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Ngauranga to Airport Aimsun Model

2022 Model Scenario

LGWM Transformational Programme DBC

Wellington Transport Analytics Unit, Flow, Stantec

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1 Introduction and Background

1.1 Ngauranga to Airport Aimsun Model

The Ngauranga to Airport Aimsun Model (N2AM) is an operational traffic assignment model covering the Wellington CBD area. It extends from roughly the SH1 / SH2 interchange in the north, to the Airport and Miramar area in the southeast.

The model has a base year of 2016 and over time has gone through a series of refinements, adjustments and updates.

The model is managed, overseen, updated and applied by the Wellington Transport Analytics Unit (WTAU), a team within Greater Wellington Regional Council (GWRC).

1.2 Model Update Stages and Reports

The model build commenced in March 2016 and the base year calibration was completed in December 2017 with the publication of Note 15 (TN15), the base calibration report.

In 2019 the N2AM model underwent a software version update and recalibration / revalidation of the meso layer. This is detailed in GWRC report, 'Ngauranga to Airport Aimsun Model, 2019 Recalibration' September 2019. The 2019 meso recalibration work did not carry through, at the time, to an update of the micro-hybrid layer.

Following the 2019 modelling work, the structure of the model was reviewed, tested, and reconsidered. This resulted in the structure of the model being refined to a macro assignment feeding a full microsimulation-only assignment with updated and refined assignment settings.

The testing, work to refine the model structure, updated model settings / inputs / parameters, and resulting calibration and validation outcomes from the macro/micro structured model are described in Stantec report, 'Ngauranga to Airport Aimsun Model – 2021 Micro Calibration, Sept 2021'.

Peer Reviews were carried out of the original base calibration work, the 2019 meso update, and the 2021 restructured model. This work is detailed in several Peer Review reports.

2 2022 Model Scenario

2.1 LGWM Project Background

The Let's Get Wellington Moving (LGWM) Detailed Business Case (DBC) anticipates applying the N2A operational macro/micro model to a range of DBC transport assessment elements. A key element of this will be representing the full Mass Rapid Transport (MRT) option within the N2A model. A range of analyses are anticipated, e.g. corridor travel times, intersection performance, traffic flow analysis etc, and importantly the assessment may extend to informing the traffic economics analyses (i.e. examining the travel time and distance differences between the Do Minimum and Option scenarios).

The N2A model is well suited to this assessment; the form of the model is appropriate to reflect the dynamic operations of the MRT elements, it captures the affect options have on the localised and wider network traffic operation, and the model study area effectively encapsulates the area of traffic influence of the LGWM option.

2.2 2022 Model Scenario Report

This report provides a summary of the data used to develop the 2022 model scenario, the alterations and refinements to the model network and settings, the development of the 2022 demand inputs, and the resulting observed vs. modelling comparisons carried out with the 2022 model scenario.

Waka Kotahi provides model calibration / validation guidance in the Transport Model Development Guidelines (TMDG). Within the TMDG various criteria are listed for a range of model types. The micro layer of N2AM has been calibrated considering Category D targets, defined as a "Transport Agency scheme/project model," as was done for the original 2016 base model development project.

A full calibration / validation has not been carried out on the 2022 N2A model scenario, particularly as the traffic count dataset does not comprehensively cover the wider network. However, the 2022 observed data vs. modelled counts and travel times has been carried out with these TMDG targets in mind.

2.3 Software Version

N2AM was initially calibrated in Aimsun Version 8.1.5. Aimsun Next 20.0.4 was released in September 2021 and was used for the calibration of the N2AM micro model.

3 Transport Data and Model Inputs

3.1 Wellington Transport Strategy Model (WTSM)

The N2A Aimsun operational model is linked with the regional Wellington Transport Strategy Model (WTSM). WTSM provides base year travel pattern data and, importantly, travel demand forecasts to the N2A model. The travel demand forecasts from WTSM that are fed to the N2A model include the effects mode share changes have on the volume and pattern of vehicle demand in the central city study area.

The base year travel pattern data for the 2016 N2A base year model was based on the 2013 WTSM base year.

WTSM has been updated recently. The current base year model is 2018 and a 2023 forecast scenario has also been developed, along with further forecasts beyond 2023.

3.2 COVID-19 Transport Effects & 2016 vs 2022 Data

By late-2022 / 2023 there is on-going discussion and consideration on the affects COVID-19 may be having, and continue to have into the future, on traffic (specifically vehicle movement) volumes, travel patterns, and time-of-day patterns. Possible COVID traffic effects include elements such as increased Working From Home (WFH), which would typically reduce vehicle trips, and decreased use of Public Transport (additionally effected by bus service issues, such as those exacerbated by bus driver shortages), which may increase vehicle trips.

Flow carried out comparisons of the March 2016 and November 2022 intersection turning movement volumes where the same locations were surveyed. Broadly, what this comparison demonstrated was;

- In the 07:00 - 09:00 AM peak, there is a clear general trend for 2022 volumes to be lower than 2016.
- In the 11:00 - 13:00 Inter-Peak and 16:00 - 18:00 PM peak, the results are mixed. In some locations 2022 volumes are lower and in some locations they are higher. Overall the total volume in the Inter Peak is very similar between 2016 and 2022 and the PM peak is around 3-4% lower in 2022.

Differences are also evident between the profile of traffic through the day / peak periods between the 2016 and 2022 data. However, trends or generalised outcomes are difficult to establish from these comparisons.

Flow also carried out travel time comparisons between the TomTom 2016 and 2022 route travel times. This analysis was carried out for the same months and weekdays; Tuesdays, Wednesdays and Thursdays for August-September in both 2016 and 2022. This analysis shows the following outcomes;

- In the AM peak, around 60% of the routes show reduced travel times in 2022.
- In the Inter-Peak, 35% of routes show travel time reductions and 12% show increases (the rest show no change).
- In the PM peak the results are mixed, 30% of routes show reduced travel times in 2022 and 35% show increases (again the rest show no change).

Overall, the AM peak appears to show a more distinct change post-COVID; lower traffic volumes and lower travel times. The IP and PM peaks are mixed with distinct changes or generalised trends difficult to identify.

3.3 2022 Model Scenario Development

A 2022 model scenario has been developed utilising the 2022 observed traffic count and travel time data and the 2018 and 2023 demand inputs from the recently updated version of WTSM. Considering the potential on-going effects of COVID on vehicle traffic outlined above, the decision to develop a 2022 N2A scenario reflects the importance of verifying the N2A model in key areas of the LGWM scheme, the age of the calibrated / validated 2016 model, and the benefit of re-aligning the N2A operational model with the updated WTSM model and shifting away from the 2013 WTSM base year travel pattern data which was the basis for the 2016 N2A base year model.

3.4 2022 Transport Data

To support the LGWM DBC, a traffic data collection exercise was undertaken in late 2022. The traffic counts were collected to cover key areas of the central city and focus on several key corridors outside of the central area which are important to the LGWM options; Kilbirnie and particularly Newtown and Island Bay.

Travel time data, from Waka Kotahi's TomTom system, is available across the network and a comprehensive comparison between 2022 observed and modelled travel times has been carried out.

This data has been used to develop and check the 2022 N2A model scenario against (i.e. report calibration / validation comparisons) and the sections below describe this data further.

3.4.1 2022 Traffic Count Data

38 intersection turning movement surveys were carried out on Wednesday 9th November and Thursday 10th November 2022 (intersections were counted on both days). 15-minute surveys were carried out with vehicle classification of Cars, Trucks, Buses and Cyclists over 13-hours from 06:00am to 19:00pm. The 2016 core intersection turning movement surveys had the same vehicle classification and covered a slightly shorter time period; 06:30-09:30, 11:00-14:00, 15:30-18:30.

The figures below show the locations of the 2022 intersection turning movement surveys followed by the locations of the both the 2016 and 2022 surveys.

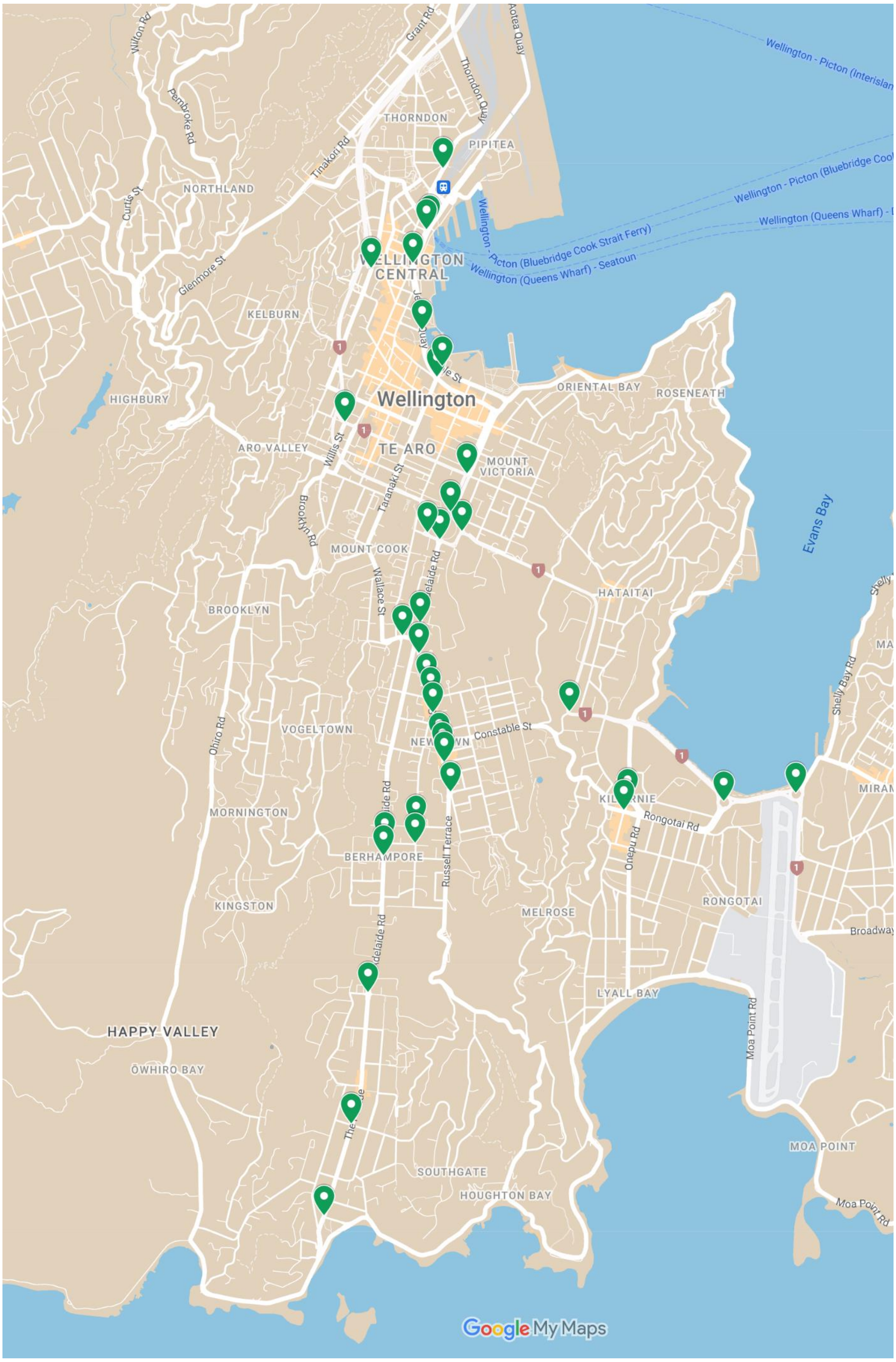


Figure 3-1: 2022 Intersection Turning Movement Surveys (38 Locations)

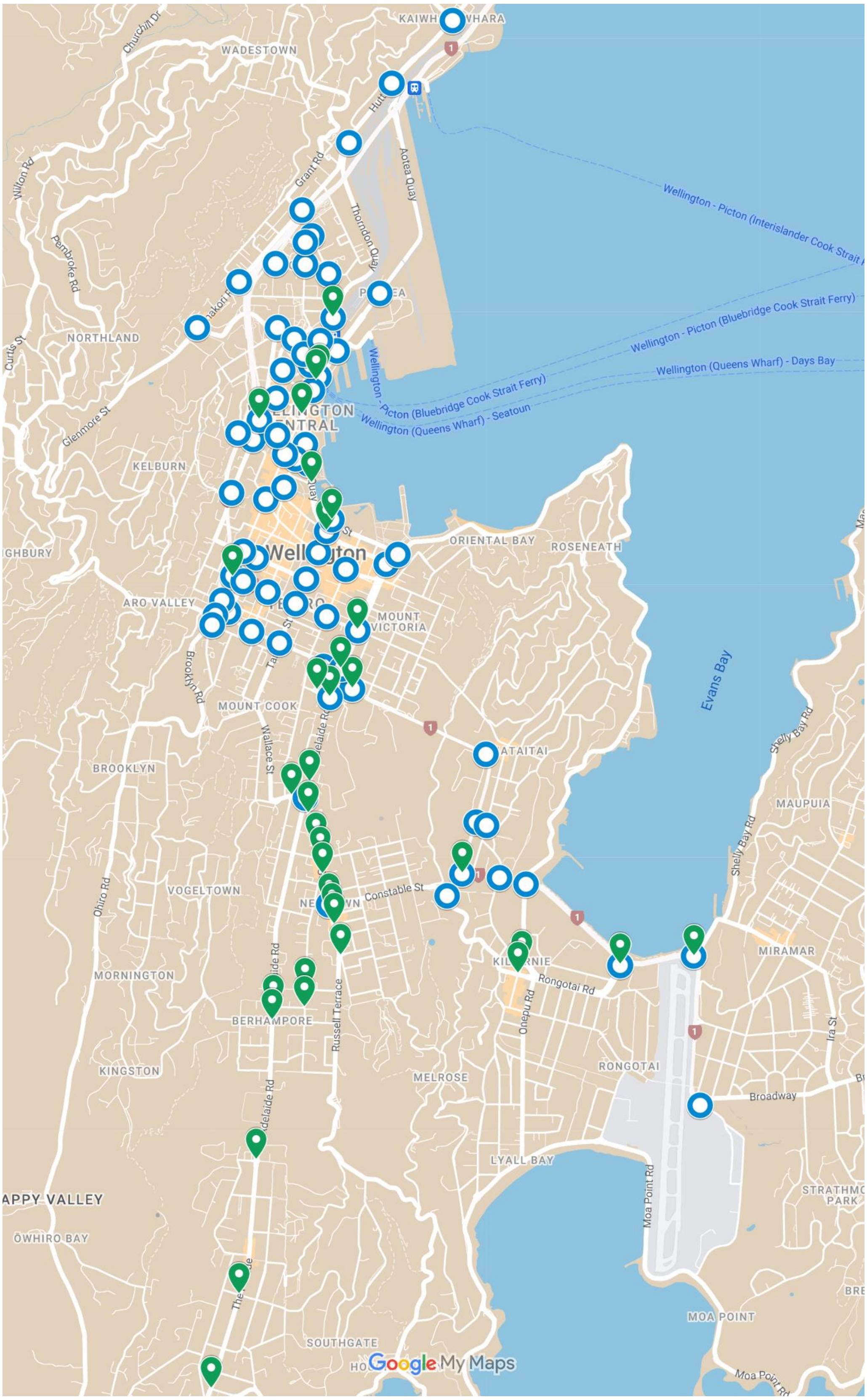


Figure 3-2: Combination of 2022 (Green Arrows) and 2016 (Blue Circle) Intersection Count Locations

3.5 2022 Travel Time Data

The Waka Kotahi TomTom travel time system enables observed travel time data to be extracted for routes through the network and the outputs are provided by distance segments. Travel times can be examined in five percentile increments and for the purposes of checking the model the 15^{th}, 50^{th}, and 85^{th} percentile travel times have been assessed.

Tuesday / Wednesday / Thursday data was extracted across October – November 2022 data in 30-minute time intervals from 06:00am to 18:00pm. A comprehensive set of travel time route data was extracted, 23 routes through the network were defined and these are shown in the two figures below.

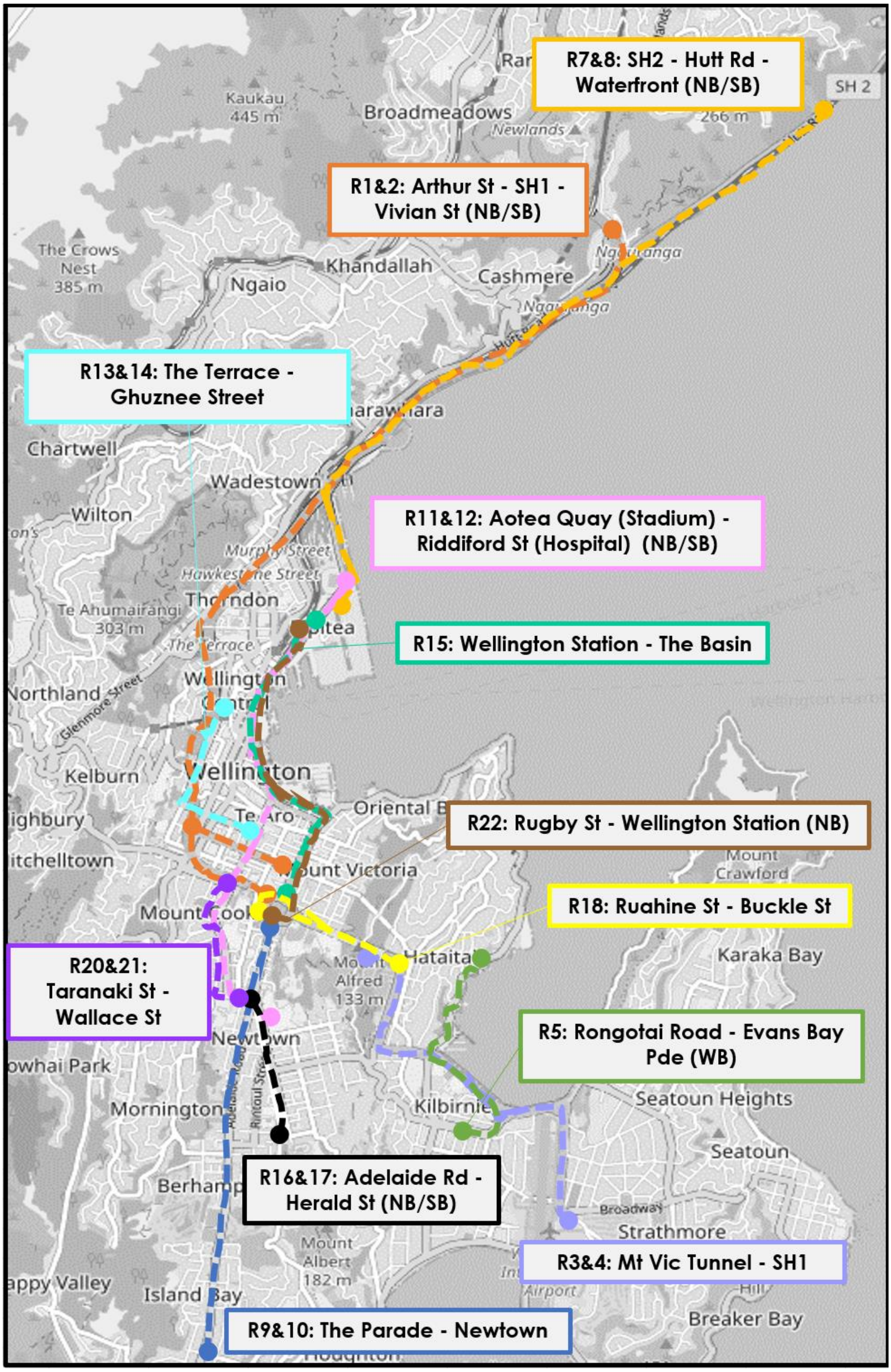


Figure 3-3: TomTom 2022 Observed Travel Time Routes

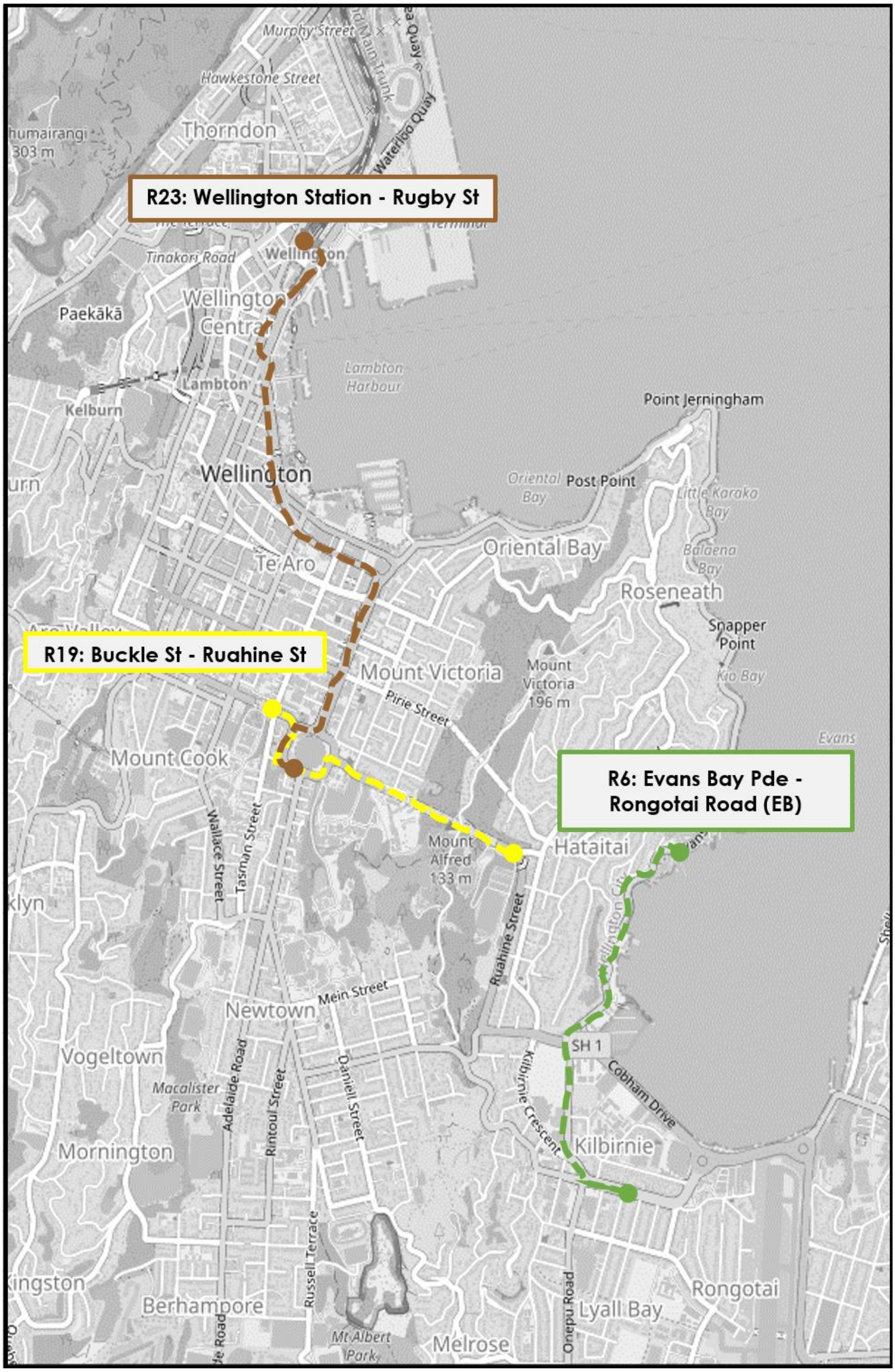


Figure 3-4: TomTom 2022 Observed Travel Time Routes

3.6 Data Used in 2022 Model Checks

The 2022 intersection counts and the 2022 TomTom route travel time data is considered appropriate for checking that the 2022 N2A model scenario (demands refined from the updated WTSM) is appropriately representing traffic flows in key areas around the LGWM scheme and that the modelled performance (vehicle route travel times) are representative of observed conditions across the wider network.

These datasets have been used to carry out a comparison between the 2022 observed and modelled information. Whilst this isn't considered full model calibration / validation, particularly as the 2022 count data does not comprehensively cover the full N2A model study area, these checks provide an indication of the 2022 model scenario robustness in key areas as noted above.

4 2022 Model Updates and Refinements

4.1 Overview

Updates to the Base Year N2A model have been made in order to prepare the N2A model for application to testing the LGWM scheme in its entirety. This has concentrated on ensuring that the model robustly reflects traffic volumes in key locations, is more responsive / adaptable to elements of the LGWM scheme where zone access loading points change more significantly due to the traffic network layout changes associated with the Options, and where possible to improve the general operation and stability of model network.

Subsequently an important point, the previous calibrated version of the model had transit lines turned off, i.e. buses were not represented in the network. At that time there was an unresolved issue with the traffic modelling software which caused buses to unexpectedly stop at arbitrary locations and remain stationary for the remainder of the simulation. Re-implementing the transit lines was a task within the work to prepare the N2A model for application to the LGWM DBC.

4.2 Consolidation of Vehicle Types

The separated static / dynamic vehicle types, and associated demands, were consolidated at an early stage of the model refinement process. This simplifies reporting and the development of Origin-Destination (OD) demands and allows for a more straightforward implementation of High Occupancy Vehicles (HOV) splits if required in future tests.

4.3 Reimplementation of Buses and Model Blocking

Re-implementing the transit lines in the updated software version was carried out alongside some of the initial zone disaggregation refinement work (described below). The result of these changes is that model blocking in simulation runs became significantly more of an issue than in the previous version of the model network. This was not directly associated with the unexpected bus stopping issue described above, network blocking occurred both in areas around some bus-stops but also in general traffic areas throughout the network.

Model blocking is when vehicles within a simulation run become ‘stuck’ and cannot complete their journeys during the simulation period (the demand loading period, followed by the run-out). Blocked runs cannot be used for analysis as the outputs are typically nonsensical.

Due to increased model blocking, the task of updating and refining the 2022 model became more significant than originally anticipated. This work expanded to include refinements and improvements aimed at reducing the occurrence of stuck vehicles and blocked runs. These updates are described in the sections below.

4.4 Zone Disaggregation and Loading Refinement

A key element of the update to the models in preparation for the LGWM DBC scheme testing was reviewing and updating the zoning detail, zone loading points, and splitting zones in key areas in order to improve the representation of vehicle movements in key locations (i.e. main intersections along key corridors).

Zones in Newtown, Island Bay, Miramar and Kilbirnie were reviewed, and 7 of these zones were split while 1 was aggregated (i.e. two zones with unnecessarily high detail were combined to one zone.)

More significantly, through key areas of the network, particularly the northern CBD, many zones which roughly cover a city block had just one or two loading / unloading points. Aimsun has the ability to include multiple connection points to/from zones and therefore the model has been improved with a number of zones having additional loading / unloading connections added. Where this adjustment was made, connections were increased to two, three or four loading points. The figure below shows an example of an area of zones where additional connections were added to the zones in central areas of the CBD. The image on the left shows the 2016 Base Model centroid connections around Grey and Victoria Street, and the additional zone connections in the 2022 model on the right.

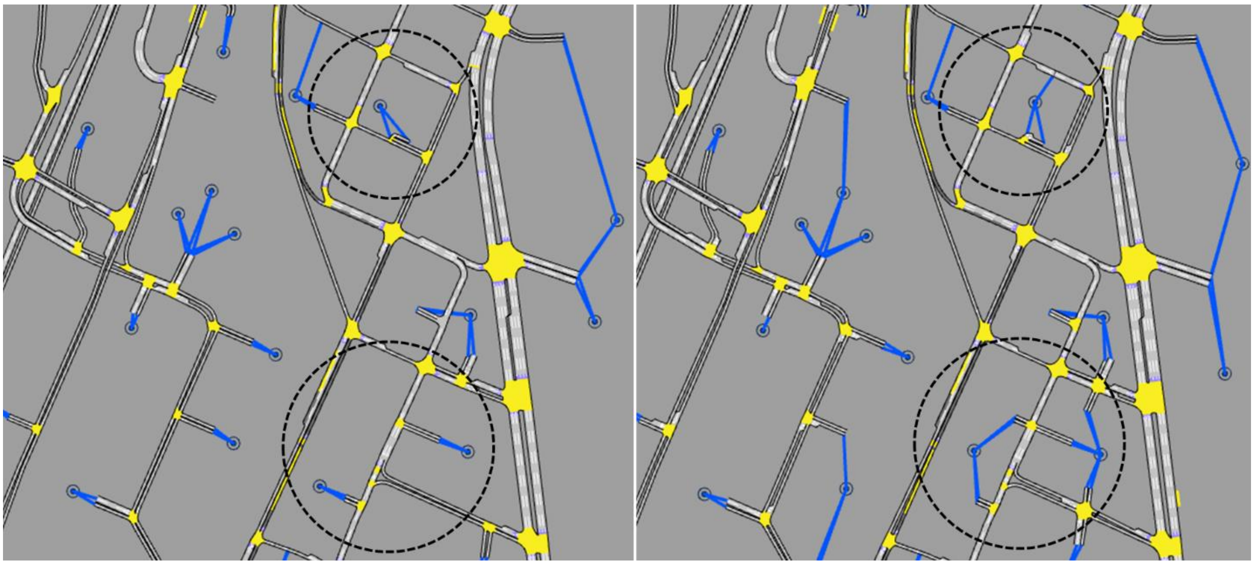


Figure 4-1: 2016 Base Model and 2022 Model Scenario with Additional Zone Connections

4.5 Refinements to Reduce Blocking

There are two more common reasons for a simulation model run to block. Either a vehicle literally becomes 'stuck', often in the central area of a priority intersection, a stalemate occurs with other vehicles in the network that are unable to pass the stuck vehicle, and larges queues of blocked vehicles form around this incident. Or a queue forms on an approach to an intersection, this queue interacts with an adjacent intersection, and this effect cascades. If this queue->intersection->queue->intersection etc. effect occurs in certain areas of the (e.g. denser grid network locations), again a stalemate can occur where the series of queues block each other and vehicles become stuck.

The refinements that are described in the sections below were specifically carried out to target either or both blocking issues.

4.5.1 Right Turn Bay Representation

Right turn bays were not coded in some locations in the model where either separate marked bays exist, or the road width / carriageway would allow following through vehicles to navigate around a stationary vehicle waiting to turn right. This resulted in higher levels of queueing where a single stationary right turning vehicle blocked the following straight through traffic.

A comprehensive review of the representation right bays was carried, and additional right turn bays included. This strategy erred towards a liberal interpretation of the space available to navigate around waiting right turners. The model is a simplified representation of the on-ground environment, along a stretch of road not every access point is represented and therefore right turn movements can be concentrated into one location along a modelled road section. To reflect the reality that right turners only intermittently block through traffic, short turn bays were added unless there was clearly a physically constrained road environment and no room to navigate around waiting right turning vehicles. Right turn bay lengths need to be at least as long as the longest vehicle type represented in the model (12m bus) in order to prevent vehicles becoming lost and circulating through the network.

Subsequently, it was determined that some of these additional right turn bays led to a high number of ‘missed turns’ in the Base model. This is where vehicles in the Aimsun modelled network do not enter the correct lane to make a turn and continue along an alternative route, hence ‘missing’ the turn. These vehicles then navigate through the network to reach their destination, making circuitous trips. This was corrected where possible, and in some cases, this resulted in right turn bays being removed.

4.5.2 Roundabout Coding

The model coding at roundabouts was reviewed and adjusted to improve vehicle behaviour and operation. Importantly, the ‘visibility along mainstream’ parameter was reduced at roundabouts in the network so that vehicles approaching the roundabout would only look into the circulating carriageway of the roundabout when giving-way. If the ‘visibility along mainstream’ parameter is set inappropriately high vehicles may look some distance along approach links feeding into the roundabout and, again, this can lead to long queues forming and ‘stuck’ vehicles.

4.5.3 Off-set Priority Intersections and Zone Loaders

A common model layout where queues and stuck vehicles interact are locations where there is only a short distance between two priority intersections (often zone loaders) along a road section. This is particularly the case where the priority intersections are ‘offset’, e.g., when the side arm is on the south side of the main road at one intersection and on the north side of the main road at the immediately adjacent intersection. With this layout, right turners turning out of the side arms of each intersection could block through traffic causing a stalemate.

Where possible, the space between off-set priority intersections and zone loaders was increased to reduce the occurrences of these blockages.

4.5.4 Yellow Box Parameters

‘Yellow Box’ settings in Aimsun are an element which has an important influence over whether vehicles become ‘stuck’ in the central part of the intersection. A yellow box should stop a vehicle on a lower priority movement turning into an intersection when there is a queue in the downstream link, i.e. when the vehicle cannot freely make the complete turn. The ‘yellow box’ settings and parameters have a direct effect on vehicles becoming stuck in central areas of intersections.

The previous N2AM specified a large number of turns with the ‘Yellow Box Speed’ = 0, that allows vehicles to enter the yellow boxes when the traffic is stationary at downstream section. This essentially increases the chance of network gridlocking due to vehicles stuck in the middle of intersections and blocking other movements. The current model version has significantly reduced the number of that behaviour, most of the 0 speed ‘Yellow Box Speed’ in the new model are associated with the roundabouts to prevent vehicle to stay on circulating lanes. The locations of 0 ‘Yellow Box Speed’ of the previous and current models are shown in the Figure 4-2:

Before (2016 Base Model)	After (2022 Base Model)

Figure 4-2: Locations of 0 ‘Yellow Box Speed’ in the two model’s versions

4.6 2022 Network Layout Review And Update

The base year network layout was reviewed and updated to reflect the 2022 on-street environment. There were two elements to this; firstly the details of known traffic projects and upgrades (e.g. intersection layout changes) were established and incorporated in the model and secondly a review of 2022 aerial photography was carried out to identify any further network changes since 2016. The major adjustments made to reflect the 2022 on-street environment were as follows;

- SH1 Ngauranga to Aotea Quay northbound 4-laning
- Temporary construction management along Wakefield Street and Jervois Quay
- Ruahine Street speed limit reduction
- Riddiford Street speed limit reduction
- SH1 Cobham Street speed limit reduction (between Troy Street and Evans Bay Parade)
- Whitmore Street layout changes
- Cobham Street (SH1) / Evans Bay Parade intersection layout changes
- New roundabout layout at the Te Aroha Trl/Great Harbour Way intersection

4.7 Signal Timing Review and Adjustment

Over the series of N2A model updates the model signal timings and settings have undergone a series of updates and adjustments. For the 2022 model scenario, SCATS history files were downloaded for every signalised intersection in the network for Wednesday 9 November. These files contain the start / end times of every phase as occurred on-street across this day, this enables peak timings to be established along with phase call frequencies, green time variation, cycle times etc. This data was used for three key updates/checks;

- The 2022 observed SCATS signal timings for intersections where layout changes and updates have occurred since 2016 were entered directly into the model in these locations.

- Because alterations and refinements to signal timings have been made over time in the N2A model, a spot check was carried out at a small number of key intersections (e.g. along the critical central SH1 one-way corridors) to confirm that the timings in the model currently remained within a reasonable range of the 2022 observed signal timings. This was confirmed to be the case, the phase times reviewed were largely within 10-seconds of observed.

- The coordination of signals along the one-way corridors during peak times was reviewed and confirmed by verifying that the average cycle time over the peak-hours was consistent between intersections along the key corridors.

4.8 Road Type Review and Refinement

During the work to refine the model operation and reduce blocking it was observed that a higher-than-desirable number of vehicles were re-routeing through a residential street in response to a relatively small delay. This prompted a review of the how the road types have been selected and applied in areas of the network and the appropriateness of the user defined cost factors by road type. The cost factors reflect the attractiveness / unattractiveness of the road types as applied through the wider network. It is generally important in dynamic operational modelling that lower level routes such as residential streets have distinctly higher cost factors so that rerouting onto these local roads is not over represented in the model.

The road types were updated in key areas and the table below provides the list of road types and associated cost factors.

Table 1: List of Road Types and User Defined Cost Factor

Name	Speed	Section Cost
CBD/Shopping - high friction	30	2.5
CBD/Shopping - low friction	40	1.6
CBD/Shopping - medium friction	40	2.0
Collector - low friction / good alignment	50	1.2
Collector - high friction / poor alignment	50	1.5
Expressway / Motorway - low speed	80	0.9
Local High Speed Street	50	1.6
Motorway	100	0.85
Urban arterial - medium speed	60	1.2
Urban Arterial - low speed	50	1.2
Hill / Curve Sections	25	2.0
On / Off Ramps	70	0.95
Rural - restricted speed (Not Used)	70	1.2
Rural - unrestricted speed (Not Used)	100	1.2
Rural state highway (Not Used)	80	1.0
Terrace Tunnel	70	0.9
Urban arterial - high speed	70	1.2
Nguaranga Merges	100	0.85
Lambton Quay - 30km/h	30	1.2
Oriential Parade	50	0.9
Urban Arterial - low speed - Vic Tunnel	50	1.2
Local Access Road	25	3.0
Great Harbour Way/Thorndon Quay	50	0.9

5 2022 Demand Development

5.1 Origin-Destination (OD) Demand Adjustment Process

As described earlier, an important element of the N2A 2022 scenario development is updating the Aimsun operational model linkage with the recently updated WTSM regional strategic transport model. A series of Origin-Destination (OD) adjustment layers were developed in order to refine the 2016 demands to reflect the 2022 environment. A key element of this was incorporating the updated version of WTSM by developing an adjustment layer which reflects OD travel pattern changes between the older base year (2016/18) and the current traffic environment (2022/23). The adjustment layers are shown diagrammatically in the figure below.

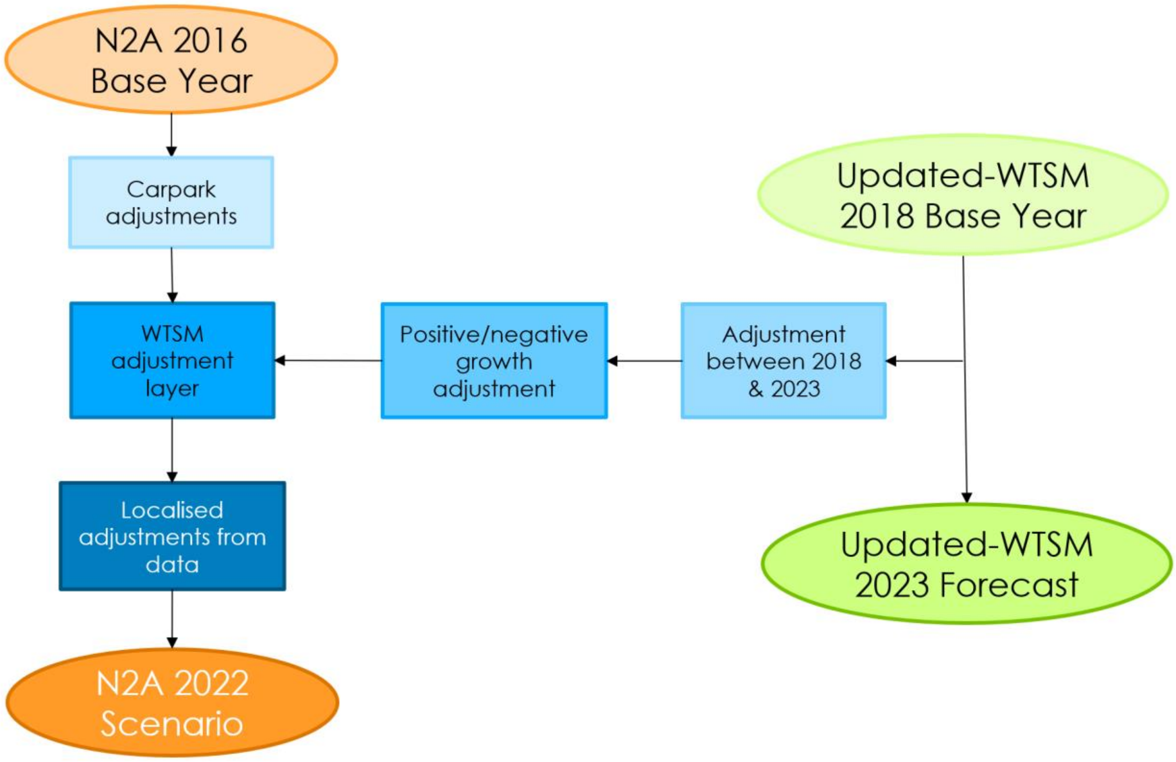


Figure 5-1: Demand Adjustment Process to Develop 2022 Scenario

The adjustment layers and process are described further below.

- **Carpark adjustments**: Between 2016 and 2022 the carpark building on Tory Street / Wakefield Street was demolished (Reading Cinema site). A proportion of vehicle trips to/from this zone were allocated to the carparking locations in nearby central city vicinity.

- **WTSM growth adjustments:** WTSM OD growth was estimated from 2018 and 2023 cordons matrices which are passed through the N2A disaggregation system (i.e. cordon matrices converted to the N2A zone system). The positive and negative OD cell changes were reviewed and +/- growth levels adjusted so that the overall broad matrix changes were in-line with the traffic volume changes anticipated through the comparison of the 2016 and 2022 traffic count data.

- **Localised adjustments based on data:** As a final step, an additional layer of localised adjustments was included to improve the representation of turning movements at key locations based on the 2022 observed count data.

The table below provides the demand matrix totals for the N2A 2016 base year and 2022 scenario and includes the totals for the adjustment layers.

The “WTSM Adjustment” layer includes the growth adjustment to ODs as noted above, i.e. it is not the raw unadjusted cordon change predicted in the study area by WTSM between 2018 and 2023. The process allowed for the calculation and inclusion of an expansion factor to expand the WTSM 3-hour cordons to 4-hour cordons. However, as shown in the tables below, largely the requirement was to *reduce* the 2016 Aimsun N2A study area demands to align with the 2022 observed count data and therefore an expansion factor was not required.

Table 2: OD Adjust Layer Totals and Final 2022 Scenario Demand Levels

AM 4-Hour Modelled Period	Light	Heavy	Total
2016 Base Year	97,996	4,276	**102,272**
Carpark Adjustment	-12	0	**-12**
WTSM Adjustment	-1,047	0	**-1,048**
OD Refinement	1,810	214	**2,024**
2022 Total	98,746	4,489	**103,236**
% Difference to 2016	0.8%	4.8%	**0.9%**

Inter-Peak 4-Hour Modelled Period	Light	Heavy	Total
2016 Base Year	105,689	6,393	**112,082**
Carpark Adjustment	-6	0	**-6**
WTSM Adjustment	-1,493	-92	**-1,584**
OD Refinement	4,049	-630	**3,419**
2022 Total	108,240	5,671	**113,911**
% Difference to 2016	2.4%	-12.7%	**1.6%**

PM 4-Hour Modelled Period	Light	Heavy	Total
2016 Base Year	146,290	4,021	**150,311**
Carpark Adjustment	-17	0	**-18**
WTSM Adjustment	-7,243	-17	**-7,260**
OD Refinement	-5,448	-901	**-6,349**
2022 Total	133,582	3,103	**136,685**
% Difference to 2016	-9.5%	-29.6%	**-10.0%**

The tables above indicate that the more significant changes were made in the PM peak period where the overall demand has reduced by 10%. The turn count XY scatter plots (Appendix A) which provide the general modelled traffic flow trend compared to the 2022 observed turn counts indicate that the PM peak modelled volumes in the two key central modelled hours are broadly well matched to the observed volume levels, with a tendency to be slightly higher than observed overall.

This indicates that the above demand reduction in the PM peak was necessary to reflect the broad overall 2022 observed traffic volumes.

The changes in the AM and IP, around 1-2% traffic growth, reflect the anecdotal trend / observation anticipated between 2016, through the COVID period, and into the 2022/23 period, i.e. that COVID may have suppressed the more typically 2% per annum vehicle growth rate and result in a lower level of traffic growth through this 6-year period.

5.2 2022 Demand Release Profiles

The comparison between the 2016 and 2022 traffic count data indicated that there were some changes in the departure patterns of trips in different areas of the network. Again, this was more evident in the AM peak where later departure profiles in 2022 may be linked with reduced volumes and reduced delays.

To reflect the post-COVID traffic environment the demand release profiles were redeveloped utilsing the 2022 data. A similar process to the 2016 base year profiles method was used; sectors were identified and where data was available unique sector-to-sector profiles were estimated. This process concentrated on using the 2022 count data as far as feasible, with to use Waka Kotahi 2022 TMS linkcounts in key locations (e.g. from SH1 and SH2 north), and the 2016 counts in areas where 2022 counts were not available.

19 sectors were identified, very similar to the 2016 model, and are shown in the figure below.

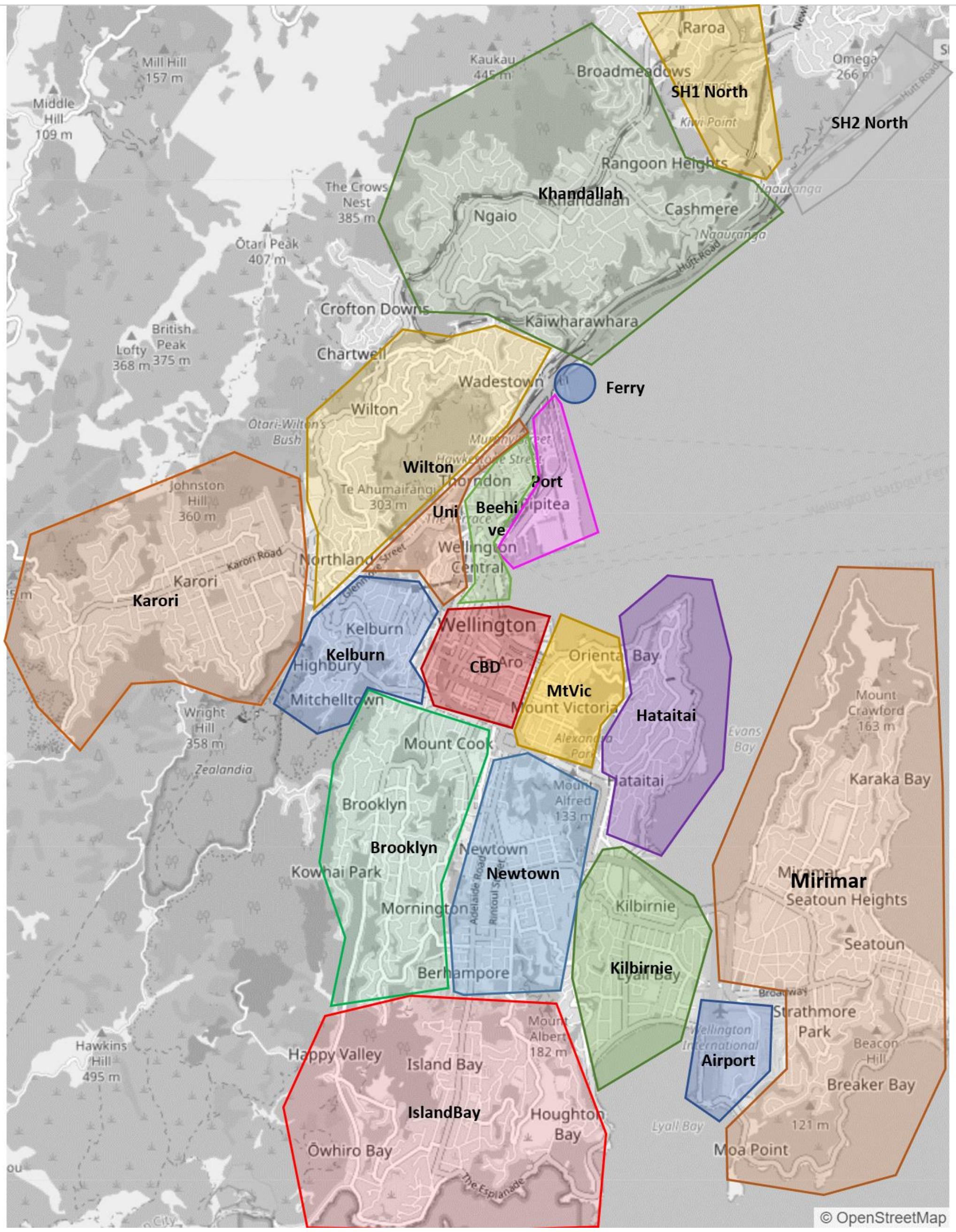


Figure 5-2: N2A 2022 Sectors Used to Develop Demand Release Profiles

Demand release profiles were developed in 15-minute intervals and applied to the 4-hour OD demands based on the sector-to-sector movements. The following minor adjustments and refinements were made to the raw estimated percentage releases from the count data;

1. Where 2016 data was used, the first and last 30-minutes profiles was synthesized based on the 2022 profile in these time-slices.

2. A small load/unload adjustment was made to the first two 15-minute time slices (upwards) the last two time-slices (downwards) to account for vehicles loading into the network and unloading at the end of the simulation period. This adjustment was applied to all profiles and is made in addition to the 15-min Aimsun 'warm up' pre model demand period. The observed vs modelled

turn count XY scatter graphs were used to verify that the overall modelled hour-to-hour traffic volume patterns aligned with the observed levels and one iteration was carried out to refine the level of load/unload adjustment in the profiling.

3. Profiles that were developed from counts some distance from the origin sector location were times-shifted forwards to account for travel time between the count location and vehicles trip origin. This was only necessary for one profile, the SH1-North inbound profile where in the AM peak the observed count is a result of a demand profile from trip origins some distance from the count.

4. A congestion adjustment was made to profiles that were developed from counts that 'flatten' (and sometimes dip downwards before increasing again) through peak period in locations where queues / delays occur. Use of the raw count data in these situations results in the profile not reflecting the true demand departure pattern, rather the observed throughput. Four profiles had congestion adjustments applied.

The SH1-North inbound profile was the only profile that included three adjustments; load/unload, timeshift, and congestion. Three other profiles just had loading/unloading and congestion adjustments applied. Two examples, including the SH1-North inbound profile, are provided in Appendix B.

In total 49 profiles were developed separately for Light and Heavy vehicle types (98 in total) and these are listed in the table below.

Table 3: 2022 N2A Model Scenario List of Profiles

Ref	From	To
1	All / General	
2	Mirimar	City
3	Mirimar	Kilbirnie
4	Airport	Kilbirnie
5	Airport	Mirimar
6	Airport	City
7	Kilbirnie	Kilbirnie
8	Kilbirnie	Airport
9	Kilbirnie	Mirimar
10	Kilbirnie	City
11	IslandBay	Brooklyn
12	IslandBay	Newtown
13	Island Bay	City
14	Brooklyn	IslandBay
15	Brooklyn	Newtown
16	Brooklyn	City
17	Newtown	IslandBay
18	Newtown	Brooklyn
19	Newtown	City
20	Newtown	Mirimar
21	Newtown	Airport
22	Kelburn	All
23	Karori	All
24	Wilton	All
25	Khandallah	SH1 North
26	Khandallah	SH2 North
27	Khandallah	City
28	SH1 North	All
29	SH2 North	All
30	Ferry	All
31	Port	SH1 North
32	Port	SH2 North
33	Port	City
34	Hataitai	Mirimar
35	Hataitai	Kilbirnie
36	Hataitai	Airport
37	Hataitai	City
38	MtVic	All
39	Beehive	Wilton
40	Beehive	North
41	Beehive	City
42	Uni	North
43	Uni	City
44	CBD	North
45	CBD	CBD
46	CBD	East
47	CBD	South
48	Hospital	South
49	Hospital	City

6 2022 Scenario Comparison with Observed Data

6.1 Overview of 2022 Comparisons

As noted, full model calibration / validation utilising the 2022 count data is not possible as the network coverage of the intersection turning movement surveys is concentrated in certain areas and not as widespread across the network as would be desired for a fuller model update / redevelopment process. Comparisons between the N2AM 2022 model scenario and the 2022 count data have been carried out and should be considered as indicative checks on the robustness of the N2A 2022 model scenario.

It is not possible to form robust screenlines from the 2022 observed count data, therefore the key count comparison is the individual turning movement volume comparison.

The screenline comparison has been carried out by comparing the 2016 modelled flows with the 2022 modelled flows in order to check the level of change in flow across screenlines in the 2022 model.

The 2022 travel time route data does cover the network comprehensively. However, because the 2022 traffic volumes have not been checked, refined, and updated in all areas of the network, the 2022 travel time route comparison isn't considered fully comprehensive (robust modelled traffic volumes in all locations would be required to produce robust modelled travel times across all locations).

The sections below present the 2022 turn count comparison, the 2016 vs. 2022 screenline comparisons, and the 2022 travel time comparisons.

6.2 2022 Turn Count Comparisons

The figure below provides the Waka Kotahi / NZ Modelling User Group Transport Model Development Guidelines (TMDG) count comparison calibration / validation targets. The N2A model has generally considered the targets for model purpose C (urban area) and D (Waka Kotahi project) and the results below are discussed in the context of these targets. The bottom section of this table provides the targets for individual turning movement comparison.

COUNT COMPARISON	PURPOSE CATEGORY						
	A: REGIONAL	B: STRATEGIC NETWORK	C: URBAN AREA	D: NZ TRANSPORT AGENCY PROJECT	E: SMALL AREA /CORRIDOR	F: INTERSECTION / SHORT CORRIDOR	G: HIGH FLOW, SPEED, MULTI LANE
TOTAL DIRECTIONAL COUNT ACROSS SCREENLINE:							
GEH<5.0 (% OF SCREENLINES)	>60%	>75%	>85%	>90%	NA	NA	NA
GEH<7.5 (% OF SCREENLINES)	>75%	>85%	>90%	>95%	NA	NA	NA
GEH<10.0 (% OF SCREENLINES)	>90%	>95%	>95%	100%	NA	NA	NA
INDIVIDUAL DIRECTIONAL LINK COUNT ON SCREENLINES:							
GEH<5.0 (% OF COUNTS)	>65%	>80%	>85%	>87.5%	NA	NA	>90%
GEH<7.5 (% OF COUNTS)	>75%	>85%	>90%	>92.5%	NA	NA	>95%
GEH<10.0 (% OF COUNTS)	>85%	>90%	>95%	>97.5%	NA	NA	100%
GEH<12.0 (% OF COUNTS)	>95%	>95%	100%	100%	NA	NA	100%
INDIVIDUAL TURNING MOVEMENTS AND / OR DIRECTIONAL LINK COUNTS:							
GEH<5.0 (% OF TURNS)	NA	>75%	>80%	>82.5%	>85%	>95%	>85%
GEH<7.5 (% OF TURNS)	NA	>80%	>85%	>87.5%	>90%	100%	>90%
GEH<10.0 (% OF TURNS)	NA	>85%	>90%	>92.5%	>95%	100%	>95%

Figure 6-1. TMDG Screenline Total, Screenline Individual Links, and Individual Turning Movement Criteria

The tables below provide the GEH summaries comparing the 2022 N2A modelled turning movements with the 2022 observed data. An additional GEH level has been included, 6.5, which does not have a TMDG target. This has been included to indicate the percentage of movements between a GEH of 5.0 (requires the closest match between observed and modelled) and GEH of 7.5 (higher GEH values indicate a greater difference between observed and modelled values).

All four modelled hours are presented, the main focus is on the two central modelled hours in each time period.

Table 4: 2022 N2A Model Scenario Compared with 2022 Intersection Turning Movement Surveys

GEH Summary	TMDG Criteria		AM Peak							
			0600-0700		0700-0800		0800-0900		0900-1000	
	Cat C	Cat D	Total	%	Total	%	Total	%	Total	%
GEH < 5.0	80%	82.50%	214	86%	199	76%	177	68%	181	69%
GEH < 6.5	NA	NA	235	94%	222	85%	209	80%	210	80%
GEH < 7.5	85%	87.50%	241	96%	232	89%	227	87%	222	85%
GEH < 10.0	90%	92.50%	248	99%	253	97%	249	95%	253	97%

GEH Summary	TMDG Criteria		IP Peak							
			1000-1100		1100-1200		1200-1300		1300-1400	
	Cat C	Cat D	Total	%	Total	%	Total	%	Total	%
GEH < 5.0	80%	82.50%	191	73%	194	75%	181	70%	192	74%
GEH < 6.5	NA	NA	218	83%	223	89%	209	80%	220	88%
GEH < 7.5	85%	87.50%	238	91%	236	91%	230	89%	231	89%
GEH < 10.0	90%	92.50%	256	98%	257	99%	249	97%	252	97%

GEH Summary	TMDG Criteria		PM Peak							
			1500-1600		1600-1700		1700-1800		1800-1900	
	Cat C	Cat D	Total	%	Total	%	Total	%	Total	%
GEH < 5.0	80%	82.50%	182	69%	180	68%	176	67%	186	71%
GEH < 6.5	NA	NA	213	85%	207	83%	212	85%	214	86%
GEH < 7.5	85%	87.50%	228	87%	225	85%	225	86%	226	86%
GEH < 10.0	90%	92.50%	257	98%	249	94%	256	98%	252	96%

The tables above indicate that the 2022 N2A model scenario does not meet the GEH <5.0 criteria in all modelled hours. In all but the second modelled hour in the PM peak the GEH <7.5 criteria is met, and in all hours the <10.0 criteria is met.

In the majority of hours the GEH < 6.5 check indicates that a reasonable proportion (8% to 18%) of movements have GEHs between 5.0 and 6.5, i.e. for these comparisons there is a reasonable match between observed and modelled values.

The 17:00-18:00 PM peak hour and the 08:00-09:00 AM peak hour demonstrate the weakest outcome. The GEH < 5.0 is some way below the target in these hours, however the GEH < 7.5 target is achieved 12% of GEHs in this AM hour are between 5.0 and 6.5 and 18% of GEHs in the PM hour are between 5.0 and 6.5.

This level of calibration achieved is a mild reduction from the previous calibration phase where the GEH < 5.0 criterial ranged from 70% (again, weakest in the AM peak hour) through to 79% and the GEH < 7.5 criteria ranged from 88-94%.

From the outcomes above, some care is required around presenting and assessing individual intersection turning movement volumes when applying the model. Improving the outcomes of the criteria requiring the closest match between observed and modelled traffics results would require investing continued resource in smaller model input refinements, notably the base year OD demand, this has diminishing benefits.

Appendix D contains a list of locations with GEHs greater than 10 for the two central hours in each modelled time period. The following locations demonstrate the highest GEHs (weaker comparison between observed and modelled turning movements);

- In the AM peak; the left turn from Riddiford Street north approach into Constable is significantly overestimated in the model, the left turn from The Parade south approach into Mersey Street is significantly higher in the model than observed, the left turn from Vivian Street onto Cambridge Tce is overestimated in the model, the left turn from Taranaki Street south at the Jervois Quay /

Wakefield Street intersection is underestimated, the left turn from Wellington Road west onto Ruahine Street is underestimated, and the through movement northbound on Ruahine Street, the through movement northbound on Adelaide Road , and the left turn onto the Basin Reserve are overestimated in the 08:00-09:00 hour.

- In the Inter-Peak; the right turn from Rongotai Road east into Evans Bay Parade is overestimated, the Right Turn from Mersey Street onto The Parade is overestimated, the left turn from Cobham Drive east onto Troy Street is overestimated in the model, and the through movement southbound on Thorndon Quay at Mulgrave Street is underestimated.

- In the PM peak; the Evans Bay Parade north through movement at Rongotai Road is underestimated, the left turn from Mulgrave Street west onto Thorndon Quay is overestimated, the right turn from Waterloo Quay north into Whitmore Street is overestimate, the left turn from Kent Terrace at the Basin reserve is overestimated, and the right turn from Cobham Drive east at the Troy Street roundabout is overestimated.

The table below provides the TMDG XY Scatter graph targets by model purpose category.

STATISTIC	PURPOSE CATEGORY						
	A: REGIONAL	B: STRATEGIC NETWORK	C: URBAN AREA	D: NZ TRANSPORT AGENCY PROJECT	E: SMALL AREA /CORRIDOR	F: INTERSECTION / SHORT CORRIDOR	G: HIGH FLOW, SPEED, MULTI LANE
R SQUARED VALUE	>0.85	>0.9	>0.95	>0.95	>0.95	>0.95	>0.95
LINE OF BEST FIT	y=0.9x - 1.1x	y=0.9x - 1.1x	y=0.9x - 1.1x	y=0.925x - 1.075x	y=0.95x - 1.05x	y=0.97x - 1.03x	y=0.97x - 1.03x

Figure 6-2. TMDG Observed vs. modelled count comparison XY scatter criteria

XY Scatter Plots for each modelled hour are provided in Appendix A and a summary of the key measures is provided in the table below.

Table 5: XY Scatter Graph Key Information

Time Peiod	XY Measure	TMDG Target	Hour 1	Hour 2	Hour 3	Hour 4
AM Period	Equation	y = 0.9x to 1.1x	0.9216x	0.9119x	1.0151x	0.9577x
	R-Squared	> 0.95	0.9761	0.9812	0.9734	0.9686
Inter-Peak	Equation	y = 0.9x to 1.1x	0.9909x	1.0193x	0.963x	0.9509x
	R-Squared	> 0.95	0.9717	0.975	0.9724	0.9696
PM Period	Equation	y = 0.9x to 1.1x	0.9468x	0.9869x	0.9934x	0.9746x
	R-Squared	> 0.95	0.9709	0.9655	0.9663	0.9406

These graphs and table above show that generally there is a good representation of the overall observed traffic volumes through each modelled hour in each of the time periods. The exceptions are the first two hours in the AM period where the modelled volumes are slightly underestimated. The Inter-Peak and PM periods show a strong outcome across all modelled hours.

6.3 Screenline Comparison Review

Due to the limited data collected in 2022, focusing on the LGWM PT corridor, the development of screenlines from the observed data is not possible to compare against the modelled results. Screenline comparisons are still an important check to demonstrate the model performance.

Table 6 shows the screenline comparison between the previous 2016 model results and the updated 2022 model results.

Table 6: Screenline Comparisons Modelled 2016 vs 2022

Screenline	Direction	N2A Micro AM 2hrs Peak 7-9				N2A Micro Inter 2hrs Peak 11-13				N2A Micro PM 2hrs Peak 16-18			
		Modelled 2016	Modelled 2022 Diff	% Diff	GEH	Modelled 2016	Modelled 2022 Diff	% Diff	GEH	Modelled 2016	Modelled 2022 Diff	% Diff	GEH
Airport	Outbound	4344	-592	-14%	6.6	3349	456	14%	5.4	3774	580	15%	6.4
	Inbound	3568	-515	-14%	6.3	3148	103	3%	1.3	4725	-415	-9%	4.4
	Total	7912	**-1107**	**-14%**	9.1	6498	**559**	**9%**	4.8	8498	**165**	**2%**	1.3
West of CBD	Outbound	4075	195	5%	2.1	3725	662	18%	7.4	6193	71	1%	0.6
	Inbound	6834	-45	-1%	0.4	3655	1095	30%	11.9	5161	566	11%	5.4
	Total	10909	**151**	**1%**	1.0	7380	**1757**	**24%**	13.7	11353	**637**	**6%**	4.2
Northern External	Outbound	9180	-586	-6%	4.4	8351	1157	14%	8.7	16677	-662	-4%	3.7
	Inbound	16384	90	1%	0.5	8475	1143	13%	8.5	11909	763	6%	4.9
	Total	25563	**-496**	**-2%**	2.2	16825	**2301**	**14%**	12.1	28586	**100**	**0%**	0.4
South of CBD	Outbound	1236	-205	-17%	4.3	1611	179	11%	3.1	3032	-553	-18%	7.5
	Inbound	3078	-171	-6%	2.2	1550	156	10%	2.7	2098	-85	-4%	1.3
	Total	4313	**-376**	**-9%**	4.1	3160	**335**	**11%**	4.1	5130	**-638**	**-12%**	6.5
Karori	Outbound	932	66	7%	1.5	1139	171	15%	3.5	2181	84	4%	1.3
	Inbound	2869	-338	-12%	4.6	1185	139	12%	2.8	1319	123	9%	2.3
	Total	3801	**-271**	**-7%**	3.2	2324	**311**	**13%**	4.4	3500	**208**	**6%**	2.4
East + South of CBD	Outbound	5421	-503	-9%	4.9	5322	310	6%	3.0	8552	-687	-8%	5.4
	Inbound	8386	-781	-9%	6.2	5793	725	13%	6.5	6789	-65	-1%	0.6
	Total	13807	**-1284**	**-9%**	7.9	11115	**1035**	**9%**	6.8	15341	**-752**	**-5%**	4.3
North of CBD	Outbound	6721	-586	-9%	5.2	6265	1035	17%	8.9	14243	-909	-6%	5.5
	Inbound	14854	-215	-1%	1.3	6506	979	15%	8.3	9096	334	4%	2.5
	Total	21575	**-801**	**-4%**	3.9	**12771**	**2014**	**16%**	12.1	23339	**-576**	**-2%**	2.7

The table above shows that the AM and PM results are similar across the majority of screenlines. The AM period shows less traffic across the Airport and East + South Screenlines. The Interpeak shows larger differences across the Western and both Northern screenlines. This reflects the count data observations where the north and western counts available also showed reductions, however these only cover limited locations.

6.4 2022 Travel Time Comparisons

Figure 3-3 and Figure 3-4 in Section 3.5 show a map of the 23 observed travel time routes which provide good network coverage for reviewing the N2A 2022 model scenario corridor performance (travel times and delays). As noted, although the observed travel time data provides robust coverage of the network the 2022 counts are concentrated in key areas only. This means that the comparison of modelled travel times in areas where 2022 counts are not available may be weaker.

The tables below provides the TMDG targets for travel time comparisons.

Table 7: TMDG Travel Time Comparison Targets

TOTAL ROUTE DIRECTIONAL PEAK JOURNEY TIME	PURPOSE CATEGORY						
	A: REGIONAL	B: STRATEGIC NETWORK	C: URBAN AREA	D: NZ TRANSPORT AGENCY PROJECT	E: SMALL AREA /CORRIDOR	F: INTERSECTION / SHORT CORRIDOR	G: HIGH FLOW, SPEED, MULTI LANE
WITHIN 15% OR 1 MINUTE (IF HIGHER) (% OF ROUTES)	>80%	>85%	>85%	>87.5%	>90%	>90%	>90%
WITHIN 25% OR 1.5 MINUTES (IF HIGHER) (% OF ROUTES)	>85%	>90%	>90%	>92.5%	>95%	100%	100%

The model purpose C / D targets are for 85-87.5% of routes to pass the first criterion and 90-92.5% of routes to pass the second criterion.

The tables below provide the observed vs. modelled total route travel time comparisons for the 23 routes for the two central hours in each modelled period. Time vs. distance XY scatter graphs are provided in Appendix C.

Table 8: AM Observed vs. Modelled Travel Time Comparison

Hour Start	Route		Observed TT min			Modelled TT Min	Difference to Mean		Within 15% or 1min?	Within 25% or 1.5min?
			15th %ile	50th %ile	85th %ile		Min	%		
07:00	1	Arthur St to SH1	5.4	6.4	7.0	6.8	0.4	6%	yes	yes
07:00	2	SH1 - Vivian Street	10.3	18.4	26.3	19.4	1.0	6%	yes	yes
07:00	3	Mt Vic Tunnel - SH1	4.0	5.2	6.3	4.4	-0.8	-16%	yes	yes
07:00	4	SH1 - Mt Vic Tunnel	5.1	9.9	14.8	7.5	-2.4	-24%	no	yes
07:00	5	Rongotai Road to Evans Bay Pde	1.9	3.6	5.3	3.0	-0.6	-16%	yes	yes
07:00	6	Evans Bay Pde to Rongotai Rd	1.8	2.9	3.2	2.3	-0.6	-21%	yes	yes
07:00	7	SH2 - Hutt Rd - Waterfront	5.9	8.3	10.5	7.7	-0.6	-8%	yes	yes
07:00	8	Waterfront - Hutt Rd - SH2	5.4	7.5	9.5	7.5	-0.1	-1%	yes	yes
07:00	9	The Parade to Newtown	6.2	9.1	11.8	8.5	-0.7	-7%	yes	yes
07:00	10	Newtown to The Parade	6.6	10.9	14.6	8.6	-2.3	-21%	no	yes
07:00	11	Riddiford St (Hospital) to Aotea Quay (Stadium)	5.9	12.4	19.2	12.0	-0.4	-3%	yes	yes
07:00	12	Aotea Quay (Stadium) to Riddiford St (Hospital)	6.3	13.2	19.4	12.9	-0.2	-2%	yes	yes
07:00	13	The Terrace to Ghuznee Street	3.3	6.2	8.9	6.8	0.6	9%	yes	yes
07:00	14	Ghuznee Street - The Terrace	3.5	6.5	9.6	6.8	0.3	4%	yes	yes
07:00	15	Wellington Station to the Basin (SB)	4.2	9.0	13.8	9.2	0.2	2%	yes	yes
07:00	16	Adelade Rd to Herald St	2.5	5.4	8.5	4.4	-1.1	-20%	no	yes
07:00	17	Herald St to Adelade Rd	2.4	4.6	6.7	4.1	-0.5	-11%	yes	yes
07:00	18	Ruahine St to Buckle St	2.6	3.9	5.2	3.5	-0.4	-11%	yes	yes
07:00	19	Sussex St to Buckle St	1.9	2.7	3.3	2.7	0.0	-1%	yes	yes
07:00	20	Taranaki St to Wallace St to John St	2.0	3.9	5.8	3.2	-0.7	-18%	yes	yes
07:00	21	John St to Wallace St to Taranaki St	2.0	3.8	5.7	3.1	-0.7	-19%	yes	yes
07:00	22	Rugby St to Wellington Station	4.0	8.7	14.2	7.6	-1.1	-13%	yes	yes
07:00	23	Wellington Station to Rugby St	4.2	8.5	12.2	9.0	0.5	6%	yes	yes
					% of Routes Passing:				**87%**	**100%**
08:00	1	Arthur St to SH1	5.5	6.7	7.3	7.5	0.8	12%	yes	yes
08:00	2	SH1 - Vivian Street	11.1	21.8	32.6	24.5	2.7	12%	yes	yes
08:00	3	Mt Vic Tunnel - SH1	4.1	5.6	7.1	5.0	-0.6	-12%	yes	yes
08:00	4	SH1 - Mt Vic Tunnel	10.6	21.8	35.3	14.2	-7.6	-35%	no	no
08:00	5	Rongotai Road to Evans Bay Pde	2.1	4.8	8.1	5.0	0.2	4%	yes	yes
08:00	6	Evans Bay Pde to Rongotai Rd	2.0	3.4	4.3	2.5	-0.9	-25%	yes	yes
08:00	7	SH2 - Hutt Rd - Waterfront	6.5	11.0	15.2	13.2	2.2	20%	no	yes
08:00	8	Waterfront - Hutt Rd - SH2	5.4	7.7	9.9	7.9	0.2	2%	yes	yes
08:00	9	The Parade to Newtown	6.4	10.1	13.2	10.4	0.2	2%	yes	yes
08:00	10	Newtown to The Parade	7.0	13.1	19.5	12.6	-0.5	-4%	yes	yes
08:00	11	Riddiford St (Hospital) to Aotea Quay (Stadium)	6.3	15.2	24.9	15.7	0.5	3%	yes	yes
08:00	12	Aotea Quay (Stadium) to Riddiford St (Hospital)	6.8	15.5	23.3	21.7	6.2	40%	no	no
08:00	13	The Terrace to Ghuznee Street	3.7	7.6	11.5	7.9	0.4	5%	yes	yes
08:00	14	Ghuznee Street - The Terrace	3.9	8.6	13.7	8.0	-0.6	-7%	yes	yes
08:00	15	Wellington Station to the Basin (SB)	4.7	11.8	19.1	12.1	0.3	3%	yes	yes
08:00	16	Adelade Rd to Herald St	2.8	7.3	11.6	8.2	1.0	13%	yes	yes
08:00	17	Herald St to Adelade Rd	2.5	5.4	7.7	4.6	-0.7	-13%	yes	yes
08:00	18	Ruahine St to Buckle St	2.8	4.4	6.1	5.2	0.8	17%	yes	yes
08:00	19	Sussex St to Buckle St	1.9	2.9	3.7	6.1	3.2	110%	no	no
08:00	20	Taranaki St to Wallace St to John St	2.1	4.6	6.8	6.8	2.2	48%	no	no
08:00	21	John St to Wallace St to Taranaki St	2.1	5.1	8.1	4.6	-0.5	-9%	yes	yes
08:00	22	Rugby St to Wellington Station	4.4	11.5	20.1	9.2	-2.3	-20%	no	yes
08:00	23	Wellington Station to Rugby St	4.5	11.0	16.8	14.6	3.6	33%	no	no
					% of Routes Passing:				**70%**	**78%**

The table above demonstrates a reasonable travel time comparison outcome in the AM peak period. Route 12 in the second hour demonstrates higher average modelled travel time compared to observed. The time vs. distance graph for this route in Appendix C demonstrates that model is reflecting the location and patterns of congestion along this route, but with levels of delay higher than observed.

Table 9: Inter-Peak Observed vs. Modelled Travel Time Comparison

Hour Start		Route	Observed TT min			Modelled TT Min	Difference to Mean		Within 15% or 1min?	Within 25% or 1.5min?
			15th %ile	50th %ile	85th %ile		Min	%		
11:00	1	Arthur St to SH1	5.4	6.4	7.0	7.1	0.7	11%	yes	yes
11:00	2	SH1 - Vivian Street	7.0	10.7	14.2	9.0	-1.8	-16%	no	yes
11:00	3	Mt Vic Tunnel - SH1	4.0	5.0	5.9	4.4	-0.6	-11%	yes	yes
11:00	4	SH1 - Mt Vic Tunnel	4.2	5.5	6.8	5.4	-0.1	-2%	yes	yes
11:00	5	Rongotai Road to Evans Bay Pde	2.0	3.7	5.4	2.7	-1.0	-26%	yes	yes
11:00	6	Evans Bay Pde to Rongotai Rd	1.9	2.6	3.1	2.3	-0.3	-12%	yes	yes
11:00	7	SH2 - Hutt Rd - Waterfront	5.4	6.8	7.7	7.0	0.2	3%	yes	yes
11:00	8	Waterfront - Hutt Rd - SH2	5.4	7.3	9.0	7.1	-0.2	-3%	yes	yes
11:00	9	The Parade to Newtown	6.3	9.3	11.5	8.6	-0.7	-8%	yes	yes
11:00	10	Newtown to The Parade	6.5	9.8	12.4	8.6	-1.2	-13%	yes	yes
11:00	11	Riddiford St (Hospital) to Aotea Quay (Stadium)	6.0	13.0	20.1	13.3	0.3	2%	yes	yes
11:00	12	Aotea Quay (Stadium) to Riddiford St (Hospital)	6.0	12.7	18.4	13.0	0.3	2%	yes	yes
11:00	13	The Terrace to Ghuznee Street	3.5	6.6	9.5	6.8	0.2	4%	yes	yes
11:00	14	Ghuznee Street - The Terrace	3.5	6.8	9.4	7.2	0.4	6%	yes	yes
11:00	15	Wellington Station to the Basin (SB)	4.3	9.1	13.6	7.9	-1.1	-13%	yes	yes
11:00	16	Adelade Rd to Herald St	2.7	6.0	9.2	4.3	-1.8	-29%	no	no
11:00	17	Herald St to Adelade Rd	2.6	5.6	8.1	3.8	-1.8	-32%	no	no
11:00	18	Ruahine St to Buckle St	2.3	3.4	4.7	4.0	0.5	15%	yes	yes
11:00	19	Sussex St to Buckle St	1.9	2.7	3.4	2.4	-0.3	-11%	yes	yes
11:00	20	Taranaki St to Wallace St to John St	1.9	3.7	4.8	3.7	0.0	1%	yes	yes
11:00	21	John St to Wallace St to Taranaki St	2.0	3.8	5.5	2.9	-0.8	-22%	yes	yes
11:00	22	Rugby St to Wellington Station	4.2	8.9	13.8	10.1	1.2	13%	yes	yes
11:00	23	Wellington Station to Rugby St	4.2	8.3	12.5	8.7	0.4	4%	yes	yes
					% of Routes Passing:				87%	91%
12:00	1	Arthur St to SH1	5.5	6.4	7.0	7.1	0.7	11%	yes	yes
12:00	2	SH1 - Vivian Street	7.1	11.6	16.0	8.9	-2.7	-23%	no	yes
12:00	3	Mt Vic Tunnel - SH1	4.0	5.1	6.0	5.1	0.0	1%	yes	yes
12:00	4	SH1 - Mt Vic Tunnel	4.3	6.1	8.1	8.0	1.9	31%	no	no
12:00	5	Rongotai Road to Evans Bay Pde	2.0	3.7	5.4	3.6	-0.1	-2%	yes	yes
12:00	6	Evans Bay Pde to Rongotai Rd	1.9	2.9	3.3	2.5	-0.4	-12%	yes	yes
12:00	7	SH2 - Hutt Rd - Waterfront	5.3	6.9	7.7	7.0	0.1	2%	yes	yes
12:00	8	Waterfront - Hutt Rd - SH2	5.4	7.4	9.0	7.2	-0.2	-2%	yes	yes
12:00	9	The Parade to Newtown	6.3	9.5	11.7	8.7	-0.8	-9%	yes	yes
12:00	10	Newtown to The Parade	6.5	10.0	12.8	8.6	-1.4	-14%	yes	yes
12:00	11	Riddiford St (Hospital) to Aotea Quay (Stadium)	6.1	13.4	20.5	13.3	-0.1	-1%	yes	yes
12:00	12	Aotea Quay (Stadium) to Riddiford St (Hospital)	6.1	13.1	19.4	13.9	0.8	6%	yes	yes
12:00	13	The Terrace to Ghuznee Street	3.5	6.8	9.8	6.8	0.0	0%	yes	yes
12:00	14	Ghuznee Street - The Terrace	3.6	7.1	9.8	7.3	0.3	4%	yes	yes
12:00	15	Wellington Station to the Basin (SB)	4.3	9.2	13.9	8.3	-0.9	-9%	yes	yes
12:00	16	Adelade Rd to Herald St	2.7	6.2	9.3	4.5	-1.7	-27%	no	no
12:00	17	Herald St to Adelade Rd	2.7	5.7	8.4	3.9	-1.8	-31%	no	no
12:00	18	Ruahine St to Buckle St	2.4	3.6	4.8	4.3	0.7	18%	yes	yes
12:00	19	Sussex St to Buckle St	1.9	2.8	3.6	3.1	0.3	11%	yes	yes
12:00	20	Taranaki St to Wallace St to John St	2.0	3.8	5.1	4.7	0.8	22%	yes	yes
12:00	21	John St to Wallace St to Taranaki St	2.0	3.9	5.7	3.0	-0.9	-23%	yes	yes
12:00	22	Rugby St to Wellington Station	4.3	9.6	15.0	10.4	0.9	9%	yes	yes
12:00	23	Wellington Station to Rugby St	4.2	8.6	13.1	9.3	0.6	7%	yes	yes
					% of Routes Passing:				83%	87%

The table above demonstrates a reasonable representation of modelled travel times in the Inter-Peak.

Table 10: PM Peak Observed vs. Modelled Travel Time Comparison

Hour Start	Route		Observed TT min			Modelled TT Min	Difference to Mean		Within 15% or 1min?	Within 25% or 1.5min?
			15th %ile	50th %ile	85th %ile		Min	%		
16:00	1	Arthur St to SH1	5.8	8.2	10.5	10.1	1.9	23%	no	yes
16:00	2	SH1 - Vivian Street	7.7	13.1	17.9	14.3	1.2	9%	yes	yes
16:00	3	Mt Vic Tunnel - SH1	4.0	5.4	6.6	5.8	0.4	8%	yes	yes
16:00	4	SH1 - Mt Vic Tunnel	6.4	15.6	24.8	7.0	-8.6	-55%	no	no
16:00	5	Rongotai Road to Evans Bay Pde	2.0	4.6	7.0	3.4	-1.1	-25%	no	yes
16:00	6	Evans Bay Pde to Rongotai Rd	1.9	3.0	3.6	2.7	-0.3	-11%	yes	yes
16:00	7	SH2 - Hutt Rd - Waterfront	5.4	7.5	9.1	7.5	0.0	0%	yes	yes
16:00	8	Waterfront - Hutt Rd - SH2	6.3	10.6	14.7	7.6	-3.0	-28%	no	no
16:00	9	The Parade to Newtown	6.5	10.2	13.4	10.1	-0.1	-1%	yes	yes
16:00	10	Newtown to The Parade	6.9	12.6	17.8	9.8	-2.8	-22%	no	yes
16:00	11	Riddiford St (Hospital) to Aotea Quay (Stadium)	6.6	18.0	30.6	15.5	-2.5	-14%	yes	yes
16:00	12	Aotea Quay (Stadium) to Riddiford St (Hospital)	6.5	16.5	27.5	13.9	-2.7	-16%	no	yes
16:00	13	The Terrace to Ghuznee Street	3.7	7.6	11.3	7.0	-0.6	-8%	yes	yes
16:00	14	Ghuznee Street - The Terrace	3.7	7.9	11.4	7.6	-0.3	-3%	yes	yes
16:00	15	Wellington Station to the Basin (SB)	4.5	12.3	19.9	9.6	-2.7	-22%	no	yes
16:00	16	Adelade Rd to Herald St	2.9	7.6	12.6	6.7	-0.8	-11%	yes	yes
16:00	17	Herald St to Adelade Rd	2.6	5.8	9.2	4.8	-1.1	-18%	no	yes
16:00	18	Ruahine St to Buckle St	3.2	8.4	14.2	5.7	-2.6	-31%	no	no
16:00	19	Sussex St to Buckle St	2.5	5.0	7.1	2.5	-2.5	-50%	no	no
16:00	20	Taranaki St to Wallace St to John St	2.2	5.8	9.8	3.8	-2.0	-34%	no	no
16:00	21	John St to Wallace St to Taranaki St	2.4	8.0	14.8	5.1	-3.0	-37%	no	no
16:00	22	Rugby St to Wellington Station	5.0	13.6	22.5	10.0	-3.7	-27%	no	no
16:00	23	Wellington Station to Rugby St	4.6	13.2	22.0	9.8	-3.4	-26%	no	no
					% of Routes Passing:				39%	65%
17:00	1	Arthur St to SH1	5.9	9.5	13.5	10.0	0.5	5%	yes	yes
17:00	2	SH1 - Vivian Street	9.4	16.8	24.7	29.7	13.0	77%	no	no
17:00	3	Mt Vic Tunnel - SH1	4.0	5.5	6.8	5.6	0.2	3%	yes	yes
17:00	4	SH1 - Mt Vic Tunnel	5.2	15.2	25.9	7.2	-8.0	-53%	no	no
17:00	5	Rongotai Road to Evans Bay Pde	2.1	4.6	7.2	4.2	-0.5	-10%	yes	yes
17:00	6	Evans Bay Pde to Rongotai Rd	1.9	2.9	3.5	2.7	-0.2	-5%	yes	yes
17:00	7	SH2 - Hutt Rd - Waterfront	5.5	8.4	9.9	7.8	-0.6	-7%	yes	yes
17:00	8	Waterfront - Hutt Rd - SH2	6.8	12.7	18.1	7.6	-5.1	-40%	no	no
17:00	9	The Parade to Newtown	6.5	10.6	13.9	12.7	2.0	19%	no	yes
17:00	10	Newtown to The Parade	6.7	11.6	15.9	11.6	0.0	0%	yes	yes
17:00	11	Riddiford St (Hospital) to Aotea Quay (Stadium)	6.5	17.9	29.9	18.9	1.0	6%	yes	yes
17:00	12	Aotea Quay (Stadium) to Riddiford St (Hospital)	7.0	22.3	39.0	22.7	0.4	2%	yes	yes
17:00	13	The Terrace to Ghuznee Street	4.0	12.7	21.4	14.2	1.5	12%	yes	yes
17:00	14	Ghuznee Street - The Terrace	3.8	9.8	14.8	9.5	-0.3	-3%	yes	yes
17:00	15	Wellington Station to the Basin (SB)	4.9	15.1	26.6	11.3	-3.8	-25%	no	no
17:00	16	Adelade Rd to Herald St	2.7	6.7	10.9	6.1	-0.6	-9%	yes	yes
17:00	17	Herald St to Adelade Rd	2.6	5.9	9.1	5.9	0.0	0%	yes	yes
17:00	18	Ruahine St to Buckle St	3.3	8.8	14.8	7.3	-1.4	-17%	no	yes
17:00	19	Sussex St to Buckle St	2.5	5.2	7.5	3.0	-2.2	-42%	no	no
17:00	20	Taranaki St to Wallace St to John St	2.5	8.0	13.8	5.4	-2.6	-33%	no	no
17:00	21	John St to Wallace St to Taranaki St	2.3	6.7	11.2	8.5	1.8	28%	no	no
17:00	22	Rugby St to Wellington Station	5.1	15.6	27.1	10.5	-5.0	-32%	no	no
17:00	23	Wellington Station to Rugby St	4.9	16.6	30.0	12.7	-3.9	-24%	no	yes
					% of Routes Passing:				52%	65%

The table above demonstrates a weaker travel time validation outcome in the PM peak period. Only two routes, route 4 in the 16:00-17:00 hour and route 2 in the 17:00-18:00 hour, fall outside the range of 15th and 85th percentile observed times. Generally the modelled route times are not significantly different to the observed times, as demonstrated in Appendix C other than the exceptions noted all other routes in both hours are within the observed 15th to 85Th percentile ranges, i.e. the modelled times are largely within the range of plausible observed travel times.

There are reasons for several of the weaker outcomes;

- Route 8: This route is northbound out of the CBD along SH2 towards Petone. The model does not include the Petone interchange, therefore observed delay / congestion washing back from Petone in the PM peak is not represented in the model and the modelled travel times towards the end of this route do not represent this area of observed delay.

- Route 18: This route is unusual, it starts on the southwest corner of the Basin, loops around the Basin, passes through the short give-way section of Buckle St to the north of Basin (which includes a Pedestrian crossing) before rejoining the main carriageway eastbound through the Mt Victoria tunnel. Few vehicles make this movement (observed or modelled) and therefore replicating the range of delays on this route is challenging.

In general, the observed and modelled PM peak travel times both demonstrate a wider degree of variability and there is a trend for the modelled travel times to be lower than observed particularly in the first of the central hours in the PM period (16:00 – 17:00).

Delays and congestion may be underpredicted in the 16:00-17:00 period in modelled scenarios. This should be considered when running the model, analysing and extracting model outputs, and presenting results.

XY scatter time vs. distance graphs for each route for the two central modelled hours in each modelled time period are provided in Appendix C. These show that many routes have a strong correlation between observed and modelled average travel times along the routes examined and that there is largely a robust comparison between the observed and modelled patterns and location of congestion along these routes in the central modelled hours in each time period.

6.5 Deleted Vehicles

To improve model stability, the Aimsun "Network Checker" has been enabled which includes functionality to remove vehicles from the simulation which are stationary for long periods. As described in Section 4.5, this is commonly in intersections where a stalemate of giveway conditions has occurred. A low level of removed vehicles is appropriate but this should be monitored in scenarios where high congestion occurs. The Network Checker has been limited to 300 seconds generally and 60 seconds in yellow box intersections. This is a reduction from the default settings.

The table below provides a summary of the number of deleted vehicles in each model run used to produce the observed vs. modelled comparisons above and the number of individual sections that deletions occur on in each of the model runs.

Table 11: Vehicle Deletions

Run	No. Of Vehicles Deleted			No. of Unique Sections		
	AM	IP	PM	AM	IP	PM
1	5	19	22	4	1	6
2	4	10	19	3	2	5
3	3	16	12	2	1	5
4	2	24	47	1	2	7
5	4	6	30	3	2	6
Average:	**3.6**	**15.0**	**26.0**	**2.6**	**1.6**	**5.8**

Vehicle deletion is limited to, at most, 7 locations in the PM peak period. In the IP and AM and deletions occur on fewer sections. The table below provides the list of sections with deletions from the model run in each time period which has the most unique sections with deletions.

Table 12: Sections with Deletions

AM	IP	PM
27575	848	7112
874	7112	26953
932		27575
26868		848
		26954
		6499
		26868

The inter-peak vehicle deletions occur consistently within on section 848 and this section features in the PM deletions. This has been investigated and this section is a circulating carriageway of a roundabout which is affected by a queue on a downstream link. Attempts to improve this location have not been successful and therefore deletions on this section remain.

7 Summary and Conclusions

7.1 N2AM Model Overview

The Ngauranga to Airport Aimsun Model (N2AM) is an operational traffic assignment model covering the Wellington CBD, from the roughly the SH1 / SH2 interchange in the north, to the Airport and Miramar area in the southeast. The original model has a base year of 2016 and has undergone a series of updates since then.

7.2 2022 Model Scenario and LGWM DBC Application

This report has outlined the development of a 2022 model scenario and checks of this N2A model against 2022 observed count and travel time data. The development of the N2A 2022 scenario has included the following.

- Collection of 2022 observed traffic count data and 2022 observed travel time data.
- Comparison of 2022 and 2016 observed data which shows a level of traffic flow and delay reduction in the AM peak (post-COVID) and mixed results in the IP and PM periods.
- Reimplementation of buses in the N2A model and subsequent work to reduce model locking.
- A series of refinements and updates to the N2A model made to improve the application to LGWM DBC option testing, generally improve the model operation, and reflect the 2022 transport environment.
- A 2022 demand scenario developed from the updated WTSM 2018 base year and 2023 forecast year.
- Demand release profiles redeveloped from the 2022 count data where possible.

7.3 2022 Observed vs. Modelled Comparison Checks

A comprehensive 2022 model calibration / validation exercise has not been carried out. The main reason for this is that the 2022 observed traffic count dataset does not comprehensively cover the wider network. Observed vs. modelled comparisons have been carried out between the 2022 N2A model and the 2022 count data, which is concentrated in key areas of the LGWM scheme, and the 2022 observed travel time which does comprehensively cover the wider network. The 2022 observed vs. modelled comparisons demonstrates the following key outcomes;

- The traffic count calibration check demonstrates that the N2A 2022 model scenario passes the majority of the higher-level threshold tests, but is at a lower than desired level of turning movement representation for the checks which require the closest match between observed and modelled traffic flows. This is particularly the case in the AM peak hour.
- The travel time comparisons demonstrate some weakness in the PM peak period. However, all but two of the modelled route travel times are within the plausible range as indicated by the observed data and generally the observed and modelled travel times both demonstrate a wider level of variability.

These weaknesses are not considered significant, they are largely a result of resource constraints and the diminishing return from investing continued resource in small refinements to improve these observed vs. modelled comparisons. These weaknesses need to be considered when applying the model to testing, e.g. the representation of individual modelled turning movements in the AM and PM peaks is not comprehensively robust across all turning movements and the variation in PM delays and lower modelled travel times in the 16:00-17:00 hour may need to be considered when running the model, extracting / analysing outputs, and presenting results.

7.4 2022 N2A Model Scenario Summary

In summary, the 2022 N2A model scenario has been updated to improve the model operation, reflect the 2022 transport environment, reflect the post-COVID traffic environment, and link the N2A operational Aimsun model to the updated WTSM 2018 base year.

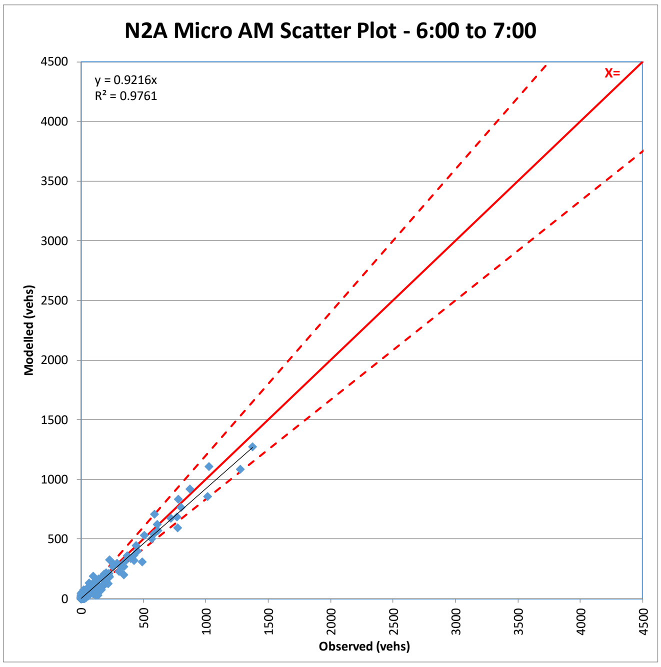
Although the 2022 observed vs. modelled comparisons are not as robust as desired, the model is deemed appropriate for application to the LGWM DBC option assessment and the weaknesses outlined above should be considered when applying the model to project analys

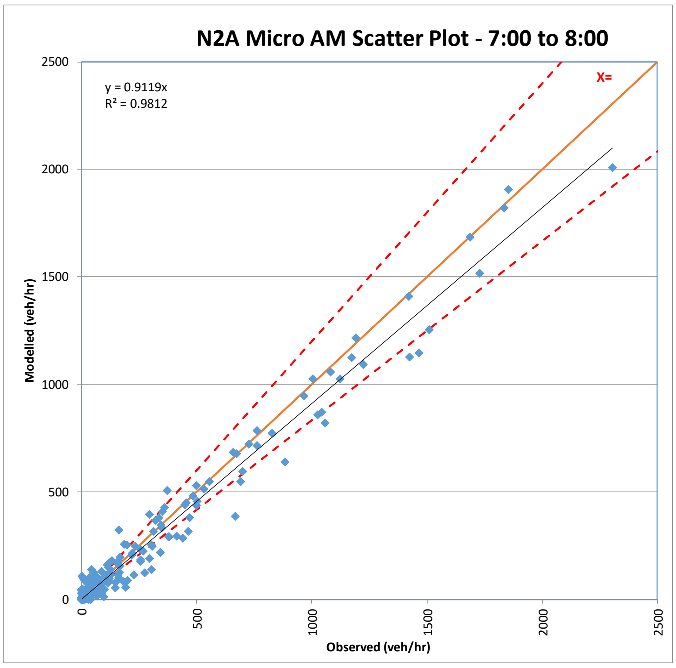
Appendices

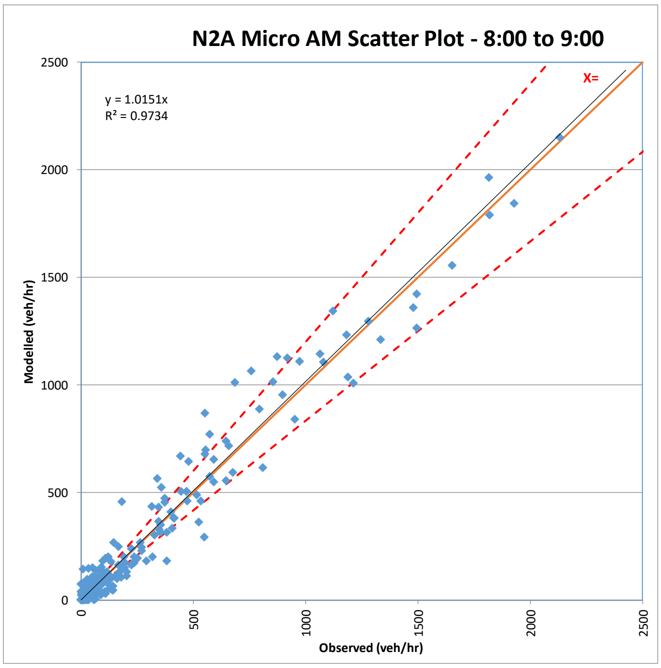
Appendix A: 2022 Turn Count XY Scatters

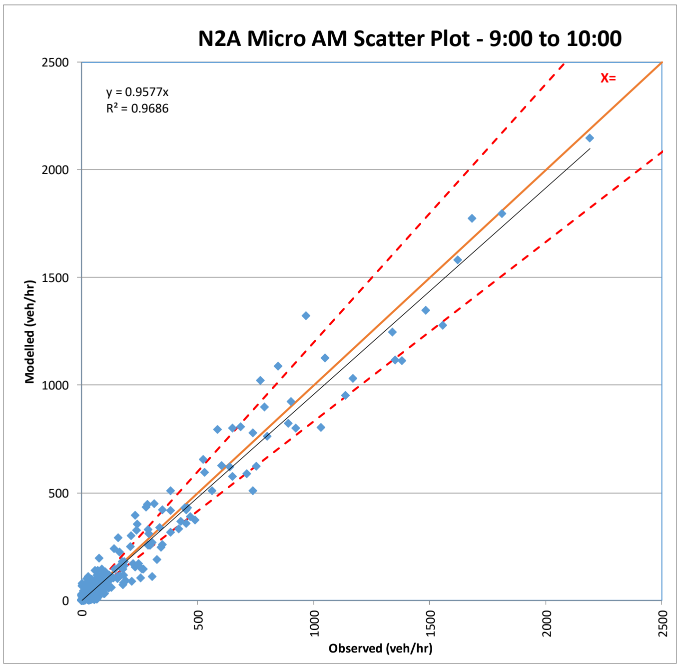
The figures below show the observed vs. modelled XY Scatter graphs for the 2022 intersection turning movement survey for each modelled hour.

2022 AM Period Hourly Observed vs. Modelling Turning Movement XY Scatter Comparison

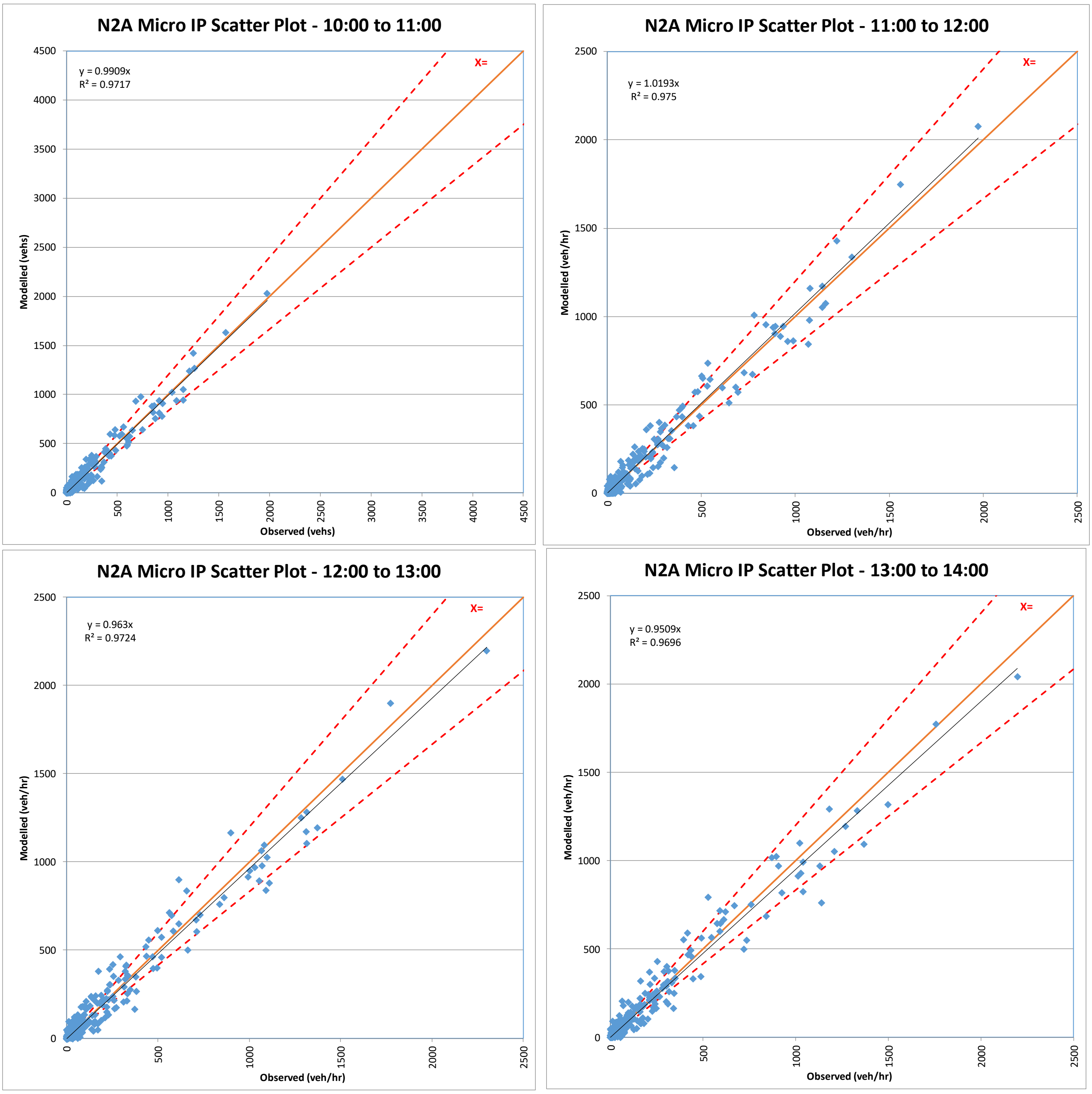




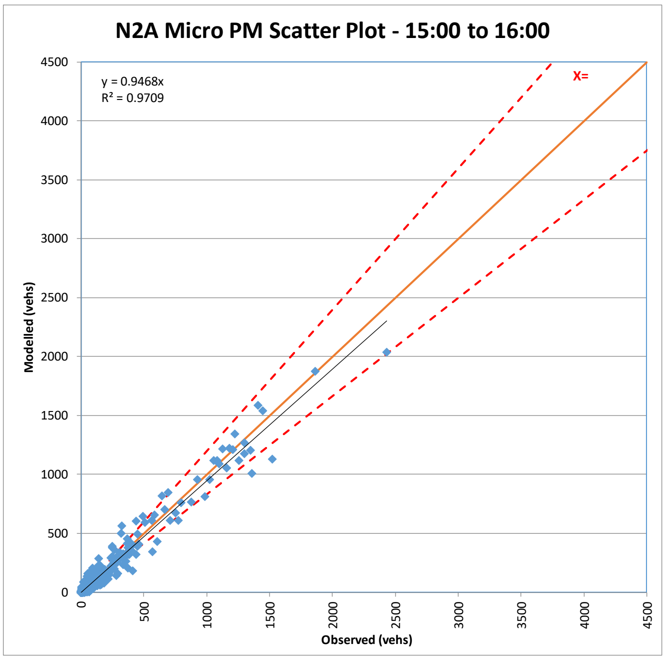


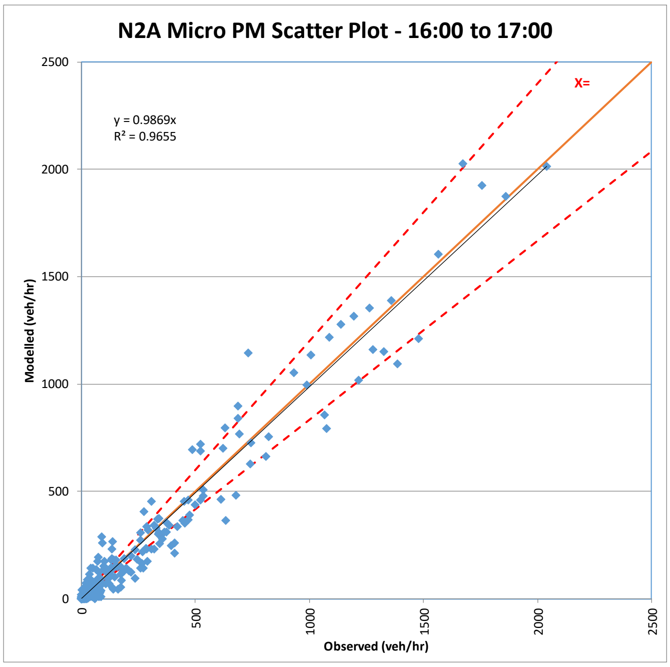


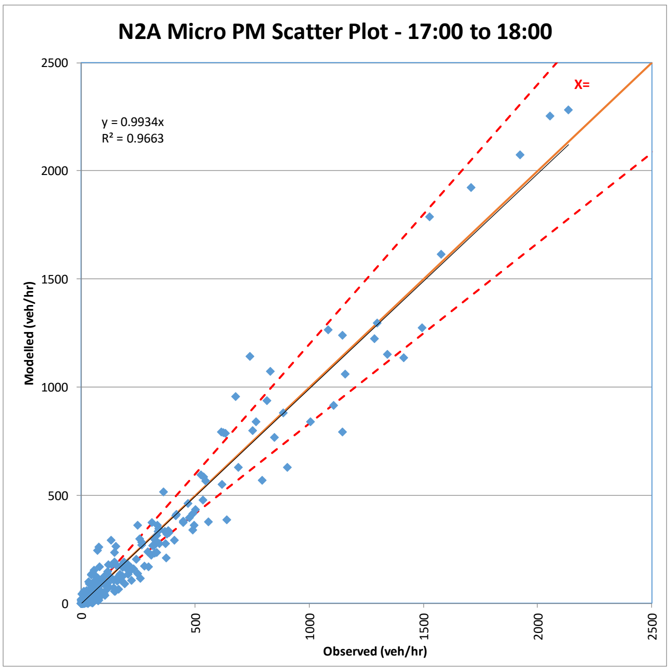
Inter-Peak Period Hourly Observed vs. Modelling Turning Movement XY Scatter Comparison

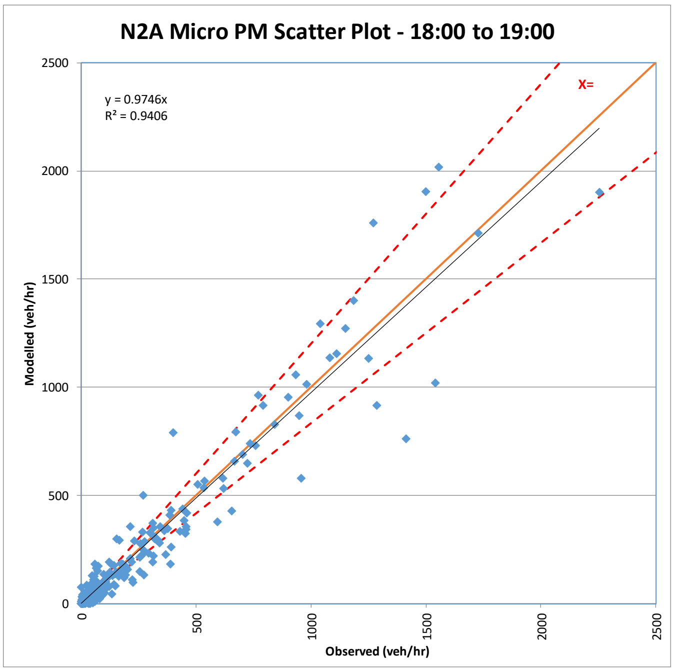


PM Period Hourly Observed vs. Modelling Turning Movement XY Scatter Comparison



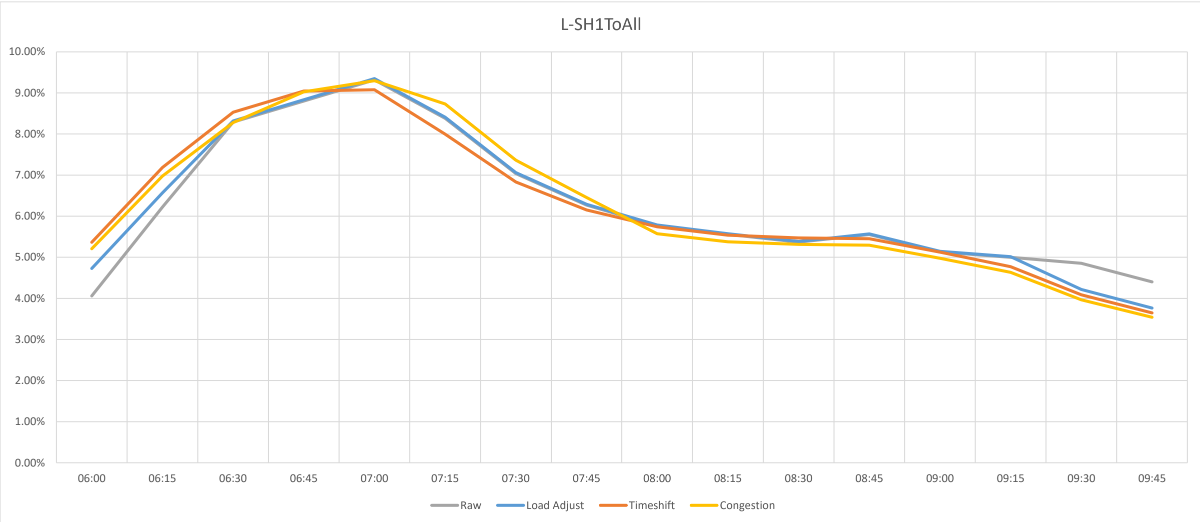




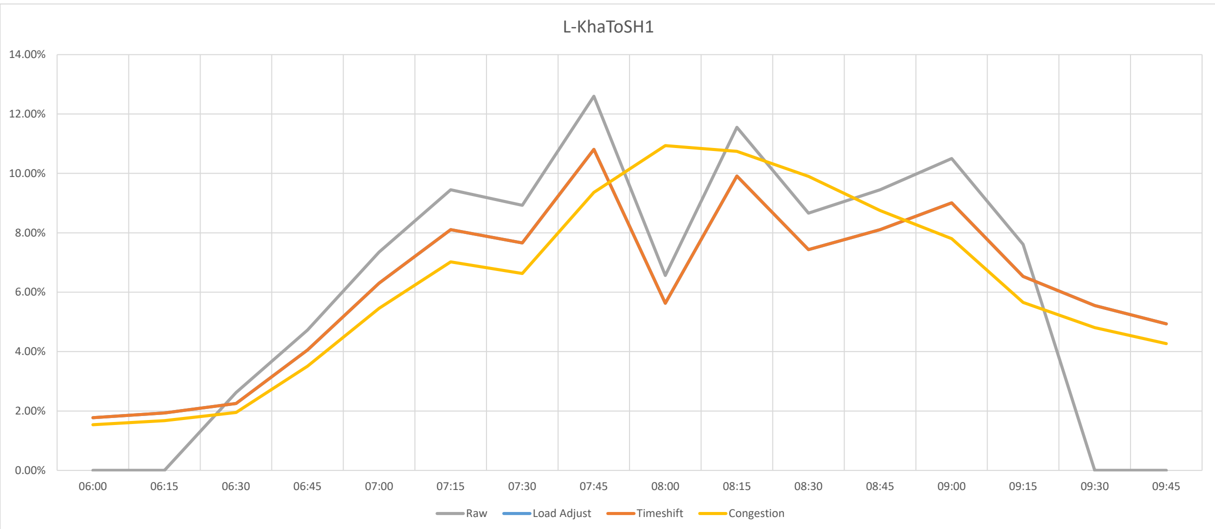


Appendix B: Example of Adjusted Profiles

SH1-North inbound AM peak profile; loading / unloading adjustment, timeshift adjustment, and congestion adjustment.

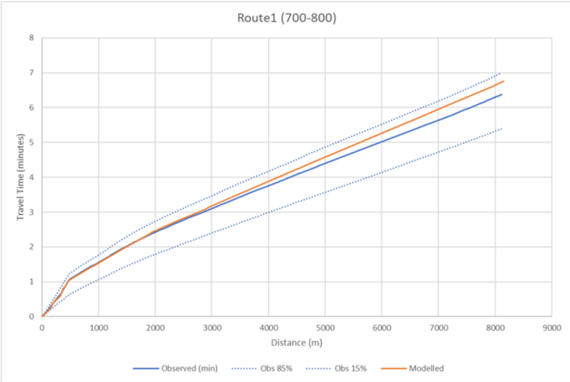


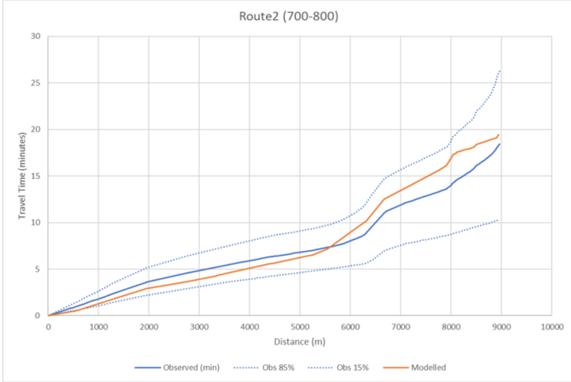
The Khandallah to North profile which is calculated from the 2016 left turn movement from Kaiwharawhara Road onto Hutt Road shows evidence in the morning peak of queues/delays resulting in the count not reflecting the true demand profile. This is one profile where the congestion correction was more significant.

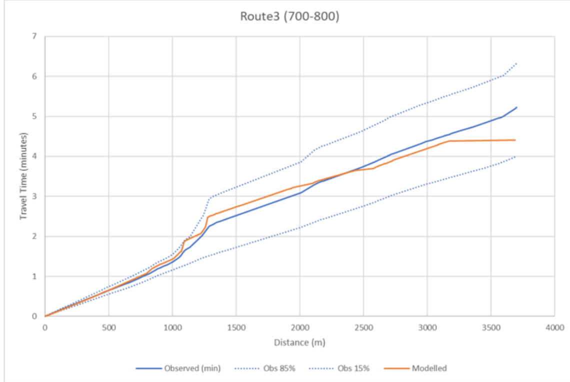


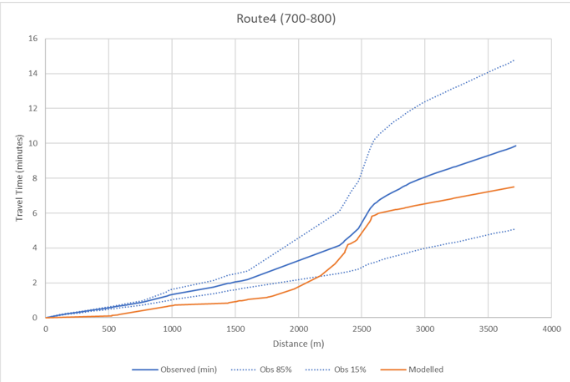
Appendix C: Time vs Distance Travel Time Graphs

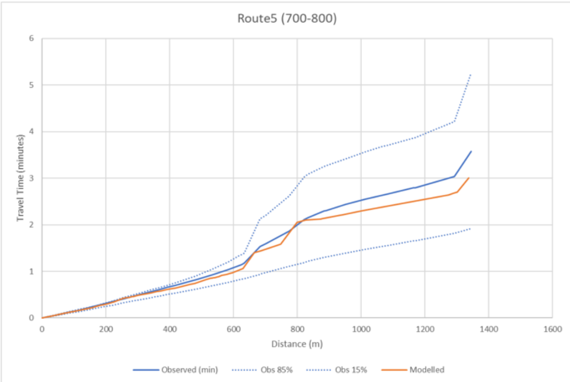
The graphs below show the time vs. distance XY scatter plots for the two central AM period modelled hours for the 23 TomTom routes.

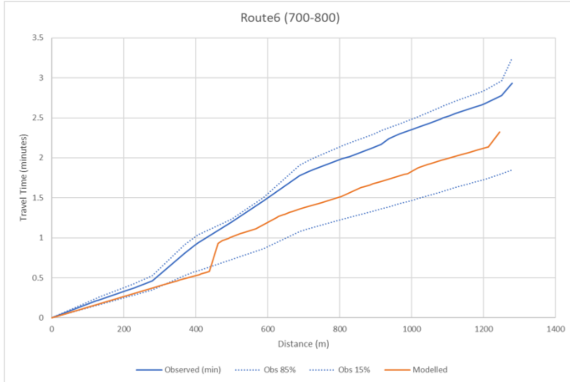

Route1 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

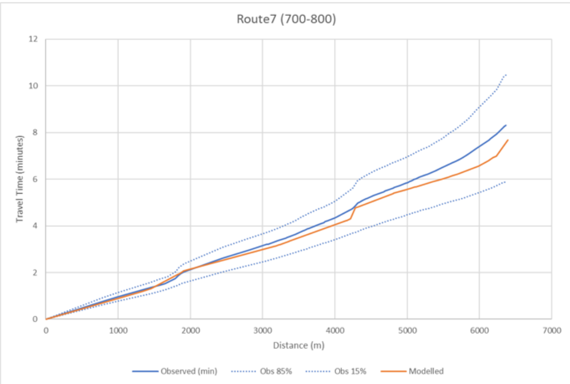

Route2 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

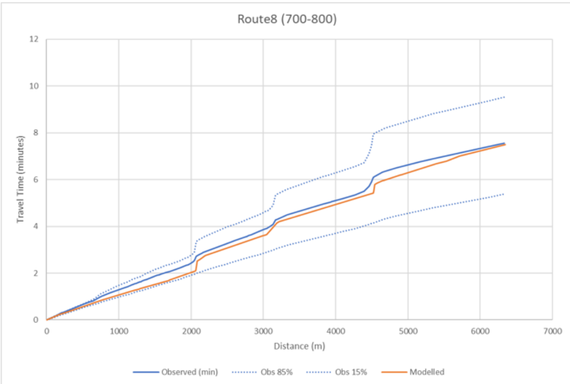

Route3 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

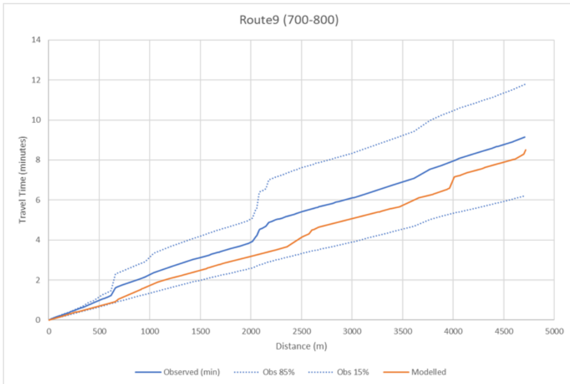

Route4 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

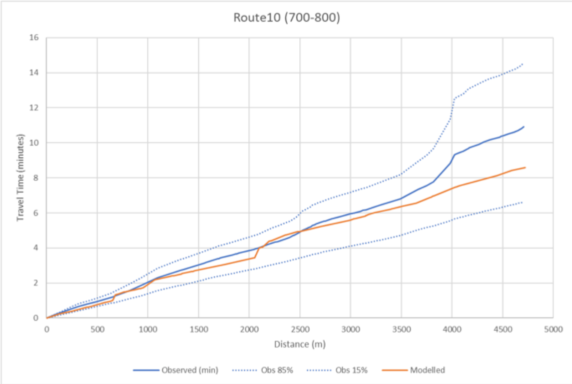

Route5 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

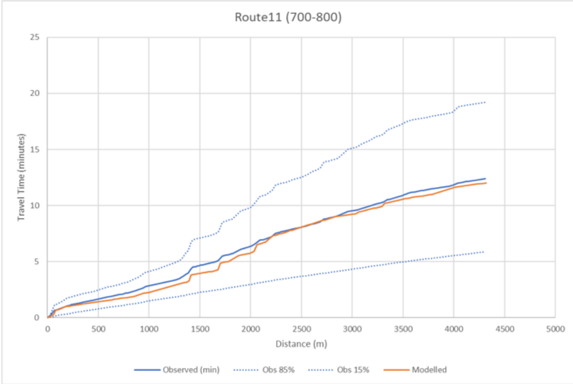

Route6 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

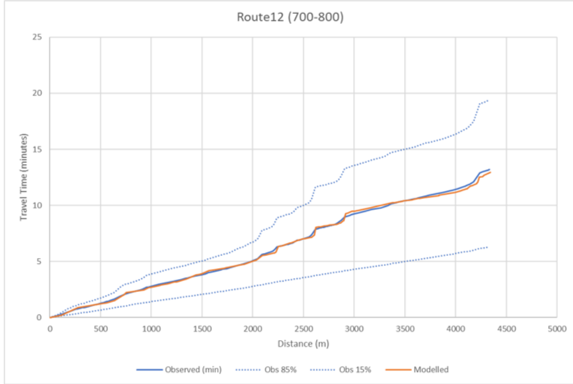

Route7 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

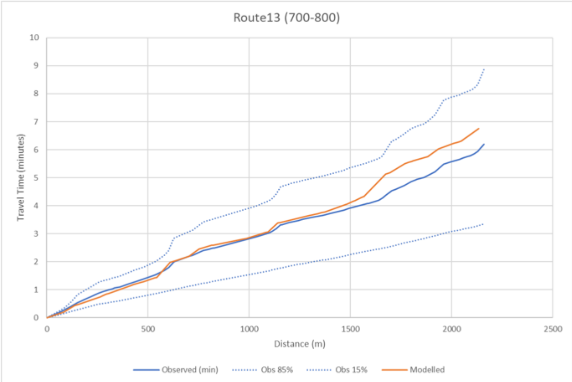

Route8 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

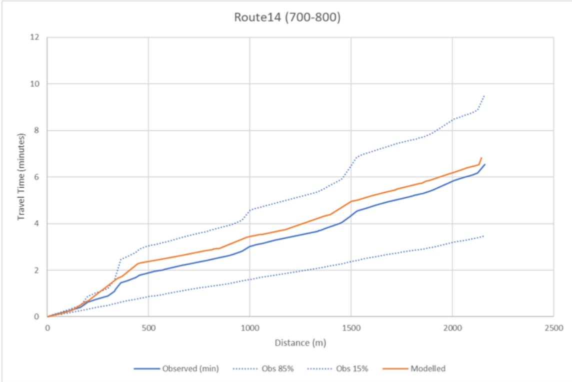

Route9 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

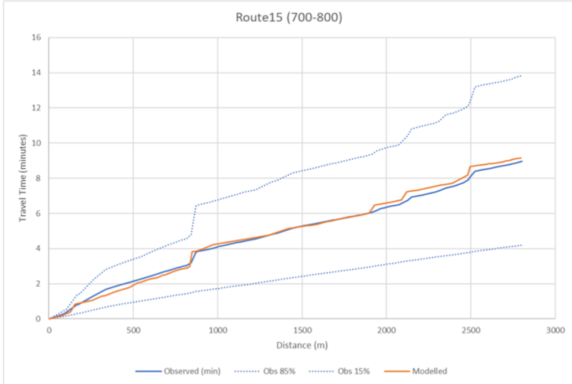

Route10 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

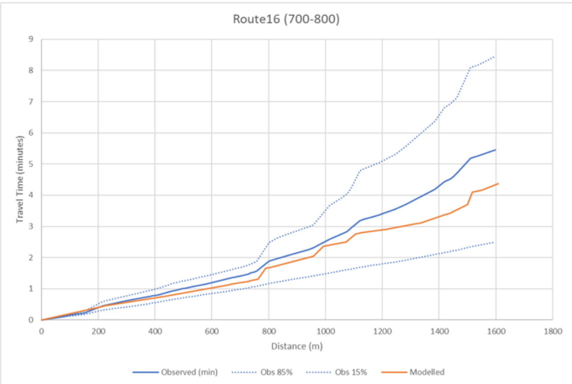

Route11 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

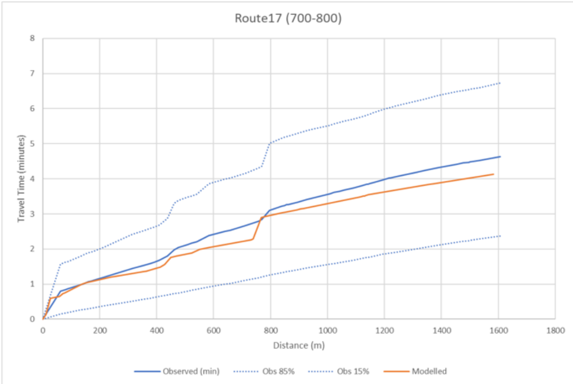

Route12 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

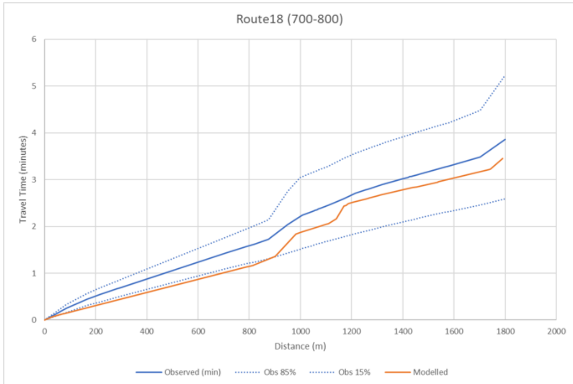

Route13 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

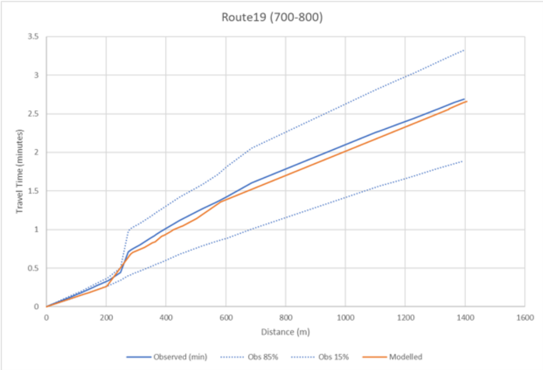

Route14 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

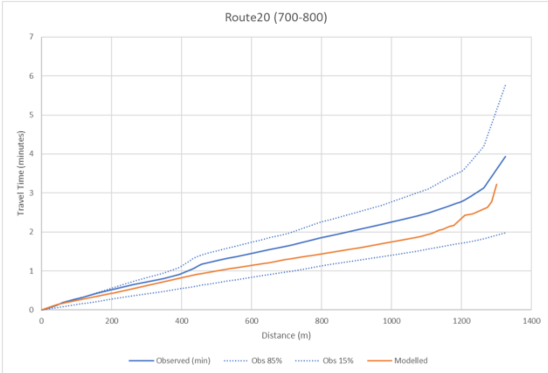

Route15 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

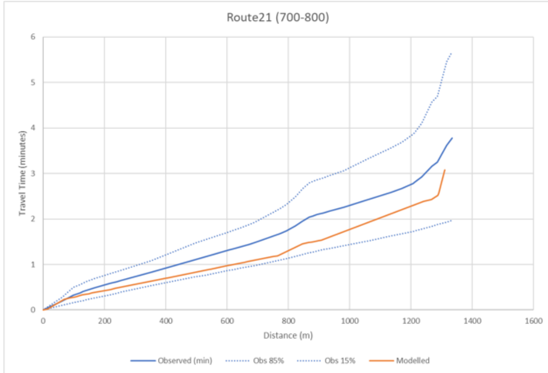

Route16 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

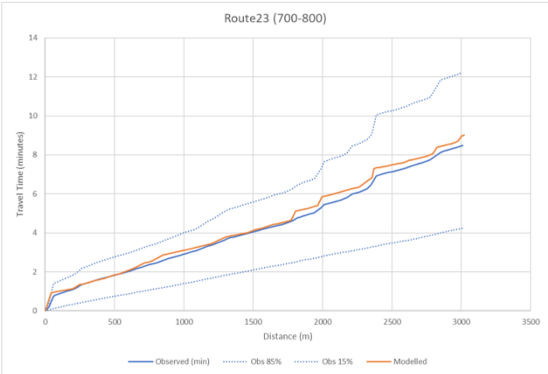

Route17 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

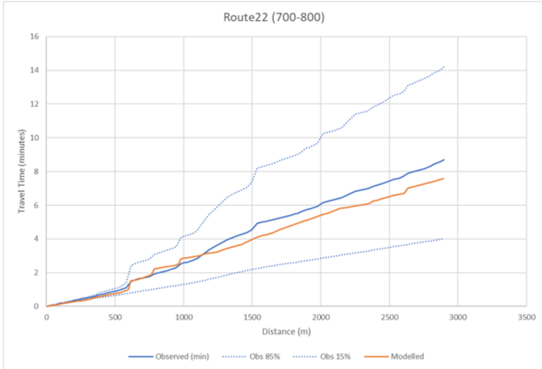

Route18 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

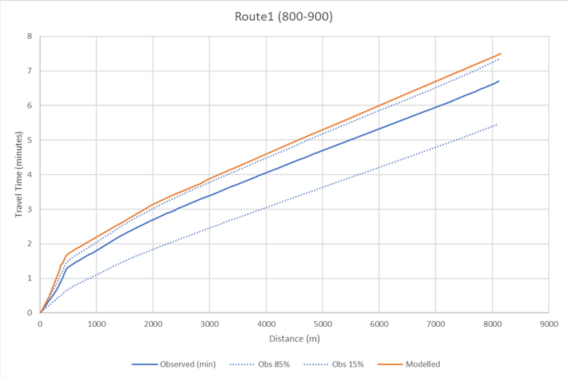

Route19 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

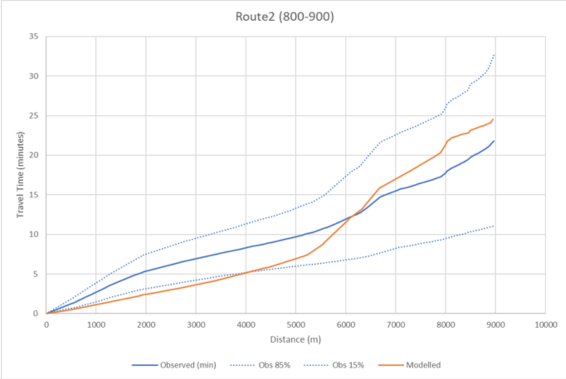

Route20 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

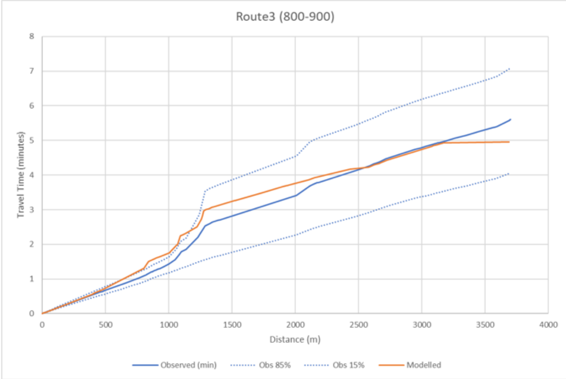

Route21 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

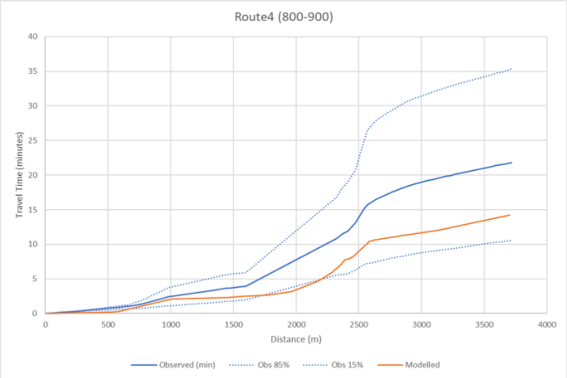

Route23 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

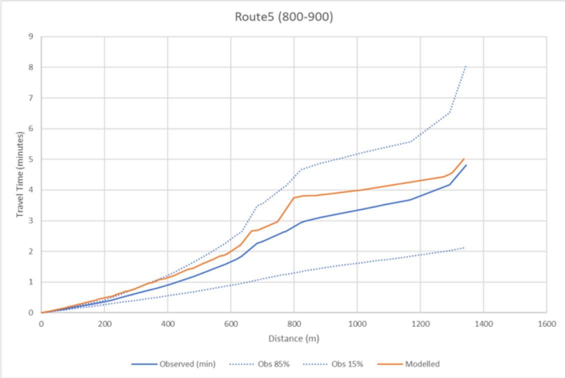

Route22 (700-800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

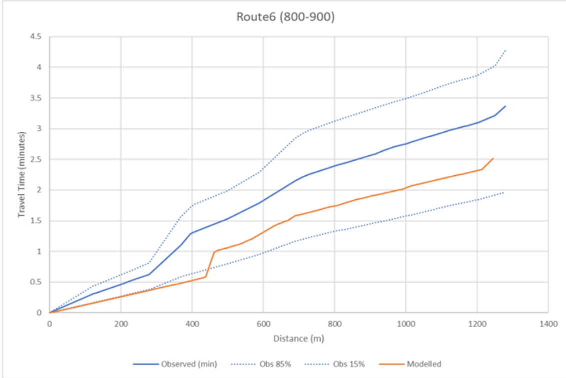

Route1 (800-900)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

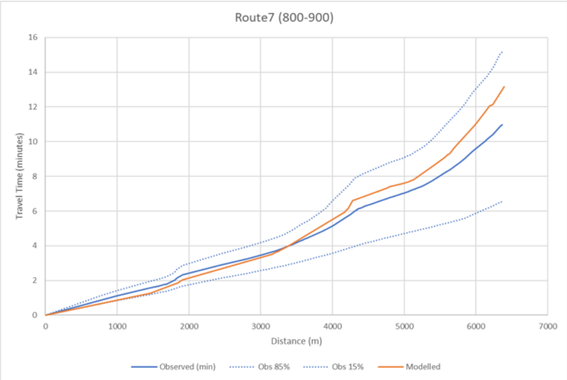

Route2 (800-900)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

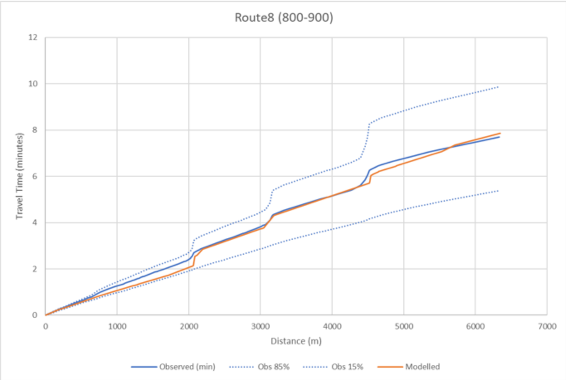

Route3 (800-900)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

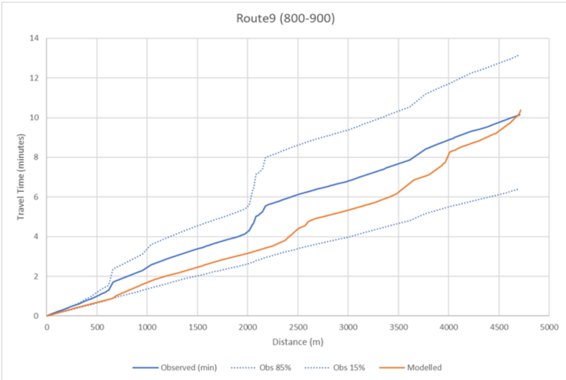

Route4 (800-900)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route5 (800-900)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

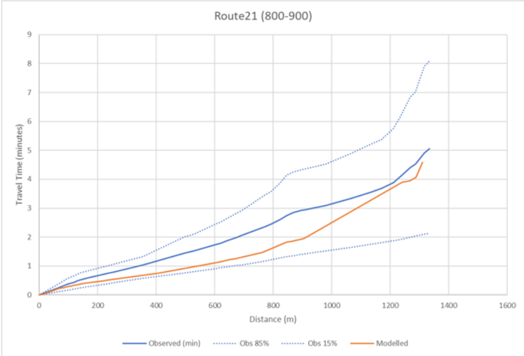

Route6 (800-900)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

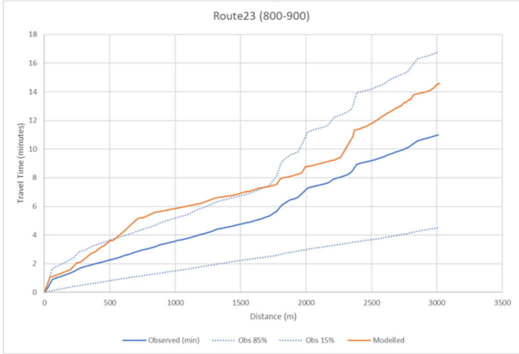

Route7 (800-900)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

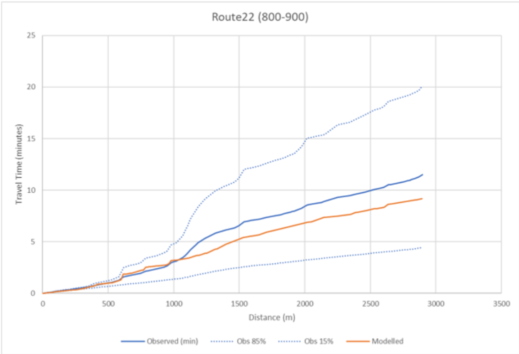

Route8 (800-900)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

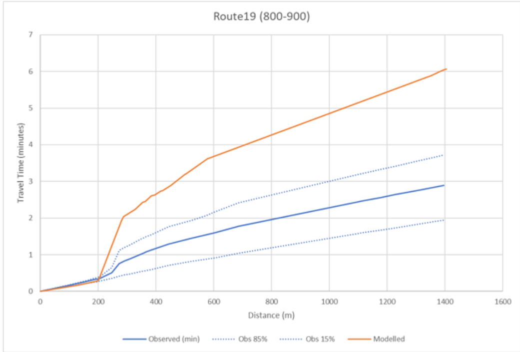

Route9 (800-900)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route20 (800-900)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

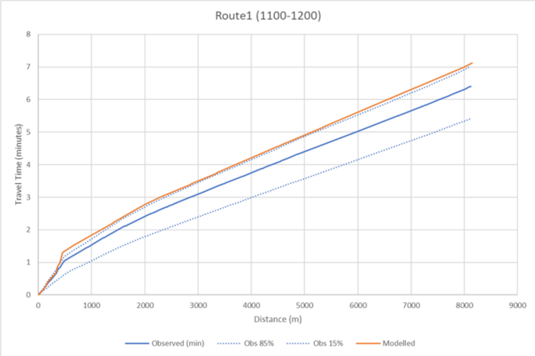

Route21 (800-900)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

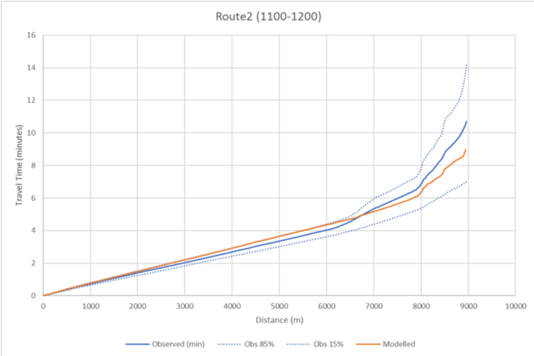

Route23 (800-900)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

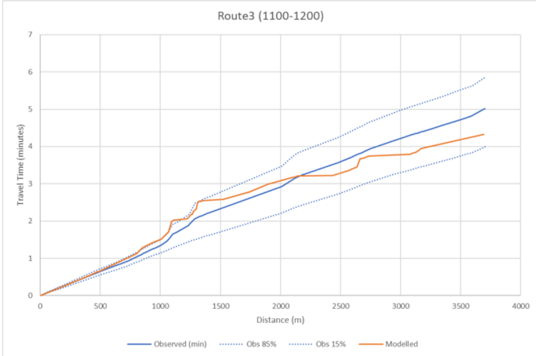

Route22 (800-900)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

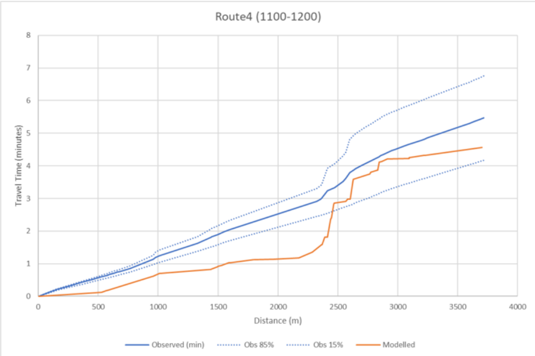

Route19 (800-900)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

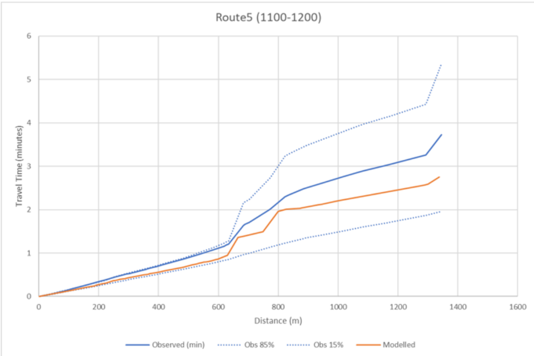
The graphs below show the time vs. distance XY scatter plots for the two central inter-peak modelled hours for the 23 TomTom routes.

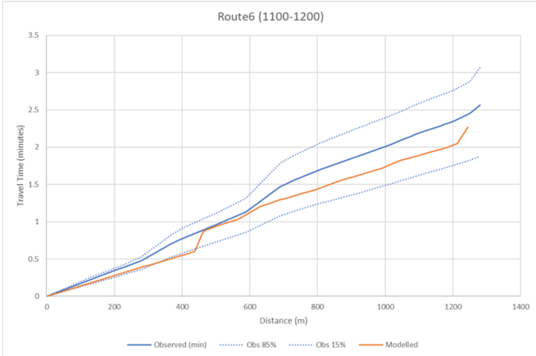

Route1 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

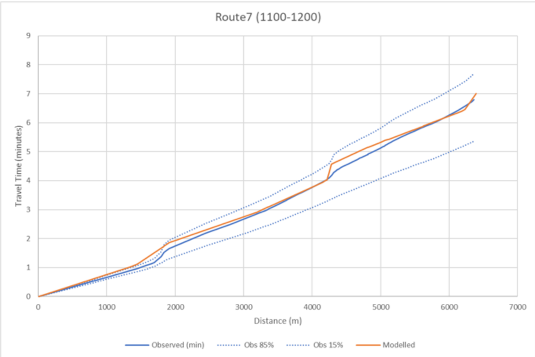

Route2 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

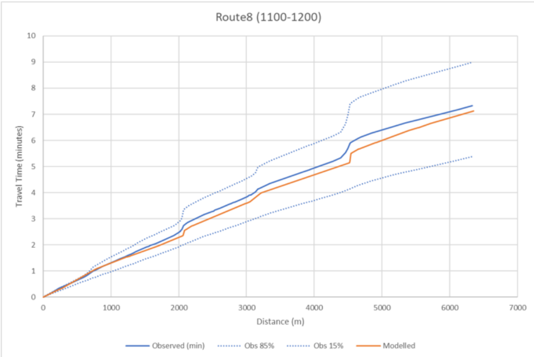

Route3 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

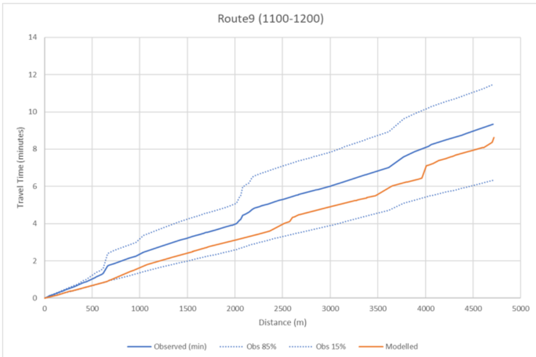

Route4 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

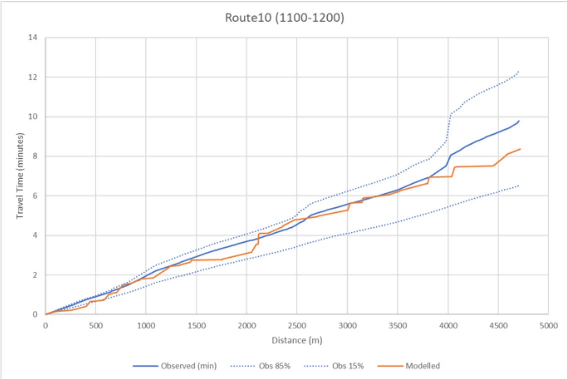

Route5 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

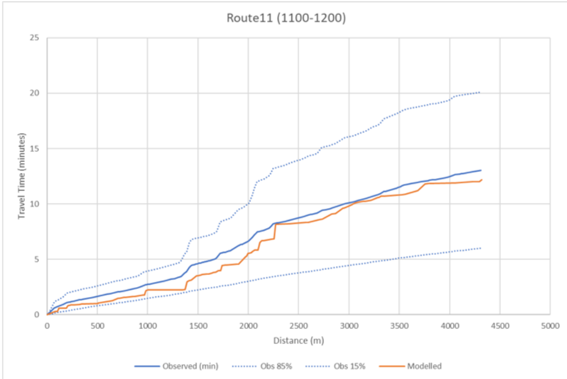

Route6 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

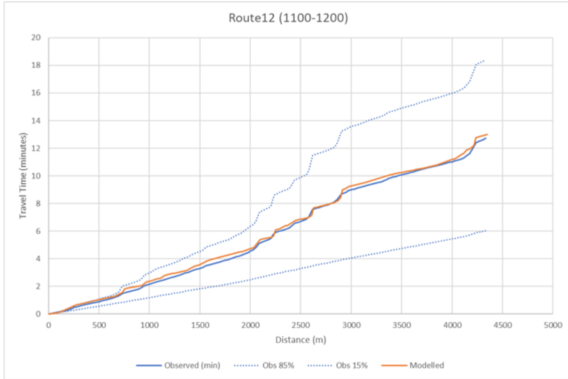

Route7 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

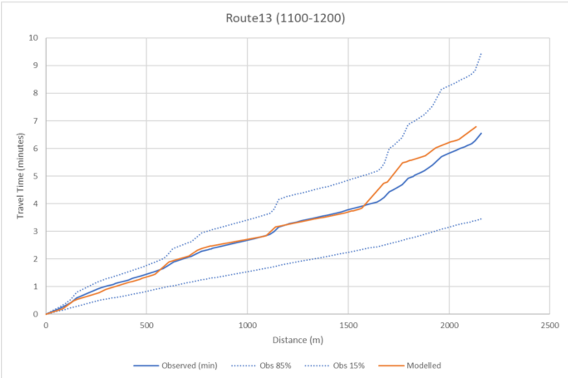

Route8 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

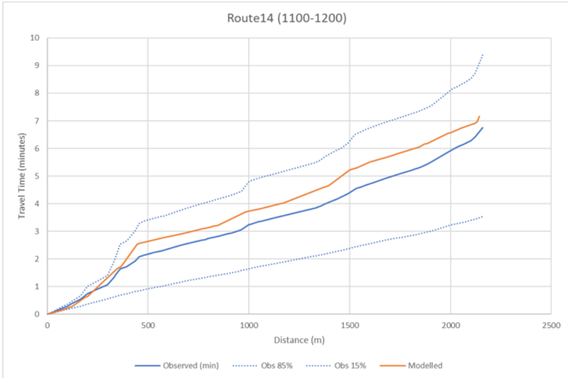

Route9 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

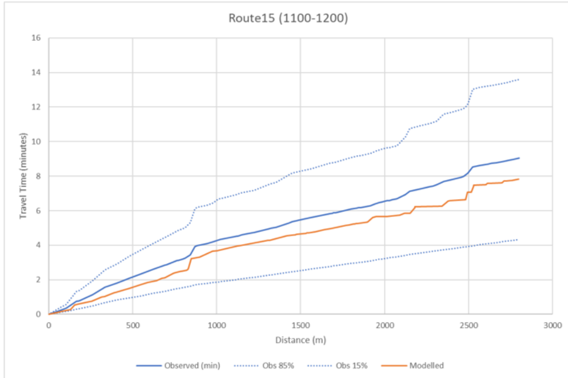

Route10 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

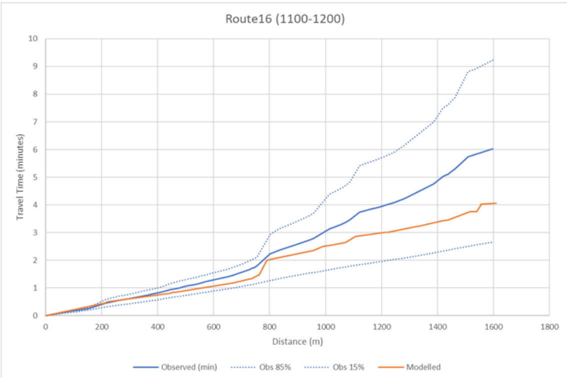

Route11 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

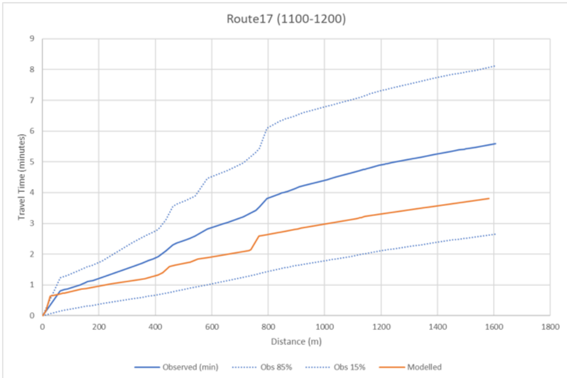

Route12 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

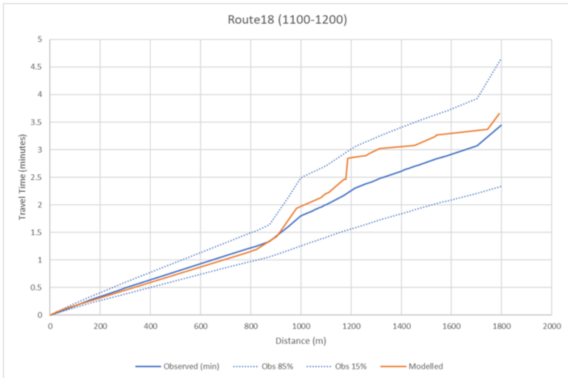

Route13 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route14 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

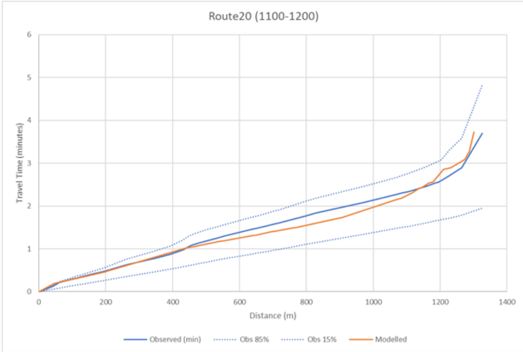

Route15 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

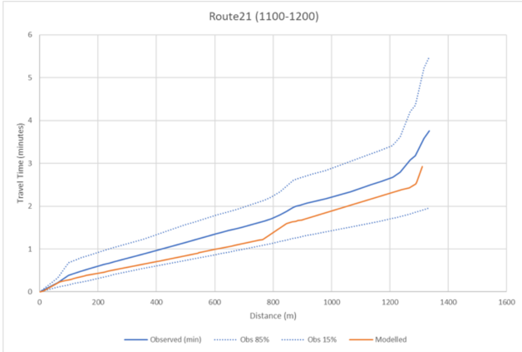

Route16 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

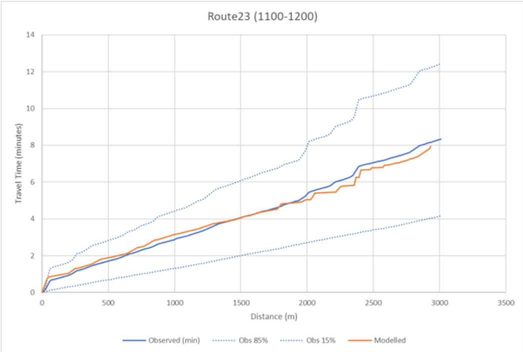

Route17 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

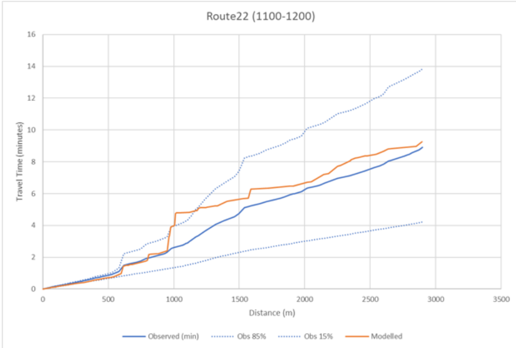

Route18 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

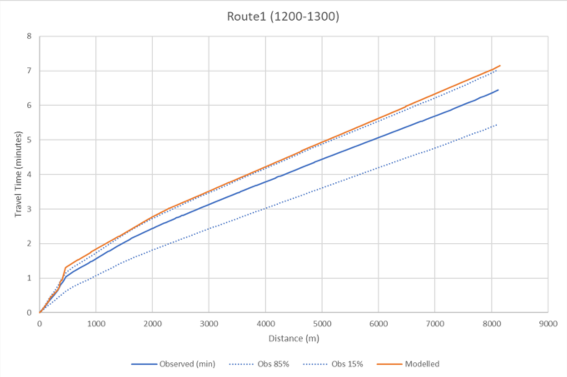

Route19 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

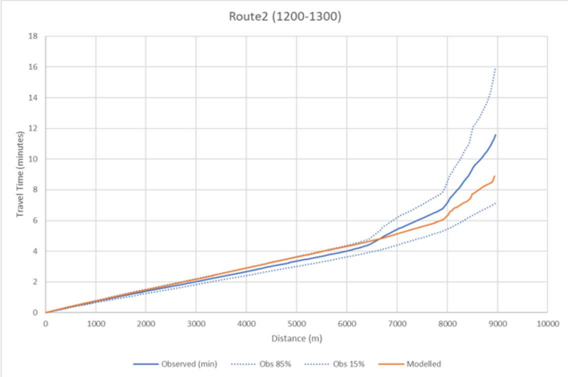

Route20 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

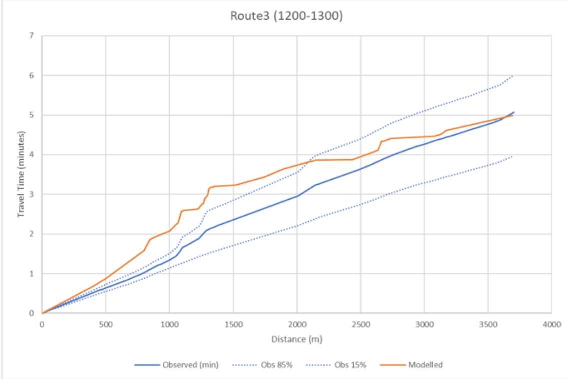

Route21 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

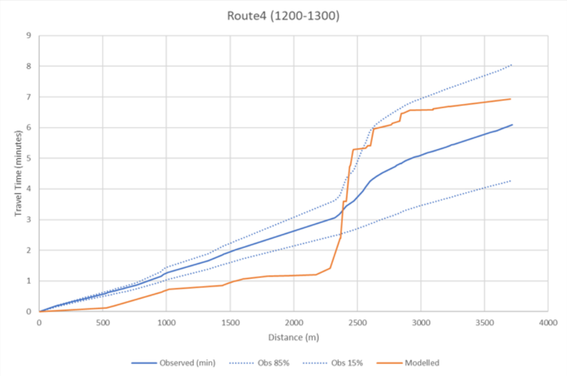

Route23 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

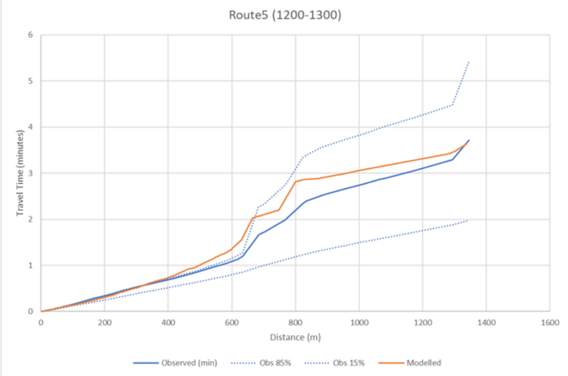

Route22 (1100-1200)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

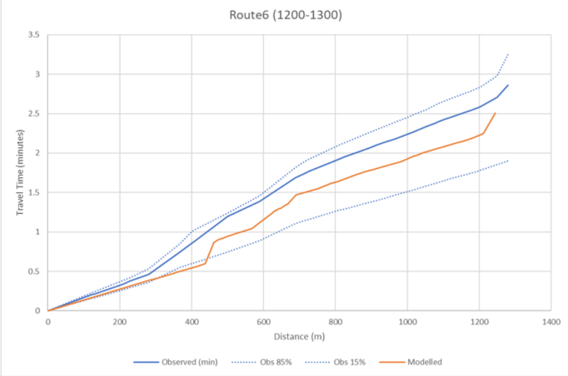

Route1 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

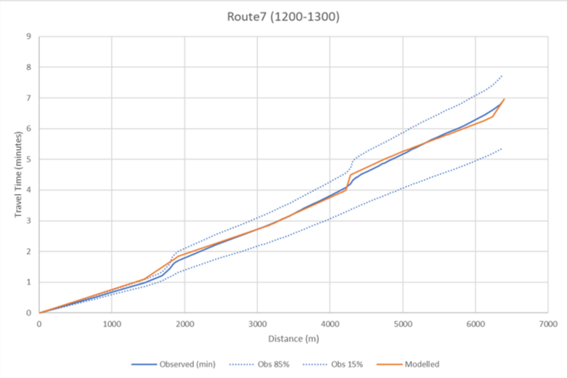

Route2 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

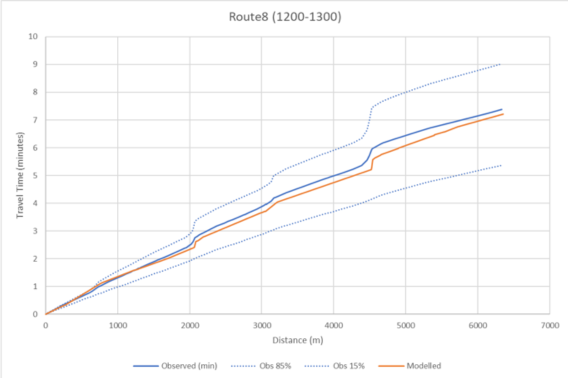

Route3 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

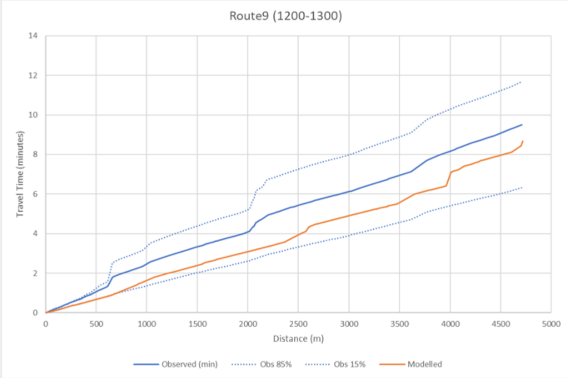

Route4 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

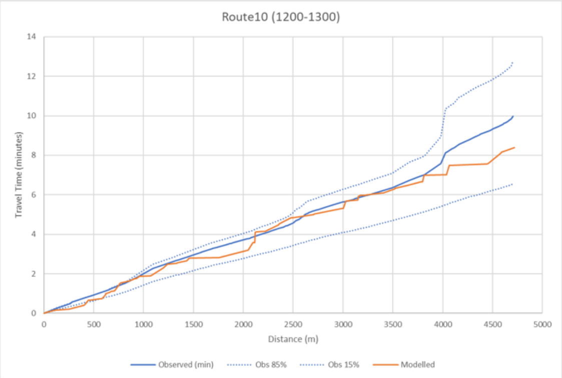

Route5 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

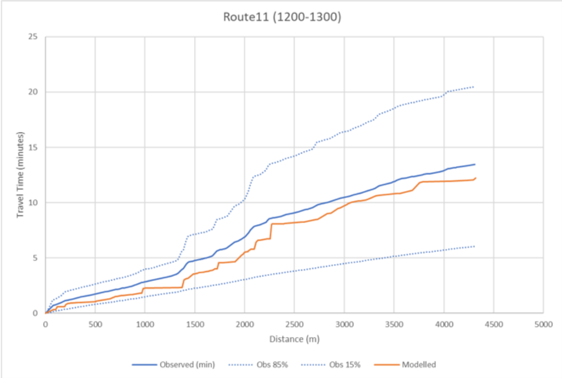

Route6 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

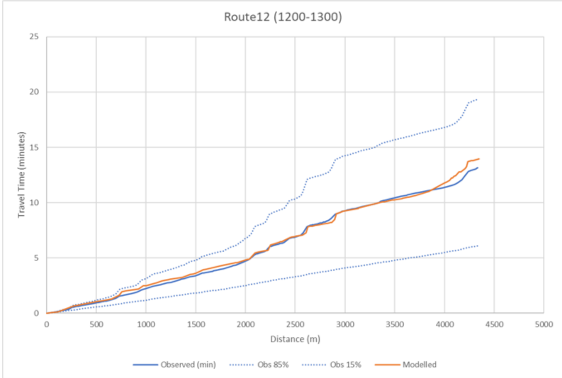

Route7 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

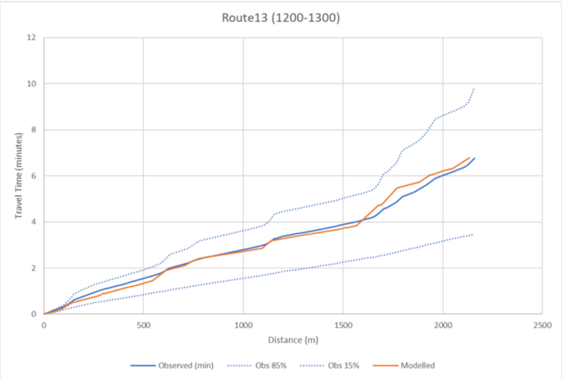

Route8 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

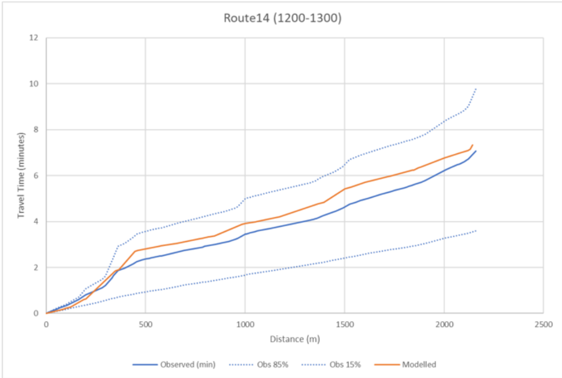

Route9 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

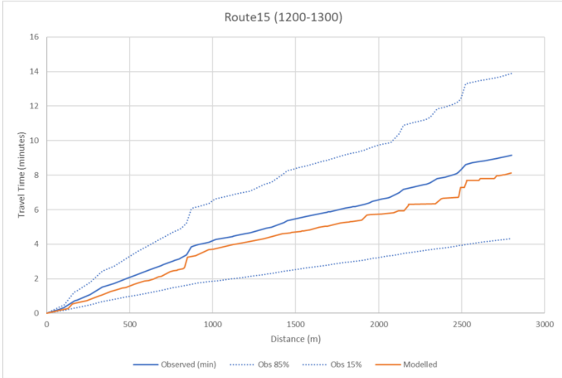

Route10 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

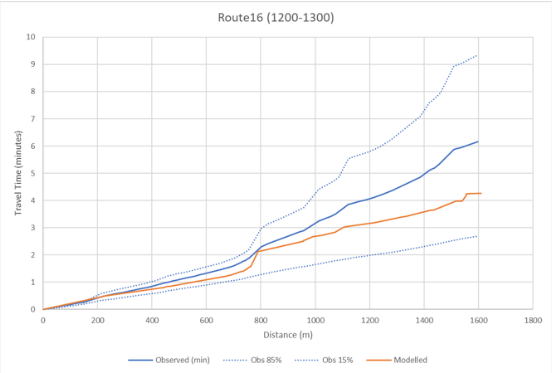

Route11 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

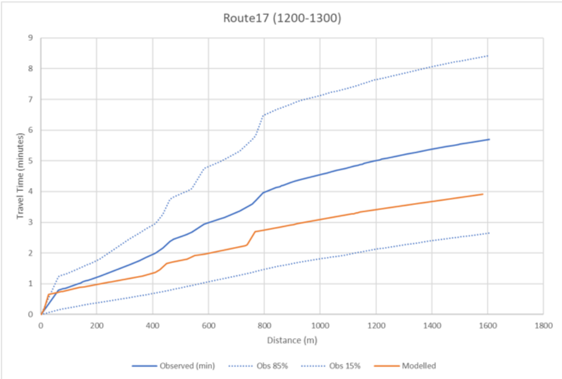

Route12 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

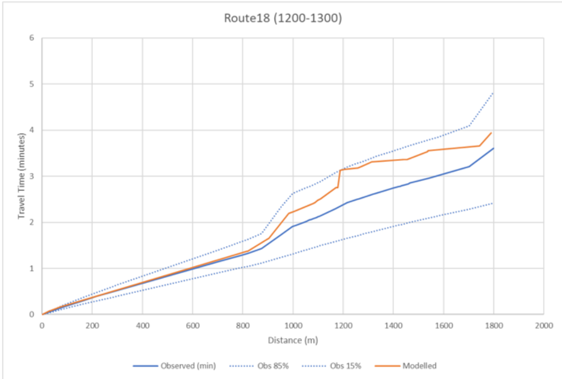

Route13 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route14 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

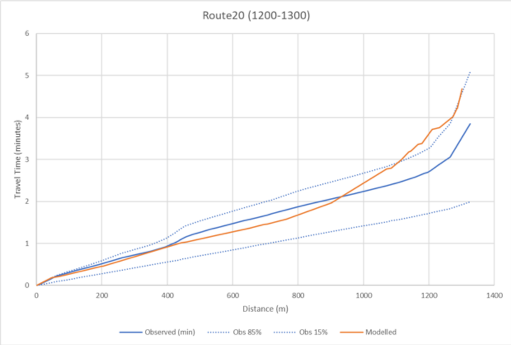

Route15 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

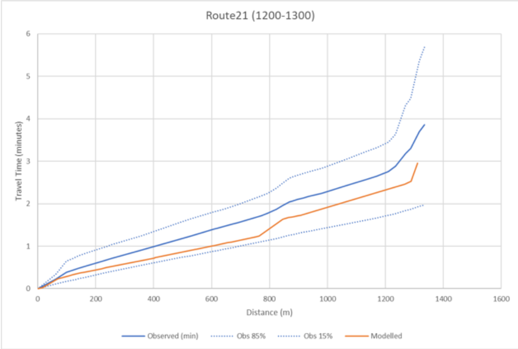

Route16 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

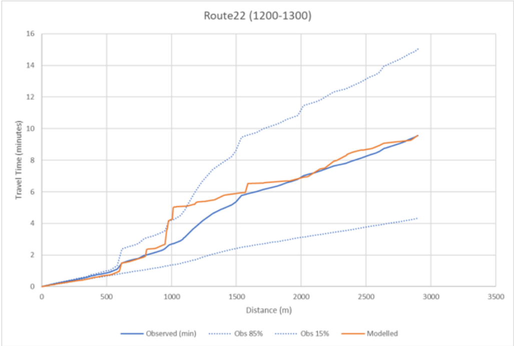

Route17 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

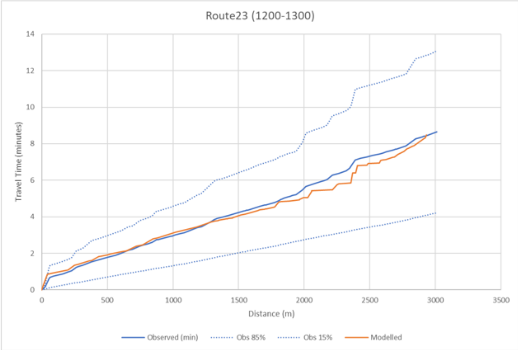

Route18 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route19 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

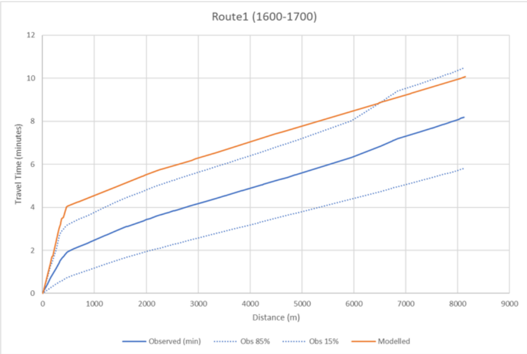

Route20 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

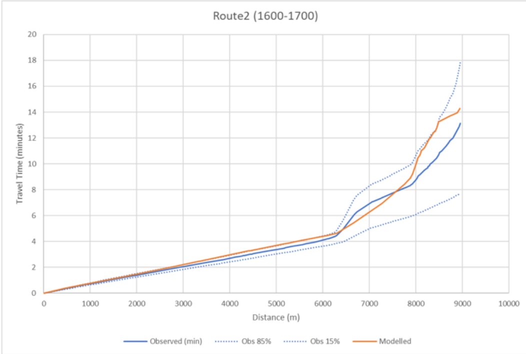

Route21 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

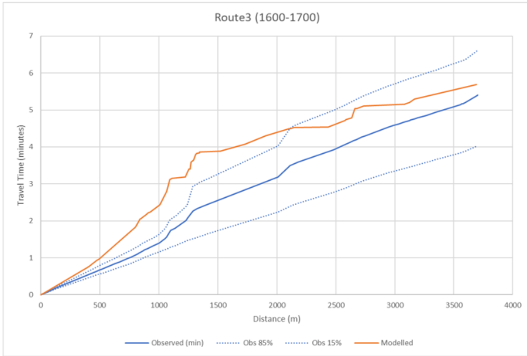

Route22 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

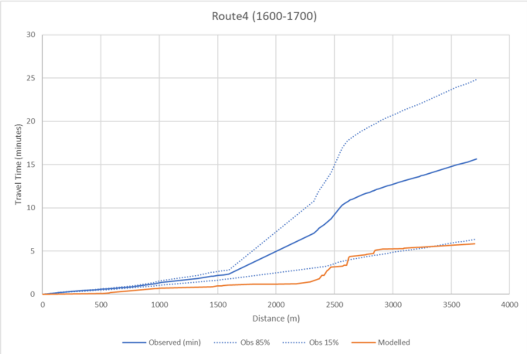

Route23 (1200-1300)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

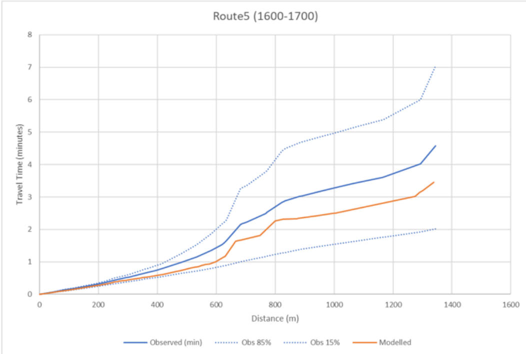
The graphs below show the time vs. distance XY scatter plots for the two central PM period modelled hours for the 23 TomTom routes.

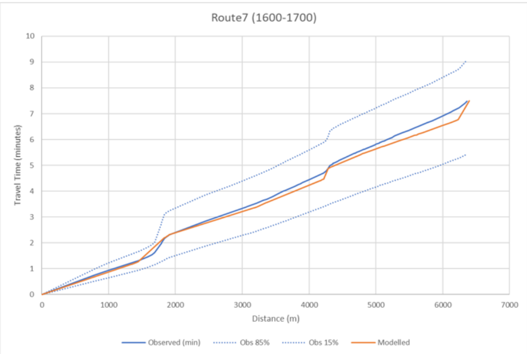


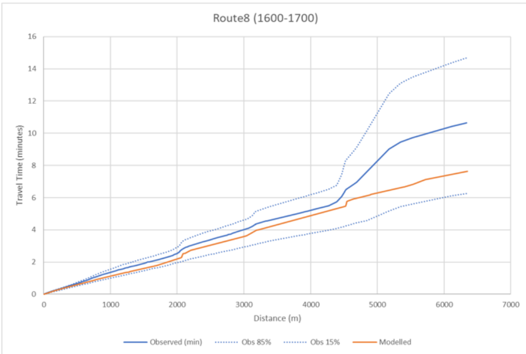


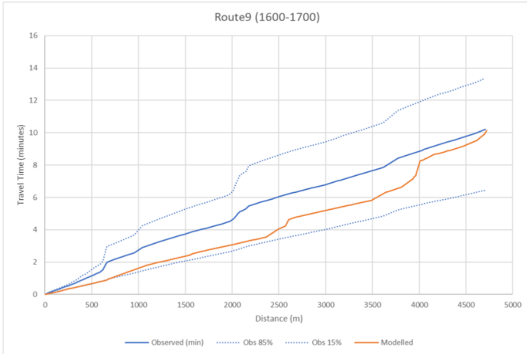


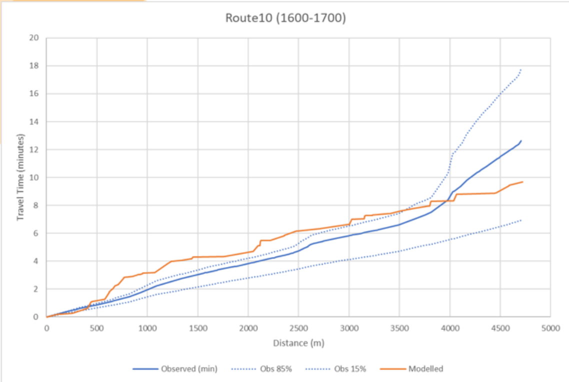


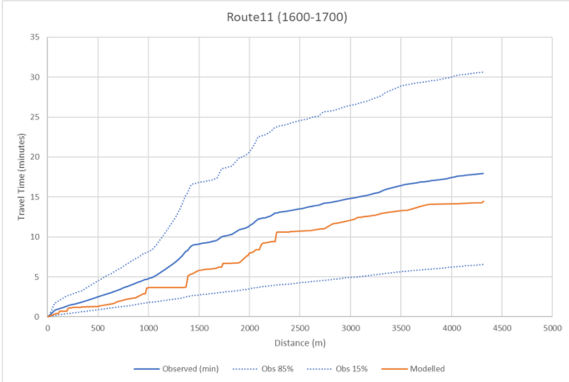


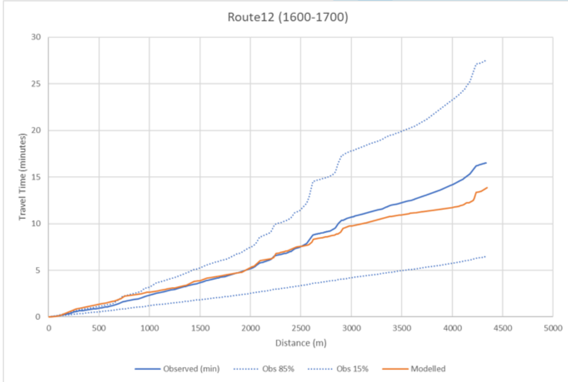


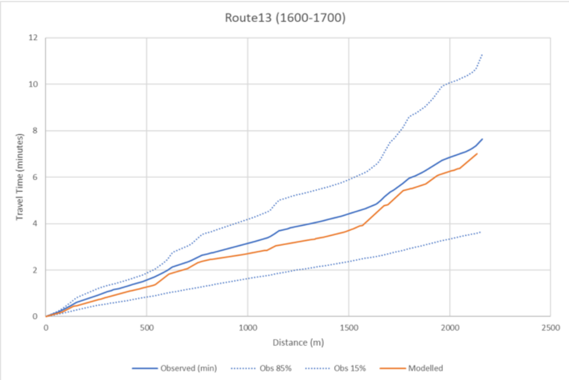


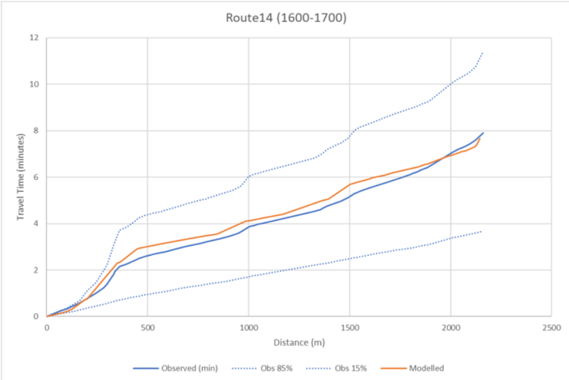


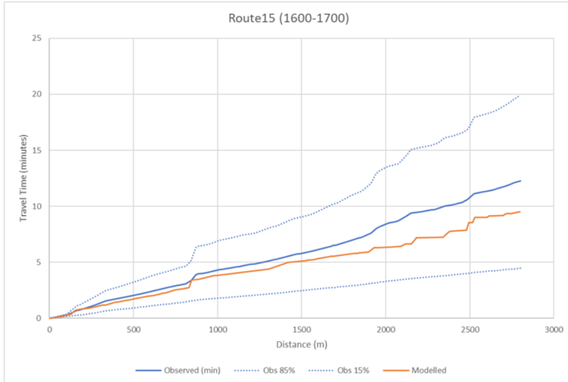

Route10 (1600-1700)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

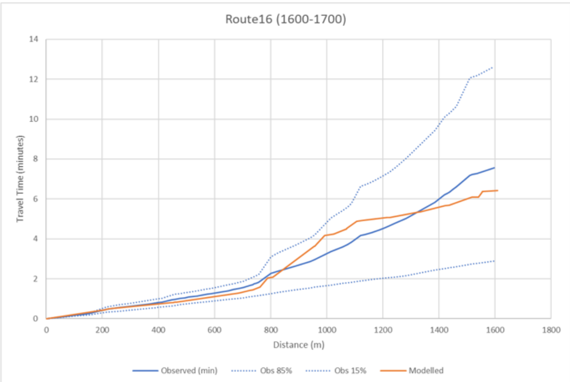

Route11 (1600-1700)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

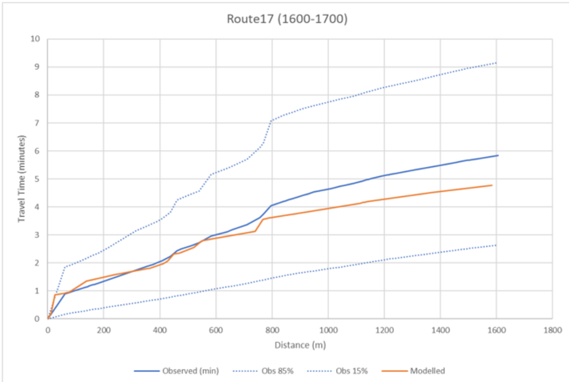

Route12 (1600-1700)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

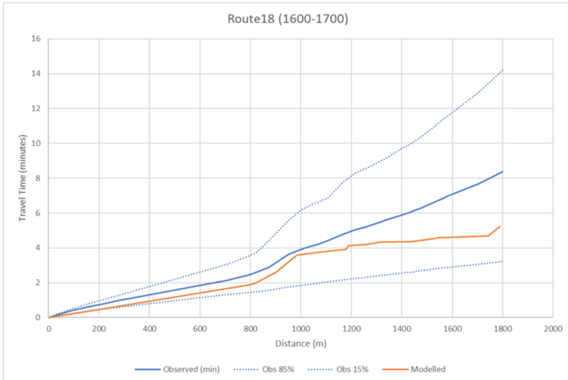

Route13 (1600-1700)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

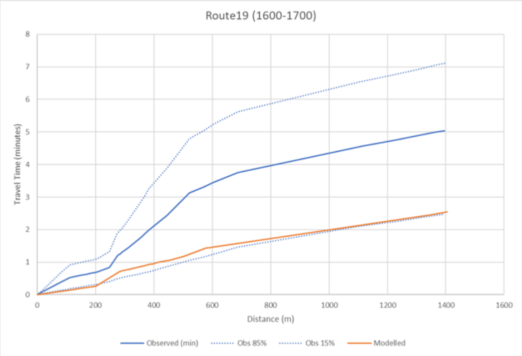

Route14 (1600-1700)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

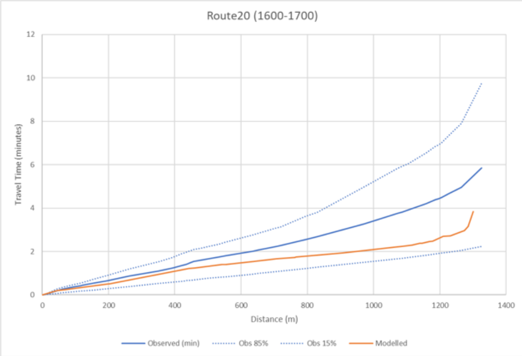

Route15 (1600-1700)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

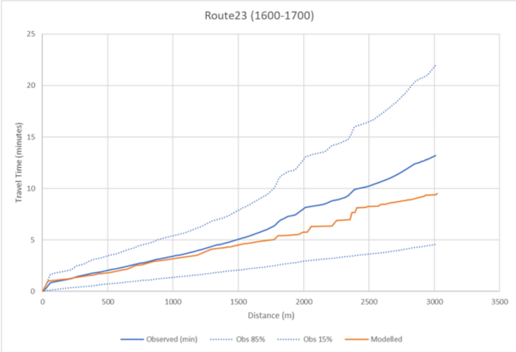

Route16 (1600-1700)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route17 (1600-1700)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

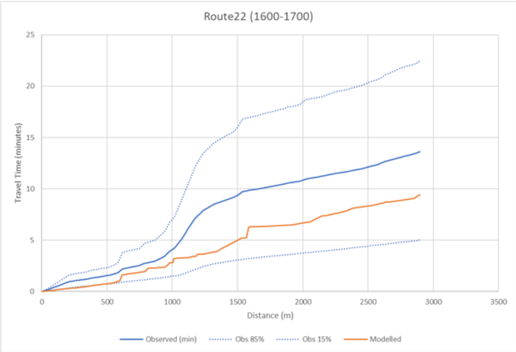

Route18 (1600-1700)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

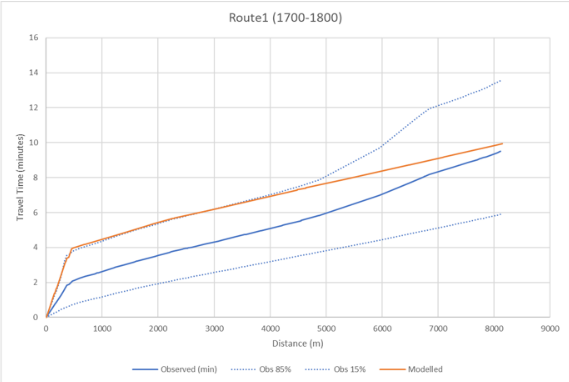

Route19 (1600-1700)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

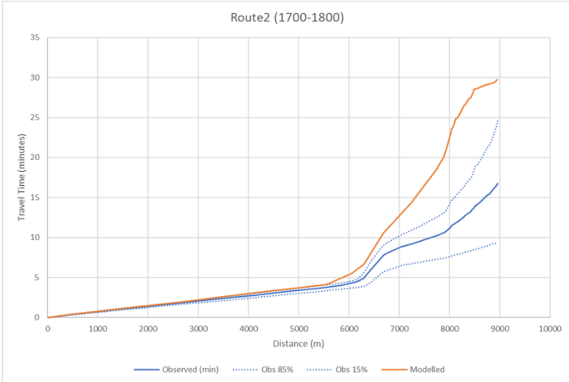

Route20 (1600-1700)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

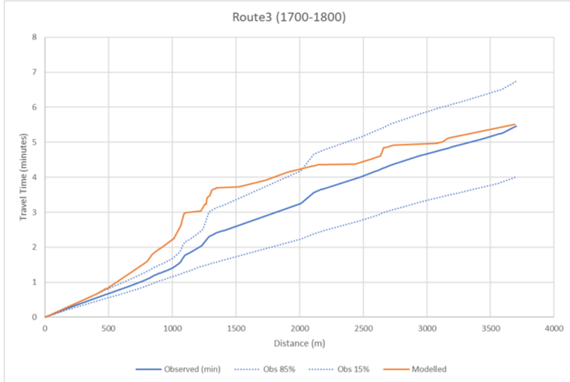

Route23 (1600-1700)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

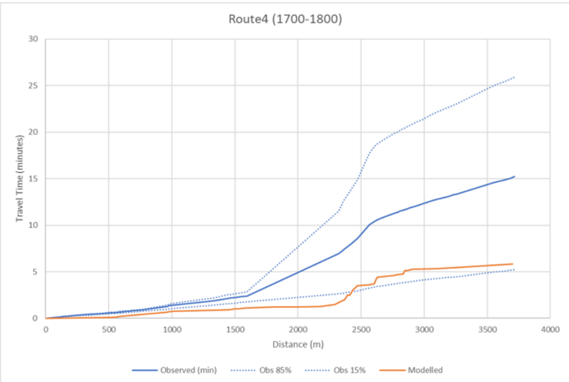

Route21 (1600-1700)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

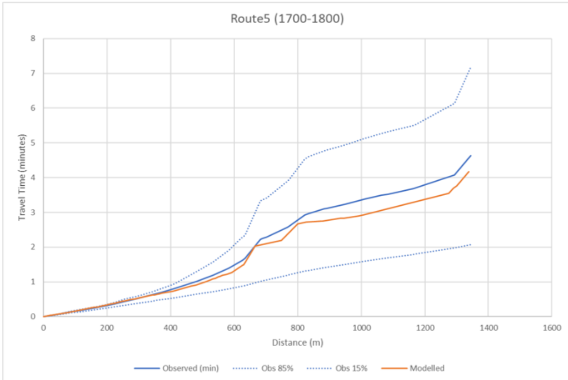

Route22 (1600-1700)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

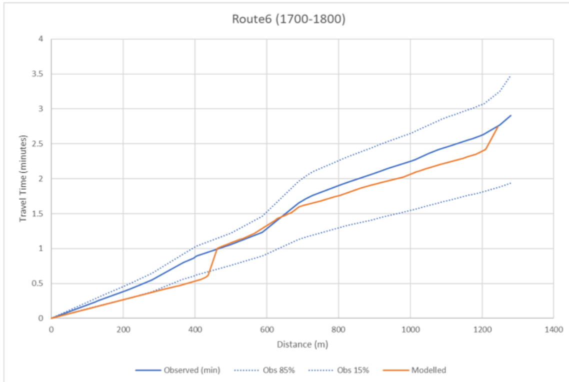

Route1 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

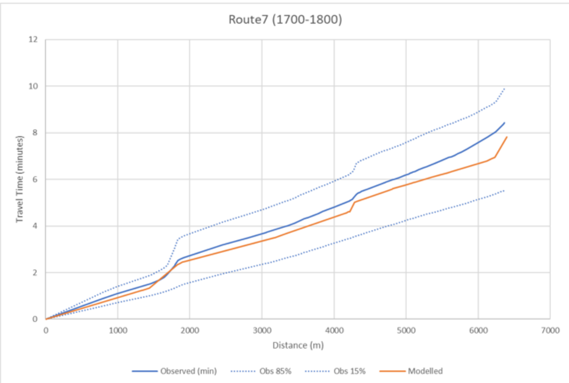

Route2 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

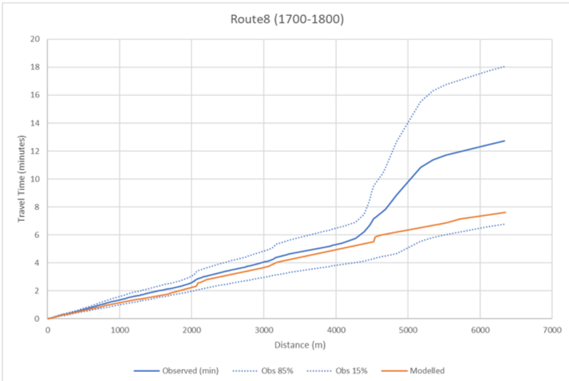

Route3 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

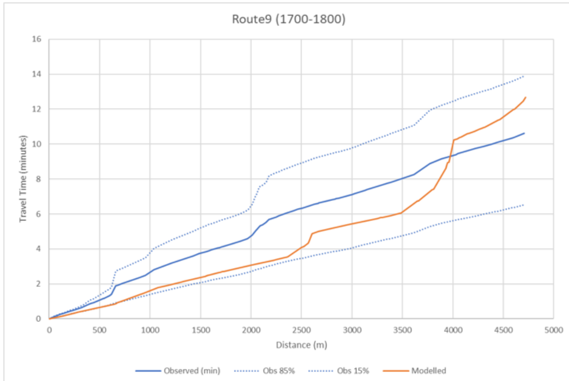

Route4 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

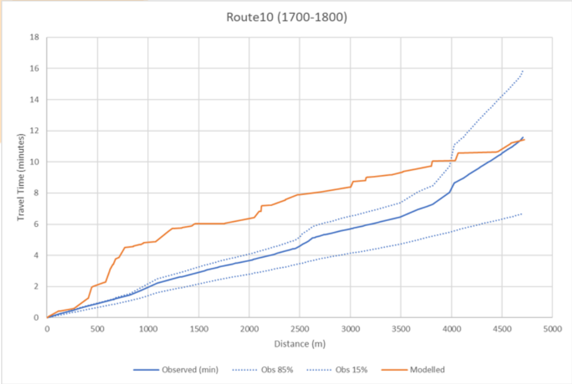

Route5 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

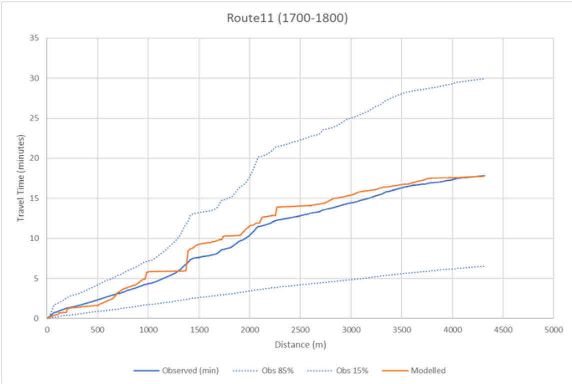

Route6 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

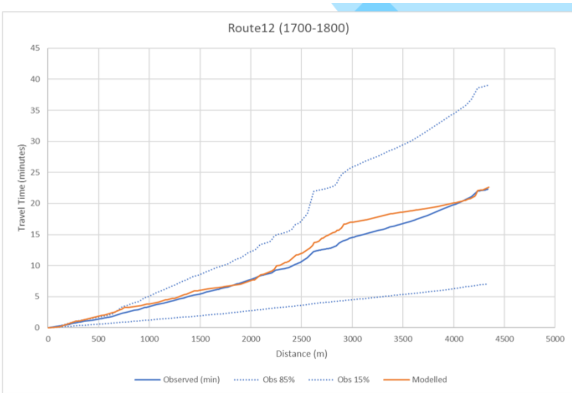

Route7 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

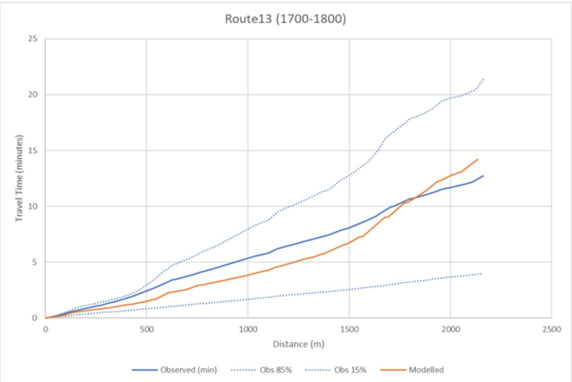

Route8 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

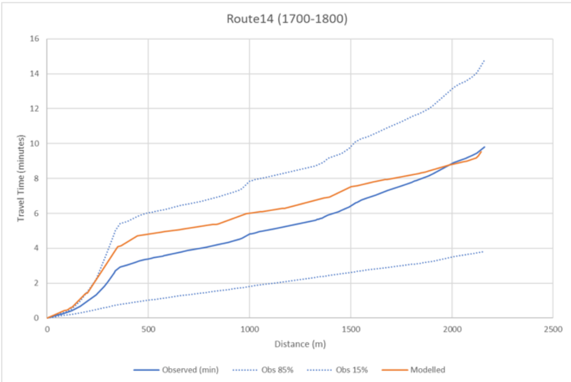

Route9 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

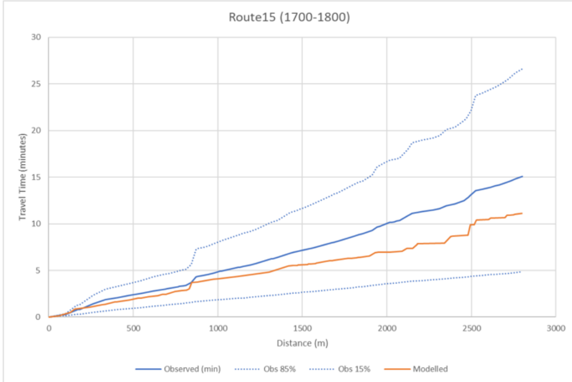

Route10 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

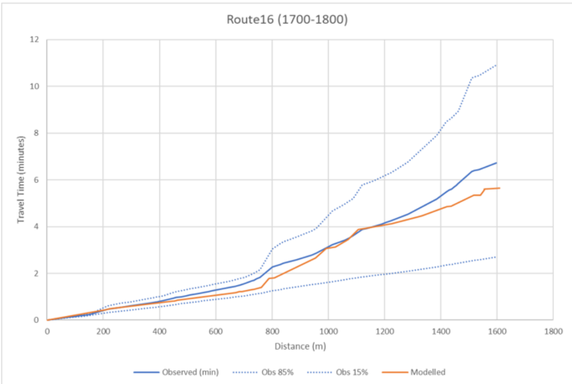

Route11 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

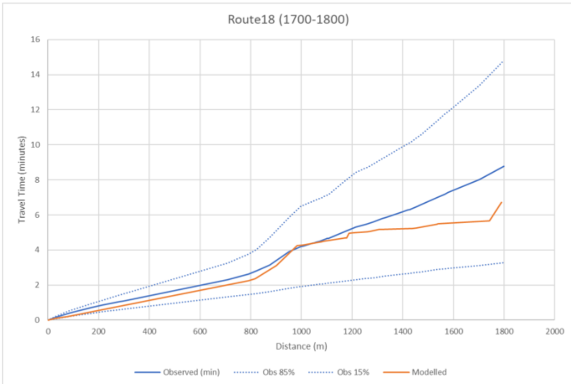

Route12 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route13 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route14 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route15 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route16 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route18 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
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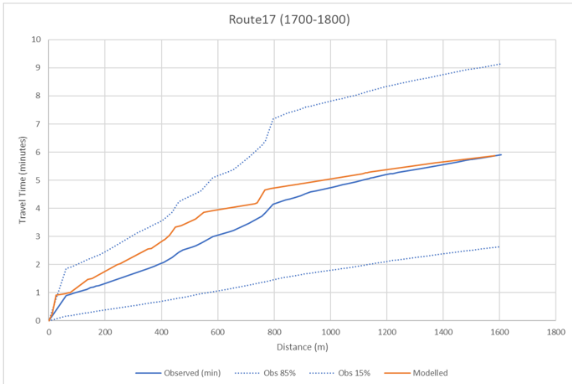
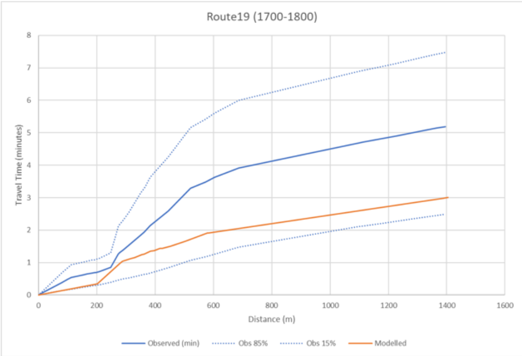
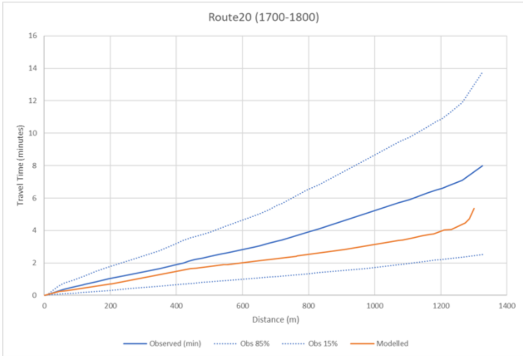
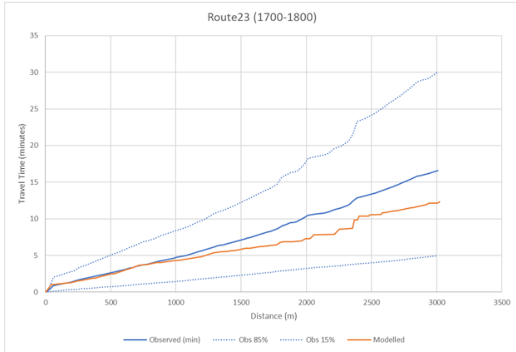
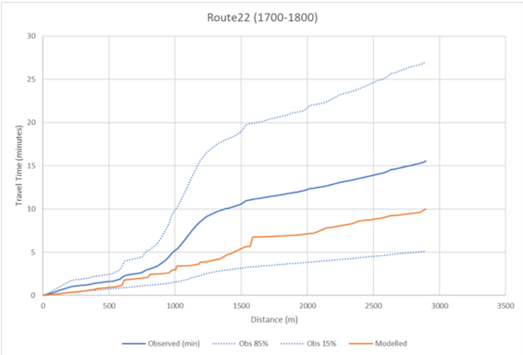
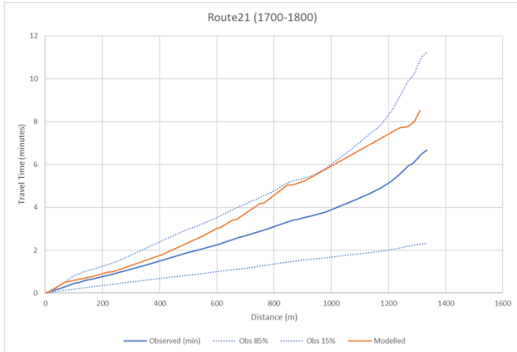

Route17 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route19 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route20 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route23 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route22 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled


Route21 (1700-1800)
Travel Time (minutes)
Distance (m)
Observed (min)
Obs 85%
Obs 15%
Modelled

Appendix D: Turn count GEHS Greater than 10

The tables below show the turning movements with GEHs greater than 10 for the two central AM peak hours

	07:00 - 08:00			
MOVEMENT	Obs	Mod	Diff	GEH
The Parade - Mersey St (The Parade, South, LT)	4	109	105	13.9
Waterloo Quay - Whitmore St (Waterloo Quay, South, TH)	667	386	-281	12.3
Vivan St - Willis St (Vivian St, West, LT)	10	98	88	12.0
Cobham Dr - Troy St (Cobham Dr, West, RT)	191	58	-133	11.9
Luxford St - Adelaide Rd (Luxford St, East, RT)	98	12	-86	11.6
Riddiford St - Constable St (Riddiford St, South, TH)	303	140	-163	11.0
Taranaki St - Jervois Quay - Wakefield St (Taranaki St, North, RT1)	13	92	79	10.9
Ruahine St- Wellington Rd (Wellington Rd, West, LT)	276	124	-152	10.7
Riddiford St - Constable St (Riddiford St, North, LT)	162	324	162	10.4
Thordon Quay - Mulgrave St - Great Harbour Way (Mulgrave St, West, LT)	44	140	96	10.0

	08:00 - 09:00			
MOVEMENT	Obs	Mod	Diff	GEH
Riddiford St - Constable St (Riddiford St, North, LT)	182	455	273	15.3
The Parade - Mersey St (The Parade, South, LT)	10	141	131	15.1
Taranaki St - Jervois Quay - Wakefield St (Taranaki St, South, LT2)	549	292	-257	12.6
Jervois Quay - Harris St (Jervois Quay, South, LT)	-	74	74	12.2
Ruahine St- Wellington Rd (Wellington Rd, West, LT)	382	180	-202	12.1
Adelaide Rd - Basin Reserve (Basin Res, East, LT)	551	867	316	11.9
Vivan St - Kent Tce - Cambridge Tce (Vivian St, West, LT)	34	146	112	11.8
Ruahine St- Wellington Rd (Ruahine St, South, TH)	684	1,011	327	11.2
Evans Bay Pde - Kilbirnie Cres (Bay Rd, South, RT)	6	76	70	11.0
Vivian St - Willis St (Willis St, South, RT)	338	564	226	10.6
The Parade - Mersey St (Mersey St, West, LT)	57	0	-57	10.6
Te Warepouri St - Rintoul St (Rintoul St, North, LT)	65	4	-61	10.5
Adelaide Rd - Hospital Rd (Adelaide Rd, South, TH)	759	1,064	305	10.1
Luxford St - Adelaide Rd (Luxford St, East, RT)	143	46	-97	10.0

The tables below show the turning movements with GEHs greater than 10 for the two central Inter Peak hours.

	11:00 - 12:00			
MOVEMENT	Obs	Mod	Diff	GEH
Thordon Quay - Mulgrave St - Great Harbour Way (Thorndon Quay, North, TH)	358	147	-211	13.3
Evans Bay Pde - Kilbirnie Cres (Kilbirnie Cres, West, RT)	71	6	-65	10.4
The Parade - Dee St (The Parade, North, RT)	17	94	77	10.4

	12:00 - 13:00			
MOVEMENT	Obs	Mod	Diff	GEH
Thordon Quay - Mulgrave St - Great Harbour Way (Thorndon Quay, North, TH)	373	166	-207	12.6
Evans Bay Pde - Rongotai Rd (Rongotai Rd, East, RT)	175	382	207	12.4
Ruahine St- Wellington Rd (Wellington Rd, West, LT)	171	48	-123	11.8
Riddiford St - Rintoul St (Emmett St, East, LT)	14	96	82	11.1
Taranaki St - Jervois Quay - Wakefield St (Taranaki St, North, RT2)	63	1	-62	11.0
Cambridge Tc- Kent Tc - Basin Res (Basin Res, West, TH)	148	41	-107	11.0
Cobham Dr - Troy St (Cobham Dr, East, LT)	615	899	284	10.3
Evans Bay Pde - Kilbirnie Cres (Kilbirnie Cres, West, RT)	73	9	-64	10.0

The tables below show the turning movements with GEHs greater than 10 for the two central PM peak hours.

	16:00 - 17:00			
MOVEMENT	Obs	Mod	Diff	GEH
Ruahine St- Wellington Rd (Ruahine St, South, LT)	91	288	197	14.3
Cobham Dr - Troy St (Cobham Dr, East, RT)	732	1,145	413	13.5
Thordon Quay - Mulgrave St - Great Harbour Way (Mulgrave St, West, LT)	94	261	167	12.5
Hanson St - John St (John St, West, TH)	634	364	-270	12.1
Riddiford St - Mein St - Hall St (Riddiford St, South, LT)	161	45	-116	11.4
Evans Bay Pde - Rongotai Rd (Rongotai Rd, West, RT)	173	54	-119	11.1
Vivian St - Willis St (Willis St, South, TH)	408	213	-195	11.1
Cobham Dr - Troy St (Cobham Dr, West, RT)	235	96	-139	10.8
Taranaki St - Jervois Quay - Wakefield St (Taranaki St, North, RT2)	61	1	-60	10.8
Evans Bay Pde - Kilbirnie Cres (Kilbirnie Cres, West, RT)	86	11	-75	10.7
Evans Bay Pde - Kilbirnie Cres (Bay Rd, South, TH)	41	144	103	10.7
Waterloo Quay - Whitmore St (Waterloo Quay, North, RT)	75	194	119	10.3
Adelaide Rd - Hospital Rd (Hospital Road, East, LT)	79	11	-68	10.1

	17:00 - 18:00			
MOVEMENT	Obs	Mod	Diff	GEH
Waterloo Quay - Whitmore St (Waterloo Quay, North, RT)	78	260	182	14.0
Thordon Quay - Mulgrave St - Great Harbour Way (Mulgrave St, West, LT)	71	245	174	13.8
Cobham Dr - Troy St (Cobham Dr, East, RT)	741	1,142	401	13.1
Vivian St - Willis St (Vivian St, West, TH)	1,146	792	-354	11.4
Ruahine St- Wellington Rd (Ruahine St, South, LT)	131	293	162	11.1
Riddiford Rd - Hospital Entrance North (Riddiford Rd, North, TH)	639	388	-251	11.1
Evans Bay Pde - Rongotai Rd (Evans Bay Pde, North, TH)	259	115	-144	10.5