# Woodend Bypass

## Toll Modelling Technical Report

**September 2024**

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## Contents

# 1 Executive Summary

1.1 The Woodend Bypass was designated in the Waimakariri District Plan around 2015. The project has been identified for delivery in the draft GPS2024.

1.2 This report summarises the third phase of traffic modelling and economic assessment progressed by QTP for the New Zealand Transport Agency Waka Kotahi (**NZTA**) in relation to the Woodend Bypass. Specifically, this report relates to modelling of the bypass under a scenario where it is tolled. The three phases of work are broadly summarised as:

1. Traffic modelling to estimate design flows for the bypass (untolled)
2. Economic assessment of the scheme based on the outputs of the traffic modelling
3. Traffic modelling and economic assessment for a tolled bypass

1.3 The agreed scope of the modelling work is to use the latest version of the Christchurch Assignment and Simulation Traffic model (**CAST**) to estimate design flows for the Woodend Bypass. The process of checking, refining and application of the model for this purpose is described within the Woodend Bypass Traffic Modelling Technical Report[1]. Subsequent use of the model outputs for economic assessment is described within the Woodend Bypass Preliminary Economic Assessment[2].

1.4 The scope and methodology for this tolling work is based on two primary inputs:

1. Modelling progressed by QTP since 2021 to assess potential toll scenarios for the proposed Ōtaki to North of Levin (Ō2NL) project
2. A Working Draft document prepared by NZTA for tolling assessment

1.5 The methodology for tolling assessment requires different and more detailed segmentation of the model's travel demand matrices to reflect the range of potential users of a toll road and their varying values of time attributed to their Willingness to Pay (**WtP**) a toll. For example, potential users of a toll road in the course of business have very high WtP values and may be willing to pay a relatively high toll to save time, whilst potential users in the course of shopping or social activities are less likely to be willing to pay a high toll to save time.

1.6 The Woodend Bypass project model version of CAST retained the full model extent, covering greater Christchurch. The increased number of classes of users required to be modelled for the tolling assessment, coupled with the fact that the model is a relatively detailed simulation model of the whole of Greater Christchurch, together with the need for 'elastic assignments' for the modelling to provide a travel demand response to the tolls (in addition to a routing response), means that the full Woodend Bypass project model cannot practically be applied for this purpose (due to implied model run times). Accordingly, a smaller area of the Woodend Bypass project model has been 'cordoned' at the Waimakariri River to form the toll model.

1.7 In essence the work described more fully in this report is summarised as:

[1] Version 1a dated 13 August 2024, prepared by QTP Limited for the NZ Transport Agency

[2] Also Version 1a and also dated 13 August 2024, prepared by QTP Limited for the NZ Transport Agency

- 'Cordoning' of the Woodend Project model at the Waimakariri River for practicality of model run times for the more disaggregate modelling required to estimate responses to road tolling
- Splitting of the light vehicle class to different trip purposes (Home-Based-Work, Employers Business and Other trip types) based predominantly on trip purposes estimates within the regional multi-modal demand model, the 'parent' Christchurch Transportation Model (**CTM**).
- Further splitting of the resulting 3 light vehicle purpose classes and the heavy vehicle class by low, medium and high willingness to pay bands, yielding some 12 user classes
- Modelling of three alternative toll values to identify how such tolls will likely affect the number of users willing to pay to use the new road, the effects of the tolls on the operation of the surrounding road network and identification of the revenue under each scenario.
- Providing an updated economic assessment of the tolled bypass using the methodology established for the non-tolled bypass

1.8 The proposed Woodend Bypass is a relative short section of motorway-standard road at around 6.2km in length compared to a length of around 5.5km via the existing alignment of SH1. Modelling indicates that even a relatively low toll of $1.00 for light vehicles (and $2.00 for heavy vehicles) has a large effect on the number of users of the bypass, with modelled flows reducing to around half of those of the untolled scenario.

1.9 Sense-checks of this modelled response indicate that for the relatively modest modelled travel time savings for users of the bypass of around 2.3 minutes for much of the day for the opening year, a toll in excess of $0.60 is likely to have a significant effect on the number of users of the bypass compared to an untolled bypass.

1.10 This finding is predicated on the WtP values used in this assessment. These have been supplied by the NZ Transport Agency and are based on calibration of the Tauranga Transport Strategic Model to reflect observed flows on the toll roads and alternative routes in the region.

1.11 The decision whether to proceed with a toll strategy for a road must weigh-up:

a. How the toll strategy impacts the intended scheme benefits, which in this case include reduced congestion on the wider road network and reduced community severance in the township of Woodend caused by high traffic volumes on SH1 (presently around 21,000 vpd);

b. The potential revenue from tolling; and

c. How the tolling affects the economic case for the project

1.12 Information presented within this report illustrates that for a toll of $1.25 ($2.50 for heavy vehicles) much of the relief sought to traffic volumes through Woodend through the provision of the (untolled) bypass is lost. For modelling at the mid-term horizon year of 2038, with just 8,000 vpd using the tolled Woodend Bypass, modelled daily volumes on SH1 through the township remain high at 16,000 to 19,500 vpd.

1.13 Modelling of the untolled Woodend Bypass indicated significant delay relief to several minor road approaches to SH1 and on approach to SH71 Lineside Road between Rangiora and SH1. Modelling of the toll scenarios suggests that much of this relief will be lost due to the high traffic volumes remaining on SH1. This in-turn significantly reduces the assessed economic benefits of the scheme, including crash benefits.

1.14 Net revenue for the three toll scenarios modelled ($1.00, $1.25 and $1.50 for light vehicles) is relatively low due to the low daily volumes forecast on the bypass, which are typically around half the volumes of the untolled scenario (but varying with year of assessment and toll scenario). Consequently, the Net Present Value (NPV) of net revenue is modest, ranging between $26M and $41M compared to a rough-order scheme cost NPV of around $500M adopted in the economic assessment.

1.15 A sensitivity test has been undertaken to model a potential perceived 'quality bonus' of the tolled toll road relative to a 'standard motorway', equivalent to a 10% reduction in the travel time on the Woodend Bypass. This sensitivity test, applied at 2038 for the $1.50 toll scenario, results in an increase in modelled total vehicles volumes on the bypass of 13% and a net revenue increase of 15%.

1.16 Outputs from the toll modelling have been used to provide an economic assessment.

1.17 The economic assessment process and methodology remain mostly the same as that used in the second phase of work to assess the project without tolls, as reported in the document "*Woodend Bypass – Preliminary Economic Assessment*". This follows procedures specified in the Section 4.3 (road improvement activities) of the Waka Kotahi Economic Monetised Benefits and Costs Manual (MBCM) version 1.7 (May 2024).

1.18 The economic assessment for this phase now includes reporting of the government benefit to cost ratio ($BCR_G$). The $BCR_G$ is used to indicate the level of benefits obtained from investment of local and central government funds in situations where government funding is supplemented by the availability of third-party funding or tolling revenue.

1.19 Only a single toll scenario has been assessed. This assumes a $1.25 ($2.50 for heavy vehicles) toll. This single scenario was selected because the $1.00 scenario provides relatively little net revenue (after 80c admin removed) and the $1.50 scenario significantly reduces the number of vehicle trips using the by-pass (and so any benefits are significantly reduced as well).

1.20 The assessment indicates a **$BCR_N$ of 0.9**. This is significantly less than the previous phase (no tolling scenario) $BCR_N$ of 1.3.

1.21 The low BCR is also reflected in that the PV net benefits equate to just 70% of the total benefits for the non-toll scenario.

1.22 The total PV net toll revenue ($34.1m) equates to 7% of the total project costs.

1.23 Using the revenue based on the levied tolls, net of the assumed 80c transaction fee, the resulting **$BCR_G$ is 0.9**.

# 2 Introduction

2.1 The Woodend Bypass was designated in the Waimakariri District Plan around 2015. The project has been identified for delivery in the draft GPS2024.

2.2 The final scope of the (construction) project will be confirmed through the Scheme Design Review that was due for award on 19 July 2024. As an input to that work, the New Zealand Transport Agency Waka Kotahi (**NZTA**) have requested updated design flows from readily available traffic models.

2.3 This report summarises the third phase of traffic modelling and economic assessment progressed by QTP for NZTA in relation to the Woodend Bypass.

2.4 This report relates specifically to modelling of the bypass under a scenario where it is tolled.

2.5 This report builds on the first phase of work to apply the latest version of the Christchurch Assignment and Simulation Traffic model (**CAST**) to estimate design flows for the Woodend Bypass. Refer to the Traffic Modelling Technical Report (13 August) for details of the modifications to the generic CAST models and the resulting Woodend Bypass traffic volume forecasts and effects on the road network.

2.6 This report sets out further modifications to the CAST Woodend project model for the purposed of toll modelling. In essence the work described more fully in this report is summarised as:

- 'Cordoning' of the Woodend Project model at the Waimakariri River for practicality of model run times for the more disaggregate modelling required to estimate responses to road tolling;
- Splitting of the light vehicle class to different trip purposes (Home-Based-Work (**HBW**), Employers Business (**EB**) and 'Other' trip types) based predominantly on trip purposes estimates within the regional multi-modal demand model, the 'parent' Christchurch Transportation Model (**CTM**).
- Further splitting of the resulting 3 light vehicle purpose classes and the heavy vehicle class by low, medium and high willingness to pay bands, yielding some 12 user classes
- Modelling of three alternative toll values to identify how such tolls will likely affect the number of users willing to pay to use the new road, the effects of the tolls on the operation of the surrounding road network and identification of the revenue under each scenario.

2.7 The scope and methodology for this tolling work is based on two primary inputs:

1. Modelling progressed by QTP since 2021 to assess potential toll scenarios for the proposed Ōtaki to North of Levin (Ō2NL) project
2. A Working Draft document prepared by NZTA for tolling assessment.

2.8 These is a high level of alignment between the Ō2NL methodology, that outlined in the NZTA working document and hence the methodology applied for this appraisal of the Woodend Bypass.

# 3 Woodend Bypass Project Model Cordoning

## 3.1 Overview

3.1.1 CAST is perhaps unique in New Zealand in that it is a regional (wide-area) model, yet implemented with a level of network detail, zonal detail and software capability that enables simulation of the road network at detailed level. The model includes approximately 1,500 geographical zones, all roads with any significant through-road function (including the local road network) and includes capacity constrained modelling and sophisticated cyclical flow profile modelling that allows the variation of traffic profiles throughout a typical intersection 'cycle' to be modelled, in addition to intersection interactional effects. As such, the model may be applied to understand network-wide effects ranging from a minor modification at a single intersection to comprehensive changes to the road network and / or future development patterns.

3.1.2 Generally, the model maintains reasonable run times for 'fixed' demand assignments. Modelling of the peak periods may be undertaken most expediently as single peak hour model runs for many applications, resulting in model total run times of around 15-30 minutes for AM, interpeak and PM peak periods for a given year. Model run times are however extended to over an hour for a given year when time-slice modelling is invoked during the peak 2-hour periods. Time-slice modelling more accurately reflects the varying demand profile during the shoulders of the peaks and 'passes' residual queueing from one period to the next. This provides a more accurate basis for economic assessment, whereby each of the peak periods is modelled as three separate time-slices. Thus time-slice assignments for base and future years typically takes several hours for a given scenario.

3.1.3 The use of 'elastic' assignments to reflect how traffic demand may respond in relation to changes in future year network operation however take considerably longer (u to 10 times longer) than conventional fixed demand assignments. The 'generic' release of the CAST v23 future year models for 2028, 38 and 48 are previously run as elastic assignments to capture the demand response to overall changes in network travel times (principally due to increased congestion under increased population and workers in future years). The models are then, by default, configured to for application at a project-level as fixed assignments using the demands resulting from the generic model elastic assignments. Typically, only scenarios involving major infrastructure changes or changes to demographics from those of the generic models warrant running as elastic assignments.

3.1.4 The Woodend Bypass project models developed for the first phase of this assessment have been run as elastic assignments in order to capture the demand response to the new infrastructure. They are run with 3 vehicle classes per the generic models, being light single occupant vehicles, heavy vehicles and high occupancy vehicles. Model runs for a scenario for all years are typically 'overnight'.

3.1.5 For the toll appraisal, some 12 user classes are required as outlined in the previous chapter. This is to represent varying levels of 'willingness to pay' by different users. If a single 'average' perceived toll value (or 'penalty') were to be used for all light vehicles, the modelling would result in 'all-or-nothing assignments' where either all potential users of the toll road would use it, or none would: the perceived value of the toll is modelled as being the same for all users. In practice, the willingness to pay a toll varies by trip purpose and within a trip purpose. By splitting the light vehicles by purpose (Home-Based-Work, Employers Business and Other trip types) and further splitting these trips and heavy vehicles by low, medium and high willingness to pay classes, assignments are more realistic in that they better reflect the range of differing tolls that users are willing to pay.

3.1.6 It is highly desirable that toll modelling includes not-only route-choice in the assignment model (to use the new tolled road or not) but also that the varying 'cost' of travel under alternative toll scenarios includes a demand response. For this reason, elastic assignments are highly desirable for the toll modelling.

3.1.7 As such, it can be seen that the desire to adopt time-slice modelling, elastic assignments and numerous user classes (12) is not practical in terms of model run times. Fortunately, the location of the proposed scheme in Waimakariri District, north of the Waimakariri River, lends itself well to cordoning of the model at this 'clean' cut-line, as illustrated within the following image of the full CAST model coverage.

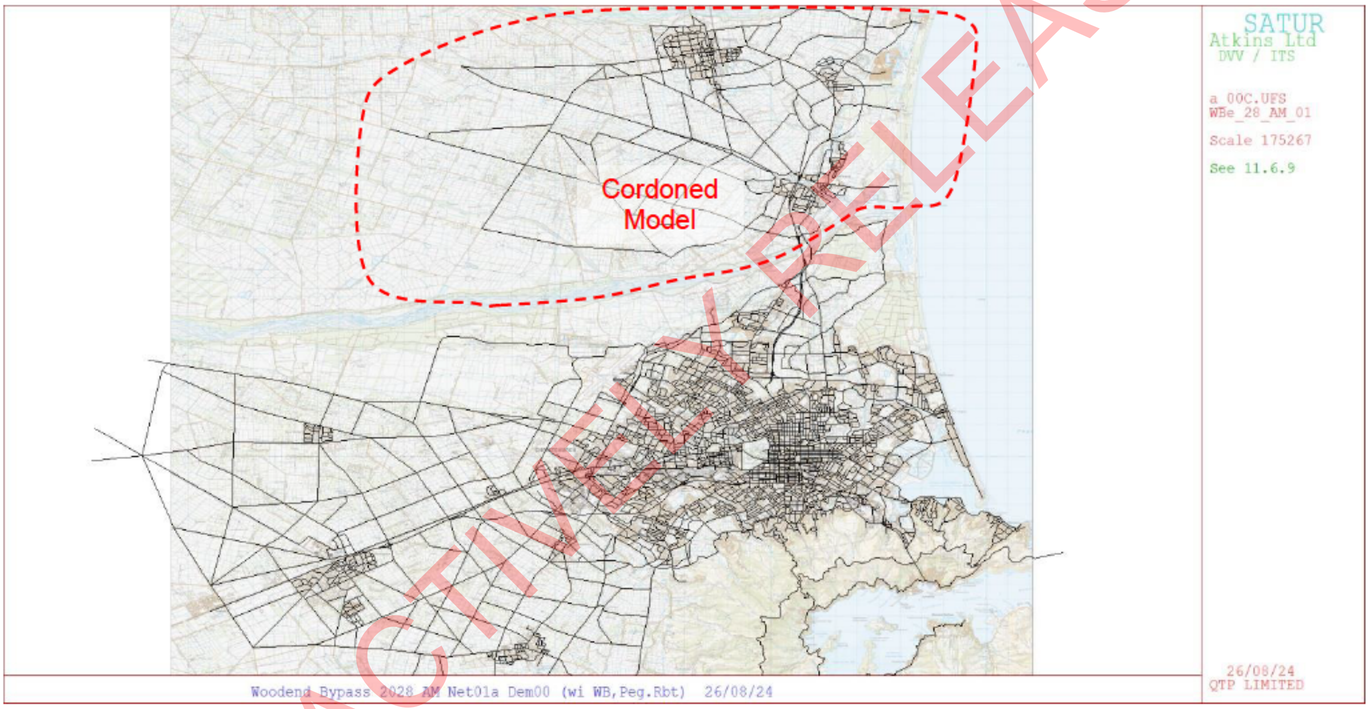


**Figure 3.1: Cordoning of the Woodend Bypass Model for Toll Modelling**

3.1.8 A potential issue with cordoning a model is that the demands on the links at the cordon cut points become fixed and cannot provide an assignment response at or beyond such locations when different scenarios are run within the cordon model.

3.1.9 In this case, there are only two links at the new southern external, being that of SH1 and of parallel Main North Road to the east. It is considered unlikely that different toll scenarios will materially change the balance of flows across these two links because the bypass route choice is at the Pineacres (Williams Street) intersection north of Kaiapoi, several kilometres north of the Waimakariri River. Note also that the methodology employed involves cordoning of both the Do-minimum (no bypass) and Do-something (with bypass) models in each year, such that any changes in demands between the two links resulting from the untolled Woodend Bypass scheme are reflected within the cordoned models.

## 3.2 Cordoned Network

3.2.1 The cordoned network was initially generated in the SATURN software's SATCH process. This creates a period-specific network (i.e. with parameters and signal timings specific to each time period modelled). Further edits have been made to the cordoned networks to incorporate parameters and period-specific coding to yield cordoned network 'Masterfiles' (per the full CAST model). This facilitates subsequent editing and maintains consistency between periods models.

3.2.2 The following model plot illustrates the extent cordoned model using for the tolling appraisal.

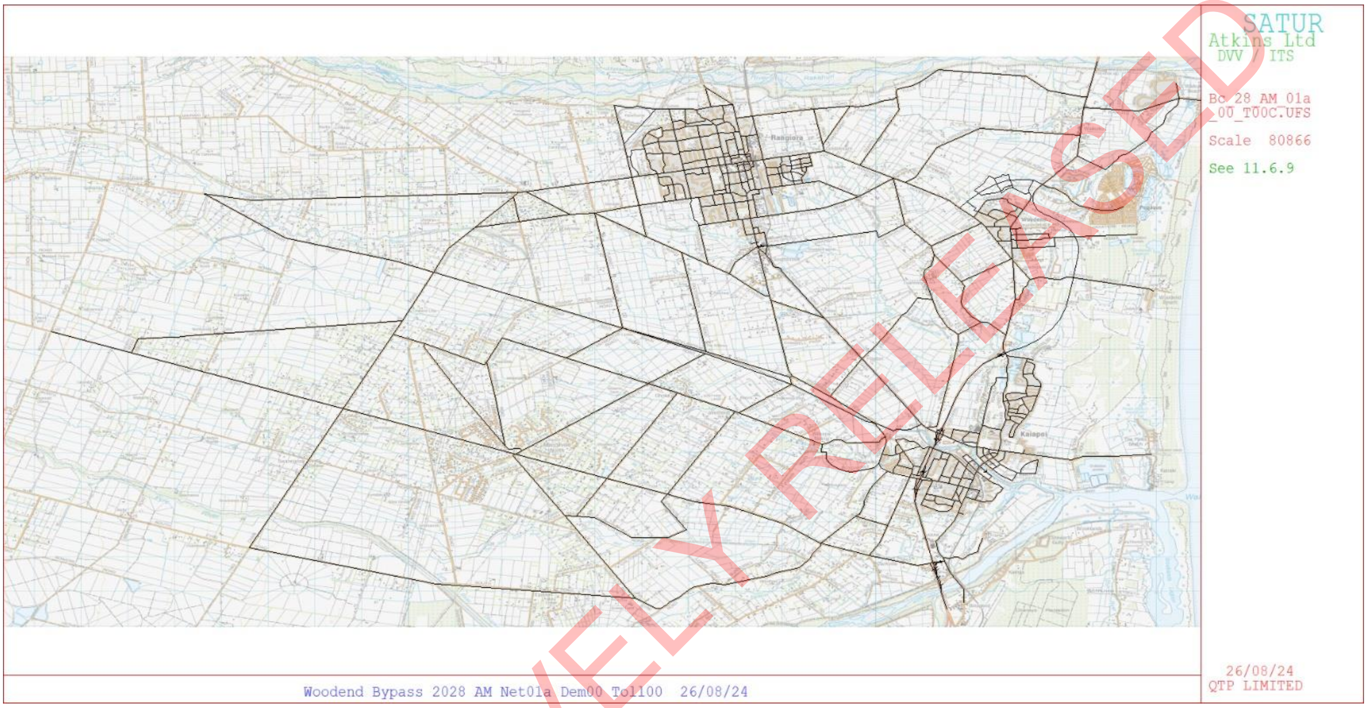


**Figure 3.2: The Cordoned Woodend Bypass Toll Model**

3.2.3 The cordoning process reports on the average trip lengths and travel times at the cordon cut points (the Waimakariri River bridges). These have been reflected in the external zone connectors (distances and speeds) and vary for each period, year and scenario. In this way, the demand response to the tolls is, appropriately, relative to the change in cost for the entire trip, albeit with average trip costs south of the river.

## 3.3 Cordoned Demands

3.3.1 Per the cordoned networks, the cordoned demands were generated using the SATCH module. Note that the cordoned demands at the southern external are for 'actual' flows in the full Woodend Bypass project models. In future years, congestion on the wider Christchurch network means that some of the northbound demand does not reach the Waimakariri River within each time-slice modelled, resulting in residual queuing on the network. Because the cordoning uses 'actual' flows that are constrained to what the network can deliver in the inbound direction, this avoids unrealistically high demand flows entering the model northbound from the south. More simply put, the demand flows at this location are in harmony with the wider-network Woodend Bypass project model.

## 3.4 Cordon Model Checks

3.4.1 The cordoned demands have been assigned to the cordoned networks. Cordoned models do not necessarily provide exactly the same flows as parent models due to the limits of precision to which modelled flows 'converge'. This is related to the iterative assignment / simulation techniques used in modelling whereby the iterative process terminates at a point where the model is considered sufficiently converged to a solution, which in-turn is related to the use of the model. Perfect convergence is not possible in a congested model under equilibrium assignment.

3.4.2 The cordoned model assignments have been checked against those of the full model assignments, graphically. Generally the flow changes between the models are generally very small, being less than 500 vpd and much less than this on SH1 and the bypass itself. The following plot illustrates the changes in modelled daily flows between the cordoned and parent full Woodend Bypass model at 2039.

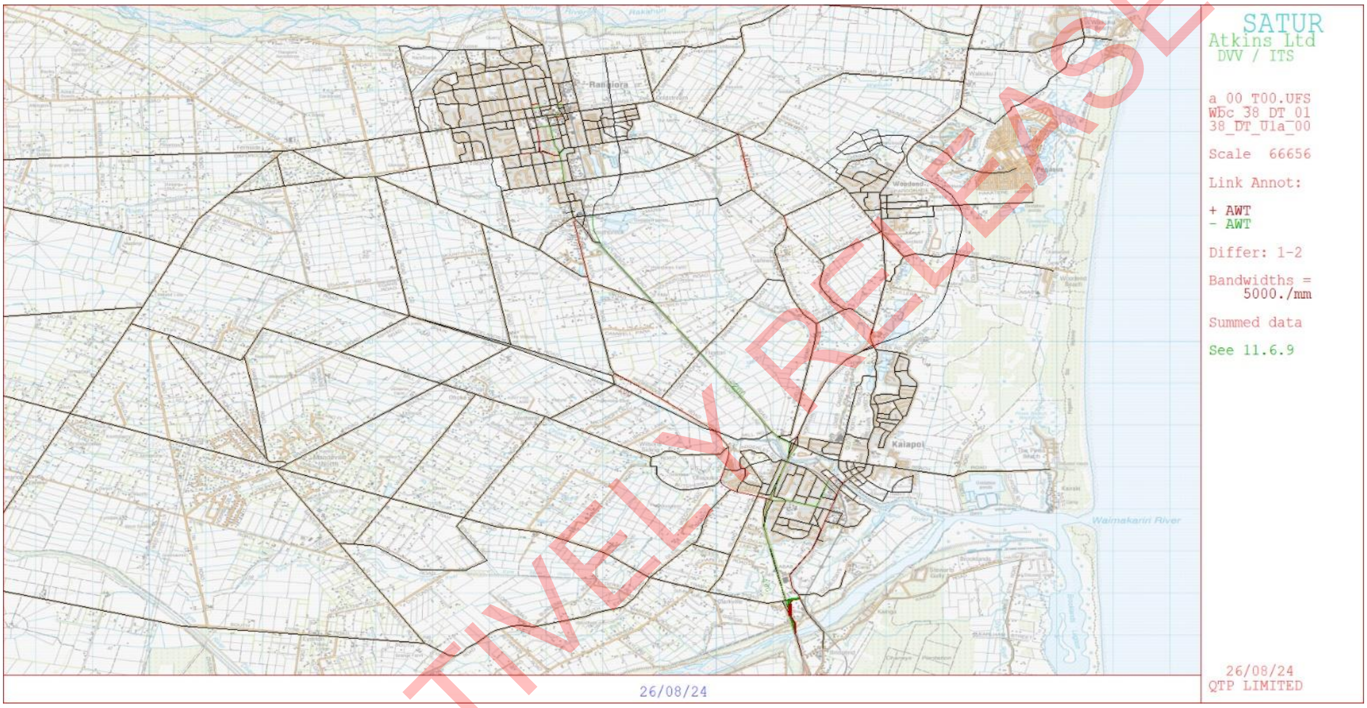


**Figure 3.3: Changes in Daily flows Cordoned Toll Model vs Full Woodend Bypass Model**

3.4.3 Generally, the changes in flows are insignificant, particularly in the vicinity of the bypass. At the southern extent of the model, there is however a small change illustrated.

3.4.4 This is related to the modelling of HOVs in the v23 generic model and the Woodend Bypass project model. The V23 model includes HOVs as a separate light vehicle class. At the Tram Road interchange, immediately north of the Waimakariri River, there is an HOV-only lane that allows westbound traffic on the Tram Road overbridge to bypass the traffic signals and join a short section of HOV lane on SH1. For the toll modelling, HOVs are not reflected, with the 9 light vehicle classes being sub-classes of all light vehicles. As a consequence, all light vehicles are able to use the HOV lane in the toll model. This is of little consequence for two reasons:

- First, use of the HOV lane has never been enforced in practice. Thus the toll-model representation may be no-less accurate than the general model representation of enforced use of the HOV lane (the reality will be somewhere between the two scenarios).
- Second, the use of general traffic in the HOV lanes is not material to the Woodend Bypass assessment. As can be seen from the above plots, this is a highly localised issue mainly concerned with the direct use of the HOV facilities. Only minor changes in daily flows are

modelled on SH1 and Main North Road south of Kaiapoi (around 400vpd or less) and no significant changes are illustrated in the vicinity of the bypass.

# 4 Model Demand Segmentation

## 4.1 Overview

4.1.1 In-line with NZTA's draft tolling guidance and the approach undertaken to toll modelling for Ō2NL, the CAST model light vehicle classes have been segmented by purpose to HBW, EB and Other trip purposes. The regional multi-modal demand model, the CTM, has been used as the basis of the purposes adopted for trips that are wholly internal to the model.

4.1.2 CTM external<>internal trips are **not** included within the CTM demands by purpose. External trips are wholly separate to the internal trips and are not (directly) available by purpose type.

4.1.3 External trip purposes have instead been estimated from the Roadside Interview Surveys (**RIS**s) undertaken for the original model build, as supplied by NZTA.

## 4.2 Internal Trips

4.2.1 CAST zones have a clear relationship with the CTM zones, each zone being a sub-zone of the CTM, with the zone numbering reflecting this. The CTM model light vehicle demands by purpose have been aggregated to HBW, EB and Other trips. All CTM purpose demands to/from zones south of the Waimakariri river have been aggregated to a single zone and the compressed matrices expressed as purpose proportions for each CTM zonal pair.

4.2.2 CAST model demand trip purpose proportions (for each zonal pair) have then been based on the CTM parent zonal pair proportions. CTM purpose proportions for all trips to/from south of the river have been applied to both southern external CAST toll model zones. Further, note that the new zone introduced within the CAST Woodend Bypass project model to represent trips diverting via the Pegasus 'services' has been assigned the purpose proportions based on the single Pegasus model zone, as this zone is the largest contributor to diverted trips.

4.2.3 The following tabulation provides a summary of the CTM Waimakariri District interzonal[3] internal trips, including those to/from locations south of the Waimakariri River. Note that these are provided as a coarse sense-check only as the actual proportions applied vary on a zonal trip basis.

| | 2028 | | | 2038 | | | 2048 | | |
|---|---|---|---|---|---|---|---|---|---|
| | AM | IP | PM | AM | IP | PM | AM | IP | PM |
| **Trips** | | | | | | | | | |
| HBW | 63,084 | 43,753 | 59,922 | 70,199 | 48,721 | 66,728 | 76,331 | 52,985 | 72,600 |
| EB | 20,445 | 82,502 | 20,570 | 22,760 | 92,391 | 22,881 | 24,728 | 100,898 | 24,812 |
| Other | 83,547 | 449,688 | 127,713 | 92,153 | 500,837 | 142,557 | 99,545 | 545,351 | 155,568 |
| **Proportion** | | | | | | | | | |
| HBW | 38% | 8% | 29% | 38% | 8% | 29% | 38% | 8% | 29% |
| EB | 12% | 14% | 10% | 12% | 14% | 10% | 12% | 14% | 10% |
| Other | 50% | 78% | 61% | 50% | 78% | 61% | 50% | 78% | 61% |

**Table 4.1: Interzonal Internal Trip Purposes (Including to/from South of Waimakariri River) from CTM**

[3] Interzonal trips are provided because the compression of the large number of trips wholly within Christchurch and Selwyn District south of the Waimakariri River to a single zone become intrazonal trips are thus intentionally excluded as these are not relevant to the modelling

## 4.3 External Trips

4.3.1 As noted above, external trip purpose proportions to/from the external zones in the CAST WB Tolling project model have been based on a roadside interview surveysconducted for the original CTM model build. The survey was conducted on SH1 Main North Road, south of the Ashley River, in the vicinity of the SH1 north external location, in April 2007.

4.3.2 The data provided by NZTA is by way of a spreadsheet containing pivot table summaries of the interview surveys with 8 origin and destination purposes for each of the model periods (AM, Interpeak and PM peak). The survey numbers include expansion of the samples to manual classified counts and to annual daily averages from tube counts.

4.3.3 The 8 x 8 trip purposes have been summed to identify Employers Business as any trip to or from a location with a purpose stated as Business, HBW for trips between Home and Workplaces with all remaining trips classified as 'Other'.

4.3.4 We note that the survey was undertaken in one direction only, being northbound (outbound). The non-interviewed direction survey proportions in the AM peak hour are based on the interviewed direction in the PM peak hour and vice-versa. In the interpeak period, the surveyed trip purpose proportions are assumed to apply to both directions of travel. This reflects the methodology described within the CTM reporting for compiling matrices of observed trip purposes.

4.3.5 Note that the derived trip proportions for the SH1 north site have been applied to the other external zones in the toll model in the Waimakariri District (north and west), though as such trips are unlikely to use the bypass, this is not influential to the toll appraisal.

4.3.6 The following table summarises the resulting trip purpose proportions that have subsequently been applied to all trips to/from the external zones in the toll model, with the exception of the southern external at the Waimakariri River which is based on the CTM (internal) trip purposes to/from locations south of the river, as described above.

| | AM | | IP | | PM | |
|---|---|---|---|---|---|---|
| | NB | SB | NB | SB | NB | SB |
| HBW | 52% | 43% | 13% | 13% | 43% | 52% |
| EB | 5% | 12% | 14% | 14% | 12% | 5% |
| Other | 44% | 45% | 73% | 73% | 45% | 44% |

**Table 4.2: External Zone Trip Purposes Based on 2007 CTM Roadside Interview Surveys**

4.3.7 Overall, the resulting trip proportions for the external zones are not wildly different from those of the internal zones based on the CTM:

- %HBW at around 45% in the peaks at the Externals are somewhat higher than around 35% for the CTM internal zones, with both datasets indicating much lower HBW proportions during the interpeak (8%/13% External/Internal)
- %Employers Business are the same in the interpeak (14%) and similar in the peak commuting direction in the peak hours (around 10-12%). Non-commuting direction EB trips are lower in the peaks for the external outbound trips at around 5% and this would appear logical given the longer distances implied and the fewer opportunities for business-related trips in these directions.
- Other trip proportions are similar for external and internal trips in the AM peak (45-50%) and Interpeak (~75%) but lower for external trips in the PM peak hour (~50% vs ~60% Internal).

## 4.4 Low / Medium / High Willingness to Pay Segments

4.4.1 Per the draft guidance methodology and that adopted for Ō2NL, the resulting light vehicle trip purpose matrices and the heavy vehicle matrices have each been equally divided to three categories reflecting Low, Medium and High WtP segments for each trip purpose to yield a total of 12 user classes represented in the model. Each class adopts a different WtP value as described in the following Chapter.

# 5 Toll Model Parameters

## 5.1 WtP Values of Time

5.1.1 The draft tolling guidance suggests the following values of time. They are understood to be based on calibration of the Tauranga Strategic Model to observed traffic flows on two toll roads in the region. The guidance notes that historically, the WtP values of time have escalated at around 1% faster than inflation. Per the Ō2NL tolling assessment undertaken in 2022, the escalation applied in the future years, relative to 2018 values, is 1.05% per year. This yields the following values of time used in the Woodend Bypass toll model.

| Purpose | Segment | 2018 | 2028 | 2038 | 2048 |
|---|---|---|---|---|---|
| Home Based Work | Low | $18.29 | $20.21 | $22.13 | $24.05 |
| | Medium | $28.11 | $31.06 | $34.02 | $36.97 |
| | High | $42.62 | $47.10 | $51.58 | $56.05 |
| Employers Business | Low | $35.17 | $38.87 | $42.56 | $46.26 |
| | Medium | $50.81 | $56.15 | $61.49 | $66.83 |
| | High | $108.66 | $120.08 | $131.49 | $142.91 |
| Other | Low | $8.66 | $9.57 | $10.48 | $11.39 |
| | Medium | $14.00 | $15.47 | $16.94 | $18.41 |
| | High | $23.32 | $25.77 | $28.22 | $30.67 |
| HCV | Low | $23.71 | $26.20 | $28.69 | $31.18 |
| | Medium | $44.24 | $48.89 | $53.54 | $58.18 |
| | High | $79.64 | $88.01 | $96.37 | $104.74 |

**Table 5.1: WtP Values of Time Assumed**

5.1.2 The above values of time are converted to time 'penalties' applied to the model links based on the toll value and the location of the toll scenario being modelled.

## 5.2 CAST Generalised Cost

5.2.1 The CAST model uses only time and distance components for the purpose of assigning traffic to routes on the road network. The relativity of time (in minutes, or the Pence Per Minute, the **PPM** parameter) and distance components (in kilometres, or Pence Per Kilometre, the **PPK** parameter) were calibrated as part of the original CAST model build. The model uses 1.0 / 0.5 PPM / PPK for light vehicles and 1.0 / 1.0 for heavy vehicles. Thus, for example, a typical 8 kilometre commuting trip with an average net speed of 40kph and therefore 12 minutes has cost components of 12 x 1 = 12 for time and 8 x 0.5 = 4 for distance. Thus it can be seen that time is the dominant factor in the model's route choice, as it is perceived to be in practice.

5.2.2 CAST adopts a relatively detailed methodology for classifying road sections by link type and applying appropriate free-speeds, capacity and the speed-flow curve relationship. This is undertaken based on the road hierarchy (7 link types), the reference speed (usually related to the posted speed limit) and the number of lanes, yielding over 120 link types. Because the free-speed and speed-flow curves vary based on the link type, for a given posted speed-limit, routes with a higher traffic function in the road hierarchy (e.g. arterial routes) that are typically of a higher standard and a higher number of lanes have slightly higher speeds for a given traffic volume, thereby making these routes more attractive to traffic.

5.2.3 Some models introduce the concept of route perception factors, or 'sign-posting factors'. These somewhat arbitrary factors have not been necessary in the CAST model to achieve good levels of validation of model flows to counts, including on motorway sections. In our experience, the use of such factors can make a model ‘blind’ to potential rat-running on more minor roads, that frequently occurs in practice.

5.2.4 Notwithstanding the above, given that ‘road type factors’ are briefly described in the draft tolling guidance and there *could* be a perceived ‘quality bonus’ for a toll road relative to a ‘standard motorway’ a sensitivity test has been undertaken to introduce a perception factor for the tolled Woodend Bypass. This is based on a 10% reduction to the travel time ‘cost’ from that which would otherwise apply to a four-lane motorway. Note that the reduction is applied based on cost, using the SATURN software’s KNOBS facility and as such the simulated travel time is not affected.

## 5.3 Demand Response

5.3.1 In-line with the draft tolling guidance, and the methodology applied for the Ō2NL toll modelling, a demand response to tolling (in addition to route choice response) has been included. This is achieved through the use of elastic assignment, as introduced in Chapter 3 of this report. Recall that the demands within the cordoned toll model are based on with and without bypass scenario model runs in the ‘full’ Woodend Bypass Project model. As such, a demand response to the new infrastructure (and to changes in congestion on the wider network) relative to the base year is already captured within the Do-Minimum and Do-Something demands cordoned from the full model elastic assignments.

5.3.2 For the toll model, elastic assignments are again applied. However, unlike the full Woodend Bypass (non-toll) project models, the elasticity of demand applies to the change in costs of the ‘with-toll’ scenarios relative to the ‘untolled’ scenario in each year. By contrast, the full Woodend Bypass models ‘pivot’ relative to the 2018 base model to capture the demand response to network-wide changes in costs, including due to increased congestion and to reduced travel times due to new infrastructure, including the Woodend Bypass.

5.3.3 The elasticity values used in the demand response to the change in cost are those provided within Table A14 of the MBCM, being long-run elasticities for low modal competition of -0.4 in the peak periods and -0.7 during the interpeak, applied using a power function and to light vehicles only.

# 6 Toll Scenarios Modelled

6.1 The proposed Woodend Bypass is a relative short section of motorway-standard road at around 6.2km in length compared to a length of around 5.5km via the existing alignment of SH1[4].

6.2 With no interchanges proposed between the southern and northern ends of the bypass, a single toll strategy has been modelled, being a single toll levied for light and heavy vehicles using the route.

6.3 Given the short length of the route and the implied relatively low time advantage in its use, initial tolls tested are relatively low as the WtP values suggest that higher tolls will result in the large majority of potential users not using the route.

6.4 Given also the transaction costs provided in the draft tolling guidance of 80c per transaction, a lower bound of $1.00 (for light vehicles) has been considered. Per the Ō2NL modelling and the draft tolling guidance, heavy vehicle tolls are set at twice the light vehicle tolls. The two toll scenarios initially modelled were:

i. T100 - $1.00 light vehicles and $2.00 heavy vehicles
ii. T150 - $1.50 light vehicles and $3.00 heavy vehicles

6.5 Given initial model results of significantly lower numbers of vehicles using the bypass for T150 than T100 but with a higher net revenue, a third toll scenario was modelled between the two with the aim of increasing net revenue:

iii. T125 - $1.25 light vehicles and $2.50 heavy vehicles

6.6 Finally, a fourth toll scenario was run to consider further effects on modelled bypass flows and revenue, being reflective of the baseline toll formula put forward within the NZTA's draft tolling approach document which suggests a toll of $2.30 + 5c/min travel time benefit (with heavy vehicles double this):

iv. T250 - $2.50 light vehicles and $5.00 heavy vehicles



[4] The Woodend Bypass plans include diversion of the existing SH1 route at its northern end via Garlick Street near Pegasus. The comparative non-bypass distance includes this relatively short diversion.

# 7 Toll Modelling Results

## 7.1 Overview

7.1.1 The decision whether to proceed with a toll strategy for a road must weigh-up:

- How the toll strategy impacts the intended scheme benefits, which in this case include reduced congestion on the wider road network and reduced community severance in Woodend;
- The potential revenue from tolling; and
- How the tolling affects the economic case for the project

## 7.2 Revenue

7.2.1 First, we consider here the potential net revenue of the four tolling scenarios modelled. The revenue is based on the levied tolls, net of the assumed 80c transaction fee (refer previous chapter). Revenue is calculated based on estimated average weekday total (**AWT**) flows for light and heavy vehicles (expanded separately from the period models) over a 40 year appraisal period discounted to present day (at 4%).

| Scenario | AWT | | | Net Revenue $M NPV |
|---|---|---|---|---|
| | 2028 | 2038 | 2048 | |
| No toll | 17,000 | 19,000 | 21,000 | $ - |
| T100 | 7,500 | 9,500 | 11,500 | $ 26.4 |
| T125 | 5,500 | 7,500 | 10,000 | $ 34.1 |
| T150 | 5,000 | 6,000 | 7,500 | $ 40.7 |
| T250 | 2,000 | 3,500 | 5,000 | $ 52.7 |

**Table 7.1: Estimated Woodend Bypass Daily Volumes and Revenue from Tolling**[5]

7.2.2 As can be seen from the daily flows presented above, even the lowest toll tested of $1.00 / $2.00 light / heavy vehicles has a large effect on modelled users of the bypass, reducing to around half of the users in the untolled scenario. As would be anticipated, the number of modelled users of the bypass reduces with the increasing toll values, though the net revenue increases.

7.2.3 Net revenue is modest, ranging between $26M and $53M compared to a rough-order scheme cost NPV of around $500M adopted in the economic assessment.

7.2.4 As a sense check of the modelled response to the tolls, consider the WtP values of time of Table 5.1. Bearing in mind that the interpeak period is dominant in forecasting daily flows[6], and that Other trip purposes dominate the interpeak period[7], the Medium WtP value for other trip purposes is around $15.50 around the opening year (2028). Analysis presented in the Woodend Bypass Modelling Technical Report shows that modelled travel time savings in using the bypass in the interpeak period in 2028 are around 2.3 minutes. This time saving equates to a 'cost' saving of 2.3/60 x $15.50 = $0.60. Thus any toll significantly greater than this will have a very significant

[5] Note that these values, based on elastic assignment to capture a demand response to the toll scenario, vary slightly from those presented for the economic analysis that use a fixed-matrix approach.

[6] Interpeak average hourly flows are factored by approximately 10.5 in the estimation of daily flows whereas the average flows during each of the 2-hour AM and PM peak periods are each factored by 2.0.

[7] Other purpose trips comprise around 75% of modelled demands in the interpeak period

effect on the modelled number of users of the bypass as 2/3 of the Other trip purposes (Low and Medium WtP segments) do not have a time saving sufficiently high for these trip purposes to be willing to pay the toll.

## 7.3 Users of the Toll Road

7.3.1 The following graph illustrates the modelled users of the toll road for an example scenario, being for the $1.25 toll in 2038.

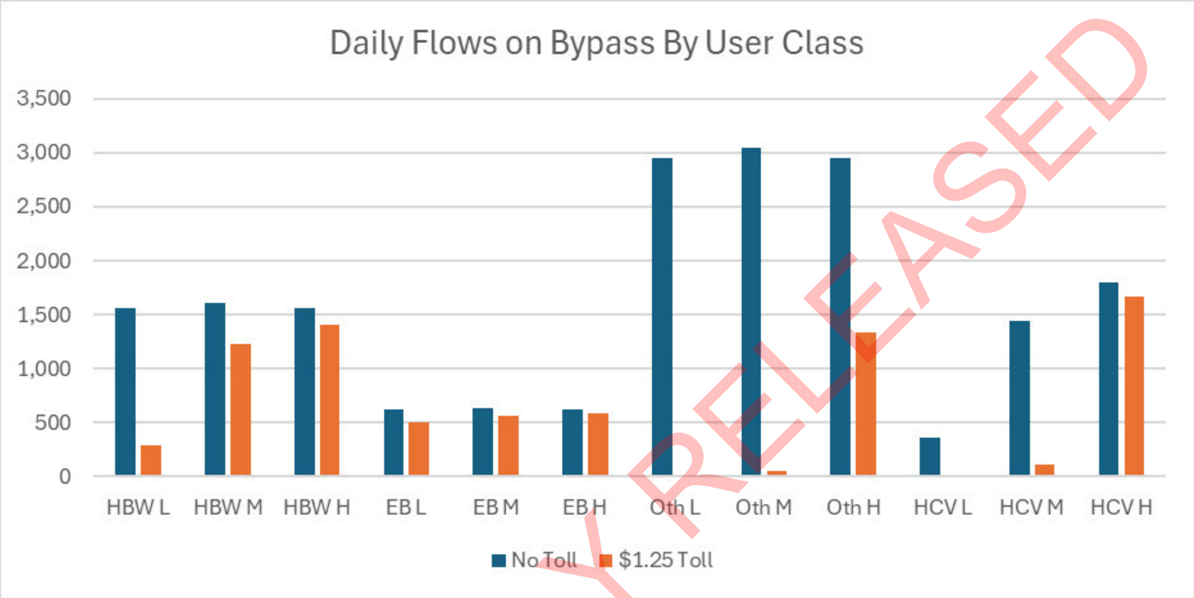


**Figure 7.1: Modelled Daily Flows on the Woodend Bypass by User Class, Without and With $1.25 Toll, 2038**

7.3.2 As might be expected given the cross-check described above, no 'Other' trip purpose Low and Medium WtP segment users are modelled as using the bypass. Notably, for HCVs, only the High WtP segment are modelled as using the bypass. Given the relatively high values of time assumed for Employers Business trips, the large majority of these continue to use the bypass when tolled. With the next highest values of time, a majority of Home-Based Work trips that are modelled as using the bypass without a toll continue to do so with the $1.25 toll in place.

## 7.4 Modelled Effects of Tolling the Woodend Bypass

7.4.1 A large number of model plots have been generated to allow traffic volumes, modelled delays and modelled changes between scenarios to be visualised at the model period and daily level. A great number of comparisons may be made, but here we illustrate only key matters arising with plots for example scenarios (years, tolls, periods).

7.4.2 We start the story by presenting the modelled daily flows in 2038 and delays on the road network in the peak periods for the Do-Minimum scenario (without the Woodend Bypass), as provided in the traffic modelling report, but now based on the cordoned toll model.


**Figure 7.2: Modelled Daily Flows, No Bypass, 2038**

7.4.3 We note the high volumes of traffic (23,000 to 25,500 vpd) on SH1 through Woodend and the associated community severance and amenity issues.

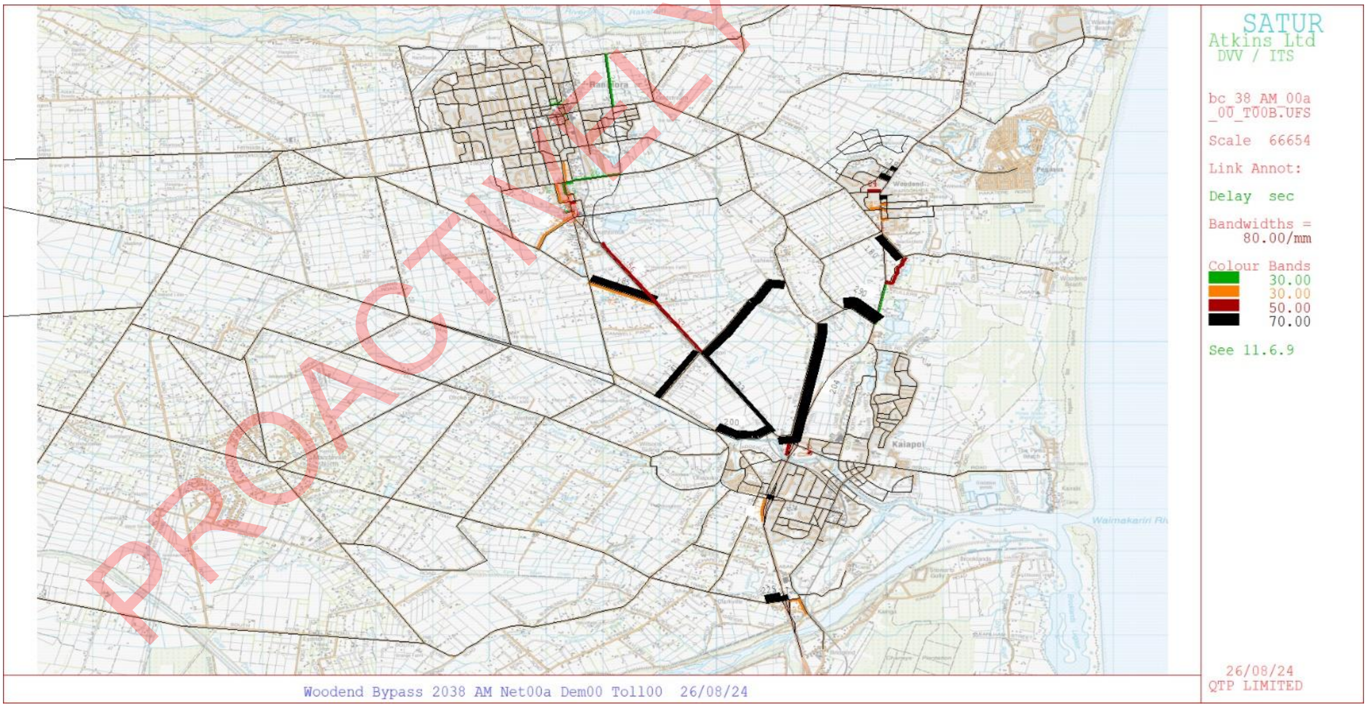


**Figure 7.3: AM Peak Delays (07:30-08:00), 2038 No Woodend Bypass**

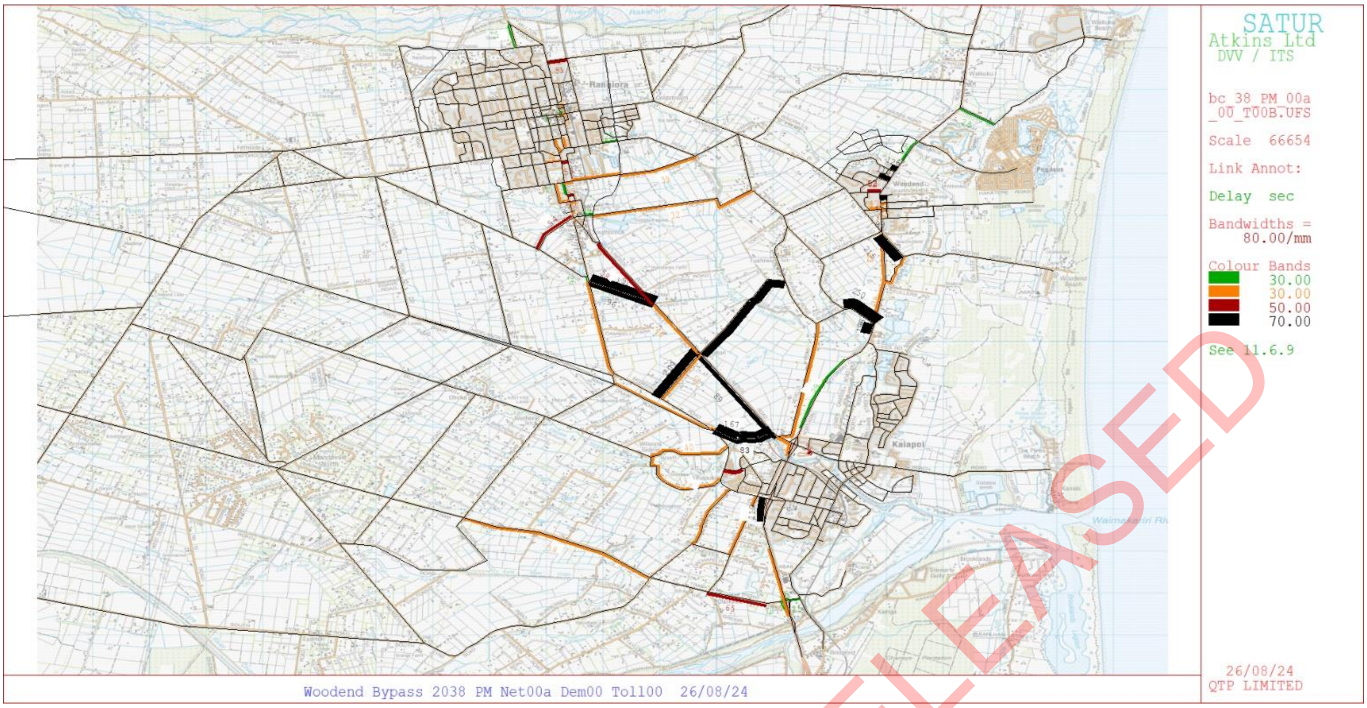


**Figure 7.4: PM Peak Delays (16:30-17:30), 2038 No Woodend Bypass**

7.4.4 We note the high delays illustrated on several of the minor road approaches to SH1 and on approaches to State Highway 71 Lineside Road between Rolleston and Kaiapoi.

7.4.5 The following plot illustrates the effect of the untolled Woodend Bypass on daily flows in 2038.

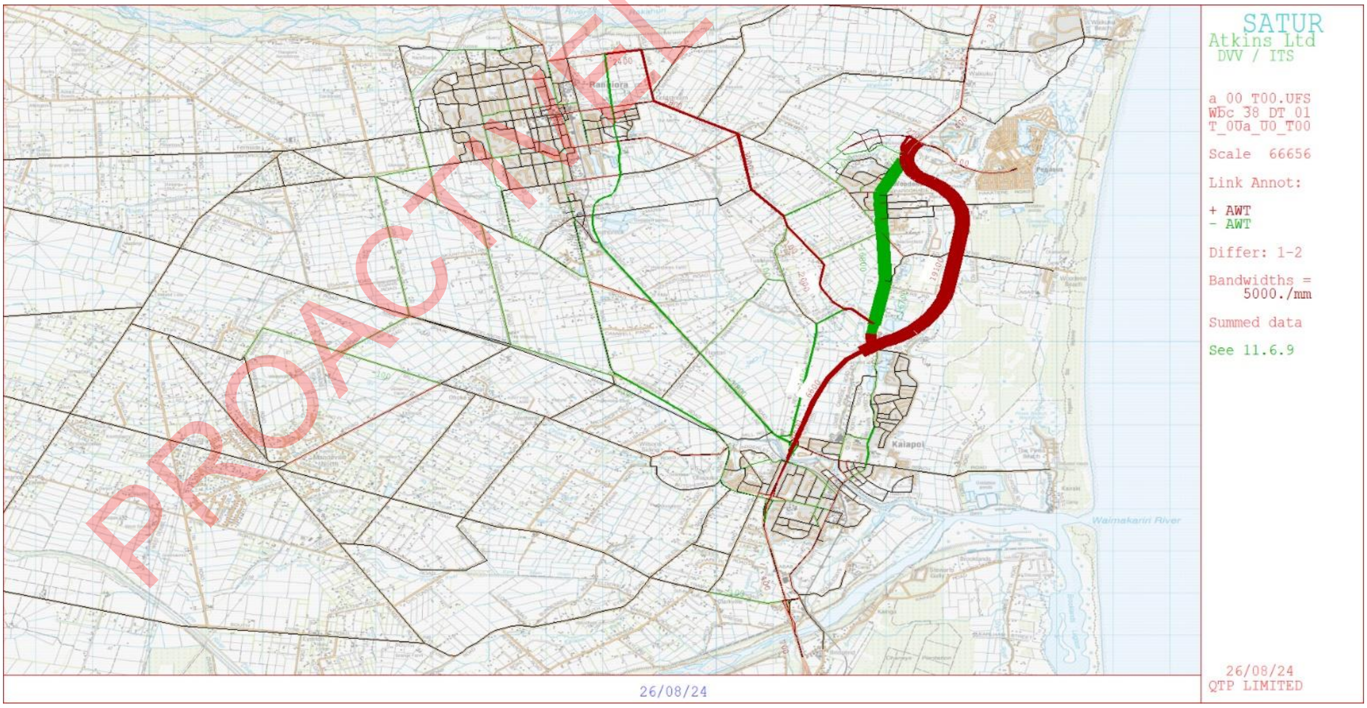


**Figure 7.5: Changes in Estimated Average Weekday Flows Due to Bypass, 2038**

7.4.6 Modelled flows on SH1 through Woodend reduce by around 17,000 vpd. A secondary effect is that high delays on the Pa Rd approach to SH1 in the Do-Minimum are greatly relieved, attracting traffic back on to this corridor and away from other corridors such as Lineside Road and Revells Road. This results in modelled widespread delay reductions across the road network in the area, with much lower delays illustrated in the following diagrams with the untolled bypass in place compared to those of the Do-Minimum presented above.

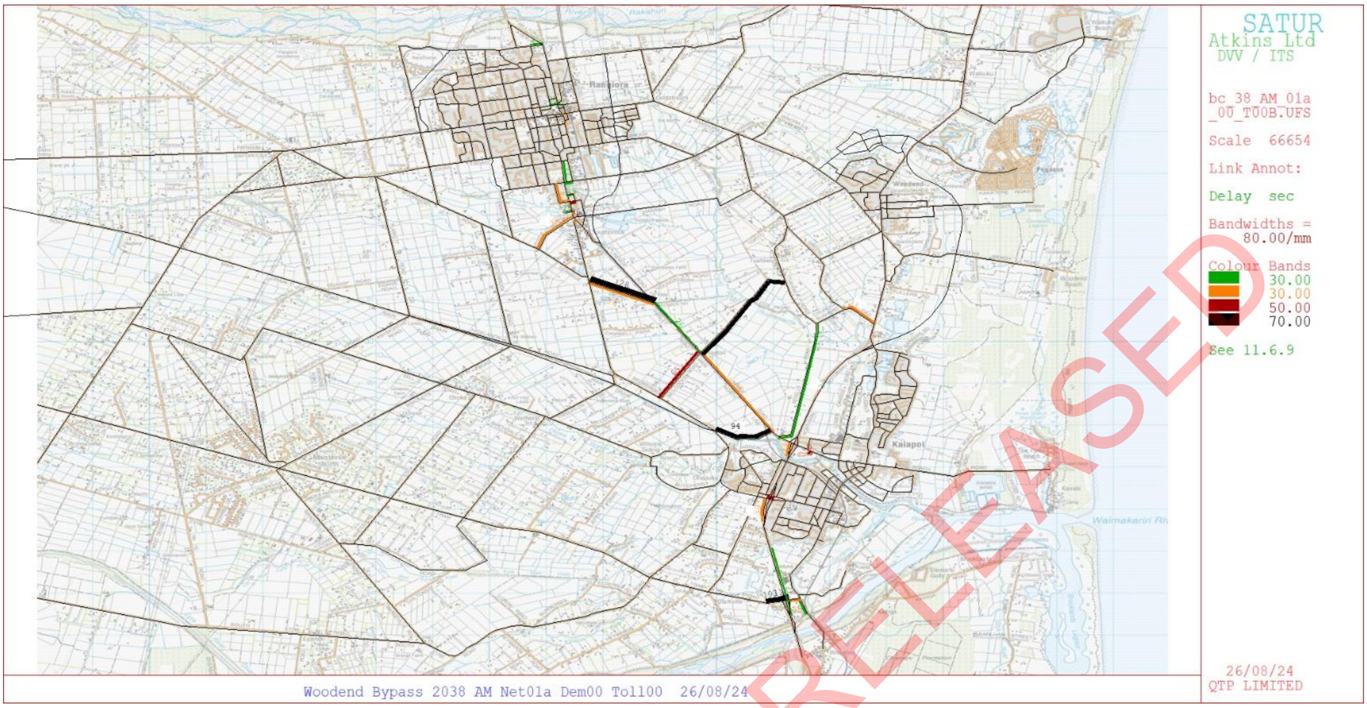


**Figure 7.6: AM Peak Delays (07:30-08:00), 2038 With Untolled Woodend Bypass**

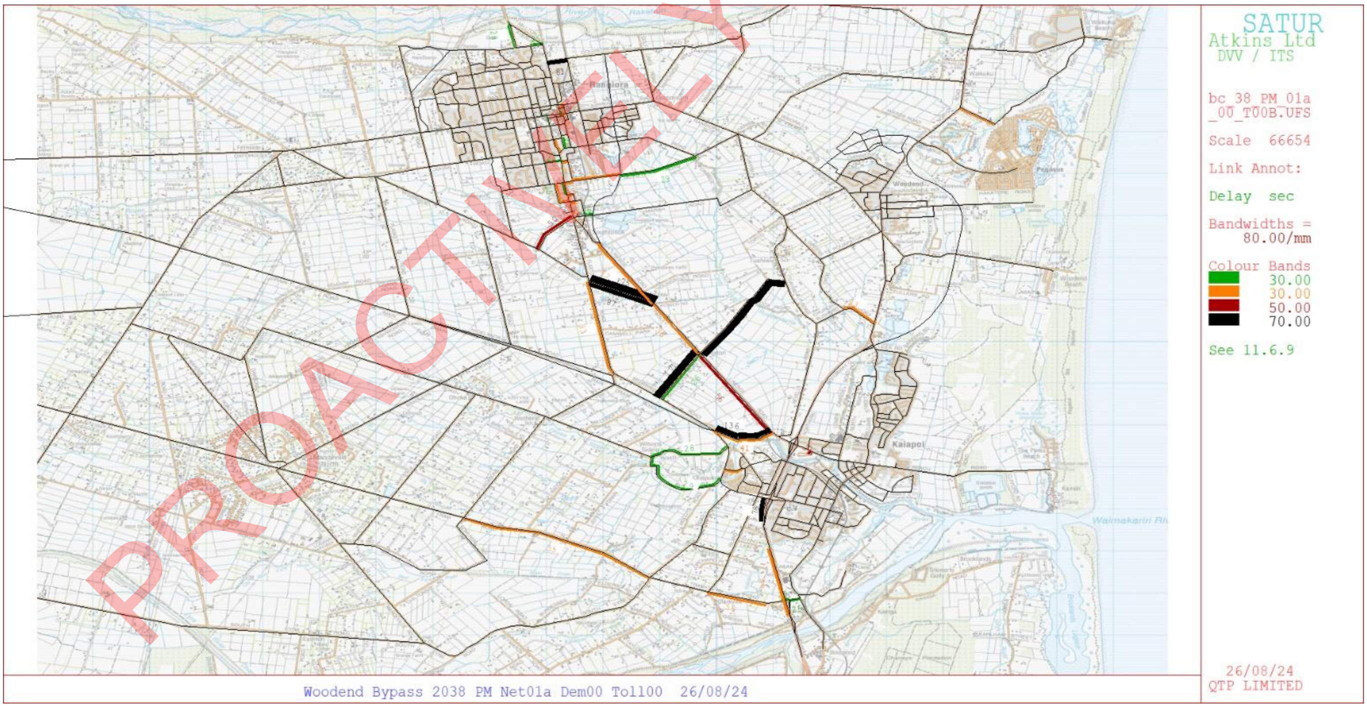


**Figure 7.7: PM Peak Delays (16:30-17:30), 2038 With Untolled Woodend Bypass**



7.4.7 We now consider the situation for the tolled, scenario, using the $1.25 toll as an example. The following plot illustrates the modelled daily flows in 2038.


**Figure 7.8: Modelled Daily Flows, With Tolled Bypass ($1.25), 2038**

7.4.8 With just 7,500 vpd using the tolled Woodend Bypass, modelled daily volumes on SH1 through the township remain high at 15,500 to 19,500 vpd. Much of the potential community severance and amenity benefits of the untolled bypass are lost.

7.4.9 The following diagrams illustrate the modelled delays on the network for comparison with those of the untolled scenario presented above (Figure 7.6 and Figure 7.7).

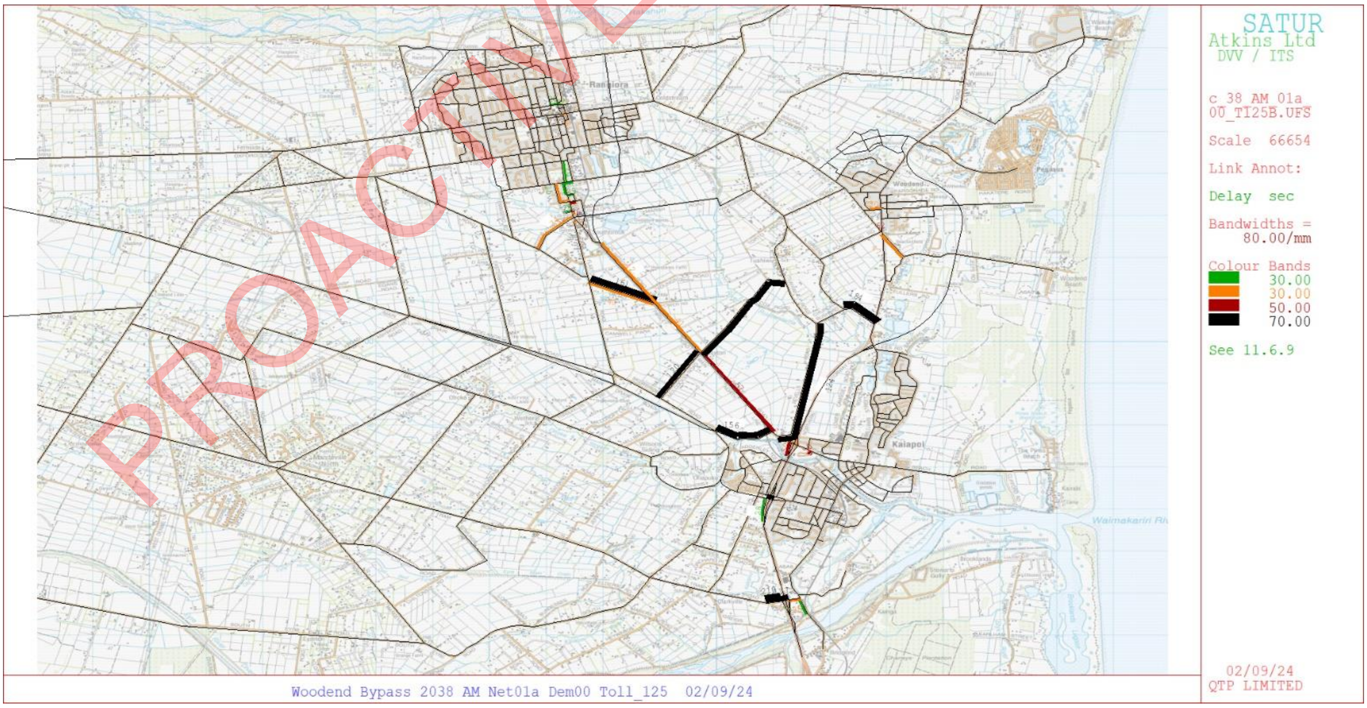


**Figure 7.9: AM Peak Delays (07:30-08:00), 2038 With Tolled Woodend Bypass ($1.25)**

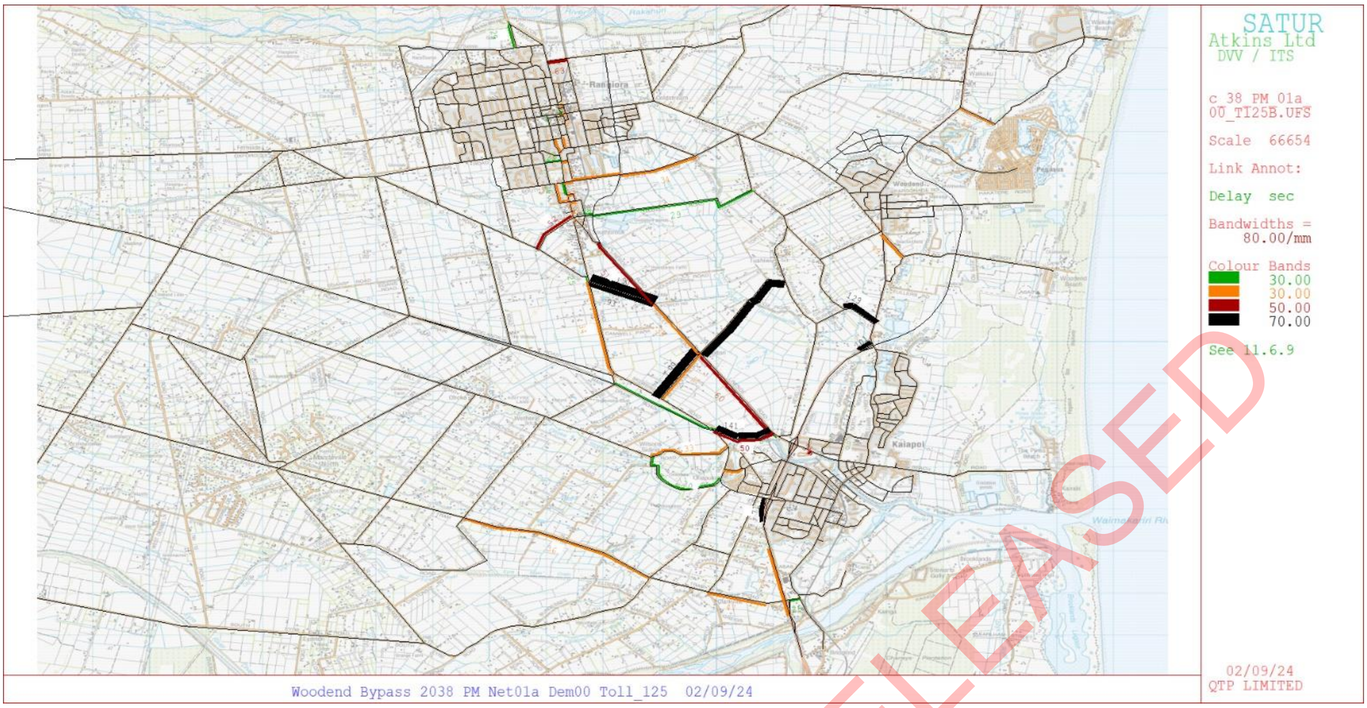


**Figure 7.10: PM Peak Delays (16:30-17:30), 2038 With Tolled Woodend Bypass ($1.25)**

7.4.10 The next plot illustrates the change in daily flows due to tolling the Woodend Bypass, i.e. the modelled effects of introducing the $1.25 toll vs the untolled bypass.

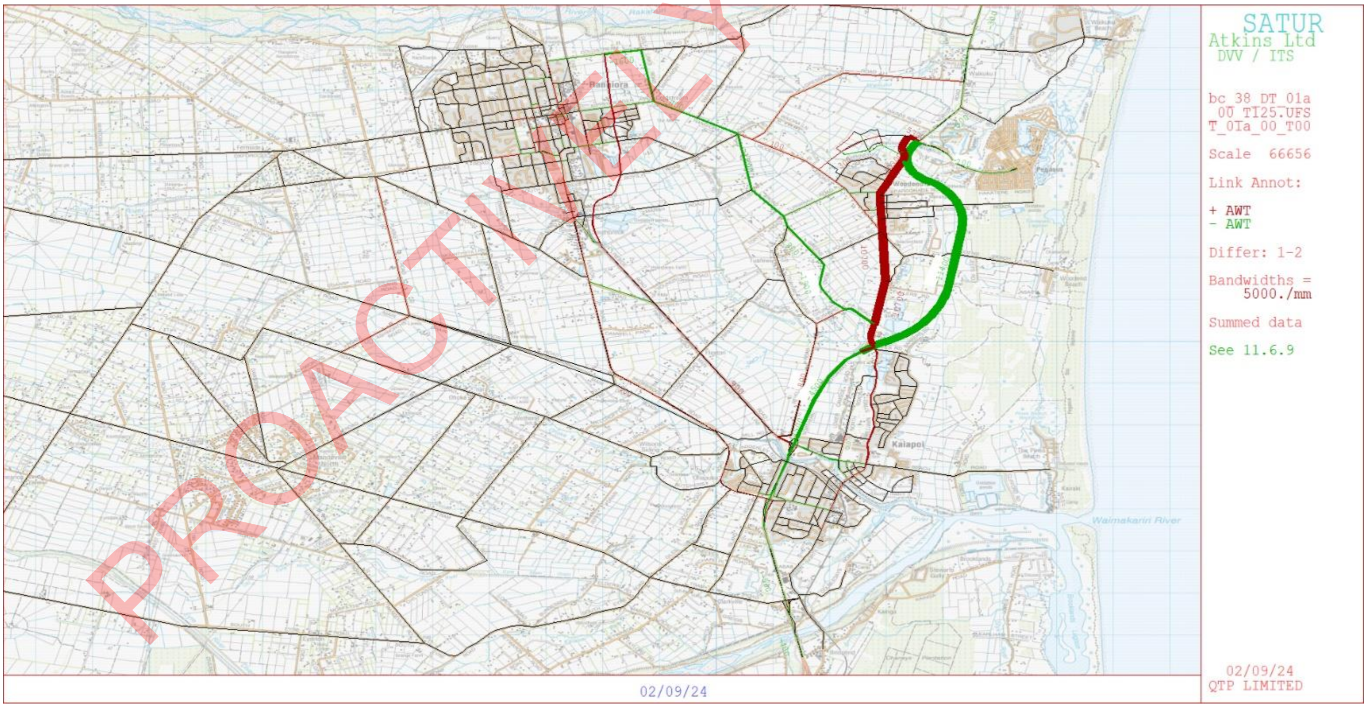


**Figure 7.11: Changes in Estimated Average Weekday Flows Due to $1.25 Toll vs No Toll, 2038**

7.4.11 It can be seen that the introduction of the $1.25 toll results in an increase in flows on SH1 through Woodend of around 10,500 vpd compared to the untolled bypass scenario.

7.4.12 The following plots illustrate the changes in modelled delays on the road network as a result of introducing the $1.25 toll compared to the bypass being untolled.


**Figure 7.12: Changes in Modelled Delays, AM peak (07:30-08:00), Due to $1.25 Toll vs No Toll, 2038**

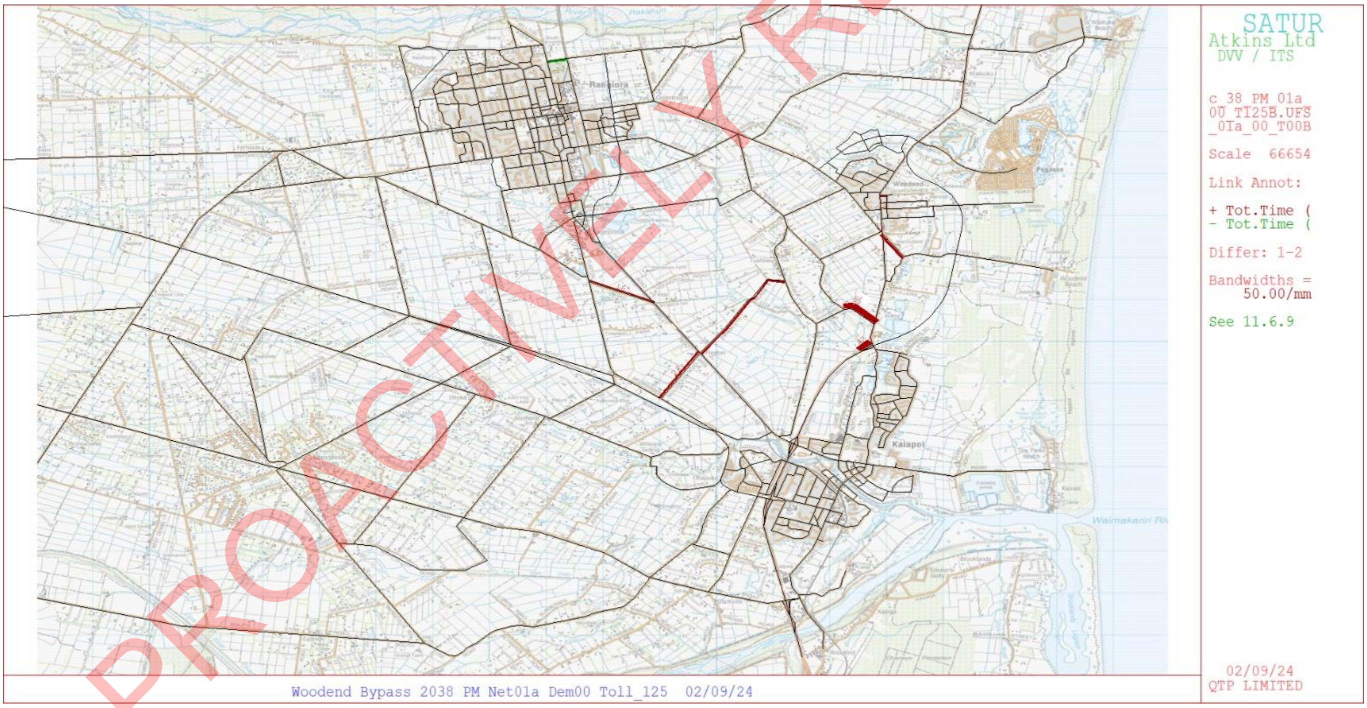


**Figure 7.13: Changes in Modelled Delays, PM peak (16:30-17:30), Due to $1.25 Toll vs No Toll, 2038**

7.4.13 The above plots illustrate several locations of significant delay increases attributable to tolling that will likely erode the economic benefits of the scheme, considered further in the next Chapter.

## 7.5 Route Perception Factor Sensitivity Test

7.5.1 As described in section 5.2, the CAST model is calibrated and validated without the need for route perception factors, including for motorway standard roads. However, there could be a perceived 'quality bonus' for a toll road relative to a 'standard motorway' and for this sensitivity test this has been modelled as a 10% reduction in the time component of cost on the Woodend Bypass.

7.5.2 The result of the sensitivity test, applied at 2038 for the $1.50 scenario, is to increase modelled total vehicles volumes on the bypass by 12% and revenue by 14%.

# 8 Economic Assessment

## 8.1 Overview

8.1.1 Outputs from the toll modelling described in the previous section have been used to provide an economic assessment.

8.1.2 The assessment process and methodology remain mostly the same as that reported in the document "*Woodend Bypass – Preliminary Economic Assessment*"[8]. This follows procedures specified in the Section 4.3 (road improvement activities) of the Waka Kotahi Economic Monetised Benefits and Costs Manual (MBCM) version 1.7 (May 2024). Both the preliminary economic assessment for the non-tolled bypass and this assessment of a tolled bypass used a fixed demand approach, adopting the do-minimum demands to provide a conservative assessment of economic benefits of the bypass.

8.1.3 The traffic toll model outputs have been used to estimate the following benefits, using a link-by-link analysis to obtain the following benefits:

- Travel Time Saving
- Vehicle operating cost savings
- Emission reduction (GHG)
- Emission reduction (air pollutants)
- Crash Cost Saving

8.1.4 Reliability benefits have not been included because it is a complex process, and the previous assessment of the untolled bypass indicated that they only provide a minor contribution to total benefits.

8.1.5 In addition to the national benefit-cost ratio ($BCR_N$, as reported in the previous assessment), the introduction of tolling requires reporting of the government benefit to cost ratio ($BCR_G$). The $BCR_G$ is used to indicate the level of benefits obtained from investment of local and central government funds in situations where government funding is supplemented by the availability of third-party funding or tolling revenue.

8.1.6 Toll revenue, as reported in section 7.2, has been used to calculate the $BCR_G$.

8.1.7 Whilst four toll scenarios have been developed, only the T125 ($1.25 light vehicles and $2.50 heavy vehicles) is included in the economic assessment, noting that the T100 scenario provides considerably less net revenue and the T150 scenario significantly reduces the number of vehicle trips using the by-pass (and associated community benefits). The adopted scenario is likely to reflect the best balance between all three scenarios.

8.1.8 The BCR calculations are based on the formulae provided within the tolling guidance note, which in-turn reflect those of the MBCM where revenue is included:



[8] "Woodend Bypass Economic Assessment v01a.pdf", QTP Ltd, August 2024

$$BCRn = \frac{PVb}{PVc + PVt}$$

$$BCRg = \frac{PVb - PVr}{PVc - PVr + PVt}$$

where:

PVc = PV of Road Costs (construction and ongoing operations & maintenance)

PVt = PV of tolling infrastructure capital costs (excluding maintenance and toll collection costs)

PVr = PV of net toll revenue (excluding 80c transaction costs)

PVb = PV Transport Benefits

## 8.2 Project Costs

8.2.1 The assumed project costs are largely unchanged from the previous assessment. NZTA have advised an indicative price for the installation of the tolling gantries s 9(2)(j) [redacted]. This figure is very small relative to the overall project costs of around $500 million and does not have a material impact on the benefit cost ratio. The assumed costs are summarised below:

| CAPEX | 2026 | 2027 | 2028 | 2029 | 2030 | Total |
|---|---|---|---|---|---|---|
| Pre-Implementation Phase | s 9(2)(b)(ii) [redacted] | | | | | |
| Land/Property | | | | | | |
| Construction | | | | | | |
| Tolling Infrastructure | | | | | | |
| **Total** | **$5m** | **$25m** | **$145m** | **210m** | **152m** | **$537m** |

**Table 8.1: Preliminary Assessment Capital Costs**

8.2.2 This results in a net increase in Present Value CAPEX cost of **$479.5m**, based on the default MBCM 40-year analysis period and 4% discount rate.

8.2.3 Periodic Maintenance (at 10-year increments) for resealing and general maintenance has been estimated based on the current average annual NZTA maintenance cost of $1.131m/km. When applied to the 9km corridor length, this results in $10m being spent per 10 yearly renewal period (nominally 2041, 2051 and 2061).

8.2.4 This results in a net increase in Present Value (PV) OPEX cost of **$11.8m** (assuming a 40-year analysis period and 4% discount rate).

8.2.5 The combined PV CAPEX and OPEX total is **$491.4m**.

## 8.3 Project Benefits

8.3.1 The benefits derived from the toll modelling T125 scenario outputs for each of the forecast years (2028, 2038 and 2048) are summarised below:

| Project Benefits | 2028 | 2038 | 2048 |
|---|---|---|---|
| Travel Time Saving | $11.580 | $21.765 | $38.599 |
| Vehicle operating cost savings | -$2.880 | -$3.278 | -$4.209 |
| Emission reduction (GHG) | -$0.119 | -$0.111 | -$0.078 |
| Emission reduction (air pollutants) | -$0.017 | $0.014 | $0.012 |
| Crash Cost Savings | $0.423 | $0.826 | $0.788 |
| **TOTAL** | **$8.987** | **$19.195** | **$35.112** |

**Table 8.2: Annualised Project Benefits by Model Year ($m July 2024)**

8.3.2 The resulting benefits are significantly lower than the non-toll scenario (achieving 48% of non-toll benefits for 2028, 61% at 2038 and 73% at 2048).

8.3.3 This results in a net Present Value benefit of **$442.7m**, based on the default MBCM 40-year analysis period and 4% discount rate. This is 68% of the PV benefits ($631.8m) obtained from the non-tolled modelling.

## 8.4 Benefit Cost Ratios

8.4.1 The resulting present value (PV) of net benefits using the standard MBCM 40-year analysis period and 4% discount rate are summarised below for the T125 scenario.

- Travel time saving $ 491.6m
- Vehicle operating cost savings $ -59.0m
- Vehicle emission reduction benefits (GHG) $ -1.3m
- Vehicle emission reduction benefits (air pollutants) $ 0.1m
- Crash cost savings $ 11.2m
- **TOTAL BENEFITS $ 442.7m**

8.4.2 The PV of costs are summarised below:

- Additional CAPEX (98%): $ 473.7m
- Additional OPEX (2%): $ 11.8m
- **TOTAL COST $ 485.6m**

8.4.3 The PV of net toll revenue is summarised below:

- **TOTAL REVENUE $ 34.1m**

8.4.4 The total PV net benefits equate to 70% of the total benefits for the non-toll scenario, while the total PV net toll revenue equates to 7% of the total project costs. It is likely that when increasing toll values further, the benefits will drop off at a faster rate than additional revenue is generated.

8.4.5 Based on the PV benefits and costs described above, the resulting **$BCR_N$ is 0.9**. This is less than the previous (no tolling scenario) $BCR_N$ of 1.3.

8.4.6 The First Year Rate of Return (FYRR) is **2.0%**. This is significantly less than the previous (no tolling scenario) FYRR of 3.7%.

8.4.7 Using the revenue based on the levied tolls (net of the assumed 80c transaction fee) in conjunction with the national benefits and costs, the resulting **$BCR_G$ is 0.9**.