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Technical Note

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Subject	**Southwest Gateway Programme Economics**		

1 Introduction

This note describes the economic assessment for the Southwest Gateway Programme (SWGP).

This note describes how annual and whole of life benefits from the preferred option for the SWGP were calculated, relative to a base case scenario. The purpose of this economic assessment is to detail the methodology for evaluating the costs and benefits that arise from different components of the project in order to inform the staging of the preferred option as well as the overall economic value of the preferred option.

2 Horizons

A set of five horizons have been developed to stage the SWGP interventions. These horizons are also used for the economics, to compute an economic assessment for each horizon individually, separately to the full programme economics.

Schematics describing each of the horizons are in Technical Note 502334-7000-TEC-JJ-0006. A brief description of each of the horizons is included below.

Table 1 Horizon descriptions and models used for benefits

Horizon	Operational year	Benefit types and models used				Overview
		Public transport (MSM)	Road users on highways (SATURN)	Walking and cycling (Auckland Cycle Model)	Wider economic benefits (MSM)	
Horizon 1	*2021*					*Short-Term Airport Access Improvements. This forms the base case for the long-term projects.*
Horizon 2	2025	✓			✓	A2B service extension to Botany.
Horizon 3	2030	✓	✓		✓	Construction of ultimate SH20B corridor (for A2B and general traffic), A2B corridor developed through Manukau, and new bridge across rail at Puhinui.
Horizon 4	2035	✓		✓	✓	Construction of the ultimate A2B rapid transit infrastructure for the full corridor.
Horizon 5	2040		✓	✓	✓	Construction of the ultimate 20Connect infrastructure on state highways 20 and 20A.

3 Models

This section details the network assumptions for the base case and for the model runs that were used for the benefit estimates.

3.1 Public transport model (MSM)

Auckland Transport's Macro Strategic Model (MSM) of the vehicle and public transit (PT) network is a regional transport model and was used to estimate the benefits of the A2B infrastructure improvements. Due to some concerns related to the estimation of car user (dis)benefits from the public transport elements of the SWGP, an additional, more detailed model was tested but was found to estimate a similar level of disbenefits as MSM, so was not used for the final economics. More details about this test of the modelling are included in the Appendix (sections 15 and 16).

Additional modelling of general traffic is being carried out using SATURN to estimate the benefits of the 20Connect project, and uses model runs based on the MSM models described next. The models for this economic assessment use the *ATAP 2 Update* scenarios as the base case for the public transport network assumptions. Some additional variations were made to the PT network, reflecting the recommended network changes in the early deliverables programme of the SWGP; these are:

- Standard bus lanes between the Airport and Manukau, on SH20B, Puhinui Road, Lambie Drive, Ronwood Avenue and Davies Avenue to Manukau Station.[1]
- A frequent service operating with a 10-minute headway between the Airport and Manukau (replacing the Airport to Manukau segment of the existing route 380) via the bus lanes noted above.
- Some changes to the surrounding public transport network including an additional Frequent Service bus route between Onehunga, Māngere, Papatoetoe and Manukau (replacing part of the former route 380).
- A new bus/train interchange at Puhinui Station.
- An upgraded road network within the Airport precinct.

Table 2 summarises the SWGP infrastructure that is included in each model run, for economics. Note that the bus lanes from the Airport to Manukau are included in the base case model run, because these are part of the early deliverables programme, which was assessed in a separate business case.

The following table summarises what components of the two projects have been modelled in each model stage. Further details of what has been modelled for each project is included in the following subsections.

[1] Ultimately it was decided to provide transit lanes in the early deliverables programme rather than bus lanes, however the effects of this in the modelling are expected to be negligible.

Table 2: Summary of MSM model scenarios used for economics (green highlighted cells represent changes from the prior model stage)

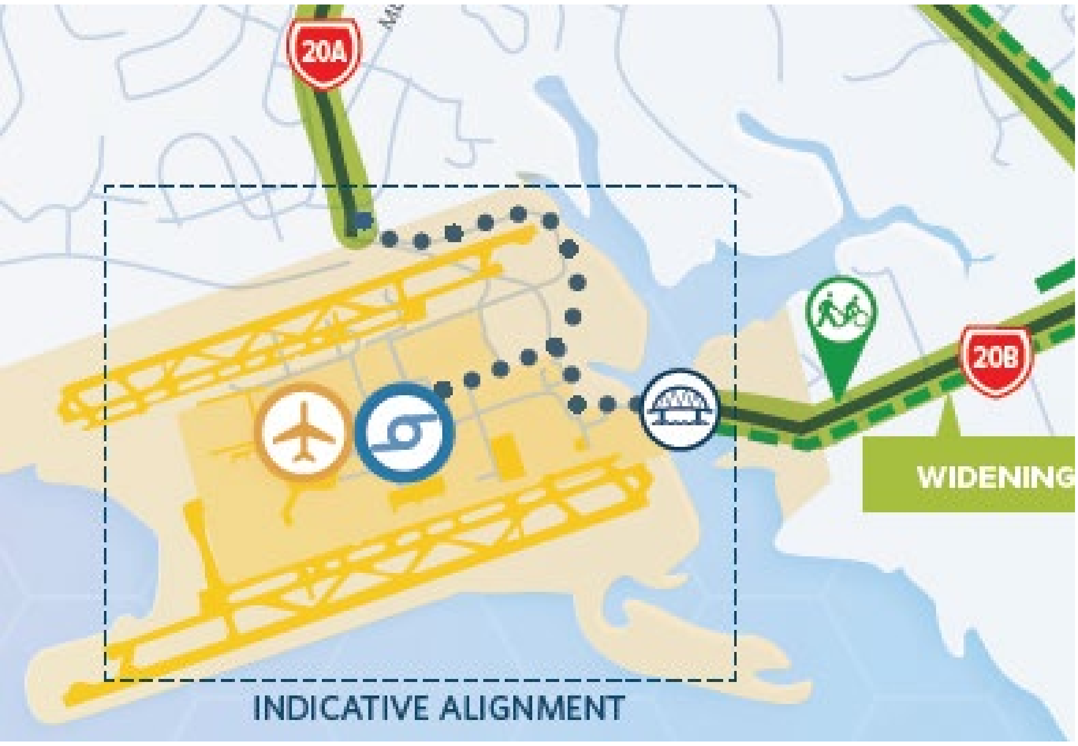
Feature		Stage 0	Stage 1	Stage 2a	Stage 2b	Stage 3	Stage 4
Description		Base Case	Airport to Botany service extension	Airport to Botany service + SH20B BRT	Airport to Botany service + full SH20B	Full Airport to Botany (BRT) + full SH20B	Full Airport to Botany + 20Connect
Relevant horizon		Horizon 1	Horizon 2	Horizon 3 (A2B components)	Horizon 3 (20Connect components)	Horizon 4	Horizon 5
A2B infrastructure	Airport to SH20B/SH20 interchange	Bus lanes	Bus lanes	Busway	Busway	Busway	Busway
	… to Manukau Station	Bus lanes	Bus lanes	Bus lanes	Bus lanes	Busway	Busway
	… to Ronwood Avenue/Great South Road intersection	None	Bus lanes	Bus lanes	Bus lanes	Busway	Busway
	… to Botany	None	On street	On street	On street	Busway	Busway
20Connect elements	SH20B widening	No	No	No	Yes	Yes	Yes
	SH20B-SH20 southbound ramps	No	No	No	Yes	Yes	Yes
	SH20 southbound widening south of SH20B	No	No	No	Yes	Yes	Yes
	SH20 remaining widening	No	No	No	No	No	Yes
	SH20A-SH20 southbound ramps	No	No	No	No	No	Yes

3.1.1 Airport road upgrades in base MSM scenario

MSM also includes planned upgrades to local airport roads that would complement 20Connect interventions. These airport road upgrades are included in the base case scenario as they are expected to be completed by AIAL independently of these projects. Furthermore, all costs for these upgrades accrue to AIAL and the benefits to AIAL are not considered here. The airport road upgrades include the following and are shown indicatively in Figure 1:

- New on- and off-ramps from SH20A to Verissimo Drive and George Bolt Memorial Drive.
- Upgrades to Westney Drive and Verissimo Drive, including grade separation with SH20A and a new link to Ihumatao Road.
- A new road between Nixon Road and SH20A.
- A new road linking Ray Emery Drive and SH20A.
- Signalised intersections along SH20A and Tom Pearce Drive.

Figure 1: Airport Road Upgrades



Transport network upgrades planned for within the Auckland Airport precinct are being undertaken for numerous reasons and to facilitate a number of projects. The more significant upgrades which have been assumed to be implemented prior to these projects, as part of the wider Southwest Gateway Programme (SWGP) of interventions, are expected to include:

- City Centre to Māngere Light Rail (CC2M)
- Reconfiguration of the road network to accommodate the Northern Runway and other changes to the Airport layout
- Four-laning of Puhinui Road (AIAL) / SH20B (i.e. 20Connect) – undertaken as part of the early deliverables, with one lane in each direction operating as a transit lane
- Transit lanes within the Airport precinct – undertaken by AIAL as part of the early deliverables

Detailed design and progress of these upgrade works within AIAL's precinct are not known at this point in time. Therefore, assumptions for transport network upgrades within the 20Connect and A2B single stage business cases are based on the most up to date proposals shared by the SWGP project partner, AIAL.

Impact of COVID-19 on airport road upgrades

COVID-19 has affected two important assumptions relating to the SWGP: reduced air travel and reduced employment in the airport precinct. Given the impacts of COVID-19, AIAL have indicated (after this economic assessment was largely complete) that investment in infrastructure apart from the runways has been put on hold. While airport road alignment assumptions are known to affect MSM results, it is expected that AIAL is likely to restart their infrastructure investments when air travel begins to grow again, which may still occur before the SWGP reaches its first investment gateway or progresses to implementation.

Given the level of uncertainty about the timing of the AIAL upgrades and the stage this business case was at when this changed, it is recommended that during the investment gateway approach, particularly for Horizon 2, the following investment drivers should be considered:

- What road infrastructure is expected to be provided by AIAL and when.
- Changes in number of air travellers and employment numbers in the airport precinct.
- Updated MSM runs, if necessary.

Regardless of these specific considerations, the investment gateway approach for decision making on the SWGP is designed to ensure decisions are made on the most recent information, as reflected by the *Investment Gateway Approach Principle 4 – Proposed approach needs to provide flexibility*, which requires the ongoing monitoring of a range of factors including key investment drivers.

Nevertheless, to provide some understanding of the scale of Horizon 2 benefits attributed to the airport demands, the proportion of the 2028 benefit that accrues to the airport zone in MSM has been assessed, with the following findings:

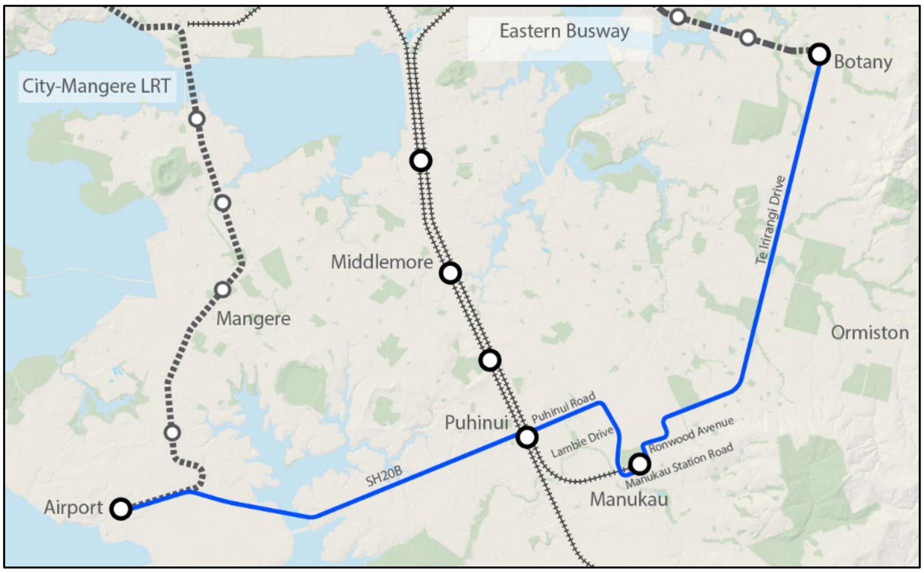
- 7-14% of conventional transport benefits for 2028, Horizon 2 relate to trips ending in the airport zone.
- 12-17% of wider economic benefits for 2028, Horizon 2 relate to trips starting or ending in the airport zone.

It is clear from this assessment that the conditions at the airport should be closely reviewed at the investment gateways, as the employment and passenger arrivals to the airport are likely to affect the benefit realisation.

3.1.2 A2B MSM model details

In MSM, the A2B service was routed according to the preferred route alignment, which is shown in Figure 1 below.

Figure 2: A2B alignment



3.1.3 20Connect MSM model details

In the MSM, the interventions associated with the 20Connect preferred option are summarised below and shown in Figure 3. These interventions are split between Stage 2b (Horizon 3) and Stage 4 (Horizon 5), as described in Table 2.

Stage 2b (Horizon 3)

- **SH20B widening**: four lane expressway, including the widening of Pukaki Bridge which is being funded by AIAL.[2]
- **SH20B-SH20 southbound ramp and SH20 widening south of SH20B**: SH20B to SH20 southbound ramp will replace the existing braided ramp, between Puhinui Road and Cavendish Drive interchanges. SH20 widening to three lanes southbound from SH20B to Lambie Drive.

Stage 4 (Horizon 5)

- **SH20A-SH20 southbound ramp**: SH20A / SH20 SB ramp (including removal of Bader Drive off-ramp).
- **SH20 widening north of SH20B**: widening of SH20 between SH20B and SH20A to three lanes each direction. Widening of SH20 north of SH20A, to Mangere Bridge, to four lanes in each direction.

[2] As the widening of Pukaki Bridge is included in the model runs, some transport benefits are recognised, despite not including the costs. This is a relatively small element in the model and it is expected that AIAL has non-transport related benefits and justifications for the upgrades. Therefore, there is no concern of double-counting the benefits of widening the bridge.

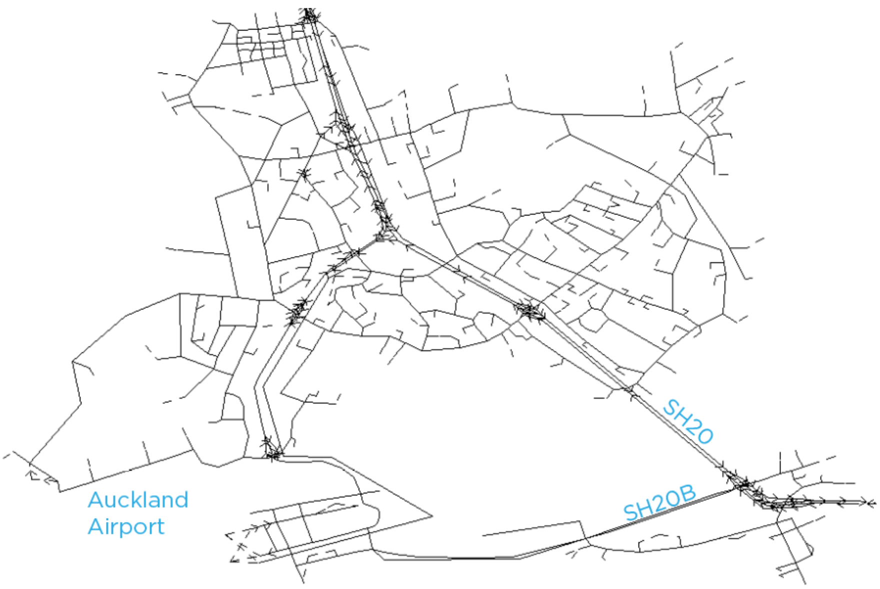
Figure 3: 20Connect Interventions (shown in green)

3.2 Vehicle traffic model for Airport area (SATURN)

A SATURN model was developed to enable the effects of the 20Connect project on travel times and traffic congestion in the vicinity of the airport to be assessed in greater detail than can be achieved through the MSM.

The SATURN model encompasses the area between the SH20 Mangere Bridge in the north through to south of the SH20 Cavendish Drive/Roscommon Road interchange in the southeast. It also includes the SH20A and SH20B routes from SH20 to the Auckland International Airport and the airport road upgrades described above. The extent of the SATURN model is included in Figure 4.

Figure 4: SATURN Model Extent



The base model was validated to 2017 traffic flows and conditions and this model reflects the network with the substantial completion of the SH20A Kirkbride Interchange project. Forecast models have been developed for the years 2028 and 2048, with changes in forecast traffic demands derived from the MSM.

3.3 Auckland Cycle Model

The Auckland Cycle Model (ACM), developed by Flow, was used to estimate the benefits arising from the proposed cycling infrastructure in the SWGP area.

The ACM used the most recent Auckland Council land use forecasts ("Scenario i11.5") as well as forecast person trips from MSM to estimate future cycle demands, in response to proposed walking and cycling components of the Southwest Gateway Programme. The programme includes walking and cycling infrastructure upgrades from the SWGP, as below.

A2B infrastructure:

- Cycle infrastructure on Te Irirangi Drive, Puhinui Road, SH20B, Lambie Drive, and through Manukau centre. The improvements will generally provide either physically protected cycle lanes, or allow bikes and cars to mix within low volume, traffic calmed environments
- New and improved pedestrian crossings would be provided throughout the route

20Connect infrastructure:

- A new walking and cycling route parallel to SH20, and improvements to the existing pedestrian route on SH20A. The improvements will generally be shared use paths, but may utilise local streets where these run close to the state highway corridors
- New and improved pedestrian crossings would be provided where the route meets arterial roads

The programme has been benchmarked against a future Reference Case that includes all existing cycle infrastructure, in addition to future infrastructure either currently proposed, or expected to be implemented in the future.
More detail on Flow's methodology for estimating economic benefits from increased cycling can be found in Section 9.3 and in the document *Southwest Gateway Walking and Cycling Improvements, Economic Benefit Evaluation* (Section 18).

4 Economics approach

4.1 Economics assumptions

Waka Kotahi NZ Transport Agency's *Economic Evaluation Manual (2018)* [3] (EEM) procedures were used to compute the economic benefits of these projects. The 2019 values of time were used for this assessment [4] and the base evaluation year is the year ended June 2021. The new 4% discount rate that come into effect as the standard assumption on 1 July 2020 was applied, along with an extended evaluation period of 60 years. Given the expected horizon staging with Horizons 4 and 5 being implemented 10-15 years after Horizon 2, a 60-year evaluation period is considered more appropriate than the default 40-year evaluation period to reflect the benefits of these investments and support a fairer economic efficiency test. Figure 5 shows a timeline of the estimated horizon timings and the 40- and 60-year evaluation period options, exemplifying how short the 40-year evaluation period would be for the later horizons.

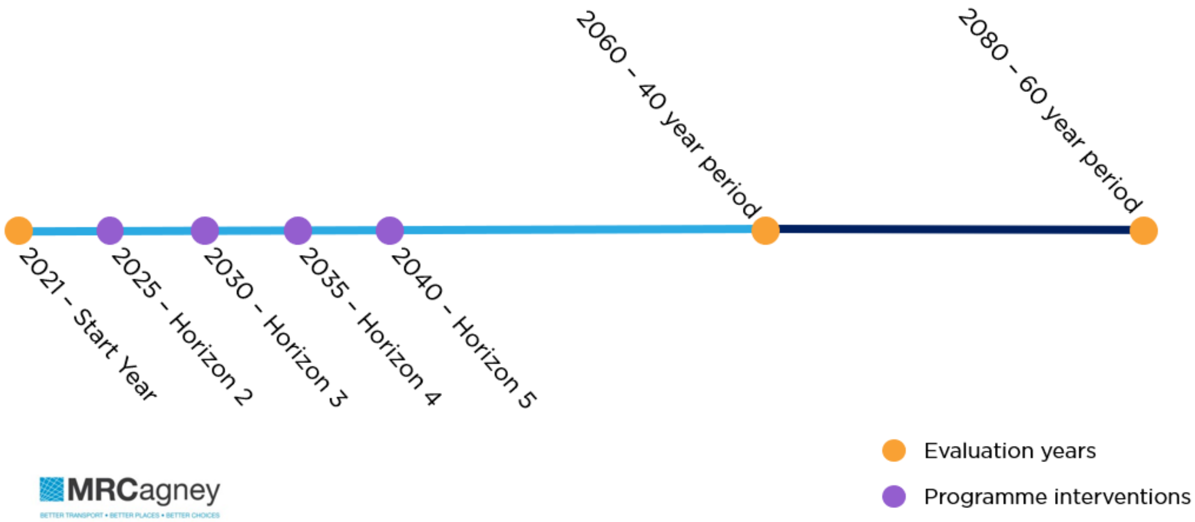


Figure 5: Timeline of economic analysis period and horizon staging

Consideration of impact of COVID-19

The impacts of COVID-19 have been considered as to how they might affect demands for components of the SWGP, particularly relating to PT patronage. This is of particular interest for the SWGP due to its proximity to the airport, which is likely to be one of the 'harder hit' areas by COVID-19 impacts. The immediate impact on employment located at the airport related to international air travel has been significant; however, these effects are most likely expected to be temporary and employment in the area is likely to recover as international air travel bounces back. A technical note on the expected impacts of COVID-19 on the SWGP has been included with the business case (reference 502334-8000-TEC-JJ-0006). The key finding from that work was that if the effects of COVID-19 persist beyond 2-3 years, the effects on transport demand are likely to be relatively small for the SWGP, equivalent to a delay of demand growth of around 1-2 years. Ultimately, the investment gateway/trigger approach to support future decision making for the SWGP is the ideal way to inform the decision-making process with respect to the lasting impacts (or not) of COVID-19 by ensuring the most up to date information is available for decision makers (eg international arrival and departure numbers) at the time decisions must be made.

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[3] The Monetised Benefits and Costs Manual (2020) is not required to be applied here as this business case began in 2018, however, the two manuals are consistent in many ways.
[4] At the time of assessment, the 2019 update factors were the most recent ones available.

4.2 Programme approach

Section 6 identifies the benefits that were estimated for this programme of interventions. Section 9 has been included as an Appendix, to provide full details on how the economic benefits were computed from each of the models. Additionally, the Appendix in Section 12 presents the incremental results for each of the horizons that make up the full programme of recommendations.

The economic assessment focuses on the results of the programme economic assessment. The incremental horizons were developed as a pragmatic way to stage the implementation of the full suite of SWGP interventions and to bring in some early benefits to a part of Auckland that has historically been transport deprived. The timing of implementing horizons involves several decision gateways to ensure that the timing of investments is sensible given the latest information available to ensure the best understanding of demands is known at the final decision points. Therefore, whilst the incremental results give some indication of the value for money of each stage of investment, they are only 'stepping stones' on the path to completing the programme of interventions that addresses the full set of transport problems identified in this business case.

The SWGP is comprised of A2B and 20Connect, which are interrelated and complementary projects that are being jointly delivered. These projects affect the same corridors and have some interrelated costs and benefits, for example:

- SH20B upgrades generate a range of road user benefits while also enabling rapid transit on this key portion of the A2B corridor.
- New southbound ramps at the SH20B/SH20 interchange are required to mitigate the impacts on constructing and operating the busway infrastructure through this section.
- Early deliverables of SWGP (Horizon 1) and Horizon 2 provide transit lanes as initial infrastructure for A2B, which provides benefits for both PT and road users.

Because of the interrelated nature of the project costs and benefits, this economic assessment takes a programme-wide approach to measure the ultimate benefit cost ratio of the SWGP. This approach was discussed and agreed upon at the *Economics Overview Workshop* on 18 October 2019, with representatives from the Waka Kotahi NZ Transport Agency, Auckland Transport, and the consultant team.

Costs and benefits for the programme are thus calculated by horizon rather than project. Horizons incorporate elements of both A2B and 20Connect as follows:

- Progression from Horizon 1 to Horizon 2 adds elements of A2B only.
- Progression from Horizon 2 to Horizon 3 adds elements of both 20Connect and A2B.
- Progression from Horizon 3 to 4 adds elements of A2B.
- Progression from Horizon 4 to 5 adds elements of 20Connect.

Costs and benefits are reported incrementally for each horizon to provide an indication of the *value for money* for each individual horizon. However, the focus of the economics assessment is on the programme economics results for Horizon 4 and Horizon 5, which represent the costs and benefits of that horizon and all preceding horizons. These reflect the last horizon involving A2B elements and the last horizon involving 20Connect elements, respectively.

As SH20B upgrades are necessary for implementation of both 20Connect and A2B, it is not appropriate to separate out the cost attributable to either project; therefore, SH20B benefits and costs are reported in total and not split between A2B and 20Connect. SH20B upgrades occur during Horizon 3.

5 Costs

This section identifies the cost estimates used for the economic assessment. For details on the estimates of the capital expenditure, refer to the Financial Case. Details of the Operating Expenditure are included here in detail.

Table 3: Overview of project costs (see Financial Case for full details on sources of estimates)

Category	Description
Construction costs	Costs to physically build infrastructure for the SWGP, broken down to each component. Focused on the P50 cost estimate as the most likely outcome.
Land costs	Costs to acquire land for the SWGP, broken down by segment.
Maintenance costs	Expected annual maintenance costs for the SWGP infrastructure.
Renewal costs	Expected renewal costs for the pavement, every 25 years.
Annual operating costs	Future changes to operating costs arising from additional A2B services, and implementation of new stations/ interchanges enabling bus network simplification.

5.1 Capital Expenditure

Table 4 summarises the capital expenditure estimates involved in this programme, as they relate to each horizon. The following bullet points explain the assumptions applied for implementing these costs

Table 4 Capital expenditure summary

[5] Early demand assessments from MSM models indicated that 35% of the rapid transit network demand at Botany was from A2B, and 65% from Eastern Busway, so this is the split of costs.
[6] Portion attributable to SWGP

[redacted]

5.2 Operating and Ongoing Expenditure

This section details the operating, maintenance and renewal costs that are incurred throughout the lifetime of these projects.

5.2.1 Maintenance costs

Annual maintenance costs have been assessed [redacted] based on recent records available from the Auckland Motorway Alliance. For details on this estimate, see Technical Note 502334-7000-TEC-RR-0050. This has been applied to all additional lanes in the 20Connect project and the A2B route, which are expected to require similar maintenance.

Above and beyond the lane km cost described above, A2B also incurs a maintenance cost for each station. This maintenance cost is, per station:

- [redacted]

The maintenance for each station is incurred every year from the first *operational* year of the final/ ultimate station.[7] The resulting annual maintenance costs are shown in Table 5. Maintenance costs are assumed to be incurred annually from the first operational year of each horizon.

[redacted]

5.2.2 Renewal costs

A resurfacing renewal cost has been assumed at a cost of [redacted] additional pavement following 25 years. This has been applied to all additional pavement area for 20Connect and for the A2B route,

[7]Stations incur maintenance costs based on: Horizon 3 includes Botany, Puhinui and Manukau stations; Horizon 4 includes all remaining stations.

which is expected to require similar maintenance. For details on this estimate, see Technical Note 502334-7000-TEC-RR-0050.

Renewal costs for each horizon are expected to be incurred 25 years after the infrastructure for that horizon has been completed, for all permanent, long-term infrastructure. The renewal cost for these projects is shown in Table 6.

Table 6: Renewal costs

[redacted]

5.2.3 Public transport operating costs

The assumptions for the operating cost estimates are detailed below. It is important to acknowledge that the actual service offering may differ when implemented, as up-to-date information and models will be available in the future, to ensure the service offering matches the ridership potential.

The following points note the general assumptions for the operating cost estimates.

- 21-hour span of service of the A2B service:
  - 4 hours of peak service level operation
  - 17 hours of off-peak service level operation
- Annualisation factors:
  - 250 working weekdays per year
  - 115 weekend days/public holidays
- Layover/recovery rate[8] of +10% (ie the layover time is an additional 10% of the return trip runtime)
- Operating cost unit rates[9] as per Table 7
- Headway assumptions as per Table 8

Table 7: Operating cost unit rates

[redacted]

[8] A layover rate of 10% is standard for regular diesel buses. It is unclear if/how this might change with an electric fleet.
[9] Operating cost unit rate estimates provided by Darek Koper on 16 March 2020 and include charging infrastructure at depots (operator-provided) but not on-route infrastructure.

Table 8: Headway assumptions

Year	2028 (headway, min)			2048 (headway, min)		
Period	Late night	Base all-day	Peak	Late night	Base all-day	Peak
Horizon 1 (STAAI)	15	15	10	15	15	10
Horizon 2 (A2B service extension)	10	10	7	10	10	7
Horizon 3 (Targeted infrastructure)	10	10	5	10	10	5
Horizon 4 (Ultimate A2B)	10	10	5	10	5*	3
Horizon 5 (Ultimate SWGP)	10	10	5	10	5*	3

* 5-minute base headways for Horizons 4 and 5 are conservative assumptions used for the purposes of economics. Elsewhere, including in the SSBC, 10-minute base headways have been assumed.

The resulting estimated operating cost for the A2B service is shown in Table 9. [redacted]

Table 9: Estimated additional public transport operating cost for the A2B service

[redacted]

5.3 Costs incurred by third parties

Costs incurred by Auckland International Airport Limited (AIAL) are not included in this economic assessment. [redacted]

[redacted]

It is also important to note that the airport precinct upgrades are being undertaken to facilitate a number of projects including the Northern Runway and general airport layout changes, City Centre to Māngere Light Rail, Airport to Botany rapid transit, and four-laning of Puhinui Road/SH20B.

6 Benefits

This section describes the benefits estimated for the Southwest Gateway Programme, including how annual benefit estimates from models were extrapolated across the evaluation period and identifying several benefits that were not quantified in the base economic assessment due to uncertainties in the total benefit value.

The new Monetised Benefits and Costs Manual (MBCM) from Waka Kotahi revises the discount rate used in cost benefit analysis from 6% to 4% and provides for an increase in the analysis period from 40-years to 60-years where appropriate, as in the SWGP. These updated parameters are applied here and sensitivity tests of these parameters (including to use the previous base parameters) are also included in the results.

The detailed methodology for computing annual benefits from the models is detailed in the Appendix in Section 9. Results of the annual benefit estimates and the incremental cost benefit analysis for individual horizons are included in the Appendix in Section 12.

Table 10: Overview of project benefits

Benefit (section)	Description	Source
Public transport-related benefits		
Public transport user benefits (9.1.3) ***Only for A2B***	Reductions in journey time and improvements in journey quality for existing and new public transport users.	MSM model outputs used to estimate reduction in generalised cost of travel for PT users. EEM value of time parameters were used to monetise benefits.
Public transport reliability benefits (9.1.4) ***Only for A2B***	Reductions in the variability of journey time for public transport users of the A2B service.	The PT reliability benefit is estimated based on the methodology for car reliability benefits in the EEM rather than the public transport reliability benefit in the EEM. The relative magnitude of this benefit comes from the improved average travel time and improved reliability estimated using AT real time bus data and assumptions about future reliability on each segment of the corridor.
Health benefits from walking to stations (9.1.5) ***Only for A2B***	Increased public transport use also increases walking to and from stations/ stops, resulting in some health benefits.	Demand outputs from the MSM model used to estimate additional walking trips to and from public transport. EEM values used to monetise resultant health benefits.
Standard road user benefits		
Road user benefits (9.1.3 and 9.3.5) ***For A2B and 20Connect***	20Connect: primarily from increased road capacity and some mode shift due to the new cycling facilities. Includes travel time savings, vehicle operating cost, crash reduction, driver frustration, and trip reliability benefits. For the A2B project, a decongestion benefit could result from reduced congestion due to mode shift caused by the project. Road user disbenefits may also occur, for example through increased travel times caused by removal of right turns, or signal phasing optimised for rapid transit.	MSM and SATURN model outputs used as appropriate to estimate reduction in generalised cost of travel for drivers. Auckland Cycle Model used to estimate additional benefits from mode shift to cycling. EEM value of time parameters used to monetise benefits. Detailed methodology for 20Connect road user benefits available in Flow Airport Access Study Economic Evaluation Summary (Section 19).

Benefit (section)	Description	Source
Vehicle emission cost reduction (9.1.6) ***For A2B and 20Connect***	Mode shift from car to public transport reduces private vehicle emissions affecting the environment (carbon dioxide) and human health (fine particulates). Conversely, road improvements typically increase vehicle travel and therefore emissions. Additionally, shifting from diesel to electric buses reduces the emissions from public transport operations.	For A2B, demand outputs from the MSM model used to estimate reduction in car emissions. EEM values used to monetise benefits. For 20Connect, vehicle emission cost reductions calculated as 4% of calculated vehicle operating costs, as specified in the EEM.
Standard benefits for active modes		
Cycling travel time benefits (9.3.2) ***For A2B and 20Connect***	Reductions in journey time for cyclists using new cycling facilities along 20Connect and the A2B corridor. Travel time savings may arise from a more direct route and/or reduced wait times at intersections. Travel time cost savings (in the form of generalised costs) also arise from increased attractiveness of the route.	Auckland Cycle Model used to estimate travel time benefits and demands for cyclists from cycle facility improvements along 20Connect and the A2B corridor.
Health and environmental benefits of new walking trips from new walking facilities (9.5.1) ***Only for 20Connect***	New shared paths under 20Connect result in new pedestrian trips, resulting in some health and environmental benefits. Additional health and environmental benefits may be realised for the A2B project if new pedestrian links are created to access A2B stations. As no plans yet exist for such links, these potential benefits have not been quantified at this stage.	Benefits estimated based on the estimated average daily number of pedestrians using each section of new shared path to be constructed under 20Connect.
Health benefits from new cycling facilities (9.3.3) ***For A2B and 20Connect***	New cycling infrastructure along 20Connect and the A2B corridor induces additional cycling by new and existing cyclists, which results in increased physical activity and corresponding health benefits.	Auckland Cycle Model used to estimate health benefits from collective increase in total distance cycled by new and existing cyclists.

Benefit (section)	Description	Source
Safety benefits from new facilities for cyclists and pedestrians (9.3.4 and 9.5.1) ***For A2B and 20Connect***	New cycle and pedestrian infrastructure results in improved safety and reduced crash risk.	Auckland Cycle Model used to estimate safety benefits from new or improved cycling infrastructure for existing and new cyclists. Pedestrian safety benefits are estimated based on a blanket reduction in pedestrian-related crashes near stations and along the A2B corridor.
Wider economic benefits		
Agglomeration benefits (9.4.2)	Reduced journey times between firms and workers results in higher economic productivity.	MSM model outputs used to estimate reduction in the generalised cost of commuting and work purpose trips, by car and PT. EEM procedures were used to estimate resulting percentage change in productivity within individual model zones. MRCagney's Urban Productivity Database was used to estimate dollar value of agglomeration benefits.
Imperfect competition benefits (9.4.3)	Reduced journey times for work purpose trips result in an additional saving due to the price-cost margin between travel costs and prices charged to customers.	MSM model outputs used to estimate reduction in the generalised cost of work purpose trips, by car and PT. EEM values were used to estimate added imperfect competition benefits.
Tax wedge on increased labour supply (9.4.4)	Reduced journey times for commuting trips enable some people to enter the labour market. This results in an additional benefit associated with the taxes that they pay on labour income.	MSM model outputs used to estimate reduction in the generalised cost of commuting trips, by car and PT. EEM procedures were used to estimate resulting change in labour market participation. Data from the 2013 Census and MRCagney's Urban Productivity Database were used to estimate dollar value of labour supply benefits.

6.1 Extrapolating benefits across evaluation period

MSM model forecasts of AM peak public transport demand in 2028 and 2048 were used to linearly extrapolate project benefits to other years for all Horizons except for Horizon 4 (reasoning described further below).

The MSM model for stage 3 (horizon 4) was unstable and returned unusual results for the 2028 model year. The results for 2038 and 2048 model years were both reasonable and as expected, therefore the models from these two years have been back-extrapolated, rather than using the 2028 and 2048 model years.

This is not expected to yield unreasonable results, particularly given that Horizon 4 is expected to be operational only in 2035. Furthermore, analysis of the benefit trend of stage 4 from 2028-2038-2048 suggest that the trend is likely to be relatively linear across this timeframe anyway. The benefits of stage 4 are shown in Figure 5.

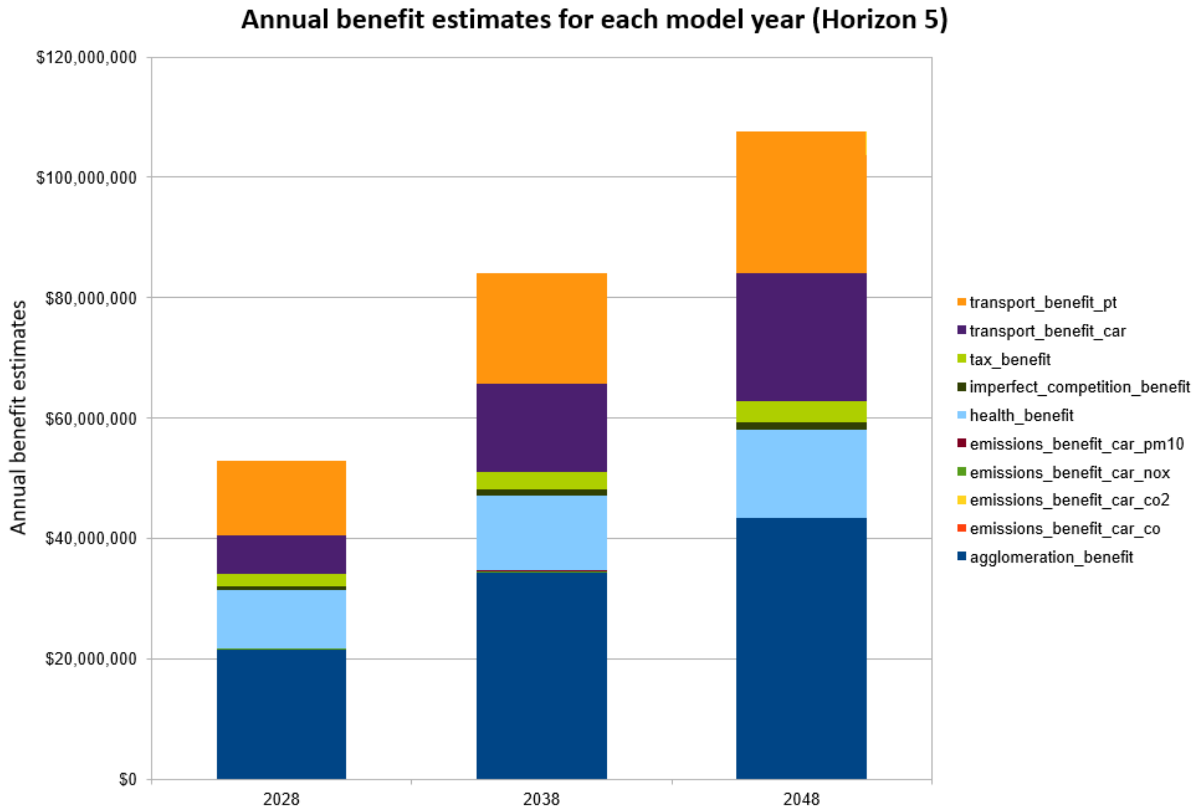


Figure 6: Annual benefit estimates for each model year for stage 4 are approximately linear

7 Economic evaluation

This section summarises the results of the programme economic evaluation of the preferred option for both Horizon 4 and 5, and presents the sensitivity tests. An incremental cost-benefit analysis of each of the horizons is included in the Appendix in Section 12.

7.1 Economic evaluation for recommended staging

This section details the economic evaluation of the full Southwest Gateway Programme, as per the horizon assumptions described above. Table 13 presents cumulative costs and benefits to Horizon 4 and Horizon 5 including all preceding horizons. Horizon 4 includes the full A2B infrastructure and SH20B upgrades, while Horizon 5 completes the full SWGP.

Table 13 shows that the present value of projected benefits is substantially larger than the present value of projected costs; each of these horizons has a BCR greater than 2, for both the BCR with WEBs and the sensitivity tested BCR without WEBs. The ultimate programme BCR is expected to be 3.0.

Table 11 Cost benefit analysis of recommended Southwest Gateway Programme staging option

Costs/benefits		Horizon 4 (Full A2B + SH20B)	Horizon 5 (Full SWGP)
Project Costs (PV, $millions)			
Construction costs		$1,014	$1,386
Land costs		$213	$236
Maintenance costs		$33	$39
Renewal costs		$3	$3
Operating costs		$226	$226
Pre-implementation costs		$21	$21
Total project costs		**$1,510**	**$1,912**
Project Benefits (PV, $millions)			
Public transport-related benefits	Public transport user benefits	$366	$372
	Public transport reliability benefits	$410	$410
	Health benefits from added walking to stations	$81	$73
Road user benefits	Road user travel time benefits	$1,592	$2,734
	Vehicle operating cost benefits	$170	$378
	Crash reduction benefits	$99	$167
	Vehicle emission benefits	$31	$39
	Reduced driver frustration benefits	$226	$382
	Trip reliability benefits	$94	$159

Costs/benefits		Horizon 4 (Full A2B + SH20B)	Horizon 5 (Full SWGP)
Active mode benefits	Cycling travel time benefits	$1	$2
	Health and environmental benefits from walking facilities	$0	$17
	Health benefits from cycling facilities	$39	$62
	Safety benefits from cycle facilities	$1	$2
	Pedestrian safety benefits	$5	$5
	Decongestion benefits from active mode shift	$7	$12
Wider economic benefits	Agglomeration benefits	$526	$772
	Imperfect competition benefits	$13	$24
	Tax wedge on increased labour supply	$53	$63
Total project benefits		**$3,714**	**$5,673**
Cost-benefit measures			
Net benefits (PV, $millions)		**$2,204**	**$3,762**
Benefit-cost ratio		**2.5**	**3.0**

7.2 Sensitivity testing

The economic assessment presented above involves various assumptions that have been detailed throughout this assessment. Table 14 presents the effect of some key assumptions on the cost-benefit assessment. A sensitivity test of timing of construction on each horizon is included in the Appendix in Section 12.

The sensitivity tests included, and the reason for understanding the impact of each of them is noted here:

- Evaluation parameters

  The new evaluation parameter from the MBCM of a 4% discount rate is only strictly required for business cases that began after 1 July 2020, with the choice to use them being discretionary on business cases that began before then. Given the delayed timing of this business case, the new discount rate has been adopted. Additionally, the MBCM allows for an extended evaluation period of 60-years to be applied where appropriate, as in this case, where the horizons become operational over such a long time span between 2025 to 2040. The standard evaluation period of 40 years is particularly inappropriate for Horizons 4 and 5, where 10-15 years are 'wasted' before construction would even begin. Sensitivity tests of the previous discount rate of 6% and of the standard evaluation period of 40 years are included.

- Cost estimates

  The standard sensitivity test of the 95th percentile cost estimates has been conducted for each horizon.

- Horizon timing

  A sensitivity test of shifting all horizons to begin construction as early as possible, and of delaying construction for all horizons by five years has been conducted and included below. The incremental results of this sensitivity test on each horizon are also included in the Appendix in Section 12.

- Wider economic benefits (WEBs)

  A +/-25% of the WEBs was tested because this is considered to capture the level of certainty attached to the WEBs component. An additional 'no WEBs' sensitivity test has been included for completeness; however, it is noted that this programme is expected to generate WEBs and the only uncertainty relates to the magnitude of these WEBs.

  'No WEBs' benefit cost ratios for incremental results have also been included in the Appendix in Section 12. More details of work into understanding the WEBs is included in the Appendix in Section 9.4.1.

- Health benefit from walking to public transport

  This benefit applies the health benefit value from the EEM to the number of PT trips, assuming the average distance walked at each end of a trip is 500m. Evidence supporting this assumption is included in the Appendix in Section 9.1.5. This average length at each end of a trip is sensitivity tested with 200m.

- Public transport reliability benefit

  The reliability benefits estimated for the A2B project are (just) outside the EEM limit, which does not allow reliability benefits to be greater than travel time benefits. The magnitude of these benefits is nevertheless considered sensible, given the significant infrastructure improvements in the options, that affect reliability more than average travel times. Nonetheless, to understand the impact of this benefit, some sensitivity tests are included.

Table 12: Sensitivity testing of programme economics

Test type	Assumptions	Horizon 4 BCR	Horizon 5 BCR
Base assumptions		2.5	3.0
Evaluation parameters	Standard evaluation period *4% discount rate,* *40-year evaluation period*	1.7	2.0
	Previous EEM parameters *6% discount rate,* *40-year evaluation period*	1.3	1.5
Costs	95^{th} percentile cost	2.2	2.6
Horizon timing	Early: construction for Horizons 1-4 begins in 2023, for Horizon 5 in 2024	2.3	2.8
	Delayed: all horizons delayed by 5 years	2.7	3.2
Wider economic benefits	No WEBs (unrealistic)	2.1	2.5
	-25%	2.4	2.9
	+25%	2.6	3.1
Health benefit from walking to PT	Assume average walk at each end of trip is 200m (instead of 500m)	2.4	2.9
	-15%	2.4	2.9

Test type	Assumptions	Horizon 4 BCR	Horizon 5 BCR
Reliability benefit	+15%	2.5	3.0

The programme cost-benefit assessment is relatively insensitive to almost all of these assumptions. Despite this, care has been taken to ensure the most appropriate assumptions for each of these tests have been included in the base economic assessment. The only assumptions that have a meaningful impact on the programme BCR are the evaluation parameters.

The results are very sensitive to the evaluation parameters applied, so it is important to ensure the most appropriate ones have been selected for the base assumptions. The new MBCM parameter of a 4% discount rate and an extended 60-year evaluation period are reasonable for this programme, with horizons coming online between 2025-2040. A 40-year evaluation period would be half-finished by the time horizon 5 is expected to be implemented and would therefore not provide enough opportunity for benefits to recoup the costs of that horizon.

8 Summary

The costs and benefits are computed based on the latest recommended project staging (first operational year in brackets), as follows:

- Horizon 1 (2021): Short-Term Airport Access Improvements (constructed by 2021). This forms the base case for the long-term projects.
- Horizon 2 (2025): A2B service extension to Botany.
- Horizon 3 (2030): Construction of ultimate SH20B corridor (both for A2B and for general traffic under 20Connect).
- Horizon 4 (2035): Construction of the ultimate A2B rapid transit infrastructure for the full corridor.
- Horizon 5 (2040): Construction of the ultimate 20Connect infrastructure on state highways 20 and 20A.

The assessment finds that these interventions result in a programme BCR of 3.0, with sensitivity tests of evaluation parameters (discount rate and evaluation period) resulting in a BCR of 1.5-3.7 and all other sensitivity tests leading to a BCR of 2.5-3.2. The BCR for the programme up to Horizon 4 (ie excluding highway improvements on SH20 and SH20A) is estimated at 2.5.

Construction costs account for the greatest proportion of projected costs. They account for 72% of all costs for the full Southwest Gateway Programme. Land acquisition costs and public transport operating costs each account for a similar share of project costs to one another, at around 12% of total costs each.

Road user travel time benefits comprise the largest proportion of total benefits, at 48%; followed by agglomeration benefits contributing 12% of the total benefits. Other benefits contributing more than 5% each include public transport user benefits, public transport reliability benefits, vehicle operating cost benefits, and driver frustration benefits.

Sensitivity tests reveal that the benefit cost ratio is meaningfully sensitive to the assumed discount rate and evaluation period. The base economic assumptions (4% and 60 years) are considered most appropriate for this programme, with later horizons only becoming operational 15-20 years into the evaluation period, such that a 40-year evaluation period would be too short.

Approved by:

Title	Name	Position	Signature	Date
Author	[redacted]	Consultant - Transport Planning and Economics	[redacted]	17 December 2020
Reviewer	[redacted]	Sustainable Transport Planner	[redacted]	17 December 2020

9 Appendix: Detailed methodology of benefit calculations

This Appendix provides additional detail about the methodology for computing the benefits outlined in Section 6. The following sections are organised by modelling approach used.

- Transport benefits from MSM (Section 9.1)
- Transport benefits from SATURN (Section 9.2)
- Transport benefits from Auckland Cycling Model (Section 9.3)
- Wider economic benefits (section 9.4)
- Other transport benefits, out-of-model (Section 9.5).

9.1 Standard transport benefits from MSM

9.1.1 Inputs and data

Transport model outputs

Auckland Forecasting Centre's MSM was run to produce forecasts for the base case scenario (a 'do-minimum' option) and the preferred option scenario. The model output contains origin-destination matrices between the 596 MSM zones, with different matrices for each scenario (base or option), matrix type (number of trips, distance, and generalised cost of trips), mode (car and public transport), and purpose (commute, work, etc), for the AM peak period for a typical work day of the scenario year.

The generalised cost matrices are represented as minutes per user trip, which are converted to assessment year dollars per user trip using the EEM values of time depending on trip purpose. The 2019 values of time [10] are:

- Work trips: $36.73 per hour
- Commuting trips: $12.01 per hour
- Other trips: $10.63 per hour

All generalised cost matrices mentioned throughout this and following sections refer to the adjusted generalised costs, in assessment year dollars.

In the base scenario, transport user benefits and other categories of benefits, such as health benefits and emissions reduction benefits, were assumed to be constant in real terms – ie they were not assumed to increase over the evaluation period.

Future land use

The MSM models are based on the Auckland Plan land use scenario i11.5, which is the accepted source for land use and transport planning in Auckland. The i11.5 land use scenario projects residential population and employment by MSM zone.

Economic data

MRCagney's (2016) *Urban Productivity Database for Auckland* was used for estimates of economic activity (GDP) and employment by Census area unit and ANZSIC one-digit industry sector. This database was estimated using economic data from Statistics NZ's *Regional GDP* series and the

[10] 2019 values of time calculated from the EEM using: Table A4.1b, Table A12.3 (EEM benefit update factors).

2013[11] New Zealand Census. It provides detailed estimates of GDP, full-time-equivalent employment, and income, by industry sector and Census area unit. This data was resampled to MSM zones using a weighted average by area.

Parameter values

Parameter values for benefits were sourced from the EEM and supplemented with additional information where needed.

Benefits are computed for each MSM period (AM, IP, SP, PM, OP) to estimate the daily benefit, and then annualised. Annualisation factors were computed by MRCagney as Auckland Forecasting Centre does not have suggested annualisation factors for their transport models.

The annualisation factor for public transport travel has been estimated at 320. The following methodology was used to determine this factor:

1. Compute the average boardings per trip from the base 2016 MSM model run
2. Apply the average boardings per trip to the modelled number of trips to determine the total modelled boardings
3. Compare the 2016 total MSM modelled boardings (from step 2) to Auckland Transport's reported annual public transport boardings for 2016 to get the annualisation factor

The annualisation factor for car travel has been estimated at 343. The following methodology was used to determine this factor:

1. Collect Auckland Transport's Traffic Count data from July 2012 to March 2019
2. Compute totals from all samples: 5 Day ADT, Saturday ADT, Sunday ADT
3. Compute total estimated annual trips from the data compiled in step 2, by assuming an average year has 52 weeks with five weekdays, one Saturday and one Sunday
4. Divide total estimated annual trips by the total estimated 5 Day ADT (weekday).

9.1.2 Notation and sources for benefit equations

To ease notation throughout, all matrices are denoted by capital letters and all matrix operations are computed pointwise, eg *A* + *B* and *AB* denote the pointwise sum and the pointwise product of matrices *A* and *B*, respectively. To avoid a multitude of subscripts in equations, the (i, j) notation for matrices is only included where summing across one or both of these indices.

Notation	Value	Description	Source
$\boldsymbol{D^S_{m,p,T}}$		Demand for scenario S, mode m, purpose p, time period T	MSM output: demand (number of trips) matrix
$\boldsymbol{GC^S_{m,p,T}}$		Generalised cost (minutes) for scenario S, mode m, purpose p, time period T	MSM output: generalised cost (origin-destination) matrix adjusted to dollars as described in Section 9.1.1 of this report
$\boldsymbol{L^S_m}$		Length (km) of trip for scenario S, mode m	MSM output: distance matrix
$\boldsymbol{AGC^S}$		Average (across mode and/or purpose) generalised cost for scenario S	*See Section 9.4.4*

[11] Since the time of assessment, this has been updated to use 2018 data; the effect on results is minor and increases the benefits, so the results reported here have not been updated to reflect these updated inputs.

Notation	Value	Description	Source
δGC_i		Total annual commuting cost savings in the option compared to the base scenario, for commuters living in zone i	See Section 9.4.4
$B_{m,p}$		Travel time benefit for mode m and purpose p	See Section 9.1.3
V		Variability of journey time	See Section 9.1.4
GDP_i		GDP in zone i	Statistics NZ Business Demography data, Statistic NZ Regional GDP data, and Census 2013
E_i^z		Full time equivalent employees in zone i and sector z	Statistics NZ Business Demography data, and Census 2013
ED_i^S		Effective density of employment for scenario S, zone i	See Section 9.4.2
δPR_i		Relative productivity gain for zone i	See Section 9.4.2
dPR_i		Absolute increase in productivity in zone i	See Section 9.4.2
ε^z		Agglomeration elasticity in sector z	EEM Table A10.1
ε_i		Agglomeration elasticity for zone i	See Section 9.4.2
y_i		Mean personal income per worker living in zone i	See Section 9.4.4
M_i		Mean personal productivity per worker living in zone i	See Section 9.4.4
$k_{emp,i}$		Factor of full-time equivalent workers to total workers in zone i	Statistics NZ Business Demography data, and Census 2013
v_o	$10.63 per hour	Value of 'other' time	EEM: Table A4.1b, Table A12.3 (EEM benefit update factors)
v_c	$12.01 per hour	Value of commuting time	
v_w	$36.73 per hour	Value of work time	
v_{ave}	$13.93 per hour	Average value of time in AM peak (given mix of journeys in EEM)	EEM: Table A4.1b, Table A2.4, Table A12.3 (EEM benefit update factors)
a_m	Car = 343 PT = 320	Annualisation factor for mode m	MRCagney estimates, described in section 9.2.1
d	1km	Average distance walked per PT trip	EEM Section A20.2
r_e	CO: 4.741g/km CO_2: 226.4g/km PM10: 0.03979g/km NO_x: 0.5176g/km	Emissions rate for emissions type e	Sridhar et al (2014) Table A.3, based on average across all vehicles except heavy vehicles and buses.
ε^{ls}	0.4	Elasticity of labour supply with respect to effective wages	Kernohan and Rognlien (2011) Table 10.7
τ^{ls}	0.32	Factor to convert gross to net earnings	Kernohan and Rognlien (2011) Table 10.7

Notation	Value	Description	Source
τ^{tax}	0.26	Tax take on increased labour supply	Kernohan and Rognlien (2011) Table 10.7
k_{walk}	\$3.22/km	Monetary health benefit factor	EEM Table A20.3 and Table A12.3 (walking and cycling update factor)
k_e	CO: \$4.54/tonne CO_2: \$72/tonne PM10: \$506,013/tonne NO_x: \$17,982/tonne	Monetary emissions factor for emission type e	For CO_2: EEM Section A9.7; for all other emission types: EEM Table A9.1, Updated with Ministry of Transport's *Value of Statistical Life*
k_{comp}	0.107	Imperfect competition uplift factor to business user benefits	EEM Table A10.3
k_y	$1.026^{2020-2013}$	Price inflation and productivity increases from the economics year (2013) to the assessment year (2020)	Stats NZ labour productivity statistics (0.6% productivity growth per annum from 2013 to 2015) Stats NZ implicit GDP price deflator used to calculate inflation – 2.0% per annum from 2013 to 2016

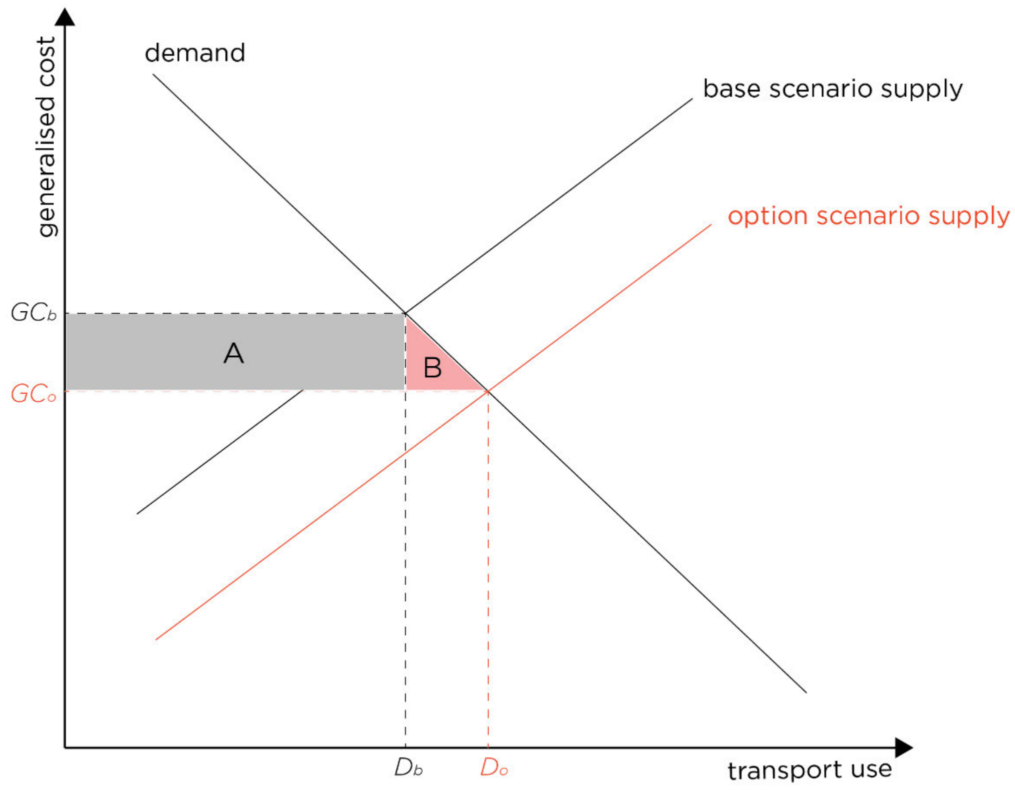
9.1.3 Travel time benefits

The travel time benefit includes the car travel time benefit and the public transport travel time benefit.

The car travel time benefit for A2B was computed using MSM data. Section 9.2.2 details the methodology for calculating transport user benefits from 20Connect, which was conducted using SATURN.

The travel time benefits assume that an improvement to transport infrastructure shifts the supply curve outwards. This means that users can make the same trips at a lower cost, as shown in Figure 6. The resulting benefits are then computed as the difference in travel cost between the base and option scenario, adjusted to consider that new users who may be induced to travel (or switch modes) by an improvement will tend to place a lower value on the opportunity to travel than people who were already travelling.

Figure 7: Transport use supply and demand curves with benefits shaded assuming the standard approximation for consumer surplus



In this graph, the benefit of a supply increase for existing users is given by the area, $A = (GC^b - GC^o)D^b$. The benefit for new users is given by the area $B = (1/2)(GC^b - GC^o)(D^o - D^b)$, including a 'rule of half' adjustment to reflect the fact that new users generally have a lower willingness to pay for travel than existing users. Total benefit is $A + B = (1/2)(GC^b - GC^o)(D^b + D^o)$.

Thus, the user benefit (for each origin-destination pair) for each mode m and purpose p is:

$$B_{m,p} = a_m \sum\nolimits_T (1/2)\left(GC^b_{m,p,T} - GC^o_{m,p,T}\right)\left(D^b_{m,p,T} + D^o_{m,p,T}\right),$$

for:

- T in all time periods

$D^S_{m,p,T}$ is the demand matrix for scenario S, mode m, purpose p, time period T; $GC^S_{m,p,T}$ is the generalised cost matrix for scenario S, mode m, purpose p, time period T; a_m is an annualisation factor (343 for cars and 320 for PT). The total benefit for each mode is then computed as follows:

$$Standard\ user\ benefit = \sum\nolimits_{p,(i,j)} B_{m,p,(i,j)}$$

for:

- p in all time purposes
- i, j in all origins and destinations

9.1.4 Public transport reliability benefit

Reliability represents the consistency of travel times for journeys taking place on the same corridor at similar times on different days. It can be measured by looking at the distribution of travel times for repeated journeys. A common approach to valuing improved reliability is to calculate the reduction in the standard deviation of travel times resulting from the project (EEM Appendix A4.5; Small and Verhoef, 2007). Under this approach, users are expected to time their departures to arrive on time or early roughly 85% to 90% of the time.

Public transport reliability benefits are estimated separately to the benefits that are derived directly from the model outputs. This is because the model does not estimate variation in travel times, thus reliability benefits cannot be estimated without further investigation. Public transport reliability benefits reflect reductions in variability of travel time on the relevant segment of the route resulting from improved public transport vehicle priority.

These benefits can be valued using analysis of real-time data and supplementary estimates about the typical variability of travel time in various settings with different levels of public transport vehicle priority. For an individual corridor, reliability can be measured as the difference in travel time along that segment between the median journey time (50th percentile, P50) and the upper decile journey time (90th percentile, P90). This figure reflects how much variation in travel time users are likely to account for in journey planning, as variation in journey times increases the amount of time users need to allow for travel to ensure they are likely to arrive at their destination on time.

The variability for a given period is:

$$\mathrm{V_S} = P90 - P50$$

where $\mathrm{V_S}$ is a measure of variability for a given time period and option for scenario S. The variability for the option scenario would be represented as $\mathrm{V_o}$. The change in variability can then be denoted as:

$$\Delta V = V_b - V_o$$

where $\Delta\mathrm{V}$ represents the change in variability in the option compared to the base case. The standard rule of half[12] (explained in Section 9.1.2) is applied to reliability benefits, such that existing users experience the full benefit, whilst new users experience only half the benefit reflecting the lower willingness to pay of new users. The effective demand for the reliability benefit is therefore:

$$D = D^b + \frac{1}{2}(D^o - D^b)$$

where D^b is the demand in the base case and D^o is the demand in the option scenario. The reliability benefit is computed by applying the reduction in variability to the effective demand for the given period and multiplying by an annualization factor and the average value of time.

$$Reliability\ benefit = a_{PT}\ v_{ave}\ (D_{AM}\ .\Delta V_{AM} + D_{PM}\ .\Delta V_{PM})$$

where a_{PT} is an annualization factor of 250 (the number of workdays per year), v_{ave} is the average value of time ($13.93 per hour), and $\mathrm{D_{AM}}$ is the effective demand in the AM peak.

Benchmarking future reliability

Travel time variability for future services must be estimated separately to the model outputs because the MSM models estimate only an average travel time, not a range of travel times. An upper limit of travel times must therefore be estimated in order to estimate future variability.

An upper limit of modelled travel times can be estimated by applying the current (2019) ratio of P90/P50 to estimated future median travel times (based on average travel speed assumptions). By

[12] NZEEM (2016 update), section 4.3.3, page 4-68.

applying the current ratio of P90/P50 to future estimated median travel times, the estimated variability will increase as median travel times increase (reflecting the negative impact of congestion on variability). The formula for estimating an upper limit (equivalent to the 90th percentile travel time) is therefore:

$$P90_y = \frac{P90_{2019}}{P50_{2019}} * P50_y$$

where $P50_y$ is the estimated 50th percentile travel time in the future year y, and $P90_{2019}$ (or $P50_{2019}$) is the 90th (or 50th) percentile travel time in 2019 based on Auckland Transport real time data. Each travel time estimate is specific to a direction, period (eg AM) and scenario (ie base case or A2B option).

Once the upper limit travel time ($P90_y$) has been estimated, the future variability estimate can be computed using the equations defined above in 9.1.4.

Assumptions for future reliability estimates

The reliability calculations require inputs for the:

- Peak periods (for which reliability benefits will be calculated),
- Ratio of P90/P50 in 2019 (to benchmark future reliability), and
- Estimated bus travel speeds (for estimating the future year P50 and P90).

The assumptions made for each of these inputs are detailed below. As reference, the Appendix in Section 10 includes the charts of the observed ratio of 90th to 50th percentile travel times for each of the segments from February 2019 data.

Peak periods

The peak periods were defined by observing the real time bus travel time data from February 2019 and identifying the periods when travel times were slower and variabilities greater (ie the periods where reliability improvements would be material). The plots of P90/P50 throughout the day, that were used to inform the peak periods, are included in the Appendix in Section 10. The resulting peak periods are defined in Table 15.

Table 13: Peak period assumptions for reliability benefit estimates

Segment	Direction	AM	IP	PM	Evening
Te Irirangi Drive (north)	Northbound	8am – 10am	1pm – 5pm	5pm – 7pm	8pm – 10pm
	Southbound	7am – 9am	1pm – 3pm	3pm – 5pm	NA
Te Irirangi Drive (south)	Northbound	7am – 9am	2pm – 5pm	5pm – 7pm	NA
	Southbound	7am – 9am	9am – 11am 1pm – 5pm	5pm – 7pm	NA
SH1 bridge(1)	Eastbound	7am – 9am	2pm – 5pm	5pm – 7pm	NA
	Westbound	7am – 9am	9am – 11am 1pm – 5pm	5pm – 7pm	NA
Manukau (east of Manukau Station)	Eastbound	7am – 9am	12pm – 5pm	5pm – 7pm	NA
	Westbound	7am – 9am	3pm – 5pm	5pm – 7pm	NA
Manukau (west of Manukau Station)(2)	Eastbound	7am – 9am	4pm – 6pm	NA	NA
	Westbound	7am – 9am	4pm – 6pm	NA	NA

Segment	Direction	AM	IP	PM	Evening
Puhinui Road[2]	Eastbound	7am – 9am	4pm – 6pm	NA	NA
	Westbound	7am – 9am	4pm – 6pm	NA	NA
SH20B[2]	Eastbound	7am – 9am	4pm – 6pm	NA	NA
	Westbound	7am – 9am	4pm – 6pm	NA	NA

[1] The SH1 bridge segment relies on the same real time data as the Te Irirangi Drive (south) segment, because there are currently no bus routes that travel over this bridge.

[2] Note that these segments use the standard definitions of peak periods for public transport because the short-term improvements are expected to ease the existing variability issues in the interpeak periods.

Ratio of 90th to 50th percentile travel times

The ratio of 90th to 50th percentile travel times (P90/P50) were defined based on observations from the real time bus travel time data from February 2019. The base case P90/P50 is the P90/P50 from real time data for each hour of the day. The current interpeak variability was considered a reasonable estimate for the achievable P90/P50 with an rapid transit option. The plots of P90/P50 throughout the day for each segment are included in the Appendix in Section 10. The resulting benchmark P90/P50 ratios are shown in Table 16.

Table 14: Benchmark ratio of 90th to 50th percentile travel times

Segment	Direction	Base case P90/P50	A2B P90/P50
Te Irirangi Drive (north)	Northbound	1.20 – 1.75	1.15
	Southbound	1.16 – 1.26	1.15
Te Irirangi Drive (south)	Northbound	1.26 – 1.50	1.20
	Southbound	1.29 – 1.83	1.20
SH1 bridge[1]	Eastbound	1.26 – 1.50	1.20
	Westbound	1.29 – 1.83	1.20
Manukau (east of Manukau Station)	Eastbound	1.27 – 1.71	1.26
	Westbound	1.22 – 1.44	1.26
Manukau (west of Manukau Station)[2]	Eastbound	1.20	1.15
	Westbound	1.20	1.15
Puhinui Road[2]	Eastbound	1.20	1.15
	Westbound	1.20	1.15
SH20B[2]	Eastbound	1.20	1.10
	Westbound	1.20	1.10

[1] The SH1 bridge segment relies on the same real time data as the Te Irirangi Drive (south) segment, because there are currently no bus routes that travel over this bridge.

[2] Note that these segments assume a constant base case P90/P50 of 1.20 because that is the assumed variability benchmark following the short-term improvements. The other segments use a range, based on the 2019 observed P90/P50 for each hour of the day.

Estimated travel speeds

Travel speeds along each segment need to be estimated to provide a 'median' travel time along segments. This median travel time can then be combined with the P90/P50 ratio to compute the expected upper limit of travel times, and therefore the change in variability in different years and options. The estimated travel speeds for each segment are shown in Table 17.

Table 15: Average A2B travel speed estimates (including accelerating, braking and dwell time at stops)

Segment	Base case (km/h)	A2B (km/h)
Te Irirangi Drive (north) (1)	25	41
Te Irirangi Drive (south) (1)	15	36
SH1 bridge (1)	15	30
Manukau (east of Manukau Station) (1)	15	27
Manukau (west of Manukau Station) (2)	18	27
Puhinui Road (2)	21	39
SH20B (2) (3)	32	41

Applying reliability benefit to each horizon

The reliability benefit for each horizon is computed using:

- Peak period assumptions in Table 15,
- Benchmark P90/P50 ratios for the base case and for the option, as shown in Table 16,
- Estimated travel speeds in the base case and the option, as shown in Table 17,
- Modelled passenger demands for each segment in Horizon 5, and
- A factor for each horizon of the number of A2B trips on each segment in each Horizon, so that the benefit can be factored down based on the network effects of have a direct, connected, reliable service for the extent of the A2B journey.

The reliability benefit for each segment of the corridor is computed and allocated to the horizon in which that segment is upgraded to its ultimate design. An early benefit is computed for Te Irirangi Drive, using a P90/P50 ratio of 1.60 to align with the Medium Term reliability assumptions, is also allocated in Horizon 2, to capture the expected benefit of improvements expected on Te Irirangi Drive prior to the final infrastructure being completed in Horizon 4.

9.1.5 Health benefits from added walking to access public transport

Health benefits may arise from increased walking due to a reduction in car trips that are transferred to public transport trips. The methodology for calculating this benefit is described here and is based on MSM data.

This benefit is separate from health and environmental benefits that may arise from increased walking due to improved pedestrian infrastructure. Those benefits are estimated for new shared paths as part of 20Connect and discussed in the Appendix in Section 9.5.1.

Following the EEM, health benefits from added walking to access public transport is computed from the following formula:

$$a_{car}\,(D^b - D^o)\,d\,k_{walk},$$

where D^o is the daily demand for car user trips in the option scenario; D^b is the daily demand for car user trips in the base scenario; d is the average walking distance of a public transport user (1km); k_{walk} is a health factor ($3.15/km); a_{car} is the annualisation factor for car trips (343).

The assumed average walking distance of a public transport user (1km) represents an average walk of 500m at each end of the public transport journey. This is expected to be a conservative estimate, as people tend to walk further than 500m to and from rapid transit stations (Wilson, 2013) and most of the additional trips in these models are likely to be connecting to A2B, which is a rapid transit service. Sinclair Knight Merz Ltd (2013) found that the mean walking distance to/from bus stops in Auckland is 300-390m, to/from ferry terminals is 610-950m, and to/from train stations is 1320-1430m. As rapid transit, it is expected that the rates for walking to/from train stations is most appropriate, which has been found to be much greater than the 500m at each end of the journey that we assume.

Additional health benefits from walking to stations could be realised if pedestrian links to stations are improved as part of the A2B programme, and if these links induce more public transport users. Benefits from such improvements have not been quantified due to the high degree of uncertainty about the type and number of improvements that will be implemented, and the number of pedestrians expected to be using each of the upgraded facilities.

9.1.6 Emissions reduction benefits from mode shift from private vehicles to public transport

This emissions benefit comes from lower tailpipe emissions from lower vehicle use (due to mode shift to public transport), which can improve environmental quality and reduce health costs. Here we consider carbon monoxide (CO), carbon dioxide (CO_2), fine particulate (PM_{10}, or particles with a diameter of less than 10 microns), and nitrogen oxide (NO_x) emissions, because we have reliable data for these. Using MSM data for car use and following EEM Section A9.3, the benefit for each emission type was estimated separately via the formulas:

$$\Delta L = \sum_{(i,j)} L^b_{car,(i,j)} - L^o_{car,(i,j)},$$

followed by:

$$a_{car} \sum_e r_e\, k_e\, \Delta L,$$

for:

- e in the emissions types: $CO, CO_2, PM10, NO_x$

L^b is the daily distance travelled by car in the base scenario; L^o is the daily car distance travelled in the option scenario; r_e is the vehicle emission rate (g) per unit of distance travelled (parameter values in

Section 9.1.2); k_e is the monetary emission factor per gram (the per tonne parameter values are presented in Section 9.1.2); a_{car} is the annualisation factor for cars (343).

The emissions reduction benefits resulting from shifting from diesel buses to electric bus vehicles as part of the A2B project have not been estimated as this shift is considered to be business as usual for AT.

9.2 Standard transport benefits from SATURN

9.2.1 Annualisation of Benefits

Road user benefits have been assessed using the predicted travel times and distances travelled from the SATURN traffic models. These have been calculated for each of the three modelled periods, being morning peak, inter peak and evening peak periods. Weekend peak user benefits have been included by applying a factor to the inter peak models. Off-peak (night time) traffic volumes are relatively low, compared to those in the inter peak, so off-peak benefits have not been taken into account at this time. The annualisation factors used to calculate the annual road user costs are as follows:

- Morning Peak – 245 days with 2 hours per day
- Inter Peak – 245 days with 9 hours per day
- Evening peak – 245 days with 2 hours per day
- Weekday Off Peak – not taken into account
- Weekend Peak – 120 days with 10 hours per day (based on 109% of the inter-peak hour model outputs)
- Weekend Off Peak – not taken into account

Traffic counts along SH20 and SH20A, obtained from the NZ Transport Agency's Traffic Monitoring System (TMS), were used to calculate the above annualisation factors.

Heavy Commercial Vehicle (HCV) have not been included as a separate user class in the models. As such, benefits associated with HCVs have been not estimated separately as part of this assessment. Instead, HCV benefits have been calculated using the average value of time for all vehicle types (which is based on a low percentage of HCVs in the network). This may lead to a more conservative estimate of road user benefits, as travel time savings for HCV trips have greater economic value per minute and the percentage of HCV trips to and from the Auckland Airport are expected to be high.

9.2.2 Travel Time, Congestion Relief and Trip Reliability Savings

Network summary statistics produced by the SATURN traffic models have been used to calculate travel time benefits for each option, and values of time from Section A4.3 of the EEM, for an Urban Arterial, have been used. These are:

- $22.70 for morning peak period travel ($15.13 x 1.50 travel time update factor)
- $26.93 for inter-peak period travel ($17.95 x 1.50 travel time update factor)
- $22.44 for evening peak period travel ($14.96 x 1.50 travel time update factor)
- $21.14 for weekend travel ($14.09 x 1.50 travel time update factor).

Total travel time savings are made up of three components. These components include base travel time savings, Congestion Relief (CRV) and trip reliability savings.

Congestion Relief benefits are based on the SATURN outputs for turn delays and delays on links.

Trip reliability benefits are assumed to contribute an additional 5% of the total travel time savings. This is a common assumption for projects of this nature.

9.2.3 Vehicle Operating Costs and Vehicle Emission Costs

Vehicle operating cost savings have been based on the total distances travelled which are multiplied by an operating cost (based on urban arterial running costs) which are derived from the average speeds travelled by vehicles in the networks.

Vehicle emission costs are assumed to be 4% of the calculated vehicle operating costs, as specified in the EEM.

9.3 Standard transport benefits from the Auckland Cycling Model

The Auckland Cycling Model (ACM), developed by Flow, has been used to provide estimates of the benefits from new or improved cycling infrastructure.

Flow's economic evaluation has generally been based on the cycling and pedestrian benefits procedures within Simplified Procedures 11 (SP11) from the EEM. Recognising however that SP11 contains a number of simplistic approximations, Flow has extended SP11 procedures, primarily by using the 2028 and 2038 ACM to inform the economics, rather than SP11's default demand estimation tool.

Cycling benefits for intermediate years have been interpolated from the 2 forecast years. This differs from SP11, which typically considers only a single opening year, and applies a cycle growth rate to future years.

Flow's economic evaluation for cycling and pedestrian benefits has been carried out using the EEM's most recent update factors (1 December 2018), including:

- 1.21 for walking, cycling and public transport benefits
- 1.50 for travel time cost savings
- 1.07 for vehicle operating cost savings
- 1.06 for crash costs.

Economic benefits related to cycling have been calculated for the following categories, which are explained in further detail in the following sections:

- Travel time benefits for cyclists (Section 9.3.2)
- Health and benefits from increased cycling (Section 9.3.3)
- Safety benefits for cyclists (Section 9.3.4)
- Decongestion benefits for general traffic from new cycling trips (Section 9.3.5)

This section provides an overview of the benefits generated by the ACM. Additional detail on Flow's methodology estimating economic benefits from increased cycling can be found in the document *Southwest Gateway Walking and Cycling Improvements, Economic Benefit Evaluation* from March 2020 (Section 18).

Additional benefits beyond those calculated here may accrue from proposed investment to improve walking and cycling access routes to A2B stations, which are likely to increase walking and cycling to A2B stations and possibly increase total A2B patronage. These effects would generate additional benefits not quantified by the ACM, including health and environmental benefits from additional walking to stations, and benefits from reduced vehicle congestion in the road network. These potential benefits are discussed further in section 9.4.

9.3.1 Modelling cycling demand

Demand estimates are determined using the 2028 and 2038 ACM. This model estimates future cycling demand and:

- Reflects predicted land use (using to Auckland Council's most recent Scenario i11.5 land use forecasts)
- Reflects cyclists' route choice – with cyclists generally opting to travel via a slightly longer route if it provides a higher standard of infrastructure, or less adverse gradients
- Reflects realistic cycling trip lengths – with longer trips less likely to be undertaken by bicycle than shorter trips, with a probability distribution applied that is based on the existing Auckland cycle trip length distribution
- Reflects realistic cycle trip types – with trip types such as home-to-work and home-to-education more likely to be undertaken by bicycle than trip types such as trips for employer's business
- Is responsive to changes in cycle infrastructure (in terms of both demands and trip assignment), in that high-quality cycle infrastructure between any two nodes will result in more trips between those nodes being undertaken by bicycle, than a scenario with poorer quality cycle infrastructure
- Reflects "network effects" and as a result predicts higher cycle demands where a connected cycle network is provided; conversely the model predicts fewer cycle demands where a network is disconnected or is missing critical links between origin-destination pairs.

The model was built to represent a 2013 base year, and a 2016 forecast model has also been developed. This 2016 forecast model included all cycling infrastructure constructed between March 2013 and July 2016, notably including recently completed infrastructure at that time including Grafton Gully, Nelson Street, LightPath, Beach Road, and Carlton Gore Road.

The 2016 model was then calibrated against automated cycle count data collected from 21 locations, to refine the model's cycle demand process. In this way, the model's response to cycle infrastructure investment has been calibrated to match the growth observed between 2013 and 2016, given the investment in Auckland cycle infrastructure over this period.

For the economic evaluation of the Project, 2028 and 2038 forecast models have been used. These models are based on Auckland land use scenario i11.5 (the most recent available, and that reflecting Auckland Unitary Plan zoning).

The model represents morning and evening peak period (two hour) cyclist demands for each forecast year. Estimates of daily cyclists have been developed by factoring the peak period model outputs.

Sensitivity tests were conducted for walking and cycling demand. These have not been included in the economics assessment, as including even the most extreme sensitivity test was found to not change the programme BCR.

9.3.2 Travel time benefits for cyclists

Perceived travel time cost savings for cyclists have been determined for all existing cyclists, as per SP11. Existing cyclists have been determined by running the 'Project' model networks with the 'Reference Case' demand set. This 'fixed trip assessment' allows the number of existing cyclists that would reassign onto each investment option to be quantified; ie the total 'existing cyclists' required input to calculate travel time cost savings.

Travel times have been adjusted to reflect perceived travel times, depending on the quality of the cycle infrastructure on each modelled link. This is consistent with the approach applied in SP11, which adjusts travel times for Relative Attractiveness, applying ratings of 2.0 (for an off-street cycle path) to 1.0 (for on-street cycling on an arterial road with no cycle infrastructure). The evaluation has applied a graduated scale within this range, to account for the qualities of cycle infrastructure.

Travel time cost savings for cyclists have also been determined for all new cyclists predicted to use the proposed facilities, by applying the ‘rule of half’ method. This method assumes that new users gain half of the travel time benefits of existing users, relative to their travel choice without the Project (ie using other modes or not travelling at all).

A value of time of $11.16 has been applied, being the weighted average of $7.80 (cycling for commuting) and $6.90 (cycling for other purposes), updated by the current 1.50 EEM value of time update factor, and weighting for the estimated relative proportions of commuter cyclists to recreational and school cyclists. Data obtained from surveys on Quay Street and Tamaki Drive has been used to estimate these proportions (where 50% of daily cyclists were commuters); a higher proportion of commuter cyclists (60%) has been applied to the Southwest Gateway programme, where there are expected to be fewer recreational users than either Tamaki Drive or Quay Street.

It is noted that travel time cost savings may or may not be applicable to all recreational cyclists. In this instance, ‘recreational’ refers to a range of different user types, some of whom may benefit from improved perceived travel times, and some of whom may not. The issue of travel time savings in the case of recreational trips is not well defined within the EEM, and economic evaluation procedures do typically apply travel time cost savings to recreational car trips. As recreational travel time cost savings are a relatively small component of the overall benefits in this assessment, these have not been adjusted to account for users that may or may not gain these benefits.

Mean speeds of 20 km/h have been applied to both the Reference Case and Project, based on typical on-street cycle speeds obtained from cycle tube counters.

9.3.3 Health benefits from increased cycling

SP11 calculates health benefits only for that portion of a new cyclist’s trip that takes place on the facility itself, as per Equation 1 below. This is a significantly conservative assumption, as new cycle trips due to the Project are predicted on average to be in the order of 6 km long, while only a portion of that trip will be on the Project itself. The health and environment benefits calculation is:

Length of new cycling facility x *Number of new daily cyclists* x *Benefit rate from SP11*

It is also noted that some existing cyclists will gain health benefits from the project, if, by changing from their existing, arterial road route onto the new facility, they cycle a greater distance (choosing to do for the safety and amenity of the new facility).

To better account for this benefit stream, cyclist health benefits have been calculated for the collective increase in distance cycled, due to each investment option. This quantity has been obtained directly from the model, with the total length of cyclist-km travelled under the Reference Case and Project scenarios compared, and the difference being the total distance of new (or extended) cyclist-km trips. This value replaces both the ‘Length of new cyclist facility’ and the ‘Number of new daily cyclists’ from Equation 1 above.

SP11 applies a composite rate of $1.40 to cyclist health and environment benefits, with $0.10 of this attributable to environment benefits (decongestion). To avoid double counting of benefits, this component has been removed from this benefit stream, and dealt with separately as documented in Section 9.3.5 subsequently.

9.3.4 Safety benefits for cyclists

SP11 allows cycle safety benefits to be calculated for both new and existing cycle trips, where an improved cycling facility is provided. These may be calculated either per cyclist-km travelled on new the new facilities, or alternatively per cyclist in the case of ‘hazardous sites’. The Southwest Gateway programme does not specifically address hazardous sites, so the per cyclist-km method is applied.

The calculation of this benefit stream follows the SP11 process, and applies the rate of $0.05 per cyclist-km travelled on improved routes. Forecast estimates of cyclists on each of the improved routes have been obtained directly from the ACM.

9.3.5 Decongestion benefits for general traffic from new cycling trips

Decongestion benefit rates

Decongestion benefits are a significant proportion of the overall project benefits, as each investment option would provide improved alternatives to private car travel on currently congested road corridors. As a result, any mode shift in favour of cycling will reduce existing (or forecast future) congestion on the road network.

The default SP11 decongestion value of $0.10 per new cycle-km travelled applies to all cycle trips, regardless of time of day or weekday, but is known to under value decongestion benefits.

The EEM also allows a decongestion value of $1.89 per vehicle-km removed from the commuter peak period network within Auckland (Table SP9.1, updated to 2018 values). This flat value was derived in 2008 however, and does not recognise how congestion may vary across Auckland however, nor how congestion may be expected to increase over time.

In lieu of a more area-specific value, the $1.89 per vehicle-km removed from the network during the commuter peak has been applied to the economic evaluation. This rate may be revised if/when more appropriate decongestion rates have been obtained from local traffic models.

Car diversion rates

It is important to recognise that not every new cyclist trip due to the Project would otherwise take place by private car. EEM Table SP9.1 provides a car diversion rate of 0.725 for new public transport trips within Auckland (ie 72.5% of new public transport person-trips are assumed to correspond to users who previously drove a car). It is expected that lower car diversion rates would apply to new cycle trips, but the EEM does not provide an alternative.

Car diversion rates have been developed and applied to the forecast new cycle trips at a matrix level. More detail is provided in the document *Southwest Gateway Walking and Cycling Improvements, Economic Benefit Evaluation* (Section 18). The resulting car diversion rates range from 0.48 to 0.55, which is sensibly lower than the 0.725 given in the EEM for new public transport trips.

Dis-benefits due to reduced general traffic provision

The cycle infrastructure proposed by the Southwest Gateway programme will generally either be off-road shared paths, protected cycle lanes, or traffic calmed quiet routes. These facilities are not generally expected to require reductions in the number of traffic lanes available for general traffic. However, where new signalised pedestrian and cyclist crossings of arterials are proposed, this may result in small travel time reductions for general traffic.

Section 2.7 of the EEM allows the Do Minimum to include the proposed operating speed, where a project seeks to “address unacceptable levels of collective and/or personal risk”. While the proposed improvements may not affect the operating speed on existing arterials as such, the proposed new crossings are required to address pedestrian and cyclist risk that would be unacceptable if the crossings were not installed. As such, changes in general traffic speeds or travel times are considered part of the Do Minimum, and have been excluded from the evaluation accordingly.

General traffic safety benefits

Recent research from the US[13] suggests that installing separated cycling infrastructure may lead to reduced crash rates for general traffic, as well as for bicycle users. The research concludes that safe cycle infrastructure has a traffic calming effect, reducing vehicle speeds and reducing the risk of death or serious injury among motorists.

The evaluation has conservatively omitted this potential benefit stream however.

9.4 Standard wider economic benefits from MSM

Standard 'static' wider economic benefits (which do not account for land use changes induced by A2B) are calculated following EEM procedures. These benefits used the same inputs and notations as described in sections 9.1.1 and 9.1.2.

9.4.1 Understanding the wider economic benefits

Waka Kotahi requested further detail to be provided on the computation of the WEBs, with questions particularly relating to:

1. Understanding why the WEBs in Horizon 2 are proportionally large compared to other benefits
2. Understanding the no-WEBs BCR because of uncertainty in the results

This section explains the guidance that was followed and the results obtained from that guidance and proposes sensitivity tests to understand the sensitivity of these estimates. The proposed sensitivity tests acknowledge that there is no question over whether these benefits exist or not, rather just around the magnitude of them.

Guidance in the Economic Evaluation Manual

The purpose of the Economic Evaluation Manual (EEM) (recently superseded by the Monetised Benefits and Costs Manual, albeit with largely the same content) is "to provide consistency, transparency and comparability between the economic efficiency of multiple activities." (EEM P1-2)

The EEM provides clear guidance on WEBs, including that (EEM P2-8) "the following wider economic benefits are applicable in the New Zealand context:

- Agglomeration where firms and workers cluster for some activities that are more efficient when spatially concentrated.
- Imperfect competition where a transport improvement causes output to increase in sectors where there are price cost margins.
- Increased labour supply where a reduction in commuting costs removes a barrier for new workers entering the workforce."

Therefore, WEBs are provided as a core component of the economic efficiency assessment of projects under the EEM.

In recent years, WEBs have been included in the base economic assessment for numerous projects, including both public transport and roading improvement projects. If these are excluded from the assessment of only some projects, like this one, there is a real possibility that this will result in

[13] Why are bike-friendly cities safer for all road users?; W.E. Marshall, N. Ferenchak and B. Janson; December 2018

inconsistency and lack of comparability between competing investments, which is counter to the function of the EEM.

Magnitude of benefits for these projects

Some concern has been raised that the WEBs estimated for these projects are larger than should be expected. This concern seems to relate only to the agglomeration benefit estimated for Horizon 2. A summary of the benefits is provided here to understand the relative magnitude of WEBs for each horizon.

Table 16: Incremental benefits for each horizon

Benefit group	Horizon 2 ($millions)	Horizon 3 ($millions)	Horizon 4 ($millions)	Horizon 5 ($millions)
Public transport-related benefits	$110	$92	$651	-$3
Standard road user benefits	$19	$2,283	-$90	$1,647
Active mode benefits	$0	$0	$53	$47
Wider economic benefits	$87	$405	$101	$267
Total project benefits	**$215**	**$2,779**	**$715**	**$1,959**

Table 17: Incremental proportional benefits for each horizon

Benefit group	Horizon 2	Horizon 3	Horizon 4	Horizon 5
Public transport-related benefits	51%	3%	91%	0%
Standard road user benefits	9%	82%	-13%	84%
Active mode benefits	0%	0%	7%	2%
Wider economic benefits	40%	15%	14%	14%
Total project benefits	***100%***	***100%***	***100%***	***100%***

Based on previous discussions, the *relatively* high proportion of WEBs in Horizon 2 appears to be driving the questions thus far. Regarding the questions raised, it is important to note that:

1. The arithmetic has been peer reviewed, with no subsequent concerns relating to methodology, and
2. It is the proportion of total benefits that has raised concern, not the magnitude of those benefits.

Each of these areas of concern are addressed separately here.

Confidence in estimates

MRCagney and peer reviewer (Richard Paling) have reviewed the methodology applied and sense-checked the results by isolating individual effects and elements of the agglomeration benefits. Furthermore, over time MRCagney has developed a library of code to compute economic benefits from EEM inputs and transport models to ensure our analysis on each project is consistent, robust and reproducible, giving us further confidence in the results generated.

Following this review, we are confident that the methodology that has been applied accurately applies the procedures from the EEM to Auckland Forecasting Centre's transport models that were run for these projects.

Any questions that remain relate to the underlying EEM procedures and/or the outputs of Auckland Forecasting Centre's transport models. Deviating from either of these simply because the benefits may be larger than on other projects seems counterintuitive to the purpose of the EEM to ensure projects can be compared on consistent grounds, having followed the same methodology.

Proportion of wider economic benefits in other transport projects

To help gain an understanding of whether or not the A2B results are outside of usual expectations we have undertaken a comparison of the relative magnitude of WEBs to transport benefits for a range of other Auckland projects and compared these result to the position for A2B. These results are presented in Table 20.

Table 18: Ratio of wider economic benefits to transport benefits

Project	Ratio WEBs to Transport Benefits
AMETI Stage 2A (EB1 & EB2)	51%
East West Link	35%
City Rail Link	37%
North West RT Corridor	41%
SWGP Full Programme	16%
Incremental benefits	
SWGP H2	*40%*
SWGP H3	*15%*
SWGP H4	*13%*
SWGP H5	*14%*

The comparison suggests that at the programme level A2B is generating a significantly lower level of WEBs relative to transport benefits (16%) than any of the other projects considered, including the East-West Link (35%).

This assessment does indicate that the SWGP Horizon 2 generates a significantly higher level of WEBs relative to transport benefits than any of the other Horizons (40%). However, when compared with the other Auckland projects referred to in the table the results for H2 do not appear to be unusually high.

Factors causing agglomeration benefit

We recognise that alongside the additional confidence in the computations of the economic benefits, it is meaningful to understand what factors from the transport model is causing the agglomeration benefit. Firstly, it is important to understand that despite Horizon 2 being the first stage in a large programme, the interventions are not minor. In particular, elements of Horizon 2 that are likely to drive WEBs include:

- Travel time improvements
  - Airport service extended to connect through to Botany, rather than terminating at Manukau.
  - Botany (metropolitan centre and connection to Eastern Busway) to Manukau (metropolitan centre, major employment centre and connection to rail network) travel time:

  - 45 minutes in Horizon 1 (using route 35)
  - to just 23 minutes using the new, extended A2B service
  - ***This journey time is halved in Horizon 2 compared to Horizon 1***
- – Botany (metropolitan centre and connection to Eastern Busway) to Airport (major employment and connection to City Centre to Māngere PT) travel time:
  - 69 minutes + transfer time and penalty in Horizon 1
  - to 49 minutes in Horizon 2 (with no transfer)
  - ***The in-vehicle time is reduced by 30%, and there is no transfer***

- Significant reductions in average generalised cost
  - These significant travel time improvements result in significant reductions to average generalised costs (an input to effective employment density, and thus agglomeration estimates) for affected zones.
- Significant improvements in effective employment density
  - The reduced average generalised costs then generate an improvement to the effective employment density in Horizon 2 compared to Horizon 1.
  - The agglomeration benefit effectively then applies various factors and calculations to the effective employment densities.

Figure 7 and Figure 8 show the computed agglomeration benefit for each zone for Horizon 2 in each of the model years 2028 and 2048. The distribution of these benefits is reasonable given the extent and type of improvements included in Horizon 2.

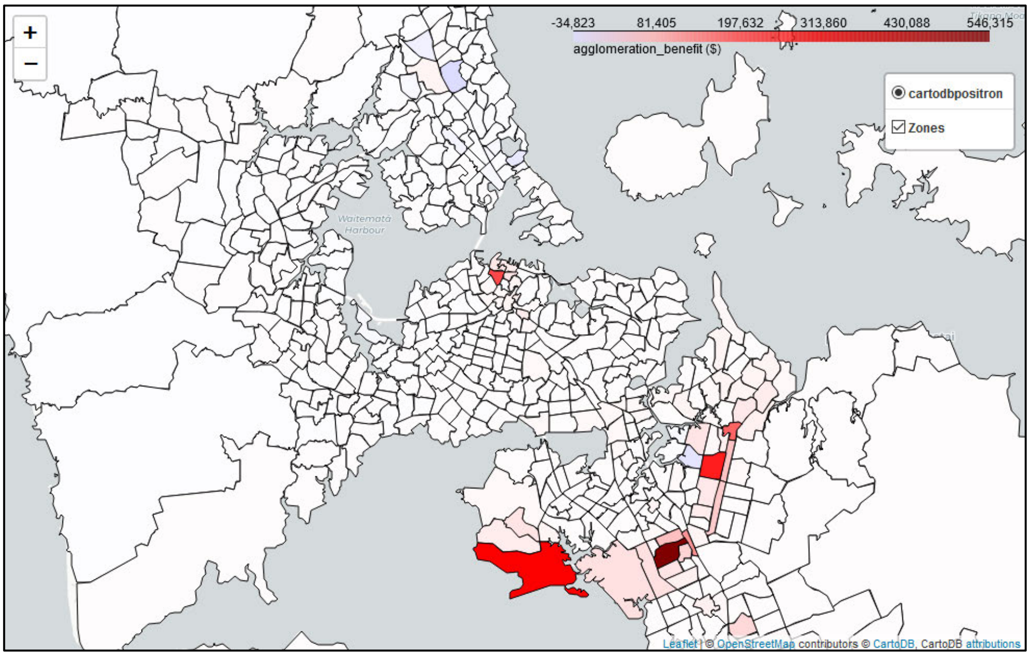


Figure 8: Agglomeration benefit per zone, Horizon 2 2028

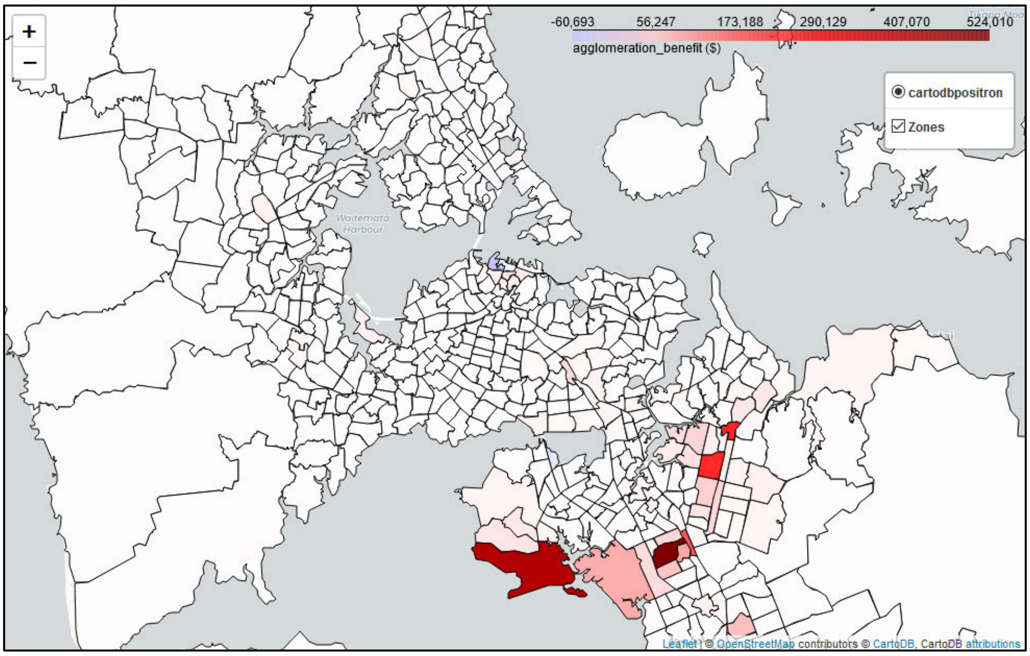


Figure 9: Agglomeration benefit per zone, Horizon 2 2048

Concluding remarks

The EEM rationalises and guides the inclusion of wider economic benefits for significant projects, such as in this case.

There are no concerns with the application of the transport model outputs and EEM requirements in computing the agglomeration benefits.

The proportion of WEBs relative to transport benefits for the programme are very low compared to other projects. Horizon 2, with the highest proportion of WEBs relative to transport benefits has a similar proportion of WEBs as other transport projects.

The spatial distribution of benefits is sensible given the interventions included in the scenarios.

Due to the significant nature of the WEBs, we agree that it is helpful to understand how sensitive the project benefit-cost ratio is to the magnitude of these benefits. As there is no question about the existence of WEBs entirely, rather just about the magnitude of such benefits, we have sensitivity tested the WEBs at +/-25% of the calculated benefit.

9.4.2 Calculating the agglomeration benefit

The agglomeration benefit comes from increased economic productivity from improved accessibility between firms and workers which better matches workers to jobs, better links supply chains between firms, and increases knowledge between workers and firms. This benefit was computed using MSM data and following guidance from EEM Section A10.4.

First, agglomeration elasticities ε_i were computed for each MSM zone i by weighting across all ANZSIC industry sectors z via the formula:

$$\varepsilon_i = \frac{\sum_z \varepsilon^z E_i^z}{\sum_z E_i^z},$$

for:

- z in all ANZSIC industry sectors

Where ε^z is the agglomeration elasticity for industry sector z; E_i^z is the number of full-time equivalent workers working in zone i and sector z in the scenario year taken from the economic data. Note that ε^z is computed from 2013 Census data, because forecasts of employment by industry for future years are not available.

Second, the average transport cost matrix, AGC^S, for each scenario S was computed via the formula:

$$\mathrm{AC}\ ^{S} = \frac{\sum_{m,p}\ \left(D_{m,p}^{o} + D_{m,p}^{b}\right) GC_{m,p}^{S}}{\sum_{m,p}\ \left(D_{m,p}^{O} + D_{m,p}^{b}\right)},$$

for:

- m in all modes (ie car and PT)
- p in the purposes: work and commute

All matrices pertain to all day; $D_{m,p}^{o}$ is the demand matrix for the option scenario, mode m, and purpose p; $D_{m,p}^{b}$ is the demand matrix for the base scenario, mode m, and purpose p; $GC_{m,p}^{o}$ is the generalised cost matrix for the option scenario, mode m, and purpose p.

Third, the effective density of employment ED_i^S was computed for each scenario S and zone i via the formula:

$$ED_i^S = \sum\nolimits_j \frac{E_j}{\mathrm{AC}\ _{ij}^{S}},$$

for:

- j in all transport model zones

where E_j is the number of full-time equivalent workers working in zone j; $\mathrm{AC}\ _{ij}^{S}$ is the (i,j)-entry of matrix AGC^S.

Fourth, the relative productivity gain δPR_i was computed for each zone i via the formula:

$$\delta PR_i = \left(\frac{ED_i^o}{ED_i^b}\right)^{\varepsilon_i} - 1.$$

Fifth, the absolute increase in productivity by zone (ie the GDP), dPR_i, for each zone i was computed via the formula:

$$dPR_i = \delta PR_i \, GDP_i,$$

where GDP_i is the GDP for zone i from the economic data.

Finally, the agglomeration benefit is:

$$k_y \sum_i dPR_i$$

for:

- i in all transport model zones

And where k_y is a price inflation factor to scale dollars from the year of the economic data to the assessment year (described and defined in Section 9.1.2). In addition, modelled agglomeration benefits for future years can be scaled up to reflect expected productivity growth throughout the modelling period. By default, productivity is assumed to grow at 1.5% per annum, as per MSM model assumptions for economics.

9.4.3 Calculating the imperfect competition benefit

The imperfect competition benefit comes from higher price cost margins from lower costs of work travel. Using MSM data and following EEM Section A10.5, the benefit was computed via the formula:

$$\left(B_{pt,p}\, a_{pt} + B_{car,p}\, a_{car}\right) k_{comp},$$

for:

- p = work purpose only

where $B_{m,p}$ is the daily travel time benefit for mode m and for p = work purpose trips (computation $B_{m,p}$ is described in Section 9.1.3); a_m is the annualisation factor for mode m; k_{comp} is the imperfect competition factor (0.107).

In addition, modelled imperfect competition benefits for future years were scaled up to reflect expected productivity growth throughout the modelling period. By default, productivity is assumed to grow at 1.5% per annum, as per MSM model assumptions for economics.

9.4.4 Calculating the tax wedge on increased labour force participation

The tax benefit comes from increased tax revenue from an increased labour force that comes about from lower commute costs. Using MSM data and following EEM Section A10.6 (and its source, Kernohan & Rognlien (2011), Section 17), the benefit was calculated as follows.

Step 0: Background calculations

The mean personal income y_i and the mean personal productivity M_i was computed for those who live in zone i by taking weighted averages of those quantities across destination (ie work location) zones j:

$$y_i = \frac{\sum_j \hat{y}_j \, D^o_{p,(i,j)}}{\sum_j D^o_{p,(i,j)}}$$

$$M_i = \frac{\sum_j \widehat{M}_j D^o_{p,(i,j)}}{\sum_j D^o_{p,(i,j)}},$$

for:

- p = commute purpose
- j in all transport model zones

$\hat{y}_j$ is the mean personal income of all workers working in zone j. $D^o_{p,(i,j)}$ is the annual number of commute trips (car and public transport) from zone i to zone j in the option scenario; $\widehat{M}_j$ is the GDP of zone j divided by the total number of workers working in zone j. As $\hat{y}_j$ and $\widehat{M}_j$ are based on the *total* number of workers instead of *FTE* workers, this implicitly assumes that the mix of full time to part time commute trips to each zone j is reflective of the mix of full time to part time jobs in each zone j as observed in the economics dataset.

Step 1: Calculate commuting costs

First, the average (across all modes) change in annual commute costs per MSM zone was estimated, by computing the matrix:

$$\delta AGC = \frac{\sum_m \left(D^o_{m,p} + D^b_{m,p}\right)\left(GC^o_{m,p} - G^b_{m,p}\right)}{\sum_m \left(D^o_{m,p} + D^b_{m,p}\right)},$$

for:

- p = commute purpose
- m in all modes (ie PT and car)

$D^o_{m,p}$ is the demand matrix[14] for the option scenario, mode m and the commute purpose p; $D^b_{m,p}$ is the demand matrix[14] for the base scenario, mode m and the commute purpose p; $GC^o_{m,p}$ is the generalised cost matrix[15] for the option scenario, mode m and commute purpose p; $GC^b_{m,p}$ is the generalised cost matrix for the base scenario, mode m and commute purpose p.

The total annual commuting cost savings for workers living in zone i is then calculated by multiplying the change in commuting cost for each destination by the number of commuters and summing.

$$\delta GC_i = 500 \sum_{m,j} D^o_{m,p,(i,j)}\, \delta AGC_{(i,j)}$$

for:

- p = commute purpose
- m in all modes (ie PT and car)
- j in all transport model zones

$D^o_{m,p,(i,j)}$ is the demand matrix[14] for the option scenario, mode m and the commute purpose p, between zones i and j; 500 represents an annualisation factor for commute trips (2 trips per day x 250 working days per year). δGC_i is then the total annual change in commute costs for workers living in zone i.

[14] The demand matrix of commuters is referred in Section A10.6 of the EEM to as T and the demand matrix for commute purpose is referred to as W. For consistency with the rest of the equations in this technical note (and the EEM), we maintain the D notation for demand, with subscripts to denote specific purposes.
[15] The generalised cost matrix is denoted by G in the EEM, Section A10.6. For consistency with the rest of the equations in this technical note, we maintain the GC notation.

Step 2: Labour supply response

Second, the change in employment per zone i was estimated via the formula:

$$\delta E_i = \varepsilon^{ls} \frac{1}{y_i(1-\tau^{ls})} \delta GC_i,$$

where ε^{ls} is the elasticity of labour supply (0.4); y_i is the mean personal income per worker; τ^{ls} is a factor to convert gross to net earnings (0.32).

Step 3: Gross labour supply impact

The increased productivity from the labour supply response is estimated as the product of the change in the labour supply and the mean personal productivity of workers *and maybe a factor for the relative productivity of the marginal labour supply*:

$$LSI = \sum_i \delta E_i \, M_i$$

for:

- i in all transport model zones

where M_i is the mean personal productivity per worker living in zone i.

Step 4: Net labour supply impact

Finally, the wider economic impact from the labour supply impact is computed by applying the labour supply tax rate to the increased productivity from the labour supply, as follows:

$$Benefit = k \, \tau^{tax} \, LSI$$

where k_y is a factor to convert dollars from the year of the economic data to the assessment year; and τ^{tax} is the tax take on increased labour supply (0.26). In addition, modelled tax wedge benefits for future years were scaled up to reflect expected productivity growth throughout the modelling period. By default, productivity is assumed to grow at 1.5% per annum, as per MSM model assumptions for economics.

9.5 Standard transport benefits (out of model)

9.5.1 Pedestrian benefits

Flow has developed the methodology to estimate benefits to pedestrians from new shared paths under 20Connect, and from infrastructure changes to improve pedestrian safety near A2B stations and along the A2B corridor. This methodology is described in this section. Further detail can be found in the document *Southwest Gateway Walking and Cycling Improvements, Economic Benefit Evaluation* (Section 18).

The 20Connect programme will provide new pedestrian routes parallel to SH20, and these new routes may provide travel time savings for some existing pedestrian trips. The majority of pedestrian users of the new shared paths are expected to be recreational users however, and as a result, may not benefit from any travel time saving. This benefit stream has been assumed to be negligible and omitted accordingly.

Additional pedestrian benefits may accrue from investment proposed to improve access routes to A2B stations as part of the A2B programme. Existing EEM procedures limit the benefits from walking trips to travel time cost savings, crash cost savings, and health benefits for new facilities.

- Improvements such as new pedestrian links between disconnected streets or new crossings that shorten walking distances to stations would decrease pedestrian travel times, leading to travel time savings benefits. However, no new pedestrian links or crossings have been planned at this stage.
- The investment in station access routes is likely to include a range of improvements that could provide crash cost savings by reducing crash rates, such as lighting upgrades, raised table treatments, pedestrian refuges, kerb extensions, and controlled mid-block crossings.
- Health benefits can be applied to new pedestrian facilities, or where an improved pedestrian facility encourages more walking trips. Station access improvements are expected to increase the likelihood of people using the A2B service.

Benefits from such improvements have not been quantified at this stage due to the high degree of uncertainty about the type and number of improvements that will be implemented, and the number of pedestrians expected to be using each of the upgraded facilities.

Further, although economic benefits from improvements to pedestrians' experience are not currently accounted for in existing EEM procedures, we are aware that the NZ Transport Agency is drafting guidance for valuing footpaths and pedestrian improvements. Infrastructure improvements may improve the quality of the pedestrian experience along 20Connect and the A2B corridor and in surrounding neighbourhoods near stations. These improvements would be expected to have additional economic benefits not currently captured in this benefit analysis.

As well as providing benefits to existing users, improvements in the safety and quality of the pedestrian experience may induce new walking trips and induce new riders on the A2B system. New riders would generate a multitude of flow-on economic benefits as described elsewhere in this report.

The benefits estimated from improved pedestrian infrastructure on the 20Connect shared path and along the A2B corridor are outlined in the following sections.

Estimating pedestrian safety benefits

The programme will likely result in improved pedestrian safety outcomes, as a result of new and improved pedestrian crossings and treatments of side roads. This level of detail has not yet been resolved at this stage of the programme development however. To account for this benefit stream, a blanket reduction in pedestrian related crashes has been applied to the following locations:

- Within 50m of locations where the 20Connect shared use paths meet arterial roads at new or improved signalised crossings (Mahunga Drive, Walmsley Road, Massey Road and Puhinui Road), and where treatments are proposed on Portage Road and Selfs Road
- Along the extent of the A2B corridor, including Puhinui Road, Lambie Drive, Te Irirangi Drive and through Manukau centre

Pedestrian crash data collected for the last 5 years (2014 to 2018, inclusive) has been obtained from NZ Transport Agency's Crash Analysis System (CAS).

A 20% crash reduction has been assumed and applied to the report crashes, based on the following published crash rate reductions within the EEM's Crash Estimation Compendium for pedestrian improvements:

- 55% to 80% reductions for lighting upgrades
- 20% for raised table treatments
- 15% to 45% for pedestrian refuges
- 35% for kerb extensions
- 45% for mid-block signalised crossings

The 20% reduction applied falls within the lower end of the above range, and acknowledges that specific pedestrian improvement elements of the projects have not yet been determined.

Standard EEM procedures have been used to annualise the cost of the above pedestrian crashes, using:

- An assumed average speed of 60 km/h on the corridor (speed limits on the A2B corridor range from 50 to 80 km/hr)
- An assumed 1% annual growth in traffic/pedestrian volumes
- Under-reporting factors for roads within the 50-70 km/hr range – a conservative assumption that applies lower factors than higher speed roads (EEM tables A6.3(a)-(b))
- Resulting average pedestrian crash costs of $4.13 million for fatal crashes, $439,000 for serious injury crashes, $24,800 for minor injury crashes and $2,000 for non-injury crashes (EEM Tables A6.4(b)-(h))
- The 1.06 crash cost update factor (1 December 2018)

Estimating pedestrian health and environment benefits

SP11 also allows health and environment benefits to be calculated for new pedestrian trips, where an improved pedestrian environment encourages more walking trips. These may be calculated either per new pedestrian-km travelled on new pedestrian facilities such as footpaths, or alternatively per new pedestrian in the case of 'hazardous sites'. In the case of the Southwest Gateway programme, the per pedestrian-km method has been applied.

These benefits are estimated based on:

- The estimated average daily pedestrians on each section of new shared path
- The length of each new section of shared path (where that shared path does not replace an existing footpath)

The increase in pedestrian trips on new shared paths has been estimated based on count data obtained from the automated pedestrian count sites on existing State Highway shared use paths within Auckland. At these four sites – the Northwestern Cycleway (Kingsland), SH20 (Mangere Bridge), SH20A (Kirkbride Road) and SH20 shared path (Dominion Road) – the average daily pedestrian count for the year to December 2019 was 152 pedestrians. This figure has been assumed to apply to the new sections of shared path on SH20 and SH20A, and has been inflated to 163 daily pedestrians in 2028 and 2038 to account for the forecast 7% population growth within Mangere area[16].

9.5.2 Economics for Botany Station

Botany Station was originally expected to be funded and constructed under the AMETI Eastern busway programme, so was included in all the base modelling and assumptions for A2B. However, this assumption has been updated such that Botany Station will be delivered by both projects, as both projects require the station upgrade, and costs attributable to A2B have been included in the costs for this economic assessment.

Because of the original assumptions, all modelling includes Botany Station in the base case. Therefore, out-of-model calculations have been computed to estimate the additional benefits to the SWGP of upgrading Botany Station, to account for the additional costs that have been included in the assessment.

Timing of benefits and costs for Botany Station

Firstly, it is important to note that the Horizons are developed as one (albeit well-considered and likely) scenario of the SWGP evolution. The actual sequencing of the various project elements may be influenced by a range of dependencies and other influences. The proposed approach to programming, management and delivery will deal with these influences over time.

Secondly, it is noted that the assumption for the H2 service is that it can operate from part of the Botany Station delivered by the Eastern Busway project in 2025. The Concept Design for Botany Station carried out in 2019 identified that additional platforms and facilities will be required for the ultimate A2B service, so developing the remainder of Botany Station will need to be included in the SWGP somewhere.

Horizon 3 is the first stage at which the service can be considered part of the rapid transit network (RTN). It will have sections of fully separated running ways on SH20B and through Manukau, will see the full implementation of all the other ‘major’ stations for A2B, and it will be required to operate at an RTN level of service. The H2 service is not considered an RTN.

Botany, being the remaining major station as well as the terminal and commencement station would logically be delivered at this time. This is to achieve the following:

- Quality and consistency of customer experience
- Operational reliability

Botany Station is also important for the connection with local buses. Forecasts indicate that a quarter of AM peak users of the A2B service crossing a westbound screenline at Manukau will have transferred from local buses at Botany. It is important for delivering the full benefits of the A2B investment that Botany Station is effective as an interchange as well as a terminal, early in the programme.

The alternative is to include Botany Station in Horizon 4, when the Te Irirangi Drive running way section is proposed to be delivered. While there is some logic in doing this, the logic for Horizon 3 is considered significantly stronger. In addition, there is clear experience in, for example Albany Station on the Northern Busway that having an RTN quality service, operating from an RTN quality station creates the customer experience of the RTN commencing at that location and can provide patronage uplift (mode shift) driven by customer experience without there being immediate RTN running way.

[16] Within MSM zones 458 to 486

Direct benefits to passengers

The benefits attributable to a Botany Station upgrade have been estimated out of the model for the two model years of Horizon 2038 and 2048, and the annual benefit estimates extrapolated as per the other benefit estimates described in this report.

The out-of-model benefit estimates made the following assumptions:

- Demands for A2B at Botany Station were collected from the model outputs for the standard AM, IP and PM periods for two model years (2038 and 2048).
- School peak and off-peak demands were estimated as 76% of the total six-hour interpeak demand (the network-wide standouts indicate 75-76% is appropriate, with the average being 76%).
- The total daily demand was then estimated using the modelled results for AM, IP and PM and the inferred school peak and off-peak demands.
- The total daily demands were then annualised using a factor of 320, as is used for other public transport benefits, and is explained in Section 9.1.1.
- A 3-minute benefit for the station upgrade is assumed (as per Section A18.7 of the EEM) and is applied to the demand for each horizon, including applying the rule of half for new users.
- The total benefit for each period is then monetised using the period-specific 2019 values of time as computed using EEM Tables A4.1(b), A12.3, A2.4.

This results in the following annual benefit estimates for the Botany Station upgrade:[17]

- 2038: $2,294,899 (Horizon 4 estimate)
- 2048: $2,691,346 (Horizon 4 estimate)

This ultimately results in a net present value benefit of $32.9m (using a discount rate of 4% and 60-year evaluation period) for the Botany Station upgrade. This benefit is included within the line item “Public Transport User Benefits” in the economic assessment results tables.

Decongestion benefits from mode shift

In addition to direct benefits to passengers, construction of the high quality Botany Station is expected to result in some mode shift towards public transport trips, which will cause indirect benefits to road users. The most significant indirect benefit is expected to be a decongestion benefit due to mode shift from driving. These decongestion benefits have been estimated (out of the model) for the two model years of 2038 and 2048.

The expected mode shift induced by the Botany Station upgrade was estimated as follows:

- The generalised costs for each trip purpose for public transport trips to and from MSM zone 419, which contains Botany Station, were collected from the model outputs for the standard AM and PM periods for two model years (2038 and 2048). Demands were not collected for the IP period as decongestion benefits are expected to be minimal outside of the peak commuting periods.
- Demands for each trip purpose for public transport trips to and from MSM zone 419 were collected from the model outputs for the standard AM and PM periods for two model years (2038 and 2048).
- A weighted average generalised cost was estimated for public transport trips to Botany for the 2038 and 2048 AM and PM periods.
- A 3-minute generalised cost reduction for the full station upgrade was assumed (as per Section A18.7 of the EEM) and applied to the average generalised cost for each horizon.

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[17] Two annual benefit estimates included for each horizon

- The demand response to the generalised cost reduction is estimated at an elasticity of -1.5. This coefficient is taken from an assessment of supplementary economic benefits for Lower Albert Street Bus Interchange (Richard Paling Consulting, 2019), which derived the coefficient based on RR 472 New Zealand Bus Policy Model (Wallis & Schneiders, 2012).
- This coefficient was applied to the percentage change in the average generalised cost for the AM and PM periods for the two model years to obtain the estimated increase in public transport patronage.

This mode shift was monetised as follows:

- The EEM in Table SP10.1 gives the decongestion benefits during the peak period in Auckland by bus/ferry at $11.73 per public transport boarding in 2008 prices. This is uplifted by 1.54 to give a value in 2019 prices of $18.06, which is applied to the estimated increase in public transport passengers to estimate the resulting decongestion benefits.
- The daily decongestion benefits were estimated by summing the AM and PM benefit estimates and annualised using a factor of 250, which approximates the number of annual workdays.

This results in the following annual benefit estimates for the Botany Station upgrade:

- 2038: $664,254 (Horizon 4 estimate)
- 2048: $817,411 (Horizon 4 estimate)

This ultimately results in a net present value benefit of $12.7m (using a discount rate of 4% and 60-year evaluation period). This benefit is included within the line item “road user travel time benefits” in the economics results.

9.5.3 Station quality benefits in Horizon 2

Since the modelling for this programme was completed, the development of the interventions progressed to provide more improvements in Horizon 2 than was originally expected and modelled. One such improvement that was not modelled was the station quality improvements of all stations within the Horizon 2 timeframes. Improvements included within these timeframes will include:

- Information terminals, real-time information, clock, maps, simple timetable, contact number (EEM value = 1.7 minutes)
- Ticketing machines (EEM value = 0.1 minutes)
- Lighting (EEM value = 0.1 minutes)

The total benefit per person is 0.95 minutes (as the value of multiple features combined must be halved). Using similar analysis to Section 6.2.1, the daily boardings for all relevant stations with upgrades in Horizon 2 was estimated at around 3,000. The stations excluded will already have these valued station improvements.

Table 19: Estimation of additional benefit from station quality improvements, for journeys starting at Lambie, Ronwood, Diorella, Dawson, Ormiston, Accent and Smales

Measure	Variable	Value	Source
Estimated daily boardings (including transfers) at Lambie, Ronwood, Diorella, Dawson, Ormiston, Accent and Smales Stations	A	2,936	MSM model for Horizon 2, 2028
Total estimated boardings annually	B=A*320	939,670	320 is the public transport annualisation factor
Benefit (willingness to pay) per person (minutes)	C	0.95	EEM Table A18.5
Value of time ($/hour)	D	$14.75	Period-neutral value of time estimated from EEM Tables A4.1b, A12.3, A2.4 (purpose-split for all periods).
Annual benefit for journeys using relevant stations	E=B*C/60*D	$219,452	

The additional benefit of $219,452 per year was added to the public transport user benefits for Horizon 2.

9.5.4 Horizon 2 travel time benefit not quantified

This section estimates the potential additional travel time benefit for Horizon 2 that has not been fully quantified as the recommended option was not confirmed until after completion of the MSM modelling.

No public transport priority was modelled between Great South Road and Botany Station in Horizon 2. However, ultimately the business case recommends that one lane in each direction on Te Irirangi Drive should be converted to T2 in Horizon 2. AIMSUN modelling was completed to assess the impact of these interventions on different types of road users (i.e. buses, other T2 lane users and single occupancy vehicles). The model also assumed that there would be a 10% reduction in single occupant vehicles on Te Irirangi Drive, assuming some of those road users would shift to PT, carpooling, or travelling on different corridors or at different times. This assumption was conservative compared to observed reductions in single occupant vehicles on other corridors after the conversion to transit lanes.

This modelling indicated that this will have the following travel time effects on road users:

- Bus passengers will save 2.7 minutes along the length of Te Irirangi Drive.
- T2/freight vehicles will save 2.3 minutes along the length of Te Irirangi Drive.
- Single occupancy vehicles will take 0.1 minutes longer to travel the length of Te Irirangi Drive.

The net effect of these changes is that the average vehicle saves 0.4 minutes, and the average person (accounting for bus passengers and higher occupancy vehicles) saves 1.3 minutes across the full length of Te Irirangi Drive (the travel time saving for carpooling outweighs the slight delay for single-occupancy vehicles).

The relevant select link data to understand the total vehicles travelling the length of Te Irirangi Drive was not available at the time of writing, so only the benefit for bus passengers is estimated here. As the net benefit to people in vehicles is positive, there is no concern of missing disbenefits that accrue from the benefits to bus passengers.

Table 13 details the derivation of the potential uncaptured benefit from these travel time savings.

Table 20: Estimation of additional benefit from peak travel time savings on Te Irirangi Drive in Horizon 2

Measure	Variable	Value	Source
Public transport daily demand along full length of Te Irirangi Drive	A	976	MSM model for Horizon 2, 2028
Annual demand affected by peak travel time improvements on Te Irirangi Drive	B=A*320	312,320	320 is the public transport annualisation factor
Travel time saving per passenger (min)	C	2.7	AIMSUN model of A2B corridor
Value of time ($/hour)	D	$14.75	Period-neutral value of time estimated from EEM Tables A4.1b, A12.3, A2.4 (purpose-split for all periods).
Annual benefit of peak travel time savings for public transport	E=B*C/60*D	$207,302	
Present value		$4,094,914	Assume benefit incurred from 2025 onwards

The additional annual benefit in Horizon 2 from peak travel time savings is estimated to be around $210,000. The present value of these benefits was estimated using the same approach as in section 6.2.1, resulting in an **estimated present value of peak travel time savings of $4.1 million**.

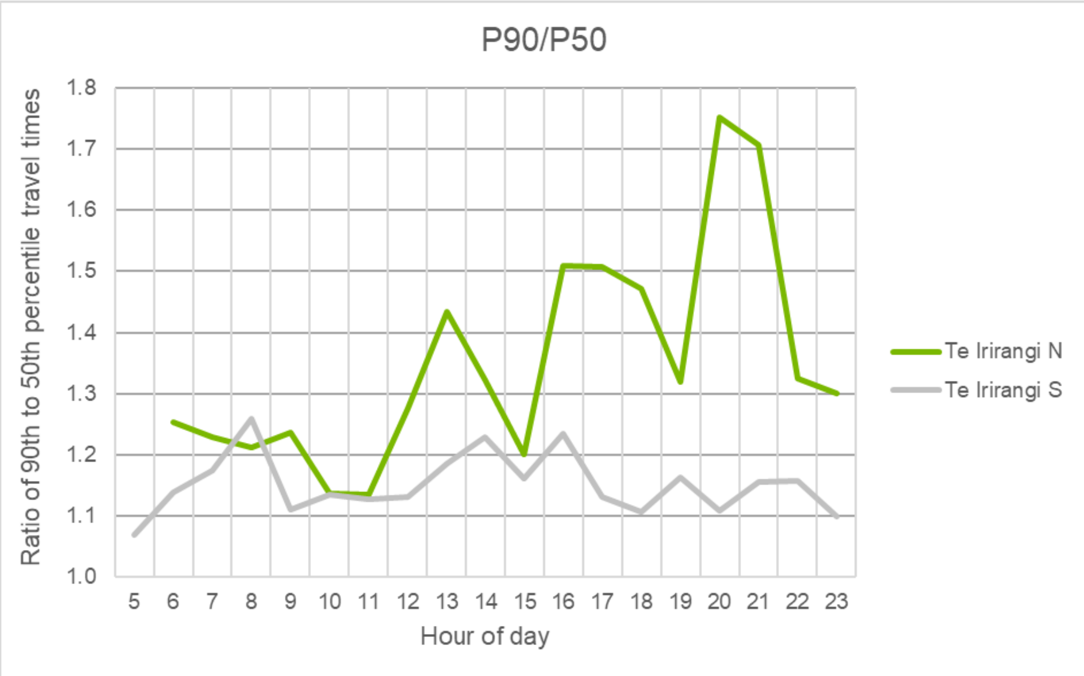
10 Appendix: Reliability benchmarks

This Appendix presents charts of the observed (from February 2019 AT realtime data) 90th and 50th percentile travel times for bus services in and around the proposed A2B corridor. The purpose of these charts is to inform and support the assumptions for the reliability assessment, regarding peak hours, ratio of 90th to 50th percentile travel times.

10.1 Te Irirangi Drive (north)

The base case reliability for the northern segment of Te Irirangi Drive (north of Dawson Road) uses February 2019 real-time data from route 35, between Dawson Road and Botany Town Centre (on Chapel Road).

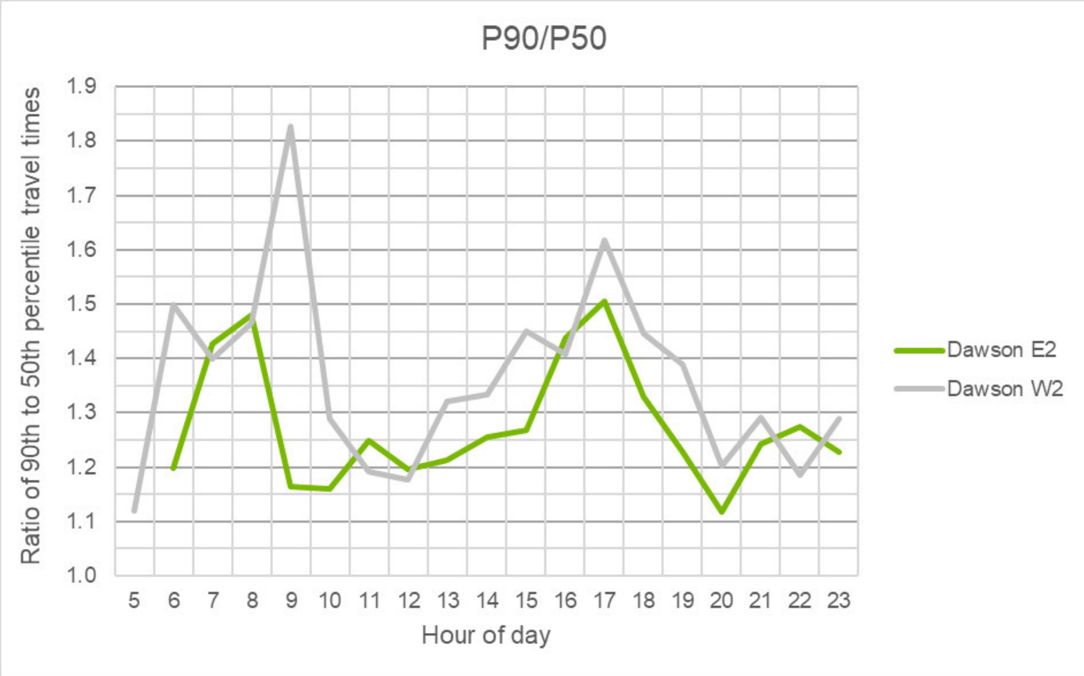
Figure 10: Te Irirangi Drive (north), P90/P50 (February 2019)



10.2 SH1 bridge and Te Irirangi Drive (south)

No bus services currently travel along Te Irirangi Drive to cross over SH1. Therefore, it was assumed that the reliability would be similar to that along the southern part of Te Irirangi Drive. The base case reliability for the south segment of Te Irirangi Drive uses February 2019 real-time data from route 35, between Redoubt Road (just east of the bridge over SH1) and Dawson Road.

Figure 11: Manukau to Dawson Road, route 35 P90/P50 (February 2019)



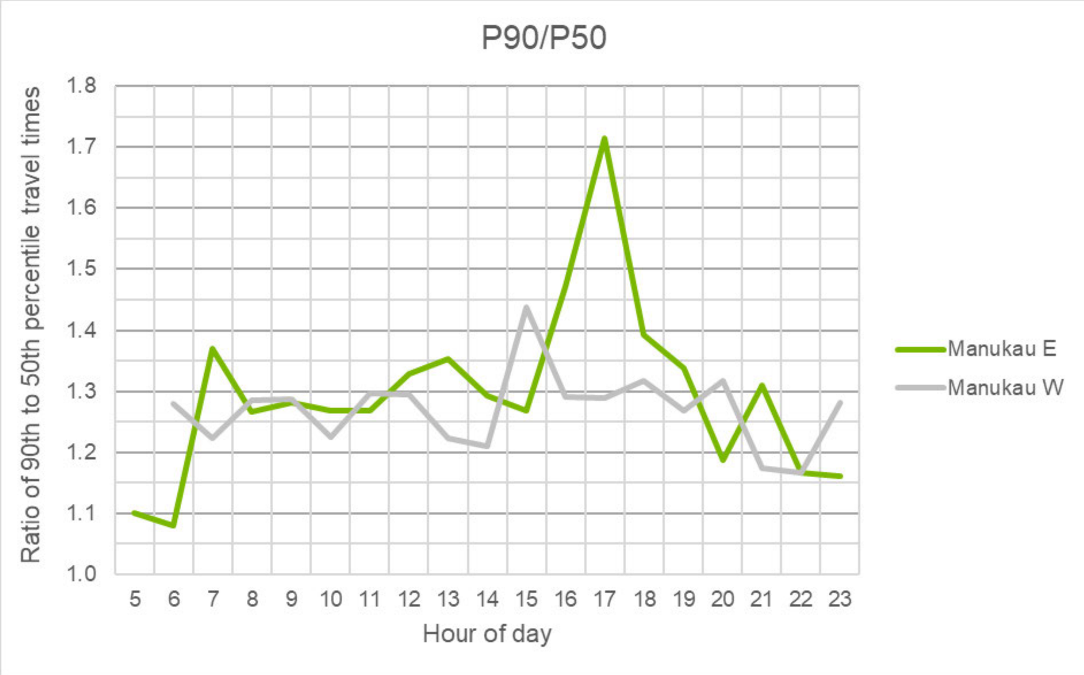
10.3 Manukau

The base case reliability for Manukau is split into the segments to the east and to the west of Manukau Station. This is because the base case option does not include a single service that travels the whole way through the Manukau segment, however it does include services on each of the east and west sides of the station.

10.3.1 East of Manukau Station (Davies Ave, Ronwood Ave, Great South Road)

The base case reliability for the Manukau segment east of Manukau Station uses February 2019 real-time data from route 33, between Manukau Station and the intersection of Great South Road and Te Irirangi Drive.

Figure 12: Manukau Station to Great South Road/Te Irirangi Drive intersection, route 33 P90/P50 (February 2019)



10.3.2 West of Manukau Station (Lambie Drive)

The base case reliability for the Manukau segment west of Manukau Station uses February 2019 real-time data from route 380, between Manukau Station and the intersection with Puhinui Road.

Figure 13: Lambie Drive, southbound, route 380 P90/P50 (February 2019)

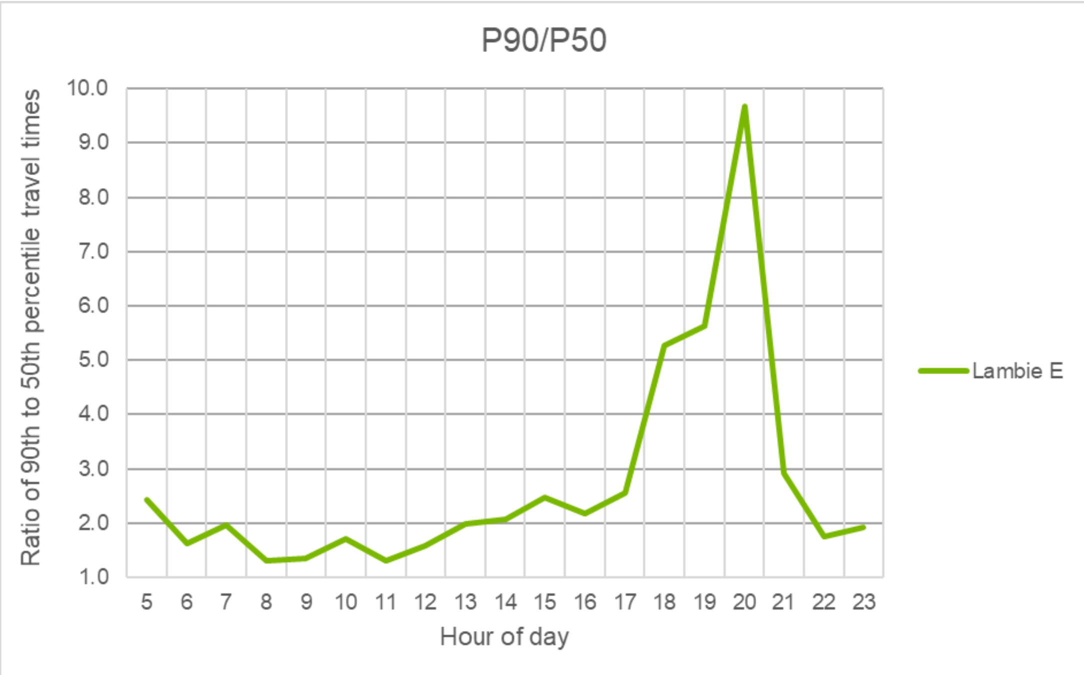
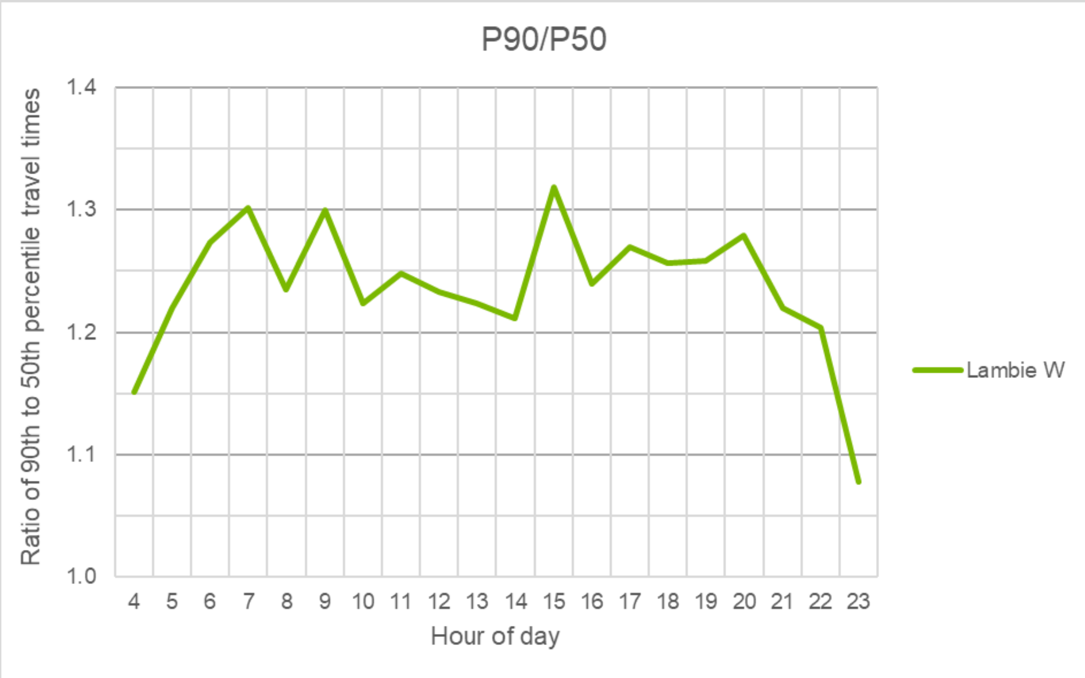


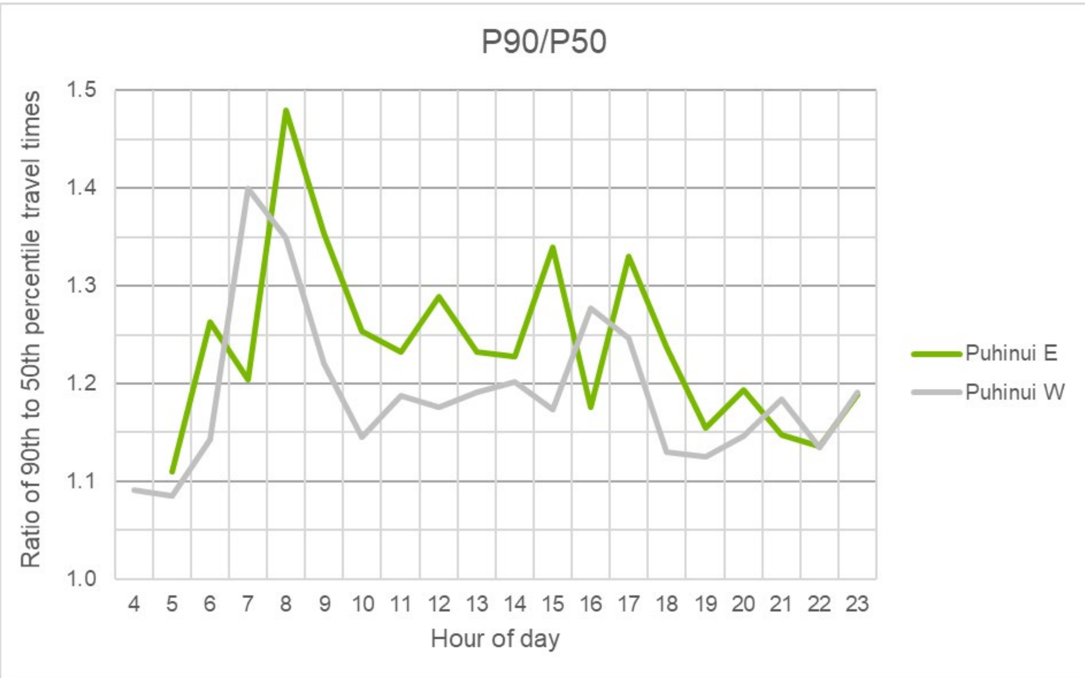
Figure 14: Lambie Drive, northbound, route 380 P90/P50 (February 2019)



10.4 Puhinui Road

The base case reliability for Puhinui Road is informed from the assumptions made for the economic assessment of the short-term improvements. The short-term improvements expect to reduce the ratio of 90th to 50th percentile travel times to 1.20. It is expected that the full improvements will achieve the current 'best' ratio of 1.15.

Figure 15: Puhinui Road, between Wylie Road and Lambie Drive, route 380 P90/P50 (February 2019)



10.5 SH20B

No chart has been provided for the SH20B segment, as the short-term improvements along SH20B inform the input assumptions for that segment. The short-term improvements also largely inform the input assumptions for Puhinui Road and Lambie Drive; however, their charts have been included as they were used to aid the consideration of the extent of additional improvements expected from the full A2B MRT improvements.

11 Appendix: Growth projections post-2048

We consider it to be appropriate to adjust to the new discount rate of 4% and an extended 60-year evaluation period. As per the IDMF update, these parameters apply to all business cases beginning from 1 July 2020, and the full MBCM applies for all business cases beginning after 31 August 2020.

The use of the new parameters for the economic assessment of this programme is intended to be forward-looking and make use of the latest guidance. Any future updates to the programme's economic assessment are likely to require the use of the new evaluation parameters, so it is considered prudent to use these parameters now. Additionally, given the staging plan for this programme, with horizon 4 and 5 interventions becoming operational in 2035 and 2040 respectively, a 60-year evaluation period is considered by AT to be more appropriate to reflect the benefits of these investments and support a fairer economic efficiency test.

The following discussion describes the proposed approach for extrapolating modelled benefits beyond 2048.

11.1 Suggestion of applying a 'flat' growth rate

In the face of the obvious uncertainty around future growth, adopting the assumption of flat (zero) growth in benefits post 2048 has the appeal of being conservative. However, this approach raises the obvious challenge, that the assumption of flat (zero) growth has no greater validity than any other growth rate without supporting evidence. We have considered whether there is evidence to support flat (zero) growth in benefits post 2048, or whether the evidence supports an alternative growth rate.

11.2 Regional population growth

Firstly, we have considered whether Auckland's population is likely to continue growing beyond 2048. Statistics NZ's population projections indicate that Auckland's population is projected to continue growing until at least 2068, albeit at a lower rate than we are currently experiencing.

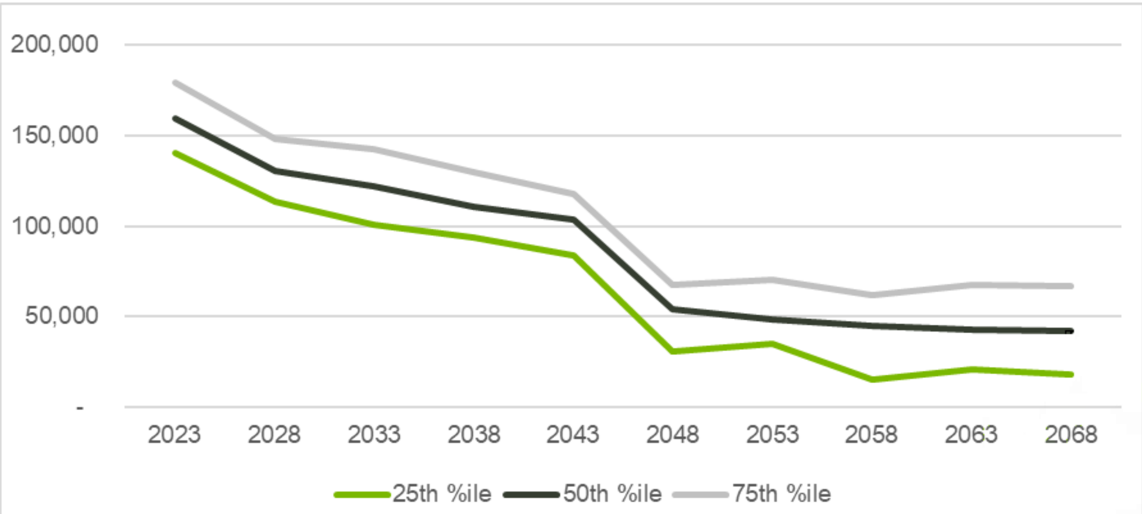


Figure 16: Auckland Population Growth Projections 2018-2068

The data is sourced for SNZ's "Summary of New Zealand population projections 2016 base". The three scenarios reported represent the projected probability distribution (percentiles), with the 50th percentile being the median projection. We have adapted the National Growth Projections to Auckland by using the projected proportion of Auckland's population relative to the national population. This rises from 35% in 2018 to 39% in 2048 and is held constant at this point. Assuming that Auckland then grows at the same rate as NZ as a whole post 2048 is conservative.

One important observation from the data is that although the population growth rate declines quite noticeably over time, from 1.7%/pa in 2023 to 0.4%/pa in 2048 (for the median scenario), the actual number of new residents does not decline as sharply (as the declining growth rate is applied to a larger population). For example, under the median scenario, in 2048 Auckland could still expect to receive around 67,500 new residents annually.

This analysis suggests that assuming a growth rate of zero post 2048 would be inconsistent with the most recent SNZ population growth projections.

11.3 Trip demand based on regional growth

To the extent that trip demand is at least partly related to the population level, then it would be prudent to start with an assumption that a growing population will be associated with increasing trip demand. In Auckland, this growth in trip demand has shifted towards PT, particularly in the peaks, where road capacity is significantly constrained.

The MSM model projects increasing trip demand for all modes to 2048, with no evidence to indicate that trip demand will stop growing from 2048. This is particularly true for PT trips, as the road conditions become increasingly congested over time. The MSM projections for horizon 5 (model stage 4b) are:

- Vehicle trips increase 14% from 2028 to 2048
- Car (individual people in cars) trips increase 12% from 2028 to 2048
- PT trips increase 55% from 2028 to 2048 (from 551,751 daily trips to 853,806)
- PT mode share in 2028 = 13%
- PT mode share in 2048 = 17% (average increase of 0.2% pa)

The MSM model also indicates that for the AM peak, PT trips per person increase from 68 per 1,000 people in 2028 to 76 per 1,000 people in 2038 and 85 per 1,000 people in 2048, an overall increase of 25%.

11.4 Location of future growth – local projections

In practice, population and employment growth will not be spread evenly across the city, and it is important to try and gain some understanding as to how growth may occur within the area served by the programme.

Looking at the SWGP area, the evidence (from the Auckland Council's ASP model) suggests that population growth will occur unevenly. For a number of intermediate zones along the corridor growth slows towards 2048 and in the last decade a number of intermediate zones may experience small population decreases. This is due at least in part to existing development patterns in these zones, with typically single unit dwellings on small sections limiting opportunities for more intensive infill development, combined with falling household size. Set against this, strong population growth is forecast to continue to 2048 for the Manukau city centre, Botany and Flatbush areas, and also for nodes along the AMETI corridor (which connects with A2B at Botany).

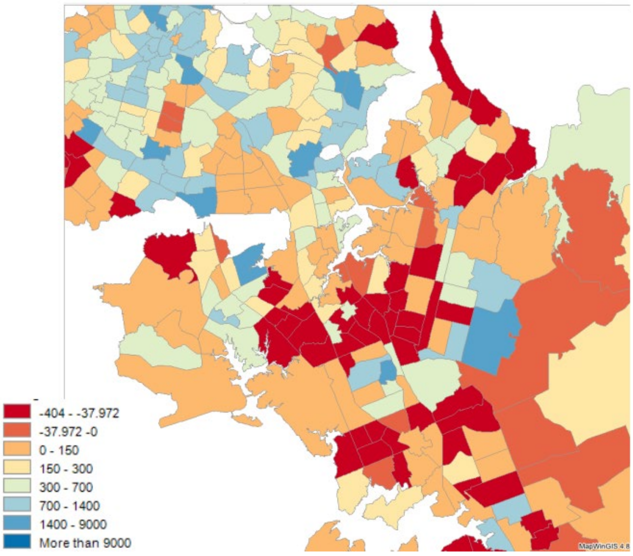


Figure 17: Population growth in the SWGP and wider area (2038-2048)

Beyond the immediate corridor area, south Auckland (south of Manurewa) is projected to experience significantly greater growth than Auckland regional average between 2013 and 2048, based on the MSM projections.

Employment growth is also expected to be uneven along the corridor and across the wider South Auckland area, with very strong growth forecast for the airport and environs forecast out to 2048, the Southern Gateway area (development area south of SH20B) and to a lesser extent the Manukau centre. Highbrook/East Tamaki is expected to continue to grow, but at a more modest rate and declines are predicted for employment areas to the north of the Mangere Inlet (Onehunga and Penrose), which have traditionally employed workers from South Auckland.

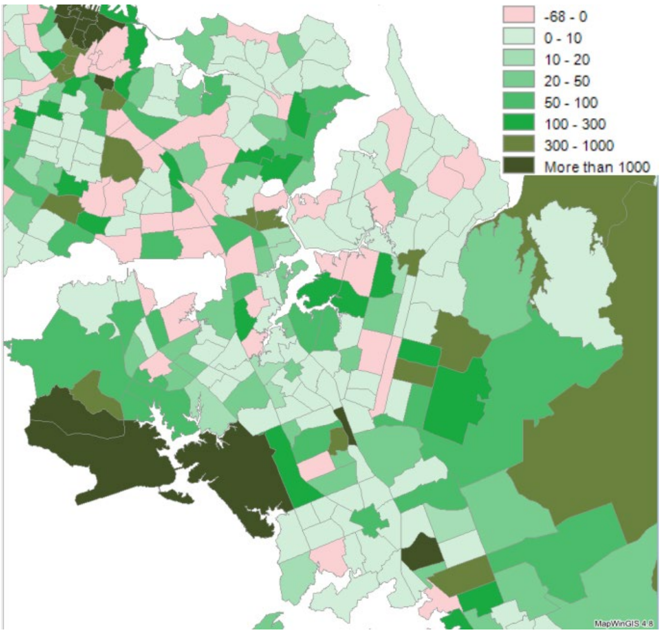


Figure 18: Employment growth in the SWGP and wider area (2038-2048)

This evidence suggests that employment growth within the wider airport area can be expected to significantly exceed the regional growth rate from 2018 to 2048.

11.5 Trip demand based on regional and local growth

These local growth patterns are likely to result in a degree of rearrangement of travel patterns, with the Airport and Southern Gateway employment areas drawing on workers displaced from the declining opportunities in Penrose and Onehunga. The rapid growth of the airport area is also likely to attract workers from the growth areas to the south (e.g. Drury) who would be attracted to the services along SH20B. Similarly, workers from further north in the A2B corridor may be attracted to the increased opportunities in Highbrook. Continuation of these trends beyond 2048 would be likely to generate increased demands for services particularly between Puhinui and the airport but also on the link between Botany and Manukau.

In summary, the evidence suggests that beyond 2048, there is likely to continue to be strong growth in the demand for movement along the corridor between Manukau and the airport, whilst there is likely to be continued but more limited growth in demand from the areas to the north of Manukau.

11.6 Project Benefits

The following considerations are relevant to determine if the SWGP will provide additional benefits to existing and new users after 2048.

- **Relative Performance:** If changes in the performance of other parts of the network means that the project continues to offer a relative improvement in level of service for existing users, then it will continue to deliver benefits for existing users post 2048.
- **Capacity:** If the project is not at capacity in 2048, then there is potential to provide benefits to new users.

The current modelling confirms that the project is unlikely to be at full capacity in 2048, and that it will therefore provide additional benefits to both new and existing users post 2048.

11.7 Key findings and possible growth rates for post-2048

This assessment suggests that there is no evidence to support the assumption of a flat (zero) growth in benefits post 2048. It is projected that population, employment and trip demand will all continue to grow beyond 2048 and that the project has the capacity to deliver additional benefits. We have developed two growth scenarios which are evidence based:

Scenario 1: Growth Rate Derived from Regional Population Growth Projections

This scenario suggests that it would be appropriate to apply a growth rate of 0.4% pa (base growth rate), as derived from the regional SNZ population projection (median). This growth rate could then be adjusted to reflect two further factors:

- Mode shift: PT mode share has increased by an average 0.2% pa. between 2028 and 2048.
- Auckland Unitary Plan enabled development potential (not yet quantified).

If we continued to extrapolate the 2028 and 2048 benefits with no dampening, our ‘100% of benefits’ would equate to the 1.7% growth rate in earlier years. So, to dampen down the growth in benefits to reflect the population growth rate and PT mode share, we could extrapolate the benefits post-2048 at 36% (0.6/1.7) of the pre-2048 benefit growth rate.

Scenario 2: Growth Rate Derived from Local Projections

However, at the local level, the evidence suggests that trip growth is likely to exceed the regional average. For example, projections suggest that employment growth in the airport and southern gateway is likely to continue strongly beyond 2048. The projected decline in employment in the traditional areas of Onehunga-Penrose is only likely to re-enforce the shift of employment activity to these growth areas.

When combined with strong population growth in key nodes (Manukau and Botany) and also in the areas to the south (eg Drury), this suggests a higher growth rate than the regional average would be appropriate for the SWGP, quite probably close to the 1.7% rate used already.

Recommended Approach

Ideally it would be best to apply a growth rate derived from local projections, which suggests that Scenario 2 would be the more appropriate choice for the SWGP post 2048. This approach has been used in this economics assessment.

12 Appendix: Incremental benefits for horizons

This appendix details the annual benefit estimates computed by the methodologies detailed in the Appendix in Section 9 and the incremental cost benefit assessment for each horizon.

12.1 Annual benefits estimates

The following tables outline the annual benefit estimates for the model years of 2028, 2038 and 2048 as used for interpolating and extrapolating to annual estimates across the entire evaluation period. For full details on the methodology for arriving at these annual benefit values, see the Appendix in section 9.

Benefits are extrapolated between 2028/38 and 2048 as possible based on model runs available. In particular:

- Horizon 2: all benefits are extrapolated from the 2028 and 2048 model runs
- Horizon 3: most benefits are extrapolated from the 2028 and 2048 model runs (with the exception of the out-of-model decongestion benefit from Botany Station upgrades)
- Horizon 4: walking and cycling benefits are extrapolated from 2028 and 2048 estimates, whilst all other benefits are extrapolated from 2038 and 2048 model runs
- Horizon 5: walking and cycling benefits are extrapolated from 2028 and 2048 estimates, whilst all other benefits are extrapolated from 2038 and 2048 model runs

Table 21, Table 22 and Table 23 show the annual benefit estimates for each benefit type for each horizon as requested by Waka Kotahi IQA, including separating the A2B and the 20Connect components of horizon 3. Whilst these have been separated for the purposes of estimating the benefits using different models, it is important to note that Horizon 3 only works if both the A2B and 20Connect interventions are included (further descriptions on this are in 4.2).

Table 21: Annual benefit estimates for 2028

Benefit	H2	H3 (A2B)	H3 (20C)	H4	H5
Public transport user benefits	$3,179,768	$1,300,795	$312,272		
Public transport reliability benefits	$646,333	$642,909	$0		
Health benefits from added walking to stations	$972,733	$254,987	-$425,434		
Road user travel time benefits (from MSM)	$392,376	$1,866,945	$0		
Road user travel time benefits (from SATURN)			$14,170,762		
Vehicle operating cost benefits			$201,260		
Crash reduction benefits			$800,723		
Vehicle emission benefits (from MSM)	$198,001	$9,018	$0		

Benefit	H2	H3 (A2B)	H3 (20C)	H4	H5
Vehicle emission benefits (from SATURN)			$8,050		
Reduced driver frustration benefits			$1,081,105		
Trip reliability benefits			$762,593		
Cycling travel time benefits				$46,435	$34,086
Health and environmental benefits from walking facilities				$0	$1,739,650
Health benefits from cycling facilities				$2,438,160	$1,549,028
Safety benefits from cycle facilities				$70,957	$42,687
Pedestrian safety benefits				$402,087	$408
Decongestion benefits from active mode shift				$507,347	$340,929
Agglomeration benefits	$2,332,103	$2,640,574	$6,283,294		
Imperfect competition benefits	$47,827	$86,273	$235,720		
Tax wedge on increased labour supply	$278,881	$241,280	$586,271		

Table 22: Annual benefit estimates for 2038 (only including benefits where 2038 is required for extrapolation purposes – see discussion in Section 6.1)

Benefit	H3 (A2B)	H4	H5
Public transport user benefits		$13,053,865	$949,496
Botany station direct benefit (out of model)	$2,294,899		
Public transport reliability benefits		$12,737,877	$0
Health benefits from added walking to stations		$3,568,824	-$358,742

Benefit	H3 (A2B)	H4	H5
Botany station decongestion benefit (out of model)	$664,254		
Road user travel time benefits (from MSM)		$4,048,605	$0
Road user travel time benefits (from SATURN)			$74,650,000
Vehicle operating cost benefits			$6,709,000
Crash reduction benefits			$4,252,815
Vehicle emission benefits (from MSM)		$775,531	$0
Vehicle emission benefits (from SATURN)			$268,000
Reduced driver frustration benefits			$6,356,000
Trip reliability benefits			$4,050,300
Agglomeration benefits		$16,140,871	$9,043,427
Imperfect competition benefits		$374,211	$364,166
Tax wedge on increased labour supply		$1,637,693	$497,698

Table 23: Annual benefit estimates for 2048

Benefit	H2	H3 (A2B)	H3 (20C)	H4	H5
Public transport user benefits	$3,867,107	$1,785,278	$1,153,770	$16,203,490	$725,868
Botany station direct benefit (out of model)		$2,691,346			

Benefit	H2	H3 (A2B)	H3 (20C)	H4	H5
Public transport reliability benefits	$1,188,462	$1,755,030	$0	$25,232,154	$0
Health benefits from added walking to stations	$1,056,183	$390,681	-$1,272,736	$5,372,499	-$641,143
Botany station decongestion benefit (out of model)		$817,411			
Road user travel time benefits (from MSM)	$873,276	$1,088,953	$0	-$5,732,981	$0
Road user travel time benefits (from SATURN)			$109,446,128		$99,169,000
Vehicle operating cost benefits			$11,287,677		$15,330,000
Crash reduction benefits			$6,532,982		$5,835,795
Vehicle emission benefits (from MSM)	$192,429	$156,612	$0	$1,265,633	$0
Vehicle emission benefits (from SATURN)			$451,507		$613,000
Reduced driver frustration benefits			$14,991,627		$11,989,000
Trip reliability benefits			$6,221,888		$5,557,900
Cycling travel time benefits				$49,592	$76,903
Health and environmental benefits from walking facilities				$0	$1,739,650
Health benefits from cycling facilities				$3,020,647	$2,135,188
Safety benefits from cycle facilities				$96,114	$67,027
Pedestrian safety benefits				$402,087	$408
Decongestion benefits from active mode shift				$558,586	$475,989
Agglomeration benefits	$2,787,782	$2,471,192	$12,323,682	$8,341,983	$12,182,652
Imperfect competition benefits	$79,699	$67,513	$405,955	$120,711	$514,621

Benefit	H2	H3 (A2B)	H3 (20C)	H4	H5
Tax wedge on increased labour supply	$253,088	$253,227	$914,080	$1,144,161	$556,794

12.2 Incremental economics (per horizon)

This economic assessment covers the evaluation of the SWGP. This is a significant programme of improvements, and as such, a staging plan has been developed to manage the implementation of interventions. The programme economics results should be considered the primary results for this programme, however an incremental assessment of each of the horizons has also been conducted to provide an indication of *value for money* for each individual horizon.

Table 24 shows the incremental cost benefit assessment of each option, assuming it is implemented at the time stated in the staging plan, and the interventions are in place for the remainder of the 60-year evaluation period. This is intended to give insight into the economic efficiency of each individual horizon, given that the horizons before are in place and without including any benefits of the subsequent horizons. It is important to note that each horizon is just one part of the full programme of improvements recommended by the Southwest Gateway Programme, and the results should be considered from that perspective, rather than trying to assess each increment as a standalone project.

The expected benefit-cost ratio (BCR) of each individual horizon ranges from 1.0 to 4.9. Care has been taken to ensure that the most appropriate base assumptions have been selected for the base economic assessment, to ensure these BCRs represent the most likely expected outcome.

Table 24 Incremental cost benefit analysis of each horizon

Costs/benefits		Horizon 2 (2025)	Horizon 3 (2030)	Horizon 4 (2035)	Horizon 5 (2040)
Project Costs (PV, $millions)					
Construction costs		$23	$522	$469	$372
Land costs		$0	$82	$131	$23
Maintenance costs		$0	$16	$18	$6
Renewal costs		$0	$1	$2	$0
Operating costs		$116	$29	$81	$0
Integrated consenting costs		$0	$9	$12	$0
Total project costs		**$139**	**$658**	**$713**	**$402**
Project Benefits (PV, $millions)					
Public transport-related benefits	Public transport user benefits	$73	$78	$215	$6
	Public transport reliability benefits	$21	$27	$362	$0
	Health benefits from added walking to stations	$20	-$13	$74	-$8
Road user benefits	Road user travel time benefits	$15	$1,686	-$108	$1,142
	Vehicle operating cost benefits	$0	$170	$0	$209
	Crash reduction benefits	$0	$99	$0	$68
	Vehicle emission benefits	$4	$9	$18	$8
	Reduced driver frustration benefits	$0	$226	$0	$156
	Trip reliability benefits	$0	$94	$0	$65

Costs/benefits		Horizon 2 (2025)	Horizon 3 (2030)	Horizon 4 (2035)	Horizon 5 (2040)
Active mode benefits	Cycling travel time benefits	$0	$0	$1	$1
	Health and environmental benefits from walking facilities	$0	$0	$0	$17
	Health benefits from cycling facilities	$0	$0	$39	$23
	Safety benefits from cycle facilities	$0	$0	$1	$1
	Pedestrian safety benefits	$0	$0	$5	$0
	Decongestion benefits from active mode shift	$0	$0	$7	$5
Wider economic benefits	Agglomeration benefits	$77	$364	$84	$246
	Imperfect competition benefits	$2	$12	-$	$11
	Tax wedge on increased labour supply	$7	$28	$18	$10
Total project benefits		**$219**	**$2,779**	**$715**	**$1,959**
Cost-benefit measures					
Net benefits (PV, $millions)		**$81**	**$2,121**	**$2**	**$1,557**
Benefit-cost ratio (no WEBs)		**0.96**	**3.6**	**0.86**	**4.2**
Benefit-cost ratio		**1.6**	**4.2**	**1.0**	**4.9**

The BCR for Horizon 2 and 4 are much lower than for Horizons 3 and 5. It is important to note with each of these:

- Horizon 2: the development of the preferred option (and the costs applied) differ from what was originally expected and modelled. In particular, travel time benefits from the proposed interventions on Te Irirangi Drive were not quantified within this assessment (further details in Section 9.5.4) and are expected to meaningfully improve the BCR of this horizon.
- Horizon 4: because Horizon 4 is not operational until 2035, benefits do not accrue until 15 years into the evaluation period and are significantly discounted. As seen in the sensitivity tests below, if the benefits accrue earlier in the evaluation period, this improves the BCR of Horizon 4.

Table 25 shows a sensitivity test of different construction start dates. It includes a test of beginning construction for horizon to 2023, which is estimated to be the earliest year that construction could feasibly begin (with the exception of Horizon 5, for which the construction start year is tested at 2024). It also includes a test of shifting all construction start years back by 5 years, to explore the impact of delays to the project. This test finds that the BCR for Horizon 2 and Horizon 4 are relatively *insensitive* to an earlier start year, while an earlier start year would somewhat reduce the BCR for Horizon 3 and Horizon 5.

Table 25: Sensitivity of horizons to construction year ($millions)

Costs/benefits		Incremental			
		Horizon 2	Horizon 3	Horizon 4	Horizon 5
Base	Operational year	2025	2030	2035	2040
	BCR	1.6	4.2	1.0	4.9
Shift earlier	Operational year	2024	2028	2029	2029
	BCR	1.6	4.0	1.1	4.2
Shift later	Operational year	2030	2035	2040	2045
	BCR	1.7	4.8	0.93	5.1

It is important to note that although the BCR of Horizon 4 reduces if construction is delayed, in this scenario the first 20 years of the evaluation period are waiting for construction – if the evaluation period was shifted to the beginning of the construction period, there would be another 15-20 years in which benefits would be accrued for Horizon 4.

13 Appendix: Additional evidence from MSM

This appendix provides some outputs from MSM to help understand the source of some of the benefits computed from these models.

Further difference plots of demands are available upon request from MRCagney (if we have them available) or Auckland Forecasting Centre (AFC).

Table 26: Travel time (minutes) in the AM peak for A2B journeys

Horizon	Model year/ scenario	Airport to Manukau	Manukau to Botany	Botany to Manukau	Manukau to Airport
1 (2021)	2028 (28152)	27	43 *(route 35)*	45 *(route 35)*	27
2 (2025)	2028 (28154)	25	22	23	26
3 (2030)	2028 (28156)	16	22	23	16
4 (2035)	2038 (38166)	14	15	15	14
5 (2040)	2038 (38168)	14	15	15	14

MSM difference plots (which can be provided by MRCagney or AFC) for public transport demand in each option, period, and available model year. Additionally, some charts are included in the business case to help understand the demands of A2B as a rapid transit service compared to just an on-road service, and the growth over time for the ultimate A2B service.

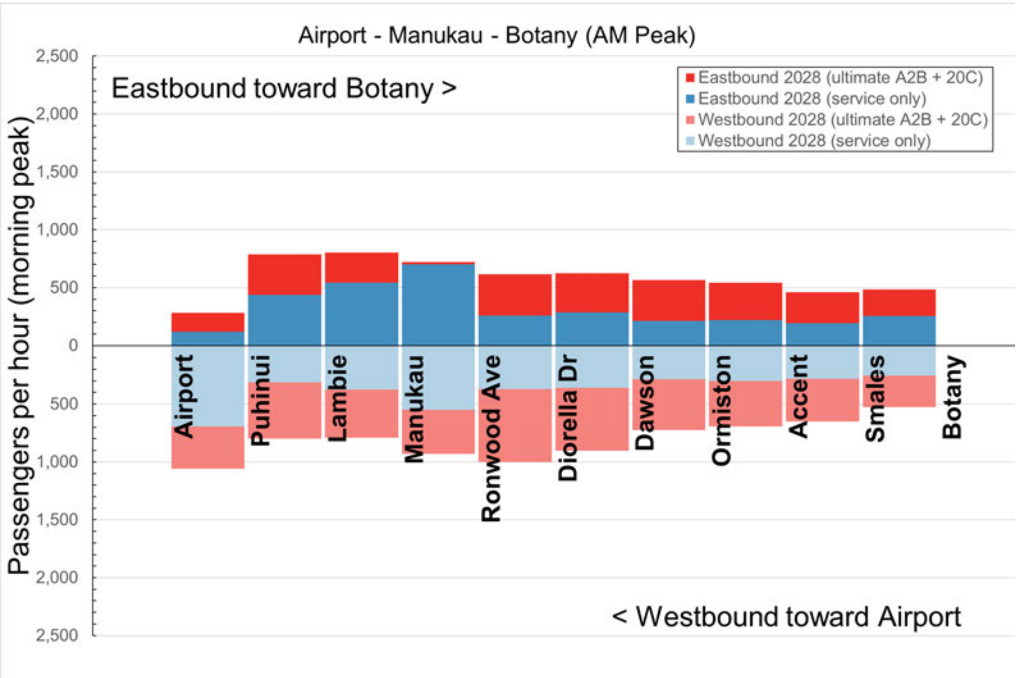


Figure 19: 2028 modelled demands for a service only (horizon 2) compared to a full RTN on A2B

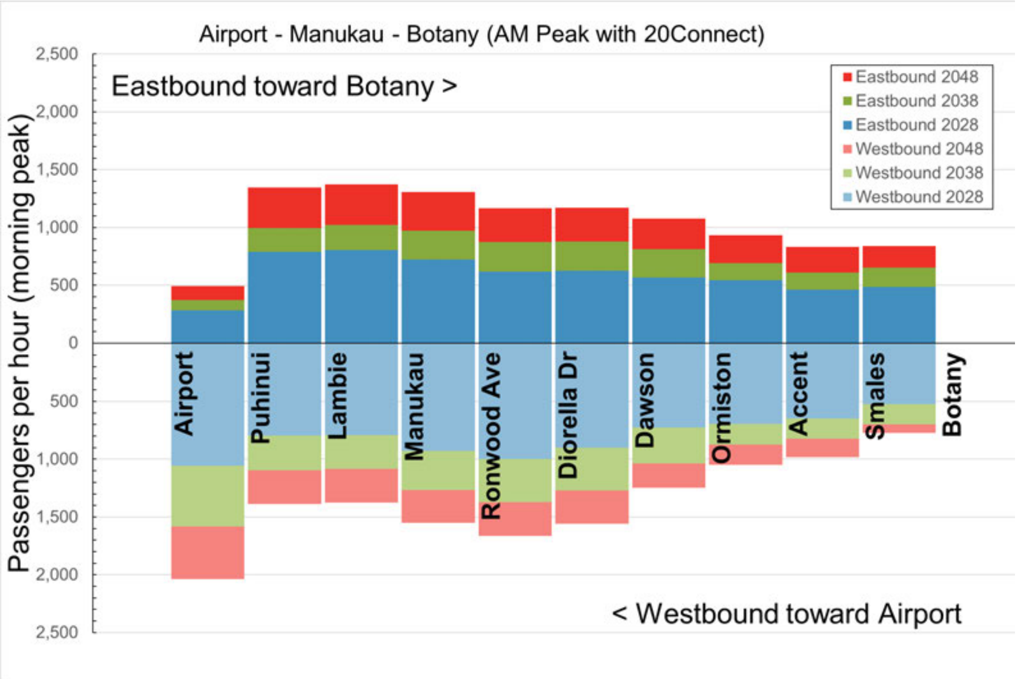


Figure 20: Demands on A2B service for the 'Horizon 4/5' service level as estimated by each model year

14 Appendix: Additional evidence from SATURN

flow
TRANSPORTATION SPECIALISTS

technical note

PROJECT	**AIRPORT ACCESS/ 20 CONNECT STUDY**
SUBJECT	**ANALYSIS OF TRAVEL TIME BENEFITS**
TO	**PROJECT TEAM**
FROM	[redacted]
REVIEWED BY	[redacted]
DATE	21 AUGUST 2020

1 INTRODUCTION

This technical note provides details of the travel time benefits of the roading components of the Aiirport to Botany (A2B) Rapid Transit and 20 Connect projects. It uses the modelling output check procedures set out in EEM Worksheet 8 to respond to the questions raised at the recent meeting. That is to say, it covers the following points:

- The derivation of the total road user benefits predicted for each horizon
- The source of those benefits, being predominatly travel time savings derived from traffic models
- The traffic modelling process, including the validation of the base models
- The levels of forecast growth in vehicle demands (noting that significant investment in other transport modes is assumed in the Future Do Minimum scenario) and the key areas of growth
- The time periods that are predicted to lead to significant travel time benefits
- The routes that are predicted to have benefits during the key time periods, including quantification of the predicted volumes of traffic and reduced travel times per vehicle.

As a result, the technical note identifies how these benefits per vehicle multiply through to the total monetary value of travel time savings predicted.

2 MAIN SOURCES OF OVERALL BENEFITS

The information set out in Flow's technical notes: 'Airport Access/20 Connect Study: Economic Evaluation Summary (May 2020)' and 'Addendum to Economic Evaluation for Stage 2B (June 2020)', states that the roading related components of the projects are estimated to produce overall benefits of $945 million and $730 million, for Horizon 3 and Horizon 5 respectively, over a 40 year evaluation period. The majority of the economic benefits, some $695M (75%) for Horizon 3 and $515M (70%) for Horizon 5, are predicted to be attributed to travel time savings.

We note that MRCagney have calculated the economic evaluation of the overall package over a 60-year period, as is now permitted, so their reporting of the total benefits uses different values to those set out here. Also, we understand that MRCagney are currently discussing the extrapolation of benefits beyond 2048, which will also affect the total benefits predicted in Flow's previous technical notes. However, while these issues (40 v 60 years and the rate of growth after 2048) will affect the total benefits, the analysis presented here still represents a valid breakdown of the predicted travel time savings of the roading components of the projects.

3 TRANSPORT MODELLING PROCESS

Travel time savings and vehicle operating cost benefits have been derived from a SATURN traffic model, covering SH20, SH20A and SH20B and the surrounding areas. The extent of the model was set out in the Flow report dated February 2018.

3.1 Base SATURN Models

Details regarding the validation of the base SATURN models were set out in the Flow report dated February 2018.

3.2 Future SATURN Models

The SATURN models have been informed by MSM runs which were carried out specifically for the various "Project Horizons". The SATURN models were only used to isolate the traffic benefits of two components of the overall project, as set out in the Flow Technical Note of May 2020.

- Stage 2B will include HOV lanes (T3 lanes) along SH20B in both directions, between the Airport and west of the SH20B/ SH20 interchange. It also includes a new ramp from SH20B to SH20 south will be provided along with the widening of SH20 between the SH20B/ SH20 interchange and Manukau.
- Stage 4 proposes widening on SH20 and a new connection from SH20A to SH20 southbound. The widening on SH20 would consist of increased number of lanes between the SH20B/SH20 interchange and the SH20A/SH20 interchange, from two to three in each direction. Between the SH20A/SH20 interchange and Mangere Bridge, the number of lanes in each direction would be increased from three to four.

The MSM modelled the proposed HOV lanes along SH20B by assuming an increase in capacity from one traffic lane per direction, without the HOV lanes, to 1.15 lanes per direction with the HOV lanes. For the SATURN model, separate HOV lanes were coded, with only HOVs and buses permitted to use those lanes in the model.

As discussed in the Technical Note of May 2020, two forecast year models have been used to calculate benefits for each of the two relevant project horizons, as detailed below：

- Horizon 3 (Stage 2a and Stage 2b) – 2028 and 2048
- Horizon 5 (Stage 3 and Stage 4) – 2038 and 2048

4 GROWTH IN DEMANDS AND BENEFITS

To understand the benefit stream of each horizon, the predicted yearly travel time benefits in each forecast year are summarised in Table 1 below:

Table 1: Yearly Summary – Total Travel Time Benefits

	2028	2038	2048	Total Benefits (over 40 years)
Horizon 3	$14 Million	N/A	$109 Million	$695 Million
Horizon 5	N/A	$75 Million	$99 Million	$515 Million

It can be seen that the benefits associated with Horizon 3 improvements are predicted to increase significantly between 2028 and 2048, while the predicted benefits for Horizon 5 projects are relatively similar between 2038 and 2048.

As discussed, travel time benefits are predicted to contribute the vast majority of project benefits. The travel time benefits are predicted to be most significant along the State Highway corridors included in the model, namely SH20, SH20A and SH20B. The predicted daily traffic volumes along these routes are presented in the tables below, including the existing counts and modelled flows (Table 2) and forecast flows (Tables 3 and 4). The modelled flows are provided both in terms of the 'Actual' and 'Demand[1]' traffic volumes.

Table 2: Comparison between daily taffic counts and Predicted Daily Traffic Volumes[2] (vehicles per day), in Base models, 2017

	Count	Base Model	
		Demand	**Actual**
SH20A	38,000	37,000	36,000
SH20B	29,000	26,000	25,000
SH20	80,000	83,000	82,000

Table 3: Predicted Daily Traffic Volumes (vehicles per day), in Stage 2A (Horizon 3) models

	Horizon 3 (Stage 2A, Do Minimum)			
	Demand		**Actual**	
	2028	2048	2028	2048
SH20A	52,000	91,000 (+75%)	52,000	88,000 (+70%)
SH20B	35,000	43,000 (+22%)	35,000	39,000 (+11%)
SH20	102,000	112,000 (+10%)	102,000	100,000 (-2%)

1 The 'Demand' flows represent the traffic volumes want to travel through road sections while the 'Actual' flows indicate volumes that will be able to get through (usually actual flows are less than demand flows due to up stream bottlenecks).
2 Predicted Daily taffic volumes are calculated by 2*Morning Peak flows + 9* Inter Peak flows + 2* Evening Peak flows

Table 4: Predicted Daily Traffic Volumes (vehicles per day), in Stage 3B (Horizon 5) models

	Horizon 5 (Stage 3B, Do Minimum)			
	Demand		Actual	
	2038	2048	2038	2048
SH20A	75,000	92,000 (+22%)	75,000	90,000 (+20%)
SH20B	38,000	42,000 (+11%)	37,000	39,000 (+4%)
SH20	107,000	112,000 (+4%)	103,000	102,000 (-1%)

The following points are noted:

- Table 2 indicates a good correlation between the base model and the observed flows, at a daily level
- Significant traffic growth is predicted along the State Highways. SH20A in particular is predicted to experience some 75% increase in demands between 2028 and 2048 (ie around 3.75% per year), and 22% between between 2038 and 2048
- Growth is also predicted along SH20 for each horizon. While the percentage increases are not as significant as predicted for SH20A, the absolute increases in demand flows are still predicted to be 10,000 vehicles per day between 2028 and 2048. We note that due to capacity constraints predicted in the Do Minmum scenario, minor changes are predicted to the daily volumes on SH20
- Similarly, the increases along SH20B are predicted to be some 10 to 20% in Horizon 3 and Horizon 5 respectively. It can be seen that the growth in actual volumes is predicted to be less than the predicted growth in demands, indicating that congestion will present along SH20B. Indeed, this will be one of the factors for the high increase in forecast flows on SH20A.

It needs to be stressed that the above growth figures include the assumption of significant investment in public transport to the Airport from the north and east, in the Do Minimum scenario.

Section 5 below notes that travel time benefits from the interpeak model are predicted to contribute the majority of the project benefits. As a result, the following table sets out the predicted inter peak traffic generation from the main growth areas around the Airport, these being MSM zones 597 and 598 (representing the Auckland Airport Terminals) and 509 (representing the Southern Gateway development area to the east of the Airport:

Table 5: Predicted Traffic Demands (vehicles per hour in the inter peak)

	Horizon 3		Horizon 5	
	2028	**2048**	**2038**	**2048**
Auckland Airport	4,155	6,430	5,330	6,405
Puhinui Precinct	3,330	7,070	5,325	7,070
Total	7,485	13,500	10,655	13,480
Growth	N/A	80%	N/A	25%

The above table indicates the magnitude of growth anticpated in the Airport area and at the live zoned land around the Southern Gateway.

5 SOURCES OF TRAVEL TIME BENEFITS

To understand the source of the predicted benefits, a breakdown of the travel time benefits over the three modelled periods is set out below:

For Horizon 3

- Morning peak: $ 75 million – 11% of total travel time benefits
- Inter peak: $ 505 million – 72% of total travel time benefits
- Evening peak: $ 120 million – 17% of total travel time benefits

For Horizon 5

- Morning peak: $ 15 million – 3% of total travel time benefits
- Inter peak: $ 445 million – 86% of total travel time benefits
- Evening peak: $ 55 million – 11% of total travel time benefits

From the above, we note that:

- The inter peak period is predicted to contribute the most significant proportion of total travel time benefits, mainly due to the fact that it relates to a much longer period of time than the two other modelled periods. In addition, the weekend benefits are also calculated by applying a factor to the inter peak models.
- The evening peak period contributes the highest travel time benefits per modelled hour.

As such, the following analysis focuses on both the inter peak and evening peak periods.

5.1 Inter Peak Period Benefits

Table 6 below summarises the travel time savings per hour and annual travel time benefits in dollar values derived from the inter peak models for both Horizon 3 and Horizon 5.

Table 6: Benefits Summary, Inter peak

	Travel Time Savings (Vehicle hours)		Annual Travel Time Benefits ($ Million)	
	2028	**2048**	**2028**	**2048**
Horizon 3	100	860	$8.9 M	$76.8 M
Horizon 5	560	700	$50 M	$62.5 M

Annual travel time benefits have been calculated by the forecast travel time savings, in vehicle hours, multiplied by the value of time, the number of hours per day and the number of days in a year, and full details of the values assumed are set out in Sections 4.1 and 4.2 of Flow's Technical Note of May 2020. The benefits derived from the inter peak model are as follows:

Weekday interpeak

- Value of time (including update factor): $27.64 per hour
- The number of hours per day: 9
- the number of days per year: 245

Weekend day

- Value of time (including update factor): $21.70 per hour
- The number of hours per day: 10 (based on 109% of the weekday inter peak, based on observed traffic profiles)
- the number of days per year: 120

So as an example, 100 hours of travel time saving in a single hour, according to the weekday inter peak model leads to $8,933,000 benefit, this being the value predicted for Horizon 3 in 2028 in Table 6 above.

5.1.1 Horizon 3

The following tables provide a summary of the locations which are predicted to contribute the most significant travel time inter peak benefits for Horizon 3, in both 2028 and 2048. This information is provided in a manner consistent with EEM worksheet 8.2(a) and worksheet 8.2(b):

Table 7: Interpeak Benefit Analysis, Horizon 3, 2028

<table>
<tr><th rowspan="2"></th><th rowspan="2">Locations</th><th colspan="2">Stage 2a (Do Minimum)</th><th colspan="2">Stage 2b (Option)</th><th rowspan="2">Travel Time Savings (vehicle hours)</th><th rowspan="2">Percentage to total Travel Time savings (%)</th></tr>
<tr><th>Demands (veh)</th><th>Delay (seconds)</th><th>Demands (veh)</th><th>Delay (seconds)</th></tr>
<tr><td rowspan="2">SH20B</td><td>Along SH20B</td><td>820 – 1,320</td><td>20 – 60</td><td>810 – 1,150</td><td>15 – 50</td><td rowspan="2">40</td><td rowspan="2">40%</td></tr>
<tr><td>SH20B/ Puhinui Interchange</td><td>540 -1,460</td><td>15 – 55</td><td>180 – 1,430</td><td>0 – 45</td></tr>
<tr><td rowspan="3">SH20</td><td>Both directions, north of Massey Interchange</td><td>3,590 – 5,520</td><td>10 – 20</td><td>3,520 – 5,430</td><td>10 – 15</td><td rowspan="3">60</td><td rowspan="3">60%</td></tr>
<tr><td>Both directions, between Massey Interchange and Puhinui Interchange</td><td>3,980 – 4,160</td><td>65 – 90</td><td>3,910 – 4,120</td><td>60 – 80</td></tr>
<tr><td>Southbound, South of Puhinui Interchange</td><td>3,680 – 4,160</td><td>10 – 20</td><td>3,780 – 4,220</td><td>0 - 5</td></tr>
<tr><td colspan="6">Total Benefits</td><td>100</td><td>100%</td></tr>
</table>

Table 8: Interpeak Benefit Analysis, Horizon 3, 2048

	Locations	Stage 2a (Do Minimum)		Stage 2b (Option)		Travel Time Savings (vehicle hours)	Percentage to total Travel Time savings (%)
		Demands (veh)	Delay (seconds)	Demands (veh)	Delay (seconds)		
SH20B	Along SH20B	1,130 – 1,710	130 - 510	1,190 – 1,550	110 - 450	280	33%
	SH20B/ Puhinui Interchange	630 -1,770	15 – 50	420 – 1,770	5 - 115[3]		
SH20	Southbound, South of Massey Interchange	4,790	720	4,500	590	230	27%
Intersections in Wiri, including Roscommon Interchange		300 – 2,660	20 - 410	300 – 2,400	10 - 260	350	40%
Total Benefits						860	100%

Table 7 indicates that SH20 and SH20B are expected to contribute travel time benefits in 2028. Specifically, SH20 is predicted to contribute 60% of the total travel time benefits, with modest benefits per vehicle, but these are predicted to apply to large volumes of traffic. This modest travel time saving (per vehicle) is due to the additional capacity provided along Sh20B in Stage 2b which is predicted to divert traffic away from the busy sections of SH20. As such, SH20B is expected to contribute 40% of total time benefits during the interpeak in 2028.

Similarly, Table 8 indicates that SH20, SH20B and intersections within the Wiri/Southern Gateway area will contribute travel time benefits, with the latter predicted to contribute 40% of the total travel time benefits. This is followed by SH20B (around 35%) and SH20 (around 25%).

The above tables also confirm that the project benefits are predicted to increase significantly between 2028 and 2048. The travel time benefits along SH20 and SH20B are predicted to increase from some $9 Million in 2028 to some $77 Million in 2048, as significant delays are predicted in the model with the Stage 2a layout.

5.1.2 Horizon 5

The following tables provide a summary of the locations which are predicted to contribute the most significant travel time benefits for Horizon 5, in both 2038 and 2048.

3 The SH20B/Puhinui interchange is predicted to experience increased delays due to increased traffic volumes on the southbound off ramp. The resulting disbenefits however, are not expected to be significant.

Table 9: Interpeak Benefit Analysis, Horizon 5, 2038

	Locations	Stage 3b (Do Minimum)		Stage 4 (Option)		Travel Time Savings (vehicle hours)	Percentage to total Travel Time savings (%)
		Demands (veh)	Delay (seconds)	Demands (veh)	Delay (seconds)		
SH20B	Along SH20B and SH20B/ Puhinui Interchange	360 – 1,700	5 – 90	250 – 1,630	7 - 75	40	7%
SH20	Both directions, between Mahunga Interchange and Walmsley Interchange	1,650 – 6,030	10 – 50	1,110 – 6,210	0 - 10	520	93%
	Both directions, between Walmsley Interchange and Massey Interchange	3,620 – 5,420	5 – 20	4,040 - 5,720	0 - 5		
	Both directions, between Massey Interchange and Puhinui Interchange	4,110 - 4,530	100 - 200	4,330 – 4,890	0 - 10		
	Southbound, south of Puhinui Interchange	3,160 – 5,070	2 – 10	3,340 – 5,040	2 - 50[4]		
Total Benefits						560	100%

Table 10: Interpeak Benefit Analysis, Horizon 5, 2048

	Locations	Stage 3b (Do Minimum)		Stage 4 (Option)		Travel Time Savings (vehicle hours)	Percentage to total Travel Time savings (%)
		Demands (veh)	Delay (seconds)	Demands (veh)	Delay (seconds)		
SH20B	Along SH20B	1,280 – 1,950	50 - 280	1,240 – 1,640	20 - 180	160	23%
	SH20B/ Puhinui Interchange	590 – 1,620	5 – 50	400 – 1,880	10 - 95[5]		
SH20	Both directions, between Mahunga Interchange and Walmsley Interchange	1,910 – 6,480	15 – 80	1,260 – 6,610	5 - 20	540	77%
	Both directions, between Walmsley Interchange and Massey Interchange	3,530 – 5,880	5 – 25	4, 160 - 6,280	0 - 5		
	Both directions, between Massey Interchange and Puhinui Interchange	4,060 – 4,950	60 – 510	4,500 – 5,130	0 - 20		

4 Increased delays are predicted on the Roscommon Interchange eastbound onramp, due to increased demands between Stage 2a and 2b, which result in minor disbenefits.
5 The SH20B/Puhinui interchange is predicted to experience increased delays due to increased traffic volumes on the southbound off ramp. The resulting disbenefits however, are not expected to be significant.

	Southbound, south of Puhinui Interchange	3,330 – 5,100	0 – 80	3,260 – 5,730	60 - 300[6]		
Total Benefits						700	100%

Table 9 and Table 10 indicate that in Horizon 5, during the inter peak period in both 2038 and 2048, SH20 is predicted to contribute the most significant travel time benefits (95% and 75% in 2038 and 2048 respectively). Compared with Stage 3b, Stage 4 proposes widening on SH20 and a new connection from SH20A to SH20 southbound. This is predicted to increase the traffic volumes on SH20 and reduce delays, particularly on the section between Massey Interchange and Puhinui interchange, where significant delay reductions/benefits are predicted.

SH20B is predicted to contribute 5% and 25% of travel time benefits during the inter peak period in 2038 and 2048, respectively. This is considered reasonable as in Horizon 5, no further investments will be provided along SH20B, and the travel time savings predicted will be mostly associated with delay reductions due to re-routing.

5.2 Evening Peak Period Benefits

Table 11 below summarises the forecast travel time savings per hour and annual travel time benefits in dollar values derived from evening peak models for both Horizon 3 and Horizon 5.

Table 11: Benefits Summary, Evening Peak

	Travel Time Savings (Vehicle hours)		**Annual Travel Time Benefits ($ Million)**	
	2028	**2048**	**2028**	**2048**
Horizon 3	170	1,690	$1.9 M	$19.1 M
Horizon 5	360	650	$4.1 M	$7.3 M

Annual travel time benefits are calculated by the forecast travel time savings, in vehicle hours, multiplied by the values of time, the number of hours per day and the number of days in a year. The benefits derived from the evening peak models are as follows:

- Value of time (including update factor): $23.04
- The number of hours per day: 2
- the number of days in a year: 245

5.2.1 Horizon 3

The following tables provide a summary of the locations which are predicted to contribute the most significant travel time benefits for Horizon 3, during the evening peak period, in both 2028 and 2048.

6 Increased delays are predicted on the Roscommon Interchange eastbound onramp, due to increased demands between Stage 3b and 4, which results in some disbenefits.

Table 12: Evening Peak Benefit Analysis, Horizon 3, 2028

	Locations	Stage 2a (Do Minimum)		Stage 2b (Option)		Travel Time Savings (vehicle hours)	Percentage to total Travel Time savings (%)
		Demands (veh)	Delay (seconds)	Demands (veh)	Delay (seconds)		
SH20B	Along SH20B	850 – 1,270	50 – 290	880 – 1,390	40 - 200	140	82%
	SH20B/ Puhinui Interchange	475 – 1,525	10 – 190	260 – 1,290	5 -105		
Intersections in Wiri, including Roscommon Interchange		600 – 2,300	20 -290	560 – 2,400	20 - 240	30	18%
Total Benefits						170	100%

Table 13: Evening Peak Benefit Analysis, Horizon 3, 2048

	Locations	Stage 2a (Do Minimum)		Stage 2b (Option)		Travel Time Savings (vehicle hours)	Percentage to total Travel Time savings (%)
		Demands (veh)	Delay (seconds)	Demands (veh)	Delay (seconds)		
SH20B	Along SH20B	1,300 – 1,820	330 - 1,170	1,300 – 1,750	210 - 1,110	440	26%
	SH20B/ Puhinui Interchange	580 -2,170	15 – 320	590 - 1510	5 - 210		
SH20A	Northbound, north of Landing Drive Interchange	4,400 – 4,630	90 – 360	4,170 – 4,270	110 - 160	240	14%
Intersections in Wiri, including Roscommon Interchange		290 – 2,990	50 – 2,530	290 -2,870	10 – 1,210	1,010	60%
Total Benefits						1,690	100%

Table 12 indicates that SH20B is predicted to contribute the majority of benefits during the evening peak with Horizon 3, making up almost 80% of the total travel time benefits. Intersections in Wiri/Southern Gateway are expected to provide some 20% of total travel time benefits in 2028.

Table 13 shows that during the 2048 evening peak, intersections in Wiri are expected to contribute some 60% of the travel time benefits. This is mostly associated with the proposed fly-over ramp between SH20B and SH20, which is predicted to improve traffic operations at the SH20 Puhinui Interchange. This in turn will lead to reduced delays at the Roscommon Interchange as well as at the intersections in the Wiri area. SH20A and SH20B are expected to contribute 15% and 25% of travel time benefits, respectively, as some northbound traffic on SH20A is predicted to reroute via SH20B. This is predicted to lead to reduced traffic volumes on SH20A and therefore improved delays/travel time benefits.

5.2.2 Horizon 5

The following tables provide a summary of the locations which are predicted to contribute the most significant travel time benefits for Horizon 5, during the evening peak period, in both 2028 and 2048.

Table 14: Evening Peak Benefit Analysis, Horizon 5, 2038

	Locations	Stage 3b (Do Minimum)		Stage 4 (Option)		Travel Time Savings (vehicle hours)	Percentage to total Travel Time savings (%)
		Demands (veh)	Delay (seconds)	Demands (veh)	Delay (seconds)		
SH20B	Along SH20B	990 – 1,860	20 - 220	1,040 – 1,830	20 - 210	70	19%
	SH20B/ Puhinui Interchange	650 – 1,270	5 - 125	550 – 1,610	5 - 100		
SH20	Both directions, between Mahunga Interchange and Walmsley Interchange	1,340 – 5,780	10 - 20	950 – 4,780	0 - 5	80	22%
	Both directions, between Walmsley Interchange and Massey Interchange	2,780 – 4,550	0 - 15	3,130 – 4,890	0 - 5		
	Both directions, between Massey Interchange and Puhinui Interchange	3,200 – 3,640	0 - 30	3,400 - 4,550	0 - 5		
	Southbound, south of Puhinui Interchange	2,400 – 4,700	0 – 5	3,000 – 5,100	0 - 20[7]		
Intersections in Wiri, including Roscommon Interchange		260 - 2670	30 – 700	230 - 2640	30 - 660	160	45%
Kaka Street/ Walmsley Road		940 – 1,170	30 - 160	880 – 1,200	20 - 100	50	14%
Total Benefits						360	100%

7 Increased delays are predicted on the Roscommon Interchange eastbound onramp, due to increased demands between Stage 3b and 4, which results in some disbenefits.

Table 15: Evening Peak Benefit Analysis, Horizon 5, 2048

	Locations	Stage 3b (Do Minimum)		Stage 4 (Option)		Travel Time Savings (vehicle hours)	Percentage to total Travel Time savings (%)
		Demands (veh)	Delay (seconds)	Demands (veh)	Delay (seconds)		
SH20B	Along SH20B	1,110 – 2,150	220 - 700	1,110 – 2,080	110 - 640	90	14%
	SH20B/ Puhinui Interchange	700 – 1,310	0 - 135	700 – 1,600	0 - 175[8]		
SH20	Both directions, between Mahunga Interchange and Walmsley Interchange	1410 - 6170	10 - 25	970 - 6400	0 - 5	120	18%
	Both directions, between Massey Interchange and Puhinui Interchange	1,130 – 3,600	0 – 105	1,040 – 4,400	0 – 35		
Intersections in Wiri, including Roscommon Interchange		280 – 3,100	10 – 2,320	300 – 3,010	10 – 1,420	390	60%
Kaka Street/ Walmsley Road		940 – 1,200	160 - 290	980 – 1,260	150 - 180	50	8%
Total Benefits						650	100%

Tables 14 and 15 indicate that intersections in Wiri are predicted to contribute 45 to 60% of the total travel time benefits during the evening peak period, in years 2038 and 2048. This is due to the widening of SH20 which is predicted to lead to traffic re-routing. This is predicted to reduce traffic volumes travelling along Roscommon Road, therefore, reducing predicted delays at intersections in Wiri.

SH20 and SH20B are both predicted to contribute around 20% of travel time savings during the evening peak in 2038 and similar percentages (14 to 18%) are also predicted in 2048. We, however, note that SH20 and SH20B are predicted to result in more benefits during the evening peak in 2048, due to the predicted traffic growth between 2038 and 2048.

The travel time savings at the Kaka Street/Walmsley Road intersection are predicted to contribute some 15% of the travel time benefits in 2038 and 10% of travel time benefits in 2048. At first glance these seem questionable. However, the model predicts that some eastbound traffic along James Fletcher Drive will reroute due to the proposed SH20 widening.

8 The SH20B/ Puhinui interchange is predicted to produce negative benefits due to increased traffic volumes on the southbound off ramp. The negative benefit is not significant.

15 Appendix: Dynamic Wider Economic Benefits

This Appendix describes the basis for investigating dynamic wider economic benefits (WEBs) and land use change benefits for the SWGP, the work done by the programme, and the reasons that they are not included in the final economics assessment.

Transport appraisal methods traditionally focus on first-order benefits of transport projects, such as road or public transport user benefits. Frequently, appraisal methods also account for 'static' second-order benefits, including agglomeration benefits, imperfect competition benefits, and a tax wedge on increased labour supply. More rarely, appraisal methods account for second-order benefits under 'dynamic' land use scenarios, which incorporate benefits from people and/or jobs relocating due to a transport project.

These dynamic second-order benefits are described in the interim guidance for the Waka Kotahi Economic Evaluation Manual (EEM): *Transformative Transport Projects (Dynamic WEBs and Land Use Benefits and Costs), 4 December 2019*. These include the following:

- **Dynamic agglomeration**, in which the relocation of workers or firms induced by a transport project results in an increase in net density and effective employment density, increasing worker and firm productivity.
- **Move to more productive jobs**, in which a transport project induces workers to relocate and take up a more productive job, thereby increasing their average tax take.
- **Land use benefits**, which may include land value changes, public infrastructure cost changes, second round transport externalities, second round costs and benefits, and public health cost changes resulting from relocation of workers or firms.

The consideration of including dynamic WEBs and land use change benefits for these projects included the following components:

- A memorandum exploring global and local evidence that major public transport projects can induce relocation of jobs and residents, which is a necessary pre-condition for dynamic WEBs and land use change benefits.
- A draft methodology outlining how dynamic WEBs and land use change benefits could be estimated, based on interim guidance for the Waka Kotahi Economic Evaluation Manual (EEM): *Transformative Transport Projects (Dynamic WEBs and Land Use Benefits and Costs), 4 December 2019*.
- Discussions and workshops with the project team, clients and peer reviewers on the plausibility of dynamic WEBs and land use change benefits from the SWGP.
- Preliminary calculations of some of the potential dynamic WEBs and land use change benefits.

As outlined in Section 15.3, the global and local evidence suggests that major transport projects, including bus rapid transit projects, are capable of inducing relocation of jobs and residents, and thus are capable of creating dynamic WEBs and land use change benefits. Furthermore, Auckland has complementary land use strategies that may support relocation of jobs and residents in response to a major transport project.

Preliminary calculations revealed, however, that the Southwest Gateway Programme is expected to have mixed implications for density change. The programme is expected to trigger *increased* density in some locations with medium and high-density developments while *reducing* density in some locations with very high density (such as the city centre). They also suggest that overall land use impacts would be small. Of the preliminary dynamic WEBs and land use change benefits calculated, some were found to be positive and others negative, and with similar magnitudes. This suggests overall benefits may be immaterial for the economic assessment. Further, preliminary calculations were relatively sensitive to varying the scale of land use change further from the project areas, each of which appear similarly plausible. These land use models are described in Section 15.1 and the calculation methodology is described in Section 15.2.

It was therefore determined that any results obtained for dynamic WEBs and land use change benefits would be regarded with a relatively low confidence level, would be relatively small, and would not be appropriate to apply to the programme benefit-cost calculations.

The following sections include the preliminary calculations, methodology, and memorandum on global and local land use changes from major transport projects.

15.1 Preliminary results of dynamic WEBs and land use change benefits

Preliminary calculations found that the Airport to Botany and 20Connect projects were likely to produce some positive and some negative dynamic WEBs and land use change benefits.

The programme is expected to meaningfully reduce generalised cost of travel to and from south and east Auckland, resulting in increased employment and residential density in these areas. The net effect is for overall movement of people from low- and medium-density zones in Auckland to medium- and high-density zones. This fuels public infrastructure cost savings, for which preliminary calculations are shown below.

Simultaneously, some projected relocation of employment is also estimated to shift away from very high-density zones, such as the city centre. These areas currently have very high agglomeration with many businesses and employees located very close together. Agglomeration impacts of land use change caused by these projects are thus likely to be negative.

The following bullet points show that the range of estimated benefits is wide and quite uncertain given the data available for the analysis.

- Dynamic agglomeration: -$10 million to -$35 million
- Move to more productive jobs: -$10 million to -$62 million
- Higher value land use: not estimated
- Public infrastructure cost savings: -$1 million to $15 million
- Second round benefits and costs: -$10 million to -$40 million
- Public health cost changes: -$0.01 million to $0.02 million

It should be noted that these results are from preliminary calculations and should not be interpreted as final results, though their direction and order of magnitude would likely be consistent with any final calculations.

15.2 Draft methodology for calculating dynamic WEBs and land use change benefits

The following draft methodology was created for the SWGP to estimate the likely scale of dynamic WEBs and land use change benefits. The preliminary results in Section 15.1 were estimated using this draft methodology.

The draft methodology was also presented to and discussed with the project team, clients and peer reviewers to confirm the approach being taken. The base land use change estimations were adjusted to include various levels of distance-weighting based on discussions relating to the extent that which land use change effects would be likely to be observed from these projects. This distance-weighting reduces the jobs and residents projected to relocate from areas throughout Auckland further away from south and east Auckland, such as the city centre.

Note that this methodology follows the suggested quantitative approaches in Waka Kotahi, NZ Transport Agency's economic evaluation manual (EEM) interim guidance: *Transformative Transport Projects (Dynamic WEBs and Land Use Benefits and Costs), 4 December 2019*. For reference, some terms we use in this document are:

- Base case transport model: to refer to the transport model *WITHOUT* the SWGP.
- Original option transport model: to refer to the transport model with the projects and the base land use assumptions.
- Second-round transport model: to refer to the transport model including the adjusted land use assumptions.
- Base (i11.5) land use assumptions: Auckland Council's i11v5 land use forecast assumptions.
- Adjusted land use assumptions: the estimated land use given the SWGP, by applying the methodology in Section 15.2.2.

15.2.1 Introduction

This methodology seeks to obtain quantitative results for all land use benefits and dynamic WEBs to be applied to the SWGP. In all cases, it attempts to use a rigorous methodology, including using New Zealand-based parameters, to obtain outputs with relatively high degrees of confidence. Some limitations exist that reduce our degree of confidence for some outputs, and these are discussed in this methodology where they have been identified.

The benefits described in the interim guidance and included in this methodology are:

- Dynamic agglomeration
- Move to more productive jobs (M2MPJ)
- Land use benefits
- Public infrastructure cost changes
- Second round user benefits and costs
- Public health cost changes

The following sections describe the methodology for estimating each benefit.

The presence of these dynamic WEBs depends upon the increased population and/or employment density induced by the projects, as is described in Section 15.2.2. Without changes in these densities, there are no dynamic WEBs.

15.2.2 Estimating Land Use Change

Land use changes were estimated based on Auckland Council i11.5 land use forecasts and initial regional transport model results that include the SWGP. This modelling shows that the projects are likely to materially impact growth patterns across Auckland, with increased population densities projected near the A2B route (and to a lesser extent throughout much of South Auckland) and decreased population densities across the rest of Auckland, relative to the base land use forecasts.

Two methods for modelling land use change from the SWGP were tested, applying econometric techniques to identify the causal impact of improved transport access on people's and firms' location choices. The two methods applied are both demand-side/attractiveness models, that attempt to develop statistical relationships between transport accessibility and the distribution of population and employment throughout the region. These methods are consistent with the approach in the interim guidance. One of the models (the spatial general equilibrium model) yielded unusual results, suggesting that a material factor was missed in the regression model, therefore the other model (the accessibility-density model) has been relied on for the land use change estimation from these projects.

Endogeneity (understanding which variable causes changes in the other variable) is a major challenge to modelling the impacts of transport on land use. In some cases, developments respond to improved transport access, however in other cases, transport agencies respond to demand induced by developments. Instrumental variables are therefore used in both models to control for endogeneity, by including variables in the models that *are* correlated with the explanatory variable (transport accessibility) and are *not* correlated with other factors that might affect the outcome variable (population/employment density). The preference of fixed geographical features like hills and harbours that have shaped accessibility both directly and indirectly is used for the instrumental variables in each of the models.

Accessibility-density model

This model attempts to estimate the impact of accessibility improvements on attractiveness of locations.

The cross-sectional correlation between transport accessibility and density of development can provide an indication of the *long-run* relationship between these variables. Volterra Partners (2017) suggests using this approach to predict the long-run effects of a future transport improvement. This method assumes that future land use will respond to transport changes in the same way that historical developments have.

The accessibility-density model applied here uses the effective job density (EJD) measure that the EEM defines for use in calculating agglomeration benefits of transport improvements. EJD calculates the number of jobs accessible via the transport system, assigning a lower weighting to jobs that are further away in terms of travel time.

The basic results of the scatterplots included in Figure 20 and Figure 21 show that areas that are more accessible to jobs via the transport system also tend to be denser, although there can be significant differences in density between areas with a similar level of transport accessibility.

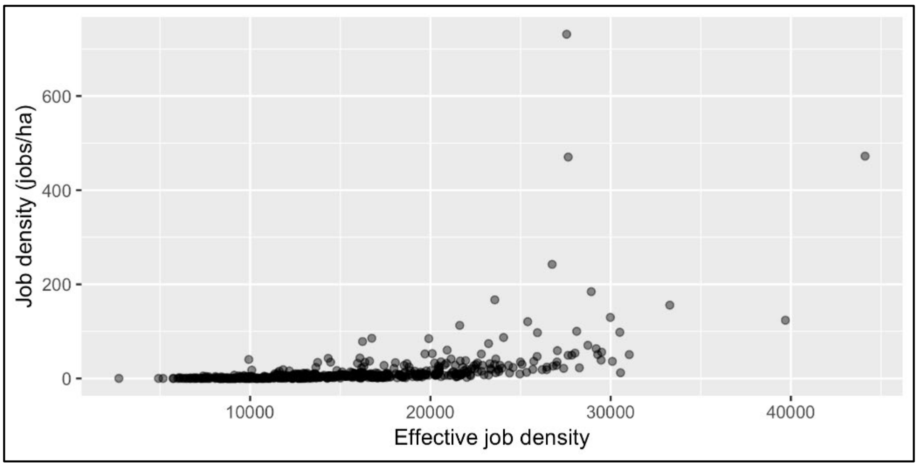


Figure 21: Accessibility density graphs for Auckland (2013): EJD and job density

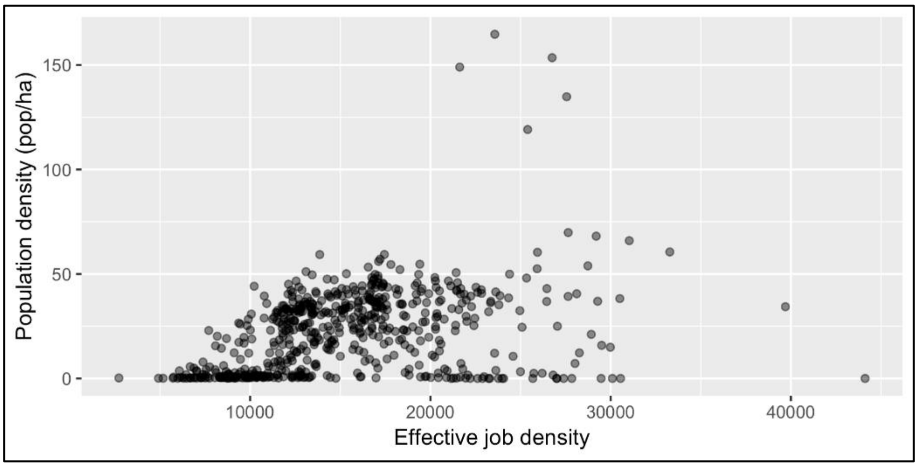


Figure 22: Accessibility density graphs for Auckland (2013): EJD and population density

These charts alone merely indicate that there is correlation between EJD and local job/population density, however they do not reveal whether EJD is a likely cause of that correlation.

To identify the causal effect of increased EJD on population and employment density, instrumental variables (IV) regression[18] is applied. The following instruments for EJD were developed to exploit the presence of fixed geographical features like hills and harbours that have shaped accessibility both directly (by making some journeys longer or more inconvenient) and indirectly (by raising the cost to build or expand transport infrastructure):

- Length of the straight line between the model zone centroid and the town hall (as a proxy for the City Centre)
- The share of that line that cross land (not water)
- Elevation of the model zone above sea level

Results of accessibility-density model

The causal accessibility-density relationships were estimated from 2016 base year outputs from MSM. Table 27 summarises the estimated causal effect of EJD on population and employment density. The coefficients on the EJD variable (highlighted in bold) indicate that a 10% increase in EJD causes a 15% increase in local job density and a 20% increase in local population density.

[18] Instrumental variables regression is used to estimate causal relationships between variables by including other variables that are correlated with the explanatory variable (EJD) and is not correlated with the outcome variable (population/employment density).

Table 27: Accessibility-density relationships in Auckland

Model	Population density model			Employment density model		
Outcome variable	**ln(2016 population density)**			**ln(2016 job density)**		
Explanatory variables	**Coefficient**	**Robust SE**	**p-value**	**Coefficient**	**Robust SE**	**p-value**
ln(effective job density)	**2.012**	0.495	0.000***	**1.552**	0.319	0.000***
ln(distance to CBD)	-0.129	0.160	0.422	-0.396	0.103	0.000***
Elevation of model zone centroid	-0.002	0.001	0.305	-0.003	0.001	0.005**
Constant	-15.5	6.2	0.013*	-9.3	4.0	0.020*
Model statistics						
R^2	0.17			0.62		
Wald test	97.3*** (df=3; 592)			150.6*** (df=3; 592)		

*Notes: (1) ln(EJD) is instrumented with three variables: average slope of straight line from model zone centroid to town hall; share of that line that crosses land, and the square of land share. (2) Statistical significance levels: . p<0.1; * p<0.05; ** p<0.01; *** p<0.001*

Application of results to update land use forecasts

These results can be used to forecast the land use changes caused by these projects using a two-step process that is analogous to existing EEM procedures for modelling agglomeration benefits.

The first step is to use the original transport model outputs to calculate the change in EJD between the base case and the SWGP scenario, under base land use assumptions. Differences in EJD are calculated for each MSM zone using the approach outlined in the EEM, which involves averaging modelled mode shares from the two scenarios.

The second step is to apply the elasticities found from the IV regression above to predict the resulting change in job and population densities in each MSM zone resulting from the option scenario. The following formulas are applied to calculate changes in population and employment within each model zone as a function of changes in EJD.

$$\Delta Jobs_i = \left(\frac{EJD_i^{Opt}}{EJD_i^{DM}}\right)^{\delta} - 1$$

$$\Delta Pop_i = \left(\frac{EJD_i^{Opt}}{EJD_i^{DM}}\right)^{\epsilon} - 1$$

where $\Delta Jobs_i$ is the change in job density for zone i; EJD_i^{Opt} and EJD_i^{DM} are the effective job density for zone i for the option scenario and the do minimum/base case scenario respectively; $\delta = 1.552$ is the elasticity of employment density with respect to EJD; and $\epsilon = 2.012$ is the elasticity of population density with respect to EJD.

A third step is to then assume that the transport project will not affect the overall level of population/job growth in the region, and therefore adjust the model zone population and job numbers across the region to ensure there is no region-wide growth. This assumes that the project does not increase the overall attractiveness of Auckland as a city in which to locate. It is also a constraint in the second-round transport models that regionwide population and employment estimates do not change.

Spatial general equilibrium model

This model attempts to estimate impacts on commuting decisions, rather than aggregate land use outcomes.

In this model, people are assumed to simultaneously choose their home and work locations, based on the underlying attractiveness of different locations and the costs of travelling between various locations (Mulalic, 2015) (Donovan, 2017). This model analyses the impact of faster car or public transport journey times on the total volume of commuting flows between origin and destination points.

In this model, people are assumed to choose their home and work locations and commute mode based on the attractiveness of living and working in those locations and the 'cost' of travelling between the two places. A Poisson regression model was used to estimate the number of people commuting between each pair of zones, using the following explanatory variables:

- Car travel time between model zones in the AM peak period
- Public transport travel times during the AM peak period
- Public transport fares for travel between model zones

The straight-line distance between model zones were also controlled for, so results should be interpreted as the impact of faster or slower travel times for a journey of a similar length.

Commuting flows and travel times may be endogenous (ie affected by other variables) as transport agencies may respond to expected levels of demand by increasing road capacity or providing more or better public transport. The control function method is used to deal with this issue (Imbens, 2007). An ordinary least squares regression of the car and public transport travel times was run on the explanatory variables described above plus the following instrumental variables[18]:

- Average slope of the straight line between area unit centroids
- The share of that line that crosses water instead of land
- The straight-line distance between the centroid of the neighbouring area units

The fitted residuals from the control function models are included as additional control variables in the Poisson regression model, in effect controlling for the endogenous component of car and public transport travel times.

Results of the spatial general equilibrium model

Results from this model are not necessarily intuitive: the coefficient on car travel times is positive, indicating that longer car travel times cause an increase in commuting flows. Additionally, the coefficients of this regression model were significantly larger than a similar model for Wellington, which yielded more intuitive results.

The inconsistencies in the results of this model suggests an important control factor may have been missed in the model development, so the accessibility-density model was chosen as the preferred model to estimate land use changes for these projects.

15.2.3 Land use change estimate results

The results of the accessibility-density model represent the expected land use change from the SWGP. In general, the improved accessibility provided in south and east Auckland, directly through SWGP, and indirectly through connections to the rest of the rapid transit network and other state highways, increase the attractiveness of that part of Auckland.

The adjusted land use assumptions resulting from the approach described above yields the following expected shift in population and employment locations across Auckland in 2048:

- 0.42% shift in population location choices
- 0.46% shift in employment locations

The general trends for both population and employment in these land use adjustments is that growth in south and east Auckland is faster than would otherwise be expected and in turn, growth in the isthmus, west and north of Auckland are less than would be expected if these projects were not implemented in south and east Auckland.

Adjusted employment estimates

The overall employment location trends differ only marginally in the adjusted land use estimates that account for the expected effects of the SWGP. To account for the slightly faster growth than expected in south and east Auckland, there must be a reduction in growth in other parts of Auckland. However, these reductions are minimal relative to the overall growth expected in those areas – growth in these areas is expected be reduced by less than two percentage points.

Figure 23: Estimated employment growth: 2016 – adjusted 2048 (including projects)

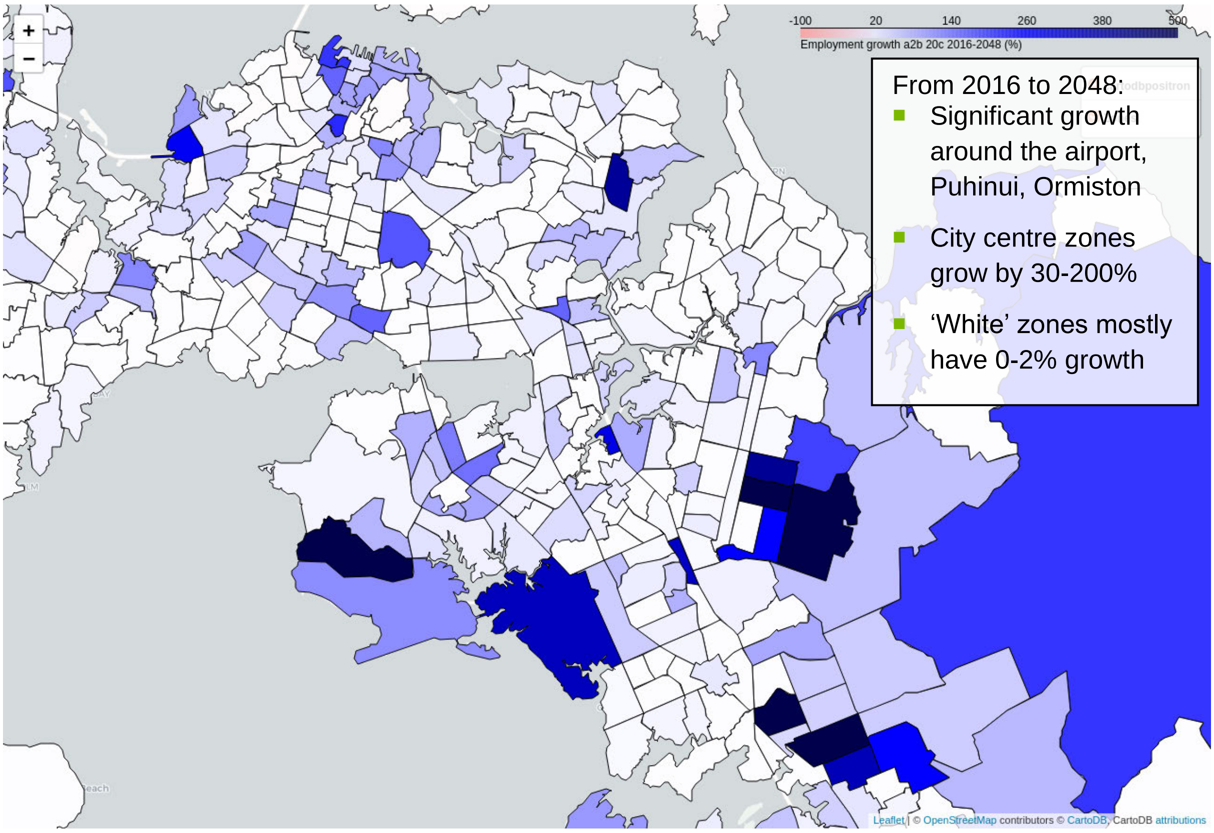


Figure 24: Relative employment growth effects of the projects, compared to estimates excluding the projects, 2048

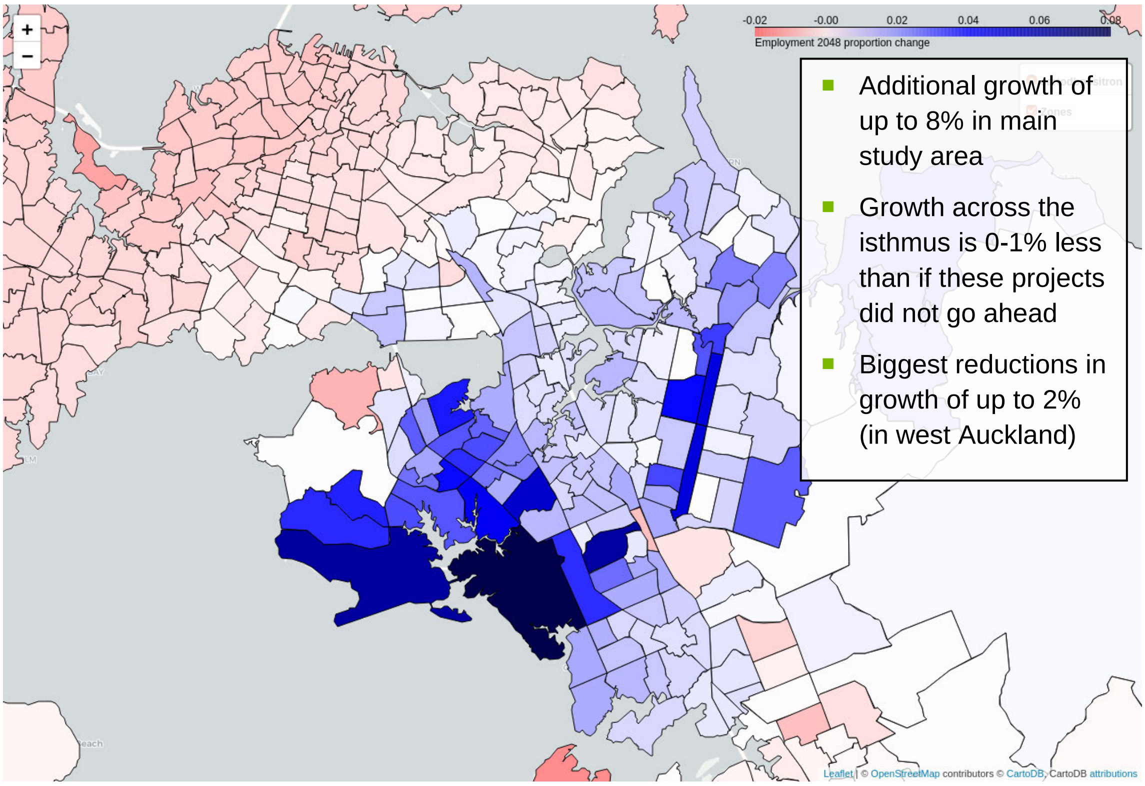
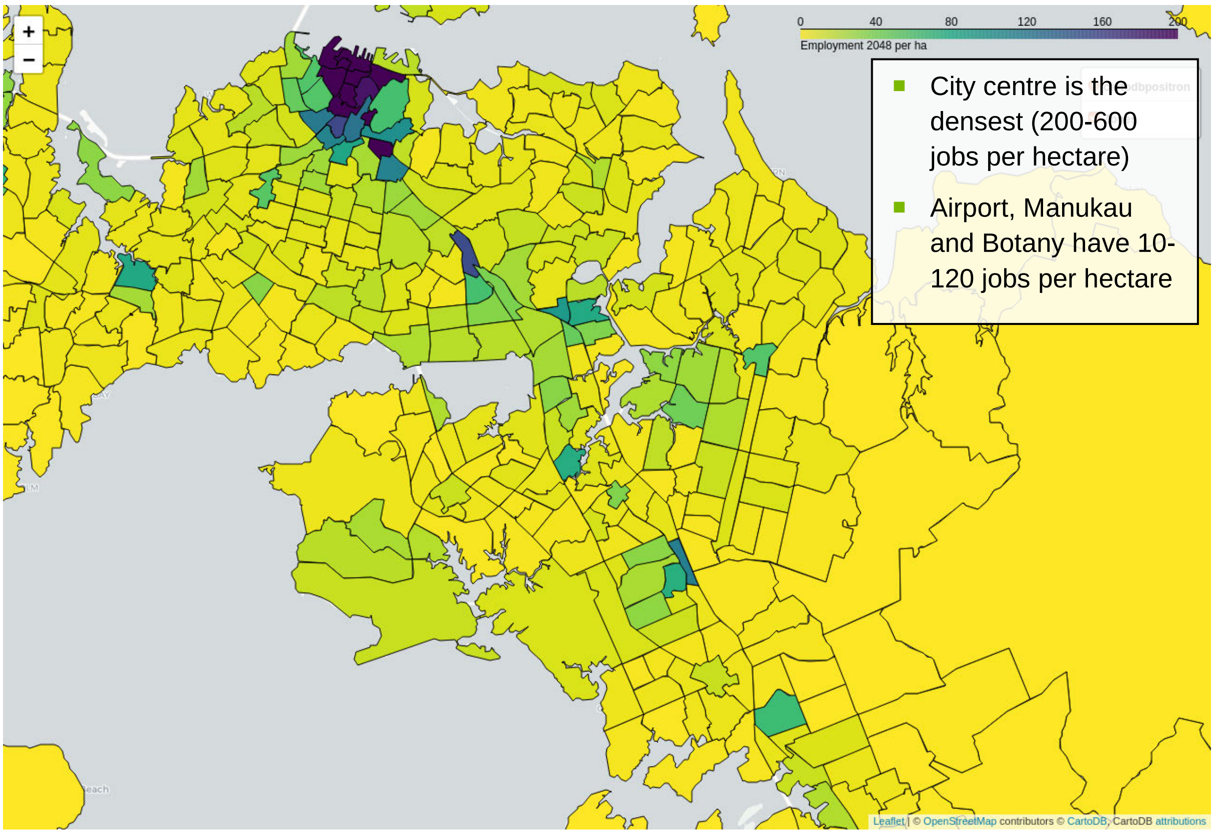


Figure 25: Estimated employment per hectare including land use effects from the projects, 2048



Adjusted population estimates

The overall population location trends differ only marginally in the adjusted land use estimates that account for the expected effects of the SWGP. To account for the slightly faster growth than expected in south and east Auckland, there must be a reduction in growth in other parts of Auckland. However, these reductions are minimal relative to the overall growth expected in those areas – growth in these areas is expected to be reduced by less than three percentage points.

The increased population density expected near A2B is expected to be serviced largely by medium-density developments. Some densification is feasible within existing zoning near most A2B stations; further, there will be the potential to up-zone some areas near stations, for example from Mixed Housing – Suburban to Mixed Housing- Urban or Terrace Housing and Apartment Building Zone (for more information, see Transit Oriented Land Use Study: 502334-7000-TEC-NN-0033).

Figure 26: Estimated population growth: 2016 – adjusted 2048 (including effect of projects)

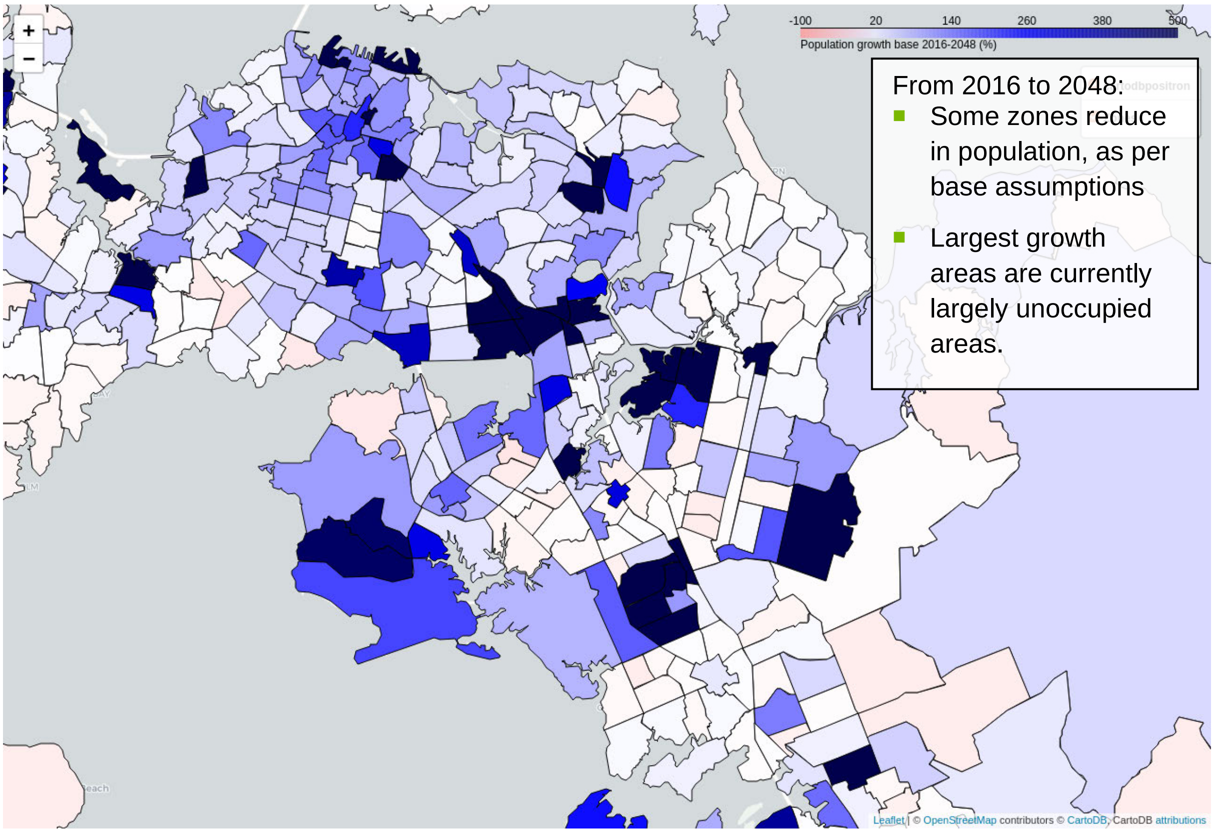


Figure 27: Relative population growth effects of the projects, compared to estimates excluding the projects, 2048

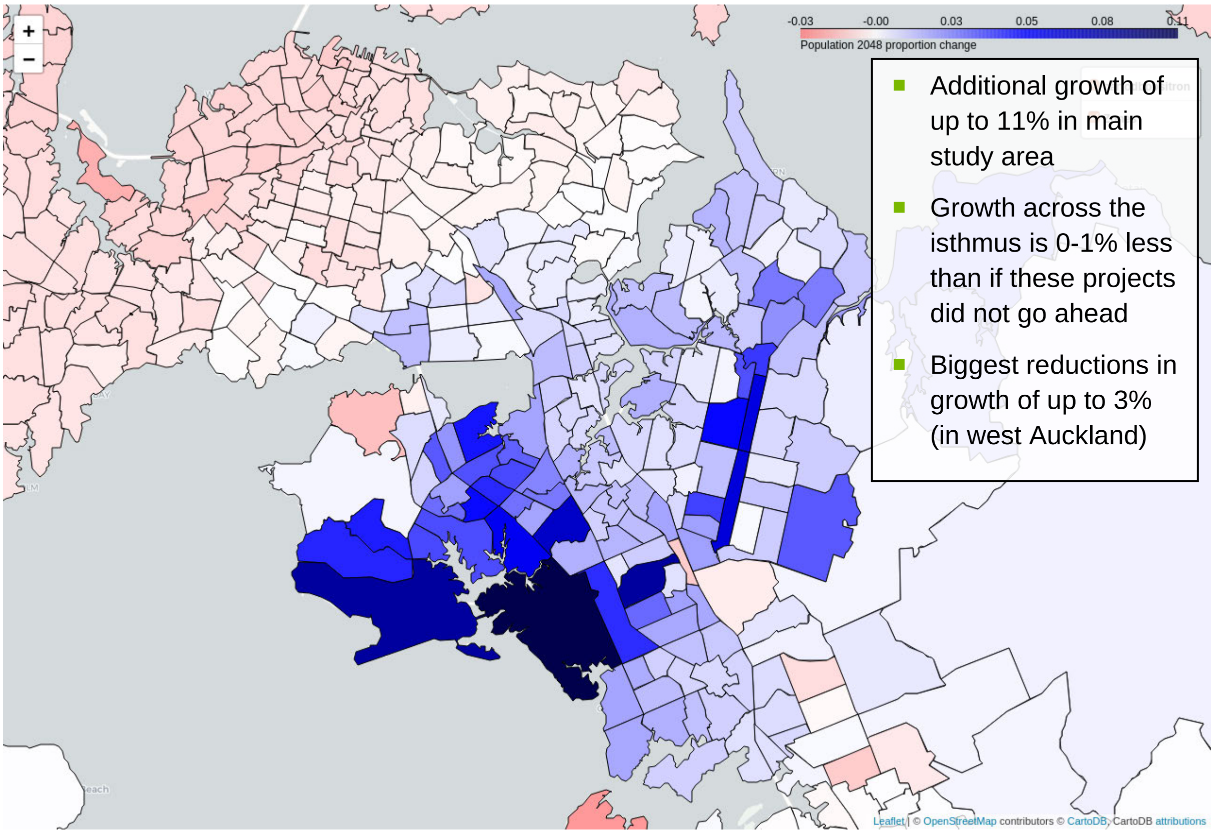
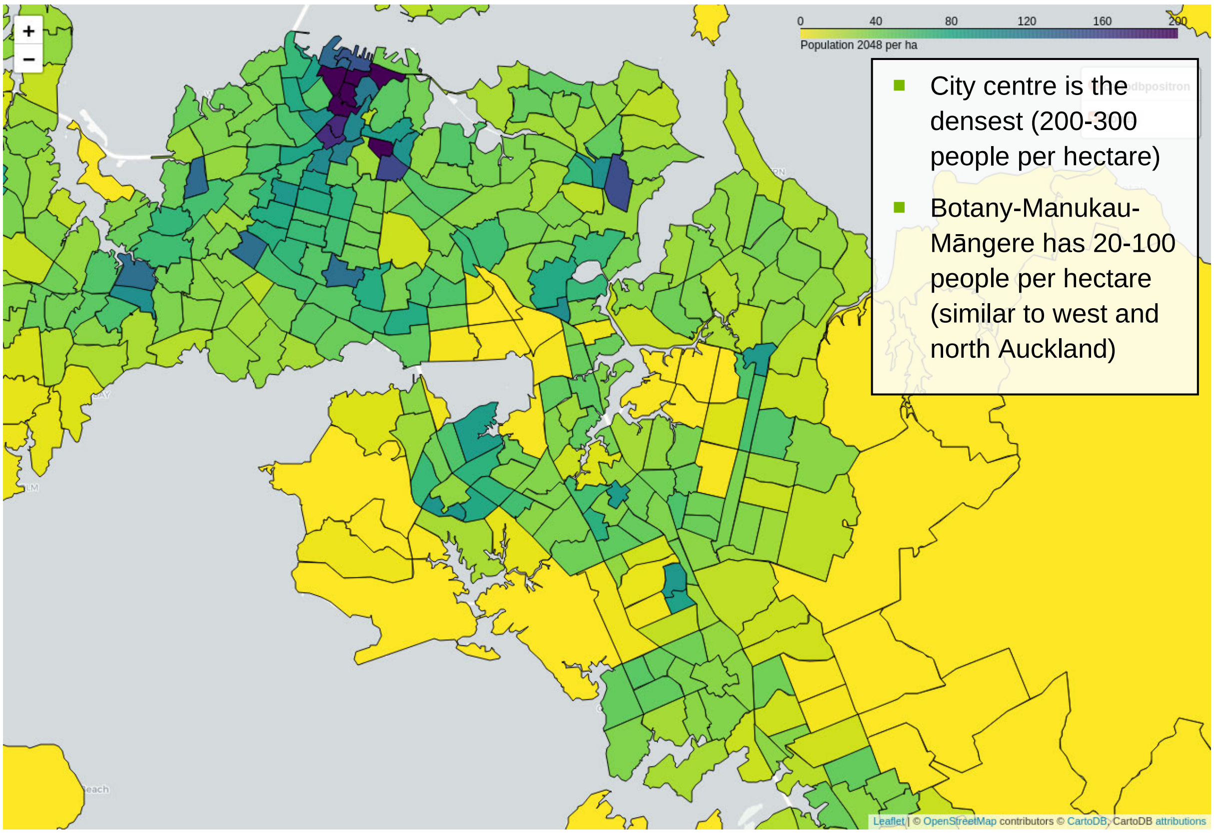


Figure 28: Estimated population per hectare including land use effects from the projects, 2048



Second-round transport model

The resulting land use estimates, incorporating the expected land use change from the projects, is then used as the input in an additional run of the transport model, including the projects. This then models the expected travel demand given the transport effect and the land use effect of the projects. This model is referred to as the 'second-round transport model' whilst the original model run with the standard land use assumptions is referred to as the 'original option transport model'.

15.2.4 Dynamic agglomeration

The methodology for computing the dynamic agglomeration benefit is simply to compute the agglomeration benefit of the second-round transport model relative to the original transport model. This captures the agglomeration benefits of the adjusted land use changes relative to the base land use assumption. This is additional to the standard agglomeration benefit computed as the benefit between the base case transport model and the original option transport model. In other words, the two agglomeration benefits vary according to:

- Standard agglomeration benefit: the benefit of the transport projects, holding land use constant.
- Dynamic agglomeration benefit: the benefit of the land use response, holding the transport infrastructure constant.

15.2.5 Move to more productive jobs

The methodology for computing this benefit, as proposed in the interim guidance, is relatively straightforward, provided that the appropriate sources are found for the required inputs. The following table outlines the inputs required and the proposed sources for this study.

Parameter	Source
GDP (average gross value added per worker for marginal labour supply in the study area)	Statistics NZ
Employment estimates	i11.5 base land use assumptions and adjusted land use assumptions as per Section 15.2.2.
Productivity differential between each MSM zone and average for study area	Census data to estimate existing wage/income differentials between locations, controlling for industry or occupation.
Average tax rate on wages	26% as per assumptions for standard economics assessment.

The methodology to apply these sources is then simply to multiply the GDP by the estimated growth in employment in each zone, the productivity differential of each zone relative to the average for the study area, and the average tax rate on wages.

15.2.6 Land use benefits

The methodology for calculating land use benefits from the SWGP includes the following components:

- Estimating ground floor area (GFA) changes for commercial and industrial properties due to the SWGP
- Estimating GFA changes for residential properties due to the SWGP
- Estimating residual land value for commercial, industrial, and residential properties in areas that will experience population growth due to the SWGP
- Estimating land use benefits

These are divided into steps and sub-steps below, with data sources and commentary where relevant. Key assumptions that will be made for these calculations are listed subsequently.

Estimating GFA changes for commercial and industrial properties

Step/sub-step	Data source	Commentary
1) Calculate GFA per employee by broad sector in Auckland		
Obtain change in GFA for all building types across Auckland region from 2010 – 2019	Building consent data from Stats NZ Infoshare	Sort this data into high-level building categories (eg 1. Health care, education, social facilities; 2. Shops, restaurants, bars etc.).
Obtain changes in employment count by ANZSIC06-3 digit from 2010-2019 across Auckland region	NZ.Stat	Sort this data into broad sector categories (eg 1. Health, education, and community services; 2. Retail and personal services etc.).
Match high-level building categories with broad sector categories	n/a	(eg GFA for building category of *Health care, education, social facilities* matched with employment count for the same industry).
Divide change in GFA by change in employment for properties and employees in the same building and sector categories	n/a	
2) Obtain 2019 GFA by broad sector for each Auckland statistical area		
Obtain 2019 employment count by ANZSIC06-3 digit by Auckland statistical area	NZ.Stat	Sort this data into broad sector categories (as above).
Multiply employment count for each statistical area by GFA per employee by broad sector obtained in step 1	n/a	
3) Obtain overall employment growth by statistical area attributable to the SWGP		
Calculate difference in employment count for 2028 and 2048 from i11.5 with the SWGP and without for each MSM zone	n/a	
Match data to statistical areas	n/a	
4) Obtain change in GFA by sector attributable to the SWGP for each statistical area		
Multiply change in overall employment count attributable to projects within each statistical area by percentage of GFA attributed to each sector within that statistical area (as obtained in step 2)	n/a	

Estimating GFA changes for residential properties due to the SWGP

Step	Data source	Commentary
Calculate difference in dwelling count for 2028 and 2048 from i11.5 with the SWGP compared to without for each MSM zone	i11.5 and MRCagney land use change estimates	See Section 15.2.2 for details and MRCagney's land use change estimates.
Estimate average GFA between apartments category and townhouses, flats, units, and other dwellings category	n/a	See assumption 1 in Assumption table below
Multiply average GFA per dwelling by number of new dwellings per MSM zone attributable to the SWGP	n/a	
Sort data into statistical areas	n/a	

Estimating residual land value for commercial, industrial, and residential properties in areas that will experience population growth due to the SWGP

Step/sub-step	Data source	Commentary
1) Calculate expected revenues from development		
Gather average Capital Value per m2 of properties in all MSM zones where population is projected to increase due to the SWGP. Differentiate between commercial, industrial, and residential. For residential, only parcels with multi-unit properties will be collected, per Assumption 1.	Auckland Council	Properties sorted into commercial, industrial, and residential based on interpretation of land use categorisation data within dataset. For residential parcels, we will attempt to obtain Capital Value per m2 for properties only with attached dwellings (without differentiating between townhouses and apartments), though this may not be possible given data limitations, in which case we will calculate Capital Values per m2 for all residential properties as one.
Adjust Capital Values (2017 data) based on overall average change in house values.	QV Residential House Values	This approach will not differentiate by different trends in average prices by location or typology (eg commercial, industrial, and all types of residential housing prices would be adjusted by the same percentage). This is due to data and time limitations to accurately reflect price trends in the commercial and industrial markets.
Increase all values by 15% in order to factor up the indicative market value to a value indicative of a brand-new dwelling	n/a	See Assumption 2.
2) Calculate expected development costs		

Step/sub-step	Data source	Commentary
Use QV cost builder to estimate development costs per m2 for apartments and townhouses (per assumption that newly developed units will be split between these two categories - see assumption 1 in Assumption table)	QV cost builder	
Estimate development contribution costs. See description below.*	Auckland Council Development Contributions Estimator	
3) Calculate residual land value		
Subtract expected development costs, including estimated profit margin and land costs, from expected revenues of development, to obtain RLV per m2 by MSM zone differentiated between industrial, commercial, and residential land use.	n/a	Developer profit margin estimated at 20%.

Overview of methodology to estimate development contribution costs:

We will use the Auckland Council Development Contributions Estimator and take an average from a sample of estimated development contributions based on hypothetical residential, commercial, and industrial developments. Using the Development Contributions Estimator requires that we make several assumptions about hypothetical existing and new developments (for example number of residential units, ground floor area, impervious service area, etc.). Where these assumptions have little impact on overall development costs, we will make educated estimates using approximate average characteristics for existing sites and will assume that new developments would have similar characteristics at slightly higher density levels (eg slightly more floor space and units).

If some parameters are found to have a significant impact on estimated development contributions and overall development costs, we will build an evidence base for such parameters.

Estimating land use benefits

Step	Data source	Commentary
Multiply RLV uplift per m2 for industrial, commercial, and residential, by the increased GFA for these sectors	n/a	

Assumptions and other commentary

Assumption	Rationale
1) Assume residential density increases are realised through attached building types only. Such buildings are assumed to be split equally between apartments category and townhouses, flats, units, and other dwellings category.	Land value change benefits attributable to the **SWGP** result from increased density enabled by the project. It is therefore assumed that the increased level of density attributable to the project will be realised through moderate-high density building typologies. We assume half the additional households induced to live closer to the A2B line due to the project will live in apartments and half will live in townhouses, flats, units, and other dwellings. This approximation is based on Auckland's recent patterns of residential development. From 2014-2019, building consent data shows about an equal number of building consents for these two categories across Auckland.
2) After being adjusted to reflect the average residential price increase, Capital Values are increased by 15% to adjust for the value of a new development.	The Capital Value of a property may underestimate a developer's expected revenues from this property, as new developments that would be built (triggered by the SWGP) are likely to be more valuable due to being new. For a 2018 *Whangārei housing and business development capacity assessment*, MRCagney and Colliers determined that a value of 15% fairly reflects the average price premium for a new dwelling relative to an existing dwelling of average characteristics.
3) Developer profit margin estimated at 20%	Different developers will have different minimum profit margins. 20% is considered a reasonable 'average' estimate for a range of developers.

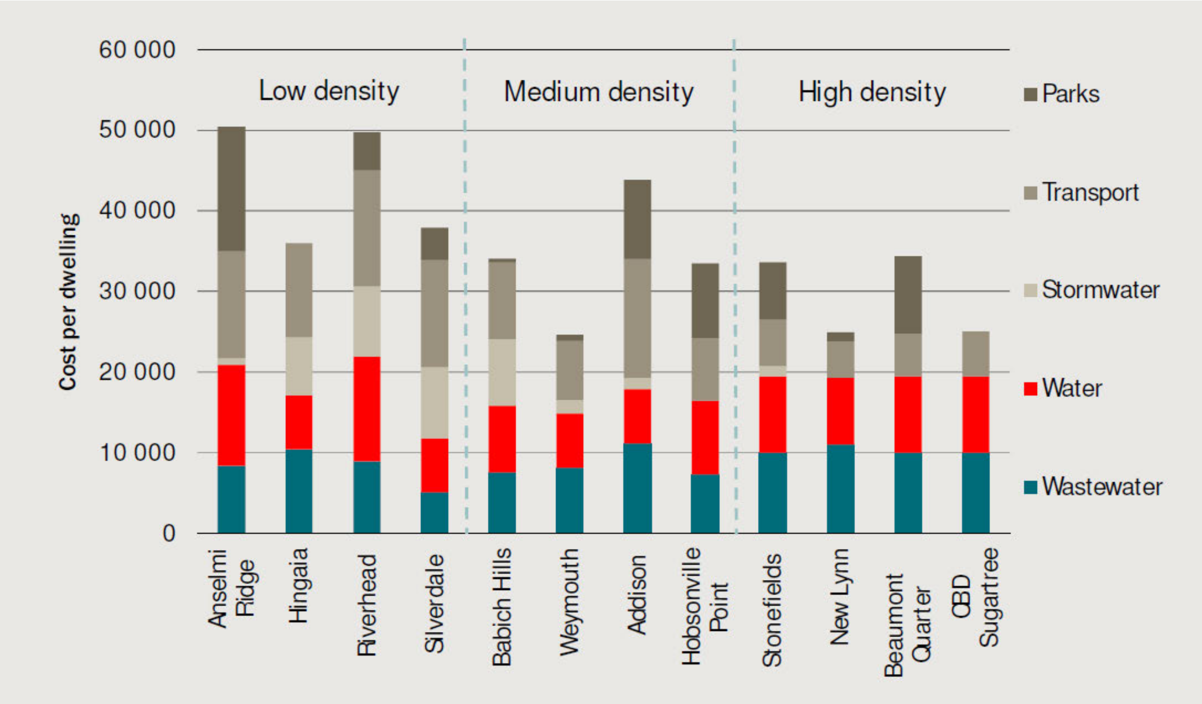
15.2.7 Public infrastructure cost changes

Public infrastructure cost savings may result from the estimated land use change from the SWGP, as the projects are expected to shift development away from lower density parts of Auckland, towards higher density areas, on net.

This methodology relies on the 2015 *Cost of Residential Servicing* report prepared for Auckland Council by the Centre for International Economics (CIE) and ARUP (The Centre for International Economics and ARUP, 2015). This report used a case study approach to measure actual costs of servicing various developments in Auckland.

It found higher public infrastructure costs for lower density developments in Auckland, as shown by Figure 28. Specifically, it found that low-density developments cost an average of $41,633 per dwelling to service, followed by medium-density developments costing an average of $33,890 per dwelling, while high-density developments cost an average of $28,077 per dwelling.

Figure 29 Summary of infrastructure costs by density and asset type



Following the interim guidance on dynamic land use benefits, this methodology estimates public infrastructure cost changes as follows:

- Calculate the expected change in dwelling mix due to the SWGP. This will be done by obtaining the difference in 2028 and 2048 projected dwelling numbers by MSM zone from i11.5 modelling with and without the SWGP.
- MSM zones will then be sorted into low-density, medium-density, and high-density categories based on 2048 projected population per hectare from i11.5 modelling with land use change induced by the SWGP. The bounds of these groups will be set so that there are an approximately equal number of low-, medium-, and high-density MSM zones.
- The public infrastructure cost changes will be calculated as the net change in dwelling mix between low-, high-, and medium-density zones multiplied by the difference in cost provision by each of these density levels found by CIE and ARUP, adjusted for inflation.

It should be noted that the CIE and ARUP study faces some limitations. As such, the report states "the costs per dwelling cannot be said to provide a precise estimate of the cost of servicing an area; rather, they provide relative indicative cost estimates of servicing the different case study developments."

These limitations include the following:

- Public infrastructure costs may vary significantly for two developments of similar density due to the need (or lack thereof) for 'lumpy' investments. This can be observed in the large variation among case studies in the CIE and ARUP study of similar densities.
- The case studies represent an estimate of the marginal cost to public infrastructure of new developments. The theoretical ideal contribution would be to calculate the long-term average costs to service urban development in different locations, as individual developments include marginal infrastructure spending that may also be intended to accommodate future developments (MRCagney Pty Ltd., 2019).
- Development contribution policy has changed in Auckland since the case study developments were built, and as such costs borne by developers for similar developments may be different today and in the future.

- The boundaries used to differentiate between low-, medium-, and high-density developments were not specified in the CIE and ARUP report, and as such they likely differ between the boundaries used to differentiate between low-, medium-, and high-density categories in our methodology. Further, there is significant variation in densities among case studies in the CIE and ARUP study within a density category. For example, the Sugartree development is located in a significantly denser area (about 165 people per hectare in 2018) than the Stonefields development (about 30 people per hectare in 2018), though both are included within the high-density category.
- The case studies do not include operating costs associated with public infrastructure, which may vary significantly based on density levels.

The public infrastructure cost savings should thus be taken with a relatively low confidence level. As such, we will apply a discount factor to the calculated benefits to ensure reported benefits are conservative. The size of this discount factor will be determined in consultation with reviewers.

15.2.8 Second round user benefits and costs

The methodology for computing the second-round user benefits and costs is simply to compute the standard costs and benefits of the second-round transport model relative to the original transport model.

This captures the transport-related costs and benefits of the land use changes, given the proposed transport projects.

15.2.9 Public health cost changes

The methodology for the public health cost changes is to collect from the cycle modelling for the SWGP (with the base i11.5 land use assumptions):

- The estimated cycle mode share for each MSM zone, and
- The average distance cycled from/to each MSM zone.

The mode share and average distance cycled from the original cycle models is then applied to the adjusted land use change estimates given the projects. This will give the additional kilometres cycled due to the land use change, which will then be multiplied by the composite value of new cycle facility benefits per kilometre, $1.80, (EEM table A20.4, and update factor from EEM table A12.2 (2019 update)).

15.3 Evidence of land use change from major transport projects

Land use change is a pre-condition for further investigation of dynamic WEBs and land use benefits, but does not guarantee that these projects would induce such benefits. This section explores the global and local evidence that major transport projects can induce meaningful land use change. It concludes that major transport projects are capable of inducing land use change under certain conditions. It is noted that land value change is a good proxy for the impact of transport projects, as land value change is empirically demonstrable, whereas evidence of people moving is less available.

15.3.1 Summary of findings

A significant body of evidence correlates transport costs and accessibility to jobs and urban amenities with demand for land. For example, numerous studies have found that highway development lowers transport costs, increases accessibility to jobs, and thus induces population growth in nearby suburban areas (Sanchez, 2004). Major public transport projects are similarly expected to increase accessibility to social and economic opportunities and decrease transport costs, thus increasing demand for land near public transport stops and stations. Density of residents and jobs under this concept would be expected to be highest, all else being equal, closer to stations, decreasing further from stations as accessibility benefits are reduced.

Global research indicates that major public transport projects are often associated with increased demand for land near stations. In the first instance, increased demand can be observed by an increase in land prices, after which changes to land use itself would follow. In a review of 36 studies documenting property value impacts from rapid transport projects, Baker and Nunns (2015) found median uplift values on nearby properties of 10% for light rail projects, 5% for commuter and metro rail projects, and 3% for BRT projects.

This effect has also been documented in Auckland. A 2014 Ernst & Young analysis found the opening of Britomart Transport Interchange in 2003 led to rapid increases in house prices near rail stations relative to the rest of Auckland (Ernst & Young, 2014). Norman and Martin (2018) also found that homes in Auckland well-served by trains or express buses command a significant premium over those that are not, and homes located within 500 meters' walk-up distance of a northern busway station have a flat premium of approximately 6.5 percent.

These property value uplifts from public transport projects suggest increased demand from residents and employers to locate near stations, which may lead to increased densities. Apart from price impacts, direct changes in land use development are difficult to attribute to a rapid transit improvement, as land use patterns are influenced by many factors. Still, some research has found that rapid transit improvements can be associated with significant relocation of people and jobs over the medium- and long-term. The following sections summarise some relevant global studies on land use impacts of rail and BRT projects.

15.3.2 Impact of rail projects on land use patterns

Several studies suggest rail transport improvements can meaningfully support nearby population and employment growth. Notable findings include:

- In Paris, using data from 1968 to 2010, the presence of a suburban rail station was found to increase the probability of the nearby area becoming an employment subcentre by four to five percent (Garcia-López, Hémet, & Viladecans-Marsal, 2017).
- Research from Portland, USA found that housing developments within a quarter mile (about 400 metres) of suburban rail stations grew at a faster rate than than the regional average between 2004 and 2014. Nearly all housing added in these areas were multifamily units. Development was concentrated around stations put into service before 2004, around which residential population grew at more than twice the regional average (Dong, 2016).
- Research from Barcelona on population growth from 1991 to 2006 found that when conditioning for existing density levels, proximity to a station had a positive effect on nearby growth (Garcia-López, 2012).
- Research on 13 rail stations in Swedish cities from 1993 to 2013 found higher population and employment growth within 1 and 3km radii of stations compared to overall municipal growth. While the authors found strong agglomeration tendencies around four of five urban stations studied, they found mixed results around stations in semi-urban areas and weak or negative population growth around peripheral stations (Adolphson & Fröidh, 2019).
- Research of the San Francisco Bay Area Rapid Transit (BART) rail system found that the system contributed to dense development near some, but not all, stations. The researchers found land use changes were primarily associated with downtown and select suburban stations. Where land use change did not occur, they posit the primary causes were neighbourhood opposition or a lacklustre

local real estate market. In total, they conclude “BART, in and of itself, has clearly not been able to induce large-scale land-use changes, though under the right circumstances, it appears to have been an important contributor” (Cervero & Landis, 1997).

15.3.3 Impact of bus rapid transit (BRT) projects on land use patterns

Most empirical research on land use changes induced by public transport projects has focused on urban rail projects rather than urban bus rapid transit projects. BRT projects appear to generate smaller – though still meaningful – impacts on nearby land prices compared to rail improvements.

Though the empirical research is limited, the existing evidence suggests BRT projects can also induce employment and residential growth near stations. Deng and Nelson (2010) studied impacts on nearby properties from a BRT line in Beijing. In a survey of residents who moved near a station after the BRT became operational, 75 percent stated the BRT was an important factor in their relocation choice. Surveying local real estate agents revealed that 86 percent believed BRT was a driver for property development along its corridor.

Rodriguez, Vergel-Tovar, and Camargo (2016) compared changes in land use, building activity, and building licenses issued in BRT intervention areas in Bogotá, Colombia and Quito, Ecuador. Their results were mixed and indicated that “BRT has the potential to influence land development, but conditions are very context dependent.”

Research from Seoul indicates that the introduction of its BRT system prompted property owners and developers to convert single-family residences to multi-family units, apartments, and mixed-use projects (Cervero & Kang, 2011).

15.3.4 Factors influencing land use response to public transport projects

While public transport projects appear to be capable of influencing land use change, many factors play a role. As such, not all public transport projects induce increased densities. For example, public transport projects do not appear to induce such change in the presence of conflicting land use policies. A study of more than 200 public transport stations that opened in California from 1992 to 2006 found that stations did not increase nearby employment growth. The author suggests most policies in its transit-oriented development (TOD) strategy discouraged commercial development relative to residential development near transit, and that explicit strategies were required to encourage commercial development (Kolko, 2011).

The magnitude of accessibility improvements provided by a transit project also impacts its ability to influence land use. Research on Atlanta’s MARTA rail transit system, for example, found no impact of population or employment growth in station areas, which the authors attribute to MARTA’s limited reach and inability to attract significant ridership in the context of a “highly decentralized automobile-dependant metropolitan area whose development has been primarily shaped by highway construction (Bollinger & Ihlanfeldt, 1997).” More broadly, Currie found that bus frequency and speed were among several factors that determined the ability of bus-based transit to spur development (Currie, 2006).

Researchers consistently find that land use impacts of public transport projects gradually dissipate further from stations. Property value impacts from public transport stations provide an indication of the possible geographic extent of public transport projects on nearby land demand. Most researchers find price impacts dissipate after ¼ or ½ mile (about 0.4 and 0.8km) from a public transport station (Shen, 2013).

Local real estate markets appear to significantly influence land use responses to public transport. In Portland, USA, for example, Dong (2016) found the presence of vacant land and presence of non-residential land near stations was associated with increased development. Previously mentioned research on the Bay Area Rapid Transit system posited that a lacklustre local real estate market was one reason some station areas did not experience population or employment growth (Cervero & Landis, 1997).

Some researchers suggest that BRT projects may have a smaller impact on land use development and nearby property prices than rail projects if they are perceived by residents and businesses to be less permanent. This possible effect is likely to be less significant when significant running way investments are made for BRT projects (Stokenberga, 2014).

15.3.5 The Auckland context

The context in which the SWGP is being developed, with permanent infrastructure, high quality stations, very frequent and reliable services, suggests it could induce densification. Public transport in Auckland is becoming increasingly well used, there is a long-term trend towards increased residential density in Auckland, and the recent land use policies in Auckland encourage growth around rapid transit (in particular the policy direction to enable high-density developments within 500 metres of frequent transport stops and stations).

Land use development patterns

We are not aware of rigorous studies conducted in New Zealand that isolate the impact of a rapid transport project on land use patterns. However, a high-level review of evidence from Auckland indicates that population has grown more quickly near rapid transit stations than elsewhere.

In July 2003, the Britomart Transport Centre began operations as the first public transport hub in Auckland's city centre. Passenger rail patronage has grown steadily in Auckland since Britomart's opening from less than 3 million per year to an estimated 25 million per year in 2020 (Slade, 2015) (Auckland Transport, 2020).

From 2003 to 2019, Auckland's population has increased 27 percent. Meanwhile, the population within 500m of Auckland's train stations has increased by 37 percent, and the population within 1000m of train stations has increased by 29 percent.[19]

Additionally, the development of the Manukau Institute of Technology campus above the Manukau Train Station is a good local example of transit-oriented development.

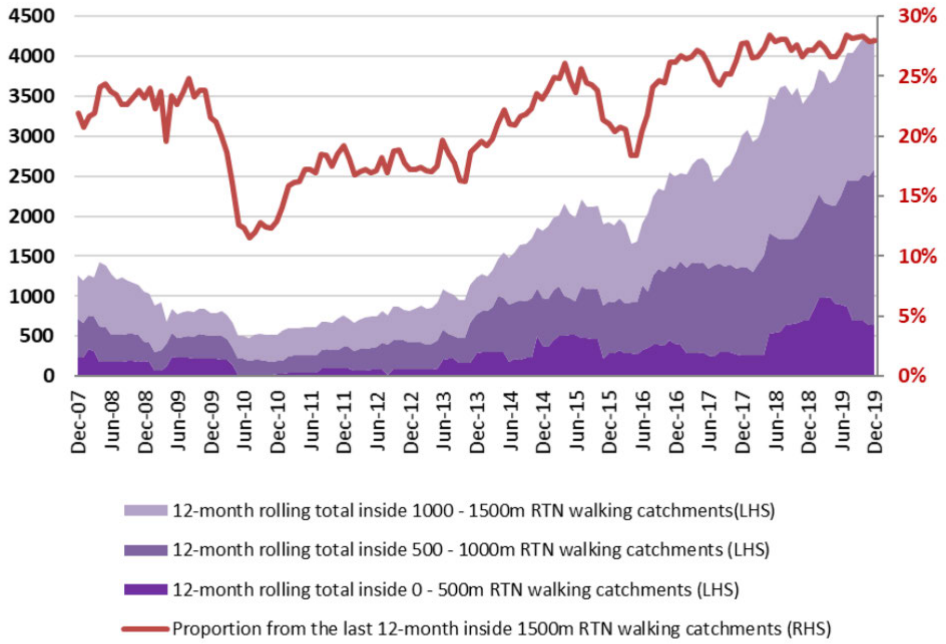
Land use policies

Concentration of population growth near rapid transit stations in Auckland is likely the result of many factors and cannot solely be attributed to rapid transit itself. Zoning changes, such as the Auckland Unitary Plan Operative in Part, have encouraged denser development near rapid transit stations. Consistent improvements to rapid transport services – including electrification of the train network from 2014-2015 and the Auckland Integrated Fares System rolled out in 2014 – likely increase the attractiveness of rapid transit services and increase the likelihood of it to induce land use change. These improvements have been accompanied by consistent patronage growth on the rapid transit network (Auckland Transport, 2020). The City Rail Link project, scheduled for completion in 2024, is projected to further increase patronage and is likely to increase the attractiveness of having close access to the rapid transit network.

Previous and forthcoming improvements to the rapid transit network, coupled with supportive land use policies through the Auckland Unitary Plan, have appeared to contribute to an increasing demand to live near rapid transit stations in recent years, as evidenced by building consent data. Figure 29 shows an increasing proportion of Auckland's building consents within 1500m of the rapid transit network (Research and Evaluation Unit, February 2020).

[19] MRCagney analysis using OpenStreetMap and Statistics NZ data.

Figure 30 Dwellings consented inside 1500m RTN walking catchments (source (Research and Evaluation Unit, February 2020)

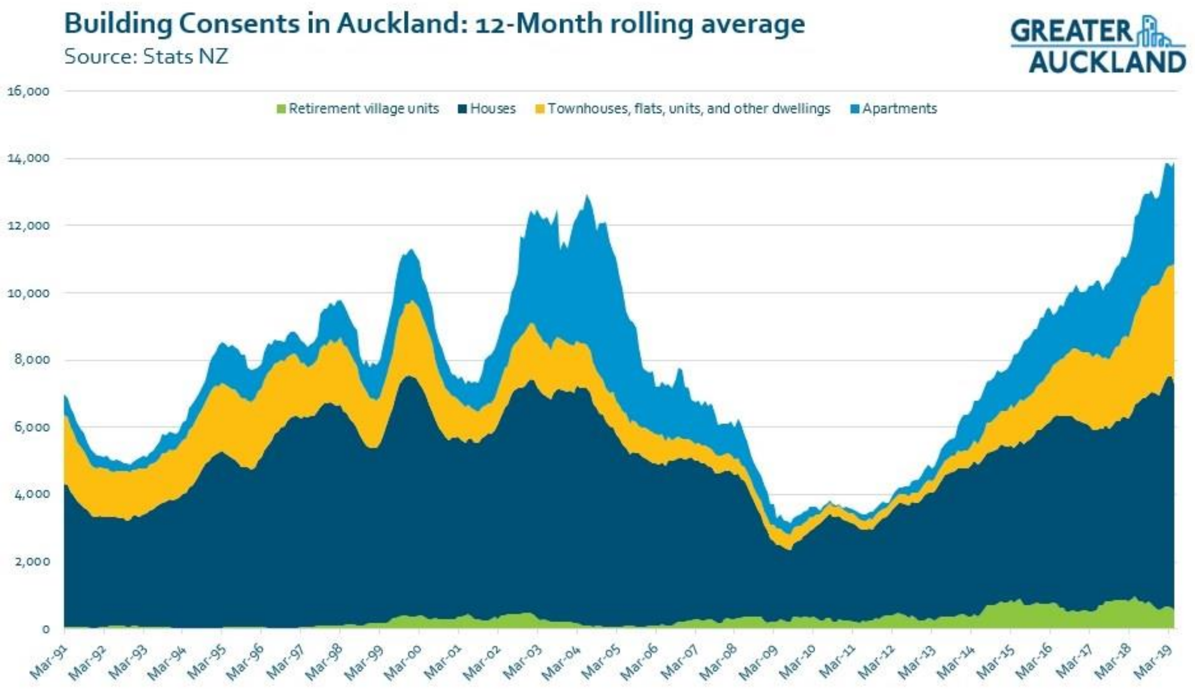


There is an opportunity for Auckland Council to use land use policies to encourage density increases near A2B stations as it has done for other rapid transit stations. Auckland Transport has completed an initial study which identifies potential opportunities for transit-oriented development near A2B stations. Engagement with Auckland Council is planned, recognising their leading role in land use policy. Auckland Transport can support intensification by identifying the transport considerations which may be critical to enable/facilitate transit-oriented development (see Transit Oriented Development Land Use Study, reference: 502334-7000-TEC-NN-0033).

This trend is in line with Auckland's long-term density increase. Built-up density has increased from an average of 30 people per hectare in 1989 to an average of 34 people per hectare in 2001, and 38 people per hectare in 2014 (UN Habitat, NYU, Lincoln Institute of Land Policy, 2020). Auckland Council land use models project additional density increases throughout Auckland.

Correspondingly, as shown by Figure 30, private developers are increasingly building attached building typologies (including townhouses and apartments). This suggests market demand exists in Auckland for higher than existing density levels.

Figure 31 Building consents by typology[20]



15.3.6 Conclusion

A wide body of research – including examples from Auckland – suggests that rapid transit projects tend to be associated with a price premium on nearby properties. This suggests corresponding increases in residential and employment density are plausible. Directly attributing land use change to rapid transit improvements is more complex, though some international studies find evidence that rapid transit projects have induced density increases near stations. Several factors appear to impact the likelihood of this effect, particularly land use zoning.

Relevant factors in Auckland that increase the likelihood of A2B inducing intensification near stations include the growing public transport ridership, land use policies encouraging transit-oriented developments, previously documented property price premiums near rapid transit stations, and rising market demand for denser building typologies.

This evidence base suggests that transport infrastructure can facilitate transit-oriented developments when paired with the relevant policy directions. The transit-oriented developments enabled can include residential and/or commercial/employment developments.

[20] Chart appears in Greater Auckland article available here: https://www.greaterauckland.org.nz/2019/07/09/auckland-building-activity-soars/

16 Appendix: Test of mesoscopic traffic model

Purpose of testing a more detailed model

The MSM models are macro-level models and there was a concern that they might misestimate congestion effects of the transport network. The A2B project does not include any major changes to the road network for general traffic. Along most of the A2B corridor, the number of general traffic lanes are intended to be retained. However, there are some necessary changes to intersections along the corridor, including:

- Some side roads will become left-in, left-out only.
- Lane configurations at intersections may change (eg reduction in right-turn lanes, combination of straight-ahead and left-turn lanes).

This raised some concerns related to the estimation of car user (dis)benefits, and whether the MSM models are detailed enough to measure the effect of the A2B project on car travellers. Due to the cost of developing a new transport model, and the uncertainty of whether it is necessary to create one to capture the effects of the A2B project, the road network in the mesoscopic *Auckland Manukau Eastern Transport Initiative* (AMETI) EMME traffic model was updated with the interventions of the A2B project. For the purposes of this test, this model was not recalibrated to the A2B project extent, however it was expected that this would not affect its ability to provide an indication of the scale of (dis)benefits expected. This model also did not include the airport road upgrades described in Section 3.1.1.

Decision not to pursue the development of a mesoscopic traffic model for A2B

After some investigation into the benefit estimated from each of the models (AMETI EMME traffic model and MSM), it was agreed that no mesoscopic traffic model would be required for the car user (dis)benefits of A2B. It was agreed that the MSM specification would be updated to ensure it best reflects the A2B designs, after which it would be appropriate to be used to capture the scale of economic impact of A2B on car users.

The updated MSM model includes the left-in, left-out turn restrictions in the Manukau area and all intersections that A2B uses are coded with the signal effects (based on A2B turning movement and signal priority) to best reflect the preferred option and associated signal priority.

Detailed initial findings from comparing benefits of the AMETI EMME traffic model and MSM model

The car user benefits from each of these models (the AMETI EMME traffic model and the MSM model) were computed and compared to assist discussions regarding which model should be used to model car travel time benefits.

One test that was conducted was to estimate the impact of mode shift due to A2B, without applying the changes to the road network (such as traffic lane rearrangements and turn restrictions). This entailed:

- In MSM: adding in the A2B rapid transit service and making no changes to the road network, to model some mode shift towards public transport, which resulted in decongestion and therefore a car travel time benefit in 2048 of +$12.17 million.
- In the AMETI EMME traffic model: applying the demands from the above MSM model (with mode shift to public transport) to the base road network. This resulted in a similar car travel time benefit in 2048 of +$11.93 million.

Another test was conducted in both models, that was intended to model the full effects of A2B on general traffic. These models included:

- In MSM: adding left-in, left-out turn restrictions to relevant roads in Manukau and adding an additional leg to four key intersections in Manukau, to represent the effect of the A2B service on signal phasing. In this test, a car travel time benefit of +$0.12 million in 2028 and of +$7.26 million in 2048.
- In the AMETI EMME traffic model: the road network was updated to reflect the final A2B design plans, including changes to the number of lanes at intersections, and an additional delay of 4 seconds per phase was applied to intersections where A2B turns left or right. In this scenario, a car travel time benefit of -$17.04 million was computed for 2028 and -$18.61 million for 2048.
- Additional MSM test: an additional MSM model was run, with an additional leg added to each intersection that A2B traversed. This is a significant over-representation of the impact of A2B on signal phasing (much harsher than the 4 seconds per phase applied to only some intersections in the AMETI EMME traffic model). The results of this test were a car travel time benefit of -$43.13 million in 2028 and -$56.74 million in 2048.

A meeting was called at Auckland Transport on 24 January 2020 (involving the modellers, economists and economics peer reviewer) to discuss the results from the above tests of benefit estimates from these two models. A summary of the key discussion points is included here:

- Noted that the AMETI EMME traffic model specified changes to the road network throughout the length of the A2B corridor, whereas the MSM model specification only made changes in the Manukau area.
- Noted that the spatial distribution of car travel time benefits from the MSM model were significantly negative around Manukau (where the changes were modelled) and were very positive in and around the airport (where mode shift will significantly ease pressure on the road network), and were marginally positive elsewhere.
- The comparison between similar underlying road networks in each model resulted in similar car travel time benefit estimates between the two models. This indicated that if MSM is coded appropriately, it should result in similar benefit estimates as the more detailed AMETI EMME traffic model.
  - Furthermore, the additional MSM test (with an additional leg at all intersections) resulted in significant car travel time disbenefits, supporting the understanding that MSM is detailed enough to capture some disbenefits to car user travel times.
- Noted that other big public transport projects have typically relied on benefit estimates from MSM alone, without relying on additional general traffic models. AMETI was an exception to this because of the major component of changes to the road network that was included under that project.

This led to the decision to focus on ensuring the MSM model specification was appropriate, in which case the car user benefits seem to be reasonably estimated.

17 Appendix: Letter on A2B Traffic Benefits from AMETI EMME Traffic Model

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30 October 2019

A2B Traffic Benefits from AMETI Traffic Model

1 Introduction

The letter is to document the process, assumptions and outcomes of the Airport to Botany (A2B) traffic modelling and initial calculation of traffic benefit using the AMETI traffic EMME model.

2 Modelling Approach and Assumptions

As agreed with the A2B study team, the existing AMETI EMME traffic model was used for this study. This model was used to calculate the initial traffic benefits for the Eastern Busway (EB) Stage 1-3 project.

No modification or update to the AMETI traffic model was made for this study. Based on the outcome of this work, a decision to refine or re-validate this traffic model will be made.

A scenario in the AMETI traffic model which includes all stage 1-3 of the Eastern Busway project was used as a starting point for the A2B option scenario. Intersection and road network (i.e. number of lanes) coding was updated to reflect the proposed A2B project as per the drawing provided by Aurecon on 16th August 2019. Numbers of turning lanes at intersections were updated and also an additional lost time (extra 4s per phase) was introduced for the intersections where the BRT/LRT corridor makes left or right turning movements.

Traffic demands were sourced from the regional strategic demand model (Macro Strategic Model, MSM) for the Do Minimum (No A2B) and Option (with A2B) scenarios for both model years, 2028 and 2048.

3 Approach to Traffic Benefit Calculation

The benefit calculation approach used for the AMETI project was adopted which are described in this section.

The A2B traffic benefits were calculated using the Variable Trip Matrix (VTM) methods as described in Appendix 11 of the NZ Transport Agency's Economic Evaluation Manual (EEM). The two benefit streams were calculated:

- Travel Time Costs (hours); and
- Vehicle Operating Costs.

3.1 Travel Time Costs

Three components of travel time were evaluated:

- Base travel time;
- Congested travel time (defined as 'CRV' in the EEM); and
- Travel time reliability.

The base travel time simply applies the Value of Travel Time Saving (VTTS) unit value to the total travel times, where the CRV value is only applied on sections of road deemed congested. CRV benefits were calculated in accordance with the EEM as follows:

- Urban roads in the model used the methodology for urban roads, whereby CRV only applies to links with a Volume/Capacity ratio greater than 70%; and
- All stopped (intersection) delay was included as congested.

Traffic reliability benefits were calculated as 8.0% of the travel time benefits;

3.2 Values of Travel Time

In undertaking the consumer surplus benefit calculations required when a variable trip matrix approach is used, two cost items are required, namely Resource costs (costs to the national economy) and User costs (costs perceived by the users).

For this evaluation, the standard EEM Urban Arterial composite Resource costs were used, however these were separated by light and heavy vehicles to match the two vehicles classes in the traffic modelling

The resulting base time and Congested (CRV) values for each class and each weekday period are shown in **Table 1**. All other periods were represented by the weekday interpeak models, in which the different time values for those periods were represented in the annualisation factors.

The base values shown are in units of $2002, which were then updated to units of $2018 using the EEM update factors of 1.5.

Table 1 – Resource Time Values, $2002

Period	Base Time		Congested Time (CRV)	
	Light Vehicles	Heavy Vehicles	Light Vehicles	Heavy Vehicles
Weekday AM	$13.84	$39.65	$3.90	$3.60
Weekday interpeak	$16.81	$39.60	$3.60	$3.57
Weekday PM	$13.77	$37.45	$3.80	$3.60

User values were derived by applying a factor of 1.07 to the Resource values. This factor was a weighted-average of factors in the EEM; namely a factor of 1.15 for non-work travel and 1.0 for work travel.

3.3 Vehicle Operating Costs

The evaluation includes three components of Vehicle Operating Costs (VOC):

- Base running costs, as a function of speed and vehicle type; and
- Additional running costs due to road congestion.
- Fuel costs due to stopped delay

Base running costs were calculated on each link based on the vehicle type and average travel speed. These were based on the regression formulas in the EEM and assuming average 0% gradients:

$VOC_B = a + c.\ln(S) + e.[\ln(S)]^2 + h.[\ln(S)]^3$

Where VOC_B = Base running cost in cents/km ($2008)

S = speed in km/hr

a,c,e,h = coefficients as per **Table 2** below.

Table 2 – Coefficients for Base VOC Models

Coefficient	Urban Arterial
a	18.467
c	34.274
e	-15.546
h	1.8558

Additional VOC running costs were calculated using the following formula and by adopting the values in the table below (adopted from EEM, Table A5.21). This can be expressed as:

$VOC_{cong} = \min \{a, \exp(b + c*VC) - \exp(b)\}$

Where VOC_{cong} = additional VOC due to congestion in cents/km

VC = Volume to Capacity Ratio, and

a -c = coefficients as indicated in **Table 3** below.

Table 3 - Coefficients for Congested VOC Models (2015)

Coefficient	Urban	Rural 2-Lane Highway		Motorway
		Strategic	Other	
a	9.211	7.704	6.979	7.084
b	-1.904	-1.235	-1.563	-5.931
c	4.327	3.210	3.408	7.866

Fuel costs due to stopped delay were assessed using the standard Urban Arterial composite cost of 1.997c/min ($2015). The above procedures provide VOC Resource costs in $2015 terms, which were updated to $2018 using the EEM update factor of 1.07.

For the resource to user cost conversion, the resource cost calculation was as per the EEM's method described above (average ~27 cent/km). The user costs were based on the perceived cost in the demand model (average ~20 cent/km). Hence the user costs were set at 74% of the calculated resource cost (20/27 cent/km).

3.4 Annualization Factors

Annual benefits have been estimated through weighted factoring of the three modelled weekday periods (am, interpeak and pm). The AM and PM peak models were used to represent the respective 2-hour weekday periods 7:00-9:00am and 4:00-6:00pm, while the inter-peak model was used to represent all other periods.

The factors were developed from a composite weekday and weekend/holiday hourly flow profile created from a combination of survey data on various key roads in the study area. Currently annualization factors used in the AMETI project was adopted for the A2B and they are provided in **Table 4**.

Table 4 - Annual Factors (Applied to 2-hour models)

AM	Interpeak	PM
245	2133	245

3.5 Sub-Area Benefits/Dis-benefit Calculations

The AMETI traffic model covers the whole Auckland Region (Wellsford to Pukekohe), so the road user benefits were only extracted from a sub-area (10km radius) of the model to reduce the effect of model 'noise'. This expected 'area of influence' is indicated in **Figure 1**. A sensitivity test was undertaken for a different influence area.

Figure 1 – Analysis Area

Traffic flow different plots for the AM and PM peaks (2048) from the AMETI traffic model are provided below. The red indicates increase in traffic flows and the green indicates decrease in traffic flows.

Figure 2 – Flow Different Plot, AM Peak 2048

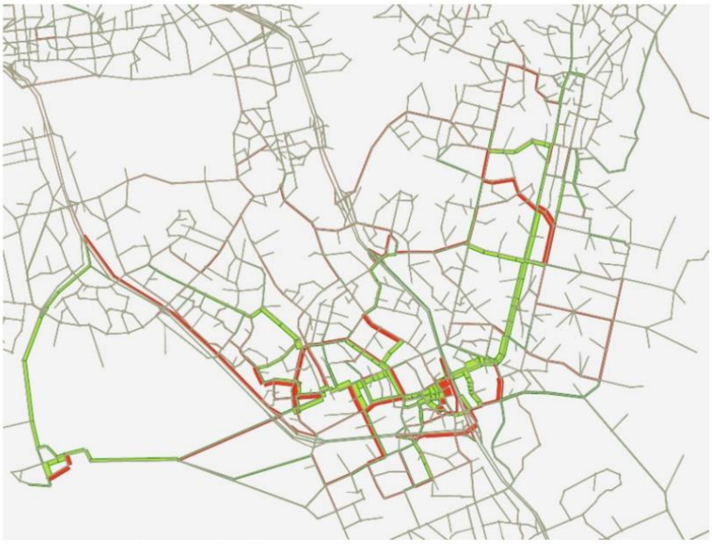


Figure 3 – Flow Different Plot, PM Peak 2048

4 Traffic Benefits/Dis-benefits

The calculated traffic benefits (dis-benefits) are summarised in **Table 5**.

Table 5 - Annual Benefits ($2018, in millions)

	Travel Time	CRV	Reliability	VOC	Total
2028	-17.04	-3.14	-1.36	-2.70	**-24.24**
2048	-18.61	-4.07	-1.49	0.11	**-24.05**

As expected, traffic dis-benefits were resulted from the reduced numbers of traffic lanes at intersections and reduced efficiency at intersections around the Manukau Town Centre.

To understand the sensitivity of assumed radius of 10km on the benefits, a sensitivity test was undertaken using a 15km radius. The results are provided in **Table 6**.

Table 6 - Annual Benefits ($2018, in millions) for 15km Radius

	Travel Time	CRV	Reliability	VOC	Total
2028	-17.44	-3.04	-1.4	-2.67	**-24.55**
2048	-19.02	-4.00	-1.52	0.08	**-24.46**

From the table, the results are very similar to those from the 10km radius.

An additional sensitivity was undertaken to separate the effect of traffic network (i.e. intersection layout and timing) changes. In this test, the DM network was used in the Option scenario and hence this test is only assessing the benefit of reduced traffic demands.

Table 7 - Annual Benefits ($2018, in millions)

	Travel Time	CRV	Reliability	VOC	Total
2048	11.93	3.10	0.95	3.29	**19.27**

Yours sincerely

Senior Associate - Transportation

on behalf of

Beca Limited

18 Appendix: Southwest Gateway Walking and Cycling Improvements, Economic Benefit Evaluation (Flow)

Southwest Gateway Walking and Cycling Improvements

Economic Benefit Evaluation

March 2020

flow
TRANSPORTATION SPECIALISTS

Project: Southwest Gateway Walking and Cycling Improvements

Title: Economic Benefit Evaluation

Document Reference: P:\aure\007 20 Connect Study (local road improvements and economic analysis)\4.0 Reporting\R1B200319 Cycling Economics.docx

Prepared by: [redacted]

Reviewed by: [redacted]

Revisions:

Date	Version	Reference	Approved by	Initials
14 January 2020	A	R1A200114	[redacted]	[redacted]
19 March 2020	B	R1B200319	[redacted]	[redacted]

EXECUTIVE SUMMARY

This report summarises the economic benefit evaluation undertaken for the proposed walking and cycling components within the Southwest Gateway Programme. The Southwest Gateway Programme consists of two separate project streams

- Airport to Botany Rapid Transit (A2B); walking and cycling improvements include
  - Cycle infrastructure on Te Irirangi Drive, Puhinui Road, SH20B, Lambie Drive, and through Manukau centre
  - The improvements will generally provide either physically protected cycle lanes, or allow bikes and cars to mix within low volume, traffic calmed environments
  - New and improved pedestrian crossings would be provided throughout the route
- 20Connect; walking and cycle infrastructure associated with this project includes
  - A new walking and cycling route parallel to SH20, and improvements to the existing pedestrian route on SH20A
  - The improvements will generally be shared use paths, but may utilise local streets where these run close to the state highway corridors
  - New and improved pedestrian crossings would be provided where the route meets arterial roads

The extent of each project is illustrated conceptually below.

Figure ES1: A2B (blue) and 20connect (green) Cycling Improvements

The economic benefits evaluation has been carried out separately for the A2B and 20Connect projects, as well as for the Southwest Gateway programme overall.

The following tables summarise the predicted undiscounted programme benefits. It is intended that these benefit streams be used as inputs to the wider transport economic evaluations for each project and the overall programme.

Table ES1: Undiscounted Project Benefits, 2028

Benefit Stream		20Connect	A2B	Southwest Gateway
Cycling Benefits	Health benefits	$1.55 million	$2.44 million	$4.14 million
	Safety benefits for cyclists	$0.04 million	$0.07 million	$0.12 million
	Travel time savings for cyclists	$0.03 million	$0.05 million	$0.09 million
Pedestrian Benefits	Health & environment benefits	$0.87 million	$0	$0.87 million
	Safety benefits for pedestrians	$0	$0.40 million	$0.40 million
General Traffic Benefits	Road traffic reduction benefit	$0.34 million	$0.51 million	$0.88 million
Total Undiscounted 2028 Benefits		**$2.84 million**	**$3.47 million**	**$6.50 million**

Table ES2: Undiscounted Project Benefits, 2038

Benefit Stream		20Connect	A2B	Southwest Gateway
Cycling Benefits	Health benefits	$1.84 million	$2.73 million	$4.63 million
	Safety benefits for cyclists	$0.05 million	$0.08 million	$0.14 million
	Travel time savings for cyclists	$0.06 million	$0.05 million	$0.11 million
Pedestrian Benefits	Health & environment benefits	$0.87 million	$0	$0.87 million
	Safety benefits for pedestrians	$0	$0.40 million	$0.40 million
General Traffic Benefits	Road traffic reduction benefit	$0.41 million	$0.53 million	$0.95 million
Total Undiscounted 2038 Benefits		**$3.23 million**	**$3.79 million**	**$7.10 million**

CONTENTS

APPENDICES

1 INTRODUCTION

This report summarises the economic benefit evaluation undertaken for the proposed walking and cycling components within the Southwest Gateway Programme. The Southwest Gateway Programme consists of two separate project streams

- Airport to Botany Rapid Transit (A2B); walking and cycling improvements include
    - Cycle infrastructure on Te Irirangi Drive, Puhinui Road, SH20B, Lambie Drive, and through Manukau centre
    - The improvements will generally provide either physically protected cycle lanes, or allow bikes and cars to mix within low volume, traffic calmed environments
    - New and improved pedestrians crossings would be provided throughout the route
- 20Connect; walking and cycle infrastructure associated with this project includes
    - A new walking and cycling route parallel to SH20, and improvements to the existing pedestrian route on SH20A
    - The improvements will generally be shared use paths, but may utilise local streets where these run close to the state highway corridors
    - New and improved pedestrian crossings would be provided where the route meets arterial roads

The extent of each project is illustrated conceptually below.

Figure 1: A2B (blue) and 20connect (green) Cycling Improvements

This document has assessed the walking and cycling economic benefits of the two individual projects identified above, as well as for the combined Southern Gateway Programme. It is intended that the economic benefits quantified in this document be used as inputs to the wider transport economic evaluations being carried out for each project and for the overall programme.

2 DEMAND ASSESSMENT

2.1 Cycle demand methodology

We have developed estimates of future cyclist trips through the Southwest Gateway Programme using the Auckland Cycle Model (ACM). This strategic cycle demand model uses the most recent Auckland Council land use forecasts ("Scenario I11") as well as forecast person trips from the Macro Strategic Model (MSM) to estimate future cycle demands, in response to cycle infrastructure investment. The ACM is documented more fully in Appendix A.

The Programme has been benchmarked against a future Reference Case that includes all existing cycle infrastructure, in addition to future infrastructure either currently proposed, or expected to be implemented in the future. The Future Reference Cases for 2028 and 2038 are documented below.

2028 Future Reference Case

The 2028 Future Reference Case includes all existing cycle infrastructure, as well as proposed future cycle infrastructure projects that have committed funding, or considered likely to receive funding by 2028. These include

- Cycle infrastructure on Lagoon Drive, Pakuranga Road and Ti Rakau Drive as part of the AMETI project
- Replacement of the Old Mangere Bridge
- Cycle infrastructure on Massey Road, Mangere Road and Walmsley Road (the "Route 32" project) as part of Auckland Transport's Connected Communities programme
- SH1 cycle infrastructure associated with the Southern Corridor Improvements (Takanini to Papakura), and the future Papakura to Drury improvements
- Cycle infrastructure associated with Stage 1 of the Mill Road corridor
- A future shared use path on SH20B and Puhinui Road, from Auckland Airport to Puhinui Station
- Cycle infrastructure within Auckland Airport

2038 Future Reference Case

The 2038 Future Reference Case includes all infrastructure included in the 2028 Reference Case. It also includes limited future cycle infrastructure projects that, while not committed, are considered the 'bare minimum' level of ongoing cycle investment over the next 20-year period. If no further background investment was assumed, this would unrealistically limit the long-term connectivity of the proposed Programme. Infrastructure included is

- Future cycle infrastructure on Pakuranga Road (Ti Rakau Drive to Howick town centre) and on Great South Road (where existing cycle infrastructure is lacking) as part of Auckland Transport's Connected Communities programme
- Future cycle infrastructure on Walmsley Road, Favona Road and James Fletcher Drive in Mangere
- Future cycle infrastructure on Roscommon Road and Weymouth Road
- Future cycle infrastructure associated with the Supporting Growth programme

It is noted that the Auckland Cycle Network (ACN) is Auckland Transport's proposed long-term network of cycle infrastructure and it contains significantly more investment than the above, with dedicated cycle infrastructure on all arterial corridors and parallel to all motorway and rail corridors. As such, the 2038 model is considered conservative, by omitting this additional, unfunded, investment.

2.2 Forecast future cyclist demands

Forecast flow plots are appended to this report and show

- The Annual Average Daily Cyclists (AADC) forecast for each of the modelled scenarios in 2028 (Appendix C), and
- The difference in AADC forecasts between the future Reference Case and the Project scenario, again in 2028 (Appendix D). In these plots, increases in cyclists are shown as green bands, while decreases (cyclists shifting to alternative routes) are shown as blue bands.

The latter plots above illustrate that the Southwest Gateway programme is predicted to result in a general increase in cycling trips on improved corridors, with smaller increases on connecting routes. Some redistribution of existing cycle trips away from parallel corridors is also predicted, including Coronation Road, Mahunga Drive and Cavendish Drive.

The following table summarises the forecast daily cycle trips on each section of the Programme in 2028.

Table 1: Forecast Annual Average Daily Cyclists

Route	2028				2038			
	Reference Case	20Connect	A2B	Southwest Gateway	Reference Case	20Connect	A2B	Southwest Gateway
20Connect								
SH20 (n of Walmsley Rd)	n/a	230	n/a	230	n/a	220	n/a	220
SH20 (n of Bader Dr)	n/a	150	n/a	160	n/a	130	n/a	130
SH20 (n of Massey Rd)	n/a	230	n/a	250	n/a	250	n/a	260
SH20 (n of Puhinui Rd)	n/a	160	n/a	200	n/a	280	n/a	320
SH20 (n of Roscommon Rd)	n/a	170	n/a	120	n/a	420	n/a	370
SH20A (w of Bader Rd)	180	270	180	270	210	330	210	330
A2B								
Puhinui Rd (w of Lambie Dr)	140	140	300	360	170	170	350	390
Lambie Dr (s of Cavendish Dr)	10	10	90	100	20	20	100	110
Te Irirangi Dr (across SH1)	50	50	120	120	70	70	160	160
Te Irirangi Dr (n of Boundary Rd)	0	0	50	50	0	0	50	50
Te Irirangi Dr (n of Ormiston Rd)	80	90	290	290	110	110	320	330
Te Irirangi Dr (n of Accent Dr)	120	120	360	360	140	140	410	410
Te Irirangi Dr (n of Smales Rd)	40	40	540	540	60	60	590	590

A number of trends are represented in the above model outputs

- Forecast demands are generally within the 100 to 500 daily cyclist range; this falls within the low end of the existing observed range on Auckland's strategic cycleway network of between 200 (Southwest Motorway shared path) and 1,000 daily cyclists (Northwestern cycleway)
- Higher forecast demands are forecast on Te Irirangi Drive north of Smales Road, due to the proximity of Botany Metropolitan Centre and Botany Downs College, and the large number of short, cyclable trips that start or end in this area
- Only generally modest increases in cyclist demands are forecast from 2028 to 2038. Larger increases are forecast in locations where additional connecting cycle infrastructure has been assumed in the 2038 Reference Case
- Forecasts for the Southwest Gateway programme overall are marginally higher than the individual forecasts for A2B and 20Connect; this is evident in locations where the two projects meet at Puhinui Road/SH20. In effect the programme is greater than the sum of its parts.

2.3 Forecast cycle trips

The following table documents the modelled summary statistics, in terms of

- The total daily cycle-km travelled within the model
- The total daily number of cycle trips
- The number of new daily cycle trips, relative to the future Reference Case

Table 2: Modelled Summary Statistics

Statistic	2028				2038			
	Ref Case	20 Connect	A2B	SW Gateway	Ref Case	20 Connect	A2B	SW Gateway
Daily cycle-km travelled	191,300	194,000	195,500	198,500	294,000	297,200	298,700	302,000
Daily cycle trips	31,570	31,940	32,330	32,730	49,970	50,430	50,810	51,280
New daily cycle trips	**n/a**	**+370**	**+760**	**+1,160**	**n/a**	**+460**	**+830**	**+1,310**

Little weight should be given to the first two indicators, as the total number of cycle trips and the distance travelled relates to the size of the model and the cycle trips included within it. The number of new daily cycle trips however provides a key measure of the overall effectiveness of the Programme at facilitating mode shift towards cycling. In total, the Programme is estimated to result in 1,160 new daily cycle trips in 2028, increasing to 1,310 new trips in 2038.

2.4 Pedestrian demands

The 20Connect will provide approximately 9.0 km of new shared use paths parallel to SH20 and SH20A in locations there are no existing pedestrian facilities. As a result, an increase in pedestrian activity on these routes is expected.

To estimate this demand, count data has been obtained from the automated pedestrian count sites on existing State Highway shared use paths within Auckland. At these four sites – the Northwestern Cycleway (Kingsland), SH20 (Mangere Bridge), SH20A (Kirkbride Road) and SH20 shared path (Dominion Road) – the average daily pedestrian count for the year to December 2019 was 152 pedestrians. This figure has been assumed to apply to the new sections of shared path on SH20 and SH20A, and has been inflated to 163 daily pedestrians in 2028 and 2038 to account for the forecast 7% population growth within Mangere area[1]. We note that there is no significant population growth predicted within Mangere beyond 2028.

An alternative method of estimating pedestrian demands was considered, where the number of pedestrians is determined as a ratio of the cycle demand forecast for each section of shared path. This ratio varies considerably on existing Auckland shared use paths, with high pedestrian ratios near schools, town centres and public transport facilities, and much lower ratios elsewhere. The average ratio is 0.7 pedestrians per cyclist however, and if this were applied to the cycle demand forecasts, the resulting pedestrian estimate would be 156 pedestrians per day in 2028. This is comparable to the 163 estimate above.

3 ECONOMIC BENEFIT EVALUATION

3.1 Methodology

This section quantifies the economic benefit evaluation of the programme. The economic evaluation has generally been based on the cycling and pedestrian benefits procedures within Simplified Procedures 11 (SP11) from the New Zealand Transport Agency's Economic Evaluation Manual (EEM). Recognising however that SP11 contains a number of simplistic approximations, the SP11 procedures have been extended, primarily by using the 2028 and 2038 ACM to inform the economics, rather than SP11's default demand estimation tool.

Cycling benefits for intermediate years have been interpolated from the 2 forecast years. This differs from SP11, which typically considers only a single opening year, and applies a cycle growth rate to future years.

3.1.1 Update factors

The economic evaluation has been carried out using the EEM's most recent update factors (1 December 2018), including:

- 1.21 for walking, cycling and public transport benefits
- 1.50 for travel time cost savings
- 1.07 for vehicle operating cost savings
- 1.06 for crash costs.

[1] Within MSM zones 458 to 486

3.2 Cycling benefits

3.2.1 Cyclist perceived travel time benefits

Perceived travel time cost savings for cyclists have been determined for all existing cyclists, as per SP11. Existing cyclists have been determined by running the 'Project' model networks with the 'Reference Case' demand set. This 'fixed trip assessment' allows the number of existing cyclists that would reassign onto each investment option to be quantified; ie the total 'existing cyclists' required input to calculate travel time cost savings.

Travel times have been adjusted to reflect perceived travel times, depending on the quality of the cycle infrastructure on each modelled link. This is consistent with the approach applied in SP11, which adjusts travel times for Relative Attractiveness, applying ratings of 2.0 (for an off-street cycle path) to 1.0 (for on-street cycling on an arterial road with no cycle infrastructure). The evaluation has applied a graduated scale within this range, to account for the qualities of cycle infrastructure.

Travel time cost savings for cyclists have also been determined for all new cyclists predicted to use the proposed facilities, by applying the 'rule of half' method. This method assumes that new users gain half of the travel time benefits of existing users, relative to their travel choice without the Project (ie using other modes or not travelling at all).

A value of time of $11.16 has been applied, being the weighted average of $7.80 (cycling for commuting) and $6.90 (cycling for other purposes), updated by the current 1.50 EEM value of time update factor, and weighting for the estimated relative proportions of commuter cyclists to recreational and school cyclists. Data obtained from surveys on Quay Street and Tamaki Drive has been used to estimate these proportions (where 50% of daily cyclists were commuters); a higher proportion of commuter cyclists (60%) has been applied to the Southwest Gateway programme, where there are expected to be fewer recreational users than either Tamaki Drive or Quay Street.

It is noted that travel time cost savings may or may not be applicable to all recreational cyclists. In this instance, 'recreational' refers to a range of different user types, some of whom may benefit from improved perceived travel times, and some of whom may not. The issue of travel time savings in the case of recreational trips is not well defined within the EEM, and economic evaluation procedures do typically apply travel time cost savings to recreational car trips. As recreational travel time cost savings are a relatively small component of the overall benefits in this assessment, these have not been adjusted to account for users that may or may not gain these benefits.

Mean speeds of 20 km/h have been applied to both the Reference Case and Project, based on typical on-street cycle speeds obtained from cycle tube counters. A sensitivity test has been run on the economics to test the scenario where speeds on the Project increase to 25 km/hr.

3.2.2 Health benefits for cyclists

SP11 calculates health benefits only for that portion of a new cyclist's trip that takes place on the facility itself, as per Equation 1 below. This is a significantly conservative assumption, as new cycle trips due to the Project are predicted on average to be in the order of 6 km long, while only a portion of that trip will be on the Project itself.

Equation 1: Health and Environment Benefits Calculation

Length of new cycling facility	x	Number of new daily cyclists	x	Benefit rate from SP11

It is also noted that some existing cyclists will gain health benefits from the project, if, by changing from their existing, arterial road route onto the new facility, they cycle a greater distance (choosing to do for the safety and amenity of the new facility).

To better account for this benefit stream, cyclist health benefits have been calculated for the collective increase in distance cycled, due to each investment option. This quantity has been obtained directly from the model, with the total length of cyclist-km travelled under the Reference Case and Project scenarios compared, and the difference being the total distance of new (or extended) cyclist-km trips. This value replaces both the ‘Length of new cyclist facility’ and the ‘Number of new daily cyclists’ from Equation 1 above.

SP11 applies a composite rate of $1.40 to cyclist health and environment benefits, with $0.10 of this attributable to environment benefits (decongestion). To avoid double counting of benefits, this component has been removed from this benefit stream, and dealt with separately as documented in Section 3.4.2 subsequently.

A sensitivity test has been run where SP11’s default cyclist health benefit equation has been applied.

3.2.3 Cycle safety benefits

SP11 allows cycle safety benefits to be calculated for both new and existing cycle trips, where an improved cycling facility is provided. These may be calculated either per cyclist-km travelled on new the new facilities, or alternatively per cyclist in the case of ‘hazardous sites’. The Southwest Gateway programme does not specifically address hazardous sites, so the per cyclist-km method has been applied.

The calculation of this benefit stream follows the SP11 process, and applies the rate of $0.05 per cyclist-km travelled on improved routes. Forecast estimates of cyclists on each of the improved routes have been obtained directly from the ACM.

3.3 Pedestrian benefits

3.3.1 Pedestrian safety benefits

The programme will likely result in improved pedestrian safety outcomes, as a result of new and improved pedestrian crossings and treatments of side roads. This level of detail has not yet been resolved at this stage of the programme development however. To account for this benefit stream, a blanket reduction in pedestrian related crashes has been assumed to apply to the following locations

- Within 50 m of locations where the 20Connect shared use paths meet arterial roads at new or improved signalised crossings (Mahunga Drive, Walmsley Road, Massey Road and Puhinui Road), and where treatments are proposed on Portage Road and Selfs Road

- Along the extent of the A2B corridor, including Puhinui Road, Lambie Drive, Te Irirangi Drive and through Manukau centre

Pedestrian crash data collected for the last 5 years (2014 to 2018, inclusive) has been obtained from NZ Transport Agency's Crash Analysis System (CAS). Reported pedestrian crashes include

- 1 minor injury pedestrian crash within the 20Connect study area, on Selfs Road
- 31 pedestrian crashes along the A2B corridor, including
    - 2 fatal pedestrian crashes (one incident), at the Puhinui Road intersection with Wyllie Road
    - 9 serious injury pedestrian crashes, including 4 at the intersection of Great South Road and Te Irirangi Drive and 4 on Te Irirangi Drive within Botany centre
    - 17 minor injury pedestrian crashes, generally at major intersections on the corridor
    - 4 non-injury pedestrian crashes

A 20% crash reduction has been assumed to apply to the above crashes, based on the following published crash rate reductions within the EEM's Crash Estimation Compendium for pedestrian improvements

- 55% to 80% reductions for lighting upgrades
- 20% for raised table treatments
- 15% to 45% for pedestrian refuges
- 35% for kerb extensions
- 45% for mid-block signalised crossings

The 20% reduction applied falls within the lower end of the above range, and acknowledges that specific pedestrian improvement elements of the projects have not yet been determined.

Standard EEM procedures have been used to annualise the cost of the above pedestrian crashes, using

- An assumed average speed of 60 km/h on the corridor (speed limits on the A2B corridor range from 50 to 80 km/hr)
- An assumed 1% annual growth in traffic/pedestrian volumes
- Under-reporting factors for roads within the 50-70 km/hr range – a conservative assumption that applies lower factors than higher speed roads (EEM tables A6.3(a)-(b))
- Resulting average pedestrian crash costs of $4.13 million for fatal crashes, $439,000 for serious injury crashes, $24,800 for minor injury crashes and $2,000 for non-injury crashes (EEM Tables A6.4(b)-(h))
- The crash cost update factor from Section 3.1.1

3.3.2 Pedestrian travel time benefits

The programme will provide new pedestrian routes parallel to SH20, and these new routes may provide travel time savings for some existing pedestrian trips. The majority of pedestrian users of the new shared paths are expected to be recreational users however, and as a result, may not benefit from any travel time saving. This benefit stream has been assumed to be negligible and omitted accordingly.

3.3.3 Pedestrian health and environment benefits

SP11 also allows health and environment benefits to be calculated for new pedestrian trips, where an improved pedestrian environment encourages more walking trips. These may be calculated either per new pedestrian-km travelled on new pedestrian facilities such as footpaths, or alternatively per new pedestrian in the case of 'hazardous sites'. In the case of the Southwest Gateway programme, the per pedestrian-km method has been applied.

These benefits have been estimated based on

- The estimated average daily pedestrians on each section of shared path, from Section 2.4
- The proportion of these pedestrian trips that are new – we have assumed that 50% of the estimated trips will be new trips that will generate health and environment benefits
- The length of each new section of shared path (where that shared path does not replace an existing footpath)

It is important to recognise that the estimated 163 daily pedestrians in 2028 and 2038 represents the average pedestrian count on each section of new shared path. It is not expected that each of these users will walk the full 9 km of new shared path, but instead, a much larger number of users will each walk a short section of path, together contributing to the average count of 163 pedestrians per day.

The calculation of the pedestrian health benefits is conservative, as it includes only that portion of each new pedestrian trip that takes place on the new shared path. As such, it ignores any health and environment benefit gained by walking on existing infrastructure to gain access to/from the shared path, and is conservative. It is not however practicable to accurately account for this trip portion.

3.4 General traffic benefits

3.4.1 General traffic safety benefits

Recent research from the US[2] suggests that installing separated cycling infrastructure may lead to reduced crash rates for general traffic, as well as for bicycle users. The research concludes that safe cycle infrastructure has a traffic calming effect, reducing vehicle speeds and reducing the risk of death or serious injury among motorists.

The evaluation has conservatively omitted this potential benefit stream however.

[2] Why are bike-friendly cities safer for all road users?; W.E. Marshall, N. Ferenchak and B. Janson; December 2018

3.4.2 Road traffic reduction benefits from new cycling trips (decongestion)

Decongestion benefit rates

Decongestion benefits are a significant proportion of the overall project benefits, as each investment option would provide improved alternatives to private car travel on currently congested road corridors. As a result, any mode shift in favour of cycling will reduce existing (or forecast future) congestion on the road network.

The default SP11 decongestion value of $0.10 per new cycle-km travelled applies to all cycle trips, regardless of time of day or weekday, but is known to under value decongestion benefits.

The EEM also allows a decongestion value of $1.89 per vehicle-km removed from the commuter peak period network within Auckland (Table SP9.1, updated to 2018 values). This flat value was derived in 2008 however, and does not recognise how congestion may vary across Auckland however, nor how congestion may be expected to increase over time.

In lieu of a more area-specific value, the $1.89 per vehicle-km removed from the network during the commuter peak has been applied to the draft economic evaluation. This rate may be revised if/when more appropriate decongestion rates have been obtained from local traffic models.

Car diversion rates

It is important to recognise that not every new cyclist trip due to the Project would otherwise take place by private car. EEM Table SP9.1 provides a car diversion rate of 0.725 for new public transport trips within Auckland (ie 72.5% of new public transport person-trips are assumed to correspond to users who previously drove a car). It is expected that lower car diversion rates would apply to new cycle trips, but the EEM does not provide an alternative.

Car diversion rates have been developed and applied to the forecast new cycle trips at a matrix level, with this process documented more fully in Appendix A. The resulting car diversion rates range from 0.48 to 0.55, which is sensibly lower than the 0.725 given in the EEM for new public transport trips.

3.4.3 Dis-benefits due to reduced general traffic provision

The cycle infrastructure proposed by the Southwest Gateway programme will generally either be off-road shared paths, protected cycle lanes, or traffic calmed quiet routes. These facilities are not generally expected to require reductions in the number of traffic lanes available for general traffic. However, where new signalised pedestrian and cyclist crossings of arterials are proposed, this may result in small travel time reductions for general traffic.

Section 2.7 of the EEM allows the Do Minimum to include the proposed operating speed, where a project seeks to "address unacceptable levels of collective and/or personal risk". While the proposed improvements may not affect the operating speed on existing arterials as such, the proposed new crossings are required to address pedestrian and cyclist risk that would be unacceptable if the crossings were not installed. As such, changes in general traffic speeds or travel times are considered part of the Do Minimum, and have been excluded from the evaluation accordingly. We also note that it is not practicable to evaluate these potential dis-benefits to general traffic, given the current lack of detail regarding interventions that may affect traffic.

It should be recognised that these potential project dis-benefits have been omitted from the analysis however. If these were to be included, this would have the effect of reducing the overall project benefits and BCR.

3.5 Project benefits

The following tables summarise the predicted undiscounted programme benefits.

Table 3: Undiscounted Project Benefits, 2028

Benefit Stream		20Connect	A2B	Southwest Gateway
Cycling Benefits	Health benefits	$1.55 million	$2.44 million	$4.14 million
	Safety benefits for cyclists	$0.04 million	$0.07 million	$0.12 million
	Travel time savings for cyclists	$0.03 million	$0.05 million	$0.09 million
Pedestrian Benefits	Health & environment benefits	$0.87 million	$0	$0.87 million
	Safety benefits for pedestrians	$0	$0.40 million	$0.40 million
General Traffic Benefits	Road traffic reduction benefit	$0.34 million	$0.51 million	$0.88 million
Total Undiscounted 2028 Benefits		**$2.84 million**	**$3.47 million**	**$6.50 million**

Table 4: Undiscounted Project Benefits, 2038

Benefit Stream		20Connect	A2B	Southwest Gateway
Cycling Benefits	Health benefits	$1.84 million	$2.73 million	$4.63 million
	Safety benefits for cyclists	$0.05 million	$0.08 million	$0.14 million
	Travel time savings for cyclists	$0.06 million	$0.05 million	$0.11 million
Pedestrian Benefits	Health & environment benefits	$0.87 million	$0	$0.87 million
	Safety benefits for pedestrians	$0	$0.40 million	$0.40 million
General Traffic Benefits	Road traffic reduction benefit	$0.41 million	$0.53 million	$0.95 million
Total Undiscounted 2038 Benefits		**$3.23 million**	**$3.79 million**	**$7.10 million**

3.6 Sensitivity tests

A series of sensitivity tests has been run on the assessment. The sensitivity tests focus on the inputs that affect the main benefit streams of pedestrian and cyclist health benefits and general traffic decongestion. The sensitivity tests area:

- Higher/lower forecast numbers of cyclists (±20%)
- Higher/lower forecast numbers of pedestrians (±20%)

- Applying a higher/lower car diversion rate for new cycle trips (±20%)
- Applying SP11's default decongestion rate of $0.10 per new cycle-km to all new cycle trips
- Higher SP9 decongestion rate per vehicle-km removed (+20%)
- Applying SP11's default cyclist health benefits
- Assuming a higher average cycle speed on the project (25 km/h)

The results of the sensitivity tests are presented below.

Table 5: Undiscounted Project Benefits, 2028 – Sensitivity Tests

Sensitivity Test Scenario	20Connect	A2B	Southwest Gateway
SP11 default cyclist health benefits	$2.29 million	$2.30 million	$4.83 million
Low cycle demands (-20%)	$2.51 million	$2.85 million	$5.63 million
SP11 default decongestion rate	$2.62 million	$3.14 million	$5.94 million
Low pedestrian demands (-20%)	$2.66 million	$3.47 million	$6.33 million
Low car diversion rate (-20%)	$2.77 million	$3.36 million	$6.33 million
Default assessment	**$2.84 million**	**$3.47 million**	**$6.50 million**
Higher average cycle speed on project (25 km/h)	$2.83 million	$3.46 million	$6.49 million
Higher SP9 decongestion rate (+20%)	$2.91 million	$3.57 million	$6.70 million
High car diversion rate (+20%)	$2.91 million	$3.57 million	$6.70 million
High pedestrian demands (+20%)	$3.01 million	$3.47 million	$6.68 million
High cycle demands (+20%)	$3.16 million	$4.08 million	$7.37 million

The programme/project benefit streams are shown to be most sensitive to changes in forecast cyclists, and less sensitive to changes in forecast pedestrians, or to changes in the general traffic decongestion methodology.

APPENDIX A Auckland Cycle Model

Auckland Cycle Model

Demand estimates have been determined using the 2028 and 2038 Auckland Cycle Model (ACM). This model estimates future cycling demand and

- Reflects predicted land use (using to Auckland Council's most recent Scenario I11 land use forecasts)
- Reflects cyclists' route choice – with cyclists generally opting to travel via a slightly longer route if it provides a higher standard of infrastructure, or less adverse gradients
- Reflects realistic cycling trip lengths – with longer trips less likely to be undertaken by bicycle than shorter trips, with a probability distribution applied that is based on the existing Auckland cycle trip length distribution
- Reflects realistic cycle trip types – with trip types such as home-to-work and home-to-education more likely to be undertaken by bicycle than trip types such as trips for employer's business
- Is responsive to changes in cycle infrastructure (in terms of both demands and trip assignment), in that high-quality cycle infrastructure between any two nodes will result in more trips between those nodes being undertaken by bicycle, than a scenario with poorer quality cycle infrastructure
- Reflects "network effects" and as a result predicts higher cycle demands where a connected cycle network is provided; conversely the model predicts fewer cycle demands where a network is disconnected or is missing critical links between origin-destination pairs.

The model was built to represent a 2013 base year, and a 2016 forecast model has also been developed. This 2016 forecast model included all cycling infrastructure constructed between March 2013 and July 2016, notably including recently completed infrastructure at that time including Grafton Gully, Nelson Street, LightPath, Beach Road, and Carlton Gore Road.

The 2016 model was then calibrated against automated cycle count data collected from 21 locations, to refine the model's cycle demand process. In this way, the model's response to cycle infrastructure investment has been calibrated to match the growth observed between 2013 and 2016, given the investment in Auckland cycle infrastructure over this period.

For the economic evaluation of the Project, 2028 and 2038 forecast models have been used. These models are based on Auckland land use scenario I11 (the most recent available, and that reflecting Auckland Unitary Plan zoning).

The model represents morning and evening peak period (two hour) cyclist demands for each forecast year. Estimates of daily cyclists have been developed by factoring the peak period model outputs. The following table presents a comparison of cyclist count data within the project area and modelled 2016 cyclists. Count data obtained in 2015 were manual counts, and subsequent data was generally obtained from Auckland Transport's automated cycle counters.

Table 6: Observed and Modelled 2016 Daily Cyclists

Count Location	Direction	Count Date	Surveyed Daily Cyclists	2016 Modelled Daily Cyclists	Difference
Walmsley Road / Mckenzie Road / Miller Road / Coronation Road	WB	2015	22	5	-17
	NB		43	27	-16
	EB		16	10	-6
	SB		37	45	+8
George Bolt Dr/ Tom Pearce Dr	WB	2015	6	6	0
	SB		4	12	+8
Buckland Rd / Massey Rd	SB	2015	21	23	+2
	WB		33	13	-20
	NB		21	17	-4
	EB		21	12	-9
Puhinui Rd / Wylie Rd	EB	2015	36	22	-13
	SB		16	14	-3
	WB		42	34	-8
	EB	2018	23	22	-1
	WB		19	34	+15
Great South Rd / East Tamaki Rd	SB	2015	51	60	+10
	WB		25	6	-20
	NB		49	59	+10
Te Irirangi Dr / Great South Rd	WB	2015	22	21	-2
	NB		24	44	+20
	EB		18	28	+10
	SB		25	35	+10
Te Irirangi Dr / Ormiston Rd	WB	2015	15	8	-7
	NB		7	18	+11
	EB		15	10	-5
	SB		30	20	-9
Highbrook Dr	NB	2015	43	18	-25
	SB		31	15	-16
	NB	2016	18	18	-
	SB		17	15	-2

Table 6: Observed and Modelled 2016 Daily Cyclists

Count Location	Direction	Count Date	Surveyed Daily Cyclists	2016 Modelled Daily Cyclists	Difference
Great South Rd / Orams Rd	WB	2015	13	27	+14
	NB		36	42	+7
	EB		18	60	+42
	SB		33	43	+10
Pakuranga Rd / Ti Rakau Dr	WB	2015	37	48	+11
	NB		48	44	-4
	EB		70	81	+12
Pakuranga Rd / Aviemore Dr / Bucklands Beach Rd	NB	2015	33	23	-10
	EB		27	30	+3
	SB		31	23	-8
	WB		24	10	-13
Botany Rd / Te Irirangi Dr / Ti Rakau Dr	SB	2015	37	53	+16
	WB		7	4	-4
	NB		24	19	-5
	EB		9	12	+3
Smales Rd / Springs Rd / Allens Rd / Harris Rd	WB	2015	24	5	-19
	NB		13	13	-
	EB		15	2	-13
	SB		21	21	-
Old Mangere Bridge	NB	2015	288	203	-85
	SB		247	193	-54
	NB	2018	189	203	+14
	SB		179	193	-14
Great South Rd	NB	2016	36	41	+5
	SB		50	33	-17
Lagoon Dr	EB	2016	70	81	+11
	WB		79	98	+19

The observed and modelled cyclists generally compare well, given that the majority of counts were obtained on a single day, and that there is typically significant variation in cyclist volumes from one day to the next. Notably, the model has underestimated cyclists on the Old Mangere Bridge, relative to the 2015 count, but more closely matches 2018 automated count data.

The above 2016 daily modelled cyclist forecasts have been derived by expanding the modelled morning and evening peak period forecasts. An expansion factor of 2.4 has been used in this process, and this best matches the observed and modelled data. This is a relatively high factor however, and elsewhere in Auckland a factor of 1.8 to 2.0 is more common on commuter cyclist routes. This is thought be a result of the generally undeveloped existing cycle network within this area of Auckland, with the expansion factor being distorted by a high proportion of off-peak sports recreational cyclists.

For the forecast 2028 and 2038 models, an expansion factor of 2.0 has been used, matching that observed in areas of Auckland that already have a more developed cycle network.

Car diversion rates for new cycle trips

New cycle trips

Estimates of new cycle trips during the commuter peak periods have been obtained by deducting the ‘Reference Case’ demand matrices from the ‘Project’ matrices. These matrices form the basis of the diverted car trips below.

Utility trips

The above new cycle trips will contain a mixture of both utility trips (travel to work, school, or some other destination) and recreational trips. The latter trip type will not generally replace a car or public transport trip, so should be removed from the new cycle trips.

There is little survey data available to distinguish utility/recreational cyclist proportions, and the ratio will also vary significantly by both location and time of day. The Household travel survey indicates that 21% of cycle trips are for sport/exercise (by distance), and a further 9% are for social visit/entertainment, which may also be recreational trips. These however are daily averages, which will tend to include more recreational trips than during peak periods.

Survey data collected on Auckland’s Quay Street and Tamaki Drive indicate peak period proportions of 80% and 70% utility trips, respectively. The higher of these two figures, 80%, is assumed to apply to the Southwestern Gateway programme, as the Tamaki Drive route is likely to be disproportionately affected by recreational trips. It is expected that this may be a conservative assessment of diverted trips, as the actual proportion of utility cycle trips in the peak periods may be higher than 80%.

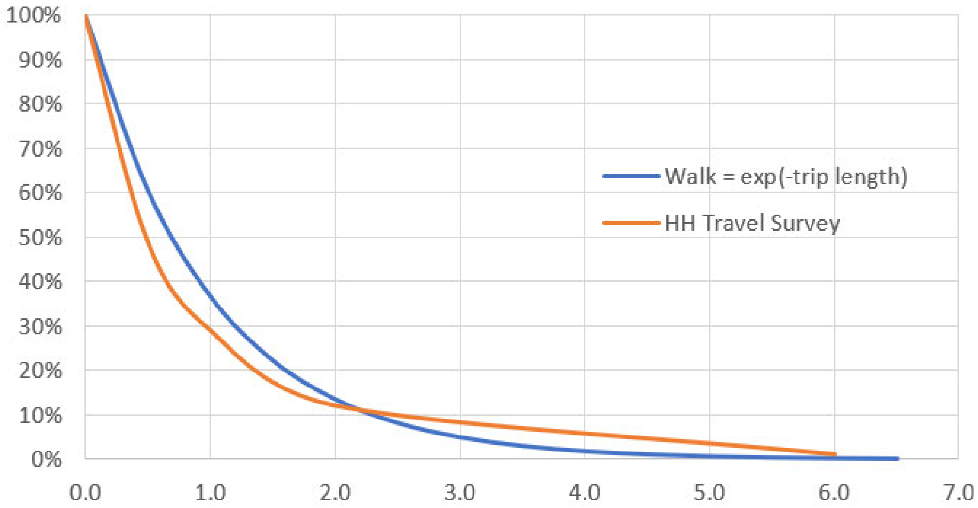
Mechanised trips

A number of the forecast new utility cycle trips will correspond to trips that would previously have taken place on foot, and this is particularly the case for shorter trips. These walking trips need to be removed from the above trips, to derive the diverted mechanised trips.

The Household Travel Survey[3] contains useful data in terms of the existing walking trip length (by time) in New Zealand, with the trip length distribution following the trend shown in Figure 2 below (assuming an average 5 km/h walking speed).

[3] https://www.nzta.govt.nz/resources/nz-pedestrian-profile/5/

Figure 2: NZ Household Travel Survey – Walking Trip Length Distribution



The above trip length distribution very closely follows a decay function of the shape:

Equation 2: Walking Trip Length Distribution

Walk percent = exp (-trip length)

The above function is assumed to apply and has been used to remove walking trips from the new cycle utility trips, for each origin-destination pair. That is to say, 37% of new cycle trips of 1 km length are assumed to replace a walking trip and are removed, 14% of new cycle trips of 2 km length removed, etc.

Mechanised mode share

The above new utility cycle trips will correspond to both car and public transport trips that divert to cycling. These have been split into their respective car and public transport components, based on the car (person) and public transport mode share to and from each MSM origin-destination pair. The pool of MSM trips included in this process has included only select trip types, being

- All public transport person-trips
- All home-based work and education car person-trips
- 25% of home-based shopping and home-based other car person-trips
- 0% of employers' business, non-home-based other car person-trips or HCV trips

This is to remain consistent with the 'potential cycle trip' matrices that were used in the development of the ACM, which recognises that some trip types are more likely to convert to cycling than others. The effect of this process has been to increase the public transport proportion of the MSM person-trips applied in this step, resulting in lower (ie conservative) car diversion rates.

Car drivers

Of the car person-trips identified above, some will correspond to car drivers while some will correspond to passengers. The latter, if changing mode to cycling, will not result in a reduced car trip on the network. Car passengers have been removed based on the ratio of car (person) to car (vehicle) trips to and from each MSM origin-destination pair.

Worked example of diverted trips

The following table presents a worked example of how the diverted trips are calculated. The example shown is for the Southwest Gateway programme in the 2028 morning peak period.

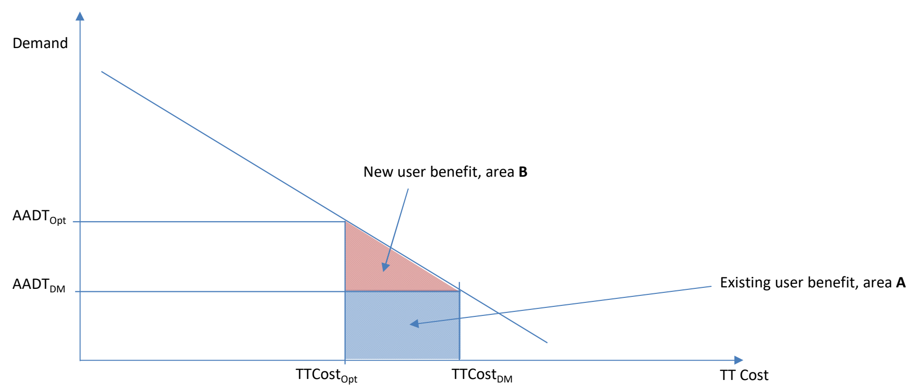
Table 7: Diverted Trips Procedure – Worked Example

Step		Example: Southwest Gateway Programme 2028 Morning Peak
1	New cycle trips	8,866 morning peak cycle trips predicted without investment 9,191 morning peak cycle trips predicted with Cycle Programme investment 325 new morning peak cycle trips
2	Utility trips	80% utility trips assumed 65 recreational trips removed 260 new utility cycle trips remaining
3	Mechanised trips	Decay curve applied to trip matrix, based on O-D pair trip length 10 pedestrian trips removed 250 diverted car and public transport (person) trips remaining
4	Car and public transport mode share	Mode share applied to trip matrix, based on MSM mode share 196 diverted car (person) trips 54 diverted public transport (person) trips (78% average car mode share)
5	Car vehicle trips	Mode share applied to trip matrix, based on MSM car occupancy 153 diverted car (vehicle) trips 43 diverted car (passenger) trips (1.28 average car occupancy)

APPENDIX B economic evaluation sheets

Travel time savings for cyclists - SW Gateway

	2028			2038				
	Ref case daily	**Option Network, Ref Case Demands daily**	**Option Network, Option Demands daily**	**Ref Case daily**	**Option Network, Ref Case Demands daily**	**Option Network, Option Demands daily**		
Total network travel distance	191298	191329	198515	293968	293859	302036	AADT x L	cycle-km
Total network generalised costs	120953	120653	125068	178683	178285	183168	AADT x L / RA	cycle-km/RA; ie corrected for EEM RA
Change in total network generalised costs: Existing users		**300**			**398**		A = ($AADT_{DM}$ x L_{DM} / RA_{DM}) - ($AADT_{DM}$ x L_{Opt} / RA_{Opt})	ie Existing users' generalised/percieved TT cost savings
Existing users using project links		1356			2098		$AADT_{DM}$	cyclists/day, from Ref Case & Option matrices trips where costs between O-D pairs have reduced due to project
Change in generalised costs/existing user		0.22			0.19			cycle-km/RA/user
New users (mode shifters)			1158			1307	$AADT_{Opt}$ - $AADT_{DM}$	cyclists/day
Change in total network generalised costs: New users			**128**			**124**	B = A/$AADT_{DM}$ x ($AADT_{Opt}$ - $AADT_{DM}$) / 2	**ie, rule of half for new users** cycle-km/RA
Total change in network generalised costs			**428**			**522**	**A + B**	**ie, existing users' percieved TT cost savings, plus rule of half for new users** cycle-km/RA
Travel speed			20			20		20km/h typical cycle speed
TT cost			$7.44			$7.44		Weighted average: 60% $7.80 Commuting
Update factor			1.50			1.50		40% $6.90 Other Purposes
days/year			365			365		0% $23.85 Travel For Work
								$7.44 $11.16
								Based on utility cyclist share on Quay St & Tamaki Dr (50%).
User Cost Savings (percieved travel time)			**$87,255**			**$106,228**		Slightly lower proportion of recreational estimated



2028 - SW Gateway

SP11 Walking and cycling facilities continued

Walking Section C and D

Cycling Section A, B, C, D

Worksheet 5 - Benefits for walking and cycling facilities:

1 Health and environmental benefits for walking facility

Pedestrian growth rate (per annum) n/a

Health and environmental benefits for footpaths and other pedestrian facilities

Benefit = number of additional pedestrians/day x length of new facility in km x 365 x $2.70

Update factor 1.21

L	9.0	x NPD	81	x 365 x $2.70 x DF	1.00	= $	869,825 (a)

2 Health and environmental benefits from improvements at hazardous sites

(provision of overbridges, underpasses, bridge widening or intersection improvements for pedestrians)

Benefit = number of additional pedestrians/day x 365 x $2.70

NPD		x 365 x $2.70 x DF	1.00	= $	- (b)

Transfer total (a) or (b) to D on Worksheet 1.

3 Health benefits for cycling facility

Cyclist growth rate (per annum) n/a

Health and environmental benefits for cycle lanes, cycleways or increased road shoulder widths

Benefit = number of additional cycle trips/day x average distance cycled in km x 365 x $1.30

Update factor 1.21

L	1.0	x NTD	7217	x 365 x $1.30 x DF	1.00	= $	4,143,742 (c)

4 Health and environmental benefits from improvements at hazardous sites

(provision of overbridges, underpasses, bridge widening or intersection improvements for cyclists)

Benefit = number of additional cycles/day x 365 x $4.20

NTD		x 365 x $4.20 x DF	1.00	= $	- (d)

Transfer total (c) or (d) to D on Worksheet 1.

5 **Safety benefits for cycle facility**

Safety benefits for cycle lanes, cycleways or increased road shoulder widths in the absence of a specific accident analysis

Benefit = number of new and existing cycle trips/day x length of new facility in km x 365 x $0.05

Update factor 1.21

L	24.6	x NSD	223	x 365 x $0.05 x DF	1.00	= $	121,033 (e)

6 Safety benefit from improvements at hazardous sites in the absence of a specific accident analysis

(provision of overbridges, underpasses, bridge widening or intersection improvements for cyclists)

Benefit = number of new and existing cycles/day x 365 x $0.15

NSD		x 365 x $0.15 x DF	1.00	= $	- (f)

Transfer total (e) or (f) to E on Worksheet 1.

SP11 Walking and cycling facilities continued

Walking Section C and D

Cycling Section A, B, C, D

Worksheet 5 - Benefits for walking and cycling facilities:

1 Health and environmental benefits for walking facility

Pedestrian growth rate (per annum) n/a

Health and environmental benefits for footpaths and other pedestrian facilities

Benefit = number of additional pedestrians/day x length of new facility in km x 365 x $2.70

Update factor 1.21

L	9.0	x NPD	81	x 365 x $2.70 x DF	1.00	= $	869,825 (a)

2 Health and environmental benefits from improvements at hazardous sites

(provision of overbridges, underpasses, bridge widening or intersection improvements for pedestrians)

Benefit = number of additional pedestrians/day x 365 x $2.70

NPD		x 365 x $2.70 x DF	1.00	= $	- (b)

Transfer total (a) or (b) to D on Worksheet 1.

3 Health benefits for cycling facility

Cyclist growth rate (per annum) n/a

Health and environmental benefits for cycle lanes, cycleways or increased road shoulder widths

Benefit = number of additional cycle trips/day x average distance cycled in km x 365 x $1.30

Update factor 1.21

L	1.0	x NTD	8068	x 365 x $1.30 x DF	1.00	= $	4,632,251 (c)

4 Health and environmental benefits from improvements at hazardous sites

(provision of overbridges, underpasses, bridge widening or intersection improvements for cyclists)

Benefit = number of additional cycles/day x 365 x $4.20

NTD		x 365 x $4.20 x DF	1.00	= $	- (d)

Transfer total (c) or (d) to D on Worksheet 1.

5 **Safety benefits for cycle facility**

Safety benefits for cycle lanes, cycleways or increased road shoulder widths in the absence of a specific accident analysis

Benefit = number of new and existing cycle trips/day x length of new facility in km x 365 x $0.05

Update factor 1.21

L	24.6	x NSD	261	x 365 x $0.05 x DF	1.00	= $	141,574 (e)

6 Safety benefit from improvements at hazardous sites in the absence of a specific accident analysis

(provision of overbridges, underpasses, bridge widening or intersection improvements for cyclists)

Benefit = number of new and existing cycles/day x 365 x $0.15

NSD		x 365 x $0.15 x DF	1.00	= $	- (f)

Transfer total (e) or (f) to E on Worksheet 1.

General traffic decongestion - A2B			
Modelled Decongestion Values			
Commuter Peak Periods (2 x 2hr)	**2028**	**2038**	**Comments**
New peak period cycle-km	3609	4034	From cycle model
am peak period veh-km removed	962	1092	from Diverted Trips spreadsheets
pm peak period veh-km removed	940	967	from Diverted Trips spreadsheets
Peak period veh-km removed	1902	2059	
effective diversion rate	0.53	0.51	car trips per new cycle trip. Compare with 0.725 default for PT (EEM SP9.1) - ie conservative
per veh-km, per year	TBC	TBC	From 20Connect models/MSM/Composite?
Daily benefit (weekdays)	#VALUE!	#VALUE!	
Annual benefit	**#VALUE!**	**#VALUE!**	245 weekdays per year

	2028	**2038**	
Alternative - EEM SP9 Default			
Peak period veh-km removed	1902	2059	
per veh-km, per year	$ 1.56	$ 1.56	Default, EEM table SP9.1
update factor	1.21	1.21	Applies to EEM default decongestion value only.
Daily benefit	$ 3,590	$ 3,886	
Annual benefit	**$ 879,458**	**$ 952,144**	245 weekdays per year

	2028	**2038**	
Alternative 2 - EEM SP11 Default			
New daily cycle-km	7217	8068	From cycle model
per veh-km, per year	$ 0.10	$ 0.10	Default, EEM SP11, environmental component of $1.40 health & environment benefit rate
update factor	1.21	1.21	Applies to EEM default decongestion value only.
Daily benefit	$ 873	$ 976	
Annual benefit	**$ 318,749**	**$ 356,327**	365 days per year

Worksheet A6 Crash cost savings - A2B

Worksheet A6.2 – Crash by crash analysis

	Project option		A2B	
	Movement category		Vehicle involvement	
1	Do-minimum mean speed	60	Road category	60-80 km/h on Te Irirangi, 50 km/h elsewhere. Average assumed
2	Posted speed limit	60	Traffic growth rate	

	Do Minimum	Severity Fatal	 Serious	 Minor	 Non-injury	
3	Number of years of typical crash rate records	5				
4	Number of reported crashes over period	2	9	17	4	
5	Fatal/serious severity ratio (tables A6.2(a) to (c))	0.08	0.92			Using pedestrian category
6	Number of reported crashes adjusted by severity (4) x (5)	0.88	10.12	17	4	When three or more fatal crashes occur at a site the crash costs do not need to be redistributed at the site
7	Crashes per year = (6)/(3)	0.18	2.02	3.40	0.80	
8	Adjustment factor for crash trend (table A6.1(a))	0.86				1% growth assumed
9	Adjusted crashes per year = (7) x (8)	0.15	1.74	2.92	0.69	
10	Under-reporting factors (table A6.3(a) and (b))	1	1.5	4.5	7	Using pedestrian category and applying conservative factors for 50-70 km/h zone
11	Total estimated crashs per year (9) x (10)	0.151	2.611	13.158	4.816	
12	Crash cost, 100 km/h limit (tables A6.4(e) to (h))	4,250,000	435,000	24,000	3,700	Using pedestrian category
13	Crash cost, 50 km/h limit (tables A6.4(a) to (d))	4,100,000	440,000	25,000	1,600	Using pedestrian category
14	Mean speed adjustment =((1) - 50)/50	0.2				
15	Cost per crash = (13) + (14) x [(12) - (13)]	4,130,000	439,000	24,800	2,020	
16	Crash cost per year = (11) x (15)	625,117	1,146,211	326,318	9,728	
17	Total cost of crashes per year (sum of columns in row (16) fatal +serious + minor + non-injury) $	2,010,436				2019 Crash factor of 1.06 has been applied

Annual crash cost saving $ 402,087 Reduction Factor 20%

Constant benefits, as 1% growth rate balances out adjustment factor of -1% from EEM table A6.1(b)

Worksheet A6 Crash cost savings - 20Connect

Worksheet A6.2 – Crash by crash analysis

	Project option		20Connect	
	Movement category		Vehicle involvement	
1	Do-minimum mean speed	50	Road category	
2	Posted speed limit	50	Traffic growth rate	

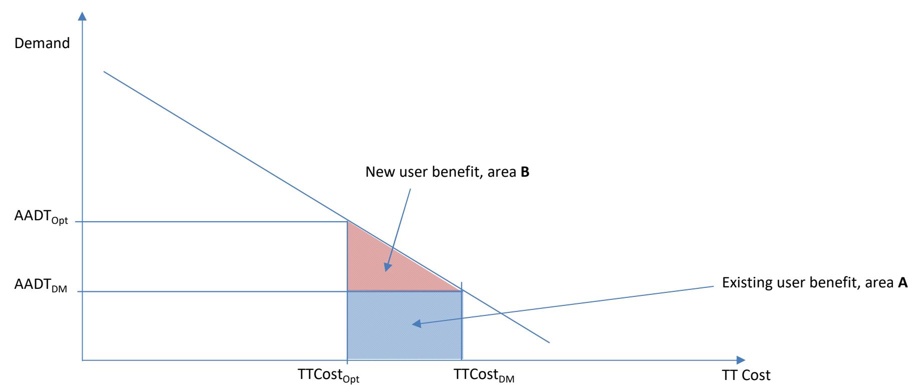
	Do Minimum	Severity Fatal	 Serious	 Minor	 Non-injury	
3	Number of years of typical crash rate records	5				
4	Number of reported crashes over period	0	0	0	1	
5	Fatal/serious severity ratio (tables A6.2(a) to (c))	0.08	0.92			Using pedestrian category
6	(4) x (5)	0	0	0	1	When three or more fatal crashes occur at a site the crash costs do not need to be redistributed at the site
7	Crashes per year = (6)/(3)	0.00	0.00	0.00	0.20	
8	Adjustment factor for crash trend (table A6.1(a))	0.86				1% growth assumed
9	Adjusted crashes per year = (7) x (8)	0.00	0.00	0.00	0.17	
10	Under-reporting factors (table A6.3(a) and (b))	1	1.5	4.5	7	Using pedestrian category and applying conservative factors for 50-70 km/h zone
11	Total estimated crashs per year (9) x (10)	0.000	0.000	0.000	1.204	
12	Crash cost, 100 km/h limit (tables A6.4(e) to (h))	4,250,000	435,000	24,000	3,700	Using pedestrian category
13	Crash cost, 50 km/h limit (tables A6.4(a) to (d))	4,100,000	440,000	25,000	1,600	Using pedestrian category
14	Mean speed adjustment =((1) - 50)/50	0.2				
15	Cost per crash = (13) + (14) x [(12) - (13)]	4,130,000	439,000	24,800	2,020	
16	Crash cost per year = (11) x (15)	-	-	-	2,432	
17	Total cost of crashes per year (sum of columns in row (16) fatal +serious + minor + non-injury) $	2,578				2019 Crash factor of 1.06 has been applied

Annual crash cost saving $ 516 Reduction Factor 20%

Constant benefits, as 1% growth rate balances out adjustment factor of -1% from EEM table A6.1(b)

Travel time savings for cyclists - A2B

	2028			2038							
	Ref case	Option Network, Ref Case Demands	Option Network, Option Demands	Ref Case	Option Network, Ref Case Demands	Option Network, Option Demands					
	daily	daily	daily	daily	daily	daily					
Total network travel distance	191298	191297	195544	293968	293932	298722	AADT x L	cycle-km			
Total network generalised costs	120953	120796	123476	178683	178497	181478	AADT x L / RA	cycle-km/RA; ie corrected for EEM RA			
Change in total network generalised costs: Existing users		**157**			**185**		A = $(AADT_{DM} \times L_{DM} / RA_{DM}) - (AADT_{DM} \times L_{Opt} / RA_{Opt})$	ie Existing users' generalised/percieved TT cost savings			
Existing users using project links		848			1533		$AADT_{DM}$	cyclists/day, from Ref Case & Option matrices			
								trips where costs between O-D pairs have reduced due to project			
Change in generalised costs/existing user		0.19			0.12			cycle-km/RA/user			
New users (mode shifters)			760			833	$AADT_{Opt} - AADT_{DM}$	cyclists/day			
Change in total network generalised costs: New users			**71**			**50**	B = $A/AADT_{DM} \times (AADT_{Opt} - AADT_{DM}) / 2$	**ie, rule of half for new users**			
								cycle-km/RA			
Total change in network generalised costs			**228**			**236**	**A + B**	**ie, existing users' percieved TT cost savings, plus rule of half for new users**			
								cycle-km/RA			
Travel speed			20			20		20km/h typical cycle speed			
TT cost			$7.44			$7.44		Weighted average:	60%	$7.80	Commuting
Update factor			1.50			1.50			40%	$6.90	Other Purposes
days/year			365			365			0%	$23.85	Travel For Work
										$7.44	$11.16
								Based on utility cyclist share on Quay St & Tamaki Dr (50%).			
User Cost Savings			**$46,435**			**$48,013**		Slightly lower proportion of recreational estimated			
(percieved travel time)											



SP11 Walking and cycling facilities continued

Walking Section C and D

Cycling Section A, B, C, D

Worksheet 5 - Benefits for walking and cycling facilities:

1 Health and environmental benefits for walking facility

Pedestrian growth rate (per annum) n/a

Health and environmental benefits for footpaths and other pedestrian facilities

Benefit = number of additional pedestrians/day x length of new facility in km x 365 x $2.70

Update factor 1.21

L 0.0 x NPD 0 x 365 x $2.70 x DF 1.00 = $ - (a)

2 Health and environmental benefits from improvements at hazardous sites

(provision of overbridges, underpasses, bridge widening or intersection improvements for pedestrians)

Benefit = number of additional pedestrians/day x 365 x $2.70

NPD x 365 x $2.70 x DF 1.00 = $ - (b)

Transfer total (a) or (b) to D on Worksheet 1.

3 Health benefits for cycling facility

Cyclist growth rate (per annum) n/a

Health and environmental benefits for cycle lanes, cycleways or increased road shoulder widths

Benefit = number of additional cycle trips/day x average distance cycled in km x 365 x $1.30

Update factor 1.21

L 1.0 x NTD 4247 x 365 x $1.30 x DF 1.00 = $ 2,438,160 (c)

4 Health and environmental benefits from improvements at hazardous sites

(provision of overbridges, underpasses, bridge widening or intersection improvements for cyclists)

Benefit = number of additional cycles/day x 365 x $4.20

NTD x 365 x $4.20 x DF 1.00 = $ - (d)

Transfer total (c) or (d) to D on Worksheet 1.

5 **Safety benefits for cycle facility**

Safety benefits for cycle lanes, cycleways or increased road shoulder widths in the absence of a specific accident analysis

Benefit = number of new and existing cycle trips/day x length of new facility in km x 365 x $0.05

Update factor 1.21

L 13.2 x NSD 243 x 365 x $0.05 x DF 1.00 = $ 70,957 (e)

6 Safety benefit from improvements at hazardous sites in the absence of a specific accident analysis

(provision of overbridges, underpasses, bridge widening or intersection improvements for cyclists)

Benefit = number of new and existing cycles/day x 365 x $0.15

NSD x 365 x $0.15 x DF 1.00 = $ - (f)

Transfer total (e) or (f) to E on Worksheet 1.

2038 - A2B

SP11 Walking and cycling facilities continued

Walking Section C and D

Cycling Section A, B, C, D

Worksheet 5 - Benefits for walking and cycling facilities:

1 Health and environmental benefits for walking facility

Pedestrian growth rate (per annum) n/a

Health and environmental benefits for footpaths and other pedestrian facilities

Benefit = number of additional pedestrians/day x length of new facility in km x 365 x $2.70

Update factor 1.21

L 0.0 x NPD 0 x 365 x $2.70 x DF 1.00 = $ - (a)

2 Health and environmental benefits from improvements at hazardous sites

(provision of overbridges, underpasses, bridge widening or intersection improvements for pedestrians)

Benefit = number of additional pedestrians/day x 365 x $2.70

NPD x 365 x $2.70 x DF 1.00 = $ - (b)

Transfer total (a) or (b) to D on Worksheet 1.

3 Health benefits for cycling facility

Cyclist growth rate (per annum) n/a

Health and environmental benefits for cycle lanes, cycleways or increased road shoulder widths

Benefit = number of additional cycle trips/day x average distance cycled in km x 365 x $1.30

Update factor 1.21

L 1.0 x NTD 4754 x 365 x $1.30 x DF 1.00 = $ 2,729,404 (c)

4 Health and environmental benefits from improvements at hazardous sites

(provision of overbridges, underpasses, bridge widening or intersection improvements for cyclists)

Benefit = number of additional cycles/day x 365 x $4.20

NTD x 365 x $4.20 x DF 1.00 = $ - (d)

Transfer total (c) or (d) to D on Worksheet 1.

5 **Safety benefits for cycle facility**

Safety benefits for cycle lanes, cycleways or increased road shoulder widths in the absence of a specific accident analysis

Benefit = number of new and existing cycle trips/day x length of new facility in km x 365 x $0.05

Update factor 1.21

L 13.2 x NSD 286 x 365 x $0.05 x DF 1.00 = $ 83,535 (e)

6 Safety benefit from improvements at hazardous sites in the absence of a specific accident analysis

(provision of overbridges, underpasses, bridge widening or intersection improvements for cyclists)

Benefit = number of new and existing cycles/day x 365 x $0.15

NSD x 365 x $0.15 x DF 1.00 = $ - (f)

Transfer total (e) or (f) to E on Worksheet 1.

General traffic decongestion - A2B			
Modelled Decongestion Values			
Commuter Peak Periods (2 x 2hr)	**2028**	**2038**	**Comments**
New peak period cycle-km	2123	2377	From cycle model
am peak period veh-km removed	541	590	from Diverted Trips spreadsheets
pm peak period veh-km removed	556	562	from Diverted Trips spreadsheets
Peak period veh-km removed	1097	1152	
effective diversion rate	0.52	0.48	car trips per new cycle trip. Compare with 0.725 default for PT (EEM SP9.1) - ie conservative
per veh-km, per year	TBC	TBC	From 20Connect models/MSM/Composite?
Daily benefit (weekdays)	#VALUE!	#VALUE!	
Annual benefit	**#VALUE!**	**#VALUE!**	245 weekdays per year

	2028	**2038**	
Alternative - EEM SP9 Default			
Peak period veh-km removed	1097	1152	From above
per veh-km, per year	$ 1.56	$ 1.56	Default, EEM table SP9.1
update factor	1.21	1.21	Applies to EEM default decongestion value only.
Daily benefit	$ 2,071	$ 2,175	
Annual benefit	**$ 507,347**	**$ 532,967**	245 weekdays per year

	2028	**2038**	
Alternative 2 - EEM SP11 Default			
New daily cycle-km	4247	4754	From cycle model
per veh-km, per year	$ 0.10	$ 0.10	Default, EEM SP11, environmental component of $1.40 health & environment benefit rate
update factor	1.21	1.21	Applies to EEM default decongestion value only.
Daily benefit	$ 514	$ 575	
Annual benefit	**$ 187,551**	**$ 209,954**	365 days per year

Worksheet A6 Crash cost savings - A2B

Worksheet A6.2 – Crash by crash analysis

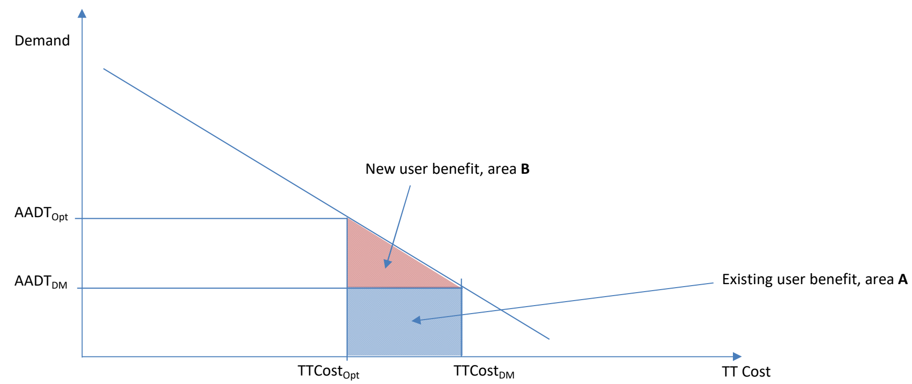
	Project option		A2B				
	Movement category		Vehicle involvement				
1	Do-minimum mean speed	60	Road category				60-80 km/h on Te Irirangi, 50 km/h elsewhere. 60 km/h average assumed
2	Posted speed limit	60	Traffic growth rate				
			Severity				
	Do Minimum	Fatal	Serious	Minor	Non-injury		
3	Number of years of typical crash rate records	5					
4	Number of reported crashes over period	2	9	17	4		
5	Fatal/serious severity ratio (tables A6.2(a) to (c))	0.08	0.92				Using pedestrian category
6	Number of reported crashes adjusted by severity (4) x (5)	0.88	10.12	17	4		When three or more fatal crashes occur at a site the crash costs do not need to be redistributed at the site
7	Crashes per year = (6)/(3)	0.18	2.02	3.40	0.80		
8	Adjustment factor for crash trend (table A6.1(a))	0.86					1% growth assumed
9	Adjusted crashes per year = (7) x (8)	0.15	1.74	2.92	0.69		
10	Under-reporting factors (table A6.3(a) and (b))	1	1.5	4.5	7		Using pedestrian category and applying conservative factors for 50-70 km/h zone
11	Total estimated crashs per year (9) x (10)	0.151	2.611	13.158	4.816		
12	Crash cost, 100 km/h limit (tables A6.4(e) to (h))	4,250,000	435,000	24,000	3,700		Using pedestrian category
13	Crash cost, 50 km/h limit (tables A6.4(a) to (d))	4,100,000	440,000	25,000	1,600		Using pedestrian category
14	Mean speed adjustment =((1) - 50)/50	0.2					
15	Cost per crash = (13) + (14) x [(12) - (13)]	4,130,000	439,000	24,800	2,020		
16	Crash cost per year = (11) x (15)	625,117	1,146,211	326,318	9,728		
17	Total cost of crashes per year (sum of columns in row (16) fatal +serious + minor + non-injury)	$ 2,010,436					2019 Crash factor of 1.06 has been applied

Annual crash cost saving $ 402,087 **Reduction Factor 20%**

Constant benefits, as 1% growth rate balances out adjustment factor of -1% from EEM table A6.1(b)

Travel time savings for cyclists - 20Connect

	2028			2038				
	Ref case	**Option Network, Ref Case Demands**	**Option Network, Option Demands**	**Ref Case**	**Option Network, Ref Case Demands**	**Option Network, Option Demands**		
	daily	**daily**	**daily**	**daily**	**daily**	**daily**		
Total network travel distance	191298	191304	193996	293968	293888	297176	AADT x L	cycle-km
Total network generalised costs	120953	120825	122432	178683	178466	180321	AADT x L / RA	cycle-km/RA; ie corrected for EEM RA
Change in total network generalised costs: Existing users		**128**			**217**		A = $(AADT_{DM} \times L_{DM} / RA_{DM}) - (AADT_{DM} \times L_{Opt} / RA_{Opt})$	ie Existing users' generalised/percieved TT cost savings
Existing users using project links		616			889		$AADT_{DM}$	cyclists/day, from Ref Case & Option matrices trips where costs between O-D pairs have reduced due to project
Change in generalised costs/existing user		0.21			0.24			cycle-km/RA/user
New users (mode shifters)			374			458	$AADT_{Opt} - AADT_{DM}$	cyclists/day
Change in total network generalised costs: New users			**39**			**56**	B = $A/AADT_{DM} \times (AADT_{Opt} - AADT_{DM}) / 2$	**ie, rule of half for new users** cycle-km/RA
Total change in network generalised costs			**167**			**272**	**A + B**	**ie, existing users' percieved TT cost savings, plus rule of half for new users** cycle-km/RA
Travel speed			20			20		20km/h typical cycle speed
TT cost			$7.44			$7.44		Weighted average: 60% $7.80 Commuting
Update factor			1.50			1.50		40% $6.90 Other Purposes
days/year			365			365		0% $23.85 Travel For Work
								$7.44 $11.16
								Based on utility cyclist share on Quay St & Tamaki Dr (50%).
User Cost Savings			**$34,086**			**$55,495**		Slightly lower proportion of recreational estimated
(percieved travel time)								



SP11 Walking and cycling facilities continued

Walking Section C and D

Cycling Section A, B, C, D

Worksheet 5 - Benefits for walking and cycling facilities:

1 Health and environmental benefits for walking facility

Pedestrian growth rate (per annum) n/a

Health and environmental benefits for footpaths and other pedestrian facilities

Benefit = number of additional pedestrians/day x length of new facility in km x 365 x $2.70

Update factor 1.21

L 9.0 x NPD 81 x 365 x $2.70 x DF 1.00 = $ 869,825 (a)

2 Health and environmental benefits from improvements at hazardous sites

(provision of overbridges, underpasses, bridge widening or intersection improvements for pedestrians)

Benefit = number of additional pedestrians/day x 365 x $2.70

NPD x 365 x $2.70 x DF 1.00 = $ - (b)

Transfer total (a) or (b) to D on Worksheet 1.

3 Health benefits for cycling facility

Cyclist growth rate (per annum) n/a

Health and environmental benefits for cycle lanes, cycleways or increased road shoulder widths

Benefit = number of additional cycle trips/day x average distance cycled in km x 365 x $1.30

Update factor 1.21

L 1.0 x NTD 2698 x 365 x $1.30 x DF 1.00 = $ 1,549,028 (c)

4 Health and environmental benefits from improvements at hazardous sites

(provision of overbridges, underpasses, bridge widening or intersection improvements for cyclists)

Benefit = number of additional cycles/day x 365 x $4.20

NTD x 365 x $4.20 x DF 1.00 = $ - (d)

Transfer total (c) or (d) to D on Worksheet 1.

5 **Safety benefits for cycle facility**

Safety benefits for cycle lanes, cycleways or increased road shoulder widths in the absence of a specific accident analysis

Benefit = number of new and existing cycle trips/day x length of new facility in km x 365 x $0.05

Update factor 1.21

L 11.3 x NSD 171 x 365 x $0.05 x DF 1.00 = $ 42,687 (e)

6 Safety benefit from improvements at hazardous sites in the absence of a specific accident analysis

(provision of overbridges, underpasses, bridge widening or intersection improvements for cyclists)

Benefit = number of new and existing cycles/day x 365 x $0.15

NSD x 365 x $0.15 x DF 1.00 = $ - (f)

Transfer total (e) or (f) to E on Worksheet 1.

SP11 Walking and cycling facilities continued

Walking Section C and D

Cycling Section A, B, C, D

Worksheet 5 - Benefits for walking and cycling facilities:

1 Health and environmental benefits for walking facility

Pedestrian growth rate (per annum) n/a

Health and environmental benefits for footpaths and other pedestrian facilities

Benefit = number of additional pedestrians/day x length of new facility in km x 365 x $2.70

Update factor 1.21

L 9.0 x NPD 81 x 365 x $2.70 x DF 1.00 = $ 869,825 (a)

2 Health and environmental benefits from improvements at hazardous sites

(provision of overbridges, underpasses, bridge widening or intersection improvements for pedestrians)

Benefit = number of additional pedestrians/day x 365 x $2.70

NPD x 365 x $2.70 x DF 1.00 = $ - (b)

Transfer total (a) or (b) to D on Worksheet 1.

3 Health benefits for cycling facility

Cyclist growth rate (per annum) n/a

Health and environmental benefits for cycle lanes, cycleways or increased road shoulder widths

Benefit = number of additional cycle trips/day x average distance cycled in km x 365 x $1.30

Update factor 1.21

L 1.0 x NTD 3208 x 365 x $1.30 x DF 1.00 = $ 1,842,108 (c)

4 Health and environmental benefits from improvements at hazardous sites

(provision of overbridges, underpasses, bridge widening or intersection improvements for cyclists)

Benefit = number of additional cycles/day x 365 x $4.20

NTD x 365 x $4.20 x DF 1.00 = $ - (d)

Transfer total (c) or (d) to D on Worksheet 1.

5 **Safety benefits for cycle facility**

Safety benefits for cycle lanes, cycleways or increased road shoulder widths in the absence of a specific accident analysis

Benefit = number of new and existing cycle trips/day x length of new facility in km x 365 x $0.05

Update factor 1.21

L 11.3 x NSD 219 x 365 x $0.05 x DF 1.00 = $ 54,857 (e)

6 Safety benefit from improvements at hazardous sites in the absence of a specific accident analysis

(provision of overbridges, underpasses, bridge widening or intersection improvements for cyclists)

Benefit = number of new and existing cycles/day x 365 x $0.15

NSD x 365 x $0.15 x DF 1.00 = $ - (f)

Transfer total (e) or (f) to E on Worksheet 1.

General traffic decongestion - 20Connect			
Modelled Decongestion Values			
Commuter Peak Periods (2 x 2hr)	**2028**	**2038**	**Comments**
New peak period cycle-km	1349	1604	From cycle model
am peak period veh-km removed	386	489	from Diverted Trips spreadsheets
pm peak period veh-km removed	351	394	from Diverted Trips spreadsheets
Peak period veh-km removed	737	883	
effective diversion rate	0.55	0.55	car trips per new cycle trip. Compare with 0.725 default for PT (EEM SP9.1) - ie conservative
per veh-km, per year	TBC	TBC	From 20Connect models/MSM/Composite?
Daily benefit (weekdays)	#VALUE!	#VALUE!	
Annual benefit	**#VALUE!**	**#VALUE!**	245 weekdays per year
	2026	**2036**	
Alternative - EEM SP9 Default			
Peak period veh-km removed	737	883	
per veh-km, per year	$ 1.56	$ 1.56	Default, EEM table SP9.1
update factor	1.21	1.21	Applies to EEM default decongestion value only.
Daily benefit	$ 1,392	$ 1,667	
Annual benefit	**$ 340,929**	**$ 408,459**	245 weekdays per year
Alternative 2 - EEM SP11 Default			
New daily cycle-km	2698	3208	From cycle model
per veh-km, per year	$ 0.10	$ 0.10	Default, EEM SP11, environmental component of $1.40 health & environment benefit rate
update factor	1.21	1.21	Applies to EEM default decongestion value only.
Daily benefit	$ 326	$ 388	
Annual benefit	**$ 119,156**	**$ 141,701**	365 days per year

Worksheet A6 Crash cost savings - 20Connect

Worksheet A6.2 – Crash by crash analysis

	Project option		Option	
	Movement category		Vehicle involvement	
1	Do-minimum mean speed	50	Road category	
2	Posted speed limit	50	Traffic growth rate	

	Do Minimum	Severity: Fatal	Serious	Minor	Non-injury	
3	Number of years of typical crash rate records	5				
4	Number of reported crashes over period	0	0	0	1	
5	Fatal/serious severity ratio (tables A6.2(a) to (c))	0.08	0.92			Using pedestrian category
6	Number of reported crashes adjusted by severity (4) x (5)	0	0	0	1	When three or more fatal crashes occur at a site the crash costs do not need to be redistributed at the site.
7	Crashes per year = (6)/(3)	0.00	0.00	0.00	0.20	
8	Adjustment factor for crash trend (table A6.1(a))	0.86				1% growth assumed
9	Adjusted crashes per year = (7) x (8)	0.00	0.00	0.00	0.17	
10	Under-reporting factors (table A6.3(a) and (b))	1	1.5	4.5	7	Using pedestrian category and applying conservative factors for 50-70 km/h zone
11	Total estimated crashs per year (9) x (10)	0.000	0.000	0.000	1.204	
12	Crash cost, 100 km/h limit (tables A6.4(e) to (h))	4,250,000	435,000	24,000	3,700	Using pedestrian category
13	Crash cost, 50 km/h limit (tables A6.4(a) to (d))	4,100,000	440,000	25,000	1,600	Using pedestrian category
14	Mean speed adjustment =((1) - 50)/50	0				
15	Cost per crash = (13) + (14) x [(12) - (13)]	4,100,000	440,000	25,000	1,600	
16	Crash cost per year = (11) x (15)	-	-	-	1,926	
17	Total cost of crashes per year (sum of columns in row (16) fatal +serious + minor + non-injury) $	2,042				2019 Crash factor of 1.06 has been applied

Annual crash cost saving $ 408 Reduction Factor 20%

Constant benefits, as 1% growth rate balances out adjustment factor of -1% from EEM table A6.1(b)

APPENDIX C cycList demand plots

Figure 3: 2016 Base Model Average Annual Daily Cyclists

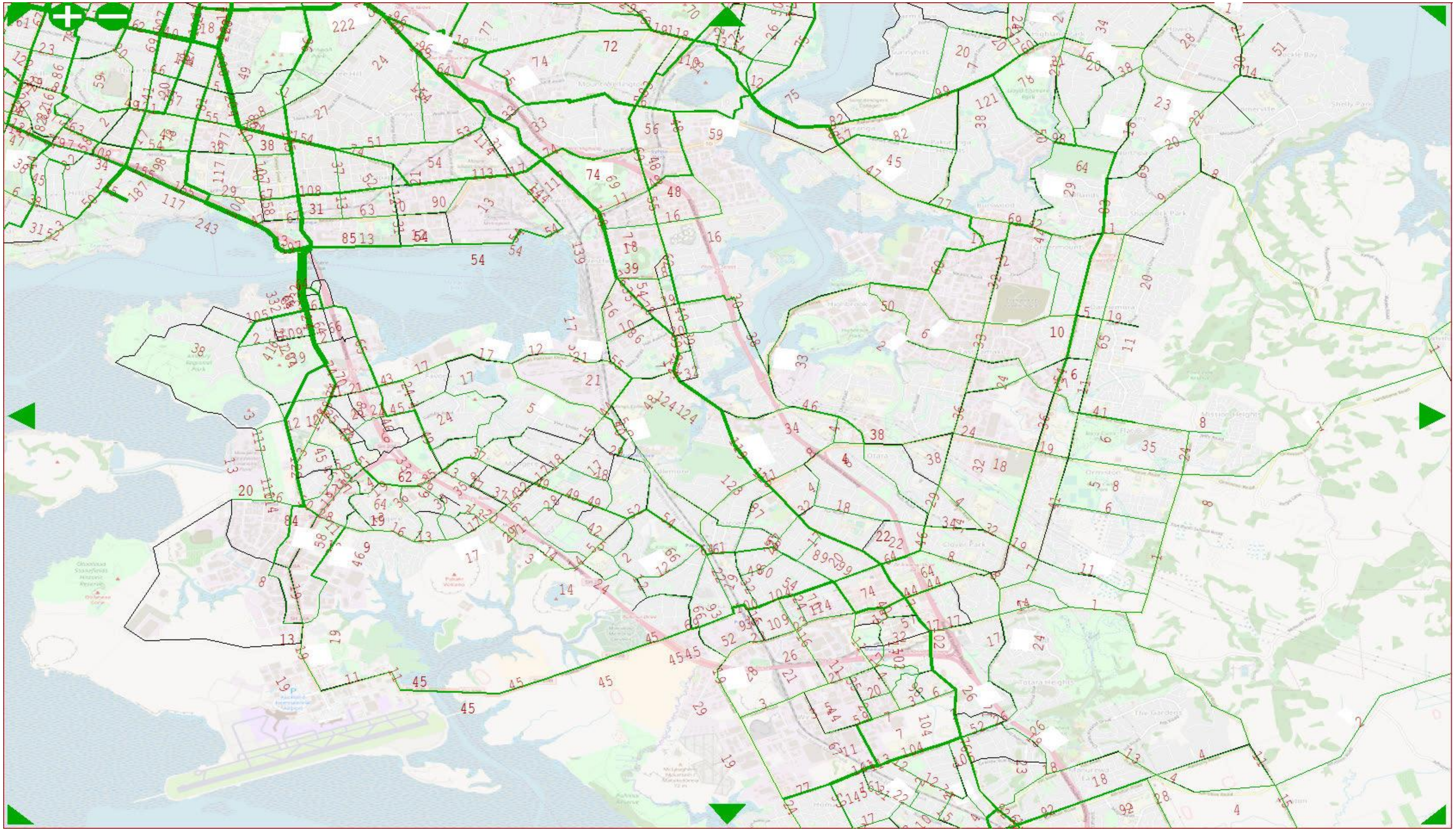


Figure 4: Forecast 2028 Average Annual Daily Cyclists, Reference Case

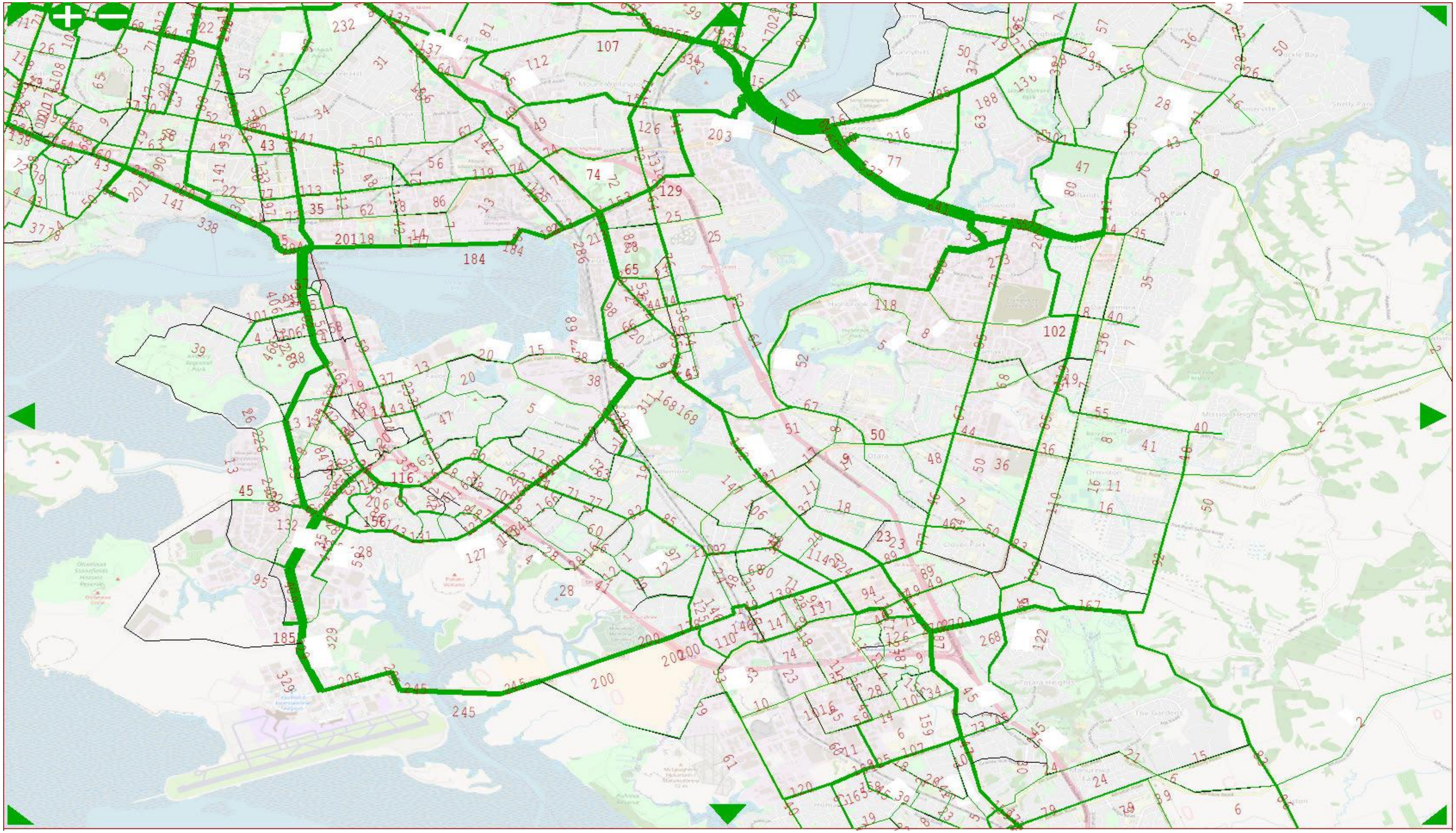


Figure 5: Forecast 2028 Average Annual Daily Cyclists, A2B

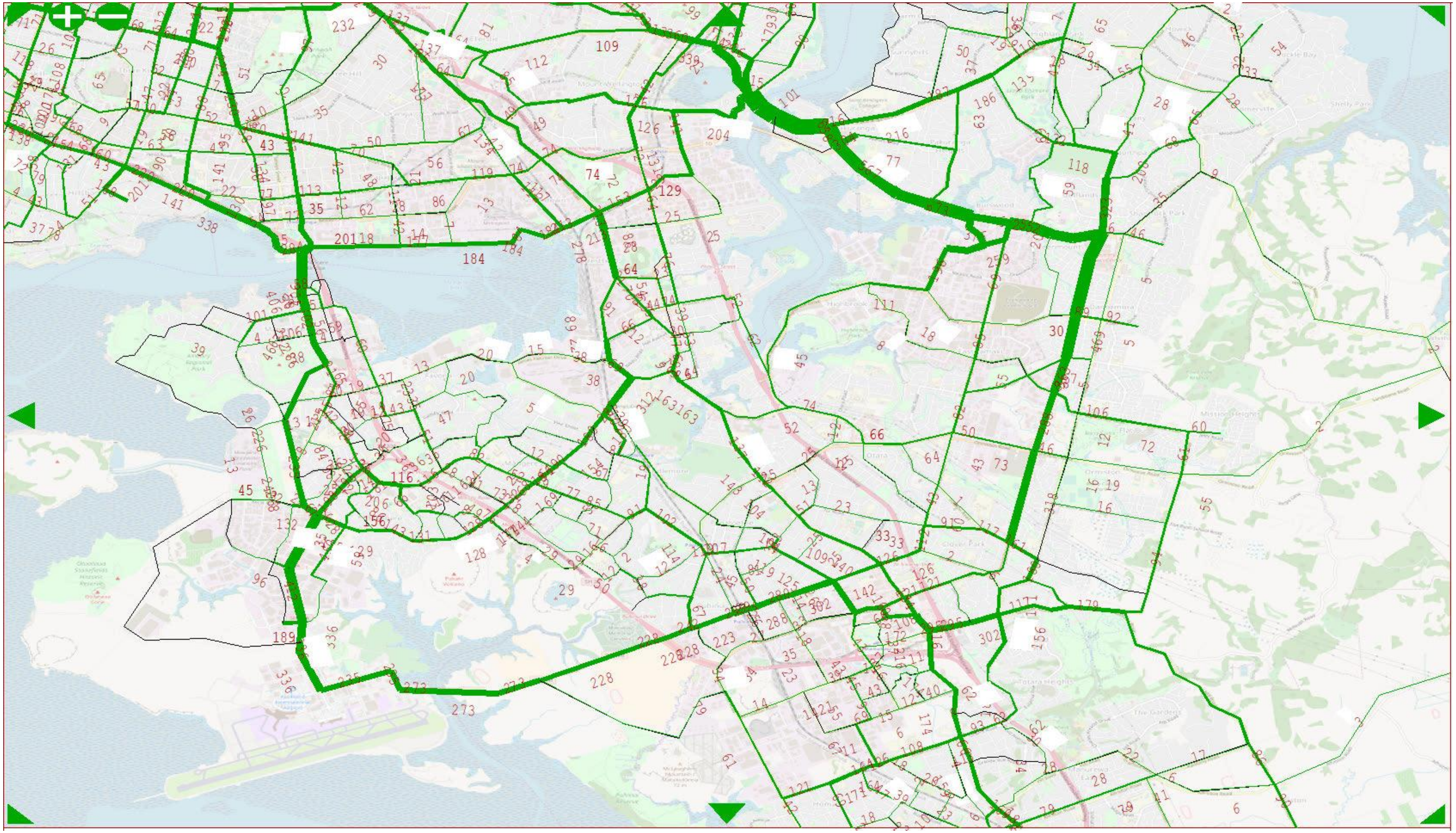


Figure 6: Forecast 2028 Average Annual Daily Cyclists, 20Connect

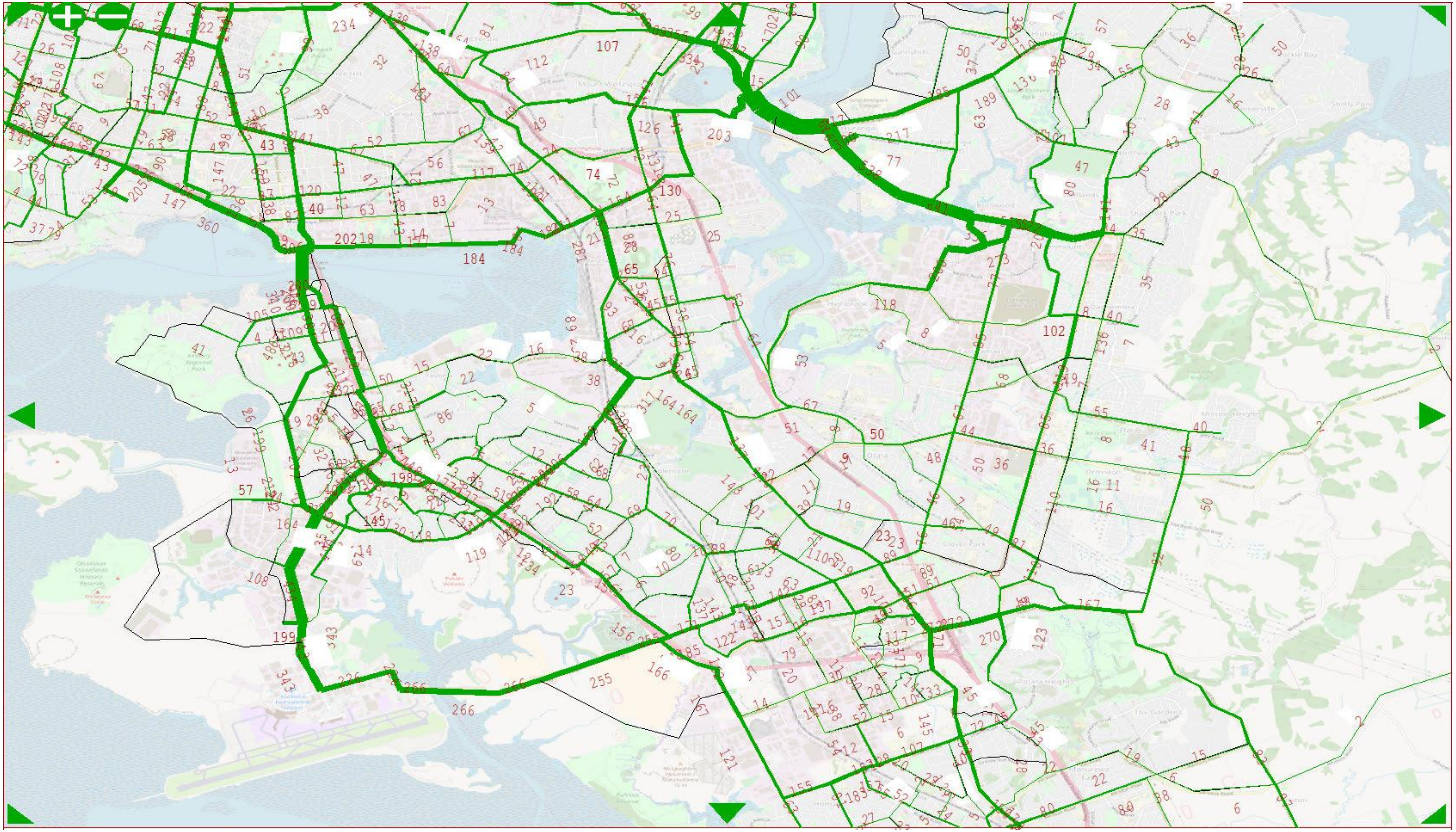
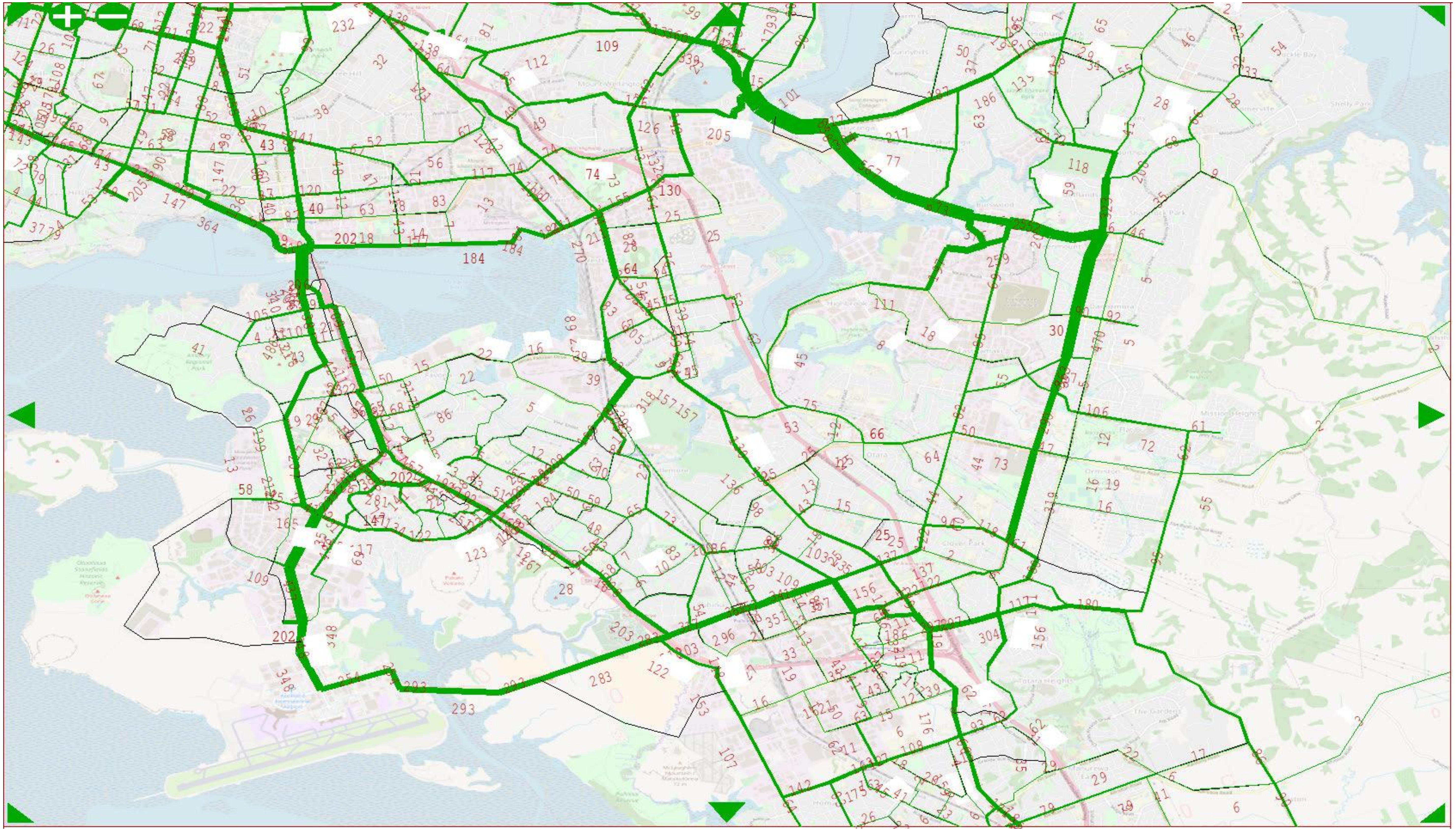


Figure 7: Forecast 2028 Average Annual Daily Cyclists, Southwest Gateway



APPENDIX D cyclist demand difference plots

Figure 8: Forecast 2028 Average Annual Daily Cyclists, Reference Case (relative to 2016 Base)

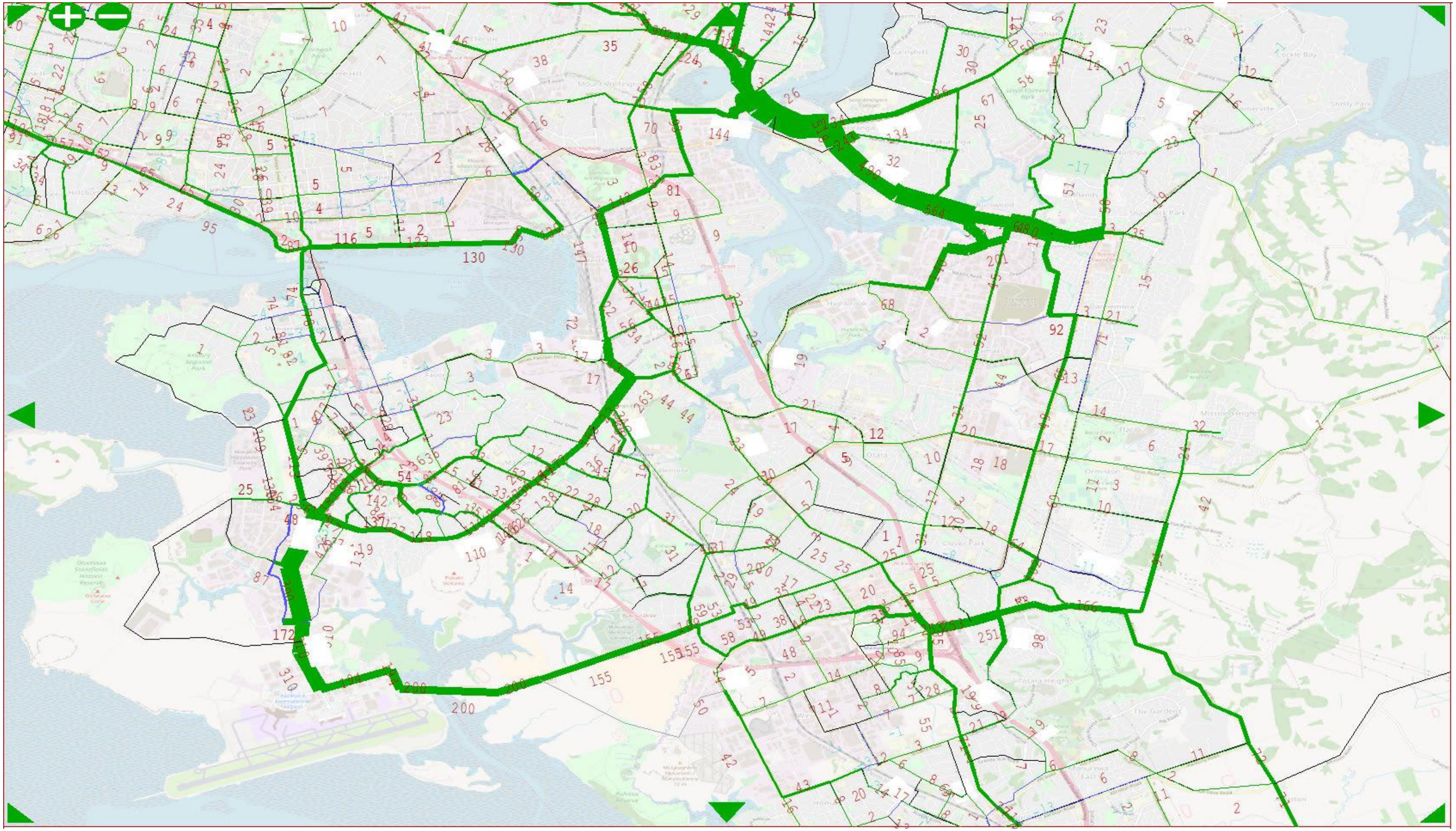


Figure 9: Forecast 2028 Average Annual Daily Cyclists, A2B (relative to 2028 Reference Case)

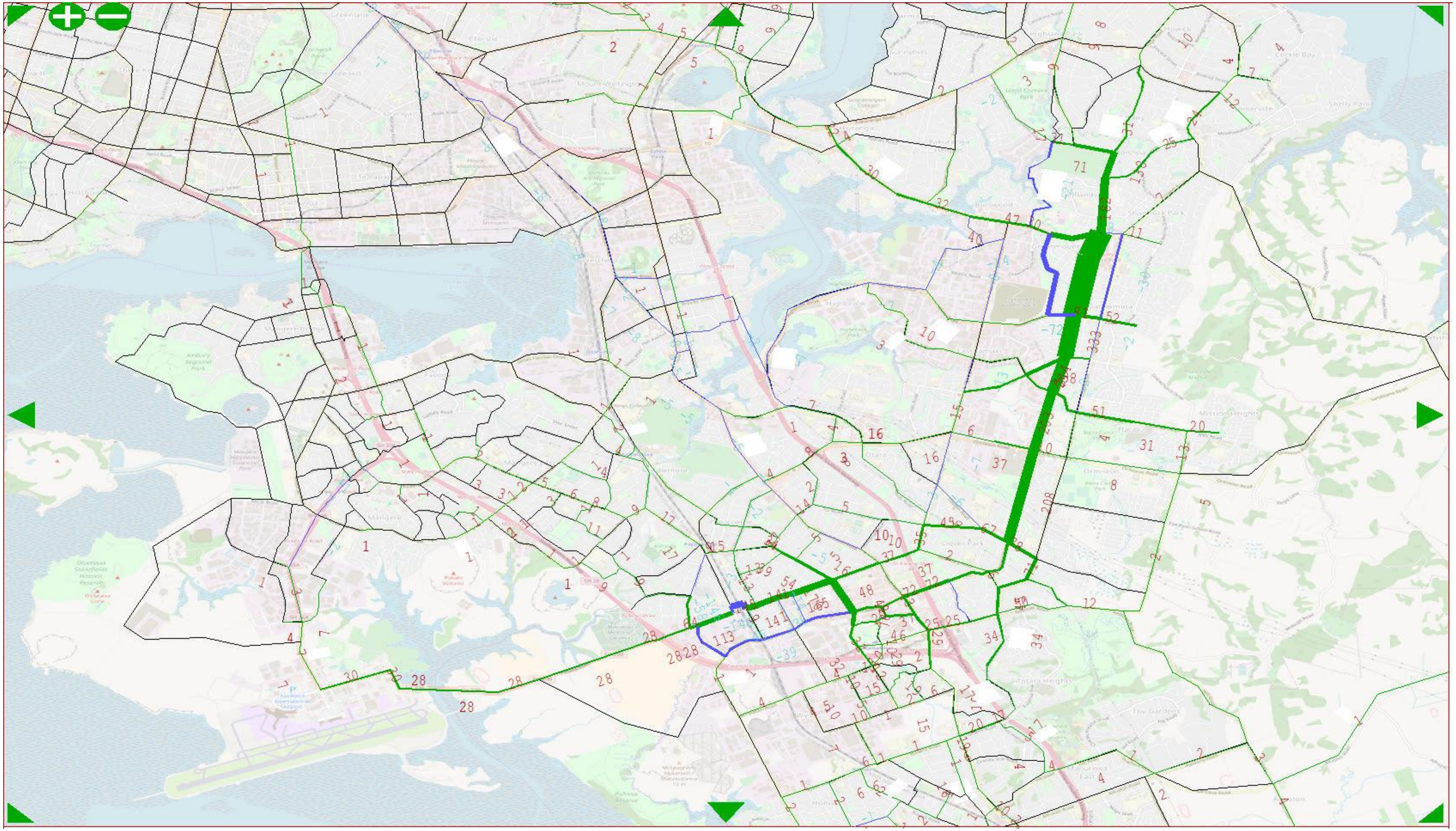


Figure 10: Forecast 2028 Average Annual Daily Cyclists, 20Connect (relative to 2028 Reference Case)

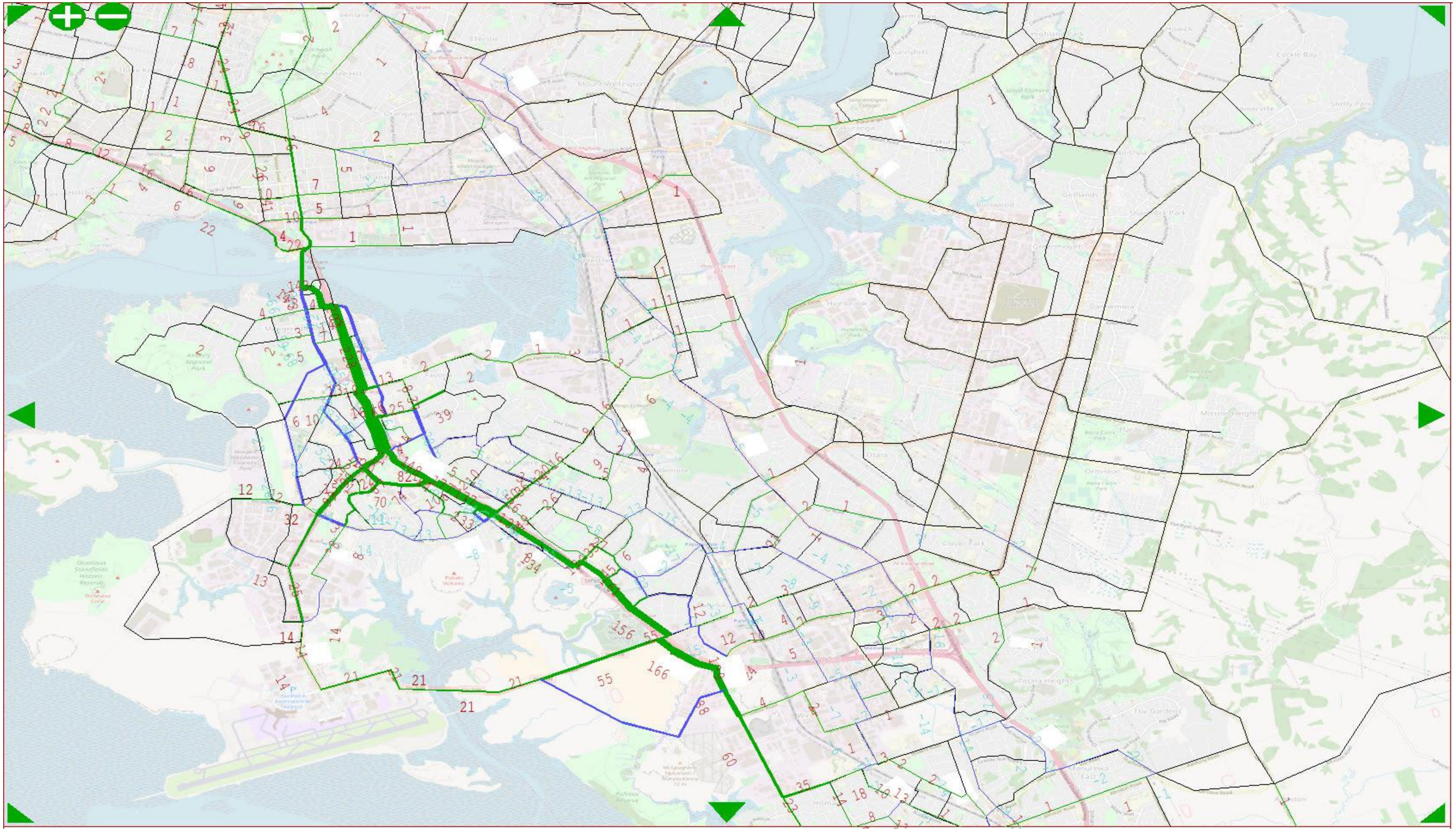
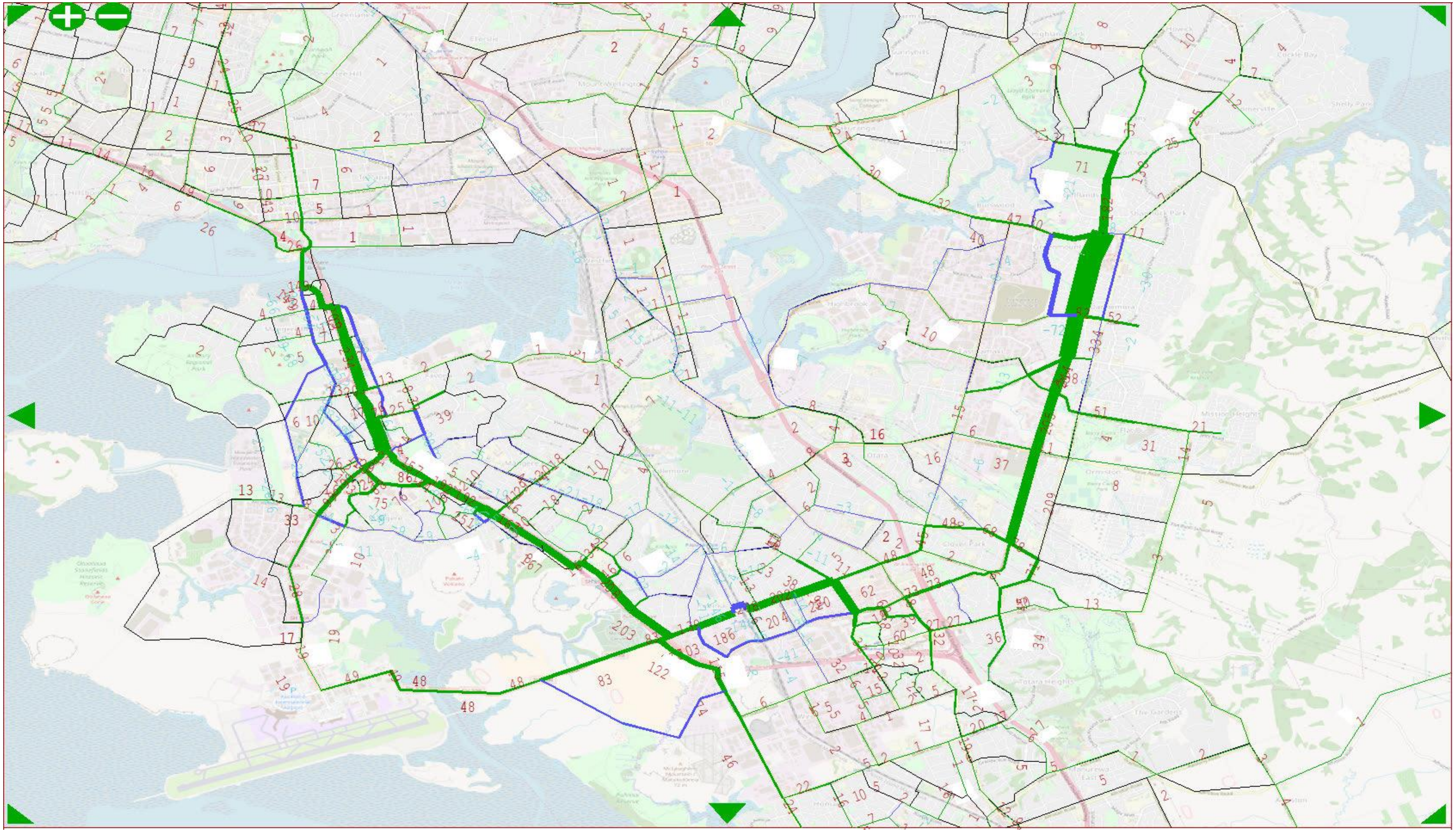


Figure 11: Forecast 2028 Average Annual Daily Cyclists, Southwest Gateway (relative to 2028 Reference Case)



19 Appendix: Economic Evaluation Summary (Flow)

flow TRANSPORTATION SPECIALISTS

technical note

PROJECT	**AIRPORT ACCESS / 20 CONNECT STUDY**
SUBJECT	**ECONOMIC EVALUATION SUMMARY**
TO	**PROJECT TEAM**
FROM	[redacted]
REVIEWED BY	[redacted]
DATE	10 MAY 2020

1 INTRODUCTION

We have prepared this technical note to provide a summary of the economic evaluation carried out to support the Airport to Botany (A2B) Rapid Transit and the 20 Connect projects.

A set of five horizons have been developed to stage the A2B and 20 Connect projects from 2021 to 2040. The majority of the economic benefits, particularly public transport benefits, are being derived by MRCagney from the Macro Strategic Model (MSM), but this technical note sets out the predicted benefits of two components of the overall package which relate to general traffic (including High Occupancy Vehicles).

For this technical note, we have carried out economic assessments for components of the following two horizons:

- Horizon 3 (2030) – The components that are additional to Stage 2b over Stage 2a are T3 traffic lanes between the Airport and west of the SH20B/SH20 interchange, plus a ramp from SH20B to SH20 southbound, and an additional traffic lane on SH20, southeast from that ramp
- Horizon 5 (2040) – The components that are additional to Stage 4 (over 3) are additional traffic lanes along State Highway 20 and a ramp connection from SH20A to SH20 southbound.

Diagrams of the horizons are appended to this technical note.

We have used outputs from SATURN models to inform the evaluation, which includes SH20 (between Mangere Bridge and north of Wiri), SH20A, SH20B and the local road network.

Our evaluation has used the Variable Trip Method for both Horizon 3 and Horizon 5, as this has been requested to form the core scenario by the peer reviewer. Our previous assessments also included Fixed Demand Methods, and these tests have also been completed for Horizon 3.

This evaluation solely includes the predicted traffic related benefits for each horizon. The predicted costs will be provided by Aurecon to MRCagney, who are coordinating the overall economic assessment of the whole project package.

2 SUMMARY OF PREDICTED BENEFITS

2.1 Variable Trip Method

Variable Trip Method needs two separate traffic demand sets to be used, one for the Reference Case and one for the Option scenario. The total discounted benefits for the traffic related components of Horizon 3 and Horizon 5 are predicted to be：

- Horizon 3: Stage 2b compared with Stage 2a: $940 million
- Horizon 5: Stage 4 compared with Stage 3: $730 million

2.2 Fixed Trip Method

We have assessed the traffic components of Horizon 3 with three sets of growth assumptions (which are explained fully in the following text). These tests are predicted to have the following ranges in the total discounted benefit, taking the results for Growth Scenarios 2 and 3:

- Horizon 3: Stage 2b compared with Stage 2a: $1,390 million to $1,640 million

3 MODEL ASSUMPTIONS

3.1 Evaluation Procedure and inputs

We have undertaken the economic evaluation in accordance with the NZ Transport Agency Economic Evaluation Manual (EEM), using a 40-year evaluation period and a 6% discount rate. We have assumed the following evaluation periods for each horizon above:

- Horizon 3: start in July 2027, with a 3-year construction period. Thus a 37-year benefit stream has been calculated, starting from July 2030
- Horizon 5: start in July 2035, with a 5-year construction period. Thus a 35-year benefit stream has been calculated, starting from July 2040

Our evaluation is based on the outputs from SATURN models, which include SH20 (between Mangere Bridge and north of Wiri), SH20A, SH20B and the local road network.

We modelled two forecast years for each horizon, being 2028 and 2048 for Horizon 3, and 2038 and 2048 for Horizon 5.

The growth in road user costs between and beyond each of the modelled years is based on straight line interpolation of costs between the modelled years. We applied a time zero of 1 July 2020 to the analysis.

3.2 Model Descriptions

We have developed several networks in order to carry out the economic evaluation. For each horizon, we have tested two stages. The first stage for each horizon is effectively the ‘Do Minimum’ for the horizon, while the second stage includes the improvements that will be provided in that horizon.

The improvements that are included in each stage were as advised by the Aurecon/MRCagney project team, and are consistent with the model scenarios tested in the MSM.

Our model networks are summarised below

- Horizon 3 (2028 and 2048)
    - Stage 2a – Airport to Botany service with BRT on SH20B (the Do Minimum for this test)
    - Stage 2b – The same as Stage 2a, plus widening on SH20B to provide T3 lanes in both directions between the Airport and west of the SH20B/SH20 interchange. A new ramp from SH20B to SH20 southbound is also assumed to be provided, along with widening on SH20 between the SH20B/SH20 interchange and Manukau. The widening on SH20 would consist of increasing the number of lanes from two to three in the southeast bound direction.
- Horizon 5 (2038 and 2048)
    - Stage 3b – Full Airport to Botany service with Light Rail Transit (LRT) and the full SH20B improvements (the Do Minimum for this test)
    - Stage 4 – The same as Stage 3b, with widening on SH20 and a new connection from SH20A to SH20 southbound. The widening on SH20 would consist of increasing the number of lanes between the SH20B/SH20 interchange and the SH20A/SH20 interchange from two to three in each direction. Between the SH20A/SH20 interchange and Mangere Bridge, the number of lanes in each direction would be increased from three to four.

3.3 Growth Scenarios

Both Horizons 3 and 5 have been tested using a single variable demand scenario, using changes in demands (from the base year) as indicated by the MSM runs. We have also carried out the Horizon 3 analysis using a Fixed Trip Method, with three growth scenarios:

- Scenario 1: this is based on the forecast demands from the MSM model (with the forecast growth between the base year and the two forecast years being added to the SATURN traffic models). The forecasts were provided by the Auckland Forecasting Centre in April 2020 for each stage
- Scenario 2: this is similar to Scenario 1, but with a lower growth rate in the interpeak period after the initial forecast years (the year 2028). This is to "dampen down" the high congestion forecast with the Do Minimum network
- Scenario 3: this is also similar to Scenario 1, but it includes reduced traffic demands in 2048 (with a 20% reduction applied to the demands to/from the airport area), again to "dampen down" the high congestion forecast with the Do Minimum network.

4 BENEFITS AND COSTS

4.1 Annualisation of Benefits

We have assessed road user (traffic only) benefits using the predicted travel times and distances travelled from the SATURN traffic models. These have been calculated for each of the three modelled periods, being morning peak, inter peak and evening peak periods. We have included weekend peak user benefits by applying a factor to the inter peak models. Off-peak (night time) traffic volumes are relatively low, compared to those in the interpeak, so off-peak benefits have not been taken into account at this time. The annualisation factors used to calculate the annual road user costs are as follows:

- Morning Peak – 245 days with 2 hours per day
- Inter Peak – 245 days with 9 hours per day
- Evening peak – 245 days with 2 hours per day
- Weekday Off Peak – not taken into account
- Weekend Peak – 120 days with 10 hours per day (based on 109% of the inter-peak hour model outputs)
- Weekend Off Peak – not taken into account

We used traffic counts along SH20 and SH20A, obtained from the NZ Transport Agency's Traffic Monitoring System (TMS), to calculate the above annualisation factors.

4.2 Project Benefits

4.2.1 Travel Time, Congestion Relief and Trip Reliability Savings

We used the network summary statistics produced by the traffic models to calculate the travel time benefits for traffic, for each option, and took the values of time from Section A4.3 of the EEM, for an Urban Arterial assessment. These are:

- $23.30 for morning peak period travel ($15.13 x 1.54 travel time update factor)
- $27.64 for inter-peak period travel ($17.95 x 1.54 travel time update factor)
- $23.04 for evening peak period travel ($14.96 x 1.54 travel time update factor)
- $21.70 for weekend travel ($14.09 x 1.54 travel time update factor).

Total travel time savings are made up of three components: base travel time savings, Congestion Relief (CRV) and trip reliability savings.

Congestion Relief benefits are based on the SATURN outputs for turn delays and delays on links.

We have assumed trip reliability benefits will contribute an additional 5% of the total travel time savings. This is a common assumption for projects of this nature.

4.2.2 Vehicle Operating Costs and Vehicle Emission Costs

We calculated vehicle operating cost savings based on the total distances travelled which are multiplied by an operating cost (based on urban arterial running costs) which are derived from the average speeds travelled by vehicles in the networks.

We assumed vehicle emission costs are based on 4% of the calculated vehicle operating costs, as specified in the EEM.

4.2.3 Crash Costs

We have not calculated crash benefits for the projects. At this stage, we have assumed that crash benefits equate with 5% of the total travel time costs. This is a common assumption for the preliminary evaluation of projects of this nature.

4.3 Project Benefits Summary

The following tables show the model outputs assessed using both the Fixed Trip Method and the Variable Trip Method.

4.3.1 Variable Trip Method – Horizon 3 and Horizon 5

We have calculated the project traffic benefits using a Variable Trip Method. The predicted discounted benefits are summarised in Table 1.

Table 1: Predicted Discounted Benefits Summary

	Discounted Benefits
Horizon 3	$940 million
Horizon 5	$730 million

Table 2 provides the predicted discounted benefits for the various components listed in Section 4.2.

Table 2: Predicted Discounted Benefits

	Horizon 3	**Horizon 5**
Travel Time Benefits	$695 million	$515 million
Vehicle Operating Cost Benefits	$70 million	$90 million
Crash savings	$40 million	$30 million
Vehicle emission Benefits	$5 million	$5 million
Driver frustration	$95 million	$65 million
Trip Reliability	$40 million	$30 million
Total Net Benefits	**$940 million**	**$730 million**

4.3.2 Fixed Trip Method – Horizon 3

The predicted benefits for the traffic components of Horizon 3, with the three growth scenarios, are set out in Table 3.

Table 3: Predicted Discounted Benefits Summary

	Discounted Benefits
Growth Scenario 1	$1,960 million
Growth Scenario 2	$1,390 million
Growth Scenario 3	$1,640 million

The following tables provide the predicted discounted benefits for the various components listed in the last section, for each test.

Table 4: Predicted Discounted Benefits – Growth Scenario 1

	Benefits
Travel Time Benefits	$1,230 million
Vehicle Operating Cost Benefits	$270 million
Crash savings	$80 million
Vehicle emission Benefits	$10 million
Driver frustration	$290 million
Trip Reliability	$80 million
Total Net Benefits	**$1,960 million**

Table 5: Predicted Discounted Benefits – Growth Scenario 2

	Benefits
Travel Time Benefits	$810 million
Vehicle Operating Cost Benefits	$170 million
Crash savings	$60 million
Vehicle emission Benefits	$10 million
Driver frustration	$290 million
Trip Reliability	$50 million
Total Net Benefits	**$1,390 million**

Table 6: Predicted Discounted Benefits – Growth Scenario 3

	Benefits
Travel Time Benefits	$1,050 million
Vehicle Operating Cost Benefits	$200 million
Crash savings	$70 million
Vehicle emission Benefits	$10 million
Driver frustration	$250 million
Trip Reliability	$60 million
Total Net Benefits	**$1,640 million**

We note that:

- The peer reviewer has requested that greater weight should be given to the variable demand method. This is predicted to lead to lower benefits, as is normally the case
- The traffic related benefits of Horizon 3 are predicted to be high with Growth Scenario 1 (with fixed demands). This reflects the fact that significant congestion is predicted with the Do Minimum network by the year 2048
- As a result, we suggest that greater weight should be given to Growth Scenarios 2 and 3 (of the fixed demand scenarios), as these reduce the effects of the "overheated" Do Minimum scenario in 2048. On this basis, the expected discounted benefits for the traffic related components of Horizon 3 would be in the range between $1,390 million and $1,640 million (with fixed demands).

Reference: P:\aure\007 20 Connect Study (local road improvements and economic analysis)\4.0 Reporting\TN12A200510.docx – Harry Shepherd

flow
TRANSPORTATION SPECIALISTS

technical note

PROJECT	**AIRPORT ACCESS / 20 CONNECT STUDY**
SUBJECT	**ADDENDUM TO ECONOMIC EVALUATION FOR STAGE 2B**
TO	**PROJECT TEAM**
FROM	[redacted]
REVIEWED BY	[redacted]
DATE	22 JUNE 2020

1 INTRODUCTION

We have prepared this technical note as an addendum to the economic evaluation carried out to support the Airport to Botany (A2B) Rapid Transit and the 20 Connect projects, as set out in Flow's Technical Note 12, dated 10 May 2020. The addendum relates solely to the evaluation of Stage 2B (compared with Stage 2A) due to a convergence issue uncovered from the outputs from the MSM.

As before, the majority of the economic benefits, particularly public transport benefits, are being derived by MRCagney from the Macro Strategic Model (MSM). This technical note updates the predicted traffic related benefits of Stage 2B, using the Variable Trip Method.

2 SUMMARY OF PREDICTED BENEFITS

We have updated results using the Variable Trip Method to undertake this assessment. The previous and updated total discounted benefits for the traffic related components (rounded to the nearest $5m) are predicted to be:

- Previous assessment (set out in Technical Note 12): $940 million
- Updated assessment: $945 million.

The above figures indicate that the updated assessment increases benefits by $5 million. In fact this is inflated by the rounding of the results. The unrounded increase is only around $2 million, from $941.6 million to $943.6 million, indicating that the results for the variable demand scenario have not been materially affected by the updated demands from the MSM. This then indicates that the previous results for the fixed test scenarios can also be assumed to remain valid.

3 MODEL ASSUMPTIONS

3.1 Evaluation Procedure and inputs

The assessment methodology is the same as that set out in Technical Note 12, namely:

- The economic evaluation has been carried out in accordance with the NZ Transport Agency Economic Evaluation Manual (EEM), using a 40-year evaluation period and a 6% discount rate

- We have assumed that Stage 2B starts construction in July 2027, with a 3-year construction period. Thus a 37-year benefit stream has been calculated, starting from July 2030
- The evaluation is based on the outputs from SATURN models, which include SH20 (between Mangere Bridge and north of Wiri), SH20A, SH20B and the local road network
- We have modelled two forecast years, being 2028 and 2048
- The growth in road user costs between and beyond each of the modelled years is based on straight line interpolation of costs between the modelled years. We applied a time zero of 1 July 2020 to the analysis.

3.2 Model Descriptions

The model networks are as follows:

- Stage 2a – Airport to Botany service with BRT along SH20B (the Do Minimum for this test)
- Stage 2b – The same as Stage 2a, plus widening along SH20B to provide T3 lanes in both directions between the Airport and west of the SH20B/SH20 interchange. A new ramp from SH20B to SH20 southbound is also assumed to be provided, along with widening on SH20 between the SH20B/SH20 interchange and Manukau. The widening on SH20 would consist of increasing the number of lanes from two to three in the southeastbound direction.

4 BENEFITS AND COSTS

4.1 Annualisation of Benefits

Details of the annualisation factors are provided within Technical Note 12.

4.2 Project Benefits

Details of the derivation of travel time, congestion relief, trip reliability, vehicle operating cost, emission and crash benefits are set out within Technical Note 12.

4.3 Project Benefits Summary

The following tables show the model outputs assessed using the Variable Trip Method. The predicted discounted benefits are summarised in Table 1.

Table 1: Predicted Discounted Benefits Summary for Stage 3B

	Discounted Benefits
Previous Assessment (Technical Note 12)	$940 million
Updated Assessment	$945 million

The table indicates that the updated assessment increases benefits by $5m. In fact this is inflated by the rounding in the table. The unrounded increase is only around $2m, from $941.6m to $943.6m

Table 2 provides the predicted discounted benefits for the various components listed in Section 4.2.

Table 2: Predicted Discounted Benefits for Stage 2B

	Previous Assessment	**Updated Assessment**
Travel Time Benefits	$695 million	$700 million
Vehicle Operating Cost Benefits	$70 million	$70 million
Crash savings	$40 million	$40 million
Vehicle emission Benefits	$5 million	$5 million
Driver frustration	$95 million	$95 million
Trip Reliability	$40 million	$40 million
Total Net Benefits	**$940 million**	**$945 million**

Reference: P:\aure\007 20 Connect Study (local road improvements and economic analysis)\4.0 Reporting\TN13A200622.docx – iclark

20 Appendix: EEM Worksheets

Worksheet 1 - Evaluation Summary and TIO Upload

Upload V1.0 (1Oct13)

This spreadsheet can be automatically uploaded into Transport Investment Online. To enable automatic upload please do not adjust the columns or rows.

						Please make any additional comments or clarifying notes as necessary to aid understanding (note that these fall outside of the set print and TIO upload range)
Activity name		Southwest Gateway Programme, 'Horizon 4', (Full Airport to				An additional worksheet has been provided for 'Horizon 5', which includes the final elements on SH20 and SH20A for 20Connect.
Reference						
Evaluator(s)	- name, organisation	[redacted] (MRCagney (NZ) Ltd)				
Reviewer(s)	- name, organisation	[redacted] (Richard Paling Consulting Ltd)				
Date of evaluation	mm/yyyy	10-2020				
Time zero / implementation start date	1 July yyyy	2021				
Construction duration	Months	144				Staged programme, construction durations are: Horizon 2: 1 year; Horizon 3: 3-5 years; Horizon 4: 6 years, each starting at different points in time
Base date of costs and benefits	1 July yyyy	2019				
Location		State Highway 20B, SH20 (between SH20B and SH1), Puhinui Road, Lambie Drive, Manukau Station				
Problem definition						
Do minimum description		Interventions as per the Short Term Airport Access Improvements SSBC (under construction)				
Alternatives considered (or page references to relevant)						
Options considered (or page references to relevant)		Various state highway and rapid transit improvements from each programme				
Preferred option description		Medium term Airport to Botany service, Long term full BRT system, SH20B widening, SH20B to SH20				
Statistics		**Base rate**	**Growth rate (%)**	**New users/transfer**		
Road traffic - Annual Average Daily Traffic (AADT)	AADT	0	0.00			
Pedestrians - Annual Average Daily	Count	0	0.00	0		
Cyclists - Annual Average Daily	Count	0	0.00	0		
Annual Patronage - Total	Count	0	0.00	0		
Annual Patronage - Peak Period	Count	0	0.00			
Freight volume	tonnes	0	0.00	0		
Heavy Vehicles Volume	AADT	0	0.00			
Heavy Vehicles Volume	%	0.00				
Road Category						
		Before	**After**			
Roughness	IRI/NAASRA	0	0			
Posted speed	km/h	0	0			
Average traffic speed	km/h	0	0			
Length of road / route	km	0.00	0.00			
Road width	metres	0.00	0.00			
Travel time on route	minutes	0	0			
		Period start am	**Period stop am**	**Period start pm**	**Period stop pm**	
Peak Period		0000	0000	0000	0000	
Peak Period Traffic flow	Vehicles/hr	0				
Period of crash analysis	yyyy - yyyy	2000	2000			
		Fatal	**Serious**	**Minor**	**Non Injury**	
Recorded crashes in period (row 4 crash analysis)		0.0	0.0	0.0	0.0	
Total estimated crashes per year - do minimum (row 11)		0.0	0.0	0.0	0.0	
Predicted crashes per year - preferred option (row 20)		0.0	0.0	0.0	0.0	
Heavy Vehicle Trips Saved (average per year)	count	0				
Vehicle Operating Cost Savings (per annum)	$/vehicle	0				
[redacted]						
Travel time cost savings	$	2,463,357,946				Travel time benefits for road users, public transport users, walking and cycling, and reliability benefits for road users and public transport users
Vehicle operating cost savings	$	169,715,533				
Crash cost savings	$	105,051,212				Crash cost savings from 20Connect, and from walking and cycling safety benefits
Seal extension benefits	$	0				
Driver frustration reduction benefits	$	$226,036,056				
Risk reduction benefits	$	0				
Vehicle emission reduction benefits	$	30,656,014				
Other external benefits (noise, visual, impact etc)	$	0				
Mode change benefits	$	120,055,730				Health benefits from added walking to public transport, health and environmental benefits from walking and cycling
Walking and cycling health benefits	$	0				
Service or facility user benefits	$	0				
Parking user cost savings	$	0				
Dis-benefits during implementation/construction	$	0				
Road Traffic reduction benefits	$	7,100,552				Decongestion benefits from mode shift to walking/cycling
National strategic benefits	$	0				
Agglomeration benefits (WEB)	$	525,550,034				
Increased Labour Supply (WEB)	$	53,239,109				
Imperfect Competition (WEB)	$	13,474,688				
Total Benefits Present Value	$	3,714,236,872				
Non monetised benefits or national strategic factors		List non monetised benefits or national strategic benefits which should be considered				
Benefit Cost Ratio (BCRn) National		2.46				
Benefit Cost Ratio (BCRg) Government		2.46				
First Year Rate of Return (FYRR)		0.00				
Sensitivity Analysis - BCR range		1.30	3.00			

Worksheet 1 - Evaluation Summary and TIO Upload Upload V1.0 (1Oct13)

This spreadsheet can be automatically uploaded into Transport Investment Online. To enable automatic upload please do not adjust the columns or rows.

Please make any additional comments or clarifying notes as necessary to aid understanding (note that these fall outside of the set print and TIO upload range)

Activity name		SWGP, 'Horizon 5', (Ultimate Airport to Botany rapid transit				
Reference						
Evaluator(s) - name, organisation		[redacted] (MRCagney (NZ) Ltd)				
Reviewer(s) - name, organisation		[redacted] Richard Paling Consulting Ltd)				
Date of evaluation	mm/yyyy	09-2020				
Time zero / implementation start date	1 July yyyy	2021				
Construction duration	Months	144				Staged programme, construction durations are: Horizon 2: 1 year; Horizon 3: 3-5 years; Horizon 4: 6 years, each starting at different points in time
Base date of costs and benefits	1 July yyyy	2019				
Location		State Highway 20B, SH20 (between SH20B and SH1), Puhinui Road, Lambie Drive, Manukau Station				
Problem definition						
Do minimum description		Interventions as per the Short Term Airport Access Improvements SSBC (under construction)				
Alternatives considered (or page references to relevant)						
Options considered (or page references to relevant)		Various state highway and rapid transit improvements from each programme				
Preferred option description		Medium term Airport to Botany service, Long term full BRT system, SH20B widening, SH20B to SH20				

Statistics		**Base rate**	**Growth rate (%)**	**New users/transfer**
Road traffic - Annual Average Daily Traffic (AADT)	AADT	0	0.00	
Pedestrians - Annual Average Daily	Count	0	0.00	0
Cyclists - Annual Average Daily	Count	0	0.00	0
Annual Patronage - Total	Count	0	0.00	0
Annual Patronage - Peak Period	Count	0	0.00	
Freight volume	tonnes	0	0.00	0
Heavy Vehicles Volume	AADT	0	0.00	
Heavy Vehicles Volume	%	0.00		
Road Category				

		Before	**After**
Roughness	IRI/NAASRA	0	0
Posted speed	km/h	0	0
Average traffic speed	km/h	0	0
Length of road / route	km	0.00	0.00
Road width	metres	0.00	0.00
Travel time on route	minutes	0	0

		Period start am	**Period stop am**	**Period start pm**	**Period stop pm**
Peak Period		0000	0000	0000	0000
Peak Period Traffic flow	Vehicles/hr	0			
Period of crash analysis	yyyy - yyyy	2000	2000		

		Fatal	**Serious**	**Minor**	**Non Injury**
Recorded crashes in period (row 4 crash analysis)		0.0	0.0	0.0	0.0
Total estimated crashes per year - do minimum (row 11)		0.0	0.0	0.0	0.0
Predicted crashes per year - preferred option (row 20)		0.0	0.0	0.0	0.0

Heavy Vehicle Trips Saved (average per year)	count	0	
Vehicle Operating Cost Savings (per annum)	$/vehicle	0	

[redacted]

Benefits (Present Value)			
Travel time cost savings	$	3,676,423,689	Travel time benefits for road users, public transport users, walking and cycling, and reliability benefits for road users and public transport users
Vehicle operating cost savings	$	378,288,007	
Crash cost savings	$	173,909,286	Crash cost savings from 20Connect, and from walking and cycling safety benefits
Seal extension benefits	$	0	
Driver frustration reduction benefits	$	381,783,227	
Risk reduction benefits	$		
Vehicle emission reduction benefits	$	38,998,002	
Other external benefits (noise, visual, impact etc)	$	0	
Mode change benefits	$	152,040,446	Health benefits from added walking to public transport, health and environmental benefits from walking and cycling
Walking and cycling health benefits	$	0	
Service or facility user benefits	$	0	
Parking user cost savings	$	0	
Dis-benefits during implementation/construction	$	0	
Road Traffic reduction benefits	$	12,246,820	Decongestion benefits from mode shift to walking/cycling
National strategic benefits	$	0	
Agglomeration benefits (WEB)	$	771,943,809	
Increased Labour Supply (WEB)	$	63,293,282	
Imperfect Competition (WEB)	$	24,138,176	
Total Benefits Present Value	$	5,673,064,744	

Non monetised benefits or national strategic factors	List non monetised benefits or national strategic benefits which should be considered	
Benefit Cost Ratio (BCRn) National	2.97	
Benefit Cost Ratio (BCRg) Government	2.97	
First Year Rate of Return (FYRR)	0.00	
Sensitivity Analysis - BCR range	1.50	3.70

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