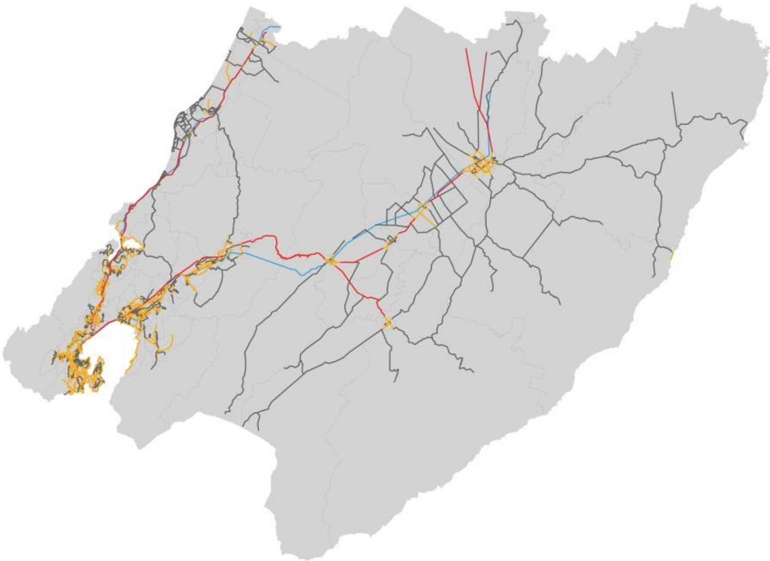
OPUS INTERNATIONAL CONSULTANTS AND ARUP

WELLINGTON TRANSPORT MODELS

Contract No C3079



TN17 Validation Guidelines and Criteria – WTSM and WPTM

Date: December 2012

Wellington Transport Models

TN17 : Validation Guidelines and Criteria – WTSM and WPTM

prepared for

Greater Wellington Regional Council

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Date:	December 2012
Reference:	g:\localauthorities\wrc\proj\5-c2050.00 - c3079 wtsm wptm\600 deliverables\630 final tech notes\tn17 validation guidelines and criteria - wtsm and wptm final.docx
Status:	Final
Revision:	2

Document History and Status

Issue	Re v	Issued To	Qty	Date	Reviewed	Approved
First draft	-	Nick Sargent - GW	1	16/11/2011	Bruce Johnson	Fraser Fleming
Second draft	A	NS and JB	1	02/07/2012	Fraser Fleming	Fraser Fleming
Third draft	B	NS and JB	1	10/07/2012	Fraser Fleming	Fraser Fleming
Final	1	NS and JB	1		David Dunlop	David Dunlop
Final	2	Nick Sargent - GW	1 Hard & 1 CD	06/12/2012	David Dunlop	David Dunlop

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

John Bolland: ______________________
(Peer Reviewer)

Nick Sargent: ______________________
(GWRC)

Contents

1 Introduction

Opus International Consultants Limited (Opus) and Arup Australia (Arup) were commissioned by Greater Wellington Regional Council (GWRC) to rebase the existing 2006 Wellington Transport Strategy Model (WTSM) to a new base year of 2011. Opus updated the WTSM while Arup developed a Wellington Public Transport Model (WPTM) based on figures from WTSM and detailed public transport surveys. The whole process of model updates and development is complex and involves several steps which have each been individually reported in a series of technical notes.

This technical note (TN) aims to set out the criteria to which both the WTSM and WPTM models will be validated, to ensure they are reasonably replicating the base case transport movements and patterns.

1.1 Background

This project involves updating WTSM with new 2011 demographic information and developing a completely new public transport (PT) model of the Wellington region. The WTSM process, being an update only, suggests that in general, the validation will be carried out against the same criteria and levels as the previous update of the model undertaken in 2008.

WPTM is an entirely new model, with trip demand from observed data sources. This has some implications for validation, and a method and criteria appropriate to this type of model is set out in this note.

This note is structured as follows:

- Approach to validation adopted for previous versions (and updates) of WTSM;
- Proposed validation approach for WTSM 2011;
- Proposed validation approach for WPTM; and
- Comparative performance of the Auckland and Christchurch models.

The Opus / Arup team see the process of agreeing these criteria with the client and the peer reviewer as highly important so as all parties understand the level to which the model will replicate the patterns and can therefore be used in future year forecasts.

1.2 SKM Update Validation Report February 2008 and June 2008

The February 2008 WTSM Validation Report documented tasks and outcomes from updating WTSM from a 2001 to 2006 base year, with Section 9 of the report discussing model validation. A file note dated 20th June 2008 was subsequently produced to present updates to some validation statistics following Peer Review comments and feedback from GWRC. These reports (and the Peer Review report discussed below) highlighted for the 2006 WTSM:

- Reasonable performance of the multi-modal demand capability of the model;
- Reasonable performance of highway assignments in comparison to Economic Evaluation Manual (EEM) validation guidelines. The report noted that the EEM

guidelines were designed for traffic project models and not strategic multi-modal models (with less stringent criteria than project models);
- Issues about the reliability of observed bus and train data that made it difficult to be certain as to how the model was performing for public transport assignments. Bearing this in mind and noting the relatively low volumes on some screenlines SKM reported that "modelled bus flows compare reasonably well with observed"; and
- The need to be aware of strengths and weaknesses of the model and for care to be taken in interpreting the model outputs. Related to this was the advice that for some purposes the model would benefit from corridor specific adjustments and enhancements.

1.3 Arup Peer Review – June 2008

Arup's peer review concluded overall that the 2006 WTSM model was fit for its intended purpose as a strategic model. In general Arup's peer review identified reasonable performance of the highway models but (in the context of overall fit for purpose performance) identified some issues in relation to public transport validation, including:

- Doubts about the reliability of bus electronic ticketing machine (ETM) data, in particular in relation to investigating growth between 2001 and 2006;
- Reliance on old rail data (2001 data factored to 2006) for rail validation;
- The previous two points meant that where there was a difference between observed and modelled performance and the lack of reliable data was a significant constraint to understanding the reasons for the discrepancies;
- There was no validation of bus journey times;
- The peer review noted that during the validation process one attempt to improve validation included adjustments to rail walk and access link connector coding. However it was noted (and supported by the peer reviewer) that this was later abandoned as it was seen as a somewhat arbitrary process that may limit model application in forecasting modes; and
- The general model structural form in WTSM of using P-connectors for modelling access to rail also limited the ability to validate some aspects of access modelling, with flow on effects such as to passenger numbers on specific bus services serving rail stations.

1.4 Implications for 2011 WTSM and WPTM Model Development and Validation

Points arising from review of the previous model update in relation to validation issues are:

- The need to recognise the strategic nature of WTSM and apply validation criteria consistent with the model's role;
- As noted in the introduction there is a well established set of criteria that have been applied to WTSM validation in the 2001 development and 2006 updating processes. It appears reasonable to apply much the same criteria in the 2011 updating process;
- The importance of having reliable observed data for the validation process. In particular, past issues in relation to bus ETM data suggest that the availability of independent sources of data (such as screenline counts) will be beneficial;
- The uncertainty of public transport data for the validation of the 2006 model will flow on to affect comparison of the relative performance between the 2006 and 2011 models in relation to public transport modelling. This may limit the nature of conclusions that can be drawn in this regard;

- One measure of WTSM PT modelling performance was comparison of modelled Journey to Work (JTW) mode shares versus 2006 Census data[1] (which showed good performance of WTSM). The absence of census data for 2011 obviates this test for the current process;
- A general philosophy that it may be better for the validation process to avoid arbitrary model adjustments to improve base year validation in order to preserve the "purity" of the model for forecasting purposes; and
- The limitations of P-connectors in WTSM will remain, but the structural change proposed to access modelling in WPTM[2] will provide a different approach requiring a specific validation process.

The last point is a specific example of various aspects that will differ between WTSM and WPTM in relation to public transport modelling. This and other points of difference highlight the need to develop criteria that may differ between the two models or perhaps apply different levels of assessment measures to the same criteria.

1.5 Overall approach to validating WTSM and WPTM together

As emphasised in the Model Investigation Report both WTSM and WPTM will be validated together. While the emphasis of this technical note is on establishing criteria for the validation of these models rather than the *process* it is worth summarising the approach being taken.

1. **Initial network development.** This task covers the initial development of networks and PT services from GIS files and GWRC's Public Transport Database. Basic model assignment algorithms are developed and unitary matrices are assigned to the network to check for coding deficiencies. These networks and services form the basis for both WTSM and WPTM assignment and aside from the different zone system (and centroid connectors) sizes will remain identical. Details concerning this stage are documented in TN1.
2. **Initial WTSM Calibration.** The purpose of this task is to get WTSM into a reliable and stable enough state to provide initial data for WPTM development. This step will provide robust highway journey times for the bus assignments and allow skimming of the network for development of the access choice model. The approach largely follows the criteria described in Section 2 with the exception of the bus screenlines – the only screenline that will be used here is the inner Wellington City Council (WCC) bus patronage cordon.
3. **Initial WPTM Calibration.** The purpose of this task (which overlaps with stage 4 described below) is to use the WTSM networks and services (with highway speeds) in the calibration of PT services and PT related parameters (new walk connectors may also be added). This phase is described in Section 3 of this technical note.
4. **WTSM – WPTM Validation Iteration.** This stage will involve iterating between the WTSM and WPTM calibration i.e. any changes in the following elements will be brought back into WTSM to maintain consistency between the models[*]:

[1] Table 27, SKM February 2008 report
[2] Refer Technical Note 6 WPTM Specification
[*] Any exceptions will be described and documented in the Model Validation Report

- Networks e.g. walk links;
- PT services e.g. if services are disaggregated; and
- PT assignment parameters.

1.6 Dependent versus Independent Data

A particular challenge in the development of the WPTM is the sourcing of data independent of the matrix development component of the model. While more precise validation criteria are described in Section 3 it is worth highlighting the team's view of this:

> *While the team are using observed data in matrices in the development of WPTM, it is at the assignment stage that the overall process of all stages of the model can be tested against observed data. The built matrices will control overall rail and bus demand to observed loadings, but the assignment process will let route choices vary, so could lead to discrepancies between modelled and observed data on specific routes. In that case it is appropriate to use some data used in model development in a different way to test model performance. However where we can, such as with the bus cordon survey, we will also use independent data for validation.*

2 2011 WTSM Update Validation

The criteria that will be used to validate WTSM will largely follow that described in Section 9 of the 2006 WTSM Validation Report. The aim is to achieve an overall level of validation that is comparable with 2006.

The validation topics covered in the 2006 WTSM update included:

1. Vehicle assignment validation across screenlines (screenline totals and links on screenlines), using absolute and percentage differences, GEH statistics, and route mean square error (RMSE);
2. Vehicle journey time validation;
3. Public transport assignment validation (screenline totals for bus plus sectors of the CBD screenline, and inbound boardings on lines for rail); and
4. Heavy commercial vehicle (HCV) validation across screenlines (totals), using absolute and percentage differences, GEH statistics, and RMSE.

As for the 2006 WTSM update, the scope of this work originally did not cover recalibrating the trip generation, trip distribution and mode split components of WTSM, however, following investigations, these became necessary elements of the project and the changes have been documented in the relevant technical notes.

2.2 Count Sites and Screenline Validation

The following tables show highway screenline performance statistics extracted from the 2006 WTSM Validation Report. It shows that many of the count sites and screenlines fail to meet EEM validation criteria, however, a number of explanations have been offered which may account for some of the variance experienced in the validation such as uncertainty over count data. Additionally, while the 2006 WTSM update had actual Census data available it was limited to assignment validation i.e. it was not possible to recalibrate the trip generation, trip distribution or mode split models. This is also the case for this 2011 update.

Table 2-1: WTSM 2006 Screenline Validation

Screenline		Direction	GEH AM	GEH IP	GEH PM
Lower Hutt	L1	North	2	4	3
	L1	South	4	2	3
	L2	North	1	5	
	L2	South	2	5	3
	L3	In	4	3	
	L3	Out	7	1	4
	L4	North	1	12	10
	L4	South	6	10	1
Porirua	P1	North	5	2	3
	P1	South	1	0	3
	P2	East	2	7	4
	P2	West	0	5	4
	P3	North	9	13	6
	P3	South	0	11	10
Upper Hutt	U1	North	18	11	1
	U1	South	4	12	14
	U2	North	3	3	4
	U2	South	7	5	2
	U3[3]	*East*	4	3	0
	U3	*West*	4	3	6
Wellington	W1	In	11	3	10
	W1	Out	7	3	9
	W2	East	0	0	6
	W2	West	6	2	8
	W3	East	9	9	10
	W3	West	11	8	10
	W4	North	1	2	2
	W4	South	4	3	2
	W5	North	2	7	5
	W5	South	2	4	1

EEM Criteria: All screenline flows should have GEH less than **4**

Table 2-2: WTSM 2006 Screenline Validation Summary

GEH*	AM	IP	PM
<5	**67%**	**60%**	**57%**
<10	**90%**	**83%**	**87%**
<12	**97%**	**97%**	**93%**

EEM Criteria:

Screenliens should have a GEH less than 4 in most cases

Table 2-3: WTSM 2006 Screenline Validation Individual Sites

GEH	AM	IP	PM
<5	**53%**	**49%**	**45%**
<10	**84%**	**78%**	**78%**
<12	**89%**	**86%**	**87%**
R2	76%	72%	74%
RMSE	0.937	0.899	0.937

EEM Criteria:

- At least 60% of individual link flows should have a GEH less than 5;
- At least 95% of individual link flows should have a GEH less than 10; and
- All individual link flows should have GEH less than 12

= did not meet EEM Project Model Criteria. As noted in Section 1.2 however the EEM guidelines were designed for traffic project models and not strategic multi-modal models (with less stringent criteria than project models)

[3] This screenline is a single link to the Manor Park residential area, and in the review of the screenlines in 2008 it was recommended that this should be removed in future updates to WTSM given its localised nature.

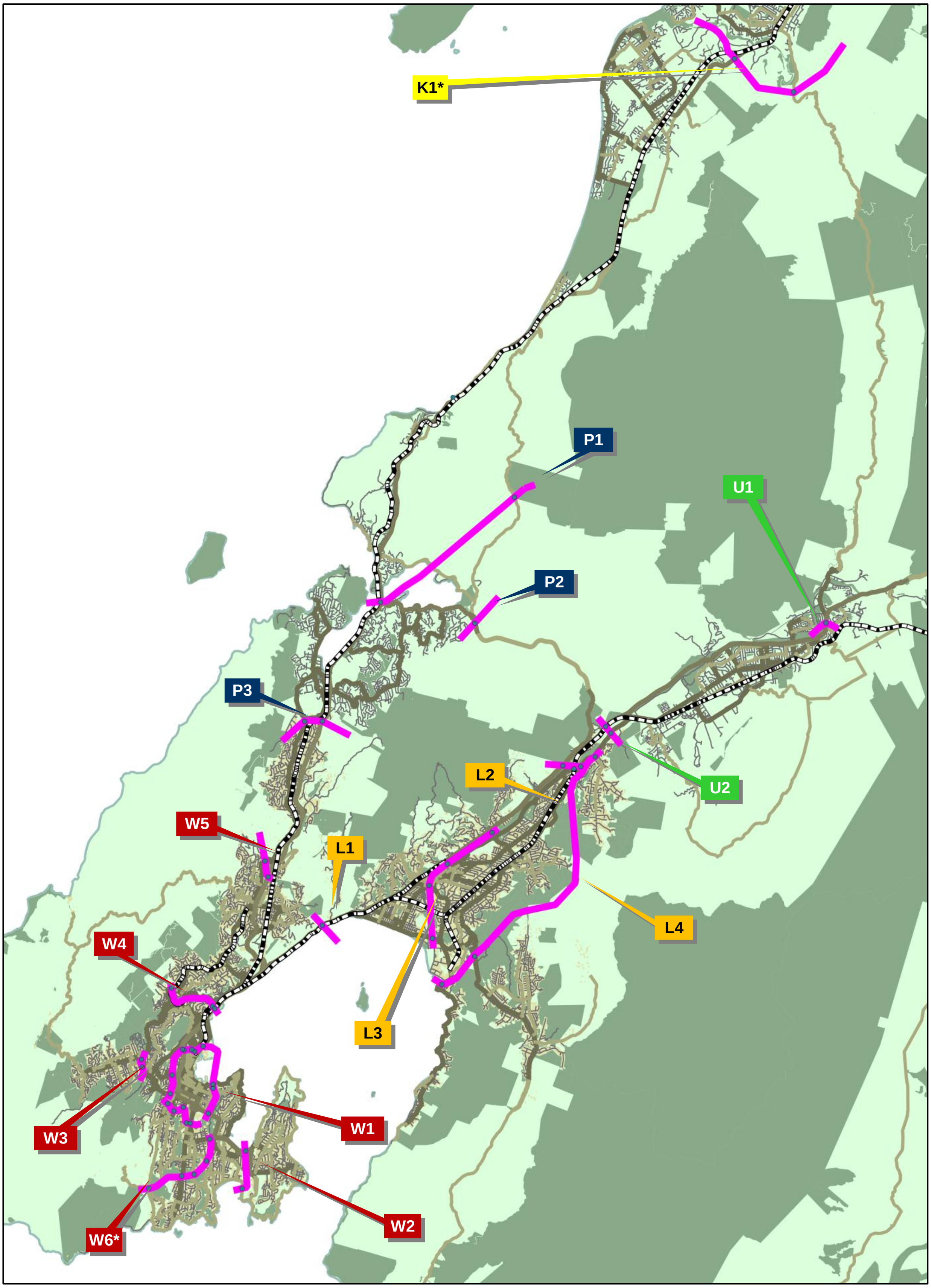

Figure 2-1: Vehicle Screenlines for 2011 WTSM Update

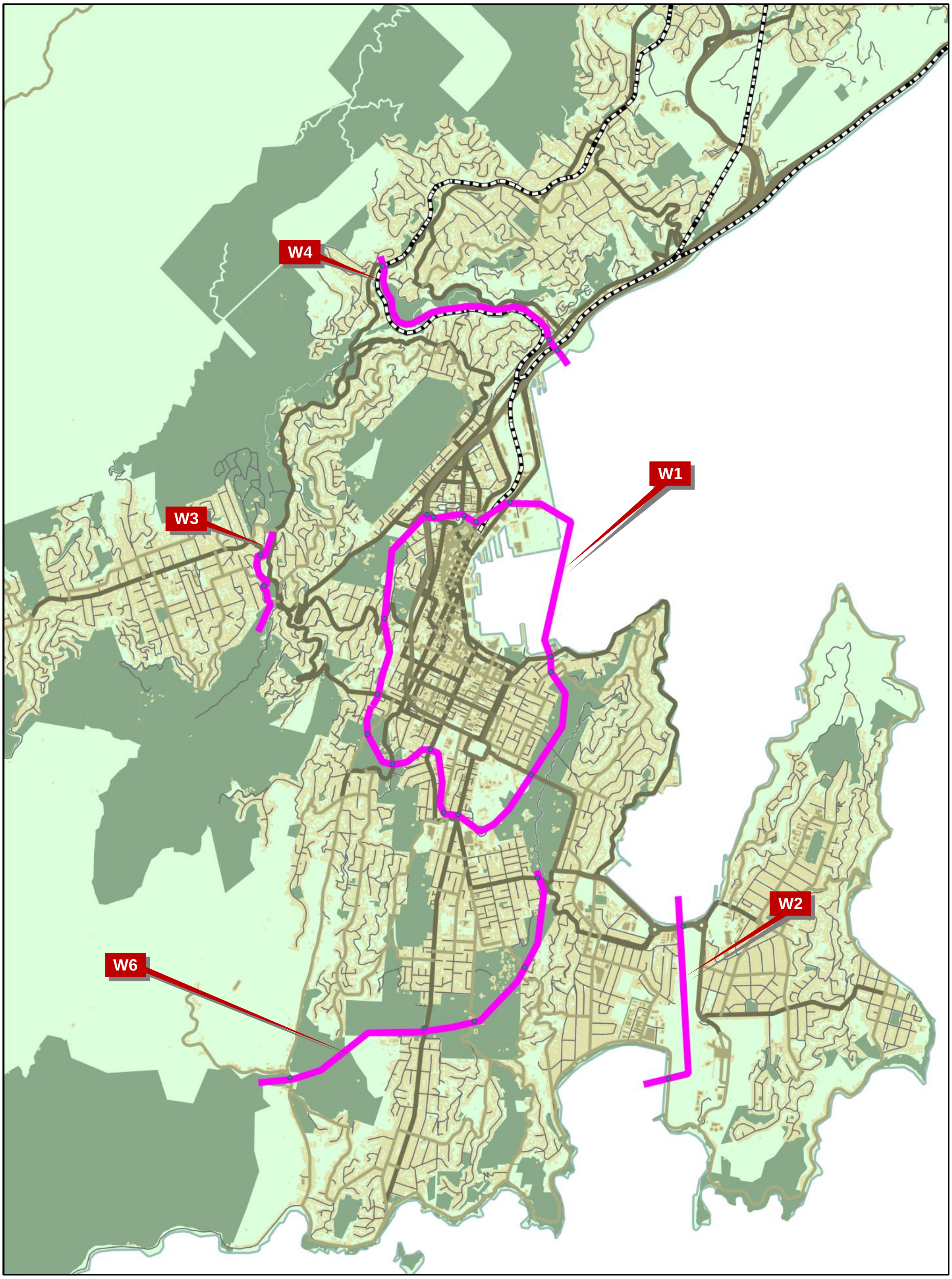

Figure 2-2: Vehicle Screenlines for 2011 WTSM Update – Wellington

All classified screenline count data has been collected by Traffic Design Group (TDG). Photos of tube sites were also supplied to reduce risk of uncertainty over count site location. Remaining screenline validation tasks include:

1. Confirm counts are useable. Compare 2001, 2006, and 2011 counts and try and account for major changes.
2. Remove screenline U3 from validation procedures. This screenline is a single link to the Manor Park residential area, and in the review of the screenlines in 2008 it was recommended that this should be removed in future updates to WTSM given its localised nature.
3. Add extra Wellington screenline W6 shown in Figure 2-1 and Figure 2-2. This screenline is made up 5 new count sites:
    1. Constable Street between Alexandra Road & Coromandel Street;
    2. Manchester Street between Owen Street & Caprera Street;
    3. Mt Albert Road between Lavaud Street & Volga Street;
    4. Adelaide Road between Dover Street & Duppa Street; and
    5. Happy Valley Road between Landfill Road & Murchison Street.
4. Add screenline Kapiti Coast K1 shown in Figure 2-1. Previous updates of WTSM had not included screenlines in the Kapiti Coast area and given the level of transport investment planned for this area through the Wellington Roads of National Signifigance (RoNS) it was considered appropriate that counts should be located in this part of the network. This screenline is made up 2 new count sites:
    1. SH1 between Otaihanga Road & Kebbell Drive; and
    2. Raikorangi Road between Poneke Drive & Ngatiawa Road.

Again, it is worth reiterating that while new screenlines have been added for the 2011 update it may be difficult to meet acceptable validation criteria for them given restrictions on calibrating the trip generation, mode split and trip distribution models.

2.3 Vehicle Journey Time Validation

The following section details findings from the journey time validation section of the 2006 WTSM Model Validation Report. Vehicle journey times have been collected on seven routes in both directions for the purposes of comparing with modelled times. The vehicle journey time data has come from a specially designed journey time survey carried out in 2006 and the routes are largely the same as those used in 2001:

- Route 1 - Waikanae Railway Station - Wellington Airport;
- Route 2 - Upper Hutt Railway Station - Wellington Airport;
- Route 3 - Porirua – Seaview (via SH58);
- Route 4 - Wellington Railway Station - Island Bay;
- Route 5 - Featherston - Upper Hutt Railway Station;
- Route 6 - Wellington Railway Station - Karori West; and
- Route 7 - White Lines / Randwick Road - Waterloo Quay / Bunny Street.

The 2006 WTSM Model Validation Report included graphs but no numbers.

For the 2011 update data, reference data for journey times are being sourced from New Zealand Transport Agency's journey times surveys with the most recent surveys being undertaken in March and November 2011:

- Between Wellington Airport & Waikanae Railway Station;
- Between Wellington Railway Station and Upper Hutt Railway Station via old Hutt Road;
- Between Wainuiomata and Porirua Railway Station via SH58;
- Between Courtenay Place and Karori; and
- Between Island Bay and Wellington Railway Station.

The rationalisation of journey time routes took place in 2003 and rather than commission a series of new surveys along the old routes the team decided to take advantage of the existing survey programme. The benefits of using this programme are that it:

1. Reduces wasteful duplication of data;
2. Is well established which enables the analysis of trend data going back over eight years. This helps establish a robustness that might not be achievable with the commission of new surveys; and
3. The routes are very similar to those previously used

2.4 Bus Trip Screenline Validation

As discussed above the validation of WTSM 2011 will largely follow criteria used in the 2006 validation. Concern was raised, however, in the 2006 Model Validation Report over the lack of criteria and whether the ETM data used to validate the model was a true reflection of the actual passenger flows on the network. To demonstrate the impact of this the 2006 bus validation statistics have been summarised in the table below.

Table 2-4: WTSM 2006 Screenline Validation Summary

GEH	AM	IP
<5	46%	71%
<10	67%	83%
<12	79%	88%
R^2	0.959	0.781

As can be seen in Table 2-4 modelled screenlines match observed estimates poorly in the 2006 model. While a similar approach will be adopted in the 2011 model update for the validation of bus passenger volumes across screenlines, much greater attention needs to be paid to processing of ETM data to ensure its robustness.

Due to extra processing and analysis undertaken and documented in TN3 we can be much more certain that the observed passenger flows produced match reality more closely.

2.5 Rail Boarding and Alighting Validation

Observed data for the 2006 rail validation was based on factoring up the 2001 rail survey data using growth rates from analysis of available existing data. The rail validation statistics from the 2006 validation report have not been produced in this technical note because they were superseded by a re-validation exercise but the figures were not updated in subsequent documentation.

The rail validation will use boarding profiles for the Johnsonville, Paraparaumu and Upper Hutt Lines over the length of the route as illustrated in the example below. The “observed flows” will be extracted from WPTM.

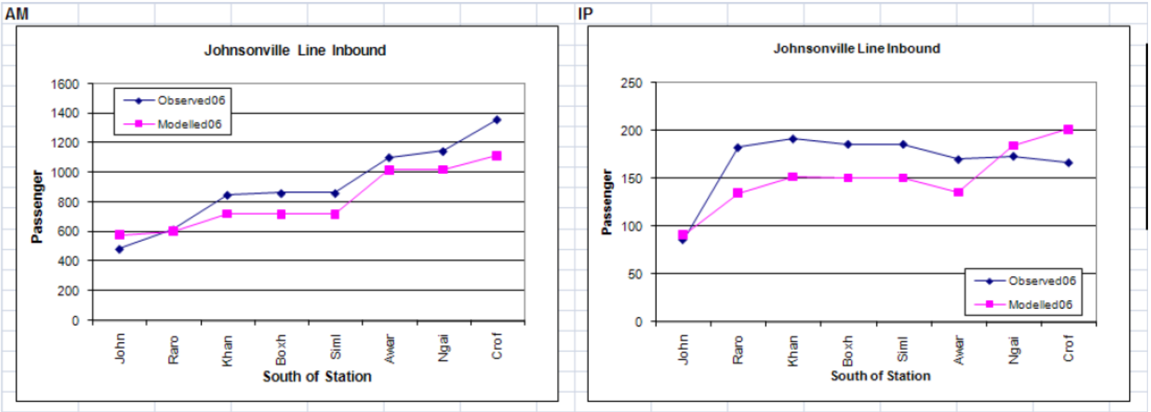

Figure 2-3: Example of Rail Validation Reporting from 2006 WTSM Validation Report

For the 2011 update:

1. The same validation statistics will be reported as those outlined above in Fig 2-3 as well as the loading profiles for the separate rail lines. Note, only AM and IP peak data models will be validated to rail boardings and alightings despite there being a PM peak PT Assignment as there is no observed PM data available.
2. Rail boarding and alighting data will be sourced from surveys undertaken in the construction of WPTM.

2.6 Airport Model Validation

The Airport Model development and validation will be documented in TN9.

2.7 Reporting Trip Distribution

As outlined in the Model Scoping Report no recalibration exercise was proposed for the distribution model. However, the team recognises that given the extent of the changes proposed for the network that monitoring of the trip length distribution should be undertaken. We will review the performance of the model with respect to distribution. We will do this by:

- Checking the highway matrices against proportional trip length distributions from the WTSM 2006 i.e. in light of the fact no new highway trip length data is being collected the patterns established in WTSM 2006 will be maintained.
- Checking Public Transport Matrices - the development of a 2011 fully observed Public Transport Matrix presents an excellent opportunity to improve the validation of the synthetic public transport trip distribution matrices. It is also desirable that the synthetic 2011 public transport matrices being generated by WTSM align as closely as possible

with the observed matrices. We anticipate only minor adjustments to model parameters in line with the network development for WPTM.

2.8 Reporting Paths / Trees

Origin Destination paths for a sample of key routes will be reported for both highway and public transport routes in all validated periods. Those sample origins and destinations will include:

1. Petone to Wellington CBD
2. Wellington CBD to Seatoun
3. Karori to Seatoun
4. Berhampore to Johnsonville
5. Berhampore to Paraparaumu
6. Upper Hutt to Waikanae
7. Porirua to Lower Hutt
8. Porirua to Upper Hutt
9. Airport to Wellington Railway Station

Engineering judgement and local knowledge will be used to analyse the paths with relevant commentary added to text where there is significant variance from expected routes.

3 WPTM Validation

The WPTM base model comprises a database of observed passenger demand, a choice model to predict access mode to the public transport network, and an assignment model to select which public transport modes and routes are used to get from origin to destination.

Our proposals for validation criteria begin by considering what outcomes are desired. The overall aim is to demonstrate that the model as a whole (and each component) were developed in accordance with a sound methodology to the satisfaction of the internal reviewer, the client, and the peer reviewer.

For each component below we consider the aim, data available, validation task, and criteria where relevant. Rather than using the term 'observed' data for the comparator, we have used the term 'reference data'– the reference data is the best estimate we can make of the 'true' situation, given all the data sources to which we have access. We will comment on the error and uncertainty associated with the reference data in the documentation of the validation.

3.1 Bus Demand

Bus demand will be created by extracting stop-to-stop movements from the ETM data, adding access and egress legs (to convert to an origin to destination matrix) and segmenting by purpose. The bus demand validation will be undertaken for the complete database of bus demand, prior to removal of bus legs of rail journeys.

Aim

- Demonstration that trip volumes, origin / destination (O-D) patterns and segmentation proportions match the reference data to a satisfactory degree.

Data sources

- Bus ETM data, 2011;
- Bus annual cordon survey (one day): 2011;
- Timetables ; and
- Bus on-board surveys, 2011.

Reference data

- Total boardings by route / direction, from ETM data;
- Adult / child ticket issues by route / direction, from ETM data;
- Passengers entering CBD (inbound only), from annual bus cordon survey;
- Trip purpose (by movement type e.g. CBD / non-CBD), from on-board survey;
- Access and egress walk distances (by movement type), from on-board survey; and
- Passenger capacity by route, from bus annual cordon survey.

Validation outputs [criteria]

- Scatter-gram of boardings by route: modelled vs reference [R^2 > 85% cf ETM],
- Maximum load vs. seated / standing capacity, by route [load <= capacity],

- Passenger volume between fare-zones, adult and child [±15% cf ETM],
- CBD inbound volume [±15% cf ETM; no target cf CBD cordon survey – report only],
- Adult journey purposes [= on-board survey], and
- Distribution of bus access / egress trip lengths [cf on-board survey: judgement]

3.2 Rail Demand

Rail demand will be created by expanding and constraining the on-board rail survey records to the boarding and alighting counts (at stations), then building a demand matrix from origin to destination by access and egress mode and by purpose.

Aim

- Demonstrate that trip volumes, O-D patterns and segmentation proportions match the reference data to a satisfactory degree.

Data sources

- Rail boarding and alighting (B+A) survey, 2011;
- Rail arrivals at Wellington Station (on day, annual, March);
- Train capacities (based on seats and standing spaces);
- Rail ticket sales / accounting system; and
- Rail on-board surveys, 2011.

Reference data

- Territorial Authority (TA) to TA passenger volumes, from expanded on-board survey data;
- Boardings by station groups, from B+A data;
- Trip purpose (by movement type), from on-board survey; and
- Access and egress modes and distances (by movement type), from on-board survey.

Validation outputs [criteria]

- Passenger volumes between TA sectors [±15% cf expanded on-board survey data];
- Boardings and alightings by station group [±10% cf B+A data];
- Maximum load by line / direction, compared against seated / standing capacities [load <= capacity];
- Adult journey purposes and car availability [=on-board survey];
- Distribution of rail access / egress trip lengths by access mode [cf on-board survey – judgement]; and
- CBD inbound volume [cf survey of arrivals at Wellington – report only].

3.3 Public Transport Demand

Total public transport demand will be created by removing the bus legs of bus-rail and rail-bus journeys from the bus matrix, these being included already, in principle, in the rail matrix. The validation requirement will be to demonstrate that access and egress modes from the on-board surveys are replicated. It is unlikely that the rail and bus on-board surveys will agree in this regard, therefore a combined access / egress reference dataset will be created from the combined data, and compared against the final PT matrices.

3.4 Access Choice

The access choice model will determine how passengers access the rail network. The model will be calibrated to produce the correct access shares at a model-wide level. If there are differences in behaviour by area, this may be reflected in area-specific constants; and if non-modelled attributes at particular stations exert a significant influence on behaviour (e.g. availability of parking, safety / security), this may be reflected through use of station-specific or station-type constants: the latter is preferred as it would allow future new stations to be attributed a value.

Aim

- To demonstrate that the model is a reasonable predictor of access mode choices to rail; and that car access trips are allocated to stations with reasonable accuracy.

Data sources

- Rail on-board surveys, 2011; and
- Inventory of parking spaces at each station plus spillover.

Reference data

- Access mode shares by station or groups of stations, from the rail on-board survey (level of aggregation will be dictated by the sample size); and
- Car parking demand by station, estimated from car parking occupancy.

Validation outputs [criteria]

- Demand by access mode by station [±20% cf on-board survey data]; and
- Demand by access mode by station group [±10% cf on-board survey data].

3.5 Network

This section is concerned with the validation, calibration and checking of the network and services used in WPTM. While coding of the network and public transport routes and headways are imported from WTSM into WPTM (and hence documented in WTSM sections) there will be a number of refinements made by the WPTM team to improve the modelling of bus journey times and fares.

> The results of this work will be documented in TN1 alongside the development of public transport files.

Aim

- To demonstrate that the coding of public transport services is complete and that journey times through the network are reasonable.

Data sources

- Sectional bus running times from the ETM data;
- Bus timetables (including General Transit Feed Specification); and
- Metlink fares tables.

Reference data

- Definitive list of bus and train services and variants;
- Sectional bus running times by route, from combined ETM and timetable; and
- PT fares by zone to zone movement, from Metlink fare tables.

Validation outputs [criteria]

- Check list of coded services against definitive list [matching];
- Scatter-gram of end-to-end running times by route [R^2 > 85% combined reference data created from combination of ETM & timetable reference data];
- Scatter-gram of sectional running times in the critical Wellington Station – Courtenay Place - Newtown corridor [R^2 > 90% reference data created from best combination of ETM & timetable reference data]; and
- Scattergram of adult and child fares by fare-zone movement [R^2 > 80% Metlink fare table].

3.6 Assignment

Public transport demand will be assigned to the network to determine which sub-modes are used and routes taken. For journeys that access bus or rail on foot, demand will be assigned from origin zone to destination zone; while for Park and Ride (P&R) and Kiss and Ride (K&R), the demand will be assigned from the access station to the destination zone.

Aim

- To demonstrate the model is able to replicate the mode (rail, bus, ferry) and route choice through the network and the demand allocation to each.

Data sources

- Bus ETM data, 2011;
- Bus and rail annual cordon survey (one day): 2006-2011;
- Rail boarding and alighting counts, 2011; and
- Metlink journey planner.

Reference data

- Passenger volumes by bus and rail at screenlines (accumulated from ETM data for bus and estimated from the B+A counts for rail); and
- Routes and times between selected locations from Metlink journey planner.

Validation outputs [criteria]

- Bus and rail volumes at screenlines [±15%];

- Bus and rail shares in competition corridors: Ngauranga Gorge, Ngaio Gorge, SH2 south of Petone [±10%]; and
- Origin to destination comparisons: Metlink journey planner [reasonable match of alternative route options and journey times – judgement].

4 Comparison with other NZ Models

4.1 Background

In order to provide some background and context to the criteria for the WTSM / WPTM calibration and validation process, Model Validation Reports from other models were assessed. The two models included are:

- The Christchurch Transportation Model (CTM) reported in May 2009; and
- The Auckland Transport Model (ART3) reported in August 2008.

CTM used a combination of NZTA EEM and Highway Capacity Manual criteria but did not adhere strictly to these as these are designed for use in project models. The Christchurch model used these criteria as guidelines only.

ART3 similarly references the NZTA EEM criteria as a guideline but it is made clear, as with the Christchurch model, that these are criteria designed for project models and are not directly applicable for strategic models such as these but are used purely as a guide.

The approach used in setting the criteria for the update of WTSM has been much the same as the Christchurch and Auckland models and therefore the criteria are considered to be comparable. It is important to note validation criteria used by ART3 and CTM may differ from the WTSM 2011 update as they represented full model rebuilds resulting from new Household Travel Surveys.

For example, the CTM and ART3 reported calibration / validation statistics for the trip production, trip attraction, mode-split, trip distribution, vehicle-occupancy and parking models. TN18 largely excludes these elements as they are not being recalibrated as part of this project. However, for common aspects such as vehicle and bus screenlines the same (or similar) criteria will be adopted. Specifically:

- **Individual and screenline vehicle counts.** ART3 and CTM measured performance against standard Project Model EEM criteria with the use of GEHs, R^2, and RMSE. WTSM followed the same approach with explanations supplied for modelled results which diverge significantly from criteria.
- **Individual and screenline bus counts.** ART3 and CTM used a mixture of % difference and GEH. WTSM is following the same approach with explanations supplied for modelled results which diverge significantly from criteria.
- **Rail boarding and alighting validation.** Similar approach to ART3 being adopted as CTM did not validate rail passenger movements (other than Tranz Alpine and Tranz Scenic tourist services, rail is not a passenger mode of transport in Christchurch).
- **Vehicle journey time validation.** No definitive criteria was applied in either the CTM or the ART3 documentation other than to state whether the modelled times fell within the minimum and maximum observed ‘envelopes’. WTSM is following the same approach with explanations supplied for modelled results which were outside the envelope.
- **Bus journey time validation.** Whereas CTM reported results of the bus journey time validation, WTSM (and WPTM) will report the calibration of the bus journey time functions in TN1 as this is thought to fit better with the input preparation discussion.
- **Trip distribution validation.** As stated above CTM and ART3 both went into detail on the calibration and validation of trip length data. Without new Household Travel Surveys

it was not possible for WTSM to validate against any independent data. However, in consultation with the peer review group, it was considered useful to compare 2011 trip length distributions against those achieved in 2006. This helped confirm that the model continued to operate largely as expected i.e. no mistakes were made during the model update which would adversely affect trip distribution and mode split models.

In addition to the criteria discussed above the approach for the WTSM update has also been to ensure that overall results are no worse than the previous WTSM and also compare well with the result achieved in the Christchurch and Auckland models. Those results are detailed further in the following sections.

4.2 Model Performance Comparison

The following section extracts a few key statistics regarding level of validation achieved in both ART3 and CTM. They will be used as high-level indicators on whether or not the 2011 updated WTSM performs at a level comparable with other major 4-Stage Models in NZ.

Figure 4-1 compares relative screenline count performance of ART3 and CTM. More specifically it compares the proportion of links which experience GEHs of less than 5, less than 10 and less than 12. Overall CTM clearly outperforms ART3 in the AM and IP Periods while ART3 out performs CTM in the PM Peak Period.

Gaps have been left for WTSM to indicate how it will be reported in TN18.

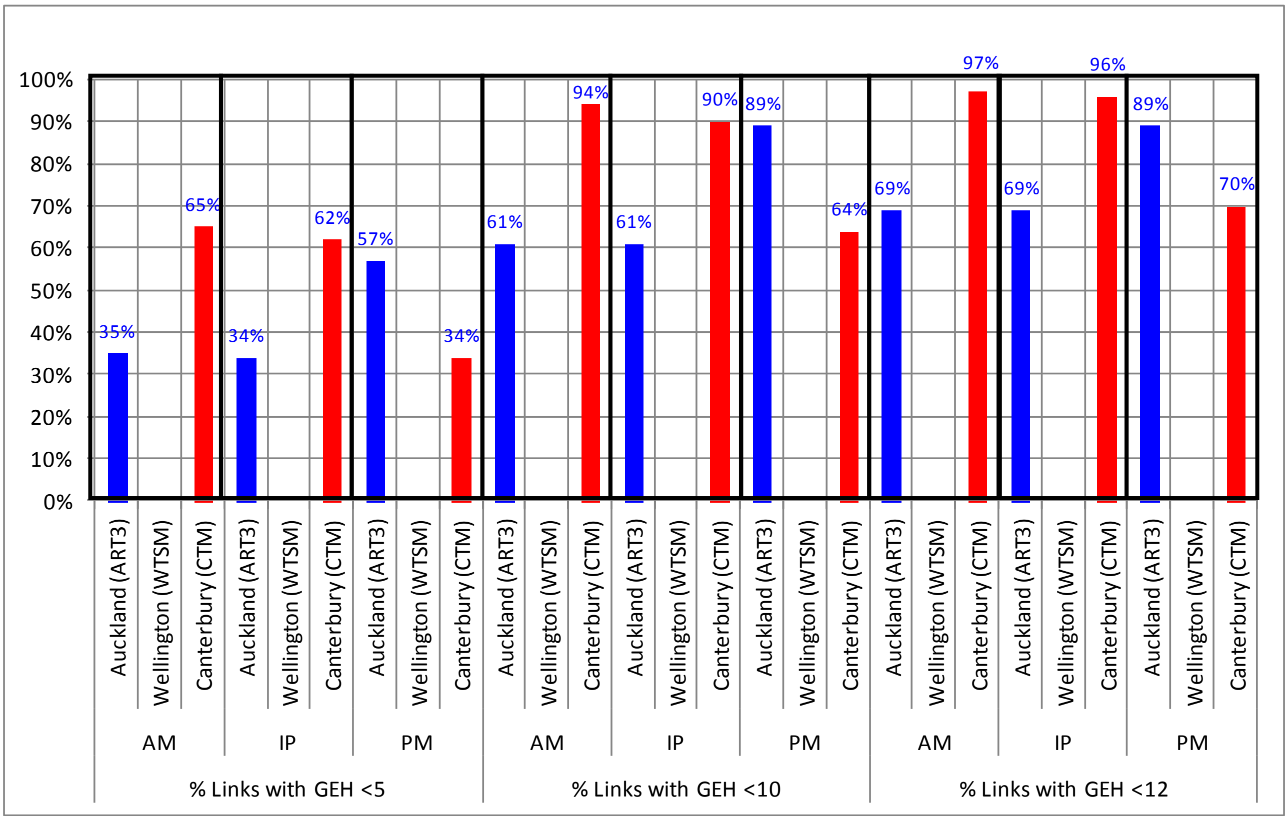

Figure 4-1: Individual Count Summaries for ART3 and CTM

Figure 4-2 compares relative bus count performance of Auckland Regional Transport Model (ART3) and Canterbury Transport Model (CTM). More specifically it compares the modelled counts against observed for everywhere there was a survey count. Overall ART3 performs the best in the AM peak period while CTM performs the best in the Inter peak[4].

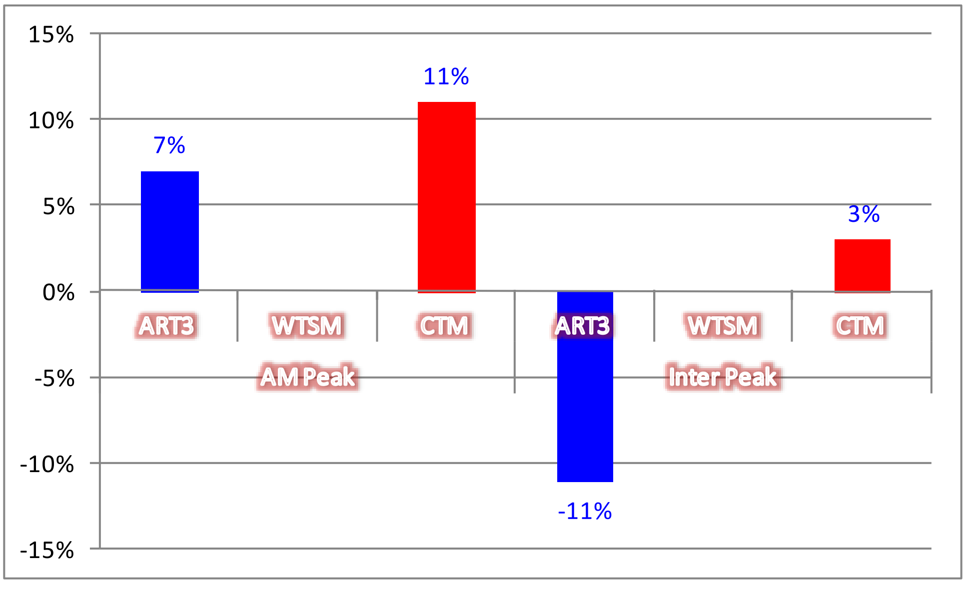

Figure 4-2: Bus for ART3 and CTM

The aim of the analysis is to provide context for the validation of 2011 WTSM i.e. if WTSM validation can at least exceed the performance of the worst performer then it is possible to say that “the 2011 updated WTSM performs at a level comparable with other major 4-Stage Models in NZ”.

Appendix A contains extracted tables of model results from the Christchurch Transportation Model reporting and show the required criteria used and the level of validation achieved whilst Appendix B shows results extracted from the Auckland Transport Model reporting.

[4] Gaps have been left for WTSM to indicate how it will be reported in TN18 and the PM results are excluded as no observed data was collected on PT counts in this period.

5 Conclusion

In the process of updating WTSM to 2011 and developing WPTM, it was important to agree on the criteria to which the models were to be validated with the peer reviewer and client before proceeding too far down the path of model development. This was discussed with the relevant parties in several meetings and agreement was reached on the criteria for the model validation.

One measure that was agreed was that as WTSM was not being changed in terms of trip generation, distribution and modal split it was considered that at worst the new 2011 model should be no worse than the previous validation achieved.

This technical note details those criteria agreed and the approaches taken to validate both WTSM and WPTM together as well detailing some of the comments from the previous model validations and the peer review and the implications those had on the model development process.

APPENDIX A – CTM Results

Extracted result from the Christchurch Transportation Model Update (2006 Census) – Model Calibration and Validation Report – Part 2 – Validation Final Report – May 2009

Description		Heavy Vehicles - Daily
Observed		1,997,589
Estimated		1,953,526
% Difference		-2%
Abs. Difference		-44.063
EEM STANDARD (Project Model)	**Desirable**	
% RMSE	<30	30%
% Links with GEH <5	60%	65%
% Links with GEH <10	95%	94%
% Links with GEH <12	100%	97%
% Screenlines with Error <10%	100%	(43 of 46) 93%
% Screenlines with GEH <4	100%	(41 of 46) 89%
Other Checks		
% Screenlines with GEH <6		(43 of 46) 93%
% Screenlines with GEH <8		(45 of 46) 97%
% Screenlines with GEH <10		(46 of 46) 100%

Table 8-14: CTM - Daily Light Vehicle Trips by Screenline – Global Statistics - Observed vs Modelled

Description		Heavy Vehicles - Daily
Observed		115,272
Estimated		115,087
% Difference		0%
Abs. Difference		-185
EEM STANDARD (Project Model)	**Desirable**	
% RMSE	<30	71
% Links with GEH <5	60%	94%
% Links with GEH <10	95%	100%
% Links with GEH <12	100%	100%
% Screenlines with Error <10%	100%	(19 of 46) 41%
% Screenlines with GEH <4	100%	(38 of 46) 82%
Other Checks		
% Screenlines with GEH <6		(43 of 46) 93%
% Screenlines with GEH <8		(45 of 46) 97%
% Screenlines with GEH <10		(46 of 46) 100%

Table 8-18: CTM - Daily Heavy Vehicle Trips by Screenline – Global Statistics - Observed vs Modelled

Description		AM Peak Vehicles (7am – 9am)		
		Light	Heavy	Total
Observed		295,218	17,452	312,670
Estimated		283,104	17,548	300,652
% Difference		-4%	1%	-4%
Abs. Difference		-12,114	96	-12,018
EEM STANDARD (Project Model)	**Desirable**			
% RMSE	<30	32	78	31
% Links with GEH <5	60%	58%	87%	58%
% Links with GEH <10	95%	87%	100%	86%
% Links with GEH <12	100%	94%	100%	93%
% Screenlines with Error <10%	100%	(34 of 46) 73%	(21 of 46) 45%	(32 of 46) 69%
% Screenlines with GEH <4	100%	(29 of 46) 63%	(32 of 46) 69%	(26 of 46) 56%
Other Checks				
% Screenlines with GEH <6		(35 of 46) 76%	(41 of 46) 89%	(34 of 46) 73%
% Screenlines with GEH <8		(43 of 46) 93%	(44 of 46) 95%	(43 of 46) 93%
% Screenlines with GEH <10		(45 of 46) 97%	(46 of 46) 100%	(45 of 46) 97%

Table 8-23: CTM - AM Peak Vehicle Trips by Screenline – Global Statistics - Observed vs Modelled

Description		Interpeak Vehicles (9am – 4pm)		
		Light	Heavy	Total
Observed		877,879	65,343	943,222
Estimated		861,003	65,057	926,060
% Difference		-2%	0%	-2%
Abs. Difference		-16,876	-286	-17,162
EEM STANDARD (Project Model)	**Desirable**			
% RMSE	<30	36	69	35
% Links with GEH <5	60%	62%	91%	62%
% Links with GEH <10	95%	91%	100%	90%
% Links with GEH <12	100%	95%	100%	96%
% Screenlines with Error <10%	100%	(43 of 46) 93%	(16 of 46) 34%	(39 of 46) 84%
% Screenlines with GEH <4	100%	(38 of 46) 82%	(36 of 46) 78%	(36 of 46) 78%
Other Checks				
% Screenlines with GEH <6		(41 of 46) 89%	(42 of 46) 91%	(41 of 46) 89%
% Screenlines with GEH <8		(46 of 46) 100%	(44 of 46) 95%	(43 of 46) 93%
% Screenlines with GEH <10		(46 of 46) 100%	(46 of 46) 100%	(46 of 46) 100%

Table 8-24: CTM - Interpeak Vehicle Trips by Screenline – Global Statistics - Observed vs Modelled

Description		PM Peak Vehicles (4pm – 6pm)		
		Light	Heavy	Total
Observed		359,960	13,957	373,917
Estimated		352,349	14,792	367,141
% Difference		-2%	6%	-2%
Abs. Difference		-7,611	835	-6,776
EEM STANDARD (Project Model)	**Desirable**			
% RMSE	<30	31	91	30
% Links with GEH <5	60%	52%	88%	52%
% Links with GEH <10	95%	86%	100%	85%
% Links with GEH <12	100%	91%	100%	92%
% Screenlines with Error <10%	100%	(40 of 46) 86%	(16 of 46) 34%	(41 of 46) 89%
% Screenlines with GEH <4	100%	(33 of 46) 71%	(30 of 46) 65%	(35 of 46) 76%
Other Checks				
% Screenlines with GEH <6		(38 of 46) 82%	(39 of 46) 84%	(38 of 46) 82%
% Screenlines with GEH <8		(40 of 46) 86%	(44 of 46) 95%	(40 of 46) 86%
% Screenlines with GEH <10		(43 of 46) 93%	(46 of 46) 100%	(44 of 46) 95%

Table 8-25: CTM - PM Peak Vehicle Trips by Screenline – Global Statistics - Observed vs Modelled

	AM Peak				Interpeak				PM Peak			
Group Name	**Obs.**	**Mod.**	**Diff**	**% Diff**	**Obs.**	**Mod.**	**Diff**	**% Diff**	**Obs.**	**Mod.**	**Diff**	**% Diff**
South East – North West	1,756	2,116	361	21%	1,735	1,899	164	9%	1,757	1,838	81	5%
North East – South West	3,135	3,000	-136	-4%	3,244	2,915	-329	-10%	3,066	2,818	-248	-8%
North – South	2,470	3,045	575	23%	2,897	3,035	139	5%	2,982	2,739	-243	-8%
Rangiora – City	720	923	203	28%	546	806	260	48%	622	768	146	24%
South West - City	902	866	-35	-4%	694	702	8	1%	706	758	53	7%
Total	**8,983**	**9,950**	**967**	**11%**	**9,116**	**9,358**	**242**	**3%**	**9,133**	**8,922**	**-211**	**-2%**

Table 8.27: PT Boardings by Peak Period from CTM – Observed vs Modelled

APPENDIX B – ART3 Results

Extracted Results from the Auckland Transport Models Project (ATM2) – ART3 Model Testing and Validation Report – August 2008

Statistics	AM	IP	PM
Proportion of screenlines with GEH < 5	46%	61%	57%
Proportion of screenlines with GEH < 10	71%	79%	89%
Proportion of screenlines with GEH < 12	82%	89%	89%
Proportion of screenlines with % difference < 10	82%	79%	93%
R^2	0.986	0.987	0.992

Table 13: ART - Screenline Fit for Vehicles

Statistics	AM	IP	PM
Proportion of link with GEH < 5	35%	34%	34%
Proportion of links with GEH < 10	61%	61%	64%
Proportion of links with GEH < 12	69%	69%	70%
Proportion of links with % difference < 10	61%	60%	64%
R2	0.877	0.861	0.866

Table 17: ART - Fit for Vehicles on Individual Screenline Links

AM Peak	Observed	Modelled	Diff	% Diff	GEH
Bus	35,083	37,459	2,376	7%	9
Rail	6,956	6,404	-552	-8%	5
Ferry	2,974	2,594	-380	-13%	5
Total	45,014	46,458	1,444	3%	5
Interpeak	Observed	Modelled	Diff	% Diff	GEH
Bus	17,179	15,334	-1,845	-11%	10
Rail	1,219	1,553	334	27%	6
Ferry	778	566	-212	-27%	6
Total	19,176	17,453	-1,723	-9%	9
PM Peak	Observed	Modelled	Diff	% Diff	GEH
Bus	29,888	31,036	1,148	4%	5
Rail	5,582	4,856	-726	-13%	7
Ferry	2,864	1,979	-884	-31%	13
Total	38,333	37,871	-462	-1%	2

Table 22: ART - Total PT Patronage