Beca

Ōtaki to North of Levin

Tolling Study

Prepared for Waka Kotahi NZ Transport Agency
Prepared by Beca Limited

4 July 2022

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Contents

Appendices

Revision History

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on behalf of	Beca Limited		

Executive Summary

Purpose and Background

This report presents an assessment of tolling on the Ōtaki to North Levin (Ō2NL) project, consistent with the Waka Kotahi policy to consider tolling suitability of all new state highways and significant upgrades to existing state highways.

State Highway 1 (SH1) is New Zealand's premier highway, but the section between Ōtaki and North of Levin is afflicted by serious safety and resilience problems. The importance of this section of SH1 is characterised by its function in connecting Wellington to the central and upper North Island, where no other resilient route exists. It also provides an essential economic connection to Palmerston North, the largest freight node in central New Zealand. Horowhenua is currently experiencing exceptionally high growth after a generation of little activity. Local and regional plans predict that this will continue for some time and large developments are currently underway. Kāpiti Coast has also been experiencing growth and this is forecast to continue.

In response to these challenges, the Ō2NL Project is proposed to improve safety and access, support economic growth, provide greater route resilience, and better access to walking and cycling facilities. In December 2018 the Waka Kotahi Board endorsed the Ō2NL Indicative Business Case and its recommended preferred route for the new offline route for State Highway 1. The preferred route is a 24km four-lane (two lanes in each direction), median divided highway between Taylors Road north of Ōtaki and north of Taitoko/Levin, where it connects back into the existing SH1.

In January 2020, the Government announced the formation of the New Zealand Upgrade Programme (NZUP) which includes the Ō2NL project. The Detailed Business Case (DBC) for the project is close to completion at the time of writing this assessment.

Under section 46 of the LTMA[1], revenue from tolling may be used to contribute towards the 'planning, design, supervision, construction, maintenance, or operation of a new road'. It is Waka Kotahi policy to assess all new roads for tolling, utilising a multi-layer assessment process to determine tolling feasibility. This report provides technical input to inform such an assessment by Waka Kotahi.

Scope and Objectives

Waka Kotahi has determined that the Ō2NL project meets the criteria to progress through to a full tolling assessment and subsequently commissioned Beca Ltd to investigate the effects of tolling Ō2NL on the transport network, to assist in recommending a suitable toll strategy and estimate revenue from tolling from the preferred toll strategy. The scope of the study included:

- the selection of a suitable toll gantry location strategy in collaboration with Waka Kotahi
- estimate revenue from tolling including a risk analysis
- assessment of network impacts from tolling of the corridor
- assessment of the safety implications of tolling of the corridor
- assessment of the impact of tolling of the corridor on enabled emissions

The scope did not include engineering, planning or implementation feasibility and does not make a recommendation on whether or not Ō2NL should be tolled.

[1] The tolling of new roads comes under Section 46 of the LTMA and requires that an Order in Council process be completed before the road is opened. The Minister of Transport holds legislative power to recommend a road for tolling to the Governor-General, provided the Minister is satisfied the requirements of the LTMA have been met, including being satisfied with the level of community support for the proposed tolling scheme.

Methodology

The assessment follows a similar process as previous studies on Puhoi-Warkworth and Penlink projects. It comprised the following key tasks:

- Modification of the existing traffic model being used for the Detailed Business Case (DBC), to respond to tolls, both in terms of route diversion and potential demand suppression
- Adopt toll willingness-to-pay parameters from Tauranga (which has a toll model to reflect the two existing toll roads), adjusted to reflect local income levels for local and through movements
- Liaison with the DBC Project team on key project outcomes, objectives, network assumptions (such as likely outcomes of the State Highway revocation works on the existing SH1) and engagement developing and assessing various toll strategies
- Liaison with the independent peer reviewer
- Assessment of a long list of potential toll gantry location strategies, with a short-listing for detailed modelling assessment
- Analysis of the short-listed options under a range of toll levels, including consideration of direct impacts on revenue, road safety (using the same methodology as used in the DBC), traffic diversion, vehicle emissions and distributional impacts on different user groups of Ō2NL
- Review of the outcomes and selection of a preferred 'balanced network' strategy that sought to find a balance between revenue implications, network effects and maintaining core project objectives
- Explicit consideration of risks and uncertainties in the toll forecasting to provide risk-adjusted traffic flow and revenue estimates

Toll Strategy Options

The study considered a long list of toll gantry location strategies that included options to toll different sections, and different combinations of sections of the Ō2NL route. In conjunction with Waka Kotahi, four strategies were selected to be taken forward to a more detailed assessment.

Tolling Ō2NL was found to:

- *Divert a proportion of traffic from Ō2NL back to the existing SH1 and SH57*
- *Maintain a significant proportion of reductions in crash cost costs and DSI compared to today and the future year Do Minimum scenario, but increase crash costs and DSI compared to the no toll scenario as a result of more traffic on the existing SH1 and other parts of the local network*
- *Reduce enabled emissions compared to the no toll scenario by reducing induced traffic and re-routing users who choose to avoid the toll to a shorter route*
- *Have no material detriment to travel times across the network*

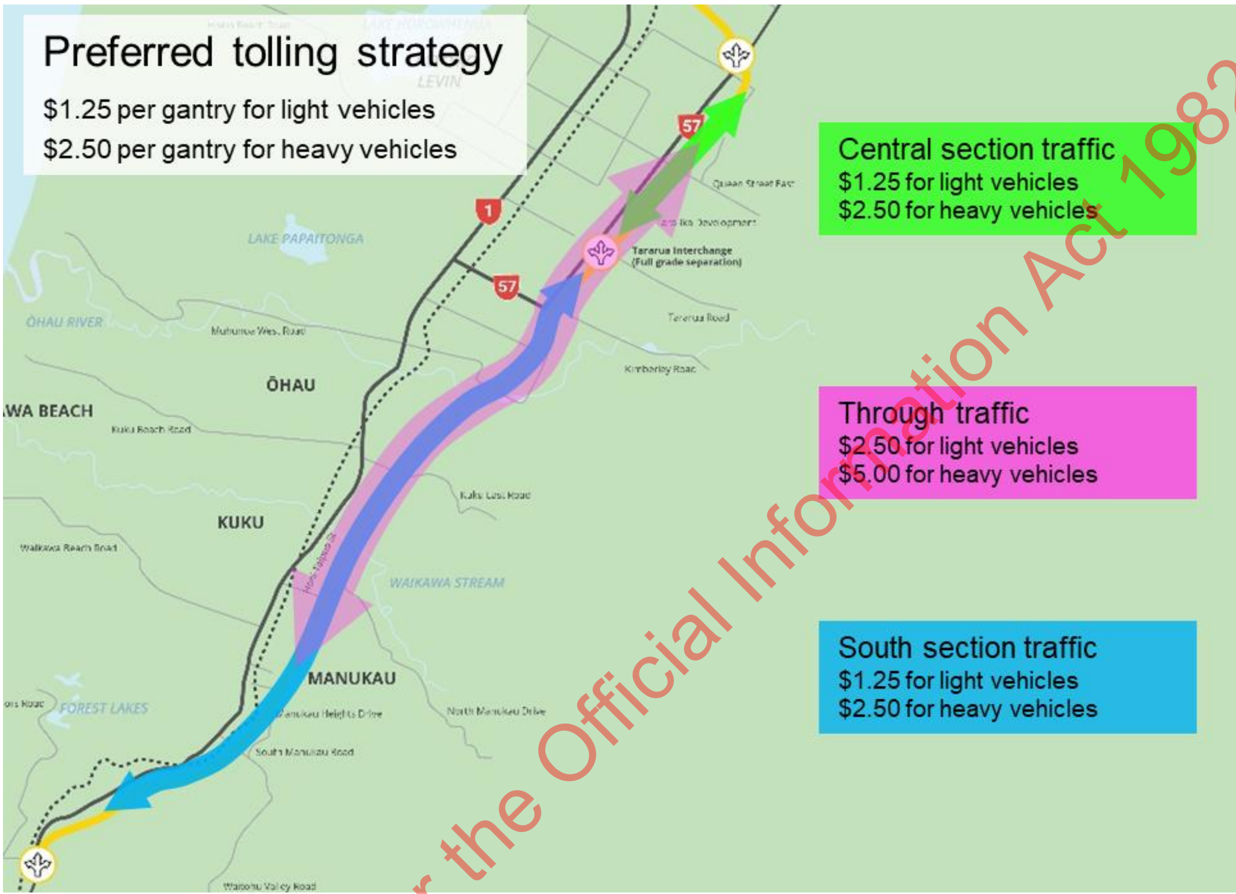
A preferred tolling strategy and tolling level was selected that balanced the need to generate sufficient revenue for the implementation of toll infrastructure and meet/contribute to maintenance and operational costs, revocation costs and construction costs, while minimising the impact on the forecast crash costs and deaths and serious injuries (DSI). The preferred strategy also had the benefit of reducing emissions more so than other strategies.

The preferred tolling strategy comprises:

- *A gantry on Ō2NL between Taylors Road interchange and the Tararua interchange*
- *A gantry on Ō2NL between the Tararua interchange and the intersection with SH57*
- *A constant, all-day toll level*
- *A $1.25 toll for light vehicles and a $2.50 toll for heavy vehicles at each toll gantry*

The pricing strategy was developed as an incremental toll to reduce the impact on local users. For context, the revenue maximising toll was found to be at approximately $2.50 per toll gantry, generating net revenues some 80% greater than the preferred (balanced) toll scenario.

Figure A Preferred tolling strategy



Traffic Flow and Revenue Forecasts

The Ō2NL traffic model was updated to allow for a demand response and a route choice response to tolling. The model was used to predict traffic volumes on Ō2NL as well as impacts on traffic levels across Levin. A range of risks and uncertainties in the forecasting were sensitivity tested, including revocation assumptions, willingness-to-pay parameters, growth assumptions etc, then combined via Monte-Carlo simulation to obtain 5^{th}, 50^{th} and 95^{th} percentile traffic flow estimates.

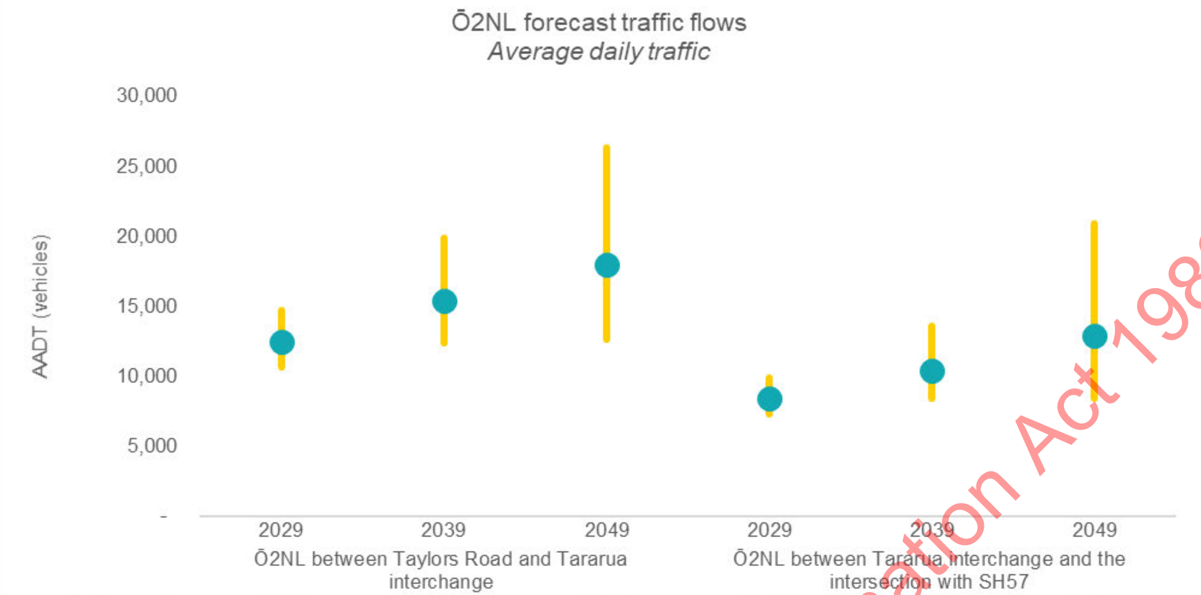
The forecast average daily flows on Ō2NL in the preferred toll strategy are presented in Table A below:

Table A Preferred toll strategy - Forecast average daily flows on Ō2NL

Year	Forecast average daily flows (50^{th} percentile) Ō2NL between Taylors Road and Tararua interchange	Ō2NL between Tararua interchange and the intersection with SH57
2029	12,500 vpd	8,400 vpd
2039	15,400 vpd	10,400 vpd
2049	18,000 vpd	12,900 vpd

The above forecasts are 50^{th} percentile average daily flows. The 5^{th} percentile, 50^{th} percentile and 95^{th} percentile forecast average daily flows are presented in Figure A below.

Figure A Forecast average daily flows on Ō2NL



	Ō2NL between Taylors Road and Tararua interchange 2029	2039	2049	Ō2NL between Tararua interchange and the intersection with SH57 2029	2039	2049
5th Percentile	10,700	12,400	12,600	7,300	8,400	8,400
50th Percentile	12,500	15,400	18,000	8,400	10,400	12,900
95th Percentile	14,700	19,900	26,300	9,900	13,600	20,900

These traffic flows are estimated to generate annual gross revenue[2] of

- $10.7m in 2029
- $13.2m in 2039
- $15.8m in 2049

With a 50th percentile toll transaction cost of 70c per journey[3] (as advised by Waka Kotahi), the 50th percentile net revenue of the preferred toll strategy is estimated to be:

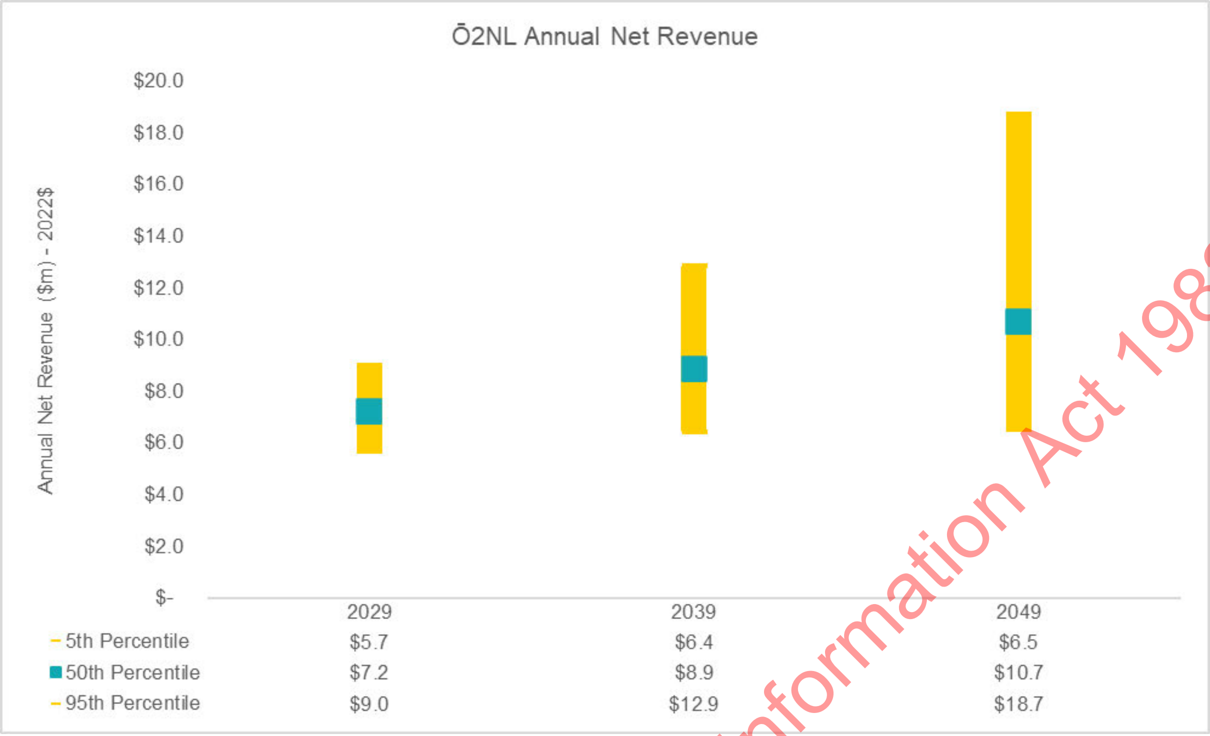
- *$7.2m in 2029*
- *$8.9m in 2039*
- *$10.7m in 2049*

The 5th percentile, 50th percentile and 95th percentile forecast net revenue from tolling with the preferred strategy is presented in Figure B below.

[2] The 50th percentile estimate of gross revenue includes a reduction to account for 'revenue leakage' of 3% for light vehicles and 2% for heavy vehicles.

[3] All revenue forecasts presented in this report exclude the impact of taxes (such as GST) on net revenue.

Figure B Forecast annual net revenue from tolling



The key risks to the forecasts are related to land use, the Tara-Ika development, and the forecast changes in users' value of time, with the land use assumptions having by far the biggest influence on the variation in the traffic volume forecasts and revenue forecasts. The land use assumptions are from the Horowhenua Socio-Economic projections report by Sense Partners (May 2020). The land use projections in the report provide 5th percentile, 25th percentile, 50th percentile, 75th percentile and 95th percentile land use projections. The difference between the 5th percentile and the 95th percentile population forecast grows over time. The difference is 12% 2029, 45% in 2039 and 100% in 2049. Note that the 75th percentile land use projections were used as the central forecast in the DBC with the 25th percentile and 95th percentile land use assumptions being used for the low and high forecasts. Whereas the forecasts above are 5th, 50th and 95th percentile forecasts and therefore use 5th, 50th and 95th land use assumptions.

Other Key Outcomes

The tolled scheme, compared to the no tolled scheme, is expected to reduce vehicle kilometres travelled by 19 million kilometres in 2029, 22 million kilometres in 2039, and 25 million kilometres in 2049 (non-risk adjusted, 75th percentile land use forecasts).

The tolled scheme, compared to the no tolled scheme, is expected to reduce CO_2e by 4,300 tonnes in 2029, 3,900 tonnes in 2039, and 2,600 tonnes in 2049 (non-risk adjusted, 75th percentile land use forecasts).

Crash costs and DSI are predicted to reduce significantly on the present-day crash costs as result of the Speed and Infrastructure Programme (SIP). With Ō2NL in place, crash costs and DSI are predicted to reduce further as a result of less traffic on the existing SH1 and the addition of revocation works and speed reductions on the existing SH1. With the toll added, crash costs and DSI are predicted to increase slightly, but are still well below the 2018 amounts, and the predictions without the scheme in place. In terms of DSI's saved, the Business Case indicates an annual reduction (2029) of some 12.7 per annum (including revocation works and speed reductions), with tolling expected to reduce this by 14% to approximately 11.0.

Limitations

This analysis is based on the existing Ō2NL traffic model (modified to represent tolling) and driver willingness to pay (WtP) parameters from other studies (albeit refined and updated to local conditions). Detailed market research into WtP has not been undertaken specifically for this work, however the effects of uncertainties in WtP and other key inputs and assumptions have been estimated via sensitivity tests and risk-profiling. While this work provides estimates of traffic volumes and revenue suitable for network planning, the revenue estimates are not considered 'investment grade' such as might be required for private-sector investment.

The purpose of this report is to assess the transport network impacts and revenue implications from tolling the Ō2NL scheme, in accordance with the parameters of our agreed scope as set out in our proposal. Further analysis may be required in order to support more detailed financial analysis.

Although in this report, Beca offers professional advice and may express opinions on likely or possible outcomes, we cannot guarantee any particular outcome and any decision to proceed with the next phase of investigation is a commercial decision for Waka Kotahi.

It should be noted that the toll revenue estimates provided as part of the Services are not a statement of absolute revenue suitable for detailed investment decisions, rather they will have an accuracy range commensurate with various factors such as the extent of relevant information provided, the certainty of data and assumptions and the level of detail available at the time of preparation.

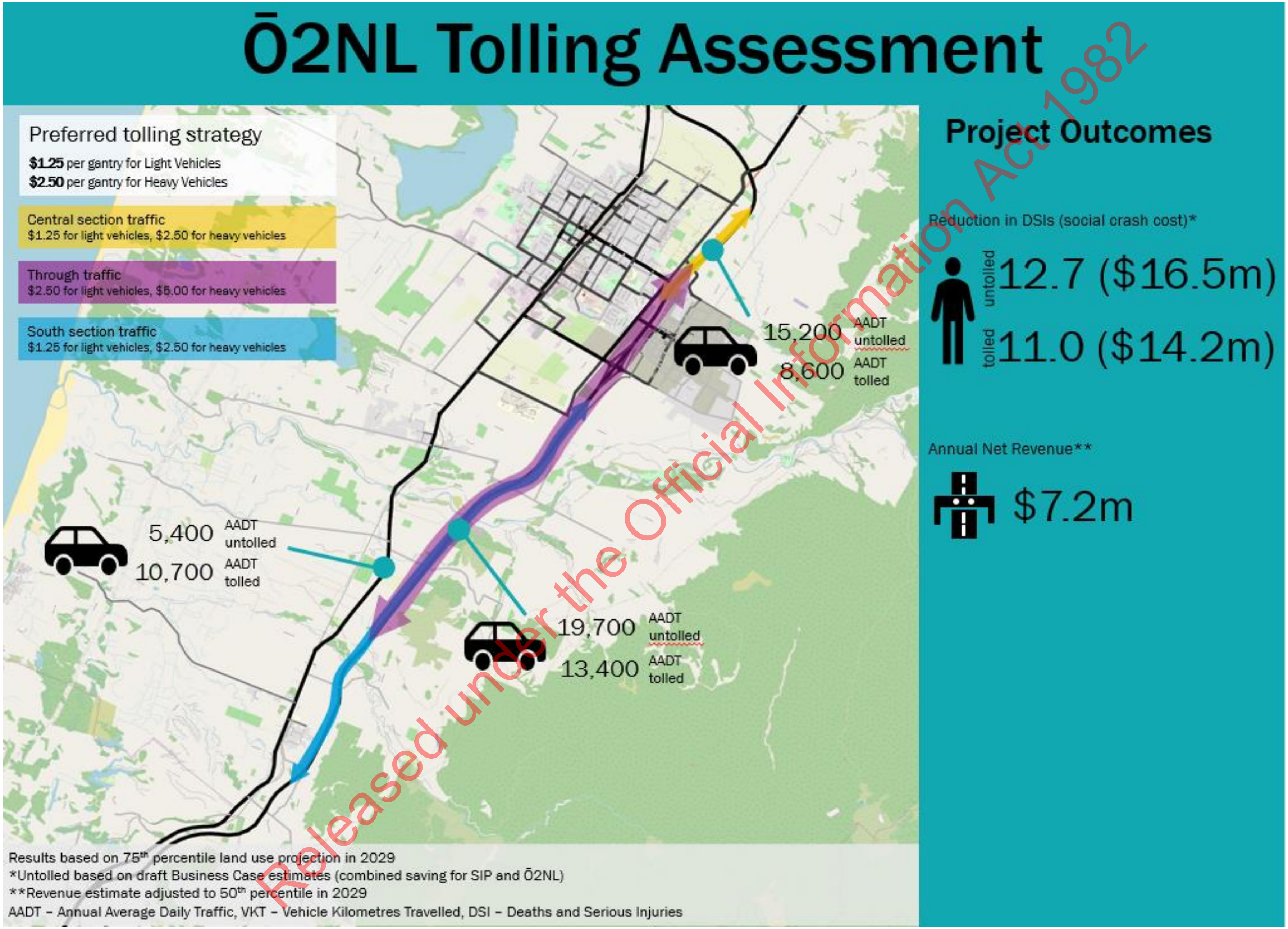
Assessment of the transport network impacts is limited to the following outcome measures:

- Traffic flows
- Travel times
- Safety – as measured by the social crash cost difference between a tolled and un-tolled scenario
- Emissions – as measured by the change in vehicle CO_2 emissions between a tolled and un-tolled scenario
- Equity – as simplistically considered in terms of pricing across the different users of the corridor
- Revenue

This assessment has included the transport system effects noted above and has not included a wider assessment against Waka Kotahi or other Government policies or frameworks. Forecasting traffic flows for a new toll road contains inherent uncertainty. While this report has attempted to quantify the potential scale of the key uncertainties, the risks associated with traffic forecasts should be considered in design and policy decisions for this project.

In preparing this assessment we have relied on the inputs and assumptions provided by or agreed with Waka Kotahi as outlined in this report, including:

- Ō2NL model and the coding of the scheme in the model
- Design of Ō2NL project
- Land use inputs from the Horowhenua Socio-Economic projections report by Sense Partners (May 2020)
- Wider network project assumptions regarding SIP
- Toll system transaction costs
- Waka Kotahi and Auckland Council's Vehicle Emission Prediction Model
- Revocation works assumptions for sensitivity tests


Ō2NL Tolling Assessment
Preferred tolling strategy
$1.25 per gantry for Light Vehicles
$2.50 per gantry for Heavy Vehicles
Central section traffic
$1.25 for light vehicles, $2.50 for heavy vehicles
Through traffic
$2.50 for light vehicles, $5.00 for heavy vehicles
South section traffic
$1.25 for light vehicles, $2.50 for heavy vehicles
15,200 AADT untolled
8,600 AADT tolled
5,400 AADT untolled
10,700 AADT tolled
19,700 AADT untolled
13,400 AADT tolled
Results based on 75th percentile land use projection in 2029
*Untolled based on draft Business Case estimates (combined saving for SIP and Ō2NL)
**Revenue estimate adjusted to 50th percentile in 2029
AADT – Annual Average Daily Traffic, VKT – Vehicle Kilometres Travelled, DSI – Deaths and Serious Injuries
Project Outcomes
Reduction in DSIs (social crash cost)*
untolled 12.7 ($16.5m)
tolled 11.0 ($14.2m)
Annual Net Revenue**
$7.2m

1 Study purpose

Waka Kotahi has determined that the Ō2NL project meets the criteria to progress through to a full tolling assessment and subsequently commissioned Beca Ltd to investigate the effects of tolling Ō2NL on the transport network, to assist in recommending a suitable toll strategy and estimate revenue from tolling for the preferred toll strategy.

The scope of the study included:

- the selection of a suitable toll gantry location strategy in collaboration with Waka Kotahi
- estimate revenue from tolling including a risk analysis
- assessment of network impacts of tolling of the corridor
- assessment of the safety implications of tolling of the corridor
- assessment of the impact of tolling of the corridor on enabled emissions

The scope did not include engineering feasibility, planning implications, implementation assessment, or a recommendation on whether or not Ō2NL should be tolled. The report does not address the level of tolling that is appropriate to recover the costs, as this will be the subject of separate consideration by Waka Kotahi.

This report presents the study methodology and outcomes.

2 Context

Introduction

State Highway 1 (SH1) is New Zealand's premier highway, but the section between Ōtaki and North of Levin (Ō2NL) is afflicted by serious safety and resilience problems.

The importance of this section of SH1 is characterised by its function in connecting Wellington to the central and upper North Island, where no other resilient route exists. It also provides an essential economic connection to Palmerston North, the largest freight node in central New Zealand.

Waka Kotahi NZ Transport Agency (Waka Kotahi) has been investigating potential upgrades and new alignment options to address the issues with the existing SH1 route and to allow sustainable growth in Levin.

The Indicative Business Case (IBC) for the project outlined a strong case for change and a thorough assessment of alternatives. In December 2018 the Waka Kotahi Board approved and endorsed the IBC's preferred option of an offline highway, from Taylors Road (in the south) to north of Levin within a 300m corridor. The Ō2NL project was included in the 'Wellington Package' of the New Zealand Upgrade Programme to *"improve safety and access, support economic growth, provide greater route resilience, and better access to walking and cycling facilities*".

A Detailed Business Case (DBC) is close to completion at the time of writing. The project objectives for the Ō2NL project set out in the DBC are:

- Enhance safety of travel on the state highway network
- Enhance the resilience of the state highway network
- Provide appropriate connections that integrate the state highway and local road network to serve urban areas
- Enable mode choice for journeys between local communities by providing a walking and cycling facility; and

- Support inter and intra-regional growth and productivity through improved movement of people and freight on the state highway network.

Problems

In the last five years to 2021, there were 72 deaths and serious injuries (DSI) along SH1 and SH57 within the project area, making it one of the country's most dangerous sections of road. It is likely that the poor safety record will worsen over time, as the trend of increasing traffic volumes and significant local development will result in a greater exposure risk for vehicles to conflict with either opposing vehicles or other hazards. (*Source: DBC, May 2022*).

The DBC describes that Horowhenua is currently experiencing exceptionally high growth after a generation of little activity. Local and regional plans predict that this will continue for some time and large developments are currently underway. Kāpiti Coast has also been experiencing growth and this is forecast to continue. Horowhenua District Council (HDC) have a programme investigating additional growth areas to proactively manage this increase. One of these which is currently being implemented is Tara-Ika, a 400ha residential and mixed-use development which would result in approximately 3,500 houses to the east of the town. This area is currently subject to a Plan Change. In addition to growth in Horowhenua, the Kāpiti Coast is also expected to grow, with over 22,000 additional people forecast to be living in the district by 2041. This is an increase of approximately 40% compared to 2021. If the growth was to occur without transport investment, local movement around the district would be severely affected.

The core resilience issues of route criticality coupled with high incident likelihood are unchanged since the IBC. As demand for travel continues to grow, coupled with climate change and the continued ageing of structures, the journeys impacted by incidents will increase in the future. This section of SH1 in particular is at high risk of closure from crashes, earthquakes (five bridges have a high or significant earthquake disruption risk) and flooding.

Tolling

Tolling is a funding mechanism Waka Kotahi may establish under the Land Transport Management Act 2003 (LTMA), which enables users of a road to contribute to its cost over time.

Under section 46 of the LTMA, revenue from tolling may be used to contribute towards the 'planning, design, supervision, construction, maintenance, or operation of a new road'. It is Waka Kotahi policy to assess all new roads for tolling, utilising a multi-layer assessment process to determine tolling feasibility. The Ō2NL project meets the criteria for full tolling assessment, and this study is in response to that policy.

3 Scheme

The DBC recommended approach to addressing the described problems is a 24km four-lane (two lanes in each direction) highway from Taylors Road running along the east of Levin to North of Levin as presented in Figure 3-1 below. The project includes the following features:

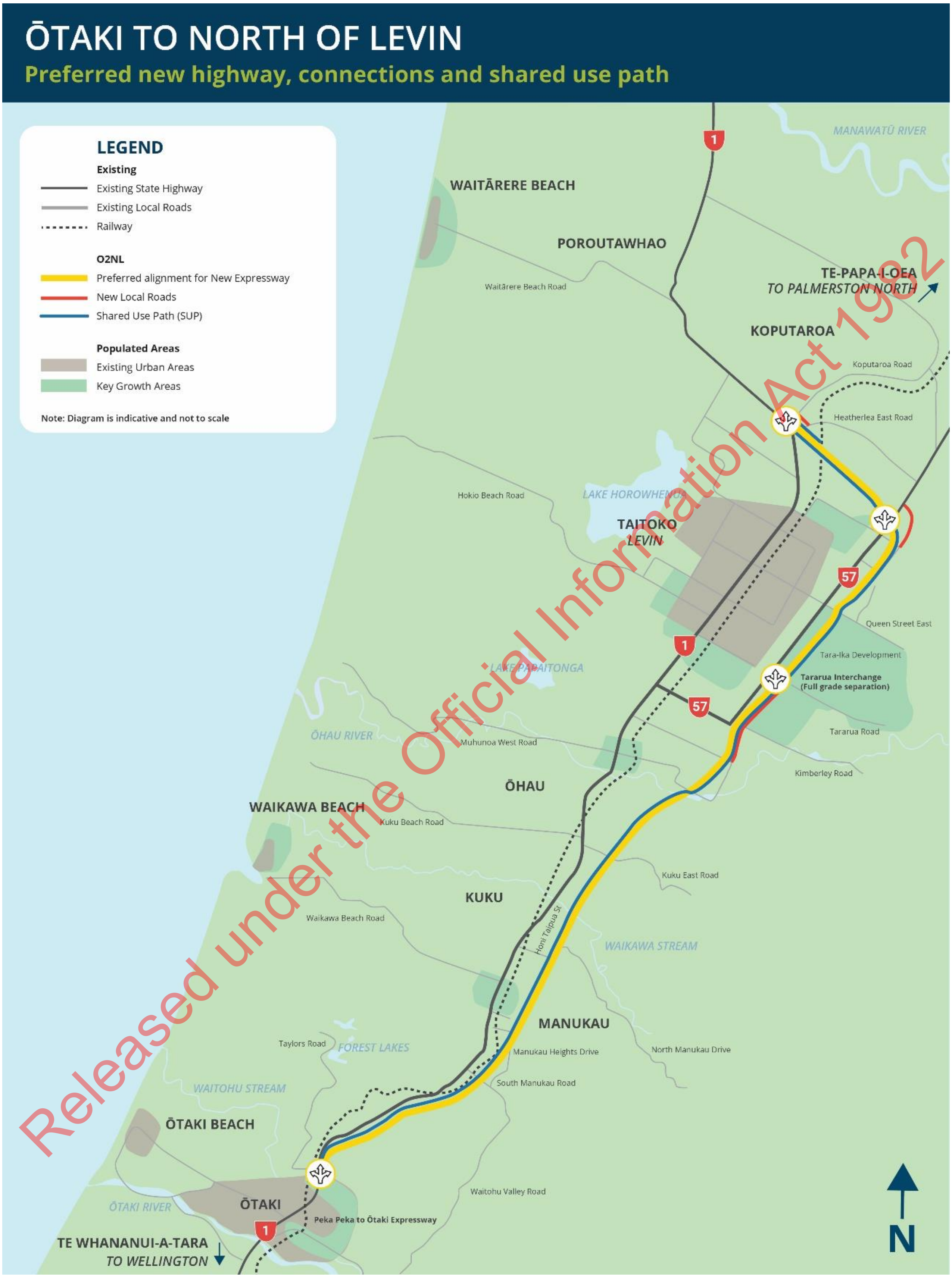
- Approximately 24km four-lane (two lanes in each direction), median divided highway between Taylors Road north of Ōtaki and north of Taitoko/Levin, where it connects back into the existing SH1.
- A highway design to enable a speed limit of either 100km/h or 110km/h and connects to the end of the Peka Peka to Ōtaki Expressway. (Modelling currently assumes a 100km/h speed limit)
- A grade separated diamond interchange at Tararua Road providing access into Levin
- Roundabouts where the Ō2NL Project crosses State Highway 57 and where it ends at State Highway 1 north of Levin
- A half interchange with southbound ramps near Taylors Road and the connection to the new Peka Peka to Ōtaki expressway
- A separated shared use path (SUP) for walking and cycling along the entire length of the new highway that will link into shared path facilities built as part of the PP2Ō expressway (and further afield to the M2PP expressway shared path)

If approved, construction is planned between 2025 and 2029 and opening is planned to be 2029. The first full year of benefits would be in 2030.

At the start of the tolling study the revocation workstream was in progress and so revocation works (such as changes to posted speed limits on the existing SH1) were not known. As such, the core modelling of the scheme with and without tolling did not include revocation works[4]. At the time of the sensitivity testing for tolling, the revocation workstream was able to advise on the recommended revocation works including posted speed limits on the existing SH1 and SH57. These were included the sensitivity tests (see section 6 Risk analysis).

[4] The modelling does include speed reductions on the existing SH1 and SH57 that are part of the SIP. These speed reductions are included in the Do Minimum (without Ō2NL) and Do Something scenarios (with Ō2NL).

Figure 3-1 Ō2NL scheme (Preferred alignment of new expressway) *Source: DBC, May 2022*



In order to improve safety in the short term, ahead of any longer-term solutions, speed limit reviews and safety upgrades are being fast tracked as part of the Speed and Infrastructure Programme (SIP).

Improvements planned during the 2021-24 National Land Transport Plan period for both SH1 and SH57 are outlined below. These have been included in the Do Minimum for Ō2NL. However, while speed limit reviews are underway for the existing SH1 and SH57 these will include community consultation activities, followed by the associated approvals processes. No timeline has been confirmed at this stage.

SH1: Taylors Road to South of Levin proposed online safety improvements include:

- Wire rope median barrier from the Peka to Ōtaki (PP2Ō) tie-in to the Manakau Township between Manakau and Ōhau wide centre lines (WCL) / flush median, edge protection and improved signs and markings are proposed [Fast tracked in 2021/22]
- Removal of two northbound and one southbound passing lanes to improve safety (i.e., substandard length, proximity to key conflict points e.g., Marae) [Fast tracked in 2021/22]
- A new roundabout at the existing SH1/57 intersection [pending review by SIP]
- Speed limit reviews are underway for this section. For the purposes of the Do-Minimum modelling an 80km/h Safe and Appropriate Speed (SAAS) from south of Manakau to South of Levin has been assumed.

SH57: SH1/57 to SH57/Heatherlea East Road proposed online safety improvements include:

- New roundabouts at SH57/Tararua Road and SH57/Queen St Corridor wide centre line (WCL), edge protection and improved signs and markings.
- Speed limit reviews are underway for this section. For the purposes of the Do-Minimum modelling an 80km/h from SH1/57 to SH57/Tavistock Road has been assumed.

The scheme assessed in the DBC is expected to reduce deaths and serious injuries by 50-55% per annum by 2030. This is primarily achieved by the reduction in traffic on a substandard section of highway and shifting them to a high quality directionally separated road. This provides much stronger protection against head on crashes.

The scheme is expected to reduce the duration of journeys affected by closures and delays by 60% by 2030. The preferred option will provide a significantly shorter viable local alternative route, remove traffic off high resilience-risk structures, improve the redundancy of the wider transport network by providing additional river/stream crossings and reduce the number of unplanned closures. The transport network will be futureproofed for a changing climate, as flood risk on the existing highway becomes more extreme. In the event of an unplanned closure the revoked section of SH1 will be a much shorter detour option than the current route via the Remutaka's (which is also prone to closures).

The scheme provides appropriate connections that integrate the state highway and local road network to serve urban areas by 2030, enables mode choice for journeys between local communities by providing a north-south cycling and walking facility by 2030, and supports inter and intra-regional growth and productivity through improved movement of people and freight by 2030.

4 Tolling study

4.1 Overview

The study considered a long list of toll gantry location strategies that included options to toll different sections, and different combinations of sections of the Ō2NL route. In conjunction with Waka Kotahi, four strategies were selected to be taken forward to more detailed assessment. The more detailed assessments utilised the Ō2NL traffic model, as used for the detailed business case (with enhancements to represent tolling) and the Ō2NL crash model, also used for the detailed business case.

The preferred scenario and tolling level were selected from the short-list by balancing a number of outcomes as described in the following sections.

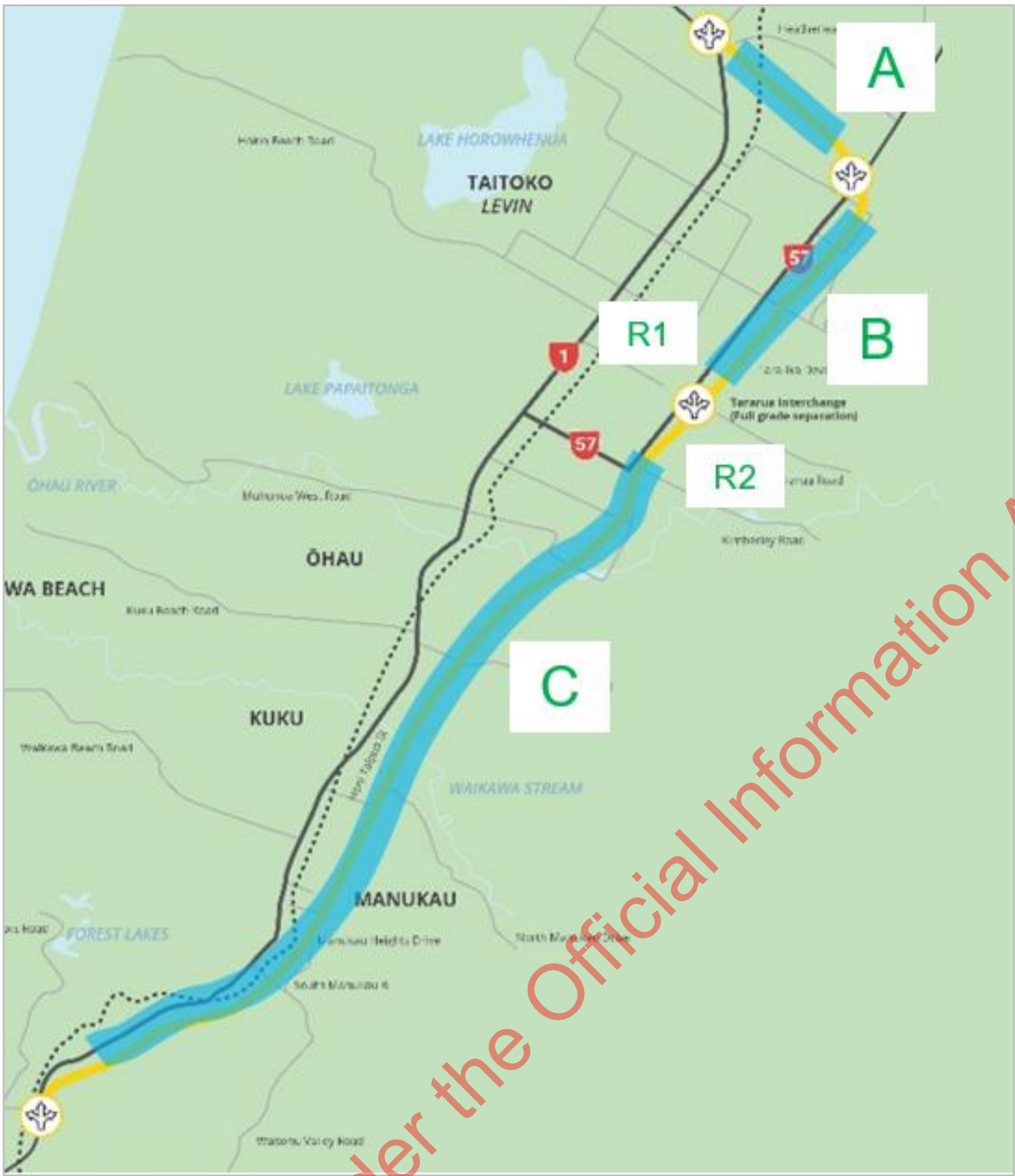
4.2 Assessment of toll gantry location strategies

The study considered a long list of 10 toll gantry location strategies. The list included options to toll different sections, and different combinations of sections of the Ō2NL route. The following five 'broad' locations were considered for locating toll gantries:

- The section north of Levin between the intersection with SH57 and the intersection with the existing SH1 (*Section* ***A***)
- The section east of Levin between the Tararua interchange and the intersection with SH57 (*Section* ***B***)
- The section south of Levin between Taylors Road interchange and the Tararua interchange (*Section* ***C***)
- The Tararua Road interchange north facing ramps (*Ramp location* ***R1***)
- The Tararua Road interchange south facing ramps (*Ramp location* ***R2***)

These sections (section A, B, C, R1 and R2) are illustrated in the road schematic presented in Figure 4-1 below. This naming convention of are used throughout the tolling study to describe the location of gantries and the sections of Ō2NL users are predicted to use.

Figure 4-1 Ō2NL road schematic and toll section system



Nine gantry location strategies were developed for the workshop and a 10th strategy was conceived at the workshop. The long list of strategies is provided in Appendix A. A preliminary assessment of each strategy was undertaken to score each strategy based on the following criteria:

Table 4-1 Long list sifting criteria

Long-list Criteria ***used to sift long list***	**Definition** ***at long list stage***
Fairness	Do users of each section of the route have similar paid/free access Is payment similar on a per-km basis. (The possible negative consequences of this kind of user cost fairness, are captured under enabled emissions and safety criteria) Is tolling consistent with similar toll road corridors in NZ.
Revenue	Potential revenue per year. High revenue potential relative to other strategies score high.
Efficiency	Revenue potential vs. transaction costs to agency.

	Note that transaction costs to would be by trip and not by gantry. For example, collecting a relatively low toll for a section would be inefficient. Revenue potential vs. Construction costs is covered by the separate criteria, so not included in this criteria assessment
Capital costs	Estimate of the total gantry costs, including provision of services. High costs relative to other strategies score low.
Safety	Will the strategy encourage routing through Levin township or other local roads, which is considered less safe on balance compared to the high speed but high-quality new route?
Enabled emissions	The GHG emissions that arise from use of the infrastructure. We are interested in the change in enabled emissions that would result from the scheme. Will the strategy encourage re-routing via longer routes, via more congested routes? Will the strategy suppress demand (reduce inefficient trips), or lead to generated traffic relative to the other strategies?

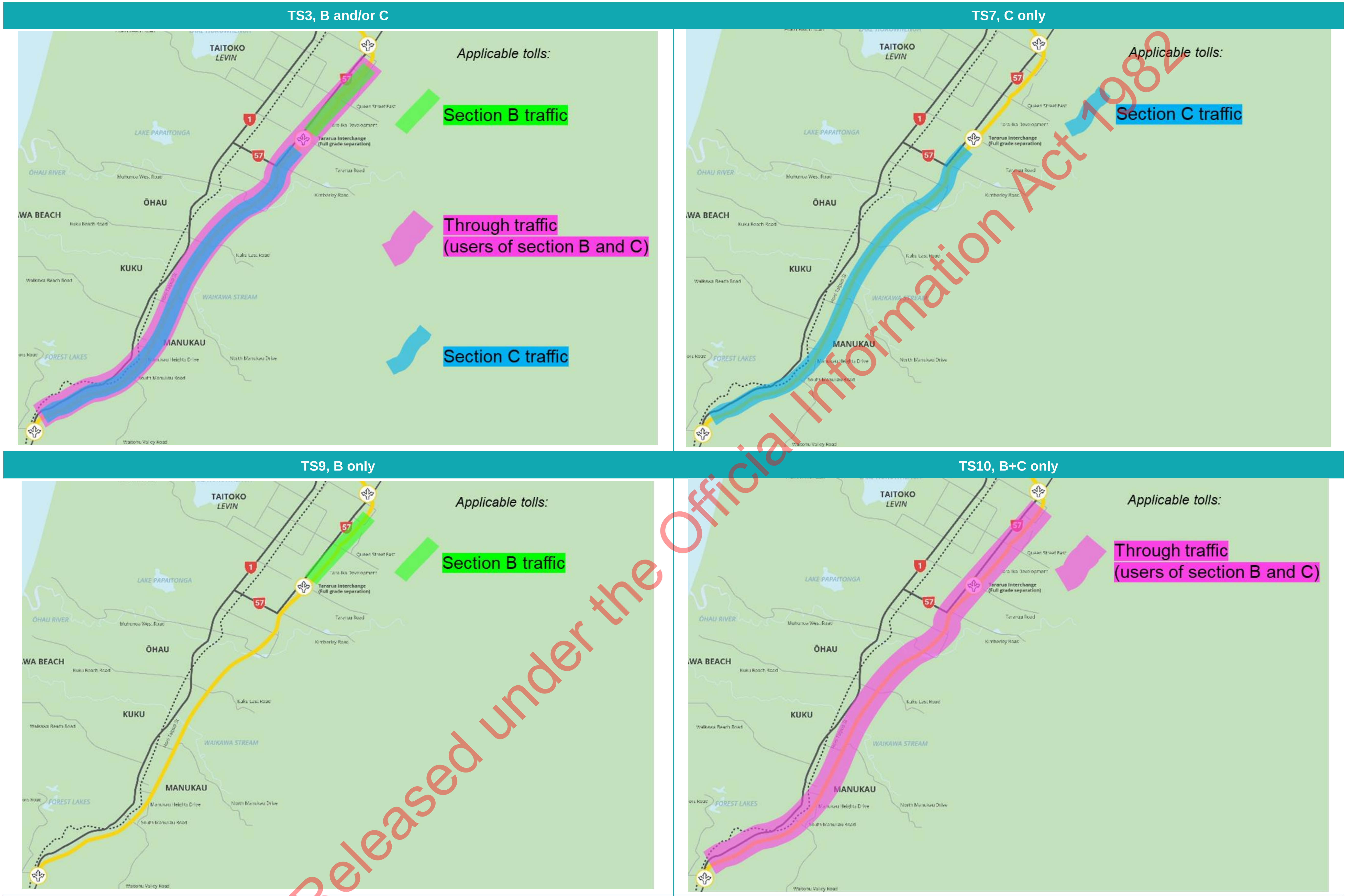
The preliminary assessment scores for each strategy against the criteria above is provided in Appendix A. At a workshop on 31 March 2022 with Waka Kotahi staff including the project director and project manager, the long list of strategies was evaluated and a short-list of four strategies were selected to be taken forward to a more detailed assessment. The more detailed assessments utilised the Ō2NL traffic model, as used for the detailed business case (with enhancements to represent tolling) and the Ō2NL crash model, also used for the detailed business case. The four short-listed gantry location strategies are described below and illustrated in Figure 4-2:

Table 4-2 Short listed toll gantry location strategies

Toll Strategy number[5]	Short-hand description	Description
TS3	B and/or C	Toll gantry on section B and on section C with incremental toll.
TS7	C only	Toll gantry on section C only, the largest section of the corridor.
TS9	B only	Toll gantry on Section B only, the middle section of the corridor.
TS10	B+C only	Toll gantries on section B and section C but only toll users of both B and C.

[5] The numbering system is from the long list of toll gantry location strategies

Figure 4-2 Short-listed toll gantry location strategies



Tolling of section A was included in some of the long list strategies but was not taken forward in the short-listed strategies. The section has the lowest flows of the three sections. It was judged inefficient to invest in a toll gantry for this section. In addition, a toll on this section would likely result in high diversion to the parallel alternative route via Heatherlea East Road.

Consideration was given to whether higher tolls in certain time periods would be suitable, such as in the traditional commuter AM and PM peaks. There was not strong case for peak tolls. The volume of traffic in the area is generally spread throughout the day, peaking in the afternoon. There is no traditional commuter AM peak and no times which are significantly quieter during daylight hours. This is likely to be a result of no strong commuter movement coupled with Levin functioning as a rural service town. As such this study assumed flat, all-day tolls in the assessment of the strategies.

Traffic modelling

The tolling study utilised the existing Ō2NL traffic model being used by Waka Kotahi for the DBC, albeit modified to respond to tolls. The model modifications are described Appendix B along with other background information regarding the traffic model and annualisation factors.

The traffic model represents three time periods:

- Weekday AM peak hour (08.00 - 09.00)
- Inter-peak average hour (09:00 - 16:00)
- weekday PM peak hour (16:30 - 17:30)

The effects of holiday traffic in the area on average daily traffic flows and forecast revenue from tolling are accounted in the factors that convert the above modelled hours into annual average daily demand. The factors are derived from 2018 Count data in Ohau on SH1. The derivation of the factors is described further in Appendix B.

The model has a base year of 2018 and the forecast modelled years are 2029, 2039 and 2049. Future year land use assumptions are based on land use assumptions from the Horowhenua Socio-Economic projections report by Sense Partners (May 2020). The modelling of the short-listed options used the 75th percentile land use estimates (consistent with the core scenario in the DBC).

The detailed assessment of the short-listed strategies involved modelling each strategy under a range of toll levels. The range chosen was $1 to $2.50 for light vehicles (with twice the amount for heavy vehicles). The tests were named as follows (named based on the light vehicle toll):

- $1.00 Test
- $1.50 Test
- $2.00 Test
- $2.50 Test

Note that the toll for the TS3 (a toll for users on B and / or C) was tested as an incremental toll, so if users use both section C and section B then users are subject to the toll on section C plus the toll and section B, i.e., twice the toll described by the test name. It is noted that in the Executive Summary, and at the end of this section and beyond, the naming convention for the toll level in this toll strategy changes. We instead describe the toll level by the toll to users of B and C and local users (those that just use C but not B, or B but no C) are given a 50% discount. In this section though, we use the convention used at the time of the shortlist assessment.

The chosen range of toll levels from $1 to $2.50 for light vehicles was chosen based on initial testing of a $2.00 toll that showed diversion from Ō2NL back to the existing SH1 was high at this level of toll.

Outcomes

The short-listed options were modelled using the Ō2NL traffic model for the year 2039 with the 75th percentile land use forecast. The traffic model outputs were used to establish the impacts of each strategy and toll price on the following network attributes and strategy statistics:

1. Net revenue from tolls
2. Traffic demand on Ō2NL
3. Traffic volumes on the existing SH1 South of Levin
4. Forecast crash costs and DSI (using the Ō2NL crash model)
5. Enabled Emissions
6. Travel times on the existing SH1
7. Distributional effects - Origin of trips using Ō2NL and origin of diverted trips in response to toll (to assess equity)

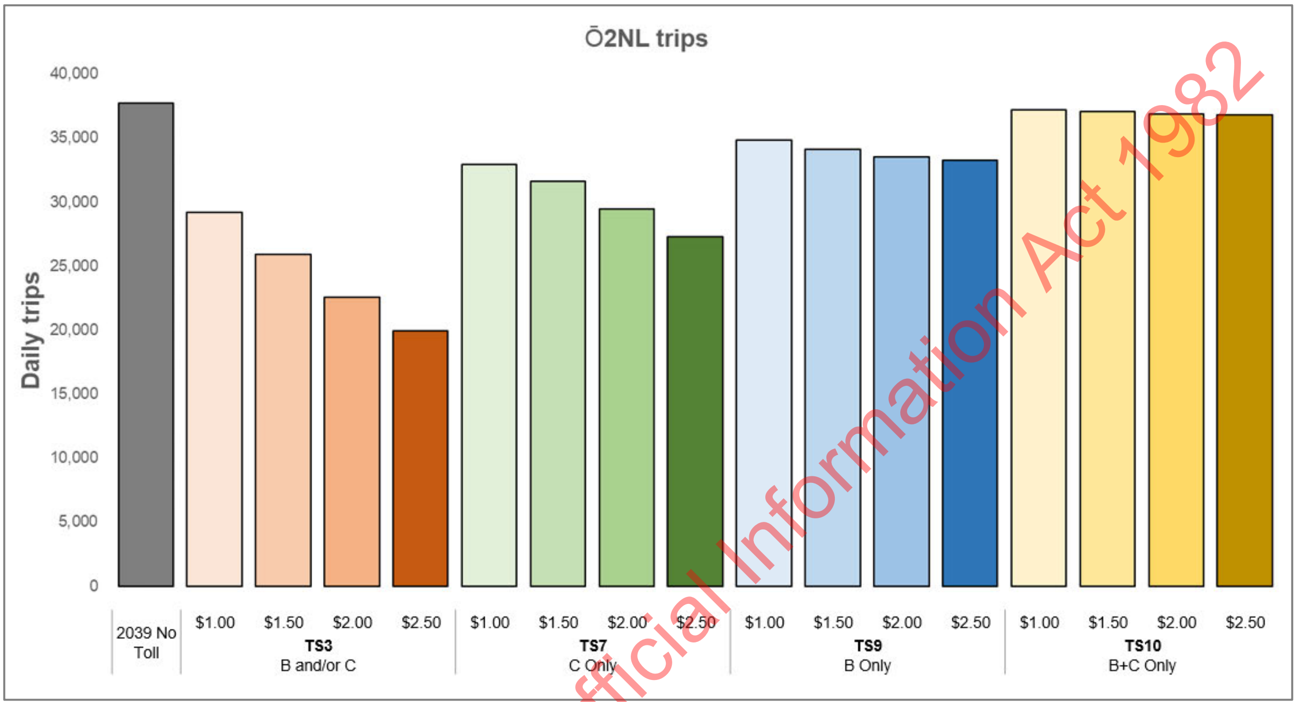
The ‘Fairness’ assessment criteria used in the long-list assessment was replaced with the distributional impacts criteria, which provided a method of quantifying an aspect of fairness that was most relevant to the project. The efficiency criteria used in the long-list assessment did not provide any material differentiation between strategies and so was not used as a criterion to select the preferred strategy.

These items are presented in the figures below with supporting discussion.

Ō2NL average daily demand

Figure 4-3 presents the forecast number of daily trips using Ō2NL (across its entire length) for each toll strategy and toll level. This is compared to the no toll scenario for the same forecast year (2039). It is useful to look at all Ō2NL demand combined, as each strategy tolls different sections or combinations of sections.

Figure 4-3 Ō2NL average daily demand



TS3 reduces Ō2NL demand by approximately 20% in the $1.00 toll test and approximately 50% in the $2.50 toll test. This is as expected as this strategy tolls more parts of the scheme than the other strategies, and users of section B and C are tolled twice as much as in the equivalent tests for TS10.

TS7 reduces Ō2NL demand by approximately 10% in the $1.00 toll test and approximately 30% in the $2.50 toll test. This strategy targets users of section C which makes up a large proportion of the Ō2NL users. This section provides a good travel time saving to many users (compared to the alternative existing SH1) and so demand is fairly resistant to the increases in toll.

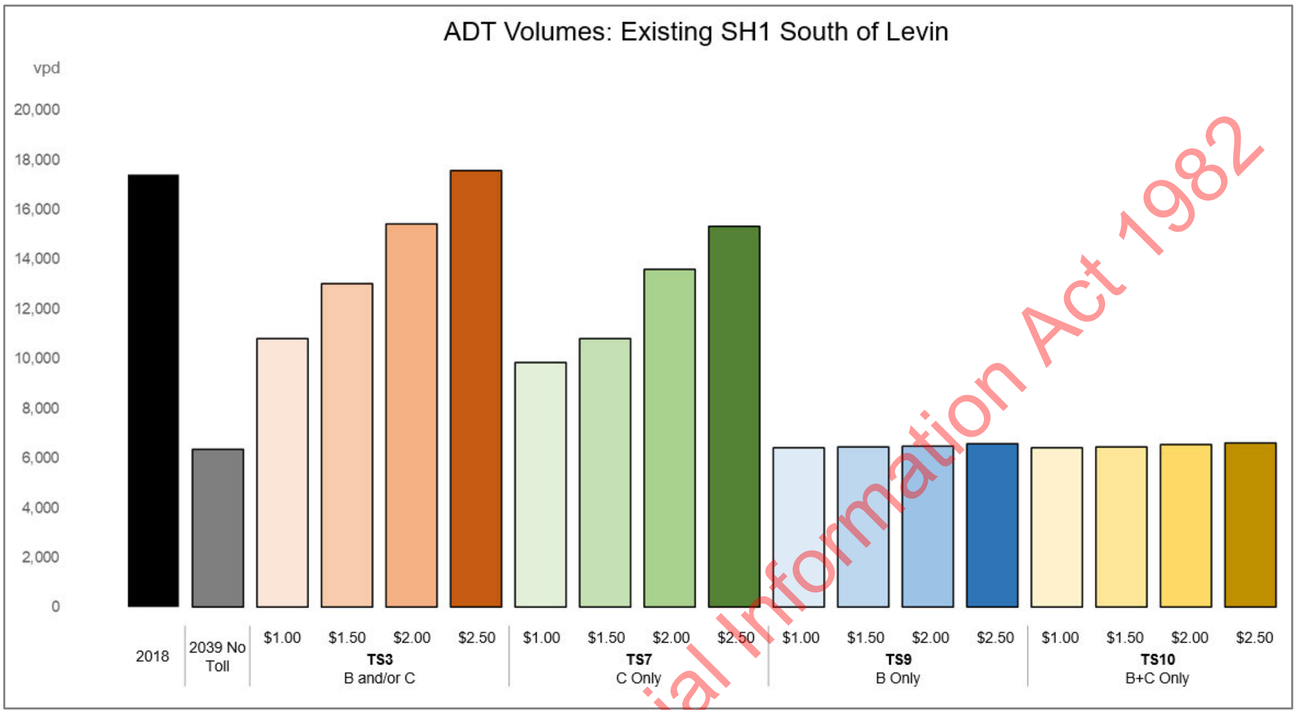
TS9 reduces Ō2NL demand by approximately 8% in the $1.00 toll test and approximately 12% in the $2.50 toll test. This strategy targets users of section B which makes up a smaller proportion of the Ō2NL users. It is noted that SH57 provides a convenient alternative route for users looking to avoid a toll on section B.

TS10 has very little impact on Ō2NL demand as it only targets a select group of users, those travelling through both section B and C. SH57 provides a convenient alternative route for users looking to avoid the section B toll, and in this scenario some users use this route to avoid the toll, but they still count toward Ō2NL demand as they use either section A or section C for part of their journey.

Traffic volumes on existing SH1 south of Levin

Figure 4-4 below presents the forecast daily traffic volumes on existing SH1 south of Levin.

Figure 4-4 ADT Traffic volumes forecast: Existing SH1 south of Levin



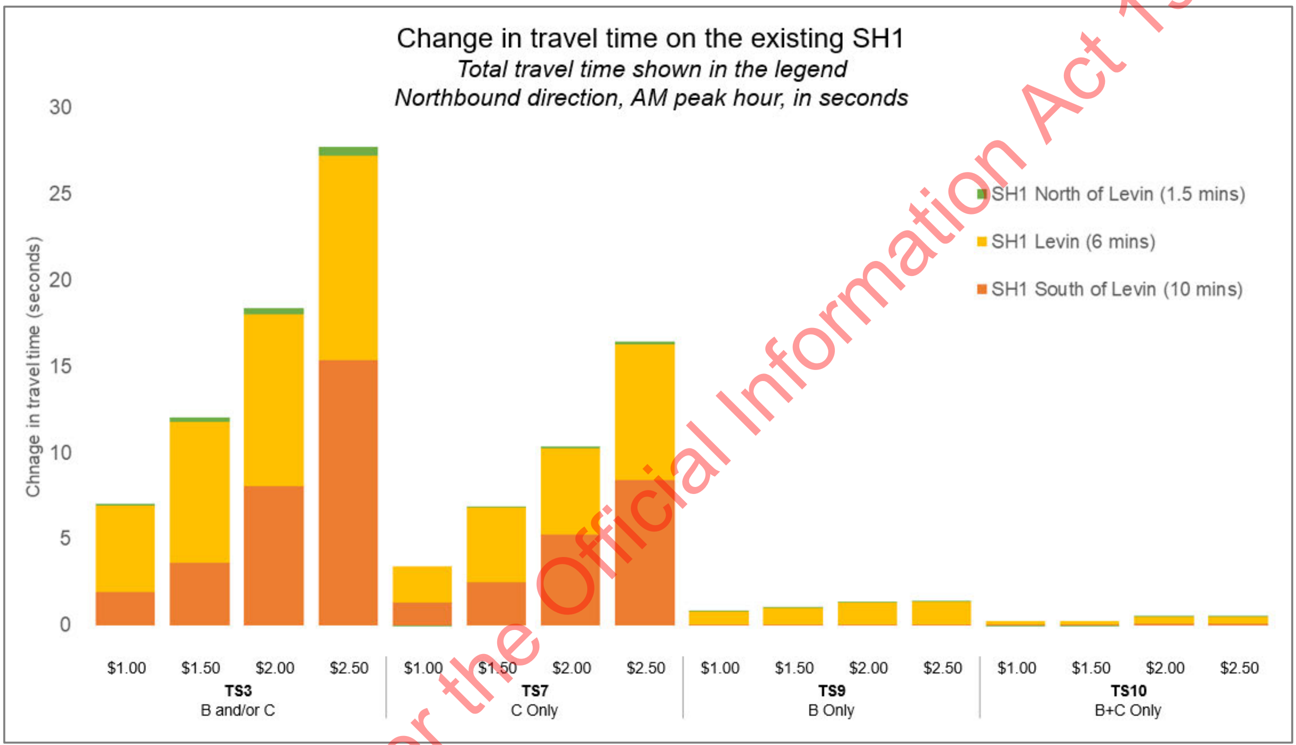
TS9 and TS10 are designed to target through trips rather than trips to or from Levin, and accordingly these strategies have a minor impact on forecast traffic volumes on the existing SH1 South of Levin. TS3 and TS7, which put a toll on section C has the impact of shifting trips back to the existing SH1 South of Levin.

The low toll test for TS3 of $1.00 would still result in nearly 50% less traffic on this section of the existing SH1 compared to 2018 levels.

Travel times

Figure 4-5 presents the change in travel times on the existing SH1 in the AM time period in the northbound direction as compared to the travel times in the 2039 No Toll scenario. The AM time period / northbound direction is presented because it was the time / direction where the most amount of change in travel time occurred as a result of the tolls tested, although that being said, the difference was not significant between time periods and direction. The change in travel times is broken down into three sections, the existing SH1 north of levin, the existing SH1 in Levin, and the existing SH1 south of Levin. The overall travel time along this route is approximately 17.5 minutes in the No Toll scenario.

Figure 4-5 Travel times on the existing SH1

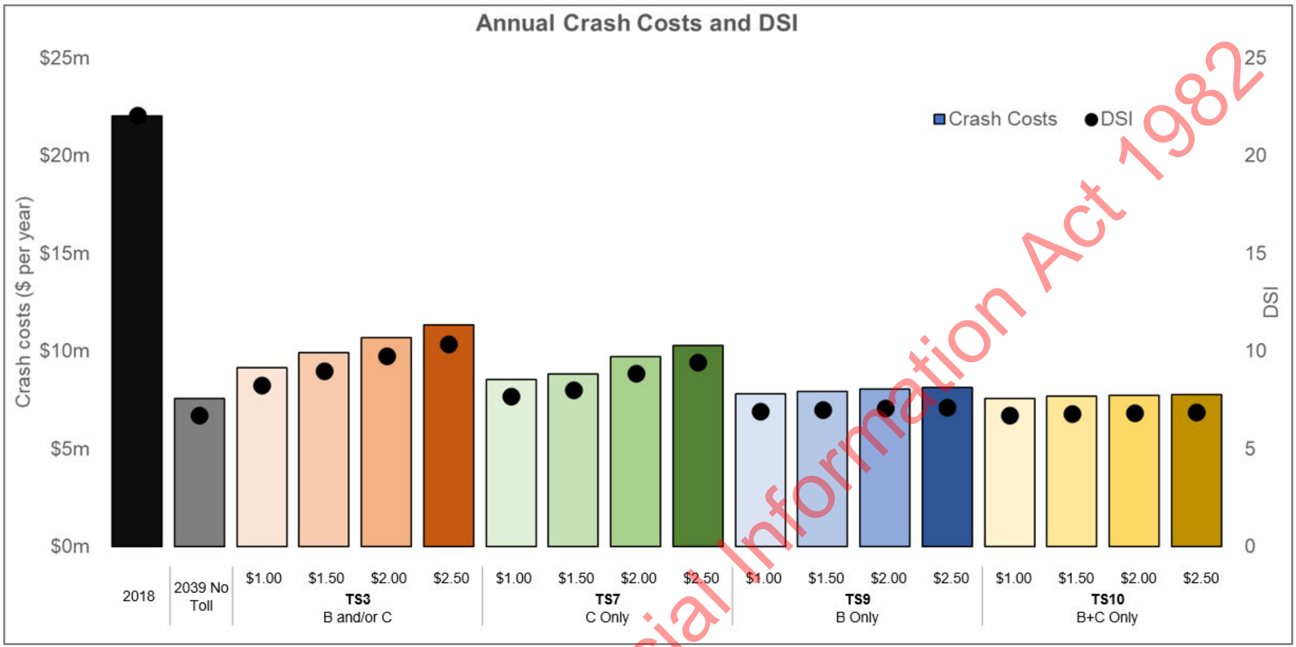


The changes are relatively modest in all toll strategies at low toll levels. For TS3, at the higher toll level of $2.00 the change in travel time is approximately 20 seconds, and at $2.50 the change in travel time is nearly 30 seconds due to traffic moving back on to the existing SH1 causing an increase in delay.

Safety

Figure 4-6 presents the annual crash costs and DSI for each toll strategy and toll level. This is compared to the no toll scenario for the same forecast year (2039) as well as the 2018 annual crash costs and DSI. These figures are calculated using the Ō2NL crash model used in the DBC.

Figure 4-6 Annual Crash costs and DSI



As shown, the 2039 No Toll scenario provides a significant reduction in crash costs and DSI. The reductions are from a combination of the reduced traffic volumes on the existing SH1 combined with the SIP works assumed in the future year scenarios.

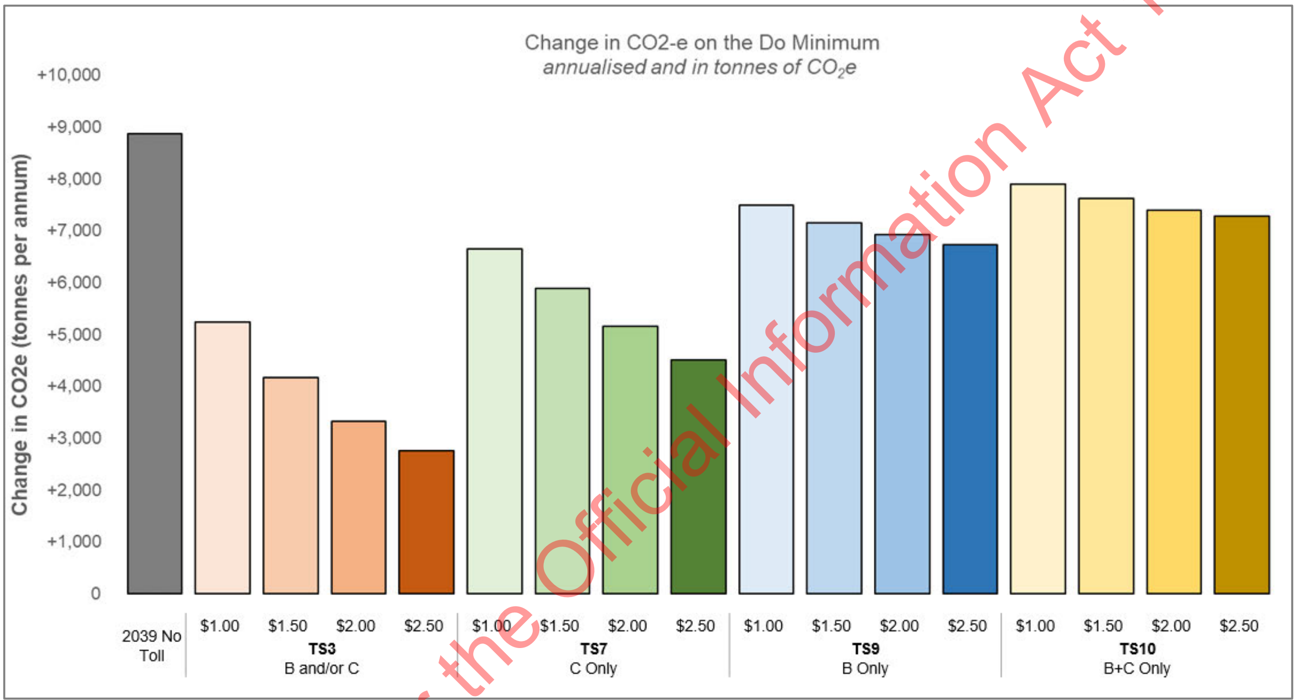
The tolled scenarios still provide a significant reduction in crash costs and DSI compared to 2018, but as some traffic shifts back to the existing SH1 as a result of tolling there is an increase in crash costs and DSI compared to the no toll scenario. This is more so in TS3 and TS7, but less so in TS9 and TS10 where crash costs are relatively unaffected. Notably, TS3 at the low toll level of $1.00 compares well with the other scenarios including the 2039 No Toll scenario.

Enabled emissions

Enabled emissions and fuel consumption have been calculated using the Waka Kotahi traffic model emissions tool. The tool applies emission rates from the Vehicle Emission Prediction Model (VEPM 6.2) to link volume and speed data from traffic models to determine the level of enabled emissions of traffic represented in the model. The outputs are annualised using the annualisation factors described in Appendix B.

Figure 4-7 below presents the change in tonnes of CO_2e per annum for the 2039 No Toll scenario and for each toll strategy and toll level as compared to the 2039 Do Minimum scenario.

Figure 4-7 Enabled emissions - Change in tonnes of CO_2e per annum



As shown, the 2039 No Toll scenario results in a net increase of approximately 9,000 tCO_2e in 2039 compared to the Do Minimum. This is due to the scheme reducing suppressed[6] traffic demand compared to the Do Minimum scenario, as well as the scheme providing a longer distance route compared to the existing SH1. The tolled scenarios all reduce CO_2e. The toll has the effect of suppressing traffic demand and moving trips to the shorter route via the existing SH1. TS3 offers the greatest reduction in CO_2e whereas TS10 offers the least reduction. TS3, even in the low toll test of $1.00 provides a better outcome in terms of CO_2e reduction compared to all TS9 and TS10 tests, and also outperforms TS7 in the $1.00 test and $1.50 test.

[6] The scheme is described as 'reducing suppressed demand compared to the Do Minimum scenario', as high travel costs in the 2039 Do Minimum as a result of congestion was found to suppress the unconstrained estimate of the travel demand in the 2039 scenario (75th percentile land use).

Distributional Effects

The analysis presented below is in relation to adding a toll to Ō2NL. Therefore, this analysis doesn't reflect that everyone will gain a benefit from the project, whether it is tolled or not. With a toll strategy implemented, users of Ō2NL will gain the travel time and safety benefit of the new road, while users who choose not to pay will gain the travel time and safety benefits on the alternative routes due to lower volumes on these roads than a "Do Minimum" without the project.

Time savings for users outside of Levin or Ōtaki ('External') are generally relatively high and therefore these users are more likely to pay the toll to realise these benefits. Time savings for local trips are generally quite low due to easy access to alternative routes and shorter distances travelled. Therefore, these users would be less likely to pay the toll to receive minimal benefit.

It is also noted that by design and as per legislation, all trips have ready access to a free alternative route.

Distributional effects were considered in the assessment of the short-listed options by looking at the origins of users of Ō2NL, and then of those users, what groups are most effected. The groups considered are local users from Levin or Ōtaki ('Local'), users from the Tara-Ika development ('Tara-Ika') and users from outside Levin or Ōtaki ('External').

Figure 4-8 presents the origin of trips using Ō2NL. As shown local users make up 56% of users in the no toll scenario, and this drops to 50-47% of users in TS3 and TS7. In the TS9 and TS10 scenario the proportion of trips by local users stays at around 55-56%.

Figure 4-8 Origin of trips using Ō2NL

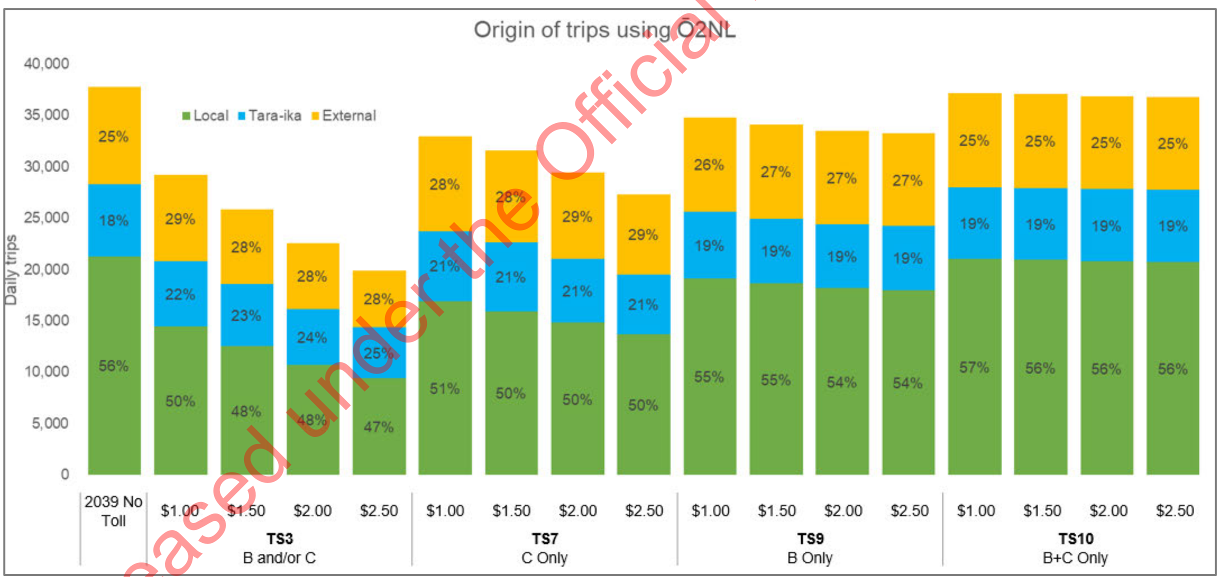
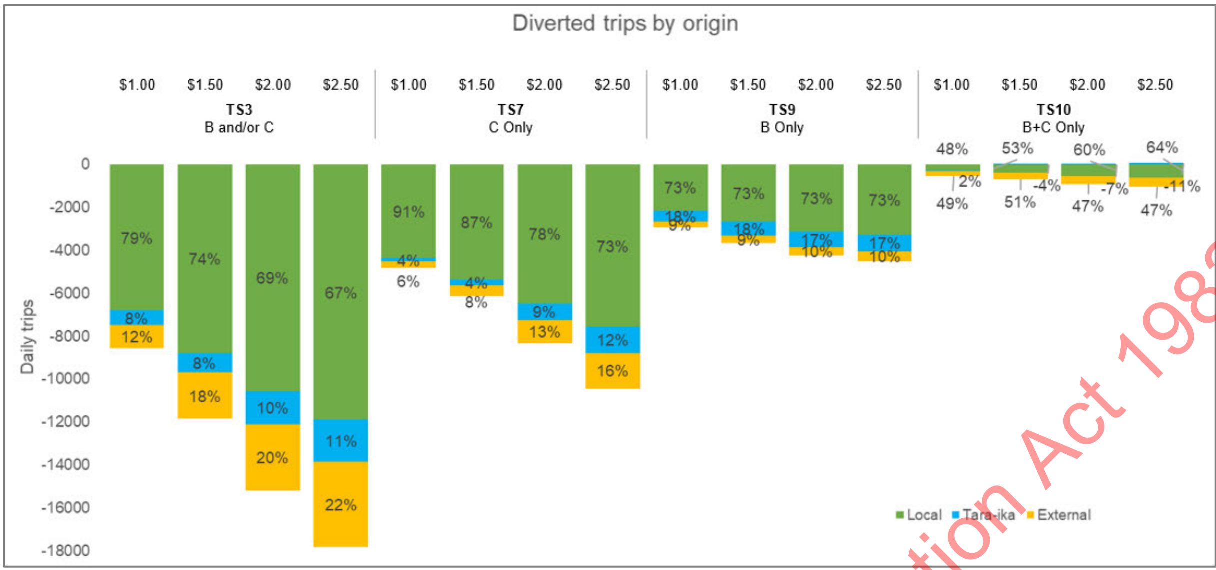


Figure 4-9 presents the origin of trips diverted trips from Ō2NL in response to toll, which highlights the story of the groups most effected by tolling as introduced in Figure 4-8. This doesn't consider the time or cost implication of users choosing not to pay the toll on Ō2NL to use it.

The figure demonstrates that of the trips no longer using Ō2NL, TS7 has the highest proportion of Local trips followed by TS3.

Figure 4-9 Origin of trips diverted trips from Ō2NL in response to toll



Revenue

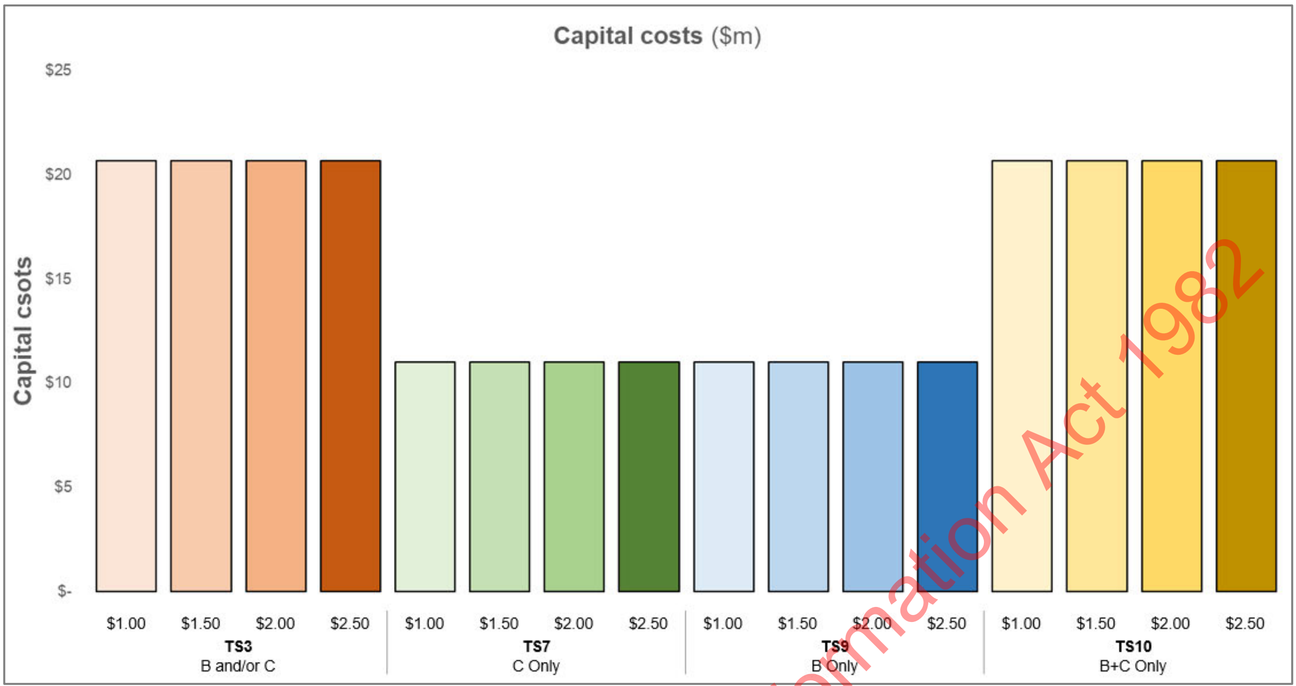
Figure 4-10 presents an estimate of net revenue for each toll strategy and toll level. Note that this is net revenue in 2039 for the 75th percentile land use scenario. The figure accounts for transaction costs but not revenue leakage or other risk adjustments[7]. This report does not address the level of tolling that is appropriate in order to recover the costs of operating and maintaining, revocation and construction costs of Ō2NL, as this will be the subject of separate consideration by Waka Kotahi.

Figure 4-10 Net revenue

As shown above, TS3 generates between $5m and $14m per year (in 2039) depending on the toll level. The gain in net revenue diminishes with each increment in toll level and starts to flatten out by the $2.50 test. TS7 generates between $3m and $12m per year (in 2039) depending on the toll level. TS9 and TS10 generate between $2m and $5m per year (in 2039). It is useful to compare the revenue amounts with the capital cost estimates. Figure 4-11 presents an estimate of capital costs for the toll gantries. Two gantries are needed for TS3 and TS10, but only one is needed for TS7 and TS9.

[7] Refer to the risk analysis in section 6 for more information risk adjustments applied in the assessment of the preferred toll strategy

Figure 4-11 Estimate of capital costs



Summary of outcomes

The short-listed strategies were evaluated against the criteria described above at a workshop with Waka Kotahi in May 2022. Table 4-3 presents a summary of the outcomes for each strategy, plus the conclusions on the strategy that was selected as the preferred strategy at the workshop.

Table 4-3 Summary of outcomes

Strategy	Summary
TS3, B and/or C *Toll gantry on section B and on section C with incremental toll.*	The high toll tests divert too much traffic back to the existing SH1 causing too much of an increase in forecast crash costs and DSI. The strategy results in an increase in travel times on the existing SH1. The high toll test adding nearly 30 seconds of additional delay, but the low test adding only a small amount of travel time (approximately 6 seconds). The strategy provides a material reduction in emissions even in the low toll tests compared to the No Toll scenario. The strategy disproportionally impacts local users, but less so than TS7. The strategy generates the most revenue as it tolls a greater number of users compared to the other scenarios. It also had the benefit of reducing emissions more so than other strategies.
TS7, C only *Toll gantry on section C only, the largest section of the corridor*	The high toll tests divert some traffic back to the existing SH1 with only a moderate increase in forecast crash costs and DSI compared to the no toll scenario. The strategy results in a small increase in travel times on the existing SH1. The strategy provides a material reduction in emissions even in the low toll tests compared to the No Toll scenario. The strategy disproportionally impacts local users and is the least equitable based on the method of assessment described in this section. The strategy generates a reasonable net revenue as it tolls a greater number of users compared to the other scenarios.
TS9, B only *Toll gantry on Section B only, the middle section of the corridor.*	This strategy, by design, has very little impact on the existing SH1 traffic flows south of Levin, and consequently crash costs and DSI are relatively unaffected compared to the no toll scenario. The strategy does not materially impact travel times on the existing SH1. The strategy provides some reductions in emissions compared to the No Toll scenario. However, revenue generation is modest at all test levels. There are also the potential negative outcomes of traffic avoiding the toll on this short section by routing off Ō2NL to use SH57 between Tararua Road and Roselyn Road then returning to Ō2NL.
TS10, B+C only *Toll gantries on section B and section C but only toll users of both B and C*	As designed, this scenario is most equitable based the method of assessment described in this section as it has a relatively low impact on local trips. The strategy targets a relatively small proportion of users of Ō2NL i.e., only through trips), and therefore the impacts of tolling are moderate. Only a small amount of revenue is generated but impacts on the existing SH1 travel times are low, impacts on crash costs and DSI are low.
Conclusion	*At the short-list assessment workshop with Waka Kotahi in May 2022, TS3 (toll of B users, C users and B+C users) with a toll at the lower end of the modelled range ($1.00 test and $1.50 test) was selected as the preferred strategy. This strategy balanced the need to generate sufficient revenue for the implementation of toll infrastructure and meet/contribute to maintenance and operational cost, revocation costs and construction costs, while minimising the impact on the forecast crash costs and DSI.*

4.3 Selection of 'optimum' toll level

The preferred strategy (selected in collaboration with Waka Kotahi) was TS3 with a toll at the lower end of the modelled range ($1.00 to $1.50 per gantry).

To determine an 'optimum' toll level we evaluated five tolling levels[8]; $0.00, $1.00, $1.25[9], $1.50, $2.00, and $2.50. Each toll level was evaluated against the four drivers that were the ones of most concern at the short-list assessment workshop. These drivers, in no particular order, were:

- Net revenue
- Safety benefits
- Emissions reduction
- Reduced flows on the existing SH1 South of Levin

We then scored each toll level between 0 and 5 for each driver, relative to how the toll level performed against the other five toll levels. We then identified the highest scoring toll level when:

1. All drivers are weighted equally
2. Net revenue is weighted twice the weight of other drivers
3. Safety benefits are weighted twice the weight of other drivers
4. Emissions reduction is weighted twice the weight of other drivers
5. Reduced flows on the existing SH1 south of Levin is weighted twice the weight of other drivers

With all drivers weighted equally, the $2.50 toll level is optimal.

When Safety is weighted twice, No Toll is optimal followed by $2.50.

When Net revenue is weighted twice, $4.00 is optimal followed by $2.50.

When Emissions reductions is weighted twice, $4.00 is optimal followed by $2.50.

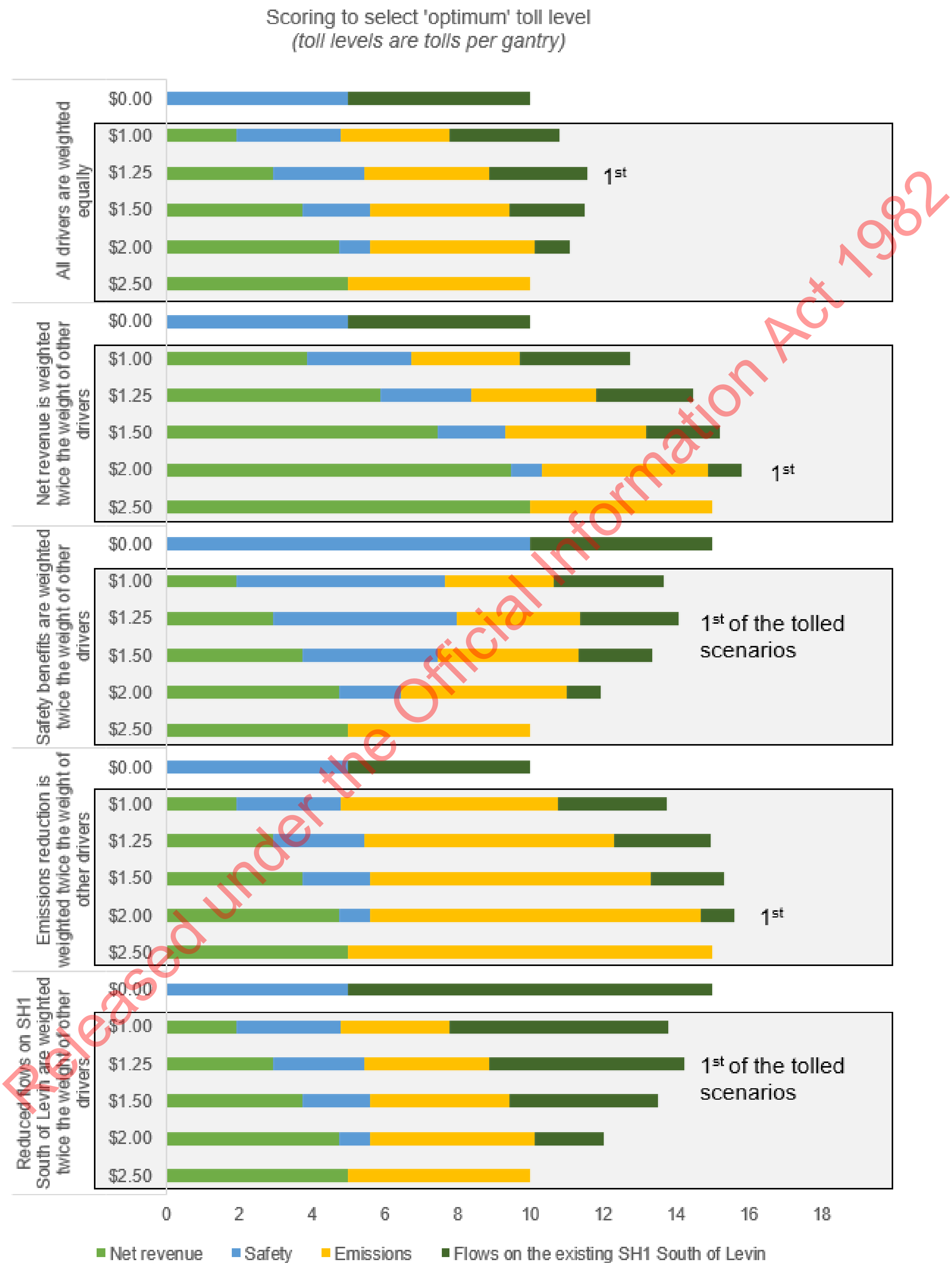
When Reduced flows on the existing SH1 South of Levin is weighted twice, No Toll is optimal followed by $2.50.

These outcomes are illustrated in the figure below:

[8] Note that $1.00 toll level is $2.00 for light vehicle users using B and C but $1.00 for users of section B only and users of section C only, and the toll for heavies is always 2x the toll level for light vehicles. The logic applies for all toll levels.

[9] An extra toll level ($1.25 per gantry) was modelled in addition to those modelled for the short-list assessment, as it looked like this toll level could generate a more net revenue without a major impact on safety.

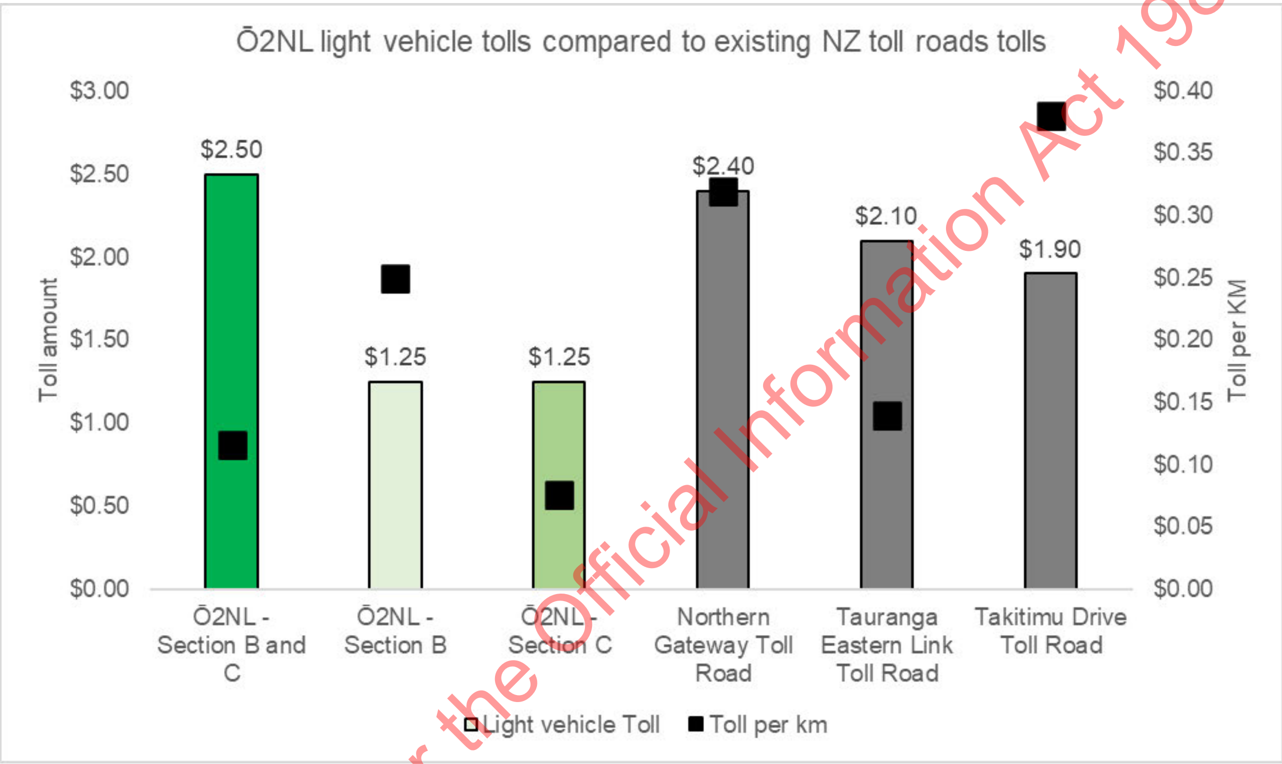
Figure 4-12 Selection of 'optimum' toll level using driver scores



Of the tolled options $1.25 is optimum in most scenarios. This toll level was agreed with Waka Kotahi to take forward as the toll level for the revenue forecasts and risk analysis work.

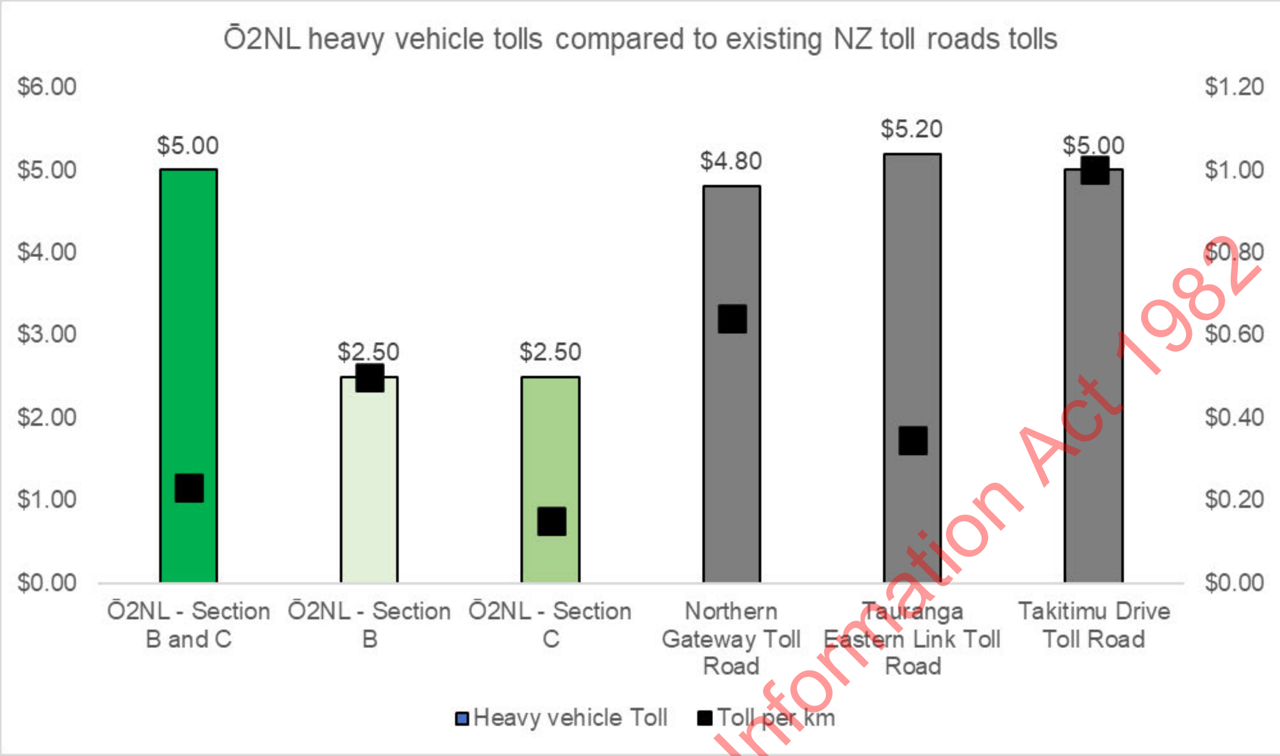
Compared to other tolls across New Zealand, $2.50 for light vehicle users of B and C is marginally higher than other toll roads, but lowest in terms of cost per KM. For light vehicle users of section C only, the cost per KM is very low compared to other toll roads. For users of section B only, the cost per KM is middle of the range compared to other toll roads. The recommended toll level for light vehicles and resulting cost per km is compared with the other tolls in New Zealand and their respective cost per km in Figure 4-13 below.

Figure 4-13 Ō2NL light vehicle tolls compared to existing New Zealand toll road tolls.



Compared to other tolls across New Zealand, $5.00 for heavy vehicle users of B and C is higher than other toll roads, but lowest in terms of cost per KM. For heavy vehicle users of section C only the cost per KM is very low compared to other toll roads. For heavy vehicle users of section B only the cost per KM is middle of the range compared to other toll roads. The recommended toll level and resulting cost per km is compared with the other tolls in New Zealand and their respective cost per km in Figure 4-14 below.

Figure 4-14 Ō2NL heavy vehicle tolls compared to existing New Zealand toll road tolls.



4.4 Peer review

Flow Transportation Planners Ltd was appointed by Waka Kotahi as independent peer reviewers for the study. Flow was engaged in the following stages of the study:

- Initial scoping of the study and Ō2NL model updates
- Review of the Toll Modelling Specification Note and Ō2NL Toll Model Update
- Review of the Tolling Study Report

In response to the above engagement Flow provided comments that were log in an Issues Register. The Issues Register is provided in Appendix E.

5 Preferred tolling strategy

5.1 Description

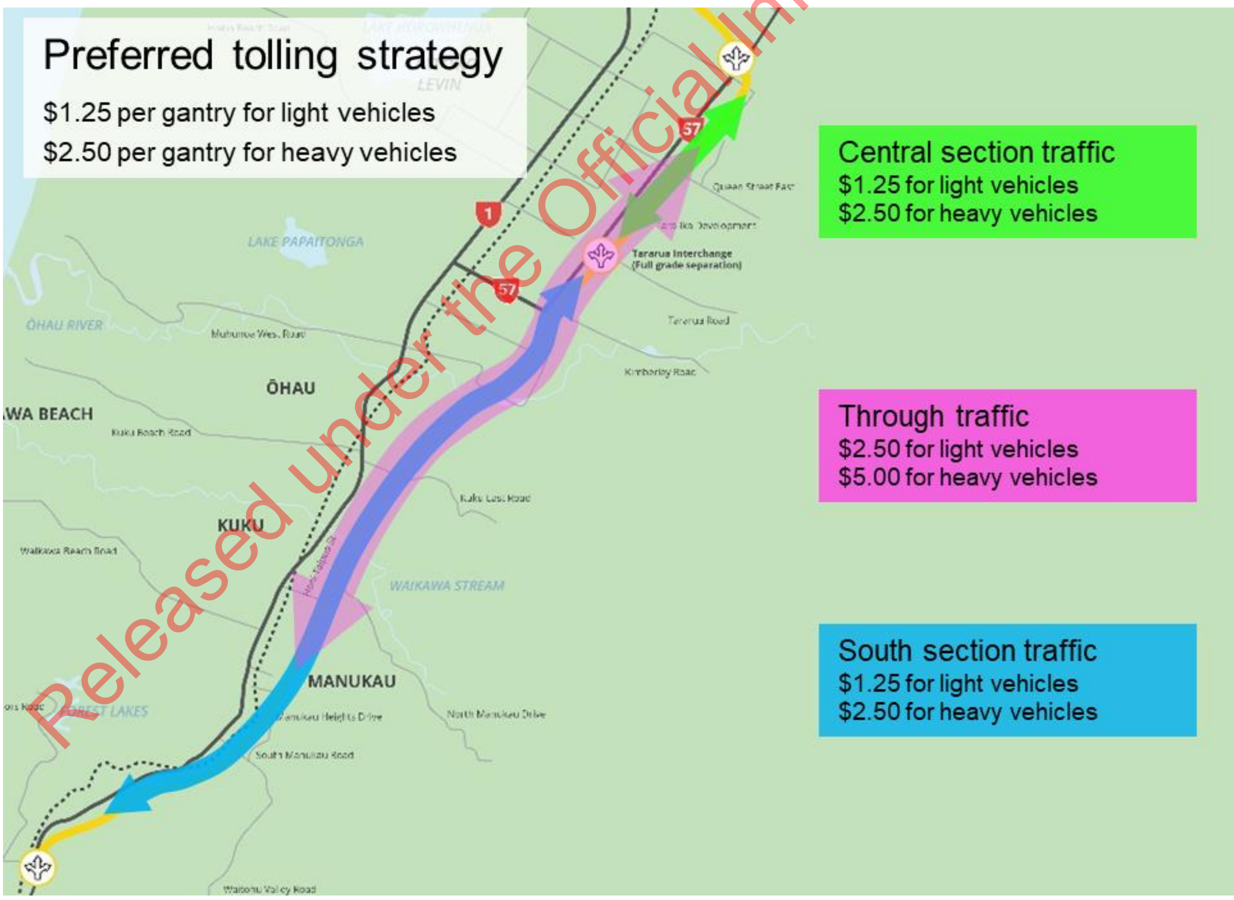
As described in the previous section, TS3 (tolls for users of B and / or C) with a $2.50 toll level (plus 50% discount for local trips) was selected as the preferred tolling strategy and tolling level as it balanced the need to generate sufficient revenue for the implementation of toll infrastructure and meet/contribute to maintenance and operational cost, revocation costs and construction costs, while minimising the impact on the forecast crash costs and deaths and serious injuries (DSI). The preferred strategy also had the benefit of reducing emissions more so than other strategies.

The preferred tolling strategy comprises:

- *A gantry on Ō2NL between Taylors Road interchange and the Tararua interchange (Section C)*
- *A gantry on Ō2NL between the Tararua interchange and the intersection with SH57 (section B).*
- *A $2.50 toll for light vehicles and a $5.00 toll for heavy vehicles*
- *A 50% discount for local users; users of section C only in light vehicles pay $1.25, and users of section B only in light vehicles pay $1.25, local heavy vehicles movement would also be provided a 50% discount.*

Figure 5-1 illustrates the preferred tolling strategy.

Figure 5-1 Preferred tolling strategy

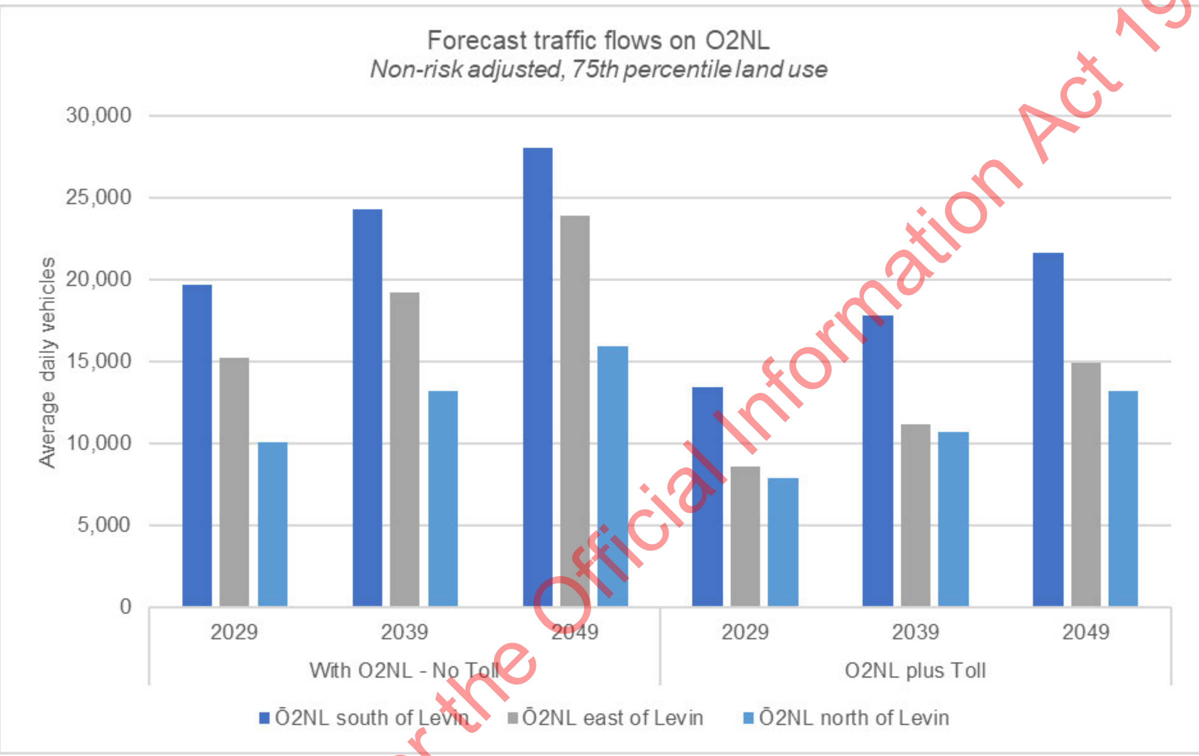


5.2 Traffic flows

The preferred tolling strategy diverts a proportion of traffic from Ō2NL back to the existing SH1 and SH57 as compared to the no toll scenario. A relatively moderate toll amount was selected to minimise the negative consequences of this on safety.

Figure 5-2 presents the effect of tolling on forecast Ō2NL traffic volumes at three locations along the route: south of Levin, east of Levin and north of Levin. The flows are non-risk adjusted and represent a 75th percentile land use assumptions.

Figure 5-2 Forecast traffic flows on Ō2NL

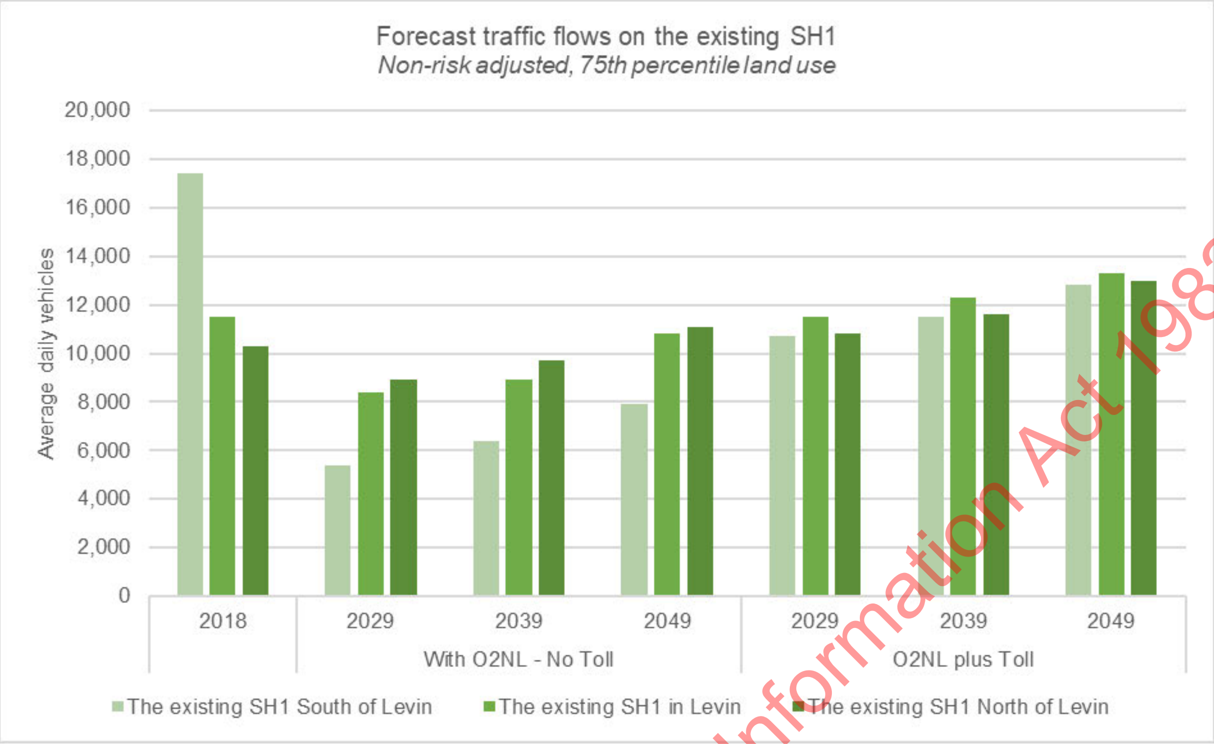


As shown in the figure, all sections of Ō2NL reduce in volume with the introduction of the toll.

The forecast traffic volume on the south section of Ō2NL is approximately 30% lower in 2029 compared to the no toll scenario, but the change reduces to -23% in 2049. The forecast traffic volume on the section east of Levin is approximately 40% less in all years. The forecast traffic volume on the section north of Levin is approximately 22% less in 2029 compared to the no toll scenario, but the change reduces to -17% in 2049.

Figure 5-3 presents 2018 and forecast traffic flows on at three locations on the existing SH1: south of Levin, within Levin, and North of Levin.

Figure 5-3 Forecast traffic flows on the existing SH1

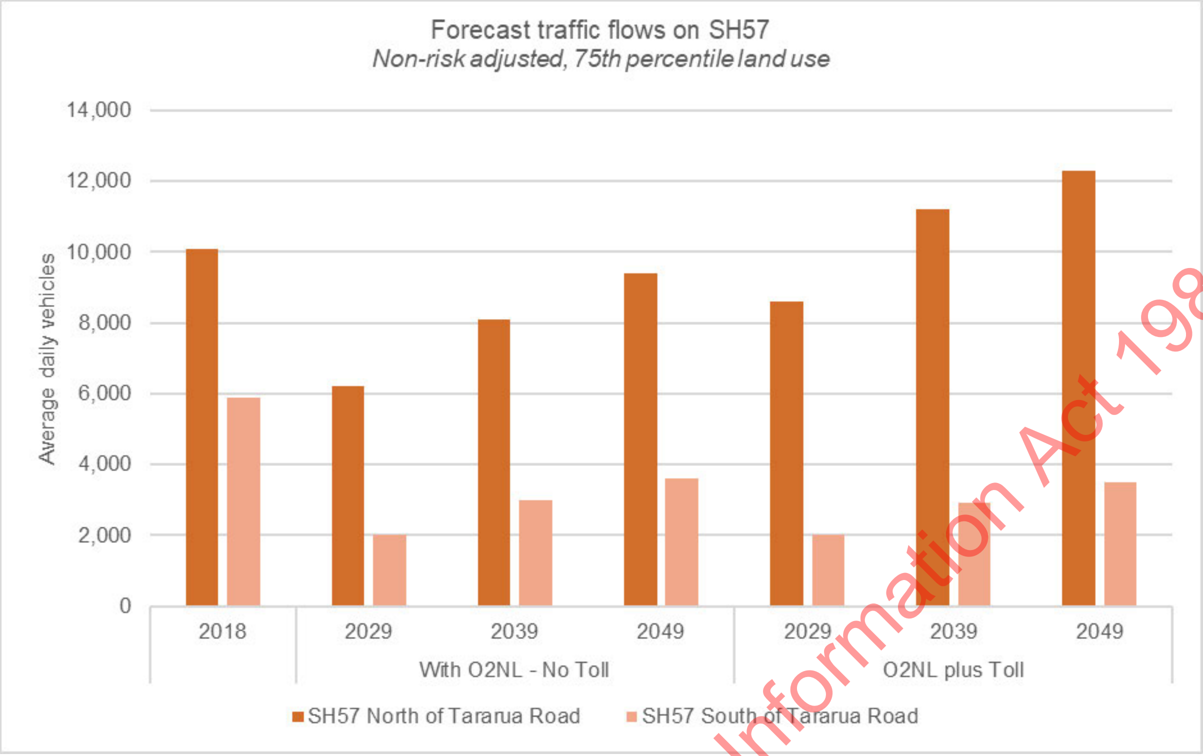


As shown in the figure, forecast traffic volumes on the existing SH1 south of Levin remain below 2018 volumes in all future year scenarios both without and with the toll in place. Noting this is for a 75th percentile land use assumption.

The introduction of the toll results in higher flows on all sections of the existing SH1 compared to the no toll scenario. The forecast traffic volume on the existing SH1 south of Levin is greater by approximately +100% in 2029 compared to the no toll scenario, and the change reduces to +60% in 2049. The forecast traffic volume on the existing SH1 in Levin is approximately +40% higher in 2029 compared to the no toll scenario and the change reduces to +20% in 2049. The forecast traffic volume on the existing SH1 north of Levin is approximately 20% greater in all years compared to the no toll scenario.

Figure 5-4 presents the effect of tolling on forecast SH57 traffic volumes north of Tararua Road and south of Tararua Road.

Figure 5-4 Forecast traffic flows on SH57



As shown in the figure, forecast traffic volumes on SH57 north of Tararua Road remain below 2018 volumes in the future year no toll scenarios but with the toll in place the forecast volumes are higher than the 2018 value by 2039. Note that this is for a 75th percentile land use assumption.

Forecast traffic volumes on SH57 south of Tararua Road remain below 2018 volumes in all future year scenarios both without and with the toll in place.

Table 5-1 presents average daily traffic flows on Ō2NL and on the existing SH1 south of Levin (and combined for the screenline) for the 2018 base scenario and the future year Do Minimum, the With Ō2NL - No Toll scenario and the With Ō2NL - Toll scenario. The table presents the impact of the tolling strategy on diversion from Ō2NL back to the existing SH1 as a result of the preferred toll. As shown in the table, approximately 6,300 to 6,500 vpd is diverted back to the existing SH1 as a result of tolling.

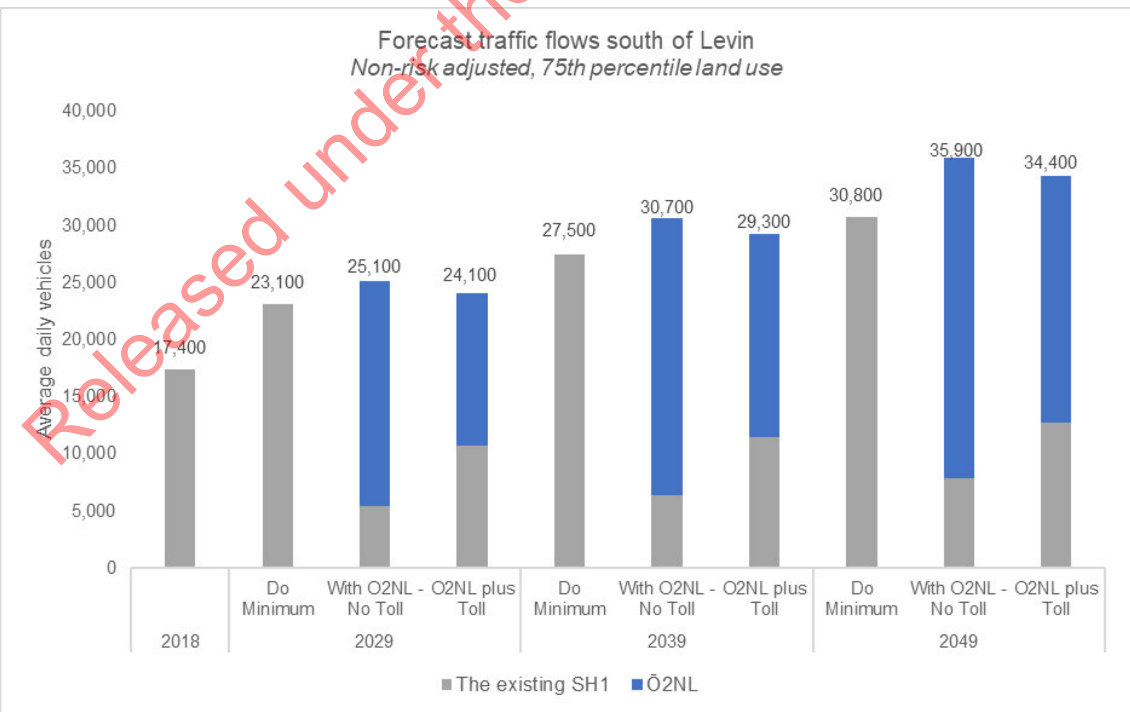
The table also presents the difference in traffic across this screenline compared to the Do Minimum as predicted by the model. This is labelled as 'induced traffic compared to the Do Minimum' in the table, but it could also be described as a reduction in suppressed demand compared to the Do Minimum scenario, as we know from analysis of the total assigned demands that the high travel costs in the Do Minimum scenario as a result of congestion was found to suppress the unconstrained estimate of the travel demand in each forecast year. The amount of 'induced traffic' as a result of Ō2NL project across this screenline is 2,000 vpd in 2039, 3,200 vpd in 2039 and 5,100 in 2049. Tolling reduces this to 1,000 vpd in 2039, 1,800 vpd in 2039 and 3,600 vpd in 2049. This reduction in induced traffic can be described as the amount of suppressed traffic that occurs because of tolling, and this is presented in the table too. The model predicts that tolling will suppress approximately 1,000-1,500 vehicles per day in across this screenline which is approximately 4-5% of traffic across this screenline.

Table 5-1 Forecast traffic flows south of Levin

		The existing SH1	Ō2NL	Combined	Induced traffic compared to Do Minimum	Percent induced traffic compared to Do Minimum	Suppressed traffic from tolling	Percent suppressed traffic from tolling
2018	Base	17,400		17,400				
2029	Do Minimum	23,100		23,100				
	With Ō2NL - No Toll	5,400	19,700	25,100	+2,000	+9%		
	Ō2NL plus Toll	10,700	13,400	24,100	+1,000	+4%	-1,000	4%
	Diverted traffic			6,300				
	Percent diverted			32%				
2039	Do Minimum	27,500		27,500				
	With Ō2NL - No Toll	6,400	24,300	30,700	+3,200	+12%		
	Ō2NL plus Toll	11,500	17,800	29,300	+1,800	+7%	-1,400	5%
	Diverted traffic			6,500				
	Percent diverted			27%				
2049	Do Minimum	30,800		30,800				
	With Ō2NL - No Toll	7,900	28,000	35,900	+5,100	+17%		
	Ō2NL plus Toll	12,800	21,600	34,400	+3,600	+12%	-1,500	4%
	Diverted traffic			6,400				
	Percent diverted			23%				

Figure 5-5 illustrates the changes in average daily traffic flows across this screenline graphically.

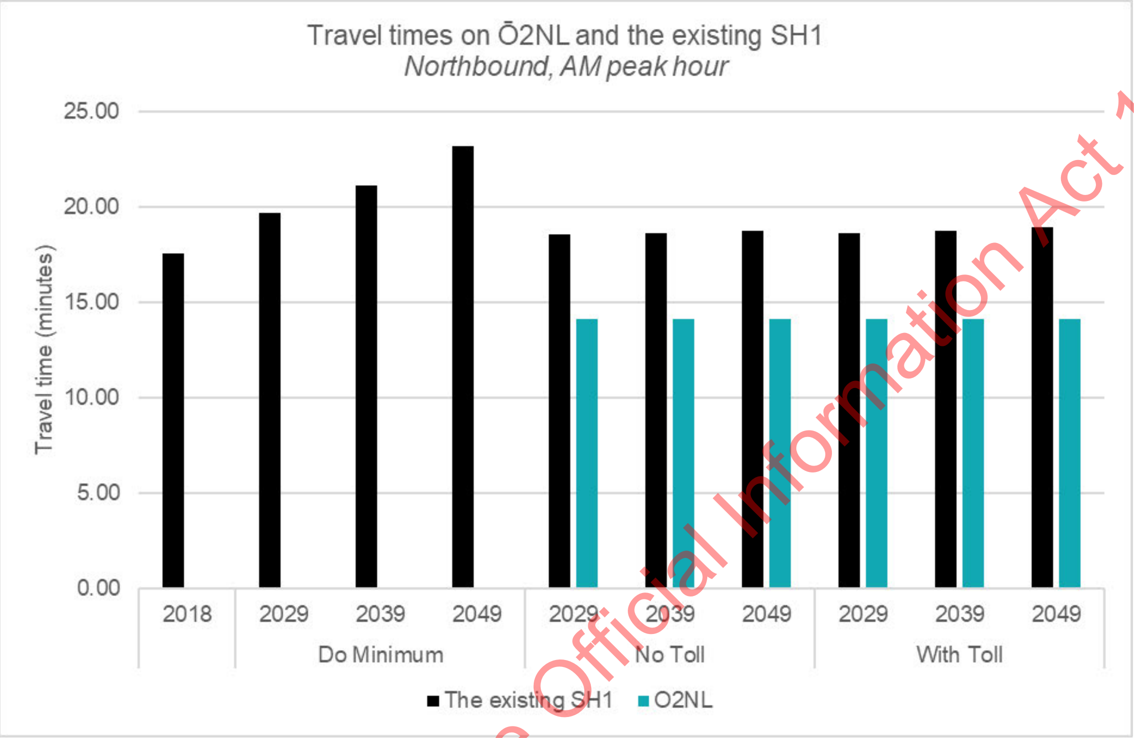
Figure 5-5 Forecast traffic flows south of Levin



5.3 Travel times

The introduction of the toll is not predicted to impact travel times across the network. To illustrate, Figure 5-6 presents forecast travel times on Ō2NL and on the existing SH1 for the AM peak hour in the northbound direction. The plot shows that without Ō2NL, travel times will increase as traffic levels grow, but with Ō2NL they stay at 2018 levels, with or without the toll.

Figure 5-6 Travel times on Ō2NL and the existing SH1 for the AM peak hour in the northbound direction



5.4 Safety

Table 5-2 below presents the discounted crash costs for the With Ō2NL - No toll scenario and the With Ō2NL - With toll scenario using Ō2NL traffic model v22 traffic volumes. The costs are presented for each scenario for each forecast year by location across the modelled area. Crash costs on the existing SH1 and on SH57 will increase in response to tolling. Crash costs on Ō2NL and other roads will decrease in response to tolling. The impact of tolling on crash costs is an overall increase of approximately $2.3m in 2029, $1.8m in 2039 and $1.1m in 2049.

Table 5-2 Discounted Crash costs tolling study (Ō2NL traffic model v22)

	2029		2039		2049	
	With Ō2NL - No Toll	With Ō2NL - with toll	With Ō2NL - No Toll	With Ō2NL - with toll	With Ō2NL - No Toll	With Ō2NL - with toll
Ō2NL	$1.1m	$0.7m	$1.2m	$0.8m	$1.3m	$0.9m
The existing SH1 South of Levin	$1.2m	$3.0m	$1.2m	$2.5m	$1.3m	$2.3m
The existing SH1 Levin	$2.2m	$3.0m	$2.0m	$2.9m	$2.3m	$2.8m
The existing SH1 North of Levin	$0.5m	$0.6m	$0.5m	$0.6m	$0.5m	$0.5m
SH57	$0.7m	$0.9m	$0.7m	$0.8m	$0.6m	$0.7m
Other roads	$1.7m	$1.6m	$1.9m	$1.7m	$2.0m	$1.8m
Total	$7.5m	$9.8m	$7.5m	$9.3m	$7.9m	$9.0m
Impact of tolling on crash costs		**+$2.3m**		**+$1.8m**		**+$1.1m**

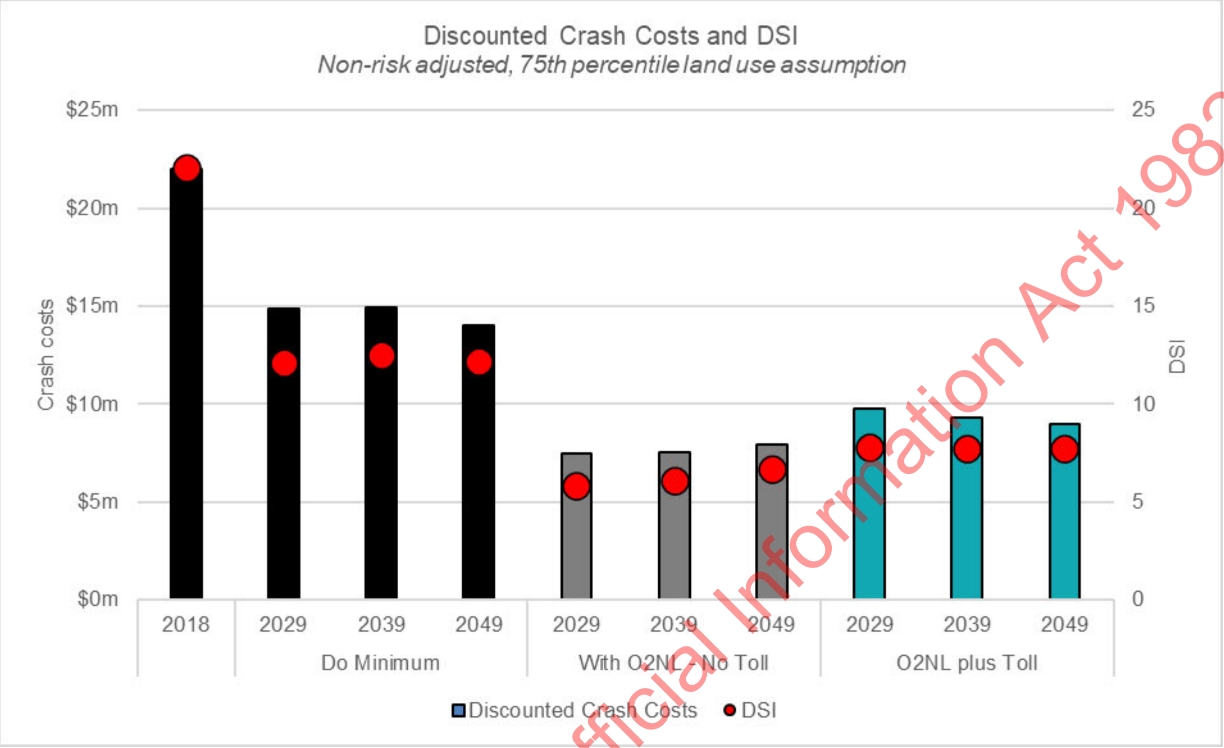
Table 5-3 presents forecasts of DSI in the modelled area for the With Ō2NL - No toll scenario and the With Ō2NL - With toll scenario using Ō2NL traffic model v22 traffic volumes. The DSI forecasts are presented for each scenario for each forecast year by location across the modelled area. Similar to crash costs, DSIs on the existing SH1 and on SH57 will increase in response to tolling. DSIs on Ō2NL and other roads will decrease in response to tolling. Tolling is forecast to change to forecast number of DSI by +1.7 in 2029, +1.3 in 2039 and +0.6 in 2049.

Table 5-3 DSI forecasts from the tolling study (Ō2NL traffic model v22)

	2029		2039		2049	
	With Ō2NL - No Toll	With Ō2NL - with toll	With Ō2NL - No Toll	With Ō2NL - with toll	With Ō2NL - No Toll	With Ō2NL - with toll
Ō2NL	0.9	0.6	1.2	0.9	1.5	1.1
The existing SH1 South of Levin	0.9	2.2	0.9	1.9	1.0	1.7
The existing SH1 Levin	2.1	2.9	2.0	2.7	2.2	2.7
The existing SH1 North of Levin	0.3	0.4	0.3	0.3	0.3	0.3
SH57	0.8	0.9	0.9	1.0	1.0	1.1
Other roads	1.7	1.5	2.0	1.7	2.2	1.9
Total	6.7	8.5	7.3	8.6	8.2	8.8
Impact of tolling on DSI		**+1.7**		**+1.3**		**+0.6**

Figure 5-7 presents the forecast crash costs and forecast of DSI for the Do Minimum scenario, the With Ō2NL - no toll scenario and the preferred toll strategy scenario for each forecast year. The forecasts are based on non-risk adjusted traffic volumes using the 75th percentile land use assumptions.

Figure 5-7 Discounted crash costs and DSI



As shown in the figure, future year crash costs and DSI are predicted to reduce significantly on the present-day crash costs as result of the SIP (as shown in the Do Minimum scenario). With Ō2NL in place, crash costs and DSI are predicted to reduce further as a result of less traffic on the existing SH1. With the toll added, crash costs and DSI are predicted to increase slightly, but are still well below the 2018 amounts, and the future year Do Minimum amounts.

The future year 'Do Nothing' scenario was not modelled as part of the tolling study, so to provide this context to the impact of tolling on DSI and crash costs we have sourced DSI and crash costs for the Do Nothing scenario, the Do Minimum scenario and the With Ō2NL (no toll) scenarios from the DBC safety model which uses Ō2NL traffic model v20 traffic volumes.

Table 5-4 presents the discounted crash costs sourced from the DBC safety model (May 2022). The costs are presented for Base Year, and the Do Nothing scenario, the Do Minimum scenario and the With Ō2NL (no toll) scenarios for each forecast year. The change on the Do Nothing scenario is presented for the Do Minimum scenario and the With Ō2NL (no toll) scenarios for each forecast year.

The change on the Do Nothing scenario for the Do Minimum scenario demonstrates the benefits of the SIP works being approximately $8.7m in 2029, $8.8m in 2039 and $8.3m in 2049. The change on the Do Nothing scenario for the With Ō2NL (No Toll) scenario demonstrates the benefits of the scheme and the SIP works being approximately $16.5m in 2029, $16.9m in 2039 and $15.8m in 2049.

Table 5-4 Discounted Crash costs sourced from the DBC (May 2022, Ō2NL traffic model v20)

	2018	2029	2039	2049
Base year and Do Nothing	$22.0m	$24.8m	$25.2m	$24.4m
Do Minimum		$16.1m	$16.4m	$16.1m
With Ō2NL (No Toll)		$8.2m	$8.3m	$8.6m
Change on the Do Nothing				
Do Minimum		-$8.7m	-$8.8m	-$8.3m
With Ō2NL (No Toll)		-$16.5m	-$16.9m	-$15.8m

Table 5-5 presents the DSIs sourced from the DBC safety model (May 2022) that used the Ō2NL traffic model v20 traffic volumes. The DSIs are presented for Base Year, and the Do Nothing scenario, the Do Minimum scenario and the With Ō2NL (no toll) scenarios for each forecast year. The change on the Do Nothing scenario is presented for the Do Minimum scenario and the With Ō2NL (no toll) scenarios for each forecast year.

The change on the Do Nothing scenario for the Do Minimum scenario demonstrates a reduction of 5.6 DSI in 2029, 5.8 DSI in 2039 and 5.5 DSI in 2049 as a result of the SIP. The change on the Do Nothing scenario for the With Ō2NL (No Toll) scenario demonstrates the benefits of the scheme and the SIP works being approximately 12.7 DSI savings in 2029, 13.0 DSI reduction in 2039 and 12.2 DSI reduction in 2049.

Table 5-5 Deaths and Serious Injury's sourced from the DBC (May 2022, Ō2NL traffic model v20)

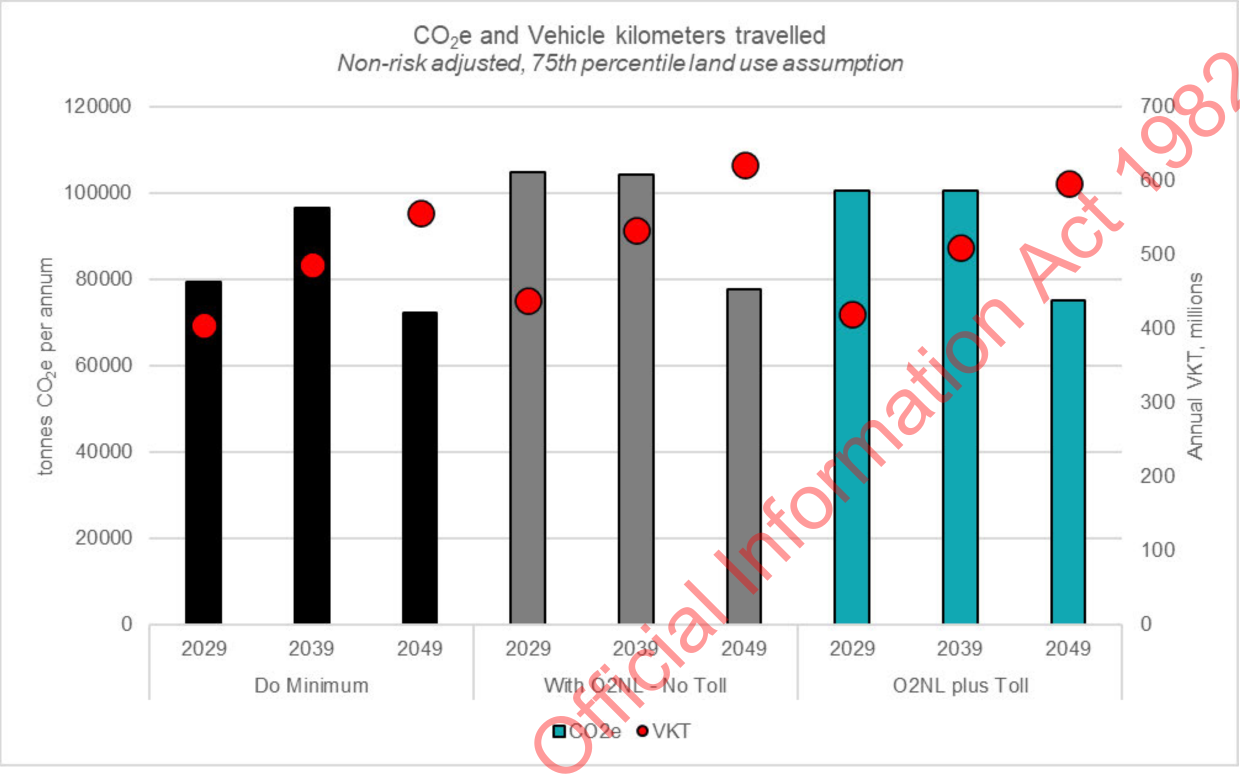
	2018	2029	2039	2049
Base year and Do Nothing	22.1	20.2	21.0	21.1
Do Minimum		14.6	15.3	15.5
With Ō2NL (No Toll)		7.4	8.1	8.8
Change on the Do Nothing				
Do Minimum		-5.6	-5.8	-5.5
With Ō2NL (No Toll)		-12.7	-13.0	-12.2

In summary, crash costs and DSI are predicted to reduce significantly on the present-day crash costs as result of the SIP. With Ō2NL in place, crash costs and DSI are predicted to reduce further as a result of less traffic on the existing SH1. With the toll added, crash costs and DSI are predicted to increase slightly, but are still well below the 2018 amounts, and the predictions without the scheme in place. In terms of DSI's saved, the Detailed Business Case indicates an annual reduction (2029) of some 12.7 per annum (including SIP works), with tolling the number of DSI is expected to increase by 1.7 DSI, so the reduction on the Do Nothing scenario will lower from a 12.7 DSI reduction to a 11.0 DSI reduction.

5.5 Emissions

Figure 5-8 presents the CO_2e and vehicle kilometers travelled for the Do Minimum, With Ō2NL - No Toll and Ō2NL plus toll scenarios for each forecast year. Note that the values are based on non-risk adjusted traffic volumes using 75th percentile land use assumptions.

Figure 5-8 CO_2e and Vehicle kilometers travelled



As shown in the figure above, VKT (shown with red dots) increases in each forecast year, and the amount of VKT is broadly similar between the Do Minimum, With Ō2NL - No Toll and the Ō2NL plus toll scenario. VKT in the Ō2NL - No Toll is slightly higher than in the Do Minimum and in the Ō2NL plus toll scenario.

The predicted amount of CO_2e reduces over time relative to VKT due to the assumptions on vehicle fleet mix i.e., higher proportions of low emission vehicles further into the future, resulting in reductions in emission rates from road vehicles over time.

When looking at the change on CO_2e between scenarios, the tolled scheme, compared to the no tolled scheme, is expected to reduce annual CO_2e by 4,300 tonnes in 2029, 3,900 tonnes in 2039, and 2,600 tonnes in 2049. The tolled scheme, compared to the Do Minimum scenario, is expected to increase annual CO_2e by 21,200 tonnes in 2029, 4,000 tonnes in 2039, and 3,000 tonnes in 2049.

The summary tab from the Waka Kotahi traffic model emissions tool is provided in Appendix D.

5.6 Revenue

Risk adjusted revenue forecasts for the preferred strategy are provided section 6.4.

6 Risk analysis

6.1 Risks to traffic volume and revenue forecasts

The key risks and uncertainties that could influence the Ō2NL traffic volume forecasts and revenue forecasts were identified in consultation with Waka Kotahi. The risks are catalogued and described in Table 6-1 below. Items 1 to 12 have impacts on the traffic volumes on the toll road and in turn the revenue forecasts. Item 13 (Revenue leakage) and item 14 (Transaction costs) only impact the revenue forecasts.

Table 6-1 Risk elements to the traffic volume and revenue forecasts

<table>
<tr><th>Risk</th><th>Risk Category</th><th>Commentary and method of assessment</th></tr>
<tr><td>Land use changes</td><td>Demand</td><td>Future year land use is a key risk in the traffic forecasts and revenue forecasts. We have used a combination of the Horowhenua population forecasts from the Horowhenua Socio-Economic Projects Report by Sense Partners (May 2020), the Ō2NL model v20 25th percentile 75th percentile and 95th percentile model runs (2029, 2039, and 2049), and the v22 Ō2NL 75th percentile 2029, 2039, and 2049 model runs to estimate demand on Ō2NL for 5th percentile, 50th percentile and 95th percentile forecast ranges for each forecast year. A key distinction being that we present 5th percentile, 50th percentile and 95th percentile data estimates rather than 25th percentile, 75th percentile and 95th percentile data estimates that are presented in the DBC.

The Horowhenua population forecasts from the Horowhenua Socio-Economic Projects Report by Sense Partners (May 2020) are presented it the table below:

Population forecasts: Horowhenua Socio-Economic Projects Report by Sense Partners (May 2020)
<table>
<tr><th></th><th>5% Percentile</th><th>25% Percentile</th><th>50% Percentile</th><th>75% Percentile</th><th>95% Percentile</th></tr>
<tr><td>2029</td><td>39,983</td><td>41,022</td><td>41,896</td><td>42,941</td><td>44,968</td></tr>
<tr><td>2039</td><td>40,822</td><td>44,138</td><td>47,006</td><td>50,913</td><td>59,010</td></tr>
<tr><td>2049</td><td>39,542</td><td>45,188</td><td>51,862</td><td>59,250</td><td>79,243</td></tr>
</table>
Appendix C presents the traffic volumes from the Ō2NL model v20 25th percentile 75th percentile and 95th percentile model runs (2029, 2039, and 2049), and the v22 Ō2NL 75th percentile 2029, 2039, and 2049 model runs, and shows how these were combined with the above population forecasts to estimate demand on Ō2NL for 5th percentile, 50th percentile and 95th percentile forecast ranges for each forecast year.</td></tr>
<tr><td>Tara-Ika development</td><td>Demand</td><td>There is inherent uncertainty in the likelihood and potential speed of development of the Tara-Ika development. The risk analysis includes scenarios with 50% less trips to/from the Tara-Ika in the low scenario and +25% trips to/from the Tara-Ika in the high scenario. Appendix C presents the forecast flows from Sector 3 (location of the Tara-Ika development) for the Central estimate (as modelled in the Ō2NL v22 traffic model forecasts (using the 75th percentile land use assumptions), alongside the Low and High estimates.</td></tr>
<tr><td>Willingness to Pay – Value of Time</td><td>Demand</td><td>VoT values are adopted from the Tauranga strategic transport model with adjustment for local income levels. The risk analysis includes sensitivity tests using lower VoTs values (based on a revised assumption about income levels in the Tauranga strategic transport model) and higher VoTs based directly on Tauranga strategic transport model VoTs without adjustment. Lower and higher HCV VoTs are also tested. The low and the high tests assume HCV VoT values change in line with greatest change in light vehicle VoT.

Appendix C presents the values used in the sensitivity test.</td></tr>
</table>

Willingness to Pay - Escalation	Demand	The assessment assumes that the tolls are escalated at the rate of inflation, but that WtP will escalate 1% faster per annum. The risk analysis includes a low scenario based on 0% escalation and a high scenario where 1.5% escalation is assumed. Appendix C presents the values used in the sensitivity test.
Willingness to Pay - Road Perception Factors	Demand	Road perception factors are used to distinguish road characteristics such as safety, comfort and gradient. There is uncertainty in how drivers perceive these characteristics, particularly for a toll road. The low scenario is based on -50% on the modelled road perception factors, the high scenario is based on +50% on the modelled road perception factors.
Demand Response	Demand	The models include a demand response to changes in travel costs (including costs of tolls), where demand elasticity is -0.32 in the peak and -0.56 in the off peak, which is the assumption suitable for locations with Low modal competition plus a -20% adjustment to account for RPFs applied in the model (see Appendix B) for further detail). The risk analysis tests a scenario with no elastic response, and a second scenario with higher elasticities, -0.6 peak and -1.0 in the off peak (which is the assumption suitable for locations with High modal competition).
SIP and Revocation works	Demand	Speed and capacity treatments based on SIP have been assumed on the alternative routes for the modelled scenarios. At the start of the tolling study the revocation workstream was in progress and so revocation works (such as changes to posted speed limits on the existing SH1) were not known. As such, the core modelling of the scheme with and without tolling did not include revocation works. At the time of the sensitivity testing for tolling the revocation workstream was able to advise on the recommended revocation works including posted speed limits on the existing SH1 and SH57. The high estimate sensitivity test assumes revocation works speed limit assumptions on SH1 of 50kph in Ohau and 50kph and Manakau and extending the 50 kph speed limit in Levin northwards to 250m south of Lindsay Road. The low estimate sensitivity test assumes 100kph between Manakau and Waitohu Valley Road (including a median barrier) which could be part of future SIP works. The speed limit assumptions for these two tests and the following two tests are tabled in Appendix E.
SH57 Revocation works	Demand	It is possible that with tolling further speed reductions may be applied on the existing SH1 or SH57. The risk analysis includes a test that assumes 50kph on SH57 from Heatherlea Road to Queen Street East in response to tolling section B.
Ō2NL Speed	Demand	The Ō2NL corridor has been modelled as a 100km/h road. There is a possibility that this could be 110kph on sections B and C. This possibility is included in the risk analysis.
Annualisation factors	Demand	The model has used SH1 Ohau 2018 count data to determine annualisation factors. We have developed alternative factors based on how we assign the modelled period flows to each hour of the day. These alternative factors are included in the risk analysis.
Traffic model driver costs per km assumptions	Demand	We have tested lower and higher driver costs per KM values (-50% and +50%).
Region-wide mode shift	Demand	We have assessed the potential magnitude of impact of high uptake of cycling and inter-regional rail /bus / coach travel on car trips. To do this, each origin and destination movement across the modelled area was judged as to whether there was a potential for car trips to switch to cycling and whether there was a potential for car trips to switch to public transport in the future. The potential for a switch to cycling was judged based on distance between the origin and destination, and potential to switch to public transport was judged on distance between the origin and destination and population density of the origin and destination (a proxy for whether a public transport service might be feasible in the future). The trips forecast to use Ō2NL that were in scope

		for a switch to cycling or public transport were then assumed to switch based on adoption rates of 5% in 2029, 10% in 2039 and 15% in 2049 for public transport and on adoption rates of 2.5% in 2029, 5% in 2039 and 10% in 2049 for cycling.
Revenue leakage	Revenue	The assessment assumes a 3% loss of revenue for lights and 2% for HCVs from non-payments. The risk analysis assumes 2% loss for lights and 1% loss for HCVs for high test and assume 5% for lights and 4% for HCVs for the low test.
Transaction costs	Transaction costs	The assessment assumes a transaction cost of 70 cents. For the low test we assume this might increase to 80 cents, for the high test we assume this may reduce to 65 cents in 2029, 55 cents in 2039 and 45 cents in 2049.

6.2 Method

There are three components of demand on Ō2NL that contribute to the revenue forecasts. These are:

1. Demand on section C, but not on section B, (named 'South demand')
2. Demand on section B but not on section C (named 'Central demand')
3. Demand for both section C and section B. (named 'Through' demand)

As each component of demand contributes to revenue, and with Through demand having a different toll amount to South demand and Central demand, we treat each component of demand individually in the risk analysis.

Some risk items impact each component of demand differently, but the impact would be similar across the three forecast years. For example, the impacts of SIP and Revocation works impact South demand to a greater degree than Central demand, but the impacts are expected to be reasonably similar across each forecast year.

Some risk items will have different impacts in different years. For example, the VoT escalation assumptions is of greater significance in the later years than in earlier years.

Some risks will have different effects to each demand component and for forecast year. The land use assumptions are an example of this.

5th percentile, 50th percentile and 95th percentile forecasts were determined using a Monte Carlo simulation to combine results of a number of sensitivity tests concerning the key risks to the traffic volume and revenue forecasts. The sensitivity tests involve defining a range of potential values for an uncertain variable in the modelling or revenue forecasts calculations and reviewing the variation in the forecast as the variable changes within the range. Appendix C provides details of the risk analysis including:

1. The assumed distribution for each risk item,
2. The distribution parameters by Ō2NL demand group, and by forecast year
3. A description of the Monte-Carlo-type simulation that combined all the risks
4. Plots of the traffic volume risk factors for each Ō2NL demand group, and by forecast year

Figure 6-1 below provides an example of the risk adjustment factors for demand on section C only in 2039. As shown in the plot, the land use assumptions result in the most uncertainty to the traffic volume forecast for demand on section C only in 2039, as does the Tara-Ika development assumptions, Willingness to Pay Road Perception factors, and the SIP and Revocation works. When all risk factors are combined, the resulting 50th percentile factor is 0.80, the 5th percentile factor is 0.63 and the 95th percentile factor is 1.03.

Figure 6-1 Example of the risk adjustment factors for South demand in 2039.

	Land Use changes	Taraika development	WtP - VoT	WtP - Escalation	WtP - RPFs	Demand Response	SIP and Revocation works	SH57 Revocation works	O2NL at 110kph	Annualisation	PPK values	Region-wide mode shift	Combined
95th	1.09	1.02	1.04	1.02	1.04	1.03	1.05	1.00	1.07	1.01	1.04	1.00	1.03
5th	0.74	0.88	0.97	0.93	0.92	0.97	0.93	1.00	1.00	0.99	0.96	0.93	0.63
50th	0.87	0.97	1.00	0.98	0.99	1.00	0.99	1.00	1.00	1.00	1.00	1.00	0.80

6.3 Final Risk adjustment factors

Figure 6-2 presents the 5th, 50th and 95th percentile risk adjustment factors for traffic volumes for each demand component for each forecast year, 2029, 2039 and 2049. As shown in the figure, the greatest uncertainty is around Central demand. This is because this demand component is more readily impacted by the land use assumptions including the Tara-Ika development. South demand has the least degree of uncertainty.

Figure 6-2 Risk adjustment factors: Traffic Volumes

As described in Table 6-1, a key distinction between the traffic volume forecasts presented in the DBC and in this report is that 5th percentile, 50th percentile and 95th percentile data estimates are presented here, rather than 25th percentile, 75th percentile and 95th percentile data estimates that are presented in the DBC.

Figure 6-3 presents the 5th, 50th and 95th percentile risk adjustment factors for revenue leakage for each demand component for each forecast year, 2029, 2039 and 2049. As shown, the revenue leakage risk adjustment factors are the same for all sections and all years.

Figure 6-3 Risk adjustment factors: Revenue Leakage

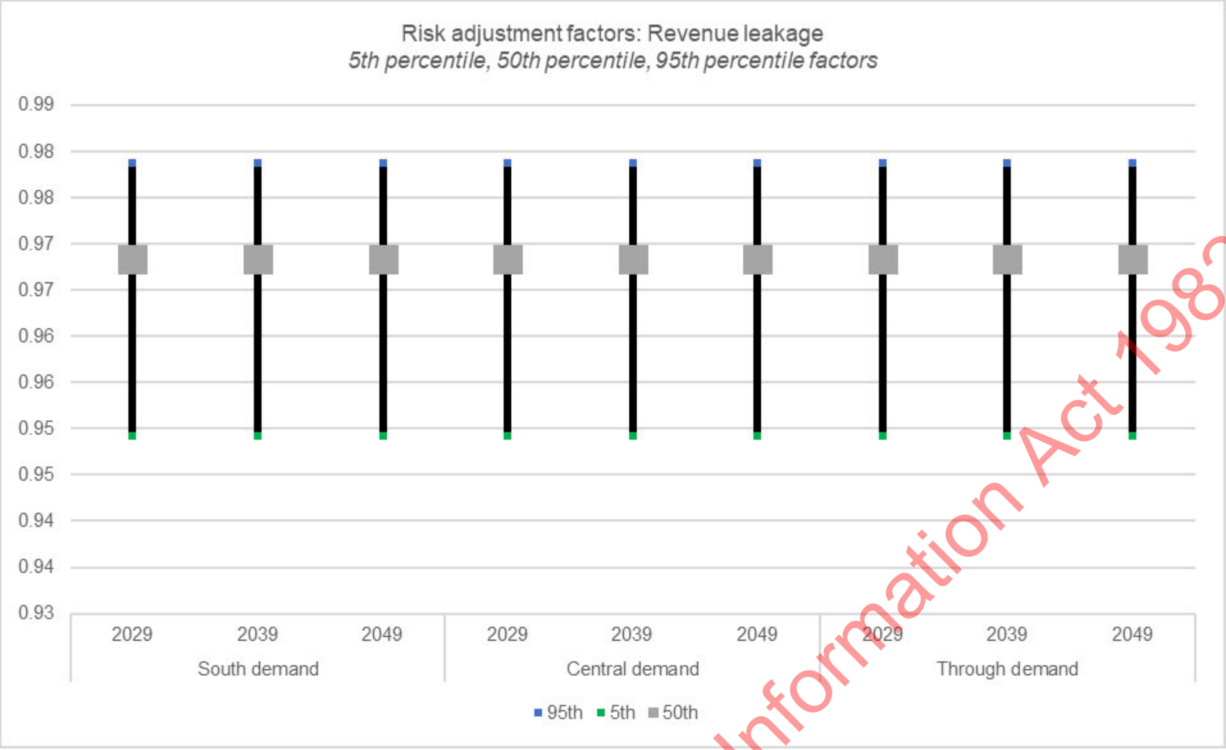
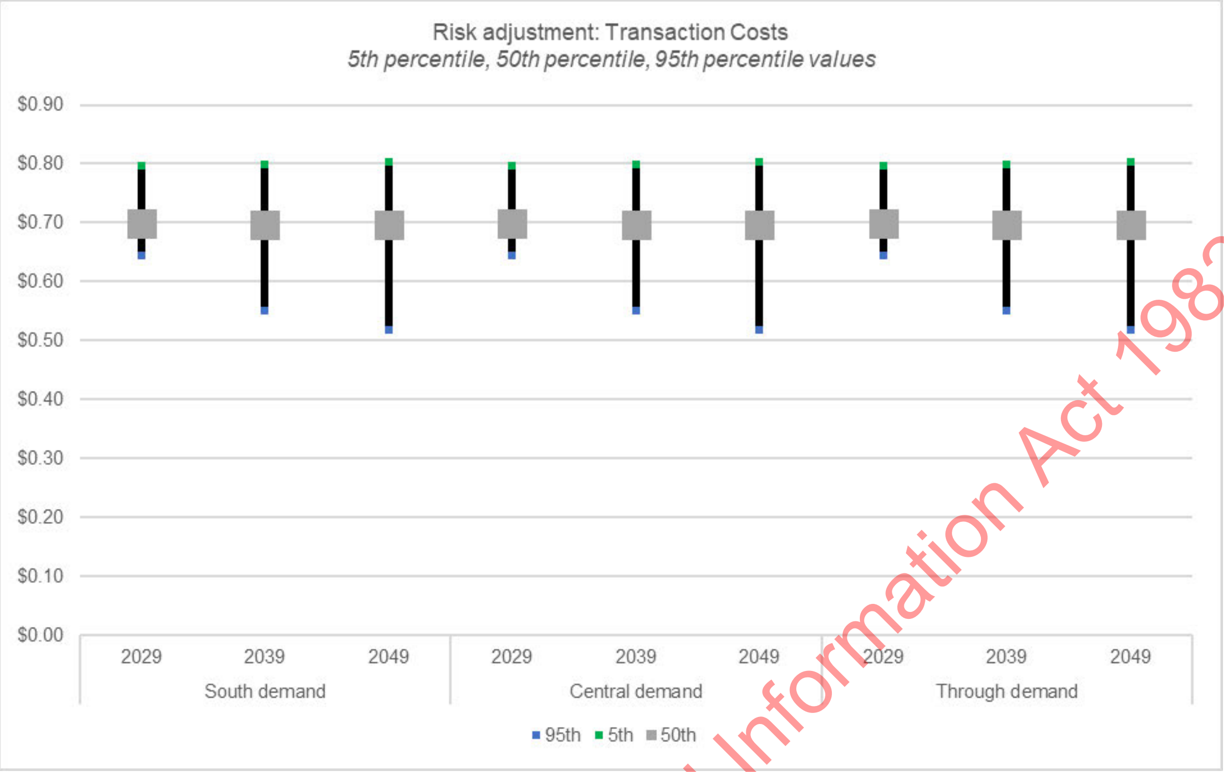


Figure 6-4 presents the 5th, 50th and 95th percentile risk adjustment values for transaction costs for each demand component for each forecast year, 2029, 2039 and 2049. As shown, the 50th percentile and 5th percentile transaction costs at the same for all years, but the 95th percentile transaction costs decrease over time.

Figure 6-4 Risk adjustment: Transaction Costs



6.4 Results

The forecast 50th percentile average daily flows on Ō2NL between Taylors Road and Tararua interchange (section C) with tolling are predicted to be:

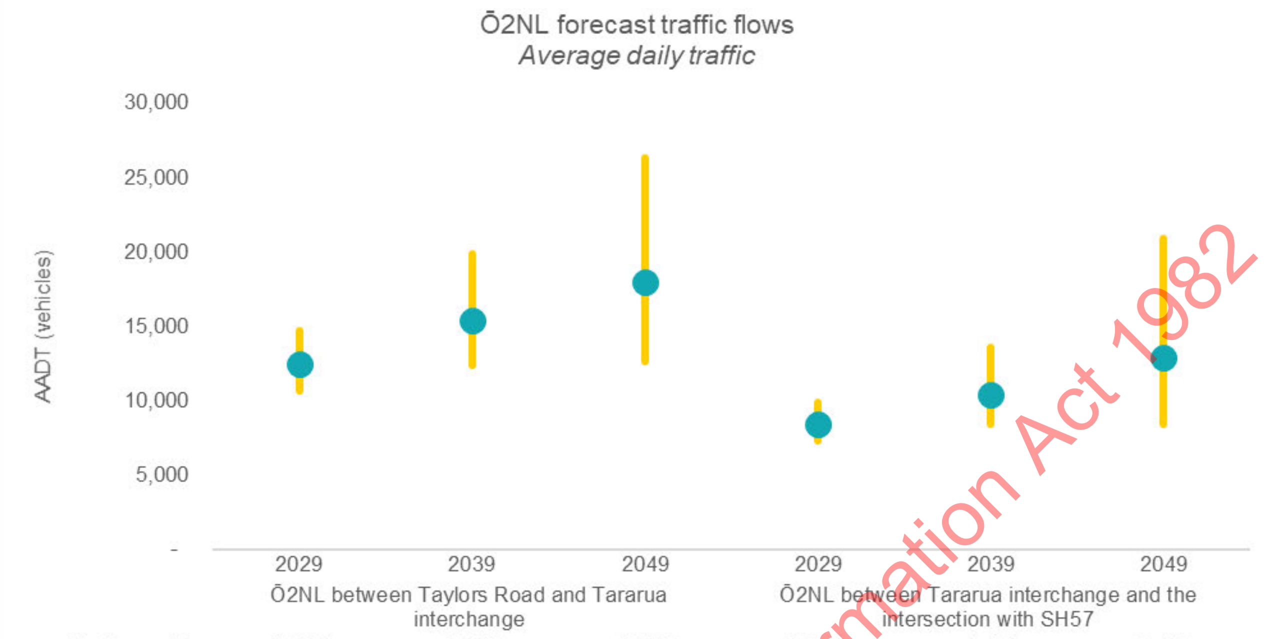
- *12,500 vpd in 2029*
- *15,400 vpd in 2039*
- *18,000 vpd in 2049*

The forecast 50th percentile average daily flows on Ō2NL between Tararua interchange and the intersection with SH57 (section B) with tolling are predicted to be:

- *8,400 vpd in 2029*
- *10,400 vpd in 2039*
- *12,900 vpd in 2049*

The 5th percentile, 50th percentile and 95th percentile forecast average daily flows are presented in Figure 6-5 below.

Figure 6-5 Forecast average daily flows on Ō2NL



	2029	2039	2049	2029	2039	2049
5th Percentile	10,700	12,400	12,600	7,300	8,400	8,400
50th Percentile	12,500	15,400	18,000	8,400	10,400	12,900
95th Percentile	14,700	19,900	26,300	9,900	13,600	20,900

These traffic flows are estimated to generate and annual gross revenue[10] of

- $10.7m in 2029
- $13.2m in 2039
- $15.8m in 2049

With a 50th percentile toll transaction cost of 70c per vehicle, the 50th percentile net revenue of the preferred toll strategy is estimated to be:

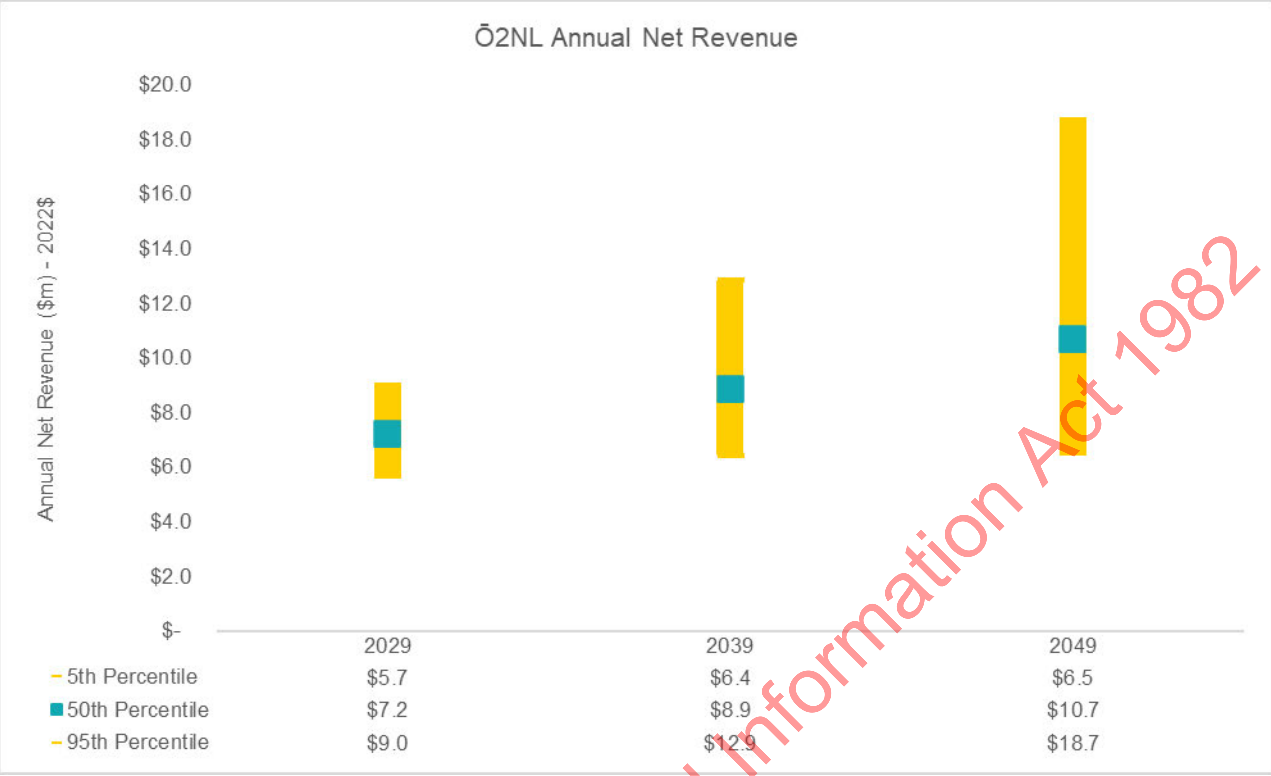
- *$7.2m in 2029*
- *$8.9m in 2039*
- *10.7m in 2049*

This report does not address the level of tolling that is appropriate in order to recover the costs of operating and maintaining Ō2NL, revocation and construction costs as this will be the subject of separate consideration by Waka Kotahi.

The 5th percentile, 50th percentile and 95th percentile forecast net revenue from tolling with the preferred strategy is presented in Figure 6-6 below.

[10] The 50th percentile estimate of gross revenue includes a reduction to account for 'revenue leakage' of 3% for light vehicles and 2% for heavy vehicles.

Figure 6-6 Forecast annual net revenue from tolling



7 Conclusions

This analysis has identified the transport system effects of imposing a toll on the Ō2NL project, including assessment of potential changes in total crash costs, enabled emissions and travel times on both Ō2NL and the existing SH1 and SH57 routes. The modelling indicated that without tolls, Ō2NL project would induce new vehicle travel Relative to this base case, tolling was found to:

- Divert a proportion of traffic from Ō2NL back to the existing SH1 and SH57
- Maintain a significant proportion of reductions in crash cost costs and DSI compared to today and the future year Do Minimum scenario, but increase crash costs and DSI compared to the no toll scenario as a result of more traffic on the existing SH1 and other parts of the local network
- Reduce enabled emissions compared to the no toll scenario by reducing induced traffic and re-routing users who choose to avoid the toll to a shorter route
- Have no material detriment to travel times across the network

A preferred tolling strategy and tolling level was selected that balanced the need to generate sufficient revenue for the implementation of toll infrastructure and [meet/contribute to] maintenance and operational costs, revocation, and construction costs, while minimising the impact on the forecast crash costs and deaths and serious injuries (DSI). The preferred strategy also had the benefit of reducing emissions more so than other strategies.

The preferred tolling strategy comprises:

- A gantry on Ō2NL between Taylors Road interchange and the Tararua interchange (Section C)
- A gantry on Ō2NL between the Tararua interchange and the intersection with SH57 (section B).
- A $1.25 toll per gantry for light vehicles and a $2.50 toll per gantry for heavy vehicles

Forecasting traffic flows for a new toll road contains inherent uncertainty. While this report has attempted to quantify the potential scale of the key uncertainties, the risks associated with traffic forecasts should be considered in design and policy decisions for this project.

8 Limitations

This analysis is based on the existing Ō2NL traffic model (modified to represent tolling) and driver willingness to pay (WtP) parameters from other studies (albeit refined and updated to local conditions). Detailed market research into WtP has not been undertaken specifically for this work, however the effects of uncertainties in WtP and other key inputs and assumptions have been estimated via sensitivity tests and risk-profiling. While this work provides estimates of traffic volumes and revenue suitable for network planning, the revenue estimates are not considered 'investment grade' such as might be required for private-sector investment.

The purpose of this report is to assess the transport network impacts and revenue from tolling the Ō2NL scheme, in accordance with the parameters of our agreed scope as set out in our proposal. Further analysis may be required in order to support more detailed financial analysis.

Although in this report, Beca offers professional advice and may express opinions on likely or possible outcomes, we cannot guarantee any particular outcome and any decision to proceed with the next phase of investigation is a commercial decision for Waka Kotahi.

It should be noted that the toll revenue estimates provided as part of the Services are not a statement of absolute revenue suitable for detailed investment decisions, rather they will have an accuracy range commensurate with various factors such as the extent of relevant information provided, the certainty of data and assumptions and the level of detail available at the time of preparation.

Assessment of the transport network impacts is limited to the following outcome measures:

- Traffic flows
- Travel times
- Safety – as measured by the social crash cost difference between a tolled and un-tolled scenario
- Emissions – as measured by the change in vehicle CO_2 emissions between a tolled and un-tolled scenario
- Equity – as simplistically considered in terms of pricing across the different users of the corridor
- Revenue

This assessment has included the transport system effects noted above and has not included a wider assessment against Waka Kotahi or other Government policies or frameworks. Forecasting traffic flows for a new toll road contains inherent uncertainty. While this report has attempted to quantify the potential scale of the key uncertainties, the risks associated with traffic forecasts should be considered in design and policy decisions for this project.

In preparing this assessment we have relied on the inputs and assumptions provided by or agreed with Waka Kotahi as outlined in this report, including:

- Ō2NL model and the coding of the scheme in the model
- Design of Ō2NL project
- Land use inputs from the Horowhenua Socio-Economic projections report by Sense Partners (May 2020)
- Wider network project assumptions regarding SIP and revocation works
- Toll system transaction costs
- Waka Kotahi’s Vehicle Emission Prediction Model

A

Appendix A – Long list of toll gantry location strategies

Long List of toll gantry location strategies

Toll Strategy no.	Gantry location strategy	Tolling Regime
1	A, B, C	Toll the full corridor using incremental toll.
2	A, R1, C	Semi-incremental / capped toll
3	B, C (incremental toll)	Toll B and C with incremental toll.
4	C, R1	Capped toll by design. B only Users get R1 toll C only Users get C toll **C+R1 users get C toll**
5	B, R2	Flat fare toll by design. B only Users get B toll C only Users get R2 toll **C+B users get B toll**
6	B, C (capped toll)	Same capped tolling regime as 4, but different gantry strategy.
7	C	Toll C only, the largest section of the corridor.
8	A	Toll A only, the shortest section of the corridor.
9	B	Toll B only, the middle section of the corridor.
10	B, C (through traffic only toll)	Target B+C users only

Preliminary assessment of long list strategies

The preliminary assessment of the long list of toll gantry location strategies is presented in the table below. Toll gantry location strategies 1 to 9 were developed for the workshop and Toll gantry strategy No. 10 was conceived at the workshop. At the 31 March 2022 workshop with Waka Kotahi staff the long list of strategies was evaluated, and four strategies as shown were selected to be taken forward to a more detailed assessment.

Preliminary assessment of long list strategies

Toll Strategy no.	Strategy	Fairness	Revenue	Efficiency	Capital Cost	Enabled Emissions	Safety	Total	Take into modelling
1	A, B, C	4	4	2	1.0	2	1	2.33	Maybe
2	A, R1, C	3.5	3.5	1.5	1.0	2	1	2.09	No
3	B,C (incremental toll)	3	3	3	1.5	3	2	2.58	Yes
4	C, R1	2	2	2	1.5	4	3	2.42	No
5	B, R2	1	1.5	1	1.5	3.5	2.5	1.84	No
6	B,C (capped toll)	2	2	2	3.0	4	3	2.42	No
7	C	1	1	4	2.8	2	4	2.46	Yes
8	A	0.3	0.3	0.5	2.8	1	0.5	0.89	No
9	B	0.5	0.5	1	2.8	1	0.5	1.04	Yes
10	B, C (through traffic only toll)								Yes

B

Appendix B – Traffic Modelling

Introduction

Waka Kotahi commissioned Beca (with subconsultant support from QTP) to undertake a tolling study for the Ōtaki to North of Levin (Ō2NL) State Highway One (SH1) Expressway Project.

The tolling study utilised the existing v20 Ō2NL traffic model being used by Waka Kotahi for the DBC, but with modifications to respond to tolls; these being:

- Toll Assignment Response model (including Road Perception Factors)
- Toll Demand Response Model

The ***Toll Modelling Specification file note*** provided in this appendix describes the specification of the toll modelling updates to the existing Ō2NL traffic model that support the tolling study.

QTP Ltd implemented the toll modelling updates described in this specification within v22 of the Ō2NL models. The QTP report ***Ō2NL Model Tolling Update v01a.docx*** dated 28 April 2022 provides in this appendix is a comprehensive description of the implementation of all the updates and changes made between v20 and v22 of the model (i.e., the implementation of the changes recommended in the toll modelling specification).

File Note

By:	section 9(2)(a)	**Date:**	10 May 2022
Subject:	Ō2NL Toll Modelling Specification File Note	**Our Ref:**	3822850

1 Introduction

Waka Kotahi commissioned Beca (with subconsultant support from QTP) to undertake a tolling study for the Otaki to North of Levin (Ō2NL) State Highway One (SH1) Expressway Project.

This study utilises the existing O2NL traffic model being used by Waka Kotahi for the project business case, albeit modified to respond to tolls. This file note describes the specification of the toll modelling updates to the existing Ō2NL traffic model that support the tolling study. Specifically, this note describes the specification for two updates:

- Toll Assignment Response model in the Ō2NL model v22
- Toll Demand Response Model in the Ō2NL model v22

The Ō2NL models have been developed by QTP for appraisal of Ō2NL since around 2015. QTP implemented the toll modelling updates described in this specification within v22 of the Ō2NL models. The QTP report (Ō2NL Model Tolling Update v01a.docx dated 28 April 2022) provides a comprehensive description of the implementation of all the updates and changes made between v20 and v22 of the model (i.e. the implementation of the changes recommended in this Specification).

2 Toll Assignment Response model

2.1 Purpose

There are two components to the Toll Assignment Response model. These are:

- The use of Road Perception Factors (RPFs) in the route choice model
- User-class segmentation and the associated willingness to pay (WtP) values of time (VoTs) for each segment

The purpose of RPFs is to reflect the effects that variation in aspects such as the safety, convenience, amenity and reliability of different roads have on the perceived attractiveness of a route (beyond those of varying speed and distance). From our experience of modelling traffic networks with toll roads in Tauranga and in Auckland, we have found that RPFs are an essential element in the representation of travellers perceived generalised costs. We have found that just using VoT (within plausible levels), do not explain the high willingness of travellers to pay a toll. We therefore believe there are other considerations beyond simple VoT that influences choices. These other considerations are represented using RPFs. It is noted that the use of RFPs is not unique to toll studies, and are included in a number of city of project models in NZ.

The purpose of the user class segmentation (and the associated values of time) in a toll model is to reflect the distribution in the travelling public's willingness to pay a toll. People's willingness to pay is context specific, and so will vary depending on a range of factors such as their purpose of travel, their income level or what time the game starts. Segmenting the vehicle demand matrices into a number of user class segments and applying varying levels of VoT for each segment is done to represent this range in people's willingness to pay a toll.

2.2 Road perception factors

RPFs are used in a number of traffic models across New Zealand. These include:

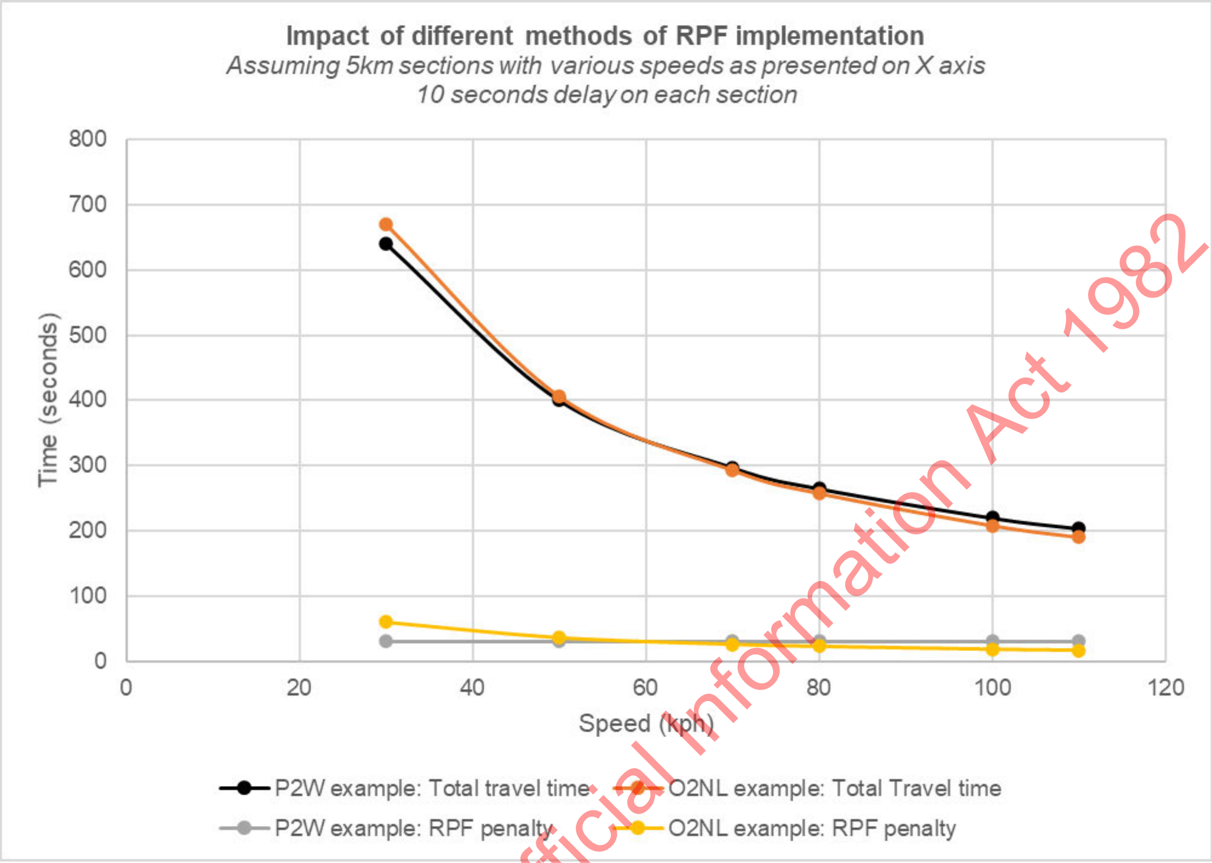
- Tauranga Transport Strategic Model (TTSM)
- Puhui to Wellsford model (P2W model)
- Penlink Traffic Assignment Model
- Auckland Council's Macro Strategic Model (MSM)

RPFs are applied in different ways across the models, in part due to the features and limitations of various modelling software packages. In the MSM, TTSM and Penlink Traffic Assignment Model the RPF's are applied to the link distance effectively increasing the Vehicle Operating Costs by the RPFs. Whereas in the P2W model it is applied as an additional time penalty per kilometre for each link.

The road perception factors from the P2W model were chosen to be used in the Ō2NL model because of the similarity in the road types in each modelled area, the similarity in the road type classification system used in the respective models and both models use the SATURN modelling software. In the P2W model, a toll motorway has a RPF of 0min/km and a standard motorway has a RPF of 0.1min/km, implying a perceived quality advantage associated with a toll motorway compared to a standard motorway. Consideration was given to applying this perceived quality advantage in the Ō2NL model. However, ultimately the rationale for this approach could not be supported with sufficient evidence and it also introduced complications with respect to induced traffic effects under an elastic assignment. It is not anticipated that the action of tolling the expressway would induce (encourage) greater demand for travel.

In the Ō2NL model, the implementation of road perception factors is different than the P2W model; additional time penalties resulting from the RPFs are calculated as a proportion of the link free-flow travel time, rather than as a time penalty per km. This method of implementation was chosen as a slight improvement of the implementation in the P2W model. This is because we would expect travellers to have a better perception of free flow time on roads than travel distance on roads. Figure 2-1 presents the impact of different methods of RPF implementation. The figure illustrates that the RPF values remain a small component of the overall travel time, but with the new method, the RPF will vary based on the speed of the section of road. The RPFs calculated using the new method have a slightly greater impact on sections of road with the free flow speed lower than 60kph, and slightly less of an impact on sections of road with the free flow speed greater than 60kph.

Figure 2-1 Impact of different methods of RPF implementation



Using free-flow time rather than travel time (that includes delay) avoids the need for any iterations of model runs to base the penalties on congested travel times and is considered likely to reflect motorist's perceived quality advantage of a route, with the congested component of travel time being modelled as part of the generalised cost of each link and route[1].

The RPFs in the Ō2NL model are presented in Table 2-1 below alongside the system used in the source model (the P2W model) for comparison.

[1] Using free-flow travel time rather than actual time (free-flow time + delay) is considered useful in giving more weight to main roads and reduce the level of rat-running in the model. This would also have the benefit of making the route choice assignment more stable in congested scenarios.

Table 2-1 Road Perception factors in the Ō2NL model

P2W Model		Ō2NL model	
Road type	**RPF** ***applied as a penalty in minutes / km***	**Road type**	**RPF** ***applied to the free flow travel time***
Toll Road	0	Motorway	+0%
Motorway	0.1		
Strategic Routes	0.2	Major Arterials	+20%
Regional	0.25	Minor Arterials	+25%
Rural – level	0.3	Not used	-
Rural – rolling	0.35	Rural Minor	+30%
Local / Collector / Urban / Town Centre	0.4	Urban Local & Collectors	+40%
Rural – mountainous	0.5	Not used	-

2.3 Willingness to Pay user-class segmentation

It was decided to adopt the user class segmentation system and associated values of time from TTSM, the Tauranga Transport Strategic Model. TTSM is considered a suitable source for these toll modelling parameters in the Ō2NL model, however there is a need to account for the differences in income levels between in modelled area of TTSM (Tauranga City and the Western Bay of Plenty District) and Ō2NL model (Levin and Ōtaki).

2.3.1 User-class segmentation

For the purposes of toll modelling, travel demand in the Ō2NL model v22 is grouped into four trip purposes, as is done in TTSM:

- Home-Based Work (HBW)
- Employer's Business (EB)
- Other light vehicle trips (Other)
- HCV trips (HCV).

Each of the above four trip purposes are split to Low, Medium and High WtP segments, to give a total of 12 user-classes for assignment (9 user-classes for light vehicles and 3 user-classes for HCVs).

As per TTSM, HBW, EB, and Other trip purpose demand is split into equal thirds (33.3% Low, 33.3% Medium and 33.3% high) and the HCV trip purpose is split into 10% Low, 40% Medium and 50% high. Table 2-2 presents the user-class segmentation.

Table 2-2 Willingness-to-pay user class segments

Vehicle Class	Journey purpose	WtP segments	Split of journey purpose demand by WtP segment
Lights	Home-Based Work	Low	33.3%
		Medium	33.3%
		High	33.3%
	Employer's Business (EB)	Low	33.3%
		Medium	33.3%
		High	33.3%
	Other light vehicle trips	Low	33.3%
		Medium	33.3%
		High	33.3%
Heavy Commercial vehicles	-	Low	10%
		Medium	40%
		High	50%

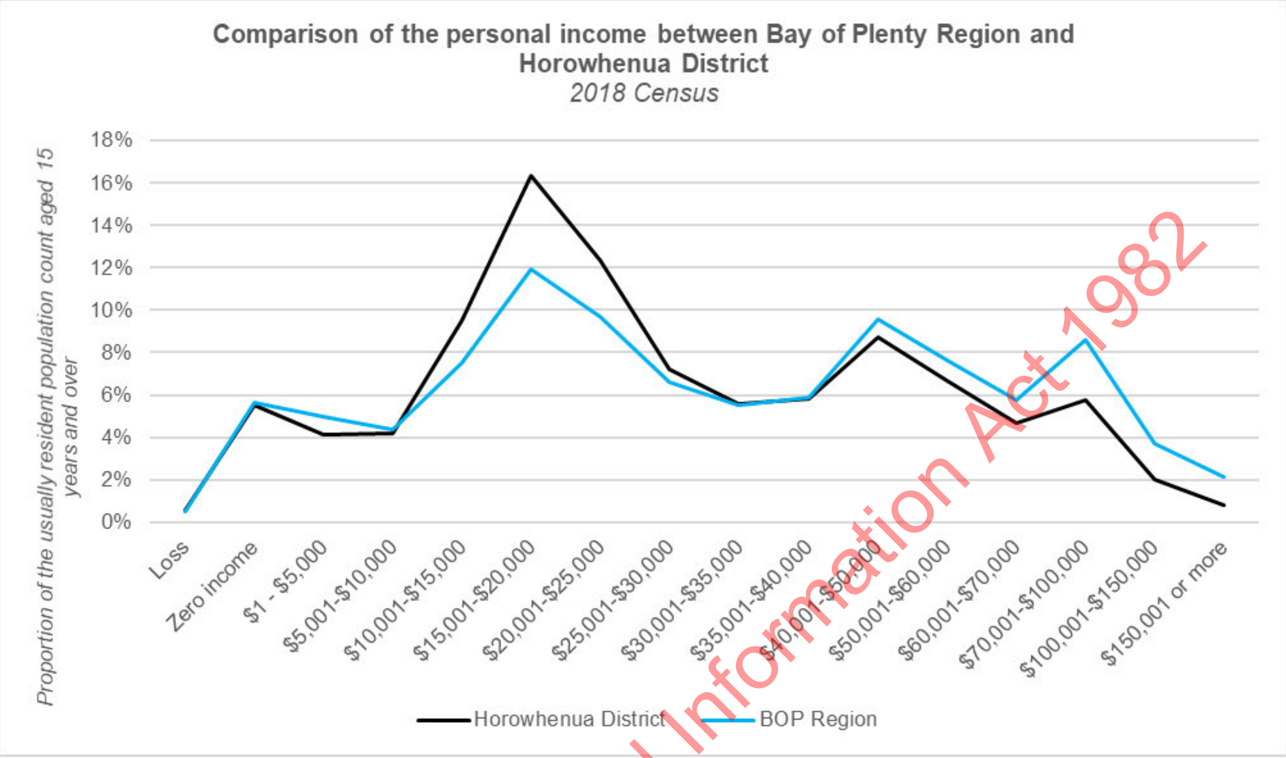
2.3.2 Values of time

As mentioned earlier the TTSM WtP VoTs are used as the source for the Ō2NL model WtP VoTs with an adjustment to allow for the different income levels between the modelled areas for each population third.

Income levels in the Bay of Plenty Region have been used as a proxy for the general willingness to pay of travellers represented in TTSM, and income levels in the Horowhenua District have been used as a proxy for the general willingness to pay of travellers represented in the Ō2NL model. These two sets of income statistics have been used to derived factors to adjust the VoT of each WtP segment for each light vehicle trip purpose.

Figure 2-2 compares of the personal income of the Bay of Plenty Region with the Horowhenua District. The figure shows that the proportion of the population on incomes around $15,000-$30,000 is higher in the Horowhenua District than in the Bay of Plenty Region. The proportion of the population on incomes $40,000 and above is higher in the Bay of Plenty Region than in Horowhenua District.

Figure 2-2 Comparison of the personal income between Bay of Plenty Region and Horowhenua District



The differences in income for each population 1/3 was derived from the comparison of the personal income statistics. The differences are presented in Table 2-3 below. WtP VoT adjustment factors are calculated from the income difference using an elasticity of 0.5. The VoT Elasticity to income has been adopted from research done as part of an update to the Auckland regional strategic model for the purpose of being able to undertake road pricing testing within the model.

Table 2-3 Income for each population 1/3 in Bay of Plenty and Horowhenua, and the WtP VoT adjustment factors

Population segment	Bay of Plenty Region Average income	Horowhenua District Average income	Income difference	WtP VoT adjustment factor
Population 1/3 on low income	$9,600	$9,753	**+2%**	**1.008**
Population 1/3 on medium income	$30,293	$24,744	**-18%**	**0.904**
Population 1/3 on high income	$78,282	$63,673	**-19%**	**0.902**
Overall	*$39,392*	*$32,724*	*-17%*	*Not used*

Equation 2-1 below presents the formula for the calculation of the WtP VoT adjustment factor presented in Table 2-3 above.

Equation 2-1 WtP VoT adjustment factor

$$WtP\ VoT\ Adjustment\ Factor = \left(\frac{Horowhenua\ Income\ by\ Pop\ 1/3}{Bay\ of\ Plenty\ Income\ by\ Pop\ 1/3}\right)^{VoT\ elasticity\ to\ income}$$

Where, VoT elasticity to Income = 0.5

The WtP VoTs for HCVs in different locations is less likely to be correlated to local income levels. Instead, we would expect them to be broadly similar across the county. We considered that there may be a difference in the average HCV WtP VoTs if the composition of truck types between the two areas was different. We reviewed the proportions of truck class in Tauranga (based on three count sites) and Levin (based on the SH1 Ohau count site) and found the split to be very similar as shown in Table 2-4. With this finding, no adjustments to the TTSM HCV WtP VoTs were made when applied in the Ō2NL model.

Table 2-4 Proportions of truck class

Truck class	Tauranga count sites	SH1 Ohau count site
MCV	36%	38%
HCV1	19%	15%
HCV2	46%	47%

Table 2-5 presents the TTSM 2018 WtP VoTs, adjustment factors, and the final WtP VoTs used in the Ō2NL v22 model to convert tolls to generalised costs.

Table 2-5 2018 VoTs by User Class

Vehicle Class	Journey purpose	Income level	TTSM 2018 WtP VoTs ($ / hour)	WtP VoT adjustment factor	Ō2NL model 2018 WtP VoTs ($ / hour)
Lights	Home-Based Work	Low	$18.43	1.008	$18.43
		Medium	$25.41	0.904	$25.41
		High	$38.44	0.902	$38.44
	Employer's Business (EB)	Low	$35.45	1.008	$35.45
		Medium	$45.92	0.904	$45.92
		High	$98.00	0.902	$98.00
	Other light vehicle trips	Low	$8.73	1.008	$8.73
		Medium	$12.65	0.904	$12.65
		High	$21.03	0.902	$21.03
Heavy Commercial vehicles	-	Low	$23.71	1.000	$23.71
		Medium	$44.24	1.000	$44.24
		High	$79.64	1.000	$79.64

2.3.3 External demand VoTs

The above Ō2NL WtP VoTs in Table 2-5 are applied in the Ō2NL across all origin to destination movements for each respective user class segment. However, because of differences between income levels in Horowhenua District as compared to the wider Wellington and Manawatū-Whanganui Region, we would expect the WtP VoT of movements between External zones to be different to that of movements originating from with the modelled area or destined to locations within the modelled area. To account for this, we have applied trip purpose splits to External-External demand that result in an overall higher average WtP VoT as compared to the average WtP VoT across other movements in the model. This method was chosen over directly applying different VoTs to the External-External demand which would have required setting up External-External demand as a separate user class in the Saturn Software.

Income levels in the Wellington and Manawatū-Whanganui Region have been used as a proxy for the general willingness to pay of demand between external zones in the Ō2NL model. The difference in income overall between the two geographies is presented in Table 2-6 below. The VoT adjustment factor is calculated from the income difference using an elasticity of 0.5.

Table 2-6 Average incomes in the Horowhenua District and Wellington and Manawatū-Whanganui Region, and the External to External demand VoT adjustment factor

Population segment	Horowhenua District Average income	Wellington and Manawatū-Whanganui Region Average income	Income difference	External to External demand VoT adjustment factor using an elasticity of 0.5
Overall	*$32,724*	*$44,368*	***+36%***	***1.16***

External to external light vehicle trip demand is estimated in v20a through GPS-data analysis and is not assigned a purpose. External HCV trips are estimated in the same way. For v22, we apply a trip purpose split External to external light vehicle trips to align with the segmentation used for all other light vehicle trips in the toll assignment response model. As a starting point for the allocation of the light vehicle trips to purposes, we used the trip purpose proportions of long-distance trips from Roadside Interview Surveys (RIS) conducted for the Tauranga Transport Strategic Model. We then applied adjustments related to differing average incomes for the Horowhenua District compared to the Wellington and Manawatū-Whanganui Regions to increase the overall average WtP VoT by 1.16 (as shown in Table 2-6) from $22.29 to $25.64. These steps are presented in Table 2-7 below.

Table 2-7 Method to establish the Light vehicles External to External trip purpose split

	All Light vehicles		External to External light vehicles			
	Demand	WtP VoT	Tauranga RSI survey	WtP VoT	Adjusted split	WtP VoT
HBW	19%	$27.42	25%	$27.42	***35%***	$27.42
EB	12%	$59.79	10%	$59.79	***15%***	$59.79
Other	68%	$14.14	65%	$14.14	***65%***	$14.14
Overall	100%	**$22.29**	100%	$22.02	100%	**$25.64**

2.3.4 Future year VoTs

We assume Ō2NL tolls will be escalated over time at the rate of inflation as defined by the Consumer Prices Index (CPI). WtP VoT is likely to escalate based on income growth, and average weekly earnings have historically been found to grow at 1%-1.1% faster than CPI. This means that the WtP VoT is expected to increase over time in real terms. To account for the difference in CPI growth and WtP VoT growth a 1% escalation effect is applied to the WtP VoT in the v22 model. Based on this assumption, Table 2-8 presents the real change in WtP VoT that are applied to the WtP VoTs for each Ō2NL modelled year.

Table 2-8 Real change in WtP VoT by modelled year

Year	Real change in WtP VoT
2018	1
2029	1.1157
2039	1.2324
2049	1.3613

Table 2-9 presents the WtP VoTs by user class for each modelled year with the future year WtP VoTs adjusted by the factors as set out in Table 2-8.

Table 2-9 WtP VoTs by User Class for each modelled year ($ / hour)

Vehicle Class	Journey purpose	Income level	2018	2029	2039	2049
Lights	Home-Based Work	Low	$18.43	$20.56	$22.71	$25.09
		Medium	$25.41	$28.34	$31.31	$34.59
		High	$38.44	$42.88	$47.37	$52.32
	Employer's Business (EB)	Low	$35.45	$39.55	$43.68	$48.26
		Medium	$45.92	$51.23	$56.59	$62.51
		High	$98.00	$109.34	$120.77	$133.41
	Other light vehicle trips	Low	$8.73	$9.74	$10.76	$11.88
		Medium	$12.65	$14.12	$15.59	$17.22
		High	$21.03	$23.47	$25.92	$28.63
Heavy Commercial vehicles	-	Low	$23.71	$26.46	$29.23	$32.28
		Medium	$44.24	$49.36	$54.52	$60.23
		High	$79.64	$88.85	$98.14	$108.41

3 Toll Demand Response Model

3.1 Purpose

The purpose of a Toll Demand Response Model is to reflect the impact that the introduction of a toll may have on travel demand given higher 'costs' of travel under tolling scenarios. In this context, 'demand' refers to the trip matrix and reflects potential changes in mode, destination, trip frequency or time of day. This is distinct from 'diversion' effects which involves changing route through the network. The demand changes are expected to respond to changes in travel costs, which includes both travel time and monetary costs. For consistency, this demand response is proposed to be applied to both the untolled and tolled scenarios.

3.2 Approach

Saturn's elastic assignment approach was applied in the v20a Ō2NL model for the purpose of a sensitivity test as part of development of the Detailed Business Case (DBC). The elastic assignment approach is a method of modelling possible responses to travel cost changes such as that resulting from new infrastructure (induced traffic) or congestion relief (suppressed demand).

A demand response to toll is considered an essential part of this toll study, and different methods of implementing a demand response in the Ō2NL model were considered at the outset of the study. The elastic assignment approach as used in the DBC sensitivity test described above was selected as a suitable and pragmatic method of representing the demand response to various levels of tolls.

The following assumptions have been applied in the demand response model which are consistent with the advice of Waka Kotahi's Monetised Benefits and Costs Manual (MBCM):

- The 'pivot' matrix is the (2018) base year matrix
- The 'pivot' costs are GCs (including RPFs) for the (2018) base year
- The Power function is applied
- Elasticities for low modal competition (with adjustments as described below) are applied.

The MBCM recommends elasticity values of -0.4 for peak periods and -0.7 for off-peak periods in areas of low modal competition (MBCM, Table A14). The Ō2NL modelled area is an area of low modal competition.

We recommend that these values are reduced by 20% to offset the RPFs that are included within the GCs calculated within the pivot costs. RPFs have been shown in other studies to be essential in representing route choice in a toll study, but they are not designed for inclusion in a toll demand response model. The adjustment to the elasticities is set out in Table 2-8 below.

Table 3-1 Adjustment to generalised cost elasticities used in the Toll Demand Response model

Time period	Long-run generalised cost elasticities (MBCM values for Low modal competition, Table A14)	Adjustment to offset the RPFs that are included within the GCs calculated within the pivot costs	Generalised cost elasticities applied in Ō2NL v22

Peak periods	-0.40	-20%	**-0.32**
Off-peak period	-0.70	-20%	**-0.56**

The scale of the adjustment to the elasticities (i.e., -20%) was applied on the basis that application of the RPFs in the model provide an approximate 20% reduction in the travel times on the Expressway, relative to the alternative State Highway route. As travel times are the major component of generalised cost, this adjustment effectively cancels out the route perception advantage of the Expressway in terms of estimation of the induced traffic effect.

4 Conclusion

Toll assignment response and toll demand response are essential elements in the assessment of tolling strategies for the Ō2NL toll study. The model updates described in this note provide a practical and robust approach to update the Ō2NL traffic model in order to represent and test different tolling strategies. Many of assumptions described uncertain, and sensitivity tests on the values adopted in the core model runs will be carried out. This will include sensitivity tests for VoT values, RPFs, Demand Elasticity and trip purpose proportions.

section 9(2)(a) **and** section 9(2)(a)

Sensitivity: General

Otaki to North of Levin Expressway Traffic Model

Tolling Update v22a

April 2022

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Contents

1 Executive Summary

1.1 The Otaki to North of Levin Traffic Model (**O2NLTM**) is a traffic model implemented within the SATURN software. It was originally developed in 2011 by consultants MWH for the NZ Transport Agency (now Waka Kotahi) to undertake the investigations for the Otaki to North of Levin (**O2NL**) State Highway One (**SH1**) Road of National Significance (**RoNS**) Expressway Project.

1.2 A number of discrete enhancements to the model were implemented by QTP between 2015 and 2017, based primarily on refining the modelled network and zone system to improve the capability of the model to accurately reflect traffic volumes and hence the network performance, with and without the proposed Expressway.

1.3 More recently, Horowhenua District Council (**HDC**) identified a desire to modify and apply the model to better understand the transport effects of demographic growth and to form an input into their Integrated Transport Strategy. The v20a update included updating the model to latest demographic estimates (census 2018) and spatial forecasts agreed with HDC. This v20a version of the model has been used as the basis of most recent appraisal of Ō2NL for the Detailed Business Case (**DBC**) modelling progressed during 2021.

1.4 This v22a update is focussed on changes to the v20a model to make it more appropriate for assessing the vehicle demand responses to potential tolling of the Expressway.

1.5 Direction on the methodology adopted has been provided by Beca. The v22a update is concerned with changes to the structure, parameters and processes within the model. It does not therefore explicitly include any changes to demographic forecasts or to the Ō2NL Expressway physical characteristics which remain as per the DBC modelling.

1.6 The key changes to the model described within this report are summarised as follows:

- **Introduction of Road Perception Factors** (**RPF**s) to reflect the effects that variation in the quality of different road standards (notably motorways) have on the perceived attractiveness of a route (beyond those of varying speed and distance).
- **Changes to the Assigned User Classes** to reflect some 12 classes varying by purpose, vehicle type and willingness to pay categories, as opposed to the 2 vehicle classes (lights and heavies) assigned in the v20a model. This change is required to provide a greater 'spread' of users in terms of their 'willingness to pay (a toll)' and therefore to better reflect for each vehicle class the effect that a toll will have on route-choice.
- **A Toll Demand Response Model** that reflects the impact that the introduction of a toll may have on demand for the motorway with its higher perceived 'cost' of travel under tolling.

1.7 Modifications to the v20a base models to introduced RPFs required for the v22a toll-modelling have been shown to have generally modest impacts on assigned traffic volumes. Overall, changes to traffic flows that result in slightly higher flows on arterial roads and lower flows on local roads indicate a small overall improvement in the fit of modelled flows to counts in the base year (2018).

1.8 Other changes to the model, including segmentation by 12 User Classes (**UC**s) for assignment (instead of two UCs, lights and heavies, for v20a) have negligible impacts on base model assigned flows and correlation with counts.

1.9 A 'with toll' demonstration model has been developed to test the response of the model. This is merely a 'straw-man' and may not form part of the options to be tested by Beca as part of their subsequent application of the model to evaluate alternative tolling strategies.

1.10 The comparisons presented in this report indicate 'sensible' modelled responses in the future year models to the refinements introduced to the models for the v22a toll modelling summarised as follows:

- Introduction of the Route Perception Factors result in Ō2NL being a more attractive route (+2% to +24%, varying with location) than the alternative State Highway corridors;
- Introduction of elastic assignments results in higher demands on Ō2NL (up to 10% higher in the untolled scenario) than for fixed demand assignments due to induced traffic effects, but with some modest levels of trip suppression in central Levin due to increased levels of congestion relative to the base year.
- The testing of an example toll on Ō2NL south of Levin indicates a realistic response to the toll, with a reduction in daily flows of approximately 40% on Ō2NL at this location, the majority of which routes instead via SH1. A net reduction in daily flows across the two corridors of 6% reflects the modelled demand-response to the example toll.
- Analysis of the 12 different user-classes flows using the tolled section of Ō2NL for both the example toll scenario and without the toll applied, indicates intuitive flows and relative changes between the two scenarios.

1.11 The Ō2NL models have been developed by QTP for appraisal of Ō2NL since around 2015. QTP have worked with Beca on the implementation of the toll modelling within the Ō2NL models. The methodology and parameters adopted have been directed by Beca based on their extensive experience with toll-road appraisal in New Zealand.

2 Overview

2.1 The Otaki to North of Levin Traffic Model (**O2NLTM**) is a traffic model implemented within the SATURN software. It was originally developed by consultants MWH for the NZ Transport Agency (now Waka Kotahi) to undertake the investigations for the Otaki to North of Levin (**O2NL**) State Highway One (**SH1**) Road of National Significance (**RoNS**) Expressway Project.

2.2 The model was originally developed during 2011 and 2012, with the Model Validation Report (**MVR**) being finalised in 2013. Model versions refer to the year in which they were developed. Hence the original model is herein referred to as v11.

2.3 A number of discrete enhancements to the model were implemented by QTP between 2015 and 2017, based primarily on refining the modelled network and zone system to improve the capability of the model to accurately reflect traffic volumes and hence the network performance, with and without the proposed Expressway.

2.4 In 2017 the NZ Transport Agency instigated a review of the requirements of the model against specific model purposes, as per the advice set out in the NZ Transport Agency Transport Model Development Guidelines (**TMDG**). Changes incorporated within the 'v17c' model included revision of the trip generation, trip distribution and model validation / calibration against limited count data for key locations.

2.5 More recently, Horowhenua District Council (**HDC**) identified a desire to modify and apply the model to better understand the transport effects of demographic growth and to form an input into their Integrated Transport Strategy. The v20a update included updating the model to latest demographic estimates (census 2018) and spatial forecasts agreed with HDC.

2.6 This v22a update is focussed on changes to the v20a model to make it more appropriate for assessing the vehicle demand responses to potential tolling of the Expressway.

2.7 Direction on the methodology adopted has been provided by Beca. The v22a update is concerned with changes to the structure, parameters and processes within the model. It does not therefore explicitly include any changes to demographic forecasts or to the Ō2NL Expressway physical characteristics which remain as per the Detailed Business Case (**DBC**) modelling progressed during 2021.

2.8 The key changes to the model described within this report are summarised as follows:

- **Introduction of Road Perception Factors** to reflect the effects that variation in the quality of different road standards (notably motorways) have on the perceived attractiveness of a route (beyond those of varying speed and distance).
- **Changes to the Assigned User Classes** to reflect some 12 classes varying by purpose, vehicle type and willingness to pay categories, as opposed to the 2 vehicle classes (lights and heavies) assigned in the v20a model. This change is required to provide a greater 'spread' of users in terms of their 'willingness to pay (a toll)' and therefore to better reflect for each vehicle class the effect that a toll will have on route-choice.
- **A Toll Demand Response Model** that reflects the impact that the introduction of a toll may have on demand for the motorway with its higher perceived 'cost' of travel under tolling.

2.9 In addition, we note that there have been minor modifications / updates to the trip distribution process and that all future year model runs have been undertaken as elastic assignments. The latter have been undertaken previously as sensitivity tests to the 'fixed demand' modelling generally undertaken for the DBC modelling to provide an indication of possible induced traffic effects of the Expressway and of trip suppression effects due to increasing congestion in future years (principally in the Do-Minimum case without the Expressway). Elastic assignments have been adopted for the toll modelling to include these important demand responses (induced traffic and trip suppression) and to provide a mechanism for a demand response to the tolls introduced.

3 Road Perception Factors (RPFs)

3.1 Transport models should be no more complex than as required for the purposes for which they are developed. The Ō2NL model was originally developed in 2011 and has been subject to incremental updates since. The requirement for investigating the effects of a tolling strategy for the proposed new road have only come to the fore in the latter stages of the DBC preparation.

3.2 The introduction of RPFs is considered an important component of toll-road modelling because potential road users perceive a quality advantage or a 'premium' with using a tolled motorway compared to alternative routes, in addition to perceived travel time savings or distance benefits / disbenefits.

3.3 To date (up to and including v20a), the Ō2NL model has not included RPFs. Comparison of modelled traffic flows to counts and travel times (both prior to, and after the application of matrix estimation techniques) has indicated a sufficiently accurate model during the v20a model update. Any perceived 'signposting' advantage in using roads higher in the road hierarchy is generally reflected in the speed/flow relationship (and capacity) defined by the link types that vary by road hierarchy.

3.4 For the v22a update, RPFs have been added to the model primarily for the purpose of reflecting a perceived advantage in the use of a high quality motorway. This approach is described within Luis Willumsen's 'Better Traffic and Revenue Forecasting' for which a 20% time saving is presented as a 'motorway bonus' for the purpose of toll modelling.

3.5 The RPFs have been implemented within v22a through the specification of time penalties for different road types, relative to a Motorway with a RPF penalty of zero. For simplicity and practicality, the RPFs are applied to the free-flow link travel time component of generalised cost. This avoids the need for any iterations of model runs to base the penalties on congested travel times and is considered likely to reflect motorist's perceived quality advantage of a route, with the congested component of travel time being modelled as part of the generalised cost of each link and route.

3.6 These GC 'penalties' in seconds, are added to all link costs using the KNOBS facility, using the following proportions of travel time by link type as advised by Beca:

Road Type	RPF	Ō2NL Model Link Types	Ō2NL Model Description
Motorway	0.00	100-199	Motorway
Strategic Routes	0.20	200-399	Major Arterials
Regional	0.25	500-599	Minor Arterials
Rural	0.35	800-899	Rural Minor
Local / Collector / Urban / Town Centre	0.40	600-799	Urban Local & Collectors

Table 3.1: Road Perception Factors Introduced for v22a

3.7 These road perception factors have been adopted from the Puhui to Warkworth model (P2W model). Consideration was given to applying a perceived quality advantage associated with a toll motorway compared to a standard motorway. However, ultimately the rationale for this approach could not be substantiated and introduced complications with respect to induced traffic effects under elastic assignment. This is because it is not anticipated that the action of tolling a motorway (of a given standard) would induce (encourage) greater demand for travel.

3.8 As indicated within the above table, the appropriate RPFs have been applied based on the coded link types within the model. This has required some rationalisation of the v20a model link types:

- The rural minor roads in the Horowhenua area historically coded by MWH simply as types 21/31 (with 70/60 kph free speeds) have been re-coded to the 800 series of Rural Road adopted in the KTM4[1] model.
- Further rationalisation of the link-types used in the model, to enable the advised RPFs to be applied by link-type ranges, has also included re-allocation of some of the KTM4 minor road categories to the Ō2NL model (Horowhenua) minor road categories (the 700 series).

3.9 The effects of introducing the RPFs have been considered by comparing the 2018 model assigned traffic flows (prior to the application of matrix estimation) without and with the addition of the factors, and by considering the effects of the RPFs on flow versus count comparisons correlation (the r-squared value).

3.10 Effects on assigned flows around the road network are generally modest, with some increases on the arterial routes and commensurate reductions on the local road routes. The following diagram illustrates the effects of introducing the RPFs for the AM peak hour, with similar trends modelled in the interpeak and PM peak periods.

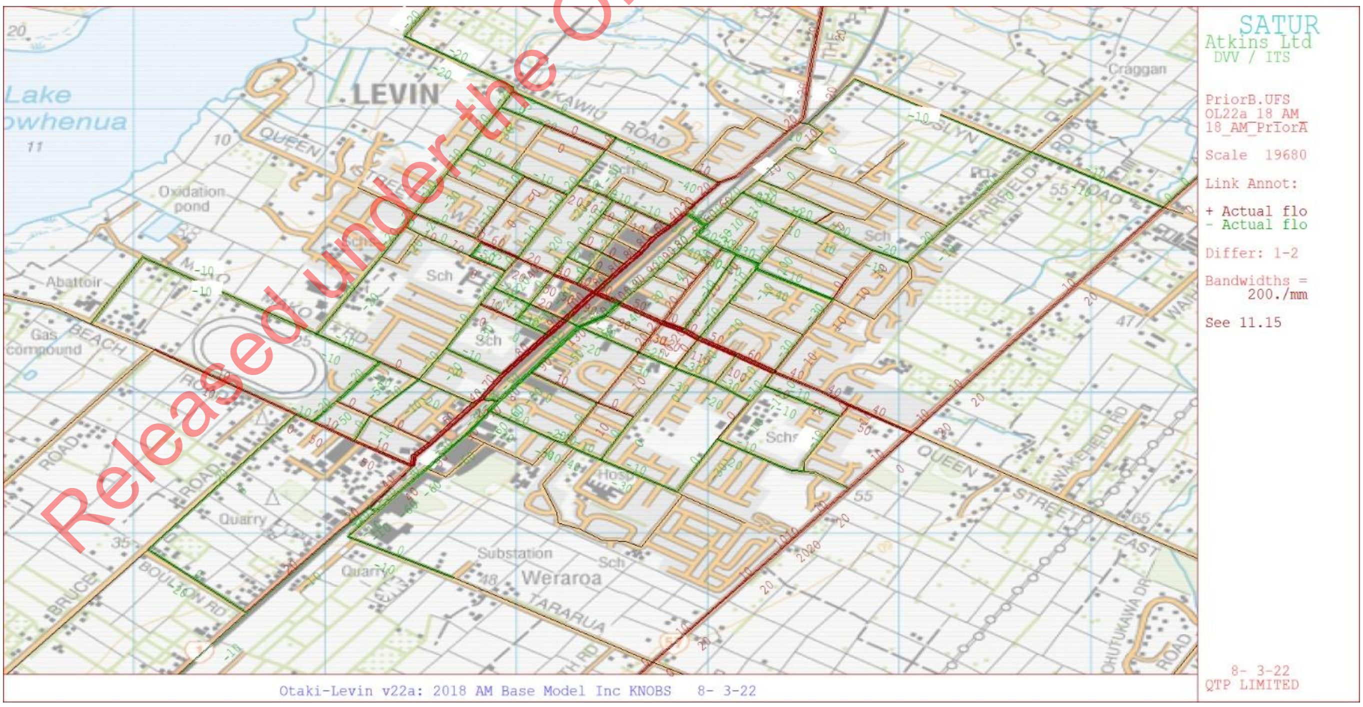


Figure 3.1: Effects of Introducing RPFs to 2018 Base Model (AM Peak Hour)

[1] The O2NL model uses a cordoned area of the Kapiti Coast KTM4 model of the Otaki area in order to extend the model south beyond the Horowhenua / Kapiti Coast District border.

3.11 The above plot indicates increases on the arterial routes through Levin (notably on SH1 and on Queen Street) with corresponding reductions on the parallel local roads. The changes in flows are generally modest, but up to around 100 vph on a directional basis, occurring on Queen Street.

3.12 Generally the effects on overall model validation to counts (prior to application of ME) based on consideration of the r-squared value[2] are very small, but beneficial for two out of the three time periods:

- AM peak R^2 reduces from 0.894 to 0.885
- Interpeak R^2 increases from 0.896 to 0.913
- PM peak R^2 increases from 0.906 to 0.916

3.13 Notably, the changes assist with the validation issue noted in the v20a reporting where high delays for right turners on the Queen and Bath Street approaches to the signalised intersections with SH1 in central Levin were low in the model compared to counts as traffic tended to 'rat-run' on alternative minor road routes.

[2] Note that these r-squared values are not exactly as reported in the O2NL v20a validation report as those values included some counts withheld from the matrix estimation process as being 'suspicious'.

4 Model Demand Segmentation

4.1 Background

4.1.1 Prior to the v20a update, the Ō2NL model estimated trip generation or 'trip-ends' for only light and heavy vehicles classes. The trip generation was based on regression analysis of selected 'similar' Wellington Transport Strategic Model (**WTSM**) zones beyond Wellington City to relate demands to simple demographics (population, jobs by 4 types and school roll) separately for light and heavy vehicles, for each model period. Some adjustments were made to initial trip generation rates to achieve reasonable overall balance between modelled flows and counts, with reference to TDB Trip Rates and other New Zealand models.

4.1.2 Trip distribution of the two vehicle classes was based on simple gravity models.

4.1.3 For the v20a update, trip distribution for light vehicles used an innovative approach to apply trip distribution (via a gravity model) separately for some 25 trip types or 'quasi-purposes'. This ensures 'sensible' distribution of trips between where people live, work, shop, school and receive health services. This refinement was sought by the Peer Reviewer acting on behalf of HDC as much of the model refinements undertaken for the v20a update were aimed at producing a tool that was more useful for HDC's transport planning purposes, including for the assessment of effects of the then-proposed Taraika Plan Change.

4.1.4 In simple terms, the existing trip generation coefficients for trips to/ from home, work, retail, school and health services were further split to estimate trip generation specifically for each of the potential 25 trip purposes based on the origin and destination of these five trip generation types. For example, based on consideration of trip rates and other New Zealand models, total car trips **From** home in the morning peak (estimated as 0.12 trips per person) are estimated to be 50% to Work, 20% to Education, 15% to Shops/Retail, 10% to Health Facilities and 5% to Home. Thus the trip generation is split for these five Home-based trip types. A similar process is applied to trips From the other four trip generation types, to yield a total of 25 'From-based' trip rates. The same process is then applied to 'To' trips and Furnessing of the resulting trips applied to settle on final 'Quasi-Purpose' trip rates.

4.1.5 Each of the 25 Quasi-Purposes (for each model period) are then distributed separately to ensure 'sensible' distribution of trips. For example, that trips that should be from home to locations of work are not instead represented as trips from home to other homes.

4.1.6 In practice, the process had only minor impacts on assigned traffic volumes. Refer to the v20a Model Update Report[3] for further information.

4.1.7 Thus the v20a model produces some 25 Quasi-Purposes (**QPs**) from which the 12 user-classes desired for the v22a Toll Modelling have been developed.

4.2 Quasi-Purpose Trip Distribution

4.2.1 The 'translation' of the v20a QP demands to the v22a toll-purpose demands occurs after the trip distribution process. In liaison with Beca, the following refinements have been made to the trip

[3] Ōtaki to North of Levin Expressway – Traffic Model Update Report v20a, Issue 01a, 29 October 2020. This report is due to be updated following some changes to the modelling (including future year demographic inputs and evolution of the Ō2NL Expressway), though the modelling process remains unchanged.

distribution process:

a. V20a model 25 Quasi-purposes (**QPs**) were distributed based on an impedance function applied to costs resulting from a nominal flat matrix applied to the 2018 base and a single future year DM network only.

b. Process revised to:
   i. Use generalised costs for 2018 base, 2029 DM, 2039 DM and DS networks, noting that the 2029 DM network varies from other years, whereas the DS does not
   ii. Update the GCs to include the Road Perception Factors (RPFs) introduced as part of the Tolling update
   iii. Use unloaded network free-flow cost skims (that in practice do not vary significantly from the more cumbersome nominal flat-matrix skims used in v20a)

c. Distributed trips within Horowhenua District are subsequently 'expanded' to include Ōtaki using existing cordons of the KTM4 model. This process is unchanged from v20a. The above trip distribution process has been applied to 'cordons' (sub-areas) of the full-model network equating to the boundary with the KTM4 model (approximately on the Horowhenua / Kapiti Coast District boundary). The relatively few trips wholly within the Ōtaki cordon and between Ōtaki and the ultimate SH1 external zones have been split to the v22a toll-purposes using the overall proportions for the Horowhenua District area of the model resulting from the translation process (refer Table 4.4, below). These trips are not influential to the assessment of Ō2NL.

4.3 V22a Toll Purposes

4.3.1 An example of the 25 Origin-Destination-based QPs (for the 2039 AM peak trips by purpose) are provided in the following Table:

AM From	Home	Work	Shops	Health	Education
Home	205	2471	985	711	687
Work	418	1003	505	360	12
Shops	36	391	444	62	6
Health	119	178	14	203	5
Educatio	69	360	185	111	55

Table 4.1: Example of Trips by v20a Quasi-Purposes (2039 AM peak hour)

4.3.2 The toll-purposes required / modelled, using similar methodologies to those applied by Beca for other tolling studies, are as follows:

- Home-Based Work (**HBW**)
- Employer's Business (**EB**)
- Other light vehicle trips (**Other**)
- HCV trips (**HCV**).

4.3.3 In addition, each of the above four trip purposes are ultimately split to low, medium and high willingness to pay segments, to yield a total of 12 user-classes for assignment.

4.4 External Trips

4.4.1 Wholly external trips (external-external) Light Vehicle (**LV**) trips (approximately 8% of all LV trips) are estimated in v20a through GPS-data analysis and are not assigned a purpose. External HCV trips are estimated in the same way. Beca have advised allocation of the LV trips to toll purposes based on the following proportions. The proportions are based on information about the trip purpose of long-distance trips from Roadside Interview Surveys (**RIS**) recently conducted for the Tauranga Transport Strategy Model, with adjustments related to differing average incomes for the Horowhenua District compared to the Wellington and Manawatu-Wanganui Regions.

Purpose	TGA RIS	Adjustments	Final
HBW	25%	+10%	35%
EB	10%	+5%	15%
Other	65%	-15%	50%

Table 4.2: Allocation of External-External Trips to Toll Purposes

4.5 Assigning Quasi-Purpose Trips to Toll Modelling Purposes

4.5.1 QP Home<>Shopping and Home<>Health trips include employee trips. Therefore adjustments have been applied to split these 4 QPs to HBW and Other sub-purposes for allocation to toll modelling purposes. These proportions have been informed by considering the relative proportions of the (Furnessed) trip rates. For example, in the AM peak hour, Home>Work QP trip rates are estimated at 0.229 trips per employee compared to a Home>Shops QP trip rate of 0.834. This implies that approximately ¼ or 25% of the (total) Home>Shops rates could be Home>Work trip rates for employees at retail locations. These assumptions are relatively crude and the proportions have been rounded and adjusted for sensibility to yield the following assumptions:

Purpose[1]	AM	IP	PM
H>S HBW	25%	10%	10%
H>S Other	75%	90%	90%
S>H HBW	25%	10%	10%
S>H Other	75%	90%	90%
H>L HBW	30%	10%	30%
H>L Other	70%	90%	70%
L>H HBW	30%	10%	30%
L>H Other	70%	90%	70%

[1]Notes: H=Home, S=Shopping, L=Health ('Lth)

Table 4.3: Splitting of QP Home-Shopping and Home-Health to HBW and Other Toll Purposes

4.5.2 Note that such adjustments are not required for education-related trips because jobs at education facilities have work-based trip generation applied, in addition to pupil (school role) – related Education trips.

4.5.3 Following these adjustments, the toll purposes are aggregated from the QPs as follows:

- HBW = HW + WH + the HBW components of HS, SH, HL & LH above

- EB = WW
- Other = Sum of all other QPs and Other components of HS, SH, HL & LH above
- HCV = v20a HCVs (trip rates based on linear regression of Industrial jobs, general jobs and population to WTSM HCV trips)

4.5.4 The following Table summarises the resulting proportion of trips by v22a toll model purpose for the 2018 demographic inputs:

Purpose	AM	IP	PM
HBW	34%	12%	36%
EB	11%	15%	6%
Other	54%	73%	58%
HCV % of Total	10%	12%	7%

Table 4.4: Resulting v22a Toll-Purpose Trip Proportions, 2018

5 Prior Matrix Assignments

5.1 The initial HBW, EB and Other demands are segmented to equal Low, Medium and High willingness-to-pay (**WtP**) User Class (**UC**s) segments for assignment within the SATURN software. Beca have advised HCV demands be split with reference to the Tauranga Transport Strategy model, being 10% Low, 40% Medium and 50% High. Assignments have been undertaken using the following relativity of time (Pence Per Minute or **PPM**) and distance (Pence Per Kilometre or **PPK**) of perceived generalised cost using the following factors:

Purpose	PPM	PPK	KNOB Factor
HBW Low	1.00	0.62	0.0167
EB Low	1.00	0.16	0.0167
Other Low	1.00	0.61	0.0167
HCV Low	1.00	1.63	0.0333
HBW Med	1.00	0.25	0.0167
EB Med	1.00	0.11	0.0167
Other Med	1.00	0.41	0.0167
HCV Med	1.00	1.01	0.0333
HBW High	1.00	0.16	0.0167
EB High	1.00	0.06	0.0167
Other High	1.00	0.26	0.0167
HCV High	1.00	0.60	0.0333

Table 5.1: Assignment Generalised Cost Components

5.2 The above PPK : PPM ratios are the same as those applied in a copy of the P2W (SATURN) model. The KNOB factor of 1/60 or 0.0167 is required to express the RPF penalties, in seconds, on the same basis as PPM. The SATURN software automatically converts the PPM values to units of GC in seconds by dividing the PPM value by 60. Per the P2W modelling, the KNOBS perception factors for HCVs are double those of the light vehicle classes.

5.3 The v22a Prior matrix assignments have been undertaken in four stages to model the effects of each on assigned flows and the correlation of modelled flows to counts (r-squared) in the base year model (prior to Matrix Estimation being applied). This monitoring is summarised as follows:

- Prior: Changes to user-class trip segmentation to assign trips by 12 user-classes for tolling assessment (with differing relativity of time and distance summarised above) as opposed to two vehicle classes (lights and heavies) used in v20a – negligible changes in assigned traffic volumes and r-squared.
- Prior A: Consolidation of link types to provide a consistent basis on which to apply the RPFs (refer 3.8, above). Insignificant effect on assigned flows (<10 pcus/hr) and marginal improvements in r-squared (at third decimal place) in all three periods.
- Prior B: Introduction of RPFs using the SATURN software's KNOBS facility – generally modest changes in flows (though up to 100 pcus/hr on Queen Street) and a small overall improvement in r-squared as reported at Chapter 3.
- Price C: Modification of the trip distribution process to use free-flow generalised costs, to

distinguish between future year Do-Minimum (**DM**) and Do-Something (**DS**) network costs and to include the RPFs in the skimmed costs – very small increases in link flows across the network, most 0-10 pcus/hr, all <20 pcus/hr and insignificant changes in r-squared (+/- 0.001).

6 Matrix Estimation

6.1 The Matrix Estimation (ME) process is effectively unchanged from v20a, though changes to the batch file scripting and module parameters is required for the v22a toll-modelling 12 User Classes (**UCs**) compared to the 2 UCs adopted in v20a. A brief summary of the v20a ME process:

a. Upper and lower limits to the degree to which and one count can factor an IJ trip are based on an XAMAX value of 1.5, meaning that individual IJ cell factors can range between 1/1.5 = 0.75 and 1.5.
b. Effects of ME are monitored by flow-change plots and reporting included sector-matrix changes and effects on trip length distribution.
c. The effects of ME are applied to future year scenarios based on the average of relative and additive base-year changes.
d. At the request of the Peer Reviewer for v20a, the resulting ME factors for the base year at the sector level for trips wholly within Levin are applied to trips between Levin and the Tara-ika subdivision, and within the Tara-ika subdivision, in future years.

7 Future Year Networks

7.1 These are the Do-Minimum (DM) and the Do-Something (DS) 'preferred' alignment emerging from the Ō2NL Detailed Business Case (**DBC**) process. The sub-option of the DS preferred alignment is referred to as 2DIs:

- '2' refers to the option of including a half-interchange with south-facing ramps at Taylors Road.
- 'DI' refers to the intersection treatments at Queen Street and Tararua Road respectively during optioneering: 'D' is for a Diverted alignment of Queen Street and 'I' is for an Interchange at Tararua Rd (dumbbell roundabouts)
- 's' refers to the sub-option relating to further network assumptions. Specifically, 's' assumes a Tara-ika Spine Road will connect with SH57 for the DS in all years. For the Do Minimum at 2029, sub-option 'h' is without the Spine Road, though this is assumed to be in place (sub-option 's') by 2039 (and 49).

7.2 There has been just one key change introduced to the future network assumptions for the v22a toll-modelling, relating to the introduction of RPFs. For the DBC modelling undertaken using v20a, a safety scheme is assumed on SH1 in the DM reflecting a posted speed-limit change from 100kph to 80kph. For the DS (with Ō2NL in place), following initial assignments it was considered by the project team that the 'revoked' SH1 remained too attractive within the model. Accordingly, for the DS, SH1 was assumed to reflect a lower speed limit of 70kph, a simple method of reflecting the perceived additional attractiveness of the new Motorway, beyond those of time and distance. With the introduction of the RPFs for the toll-modelling, this differential has been removed, such that the DS SH1 speeds are indicative of an 80kph speed limit, per the DM assumption.

8 Future Year Demands

8.1 The future year demographics and therefore Quasi-Purpose Trip Ends are unchanged from v20a. In-line with the modelling scope, to-date the tolling update has been applied to the Medium Growth assumption (actually a 75%ile growth assumption within the 'Sense Partners' population growth report). Other demand scenarios may subsequently be prepared for the toll strategy testing being progressed by Beca.

8.2 Overall population growth within the Horowhenua District has been based on the Horowhenua Socio-Economic Projects Report by Sense Partners (May 2020), utilising the 25%ile, 75th%ile and 95%ile projections. The resulting overall population growth within the district, relative to 2018, is summarised as follows:

Year	25%ile	75%ile	95%ile
2029	23%	29%	35%
2039	33%	53%	77%
2049	36%	78%	138%

Table 8.1: Sense-Partners Horowhenua District Population Growth Relative to 2018

8.3 The geographical spread of population is based on analysis provided by HDC of potential household yields at a Meshblock level throughout the district.

8.4 As total potential housing yield exceeds equivalent population growth, the take-up-rate (% complete) of housing within each zone, except Taraika, is set to be uniform and to yield the required overall population growth. Growth in Taraika is predicted to be greater due to the advanced nature of the Plan Change area, utilities infrastructure improvements being progressed and its proximity to Levin. Household numbers for Taraika for the 75%ile and 95%ile growth scenarios have been agreed with HDC as part of appraisal work conducted for the Plan Change.

8.5 Job growth has been applied to the key growth areas north and south of Tararua Road, as advised by HDC, as well as the proposed commercial development area in Tara-Ika. The balance of the wider Horowhenua District job growth is set to match the overall projected population growth. The balance of job growth required to match overall population growth in Horowhenua District has been applied uniformly to existing employment zones.

8.6 The new school within the Tara-Ika area with an advised ultimate roll of 600 pupils has been modelled as having a 50% roll at 2029 and 100% at 2039. The residual growth in school roll to match population growth has been applied to the existing school roles.

8.7 Growth of trips wholly external to the modelled area (i.e. 'through-trips') is assumed to mirror the wider model population growth assumptions for the three different growth scenarios.

9 Elastic Assignments

9.1 Elastic assignments have been applied in the v20a model as part of development of the DBC only as a sensitivity test as a simplified method of modelling possible responses to new infrastructure (induced traffic) and congestion (suppressed demand). The following assumptions have been applied broadly per the v20a DBC sensitivity testing, consistent with the advice of Waka Kotahi's Monetised Costs and Benefits Manual (**MCBM**):

- The 'pivot' costs are GCs (including RPFs) for the (2018) base year
- The Power function is applied
- Elasticities of -0.4 / -0.7 were initially applied for all UCs for the peaks/ interpeak, reflecting values expressed in the MCBM in areas of low modal competition. In discussion with Beca, these values were however subsequently tempered (reduced in scale) by 20% to reflect the fact that RPFs are included within the Generalised Costs calculated within the model, whereas it is unlikely that the MCBM elasticity values include route perception in generalised costs.

9.2 The scale of tempering of elasticities was applied on the basis that application of the RPFs in the model provide an approximate 20% reduction in the travel times on the Expressway, relative to the alternative State Highway route. As travel times are the major component or generalised cost, this 'tempering' effectively cancels out the route perception advantage of the Expressway in terms of estimation of the induced traffic effect. A consequence of this tempering is that trip suppression under areas of increased congestion relative to the base year is correspondingly reduced. In practice, this is of greatest consequence to the DM models where congestion increases on approaches to State Highway 1, including in central Levin, in future years in the absence of the Expressway.

9.3 The elastic assignments are a fundamental component of the v22a toll modelling as they include a response to the toll 'time penalties' (when present) component of GC, allowing a demand response to the tolls.

10 Toll Parameters

10.1 A 'with toll' demonstration model has been developed to test the response of the model. This is merely a 'straw-man' and may not form part of the options to be tested by Beca as part of their subsequent application of the model to evaluate alternative tolling strategies.

10.2 For the with-toll model, a single toll has been applied to Ō2NL south of Levin. It is representative of a $2.40 toll for cars and a $4.80 toll for HCVs. Beca have advised appropriate values of time (**VoT**) for the purpose of WtP to be applied for each of the 12 UCs in each of the future year models. The advised VoTs and equivalent time penalties are listed as follows:

User Class	VOTs				Toll	GC Penalties (Seconds)			
	2018	2029	2039	2049		2018	2029	2039	2049
HBW Low	$18.43	$20.56	$22.71	$25.09	$2.40	469	420	380	344
EB Low	$35.45	$39.55	$43.68	$48.26	$2.40	244	218	198	179
Other Low	$8.73	$9.74	$10.76	$11.88	$2.40	990	887	803	727
HCV Low	$23.71	$26.46	$29.23	$32.28	$4.80	729	653	591	535
HBW Med	$25.41	$28.34	$31.31	$34.59	$2.40	340	305	276	250
EB Med	$45.92	$51.23	$56.59	$62.51	$2.40	188	169	153	138
Other Med	$12.65	$14.12	$15.59	$17.22	$2.40	683	612	554	502
HCV Med	$44.24	$49.36	$54.52	$60.23	$4.80	391	350	317	287
HBW High	$38.44	$42.88	$47.37	$52.32	$2.40	225	201	182	165
EB High	$98.00	$109.34	$120.77	$133.41	$2.40	88	79	72	65
Other High	$21.03	$23.47	$25.92	$28.63	$2.40	411	368	333	302
HCV High	$79.64	$88.85	$98.14	$108.41	$4.80	217	194	176	159

Table 10.1: Toll Parameters

10.3 The toll penalties are listed directly in the network .dat file 44444 records. The software interprets these directly as GC penalties in seconds, so unlike the KNOBS RPFs, no further factoring is required.

11 V22a Future Year Assignments

11.1 Overview

11.1.1 This chapter presents the results of the v22a model assignments, by-way of a sense-check of the modifications introduced to the v20a models. Chapters 3 and 5 have described the generally modest effects the tolling-related modifications have had on the base year (2018) model. This chapter presents in a step-wise manner:

i. The changes between the 'standard' fixed-demand DM and DS models applied in the DBC development and the equivalent v22a toll-model fixed demand assignments

ii. The effects of elastic assignment undertaken in the toll-model

iii. The effects of the addition of the demonstration toll

11.1.2 For expediency, model plots presenting the above comparisons are estimated Average Daily Total (**AADT**) estimates, derived from aggregations of the AM, Interpeak and PM peak flows using the factors derived from analysis of count data from Waka Kotahi's TMS system, as described within the v20a Model Update Report. The information is presented for 2039, being the mid-term horizon of the 2029, 2039 and 2049 modelling conducted.

11.2 V22a Fixed Demand Assignments

11.2.1 The following plots illustrate the 2039 v22a modelled Annual Average Daily Total (AADT) flows for fixed demand assignments (and no tolls) followed by the changes in AADTs relative to the v20a models developed for the DBC assessment. Both DM and DS comparisons are provided.

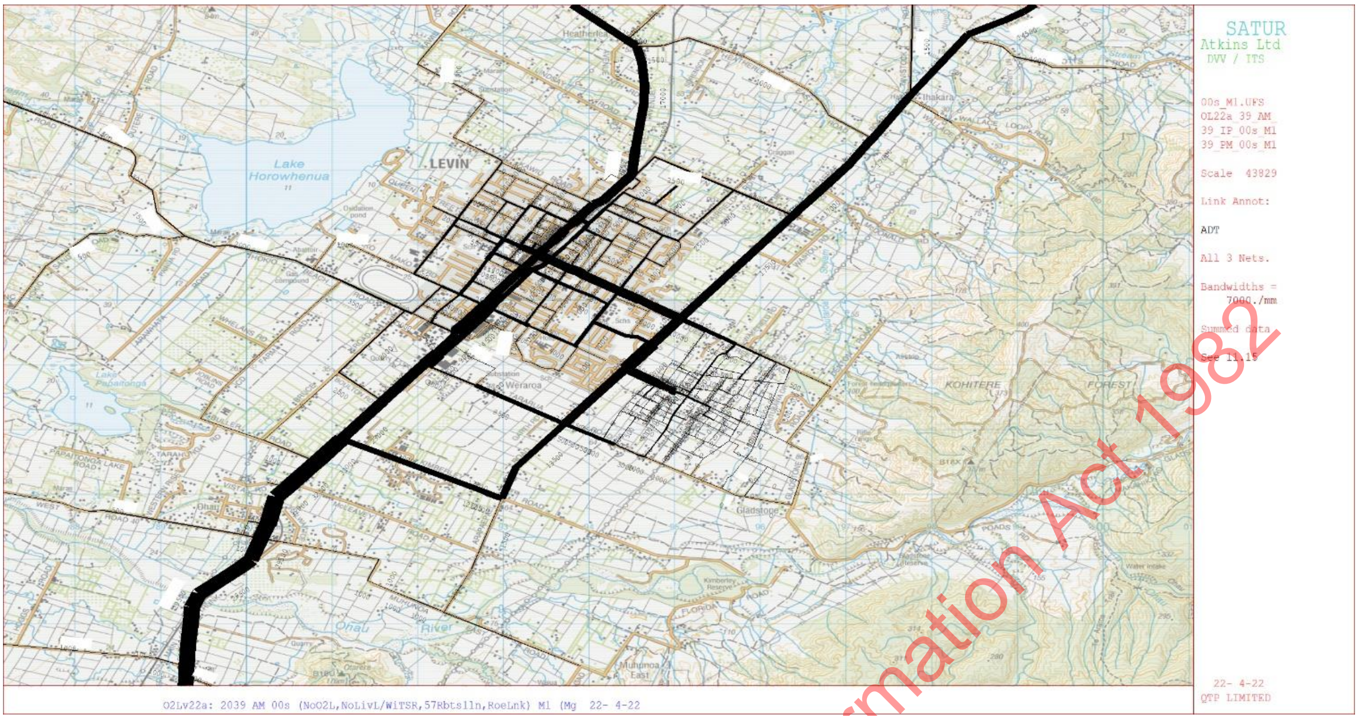


Figure 11.1: v22a Fixed Demand Assignments, AADT 2039, DM

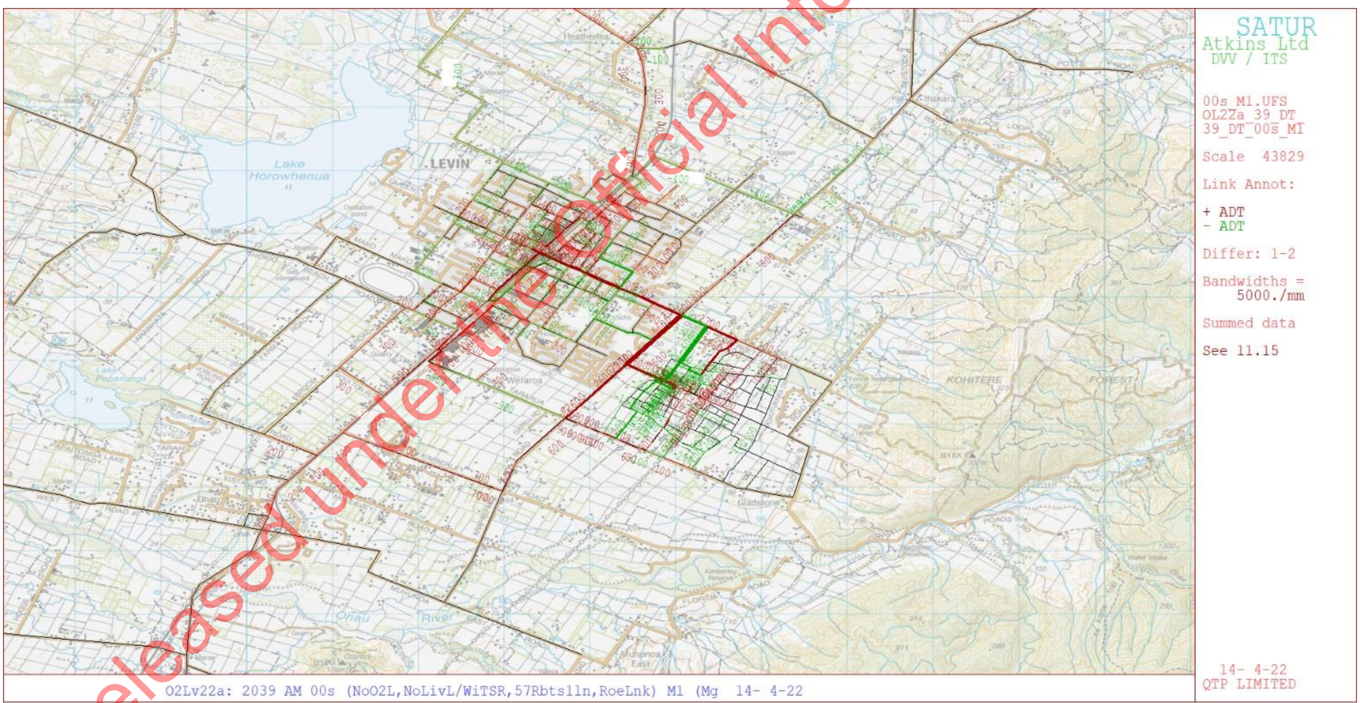


Figure 11.2: v22a Fixed Demand Assignments, AADT Change 2039 vs v20a, DM

11.2.2 For the DM scenario (without Ō2NL), the key changes are the reductions in assigned traffic volumes on the more minor roads through the Taraika subdivision in favour of use of the arterial routes. This results in increases of daily volumes on SH57 of up to around 6,500 vehicles per day (**vpd**), occurring south of Queen Street. Similarly, an increase on Queen Street between SH1 and SH57 of up to around 4,000 vpd in favour of use of more minor roads through suburban Levin is consistent with the effects of the RPFs being introduced into the base year models (refer Chapter 3).

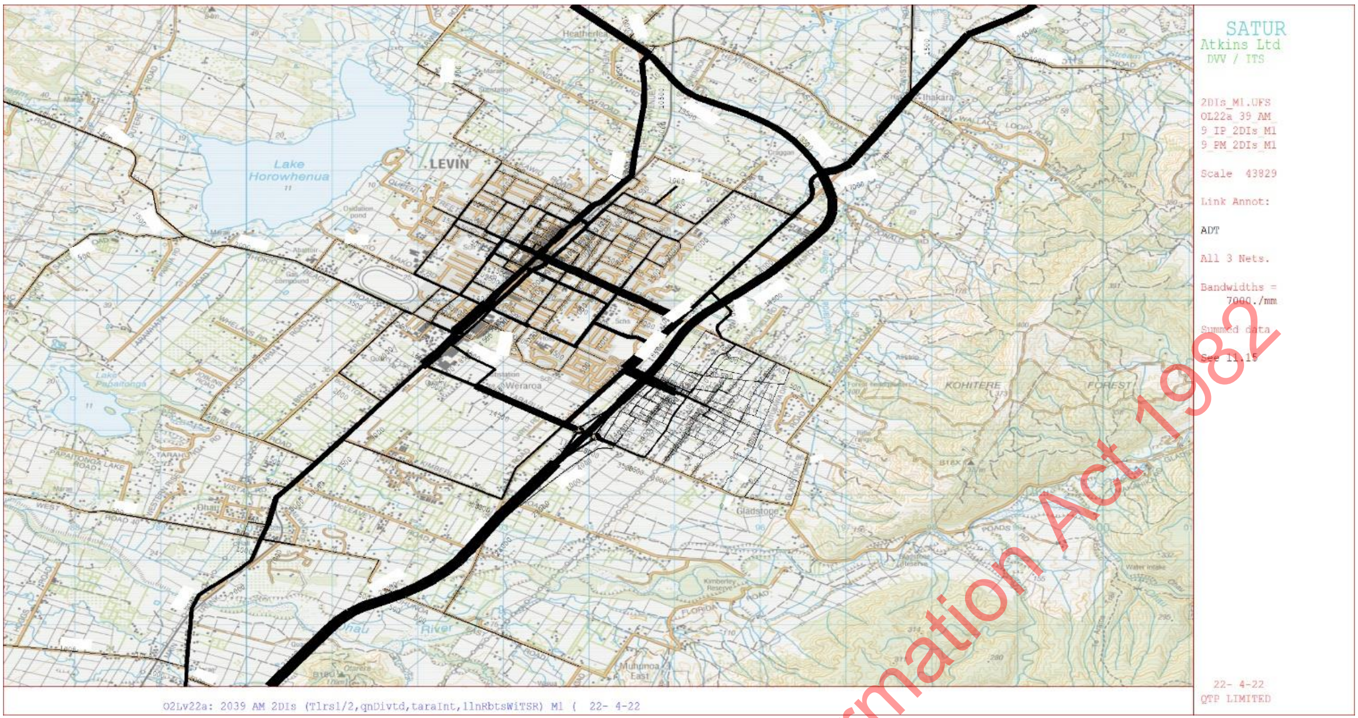


Figure 11.3: v22a Fixed Demand Assignments, AADT 2039, DS

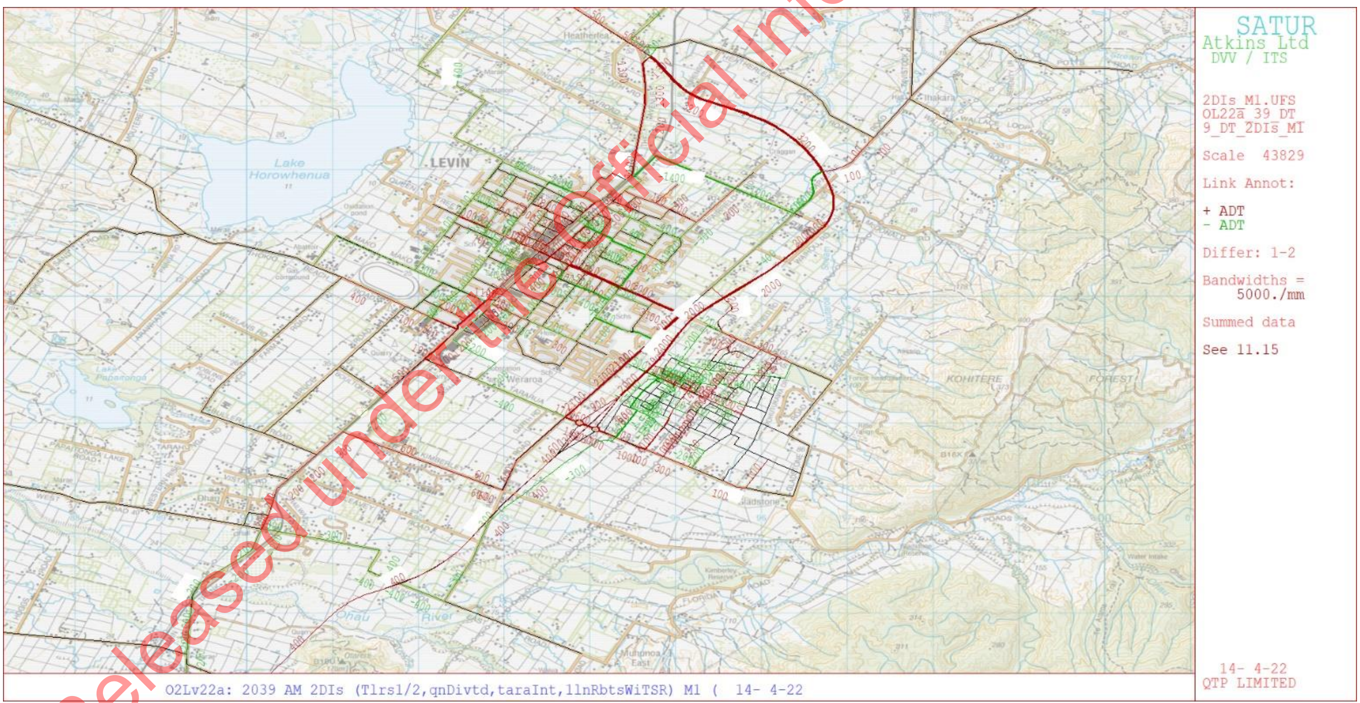


Figure 11.4: v22a Fixed Demand Assignments, AADT Change 2039 vs v20a, DS

11.2.3 For the DS models (with the introduction of Ō2NL), the changes in assigned flows on the road network are generally more modest than for the DM models owing to reduced congestion within Levin under this scenario.

11.2.4 Notably, projected traffic flows on Ō2NL south of Levin are very little changed at just +400 vpd, remaining at around 24,000 vpd per the v20a model. Thus the increase in attractivity of SH1 in v22a through the reversion of the v20a 70kph route perception 'proxy' (to 80kph per the DM) is largely balanced by the introduction of the RPFs in the v22a model that serve to increase the attractiveness of the motorway-standard Expressway, beyond the perceived time and distance changes.

11.2.5 On Ō2NL east of Levin (north of Tararua Road) and north of Levin (west of SH57), the introduction of the RPF leads to increased estimates of traffic using these two sections of Ō2NL of approximately 2,000 / 3,000 vpd respectively, comprising around 11% / 24% respectively.

11.3 V22a Elastic Assignments

11.3.1 The following plots illustrate the 2039 v22a modelled Annual Average Daily Total (AADT) flows for the elastic demand assignments (and no tolls) followed by the changes in AADTs relative to the v22a fixed assignments. Both DM and DS comparisons are provided.

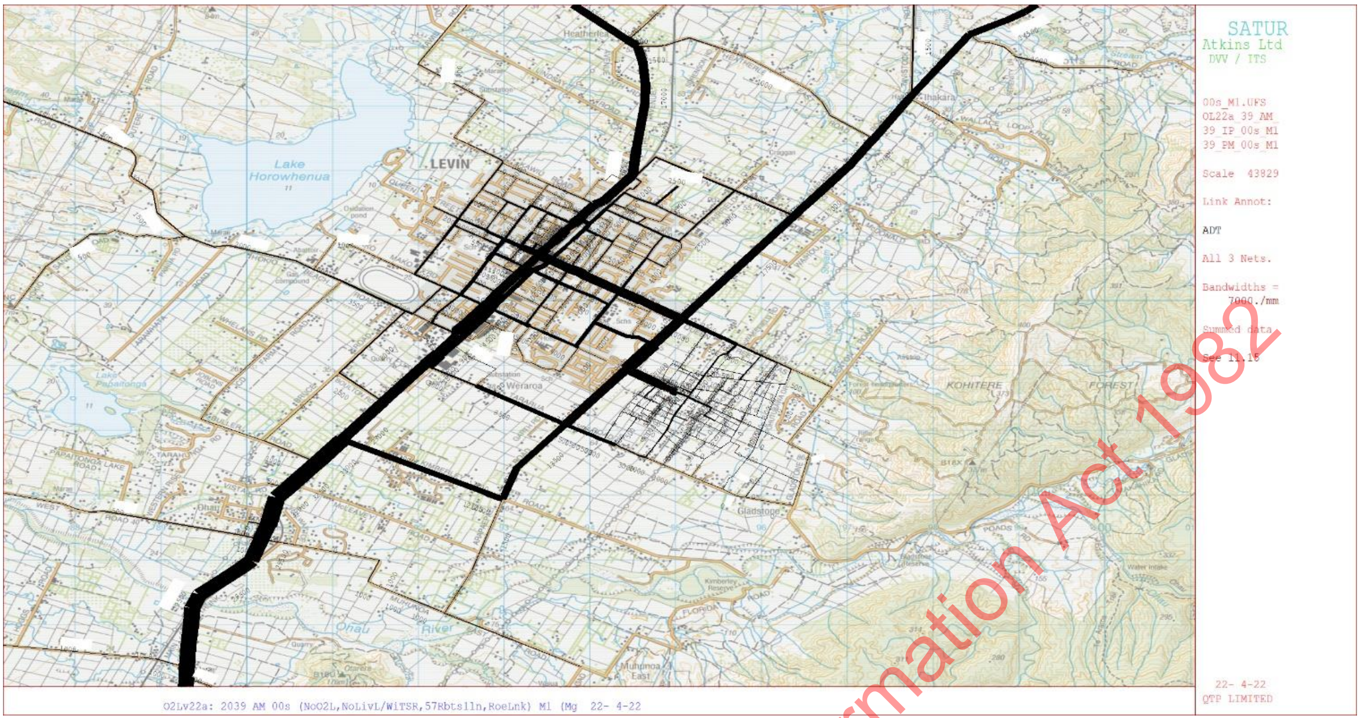


Figure 11.5: v22a Elastic Demand Assignments, AADT 2039, DM

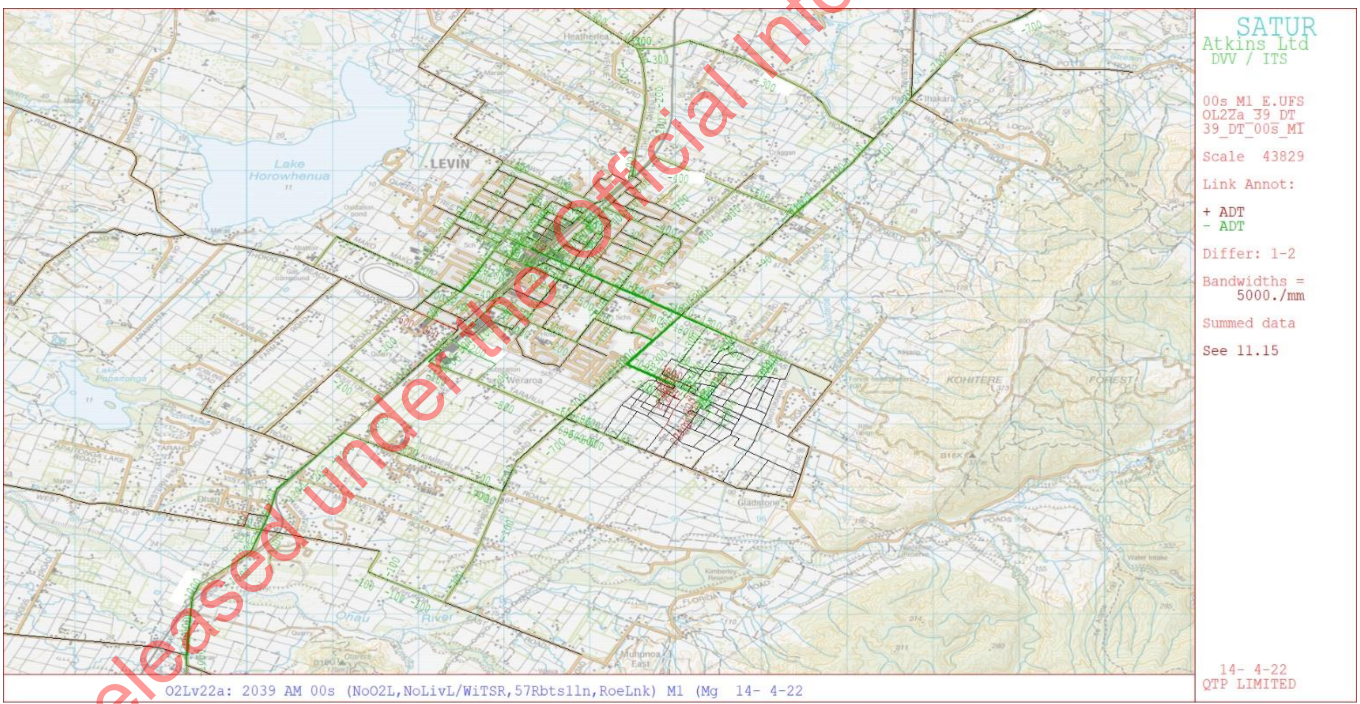


Figure 11.6: v22a Elastic Demand Assignments, AADT Change 2039 vs Fixed Demand Assignments, DM

11.3.2 For the DM scenario (without Ō2NL), the above plot illustrates the wide-spread reduction in daily traffic flows resulting from the variable demand response to increased congestion in future years. Fow example, on SH1 south of Kimberley Rd, a reduction of 1,200 vpd (of a total of 33,000 vpd) results from trip suppression due to increased congestion on the wider road network.

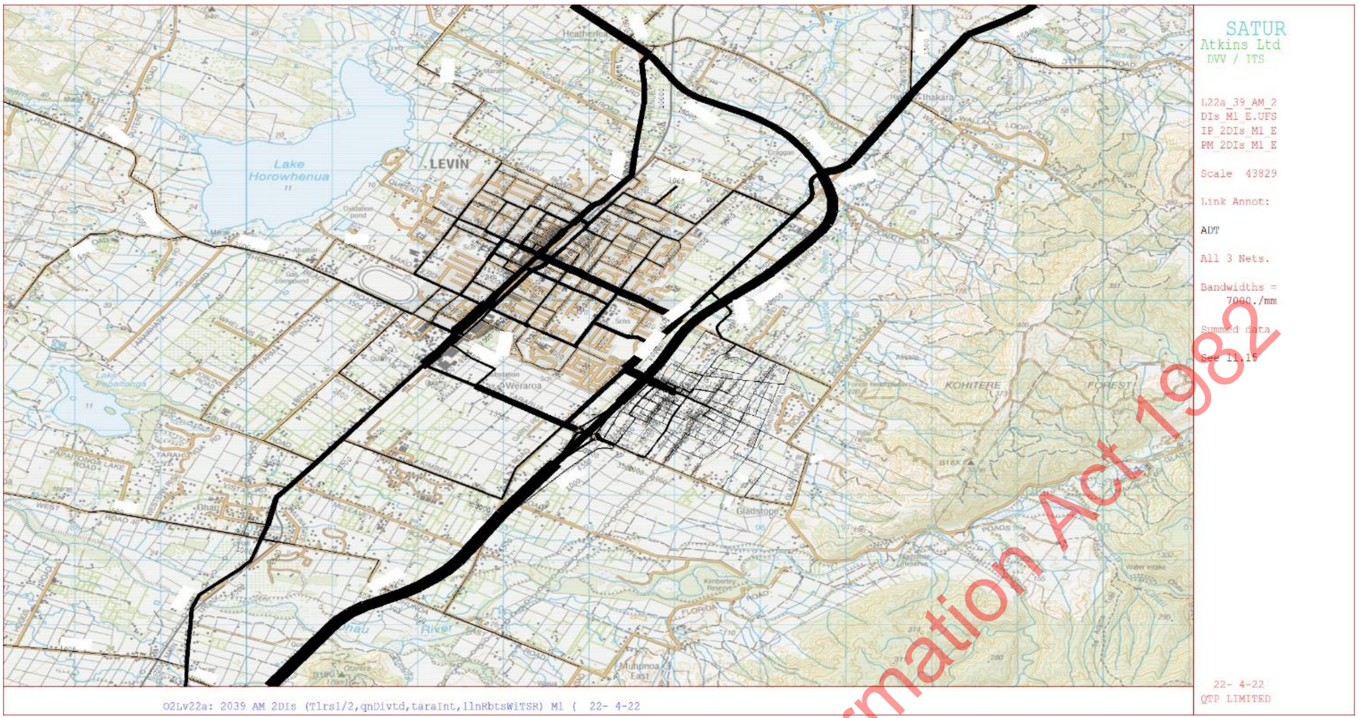


Figure 11.7: v22a Elastic Demand Assignments, AADT 2039, DS

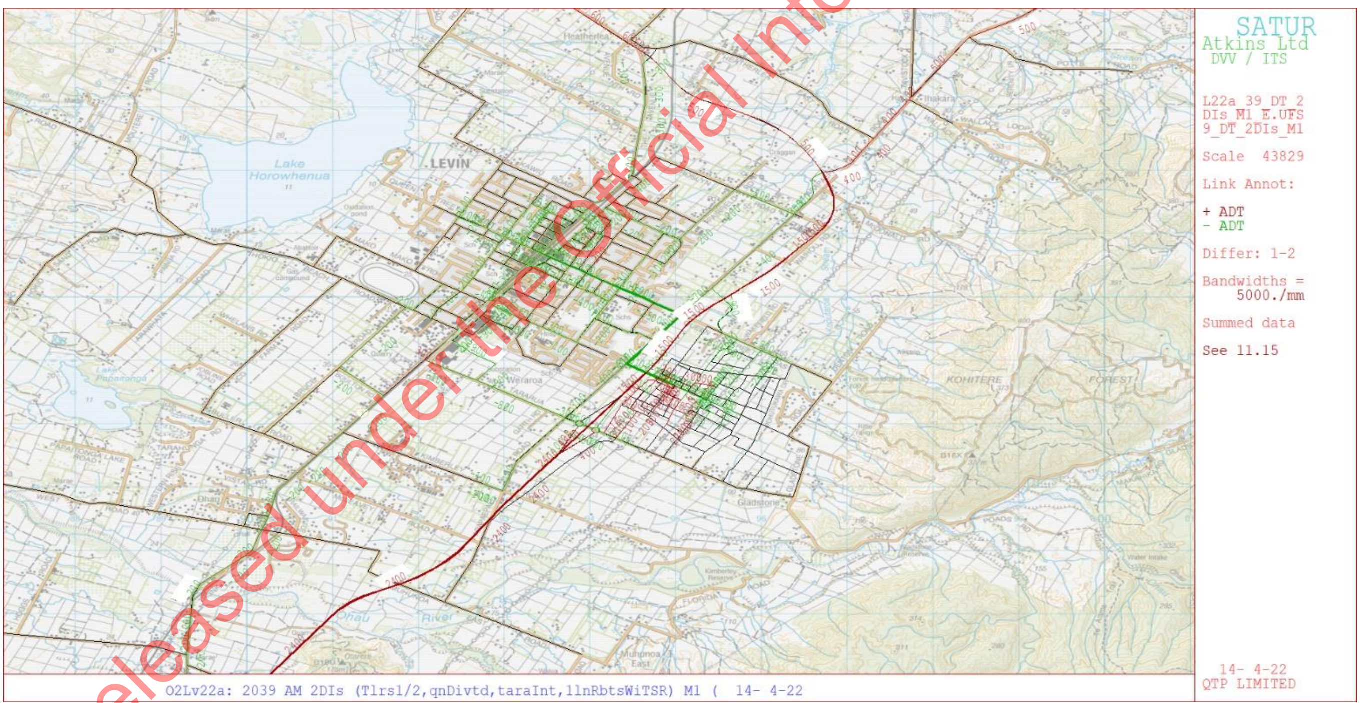


Figure 11.8: v22a Elastic Demand Assignments, AADT Change 2039 vs Fixed Demand Assignments, DS

11.3.3 For the DS models (with the introduction of Ō2NL), it can be seen that:

- Trip suppression on the non-motorway network is somewhat lower than for the DM model due to lower levels of congestion (for example, trip suppression on SH1 south of Kimberley Road reduces from 1,200 in the DM to 200 in the DS).
- Forecast traffic volumes on Ō2NL are up to 2,400 vpd higher (+10%) than under the fixed demand assignments due to the induced traffic effects of the new road that offers substantially reduced 'cost' of travel between Levin and locations to the south.

11.4 V22a Toll Demonstration Model

11.4.1 The following plots illustrate the 2039 v22a modelled Annual Average Daily Total (AADT) flows for the elastic demand assignments with the demonstration toll (applied to Ō2NL south of Tararua Road) followed by the changes in AADTs relative to the v22a non-tolled scenario.

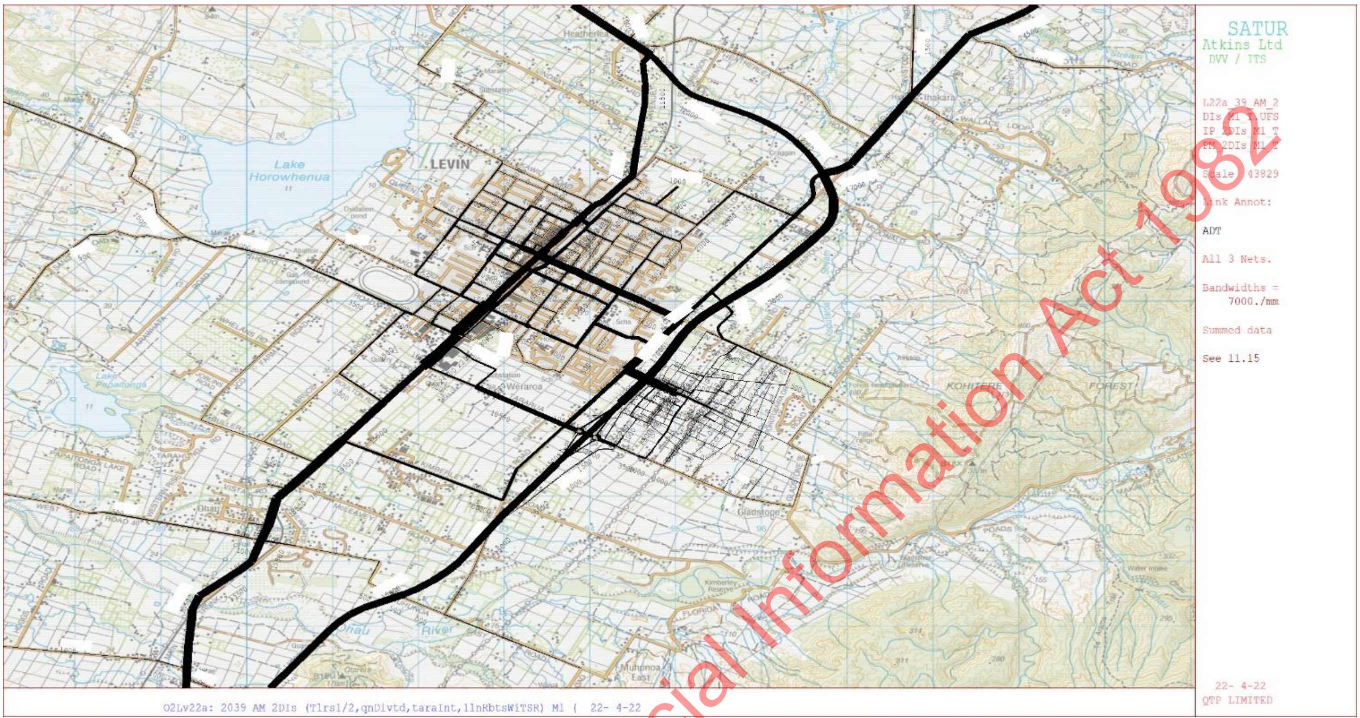


Figure 11.9: v22a Ō2NL Demonstration Toll, AADT 2039

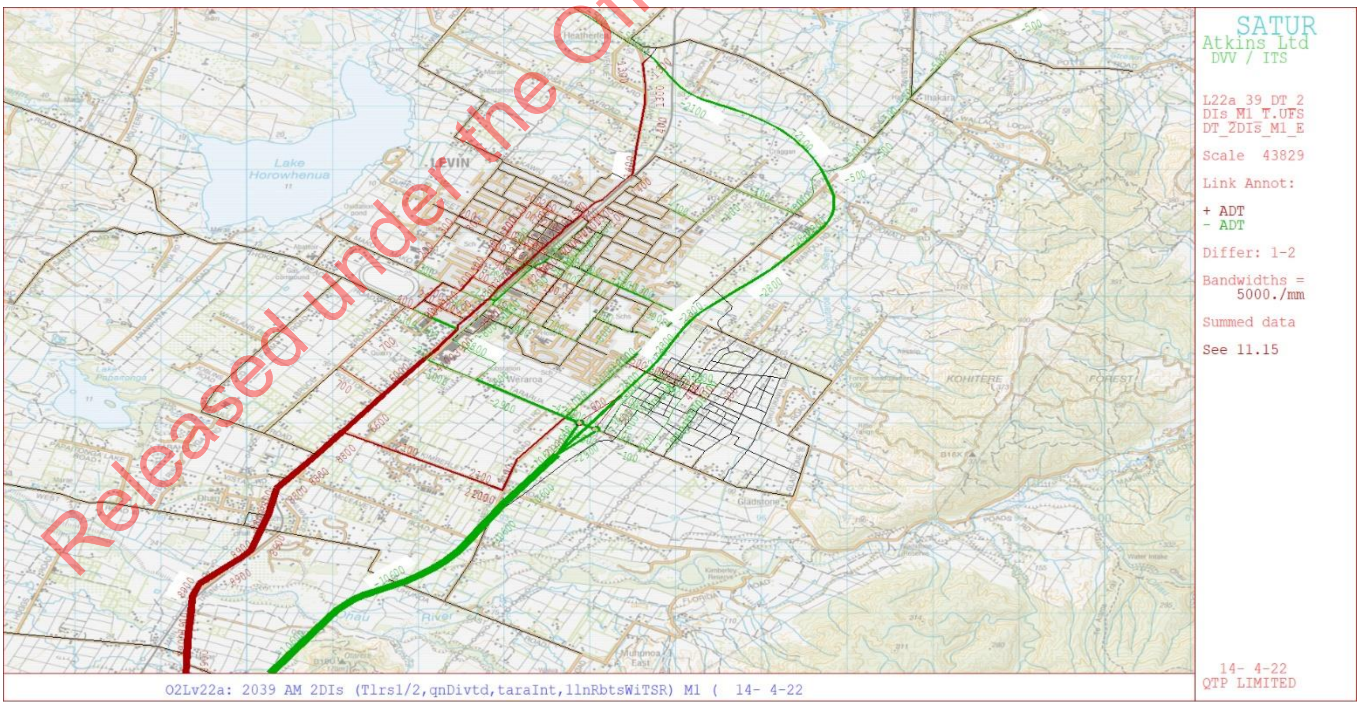


Figure 11.10: v22a Ō2NL Demonstration Toll vs No Toll, AADT 2039

11.4.2 Thus the modelled effect of this demonstration (simple) tolling strategy is to reduce projected daily volumes on Ō2NL south of Levin from 25,500 by around 10,600 vpd to around 15,000 vpd (a reduction of approximately 40%).

11.4.3 The corresponding increase on SH1 is approximately 9,000 vpd. Thus the net reduction of around 1,500 vpd reflects the demand response to the toll (trip suppression) under elastic assignment.

11.4.4 Further north on Ō2NL, east and North of Levin, the effects of the example toll are very much reduced as the toll applies only to those trips using Ō2NL south of Tararua Road.

11.4.5 The following graph illustrates the daily trips, by each of the 12 user classes (**UC**s), modelled as using Ō2NL south of Levin, without and with the toll applied. The daily two-way trips are derived from the directional AM, Interpeak and PM peak flows for which the user-class composition varies slightly by period with the varying WtP VoT values applied.

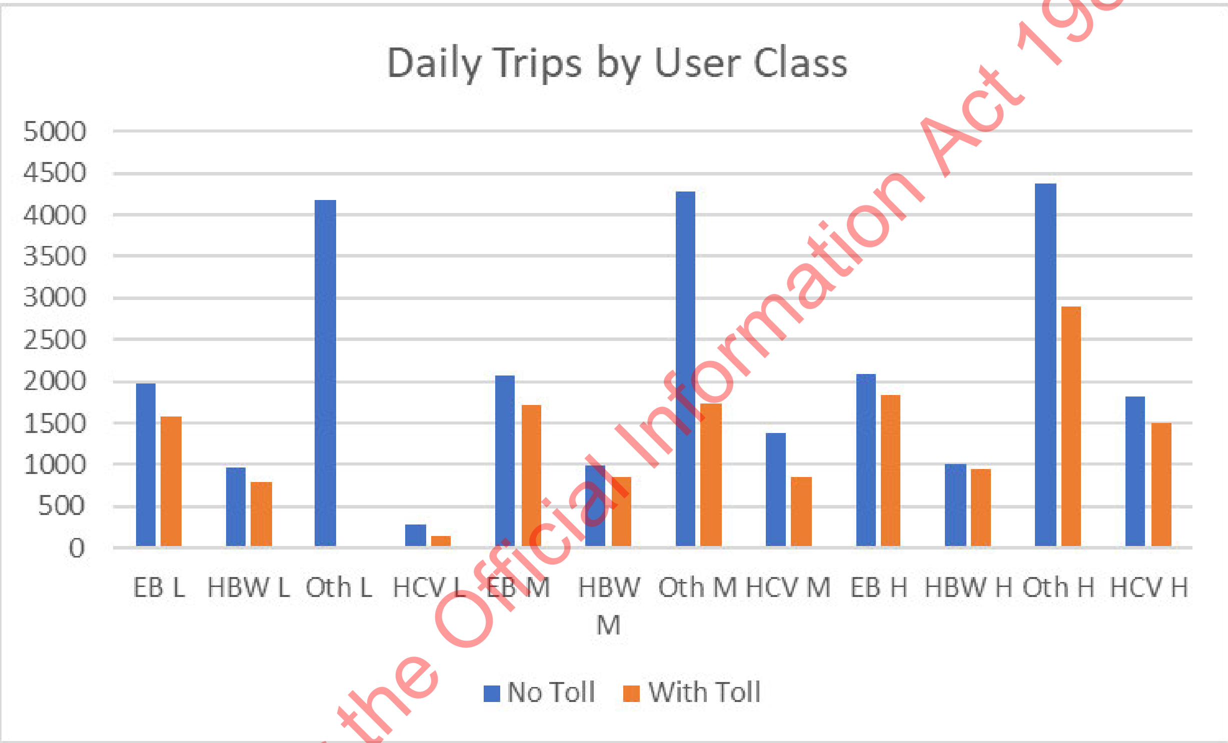


Figure 11.11: Modelled Daily Trips Using Ō2NL South of Levin by User Class, Without and With Demonstration Toll, 2039

11.4.6 From the above, the following points are noted:

- For all 12 user classes, there is a reduction in flows (on Ō2NL south of Levin) with the toll included.
- **Without the toll**, flows for the Low, Medium and High WtP segments of the three light vehicle trip purposes do not vary significantly (i.e. EB Low, Medium and High flows are similar, as they are for HBW and Other.
- Conversely, the above graph reflects the uneven split in HCVs to Low, Medium and High WtP segments advised by Beca (refer 5.1)
- With by-far the lowest WtP VoT (refer Table 10.1), no 'Other Low' UC vehicles use the section of toll road with the toll in place
- With relatively high WtP VoTs assumed, all three segments of EB and HBW UCs maintain a high proportion of the 'No Toll' scenario flows with the toll introduced.

11.5 Convergence

11.5.1 Model 'convergence' is the ability of the model to settle on a pattern of assigned flows and simulated delays. The v20a MUR identifies convergence issues with some of the modelled scenarios in the future years where severe congestion on approaches to SH1, particularly in Central Levin, prevents the model from settling on a stable pattern of flows and delays. The issue is most severe in the case of the Do-Minimum models (in the absence of Ō2NL). However, flow convergence is also noted as an issue in the MUR Do-something models for the 2049 High Growth PM peak period.

11.5.2 Checks of the v22a 2049 Medium Growth (75%ile) models developed to date indicate no significant flow convergence issues for the DS (with Ō2NL) models and only minor localised convergence issues for the DM models (localised flow changes for up to 10pcus per hour in the PM peak hour in central Levin).

11.6 Modelling Summary

11.6.1 Modifications to the v20a base models to introduced RPFs required for the v22a toll-modelling have been shown to have generally modest impacts of assigned traffic volumes. Overall, changes to traffic flows that result in slightly higher flows on arterial roads and lower flows on local roads indicate a small overall improvement in the fit of modelled flows to counts in the base year (2018).

11.6.2 Other changes to the model, including segmentation by 12 UCs for assignment (instead of two UCs, lights and heavies, for v20a) have negligible impacts on base model assigned flows and correlation with counts.

11.6.3 The comparisons presented in this Chapter indicate 'sensible' modelled responses in the future year models to the refinements introduced to the models for the v22a toll modelling summarised as follows:

- Introduction of the Route Perception Factors result in Ō2NL being a more attractive route (+2% to +24%, varying with location) than the alternative State Highway corridors;
- Introduction of elastic assignments results in higher demands on Ō2NL (up to 10% higher in the untolled scenario) than for fixed demand assignments due to induced traffic effects, but with some modest levels of trip suppression in central Levin due to increased levels of congestion relative to the base year.
- The testing of an example toll on Ō2NL south of Levin indicates a realistic response to the toll, with a reduction in daily flows of approximately 40% on Ō2NL at this location, the majority of which routes instead via SH1. A net reduction in daily flows across the two corridors of 6% reflects the modelled demand-response to the example toll.
- Analysis of the 12 different user-classes flows using the tolled section of Ō2NL for both the example toll scenario and without the toll applied, indicates intuitive flows and relative changes between the two scenarios.

11.6.4 The Ō2NL models have been developed by QTP for appraisal of Ō2NL since around 2015. QTP have worked with Beca on the implementation of the toll modelling within the Ō2NL models. The methodology and parameters adopted have been directed by Beca based on their extensive experience with toll-road appraisal in New Zealand.

Annualisation factors

Annualisation factors are used to convert model traffic volumes from modelled period flows to annual average daily flows (AADT).

The AADT factors for the tolling study were derived from 2018 TMS data at the count site on SH1 near Ohau. The site number is 01N00988. Hourly data for all of 2018, and quarter hourly data for March 2018 was available and used for the production of the AADT factors.

The Ō2NL modelled time periods are:

- AM Peak Hour (08:00-09:00)
- Interpeak Average Hour (09:00-16:00)
- PM Peak Hour (16:30-17:30)

The calibrated base year modelled flows they represent weekdays Monday-Friday traffic in March 2018.

To create annualisation factors each hour of the year needs to be categorised as being like one of the modelled periods. For instance, normal work-day weekday hours between 9am and 4pm would be categorised as being like the IP modelled time period. Weekend hours may also be categorised as being like the IP modelled time period. There may being some periods where traffic conditions are more like the AM or PM modelled hours, and these would be categorised as such.

The analysis of the 2018 SH1 count data shows that there is not a traditional commuter AM peak or PM peak at this location. Levin is as a rural service town with no strong commuter movement. As such, traffic volume was the only characteristic to judge if the hour should be categorised as like the AM, IP, or PM modelled hour. From the analysis of the 2018 count data the following rules were established to categories each modelled period to each hour across the year:

- AM for regular weekdays 7am to 9am
- PM for regular weekdays 4pm to 6pm
- IP for other hours on regular weekdays
- AM for hours outside regular weekdays where the average Light Vehicle Hourly Count > 1100
- PM for hours outside regular weekdays where the average Light Vehicle Hourly Count > 1350
- IP for all other hours

This resulted in the annualisation factors presented in Table 8-1 below.

Table 8-1 Tolling Study annualisation factors

Time Period	Lights	HCVs
AM	2.35	1.84
IP	8.20	9.16
PM	3.11	2.66

For the sensitivity tests undertaken as part of the risk analysis, other methods of categorisation were developed as set out in Table 8-2

Table 8-2 Alternative methods for the calculation of annualisation factors

	Regular Weekdays	Categorisation of other hours
Core	AM for 7am to 9am PM for 4pm to 6pm IP otherwise	AM for hours where Average Light Vehicle Hourly Count > 1100 PM for hours where Average Light Vehicle Hourly Count > 1350 IP otherwise
Sensitivity Test: Lower	Same as Core	IP for all
Sensitivity Test: Higher	Same as Core	(Lower thresholds than Core) AM for hours where Average Light Vehicle Hourly Count > 1000 PM for hours where Average Light Vehicle Hourly Count > 1250 IP otherwise
Sensitivity Test: Higher PM	Same as Core	PM for hours where Average Light Vehicle Hourly Count > 1250 IP otherwise
Sensitivity Test: Higher AM	Same as Core	AM for hours where Average Light Vehicle Hourly Count > 1000 IP otherwise

The resulting factors are presented in the table below:

Table 8-3 Annualisation factors for the alternative methods

	Lights			HCVs		
	AM	IP	PM	AM	IP	PM
Core	2.35	8.20	3.11	1.84	9.16	2.66
Sensitivity Test: Lower	1.20	11.80	1.23	1.27	10.76	1.26
Sensitivity Test: Higher	1.76	8.17	3.59	1.56	9.14	3.06
Sensitivity Test: Higher PM	1.20	8.73	3.59	1.27	9.42	3.06
Sensitivity Test: Higher AM	4.81	8.17	1.23	2.92	9.14	1.26

C

Appendix C – Risk analysis methodology and outputs from risk analysis

Land use changes and traffic forecasts

Population forecasts: Horowhenua Socio-Economic Projects Report by Sense Partners (May 2020)

	5% Percentile	25% Percentile	50% Percentile	75% Percentile	95% Percentile
2029	39,983	41,022	41,896	42,941	44,968
2039	40,822	44,138	47,006	50,913	59,010
2049	39,542	45,188	51,862	59,250	79,243

Ō2NL v20 traffic model values and estimates of demand on Ō2NL

		5% Percentile	25% Percentile	50% Percentile	75% Percentile	95% Percentile
South demand	2029	7,090	7,274	7,582	7,950	8,306
	2039	7,360	7,958	8,855	10,078	10,974
	2049	7,205	8,233	9,533	10,972	11,831
Central demand	2029	2,518	2,583	2,624	2,672	3,012
	2039	2,789	3,016	3,248	3,564	4,759
	2049	2,822	3,225	4,048	4,959	9,259
Through demand	2029	11,109	11,397	11,638	11,926	12,595
	2039	11,526	12,462	13,321	14,490	17,214
	2049	11,208	12,808	14,943	17,307	23,238

	Ō2NL v20 traffic model value
	Interpolated or extrapolated using population forecasts

Ō2NL v22 traffic model values and estimates of demand on Ō2NL

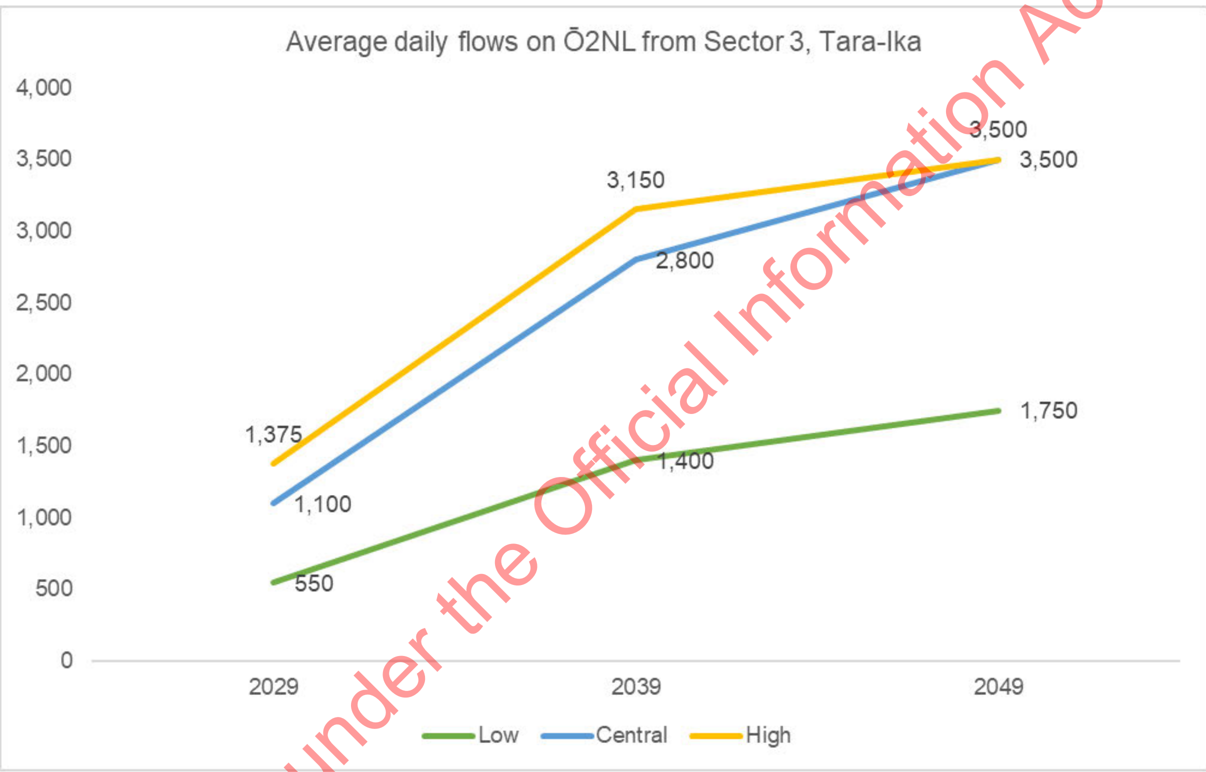
		5% Percentile	25% Percentile	50% Percentile	75% Percentile	95% Percentile
South demand	2029	5,039	5,169	5,388	5,649	5,902
	2039	5,888	6,366	7,084	8,062	8,778
	2049	5,946	6,795	7,867	9,054	9,763
Central demand	2029	808	829	842	857	966
	2039	1,126	1,218	1,311	1,439	1,921
	2049	1,345	1,537	1,930	2,364	4,414
Through demand	2029	7,209	7,396	7,552	7,739	8,173
	2039	7,729	8,357	8,933	9,717	11,544
	2049	8,148	9,312	10,864	12,583	16,894

	Ō2NL v22 traffic model value
	Interpolated or extrapolated using Ō2NL v20 traffic model values and estimates of demand on Ō2NL

Tara-Ika development

The figure below presents the forecast flows from Sector 3 (location of the Tara-Ika development) for the Central estimate (as modelled in the Ō2NL v22 traffic model forecasts (using the 75th percentile land use assumptions), alongside the Low and High estimates. The Low estimate is based on a 50% reduction in trips from sector 3 for the Low estimate which represents growth in this sector occurring more slowly than predicted in the 75th percentile forecast. The high estimate is based on a 25% increase in trips from sector 3 for the High estimate which represents growth in this sector occurring more quickly than predicted in the 75th percentile forecast (with a cap to not exceed the 2049 Central estimate).

Forecast average daily flows from Sector 3 (location of the Tara-Ika development) for the Low, Central and High estimates



Willingness to pay sensitivity tests

The willingness to pay values for the Value of Time sensitivity test are presented in the table below.

Willingness to pay values for the Value to Time sensitivity test

	Willingness to Pay values of time			Change on the Central estimate	
Purpose-Segment	Central	Low	High	Low	High
HBW L	$22.71	$21.79	$22.53	-4.1%	-0.8%
HBW M	$31.31	$30.21	$34.64	-3.5%	+10.6%
HBW H	$47.37	$46.32	$52.52	-2.2%	+10.9%
EB L	$43.68	$41.91	$43.34	-4.1%	-0.8%
EB M	$56.59	$54.61	$62.62	-3.5%	+10.6%
EB H	$120.77	$118.10	$133.91	-2.2%	+10.9%
Other L	$10.76	$10.32	$10.67	-4.1%	-0.8%
Other M	$15.59	$15.05	$17.25	-3.5%	+10.6%
Other H	$25.92	$25.35	$28.74	-2.2%	+10.9%
HCV L	$29.23	$27.76	$32.15	-5.0%	+10.0%
HCV M	$54.52	$51.80	$59.98	-5.0%	+10.0%
HCV H	$98.14	$93.24	$107.96	-5.0%	+10.0%

The willingness to pay values for the Escalation sensitivity test are presented in the table below.

Willingness to pay values for the Escalation sensitivity test

	Willingness to Pay values of time			Change on the Central estimate	
Purpose-Segment	Central	Low	High	Low	High
HBW L	$22.71	$18.43	$25.20	-18.9%	+10.9%
HBW M	$31.31	$25.41	$34.73	-18.9%	+10.9%
HBW H	$47.37	$38.44	$52.54	-18.9%	+10.9%
EB L	$43.68	$35.45	$48.46	-18.9%	+10.9%
EB M	$56.59	$45.92	$62.78	-18.9%	+10.9%
EB H	$120.77	$98.00	$133.97	-18.9%	+10.9%
Other L	$10.76	$8.73	$11.93	-18.9%	+10.9%
Other M	$15.59	$12.65	$17.30	-18.9%	+10.9%
Other H	$25.92	$21.03	$28.75	-18.9%	+10.9%
HCV L	$29.23	$23.71	$32.42	-18.9%	+10.9%
HCV M	$54.52	$44.24	$60.48	-18.9%	+10.9%
HCV H	$98.14	$79.64	$108.87	-18.9%	+10.9%

Posted speed limit assumptions

Posted speed limits	2018	Future year DM Without Ō2NL	Future year DS With Ō2NL	Sensitivity tests: SIP and Revocation works Low (SP01)	Sensitivity tests: SIP and Revocation works High (SP02)	Sensitivity tests: SH57 Revocation works (SP03)	Sensitivity tests: Ō2NL Speed (SP04)
The existing SH1							
Foxton to Heatherlea Road	100	100	100	100	100	100	100
Heatherlea Road to 250m South of Lindsay Road	100	100	100	100	100	100	100
Levin - 250m South of Lindsay Road to Kawiu Road	70	70	70	50	50	50	70
Levin - Kawiu Road to Tararua Road	50	50	50	50	50	50	50
Levin - Ohau	80	80	80	80	80	80	80
Ohau	80	80	80	50	80	50	80
Ohau to Manakau	100	80	80	80	80	80	80
Manakau	80	80	80	50	80	50	80
Manakau to Taylors Road	100	80	80	80	100	80	80
Taylors Road to Waitohu Valley Road	100	80	80	80	100	80	80
Otaki	50	50	50	50	50	50	50
SH57							
Shannon - Levin (Heatherlea Road)	100	80	80	80	80	80	80
Levin - Heatherlea Road to Roslyn Road	100	80	80	80	80	50	80
Levin - Roslyn Road to Queen Street East	100	80	80	80	80	50	80
Levin - Queen Street East to Tararua Road	100	50	50	50	50	50	50
Levin - Tararua Road to Kimberly Road	100	80	80	80	80	80	80
Levin - Kimberly Road	100	80	80	80	80	80	80
Ō2NL							
Section C			100	100	100	100	110
Section B			100	100	100	100	110
Section A			100	100	100	100	100

Risk analysis distribution parameters

2029 Central demand distribution parameters

Risk	*Distribution*	Triangular distribution parameters			Binary distribution parameters		
		Low	Likely	High	Probability	Result	Alternative Result
Land Use changes	Triangular	0.94	0.88	1.18			
Taraika development	Binary				95%	1	1.00
WtP - VoT	Triangular	0.95	1.00	1.11			
WtP - Escalation	Triangular	0.91	1.00	1.01			
WtP - Road Perception Factors	Triangular	0.94	1.00	1.10			
Demand Response	Triangular	0.96	1.00	1.04			
SIP and Revocation works	Triangular	1.00	1.00	1.01			
SH57 Revocation works	Binary				85%	1	1.22
Ō2NL Speed	Binary				90%	1	1.09
Annualisation	Triangular	0.96	1.00	1.02			
PPK in future year	Triangular	0.94	1.00	1.06			
Region-wide mode shift	Binary				75%	1	0.99
Revenue leakage	Triangular	0.94	0.98	0.98			
Transaction costs	Triangular	0.63	0.65	0.84			

2029 South demand distribution parameters

Risk	*Distribution*	Triangular distribution parameters			Binary distribution parameters		
		Low	Likely	High	Probability	Result	Alternative Result
Land Use changes	Triangular	0.89	0.88	1.11			
Taraika development	Triangular	0.86	1.00	1.08			
WtP - VoT	Triangular	1.00	0.92	1.06			
WtP - Escalation	Triangular	0.94	1.00	1.02			
WtP - Road Perception Factors	Triangular	0.88	1.00	1.06			
Demand Response	Triangular	0.96	1.00	1.06			
SIP and Revocation works	Triangular	0.86	1.00	1.11			
SH57 Revocation works	Binary				85%	1	1.00
Ō2NL Speed	Binary				90%	1	1.07
Annualisation	Triangular	0.94	1.00	1.00			
PPK in future year	Triangular	0.94	1.00	1.06			
Region-wide mode shift	Binary				75%	1	0.97
Revenue leakage	Triangular	0.94	0.98	0.98			
Transaction costs	Triangular	0.63	0.65	0.84			

2029 Through demand distribution parameters

Risk	Distribution	Triangular distribution parameters Low	Likely	High	Binary distribution parameters Probability	Result	Alternative Result
Land Use changes	Triangular	0.93	0.88	1.11			
Taraika development	Triangular	1.00	1.00	1.00			
WtP - VoT	Triangular	1.01	0.87	1.13			
WtP - Escalation	Triangular	0.91	1.00	1.00			
WtP - Road Perception Factors	Triangular	0.97	1.00	1.08			
Demand Response	Triangular	0.94	1.00	1.05			
SIP and Revocation works	Triangular	0.99	1.00	1.01			
SH57 Revocation works	Binary				85%	1	1.11
Ō2NL Speed	Binary				90%	1	1.10
Annualisation	Triangular	0.98	1.00	1.04			
PPK in future year	Triangular	0.95	1.00	1.03			
Region-wide mode shift	Binary				75%	1	0.95
Revenue leakage	Triangular	0.94	0.98	0.98			
Transaction costs	Triangular	0.63	0.65	0.84			

2039 Central demand distribution parameters

Risk	Distribution	Triangular distribution parameters Low	Likely	High	Binary distribution parameters Probability	Result	Alternative Result
Land Use changes	Triangular	0.74	0.77	1.47			
Taraika development	Triangular	0.93	1.00	1.03			
WtP - VoT	Triangular	0.99	0.92	1.11			
WtP - Escalation	Triangular	0.88	1.00	1.08			
WtP - Road Perception Factors	Triangular	0.94	1.00	1.10			
Demand Response	Triangular	0.96	1.00	1.04			
SIP and Revocation works	Triangular	1.00	1.00	1.01			
SH57 Revocation works	Binary				85%	1	1.22
Ō2NL Speed	Binary				90%	1	1.09
Annualisation	Triangular	0.96	1.00	1.02			
PPK in future year	Triangular	0.95	1.00	1.04			
Region-wide mode shift	Binary				75%	1	0.97
Revenue leakage	Triangular	0.94	0.98	0.98			
Transaction costs	Triangular	0.49	0.74	0.84			

2039 South demand distribution parameters

		Triangular distribution parameters			Binary distribution parameters		
Risk	*Distribution*	Low	Likely	High	Probability	Result	Alternative Result
Land Use changes	Triangular	0.69	0.79	1.19			
Taraika development	Triangular	0.84	1.00	1.04			
WtP - VoT	Triangular	1.00	0.92	1.06			
WtP - Escalation	Triangular	0.90	1.00	1.04			
WtP - Road Perception Factors	Triangular	0.88	1.00	1.06			
Demand Response	Triangular	0.96	1.00	1.05			
SIP and Revocation works	Triangular	0.90	1.00	1.08			
SH57 Revocation works	Binary				85%	1	1.00
Ō2NL Speed	Binary				90%	1	1.07
Annualisation	Triangular	0.98	1.00	1.02			
PPK in future year	Triangular	0.94	1.00	1.06			
Region-wide mode shift	Binary				75%	1	0.93
Revenue leakage	Triangular	0.94	0.98	0.98			
Transaction costs	Triangular	0.49	0.74	0.84			

2039 Through demand distribution parameters

		Triangular distribution parameters			Binary distribution parameters		
Risk	*Distribution*	Low	Likely	High	Probability	Result	Alternative Result
Land Use changes	Triangular	0.80	0.78	1.25			
Taraika development	Triangular	1.00	1.00	1.00			
WtP - VoT	Triangular	1.03	0.82	1.12			
WtP - Escalation	Triangular	0.89	1.00	1.09			
WtP - Road Perception Factors	Triangular	0.97	1.00	1.08			
Demand Response	Triangular	0.94	1.00	1.05			
SIP and Revocation works	Triangular	0.99	1.00	1.01			
SH57 Revocation works	Binary				85%	1	1.11
Ō2NL Speed	Binary				90%	1	1.10
Annualisation	Triangular	0.97	1.00	1.02			
PPK in future year	Triangular	0.95	1.00	1.03			
Region-wide mode shift	Binary				75%	1	0.91
Revenue leakage	Triangular	0.94	0.98	0.98			
Transaction costs	Triangular	0.49	0.74	0.84			

2049 Central demand distribution parameters

Risk	*Distribution*	Triangular distribution parameters			Binary distribution parameters		
		Low	Likely	High	Probability	Result	Alternative Result
Land Use changes	Triangular	0.46	0.49	2.05			
Taraika development	Binary				90%	1	0.87
WtP - VoT	Triangular	0.99	0.92	1.11			
WtP - Escalation	Triangular	0.82	1.00	1.10			
WtP - Road Perception Factors	Triangular	0.94	1.00	1.10			
Demand Response	Triangular	0.96	1.00	1.04			
SIP and Revocation works	Triangular	1.00	1.00	1.01			
SH57 Revocation works	Binary				85%	1	1.22
Ō2NL Speed	Binary				90%	1	1.09
Annualisation	Triangular	0.94	1.00	1.02			
PPK in future year	Triangular	0.95	1.00	1.04			
Region-wide mode shift	Binary				75%	1	0.94
Revenue leakage	Triangular	0.94	0.98	0.98			
Transaction costs	Triangular	0.44	0.77	0.84			

2049 South demand distribution parameters

Risk	*Distribution*	Triangular distribution parameters			Binary distribution parameters		
		Low	Likely	High	Probability	Result	Alternative Result
Land Use changes	Triangular	0.58	0.87	1.19			
Taraika development	Binary				90%	1	0.84
WtP - VoT	Triangular	1.01	0.92	1.06			
WtP - Escalation	Triangular	0.88	1.00	1.03			
WtP - Road Perception Factors	Triangular	0.88	1.00	1.06			
Demand Response	Triangular	0.96	1.00	1.05			
SIP and Revocation works	Triangular	0.90	1.00	1.08			
SH57 Revocation works	Binary				85%	1	1.00
Ō2NL Speed	Binary				90%	1	1.07
Annualisation	Triangular	0.99	1.00	1.02			
PPK in future year	Triangular	0.94	1.00	1.06			
Region-wide mode shift	Binary				75%	1	0.90
Revenue leakage	Triangular	0.94	0.98	0.98			
Transaction costs	Triangular	0.44	0.77	0.84			

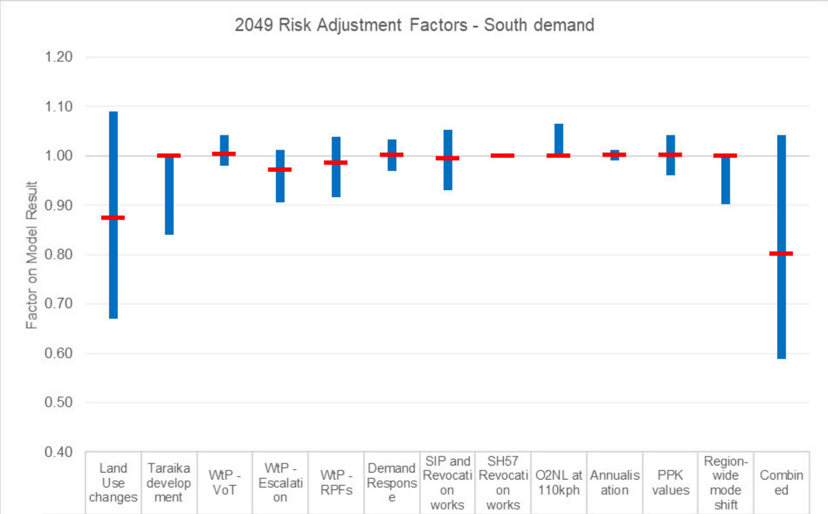
2049 Through demand distribution parameters

Risk	*Distribution*	Triangular distribution parameters Low	Likely	High	Binary distribution parameters Probability	Result	Alternative Result
Land Use changes	Triangular	0.58	0.60	1.53			
Taraika development	Triangular	1.00	1.00	1.00			
WtP - VoT	Triangular	1.01	0.90	1.12			
WtP - Escalation	Triangular	0.84	1.00	1.10			
WtP - Road Perception Factors	Triangular	0.97	1.00	1.08			
Demand Response	Triangular	0.94	1.00	1.05			
SIP and Revocation works	Triangular	0.99	1.00	1.01			
SH57 Revocation works	Binary				85%	1	1.11
Ō2NL Speed	Binary				90%	1	1.10
Annualisation	Triangular	0.98	1.00	1.03			
PPK in future year	Triangular	0.95	1.00	1.03			
Region-wide mode shift	Binary				75%	1	0.86
Revenue leakage	Triangular	0.94	0.98	0.98			
Transaction costs	Triangular	0.44	0.77	0.84			

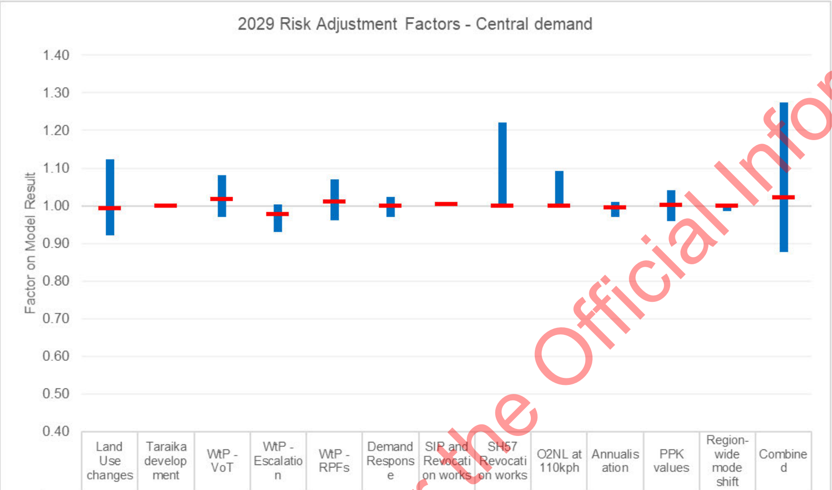
Risk analysis results

	Land Use changes	Taraika development	WtP - VoT	WtP - Escalation	WtP - RPFs	Demand Response	SIP and Revocation works	SH57 Revocation works	O2NL at 110kph	Annualisation	PPK values	Region-wide mode shift	Combined
95th	1.06	1.05	1.04	1.01	1.04	1.04	1.08	1.00	1.07	1.00	1.04	1.00	1.05
5th	0.89	0.90	0.97	0.95	0.92	0.97	0.90	1.00	1.00	0.96	0.96	0.97	0.74
50th	0.95	0.98	1.00	0.99	0.99	1.00	0.99	1.00	1.00	0.98	1.00	1.00	0.88

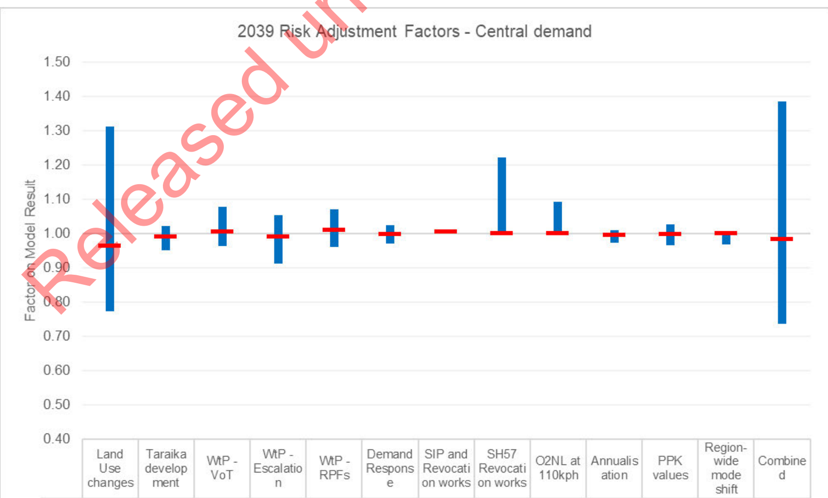
	Land Use changes	Taraika development	WtP - VoT	WtP - Escalation	WtP - RPFs	Demand Response	SIP and Revocation works	SH57 Revocation works	O2NL at 110kph	Annualisation	PPK values	Region-wide mode shift	Combined
95th	1.09	1.02	1.04	1.02	1.04	1.03	1.05	1.00	1.07	1.01	1.04	1.00	1.03
5th	0.74	0.88	0.97	0.93	0.92	0.97	0.93	1.00	1.00	0.99	0.96	0.93	0.63
50th	0.87	0.97	1.00	0.98	0.99	1.00	0.99	1.00	1.00	1.00	1.00	1.00	0.80



	Land Use changes	Taraika development	WtP - VoT	WtP - Escalation	WtP - RPFs	Demand Response	SIP and Revocation works	SH57 Revocation works	O2NL at 110kph	Annualisation	PPK values	Region-wide mode shift	Combined
95th	1.09	1.00	1.04	1.01	1.04	1.03	1.05	1.00	1.07	1.01	1.04	1.00	1.04
5th	0.67	0.84	0.98	0.91	0.92	0.97	0.93	1.00	1.00	0.99	0.96	0.90	0.59
50th	0.87	1.00	1.00	0.97	0.99	1.00	0.99	1.00	1.00	1.00	1.00	1.00	0.80



	Land Use changes	Taraika development	WtP - VoT	WtP - Escalation	WtP - RPFs	Demand Response	SIP and Revocation works	SH57 Revocation works	O2NL at 110kph	Annualisation	PPK values	Region-wide mode shift	Combined
95th	1.12	1.00	1.08	1.00	1.07	1.02	1.01	1.22	1.09	1.01	1.04	1.00	1.28
5th	0.92	1.00	0.97	0.93	0.96	0.97	1.00	1.00	1.00	0.97	0.96	0.99	0.88
50th	0.99	1.00	1.02	0.98	1.01	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.02

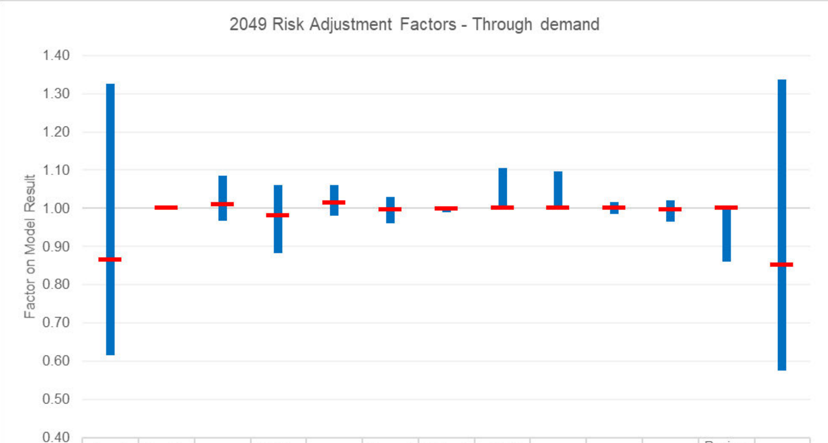


	Land Use changes	Taraika development	WtP - VoT	WtP - Escalation	WtP - RPFs	Demand Response	SIP and Revocation works	SH57 Revocation works	O2NL at 110kph	Annualisation	PPK values	Region-wide mode shift	Combined
95th	1.31	1.02	1.08	1.05	1.07	1.02	1.01	1.22	1.09	1.01	1.03	1.00	1.39
5th	0.77	0.95	0.96	0.91	0.96	0.97	1.00	1.00	1.00	0.97	0.96	0.97	0.74
50th	0.96	0.99	1.00	0.99	1.01	1.00	1.00	1.00	1.00	0.99	1.00	1.00	0.98

	Land Use changes	Taraika development	WtP - VoT	WtP - Escalation	WtP - RPFs	Demand Response	SIP and Revocation works	SH57 Revocation works	O2NL at 110kph	Annualisation	PPK values	Region-wide mode shift	Combined
95th	1.71	1.00	1.08	1.07	1.07	1.02	1.01	1.22	1.09	1.01	1.03	1.00	1.74
5th	0.51	0.87	0.96	0.87	0.96	0.97	1.00	1.00	1.00	0.96	0.96	0.94	0.49
50th	0.93	1.00	1.00	0.98	1.01	1.00	1.00	1.00	1.00	0.99	1.00	1.00	0.92

	Land Use changes	Taraika development	WtP - VoT	WtP - Escalation	WtP - RPFs	Demand Response	SIP and Revocation works	SH57 Revocation works	O2NL at 110kph	Annualisation	PPK values	Region-wide mode shift	Combined
95th	1.06	1.00	1.09	1.00	1.06	1.03	1.00	1.11	1.10	1.03	1.02	1.00	1.14
5th	0.91	1.00	0.96	0.93	0.98	0.96	0.99	1.00	1.00	0.99	0.96	0.95	0.85
50th	0.97	1.00	1.00	0.98	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97

	Land Use changes	Taraika development	WtP - VoT	WtP - Escalation	WtP - RPFs	Demand Response	SIP and Revocation works	SH57 Revocation works	O2NL at 110kph	Annualisation	PPK values	Region-wide mode shift	Combined
95th	1.15	1.00	1.08	1.06	1.06	1.03	1.00	1.11	1.10	1.01	1.02	1.00	1.19
5th	0.80	1.00	0.96	0.93	0.98	0.96	0.99	1.00	1.00	0.98	0.96	0.91	0.75
50th	0.92	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.93



	Land Use changes	Taraika development	WtP - VoT	WtP - Escalation	WtP - RPFs	Demand Response	SIP and Revocation works	SH57 Revocation works	O2NL at 110kph	Annualisation	PPK values	Region-wide mode shift	Combined
95th	1.32	1.00	1.08	1.06	1.06	1.03	1.00	1.11	1.10	1.02	1.02	1.00	1.34
5th	0.62	1.00	0.97	0.88	0.98	0.96	0.99	1.00	1.00	0.98	0.96	0.86	0.58
50th	0.87	1.00	1.01	0.98	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.85

D

Appendix D – Emissions

Traffic model emissions tool summary page

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Summary

Project Information

Name of Project	**Ō2NL tolling study**
Element/Stage	Detailed Business Case
Date	19/05/2022
Traffic Consultant	Beca
Model Software	Saturn
Model Version	Ō2NL traffic Model v22a

Model Assumptions

Analysis Years	Model years are 2018, 2029, 2039, 2049 (Assessment period is 20 years from Opening year 2029 to 2048 inclusive)	
User Class	Light	HCV
Vehicle Type (Select)	Light	Heavy
Centroid Connector Average Speed (km/h)	30	
Heavy Vehicles PCU Factor	2.0	
Buses PCU Factors	2.0	
Source of Emission and Fuel Consumption Rates	VEPM 6.2_Rates_2021	

2029

Emission and Fuel Consumption Outputs - All Vehicles

Sheet Name	Year	Peak	Scenario	VKT	CO, t	CO2-e, t	VOC, t	Nox, t	NO2, t	PM2.5 E, t	PM B&T, t	FC, 1000l	Total PM, t
2029DM_AM	2029	AM	DM	82,710	0.0221	16.6	0.0007	0.0146	0.0029	0.0004	0.0018	6.5471	0.0022
2029DM_IP	2029	IP	DM	75,131	0.0202	15.1	0.0007	0.0132	0.0027	0.0003	0.0016	5.9627	0.0019
2029DM_PM	2029	PM	DM	96,706	0.0254	17.4	0.0007	0.0146	0.0032	0.0004	0.0019	6.9415	0.0023
2029DS_AM	2029	AM	DS	87,852	0.0640	21.4	0.0024	0.0401	0.0083	0.0013	0.0017	8.4902	0.0030
2029DS_IP	2029	IP	DS	82,271	0.0603	20.1	0.0022	0.0378	0.0078	0.0013	0.0015	7.9702	0.0028
2029DS_PM	2029	PM	DS	103,246	0.0749	23.1	0.0027	0.0400	0.0092	0.0012	0.0018	9.2715	0.0030
2029Toll_AM	2029	AM	Toll	84,853	0.0592	20.7	0.0024	0.0389	0.0079	0.0012	0.0017	8.2230	0.0029
2029Toll_IP	2029	IP	Toll	78,079	0.0545	19.1	0.0021	0.0361	0.0074	0.0012	0.0015	7.5948	0.0027
2029Toll_PM	2029	PM	Toll	99,641	0.0690	22.4	0.0026	0.0384	0.0087	0.0012	0.0018	8.9637	0.0030

Emission and Fuel Consumption Outputs as ADT values by time period

Sheet Name	Year	Peak	Scenario	VKT	CO, t	CO2-e, t	VOC, t	Nox, t	NO2, t	PM2.5 E, t	PM B&T, t	FC, 1000l	Total PM, t
2029DM_AM	2029	AM	DM	189,851	0.0504	36.0	0.0015	0.0309	0.0065	0.0008	0.0039	14.2757	0.0048
2029DM_IP	2029	IP	DM	624,647	0.1685	129.3	0.0060	0.1141	0.0228	0.0027	0.0136	50.8485	0.0163
2029DM_PM	2029	PM	DM	297,359	0.0779	52.1	0.0021	0.0431	0.0097	0.0012	0.0057	20.8446	0.0069
2029DS_AM	2029	AM	DS	201,578	0.1464	47.1	0.0053	0.0847	0.0185	0.0027	0.0037	18.7658	0.0064
2029DS_IP	2029	IP	DS	684,086	0.5022	170.6	0.0185	0.3272	0.0659	0.0113	0.0128	67.5243	0.0241
2029DS_PM	2029	PM	DS	317,447	0.2300	69.8	0.0082	0.1181	0.0279	0.0035	0.0054	28.0346	0.0089
2029Toll_AM	2029	AM	Toll	194,665	0.1352	45.6	0.0053	0.0819	0.0175	0.0025	0.0037	18.1644	0.0062
2029Toll_IP	2029	IP	Toll	649,345	0.4543	162.6	0.0177	0.3129	0.0626	0.0105	0.0128	64.3748	0.0233
2029Toll_PM	2029	PM	Toll	306,334	0.2117	67.5	0.0079	0.1132	0.0264	0.0035	0.0054	27.0940	0.0089

Emission and Fuel Consumption Outputs as ADT values

Scenario	Year	Peak	Scenario	VKT	CO, t	CO2-e, t	VOC, t	Nox, t	NO2, t	PM2.5 E, t	PM B&T, t	FC, 1000l	Total PM, t
DM	2029		DM	1,111,856	0.2967	217.4	0.0096	0.1881	0.0390	0.0046	0.0233	85.97	0.0279
DS	2029		DS	1,203,110	0.8786	287.4	0.0321	0.5299	0.1123	0.0175	0.0219	114.32	0.0394
Toll	2029		Toll	1,150,344	0.8012	275.7	0.0309	0.5080	0.1065	0.0165	0.0219	109.63	0.0384
Difference	2029		DS vs. DM	+91,254	+0.58	+70.00	+0.02	+0.34	+0.07	+0.01	-0.00	+28.36	+0.01
	2029		Toll vs DS	-52,766	-0.08	-11.75	-0.00	-0.02	-0.01	-0.00	0.00	-4.69	-0.00
	2029		Toll vs DM	+38,488	+0.50	+58.25	+0.02	+0.32	+0.07	+0.01	-0.00	+23.66	+0.01
Percent Difference	2029		DS vs. DM	+8%	+196%	+32%	+234%	+182%	+188%	+278%	-6%	+33%	+41%
	2029		Toll vs DS	-4%	-9%	-4%	-4%	-4%	-5%	-6%	0%	-4%	-3%
	2029		Toll vs DM	+3%	+170%	+27%	+222%	+170%	+173%	+255%	-6%	+28%	+38%

Emission and Fuel Consumption Outputs as annual values

Scenario	Year	Peak	Scenario	VKT	CO, t	CO2-e, t	VOC, t	Nox, t	NO2, t	PM2.5 E, t	PM B&T, t	FC, 1000l	Total PM, t
DM	2029		DM	405,827,410	108	79,356	4	69	14	2	8	31,379	10
DS	2029		DS	439,135,252	321	104,907	12	193	41	6	8	41,728	14
Toll	2029		Toll	419,875,615	292	100,617	11	185	39	6	8	40,016	14
Difference	2029		DS vs. DM	+33,307,842	+212	+25,551	+8.20	+124.78	+26.74	+4.71	-0.50	+10,350	+4.21
	2029		Toll vs DS	-19,259,637	-28	4-290	-0.41	-8.00	-2.11	-0.39	0.00	1-712	-0.39
	2029		Toll vs DM	+14,048,205	+184	+21,261	+7.79	+116.77	+24.63	+4.32	-0.50	+8,638	+3.82
Percent Difference	2029		DS vs. DM	+8%	+196%	+32%	+234%	+182%	+188%	+278%	-6%	+33%	+41%
	2029		Toll vs DS	-4%	-9%	-4%	-4%	-4%	-5%	-6%	0%	-4%	-3%
	2029		Toll vs DM	+3%	+170%	+27%	+222%	+170%	+173%	+255%	-6%	+28%	+38%

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Emission and Fuel Consumption Outputs - All Vehicles

Sheet Name	Year	Peak	Scenario	VKT	CO, t	CO2-e, t	VOC, t	Nox, t	NO2, t	PM2.5 E, t	PM B&T, t	FC, 1000l	Total PM, t
2039DM_AM	2039	AM	DM	98,899	0.0262	20.2	0.0008	0.0181	0.0035	0.0005	0.0023	7.9476	0.0028
2039DM_IP	2039	IP	DM	90,070	0.0240	18.3	0.0007	0.0163	0.0032	0.0005	0.0020	7.2317	0.0025
2039DM_PM	2039	PM	DM	115,895	0.0302	21.3	0.0009	0.0182	0.0039	0.0004	0.0025	8.4968	0.0029
2039DS_AM	2039	AM	DS	106,111	0.0331	21.3	0.0008	0.0184	0.0039	0.0005	0.0020	8.4093	0.0025
2039DS_IP	2039	IP	DS	99,840	0.0313	20.1	0.0008	0.0174	0.0037	0.0005	0.0018	7.9406	0.0023
2039DS_PM	2039	PM	DS	125,589	0.0391	22.6	0.0009	0.0189	0.0044	0.0005	0.0022	9.0255	0.0027
2039Toll_AM	2039	AM	Toll	102,748	0.0309	20.7	0.0008	0.0178	0.0037	0.0005	0.0020	8.1715	0.0025
2039Toll_IP	2039	IP	Toll	95,016	0.0286	19.3	0.0008	0.0166	0.0035	0.0005	0.0018	7.5948	0.0023
2039Toll_PM	2039	PM	Toll	121,477	0.0364	21.9	0.0008	0.0183	0.0042	0.0005	0.0022	8.7492	0.0027

Emission and Fuel Consumption Outputs as ADT values by time period

Sheet Name	Year	Peak	Scenario	VKT	CO, t	CO2-e, t	VOC, t	Nox, t	NO2, t	PM2.5 E, t	PM B&T, t	FC, 1000l	Total PM, t
2039DM_AM	2039	AM	DM	226,982	0.0597	43.7	0.0017	0.0381	0.0078	0.0010	0.0050	17.3171	0.0060
2039DM_IP	2039	IP	DM	748,935	0.2003	156.9	0.0060	0.1412	0.0270	0.0044	0.0171	61.6947	0.0215
2039DM_PM	2039	PM	DM	356,330	0.0925	63.8	0.0027	0.0536	0.0118	0.0012	0.0075	25.5025	0.0086
2039DS_AM	2039	AM	DS	243,466	0.0759	46.3	0.0017	0.0394	0.0088	0.0010	0.0043	18.3618	0.0054
2039DS_IP	2039	IP	DS	830,253	0.2603	172.0	0.0068	0.1497	0.0311	0.0044	0.0153	67.6808	0.0197
2039DS_PM	2039	PM	DS	386,124	0.1202	67.8	0.0027	0.0562	0.0134	0.0015	0.0066	27.1272	0.0081
2039Toll_AM	2039	AM	Toll	235,714	0.0707	45.0	0.0017	0.0380	0.0083	0.0010	0.0043	17.8321	0.0054
2039Toll_IP	2039	IP	Toll	790,260	0.2380	164.6	0.0068	0.1430	0.0295	0.0044	0.0153	64.7638	0.0197
2039Toll_PM	2039	PM	Toll	373,449	0.1118	65.7	0.0024	0.0543	0.0128	0.0015	0.0066	26.2866	0.0081

Emission and Fuel Consumption Outputs as ADT values

Scenario	Year	Peak	Scenario	VKT	CO, t	CO2-e, t	VOC, t	Nox, t	NO2, t	PM2.5 E, t	PM B&T, t	FC, 1000l	Total PM, t
DM	2039		DM	1,332,248	0.3525	264.4	0.0104	0.2329	0.0466	0.0066	0.0296	104.51	0.0361
DS	2039		DS	1,459,844	0.4564	286.1	0.0113	0.2452	0.0533	0.0069	0.0263	113.17	0.0332
Toll	2039		Toll	1,399,424	0.4206	275.3	0.0110	0.2354	0.0506	0.0069	0.0263	108.88	0.0332
Difference	2039		DS vs. DM	+127,596	+0.10	+21.75	+0.00	+0.01	+0.01	+0.00	-0.00	+8.66	-0.00
	2039		Toll vs DS	-60,420	-0.04	-10.77	-0.00	-0.01	-0.00	0.00	0.00	-4.29	0.00
	2039		Toll vs DM	+67,176	+0.07	+10.97	+0.00	+0.00	+0.00	+0.00	-0.00	+4.37	-0.00
Percent Difference	2039		DS vs. DM	+10%	+29%	+8%	+8%	+5%	+14%	+5%	-11%	+8%	-8%
	2039		Toll vs DS	-4%	-8%	-4%	-3%	-4%	-5%	0%	0%	-4%	0%
	2039		Toll vs DM	+5%	+19%	+4%	+5%	+1%	+9%	+5%	-11%	+4%	-8%

Emission and Fuel Consumption Outputs as annual values

Scenario	Year	Peak	Scenario	VKT	CO, t	CO2-e, t	VOC, t	Nox, t	NO2, t	PM2.5 E, t	PM B&T, t	FC, 1000l	Total PM, t
DM	2039		DM	486,270,452	129	96,490	4	85	17	2	11	38,148	13
DS	2040		DS	532,843,120	167	104,427	4	90	19	3	10	41,307	12
Toll	2039		Toll	510,789,661	154	100,494	4	86	18	3	10	39,742	12
Difference	2039		DS vs. DM	+46,572,668	+38	+7,937	+0.32	+4.52	+2.44	+0.11	-1.20	+3,159	-1.08
	2039		Toll vs DS	-22,053,459	-13	3-933	-0.11	-3.61	-1.00	0.00	0.00	1-565	0.00
	2039		Toll vs DM	+24,519,209	+25	+4,005	+0.20	+0.92	+1.45	+0.11	-1.20	+1,594	-1.08
Percent Difference	2039		DS vs. DM	+10%	+29%	+8%	+8%	+5%	+14%	+5%	-11%	+8%	-8%
	2039		Toll vs DS	-4%	-8%	-4%	-3%	-4%	-5%	0%	0%	-4%	0%
	2039		Toll vs DM	+5%	+19%	+4%	+5%	+1%	+9%	+5%	-11%	+4%	-8%

2049

Emission and Fuel Consumption Outputs - All Vehicles

Sheet Name	Year	Peak	Scenario	VKT	CO, t	CO2-e, t	VOC, t	Nox, t	NO2, t	PM2.5 E, t	PM B&T, t	FC, 1000l	Total PM, t
2049DM_AM	2049	AM	DM	113,401	0.0139	15.5	0.0006	0.0089	0.0015	0.0003	0.0026	5.9769	0.0029
2049DM_IP	2049	IP	DM	103,468	0.0126	14.0	0.0005	0.0078	0.0013	0.0002	0.0023	5.3956	0.0025
2049DM_PM	2049	PM	DM	132,211	0.0159	15.1	0.0006	0.0088	0.0016	0.0002	0.0028	5.8884	0.0030
2049DS_AM	2049	AM	DS	123,641	0.0176	16.1	0.0005	0.0085	0.0016	0.0003	0.0023	6.2311	0.0026
2049DS_IP	2049	IP	DS	116,587	0.0167	15.3	0.0005	0.0080	0.0014	0.0002	0.0021	5.9179	0.0023
2049DS_PM	2049	PM	DS	146,512	0.0207	15.9	0.0006	0.0088	0.0018	0.0002	0.0025	6.2045	0.0027
2049Toll_AM	2049	AM	Toll	119,977	0.0166	15.7	0.0005	0.0083	0.0015	0.0003	0.0023	6.0793	0.0026
2049Toll_IP	2049	IP	Toll	111,248	0.0153	14.7	0.0005	0.0077	0.0013	0.0002	0.0021	5.6918	0.0023
2049Toll_PM	2049	PM	Toll	141,864	0.0194	15.4	0.0005	0.0085	0.0017	0.0002	0.0025	6.0426	0.0027

Emission and Fuel Consumption Outputs as ADT values by time period

Sheet Name	Year	Peak	Scenario	VKT	CO, t	CO2-e, t	VOC, t	Nox, t	NO2, t	PM2.5 E, t	PM B&T, t	FC, 1000l	Total PM, t
2049DM_AM	2049	AM	DM	260,184	0.0315	32.3	0.0012	0.0185	0.0033	0.0006	0.0057	12.5266	0.0063
2049DM_IP	2049	IP	DM	860,509	0.1054	121.7	0.0044	0.0678	0.0110	0.0017	0.0196	46.8583	0.0214
2049DM_PM	2049	PM	DM	406,441	0.0486	44.1	0.0017	0.0257	0.0048	0.0006	0.0084	17.3049	0.0090
2049DS_AM	2049	AM	DS	283,617	0.0403	33.7	0.0010	0.0182	0.0036	0.0006	0.0050	13.1085	0.0056
2049DS_IP	2049	IP	DS	969,710	0.1391	133.1	0.0044	0.0689	0.0118	0.0017	0.0179	51.3269	0.0196
2049DS_PM	2049	PM	DS	450,394	0.0635	46.6	0.0017	0.0261	0.0055	0.0006	0.0075	18.2790	0.0081
2049Toll_AM	2049	AM	Toll	275,163	0.0379	32.9	0.0010	0.0177	0.0033	0.0006	0.0050	12.7803	0.0056
2049Toll_IP	2049	IP	Toll	925,462	0.1275	128.1	0.0044	0.0664	0.0110	0.0017	0.0179	49.3915	0.0196
2049Toll_PM	2049	PM	Toll	436,061	0.0595	45.3	0.0015	0.0252	0.0051	0.0006	0.0075	17.7933	0.0081

Emission and Fuel Consumption Outputs as ADT values

Scenario	Year	Peak	Scenario	VKT	CO, t	CO2-e, t	VOC, t	Nox, t	NO2, t	PM2.5 E, t	PM B&T, t	FC, 1000l	Total PM, t
DM	2049		DM	1,527,134	0.1854	198.1	0.0073	0.1121	0.0191	0.0029	0.0337	76.69	0.0366
DS	2049		DS	1,703,721	0.2429	213.4	0.0071	0.1131	0.0208	0.0029	0.0304	82.71	0.0333
Toll	2049		Toll	1,636,686	0.2249	206.4	0.0069	0.1093	0.0194	0.0029	0.0304	79.97	0.0333
Difference	2049		DS vs. DM	+176,587	+0.06	+15.35	-0.00	+0.00	+0.00	0.00	-0.00	+6.02	-0.00
	2049		Toll vs DS	-67,035	-0.02	-7.03	-0.00	-0.00	-0.00	0.00	0.00	-2.75	0.00
	2049		Toll vs DM	+109,552	+0.04	+8.32	-0.00	-0.00	+0.00	0.00	-0.00	+3.28	-0.00
Percent Difference	2049		DS vs. DM	+12%	+31%	+8%	-3%	+1%	+9%	0%	-10%	+8%	-9%
	2049		Toll vs DS	-4%	-7%	-3%	-4%	-3%	-7%	0%	0%	-3%	0%
	2049		Toll vs DM	+7%	+21%	+4%	-6%	-2%	+2%	0%	-10%	+4%	-9%

Emission and Fuel Consumption Outputs as annual values

Scenario	Year	Peak	Scenario	VKT	CO, t	CO2-e, t	VOC, t	Nox, t	NO2, t	PM2.5 E, t	PM B&T, t	FC, 1000l	Total PM, t
DM	2049		DM	557,403,846	68	72,290	3	41	7	1	12	27,992	13
DS	2040		DS	621,858,206	89	77,894	3	41	8	1	11	30,191	12
Toll	2049		Toll	597,390,483	82	75,326	3	40	7	1	11	29,187	12
Difference	2049		DS vs. DM	+64,454,359	+21	+5,604	-0.07	+0.40	+0.61	0.00	-1.21	+2,199	-1.21
	2049		Toll vs DS	-24,467,723	-7	-2,567	-0.10	-1.41	-0.50	0.00	0.00	1-004	0.00
	2049		Toll vs DM	+39,986,636	+14	+3,037	-0.16	-1.01	+0.11	0.00	-1.21	+1,195	-1.21
Percent Difference	2049		DS vs. DM	+12%	+31%	+8%	-3%	+1%	+9%	0%	-10%	+8%	-9%
	2049		Toll vs DS	-4%	-7%	-3%	-4%	-3%	-7%	0%	0%	-3%	0%
	2049		Toll vs DM	+7%	+21%	+4%	-6%	-2%	+2%	0%	-10%	+4%	-9%

E

Appendix E – Peer review issues register

Peer review issues register

Issue No.	Issue.	Date	Source	Response	Remaining actions	Status
1	Is work still progressing on the DBC	15-May-22	TN1A220415 O to NoL.pdf	Yes, new revision of the DBC is imminent. DBC team are aware of V22 model. We are leaving it to the DBC team to decide on whether v22 should be adopted for the DBC.	None.	Closed
2	QTP report refers to where assumptions have been taken from, and changes to previous assumptions, but does not justify any changes. However, justification has subsequently been provided within Beca's File Note dated 10 May 2022.	15-May-22	TN1A220415 O to NoL.pdf	Ideally the reports would be combined as one, or at least issued at the same time, but in the interest of sharing information as soon as available, the reports were issued when each was ready.	None.	Closed
3	The report states that the factors have been adopted from the Puhoi to Warkworth model. These factors may or may not be applicable to the study area for the O2NL project. Having said that, the report states that the new model generally validates slightly better than V20a.	15-May-22	TN1A220415 O to NoL.pdf	Noted also that in Beca's note we describe why the P2W model RPF were selected over ones from other models. It also describes how they were implemented in a slightly different way. Following testing and the calibration results, it was decided no further change was needed to the factors or the way they were implemented.	None.	Closed
4	The reporting of the updated validation is fairly cursory. This may be adequate for this report, although the Client may require full validation details to be provided, for the record. As it is, the report indicates that the validation slightly improves for two of the three time periods (relative to V20a), and marginally deteriorates in the third.	15-May-22	TN1A220415 O to NoL.pdf	Section 3.1 and Figure 3.1 illustrate the modest changes to modelled flows in the base year as a result of introducing the RPFs. This information, coupled with the reported changes to the overall correlation of counts with modelled flows were considered sufficient to demonstrate that the effects on modelled flows were a) minor and that b) consequentially effects of model vs count comparisons would similarly be minor. We have forwarded tabulations from spreadsheets, per the v20a reporting, that show the full model vs count comparisons for the final step of the v22a base model prior to ME and with ME. The same information is provided for the v20a model. The spreadsheets themselves are also available if desired, illustrating model vs flow scatter plots for various aggregations of count sources.	None	Closed
5	Section 4 of the report sets out the changes to the demands, to develop 12 user classes for the toll modelling. It would be useful for details to be provided (maybe as appendices) to demonstrate the full process used (1) to get from quasi purpose trips to toll modelling purposes, and the proportions of those purposes and (2) and to show how the values of time were derived.	15-May-22	TN1A220415 O to NoL.pdf	We would say that the explanation in Sections 4.4 to 4.5 is pretty comprehensive. We could tabulate the model trips and proportions by the quasi purposes and externals and HCVS for each year and the resulting toll purposes for each year. Please advise if this is wanted. Income statistics are now provided in an appendix to the O2NL toll modelling specification file note. This table demonstrates how the WtP VoT adjustment factors were calculated. Truck count site data is now provided in an appendix to the O2NL toll modelling specification file note. All other calculation steps for VoTs are described and presented in the Beca file note.	None.	Closed
6	We are unclear why adjustments to the VoT are referred to in Table 2-5 of the Beca File Note, but the values for Tauranga and O2NL seem to be identical.	15-May-22	TN1A220415 O to NoL.pdf	The TTSM VoTs were copied incorrectly. Updated in revised version.	None.	Closed
7	It appears that all drivers are assumed to have the option of taking the toll road, whereas previous studies have assumed that a small proportion will not accept the toll (whether or not it makes sense, as per the values of time). This should be clarified.	15-May-22	TN1A220415 O to NoL.pdf	All drivers are assumed to have the option of taking the toll road.	None.	Closed
8	It may be worthwhile carrying out sensitivity tests on the perception factors along this route, particularly as other measures may be taken to calm speeds within the urban area.	15-May-22	TN1A220415 O to NoL.pdf	Agreed. This in one of the planned sensitivity tests.	None.	Closed
9	The V20a report refers to convergence issue with long term forecasts. This is apparently not an issue with V22a.	15-May-22	TN1A220415 O to NoL.pdf	Convergence is an issue in the 'without scheme' scenarios. This is not an issue in any of the toll tests we are doing.	None.	Closed
10	It would be useful to add a table to set out the existing and forecast flows, to easily identify the overall traffic growth rates anticipated.	15-May-22	TN1A220415 O to NoL.pdf	SH1 traffic growth presented in 'SH1 traffic growth' tab	None.	Closed
11	The results of the preliminary/example toll test include an increase in traffic on the existing SH1 (the route to be revoked), of 9,000 vehicles/day. Future reports will need to consider the extent to which tolling is consistent with or contrary to the objectives of the O2NL project, particularly in regard to safety.	15-May-22	TN1A220415 O to NoL.pdf	The DBC crash model has been adopted and used to test the impact on safety of all the short-listed tolling strategies at each tolling level. This found that yes, tolling will increase crash costs and DSI compared to the No Toll scenario. There remains a significant benefit compared to today and the future Do Min. Results will be reported in the Toll Study report.	None.	Closed
12	Figure 11.11 indicates the trip types predicted to use the toll route. It indicates the importance of the "other" trip types indicating that greatest attention needs to be given to the assumptions affecting this trip type.	15-May-22	TN1A220415 O to NoL.pdf	Agreed. The WtP VoT sensitivity tests and the Escalation sensitivity tests look at the impact of adjusting the assumptions regarding this trip purpose (and others)	None.	Closed
13	While it should it not be implied that the V20a model was "correct" (similarly that any change to that model should not be assumed to be "incorrect"), the differences to the forecasts can reasonably be assumed to represent risks to the accuracy of the forecasts, particularly if the DBC has been completed on the basis of V20a.	15-May-22	TN1A220415 O to NoL.pdf	Agreed. The DBC team are aware of this and considering their way forward. We have had a call with the DBC team to discuss this point. Note that the DBC team requested that QTP undertake a sensitivity test that reflects the incorporation of the RPFs per v22a (including consistency of speeds on SH1 DS and DM). This is the key change between the v20a and v22a models for the non-tolled scenario. Similarly, sensitivity testing of the effects of elastic assignment have previously been undertaken.	Actions lie with the DBC team	Closed
14	Also, while the land use forecasts are based on Horowhenua District Council advice, there may be a need to re-confirm these, for example as the COVID pandemic and other issues with the New Zealand economy may mean that increases in population and forecasts may take place at a slower rate than was previously envisaged.	15-May-22	TN1A220415 O to NoL.pdf	Agreed. Different growth assumptions are part of our sensitivity testing and risk assessment.	None.	Closed
15	The toll report does not focus much on the objective of improving resilience. While Section 3 of the report notes that the project will offer resilience benefits in a variety of ways, we suggest that this objective is also closely related to the safety objective, in that a reduction in Deaths and Serious Injuries will reduce the time when there are road closures.	23/06/2022	TN2A220622 O to NoL.pdf	O2NL provides an alternative route to SH1 in this area that is a much shorter detour option than the current route via the Remutaka's. This provides the step-change in the resilience of the corridor. Tolling doesn't have much impact by comparison.	None.	Closed
16	Section 4 sets out the outcomes assessed in considering toll options. These outcomes include travel times along SH1, which as noted above, is not one of the key project objectives. However, Section 4.3 suggests that this was not one of the main criteria used to select the optimum toll level.	23/06/2022	TN2A220622 O to NoL.pdf	Noted and no action needed.	None.	Closed
17	Figure 4-3 refers to total flows using the project, not to traffic on a specific section. The information within this Figure cannot easily be compared against other figures within the report.	23/06/2022	TN2A220622 O to NoL.pdf	The purpose of the figure is not for cross-checking with other figures. It is too provide a comparison of the impact on O2NL demand between the toll gantries strategies. Because each gantry strategy tolls different sections, this metric was considered a more concise of comparing the impacts, rather the plots of volumes for each of the three sections.	None.	Closed
18	Figure 4-4 gives the 2018 flow on SH1, south of Levin as around 17,500, while Figure 5-3 suggests a flow of just over 14,000 for apparently the same section of road. This can probably be explained as the two figures referring to slightly different locations, but it would be helpful for the apparent inconsistency to be resolved.	23/06/2022	TN2A220622 O to NoL.pdf	Thank you for picking up in this. There was an error in the calculation for Figure 5-3. This has been updated as a result.	None.	Closed
19	Several of the figures refer solely to results for one or more forecast year, for a scenario with the O2NL project without tolls, compared to the effect of introducing tolls. Some include the 2018 base, but few include the future Do Minimum. While this may be explained as the study considering only the effects of tolls, information on the Do Minimum would be helpful. A particular example is Figure 4-6, which gives the crash costs and DSIs for 2018 and 2039 without and with tolls, but does not give the 2039 Do Minimum (although this additional information is provided later, at Figure 5-6). Conversely, while Figure 5-6 (relating to crashes) does include the Do Minimum scenario, previous figures (5-2 to 5-5) relating to traffic flows, do not.	23/06/2022	TN2A220622 O to NoL.pdf	Yes, the intention of the study was to focus on the impact of tolling versus not tolling. For some metrics, like travel time, and safety (in the preferred option assessment) it was considered useful to present the 2018 and the Without Project statistics alongside the With Project statistics to give context and help tell the story. We don't propose updating all the plots to always include Do Minimum values.	None.	Closed
20	It would be useful to add a table to set out the existing and forecast flows across a screenline including the current SH1 and the O2NL project, to easily identify the overall diversion and suppression effects, and to identify the traffic growth rates anticipated, without and with the project.	23/06/2022	TN2A220622 O to NoL.pdf	Agreed. Table, figure and text added in this section.	None.	Closed
21	It would also be useful to give greater justification for the crash reduction results in Figure 5-6.	23/06/2022	TN2A220622 O to NoL.pdf	Agreed. Text added.	None.	Closed
22	In providing the above comment we note that it would be useful for the report to identify more numerical results. The Figures provide results in a style that is readily understood, but it is difficult to gain much precision from these Figures (excluding the unlabelled Figure at the end of the Executive Summary).	23/06/2022	TN2A220622 O to NoL.pdf	Agreed. Tables with Crash costs and DSI values added with supporting text.	None.	Closed
23	Section 4.3 notes that the selected toll level is higher than other toll roads in New Zealand. This could be cause for concern, if the toll is outside the willingness to pay parameters which have been derived from earlier studies. However, the proposed toll of $2.50 is only just higher than that on other roads, and the text notes that the rate per km is low.	23/06/2022	TN2A220622 O to NoL.pdf	Given that the proposed toll of $2.50 for use of both section (i.e. $1.25 per gantry) is only a little higher than other toll roads in NZ (e.g. North gate way $2.40) we believe the willingness to pay parameters are still valid.	None.	Closed
24	Section 6.2 sets out the method used for deriving risk adjustment factors. While we are familiar with the approach taken, we are unclear how the values were derived. For example, the 5 percentiles for land use changes are stated as being 0.74, 0.87 and 1.09. We are unclear how these values were derived. For example, while the 5th, 50th and 95th percentile means there is a 5% probability of this scenario occurring, but how much land use change does that represent, above the 2018 base?	23/06/2022	TN2A220622 O to NoL.pdf	Agree that useful detail is missing here. We have now added Land use assumptions and Tara-Ika assumptions to the appendix, and more detailed on the assumptions used for the each test is provided in the table.	None.	Closed
25	We noted as part of our review of the modelling report that all drivers are assumed to have the option of taking the toll road, whereas previous studies have assumed that a small proportion will not accept the toll (whether or not it makes sense, as per the values of time). It would be useful for the report to identify what proportion of people able to divert to the O2NL project choose not to, due to the imposition of tolls.	23/06/2022	TN2A220622 O to NoL.pdf	Our understanding is that past Beca studies did not assume a small proportion will not pay a toll in any circumstance. We are not aware of other studies that make this assumption. We now explicitly report on the amount of diversion, and yes the values are relatively high.	None.	Closed
26	There are a number of formatting errors in terms of page numbers, which reset to 1, and a number of hyperlink errors.	23/06/2022	TN2A220622 O to NoL.pdf	Apologies, yes, the version issued was one where the appendices were removed and so those hyperlinks where broken. Yes, the page number will be fixed in the final version. Thank you.	None.	Closed
27	Section 4.4 on the peer review is set in an unusual location, in the middle of the report.	23/06/2022	TN2A220622 O to NoL.pdf	Section 4 describes the Tolling Study process. We purposely positioned the peer review section at the end of the this section, as it was a component of the Tolling Study process.	None.	Closed
28	In the Executive Summary, the statement that "traffic flows were not highly ideal for commuter peaks" should be rephrased.	23/06/2022	TN2A220622 O to NoL.pdf	Agreed. Text removed as the statement about the toll being flat over the day is made further down in the exec summary.	None.	Closed
29	Also it should be clarified whether the assumption of 70c per toll transaction is per journey, with persons passing two gantries not being charged twice.	23/06/2022	TN2A220622 O to NoL.pdf	Confirmed, and wording updated in the exec summary.	None.	Closed