

Appendix G Traffic Modelling

1. SH1 – SH2 Link Road Modelling

1.1. Summary of Options

The following notation has been used to describe the variations in the link road (as noted in Figure 1-1 below).

- A1 – Connection at SH1 south of Grenada North interchange
- A2 – Connection to Westchester Drive East
- B3 - As per Figure 1-1
- C3 - As per Figure 1-1
- D1 – Connection only to The Esplanade
- D2 – Connection only to SH2
- D3 – Connection to both The Esplanade and SH2
- D4 – Connection to Dowse Interchange
- D5 – Parallel link from Horokiwi to Petone

■ Figure 1-1 Option diagram



1.1.1. Test 1

Test 1 is the 2016/2026 do minimum (DM) scenario which includes all permitted developments and planned consented upgrades in the model area. Of particular relevance to this study are the inclusion of the Dowse interchange, Korokoro Road intersection, Melling interchange, Kennedy Good Bridge and SH2/SH58 interchange upgrades.

1.1.2. Test 2

Test 2 links SH1 south of Grenada north to Dowse interchange using links A1 + B3 + C3 + D5 + D4.

1.1.3. Test 3

Test 3 is the same as Test 2 but with additional linkage at the SH1 end to Westchester Drive East. This incorporates links A1 + A2 + B3 + C3 + D5 + D4.

1.1.4. Test 4

Test 4 is the same as Test 2 but rather than running parallel to SH2 between Horokiwi and Dowse, the link ties in to the Petone interchange with access to and from the link from The Esplanade only (i.e. no direct linkage to SH2). This incorporates links A1 + B3 + C3 + D5 + D1.

1.1.5. Test 5

Test 5 is the similar to Test 4 but with access to and from SH2 only at the Petone interchange only (i.e. no direct linkage to The Esplanade). This incorporates links A1 + B3 + C3 + D5 + D2.

1.1.6. Test 6

Test 6 is a combination of Tests 4 and 5 with access to and from both SH2 and The Esplanade at the Petone interchange. This incorporates links A1 + B3 + C3 + D5 + D3.

1.2. Traffic modelling assumptions

The Wellington Transport Strategy Model (WTSM) has been run 8 times with the following inputs and output trip matrices:

- Output matrices 4021/4061 from 2016/2026 DM;
- Output matrices 4031/4071 from 2016/2026 with conceptual Grenada Petone link in place;
- Output matrices 4041/4081 from 2016/2026 with conceptual Cross Valley link in place; and
- Output matrices 4051/4091 from 2016/2026 with both above links in place.

Whilst the WTSM model incorporates fixed land use assumptions for all of the above runs, the output matrices vary slightly because of differences in trip distribution and mode choice brought about by the network changes.

The WTSM matrices are disaggregated to the SATURN zonal system using a methodology developed as part of the upgrade of the Transmission Gully SATURN model which is used here, known as the Ngauranga Triangle SATURN model.

The matrix total for each of the matrices developed from the WTSM runs are shown in Table 1-1 below:

■ **Table 1-1 Matrix totals**

Year and Matrix	AM	IP	PM
2016 4021	100,613	94,523	120,716
2016 4031	101,187	94,473	121,112
2016 4041	100,665	94,531	120,769
2016 4051	101,202	94,472	121,156
2026 4061	111,270	105,484	132,539
2026 4071	111,963	105,405	133,048
2026 4081	111,340	105,458	132,596
2026 4091	111,987	105,405	133,134

1.2.1. Test 1

The DM SATURN models incorporate coding to reflect network upgrades which has been peer reviewed as part of the Transmission Gully SATURN model build. Test 1 uses WTSM matrices 4021 and 4061 for the 2016 and 2026 model runs respectively (these are defined in 1.2 above).

1.2.2. Test 2

All tests incorporating a link between Grenada and Petone (Tests 2 to 6) tie in at SH1 as shown in Figure 1-2 below. This interchange layout is purely to facilitate access and egress to SH1 for all movements.

■ **Figure 1-2 SH1 interchange**

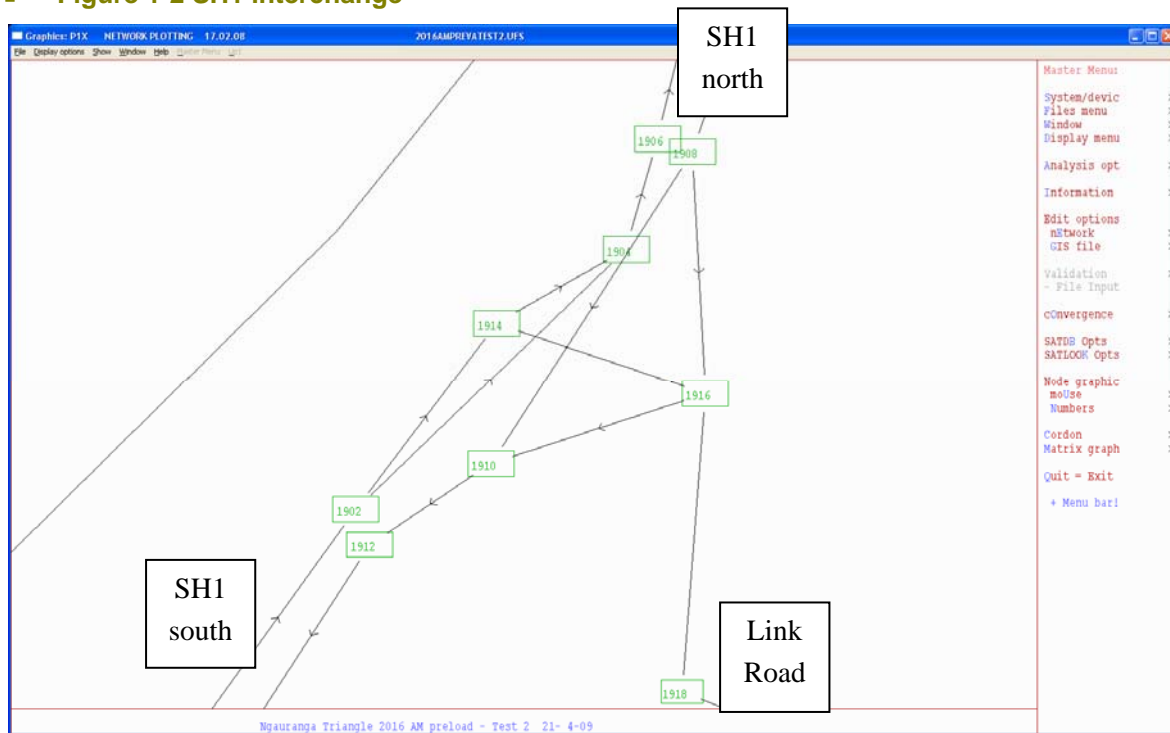
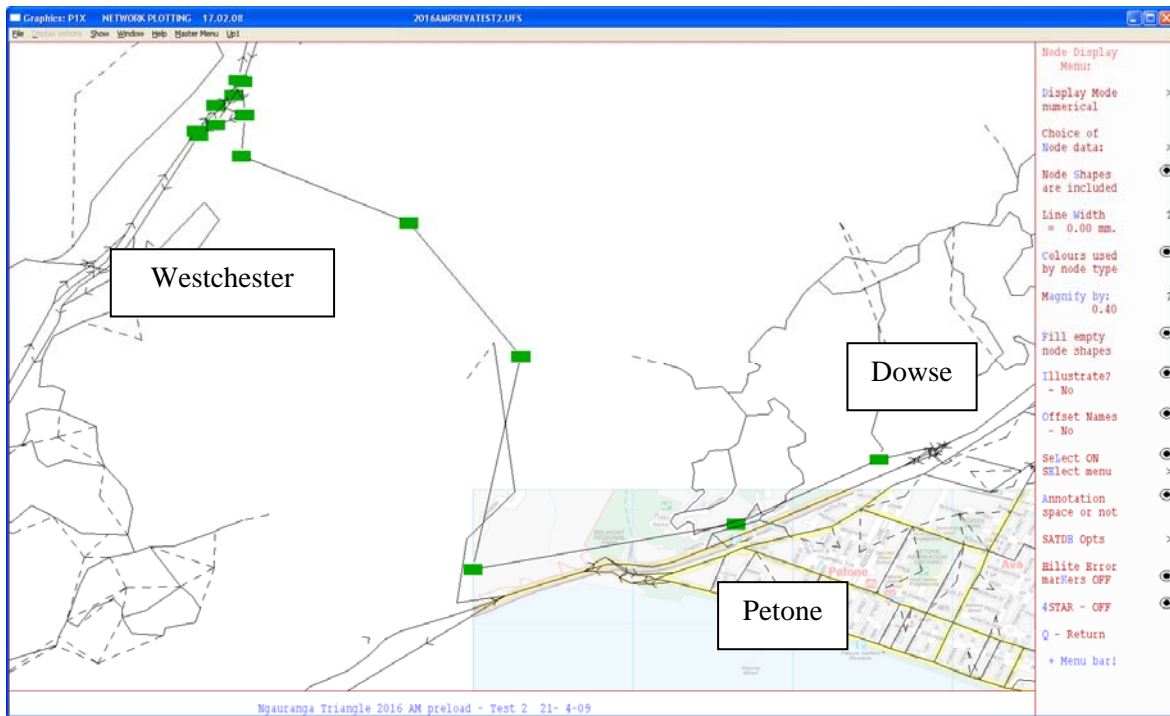


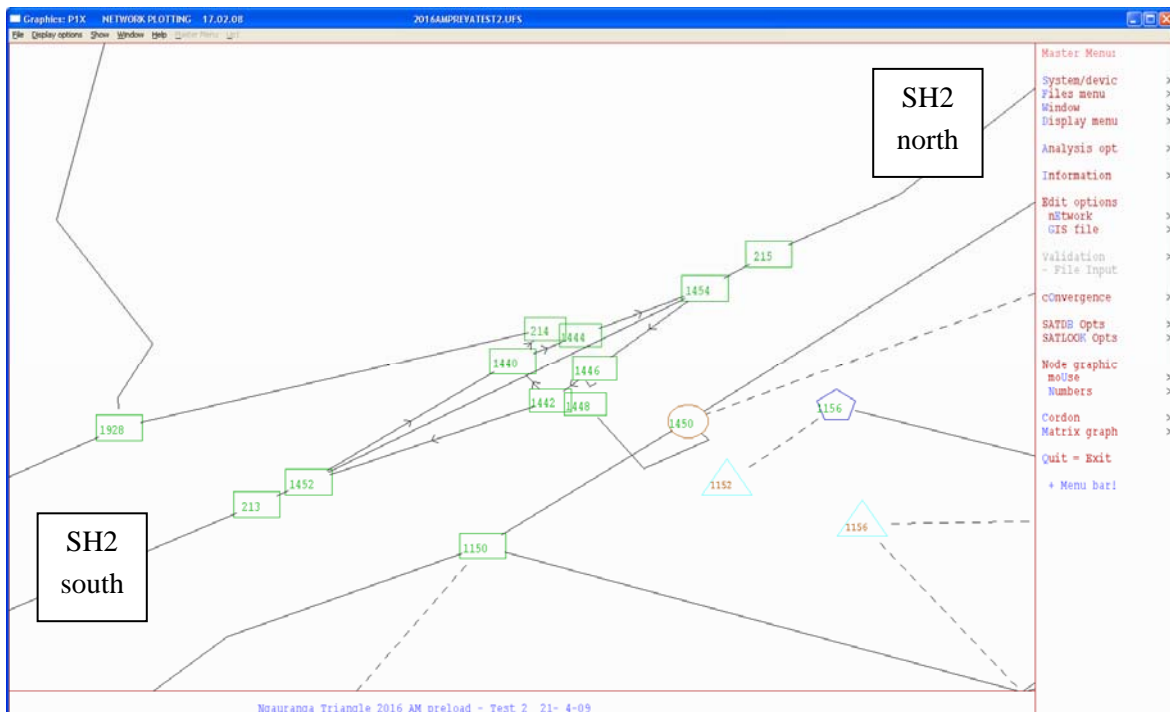
Figure 1-3 below shows the approximate alignment of the new link road between SH1 and SH2.

■ **Figure 1-3 Additional links**



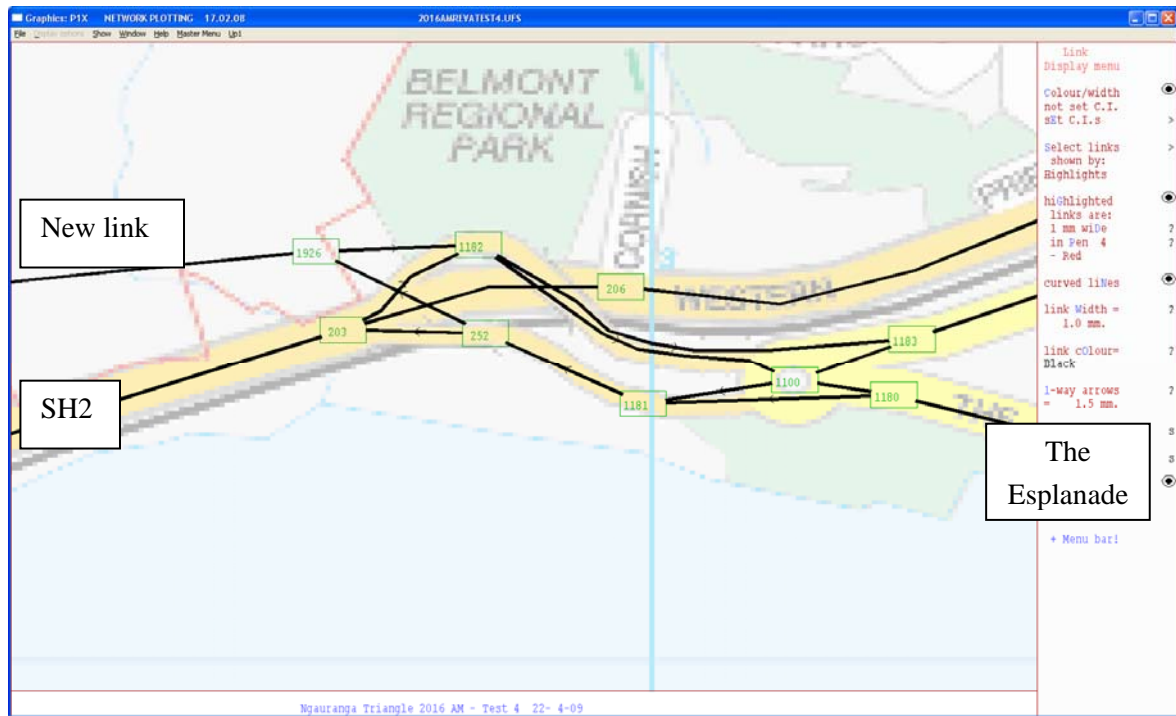
The new link road is assumed to tie in at the new Dowse interchange which is assumed to be a roundabout as shown in Figure 1-4 below:

■ **Figure 1-4 Dowse interchange**



The length of the new link is approximately 8km between SH1 and SH2 at Dowse. The free flow speed has been assumed as 70kph with a capacity of 4000 PCU/HR in each direction. A speed flow

■ **Figure 1-6 The Esplanade linkage**



Vehicles access the new link road from the SH2 southbound on ramp (node 252). Vehicles from the link road accessing The Esplanade do so via node 1182 and on to the roundabout at 1100. The distance to the Petone interchange from SH1 is assumed to be approximately 6.5km.

WTSM matrices 4031 and 4071 are used for the 2016 and 2026 model runs respectively.

1.2.5. Test 5

The new link road connection directly to SH2 is shown in Figure 1-7 below:

■ **Figure 1-7 SH2 linkage**



Vehicles access the new link road from SH2 at node 206 via 1927 and node 1926. Vehicles from the link road accessing SH2 do so via node 1926 and on to node 206.

WTSM matrices 4031 and 4071 are used for the 2016 and 2026 model runs respectively.

1.2.6. Test 6

Test 6 incorporates linkage to both SH2 and The Esplanade and as such combines the network coding from both Tests 4 and 5 above.

WTSM matrices 4031 and 4071 are used for the 2016 and 2026 model runs respectively.

1.3. 2016 Traffic modelling outputs

A large quantity of data is available from the SATURN transport models which has been filtered and combined to generate information on the following Key Performance Indicators:

- Travel time on SH1 between Grenada and Ngauranga (by peak and direction);
- Travel time on SH2 between Dowse and Ngauranga (by peak and direction);
- Travel time between Grenada and Petone via the State Highway (Ngauranga) or the link road (by peak and direction);
- Total flows on the new link road (AADT or by peak and direction);
- Total vehicle and HCV flows on The Esplanade between Fitzherbert Street and Queen Street (AADT or by peak and direction);
- Total flows on SH58 immediately to the west of SH2;
- Total flows on SH2 between Petone and Dowse;

- Total vehicle KMs travelled (VKT) on the network;
- Total travel time on the network; and
- Total vehicle delay on the network.

An important point to note when comparing options is that Test 1 (the DM) has a different trip matrix from WTSM than Tests 2 to 6. This means that total network statistics are likely to be different due to different total numbers of vehicles. 2016 model results are given in detail here, with commentary provided on any noticeable qualitative differences in the 2026 modelling.

1.3.1. Network statistics

General network statistics have been extracted from the SATURN model. This includes data from vehicles travelling on all of the modelled area from SH1 south of Ngauranga interchange to SH1 north of McKay's Crossing and SH2 north of SH58. The statistics presented in the following sections are:

- Transient queues are those which build up and dissipate throughout the modelled period (for example at signals each cycle);
- Over capacity queues are those which build up throughout the modelled period and carry over into the next period;
- Link cruise time is the total amount of time spent on links which is made up of free flow time and delays due to queuing on links;
- Total travel time includes the cruise time and additional delays at intersections from over capacity queues;
- Total travel distance; and
- Average travel speed is the ration of total distance to total time.

These are presented for the AM, inter and PM peaks separately.

The minimum value for each statistic is highlighted in green, with the minimum "non-DM" value highlighted in yellow if the DM has the minimum value.

It should be noted that overall network statistics are subject to model "noise" which is particularly prevalent in larger models such as the NT SATURN model. This means that small differences in convergence can alter delays and general network performance in areas which appear unrelated to any model alterations. The risk of this is minimised in the NT SATURN model by ensuring good convergence of all model runs and by checking of areas of high delay which are sensitive to small changes in flow.

1.3.1.1. AM peak

The general network statistics for the AM peak are shown in Table 1-2 below:

■ **Table 1-2 AM peak network statistics**

Peak	AM					
Test	1	2	3	4	5	6
TRANSIENT QUEUES (PCU. HRS./HR.)	668.7	667.9	659.2	660.4	680.2	667.8
OVER-CAPACITY QUEUES (PCU. HRS./HR.)	181.6	185.2	171.7	174.7	189.5	193.5
LINK CRUISE TIME (PCU. HRS./HR.)	5727.1	5947.9	5940	5949.9	5924.5	5906.5
FREE FLOW (PCU. HRS./HR.)	5031.9	5271.1	5272.3	5244.6	5230.4	5211.8
DELAYS (PCU. HRS./HR.)	695.2	676.8	667.8	705.3	694.1	694.7
TOTAL TRAVEL TIME (PCU. HRS./HR.)	6577.5	6801	6770.9	6785	6794.2	6767.7
TRAVEL DISTANCE (PCU. KMS./HR.)	365587.4	378628	378389.8	376367.6	376283.4	375092.9
OVERALL AVERAGE SPEED (KPH)	55.6	55.7	55.9	55.5	55.4	55.4

Note here that due to the change in distribution in the applied WTSM matrix, the lowest statistics are generally for Test 1, the Do Minimum. Tests 3 and 6 stand out as having the lower general statistics with:

- Test 3 having the lowest level of general queuing and associated delays; and
- Test 6 having the lowest overall travel time and distance on the network.

1.3.1.2. Inter peak

The general network statistics for the inter peak are shown in Table 1-3 below:

■ **Table 1-3 Inter peak network statistics**

Peak	IP					
Test	1	2	3	4	5	6
TRANSIENT QUEUES (PCU. HRS./HR.)	286.8	287.5	287.7	288	287.4	287
OVER-CAPACITY QUEUES (PCU. HRS./HR.)	14.5	5.6	10	15.6	6.8	13.5
LINK CRUISE TIME (PCU. HRS./HR.)	3429.3	3492.6	3491.6	3480.4	3482.2	3467.8
FREE FLOW (PCU. HRS./HR.)	3396.9	3471.4	3470.6	3459.8	3459.8	3446.5
DELAYS (PCU. HRS./HR.)	32.4	21.2	21	20.6	22.3	21.3
TOTAL TRAVEL TIME (PCU. HRS./HR.)	3730.6	3785.7	3789.2	3784	3776.3	3768.2
TRAVEL DISTANCE (PCU. KMS./HR.)	236676.1	239536.3	239395.2	238121	239111.9	238090.1
OVERALL AVERAGE SPEED (KPH)	63.4	63.3	63.2	62.9	63.3	63.2

In the less congested inter peak, the lower overall travel time and distance in Test 6 are also reflected by lower levels of transient queuing.

1.3.1.3. PM peak

The general network statistics for the PM peak are shown in Table 1-4 below:

■ **Table 1-4 PM peak network statistics**

Peak	PM					
Test	1	2	3	4	5	6
TRANSIENT QUEUES (PCU. HRS./HR.)	612.6	668.4	661.3	631.1	669.4	631.5
OVER-CAPACITY QUEUES (PCU. HRS./HR.)	661	654	648.4	681	668.1	666.3
LINK CRUISE TIME (PCU. HRS./HR.)	5718.3	5837.5	5836.7	5820.3	5818.3	5796.7
FREE FLOW (PCU. HRS./HR.)	5273.3	5482.9	5488.3	5487.4	5461.1	5457
DELAYS (PCU. HRS./HR.)	445	354.6	348.4	333	357.2	339.7
TOTAL TRAVEL TIME (PCU. HRS./HR.)	6992	7159.9	7146.4	7132.5	7155.9	7094.5
TRAVEL DISTANCE (PCU. KMS./HR.)	376191	387698.5	387719.4	387854	387260.4	386488.9
OVERALL AVERAGE SPEED (KPH)	53.8	54.1	54.3	54.4	54.1	54.5

Again, Test 1 generally shows the lowest overall network figures due to the difference in distribution of traffic inherent in the WTSM matrices. Again, Test 6 generally shows the lowest overall network statistics.

A.1 Cross Valley Link Modelling

1.4. Summary of options

1.4.1. Test 7

Test 7 incorporates traffic calming works on The Esplanade and Jackson Street.

1.4.2. Test 8

Test 8 includes a Cross Valley Link between Wakefield Street and White Lines West.

1.4.3. Test 9

Test 8 includes a Cross Valley Link between Wakefield Street and Randwick Road following the rail alignment, diverging from Wakefield Street where Wakefield Street passes below Cuba Street.

1.4.4. Test 10

Test 10 includes upgrading the existing Udy Street and Cuba Street to two lanes in each direction with a free flow speed of 70kph on Udy Street, retaining the 50kph free flow speed on Cuba Street.

1.4.5. Test 11

Test 11 is a combination of Test 7 and Test 8.

1.4.6. Test 12

Test 12 is a combination of Test 7 and Test 9.

1.4.7. Test 13

Test 13 is a combination of Test 7 and Test 10

1.4.8. Test 16

Test 16 involves increasing the free flow speed on The Esplanade to 70kph between Hutt Road and Waione Road, and providing 2 full lanes in each direction.

1.4.9. Test 17

Test 17 provides an alternative eastbound route to The Esplanade via SH2, Dowse Interchange, Hutt Road, Udy Street and Cuba Street. The Esplanade is closed to traffic from SH2 and Hutt Road and Udy Street are upgraded to 70kph and 2 lanes in an eastbound direction.

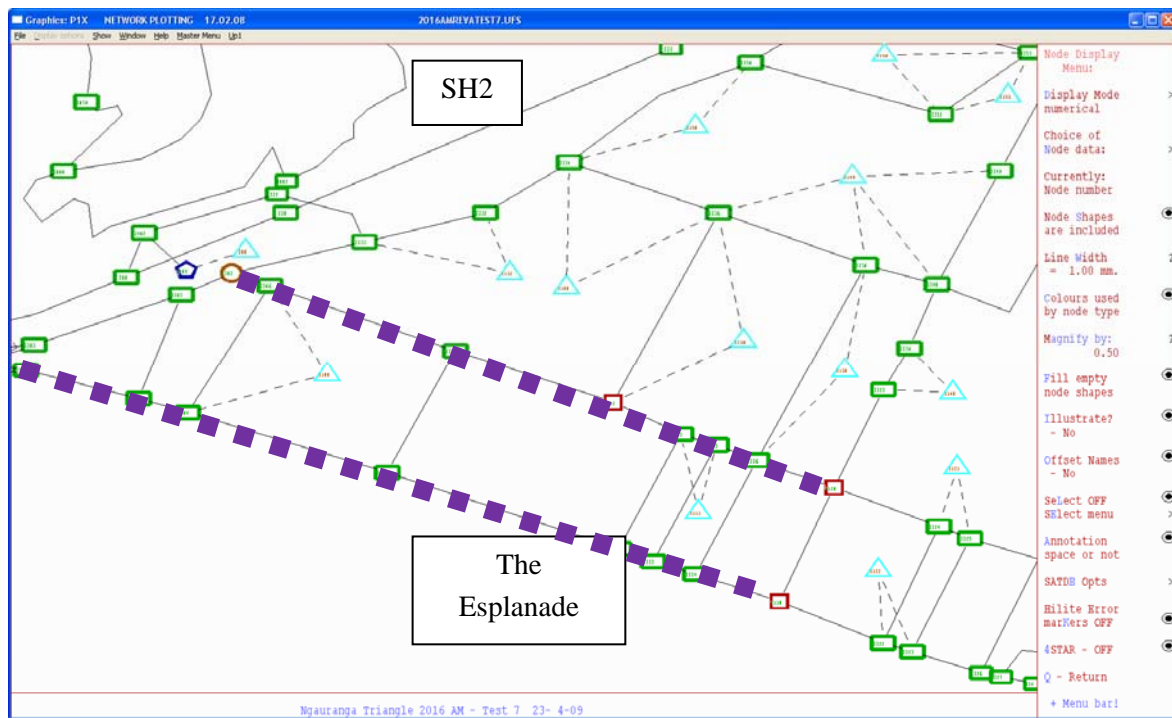
1.5. Traffic modelling assumptions

Note that for the Cross Valley Link model WTSM matrices 4041/4081 have been used.

1.5.1. Test 7

The SATURN model networks have reflected traffic calming by reducing the free flow speed on The Esplanade and Jackson Street to 30kph as marked with the purple dashed line in Figure 1-8 below:

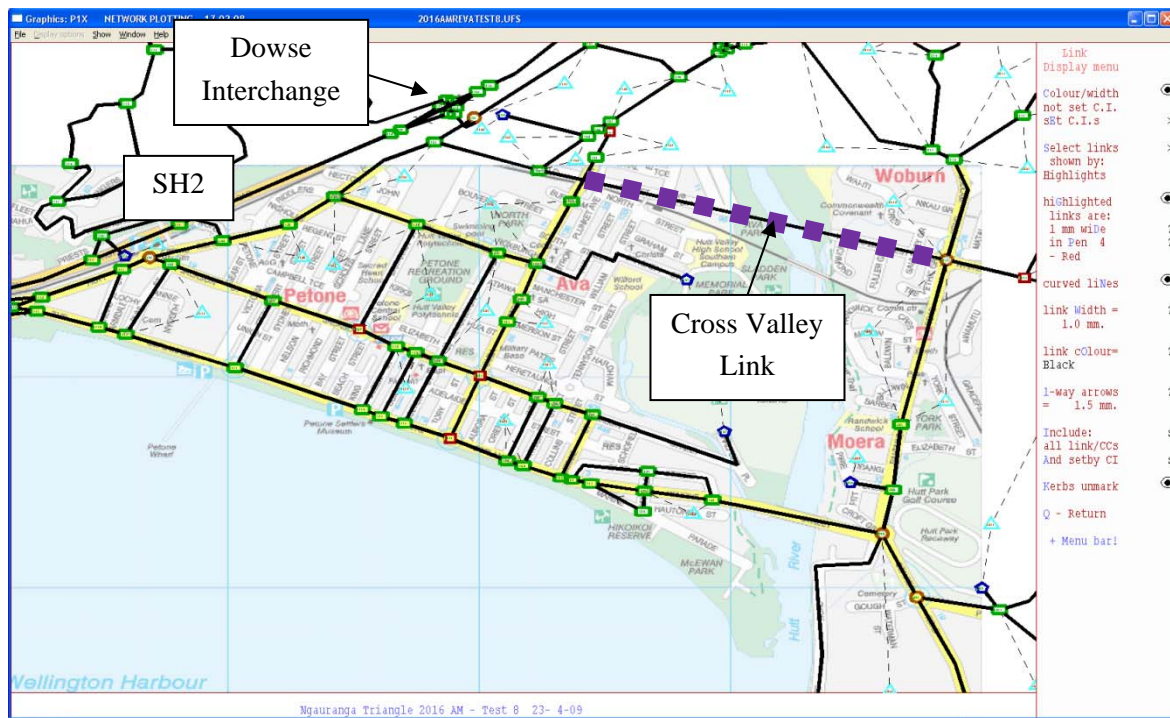
■ **Figure 1-8 Traffic calming extents**



1.5.2. Test 8

Test 8 incorporates a link from Wakefield Street at Hutt Road to Whites Line West terminating at a roundabout on Randwick Road. The free flow speed has been modelled as 70kph along the length of Wakefield Street, the Cross Valley Link and Whites Line West with a capacity of 3600 PCU/HR to reflect two lanes in each direction. The roundabout at Whites Line West / Randwick Street has been coded as a two lane roundabout with a circulating capacity of 3000 PCU/HR. Wakefield Street terminates at its western end at a priority intersection with Hutt Road. The link is denoted as a purple dashed line in Figure 1-9.

■ **Figure 1-9 Wakefield to Whites Line West Cross Valley Link**



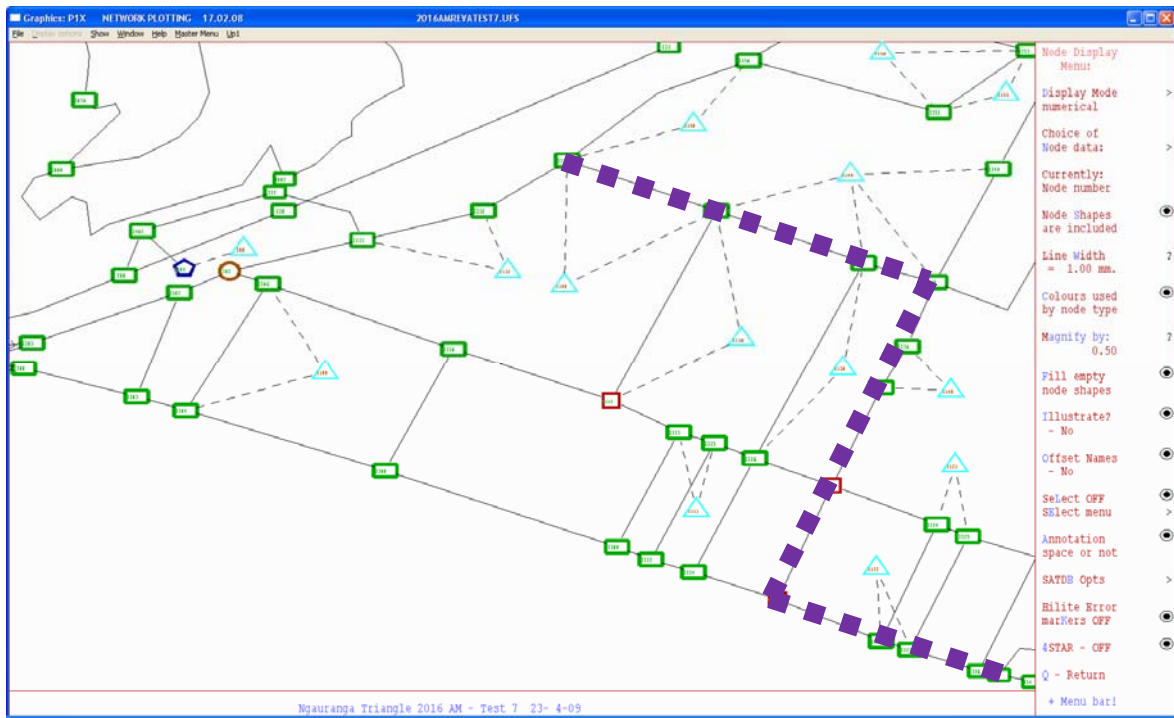
1.5.3. Test 9

The Test 9 alignment across the Hutt Valley means that there is unlikely to be any operation detail between Test 9 and Test 8 at the level of detail of the SATURN model. For the purposes of this study, Test 8 and Test 9 utilise the same SATURN modelling results.

1.5.4. Test 10

Test 10 has been coded by simply increasing the capacity (to two lanes or 3600vph in each direction) and free flow speed (to 70kph) on Udy Street with a two lane roundabout at its intersection with Hutt Road at its western end. The free flow speed on Waione Street has been increased to 60kph between Cuba Street and East Street with a 50kph free flow speed remaining on Cuba Street. The capacity has also been increased on Cuba Street and its intersections with Udy Street and Waione Street to provide 3600vph capacity along this corridor. This has involved the signalisation of Udy Street / Cuba Street intersection as well as increasing the size of the Cuba Street / Waione Street intersection. The extent of these network modifications are indicated by the purple dashed line in Figure 1-10 below:

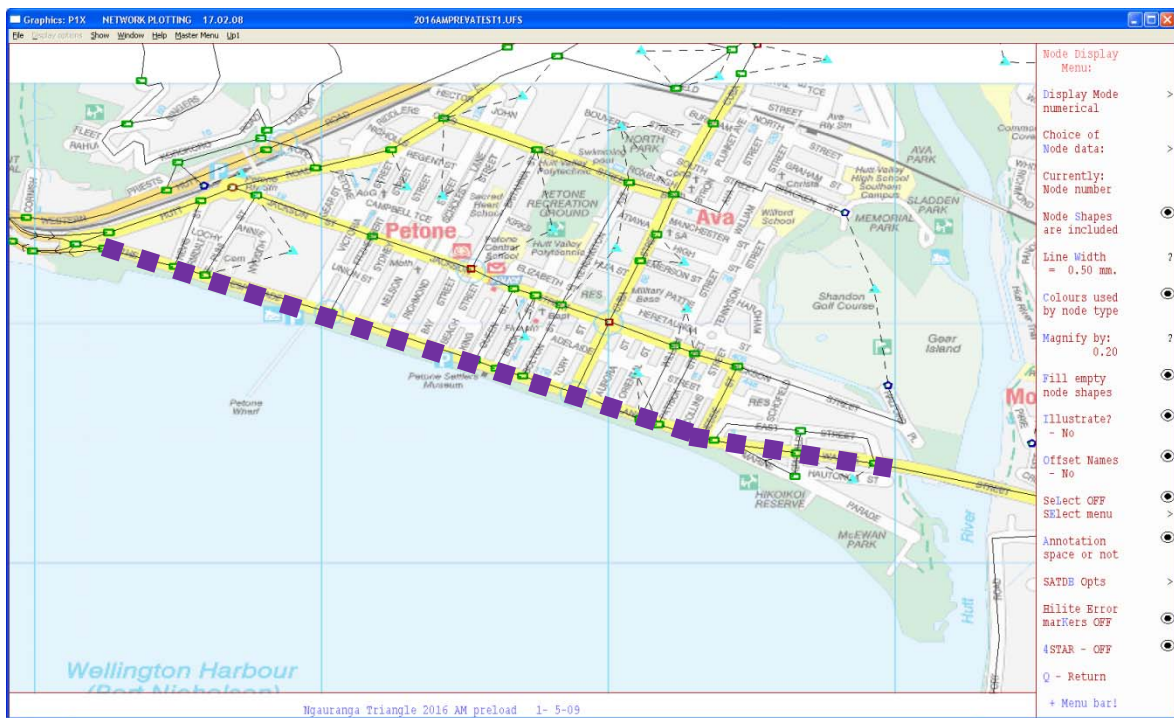
■ **Figure 1-10 Udy Street upgrade**



1.5.5. Test 16

Test 16 has been coded by simply increasing the through capacity (and lane allocation) to 3600vph and increasing the free flow speed to 70kph for all nodes as shown by the purple dotted line in Figure 1-11 below:

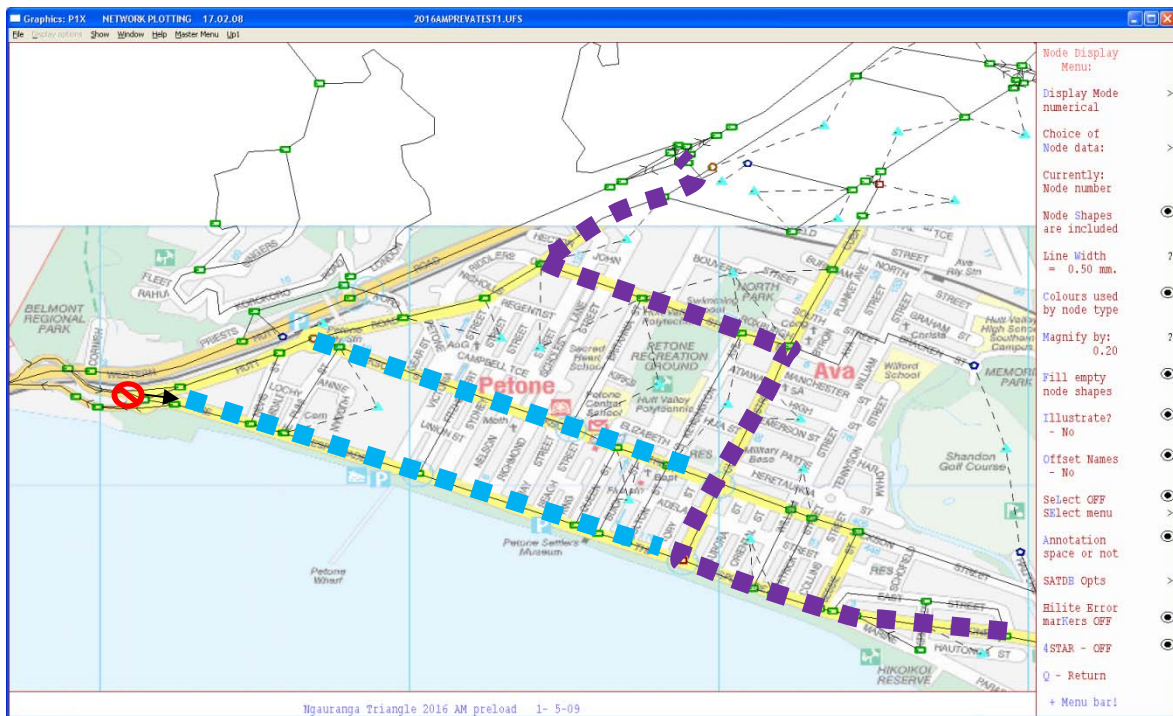
■ **Figure 1-11 The Esplanade upgrade**



1.5.6. Test 17

Test 17 involves offering an alternative eastbound route to The Esplanade using the following coding:

- A reduction in free flow speed on The Esplanade and Jackson Street to 30kph in the eastbound direction between Hutt Road and Cuba Street (the blue dotted lines in Figure 1-12);
 - An increase in the free flow speed on The Esplanade to 70kph in the westbound direction between Cuba Street and Hutt Road;
 - Banning the movement from SH2 to The Esplanade (the red no entry symbol in Figure 1-12);
 - Increasing the speed to 70kph on Hutt Road, Cuba Street, Udy Street and Waione Street as well as providing 2 lanes eastbound capacity (the purple dotted line in Figure 1-12); and
 - Providing a two lane roundabout at the Hutt Road / Udy Street intersection and a signalised intersection at Udy Street / Cuba Street (as in Test 10).
- **Figure 1-12 Eastbound alternative route**



Note that this is similar to the eastbound component of Test 10, but by banning the movement from SH2 to The Esplanade and improving the capacity on Hutt Road between Dowse interchange and Udy Street, the Udy Street / Cuba Street route becomes more favourable in the eastbound direction.

1.6. 2016 Traffic modelling outputs

A large quantity of data is available from the SATURN transport models which has been filtered and combined to generate information on the following Key Performance Indicators:

- Total vehicle and HCV flows on The Esplanade (AADT or by peak and direction);
- Total vehicle KMs travelled (VKT) on the network;

- Total travel time on the network; and
- Total vehicle delay on the network.

1.6.1. Network statistics

As with the link road, total network statistics have been extracted for each of the Cross Valley Link options and compared with Test 1 (DM). It is worth noting that Tests 7, 11 and 13 all incorporate traffic calming on The Esplanade and Jackson Street which, all else being equal, would mean an increase in link cruise time. This means that although traffic calming on The Esplanade and Jackson Street may meet objectives concerned with improving amenity in these areas, total network statistics may indicate a “worsening” of overall network performance.

1.6.1.1. AM peak

The general network statistics for the AM peak are shown in Table 1-5 below:

■ **Table 1-5 AM peak network statistics**

Peak	AM							
Test	1	7	8	10	11	13	16	17
TRANSIENT QUEUES (PCU. HRS./HR.)	668.7	665.2	674.9	676.6	676.6	675.1	669.5	684.1
OVER-CAPACITY QUEUES (PCU. HRS./HR.)	181.6	195.2	193.4	165.6	188.6	194.4	197.6	193.9
LINK CRUISE TIME (PCU. HRS./HR.)	5727.1	5761.9	5703.9	5706.7	5756.4	5740.3	5688.5	5685.1
FREE FLOW (PCU. HRS./HR.)	5031.9	5078.1	5016.5	5020.8	5065	5057.2	5002.2	5013.4
DELAYS (PCU. HRS./HR.)	695.2	683.8	687.4	685.9	691.5	683.1	686.3	671.8
TOTAL TRAVEL TIME (PCU. HRS./HR.)	6577.5	6622.3	6572.2	6548.8	6621.6	6609.8	6555.6	6563.1
TRAVEL DISTANCE (PCU. KMS./HR.)	365587.4	365977	365484.7	365901.3	366353.5	366172.1	365701.3	366701.3
OVERALL AVERAGE SPEED (KPH)	55.6	55.3	55.6	55.9	55.3	55.4	55.8	55.9

Test 8 and Test 10 which provide improved linkage across the Hutt Valley have the lowest total network travel time and distance. It is interesting to note that Test 13 which combines improvements to Udy Street with traffic calming on The Esplanade and Jackson Street actually marginally reduces over capacity queues. The additional capacity provided on the Esplanade by Tests 16 and 17 are reflected by lower delays and free flow travel time.

1.6.1.2. Inter peak

The general network statistics for the inter peak are shown in Table 1-6 below:

■ **Table 1-6 Inter peak network statistics**

Peak	IP							
Test	1	7	8	10	11	13	16	17
TRANSIENT QUEUES (PCU. HRS./HR.)	286.8	289.2	289.8	292.9	291.3	295.9	284.3	297
OVER-CAPACITY QUEUES (PCU. HRS./HR.)	14.5	4.1	6.1	19.2	5.3	2.5	1.8	2.6
LINK CRUISE TIME (PCU. HRS./HR.)	3429.3	3466.9	3409.2	3416.5	3444.1	3444.3	3397.5	3412.5
FREE FLOW (PCU. HRS./HR.)	3396.9	3435	3376.9	3384.7	3412.1	3412.3	3365.6	3380.4
DELAYS (PCU. HRS./HR.)	32.4	31.9	32.3	31.8	32	32	31.9	32
TOTAL TRAVEL TIME (PCU. HRS./HR.)	3730.6	3760.1	3705	3728.6	3740.7	3742.6	3683.6	3712.1
TRAVEL DISTANCE (PCU. KMS./HR.)	236676.1	236891.9	236375.1	236743	236548.8	236865	236557.6	237239.7
OVERALL AVERAGE SPEED (KPH)	63.4	63	63.8	63.5	63.2	63.3	64.2	63.9

In the inter peak, Test 8 shows the lowest overall VKT although delays are minimised in Test 10. Test 16 shows the largest improvement in queue reduction which would be expected given the additional capacity and increase in speed provided on the Esplanade in this test.

1.6.1.3. PM peak

The general network statistics for the PM peak are shown in Table 1-7 below:

■ **Table 1-7 PM peak network statistics**

Peak	PM							
Test	1	7	8	10	11	13	16	17
TRANSIENT QUEUES (PCU. HRS./HR.)	612.6	613.2	628.9	616.4	636.8	620.6	612.3	616.2
OVER-CAPACITY QUEUES (PCU. HRS./HR.)	661	653.7	655.5	657.7	689.7	646.1	663.7	675.5
LINK CRUISE TIME (PCU. HRS./HR.)	5718.3	5756.5	5700	5706.6	5739.8	5740.2	5682.1	5704
FREE FLOW (PCU. HRS./HR.)	5273.3	5322.8	5255.7	5261.5	5296.1	5298.2	5244.3	5264.7
DELAYS (PCU. HRS./HR.)	445	433.8	444.3	445	443.6	442	437.8	439.2
TOTAL TRAVEL TIME (PCU. HRS./HR.)	6992	7023.5	6984.3	6980.7	7066.2	7006.8	6958.1	6995.7
TRAVEL DISTANCE (PCU. KMS./HR.)	376191	376976.5	376144.7	376449.5	377012.6	376637.1	376215.1	376655.5
OVERALL AVERAGE SPEED (KPH)	53.8	53.7	53.9	53.9	53.4	53.8	54.1	53.8

As with the AM peak, Test 8 shows the lowest VKT with Test 16 generally showing lowest network statistics with regards to queues and delays.

A.2 Combined Option Modelling

This section considers the combination of the SH1 – SH2 and Cross Valley Link Roads through traffic modelling.

1.7. Summary of options

1.7.1. Test 14

Test 14 is a combination of Test 3 from section 1.2.3 and Test 11 from Section 1.4.5. Although Test 3 did not appear to have the same level of network performance, the close linkage between Wakefield Street and Dowse interchange mean that the two projects may be complementary and provide more combined benefits than the sum of each project's individual benefits.

1.7.2. Test 15

Test 15 is a combination of Test 6 from section 1.2.6 and Test 11 from Section 1.4.5. This incorporates the benefits of the lower overall network travel time and VKT with the desirable increase in amenity of The Esplanade through the provision of an additional Cross Valley Link at Wakefield Street.

1.7.3. Test 18

Test 18 incorporates the following connections:

- Wakefield Street to Whites Line East via the rail reserve;
- A grade separated roundabout at the SH2 / The Esplanade interchange;
- A link from the Tawa interchange on SH1 to The Esplanade;
- Traffic calming on The Esplanade and Jackson Street; and
- HCVs banned at either end of The Esplanade (to discourage HCV through trips).

1.7.4. Test 19

Test 19 incorporates all of the Test 18 modifications with an additional connection from the Cross Valley Link Road to the end of Elizabeth Street.

1.7.5. Test 20

Test 20 incorporates all of the Test 19 modifications with an additional connection from the Cross Valley Link Road at the end of Elizabeth Street to Parkside Road.

1.7.6. Test 21

Test 21 incorporates the following modifications:

- A grade separated roundabout at the SH2 / The Esplanade interchange;
- A link from the Tawa interchange on SH1 to The Esplanade;
- The Esplanade operating as a 50kph four lane link between SH2 and Randwick Road;
- Traffic calming on Jackson Street; and
- HCVs banned at either end of The Esplanade (to discourage HCV through trips).

1.7.7. Test 22

Test 22 incorporates all of the Test 18 modifications with an additional connection at the western end of the Grenada-Petone link road to tie in to Westchester Drive East (as per Test 3)

1.8. Traffic modelling assumptions

1.8.1. Test 14

Test 14 has been modelled by using a direct combination of coding from Test 3 and Test 11.

1.8.2. Test 15

Test 15 has been modelled by using a direct combination of coding from Test 6 and Test 11.

1.8.3. Test 18

Figure 1-13 shows the location of the Cross Valley link, following the rail alignment from Wakefield Street and tying in on Whites Line East.

■ Figure 1-13 Cross Valley Link

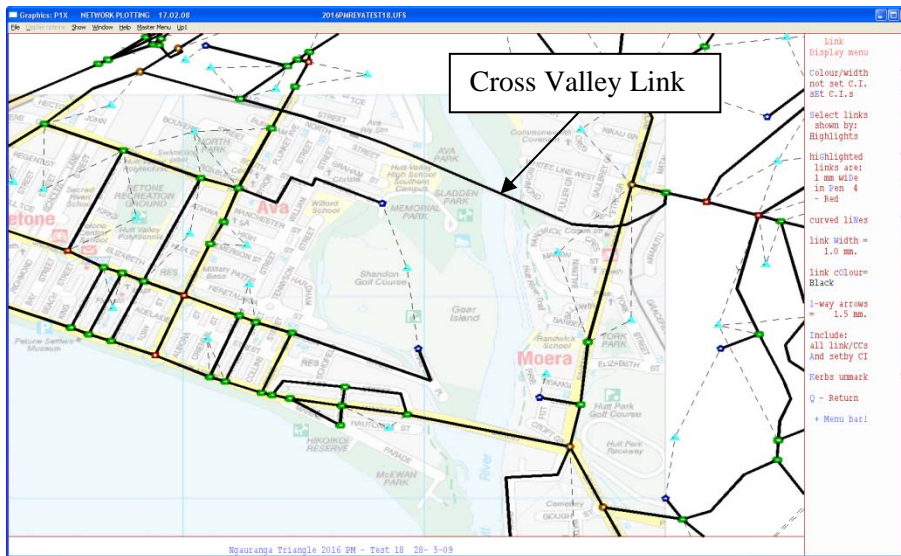


Figure 1-14 shows the assumed layout for the intersection of the link road with Whites Line East. The movement between the link road and the western end of Whites Line East feeding into Randwick Road (nodes 1152 and 1200 respectively) is the major movement with the Whites Line East approach from the east (node 1210) giving way.

- **Figure 1-14 Intersection Link Road / White Line East**

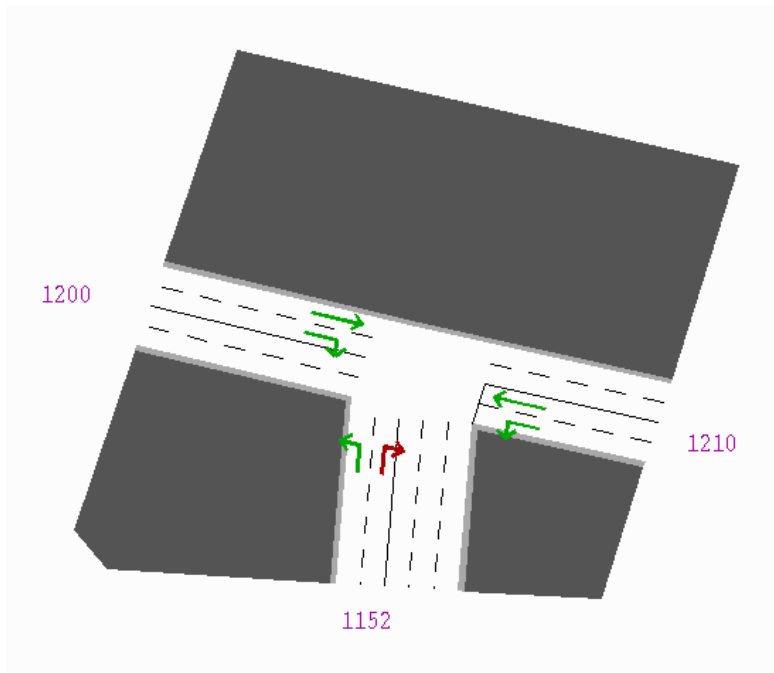
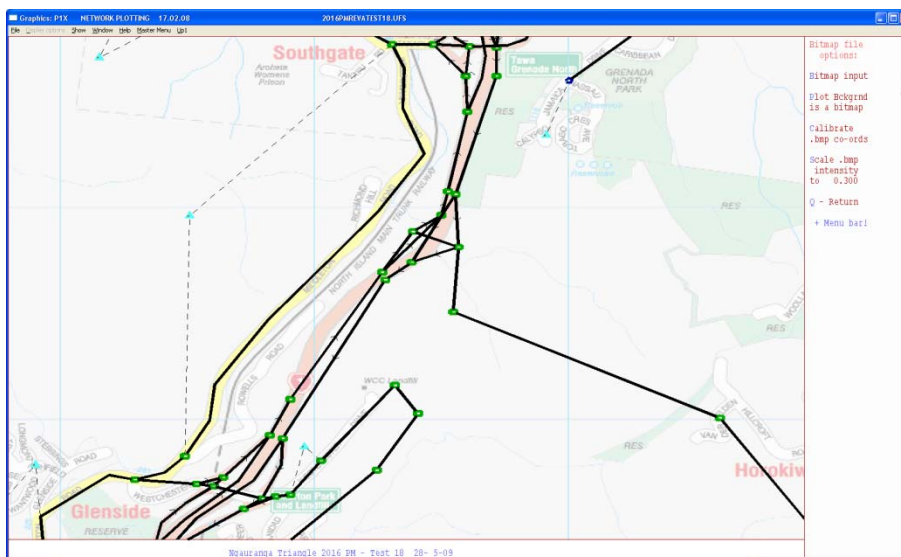


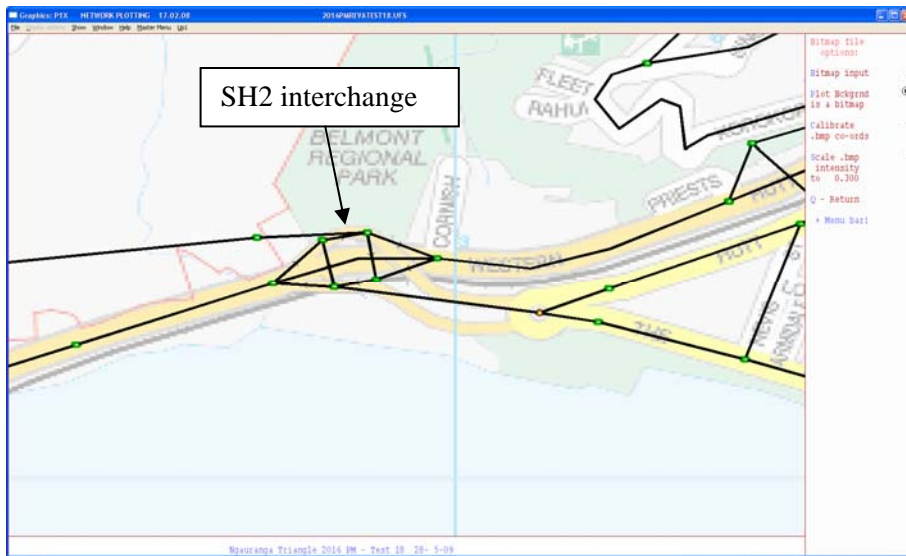
Figure 1-15 shows the connection of the Grenada-Petone Link Road at SH1 (as in Tests 2-5).

- **Figure 1-15 Western Connection to SH1**



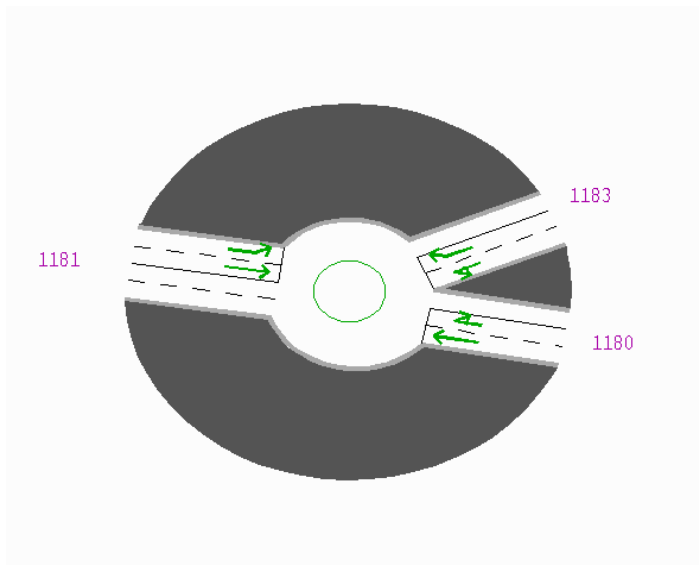
The connection at the eastern end of the Grenada-Petone link has been modified as shown in Figure 1-16 below:

- **Figure 1-16 Grenada-Petone Link Road / SH2 connection**



A full movement grade separated roundabout has been assumed at SH2 with a roundabout at the Hutt Road / The Esplanade / SH2 interchange as illustrated in Figure 1-17 below.

- **Figure 1-17 Intersection Layout Hutt Road/The Esplanade/SH2**



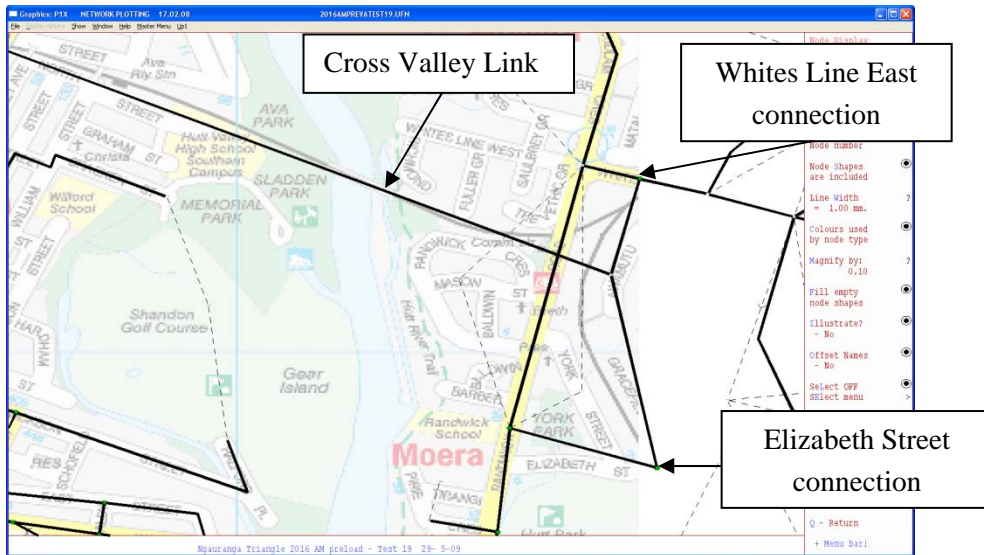
Traffic calming on The Esplanade and Jackson Street (west of Cuba Street) has been implemented with an assumed 30kph free flow speed. HCVs have also been banned from The Esplanade. A number of free flow speeds were tested to ascertain which speed would assign approximately 10,000-15,000vpd to The Esplanade. The Test 18 models indicated a daily flow of approximately 14,500 vpd on The Esplanade west of Cuba Street.

WTSM matrix 4051/4091 is assigned in Test 18.

1.8.4. Test 19

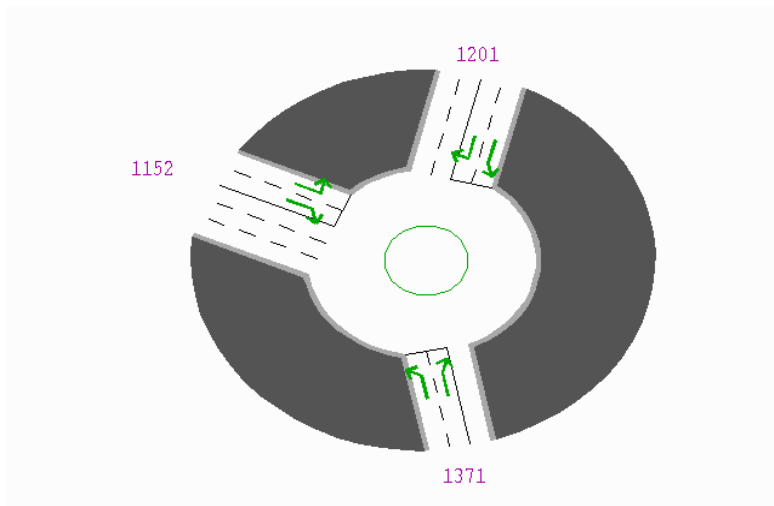
Test 19 incorporates the same modifications as Test 18 with an additional connection at the eastern end as shown in Figure 1-18 below:

- **Figure 1-18 Additional Cross Valley Link connection**



A roundabout has been coded so that vehicles travelling across the Cross Valley Link (to and from 1152) can turn north to the Whites Line East connection (to and from 1201) or south to the Elizabeth Street connection (to and from 1371) as shown in Figure 1-19.

- **Figure 1-19 Cross Valley Link eastern end**

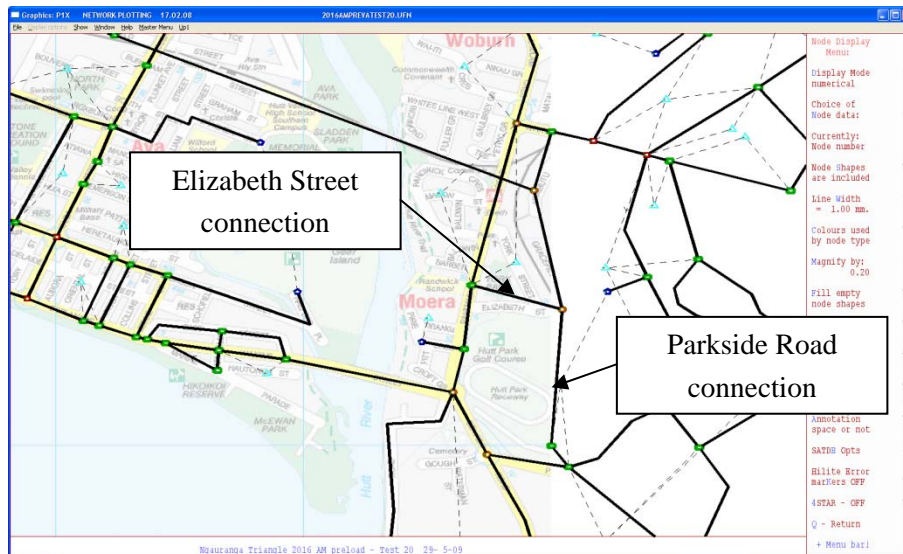


WTSM matrix 4051/4091 is assigned in Test 19.

1.8.5. Test 20

Test 20 extends the Cross Valley link Elizabeth Street connection to tie in at Parkside Road as shown in Figure 1-20. A two lane roundabout is coded at both Elizabeth Street connection / Parkside Road connection of the same form as Figure 1-19.

■ Figure 1-20 Parkside Road connection



WTSM matrix 4051/4091 is assigned in Test 20.

1.8.6. Test 21

Test 21 has the same coding as Test 18 for The Esplanade / SH2 / Grenada to Petone link road interchange as shown in Figure 1-15, Figure 1-16 and Figure 1-17. Two full lanes in each direction have been coded along the length of the Esplanade with Jackson Street remaining traffic calmed to 30kph. Note that no Cross Valley Link is assumed in Test 21 due to the upgrading of The Esplanade / Waione Street.

WTSM matrix 4051/4091 is assigned in Test 21.

1.8.7. Test 22

Test 22 has the same coding as Test 18 but with an additional connection at the western end of the Grenada-Petone link to tie into Westchester Drive East (as in Test 3)

1.9. 2016/2026 Traffic modelling outputs

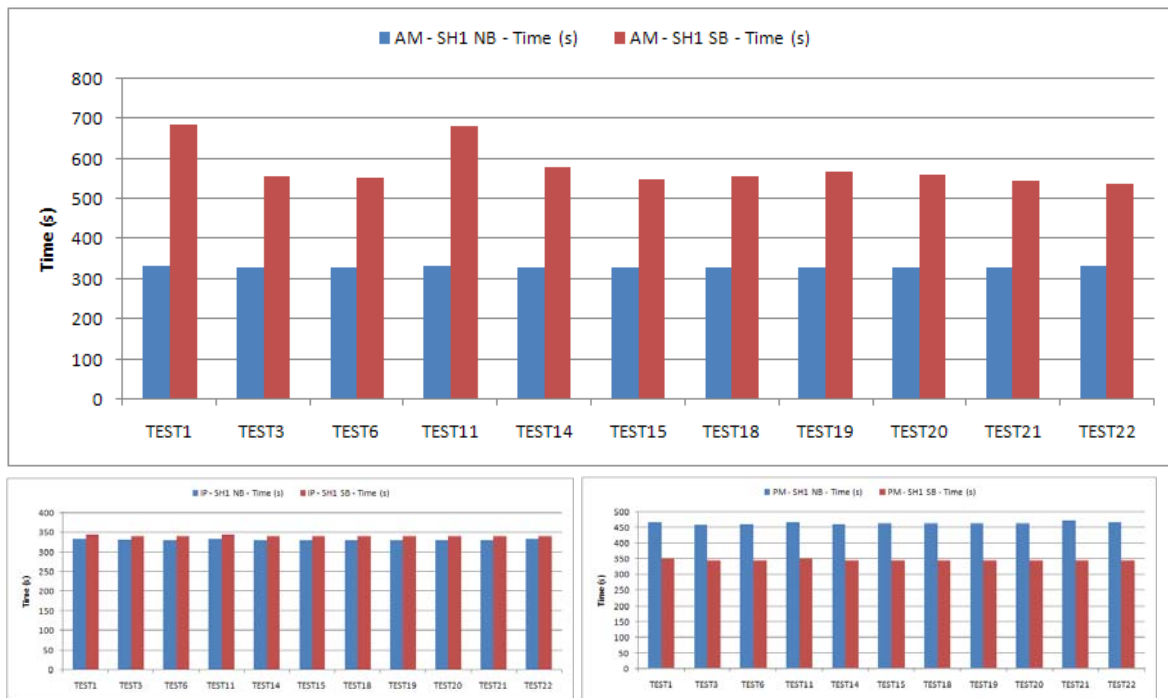
The same KPIs as for Tests 1-6 have been produced for Tests 14 and 15.

An important point to note when comparing options is that Test 1 (the DM) has a different trip matrix from WTSM than Tests 2 to 6. This means that total network statistics are likely to be different due to different total numbers of vehicles.

1.9.1. State Highway travel times

There is a reduction in flow of approximately 4000 PCU/HR on SH1 southbound in Tests 14 and 15 (similar to Tests 3 and 6) in all three peaks but the effect is largest in the congested AM peak which shows significant improvements in the travel time on this route. This reduction is shown in Figure 1-21 below.

■ Figure 1-21 2016 SH1 travel times

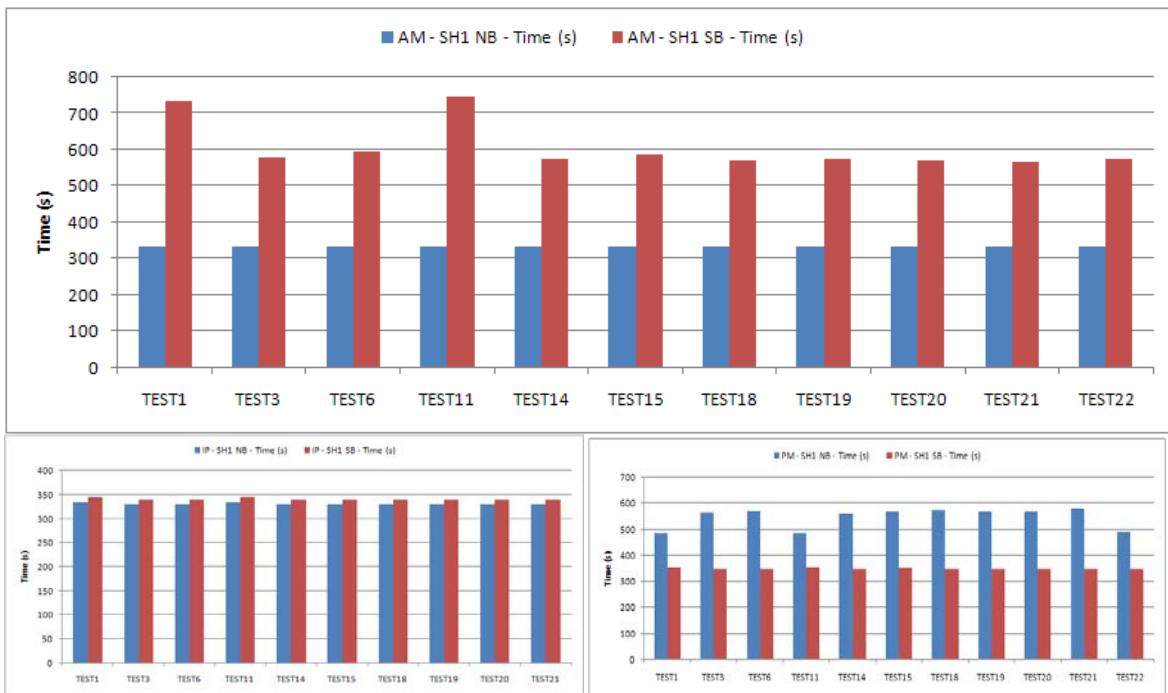


Test 11 has been included since it is combined with Test 3 or Test 6 to make Test 14 or Test 15. With no link road existing in Test 11, the minor differences in travel time are likely to be due to changes in the WTSM matrix used with only very small changes in flow on SH1. Generally Tests 14 and 22 show similar travel times to Tests 3 and 6 as would be expected with the differences between the tests being focussed in the Petone area.

The lower flows for SH1 northbound in all three peaks mean that any reductions due to the inclusion of the link road have limited effect on the travel times on this route.

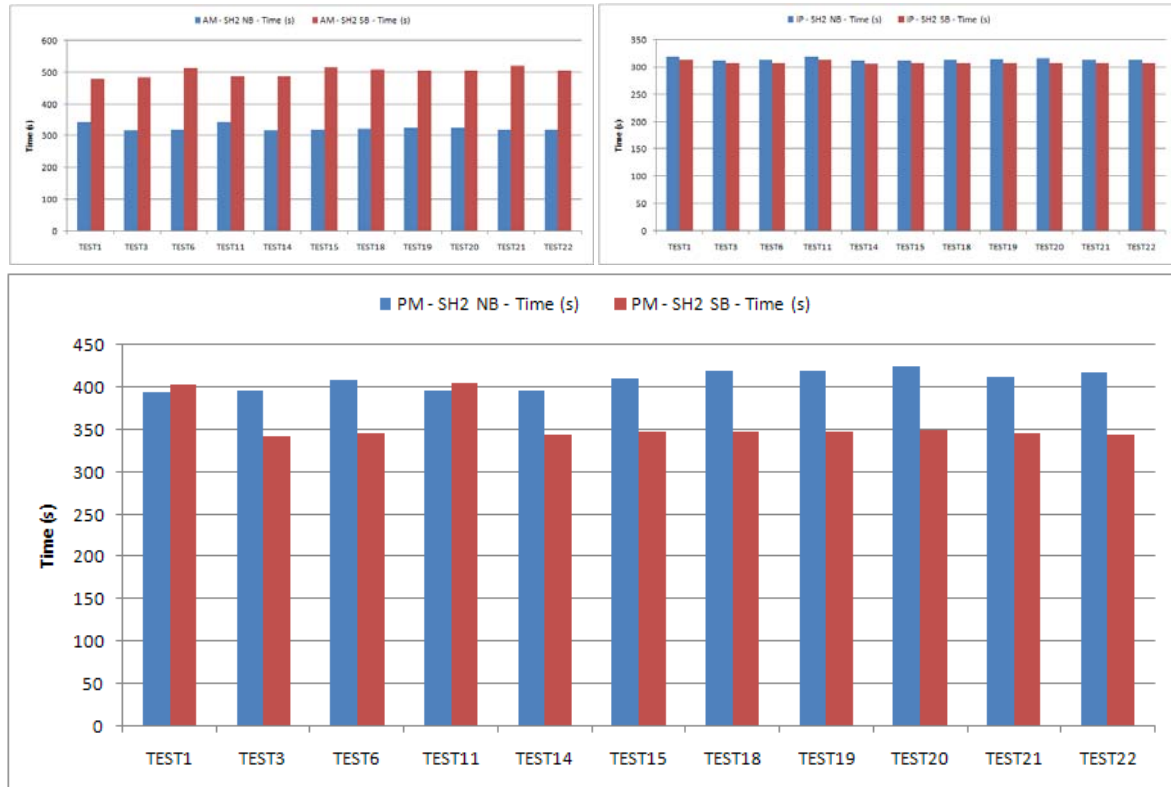
For the 2026 outputs the travel patterns for the AM and IP peak are similar to the 2016 outputs with an increase of about 1 minute. For the PM peak the overall pattern is the same but the model indicates that the upstream traffic on SH1 northbound increases north of where the new link road connects to the existing SH1. This indicates SH1 approaching capacity at the merge of the new link road leading to an additional delay of approximately 1 minute.

■ **Figure 1-22 2026 SH1 travel times**



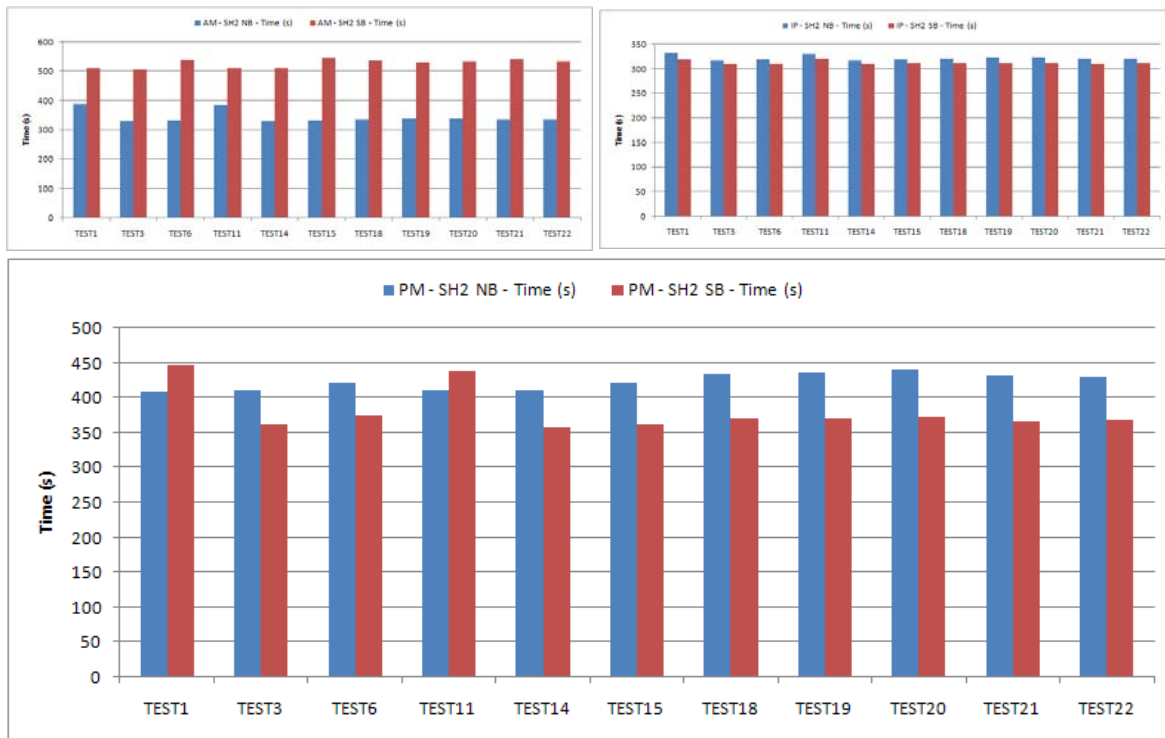
As with travel time routes on SH1, the travel times on SH2 are very similar between Tests 14 and 22 compared to Tests 3 and 6. These are shown in Figure 1-23 below.

■ **Figure 1-23 2016 SH2 travel times**



The modelling outputs for 2026 show the same patterns as the 2016 outputs with general increases in delay of approximately 10% between 2016 and 2026.

■ **Figure 1-24 2026 SH2 travel times**

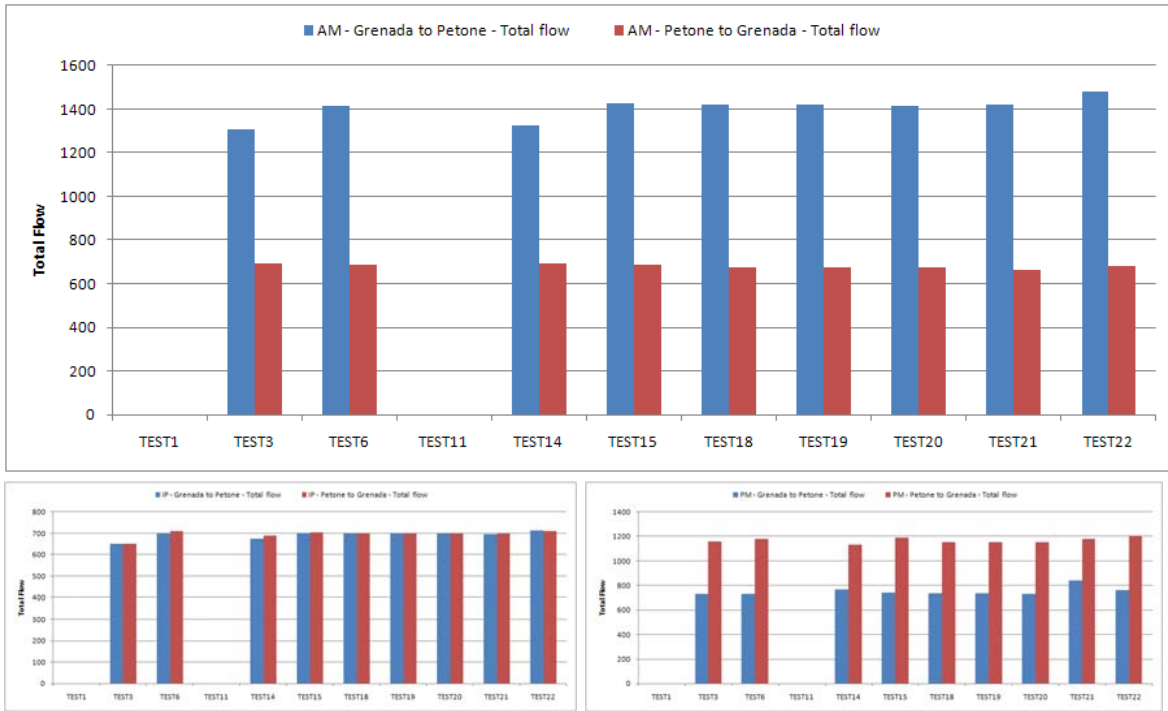


The comparison of the 2026 results and the 2016 results show similar patterns with an increase in travel time of less than a minute.

1.9.2. Flows on link road

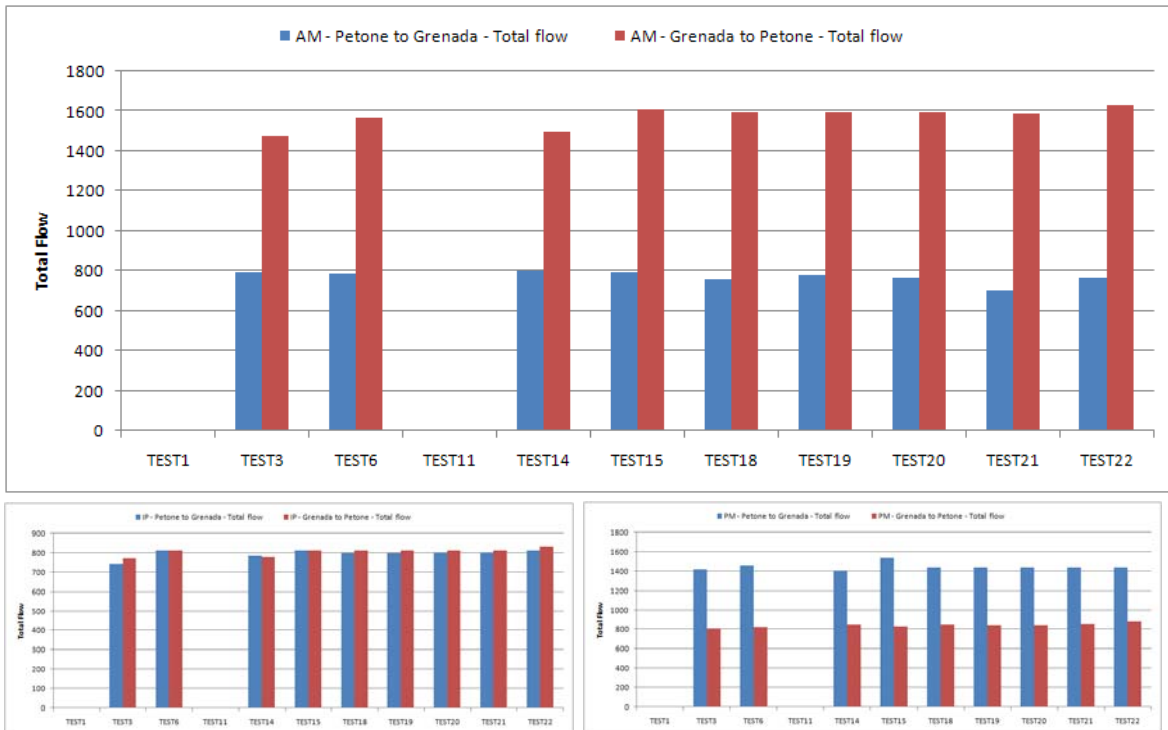
As can be seen in Figure 1-25 below, there is very little difference in flows on the link road between Tests 3 and 14 and Test 6 and 15. This indicates that the difference between the two WTSM matrices used is small for flows between SH1 and SH2. Tests 18-21 show similar flows on the link road to Tests 15 with slightly higher flows in Test 22 which incorporates the additional linkage to Westchester Drive.

■ **Figure 1-25 2016 Eastbound and westbound total PCU flows on link road**

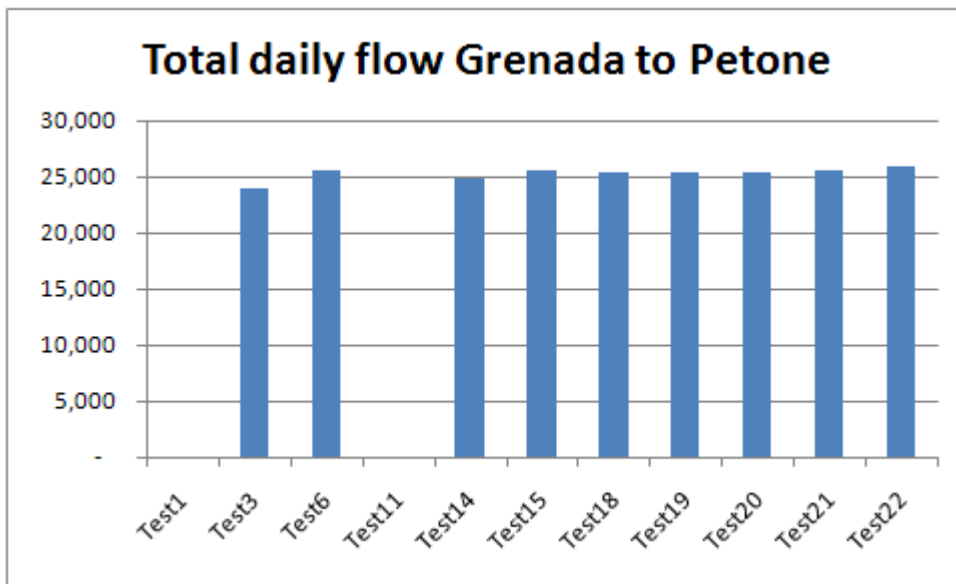


For the 2026 Grenada to Petone total flows the patterns are similar with an increase in the number of vehicles of the order of 100 – 200 pcus / hour over 2016 levels.

■ **Figure 1-26 2026 Eastbound and westbound total PCU flows on link road**

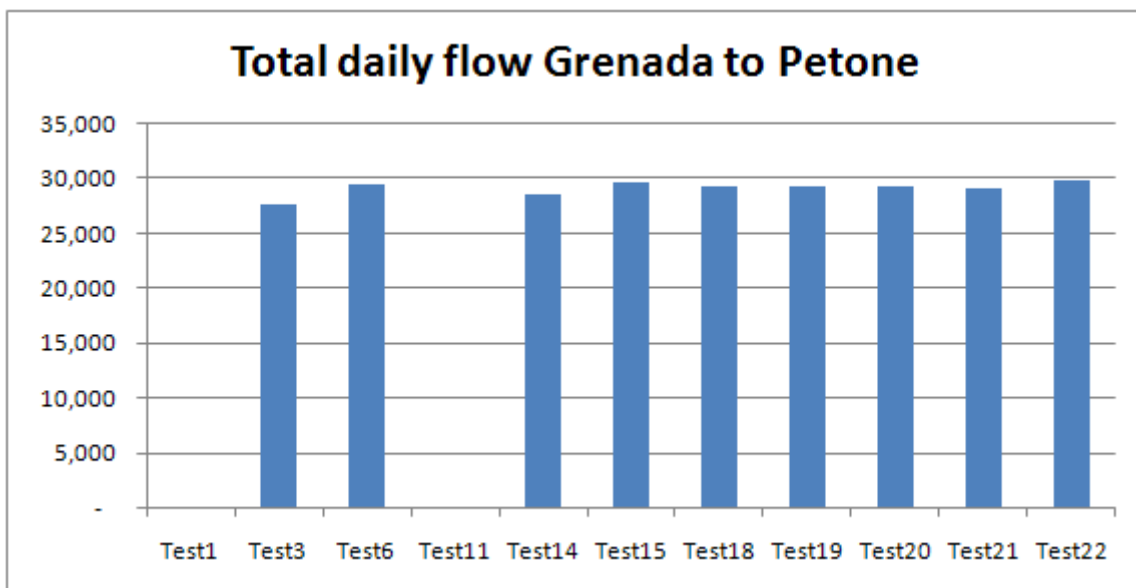


- **Figure 1-27 2016 Daily total PCU flows on link road**



Daily flows in 2026 compared to the results for 2016 show an increase in flows of about 4500 PCUs.

- **Figure 1-28 2026 Daily total PCU flows on link road**



The volumes are very slightly higher when the Cross Valley improvements are in place but only of the order of 0-3%.

1.9.3. Flows on The Esplanade

The differences between the treatment for each of the tests is evident in the differences in flows on The Esplanade as can be seen in Figure 1-29 below.

In the AM peak the flows are predominantly westbound and in the PM peak the flows are predominantly eastbound with a balance in the inter peak.

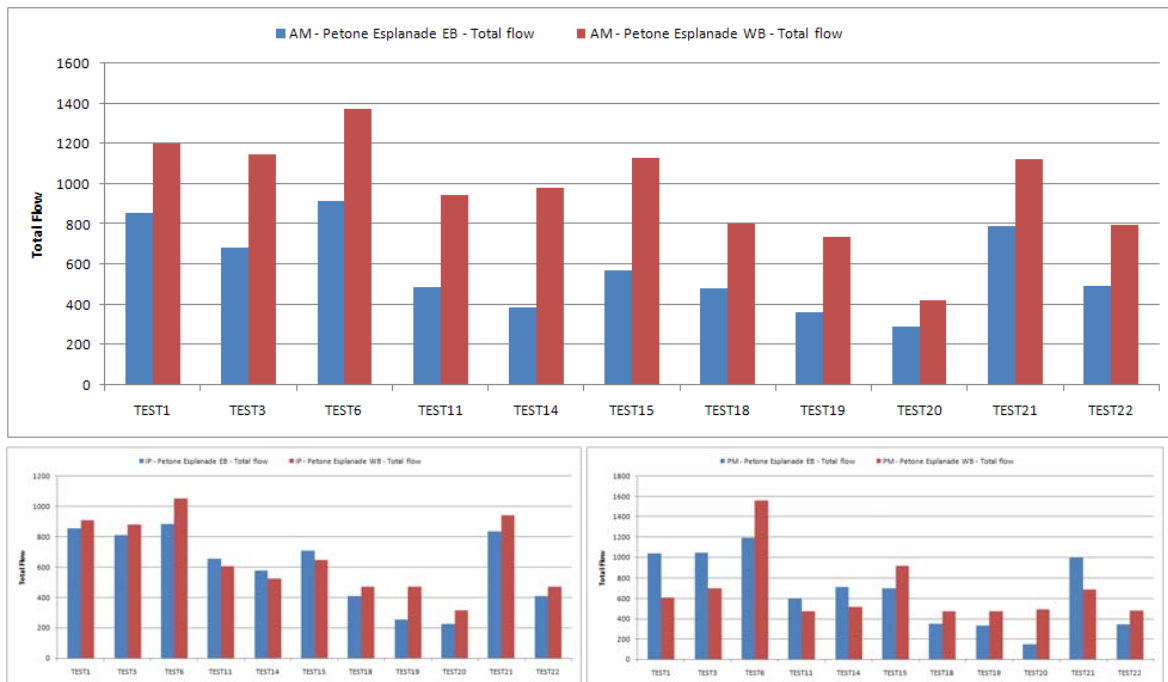
■ **Figure 1-29 2016 Eastbound and westbound total PCU flows on The Esplanade**



In all three peaks, Tests 14 and 15 show increases in flow on the Esplanade over Test 11 which doesn't include any Grenada to Petone link, although the volumes are still significantly less than Test 1 or Test 3 and Test 6. Tests 18-20 show reduced flows on The Esplanade due to the improved linkage of the Cross Valley Link, with Test 20 in particular (with the connectivity to Parkside Road) providing a viable alternative route to traffic between SH2 and the Seaview area.

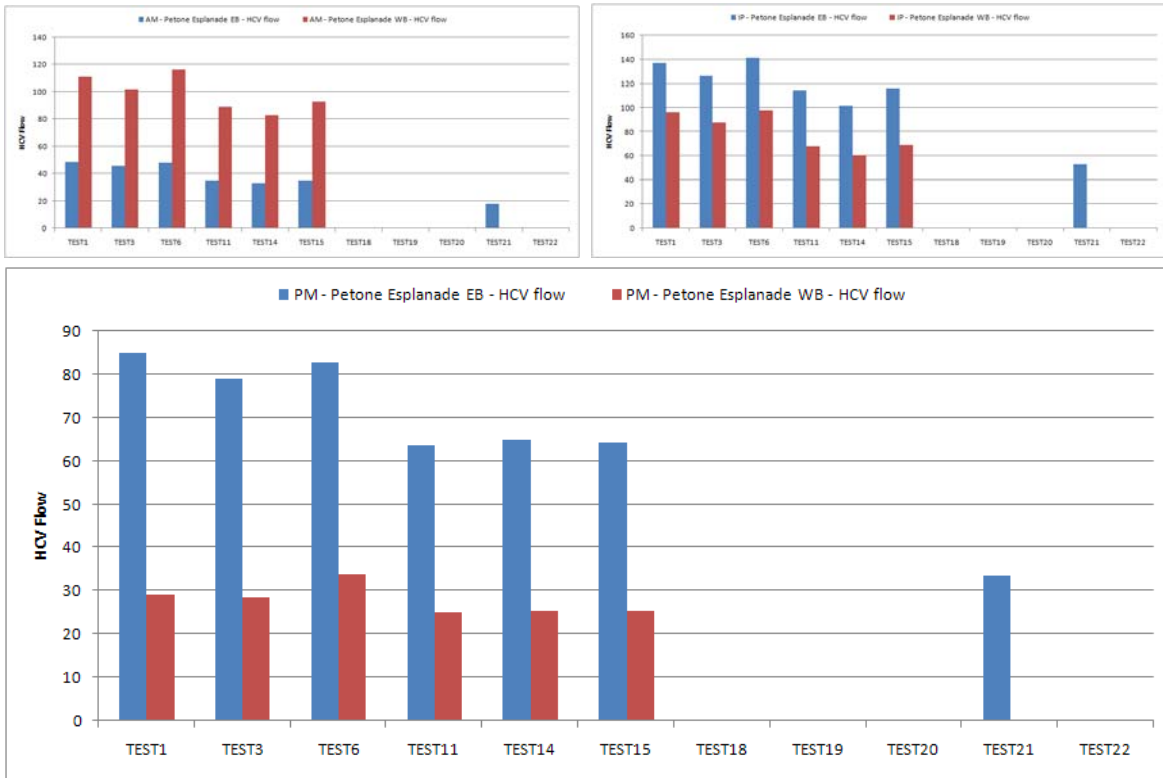
The total flow on The Esplanade shows the same pattern for the AM and PM for 2026 in comparison to 2016. The increase in flow is about 150 PCUs. For the IP the total flows eastbound stay approximately the same whereas the westbound flow increases by roughly 100 PCUs.

■ **Figure 1-30 2026 Eastbound and westbound total PCU flows on The Esplanade**



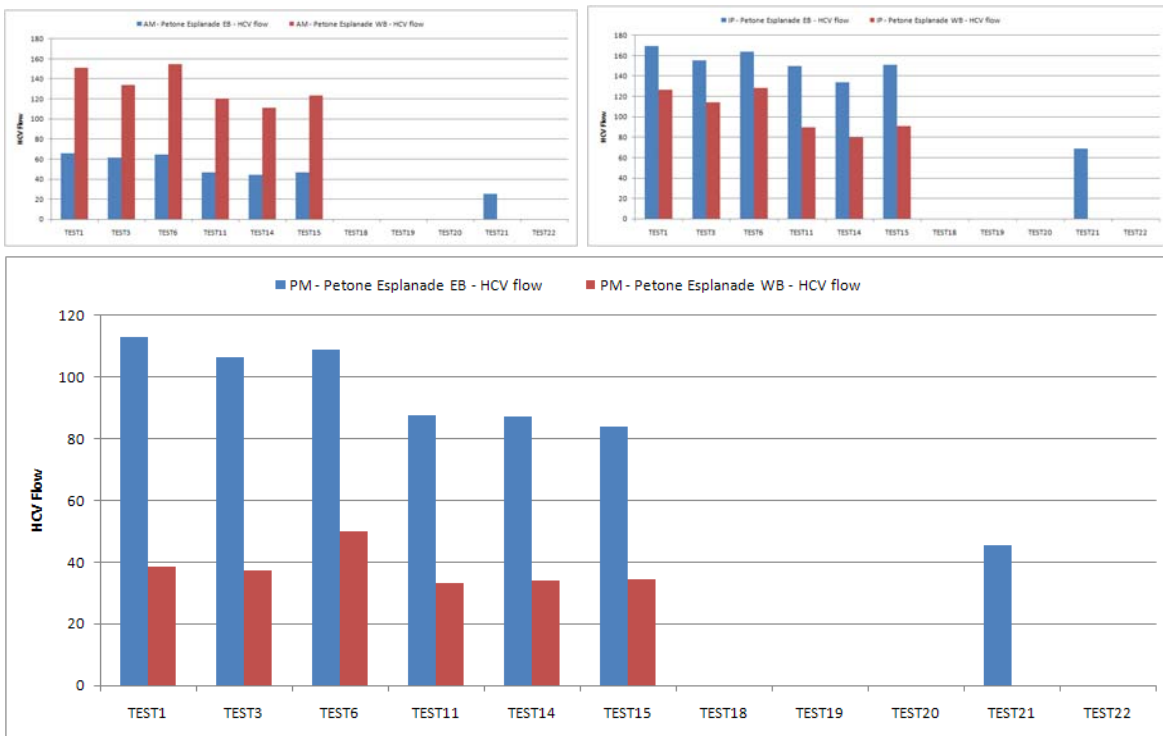
HCV volumes on The Esplanade are of the order of 30-100vph each of the peak hours modelled. The changes in flows with each of the options follow the same patterns as for total vehicles. Tests 19-22 all incorporate a ban on HCVs on links at the eastern and western end of The Esplanade. It is of note in Test 21 with the increased speed on The Esplanade (50kph as opposed to the 30kph calmed route in the other tests) that HCVs accessing zones along The Esplanade use The Esplanade instead of Jackson Street (which is still assumed to be calmed to 30kph). These 10-40 HCVs per hour are HCV travelling between The Esplanade zones (predominantly the commercial and industrial areas at the western end of the Esplanade) and the Seaview area.

■ **Figure 1-31 2016 Eastbound and westbound HCV flows on The Esplanade**

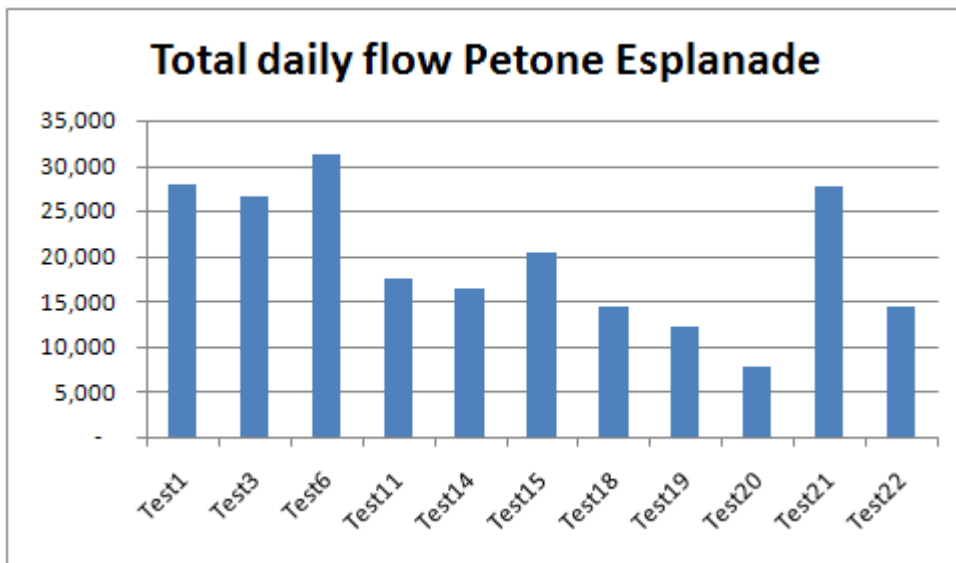


The HCV flows for the 2026 outputs indicate the same patterns and an increase of about 10-25 HCVs.

■ **Figure 1-32 2026 Eastbound and westbound HCV flows on The Esplanade**



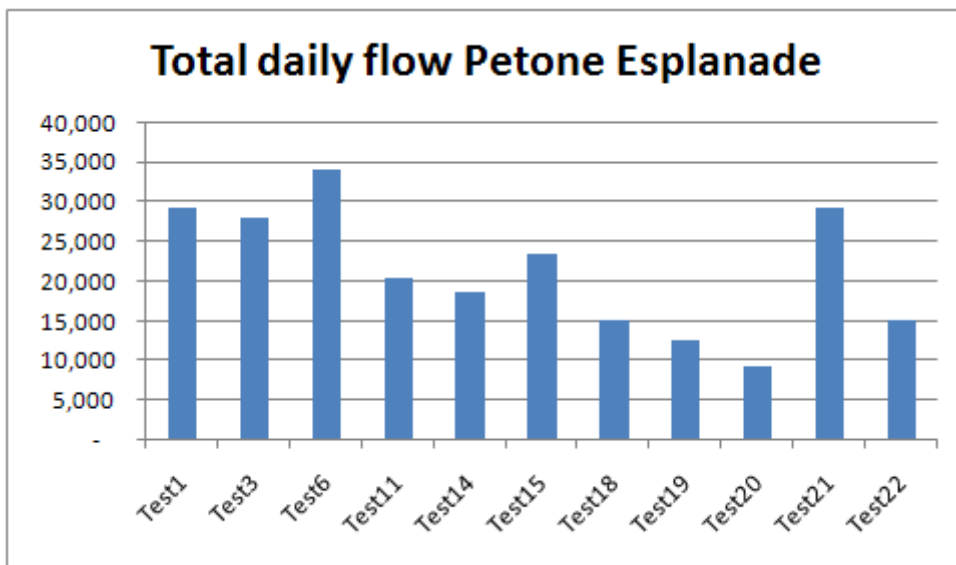
- **Figure 1-33 2016 Daily total PCU flows on The Esplanade**



The lowest flows on The Esplanade are for Test 20 which combines traffic calming on the Esplanade with an additional Cross Valley Link between Wakefield Street and Whites Line east, with linkage to Elizabeth Street and Parkside Road and a link from Grenada to the new Petone interchange.

The 2026 daily PCU flows show the same structure as the 2016 flows with an increase of about 2000 PCUs from 2016.

- **Figure 1-34 2026 Daily total PCU flows on The Esplanade**



1.9.4. Total East West flows

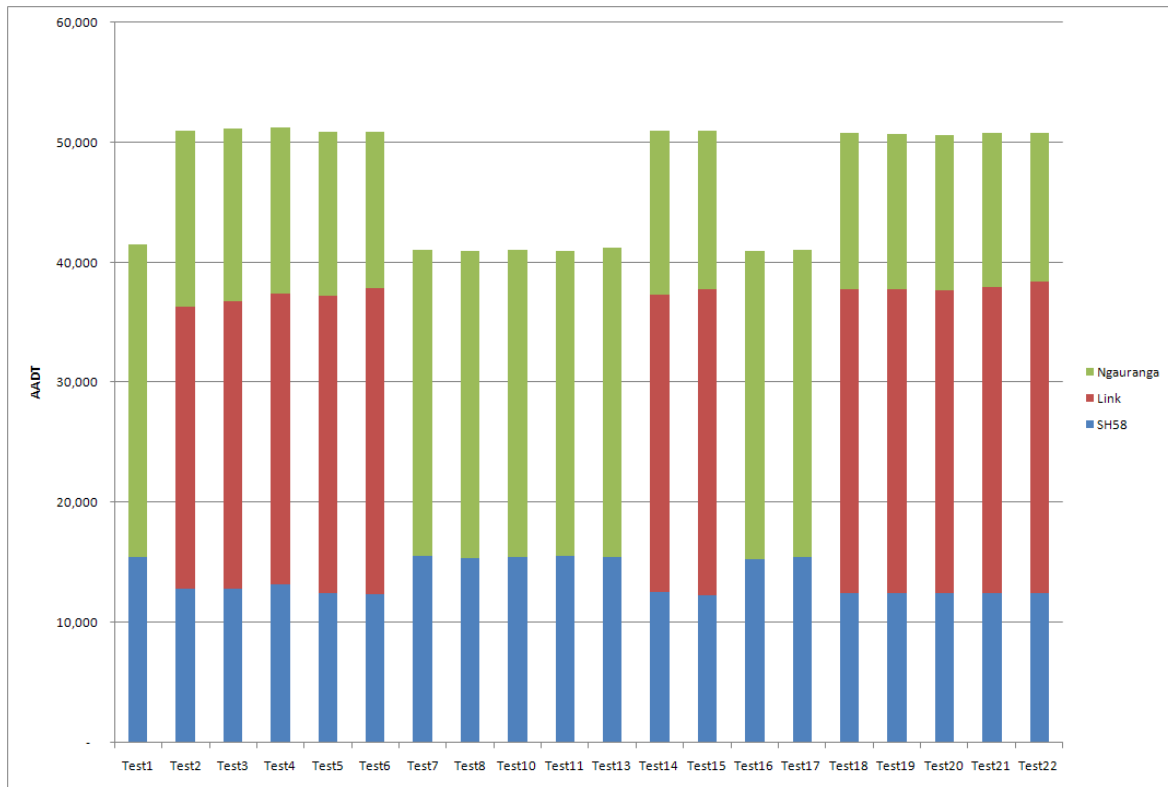
In order to provide an indication of the level of traffic rerouting and induced traffic, Figure 1-35 shows the total traffic volumes travelling between SH1 in the west and SH2 in the east via three routes:

- Ngauranga interchange;

- The proposed Grenada-Petone link; or
- SH58.

The totals show that the introduction of a Grenada-Petone link induces approximately 10,000vpd with the remaining traffic on the link road rerouting from either SH58 or the Ngauranga interchange.

■ **Figure 1-35 Two way total east-west flows**



1.9.5. Ramp flows

The possibility of ramp metering at Ngauranga (from Ngauranga interchange to SH2 northbound) and at Petone (from The Esplanade to SH2 southbound) is considered here. In order to assess the likely effectiveness of ramp metering, the maximum hourly volume on each of the ramps is considered in 2016.

1.9.6. Network statistics

The same network statistics as provided in Sections 1.6.1.1, 1.6.1.2, and 1.6.1.3 are provided below:

1.9.6.1. AM peak

The general network statistics for the AM peak are shown in Table 1-8 below. Note that green highlighting indicates an overall minimum, yellow indicates a minimum if the overall minimum is Test 1 (the lowest option) and purple indicates the minimum of the combined link options (Tests 14-22):

■ **Table 1-8: AM peak network statistics**

Peak	AM										
Test	1	3	6	11	14	15	18	19	20	21	22
TRANSIENT QUEUES (PCU. HRS./HR.)	668.7	659.2	667.8	676.6	668.5	670.4	658.9	657	665.2	667.6	650.8
OVER-CAPACITY QUEUES (PCU. HRS./HR.)	181.6	171.7	193.5	188.6	190.8	205.4	206.1	209.9	193.3	195.1	201.2
LINK CRUISE TIME (PCU. HRS./HR.)	5727.1	5940	5906.5	5756.4	5963.6	5946	5956.4	5956.3	5942.8	5944.9	5945.1
FREE FLOW (PCU. HRS./HR.)	5031.9	5272.3	5211.8	5065	5295.1	5248.8	5266.1	5265.2	5242.4	5248.3	5261.2
DELAYS (PCU. HRS./HR.)	695.2	667.8	694.7	691.5	668.5	697.2	690.4	691	700.3	696.7	683.9
TOTAL TRAVEL TIME (PCU. HRS./HR.)	6577.5	6770.9	6767.7	6621.6	6823	6821.8	6821.4	6823.2	6801.2	6807.6	6797
TRAVEL DISTANCE (PCU. KMS./HR.)	365587.4	378389.8	375092.9	366353.5	378585.8	375482.8	376763.9	377433.7	377666.8	376288.4	376136.4
OVERALL AVERAGE SPEED (KPH)	55.6	55.9	55.4	55.3	55.5	55	55.2	55.3	55.5	55.3	55.3

Note here that due to the change in distribution in the applied WTSM matrix, the lowest statistics are generally for Test 1, the Do Minimum. Tests 3 and 11 stand out as having the lower general statistics with:

- Test 3 having the lowest level of general queuing and associated delays; and
- Test 11 having the lowest overall travel time and distance on the network.

From a network statistic perspective, the combination Tests 14 and 15 do not show any additional benefit over a simple Grenada-Petone link (Test 3 and Test 6), or a Cross Valley link with traffic calming on The Esplanade (Test 11). Of the Cross Valley Link tests which incorporate traffic calming on The Esplanade and connections east of Randwick Road (Tests 18-20), Test 20 performs the best, although Test 22 (including an additional connection to Westchester Drive) has lower overall travel times.

It should be noted that:

- Test 1 uses WTSM matrix 2021;
- Tests 3 and 6 use WTSM matrix 2031;
- Test 11 uses WTSM matrix 2041; and
- Tests 14 - 15 and 18 – 22 use WTSM matrix 2051.

1.9.6.2. Inter peak

The general network statistics for the inter peak are shown in Table 1-9 below:

■ **Table 1-9: Inter peak network statistics**

Peak	IP										
Test	1	3	6	11	14	15	18	19	20	21	22
TRANSIENT QUEUES (PCU. HRS./HR.)	286.8	287.7	287	291.3	299.6	292.4	293.4	291.7	291.3	291.6	293.1
OVER-CAPACITY QUEUES (PCU. HRS./HR.)	14.5	10	13.5	5.3	8	5.9	7.6	12.4	10.3	7.4	9.9
LINK CRUISE TIME (PCU. HRS./HR.)	3429.3	3491.6	3467.8	3444.1	3498.8	3482.7	3499	3496.1	3482.1	3494.4	3499
FREE FLOW (PCU. HRS./HR.)	3396.9	3470.6	3446.5	3412.1	3478.2	3461.4	3476.9	3473	3458.4	3472.9	3477.1
DELAYS (PCU. HRS./HR.)	32.4	21	21.3	32	20.6	21.4	22.1	23.2	23.7	21.5	21.9
TOTAL TRAVEL TIME (PCU. HRS./HR.)	3730.6	3789.2	3768.2	3740.7	3806.4	3781.1	3800.1	3800.2	3783.7	3793.4	3802
TRAVEL DISTANCE (PCU. KMS./HR.)	236676.1	239395.2	238090.1	236548.8	239159.3	237789.7	238806.1	239185.9	239552.8	238591.9	238740.2
OVERALL AVERAGE SPEED (KPH)	63.4	63.2	63.2	63.2	62.8	62.9	62.8	62.9	63.3	62.9	62.8

In the less congested inter peak, the lower overall travel time and distance in Test 11 are also reflected by lower levels of transient queuing. Test 14 shows the lowest levels of delay indicating that for inter peak travel patterns the link between Grenada and Whites Line West via Dowse interchange may be reducing overall network delay. As with the AM, Test 20 performs best of the Tests 18-22.

1.9.6.3. PM peak

The general network statistics for the PM peak are shown in Table 1-10 below:

■ **Table 1-10: PM peak network statistics**

Peak	PM										
Test	1	3	6	11	14	15	18	19	20	21	22
TRANSIENT QUEUES (PCU. HRS./HR.)	612.6	661.3	631.5	636.8	691.3	646.9	631.3	630	624.2	642.1	624
OVER-CAPACITY QUEUES (PCU. HRS./HR.)	661	648.4	666.3	689.7	663.7	649.5	645	644.2	629.5	675.1	642.1
LINK CRUISE TIME (PCU. HRS./HR.)	5718.3	5836.7	5796.7	5739.8	5843.8	5821.7	5848.2	5846.7	5825.2	5849.3	5837.8
FREE FLOW (PCU. HRS./HR.)	5273.3	5488.3	5457	5296.1	5507	5481	5496.1	5495.2	5466.9	5505.9	5493.8
DELAYS (PCU. HRS./HR.)	445	348.4	339.7	443.6	336.8	340.7	352.2	351.6	358.3	343.4	344
TOTAL TRAVEL TIME (PCU. HRS./HR.)	6992	7146.4	7094.5	7066.2	7198.7	7118.1	7124.5	7120.9	7078.9	7166.5	7103.9
TRAVEL DISTANCE (PCU. KMS./HR.)	376191	387719.4	386488.9	377012.6	388033.5	386623.1	387794.8	387802.6	388472.7	388549	387342
OVERALL AVERAGE SPEED (KPH)	53.8	54.3	54.5	53.4	53.9	54.3	54.4	54.5	54.9	54.2	54.5

As with the inter peak, Test 11 appears to show the overall most favourable network performance with Test 14 having slightly lower overall network delay. Again, Test 20 performs best of the Tests 18-22.

2. Sensitivity testing for Test 20

This section applies sensitivity tests to Test 20. Test 20 incorporates Test 18 and Test 19, involving a link from Wakefield Street to Whites Line East; a grade separated roundabout at SH2 / The Esplanade interchange; a link from Tawa interchange on SH1 to The Esplanade; traffic calming on The Esplanade and Jackson Street; and has an additional connection from the Cross Valley Link Road at the end of Elizabeth Street to Parkside Road.

2.1. Summary of options

2.1.1. Test 23

Test 23 applies matrix 4131 RS1 to Test 20.

2.1.2. Test 24

Test 24 applies matrix 4051 to Test 20, but includes high growth in the area.

2.1.3. Test 25

Test 25 applies matrix 4211 to Test 20, and also includes Transmission Gully network coding in the model.

2.1.4. Test 26

Test 26 utilises Test 20 and also includes an additional connection at the western end of the Grenada-Petone link road to tie in to Westchester Drive East.

2.1.1. Test 27

Test 27 utilises Test 20 but there are only three lanes in each direction on SH1 between Ngauranga and Aotea.

2.1.2. Test 28

Test 28 utilises Test 26 and has increased traffic to and from Johnsonville (Zone 316) and existing Johnsonville ramp configuration.

2.1.3. Test 29

Test 29 utilises Test 28 (Test 26 with increased traffic to and from Johnsonville) and additionally includes the Helston south-facing ramps.

2.1.4. Test 30

Test 30 utilises Test 29 (Test 26 with increased traffic to and from Johnsonville and Helston south-facing ramps) and has the Johnsonville south-facing ramps closed.

2.2. Traffic modelling assumptions

2.2.1. Test 23

Test 23 has been modelled by directly using network coding from Test 20, but applies matrix 4131 RS1.

2.2.2. Test 24

Test 24 has been modelled by directly using network coding from Test 20, but applies matrix 4051 with high growth.

2.2.3. Test 25

Test 25 has been modelled by directly using network coding from Test 20, but applies matrix 4211 which also includes network coding for Transmission Gully.

2.2.4. Test 26

Test 26 has been modelled by directly using network coding from Test 20 and Matrix 4051 (without high growth), but applies an additional connection at the western end of the Grenada-Petone link road to tie in to Westchester Drive East.

2.2.5. Test 27

Test 27 has been modelled by directly using network coding from Test 20, but the number of lanes on SH1 between Ngauranga and Aotea has been reduced from 4 lanes to 3 lanes, in both directions.

2.2.6. Test 28

Test 28 has been modelled by directly using network coding from Test 26, but incorporates an increase in traffic to and from Johnsonville (Zone 316). The traffic increase has been determined utilising the 'Projected Weekly PM Vehicle Trip Increases' data from the "*Johnsonville Shopping Centre Redevelopment*" report by the Traffic Design Group, and applying a factor to Zone 316 of matrix 4051 to accommodate for predicted increases.

2.2.7. Test 29

Test 29 has been modelled by modifying network coding from Test 28 to incorporate Helston south-facing ramps.

2.2.8. Test 30

Test 30 has been modelled by modifying network coding from Test 29 to incorporate a 'ban' on Johnsonville south facing ramps.

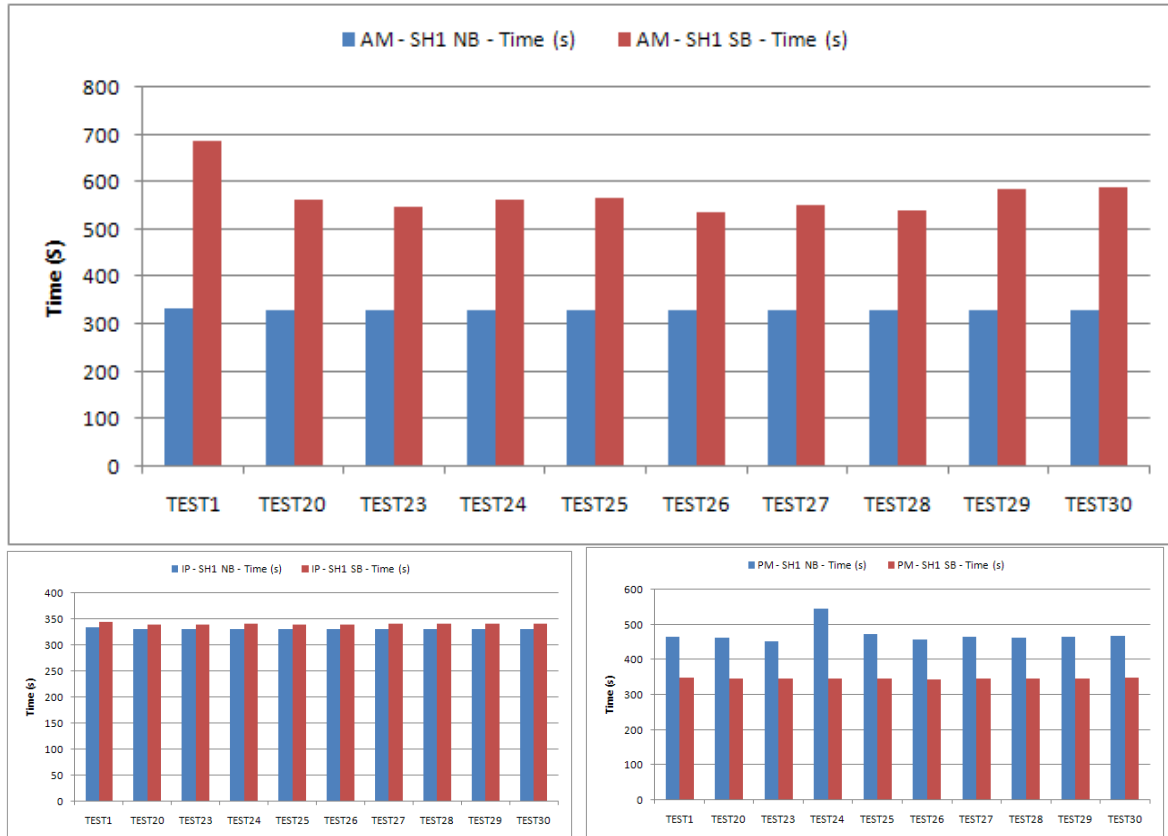
2.3. 2016 Traffic modelling outputs

An important point to note when comparing options is that Test 1 (the DM) has a different trip matrix from WTSM than Tests 20 and Tests 23 to 30. This means that total network statistics are likely to be different due to different total numbers of vehicles.

2.3.1. State Highway travel times

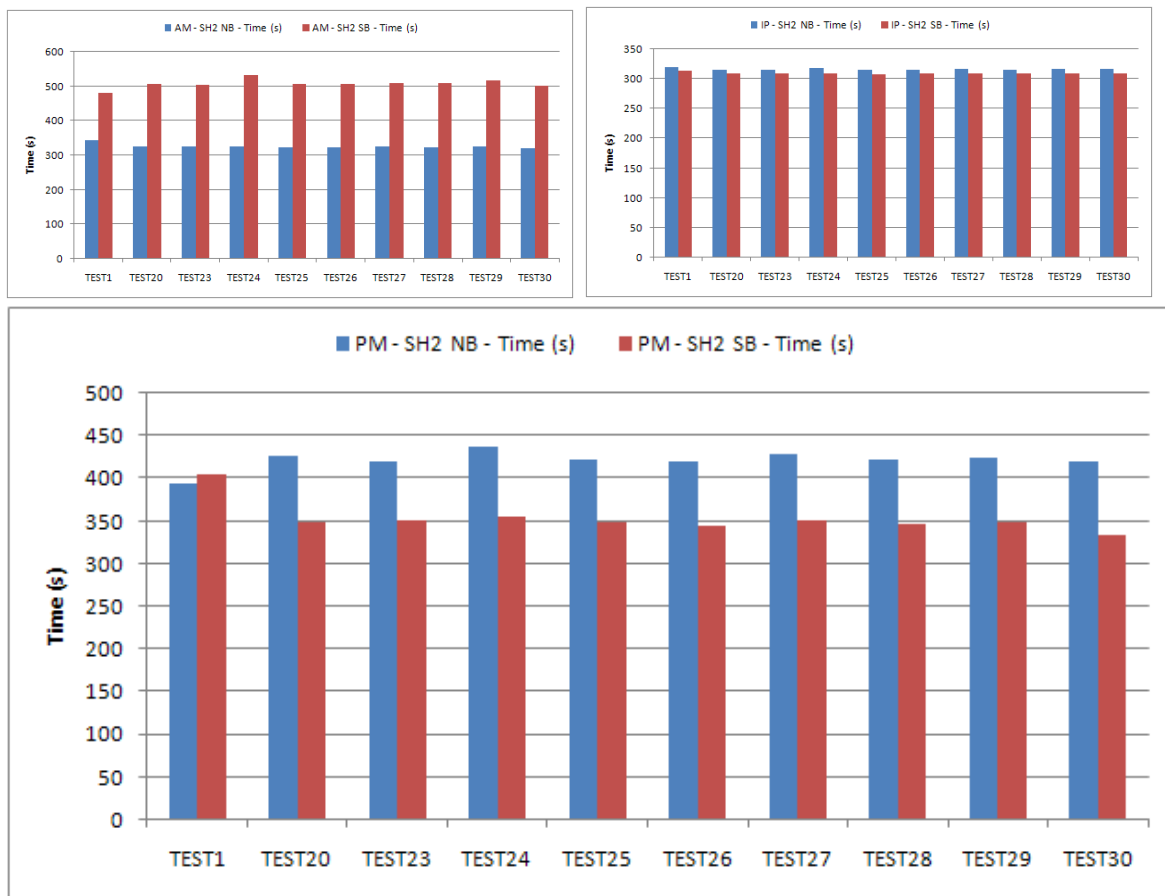
There is no significant difference in the flows on SH1 northbound and southbound for each of the sensitivity tests during the AM and IP peaks. During the PM peak, Test 24 shows to have a larger travel time for the northbound route, which is a reflection of using a high growth matrix. This is shown in Figure 1-21 below.

■ Figure 2-1 2016 SH1 travel times



As with travel time routes on SH1, the travel times on SH2 are very similar across the sensitivity tests. The travel times for SH2 are shown in Figure 1-23 below.

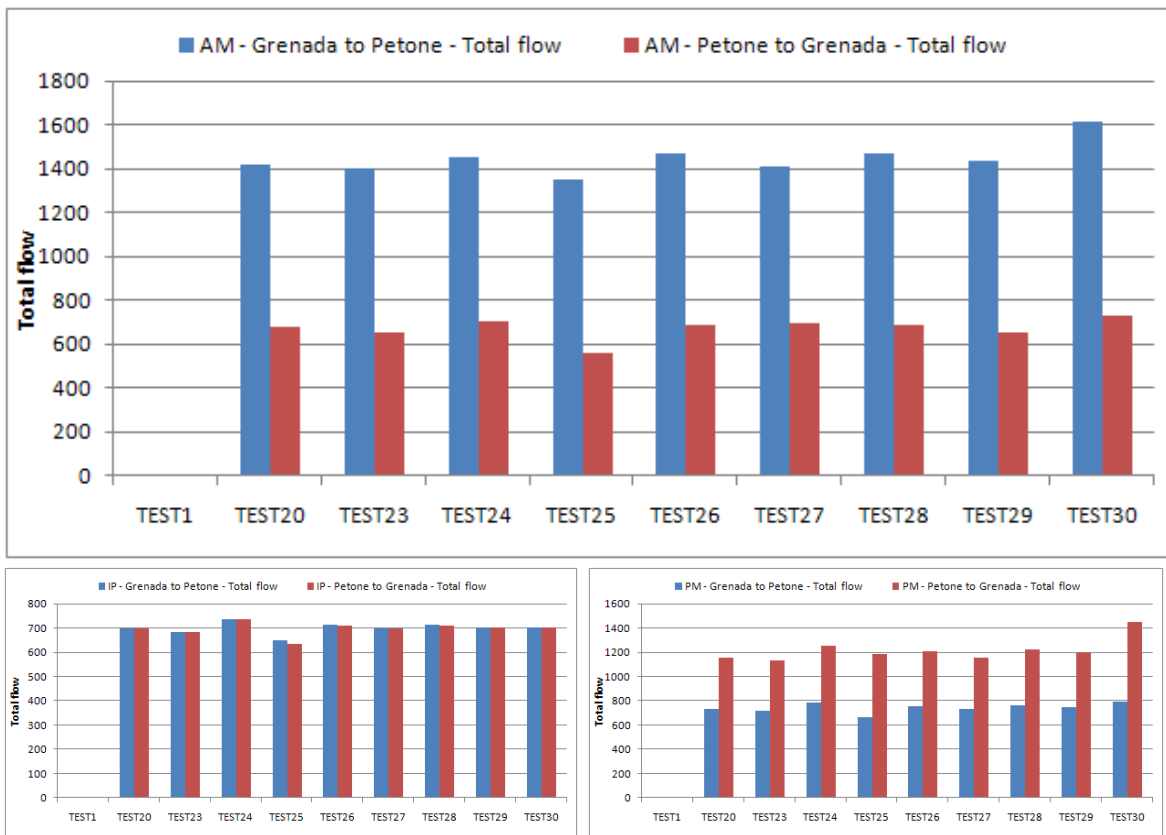
■ **Figure 2-2 2016 SH2 travel times**



2.3.2. Flows on link road

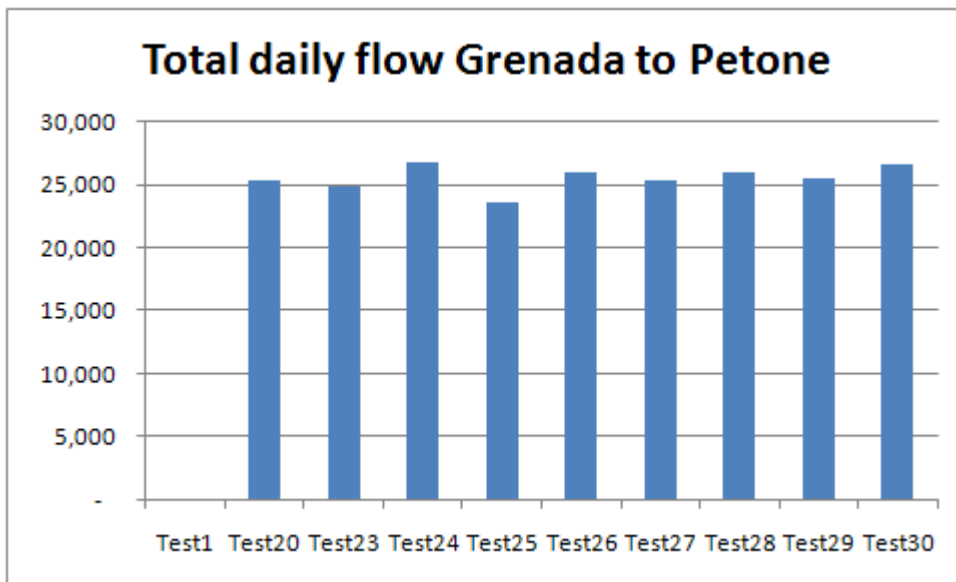
As can be seen in Figure 1-25 below there is very little difference in flows on the link road for each of the sensitivity tests. Test 30 has a slightly higher flow when travelling from Grenada to Petone in the AM, and Petone to Grenada in the PM. This indicates that traffic from south of Johnsonville is utilising the Grenada-Petone link to access the Petone area, opposed to travelling south to Ngauranga interchange. As also shown for SH1 in Figure 1-21, during the AM and PM peak Test 24 shows to have a larger travel time for the northbound route, which is a reflection of using a high growth matrix.

■ **Figure 2-3 2016 Eastbound and westbound total PCU flows on link road**



Using the same daily factors this results in the daily volumes as seen in Figure 1-27 below:

■ **Figure 2-4 2016 Daily total PCU flows on link road**



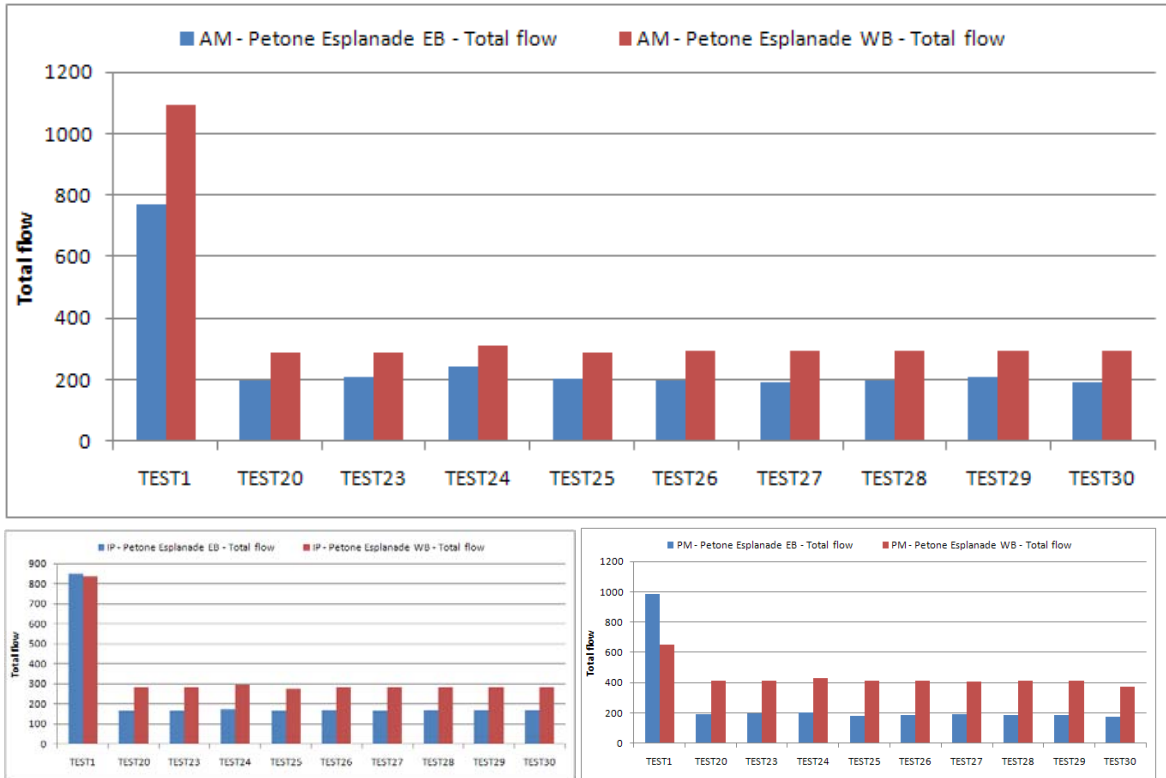
The volumes are lower when a high growth matrix is in place (Test 24), of the order of 20% in comparison to Test 20.

2.3.3. Flows on The Esplanade

The impact of applying alternative options to the network (e.g. the Cross Valley link and traffic calming) to reduce traffic on The Esplanade is apparent in Figure 1-29 by significant reductions in flow for Tests 20 and Tests 23 to 30. However there is no significant difference on the flows on The Esplanade for each of the sensitivity tests.

During all peaks the flow is predominantly in the westbound direction.

- **Figure 2-5 2016 Eastbound and westbound total PCU flows on The Esplanade**



The total daily flows on The Esplanade are shown in Figure 1-33 below.

■ Figure 2-6 2016 Daily total PCU flows on The Esplanade

