REPORT

WELLINGTON TRANSPORT ANALYTICS UNIT

Hutt Aimsun Model: TN3 Networks

PREPARED FOR HUTT CITY COUNCIL

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QUALITY STATEMENT

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CONTENTS

1. Introduction

The Hutt Aimsun Model (HAM) has been updated by the Wellington Transport Analytics Unit (WTAU) to a new base year of 2024 for use on upcoming projects in the Lower Hutt area on behalf of Hutt City Council (HCC) and Waka Kotahi (NZTA).

The previous HAM had a base year of 2017 and focused on the Lower Hutt area. This update expands the model extents to cover the SH1 corridor to the West and the Upper Hutt area to the north. This will allow currently proposed projects such as Petone to Grenada, Cross Valley Link and SH2 corridor improvements to be assessed.

This report covers the network and zonal development outlining the key features and parameters which have been implemented in the model. Consistency with the other Aimsun models in the region has been a major consideration so that results between the tools will be comparable.

2. Model Extents

HAM has been developed in the Aimsun Next 24 software (Aimsun). Aimsun allows a range of network simulation and assignment methods to cover varying levels of modelling requirements. This includes static assignment, mesoscopic and microscopic simulation, which are all utilised in HAM.

HAM primarily covers the Lower Hutt area but also extents to SH1 to the West and Upper Hutt to the north. At the project inception stage it was agreed that these extension areas don't require the same level of network detail or model simulation. The model extents are shown in Figure 1 which shows:

- The Lower Hutt area in Green. This area has detailed zonal and network coverage and is simulated in micro-simulation.
- The Western SH1 Area in Orange. This area is also in micro-simulation but has less detailed network and zonal coverage.
- Upper Hutt is shown in blue. The area is simulated in the less detailed meso-simulation and, like the Western SH1 area, also has a less detailed network and zonal coverage.

To enable the mixed use of simulation types in the model, the hybrid simulation functionality has been used. This allows a "pocket" area to be created, in this case around the orange and green area, where the network within is micro-simulated. Everything outside the area (blue area) is mesoscopic.

The full model area is also simulated with a simplified static assignment, this is mostly used to provide initial vehicle paths for the meso and micro-simulation layers.

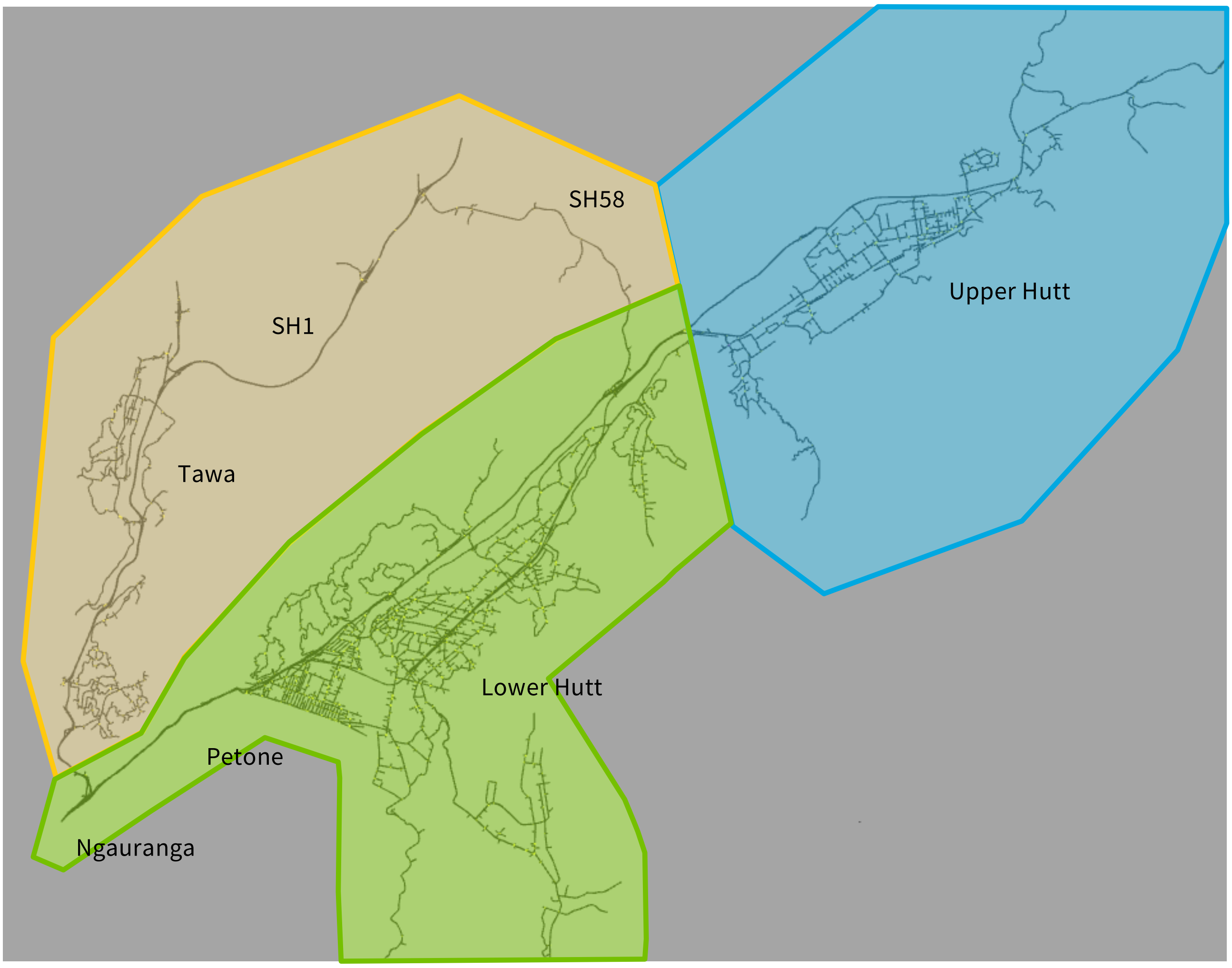

Figure 1: Model Extents

3. Zone System

A new zone system has been developed for this HAM update to suit the updated WTSM zone system and the expanded model extents. The WTSM zone system has been the starting point. WTSM zones have been split based on meshblock boundaries and local activities.

HAM has a total of 565 zones, comprised of 535 internal and 30 external zones. The internal zones are split from 336 WTSM zones which reflects the high level of zone refinement. Table 1 shows the Lower Hutt area sectors, comparing the WTSM and HAM zone count.

Table 1: Zone Splitting by Sectors

Sector	WTSM	HAM	Diff
HuttCentral	10	24	14
PetoneWest	14	53	39
PetoneEast	6	29	23
Alicetown	9	22	13
Wainuiomata	27	29	2
EasternHills	20	22	2
Woburn	9	21	12
Waiwhetu	10	22	12
Waterloo	14	26	12
Epuni	11	30	19
Naenae	14	24	10
Boulcott	4	16	12
Avalon	7	16	9
Taita	13	16	3
StokesValley	22	23	1
Eastbourne	7	7	0
Seaview	2	15	13

Figure 2 shows the overall zonal coverage across the model area. Most of the zone splitting has occurred in the Petone and Hutt CBD areas which are shown in more detail in Figure 3 and Figure 4 respectively. WTSM zones are shown in blue and the HAM splits are shown in black. Outside of these two areas, the HAM zones generally match the WTSM zones.

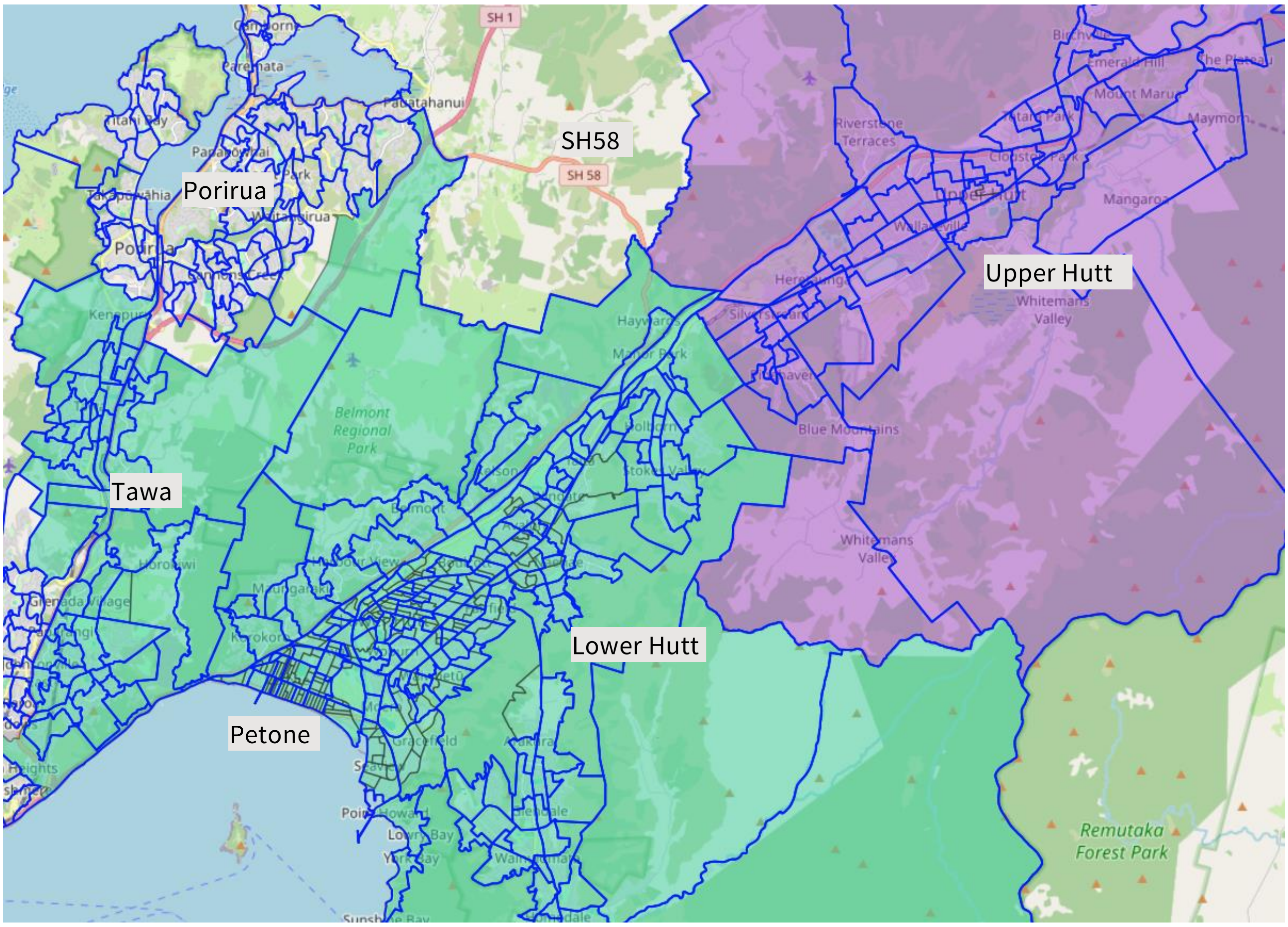

Figure 2: Overall Zonal Coverage

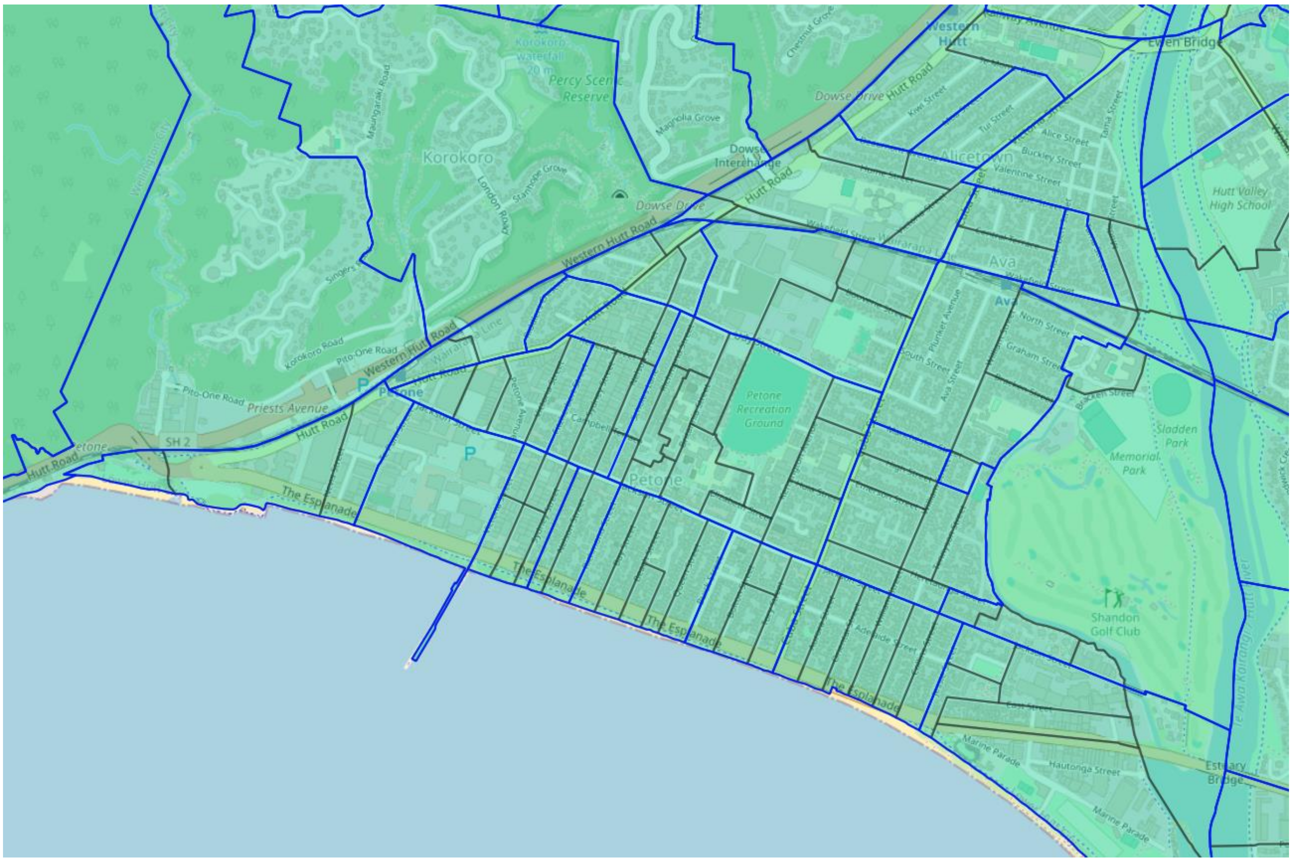

Figure 3: Petone Zone Splits

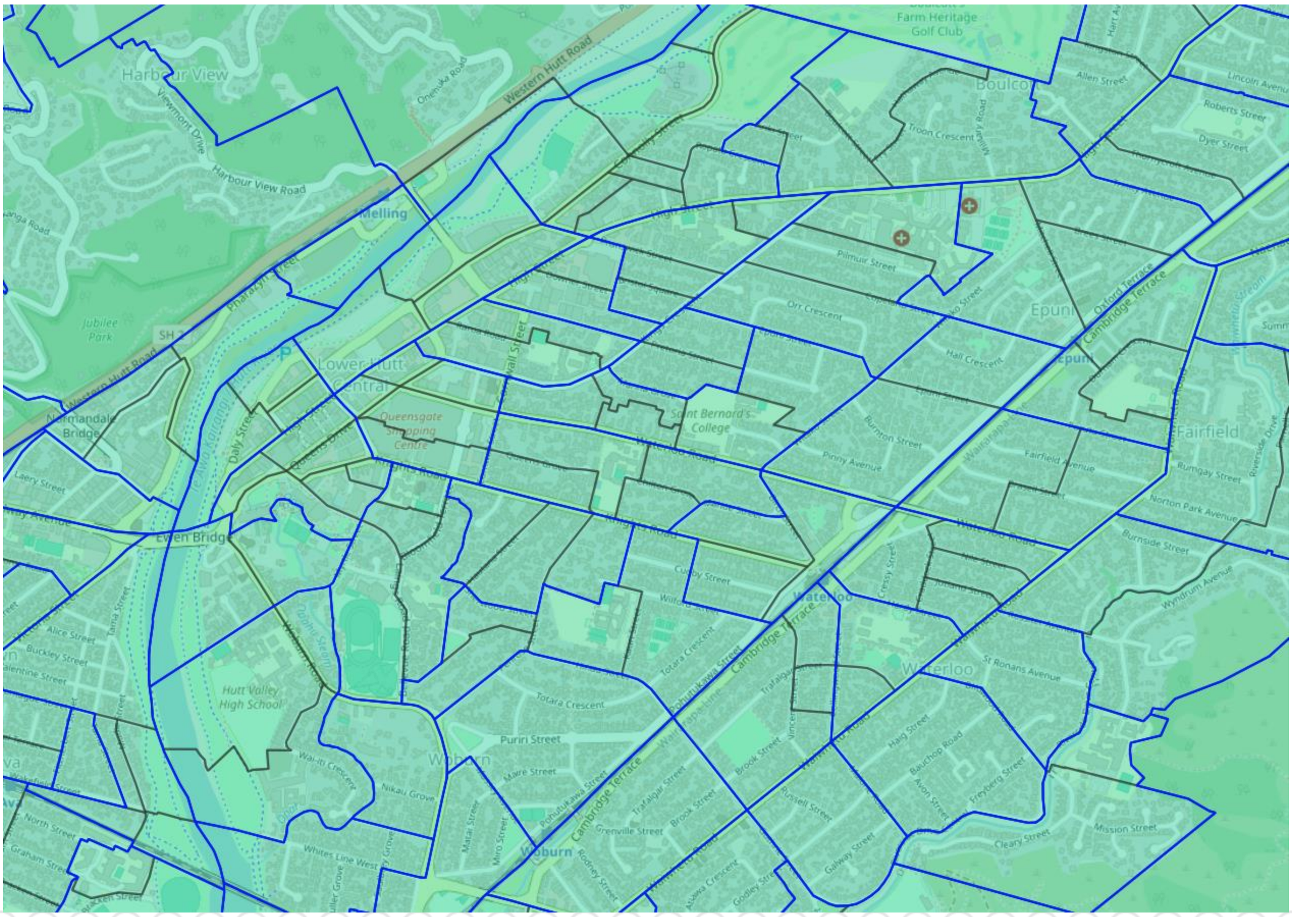

Figure 4: Hutt City Zone Splits

4. Network Build

The road network of HAM was created from a combination of sources.

- The Lower Hutt area used the previous HAM network as it's starting point, updating network object parameters to suit the new model.
- The SH1, Porirua and Tawa areas were imported from the Porirua Traffic Model.
- The rest of the network (mostly Upper Hutt and Newlands / Woodridge) has been imported from an OpenStreetMap network import. OpenStreetMap is an online repository of geographical data, which Aimsun has an import process to create network from.

The resulting network was checked and refined. Additional detail has been added to suit the Zone locations, balancing the level of detail between representative demand loading and not providing too many minor roads as route choice options (commonly referred to as "Rat-running").

Zone loaders have been placed to avoid adding traffic directly onto intersections or main arterials. Multiple loaders were preferred to spread the traffic around the zone, although this wasn't always possible or realistic. In built up areas, a major driveway or similar entrance has been added to the network to load onto. In less densified residential areas, traffic may be loaded onto side streets directly.

Figure 5 shows the initial model network after importing from the previous HAM and Porirua models. Figure 6 shows the final network which will be calibrated on.

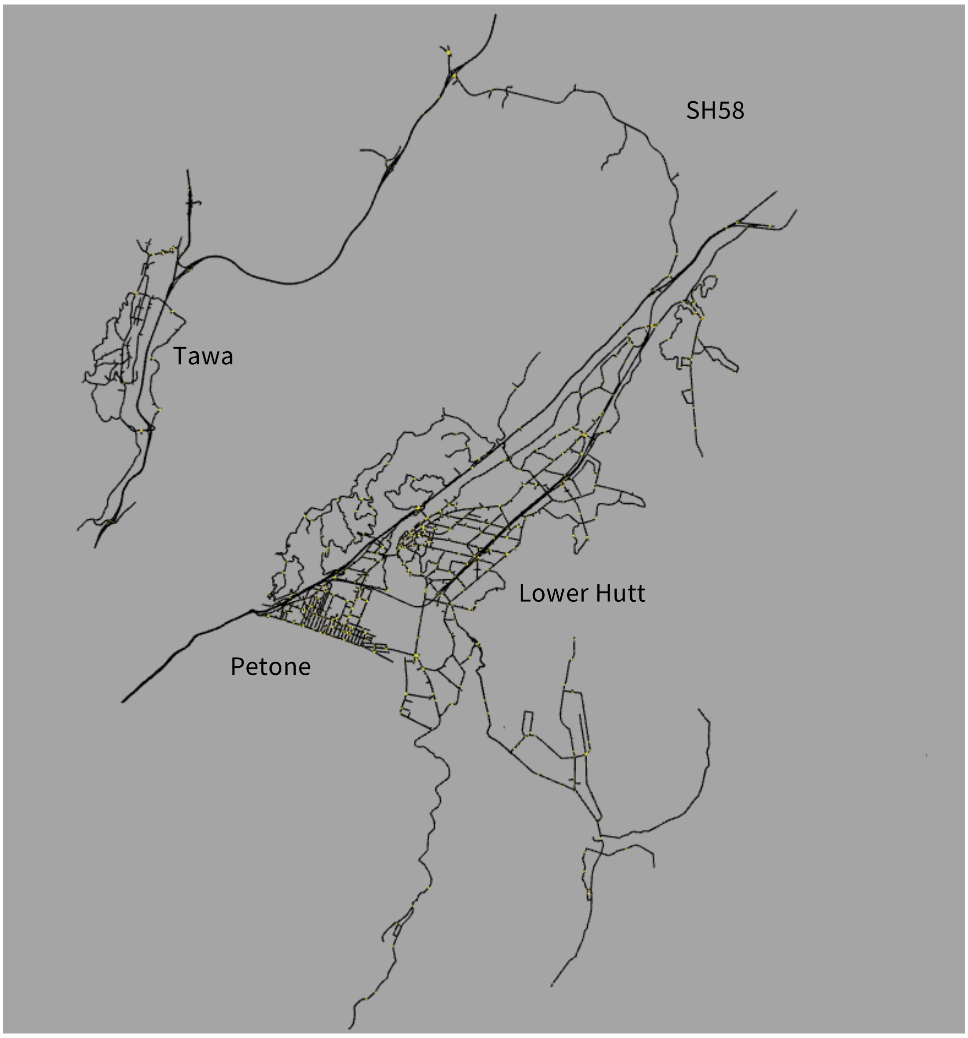

Figure 5: Initial Model Network

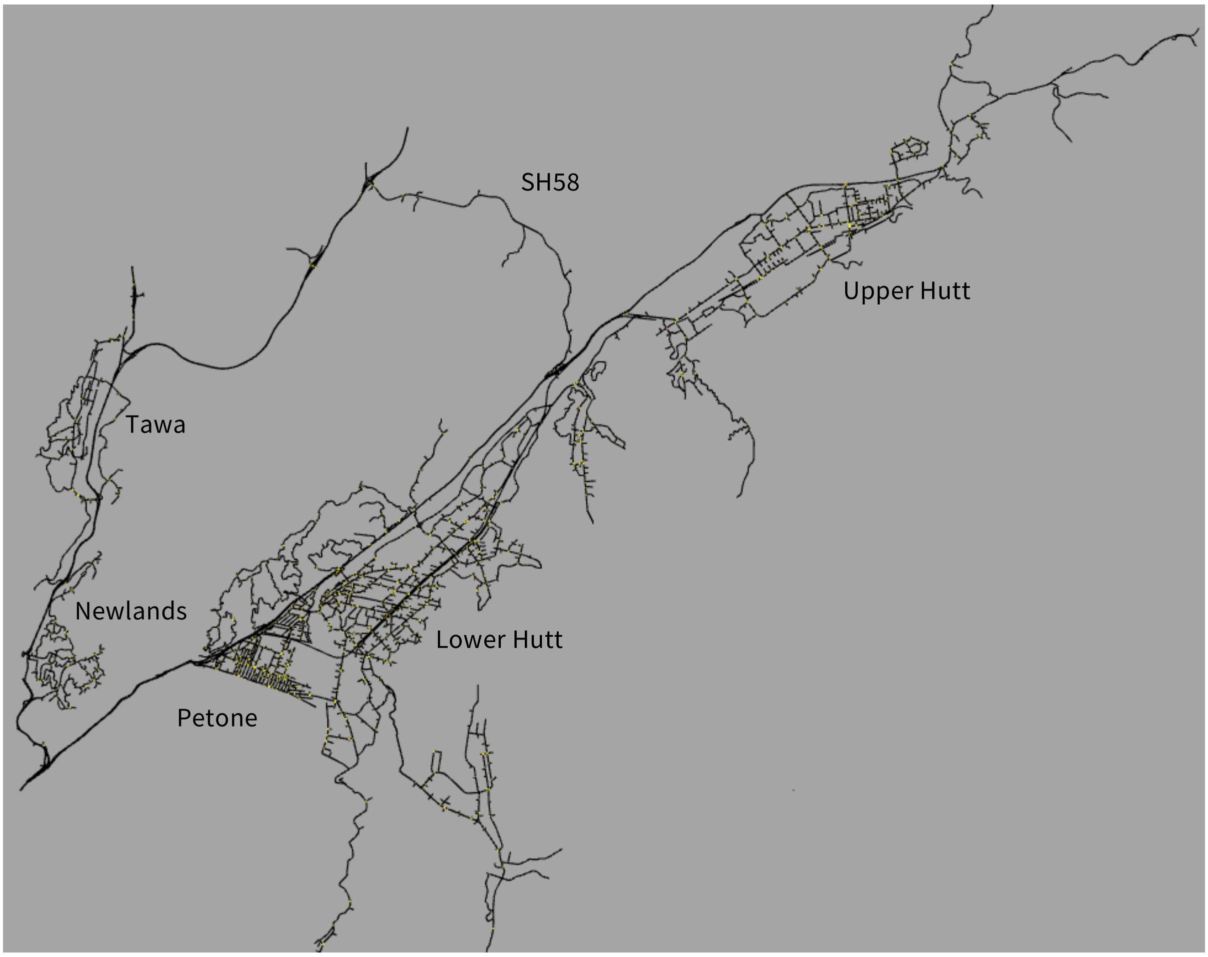

Figure 6: Refined Model Network

Figure 7 shows an example of the network refinement process. Here the Haywards Interchange has been reshaped to more closely match the on ground layout. The Park and Ride rail access legs and additional side roads have been added to improved traffic representation.

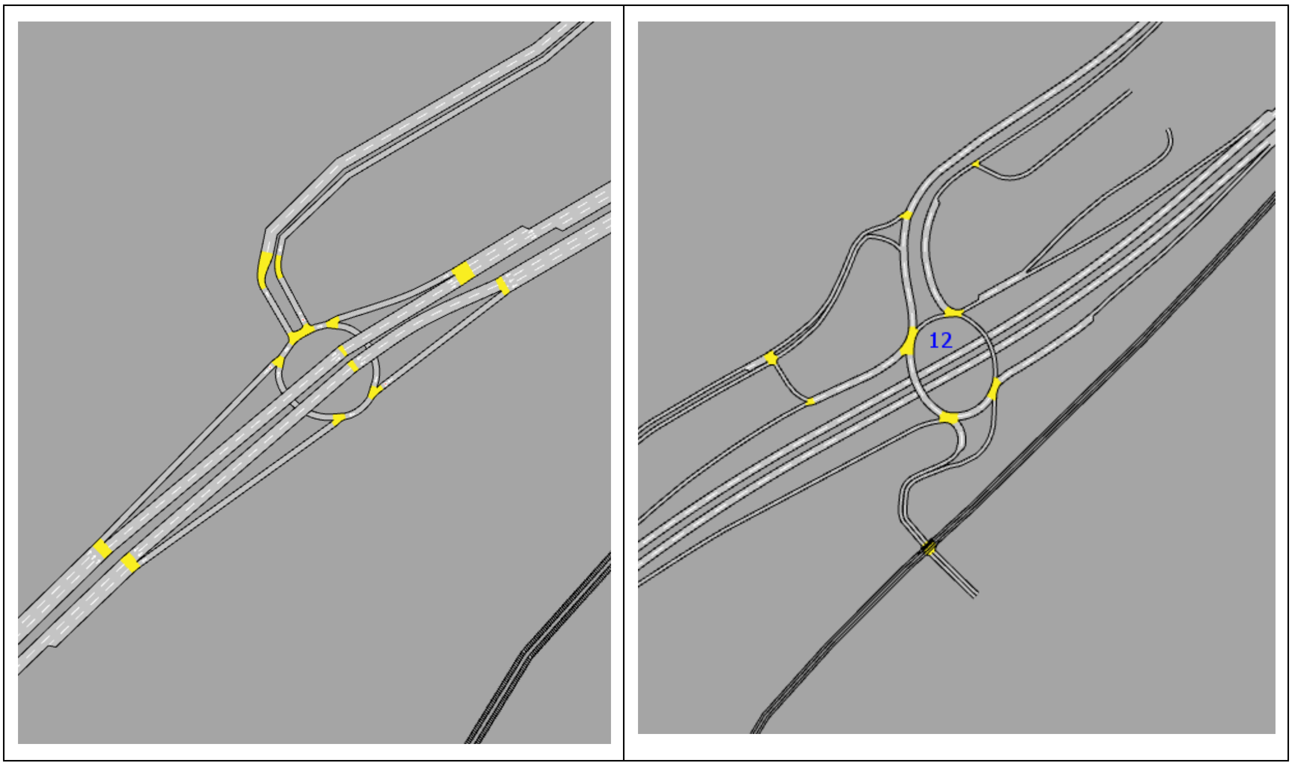

Figure 7: Haywards Interchange Before and After

Figure 8 shows the Hutt CBD roundabouts on Rutherford and High Street. Originally these were coded as full roundabouts with short sections. These have been found to be prone to gridlocking under heavier traffic volumes. For the smaller roundabouts, the coding has been updated to mini-roundabout style where all turns occur within the node.

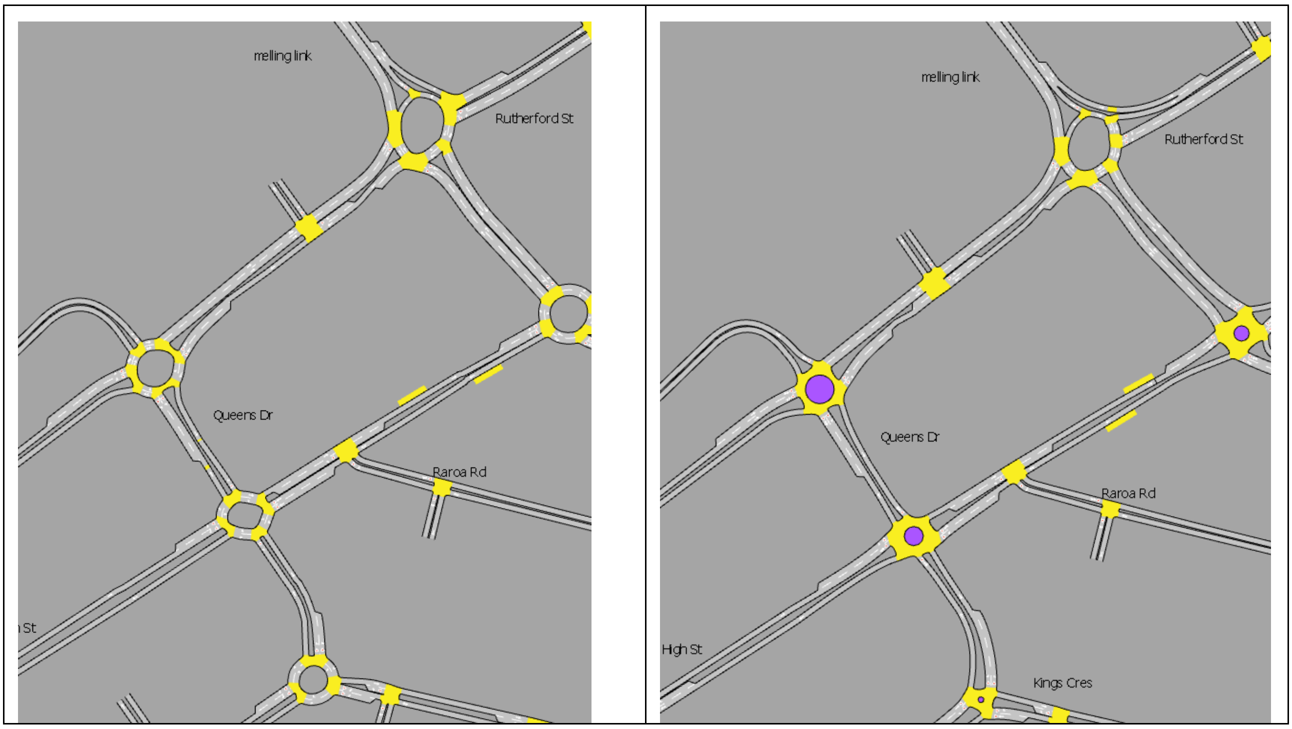

Figure 8: Hutt CBD Roundabout Refinement

5. Network Parameters

This section presents the various model parameters applied to the HAM. This includes:

- Vehicle Parameters,
- Road Types,
- Cost Functions,
- Scenario Parameters, and
- Intersection coding

Note that these may be updated during the calibration process. Any changes will be outlined in the calibration/ validation report

5.1 Vehicle Parameters

HAM has three vehicle types: Car, Truck and Bus. The dimensions of these vehicles are shown in Table 2. These are consistent with the other models in the Wellington region but the car length is an increase over that used in the previous HAM.

Table 2: Vehicle Parameters

Vehicle	Length (m)			PCU
	Min	Mean	Max	
Car	4	4.5	5.3	1
Truck	6	9	11	1.9
Bus	12	12	12	2.5

5.2 Road Types

Aimsun allows the classification of sections into road type categories, where sections of road network have similar attributes and therefore can be grouped together. Table 3 shows the road types and associated parameters used in HAM.

- **Lane Capacity:** The maximum number of vehicles the section can carry per lane per hour.
- **Jam Density:** The maximum number of vehicles that can enter the section per km.
- **Speed:** The free flow speed of the section.
- **JA:** The side friction input value to the static volume delay function. Side friction accounts for local effects not directly accounted for by the function, such as narrow road width, street parking etc. The higher the side friction value, the higher the penalty applied.
- **Link Cost:** The dynamic assignment equivalent of the JA parameter. The higher the value, the higher the cost penalty applied.

The road type parameters used on HAM are consistent with both the Ngauranga to Airport Model (Wellington) and the Porirua Traffic Model.

Table 3: Road Type Parameters

Name	Lane Capacity	Jam Density	Speed	JA	Link Cost
Roundabout 15km/h	1600	170	15	0.4	1
Traffic Calmed Road	550	120	20	5	2
Hill / Curve Sections	800	150	25	5	2
Local Access Road	250	120	25	5	2.5
Roundabout 25km/h	1600	170	25	0.4	1
CBD/Shopping - high friction	450	150	30	1.8	2.5
CBD/Shopping - medium friction	800	170	30	1.8	1.8
Local Access Road Cost, medium friction	600	120	30	5	2
CBD/Shopping - low friction Cost	1100	170	35	1.6	1.6
Collector - high friction / poor alignment Cost	1200	170	40	1.2	1.3
Collector - low friction / good alignment Cost	1600	170	45	0.4	1.2
Local High Speed / Low	800	150	45	1.4	1.4
Local High Speed Street	800	150	45	1.6	1.6
Urban Arterial - low speed	1500	160	45	1	1
Urban arterial - medium speed	1600	170	50	0.4	1
SH58 80kph section	1800	170	65	0.7	1.3
On / Off Ramps	1800	150	70	0.6	1.1
Rural - restricted speed	1400	170	70	1.4	1.2
Urban arterial - high speed	1700	170	70	0.8	1
Rural state highway	1800	170	80	0.7	1
Expressway / Motorway - low speed	1900	170	85	0.8	0.9
Motorway - Merge Section	1900	180	100	0.8	0.85
Motorway	2100	180	100	0.4	0.8
Rural - unrestricted speed	1400	170	100	1.4	1.2

5.3 Cost Functions

Cost functions are used by the model assignment to calculate the travel time or cost on each turn and section in the model. The aggregate of these turn and section costs determines the most attractive route between origin and destination trips.

At the static layer level, cost functions take the form of delay functions which are implemented separately for both turns and sections. For sections this is a volume delay function, which increases delays in response to increasing volumes.

At intersections, the opposing flow is also considered in the cost function. The static cost function used in HAM is shown below. This is the Akcelik[1] time function which is commonly used across the modelling industry including in the other Wellington region Aimsun models and the Wellington Transport Strategy Model (WTSM).

$$time = t_0 \left\{ 1 + 0.25\, rf \left[z + \left(\frac{z^2 + 8 J_A x}{Q\, t_0\, rf} \right)^{0.5} \right] \right\}$$

Where:

t = average travel time per unit distance (e.g. in seconds per km)

t_0 = minimum (zero-flow) travel time per unit distance

J_A = side friction parameter

Z = $X - 1$

X = q / Q = degree of saturation

q = demand (arrival) flow rate (in vhe/h)

Q = capacity (in veh/h)

rf = Tf / t_0 i.e ratio of flow (analysis) period to minimum travel time

This is implemented at a section level with a distance factor, so route choice is not purely based on time. The final static section cost equation is therefore:

$$SectionCost = (time \times distance) + (distFactor \times distance)$$

Where distFactor is 0.4 for cars and 1.0 for trucks

The hybrid model layer is a more detailed assignment where the movements and interactions of individual vehicles are considered as part of the simulation. The simulation in both the meso and micro components of the hybrid model layer are dynamic, in that vehicles are aware of the current network conditions and may change their behaviour in response to these network conditions. The dynamic cost functions used to facilitate this simulation occur in two parts:

- the initial costs are calculated for the network under free flow conditions (i.e. low traffic). The static paths from the macro layer are also taken into account here, reducing the computation time by providing the most likely subset of possible paths a vehicle could take.
- the dynamic costs are then calculated based on the speeds and travel times occurring on the network at that particular point in the simulation. Where the current cost of a route is higher than the initial cost, vehicles may consider rerouting to alternative paths.

[1] Travel time functions for transport planning purposes: Davidson's function, its time dependent form and alternative travel time function - R. Akcelik 1 September 1991

These dynamic cost functions were previously provided by the software developers for the Wellington Aimsun model and are utilised in both the Wellington and Porirua Aimsun models.

The initial cost function equation is:

$$initialCost = freeflowtime * AttractivenessWeight * Attractiveness + LinkCost * LinkCostWeight + distFactor * length$$

where:

- **freeflowtime:** Free flow travel time i.e. time to traverse section under low or no flow conditions
- **Attractiveness:** A parameter, based on turn capacity – higher capacity is a higher attractiveness
- **AttractivenessWeight:** Weighting for the attractiveness value – In PTM this value is 2
- **LinkCost:** The section specific link cost set by road type (see next section for further details)
- **LinkCostWeight**: Weighting for the link cost value – in PTM this weighting is 1
- **distFactor:** 0.4 for cars and 1.0 for trucks
- **length:** The length of the section or turn

The dynamic cost function equation is:

$$dynamicCost = max(initialCost, simulatedTravelTime * AttractivenessWeight * Attractiveness + LinkCost * LinkCostWeight + distFactor * length)$$

The dynamic cost function uses the same parameters as the initial cost function except the free flow time is substituted with the model simulated travel time. The function compares the result of the initial cost function with the new calculated cost result and returns whichever is higher as the final value.

5.4 Scenario Parameters

The static scenario parameters are shown in Table 4. These are consistent with the other Aimsun models in the region.

Table 4: Static Scenario Parameters

Parameter	Value	Description
Assignment type	MSA	The Method of Successive Averages (MSA) is an iterative assignment algorithm used to distribute traffic across a model network to approximate equilibrium conditions
Relative Gap	0.50%	Assignment convergence criteria

The dynamic (hybrid/meso/micro-scopic) scenario parameters are shown in Table 5. As with the static scenario parameters, these are generally consistent with the other Aimsun models in the region.

The car fixed path percentage does differ from the Wellington model (40%) and the Porirua model (70%), falling in between these two models at 60% fixed paths. The 60% setting here sets a balance between the other two models in the region and provides improved flexibility compared to the previous HAM's 90% fixed paths.

Table 5: Dynamic Scenario Parameters

Parameter	Value	Description
Assignment Type	SRC	Stochastic Route Choice
Interval	00:05:00	Interval to update vehicle routes
Number of Intervals	6	Number of pervious intervals to consider - general rule is this to cover 30 minutes
Attractiveness Weight	2	Weighting of turn attractiveness (cost) in cost function
User-Defined Cost Weight	1	Weighting of link cost in cost function
Percentage Fixed Routes		Percentage of vehicles fixed on static paths
Car	60%	
Truck	100%	
Max Paths	3	Number of static paths considered for each OD
SRC Model		
Type	C-Logit	
K-SP Paths	1	Number of shortest paths calculated at start of simulation
Scale	6	
Beta	0.15	
Gamma	1	
Algorithm	Dijkstra	Calculates a shortest path tree from one centroid destination to all sections and centroids of the network

5.5 Intersection Coding

Turns within intersections are given a turn type parameter based on the turn type. These mostly impact the static model, range from 1 to 3 and are defined as follows:

- Turn type 1: Signalised turn – all turns within a signalised intersection should have this applied.
- Turn type 2: Roundabout turn – this is applied for the entry turns into the roundabout where the turn must giveway.
- Turn type 3: Priority turn – this is applied at priority intersections where the turn must giveway to opposing movements.

6. Signal Phasing

The expanded HAM extents includes 26 signalised intersections. Initial signal phasing has been provided by the Wellington Traffic Operations Centre (WTOC) who operate the signals in the Lower and Upper Hutt city area. Wellington City Council provided the Ngauranga/Jarden Mile intersection phase timings.

Due to project timeframes and data availability, phase data was provided covering September 2023, this is assumed to be similar to September 2024. The phase timings provide the starting point for the Aimsun model, but are adjusted to suit the demands as required during the calibration.

Within Aimsun, the signal phasing has been implemented as fixed signal control plans covering the four hour average over the whole model period. Where more detailed control is required at a particular intersection, this will be done in a second control plan, covering the 30 minute period needed. Aimsun groups control plans in a master control plan. The master control plan can include multiple plans for the same intersection as additional zones where higher zones take precedence. Figure 9 shows the current Base AM peak master control plan.

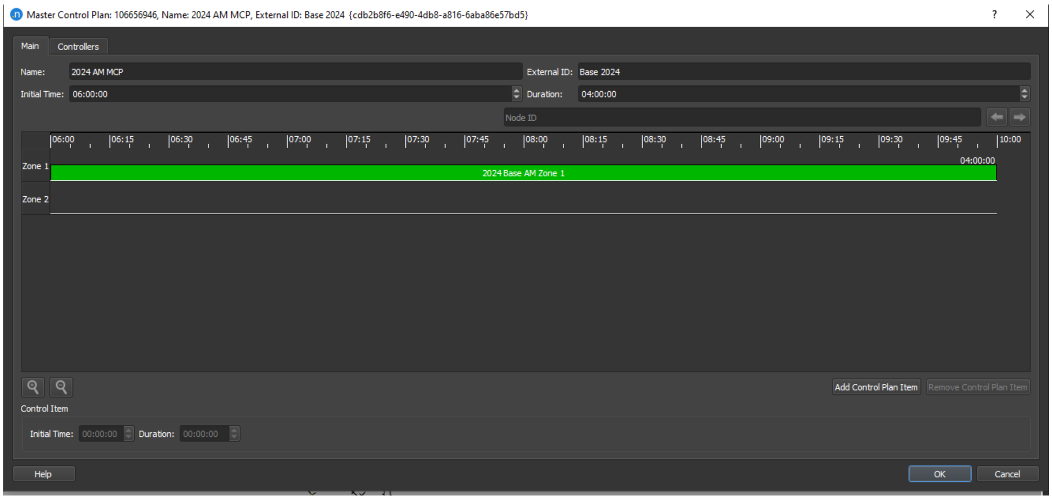

Figure 9: Master Control Plan

Figure 10 shows the location of signalised intersections in the model.

Figure 10: Signalised Intersection Locations

7. Public Transport

The public transport lines have been imported using the most recent GTFS files provided by Metlink. Aimsun has a process to read in these files and create public transport lines. The resulting lines did require some refinement as the initial import didn't filter based on date so non-typical workday services were initially in the model.

A total of 63 routes were imported into the model, these being variations of the following services:

- 81 Eastbourne - Petone - Wellington
- 83 Eastbourne - Lower Hutt - Petone - Wellington
- 84 Eastbourne - Gracefield - Petone - Wellington
- 110 Emerald Hill - Upper Hutt - Lower Hutt - Petone
- 111 Upper Hutt - Totara Park - Upper Hutt
- 112 Te Marua - Timberlea - Maoribank - Upper Hutt
- 113 Riverstone Terraces - Upper Hutt
- 114 Trentham - Elderslea - Upper Hutt
- 115 Upper Hutt - Pinehaven - Upper Hutt
- 120 Stokes Valley - Taita - Epuni - Lower Hutt
- 121 Stokes Valley - Taita - Epuni - Lower Hutt
- 130 Naenae - Waterloo - Lower Hutt - Petone
- 145 Belmont - Melling - Lower Hutt
- 149 Waterloo - Lower Hutt - Tirohanga - Lower Hutt - Waterloo
- 150 Kelson - Lower Hutt - Maungaraki - Petone
- 154 Petone - Korokoro - Petone
- 160 Wainuiomata North - Waterloo - Lower Hutt
- 170 Lower Hutt - Wainuiomata South - Lower Hutt

Aimsun can define bus stops as either bus bay or in lane stops (normal in Aimsun terminology). All bus stops have been assumed to be bus bays (room for vehicles to pass) and minimum 15m length (room for full bus). Specific locations may have a longer bus stop or be on road if that particular location requires it to represent bus and general traffic interactions.

Note that school services are not included in the model as they are such low frequency they are unlikely to have a notable impact on network traffic operations. This is also the case for WTSM and the Wellington and Porirua Aimsun Models.