From: s 9(2)(a) [redacted]
To:
Cc:
Subject: AHB cycle options traffic analysis - updated working draft
Date: Sunday, 20 June 2021 6:26:00 PM
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AHB_cycle_traffic_analysis_v0.2.docx

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s 9(2)(a) [redacted]

Updated draft attached (still a work in progress – many of the graphics still in development plus some modifications and re-testing required)

We will continue working on over the next few days.

s 9(2)(a) [redacted] – please have a read so we can discuss Monday afternoon.
I've worked in some of your comments around PT demand in the section on Traffic Demands

Thanks,

s 9(2)(a) [redacted]

Auckland System Management
M
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s 9(2)(a) [redacted]

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Contents

AHB traffic demand and capacity

Current Operation

Prior to COVID-19 the AHB carried daily traffic volumes of between 180,000 and 190,000 on typical weekdays and between 140,000 and 160,000 at weekends. Current demand has returned to around 98% of pre-COVID levels. Vehicle trips across the bridge are more or less evenly split between those to / from the CBD and those to / from SH16 to the west and SH1 to the south.

Lane configurations and lane capacity by configuration. MLB timing and capacity impacts of move operation. SMB and Fanshawe.

Figure 1 to Figure 3 illustrate typical profiles of flows arriving at the bridge and the lane capacity available on the bridge over the day, by direction for both weekdays and weekends. At weekends when the bridge remains in a 4-northbound / 4-southbound configuration from Friday evening to Monday morning, the bridge itself forms the capacity constraint on the SH1 corridor. Demands peak around 6,000 vehicles per hour and are roughly sustained between about 11am and 4pm – meaning there is around half a lane of spare capacity in each direction during this time.

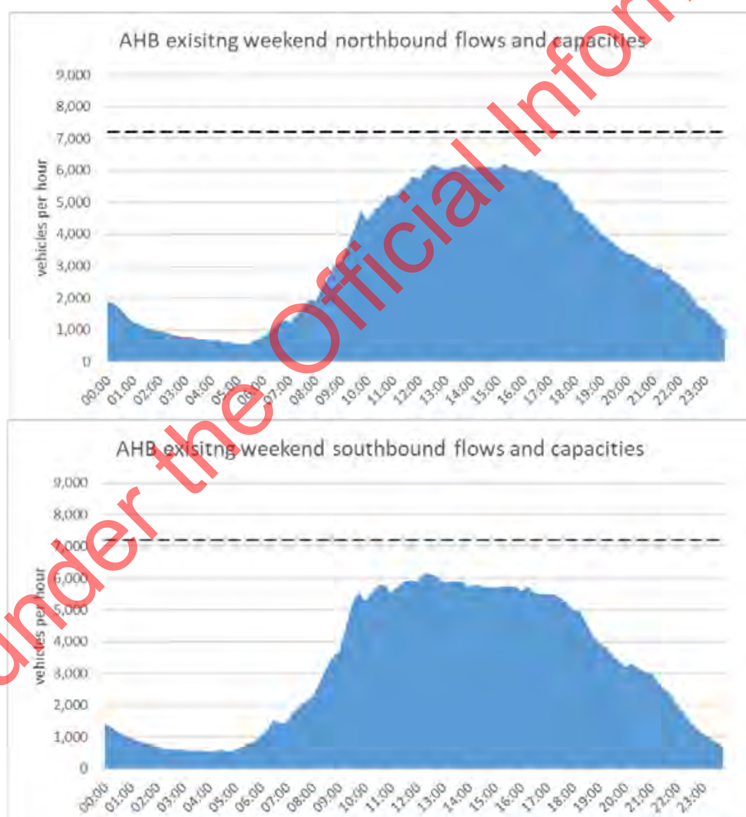


Figure 1 – Summary of typical weekend day northbound (top) and southbound (bottom)

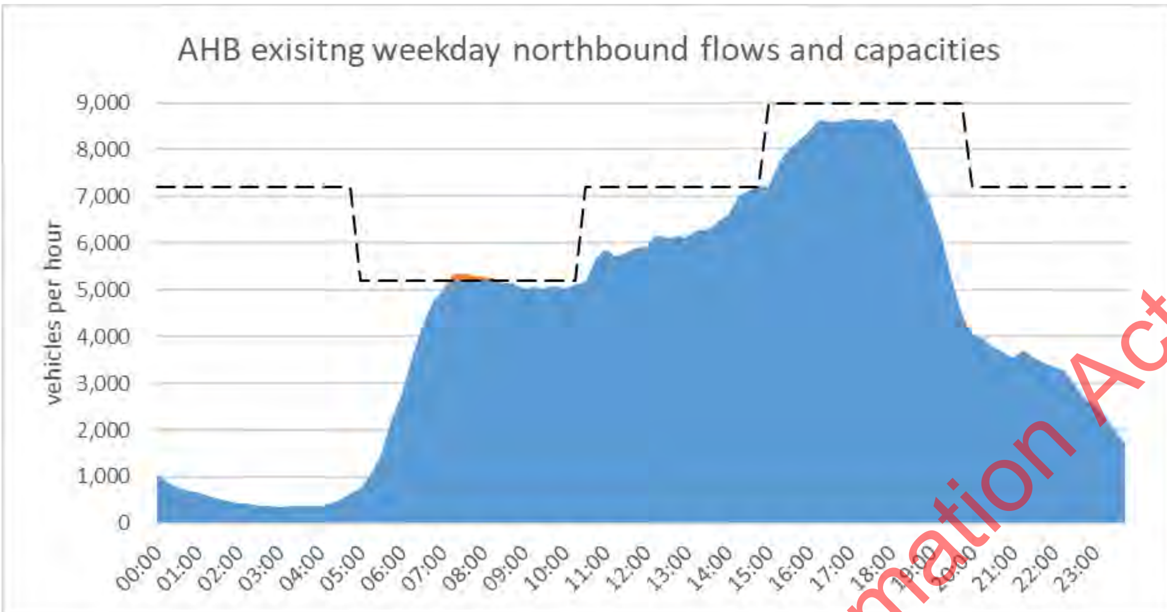
On weekdays these flows reach the capacity of the bridge during the peaks, in the counter-peak direction (3 lanes), indicated by the red lines on the graphs in Figure 2 and Figure 3. In the peak direction at these times (5 lanes) there are upstream capacity constraints where congestion forms - providing a measure of protection against bottlenecks forming at the foot of the bridge itself. As a consequence, the flows shown in the graphs do not fully reflect demand at these times, but rather the rate at which traffic can reach the bridge itself (referred to as "arrival flows"). Figure 2 and Figure 3 include lane diagrams of the approaches to the bridge in the peak (5 lane) configurations illustrating the observed flow relative to capacity at these approach constraint locations. Volume-to-Capacity (V/C) ratios in excess of 0.95 are essentially at capacity since capacity in practice is not a fixed value and flows over this level cannot be sustained for long before flow breaks down and congestion starts to form[1].

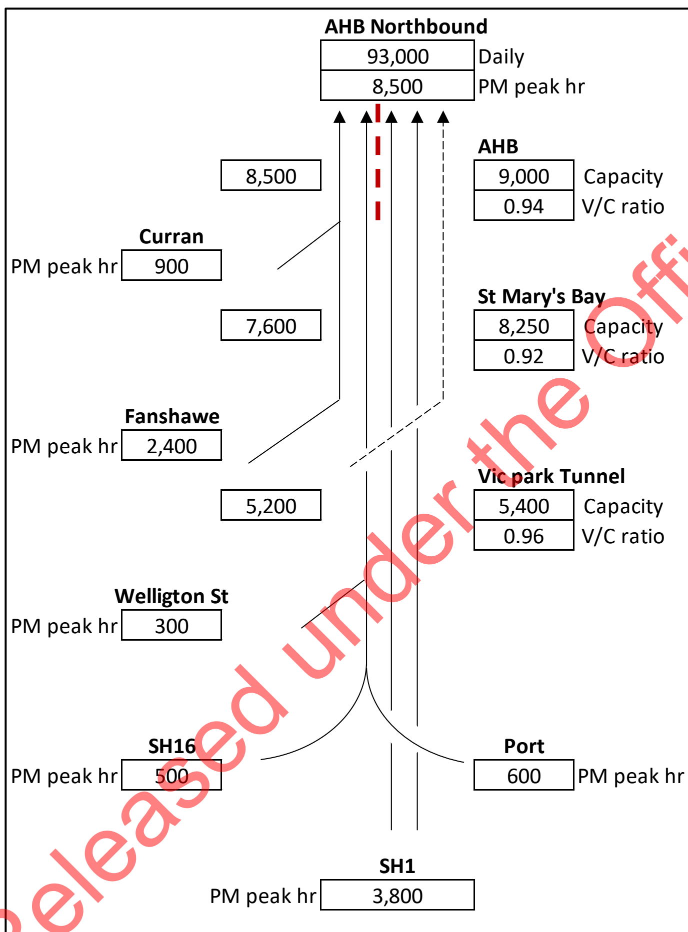
In the southbound direction the 5-lane bridge configuration in the AM peak is fed by four lanes upstream – three from downstream of Esmonde Road, plus a lane gain at Onewa Road on ramp. The Esmonde on-ramp merge is one of the primary critical bottlenecks on the motorway network, and along with the 5-lane AM peak configuration on the bridge performs an important strategic function: it ensures no delays to AM peak PT services on the Rapid Transit Network that use general traffic lanes from Onewa Rd to Fanshawe Street. The 4-lane capacity at the Onewa lane gain (immediately prior to the addition of the AM fifth lane on the right hand side) exceeds the 4-lane capacity of the bridge itself, due to the bridge approach gradient and high lane changing associated with traffic joining at Onewa Road. As a consequence, the AM peak arrival flows at the bridge exceed the capacity of a 4-lane bridge configuration.

In the northbound direction the 5-lane capacity of the bridge exceeds the 5-lane capacity of St Mary's Bay due to the significant curvature and lane changing of the St Mary's Bay section, and the gradient exiting Victoria Park Tunnel. However, traffic entering from Curran Street merges into the segregated 2-lane section leading up to the western clip-on of the bridge. The additional input of demand from this on-ramp routinely leads to the 2-lane section reaching capacity during the PM peak - causing localised flow breakdown and congestion while the 3 lanes on the main truss have some capacity remaining. This localised flow breakdown creates minor delays to peak PT services on the Rapid Transit Network that use general traffic lanes on approach to the bridge. Note that since the start of NCI construction, capacity constraints associated with the long-term traffic management at this work zone cause extensive queuing on the northern motorway northbound in the PM peak. This often extends back to the bridge – limiting the peak flows it achieves and causing more extensive congestion through St Mary's Bay. This is expected to reduce once NCI construction completes.

Figure 2 and Figure 3 also illustrate the how many vehicles using the bridge use city exits (southbound) and how many enter from the city (northbound), compared to how many vehicles come from or continue onto the southern and northwestern motorways. Vehicle flows are more or less evenly split both in the peak and over the whole day between those to/from the city and those to/from other parts of the region.

[1] *Volume-to-capacity ratios more than 1.0 cannot occur in practice. In this situation observed volume is the actual capacity achieved on that day (with the resulting V/C at, or very close to, 1.0). Excess arrival demand then queues upstream of the constraint, waiting to be discharged at the capacity rate – in other words a bottleneck.*





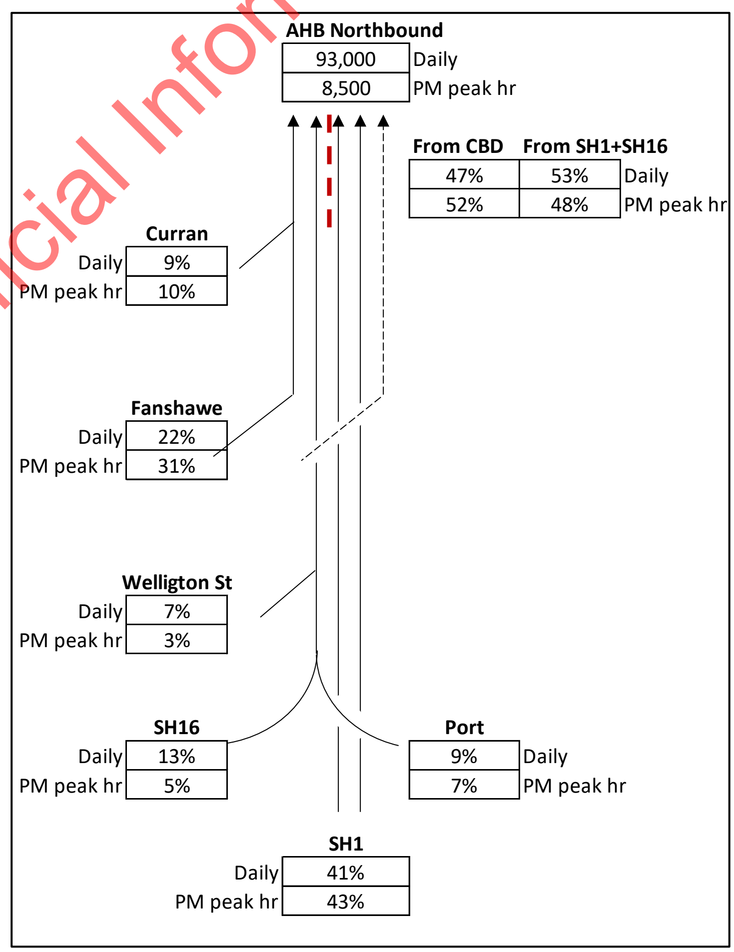


Figure 2 – Summary of typical weekday northbound

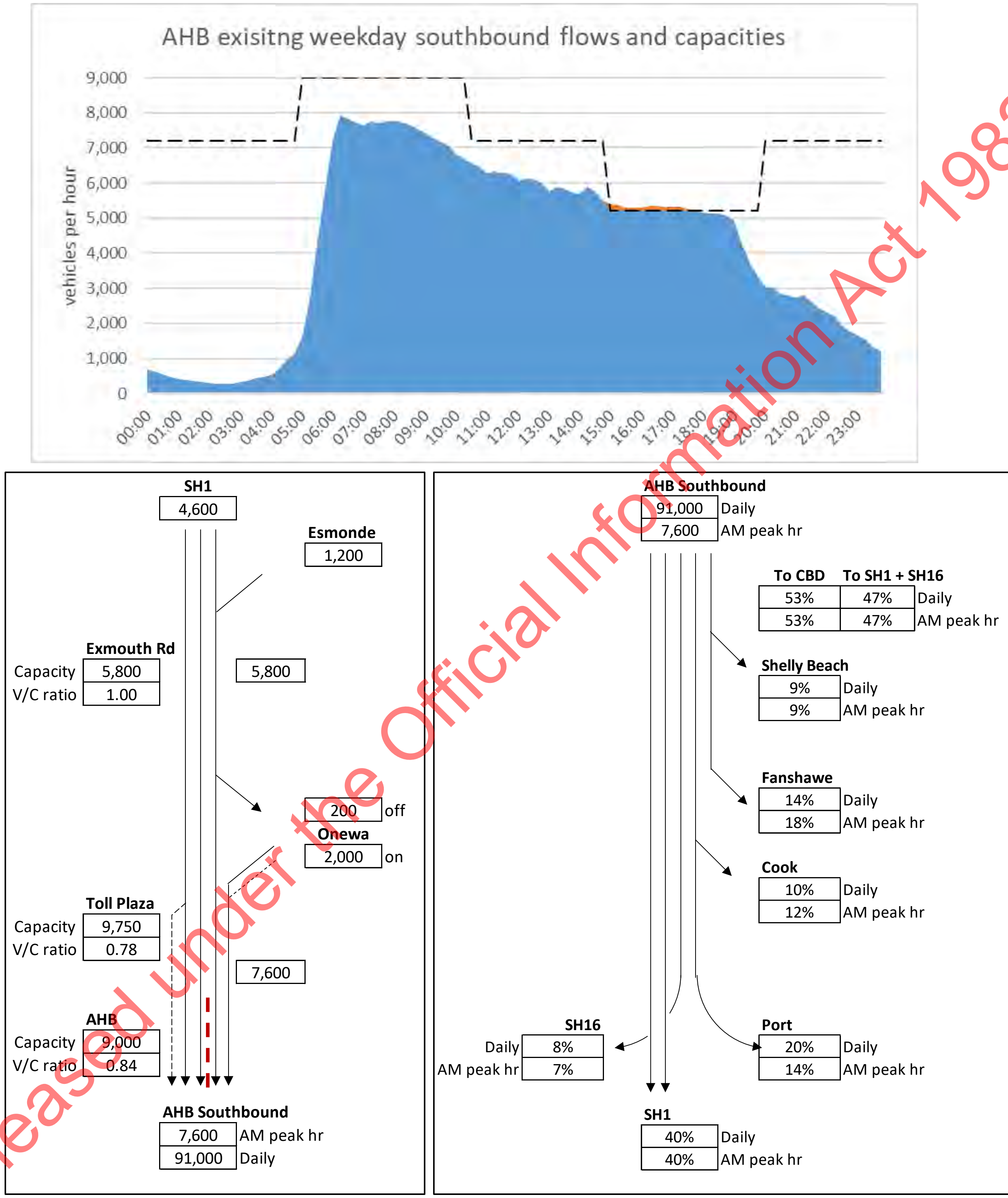


Figure 3 - Summary of typical weekday southbound

Traffic Capacity of Cycle Lane Options

All options being considered for either a temporary (weekend) or permanent (7 days per week) cycle facility across the AHB will lead to lane configurations on the bridge with capacities that are inadequate to accommodate existing peak arrival flows, to a greater or lesser extent. The red sections on the graphs in Figure 4 and Figure 5 below provide a comparative visual guide to the timing and extent of existing arrival flows that would be in excess of bridge capacity under each option.

Some of the graphs represent more than one option because the overall effect on lane capacity is the same irrespective of which side of the bridge the cycle facility is provided. For the purposes of these illustrations it has been assumed that the timing of Moveable Lane Barrier (MLB) shifts would be optimised to minimise the overall extent of the existing arrival flows profile being in excess of bridge capacity considering both directions.

Table of lane capacities by configuration (with notes to explain variances)

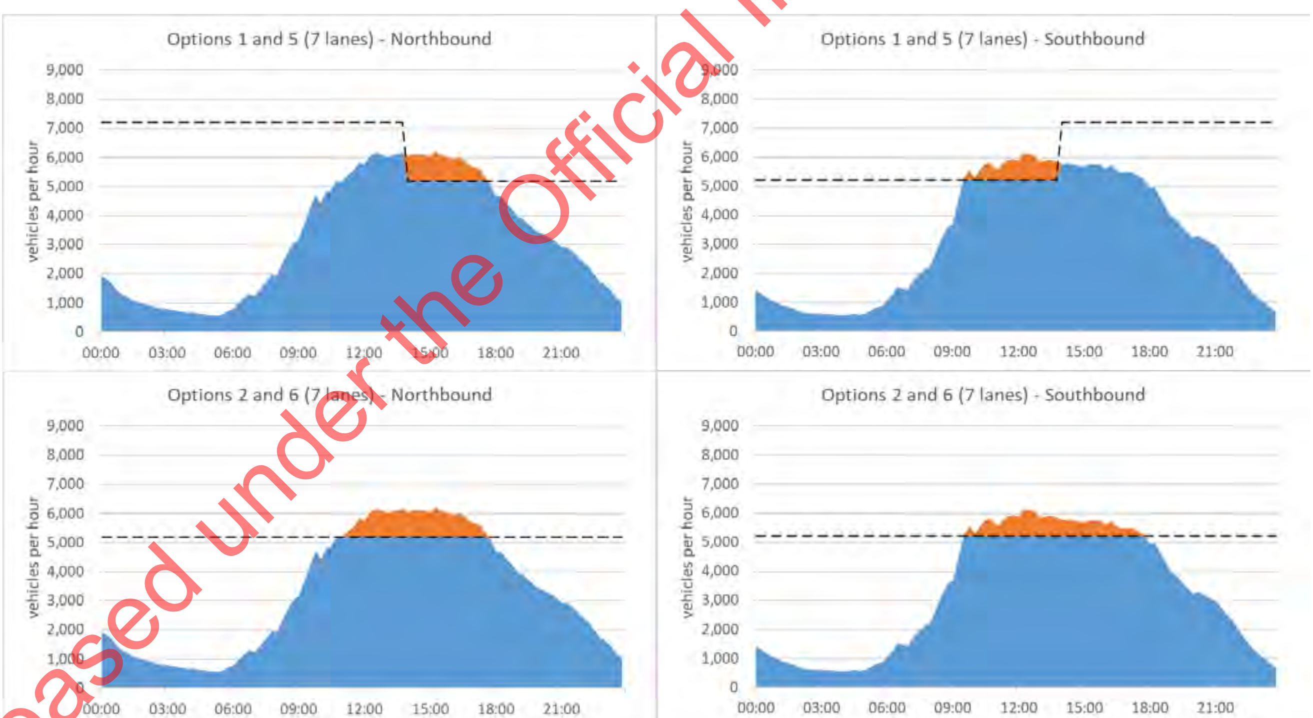


Figure 4 – Demand in excess of bridge capacity – temporary (weekend) options

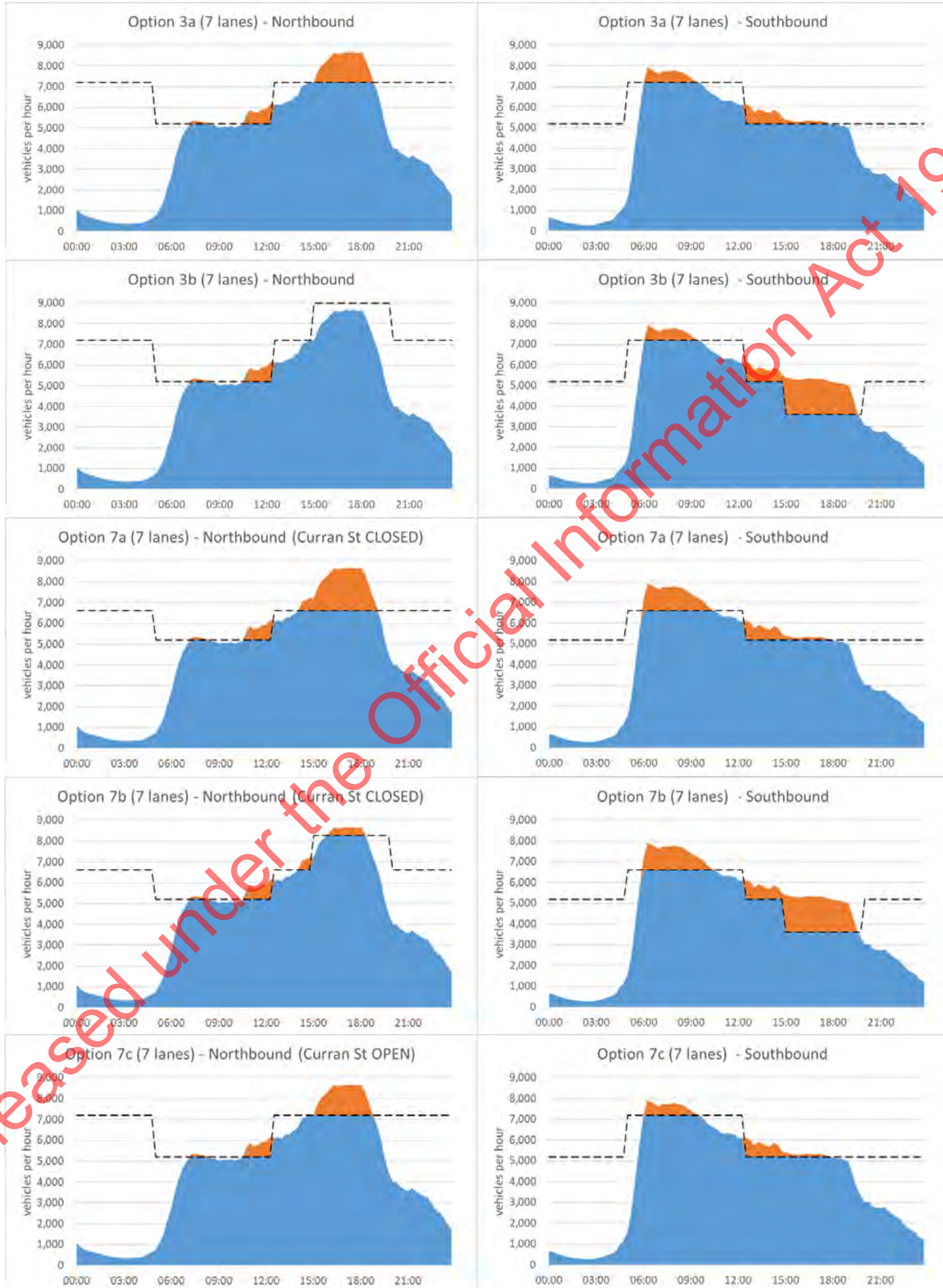


Figure 5 - Demand in excess of bridge capacity – Permanent (7-day) options (continued overleaf)

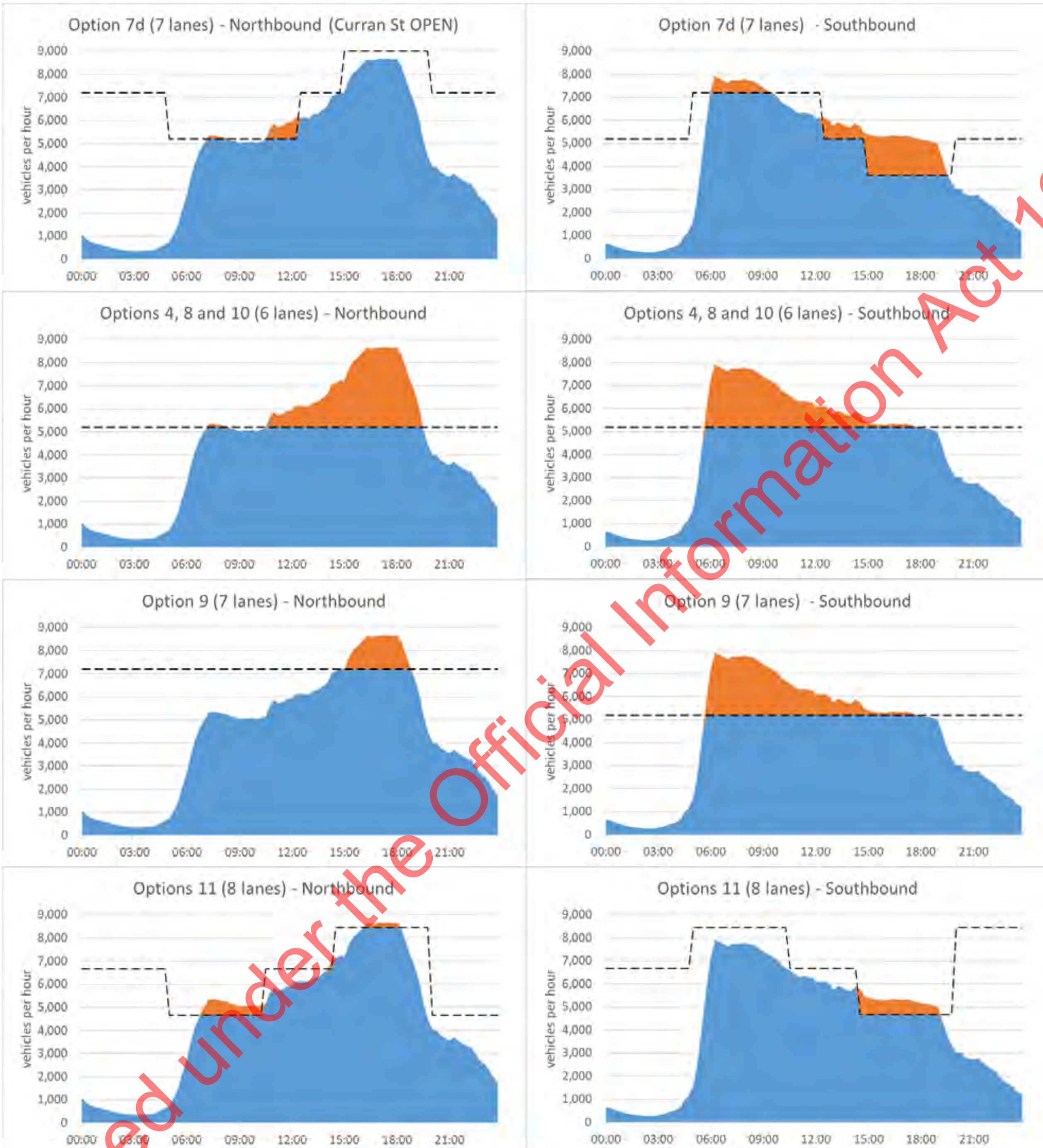


Figure 5 (continued) - Demand in excess of bridge capacity – Permanent (7-day) options

Note the following in relation to the weekday graphs in Figure 5:

- The northbound traffic capacity achieved in 4-lane and 5-lane configurations is slightly lower in options where Curran Street on ramp is closed (options 7a and 7b). This is because with the addition of Curran Street traffic at Fanshawe Street, St Mary's Bay becomes the critical capacity constraint (with its slightly lower per lane capacity than the bridge).

In option 11 the 5-lane configuration in either direction has slightly lower capacity than the current operation. This is due to the lane narrowing on the clip-ons which will introduce a capacity reduction of around 15% on each of the clip-on lanes.

The key question for the traffic analysis is - what will happen to the traffic represented by the red areas if a cycle facility is introduced on the bridge? There are two broad, interrelated responses:

1. Traffic congestion. This will be generated on the approaches to the bridge, which will propagate upstream over time impacting adjoining sections of the motorway, city and local roads - creating delays not only for cars, buses and trucks using the bridge but also for other customers caught in the upstream congestion. The congestion will persist until the available bridge capacity is able to clear the backlog.

2. Demand change. Some customers affected will chose to modify their trip behaviour to avoid the congestion and delays. This could include choosing the alternative route via SH18, SH16 and SH20, re-timing their trip to a less busy time, choosing an alternative mode of transport (including cycling or walking over the bridge on the new facility), undertaking a different trip that doesn't require crossing the harbour, or cancelling their trip altogether.

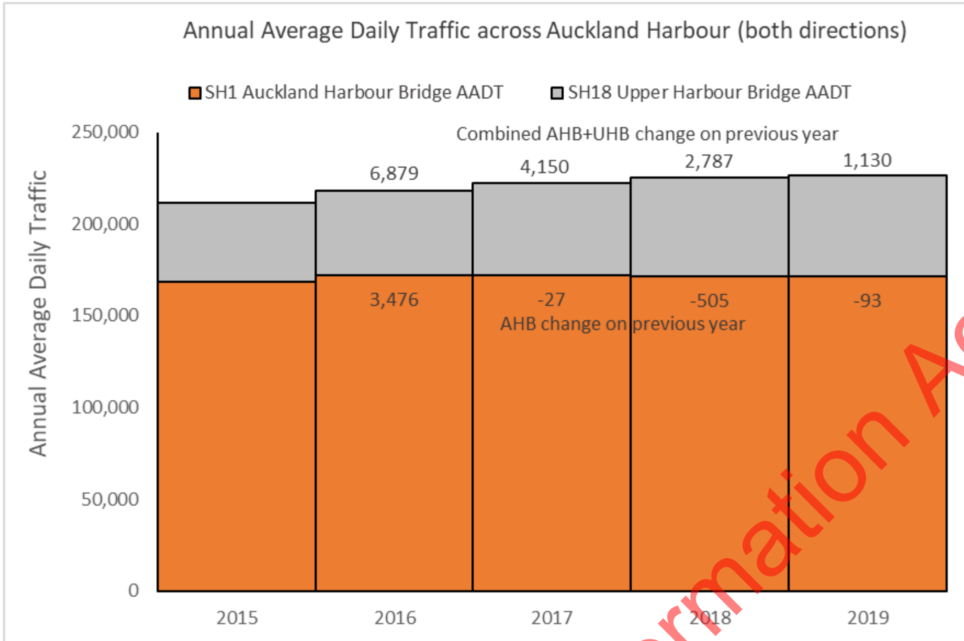
Note the following:

- Demand change in terms of mode shift to PT, re-routing to SH18, SH16 and SH20 and re-timing of trips will be driven primarily by increases in congestion. On the other hand, mode shift to active modes will largely be driven by the improved active mode connectivity a cross-harbour facility provides.
- Traffic choosing to re-route via SH18, SH16 and SH20 may increase congestion on these routes, leading to congestion impacts being spread across the wider motorway and arterial networks.

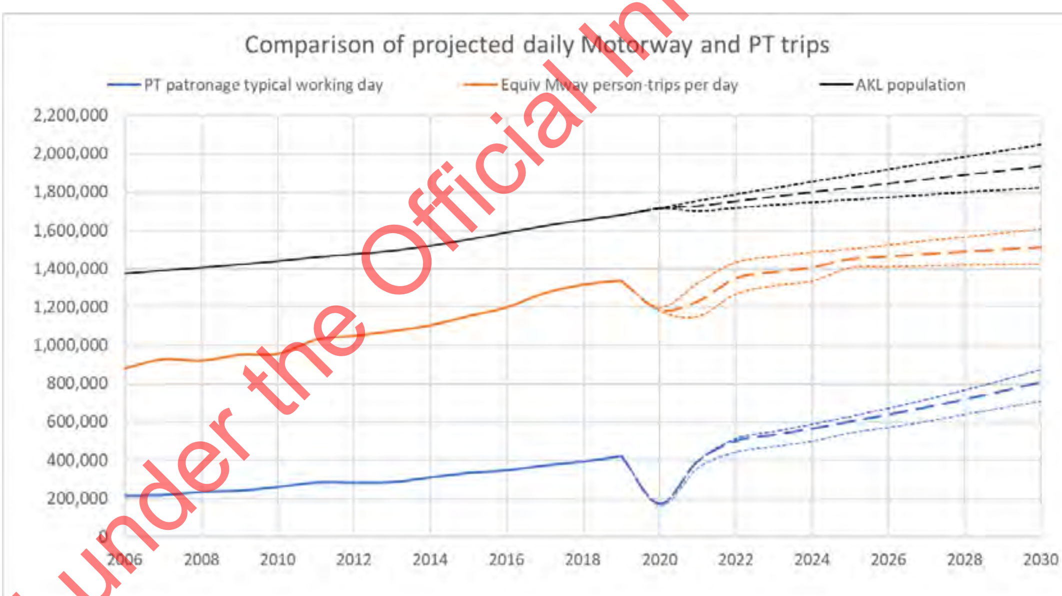
Demand changes expected over the next few years

Over the expected life of a cycle facility on the bridge there are a number of independent factors that will influence both the overall traffic demand for the bridge and potentially the profile of traffic arriving at the foot of the bridge. The main factors are:

- Ongoing regional population growth in general (and significant expected growth around Silverdale, Orewa and Warkworth in particular).
- The completion of the NCI project. Hiatus in AHB traffic growth since 2017 due to – WVT opening + NCI LT-TTM. Slow growth likely to return to AHB after NCI completes. Opposing drivers: removal of TTM = attraction back to SH1, completion of NCI = attraction to WRR.
-



Annual Average Daily Traffic across Auckland Harbour (both directions)
SH1 Auckland Harbour Bridge AADT
SH18 Upper Harbour Bridge AADT
Combined AHB+UHB change on previous year
6,879
4,150
2,787
1,130
3,476
-27
-505
-93
AHB change on previous year
Annual Average Daily Traffic
250,000
200,000
150,000
100,000
50,000
0
2015
2016
2017
2018
2019



Comparison of projected daily Motorway and PT trips
PT patronage typical working day
Equiv Mway person-trips per day
AKL population
2,200,000
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030

Review of Previous Lane-Reducing Events

Planned lane closures of the bridge occur frequently to allow maintenance work to be carried out, and crashes and other incidents frequently lead to unplanned lane closures. Number of planned closures per year? No. of crashes per year on AHB?

However neither of these types situations provide a useful comparison: planned lane closures occur overnight to avoid traffic impacts (as with the rest of the motorway network) and crashes generally lead to short durations of lane blockage / closure (and incident management protocols are designed to allow lanes to re-open as quickly as possible to minimise traffic impacts).

Planned lane closures of up to two lanes at a time occur each year over the Christmas / New Year period to enable resurfacing of lanes on the bridge. These closures are timed for this period as traffic demands are significantly reduced at this time (down by around a third compared to a typical weekday, and down by around a fifth on a typical weekend).

There are two recent events involving multiple lane closures outside of the circumstances described above that provide some relevance to the options being considered here:

- The 2019 Auckland Marathon
- The September 2020 truck strike incident

Examination of available traffic volume and travel time data during these events provides some insight into the effects of lane closures on the bridge at times when traffic demand exceeds remaining capacity over longer periods.

The Auckland Marathon

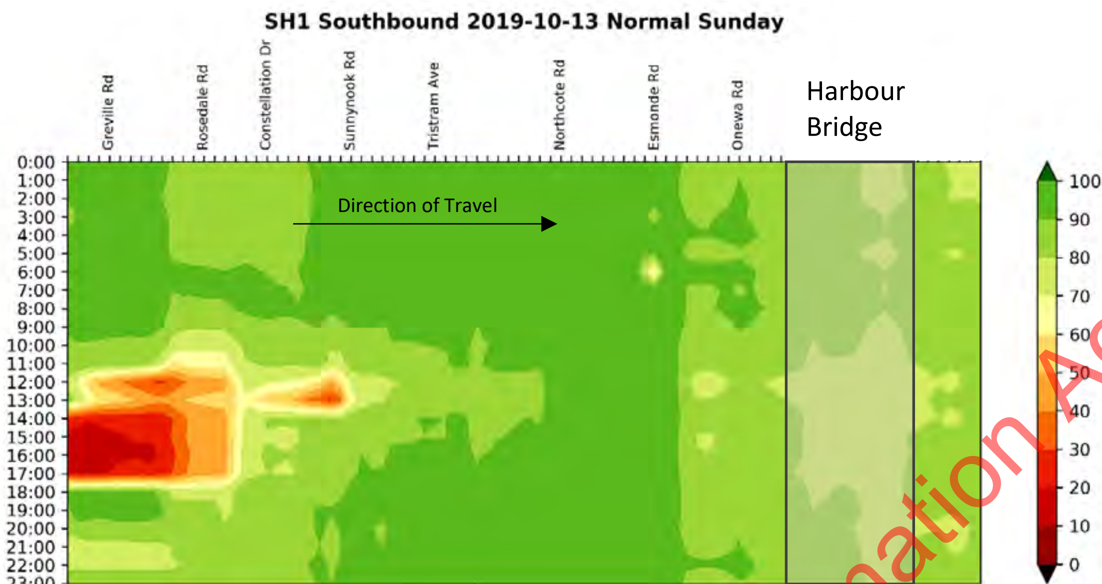
For the marathon event the two southbound clip-on lanes are closed under Temporary Traffic Management (TTM) arrangements for several hours on a Sunday morning – reopening at 11am, leaving six total lanes for traffic until this time. Access to the bridge for runners is via the northern busway (which is also closed from Smales Farm station). To provide safe separation of motorway traffic from runners along the section of southbound bus shoulder lane from Esmonde Road to Onewa Road, a lane drop on the motorway mainline is introduced just before Esmonde on ramp (access via Esmonde on ramp joins lane 2 under temporary arrangements). Onewa road on ramp then joins the mainline as a lane gain to provide the third available traffic lane across the bridge as indicated in XX. As a result, the primary restrictions to southbound motorway traffic are at the lane drop prior to Esmonde on ramp, and the merge of Esmonde on ramp with the remaining two lanes – rather than at the bridge itself.

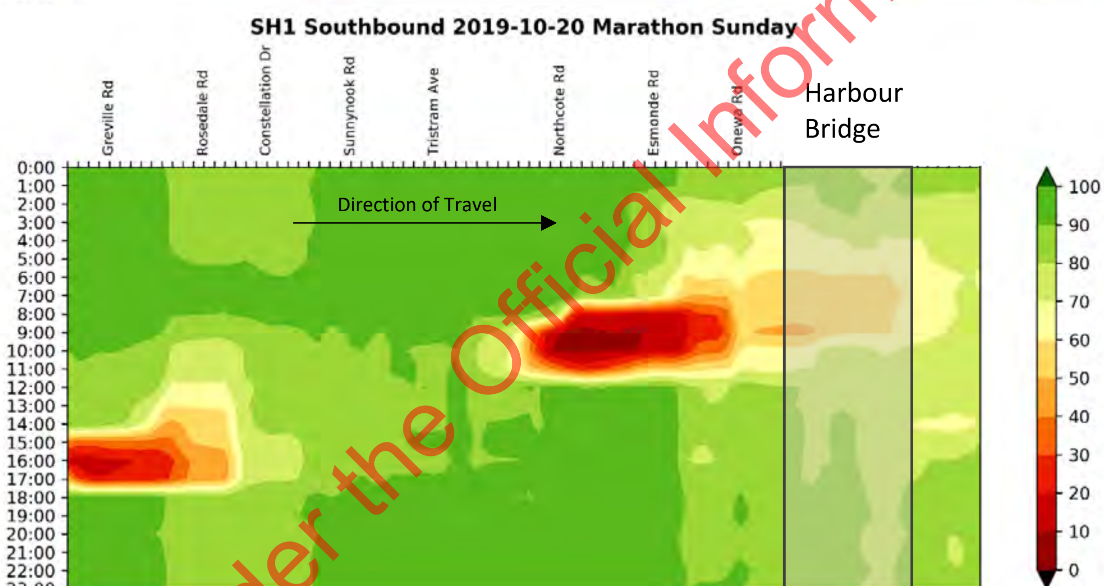
In the northbound direction the bridge is reduced to three lanes of traffic and Curran Street on ramp is closed, due to Curran Street forming part of the marathon.

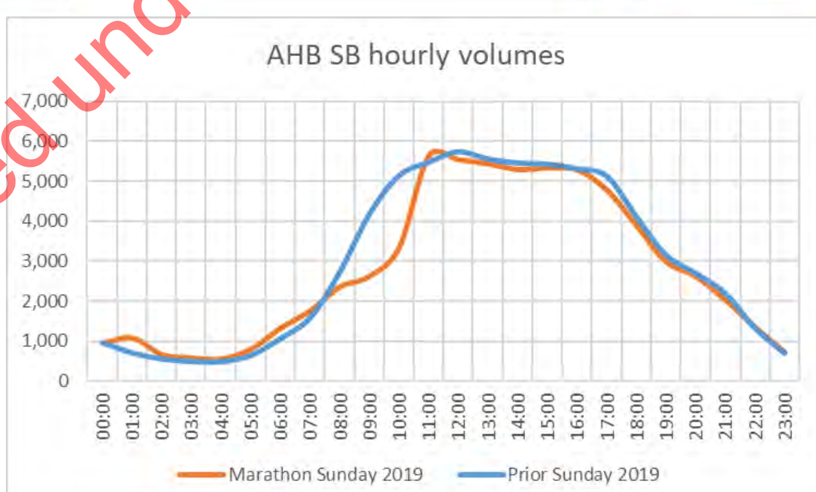
Simple line diagram of marathon lane layout is each direction.

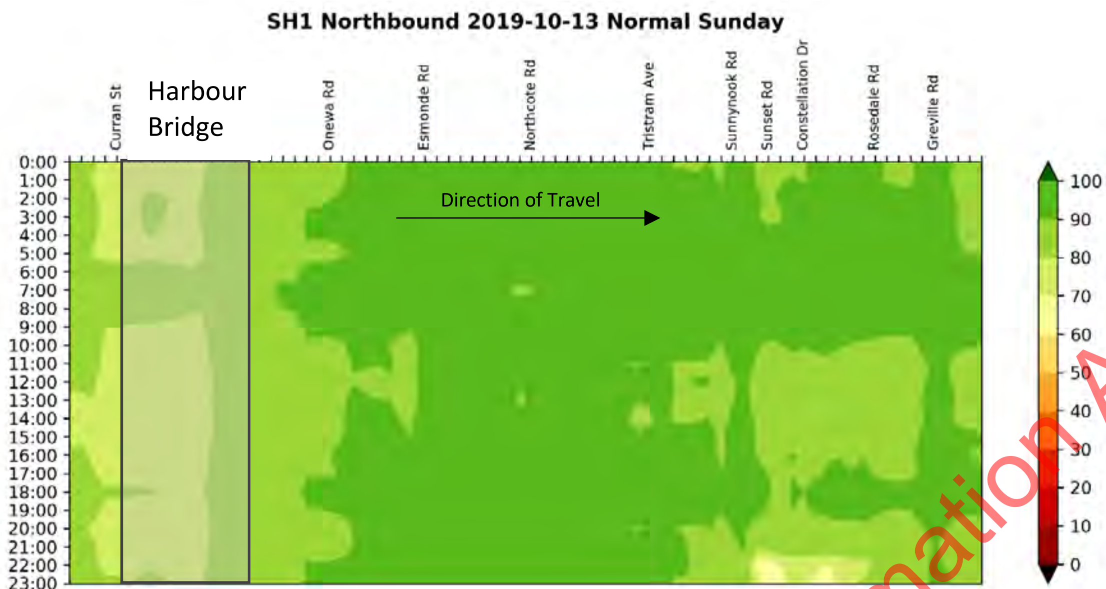
Given the disruption to traffic demand due to COVID during 2020, observed data from the 2019 marathon has been used to review traffic demand and congestion impacts.

The traffic volume graphs and time-space speed heatmaps in XX and XX compare traffic on the day of the marathon (20-Oct-19 with the prior Sunday.

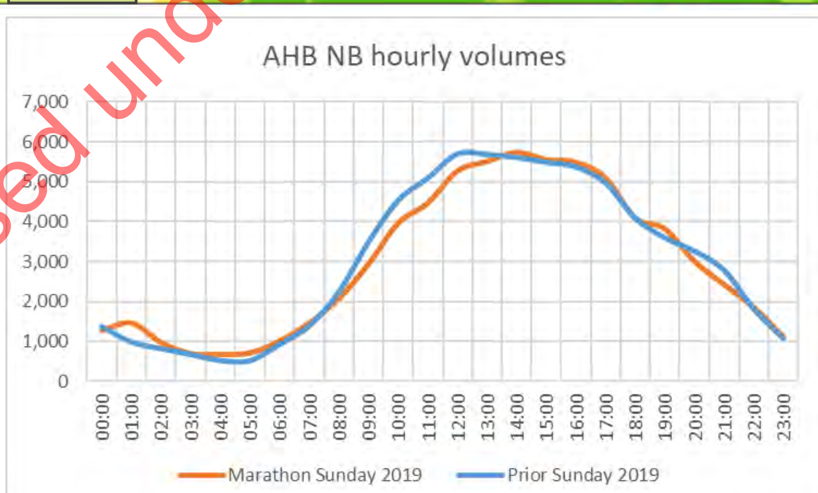

SH1 Southbound 2019-10-13 Normal Sunday
Greville Rd
Rosedale Rd
Constellation Dr
Sunnynook Rd
Tristram Ave
Northcote Rd
Esmonde Rd
Onewa Rd
Harbour Bridge
Direction of Travel
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
100
90
80
70
60
50
40
30
20
10
0


SH1 Southbound 2019-10-20 Marathon Sunday
Greville Rd
Rosedale Rd
Constellation Dr
Sunnynook Rd
Tristram Ave
Northcote Rd
Esmonde Rd
Onewa Rd
Harbour Bridge
Direction of Travel
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
100
90
80
70
60
50
40
30
20
10
0


AHB SB hourly volumes
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Marathon Sunday 2019
Prior Sunday 2019


SH1 Northbound 2019-10-13 Normal Sunday
Curran St
Harbour Bridge
Onewa Rd
Esmonde Rd
Northcote Rd
Tristram Ave
Sunnynook Rd
Sunset Rd
Constellation Dr
Rosedale Rd
Greville Rd
Direction of Travel
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
100 90 80 70 60 50 40 30 20 10 0


SH1 Northbound 2019-10-20 Marathon Sunday
Curran St
Harbour Bridge
Onewa Rd
Esmonde Rd
Northcote Rd
Tristram Ave
Sunnynook Rd
Sunset Rd
Constellation Dr
Rosedale Rd
Greville Rd
Direction of Travel
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
100 90 80 70 60 50 40 30 20 10 0


AHB NB hourly volumes
7,000 6,000 5,000 4,000 3,000 2,000 1,000 0
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
Marathon Sunday 2019
Prior Sunday 2019

No significant congestion was evident in the northbound direction, with all lanes being re-opened before traffic demand exceeded three lanes. Overall northbound traffic demand over 24-hours was down slightly on the previous Sunday, but still at typical levels.

In the southbound direction congestion was evident from around 7.30am to around 12pm, forming at the Esmonde Road lane drop and on ramp merge and extending past Northcote Road. Traffic volumes were significantly below normal between 8am and 11am with 24-hour demand 6% down on the previous week (at about the 20th-25th percentile level for Sundays in 2019). This demand suppression occurred almost entirely between 8am and 11am, although the hourly flows do not tell the whole story. Given the congestion evident the temporary layout was operating over-capacity for 3 hours – therefore the reduced volumes measured at the bridge at this time represent only what able to pass through the temporary layout, not the full demand that wished to.

The highest southbound flow achieved during the closure was around 3,300 vehicles per hour, around the capacity of TWO lanes under TTM, not three. Need Onewa Rd flows to determine if this too little demand using Onewa Road and too much demand from further north to utilise the full three lanes effectively.

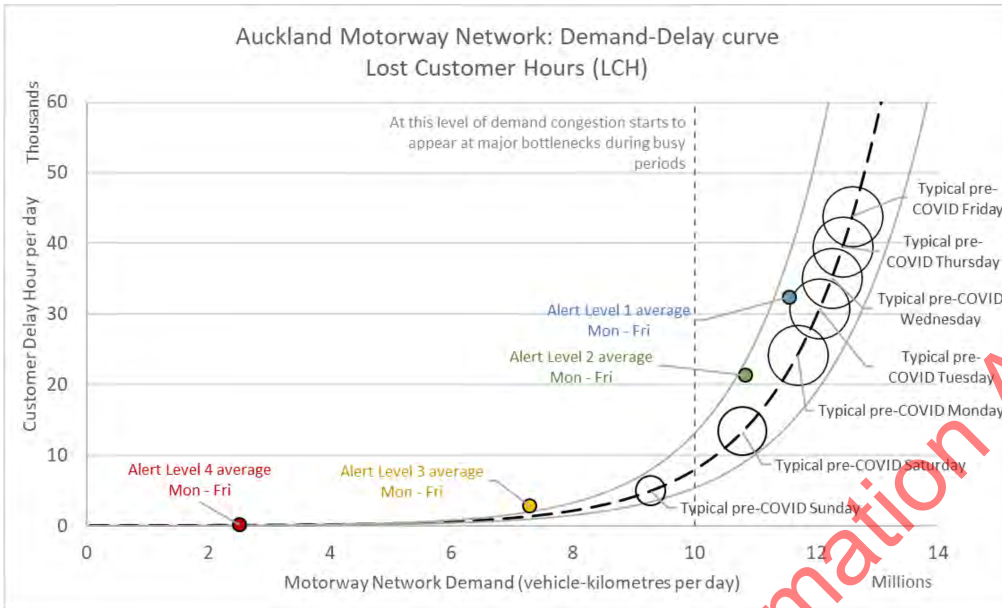
September 2020 truck strike incident

Following the impact of a truck into its main truss on 18 September 2020, the bridge operated with a reduced number of lanes for a little over two weeks. Initially reduced to just four total traffic lanes for five days, the bridge then operated at six total lanes for a further 11 days, proving a unique opportunity to review reduced capacity operation.

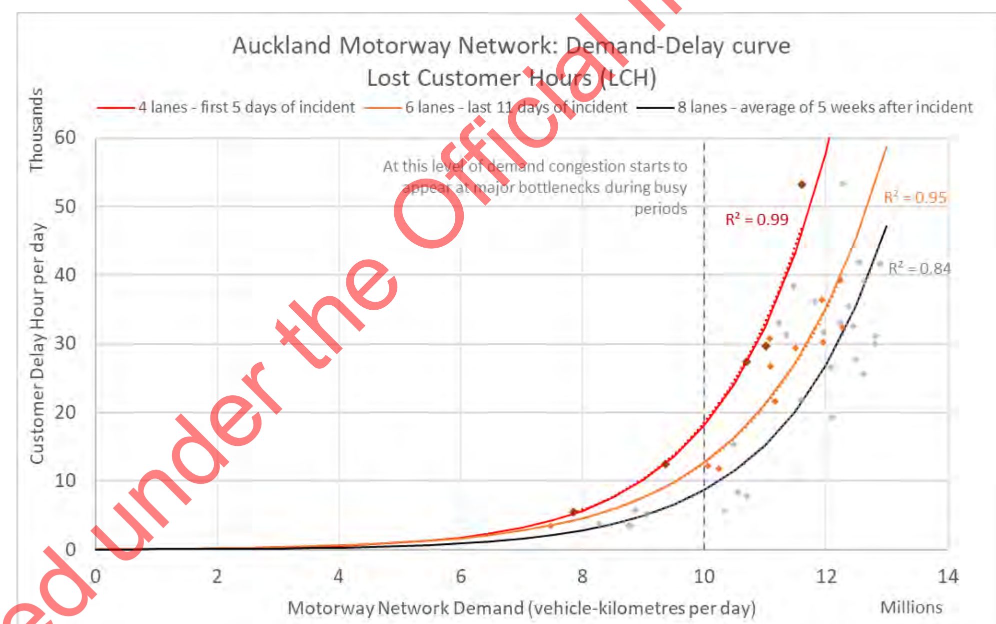
However, as Auckland was in COVID Alert Level 2 during this entire period the data needs to be interpreted with caution: motorway network daily demands were down around 10% on normal during this time and AHB daily demands were down 15-20% (need to confirm this). Based on available data sources the ASM has derived a graph which relates the level of customer delay hours per day due to congestion across the entire motorway network (in terms of journey delays over and above free flow) to the level of daily motorway demand (in terms of the number of vehicle-kilometres travelled on the motorway network), see XX. This graph essentially depicts the daily supply curve of the motorway for general traffic movement. At demand levels below 10 million vehicle-km per day no significant delays occur anywhere on the network at any time of day. The network reaches capacity around 10-11 million vehicle-km per day. As daily demand rises beyond 11 million vehicle-km per day, daily congestion rises exponentially. Typical motorway network delays ranged between 20,000 and 60,000 person-hours on weekdays in 2019.

As XX shows motorway congestion levels were greatly reduced at Alert Level 2, and XX indicates average weekday volume profiles for the AHB at each of the Alert Levels.

XX compares the network-wide motorway traffic data from the period of reduced lane operation following the truck strike to days with equivalent levels of demand earlier in 2020 and allows a broad indication of the effect of reduced lanes on the AHB to be surmised. At typical levels of daily customer delay hours post-incident, the motorway network could only handle 10-15% less daily demand at 4 available AHB lanes; and 4-5% less daily demand at 6 available AHB lanes. This underlines the critical nature of the AHB as a strategic link within the Auckland motorway network (for comparison the opening of the Waterview Tunnel provided and increase of around 5% of the network supply curve - the same as the loss of two lanes on the AHB).



Volume profile of AHB flows at different alert levels here, plus levels of increased volume at UHB



SH1 NB + SB speed heatmaps here – average of 11 days with 6 lanes open

Unfortunately, apart from this broad-brush assessment, little further insight can be gained from the period of the incident given the apples-and-oranges nature of the comparison to pre-COVID AHB and overall motorway network demands. It is therefore necessary to look at what additional insight can be gained from predictive traffic modelling tools.

Tools to Predict Traffic Impacts…and Their Limitations

"All models are wrong, but some models are useful."

The statistician George Box is known for this aphorism – and he goes on to say that the question you should ask is not "is the model true?", but "is the model good enough to be helpful for this particular application?"

There are a number of available traffic modelling tools that can help to answer the question of what will happen to the traffic represented by the red areas in the graphs of Figure 4 and Figure 5 if a cycle facility was introduced on the AHB. However, none of these tools are ideally suited to the job, and none on their own can give a fully robust answer. However, they all provide some help in trying to understand the likely impacts on traffic.

The available modelling tools are:

- Auckland Macro Strategic Model (MSM)
- Auckland Dynamic Traffic Assignment Model (ADTA)
- NCI – SATURN AWHC – SATURN
- Auckland Motorway Network Cell Transmission Model (CTM)
- AHB Queuing model (AHB-Q)

In addition, there are two historical data sources that can assist the analysis

- TomTom travel time system
- In-pavement traffic detectors

The Auckland Macro Strategic Model (MSM) covers the region's entire road network and Public Transport system. It is operated by the Auckland Forecasting Centre and its primary role is to understand how major changes to the transport system affect mode choice between private vehicles and public transport, and how private vehicles distribute themselves across the road network. The model evaluates the network in 2-hour blocks of time (there are three 2-hour blocks to cover AM peak, interpeak and PM peak). The representation of the motorway network is coarse, and congestion is represented through delays on individual links and intersections, which is suited to large models used for strategic planning purposes. However, this type of model is not well suited to replicating small-scale operational changes because it does not provide realistic propagation of congestion and queues in a way that realistically affects performance of upstream sections of the network.

Northern Corridor Improvements (NCI) SATURN (Simulation and Assignment of Traffic to Urban Road Networks) model. The primary role of this tool is to determine how a fixed amount of traffic routes itself from a series of journey start locations (origins) to series of corresponding end locations (destinations), accounting for delays along the way. In other words, it determines how traffic is distributed across a congested network. By accounting for capacity constraints of a network (primarily at intersections) SATURN incorporates "flow metering" which provides a realistic spread of congestion across a network – including how queues can block flows at upstream intersections. SATURN is normally used to model large areas (thousands of links), although it is capable of analysing the effects of relatively minor network changes. However, it is limited in relation to analysing motorway operation in two ways:

- It was not originally designed to model motorways and as such is limited in how motorway capacity can be represented. Additionally, most effort to calibrate a SATURN model is devoted to operation of intersections on the arterial network (which usually govern the routing if traffic), often leading to the use of "typical" capacities across most motorway links, where in reality individual links may differ considerably from this.

- SATURN is normally used to model the peak hour as a single one-hour block of time, which limits the ability to accurately reflect the growth of congestion spatially across the network. The buildup of queues throughout the peak can be approximated through use of an additional 1-hour "pre-peak" model – which effectively "loads" the network with queues before the peak model is run.

The NCI SATURN model has the added limitation that it only covers the Auckland network north of CMJ and the Waterview Tunnel – SH20 and the Southern Motorway are not included. This means any congestion impacts of modifying the lanes on the AHB on the southern motorway will not be represented.

The Auckland Dynamic Traffic Assignment Model (ADTA), operated by the Auckland Forecasting Centre. Dynamic Traffic Assignment models also determine the routing of traffic through and its resulting distribution across a network, but they consider the growth and spreading of congestion over time and space in a more realistic way, using multiple, smaller time periods. However, because of this they are extremely complex models - which is compounded when they are used to represent very large networks (the ADTA, like the MSM covers the entire of Auckland's road network). They are very difficult to calibrate to observed data, which means that not all parts of large models will respond realistically. A bit more……?

CTM – realistic growth and recovery of congestion in over both time and distance over the whole day. Interaction between corridors due to realistic representation of "flow metering", where congestion at one location restricts flow that can arrive further downstream further downstream. Simplicity and flexibility. But no arterial / local roads. However realistic traffic responsive and coordinated operation of ramp signals is included, and the model keeps track of the number of vehicles queued at each on ramp at all times. Hence on ramp queues can be used as proxy for likely arterial and local road impacts. Calibrated in detail for all parts of the motorway network and validated extensively against 2018 data.

A weakness of the CTM is that it only simulates the traffic impact of a given, fixed demand pattern – it does not reroute traffic when congestion delays get high. However, it is quick and easy to incrementally modify demand patterns manually and run multiple scenarios quickly.

Issue of single-result nature of most models encourages a false-sense of accuracy + certainty in the results. Uncertainty over demand changes are the biggest risk to this traffic assessment. Acknowledging the uncertainty and testing multiple demand scenarios to provide ranges of results will help to tackle this.

CTM will be the primary tool for modelling analysis with multiple demand scenarios informed by MSM, ADTA and NCI SATURN.

Network and Mode coverage

Representation of Congestion		No re-routing		Re-routing		Re-routing and PT mode shift
		AHB only	Motorway and on ramps	Motorways and local roads (partial network)	Motorways and local roads (whole network)	Motorways and local roads (whole network) plus PT
Less realistic	No upstream queuing					MSM
	Average upstream queuing - peak period only			SATURN		
	Growth and recovery of queues over peak period only				ADTA	
	Growth and recovery of queues over the whole day	AHB-Q				
More realistic	Growth and recovery of queues over the whole day, plus congestion responsive ramp signals operation		AMN-CTM			

Complexity and resource effort required

- Very simple and quick - modify and execute in minutes
- Simple and quick - modify and execute in under an hour
- Moderate - modify and exectue in under 1 day
- Complex - modifying and executing can take several days

Effects on Traffic Demand

Mode shift to active modes

Previous work[2] on cross-harbour walking and cycling has established an expected 2026 demand of around 1,600 daily pedestrian and cyclist commuter trips, increasing to 2,300 by 2046. AFC indicated that the Active Mode model provided an estimate of around 2,000 cycling trips and 500 walking trips per day. A successful reallocation of a traffic lane on the Burrard Bridge in Vancouver initially attracted an average of 1,000 trips per day in its first year (2009) which rose to 3,300 by 2017[3].

The following levels of pedestrian and cyclist demand have been adopted for the CTM analysis:

- Low – 1,000 trips per day (both directions, evenly split)
- Medium – 2,000 trips per day (both directions, evenly split)
- High – 3,000 trips per day (both directions, evenly split)

However not all active mode use of the new facility will remove traffic demand from the bridge. Some of these trips will shift from PT and some may be newly generated trips (many of these at weekends for recreational reasons). For the purposes of this assessment it has been assumed that all active mode trips using the bridge will be to/from locations in or close to the CBD. As a result the proportion of active mode trips shifting from PT (as opposed to private vehicle) has been assumed to be 50% on weekdays during peaks (based on AT patronage data and assuming all PT trips are similarly to/from locations in or close to the CBD and the proportions of vehicles using the bridge headed to/from the CBD).

Mode shift to PT

Patronage on buses that cross the AHB remains down 20% (daily) and 27% (peak hour) on pre-COVID levels (comparing March 2021 to March 2019). This means there is currently significant spare capacity for bus services across the bridge to absorb potential mode-shift from private vehicle trips. However, the lower patronage is likely related to continued concern over COVID and the inconvenience of the requirement to wear masks on PT. Completion of the vaccine rollout may help address this; particularly once younger age cohorts have received the vaccine. This may mean return to pre-COVID patronage levels is possible by early 2022 – but this is by no means certain.

The testing done using the MSM in April 2021 forecast no significant shift to PT from trips across the bridge when one lane was reassigned for active modes – primarily due to slower bus speeds as buses get caught in congestion on approach to the bridge (as they will no longer get the advantage of the current upstream constraints providing them with relatively free flowing approach to the bridge). However, the coarse nature of the MSM model means the detail of the lane layouts on approach to the bridge cannot be captured fully. It is possible that in practice careful design of layout changes could provide some time saving to buses through bypassing congestion on approaches to the bridge.

The following levels of mode shift to PT for trips to/from the CBD have been adopted for the CTM analysis (in each case this covers both directions, evenly split, following the pre-COVID distribution by time of day):

[2] *Cross-harbour Walking & Cycling – Transport Modelling and Economic Benefit Evaluation, Flow Transportation Specialists (December 2018)*

[3] *https://vancouversun.com/news/local-news/ten-years-of-bike-lanes-in-vancouver-life-goes-on-chaos-averted*

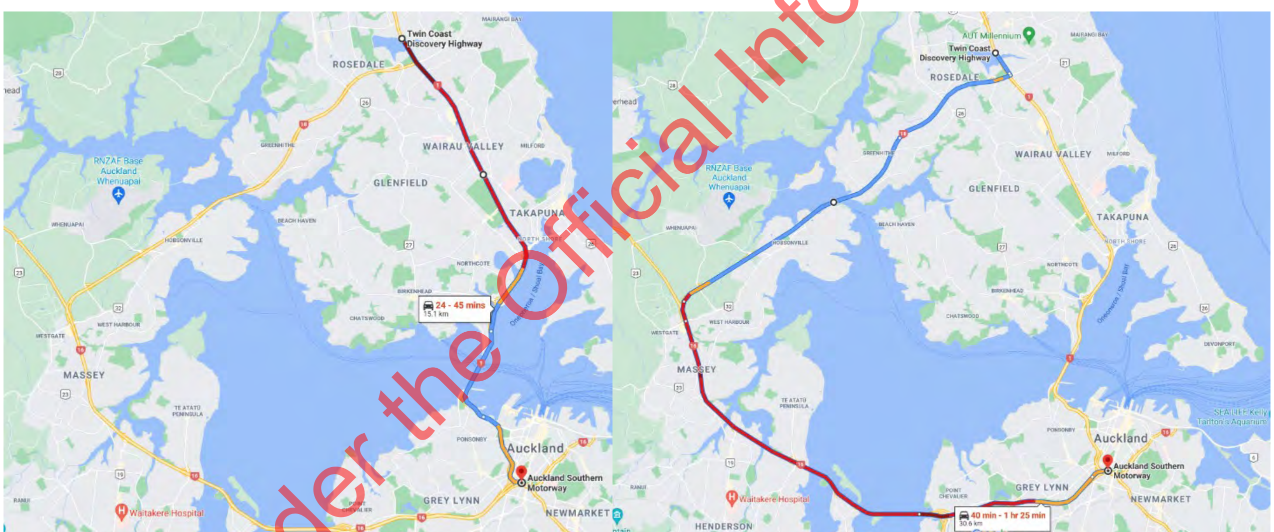
- Low – 1,000 trips per day
- Medium – 2,000 trips per day
- High – 3,500 trips per day

The high level of mode shift returns daily patronage across the bridge to pre-COVID 2019 levels.

Trip Re-routing and Re-timing

The potential re-routing options for private vehicle trips across the bridge are limited to use of SH18 by way of the Upper Harbour Bridge and SH16. Ramps at CMJ provide alternative access to/from the CBD and links to SH1 (southern) via CMJ and SH20 via Waterview Tunnel provide motorway connectivity for trips to/from further south.

Both the MSM and NCI SATURN model predict significant re-routing of traffic to these routes (up to 800 vehicles per hour) under testing of reducing AHB capacity by one lane. However, neither model accurately represents the current capacity constraints and very heavy routine congestion seen in both peaks, likely making these figures too high. A comparison of route length and typical AM peak travel times illustrates that travel times on SH1 would need to become extremely high to make the SH18/SH16 alternative attractive (need to do this analysis fully using TomTom).



The following levels of traffic re-routing have been adopted for the CTM analysis, for each direction:

- Low – 760 vehicles per day over the peak period (up to 150 in the peak hour)
- Medium – 1,400 vehicles per day over the peak period (up to 300 in the peak hour)
- High – 2,100 vehicles per day over the peak period (up to 450 in the peak hour)

These demand changes were combined to give Low, Medium and High demand sets (LLL,MMM,HHH). Profile graphs for NB and SB to show how much vehicle demand removed from the bridge in each case.

Additional demand scenarios required based on results with these demand sets – issues noted in next section.

Effects on Network and Customer Journeys

Results from Macro Strategic Model

Summarised outputs from AFC MSM model – awaiting results.

Results from Auckland Dynamic Traffic Assignment Model

Summarised outputs from AFC ADTA model – awaiting results.

Include regional heatmap of speed changes on motorways and arterials from ADTA

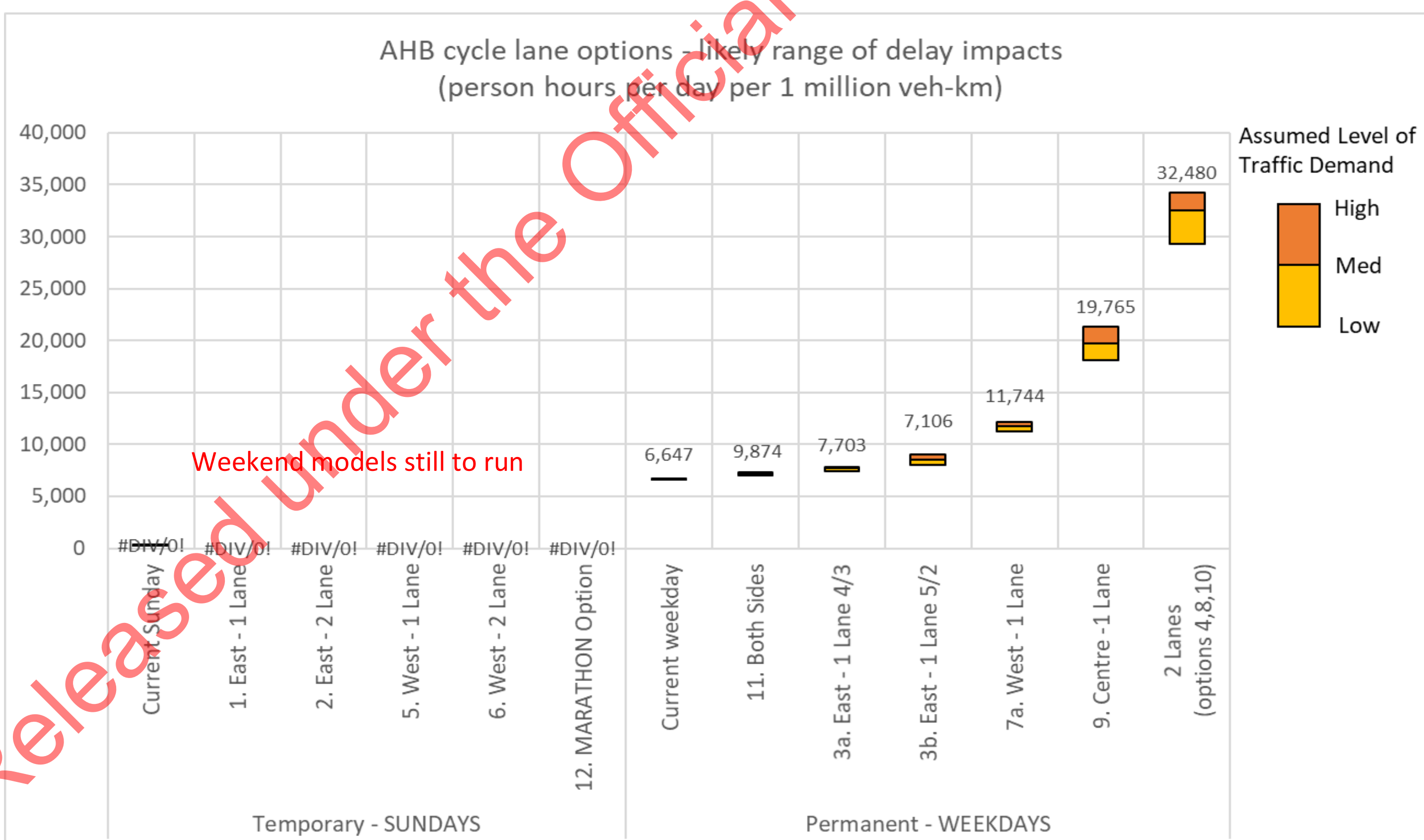
Results from NCI SATURN model

SATURN speed change results seem unrealistic – no significant speed change apart from on AHB itself. In reality the AHB will be free flow – the delays will be at the point of constraint (where the lanes drop) and upstream from in there in the queues that build. Likely conclusion that these results have little value?

Results from CTM

Overview graph of overall network delay impacts (motorway mainline + on ramp queue delays) for all options – results normalised to provide apples-with-apples comparison. Note very high impact for option 9 and 2-lane options – this makes it difficult to appreciate the additional impacts of 1-lane options. Need to consider further demand reductions for these options?

(note options 4,8,10 covered by a single model)



Context for what this means for customer journeys. Virtually all network customer delay hours occur during peaks (weekdays), affecting around 30% of total VKT (check this figure). The average length of a motorway journey is around 11km.

	Total Customer delay hours per day	Mins delay per km travelled in congestion	Minutes of delay on typical 11km journey in the peak
Current weekday	83,094	1.33	15
11. Both Sides	133,984*	2.14*	24*
3a. East - 1 Lane 4/3	97,912*	1.57*	17*
3b. East - 1 Lane 5/2	92,037*	1.47*	16*
7a. West - 1 Lane	152,331	2.44	27
9. Centre -1 Lane	266,144	4.26	47
2 Lanes (options 4,8,10)	427,569	6.84	75

*these results are not correct yet – models need to be re-run

But these are still misleading – overall magnitude of impact is only half the story - the distribution of impacts is very unequal. Discussion of interaction between motorway corridors. Some options load high impacts onto southern and NW to an unrealistic level. Most options have a huge increase in PM peak on ramp queues at Fanshawe Street – this is a proxy for gridlock in the CBD (ADTA model testing to date concurs with this).

Summary Sheets – 1 page per option for both temporary and permanent options with overview congestion maps (annotated with salient observations on results) and selected corridor heatmaps to illustrate distribution issues.

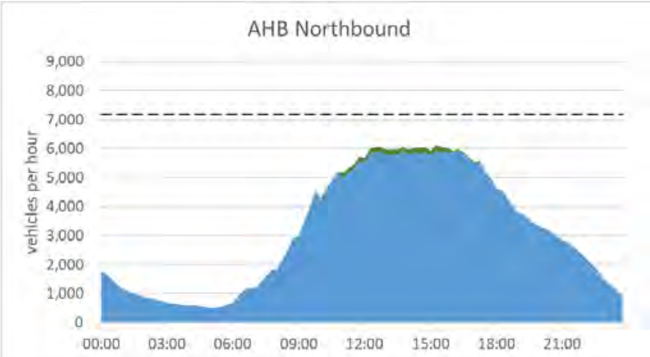
Major issue with re-routed traffic and extent of congestion on SH16/SH18 – seems unrealistic. Means less re-routing likely in reality than assumed? Need to review and re-run.

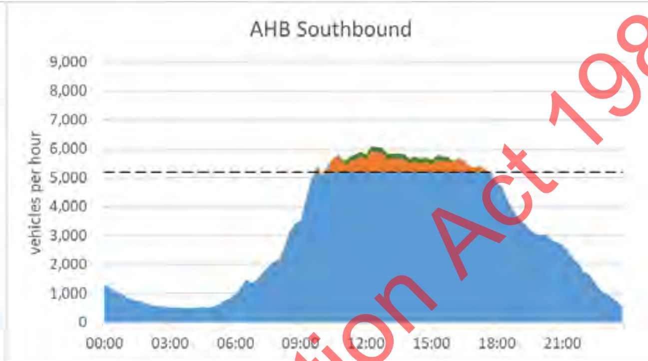
Additional demand scenarios still to run:

- PT mode shift to pre-COVID levels + 2 years growth, re-routing reduced further (7 lane options)
- PT mode shift required for neutral impact (trips to/from CBD trips only), re-routing reduced further (7 lane options)
- Network wide AL2 demands (11million-km), re-routing reduced further (6 lane options)
- Incremental global demand reductions for 6 lane options (until impacts seem feasible? But what about the removed trips? What do we assume they do?).

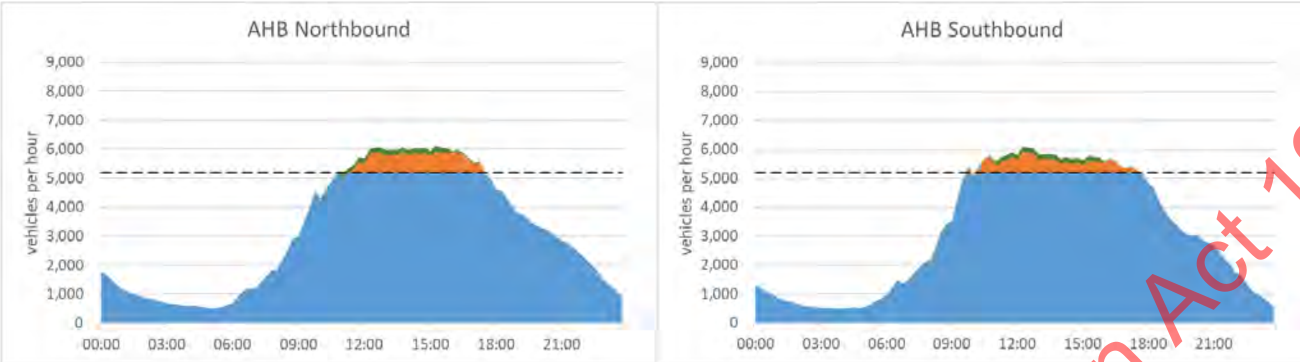
Temporary Options (Sundays)

Option 1 – One lane for active modes on eastern clip-on. 4 traffic lanes northbound, 3 lanes southbound

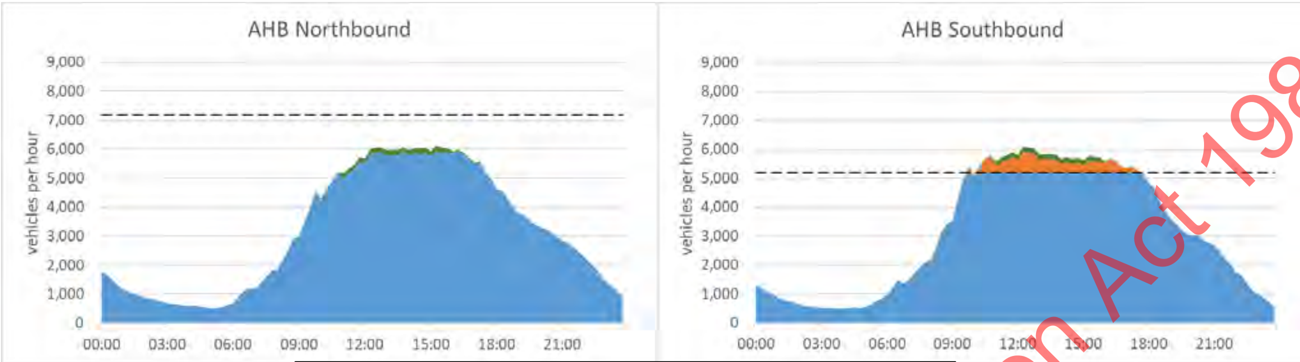




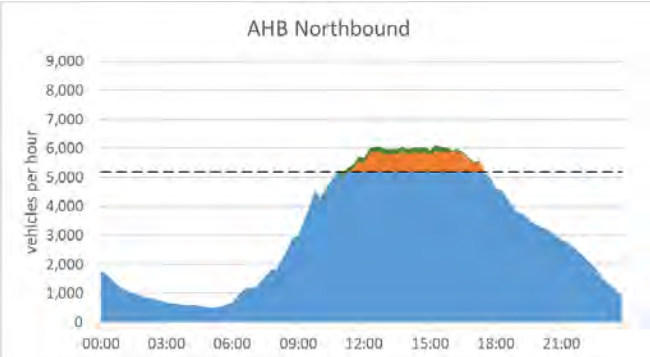
Option 2 – Two lanes for active modes on eastern clip-on.
3 traffic lanes northbound, 3 lanes southbound

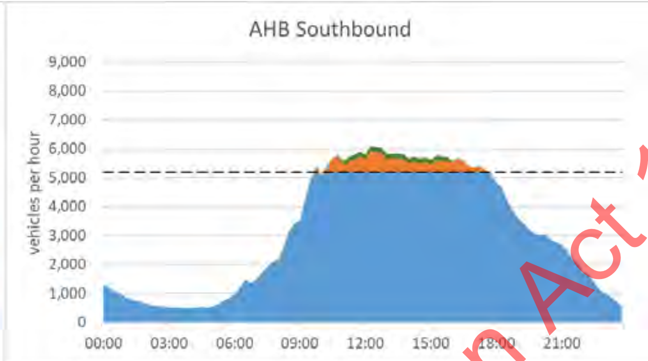


Option 5 – One lane for active modes on western clip-on.
4 traffic lanes northbound, 3 lanes southbound



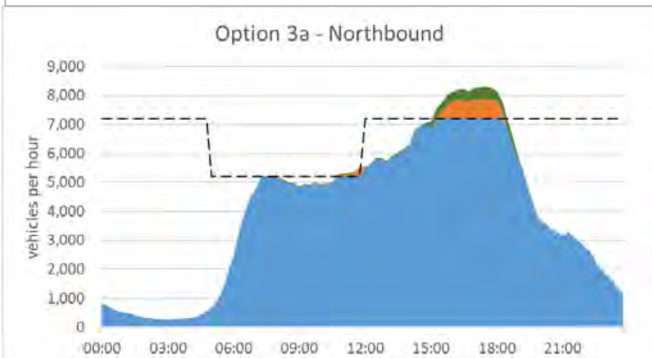
Option 6 – Two lanes for active modes on eastern clip-on.
3 traffic lanes northbound, 3 lanes southbound

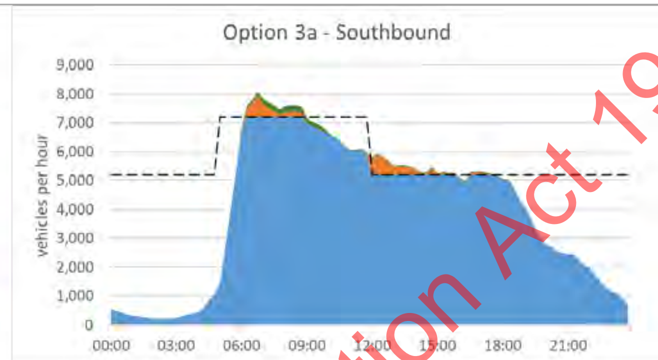


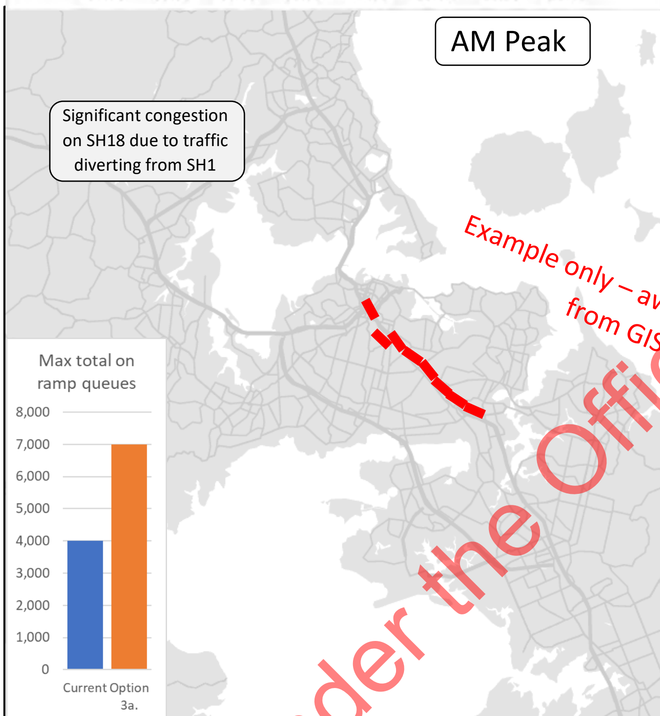


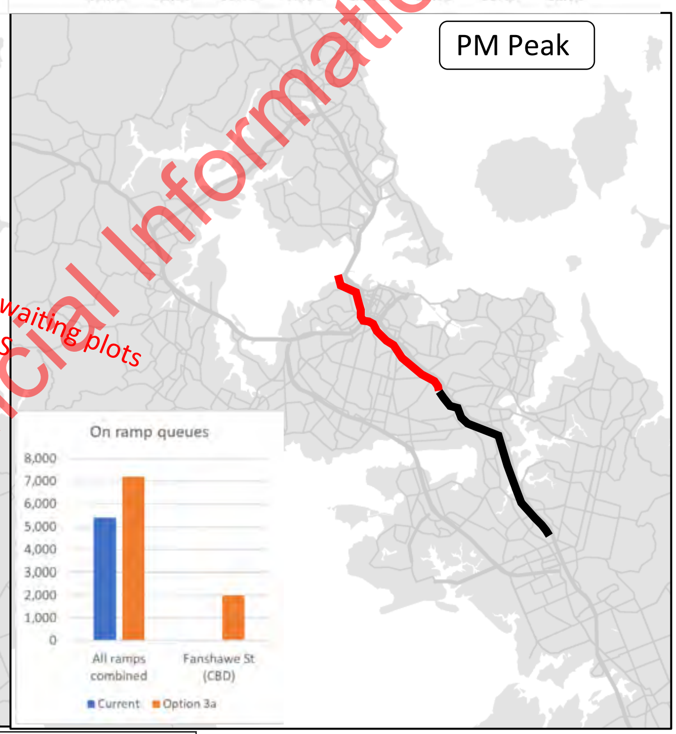
Permanent Options (weekdays)

Option 3a – One lane for active modes on eastern clip-on.
4 traffic lanes in peak direction, 3 lanes in counter peak direction









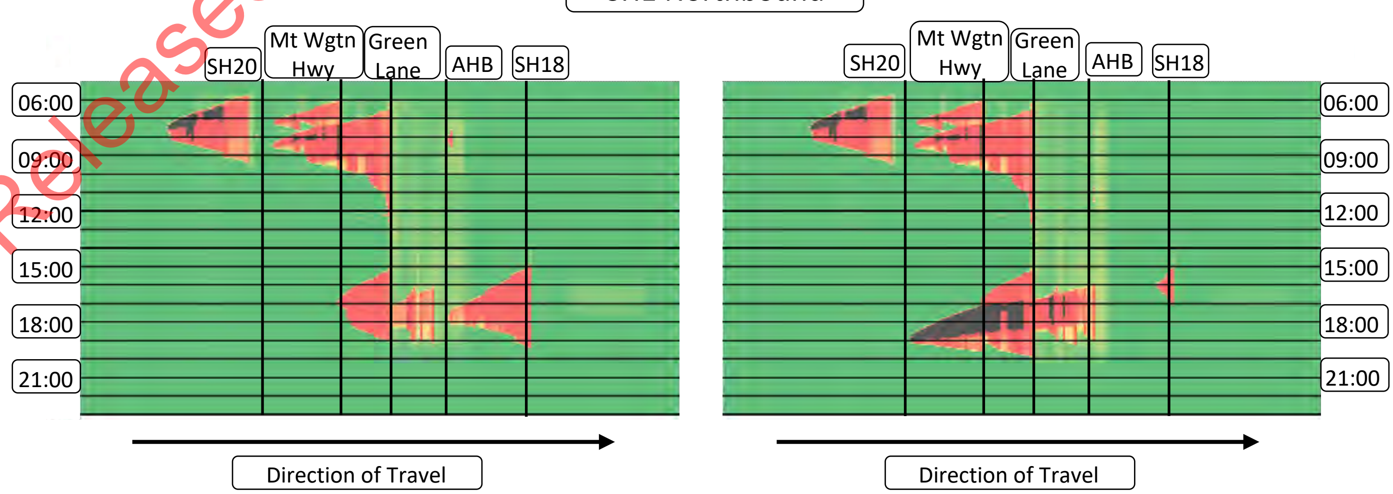
Speed scale

<15	30	40	50	60	70	>80

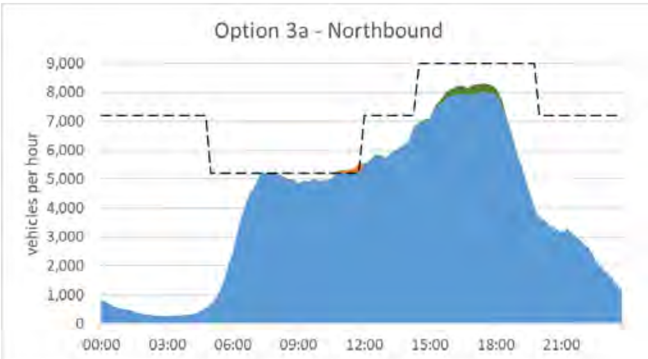
Existing

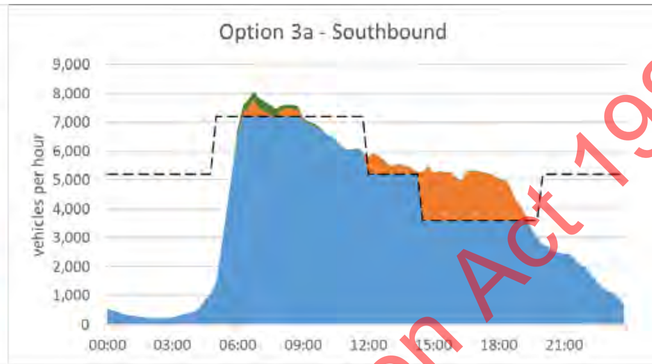
SH1 Northbound

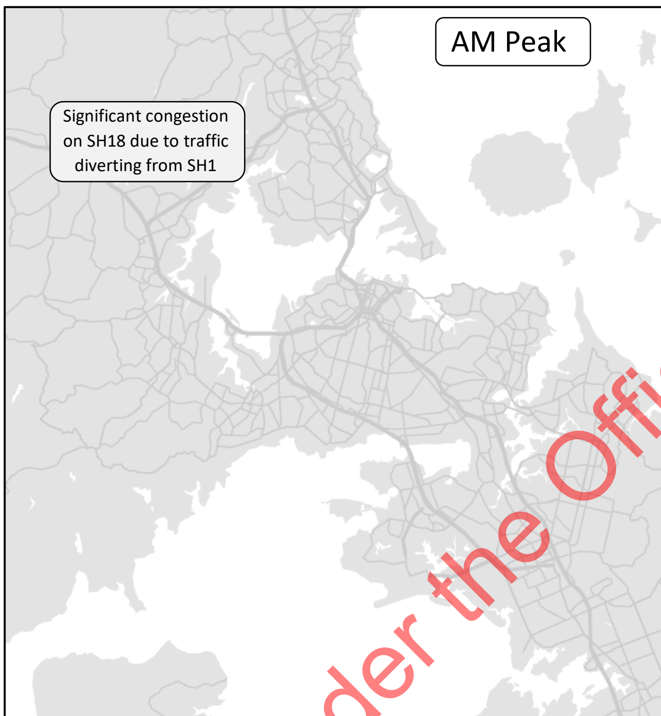
Option 3a.

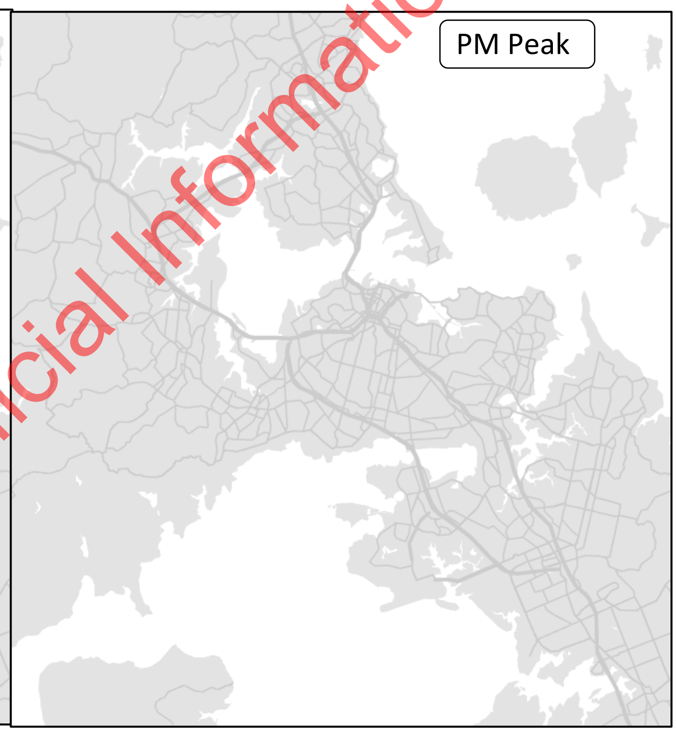


Option 3b – One lane for active modes on eastern clip-on.
AM - 4 traffic lanes SB (3 NB). PM - 5 traffic lanes NB (2 SB)

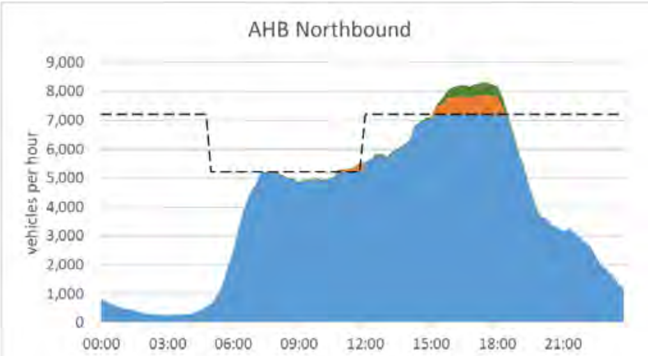


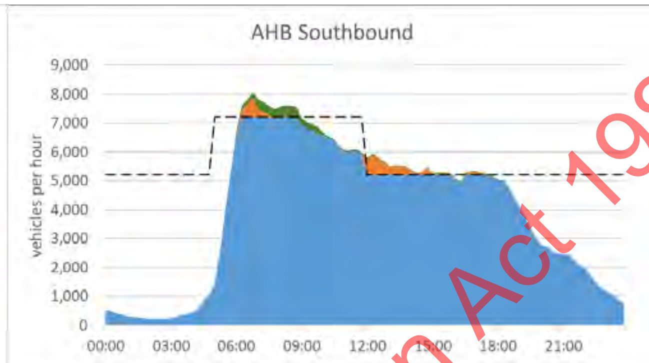


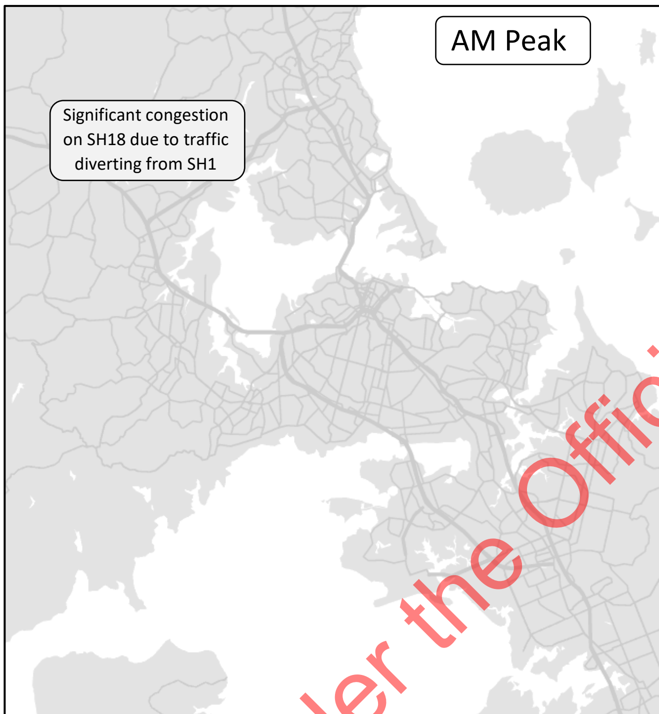


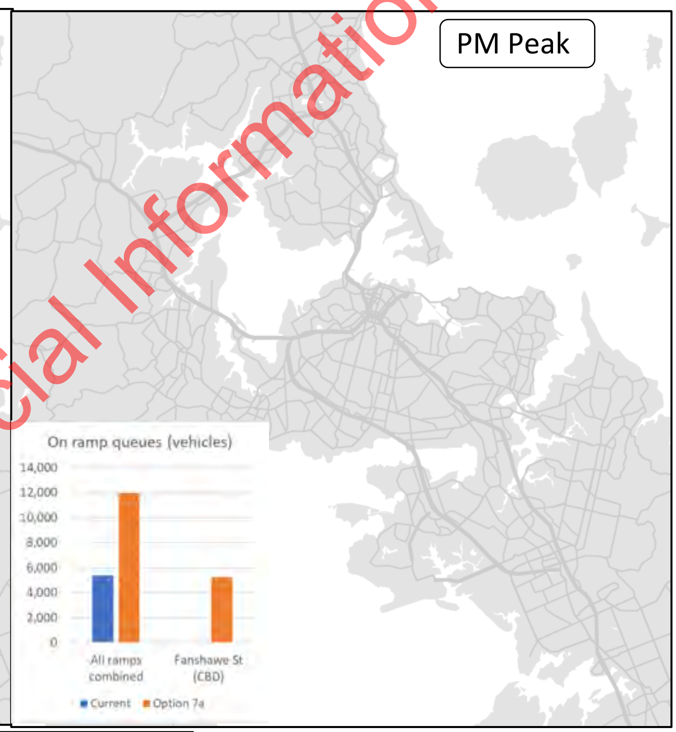


Option 7 – One lane for active modes on western clip-on (Curran on ramp CLOSED).
4 traffic lanes in peak direction, 3 lanes in counter peak direction









Speed scale

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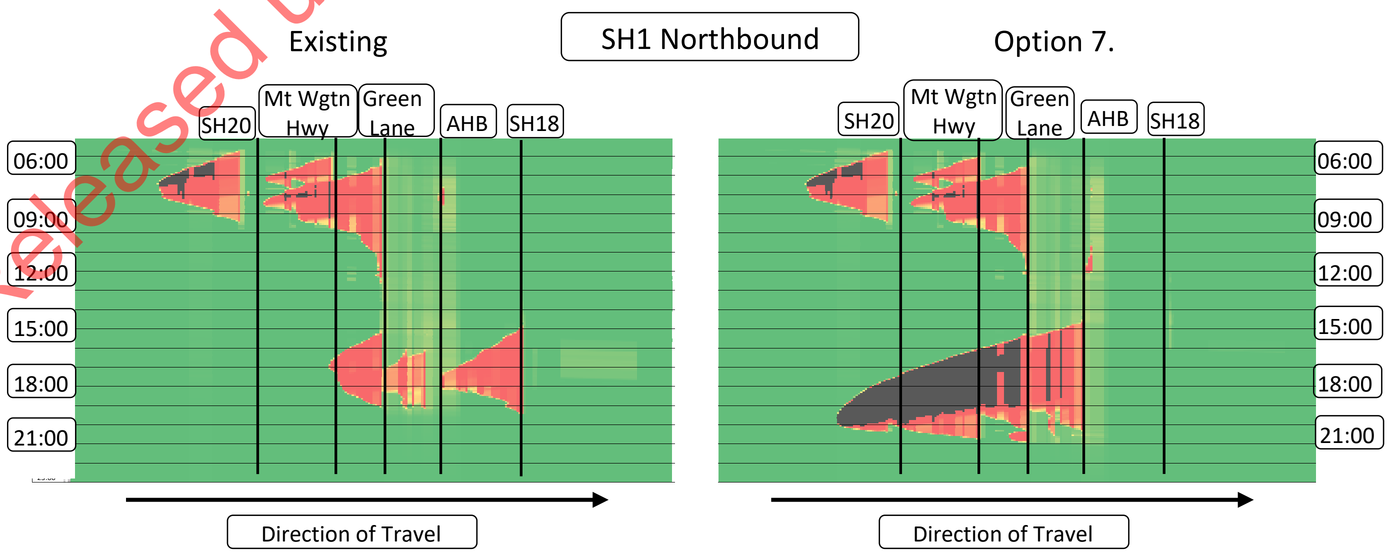
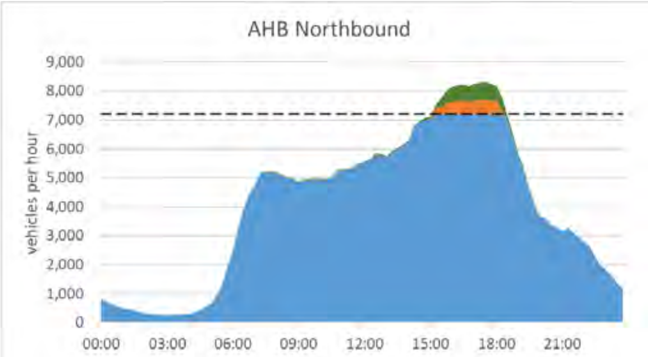
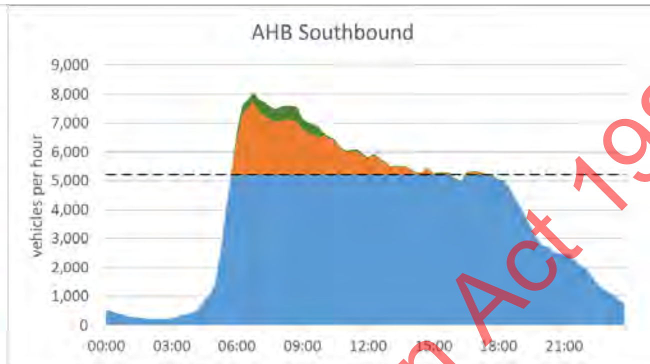
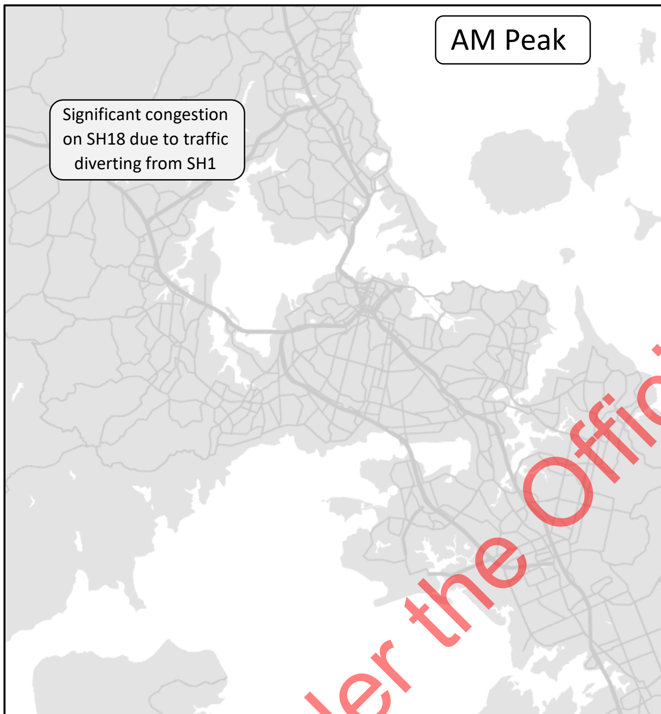
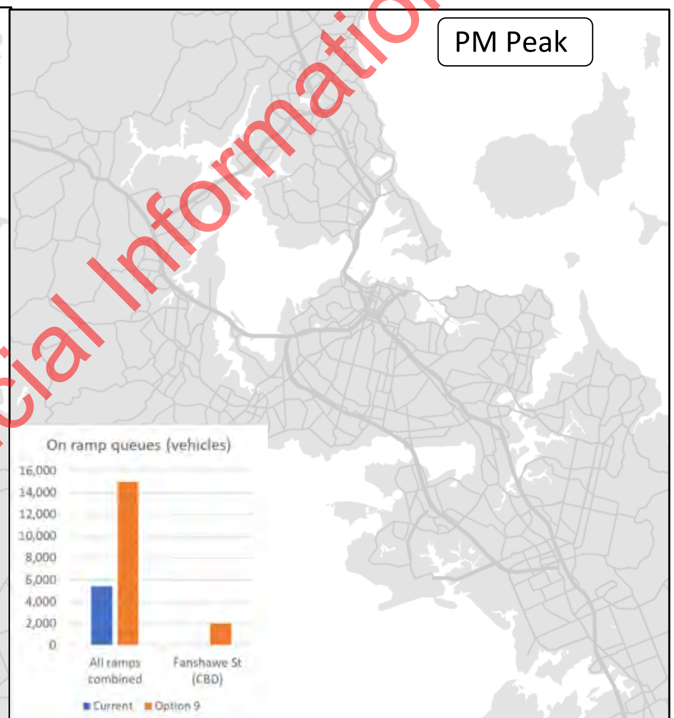


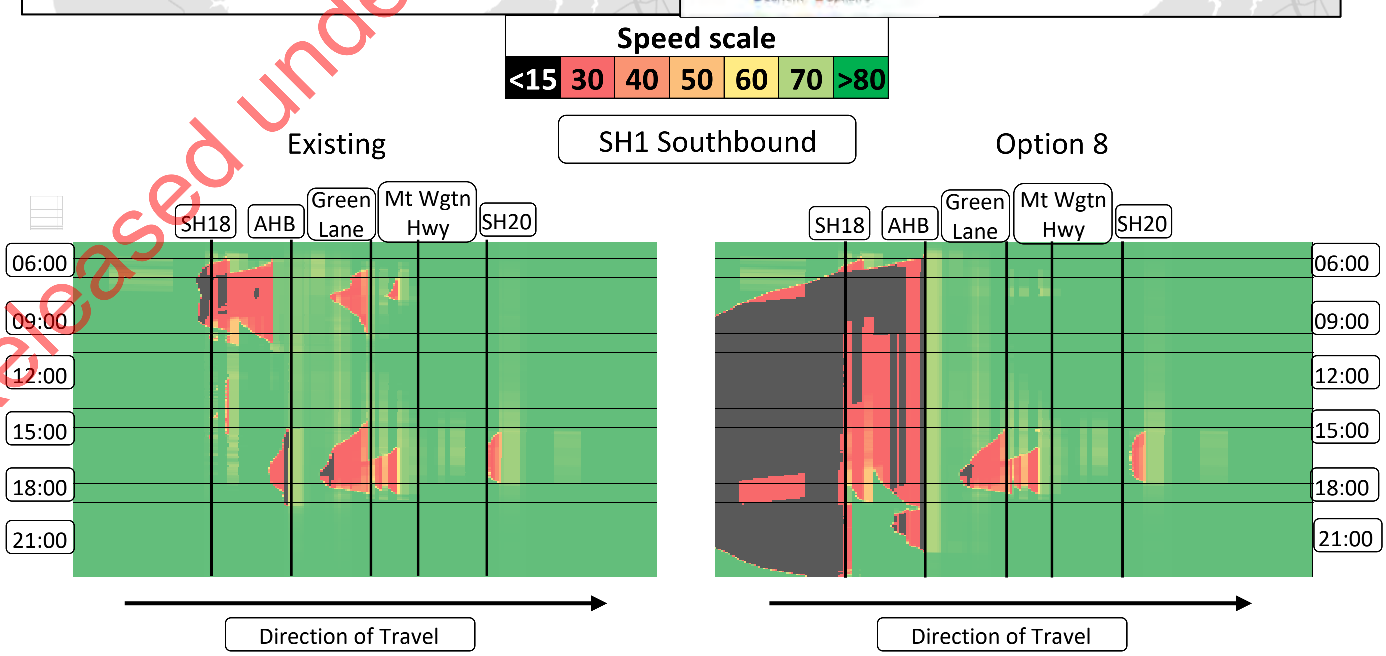
Option 9 – One lane for active modes on main truss.
4 traffic lanes NB (all day), 3 traffic lanes SB (all day)



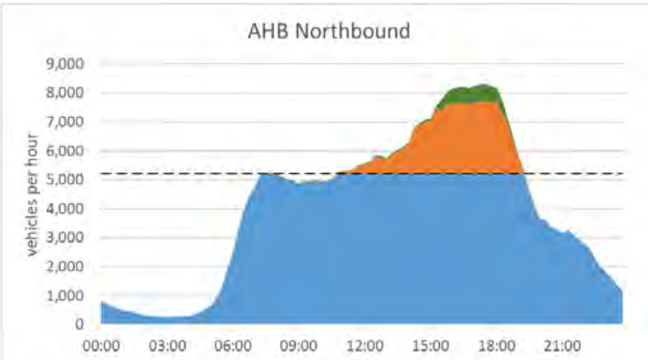


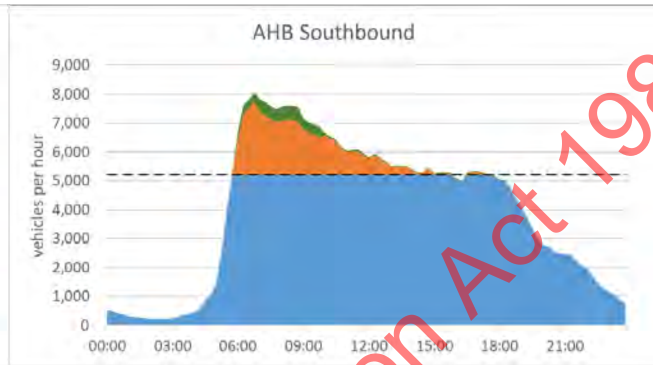


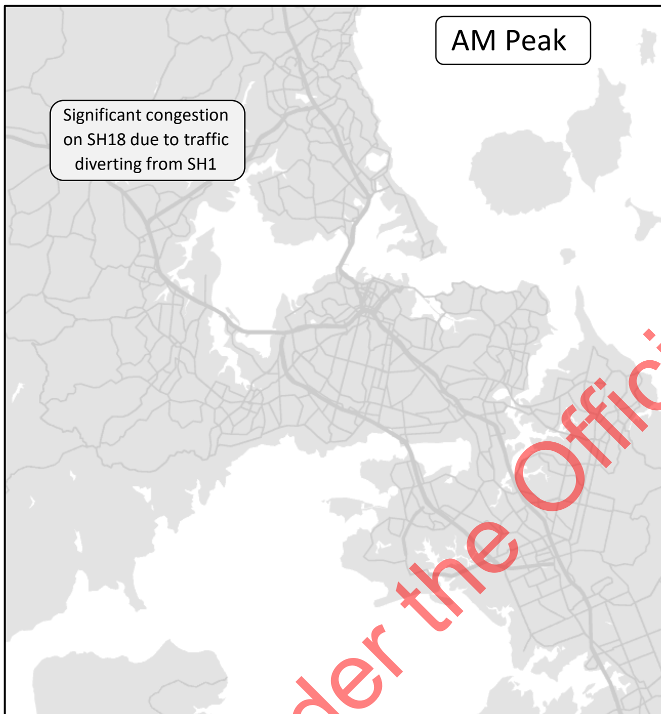


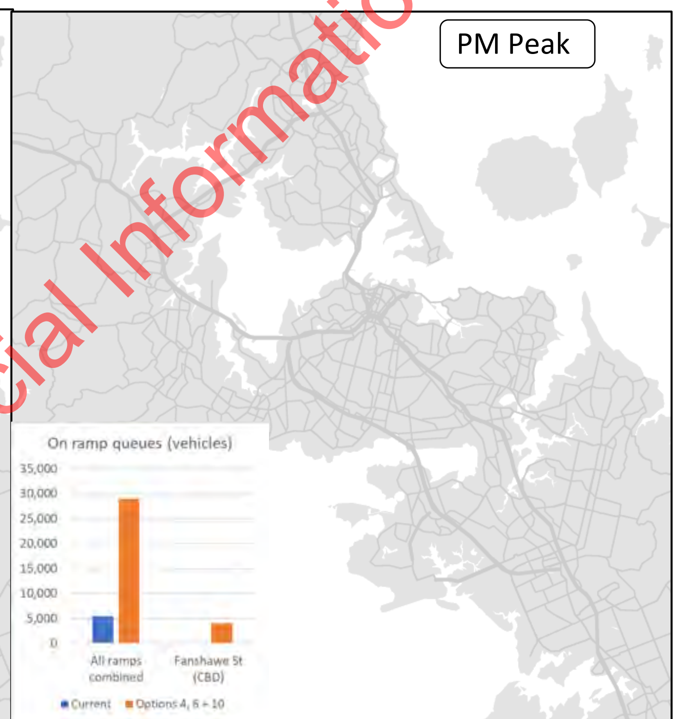


Options 4, 8 one entire clip-on for active modes (two lanes).
Option 10 - 2 lanes for active modes on main truss
3 traffic lanes NB (all day), 3 traffic lanes SB (all day)







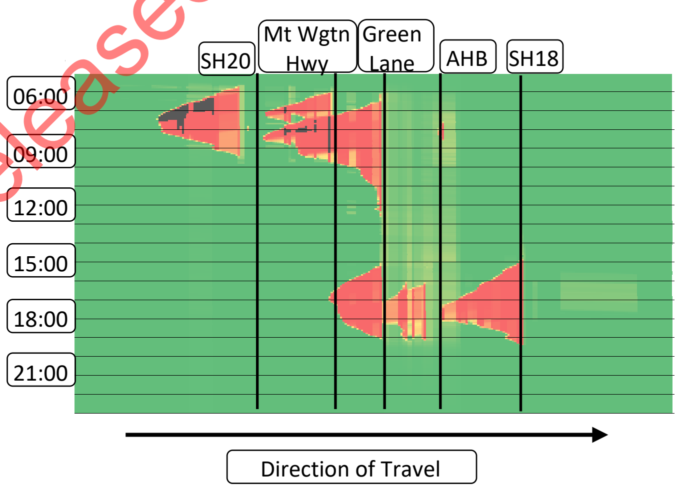


Speed scale

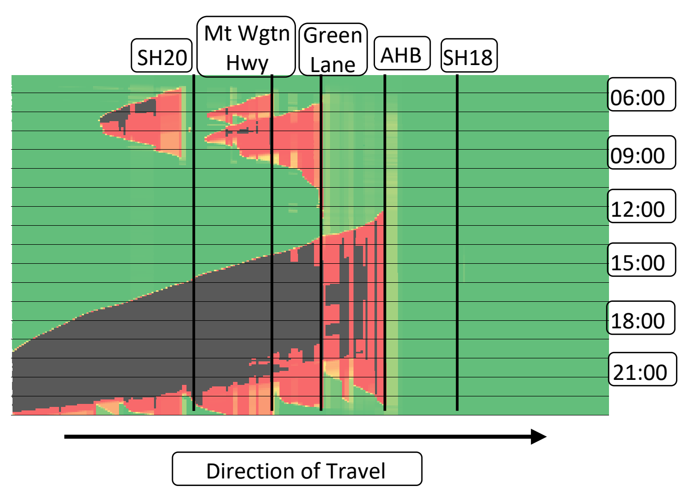
<15	30	40	50	60	70	>80

SH1 Northbound

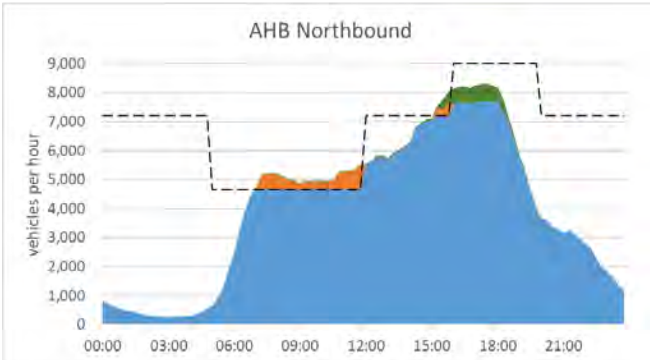
Existing

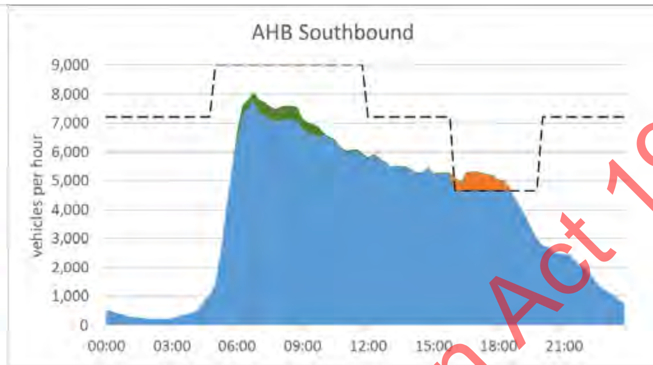


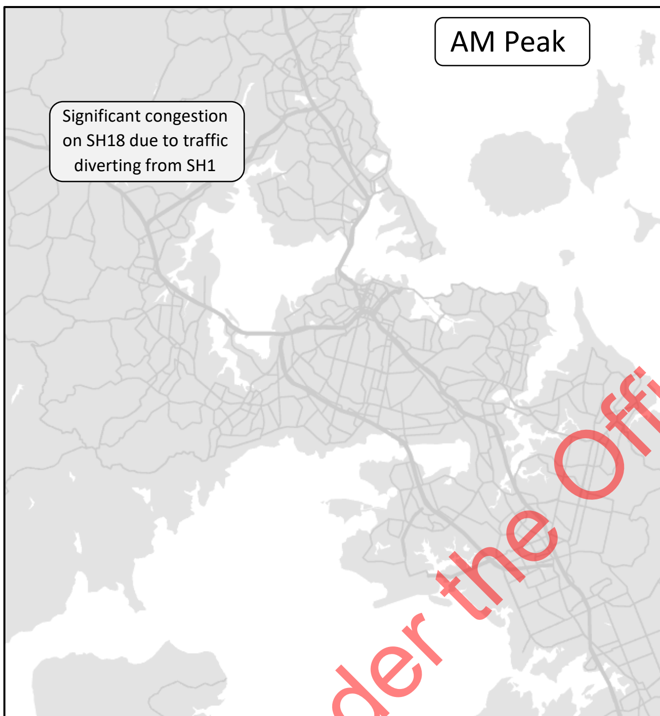
Option 4,8,10

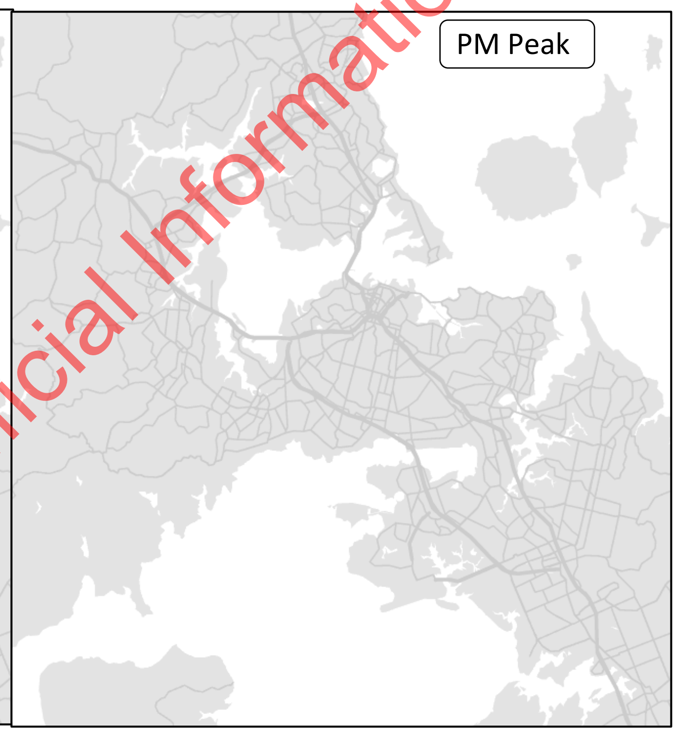


Option 11 – Two lanes for active modes – one on each clip-on (traffic lanes narrowed).
5 traffic lanes in peak direction, 3 lanes in counter peak direction









Effects on Network Resilience

Provide network delay and heatmaps from CTM tests of a 1-lane incident blocking the bridge for 1-hour

- Option 3a vs existing
- AM, IP, PM
- Need to estimate a frequency of occurrence for an annual impact
- Apply Siavash's resilience metric?

Appendices

CTM base model validation report?

Detailed heatmaps