Catarack Creek and	Two Vehicle Accidents	101-109	10,11 - 19	(voues 4 and 5) Intersection, from adjacent				30%				30%		0	0	0.0		به
Bellambi Creek		201-501	20, 50	Head-on				100%	25%	30%	60%	%06	A 90% reduction is suggested.	0	0	0.0		ы
		202-206	22 - 29	Opposing vehicles; turning										0	0	0.0		ю
A CAL		207-304	40	U-tum				30%		30%	60%	%09		0	0	0.0		Ś
Creek mp		301-303	30 - 32	Rear end	4	m	4	30% 2		30%	60%	80%	The steepness of the slope in this section of the road leads to heavy whickes 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 cristines. The addition of a thind 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 00%.	0	m	о ю		ю
		305-307	33 - 35	Lane change	2	~						60%	The third climbing lane in the offline upgrade' provided for heavy vehicles will reduce the tendency of lane changing manoeuxes by light vehicles in order to overtake slow moving heavy vehicles. This crash type will reduce by 60%.	0	-	2.0		\$ 45,0
Options 04		308-309	36 - 37	Parallel lanes; trimino										0	0	0.0		в
\$L02		401-409	42, 47, 48	Vehicle leaving drivewav				50%				50%		0	0	0.0		в
2/20/04		503-506	51, 52, 54	Overtaking,				50%	40%	30%	60%	60%		0	0	0.0		S
		601	41, 60 – 63, 94	 4 Hit parked vahicle 	2 2		1	15%				15%		0	-	\$ 7,817,54 2.0	8 \$215,832 \$9,280	\$ 45,(
		903	903	Hit railway train						30%	60%	60%		0	0	0.0		ю
- GAOR Y	Single Vehicle Accidente	001-008; 901 [.] 902	60 - 00 -	Pedestrian, crossing camaneway				50%		30%	60%	20%	A 20% reduction is suggested.	0	0	0.0		Ś
		605	64 - 66, 91	Permanent obstruction on carriadeway							60%	60%		0	0	0.0		с у
MON		609	67	Hit animal								20%	A 20% reduction is suggested.	0	0	0.0		ы
EL299M -		701-702; 502 706-709	; 70, 72	Off carriageway, on straight				10%	30%		45%	45%		0	0	0.0		ю
		703-704	71, 73	Off carriageway, hit obiect	ۍ 4	-	ũ	10%	30%		45%	60%	Off-straight crashes are concentrated in the SB direction. This implies that whickes had lost control upon exiting the curve south of Baltanbi CK. This is due to a shard transition from the curve to the straight section of the	0	ю	3.0		\$
		705; 502	74	Out of control on straight				10%	30%		45%	60%	road. As the 'offline upgrade' will smoothen this curve-to-straight transition, off-straight crashes can potentially be reduced by 60%.	0	0	0.0		ь
		801; 802	80, 82, 84, 86	Off carriageway, on curve	2		N	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	5	2.0		s. 3,7
Catarack Oreek		803-804	81, 83, 85, 87	Off carriageway, hit obiect	-	Q	ო ო	10%	20%	30%	60%	60%		0	7	4.0		3'06
		805	88	Out of control on curve				10%	20%	30%	60%	60%		0	0	0.0		ю
	Total * DCA - Definition	ons for Codin	d Accidents RI	IM - Road User Me	21 11 Wement	10 0	5 16							0 4	12	16		\$ 194,9
	Note:	r the subject <u>b</u> r the subject <u>b</u> ident reduction rcentage reduc sh sourced fro assumed the p	n undertaken usi Al Princes Motor 1 rates were estin 1 rates were estin 1 rates were estin 1 rable 45 (Pag moposed M1 Prin 2 roposed upgrade	ing crash data prov way Section betwe nated using the RM s for midbock treat e 257) of TMSW's i wes Motoway Upg t Option D4 (Offline	ded by Roads a en Picton Roads a S' Accident Rei nents: High spe Principles and C rade Option D4 Scheme) have a	and Maritime (RMS) f Land Bellambi Creek duction Guide, Augu acd environment was Suideline of Economi (Offline Scheme) inw a new pavement over	or a five year perio were used in the ; at 2005. applied. Appraisal of Trar Mes realignment d lav for entire upgra	1 from 1 August 2 inalysis. Isport Investment of the horizontal c ade section betwe	008 and 31 Octobe and Investigation, A urves and will also i en Picton Road and	r 2013. March 2013. Improve driver visib d Bellambi Creek.	lity. This in conjunction	with realignment						
	of the horizontal F:\AA007521\D-	l curves will fur Calculations	ther reduce the a Crash Analysis	amount of loss of co Offline Scheme Cr	introl crashes o ash data\[Acci	occurring in wet weat dent Reduction_Of	her. fline Scheme_Rev	vE_Willingness t	o Pay.xlsx]Accider	nt Reduction Secti	on 2							

Road Section	tehicle	DCA Code *	RUM Code *	Crash	NN	umber of of Cras	hes recorded in	period (Note 1)	Perce	entage reduction	n in accidents for	midblock treatme	ents: High speed	Proposed	Justification	Potential Accid	dent Reductio	ons by the	\$ Cost Savings per year (Not	e 5) \$ Cost (Savings
	Accidents			Description							environment	(Note 4)		percentage reduction		Off	line Upgrade			ber	·year
				a bine L softoni	Total No	orthbound So	uthbound Fata	I Injury Nor cas (tov	I- 89. I ualty vaway)	Duplicated Road CC	91. Accident eduction Rate limbing Lanes)	92. Accident Reduction Rate (Horizontal Alignment)	94. Alignment - Change Horizontal & Vert.	applied for the Offline Upgrade (%)		Fatal Injury	(towaway)	ity Total F	atal Injury Non- casua (towa	lty way)	
Section 3 - Curve section south ^T of Bellambi Creek	Two Vehicle ccidents	101-109	10,11 - 19	Intersection, from adjacent	5 11					30%				30%		0	0	0.0		φ	•
		201-501	20, 50	Head-on						100%	25%	30%	60%	%06	A 90% reduction is suggested.	0	0	0.0		ь	ï
		202-206	22 - 29	Opposing vehicles; tuming												0	0	0.0		φ	•
A A A A		207-304	40	U-tum						30%		30%	60%	%09		0	0	0.0		ь	•
Bellambi		301-303	30 - 32	Rear end	6	4	2		ω	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 offine upgrade' on M1 will potentially reduce this rear-end crash type as light vehicles and neavy vehicles will use separate lanes. Rear-end crash types are predicted to be reduced by 60%.	0	4	4.0		ю	7,431
A BOOM		305-307	33 - 35	Lane change	4	N	N	۲-	m					60%	The third climbing lane in the 'offline upgrade' provided for heavy vehicles will reduce the tendency of lane changing manoeuves 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	2	3.0		ю	46,882
		308-309	36 - 37	Parallel lanes turning	16											0	0	0.0		\$	·
		401-409	42, 47, 48	Vehicle leavir drivewav	٥L					50%				50%		0	0	0.0		Ф	•
12014		503-506	51, 52, 54	Overtaking, same directio	Ę					50%	40%	30%	60%	60%		0	0	0.0		θ	•
120/01		601	41, 60 – 63,	94 Hit parked vehicle						15%				15%		0	0	0.0	\$ 7.817.548 \$215.832 \$9.	289 \$	r.
		903	903	Hit railway tre	ain							30%	60%	60%		0	0	0.0		φ	r
11190 - GA	Single (ehicle ccidents	001-008; 901. 902	60 - 00 -	Pedestrian, crossing carriagewav	-	-	-			50%		30%	60%	20%	A 20% reduction is suggested.	1	0	1.0		\$	1,563,510
TREEK BO		605	64 - 66, 91	Permanent obstruction of carriageway	2		7		2				60%	60%		0	3	2.0		Ф	3,716
		609 701-702; 502; 700-700	67 70, 72	Hit animal Off	Ę					10%	30%		45%	20% 45%	A 20% reduction is suggested.	•	0 0	0.0		6 69	
N E 1934		703-704	71 73	carriageway, straight Off	6		-	~		10%	30%		45%	60%	Off-straight crashes were previously due to the sham transition from the	5	5	0.0		G	45 024
W - NV Id		to	21 11	carriageway, object	hit ²	-	-	-	-	2	e 200		2 7	e 200	or-restorator transmers were provincialy one to the super transmer intominent in horizontial curve, south of Bellambi CK to the straight section of road. As the 'offline upgrade will smoothen this transition, off-straight crashes can	0	-	2.0		÷	t 20 °Ct
4444		705; 502	74	Out of contro on straight	Z					10%	30%		45%	60%	potentially be reduced by 60%.	0	0	0.0		Ф	1
		801; 802	80, 82, 84, 8	36 Off carriageway, curve	on 2	~	~	~	∼	10%	20%	30%	60%	60%	The majority of the loss of control crashes were on approach to the reverse corve, souch of Belanian CA. These curves are realigned and will reduce instruct crashes by 60%.	0	-	2.0		φ	45,024
		803-804	81, 83, 85, 8	37 Off carriageway,	hit 18	5	~	G	12	10%	20%	30%	60%	60%		0	00	12.0		Ф	187,528
Creek Creek		805	88	object Out of contro on curve	ų	ę	ų	d	ų	10%	20%	30%	60%	60%		0	0	0.0		с ,	
	DCA - Definiti	ons for Codin	ig Accidents, I	RUM - Road Use	r Movement	3	2	,	3								2	2		- >	
	Note: 1. The crash an: 2. Crash data fo 2. Potential acci 1. Potential acci 7. Table C4 - Pe. Costs per crast	alysis has bee r the subject <u>N</u> dent reduction rcentage reduc sh sourced fror	n undertaken u 11 Princes Mot rates were est otion in acciden m Table 45 (Pa	Ising crash data f iorway Section be timated using the tts for midblock th ue 257) of TANSW	orovided by Ro stween Picton RMS' Accider reatments: Hig v's Principles	ads and Maritin Road and Bella nt Reduction Gu jh speed environ and Guideline o	ne (RMS) for a fi mbi <u>Creek</u> were lide, August 200 iment was appli f Economic App	ive year period used in the an)5. ed. vraisal of Transp	from 1 August 2 alysis. vort Investment.	2008 and 31 Oct and Investigatio	tober 2013. n. March 2013.										
Pebn Roed	 The analysis The analysis orizontal curves 	assumed the passumed the passumed the passumed the passumed the passumed the passumed the passumeter the passum	proposed M1 P proposed upgraid	rinces Motorway de Option D4 (Of nt of loss of contr	Upgrade Optic Tine Scheme) rol crashes oc	on D4 (Offline Si have a new paw ccurring in wet w	cheme) involves ement overlay fo reather.	realignment of or entire upgrad	the horizontal c e section betwe	curves and will a sen Picton Road	also improve drive 1 and Bellambi Cr	r visibility. reek. This in conj	unction with realig	nment of the							
	:\AA007521\D	Calculations	Crash Analysis	s\Offline Schem	ie Crash data\	\[Accident Red	uction_Offline	Scheme_RevE		o Pay.xlsx]Acci	ident Reduction	Section 3									

Cost Savings per year		•		'	1	1	90,048	1,858	•	•	1	1	1		I	1,858	1		'		,		48,740	1,858	144,362								
r (Note 5)	Non- casualty (towaway)	69	¢	A	\$	\$	φ.	\$	θ	69	θ	θ	\$	69 00 7 00 7	\$	θ	S		в	θ	\$		Ю	69	0								
ıvings per yea	Injury (0 en1E 000	8 \$213,632																			
\$ Cost Sa	Fatal												6 7 07 EA	\$ 1, 0 17, 0 4																			
ctions by the de	aay) ay)	0.0	0	0.0	0.0	0.0	4.0	1.0	0.0	0:0	0:0	0:0	0.0	0.0	0.0	1.0		0.0	0.0	0:0		0:0	4.0	1.0	£								
ccident Redu Offline Upgra	iry Non-casi (towaw	0	¢	0	0	0	7	~	0	0	0	0	0	0	0	~		0	0	0		0	3	-	0								
Potential Ac C	Fatal Inju	•		0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	,	0	0	0	0								
Justification			A AAA/	A 90% reduction is suggested.			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 how of whiches in the main traffic lane, travelenges and the main traffic lane.	utus reducting the likeliitiood of rear-end crashes by ou∞. A 20% reduction is suggested.						A 20% reduction is suggested.		A 20% reduction is suggested.																	
Proposed percentage	reduction applied for the offline Upgrade (%)	30%	2000	80%		60%	60%	20%		50%	60%	15%	60%	20%	60%	20%	45%		45%	45%	60%		60%	%09							with		
High speed	Alignment - Alignment - C Change ontal & Vert.		000	6U%		60%	60%				60%		60%	60%	60%		45%		45%	45%	60%		60%	60%							in conjunction		
k treatments:	ident 94.) n Rate (ontal Horiz (ent)			.0		.0	. 0				.0																			3. river visibility.	i Creek. This		
s for midbloc ment (Note 4)	92. Acc e Reductio s) (Horizc Alignm		000	30%		30%	30%				30%		30%	30%							30%		30%	30%			ober 2013.			n, March 201 so improve di	and Bellamb		
on in accident environr	91. Accident Reduction Rat Climbing Lane		CEON	%67							40%						30%		30%	30%	20%		20%	20%			8 and 31 Octo			d Investigatio es and will al	h Picton Road		
entage reducti	Duplicated Road ((30%	10001	%00L		30%	30%			50%	50%	15%		50%			10%		10%	10%	10%		10%	10%			1 August 200	is.		Investment ar horizontal cun	action betweer		
te 1) Perc	- 89. L ualty /away)			_			ო									2							4	-	11		ar period from	t in the analys		al of Transport gnment of the	ire upgrade se ather.		
l in period (<mark>No</mark>	al Injury Non cas (tow						7																-		67		s) for a five ye	ek were used mist 2005.	gust zuuo. /as applied.	omic Appraisa involves realiç	werlay for ent ing in wet we	5	
hes recorded	outhboun Fat															~							-	-	e 6		laritime (RMS	Bellambi Cre	ori Guide, Au environment v	eline of Econo ine Scheme)	w pavement or tshes occurr		
oer of of Cras	orthbound S d						Q	-								-							4		11	ŧ	Roads and M	on Road and	High speed e	les and Guide otion D4 (Offi	ne) have a ne of control cra		
MUN	Total	d 5) nt					a		es;	ing	uci		train		Б	2		(, on	, hit	ō		, on	, hit	0	14	ær Moveme	provided by	e RMS' Acci	treatments:	sW's Princip v Upgrade O	Offline Scher tount of loss		
Crash Description		(Notes 4 an Intersection from adjace.	approaches	Head-on	Opposing vehicles; turning	U-tum	Rear end	Lane chang	Parallel lan	Vehicle leav	Overtaking, same direct	Hit parked	Hit railway	Pedestrian, crossing	Permanent	carriagewa) Hit animal	Off	carriagewa) straight	Off carriageway	object Out of contr	on straight Off	carriagewa) curve	Off carriageway	object Out of contr	on cuive	IM - Road U	ig crash data	way Section	for midblock	e 257) of TfN6 ces Motorwa	Option D4 (educe the an		
JM Code *		lote 5)),11 - 19	ł	, 50 20	2 - 29		0 - 32	- 35	3 - 37	2, 47, 48	, 52, 54	1, 60 – 63, 94	33	60 - 0	1 - 66, 91		1, 72		1, 73		, 82, 84, 86		1, 83, 85, 87			ccidents, RU	dertaken usir	rinces Moton	es were estim	able 45 (Page sed M1 Princ	osed upgrade s will further re		
Code * R		e 4) 109 1(501 24	206 22	304 40	303 31	307 33	309 36	409 42	506 51	4	96	008; 901- 00	ð	67	702; 502; 70	602	7. 7.	502 74	802 80		804 8	38		for Coding A	has been un	subject M1 F	age reduction	ourced from T med the prop	med the proprizontal curves		
DCA		nicle 101- s		201-	202-	207-5	301-	305-3	308-	401-	503-	601	903	- 001- 902	605	609	701-1	-902	703-	705;	801;		803-	805		Definitions f	ash analysis	data for the	D4 - Percenta	per crash sc alysis assun	nalysis assur		
Vehicle Accidents		(Note 4) Two Veh Accident												Single Vehicle	Acciden										Total	* DCA - I Note:	1. The cr	2. Crash 3. Potenti	 Poterii 4. Table (5. Costs 6. The an	7. The an realignme	0	
Road Section		Section 4 - north of Bellambi	Creek		Section 4	A A A A A A A A A A A A A A A A A A A		Bellamhi	Creek					102/2010				EY ROA		TNUON	Option D4	<u>Trees</u>				Catarack	Creek						Picton Koad

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APPENDIX B

ANNUAL COSTS AND BENEFITS

Bits Water Result 2014 (a) 2014 2014	, m	Calculati	ons										
Optimulation Analysis Function Fun	ase Year	2014											
Enconduct Display	pening ear	2018											
Multisla beneficia Costs: Construction Construction Monitaria Construction	nalysis eriod conomic Life	30	years										
Paulysis Creating Annual Ven-Min Creating Total Total 2010 Coses Savings Fundination Eventing Value Value <t< th=""><th></th><th></th><th></th><th>Costs</th><th></th><th></th><th></th><th>Benefit</th><th>s</th><th></th><th></th><th></th><th></th></t<>				Costs				Benefit	s				
Bise Year 200 54, 46, 45, 45 0 54, 46, 45 59 59 59 59 50 <	Analysis Period	Year	Construction Costs	Net Mainte nance Costs	Total Costs	Annual Veh-Hr Savings	Annual Veh-Km Savings	Crash Reduction	Externality	Residual Value	Total Benefits	Net Benefit (Cost)	First Year Benefit
1 2005 566.249.057 50 556 50	ase Year	2014	\$ 4,145,455	0	\$4,145,455	\$0	0\$	\$0	\$0	0\$	\$0	0 -\$4,145,455	55
2 2011 5 (5, 7, 13, 14) 5 (5, 7, 13, 14) 5 (5, 7, 13, 14) 5 (5, 7, 13, 14) 5 (5, 7, 13, 14) 5 (5, 7, 13, 14) 5 (5, 7, 13, 14) 5 (5, 7, 13, 14) 5 (5, 7, 13, 14) 5 (5, 7, 13, 14) 5 (5, 7, 13, 14) 5 (5, 7, 13, 14) 5 (5, 7, 13, 14) 5 (5, 7, 13, 14) 5 (5, 7, 14) 5 (5,	~	2015	\$ 6,468,637	\$	\$6,468,637	\$0	\$0	\$0	\$0	\$0	\$0	-\$6,468,637	
4 2010 5 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.8 55.7.7.7.8 57.7.7.7 57.8.7.7 57.8.7.7 57.8.7.7 57.8.7.7.7 57.8.7.7.7 57.8.7.7.7 57.8.7.7.7 57.8.7.7.7.7	0 0	2016	\$ 65,259,300 \$ 40,704 544	80	\$65,259,300 #40,704 544	\$0 \$	0\$	0	\$0 \$	0\$	0) -\$65,259,300 \$40,704,544	69 6
5 2010 5 5 (0, 61)	0 4	2018	\$ 10,7%1,014	09	\$10,791,014 \$0	\$5.527.128	\$513.313	\$4.186.290	\$218.834	0\$ 0	\$10.445.565	\$10,445,565	\$10.445.56
1 2020 5 56,73,77 55,673,77 55,673,77 55,673,77 55,73,73 56,73,77 56,73,77 56,73,77 56,73,77 56,73,77 56,73,77 56,73,77 56,73,77 56,73,77 56,73,77 56,73,77 56,73,77 56,73,77 56,73,77 56,73,73 56,14,106	5	2019	י ج	\$0	\$0	\$5,700,428	\$507,760	\$4,186,290	\$216,467	\$0	\$10,610,945	\$10,610,945	
7 2021 5 5 56047027 5406 (55 %) 5610 (37) (33 %) 5010 (37) (36 %) 5010 (37) (36 %) 5010 (37) (36 %) 5010 (37) (36 %) 5010 (37) (36 %) 5010 (37) (37) (36 %) 5010 (37) (37) (36 %) 5010 (37) (37) (36 %) 5010 (37) (37) (37 %) 5010 (37) (37) (37 %) 5010 (37) (37) (37 %) 5010 (37) (37) (37 %) 5010 (37) (37) (37 %) 5010 (37) (37) (37 %) 5011 (37) (37 %) 5011 (37) (37 %) 5011 (37) (37 %) 5011 (37) (37 %) 5011 (37) (37 %) 5011 (37) (37 %) 5011 (37) (37 %) 5011 (37) (37 %) 5011 (37) (37 %) 5011 (37) (37 %) 5011 (37) (37 %) 5011 (37) (37 %) 5011 (37) (37 %) 5011 (37) (37 %) 5011 (37 %)	9	2020	۰ ج	\$0	\$0	\$5,873,727	\$502,208	\$4,186,290	\$214,100	\$0	\$10,776,325	\$10,776,325	69
8 2.022 5 - 5580.329 55.70.356 5451.53 54,165.20 5500.5956 50 511.177.466 511.177.476 511.177.476 511.177.476 511.177.476 511.177.476 511.177.477 511.477.476 511.477.477 511.477.477 511.477.476 511.477.476 511.477.476 511.477.476 511.447.726 520.410 521.447.786 511.447.726 520.411.16 501.51.23 511.447.786 511.447.786 511.447.786 511.447.786 511.447.786 511.447.786	~	2021	\$	\$0	\$0	\$6,047,027	\$496,656	\$4,186,290	\$211,733	\$0	\$10,941,706	\$ \$10,941,706	
1 2 2 5	∞ α	2022	, e	\$398,329	\$398,329	\$6,220,326	\$491,104	\$4,186,290	\$209,366	0\$	\$11,107,086	\$10,708,757	69 6
11 2.025 5 - 50	5 0	2023	, ,		0,00	\$6,393,626 #6 FEC 02F	\$485,552	\$4,186,290	\$206,999 6004 600	0.4	\$11,272,466	\$11,2/2,466	<i>,</i> ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
12 2000 5 - 1 - 1 - 1 - 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 <td>2 5</td> <td>2024</td> <td>, , ,</td> <td>00</td> <td>0.4</td> <td>\$6,200,923</td> <td>\$479,999 \$474,447</td> <td>\$4,186,290 \$4,186,290</td> <td>\$202 265</td> <td>04</td> <td>\$11,437,647 \$11,603,227</td> <td>× 11,437,647</td> <td><i>н</i> 4</td>	2 5	2024	, , ,	00	0.4	\$6,200,923	\$479,999 \$474,447	\$4,186,290 \$4,186,290	\$202 265	04	\$11,437,647 \$11,603,227	× 11,437,647	<i>н</i> 4
13 2027 5 51,967,006 \$1,967,006 \$7,500,123 \$4,166,290 \$1,97,531 \$50 \$1,91,333,986 \$51,133,3986 \$51,133,3986 \$51,133,3986 \$51,133,3986 \$51,133,3986 \$51,133,3986 \$51,200,138 \$51,200,138 \$51,200,138 \$51,91,520 \$51,200,238 \$51,200,238 \$51,200,238 \$51,200,239	12	2026	÷ vi	0\$	80	\$6.913,524	\$468.895	\$4,186.290	\$199.898	0\$	\$11.768.607	\$11.768.607	÷ 03
14 2008 5 - 50 57.2601123 54.7771 54.166.200 515.166 50 512.003.363 517.003.363 <th< td=""><td>13</td><td>2027</td><td>, • еэ</td><td>\$1,987,008</td><td>\$1,987,008</td><td>\$7,086,824</td><td>\$463,343</td><td>\$4,186,290</td><td>\$197,531</td><td>\$0</td><td>\$11,933,988</td><td>\$9,946,980</td><td></td></th<>	13	2027	, • еэ	\$1,987,008	\$1,987,008	\$7,086,824	\$463,343	\$4,186,290	\$197,531	\$0	\$11,933,988	\$9,946,980	
15 2028 5 50 577 517 523 517 523 517 523 517 523 517 523 517 523 517 517 523 517 517 523 517 517 523 517 517 523 517 517 517 517 517 517 523 517	4	2028	۰ ج	\$0	\$0	\$7,260,123	\$457,791	\$4,186,290	\$195,164	\$0	\$12,099,368	\$12,099,368	
16 2000 5 7,702,176 552.6,412 54,166.200 523,4418 50 51,263.203 51,372.25 51 19 2001 5 - 5306,323 54,166.200 523,6412 54,166.200 533,173,125 51 51,372.25 51 51,372.25 51 51,372.25 51 55 51 51 51 51 51 51 51 51 51 51 51 51 51 56 51 51 56 51 51 52 51 51 51 56 51 51 56 51 56 51 56 51 56 51 56 51 51	15	2029	ج	\$0	\$0	\$7,481,150	\$492,101	\$4,186,290	\$209,791	\$0	\$12,369,332	\$12,369,332	69
1/1 Z001 5 - \$5398,339 \$309,329 \$5398,339 \$57,122,103 \$560,123 \$41,166,290 \$253,673 \$0 \$13,1346,189 \$13,250,133 \$13,136,116	16	2030	د	80	80	\$7,702,176	\$526,412	\$4,186,290	\$224,418	0\$	\$12,639,297	\$12,639,297	69 6
10 2033 5 - 356,14,125 356,14,125 356,14,125 351,174,154 313,174,154 314,166,290 354,1436 351,344,316 351,442,500 351,442,500 351,442,500 351,442,500 351,442,500 351,442,500 351,442,500 351,442,500 351,442,500 351,442,500 351,442,500 351,442,500 351,442,500 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,442,506 351,44	/1	2031	, Э.	0\$	0\$	\$1,923,203	\$560,723 \$550,723	\$4,186,290	\$239,046	0.00	\$12,909,261	\$12,909,261	<i>•</i> •
20 2004 5 - 500 500 500 565 54,166,200 5227,554 50 513,719,1154 511 21 2005 5 - - 500 500 500 500 513,719,1154 511 513,719,1154 513,719,114 514,529,0147 514,529,0147 514,529,0147 514,529,0147 514,529,0143 514,529,0143 514,529,0143 514,529,0143 514,529,0143 514,529,0143 514,529,0143 514,529,0143 514,529,0133,5142 503,516,7442,966 516	10	2032	, , ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	\$398,329 \$0	\$398,329 \$0	\$8,144,229 \$8 365 255	\$620,033 \$620,344	\$4,186,290 \$4 186 290	\$253,673 \$268 300	04	\$13,1/9,225 \$13,440,180	0 \$12,780,896	<i>•</i>
21 2035 5 - \$5,007,308 \$5,97,965 \$4,166,290 \$573,369,116 \$14,759,012 \$14,759,013 \$14,759,011 \$16,65,200 \$15,67,442,966 \$16,76,7203 \$16,76,7203 \$16,76,7203 \$16,76,7203 \$16,76,7203 \$16,76,7203 \$16,76,7203 \$16,76,7203 \$16,76,7203 \$16,76,7203 \$16,76,76,723 \$16,76,76,723 \$16,76,76,723 \$16,76,76,723 \$16,76,76,723 \$16,76,76,723 \$16,76,76,723 </td <td>20</td> <td>2034</td> <td>Ч</td> <td>0\$</td> <td>\$0</td> <td>\$8.586.282</td> <td>\$663,655</td> <td>\$4.186.290</td> <td>\$282.927</td> <td>\$0</td> <td>\$13.719.154</td> <td>t \$13.719.154</td> <td>, 03</td>	20	2034	Ч	0\$	\$0	\$8.586.282	\$663,655	\$4.186.290	\$282.927	\$0	\$13.719.154	t \$13.719.154	, 03
22 2036 5 - - 52, 827, 193 59, 028, 335 573, 276 54, 186, 290 5312, 182 50 514, 559, 082 516, 510, 569 516, 510, 569 516, 510, 569 516, 510, 569 516, 510, 569 516, 510, 569 516, 510, 569 516, 510, 569 516, 510, 569 516, 510, 569 516, 510, 569 516, 510, 569 516, 510, 569 516, 510, 569 516, 510, 569 516, 5	21	2035	י ج	\$0	\$0	\$8,807,308	\$697,965	\$4, 186, 290	\$297,554	\$0	\$13,989,118	\$13,989,118	, 0,
23 2037 \$\$ -\$5,827,193 \$\$2,47,193 \$\$2,827,193 \$\$2,47,037 \$\$4,186,290 \$\$34,1436 \$\$0 \$\$14,759,047 \$\$11,520,047 \$\$11,520,047 \$\$11,520,047 \$\$11,520,047 \$\$11,520,047 \$\$11,520,047 \$\$11,520,047 \$\$11,520,047 \$\$11,520,047 \$\$11,520,047 \$\$11,500,115 \$\$11,520,047 \$\$11,500,115 \$\$11,500,1500,115 \$\$11,500,1500,1500,115 \$\$1	22	2036	۰ ج	\$0	\$0	\$9,028,335	\$732,276	\$4,186,290	\$312,182	\$0	\$14,259,082	\$14,259,082	57
24 2038 5 - 50 59,470,387 580,097 54,166,290 534,436 50 514,790,011 51 25 2039 5 - 50 59,0,357,555 5796,594 54,166,290 533,341 50 515,422,966 51 44,96,011 51 26 2041 5 - 50 50 50 50 510,135,388 5796,166 54,166,290 533,057 50 515,442,966 51 27 2041 5 - 50 50 510,357,055 5786,156 54,186,290 533,057 50 515,442,966 51 28 2043 5 - 50 50 510,357,055 5786,154 54,186,290 533,057 50 515,442,966 51 50 515,442,966 51 51 51 50 515,442,966 51 50 516,57,645 51 51 51 50 516,57,645 51 50 516,57,645 51 51 516,57,645 51 51 516,57,645 51 51 51 <t< td=""><td>23</td><td>2037</td><td>ч Ф</td><td>-\$2,827,193</td><td>-\$2,827,193</td><td>\$9,249,361</td><td>\$766,587</td><td>\$4,186,290</td><td>\$326,809</td><td>\$0</td><td>\$14,529,047</td><td>\$17,356,240</td><td>69</td></t<>	23	2037	ч Ф	-\$2,827,193	-\$2,827,193	\$9,249,361	\$766,587	\$4,186,290	\$326,809	\$0	\$14,529,047	\$17,356,240	69
ZB 2033 5 - 50 50 50 50 510,013,65 515,013,630 515,013,630 515,0113,609 515,013,609 515,013,609 515,013,609 515,013,609 515,013,609 515,013,609 515,013,609 515,013,609 515,013,609 515,013,609 515,013,609 515,013,609 515,013,609 515,013,609 515,013,609 515,013,609 515,013,609 516,510	24	2038	, ю.	80	\$0	\$9,470,387	\$800,897	\$4, 186,290	\$341,436	\$0	\$14,799,011	\$14,799,011	69 (
ZZ Zum S	90	2039	, Э.е	0 0	0	\$9,692,054 \$0,012,724	\$7.95,984 \$704 070	\$4, 186,290 ©1 106 200	\$339,341 \$227.247	00	\$15,013,669 #15,013,669	9 \$15,013,669	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
28 2042 5 - \$398,329 \$10,357,055 \$761,243 \$41,166,290 \$333,057 \$50 \$15,657,645 \$11 29 2044 5 - \$398,329 \$10,357,055 \$761,243 \$41,166,290 \$333,057 \$50 \$15,657,645 \$11 30 2044 5 - \$50 \$10,578,714 \$41,165,290 \$333,057 \$50 \$15,676,645 \$11 31 2044 5 - \$50 \$10,578,7265 \$766,574 \$41,166,290 \$333,057 \$50 \$15,676,645 \$11 32 2044 5 - \$50 \$11,465,329 \$576,674 \$41,166,290 \$333,057 \$50 \$515,676,645 \$11 32 2047 5 - \$51,050 \$51,145 \$51,166,762 \$512,003 \$516,507,645 \$516,507,645 \$516,507,645 \$516,507,645 \$516,507,645 \$516,507,645 \$516,507,645 \$516,507,645 \$516,507,645 \$516,507,645 \$516,507,645 \$516,506,521,853<	27	2041	, , ,	00	0\$	\$10,135,388	\$786 156	\$4 186 290	\$335 152	00	\$15 442 986	\$15,442,986	
29 2043 \$ - \$ <td>28</td> <td>2042</td> <td>، ب</td> <td>\$398,329</td> <td>\$398,329</td> <td>\$10,357,055</td> <td>\$781,243</td> <td>\$4,186,290</td> <td>\$333,057</td> <td>\$0</td> <td>\$15,657,645</td> <td>\$15,259,315</td> <td></td>	28	2042	، ب	\$398,329	\$398,329	\$10,357,055	\$781,243	\$4,186,290	\$333,057	\$0	\$15,657,645	\$15,259,315	
30 2044 5 - \$0 \$10,800,388 \$771,415 \$4,186,290 \$328,868 \$00 \$16,086,961 \$16 31 2045 \$ - \$50 \$10,800,388 \$771,415 \$4,186,290 \$323,868 \$00 \$16,086,961 \$16 31 2045 \$ - \$50 \$11,243,722 \$766,502 \$4,186,290 \$323,673 \$50 \$516,301,620 \$16	29	2043	۰ ج	\$0	\$0	\$10,578,721	\$776,329	\$4, 186, 290	\$330,962	\$0	\$15,872,303	\$15,872,303	69
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33 204/1 35 - 51,387,008 51,365,008 511,465,389 5706,14 34,136,290 532,363 543,332,433 560,063,369 500 Net	32	2046	ه	\$0	\$0	\$11,243,722	\$761,588	\$4, 186, 290	\$324,678	\$0	\$16,516,278	8 \$16,516,278	69 (
Net Net Net Discount Maintenance First Year Rate Capital Costs PV of Costs PV of Benefits Rate S17.206.544 \$11.64.829 \$78.371.373 \$200.249.962.48 \$121,876.590 2.6 \$59.561.427.22 11.0% PX \$7.770.06.54 \$71.277.571.273 \$500.249.962.48 \$121,876.590 2.6 \$59.561.427.22 11.0%	3	2047	, θ	\$1,307,UU0	\$ 1,307,000	\$11,400,309	4/00'00'¢	\$4, I 00,∠3U	50C,225¢	\$43,332,433	900, UD3, 309	4 \$30,070,301	<i>#</i>
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		4%	\$ 77,206,544	\$1,164,829	\$78,371,373	\$200,249,962.48	\$121,878,590	2.6	\$8,585,492.72 ©7 447 5 42 22	11.0%			
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