APPENDIX

A

Site Photolog

Cardno
Shaping the Future

a) View looking east along the Quarry Road route.

a) View looking west towards the quarry, with Old Mans Valley in foreground

a) View of the Quarry showing accumulated runoff.

a) View looking south along the trail connecting to Bridge Road.

a) View looking south along Bridge Street, with TAFE facility in background.

a) View looking south-west along George Street, showing railway line in background.

HORNSBY SHIRE COUNCIL

Site Photo Log

HORNSBY QUARRY LAND FILLING

APPENDIX A

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2012-11-15
Project: Lj2888
Map: G2001 HornsbyPhotolog.cdr
Photograph source: Cardno (2012)

APPENDIX

B

Traffic Report

Cardno
Shaping the Future

HORNSBY QUARRY FILLING
PARAMICS MODELLING

MODELLING DOCUMENTATION DRAFT REPORT

Prepared for
HORNSBY SHIRE COUNCIL

transportation | traffic | engineering | planning

March 2011

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1 INTRODUCTION

1.1 BACKGROUND

Cardno was commissioned by Hornsby Shire Council to undertake a traffic assessment of the likely impacts that refilling the Hornsby Quarry will have on the neighbouring road network.

There is a proposal that Hornsby Quarry be infilled over the coming years to allow for the reclamation and reuse of the land within the Hornsby community. During the infill process, there will be increased amounts of heavy vehicles accessing and egressing the site until project completion; these vehicles will use Pacific Highway as the main route into and out of Hornsby, and it is likely that this will continue until project completion estimated in this assessment to be 2021.

Part of the overall traffic assessment requirement is to evaluate the impacts that these increased truck movements will have on the surrounding road network, and to do this, Hornsby Shire Council (HSC) commissioned Cardno to build a micro-simulation traffic model of the Hornsby area, and use it as a tool to estimate the likely impacts that the refilling and associated increased truck movements could have within the Hornsby area.

The traffic modelling was carried out using Q-Paramics software, and this report firstly provides the methodology and results of the model build process for the 2010 Base Model, which represents existing conditions; models were built to represent the AM, PM, and Mid-Day (MD) peak hour periods. Following this are the details and methodology of the future year modelling tests with results, findings and recommendations discussed.

The report also shows how the current year models for 2010 have been calibrated and validated to achieve a good representation of existing conditions in the first instance, before any future year modelling was carried out. The calibration and validation of all three peak hour models has exceeded industry guidelines for traffic modelling.

The report then follows on to provide transparent methodology and assessments for future year tests, where Quarry infilling is in progress.

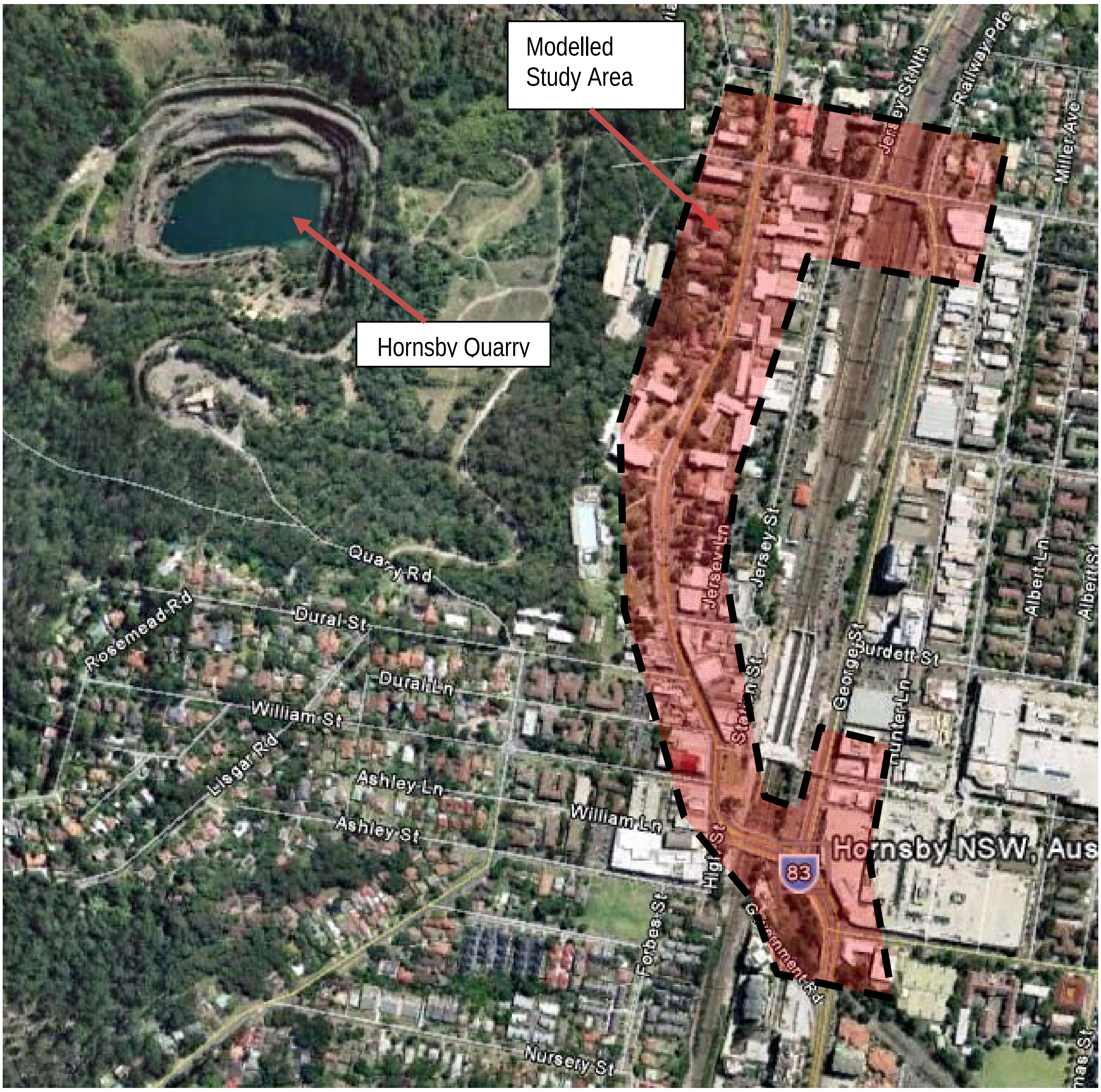
1.2 STUDY AREA

For the purpose of this study, the area which was simulated comprises of Pacific Highway between (just north of) Bridge Road and (just south of) Edgeworth David Avenue. The Paramics model also includes the northern and southern ends of George Street at its intersections with Bridge Road and Pacific Highway respectively.

It was agreed with Council at the outset of the project that the Pacific Highway route would be modelled through the study area, as this is the route that the heavy vehicles will use. Modelling George Street at the intersections of Pacific Highway and Bridge Road allows for the impacts of George Street on the vicinity of Pacific Highway to amply be assessed.

The extent of the Paramics model network, as developed for this study is shown in Figure 1.1.

Figure 1.1 Study Area



Within this study area there are

- Eight (8) existing signalised intersections:
  - Pacific Highway/Bridge Road.
  - Pacific Highway/Coronation Street.
  - Pacific Highway/Station Street.
  - Pacific Highway/William Street.
  - Pacific Highway/George Street.
  - Pacific Highway/Edgeworth David Avenue.
  - Bridge Road/Jersey Road North
  - Bridge Road/George Street.
- Five (5) existing priority-controlled junctions:
  - Pacific Highway/Dural Street.
  - Pacific Highway/Dural Lane.
  - William Lane/High Street.
  - Pacific Highway/High Street.
  - Bridge Road/Jersey Street.

1.3 PURPOSE OF REPORT

The purpose of this modelling report is to document the process carried out to build, calibrate and validate the current situation models for the 2010 AM, mid-day (MD) and PM peak hours, and also to present the subsequent analysis and findings in relation to the future year assessments carried out with and without the proposed future quarry operations in place.

An additional purpose of the modelling is to improve where possible the operations of Pacific Highway through using the opportunities that new and progressive development brings.

To this end, the report is divided into the following sections:

- Section 2 - Paramics Model Development outlines the development process of the 2010 base AM, MD and PM peak models.
- Section 3 - Model Calibration and Validation provides detailed information and results for the model calibration and validation process.
- Section 4 – Future Model Year Scenarios describes the model scenarios that have been developed for future year testing.
- Section 5 - Model Outputs presents and discusses the qualitative and quantitative outputs of the various treatment options relative to the 2010 existing scenario and also to future year 2021 treatments.
- Section 6 - Findings and Recommendations provides a summary of the findings along with the study recommendations.

2 PARAMICS MODEL DEVELOPMENT

2.1 INTRODUCTION

Paramics micro-simulation software was selected as the modelling tool of choice to deliver the required outputs for this project.

Paramics is a suite of high performance software tools for microscopic traffic simulation. It represents a radical approach to the understanding, representation and analysis of vehicle traffic, where individual vehicles are modelled in fine detail for the duration of their entire trip. Paramics provides the accurate traffic flow information and the visual observations necessary for the analysis of congested road networks, and the exploration of the solutions to address them.

Paramics represents traffic flow from the standpoint of the individual driver; therefore traffic engineers are able to distinguish between minor sub-optimal design variations without resorting to deterministic proxy. All known components likely to significantly affect traffic flow are represented, across the full range of road network types.

Cardno is committed to micro-simulation modelling and in particular Q-Paramics, and has a strong capability in its application with staff involved in its use varying between 1 and over 10 years experience.

2.2 BASE SCENARIO – EXISTING MODELS FOR 2010

Paramics models were calibrated and validated to represent average weekday conditions for the current conditions during the AM, MD and PM peak hours in 2010. A current model is simply one that gives a good approximation of the average existing conditions for a designated period; the existing year for this study is 2010.

Paramics models which represent the existing conditions as at June 2010 (named in this report as Base Scenario) were built to represent the following peak hour time periods:

- 2010 current AM peak 07:30 to 08:30 (full model period[1]: 06:30-09:30).
- 2010 current MD peak 15:00 to 16:00 (full model period[1]: 14:00-17:00).
- 2010 current PM peak 17:00 to 18:00 (full model period[1]: 16:00-19:00).

All models have been calibrated and validated to provide a good representation of existing conditions. The criteria and results for which are provided later in this report.

2.3 DATA SOURCES

2008 and 2009 traffic survey data was provided by Council for some of the intersections within the study area. Additional data was also collected in 2010 during the AM, MD and PM peak periods in order to provide a more complete and reliable data set, which could be used for calibrating and validating the 2010 Existing Models, and also for use as a target to which the older counts were adjusted.

[1] Warm-up and cool-down periods of 60 minutes either side of the critical hour were included in the model

The main data set was collected on Thursday 24 June 2010 along the Pacific Highway, Hornsby. There were also several site visits carried out during the model build process to gather additional information for queuing and travel times. The following gives a summary of the data collected.

Full Intersection Counts

Intersection turning volume counts (separated into heavy and light vehicles and including pedestrian counts) were undertaken at the following

- Signalised junctions:
  - Pacific Highway/Bridge Road.
  - Pacific Highway/Coronation Street.
  - Pacific Highway/Station Street.
  - Pacific Highway/William Street.
  - Pacific Highway/George Street.
  - Pacific Highway/Edgeworth David Avenue.
  - Pacific Highway/College Crescent/Pretoria Parade.
  - Pacific Highway/Unwin Road/Romsey Street.
  - Pacific Highway/Ingram Road/Woolcott Avenue.
  - Pacific Highway/F3 Newcastle Freeway.
  - Bridge Road/George Street.
  - Bridge Road/Jersey Street North.
- Priority intersections:
  - Pacific Highway/Dural Street
  - Pacific Highway/High Street
  - Dural Street/Frederick Street/Quarry Road
  - Frederick Street/Quarry Road

At all signalised intersections throughout the study area, full vehicle movement data was collected. The through traffic volumes at all other modelled intersections, where traffic counts were not provided, was determined based on site observations, surrounding land uses and anomalies identified with mid-block traffic flows calculated at the upstream and downstream signalised intersection(s).

Pedestrian Counts

Counts were also carried out for the pedestrian crossing on the Pacific Highway, south of Bridge Road.

Queue Lengths

Queue length information was collected on all approaches for the following signalised junctions:

- Pacific Highway/Bridge Street.
- Pacific Highway/George Street.
- Pacific Highway/Edgeworth David Avenue.

Travel Time Surveys

Travel time surveys (Northbound and Southbound) were collected along the Pacific Highway from just north of Bridge Street to just south of Edgeworth David Avenue (Shell Station).

Traffic Control Signal (TCS)

Traffic control signals (TCS) diagrams and history file information was supplied by RTA to code up the layout and phase arrangements of the signalised intersections in the study area.

2.3.1 Aerial Photographs

Aerial photography images from Google Earth were the source upon which the model network was built; the aerial photographs were also cross-checked with site inventories to ensure accuracy in the model network configuration.

2.3.2 Site Inspections and Video Inventory

Cardno carried out site inspections during the model build process to collect an array of data; a video survey was also carried out for the entire study area. Information collected included:

- Parking restrictions.
- Turn bans.
- Lane configuration.
- Junction operations.
- Lane usage.
- Driver behaviour.
- Queues.
- Pedestrian activity.
- Car park access/egress operations.
- Shopping centre and other land use locations.
- Bus stops.
- Public Transport.[2]
- Signal timings.

2.3.3 Restrictions / Pedestrians / Zoning

Lane allocation, Turn Bans, Restrictions

Site inventories were used to identify lane allocations, turn bans and restrictions, as well as how these may change during the simulation time period.

[2] Details of the service times and stop locations for all on-road public transport in the study area were collated using information available on the internet and / or from site inventories.

Pedestrian Activity

The important locations where pedestrians cause delays to traffic were identified through field observations. The impacts were accounted for in the model where appropriate.

Zoning, Bus Stops, Taxi Ranks, On-Street Parking, Car Parking Restrictions

The above were checked for relevance, and if applicable, were coded into the model as they currently exist on the ground and were used to identify impacts on traffic movements.

2.4 MODEL DEVELOPMENT

Paramics assigns vehicles through the network on the basis of the lowest travel cost route. The travel cost of a route is calculated on the basis of travel time, travel distance and monetary cost. Cost factors are specified for each of these parameters and link specific cost factors can also be applied.

Paramics also enables assignment on the basis of "all or nothing" assignment, "stochastic" assignment or "dynamic feedback" or a combination of these. The choice of assignment used for all models was the "all or nothing" assignment as there is no route choice in any of the models.

2.4.1 Major/Minor Routes and Familiarity

Paramics enables the user to define 'major' and 'minor' links and the proportion of drivers, which are either familiar or unfamiliar.

The effect is that all familiar drivers see the link costs as they are calculated whereas unfamiliar drivers see the cost of all minor links factored by two. This results in unfamiliar drivers preferring major routes to minor routes, whilst familiar drivers have no preference. Given that there is no route choice in the models for this assessment, the major / minor routing has minimal impact for modelling purposes.

2.4.2 Zoning System

Zones are defined as locations where vehicle trips originate and terminate, i.e. trip ends. The zoning system for the Paramics model is detailed, with the all important access/egress points coded in.

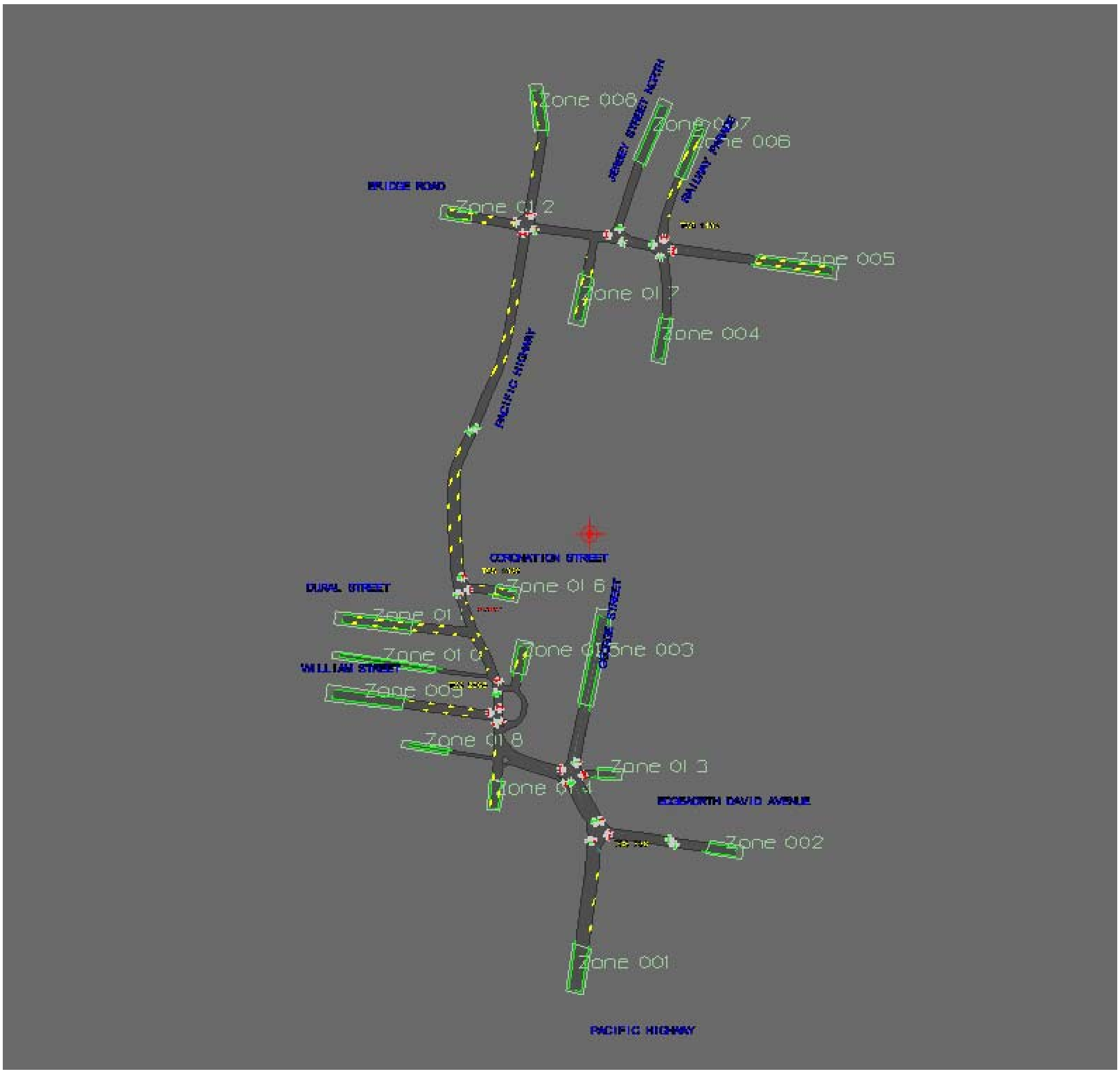
In total, 18 zones have been coded into the models with Zone 1 and Zone 8 as the zones for Pacific Highway south and north respectively. Other zones are as shown in Figure 2.1.

2.4.3 Traffic Signals

In the 2010 Base modelling, signal phasing, green splits and inter-greens were coded into the Paramics model based on site data taken from Cardno site inventory visits during the peak periods as well as information received from the SCATS history files which were made available for our modelling.

The SCATS system used along Pacific Highway allows for adaptive phase lengths at intersections to improve the efficiency of individual junctions and corridors. In Paramics the signals were coded to reflect a fixed time average during the peak periods and the linkages between signals, where applicable, were maintained.

Figure 2.1 Paramics Model Extent with Zone Numbering



2.5 TRAFFIC DEMAND & ASSIGNMENT

The AM, MD and PM peak demand matrices were developed to produce a one hour peak matrix, with a ramp up period to ensure that the peak hour matrix represents the busiest hour in both the morning and evening periods, not simply the busiest clock hour.

As noted previously, the traffic assignment method used for the base modelling is 'All-or-Nothing'; this method is the most appropriate given there is no route choice within the modelled study area. Major and minor links are still coded in for good practice.

2.5.1 Demand Matrix Development

The trip matrices for each of the models (AM, MD and PM) have been calculated from the following sources:

- Surveyed turning movement counts.
- Cordon link counts.
- Factored counts from Council for 2008 and 2009.

2.5.2 Matrices

Four (4) matrices were used in each model demand file:

- Matrix 1 – background traffic demand light vehicles only.
- Matrix 2 – background traffic demand heavy vehicles only.
- Matrix 3 – future increase in background traffic (heavy and light vehicles) (not used in the 2010 models).
- Matrix 4 – future increase in Quarry trucks (heavy vehicles) (not used in the base models).

The demands were developed this way for each of the AM, MD and PM peak models to allow for better modelling of heavy vehicles.

2.5.3 Smoothing

Smoothing was applied to all of the recorded traffic flows in order to ensure a well calibrated & validated Paramics model was achieved. Where older data was used, it was factored up to tally with the most recent data from 2010. Smoothing is a process of good practice in micro-simulation modelling where, if flows out of one junction and flows into the next are unequal, then one set of figures is adjusted to ensure that both sets are equal. The exercise is carried out throughout the network on a proportional basis until all flows match.

Paramics is a model, and as such it requires that the flows throughout the network match up. It is therefore essential for this smoothing process to take place. The balanced AM, MD and PM peak traffic flows are presented in Appendix A.

2.5.4 Demand Profile

A 15 minute demand arrival profile was applied to all matrices. The shape of the profile for each of the AM, MD and PM peaks was based on the traffic count data as surveyed by SkyHigh on 24 June 2010. These profiles specify the timing of proportional release of vehicles into the models, and were developed from the 15-minute interval turning movement counts. Different individual profiles were applied to all external zones based on the numbers of vehicles released during each 15 minute period, relative to the total amount released in the peak hour being modelled.

Using this methodology provides a robust representation of the varying local dynamics within different locations of the model. For example the profile of vehicle releases from Pacific Highway North Zone may be completely different to the release profile from the Edgeworth David Avenue Zone, and so on. Applying these types of localised profiles, allows more accurate simulation of trips and any localised issues. This profile technique is applied to all of the models.

3 BASE 2010 MODEL - CALIBRATION & VALIDATION

3.1 SIMULATION PARAMETERS AND ADJUSTMENTS

A major element of successful calibration was to ensure that the Pacific Highway between Bridge Street and Edgeworth David Avenue was being simulated accurately, and also that signal operations within the model area were realistically represented. In order to produce a goodness-of-fit in each model, numerous model attributes were carefully checked and driver behaviour and lane usage monitored to ensure accurate representation of model conditions was achieved.

3.2 MODEL CALIBRATION

There are no adopted standards in Australia for calibration and validation of traffic models, although there are standards in NSW developed by the RTA. Some of the most up to date standards are often taken from the RTA and UK Design Manual for Roads and Bridges (DMRB Volume 12) where calibration the statistical criteria for traffic models require a certain number of flows to achieve a robust level of statistical reliability, when comparing modelled volumes to the actual volumes recorded on-site. The statistical measure is known as the GEH, and any GEH value of less than 5 is regarded as being a good and accurate representation of existing conditions. Generally it is regarded that if a model has 85% of GEH values less than 5, the model is then a robust representation of the existing conditions. From the aforementioned, UK DMRB Volume 12, and RTA guidelines, we aimed to exceed the criteria that 85% of flows (including turns) should have a GEH < 5.

In reality, traffic volumes vary from day to day and from location to location. The GEH statistic was developed to cope with these types of different ranges in flows. Instead of comparing absolute or relative flow differences, a wide range of flows can confidently be deemed as being statistically accurate using the GEH formula. For example, where an absolute difference of 100 vehicles/hr can be important in a flow of 200 vehicles/hr, it is largely irrelevant in a flow of several thousand vehicles/hr.

The purpose of the above calibration criterion for the existing models is to match the traffic volume information at all key junctions and links with the following requirements for each hour for each of the three models:

- GEH statistics for Zone release, turns and other volumes with no fewer than 85% less than 5.

GEH compares the differences between observed flows and modelled flows on a link by using the following formula:

$$GEH = \sqrt{(V_O - V_A)^2 / (0.5 \times (V_O + V_A))}$$

Where:

V_O = Observed traffic flow (vehicles/hour)

V_A = Assigned (or modelled) hourly traffic flow (vehicles/hour)

The model calibration was carried out for each modelled hour in each of the three 2010 Base Models. The following section provides the calibration results for each of the 3 Existing Models for the AM, PM and MD peak hours.

In accordance with best practice, all modelled scenarios for this study were run with RTA's recommended seed values of 28, 560, 2849, 7771 and 86524 to ensure robustness of the models. The results for each scenario presented in this report are based on the average of 5 model seed runs.

3.3 CALIBRATION RESULTS

Table 3.1 to Table 3.3 show the calibration summary for each of the existing models developed. As can be seen, the calibration criteria have been exceeded significantly for each hour of each model, with 100% of flows having a GHE < 5. Detailed modelled flows and GEH statistics are attached in Appendix B.

Table 3.1 AM Peak Calibration Results Summary

Data Type	GEH < 2	GEH < 5
Intersection Counts	94%	100%
Link Counts	96%	100%
Overall	95%	100%

Table 3.2 MD Peak Calibration Results Summary

Data Type	GEH < 2	GEH < 5
Intersection Counts	99%	100%
Link Counts	100%	100%
Overall	99%	100%

Table 3.3 PM Peak Calibration Results Summary

Data Type	GEH < 2	GEH < 5
Intersection Counts	97%	100%
Link Counts	97%	100%
Overall	97%	100%

3.4 MODEL VALIDATION

Once the Paramics model was calibrated, a data set separate to that used during the calibration process, was used to validate the model. The method used was to compare the modelled travel times of vehicles through the network with the actual observed times, and to also compare the queues in the model to those observed in the field with the aim of achieving a reasonable approximation of the conditions on the ground.

3.4.1 Travel Time Validation

The required criterion for travel time validation was:

- 85% of movements to have modelled travel times within 15% (or 1 minute, whichever is higher) of the observed travel times.

In this case, where a corridor model is built, we aimed to have travel times north and south through the model to be within 15% or 1 minute whichever was greater. Model travel times on Pacific Highway were therefore compared with the actual times as recorded on site. As with calibration, the validation was carried out for each modelled hour using the average of 5 seed runs, in each of the existing AM, MD and PM peak hours.

The sections that were subject to travel time validation tests were:

- Vehicle travelling northbound on Pacific Highway from Paramics Zone 1 (just south of Edgeworth David Avenue) to Paramics Zone 8 (just North of Bridge Roads).
- Vehicles travelling southbound on Pacific Highway form Paramics Zone 8 to Zone 1.

3.4.2 Travel Time Validation Outputs

The model validation outputs for each of the AM, MD and PM Peak models were robust, with travel times in both directions giving a solid representation. A summary of the validation results for each of the models is described in Table 3.4 and Figure 3.1 to Figure 3.3, which show the validation summary for each of the existing models. The validation criteria have again exceeded the validation criteria.

Table 3.4 Travel Time Validation Results Summary (mm:ss)

Southbound Through the Model

Pacific Highway SB from Bridge Road to Edgeworth David Road	AM	MD	PM
Averaged Observed Time (mins)	05:39	05:09	04:12
Averaged Model Time (mins)	05:16	04:48	04:21
Averaged Difference (mins)	00:23	00:21	00:09
Averaged Travel Time Difference (%)	6.7%	6.9%	3.7%

Northbound Through the Model

Pacific Highway NB from Edgeworth David Road to Bridge Road	AM	MD	PM
Averaged Observed Time (mins)	02:41	03:11	03:20
Averaged Model Time (mins)	02:51	03:16	03:27
Averaged Difference (mins)	00:10	00:05	00:07
Averaged Travel Time Difference (%)	6.0%	2.8%	3.5%

Travel times to be within 1 minute or 15% (whichever is higher) of the observed travel times

The matching of modelled and observed traffic volumes as well as travel times to these levels, provides robust calibration and validation results, which represent models that are accurately replicating existing conditions within the study area.

Figure 3.1 AM Peak Travel Time Validation

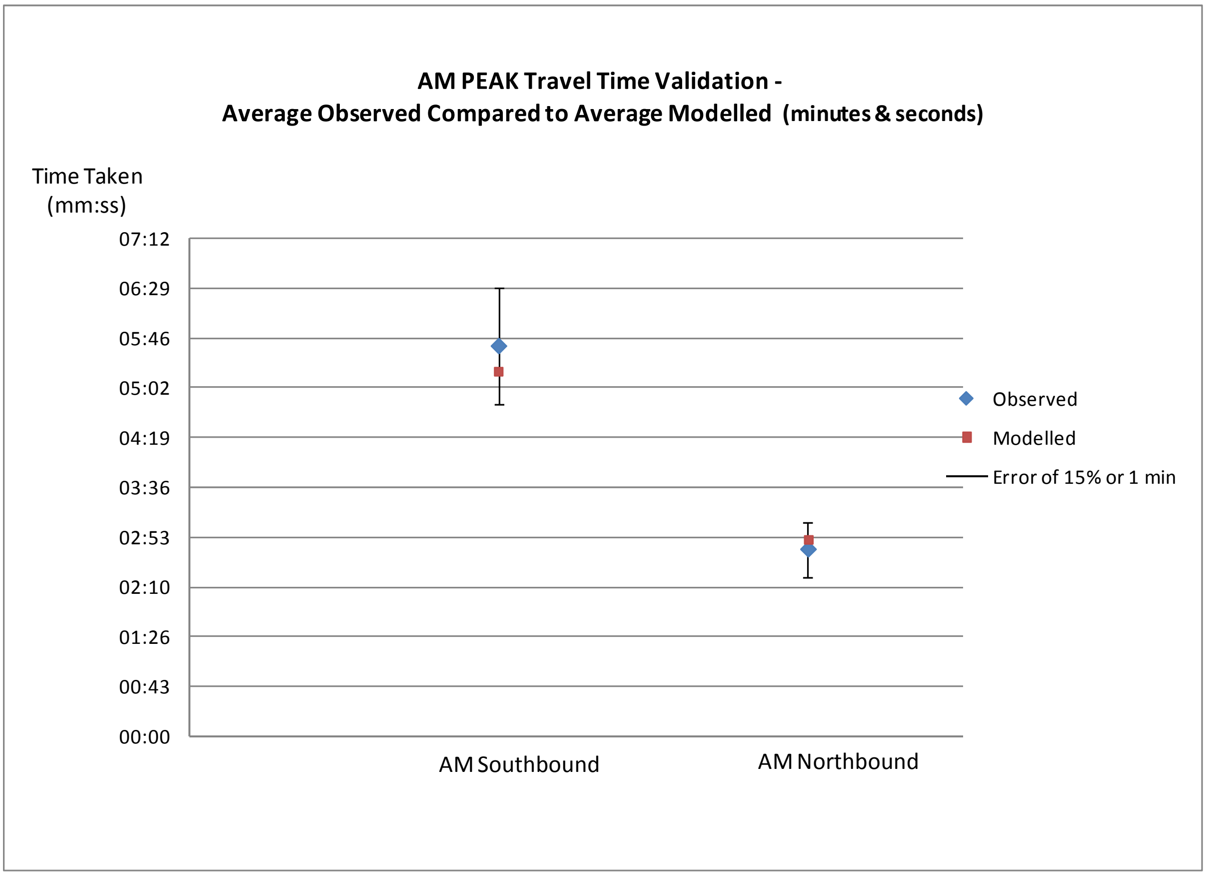


Figure 3.2 MD Peak Travel Time Validation

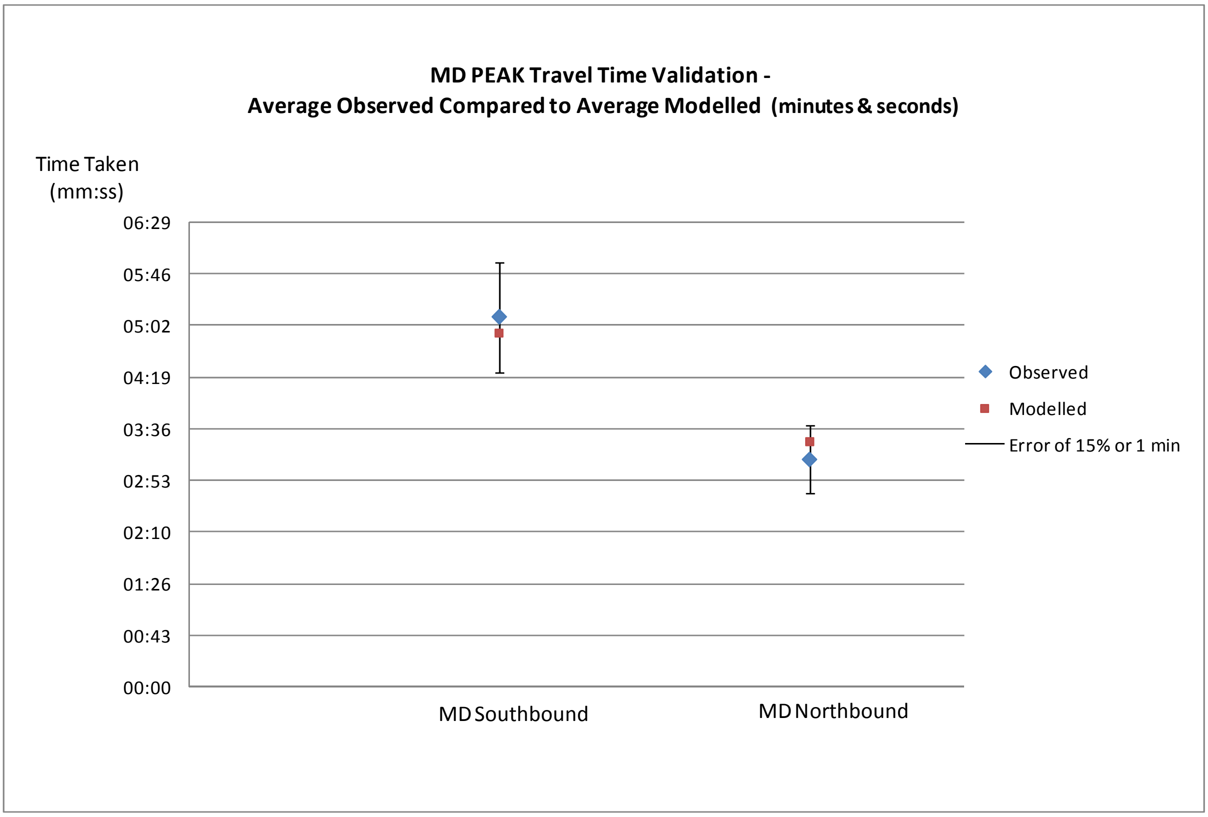
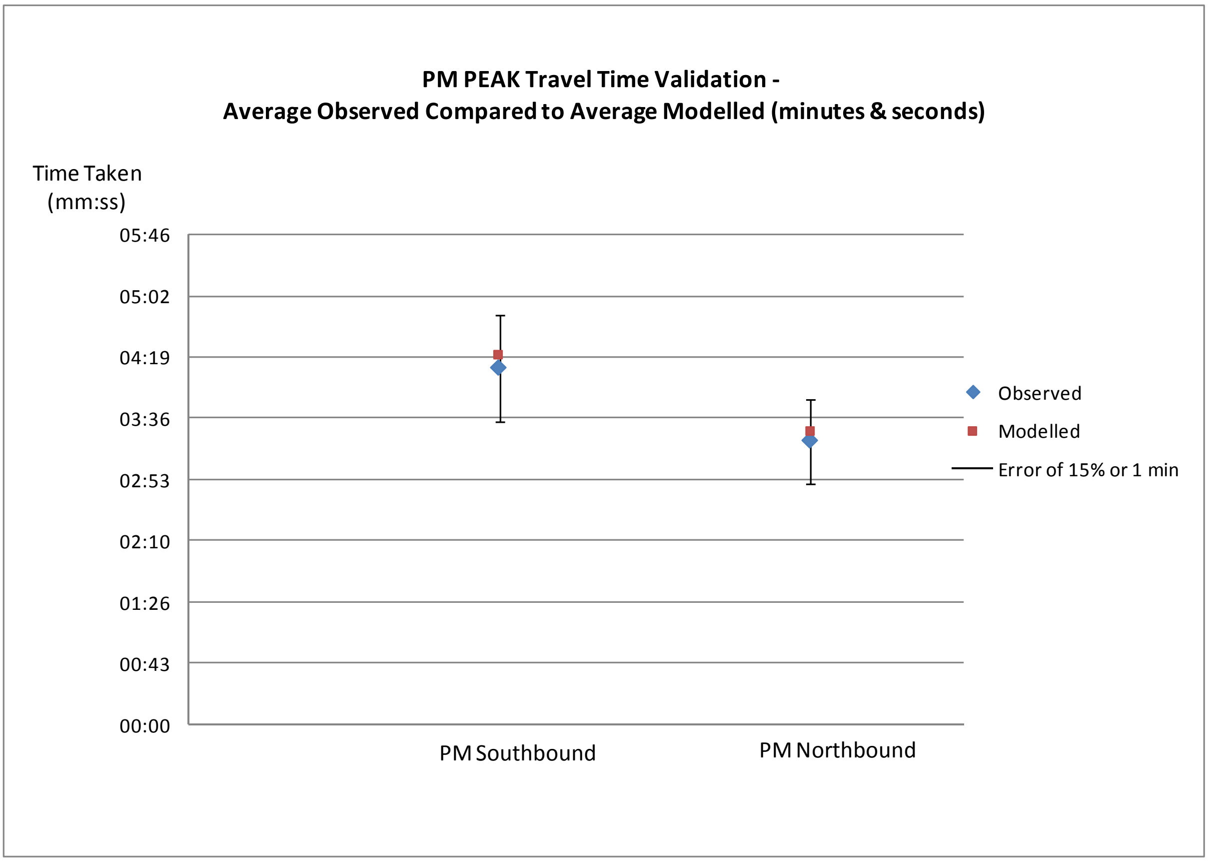


Figure 3.3 PM Peak Travel Time Validation



3.4.3 Queue Length Validation

Modelled queue lengths along Pacific Highway were also compared to the corresponding observed queues on site for the signalised approaches at the following intersections:

- Pacific Highway/Bridge Road.
- Pacific Highway/George Street.
- Pacific Highway/Edgeworth David Avenue.

This additional validation was carried for each modelled peak hour using the average of 5 seed runs, in the existing AM, MD and PM peak hours.

The model validation queuing checks for each of the AM, MD and PM Peak models were robust with the maximum observed queue lengths and modelled queue lengths broadly comparing well.

A summary of the results for queue length validation are illustrated in Table 3.5 - Table 3.7.

Table 3.5 AM Peak Maximum Queue Lengths on Approach (number of vehicles)

Intersection	Approach	Surveyed	Base Model 2010
Pacific Highway / Bridge Road	Northbound (Pacific Highway)	17	14
	Southbound (Pacific Highway)	32	32
	Eastbound (Bridge Road)	6	8
	Westbound (Bridge Road)	14	14
Pacific Highway / George Street	Northbound (Pacific Highway)	13	14
	Eastbound (Pacific Highway)	42	40
	Southbound (George Street)	54	47
Pacific Highway / Edgeworth David Avenue	Northbound (Pacific Highway)	26	30
	Southbound (Pacific Highway)	21	30
	Westbound (Edgeworth David Avenue)	19	15

Table 3.6 MD Peak Maximum Queue Lengths on Approach (number of vehicles)

Intersection	Approach	Surveyed	Base Model 2010
Pacific Highway / Bridge Road	Northbound (Pacific Highway)	37	25
	Southbound (Pacific Highway)	21	19
	Eastbound (Bridge Road)	4	4
	Westbound (Bridge Road)	15	14
Pacific Highway / George Street	Northbound (Pacific Highway)	13	10
	Eastbound (Pacific Highway)	49	38
	Southbound (George Street)	43	41
Pacific Highway / Edgeworth David Avenue	Northbound (Pacific Highway)	37	27
	Southbound (Pacific Highway)	30	26
	Westbound (Edgeworth David Avenue)	33	31

Table 3.7 PM Peak Maximum Queue Lengths on Approach (number of vehicles)

Intersection	Approach	Surveyed	Base Model 2010
Pacific Highway / Bridge Road	Northbound (Pacific Highway)	41	37
	Southbound (Pacific Highway)	20	17
	Eastbound (Bridge Road)	5	3
	Westbound (Bridge Road)	24	20
Pacific Highway / George Street	Northbound (Pacific Highway)	13	20
	Eastbound (Pacific Highway)	43	32
	Southbound (George Street)	36	30
Pacific Highway / Edgeworth David Ave	Northbound (Pacific Highway)	44	49
	Southbound (Pacific Highway)	27	21
	Westbound (Edgeworth David Avenue)	25	28

As can be seen from the results, there is a robust representation between the actual queues and the modelled queus in terms of operation. These queues should also be considered in light of the robust travel time representations and the fact that all GEHs are below 5.

Incidences where there are queues in the surveys, which are not replicated in the model occur at a couple of locations within the models; however these are not considered to be of concern form a modelling view point, as the GEHs for all flows making these movements in the model are almost all less than 2 and all less than 5 (noting that only 85% of them are required to be less than 5). This shows an excellent fit to actual volumes. The junction is therefore operating correctly form a flow perspective and also travel times. This is also the case for other junctions.

It should also be noted that the queues are robust in terms of lengths, as many approaches are 2 or more lanes, and therefore a queue of 10 vehicles difference is in actual fact negligible over 2 or 3 lanes.

3.5 SUMMARY

Each of the 2010 Base models (AM, MD and PM), for the existing situation, have been calibrated and validated to exceed industry guidelines.

The models therefore represent typical average conditions for the AM, MD and PM weekday peak periods, and incorporate pedestrian impact on traffic delays in the modelled area where appropriate.

3.6 CONGESTION LOCATIONS AND POINTS OF NOTE

The following are brief descriptions of areas in the current year base models, where there are issues from a traffic operational perspective:

- Heavy queues for the right turning movement from Pacific Highway onto Edgeworth David Avenue. The right turn bay is at capacity during the MD and PM peak period
- Long queue lengths are also experienced by southbound traffic at the Pacific Highway/George Street intersection but queues are generally cleared within one traffic signal cycle.
- Delays are experienced for vehicles travelling southbound on the Pacific Highway between Bridge Road and George Street due to the traffic signals operating at different cycle times.

4 FUTURE MODELLING SCENARIOS

Once the 2010 existing models were qualified as being robust and representative of existing road conditions, it was then possible to develop the future 2021 model scenarios to produce representations of the same AM and MD peak hours to test the impacts of the proposal.

For the purposes of this study, the following models have been developed:

- Scenario 1 (S1) – Existing AM, MD and PM Models as exist in June 2010.
- Scenario 2 (S2) – Future 2021 Base AM and MD models.(without the quarry traffic)
- Scenario 3 (S3) – Future 2021 Base with Quarry Operation Traffic AM and MD models.

It is assumed in this study that the proposed operation of the quarry is 7.00am – 5.00pm, Monday to Friday. Survey data has shown that the PM peak period is between 5.00pm – 6.00pm which falls outside the quarry operation hours. Therefore, only the AM and MD peak models have been developed for the future scenarios to evaluate the impacts the increased quarry truck movements will have on the road network.

The following section provide more details of each of the future models (Scenarios 2 and 3).

4.1 SCENARIO 2 (S2) – Future 2021 Base Models

4.1.1 Background Growth

The traffic flows used in the future 2021 base models were derived from growth factors based on the estimated resident population by travel zone (TZ) in 2006 and the NSW Government Bureau of Transport Statistics (formerly Transport Data Centre) employment forecasts provided by Council for each Paramics zone as shown in Table 4.1.

With the forecast rates as a guide, the demands from each zone are factored up based on the average percentage increase from the estimated resident population and employment forecasted figures. Table 4.1 has indicated that the growth factor for each individual zone is approximately 9% - 13% with a few outliers. The average for the shire is 6.4%.

Table 4.1 Forecast Growth Rates for Residential and Employment in 2021

Paramics Zone #	Location	Estimated Resident Population (ERP) by TZ2006 (Total persons)			TDC Employment Forecasts (October 2009 Release)			Average % Increase
		2010	2021	%	2010	2021	%	
Zone 1	Pacific Highway (South end of model)	93,260	101,724	109.1%	19,885	22,588	113.6%	11.3%
Zone 2	Edgeworth David Avenue	10,205	12,397	121.5%	4,525	4,957	109.5%	15.5%
Zone 1	George Street (acess/egress at Pacific Highway)	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%
Zone 4	George Street (acess/egress at Bridge Road)	110	120	109.6%	975	1,078	110.5%	10.1%
Zone 5	Bridge Road (east side of model)	1,758	2,069	117.7%	2,322	2,529	109.0%	13.3%
Zone 6	Railway Parade	2,846	2,888	101.5%	495	495	100.2%	0.8%
Zone 7	Jersey Street (north side of Bridge Road)	21,332	24,100	113.0%	5,003	5,527	110.5%	11.7%
Zone 8	Pacific Highway (North end of model)	21,396	23,555	110.1%	7,141	7,917	110.9%	10.5%
Zone 9	William Street	10,588	11,539	109.0%	3,708	4,218	113.7%	11.4%
Zone 10	Dural Lane	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%
Zone 11	Dural Street	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%
Zone 12	Bridge Road (west side of model)	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%
Zone 13	Westfield access/egress	165	204	123.4%	5,162	5,724	110.9%	17.2%
Zone 14	High Street	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%
Zone 15	Station Street	110	120	109.6%	975	1,078	110.5%	10.1%
Zone 16	Coronation Street	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%
Zone 17	Jersey Street (south side of Bridge Road)	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%
Zone 18	William Lane	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%

On top of the growth applied for each zone, additional trips between Zone 1 – Zone 8 and Zone 8 – Zone 1 are applied to maintain the through traffic proportion as per existing 2010 conditions shown in Table 4.2.

Table 4.2 Through Traffic Proportion

Peak Hour	To-From	Proportion of Through Trips
AM	Zone 1 – Zone 8	17%
	Zone 8 – Zone 1	21%
MD	Zone 1 – Zone 8	27%
	Zone 8 – Zone 1	27%

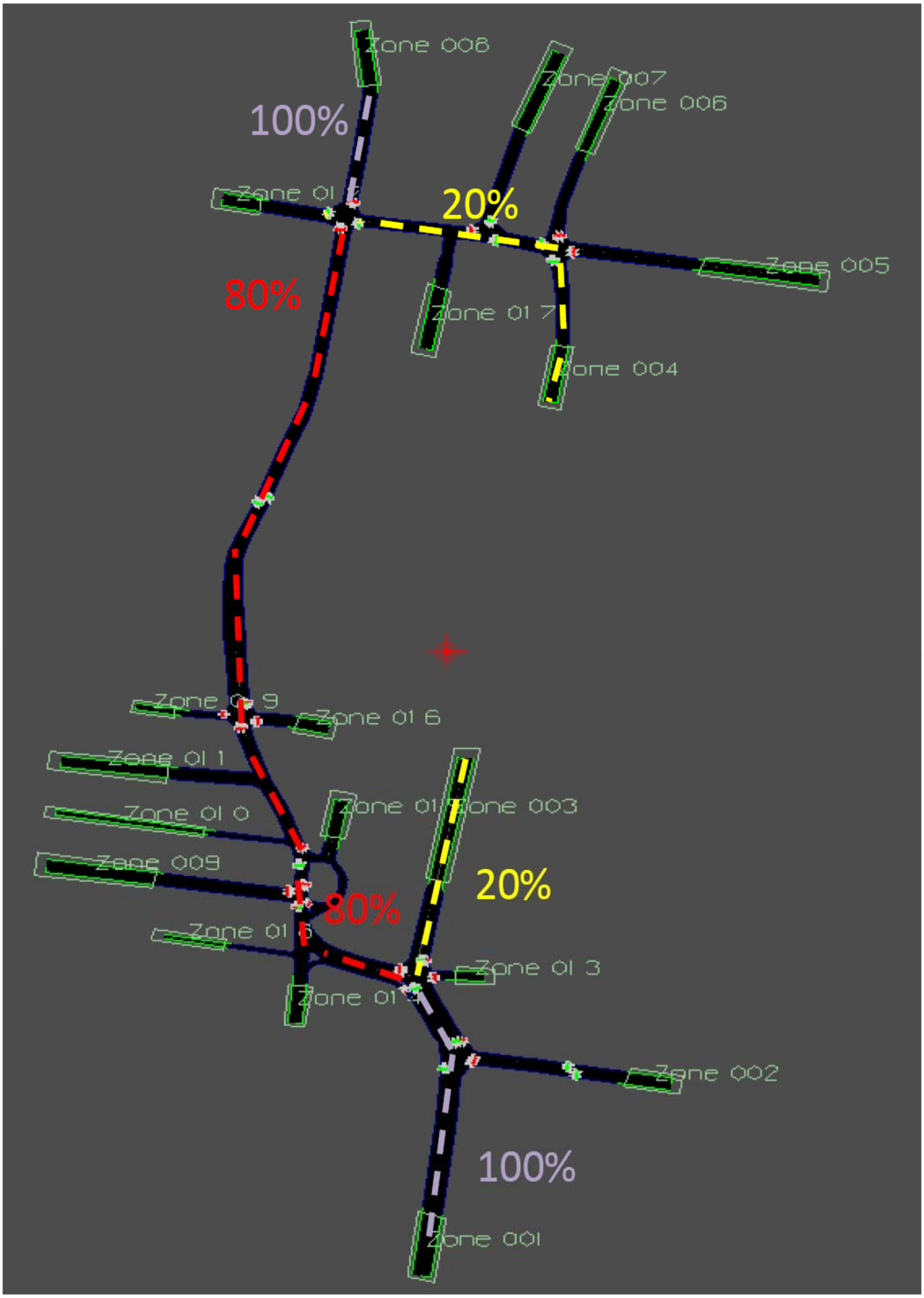
4.1.2 Through Traffic Distribution Split for Pacific Highway and George Street

Given that there are no route choices in the model network, all through trips are assigned to use Pacific Highway to travel from Zone 1 – Zone 8 and Zone 8 – Zone 1 in the existing model.

With the future increase in background traffic, delays are likely to increase on Pacific Highway. Thus, it is assumed that a proportion of the through trips will choose to use George Street for travel between Zones 1 and 8, as it is planned for George Street to have a higher priority over the Pacific Highway.

It has been assumed in the 2021 future base models therefore, that 80% of the through trips will use the Pacific Highway with 20% utilising George Street to travel through the modelled network. As the model only includes the southern and northern ends of George Street, 20% of the traffic trips have been assigned to travel between Zone 1 - Zone 3 and Zone 4 - Zone 8. Figure 4.1 illustrates this distribution.

Figure 4.1 Future Distribution Split for Through Traffic



4.1.3 Hornsby Aquatic Centre

The proposed Hornsby Aquatic Centre is expected to be completed by 2021; the impact of this development has been included in the 2021 future base models.

Network Changes

The future base model network has been developed based on the following additions to include the development:

- New Zone 19 (containing the proposed new swimming pool and associated parking).
- New western leg Pacific Highway/Coronation Street to form a four-way intersection.
- Two-way two lane access road to the aquatic centre.
- Additional right turn bay into the aquatic centre from the north, along the Pacific Highway.

Traffic Demands

As per Council's forecast, Table 4.3 shows the total number of trips generated by the aquatic centre in the AM and MD peak hour. It is also assumed in the model that 40% of trips travel to/from Zone 1 (Pacific Highway North) and 60% of the trips travel to/from Zone 8 (Pacific Highway South).

Table 4.3 No. of Trips Generated from Hornsby Aquatic Centre

Peak Hour	Total Trips IN	Total Trips OUT
AM	30	30
MD	52	20

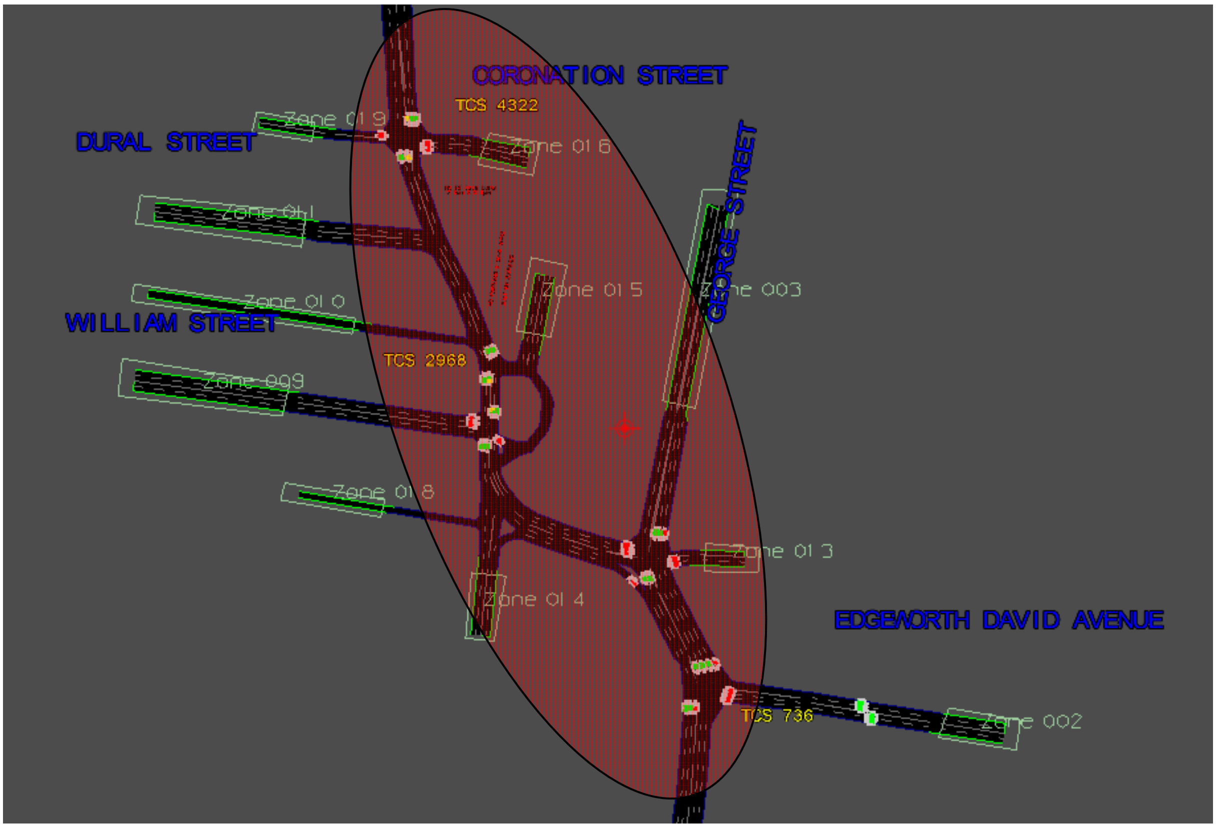
4.1.4 Signal Coordination in 2021 Base Case

Once the 2021 Base models were built, visual analysis was used to evaluate the possible operational impacts within the model network. The analysis showed significant delays to the model network and some model seed runs resulted in the model becoming grid-locked.

This was largely due to the signalised intersections on Pacific Highway between Coronation Street and Edgeworth David Avenue (as shown in Figure 4.2) running on different cycle times with limited coordination.

To mitigate this operational impact, the traffic signals along Pacific Highway between Coronation Street and Edgeworth David Avenue have been set to a cycle time of 120 seconds in the model, and coordinated with signal timings at the critical intersections of Pacific Highway/George Street and Pacific Highway/Edgeworth David Avenue.

Figure 4.2 Signal locations (which are coordinated) along Pacific Highway in the model area.



4.1.5 Summary

A summary of 2021 base model set up is as follows:

- Increased traffic demands based on Council's 2021 forecasted resident and employment growth rates.
- Through traffic were distributed in the 8-Year Quarry fill model to use both the Pacific Highway and George Street routes; this is the same distribution as used the 2021 base model.
- Included the network changes and traffic demands based on the Hornsby Aquatic Centre development.
- Optimised and coordinated signals along Pacific Highway.

4.2 SCENARIO 3 (S3) – Future 2021 Models with Quarry Infill Operations

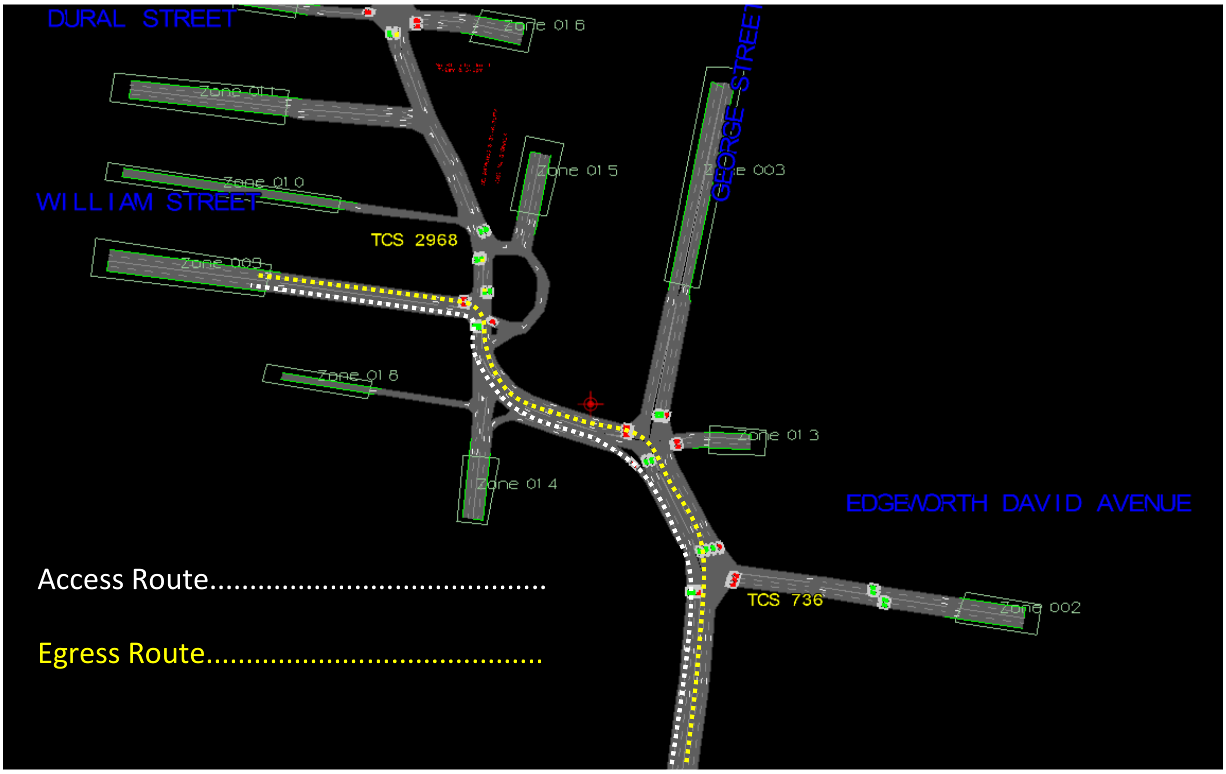
4.2.1 Model Network

The 2021 With Quarry Operation model consists of the same model network as that for the 2021 base. As with S2, signals are optimised to coordinate with the upstream and downstream signalised intersections to optimise flow and minimise delays within the network.

Figure 4.3 shows the access and egress routes for the quarry fill traffic.

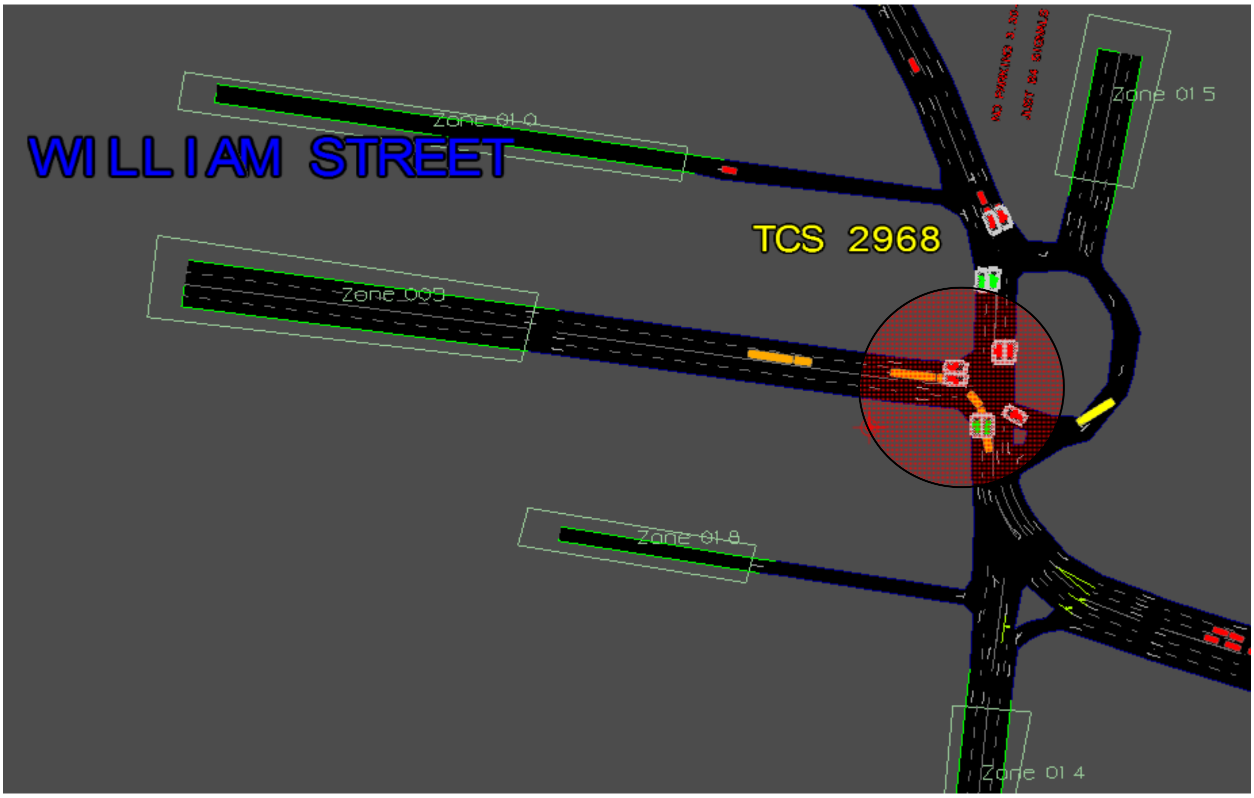
All quarry fill options to date have assumed these movements during the analysis; similarly S3 (8 year quarry fill) as been allocated these routes in all the modelling.

Figure 4.3 Access and Egress routes for Quarry Filling



Council has also advised that the semi-articulated trucks accessing the quarry will turn left at the intersection of Pacific Highway/William Street using the median lane due to the geometry of the intersection. Figure 4.4 illustrates this movement which has been coded into Paramics for the S3 modelling.

Figure 4.4 Quarry Trucks Turning into William Street



4.2.2 Quarry Demands

Based on relevant assumptions for the quarry operation, Council has estimated the proposed number of truck loads per hour in and out of the quarry site depending on the number of years it takes to fill up the quarry. Table 4.4 provides a summary of the quarry trucks required for each year scenario. Basic assumptions include:

- Quarry requires 4.3 million tonnes to fill.
- All vehicles will be a semi-articulated vehicle carrying an average load of 11.72 tonnes.
- 75% efficiency factor to take the downtime at the quarry and at the material supply location into consideration.

Table 4.4 Number of Quarry Trucks Required

Years to fill	Cubic meters per annum	Truck Loads per annum	Truck Loads per hour	Loads per hour (adjusted for efficiency factor)
1	4,300,000	366,933	136	181
2	2,150,000	183,467	68	91
3	1,433,333	122,311	45	60
4	1,075,000	91,733	34	45
5	860,000	73,387	27	36
6	716,667	61,156	23	30
7	614,286	52,419	19	26
8	537,500	45,867	17	23
9	477,778	40,770	15	20
10	430,000	36,693	13.6	18
11	390,909	33,358	12.4	16
12	358,333	30,578	11.3	15
13	330,769	28,226	10.5	13.9
14	307,143	26,210	9.7	12.9
15	286,667	24,462	9.1	12.1

Based on the figures in Table 4.4, the S3 models have been tested progressively with the different quarry year scenarios starting by assuming that the quarry will take 5 years to fill, with 36 trucks travelling in each direction from the quarry to Newcastle F3 Freeway.

Visual testings for 5 – 10 years have been undertaken for the AM and MD models to analyse the operation of the model. The results indicate:

- 5 & 6 years scenario – significant delays within the road network.
- 7 years scenario – congested at certain road sections but has potential for road network to operate with acceptable delays.
- 8 – 10 years scenario – good operation within the road network with some operational queuing.

Once the visual analyses were carried out on the infill scenarios over the 5 to 10 year range, a preferred option emerged which was then subject to more detailed quantitative analysis. The preferred option, which this analysis was undertaken for is the 8 Year infill scenario. The analysis was undertaken to determine the performance of the road network with the number of trucks required for an 8 year scenario infill, and compared to the 2010 and 2021 future scenarios for performance.

The 8 year scenario assumed 23 trucks per hour entering and leaving the site via William Street, giving a total of 46 trucks per hour.

Outputs from the modelling follow.

5 MODEL OUTPUTS

5.1 OVERVIEW

This section compares the performances of all the 2010 and 2021 models for both the AM and MD peak periods based on several measureable criteria.

The criteria on which each of the AM and PM models were assessed quantitatively and qualitatively are:

- Vehicle Flows (junction throughputs).
- Intersection Level of Service (LOS).
- Queue Lengths (at signalised intersections).
- Travel Times - northbound and southbound.

5.2 VEHICLE FLOWS (JUNCTION THROUGHPUTS)

Vehicle flows were extracted from all models for each arm of the major junctions in the model. These were then compared against each other for each junction across all models.

Figure 5.1 to Figure 5.8 illustrate vehicle flows for the AM Peak models for each of the 3 scenarios, and at each of the major junctions. The MD peak volumes are presented in Figure 5.9 to Figure 5.16. Full network volumes are presented in Appendix C, which provides more detail with regard to flows across the entire model network for each of the future scenarios.

Results for the Pacific Highway/William Street intersection show that the numbers of vehicles to and from the zone representing the quarry (and also the local residential homes) are broadly constant in the 2010 and 2021 base models.

When the 8 year quarry infill truck loads are incorporated into the 2021 model, the results remain generally similar to those from the 2021 Base model. It has been assumed that an 8 year infill scenario would be complete in 2021. This is a 'worse case' scenario, given that the traffic volumes in the 2021 models are generated by developments which are projected to be in place by that point. In other words, the development quantum for residential and employment will be higher in 2021 than in any of the years leading up to that point.

The results of the 2021 modelling incorporating the 8 year quarry infill scenario, indicate an almost negligible impact on Pacific Highway traffic operations in terms of Level of Service (LoS). There are three locations where the LoS is impacted; as can be seen from the following tables and graphics, the LoS drops from A to B at three locations on the Pacific Highway:

- Pacific Highway / Station Street.
- Pacific Highway / Edgeworth David Road.
- Pedestrian signals near the Council offices on the Pacific Highway.

A LoS B is regarded as an excellent result, especially on a road which is designated the secondary route through Hornsby.

In the instance where there is LoS F at Pacific Highway/F3 off-on ramp, the SIDRA analysis shows that there is also LoS F in 2021 without the quarry infill in place. This clearly shows that some major treatments need to be carried out at this location prior to 2021, whether or not the quarry infill proposal proceeds.

The LoS at the Cumberland Highway (Pennant Hills Road)/Pacific Highway intersection is C in the 2010 Base Model, dropping to D in the 2021 Base and 2021 Base + 8 Year Quarry Infill Scenario. Although this is a reduction in 2021, the impact of the Quarry infill operations is negligible, as the LoS would drop irrespective of whether this occurred.

These results show that the 8 year infill truck servicing levels, completing in the year 2021 have a neutral impact operationally, on the section of Pacific Highway considered under this assessment. This also includes the two intersections with George Street that were assessed (George Street/Bridge Street intersection and George Street / Pacific Highway intersection).

The traffic volume outputs show only a slight increase in the number of vehicles along Pacific Highway in the future scenarios compared to the increase in vehicles travelling to and from George Street. This is consistent with our assumptions in the future where 20% of the total through traffic from Pacific Highway is diverted to George Street which is a higher priority road.

Given that this is robustly calibrated micro simulation modelling, with the variability of 5 seed runs in AM and PM for all models, there will always be variability between numbers; it is the broad sense of difference (or lack of) that is relevant and important here. Overall, the flows as illustrated here are also supplemented with data for travel time results, queue lengths as well as the Level of Service (concerning intersection delay).

The data in the following sections has been colour coded as shown in Table 5.1 to differentiate between each of the modelled scenarios.

Table 5.1 Colour Coding for All Modelled Scenarios

No.	Scenario Description
S1	2010 Base Model
S2	2021 Base Model
S3	2021 Base + 8 Year Quarry Infill

Figure 5.1 AM Peak Volumes (vehicles/hr) – Pacific Highway/Edgeworth David Avenue

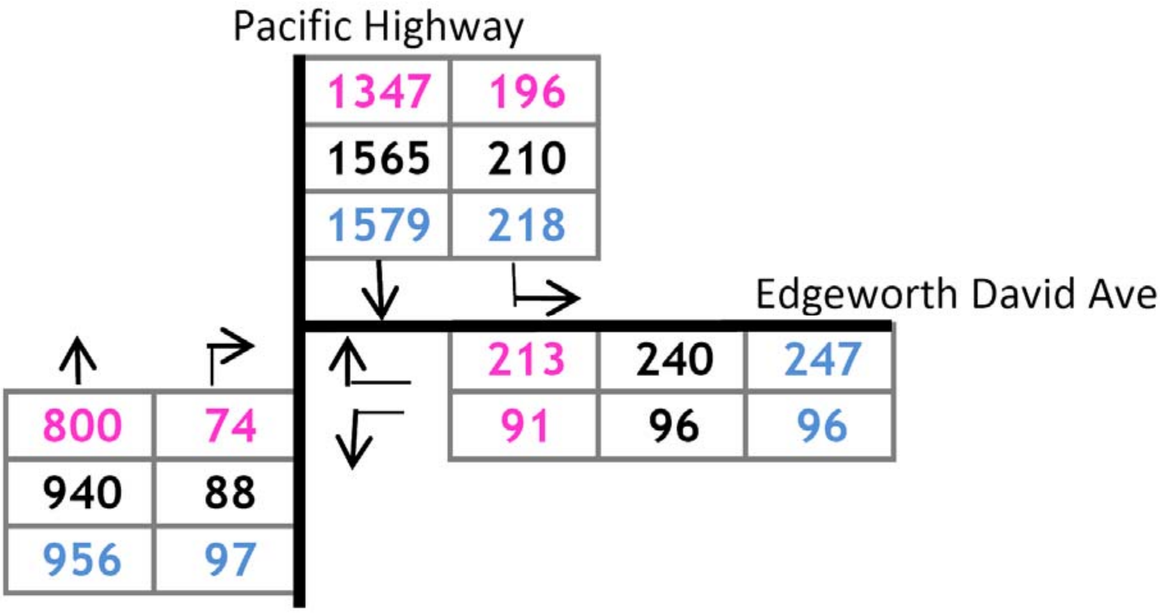
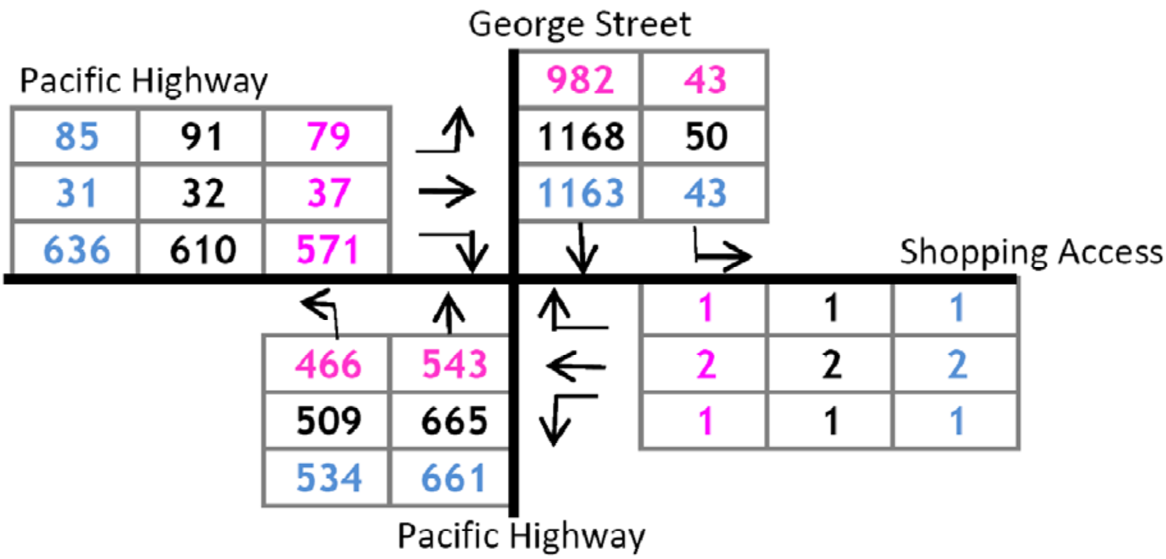


Figure 5.2 AM Peak Volumes (vehicles/hr) – George Street/Pacific Highway/Shopping Access



2010 Base Model
2021 Base Model
2021 Base + 8 Year Quarry Infill

Figure 5.3 AM Peak Volumes (vehicles/hr) – Pacific Highway/William Street

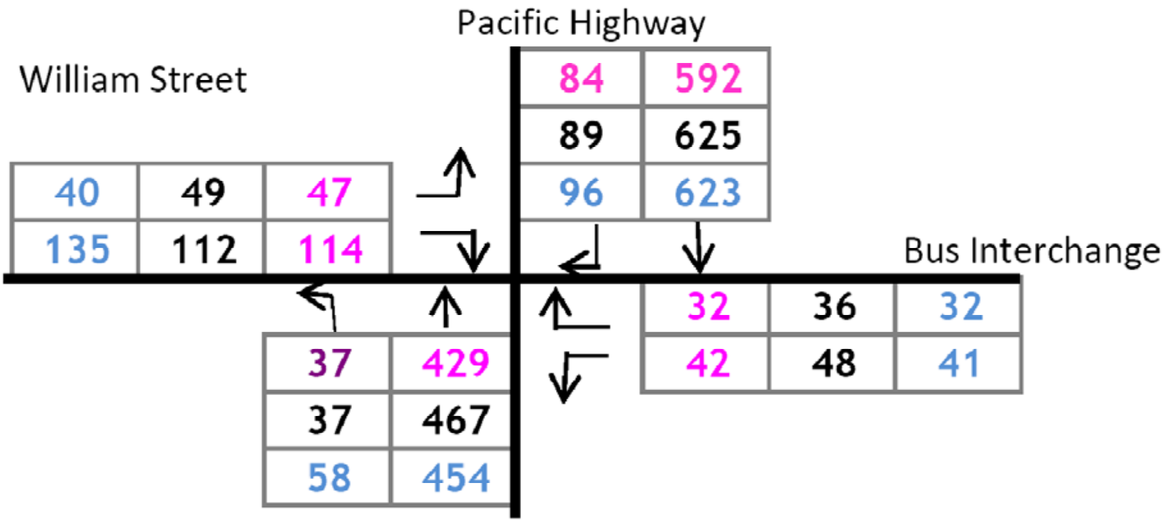
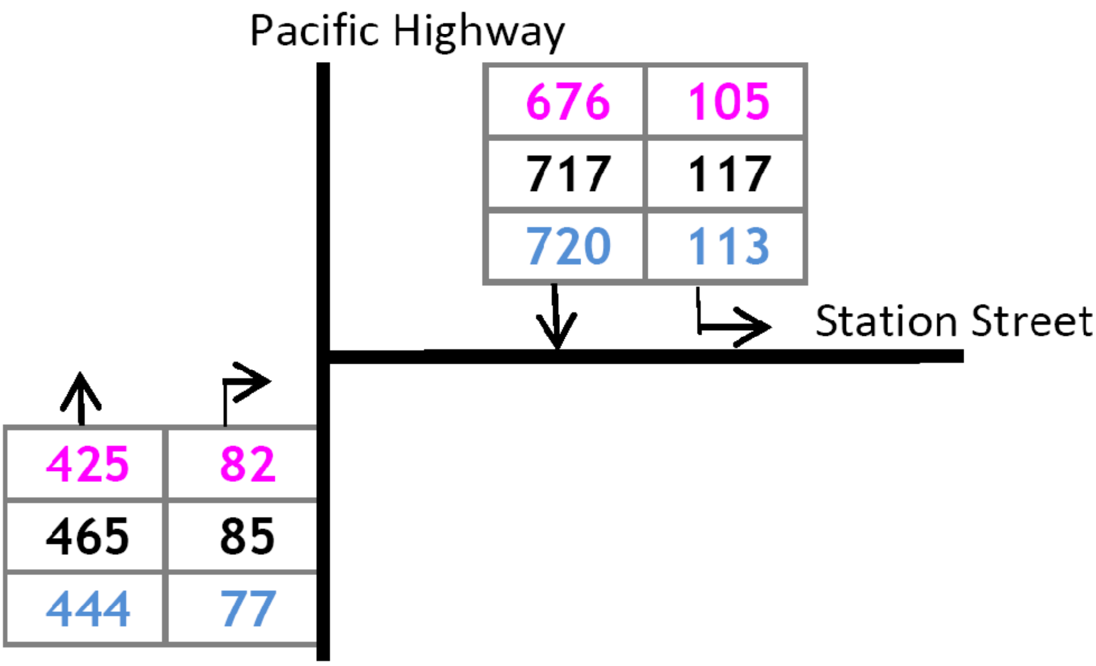


Figure 5.4 AM Peak Volumes (vehicles/hr) – Pacific Highway/Station Street



2010 Base Model
2021 Base Model
2021 Base + 8 Year Quarry Infill

Figure 5.5 AM Peak Volumes (vehicles/hr) – Pacific Highway/Coronation Street

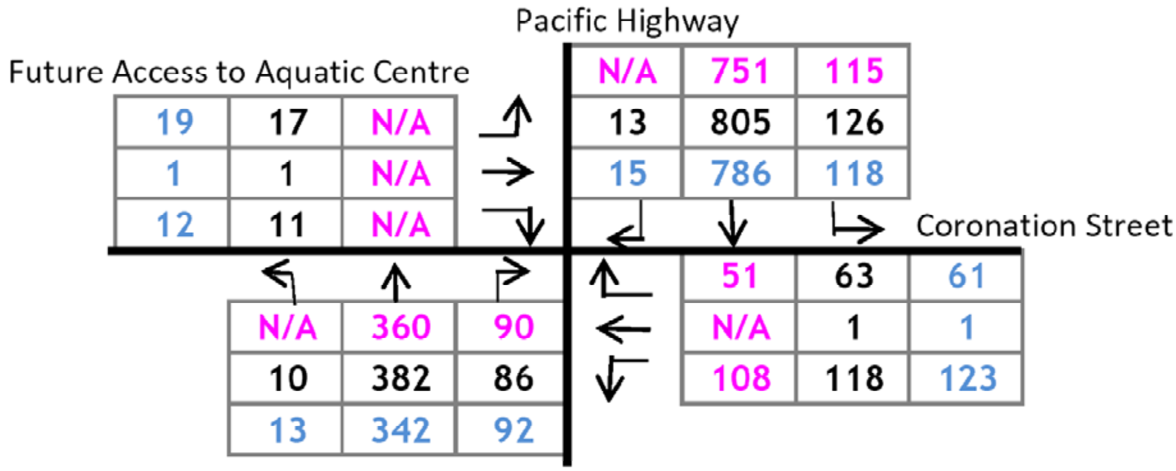
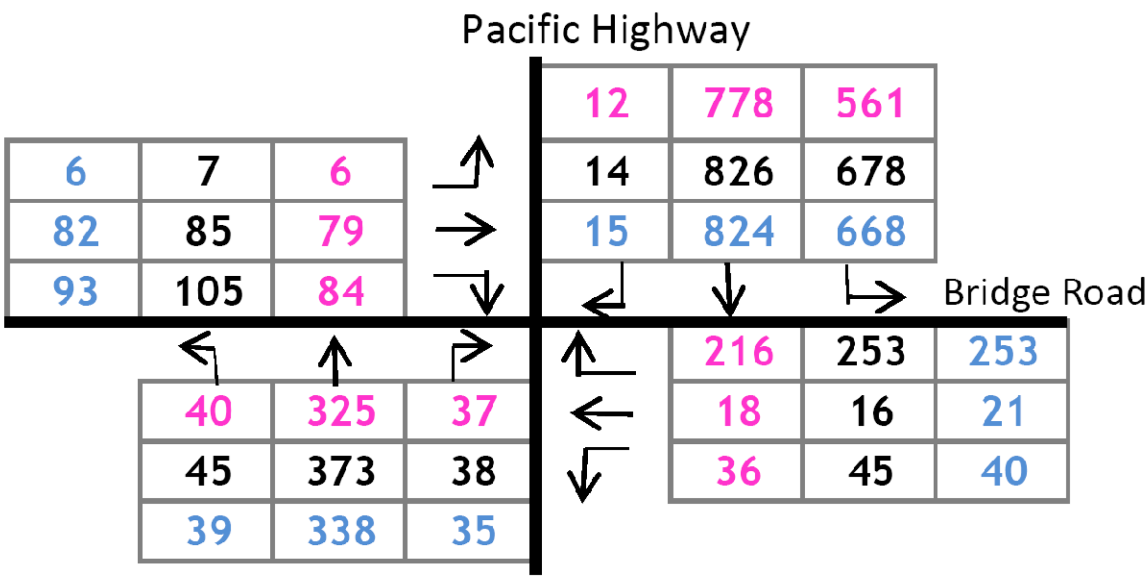


Figure 5.6 AM Peak Volumes (vehicles/hr) – Pacific Highway/Bridge Road



2010 Base Model
2021 Base Model
2021 Base + 8 Year Quarry Infill

Figure 5.7 AM Peak Volumes (vehicles/hr) – Jersey Street North/Bridge Road

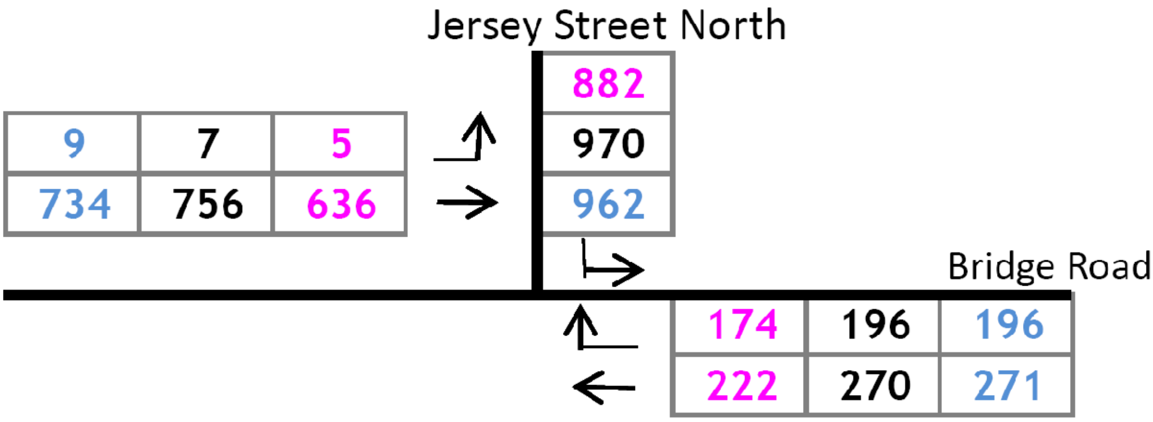
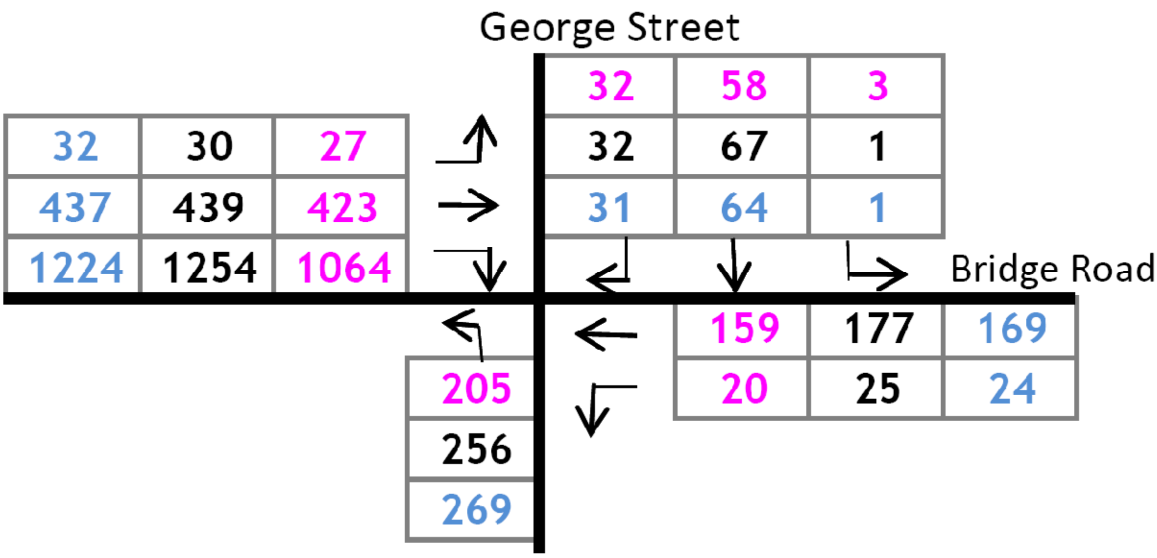


Figure 5.8 AM Peak Volumes (vehicles/hr) – George Street/Bridge Road



2010 Base Model
2021 Base Model
2021 Base + 8 Year Quarry Infill

Figure 5.9 MD Peak Volumes (vehicles/hr) – Pacific Highway/Edgeworth David Avenue

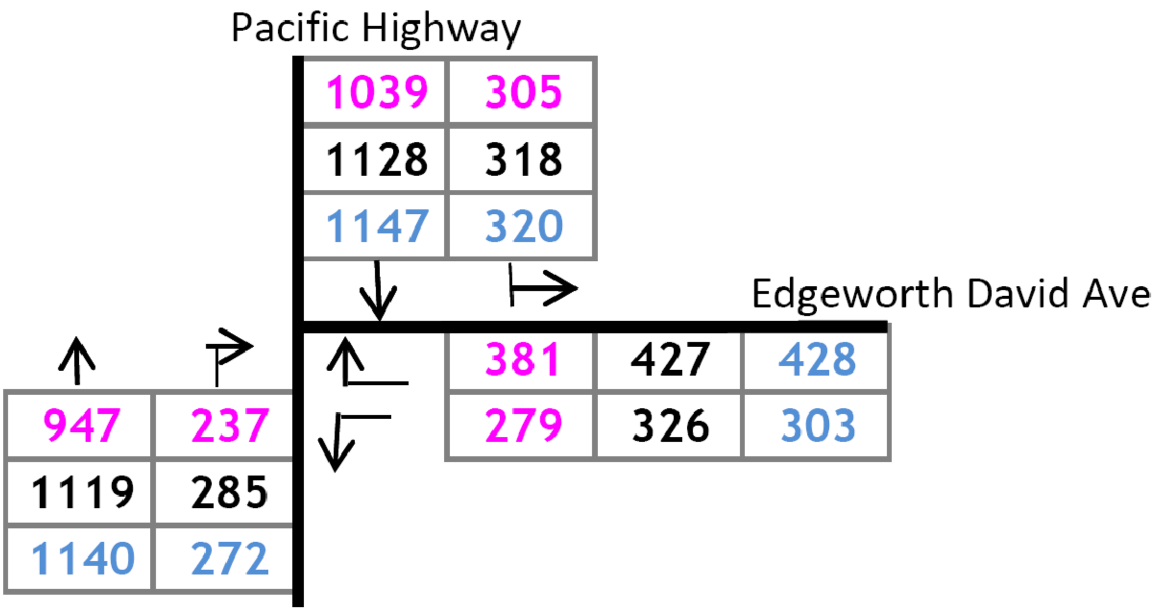
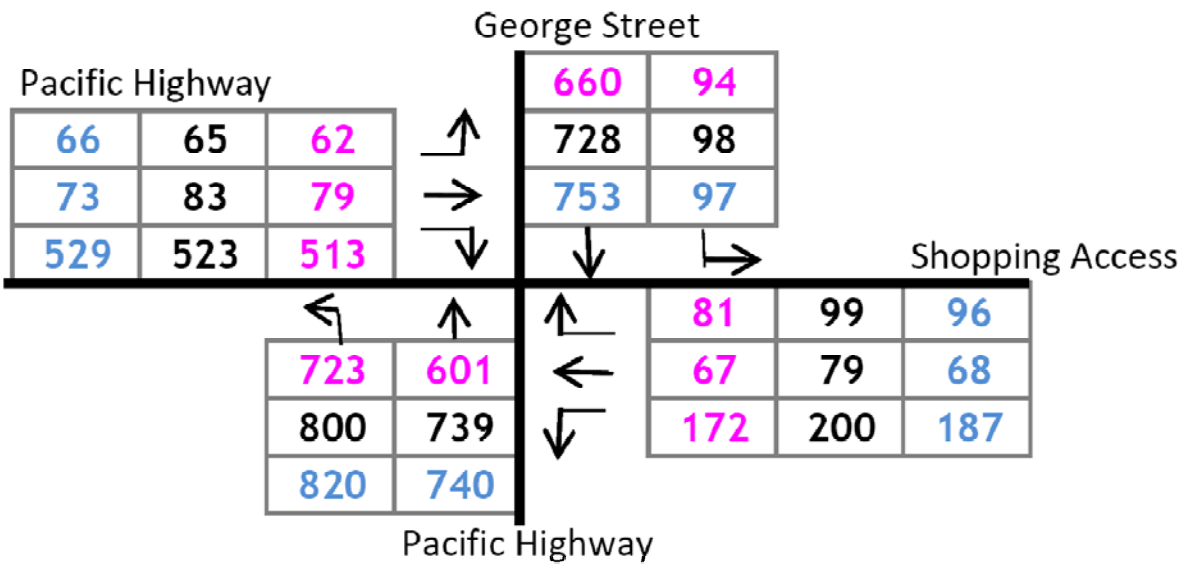


Figure 5.10 MD Peak Volumes (vehicles/hr) – George Street/Pacific Highway/Shopping Access



2010 Base Model
2021 Base Model
2021 Base + 8 Year Quarry Infill

Figure 5.11 MD Peak Volumes (vehicles/hr) – Pacific Highway/William Street

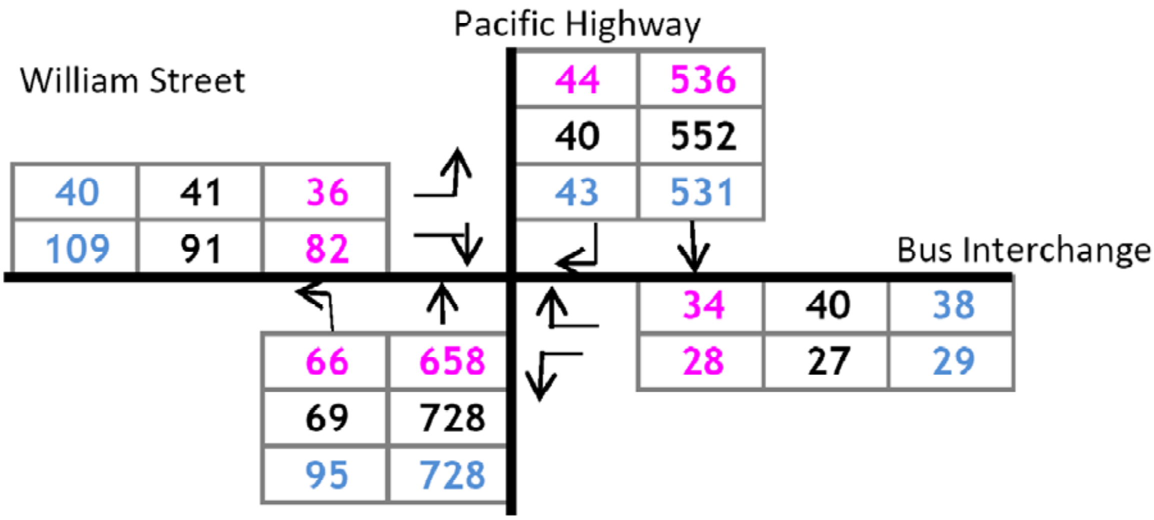
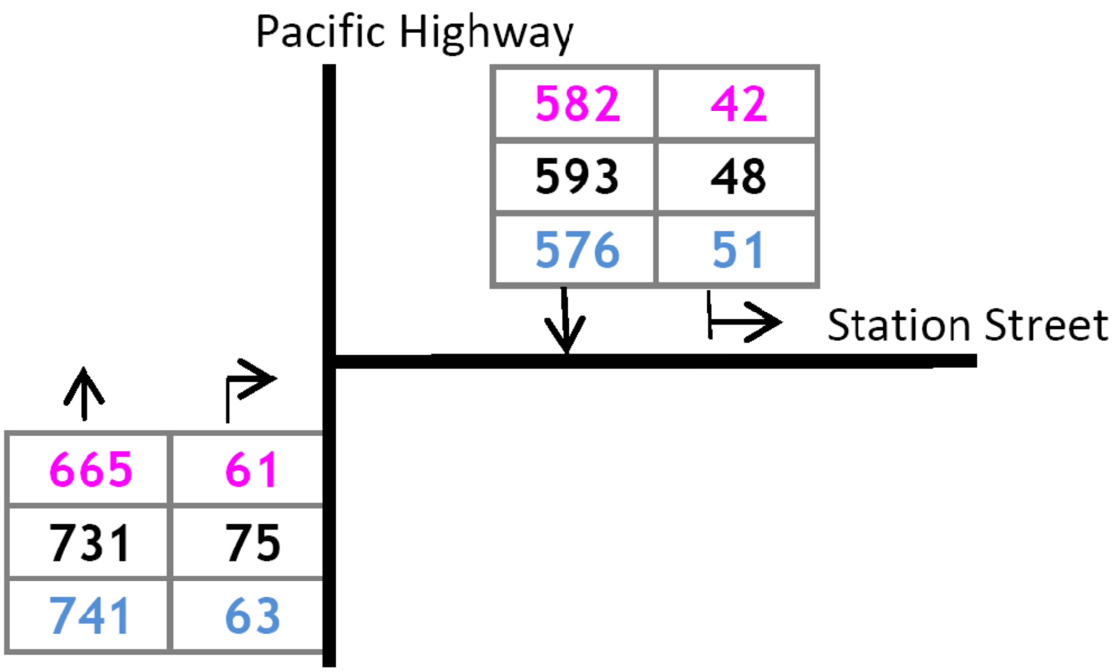


Figure 5.12 MD Peak Volumes (vehicles/hr) – Pacific Highway/Station Street



2010 Base Model
2021 Base Model
2021 Base + 8 Year Quarry Infill

Figure 5.13 MD Peak Volumes (vehicles/hr) – Pacific Highway/Coronation Street

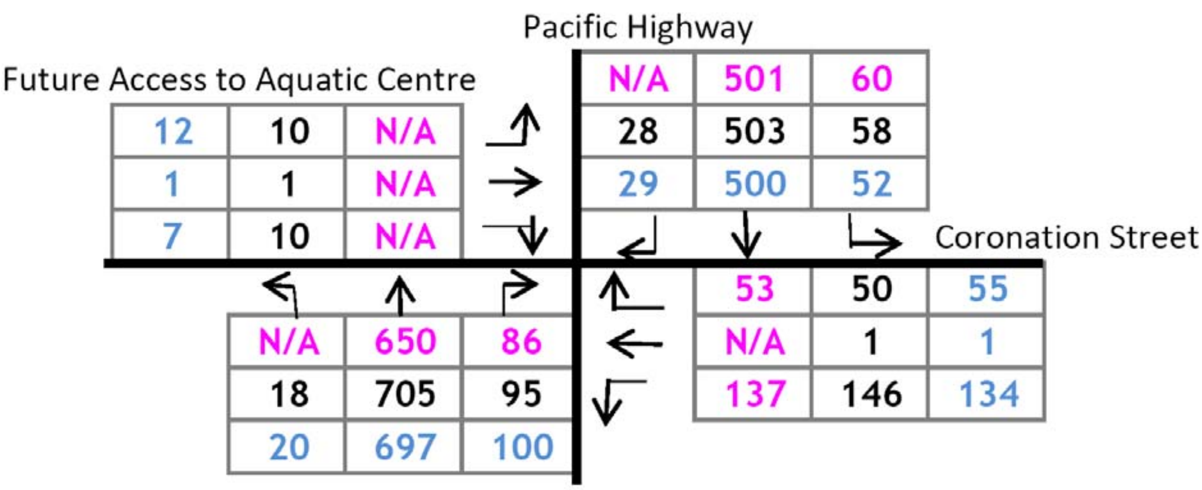
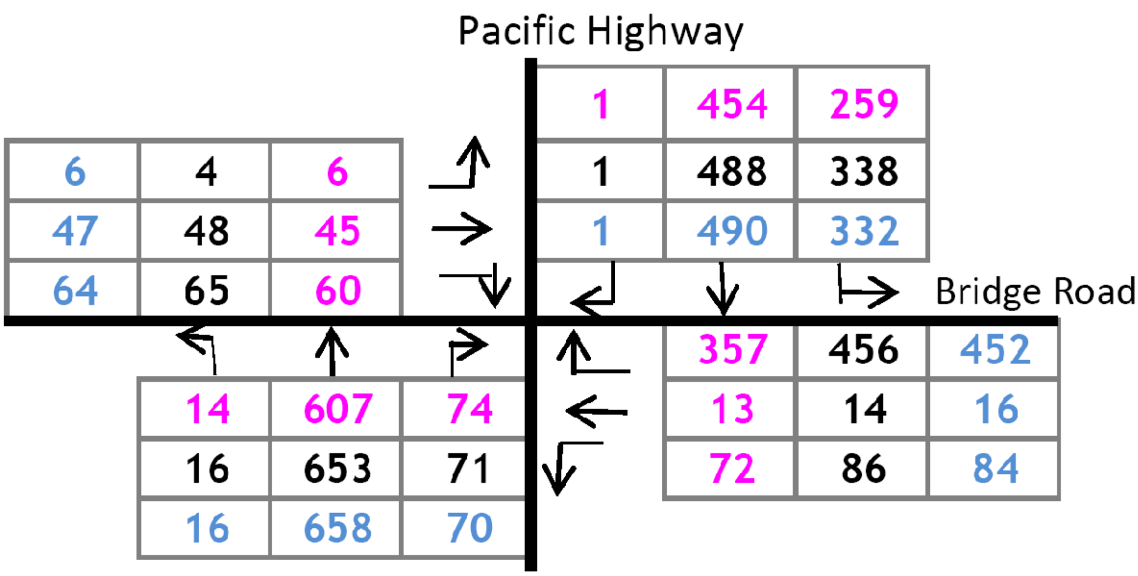


Figure 5.14 MD Peak Volumes (vehicles/hr) – Pacific Highway/Bridge Road



2010 Base Model
2021 Base Model
2021 Base + 8 Year Quarry Infill

Figure 5.15 MD Peak Volumes (vehicles/hr) – Jersey Street North/Bridge Road

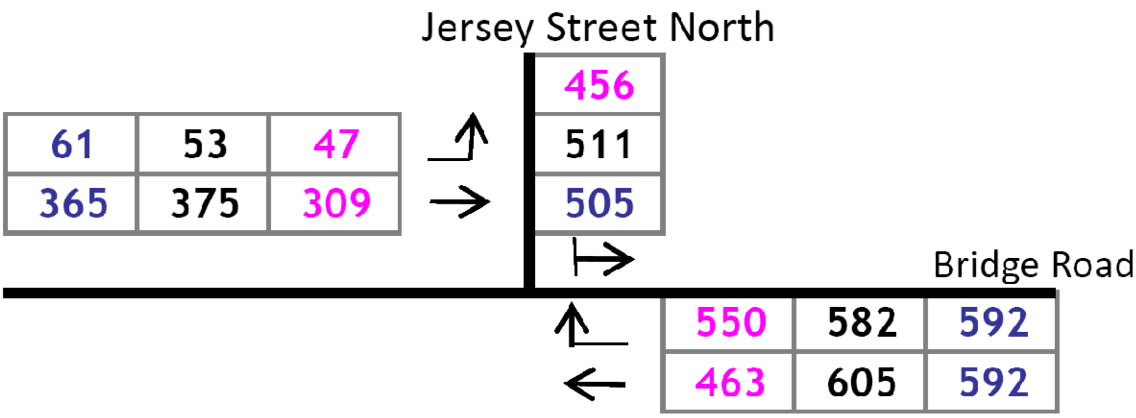
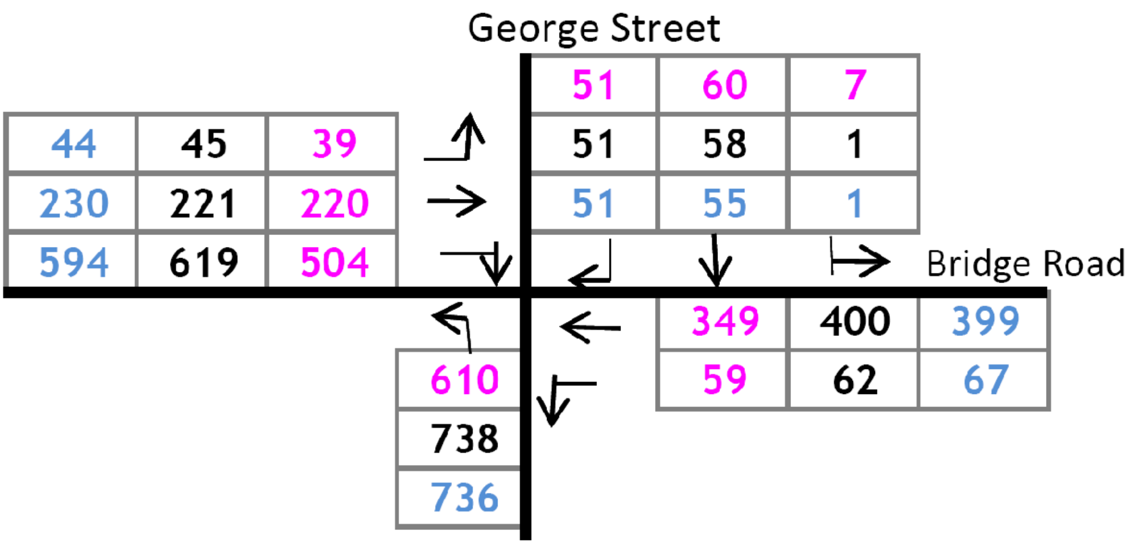


Figure 5.16 MD Peak Volumes (vehicles/hr) – George Street/Bridge Road



2010 Base Model
2021 Base Model
2021 Base + 8 Year Quarry Infill

5.3 AM AND MD INTERSECTION LEVEL OF SERVICE (LOS)

In an urban environment the performance of the road network is usually critical at intersections. The NSW Roads and Traffic Authority have adopted a method of assessing intersection performance using the level of service (LoS) criteria. LoS is a continuum from 'A' good operations to 'F' with unacceptable delays and queues. Table 5.2 provides a description of intersection level of service.

Table 5.2 Level of Service Criteria

LoS	Average Delay per Vehicle (secs/veh)	Traffic Signal/ Roundabout
A	< 14	Good operation
B	15 to 28	Good with acceptable delays & spare capacity
C	29 to 42	Satisfactory
D	43 to 56	Operating near capacity
E	57 to 70	At capacity; at signals, incidents will cause excessive delays Roundabouts require other control mode

Level of service measurements were extracted from all models at the critical signalised junctions within the model network. For intersections outside the Paramics network, analyses have been carried out using SIDRA. Table 5.3 and Table 5.4 following highlights the LoS differences between each of the AM and MD peak models respectively. It should be noted that the LoS extracted from Paramics Analyser is based on the Unites States Highway Capacity Manual method. We have taken this as being acceptable given the Council's request for Paramics to be used in these analyses; in any event it is the relativities and impacts that are of concern here and these are illustrated clearly in the following tables.

Table 5.3 AM Peak LoS Comparisons

Intersection	LoS		
	S1	S2	S3
Level of Service Based on Paramics Outputs			
Pacific Highway/Bridge Road	B	B	B
Jersey Road North/Bridge Road	B	B	B
George Street/Bridge Road	B	B	B
Pedestrian Signals near Council	A	A	A
Pacific Highway/Coronation Road	A	B	B
Pacific Highway/Station Street	A	A	B
Pacific Highway/William Street	A	B	B
Pacific Highway/George Street	C	B	B
Pacific Highway/Edgeworth David Avenue	B	A	B
Level of Service Based on SIDRA Outputs			
Pacific Highway/College Crescent/Pretoria Parade	B	B	B
Pacific Highway/Unwin Road/Romsey Street	B	C	C
Pacific Highway/Ingram Road/Woolcott Avenue	C	C	C
Cumberland Highway (Pennant Hills Road)/Pacific Highway	C	D	D
Pacific Highway/F3 on-off ramp	B	B	B
Dural Street/Frederick Street/Quarry Road	A	A	A
Frederick Street/William Street	A	A	A

In the AM peak the majority of the intersections are operating at a LoS A or B within the Paramics model network. Pacific Highway/George Street performed at a level of service C in the 2010 scenario but improves to a LoS B in the future scenarios. This is due to the signals being coordinated with the upstream and downstream intersections, enhancing the performance of the intersection.

For intersections located outside the Paramics model, SIDRA outputs indicate that most intersections are still performing satisfactorily with the future scenarios. It is important to note that in the future with the additional quarry trucks, the intersection of Cumberland Highway and Pacific Highway will operate at capacity in the AM peak period.

Table 5.4 MD Peak LoS Comparisons

Intersection	LoS		
	S1	S2	S3
Level of Service Based on Paramics Outputs			
Pacific Highway/Bridge Road	B	B	B
Jersey Road North/Bridge Road	B	B	B
George Street/Bridge Road	B	B	B
Pedestrian Signals near Council	A	A	B
Pacific Highway/Coronation Road	A	B	B
Pacific Highway/Station Street	A	A	A
Pacific Highway/William Street	A	B	B
Pacific Highway/George Street	C	C	C
Pacific Highway/Edgeworth David Avenue	B	B	B
Level of Service Based on SIDRA Outputs			
Pacific Highway/College Crescent/Pretoria Parade	B	B	B
Pacific Highway/Unwin Road/Romsey Street	B	B	B
Pacific Highway/Ingram Road/Woolcott Avenue	C	C	C
Cumberland Highway (Pennant Hills Road)/Pacific Highway	C	C	C
Pacific Highway/F3 on-off ramp	E	F	F
Dural Street/Frederick Street/Quarry Road	A	A	A
Frederick Street/William Street	A	A	A

In the MD peak period, Table 5.4 indicates that Pacific Highway/George Street intersection will perform at a satisfactory LoS C in both the existing and future scenarios. All other critical intersections within the Paramics model operate well within capacity.

Intersections outside the model area generally perform satisfactorily. It is important to note that Pacific Highway/F3 on-off ramp is predicted by SIDRA to perform at a poor level of service F in the 2021 base.

5.4 AM AND MD QUEUE LENGTHS

Table 5.5 and Table 5.6 show the queue lengths experienced at each approach for the signalised intersections, namely:

- Pacific Highway/Edgeworth David Avenue.
- Pacific Highway/George Street.
- Pacific Highway/Bridge Road.

Table 5.5 AM Peak Maximum Queue Lengths on Approach (in PCUs – Passenger Car Units)

Intersection	Approach	Surveyed Queue Length	Modelled queue length		
			S1	S2	S3
Pacific Highway / Bridge Road	Northbound (Pacific Highway)	17	14	24	21
	Southbound (Pacific Highway)	32	32	39	40
	Eastbound (Bridge Road)	6	8	9	8
	Westbound (Bridge Road)	14	14	17	17
Pacific Highway / George Street	Northbound (Pacific Highway)	13	14	23	23
	Eastbound (Pacific Highway)	42	40	42	45
	Southbound (George Street)	54	47	48	47
Pacific Highway / Edgeworth David Ave	Northbound (Pacific Highway)	26	30	32	25
	Southbound (Pacific Highway)	21	30	30	36
	Westbound (Edgeworth David Avenue)	19	15	19	20

Table 5.6 PM Peak Maximum Queue Lengths on Approach (in PCUs – Passenger Car Units)

Intersection	Approach	Surveyed Queue Length	Modelled queue length		
			S1	S2	S1
Pacific Highway / Bridge Road	Northbound (Pacific Highway)	41	37	45	46
	Southbound (Pacific Highway)	20	17	27*	27*
	Eastbound (Bridge Road)	5	3	8	8
	Westbound (Bridge Road)	24	20	21	20
Pacific Highway / George Street	Northbound (Pacific Highway)	13	20	11	10
	Eastbound (Pacific Highway)	43	32	45	46
	Southbound (George Street)	36	30	29	30
Pacific Highway / Edgeworth David Ave	Northbound (Pacific Highway)	44	49	60*	60*
	Southbound (Pacific Highway)	27	21	29	29
	Westbound (Edgeworth David Avenue)	25	28	38	37

* indicates number of vehicles queuing back into the model zone where relevant (i.e. blockages)

On the Pacific Highway, the increases are mostly in the range of 5-10 (PCUs) with some vehicles queuing back into the zone in all future scenarios. Regarding this, it should be noted that the use of fixed time signals in these Paramics models, although they are offset and linked to other signals, will actually perform better when switched to SCATS, as the adaptive capabilities of the SCATS system will be more responsive to queues and delays.

Notwithstanding this, the queues on Pacific Highway occur in 2021 with no quarry traffic (S2). In some of the scenarios with the proposal, notably the AM peak, Philip Street actually operates better because of the signal optimisations with the quarry traffic. When the RTA does optimise all future situations within SCATS, the results shown in Table 5.5 and Table 5.6 will realistically be much improved.

Overall, the model operates satisfactorily in the future with the quarry fill in operation and optimisation of the traffic signals along Pacific Highway.

5.5 AM AND MD TRAVEL TIMES

Average travel times were measured for vehicles travelling on Pacific Highway between Bridge Road and Edgeworth David Avenue (near the Shell Station) during the AM and MD peak hours, both in the northbound and southbound direction. Bridge Road is located at the position of the northernmost external Paramics zone.

The reason for measuring times from these zones is to analyse the impacts on the operation of Pacific Highway with the increased flows in various scenarios, through the entire model along the corridor mainline. Table and Table 5.8 show the travel times comparisons between all of the 2010 and 2021 AM and MD Peak Models for both the southbound and northbound directions.

Table 5.7 AM Peak Travel Times Comparison (mm:ss)

From-To	Surveyed Travel Times	Modelled travel times		
		S1	S2	S3
Pacific Highway **southbound** from Bridge Road to Edgeworth David Avenue	05:39	05:16	05:29	06:12
Pacific Highway **northbound** from Edgeworth David Avenue to Bridge Road	02:41	02:51	02:50	03:27

Table 5.8 MD Peak Travel Times Comparison (mm:ss)

From-To	Surveyed Travel Times	Modelled travel times		
		S1	S2	S3
Pacific Highway **southbound** from Bridge Road to Edgeworth David Avenue	05:09	04:48	06:34	06.40
Pacific Highway **northbound** from Edgeworth David Avenue to Bridge Road	03:11	03:16	03:47	04:06

The travel times show an increase in travel times between 2010 and 2021. This is expected given the increased volumes. More importantly, the travel times indicated that, with the 8 year fill scenario, the number of trucks required by the quarry during the peak hour had limited impacts to causing any delays in the road network.

6 FINDINGS & RECOMMENDATIONS

Overall the findings from the Paramics modelling are positive, in terms of evaluating the impacts that the increased truck movements will have on the surrounding road network in 2021 AM and MD peak, which broadly operate on par with the 2021 scenario without the proposal.

The purpose of this study was to use Paramics micro-simulation to assess the impacts on the operation of Pacific Highway between Bridge Road and south of Edgeworth David Avenue with the increased number of quarry trucks accessing via William Street. The modelling tasks also assist in determining the number of years to fill the quarry without causing significant impacts to the traffic operation in the study area.

Paramics traffic models were built for the existing conditions which were robustly calibrated and also validated with independent data, to exceed requirements.

In the 2021 base scenario, background traffic was factored up based on the forecasted rates for resident population and employment in the study area, as provided by Hornsby Council. Through traffic was also maintained at the existing level of each of the models with 20% of the total through traffic along Pacific Highway diverted to utilise George Street as an alternative route in 2021, given the strategy to convert George Street to the preferred route for through traffic (through the Paramics model area). Development traffic was also added for the proposed Hornsby Aquatic Centre, and the traffic signals optimised and coordinated along Pacific Highway, with particular focus on the section between Coronation Street and Edgeworth David Avenue.

The 2021 base modelling with quarry infill traffic initially included a visual analysis of several timeframes to fill scenarios which were tested to determine the optimum number of years whereby the quarry could be filled with minimal impacts to the surrounding road network.

These visual assessments carried out for 5, 6, 7, 8, 9 and 10 years were undertaken and the results indicate:

- 5 and 6 years scenarios – significant delays within the road network.
- 7 years scenario – congested at certain road sections but has potential for road network to operate with acceptable delays.
- 8, 9, 10 years scenarios – good operation within the road network with minimal congestion.

The best performer visually was the 8 year scenario model which has the ability to cater for the additional quarry trucks traffic in 2021. Once the visual testings were done, a quantitative analysis was undertaken to determine the performance of the road network with the 8 year scenario for comparisons with the 2010 and 2021 future base scenarios. The logic here was that if the 8 year scenario could work with vehicles accessing and egressing via William Street, then it is likely that the 9 and 10 year scenarios would also work, assuming quarry infill completion in 2021 (this being the likely busiest year from a traffic operations perspective).

Intersection flows, level of service, queue lengths and travel times were extracted and compared as key performance indicators.

Level of service at intersections within the Paramics model are satisfactory with most performing at a LoS A or LoS B in the AM and MD peak periods. Pacific Highway/George Street maintained a LoS C in the MD peak period in the future scenarios.

On the Pacific Highway, the queue length increases are mostly in the range of 5-10 vehicles with some vehicles queuing back into the Paramics zone in all future scenarios. It should be noted that the use of fixed time signals in these Paramics models, although they are offset and linked to other signals, will actually perform better when switched to SCATS, as the adaptive capabilities of the SCATS system will be more responsive to queues and delays.

Travel times data show that there is an increase in travel times between 2010 and 2021. This is expected given the increased volumes through the network. More importantly, the travel times indicated that, with the 8 year fill scenario in place in 2021, the associated truck operations during the peak hour had negligible impacts to delays in the road network.

Overall, the quantitative assessment showed that the road network has sufficient capacity to amply cater the 8 year quarry fill scenario in 2021. When comparing this 8 year quarry infill scenario to the 2021 Base scenario (i.e. with no quarry infill), there are negligible impacts to the road network in terms of LoS with no significant reductions in level of service across the modelled area.

This modelling study also indicates that consideration can be given to commencement of the quarry fill operation within the next 2 years which would then have a scheduled completion date either on or before 2021; the modelling recommendation therefore is as follows:

- Based on road network capacities, the 8 year quarry infill can proceed as it will have no significant operational impacts on Pacific Highway, over and above what is likely to happen in 2021 without the quarry infill taking place.

Additionally, should the 9 year or 10 year fill scenario be preferred by Council, the following recommendations would apply:

- A 10 year scenario infill would need to begin in 2011 (given our model test conditions) and be completed in 2021, for our recommendations to be applicable. Under these circumstances, the number of additional truck loads in 2021, would be less than those required for an 8 year quarry infill.

- Similarly for the 9 year infill scenario to take place, it would need to begin by 2012 and be completed in 2021. Similarly, the truck loads to complete filling in 2021, would be less per anum under the 9 year fill scenario than would be the case under the 8 year fill scenario.

NOTE TO COUNCIL

It's acknowledged that this is a draft for review prior to making a decision on the next step.

As such this document contains more modelling calibration information than will be in the final traffic report, unless otherwise required by Council.

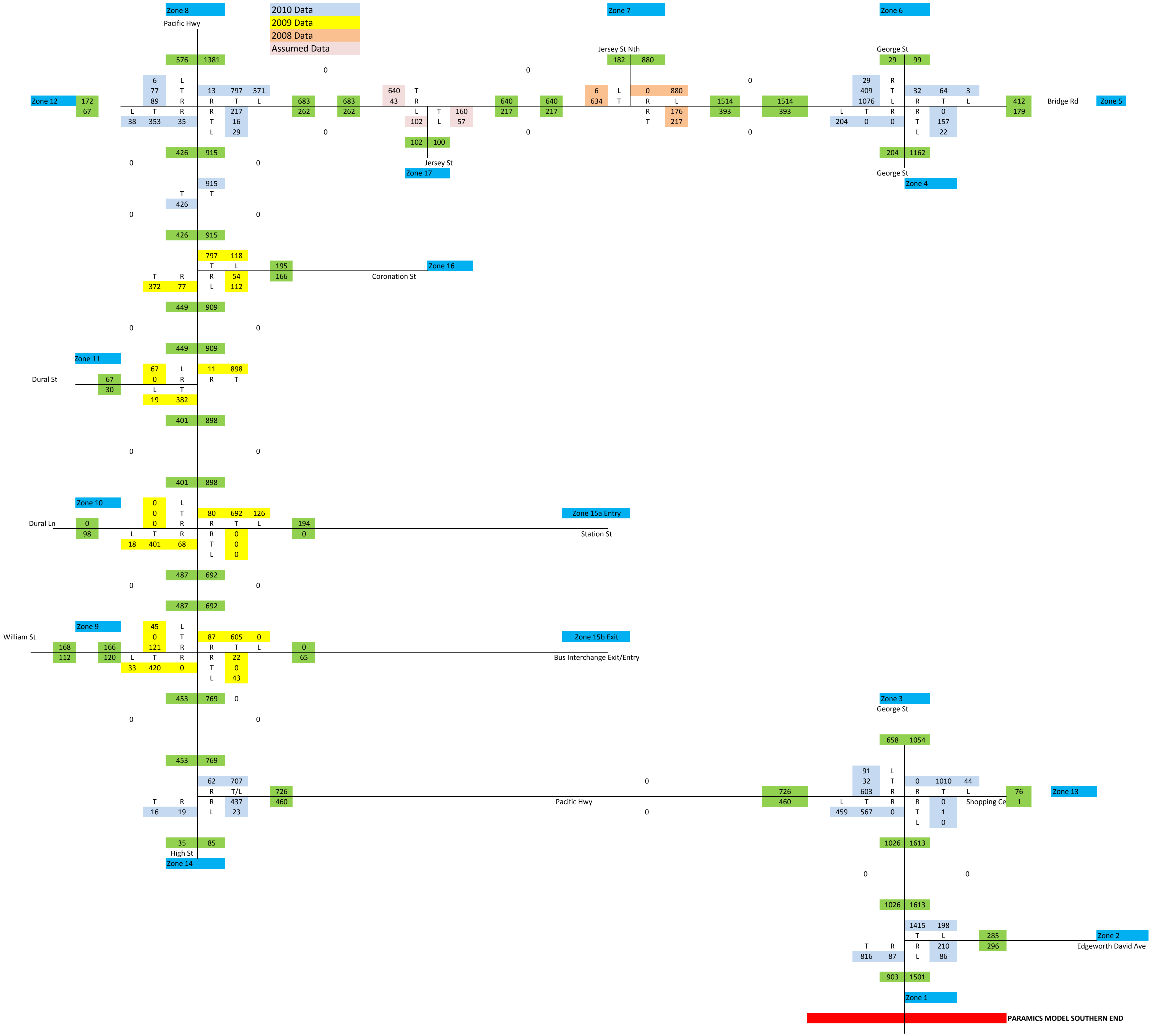
Also, the final report, with all options tested, will provide a clear conclusion for the best way to proceed in traffic operations terms.

APPENDICES

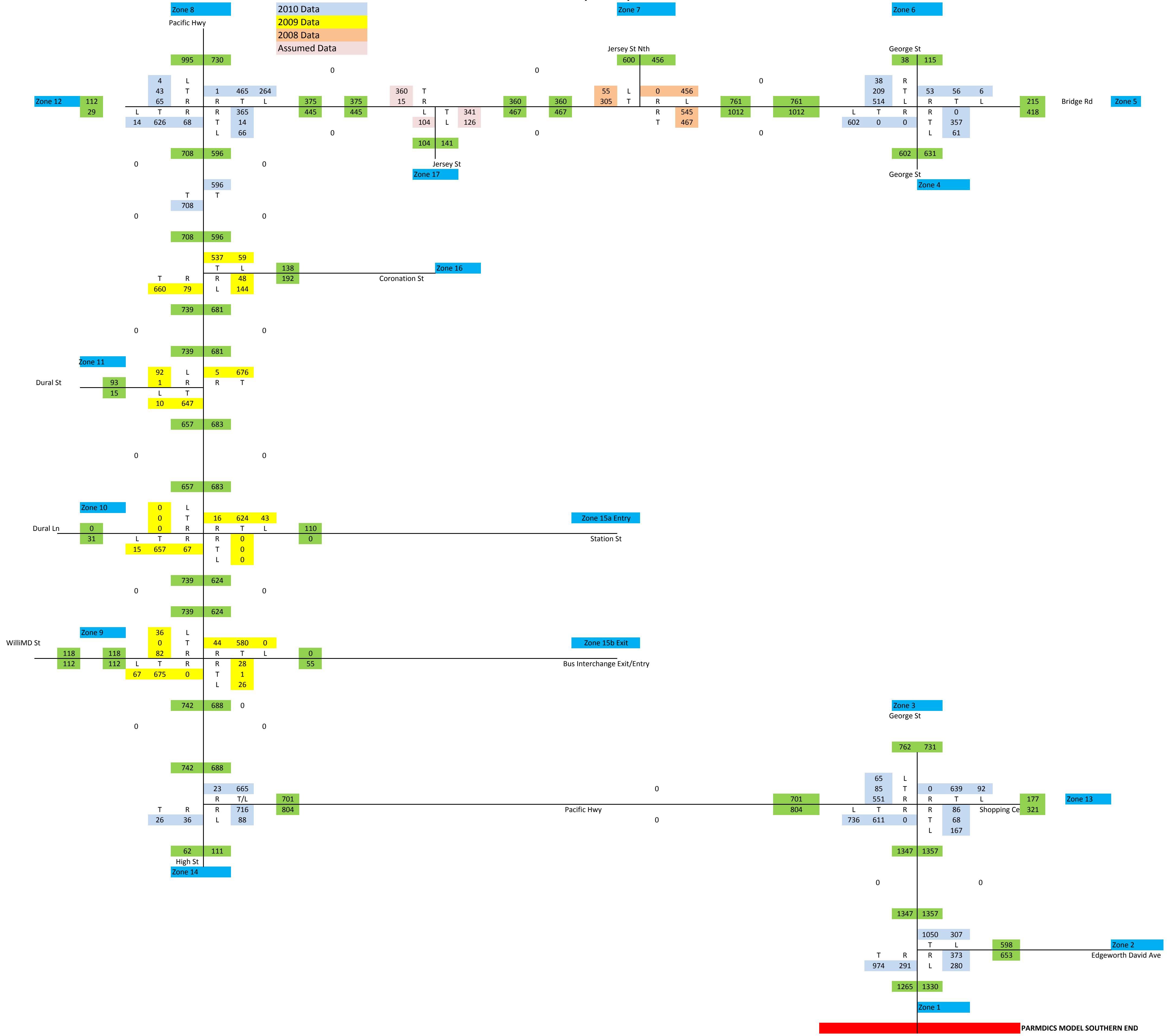
Appendix A

Balanced AM, MD and PM Peak traffic flows

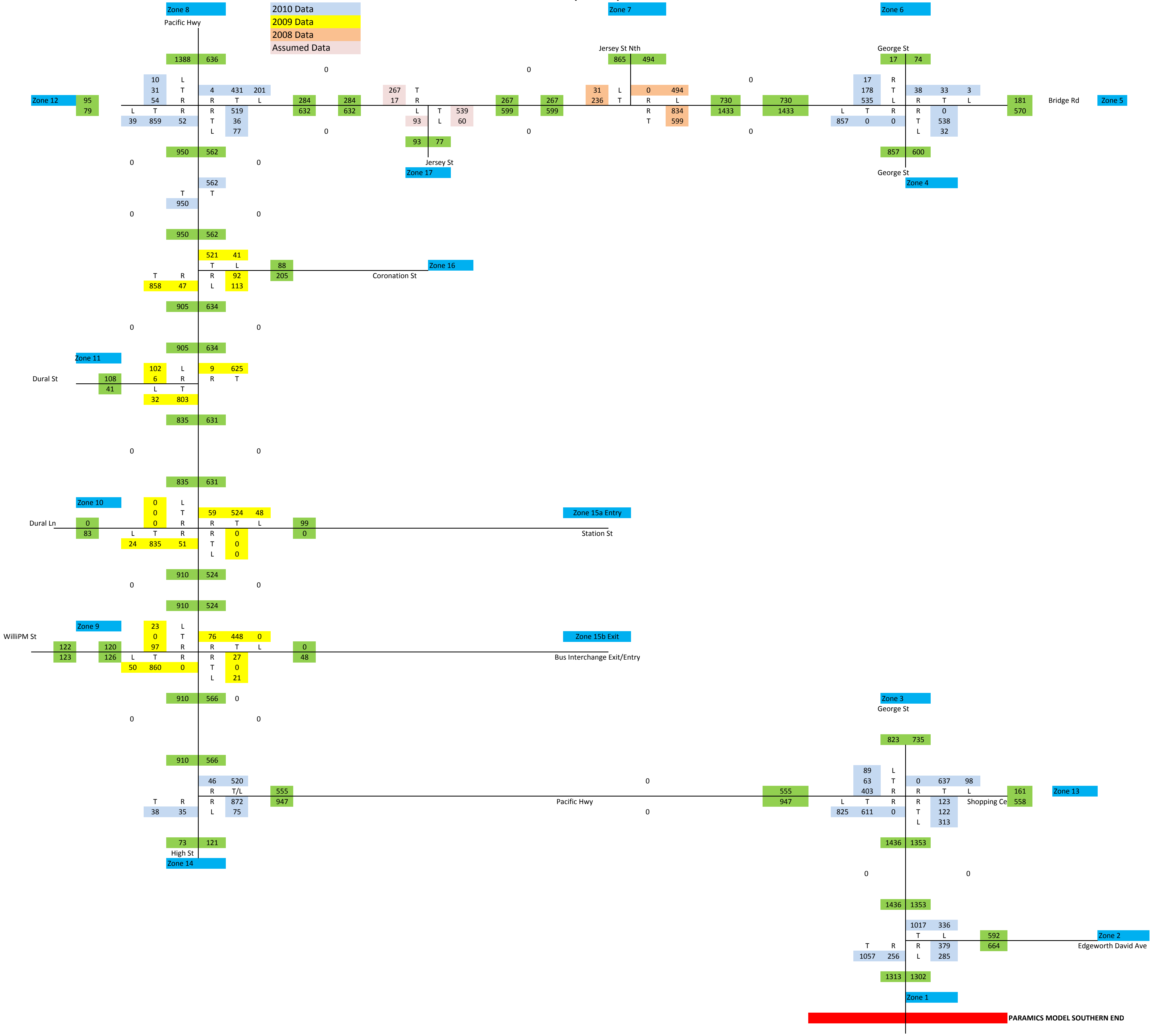
BALANCED AM TRAFFIC COUNTS 7.30AM - 8.30AM



BALANCED MD TRAFFIC COUNTS 3.00PM - 4.00PM (LV+HV)



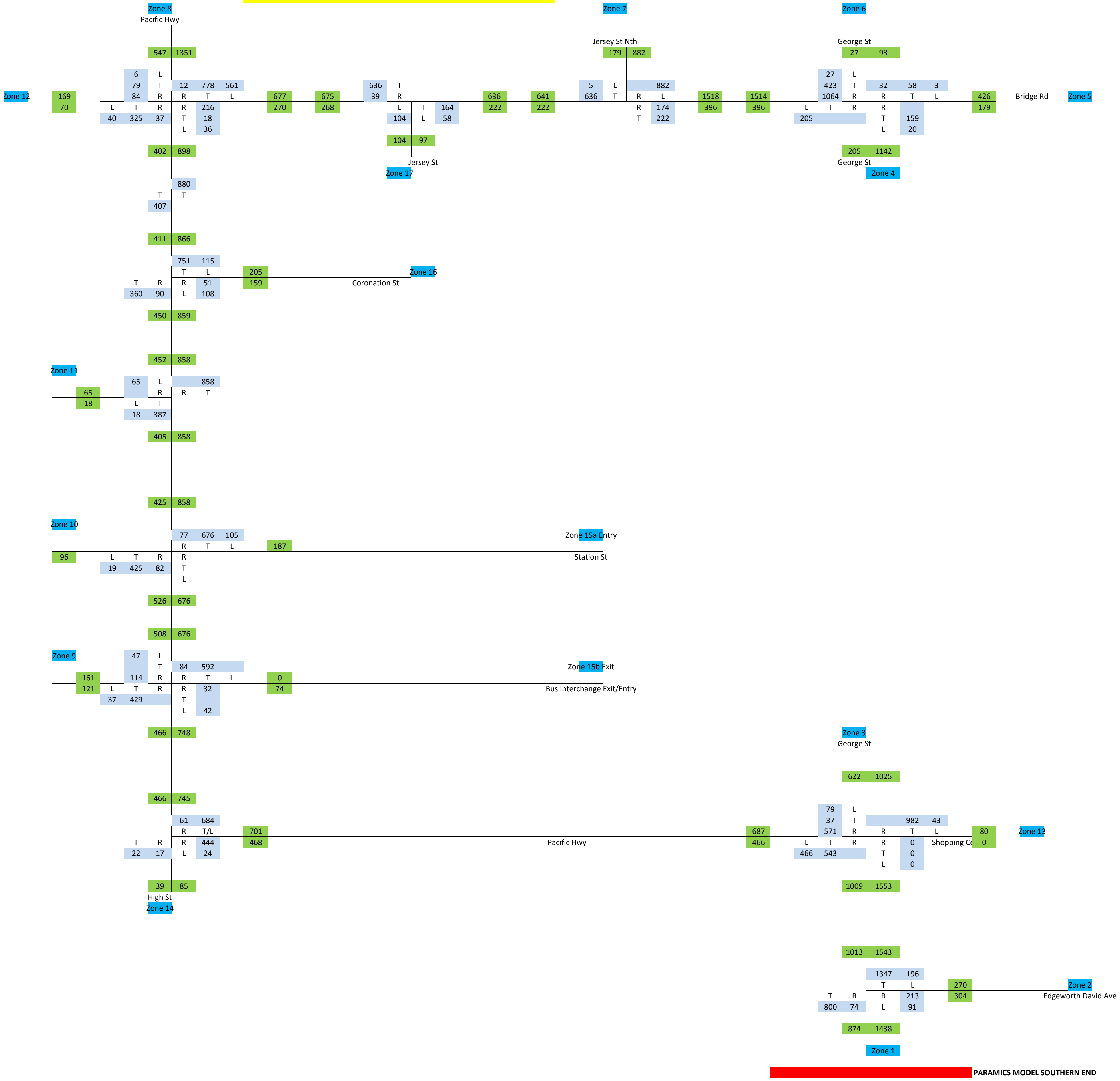
BALANCED PM TRAFFIC COUNTS 5.00PM - 6.00PM (LV+HV)



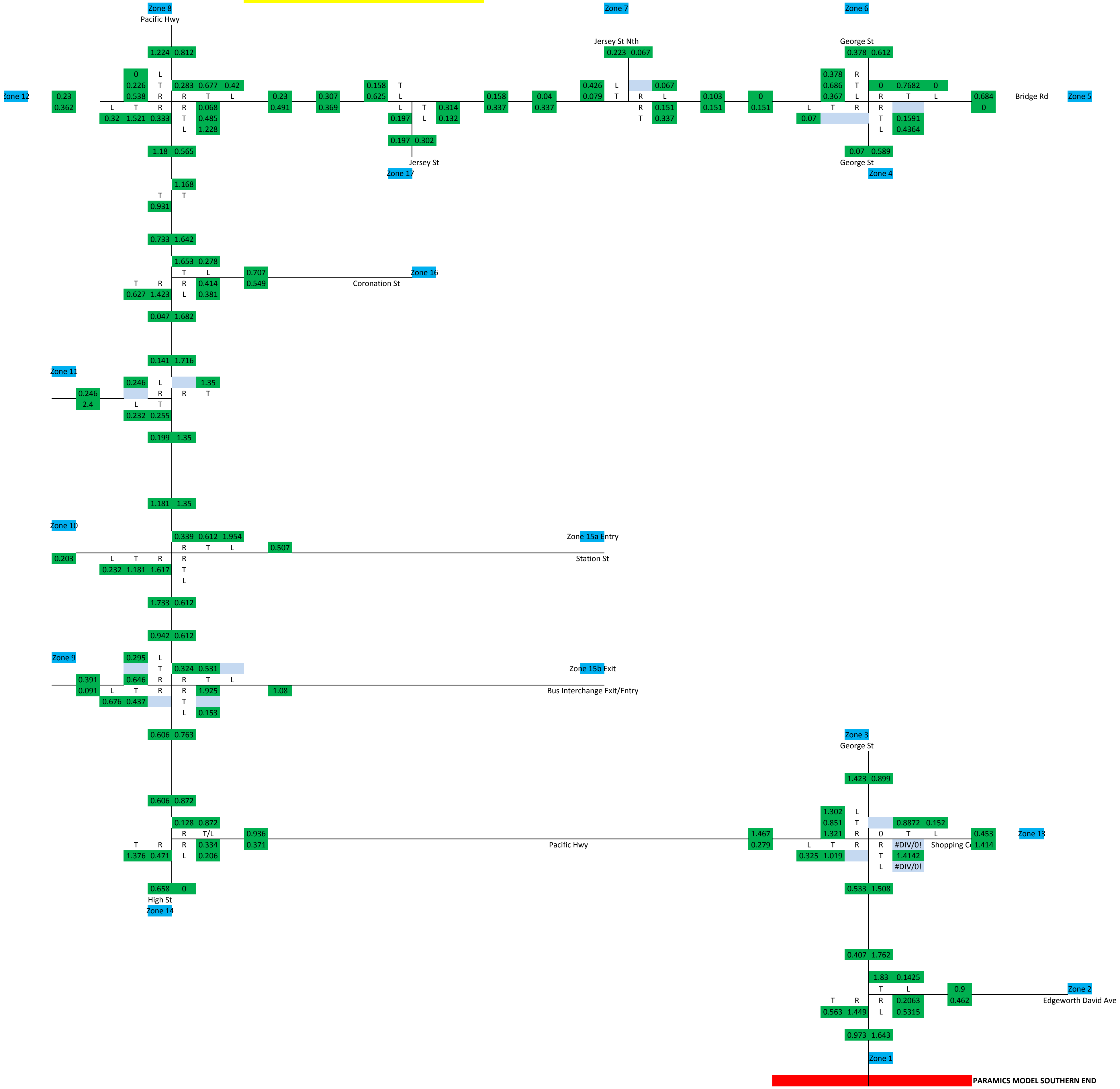
Appendix B

Modelled flows and GEH statistics

2010 Base Modelled Flows AM Peak

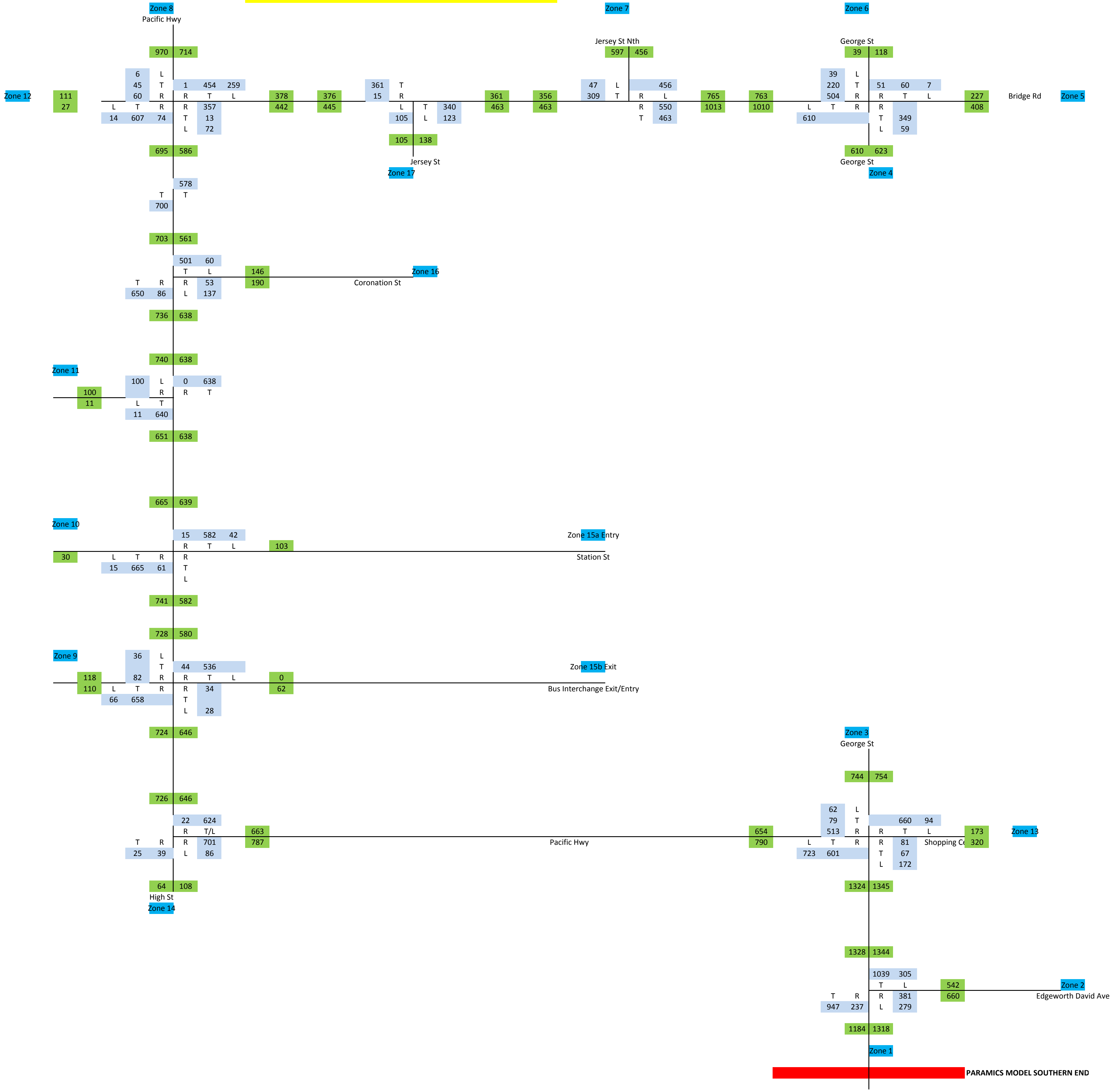


2010 GEH AM Peak

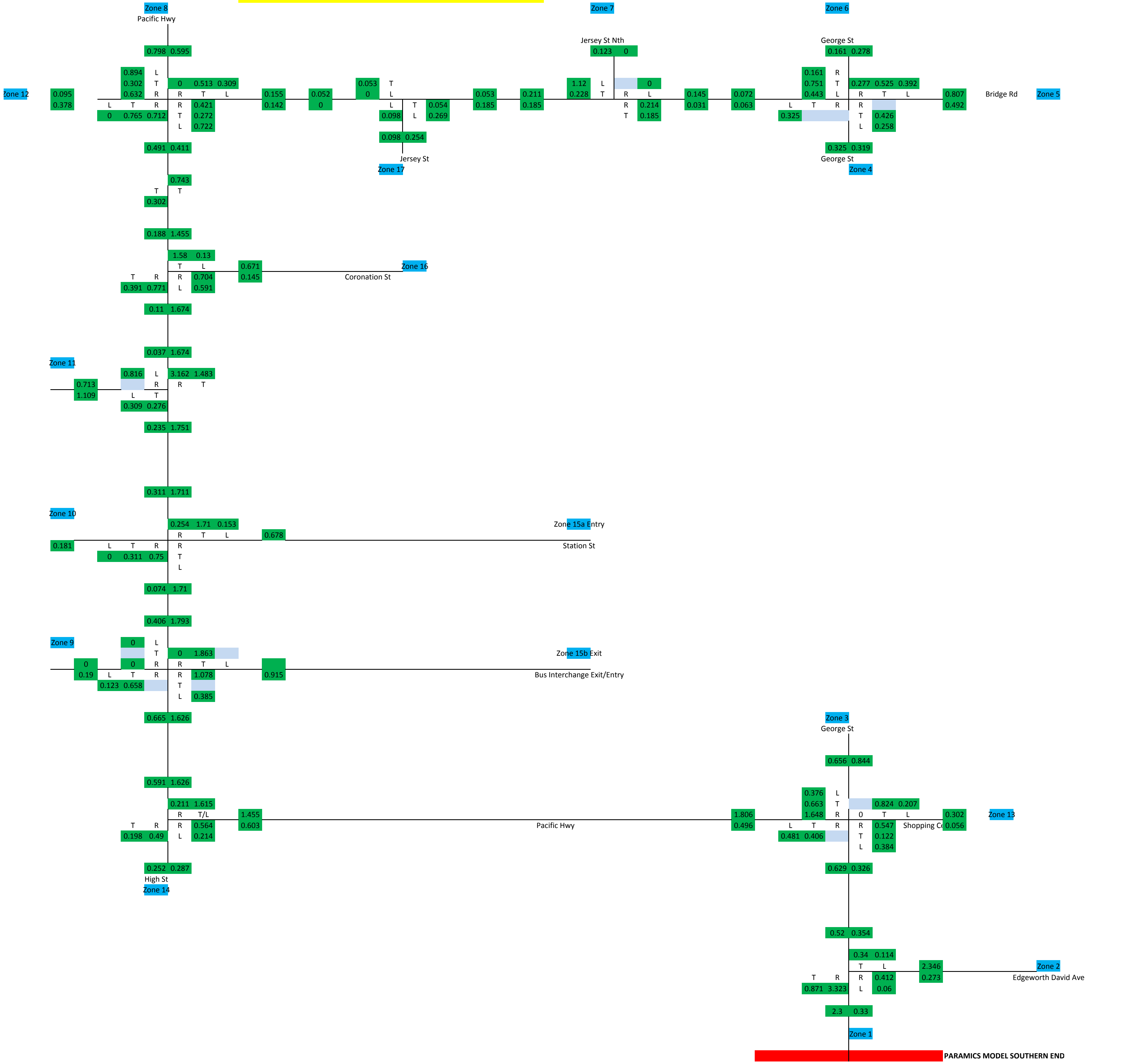


						142	
link	totals	68		intersection	totals	74	
	>2 & <5	4			>2 & <5	3	
	>5	0			>5	0	
	<2	64	94%		<2	71	96%
	<5	68	100%		<5	74	100%
				OVERALL	<2	95%	
					<5	100%	

2010 Base Modelled Flows MD Peak



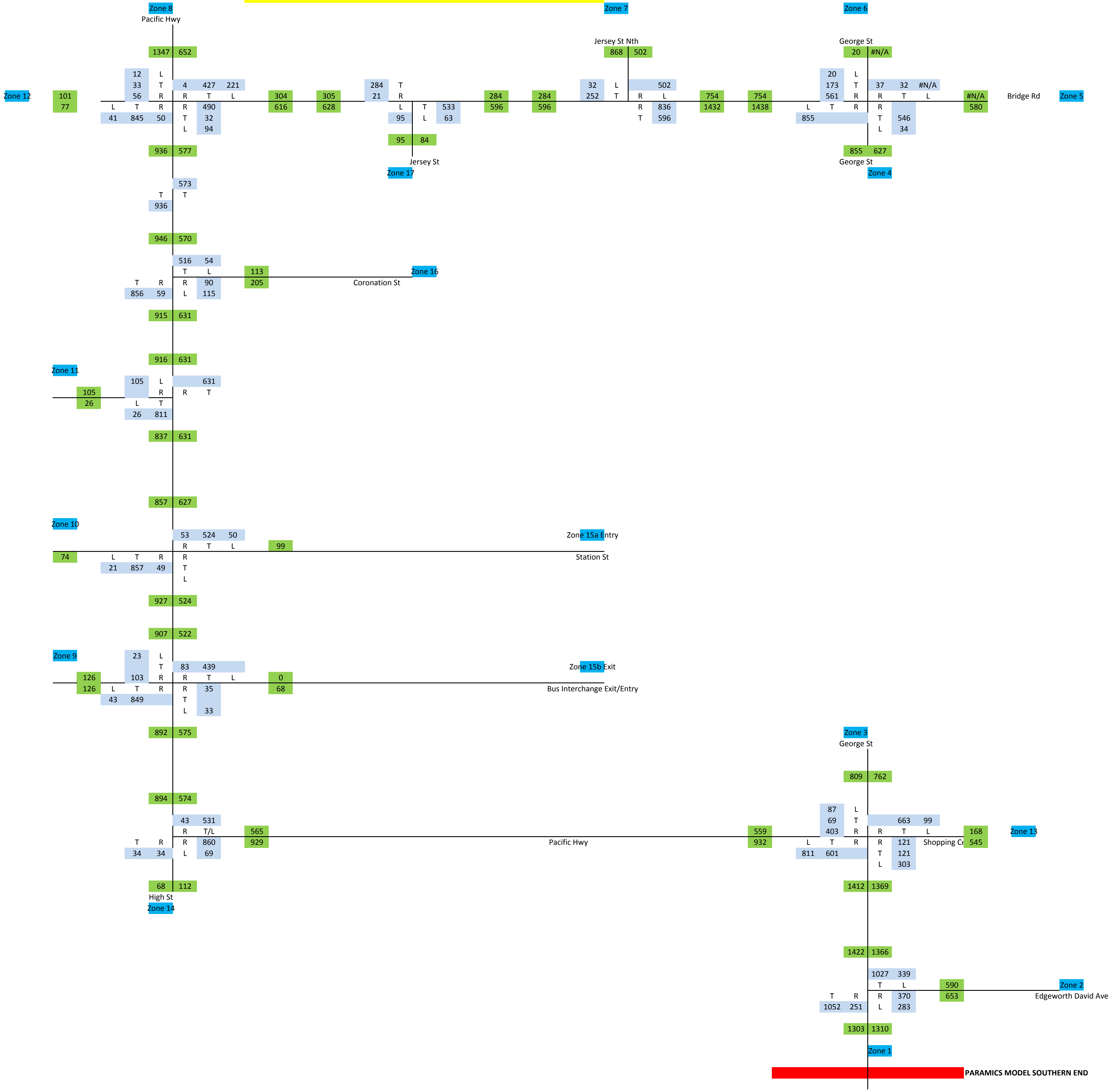
2010 GEH MD Peak



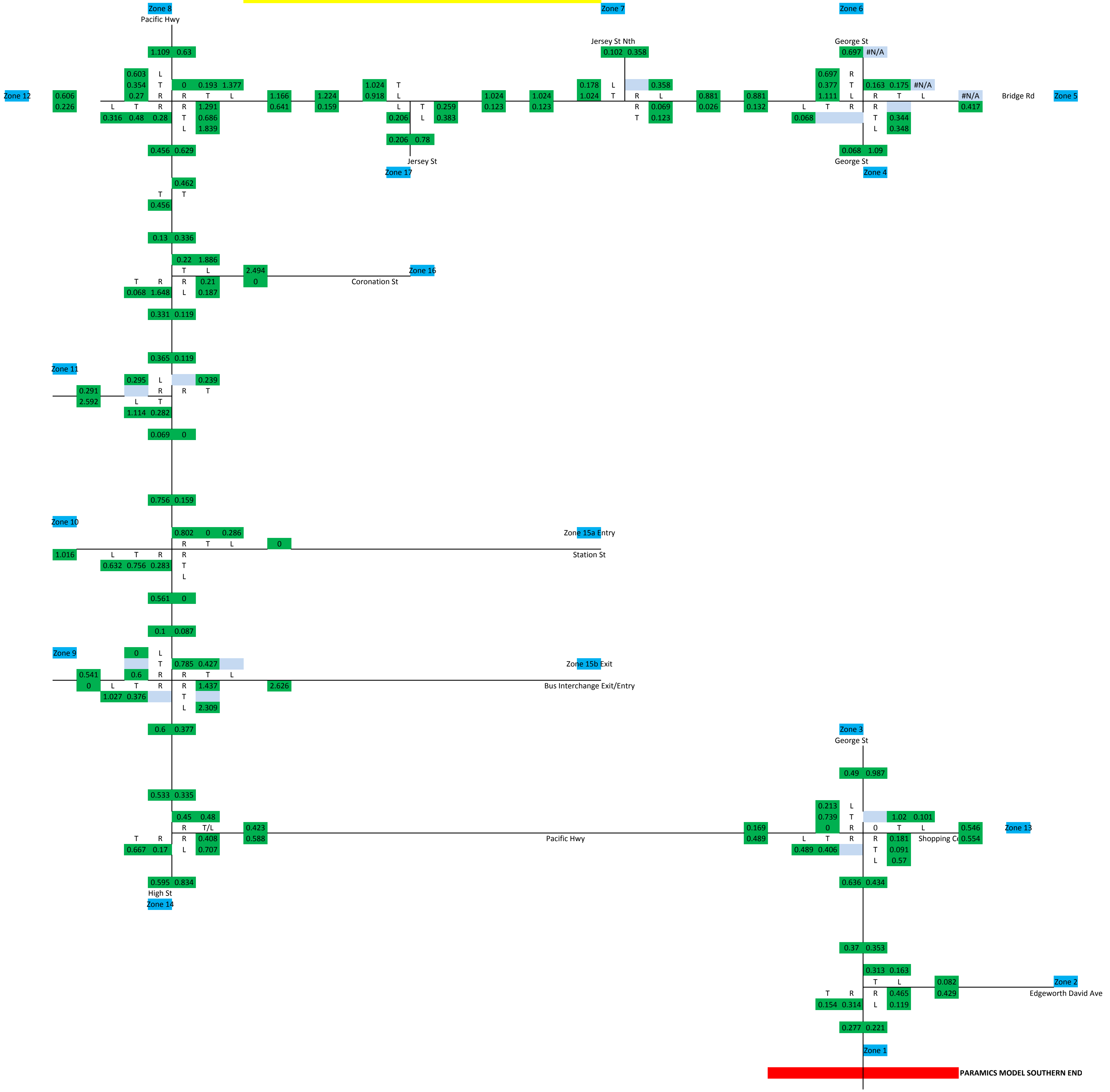
147

link	totals			intersection	totals	
>2 & <5	0			>2 & <5	1	
>5	0			>5	0	
<2	70	100%		<2	76	99%
<5	70	100%		<5	77	100%
			OVERALL	<2	99%	
				<5	100%	

2010 Base Modelled Flows PM Peak



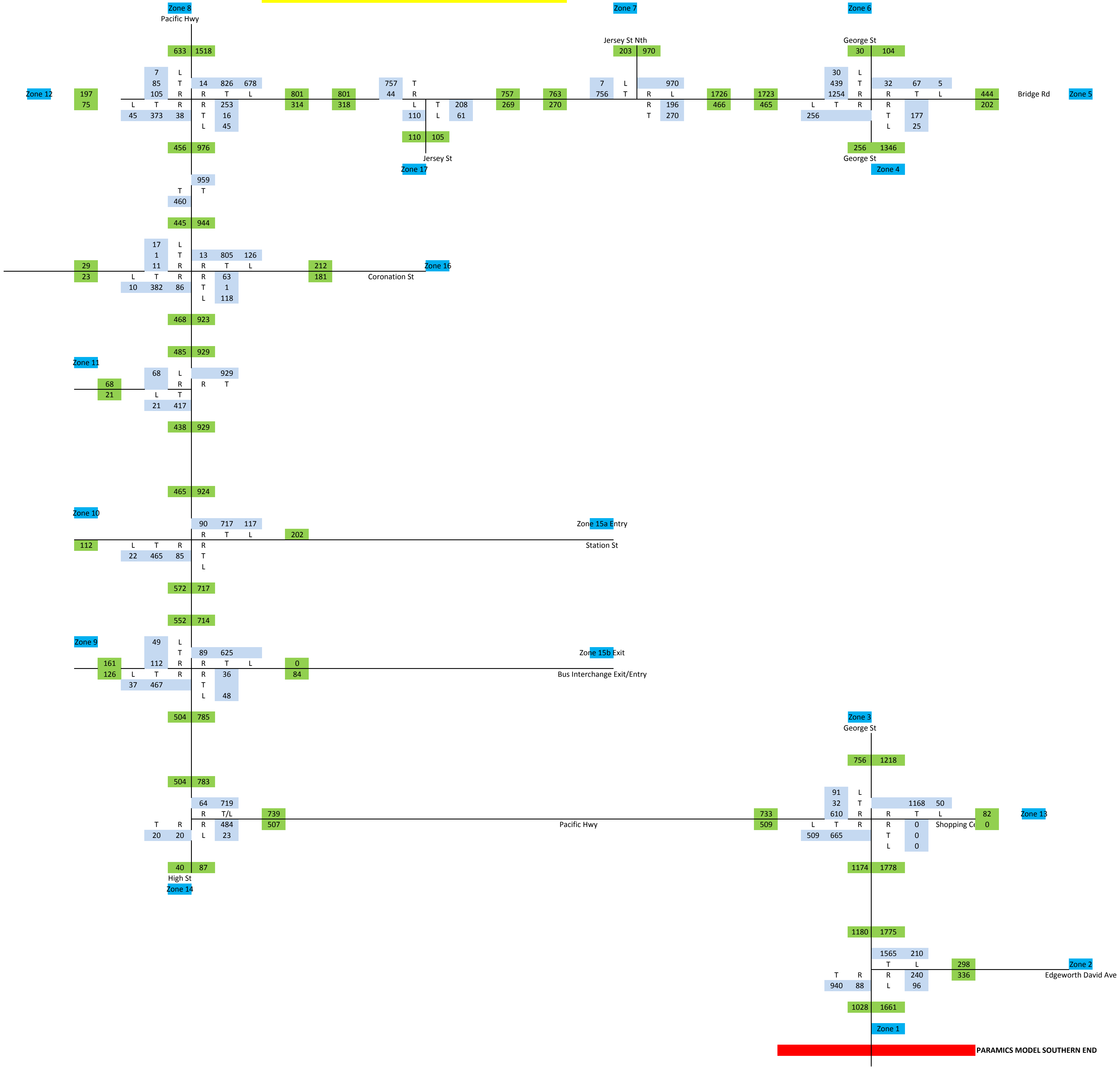
2010 Base GEH PM Peak



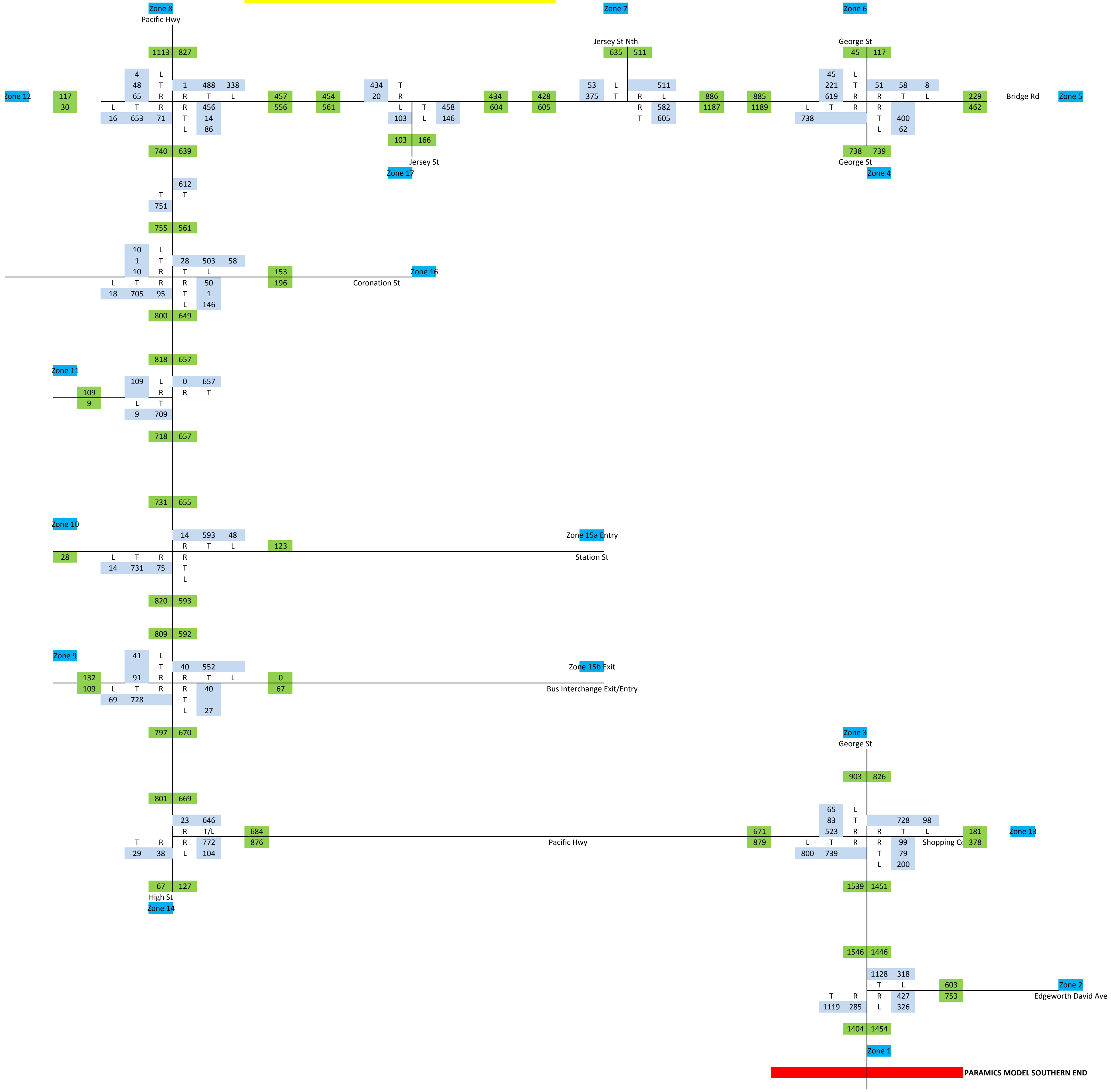
						148	
link	totals	70		intersection	totals	78	
	>2 & <5	2			>2 & <5	2	
	>5	0			>5	0	
	<2	68	97%		<2	76	97%
	<5	70	100%		<5	78	100%
				OVERALL	<2	97%	
					<5	100%	

Appendix C
Future Network Volumes

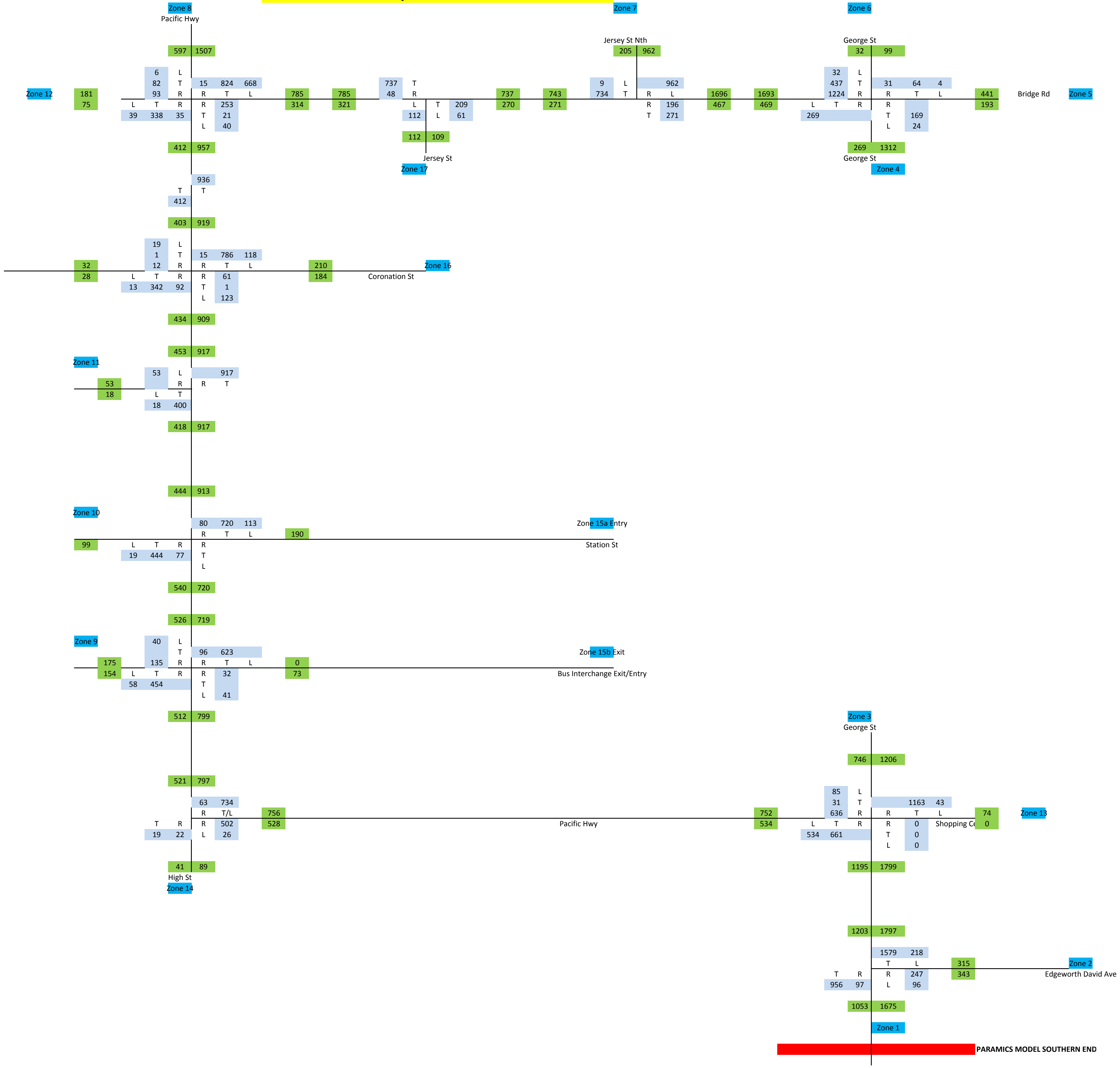
2021 Base Modelled Flows AM Peak



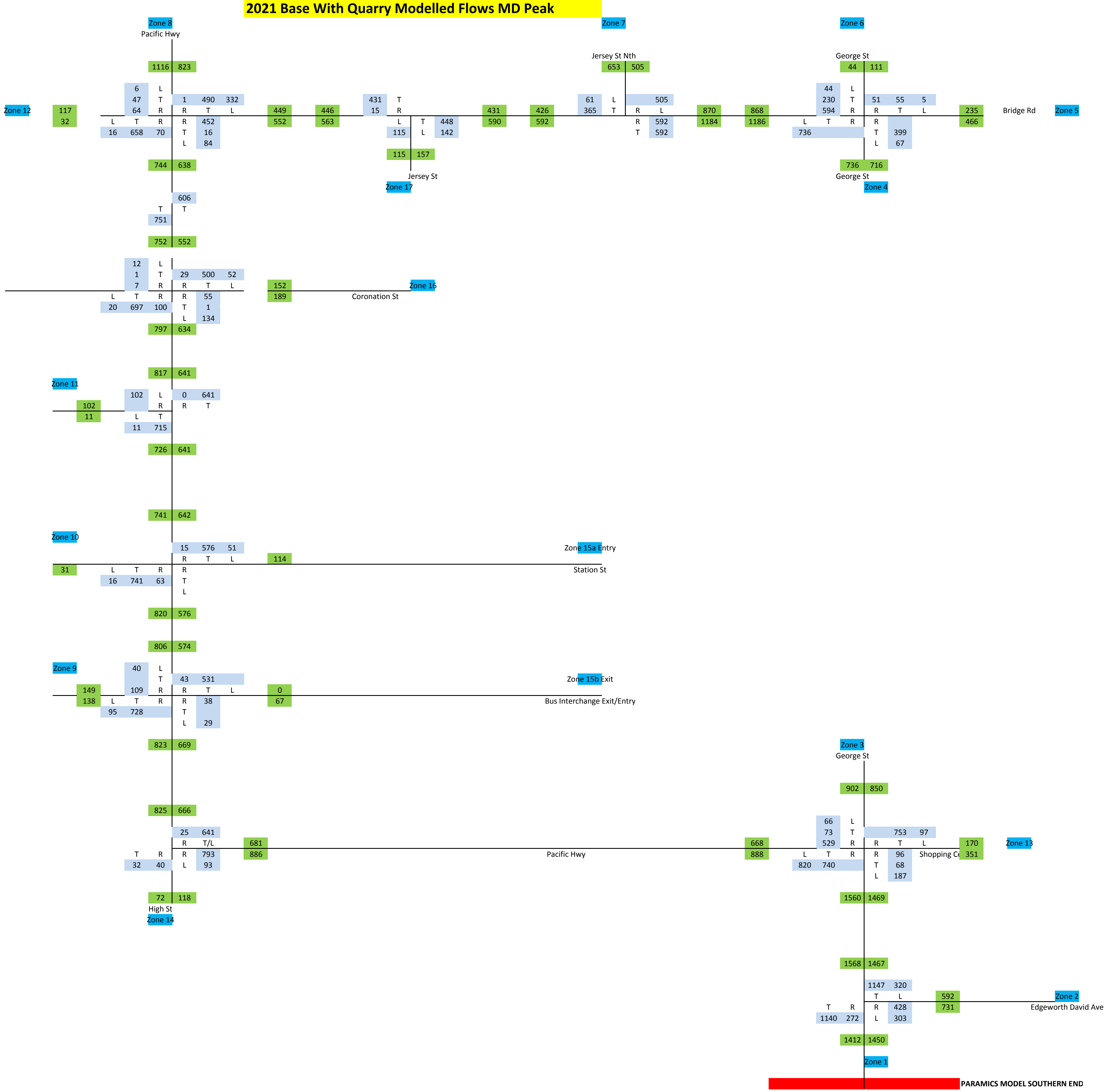
2021 Base Modelled Flows MD Peak



2021 Base With Quarry Modelled Flows AM Peak



2021 Base With Quarry Modelled Flows MD Peak



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Date 12th December 2012

TECHNICAL ADDENDUM
Hornsby Quarry Additional Paramics Modelling; Summary of Findings

1.1 Introduction

This technical addendum has been produced to supplement pervious modelling work undertaken for the Hornsby Quarry Filling project. Previously, we built 2010 models for Hornsby AM and Business Peak (BP) peak hours, calibrated and validated to existing conditions in 2010; we subsequently carried out quarry fill scenario tests to determine the operational possibilities from a traffic perspective, of filling Hornsby Quarry within different timeframes. We discovered that from an operational perspective, Hornsby Quarry could be filled within 8 years based on load and truck data provided to us by Hornsby Shire Council (HSC).

The additional work which we are assessing in this addendum (to the original report) is again based from a 2010 base scenario, and with an 8 year timeframe to fill, but with different access/egress and routing options.

This document summarises the methodology and findings of the additional Paramics modelling undertaken for the greater scope of works outlined as follows:

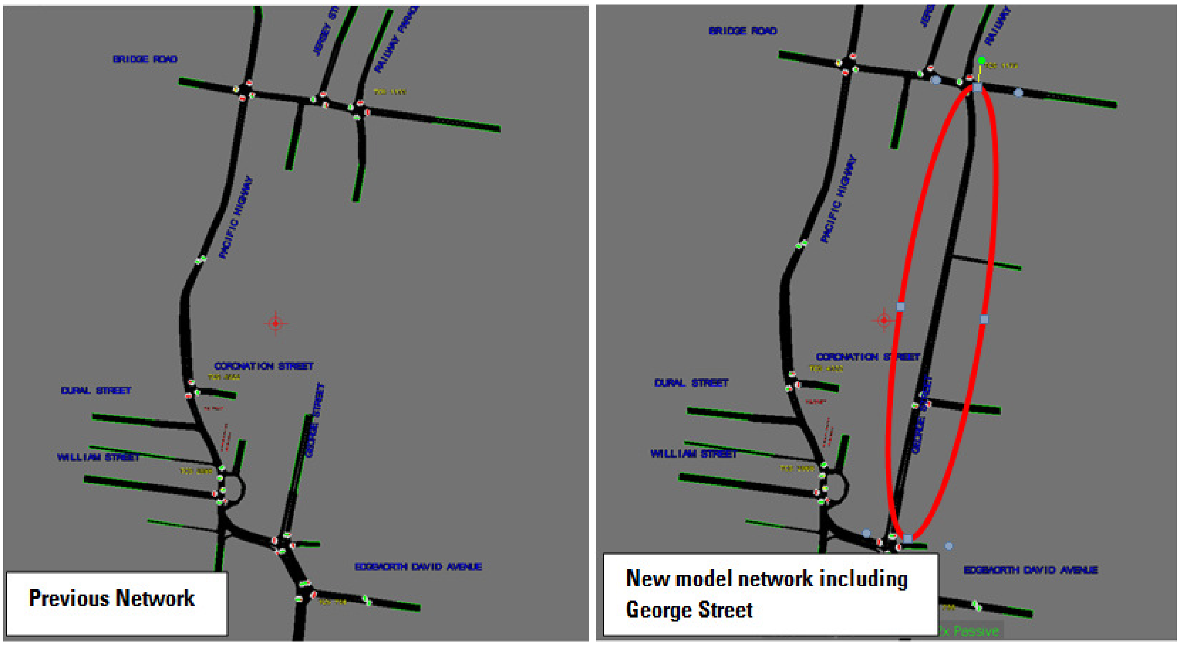
- Development of a new Paramics model network with the coding of George Street in its entirety between Bridge Road and Pacific Highway, to also include the intersections of George Street/Burdett Street and George Street/Linda Street.
- Re calibration the 2010 AM Peak and Business Peak (BP) models, with George Street coded in, to also include the IDM data and intersection counts as received from Hornsby Shire Council (HSC) at the intersections of George Street/Burdett Street and George Street/Linda Street.
- Assessment of three (3) additional entry and exit route options for trucks filling up the Quarry based on an 8 year fill scenario. The 3 options are:
  - Option 1: Entry and Exit from Bridge Road via George Street.
  - Option 2: Entry from William Street via Pacific Highway, Exit from Bridge Road via George Street.
  - Option 3: Entry from Bridge Road via George Street, Exit from William Street via Pacific Highway.

1.2 2010 Base Models – Increased Scope

Following receipt of the IDM data and intersections counts for George Street/Burdett Street and George Street/Linda Street, the new network was developed as shown in Figure 1 which includes George Street connecting Pacific Highway with Bridge Road.

The updated existing models were subsequently re-calibrated to represent average weekday conditions and provide as a base for future models to compare against. Coding up George Street in its entirety introduced route choice into the model which previously didn't exist. We therefore recalibrated the AM and BP models, with route retrofitting to 2010 base year, with route choice in place and exceeding RTA standards.

Figure 1 Network Comparison



1.3 FUTURE MODELLING SCENARIOS

Once the 2010 existing models were qualified as being robust and representative of 2010 road conditions, it was then possible to develop the future 2021 model scenarios to produce representations of the same AM and BP peak hours to test the impacts of the proposal.

For the purposes of this study, the following models were therefore developed:

- Scenario 1 (S1) – Existing AM and BP Models as per June 2010.
- Scenario 2 (S2) – Future 2021 Base AM and BP models (without the quarry traffic).
- Scenario 3 (S3) – Option 1 Future 2021 Base with Quarry Operation Traffic AM and BP models (Entry and Exit from Bridge Road via George Street).
- Scenario 4 (S4) – Option 2 Future 2021 Base with Quarry Operation Traffic AM and BP models (Entry from William Street via Pacific Highway, Exit from Bridge Road via George Street)
- Scenario 5 (S5) – Option 3 Future 2021 Base with Quarry Operation Traffic AM and BP models (Entry from Bridge Road via George Street, Exit from William Street via Pacific Highway).

It is assumed for this study that the proposed operation of the quarry is 7.00am – 5.00pm, Monday to Friday. Survey data has shown that the PM peak period is between 5.00pm – 6.00pm which falls outside the quarry operation hours. Therefore, the AM and BP peak-hour models have been developed for the future scenarios to evaluate the impacts the increased quarry truck movements will have on the road network.

It is envisaged that there will also be quarry infill operations taking place on Saturday mornings between 8am and 12midday. For traffic operations purposes however it was deemed that the week-day morning peak and the business peak are the busier hours during which the quarry infill will take place; the business peak model also includes school traffic which is significant in the Hornsby area. Both the AM and Business peak-hour periods therefore provide worse case scenarios from a traffic and road operations perspective.

1.4 SCENARIO 2 (S2) – Future 2021 Base Models

1.4.1 Model Network

The 2021 base model network has included the following future upgrade works:

- New western leg at Pacific Highway/Coronation Street for access into Hornsby Aquatic Centre.
- Signalised intersection of George Street/Linda Street.

1.4.2 Background Growth

The traffic flows used in the future 2021 base models were derived from growth factors based on the estimated resident population by travel zone (TZ) in 2006 and the NSW Government Bureau of Transport Statistics (formerly Transport Data Centre) employment forecasts provided by Council for each Paramics zone as shown in Table 1.

With the forecast rates as a guide, the demands from each zone are factored up based on the average percentage increase from the estimated resident population and employment forecasted figures. Table 1 has indicated that the growth factor for each individual zone is approximately 9% - 13% with a few outliers. The average for the shire is 6.4%.

In addition to the background growth, the future base models have also included trips generated from the Hornsby Aquatic Centre.

Table 1 Forecast Growth Rates for Residential and Employment in 2021

Paramics Zone #	Location	Estimated Resident Population (ERP) by TZ2006 (Total persons)			TDC Employment Forecasts (October 2009 Release)			Average % Increase
		2010	2021	%	2010	2021	%	
Zone 1	Pacific Highway (South end of model)	93,260	101,724	109.1%	19,885	22,588	113.6%	11.3%
Zone 2	Edgeworth David Avenue	10,205	12,397	121.5%	4,525	4,957	109.5%	15.5%
Zone 3	George Street (access/egress at Pacific Highway)	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%
Zone 4	George Street (access/egress at Bridge Road)	110	120	109.6%	975	1,078	110.5%	10.1%
Zone 5	Bridge Road (east side of model)	1,758	2,069	117.7%	2,322	2,529	109.0%	13.3%
Zone 6	Railway Parade	2,846	2,888	101.5%	495	495	100.2%	0.8%
Zone 7	Jersey Street (north side of Bridge Road)	21,332	24,100	113.0%	5,003	5,527	110.5%	11.7%
Zone 8	Pacific Highway (North end of model)	21,396	23,555	110.1%	7,141	7,917	110.9%	10.5%
Zone 9	William Street	10,588	11,539	109.0%	3,708	4,218	113.7%	11.4%
Zone 10	Dural Lane	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%
Zone 11	Dural Street	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%
Zone 12	Bridge Road (west side of model)	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%
Zone 13	Westfield access/egress	165	204	123.4%	5,162	5,724	110.9%	17.2%
Zone 14	High Street	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%
Zone 15	Station Street	110	120	109.6%	975	1,078	110.5%	10.1%
Zone 16	Coronation Street	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%
Zone 17	Jersey Street (south side of Bridge Road)	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%
Zone 18	Ashley Lane	based on avg for shire		106.4%	based on avg for shire		112.3%	9.3%

1.5 SCENARIOS 3 – 5 – Future 2021 Models with Quarry Infill Operations

1.5.1 Model Network

For scenarios 3 – 5, the 2021 With Quarry Operation model consists of the same model network as that for the 2021 base. The difference between each scenario is the ingress and egress routes of quarry trucks as described in Section 1.2. It is assumed that all quarry vehicles arrive from and return to the south of the model for each option.

1.5.2 Quarry Demands

Based on relevant assumptions for the quarry operation, Council estimated the proposed number of truck loads per hour in and out of the quarry site depending on the number of years it takes to fill up the quarry. Table 2 provides a summary of the quarry trucks required for each year scenario.

The key assumptions are:

- Weekday Operation Hours: 7am-5pm Monday to Friday.
- Saturday Operation Hours: 8am-12 midday.
- The quarry requires 4.3 million m^3 to fill.
- Vehicles will carry an average load of approximately 12 m^3 when compacted.
- 75% efficiency factor to take the downtime at the quarry and at the material supply location into consideration.
- To provide for a worse case modelling scenario in the future, all trucks involved in the quarry infill in the model have been assumed to be semi-articulated. While there will be smaller trucks involved in the actual quarry fill, using only semi-articulated trucks in the model has provided for a worst case scenario in terms of junction and road capacities, as these types of trucks require more space and time to make a turn. The delays experienced by other road users in the model, as a result of the quarry infill, are therefore likely to be higher in the model than the delays that will actually eventuate.

Table 2 Number of Quarry Trucks required for each scenario

Quarry Filling

4,300,000 cubic metres

Hours of operation	7 am to	5 pm	10 hours	Mon - Fri	50	hours/week
	8 am to	12 pm	4 hours	Sat	4	hours/week
					54	hours/week
					50	weeks/annum
Average load size	25 tonnes					
Average density of material	1.6 tonnes/cubic metre (loose)					
	15.6 cubic metres/load (loose)			Efficiency factor	75%	downtime for both quarry and material supply
Bulking factor 0.75	11.7 cubic metres/load (compacted)					

Years to fill	Cubic metres / annum	Loads / annum	Loads / hour	Loads / hour Adjusted for efficiency factor	Average time between loads (minutes)
1	4,300,000	366,933	136	181	0.3
2	2,150,000	183,467	68	91	0.7
3	1,433,333	122,311	45	60	1.0
4	1,075,000	91,733	34	45	1.3
5	860,000	73,387	27	36	1.7
6	716,667	61,156	23	30	2.0
7	614,286	52,419	19	26	2.3
8	537,500	45,867	17	23	2.6
9	477,778	40,770	15	20	3.0
10	430,000	36,693	13.6	18	3.3
11	390,909	33,358	12.4	16	3.6
12	358,333	30,578	11.3	15	4.0
13	330,769	28,226	10.5	13.9	4.3
14	307,143	26,210	9.7	12.9	4.6
15	286,667	24,462	9.1	12.1	5.0
16	268,750	22,933	8.5	11.3	5.3
17	252,941	21,584	8.0	10.7	5.6
18	238,889	20,385	7.6	10.1	6.0
19	226,316	19,312	7.2	9.5	6.3
20	215,000	18,347	6.8	9.1	6.6
21	204,762	17,473	6.5	8.6	7.0
22	195,455	16,679	6.2	8.2	7.3
23	186,957	15,954	5.9	7.9	7.6
24	179,167	15,289	5.7	7.6	7.9
25	172,000	14,677	5.4	7.2	8.3
26	165,385	14,113	5.2	7.0	8.6
27	159,259	13,590	5.0	6.7	8.9
28	153,571	13,105	4.9	6.5	9.3
29	148,276	12,653	4.7	6.2	9.6
30	143,333	12,231	4.5	6.0	9.9
31	138,710	11,837	4.4	5.8	10.3
32	134,375	11,467	4.2	5.7	10.6
33	130,303	11,119	4.1	5.5	10.9
34	126,471	10,792	4.0	5.3	11.3
35	122,857	10,484	3.9	5.2	11.6
36	119,444	10,193	3.8	5.0	11.9
37	116,216	9,917	3.7	4.9	12.3
38	113,158	9,656	3.6	4.8	12.6
39	110,256	9,409	3.5	4.6	12.9
40	107,500	9,173	3.4	4.5	13.2

1.5.3 Previous Modelling Analyses

Previous modelling works undertaken for this project includes progressive testing with different quarry year scenarios starting by assuming that the quarry will take 5 years to fill, with 36 trucks travelling in each direction from the quarry to F3 at Wahroonga.

Visual testings for 5 – 10 years have been undertaken for the AM and BP models to analyse the operation of the model. The results indicate:

- 5 & 6 years scenario – significant delays within the road network.
- 7 years scenario – congested at certain road sections but has potential for road network to operate with acceptable delays.
- 8 – 10 years scenario – good operation within the road network with some operational queuing.

Once the visual analyses were carried out on the infill scenarios over the 5 to 10 year range, a preferred option emerged which gave a minimum timeframe for quarry fill, which was then subject to more detailed quantitative analysis. This **minimum timeframe option**, which the analysis was undertaken for is **the 8 Year infill scenario**. The analysis was undertaken to determine the performance of the road network with the number of trucks required for an 8 year scenario infill, and compared to the 2010 and 2021 future scenarios for performance.

In the previous modelling tests, the 8 year scenario assumed 23 trucks per hour entering and leaving the site via William Street, giving a total of 46 trucks per hour.

1.6 SUMMARY OF MODEL FINDINGS FOR ADDITIONAL TESTS

The following sections summarises the outcomes of the additional model options tests for 2021, with an 8 year quarry infill timeframe:

1.6.1 2021 Future Base Model – No Quarry Operation

- Long queue lengths are experienced by southbound traffic on Pacific Highway between Edgeworth David Avenue and Bridge Road
- The intersections of Pacific Highway/George Street and Pacific Highway/Edgeworth David Avenue are operating close to their capacities.
- George Street is operating satisfactorily with some apparent spare capacity.

1.6.2 2021 Future Base Model + Quarry Operation Option 1 – Entry and Exit on Bridge Road via George Street

- Additional delays were experienced by northbound vehicles at Pacific Highway/Edgeworth David Avenue with the addition of the quarry trucks, but did not have a significant impact of the overall road network operation.
- This is largely due to the spare capacities available on Bridge Road and George Street to accommodate the additional truck movements in the peak hour. Overall network operation is relatively similar to 2021 Future Base Model.
- The long queuing due to the future year southbound traffic on Pacific Highway remains.

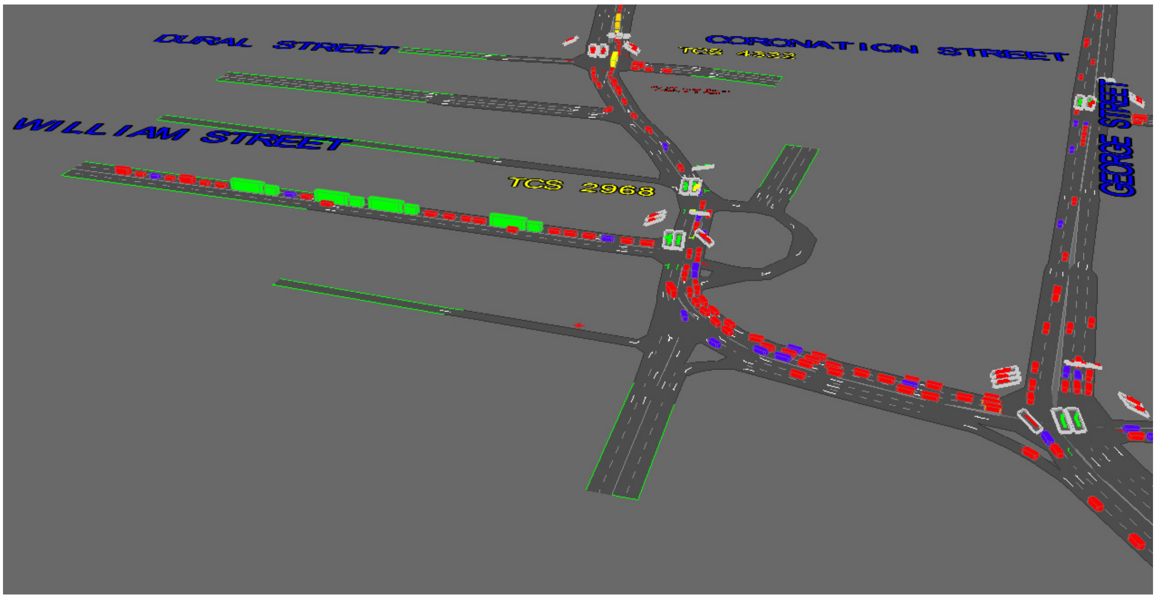
1.6.3 2021 Future Base Model + Quarry Operation Option 2 – Entry from William Street via Pacific Highway, Exit from Bridge Road via George Street

- Similar operation with Option 1 with additional delays experienced by northbound vehicles on Pacific Highway approaching Edgeworth David Avenue. The additional quarry trucks did not have a significant impact of the overall road network compared to the future base model.
- The additional quarry trucks entering via William Street did not have a significant impact of the traffic operation on Pacific Highway between George Street and William Street.
- The long queues due to the future southbound traffic on Pacific Highway remains.

1.6.4 2021 Future Base Model + Quarry Operation Option 3 – Entry from Bridge Road via George Street, Exit from William Street via Pacific Highway

- Additional delays are experienced by northbound vehicles at Pacific Highway/Edgeworth David Avenue with the addition of quarry trucks via Bridge Road, but as with Option 1, did not have a significant impact of the overall road network operation.
- The additional trucks exiting the quarry from William Street do cause some additional delays and queuing to the southbound traffic on Pacific Highway, resulting in queues extending back to Bridge Road for southbound vehicles as shown in Figure 2. Although these do clear, this option causes trucks to queue back along William Street with insufficient green time to release the right turning vehicles onto Pacific Highway.

Figure 2 Option 3 - Queues along Pacific Highway Southbound & William Street



1.7 Vehicle Flows (Junction Inputs)

Vehicle flows were extracted from all models for each arm of the major junctions in the model. These were then compared against each other for each junction across all models.

Table 3 Colour coding for newly modelled scenarios

No.	Scenario Description
S1	2010 Base Model
S2	2021 Base Model
S3	2021 Base + Option 1 (In & Out Bridge St)
S4	2021 Base + Option 2 (In William St / Out Bridge St)
S5	2021 Base + Option 3 (In Bridge St / Out William St)

An **important note** to be aware of with the comparisons in this 2012 addendum, and with those in the previous report for the 2010 base modelling (and so the previous options tests), is that changes have been made to the model network between then and now.

Previously, the Paramics model was built for Pacific Highway as the main route under assessment, as it was determined that the access to and from the quarry for infill purposes would be via Pacific Highway, and the preferred route was subsequently ascertained to be the route in and out via William Street along Pacific Highway.

Since those previous tests, Council decided that using George Street as a route via Bridge Street as an ingress and/or egress option warranted testing as it might provide an viable alternative when compared to previous tests from an operations perspective.

Given that George Street was not previously modelled as a through route between Bridge Street and Pacific Highway, it was required that we introduce George Street into an updated version of the model as a through route, and this is the context of the most recent options tests as reported here (Options 1, 2 and 3). This required a route choice model to be built and compared to an older model which was not a route choice model.

Given that this is not mathematical modelling, rather it is stochastic modelling with perturbation (variance as to which route is chosen by each vehicle); it is normal for there to be slight differences at the network locations where route choice has been introduced in the new tests.

By slight differences we are referring to less than 5%, and by 'points of route choice' we refer to the Pacific Highway / Bridge Street intersection; the Bridge Street / George Street intersection and Pacific Highway / George Street intersection. This means variance of anything less than 50 vehicles per 1,000 in an hour at a point of route choice is normal, as given traffic conditions it would be expected for this to happen at almost any location in any city during the peak hour depending on the traffic volumes and traffic signal timings.

Similarly with route choice introduced into the new model and with the slight variances that inevitably result due to the stochastic and variable nature of route choice models, the signal timings on Pacific Highway have been moderately altered to cater for the variable flows. For example, at locations such as Pacific Highway / William Street where southbound traffic may have previously required 60% of the green time, that might reduce to 58%

to balance out the system under route choice conditions and so the numbers of turners getting through may reduce or increase accordingly. Again these are normal adjustments when going from a fixed route model to a route choice model.

Following therefore are robust volumes based on the newly modelled flows, with route choice in place and with Bridge Street (via George) introduced as a potential route for the quarry infill process. Figure 3 to Figure 10 present the AM peak hour volumes, and Figure 11 to Figure 18 presents the BP peak hour volumes.

Table 4 Colour Coding for All Modelled Scenarios

No.	Scenario Description
S1	2010 Base Model
S2	2021 Base Model
S3	2021 Base + Option 1
S4	2021 Base + Option 2
S5	2021 Base + Option 3

1.7.1 AM Peak – Total Vehicles

Figure 3 AM Peak Volumes (veh/hr) - Pacific Highway/Edgeworth David Avenue

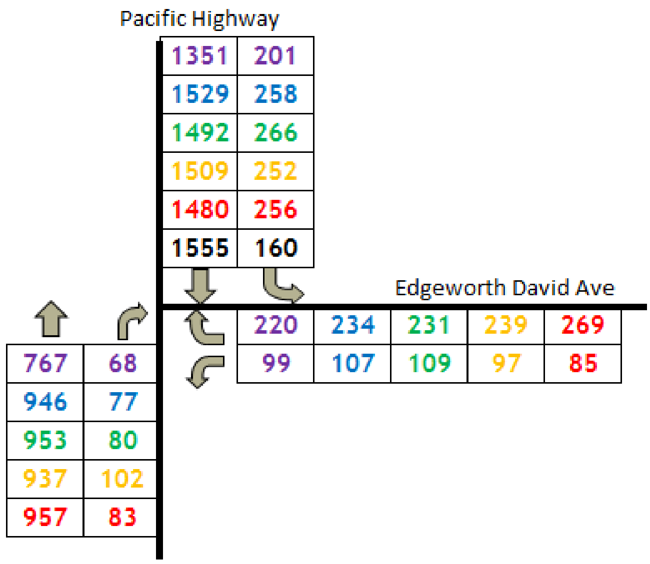


Figure 4 AM Peak Volumes (veh/hr) - Pacific Highway/George Street/Shopping Access

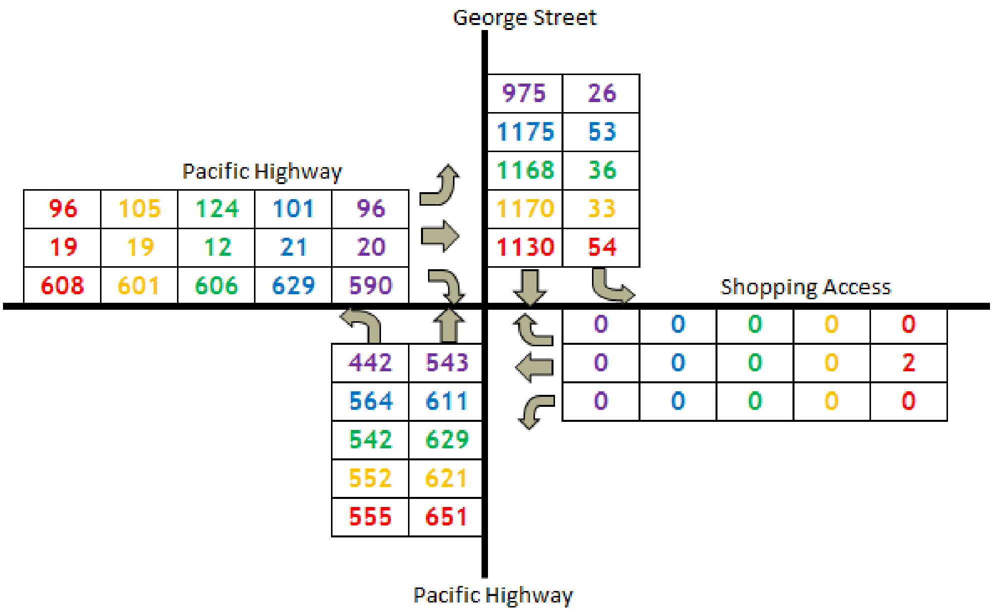
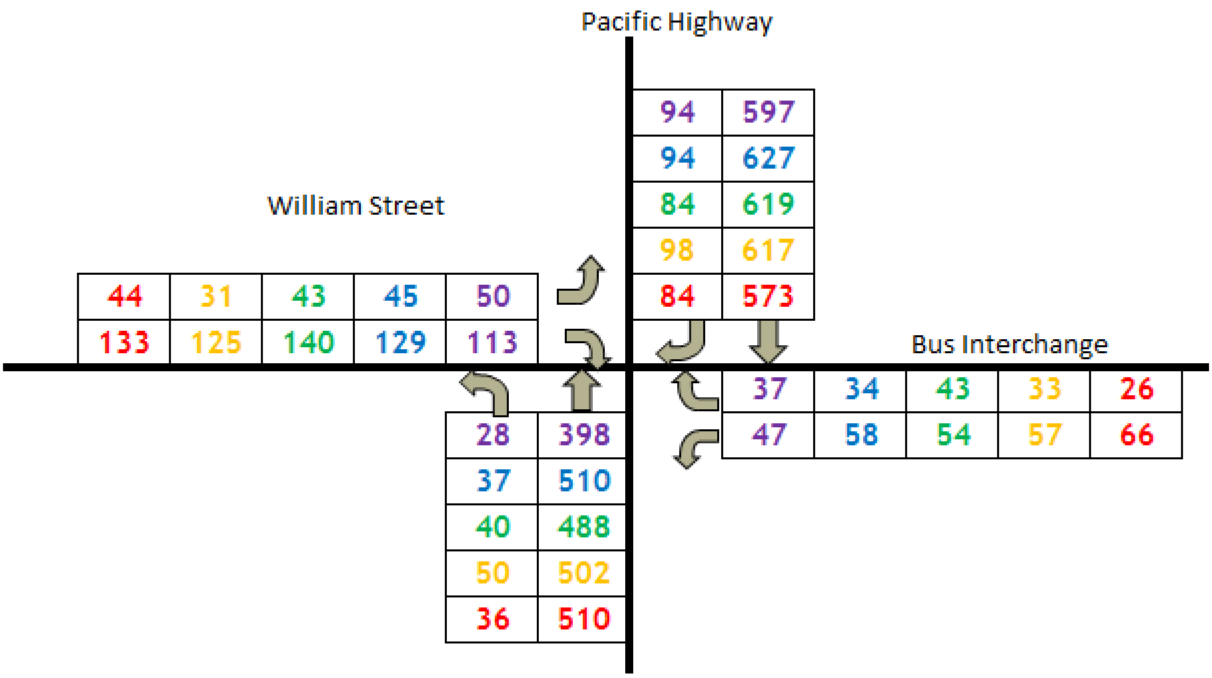


Figure 5 AM Peak Volumes (veh/hr) - Pacific Highway/William Street



No.	Scenario Description
S1	2010 Base Model
S2	2021 Base Model
S3	2021 Base + Option 1
S4	2021 Base + Option 2
S5	2021 Base + Option 3

Figure 6 AM Peak Volumes (veh/hr) - Pacific Highway/Station Street

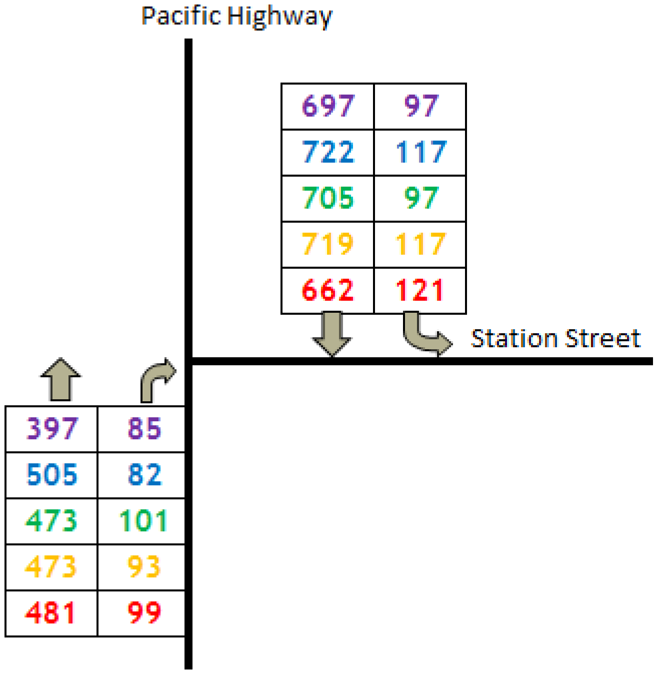
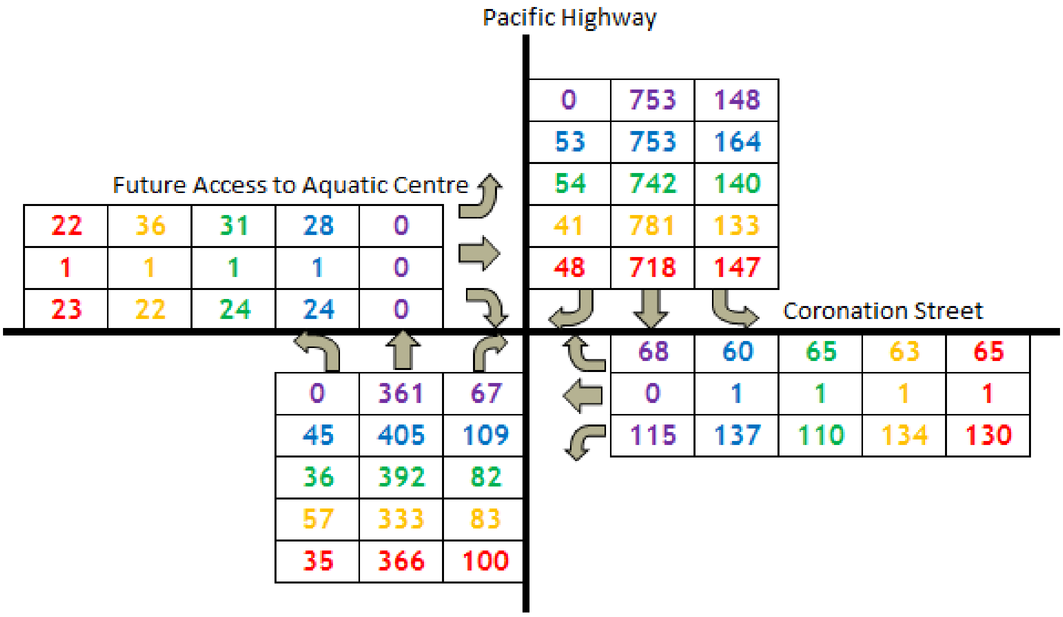


Figure 7 AM Peak Volumes (veh/hr) - Pacific Highway/Coronation Street/Aquatic Centre



No.	Scenario Description
S1	2010 Base Model
S2	2021 Base Model
S3	2021 Base + Option 1
S4	2021 Base + Option 2
S5	2021 Base + Option 3

Figure 8 AM Peak Volumes (veh/hr) – George Street/Railway Parade/Bridge Road

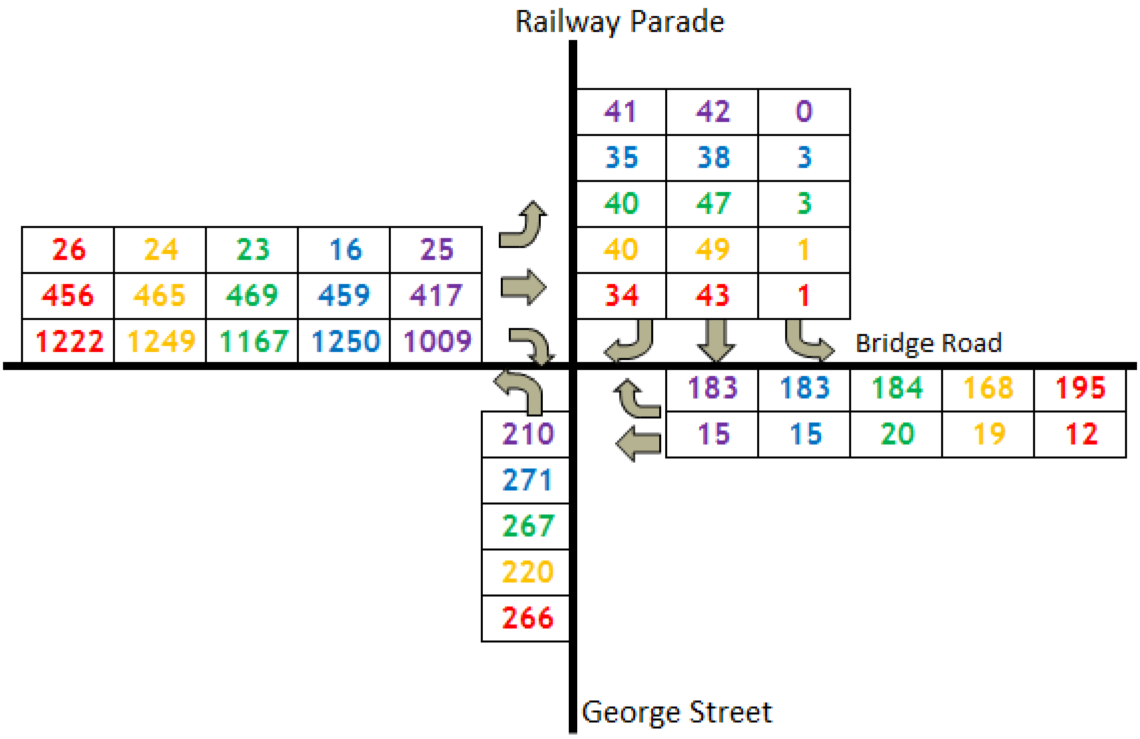
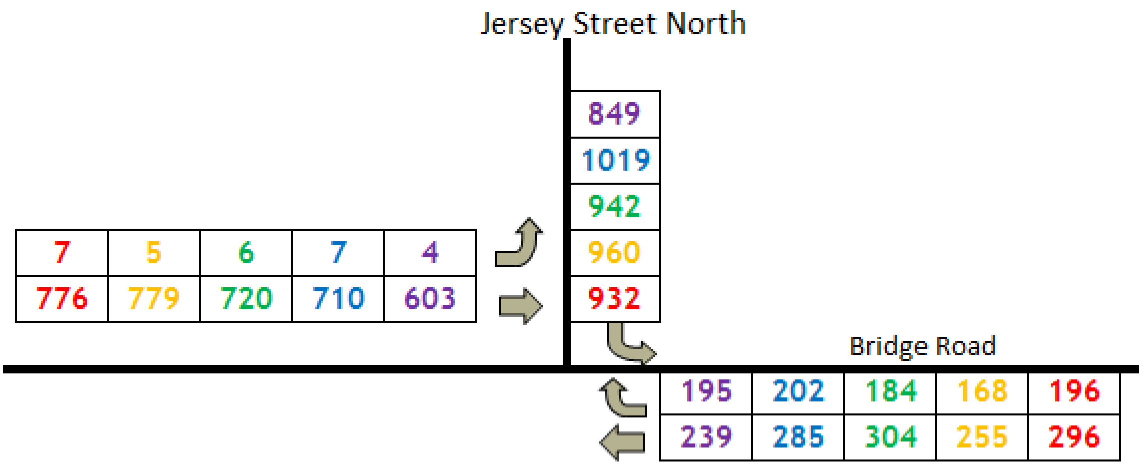
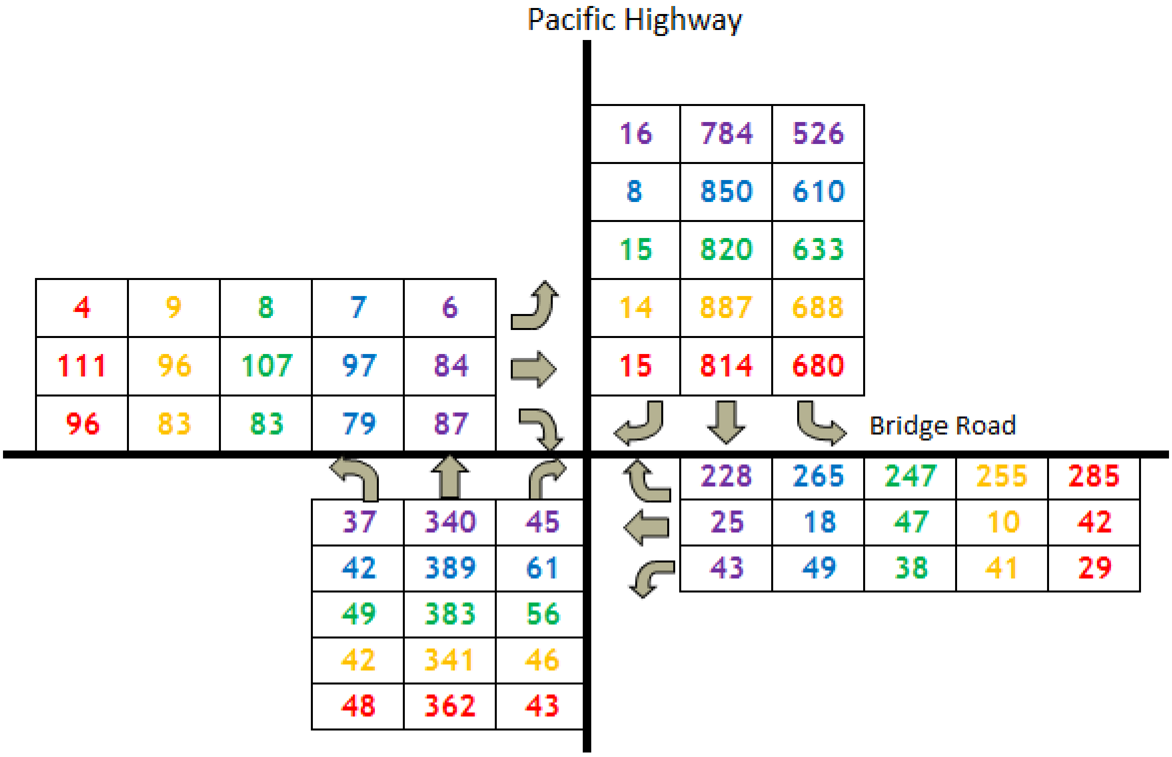


Figure 9 AM Peak Volumes (veh/hr) – Bridge Road/Jersey Street North



No.	Scenario Description
S1	2010 Base Model
S2	2021 Base Model
S3	2021 Base + Option 1
S4	2021 Base + Option 2
S5	2021 Base + Option 3

Figure 10 AM Peak Volumes (veh/hr) - Pacific Highway/Bridge Road



No.	Scenario Description
S1	2010 Base Model
S2	2021 Base Model
S3	2021 Base + Option 1
S4	2021 Base + Option 2
S5	2021 Base + Option 3

1.7.2 BP Peak – Total Vehicles

Figure 11 BP Peak Volumes (vehicles/hr) - Pacific Highway/Edgeworth David Avenue

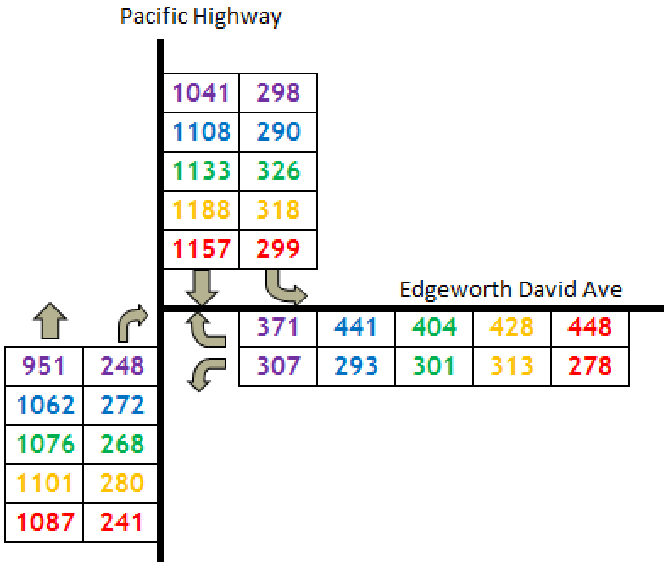
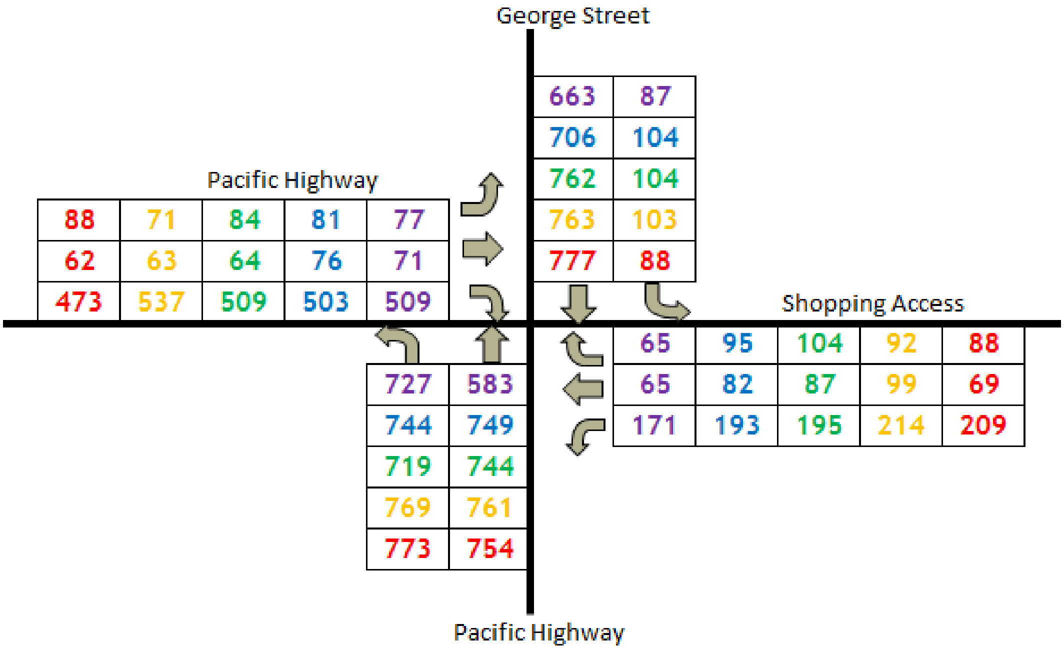


Figure 12 BP Peak Volumes (vehicles/hr) - Pacific Highway/George Street/Shopping Access



No.	Scenario Description
S1	2010 Base Model
S2	2021 Base Model
S3	2021 Base + Option 1
S4	2021 Base + Option 2
S5	2021 Base + Option 3

Figure 13 BP Peak Volumes (vehicles/hr) - Pacific Highway/William Street/Bus Interchange

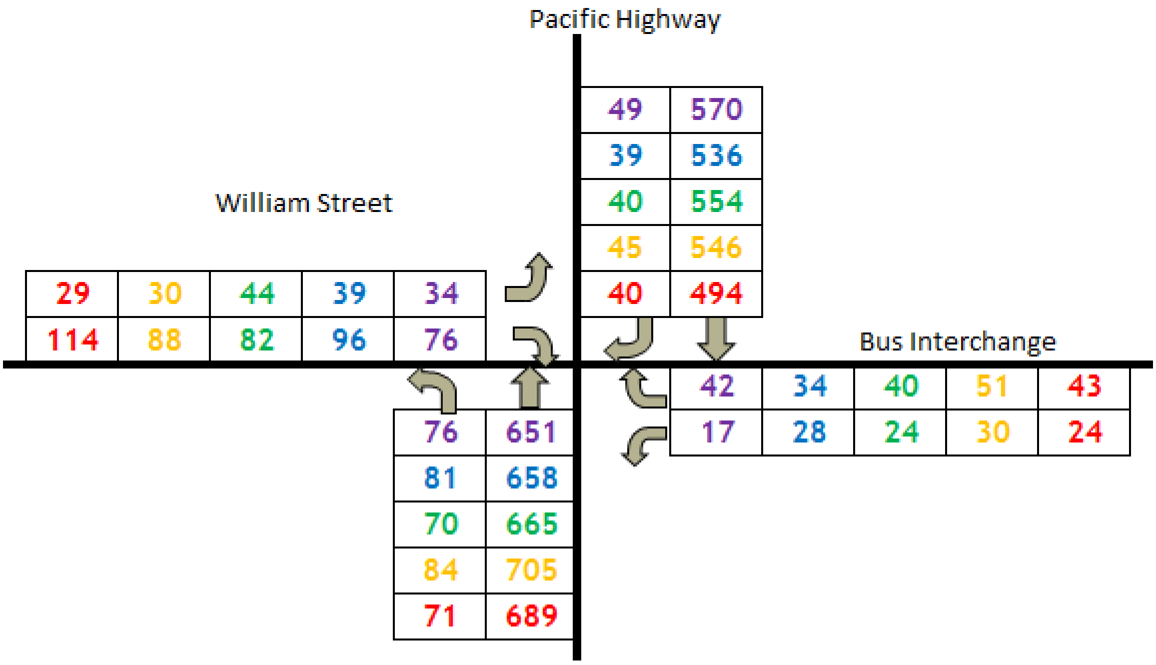
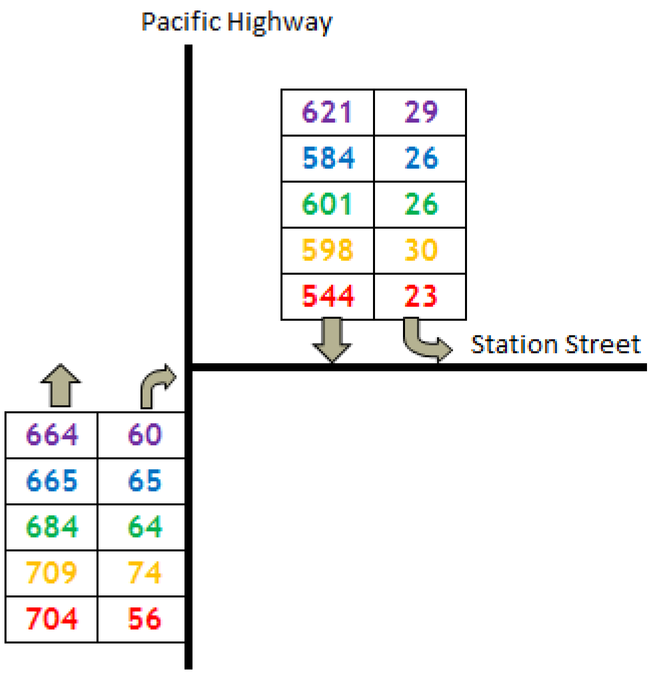


Figure 14 BP Peak Volumes (vehicles/hr) - Pacific Highway/Station Street



No.	Scenario Description
S1	2010 Base Model
S2	2021 Base Model
S3	2021 Base + Option 1
S4	2021 Base + Option 2
S5	2021 Base + Option 3

Figure 15 BP Peak Volumes (vehicles/hr) - Pacific Highway/Coronation Street

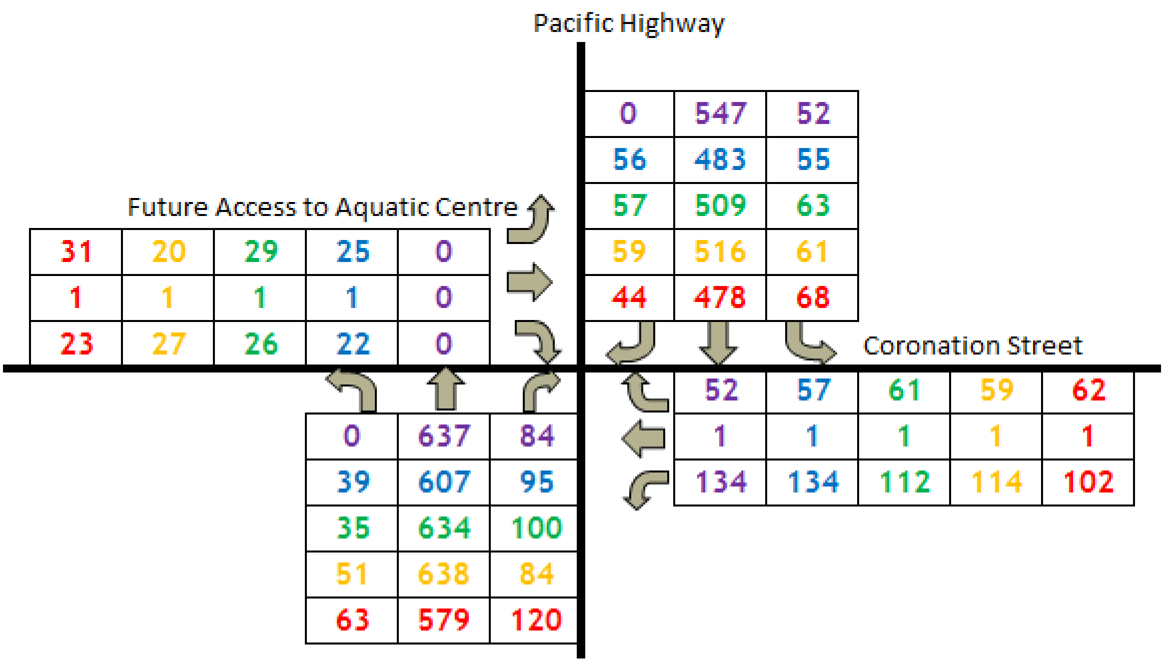
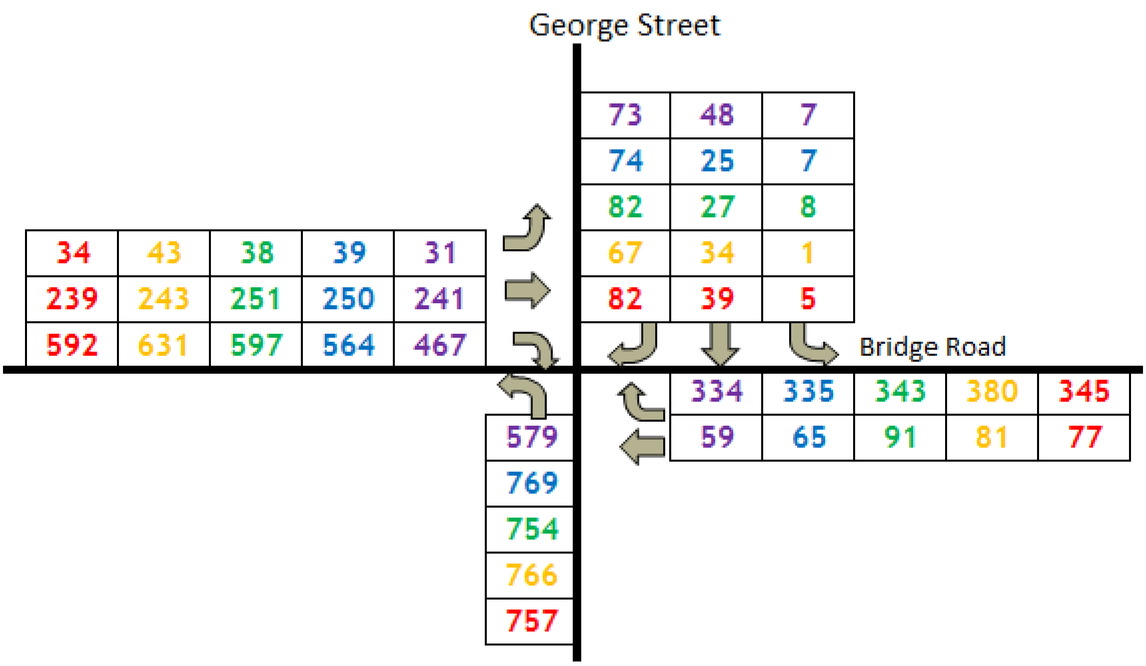


Figure 16 BP Peak Volumes (vehicles/hr) - Bridge Road/George Street



No.	Scenario Description
S1	2010 Base Model
S2	2021 Base Model
S3	2021 Base + Option 1
S4	2021 Base + Option 2
S5	2021 Base + Option 3

Figure 17 BP Peak Volumes (vehicles/hr) - Bridge Road/Jersey Street North

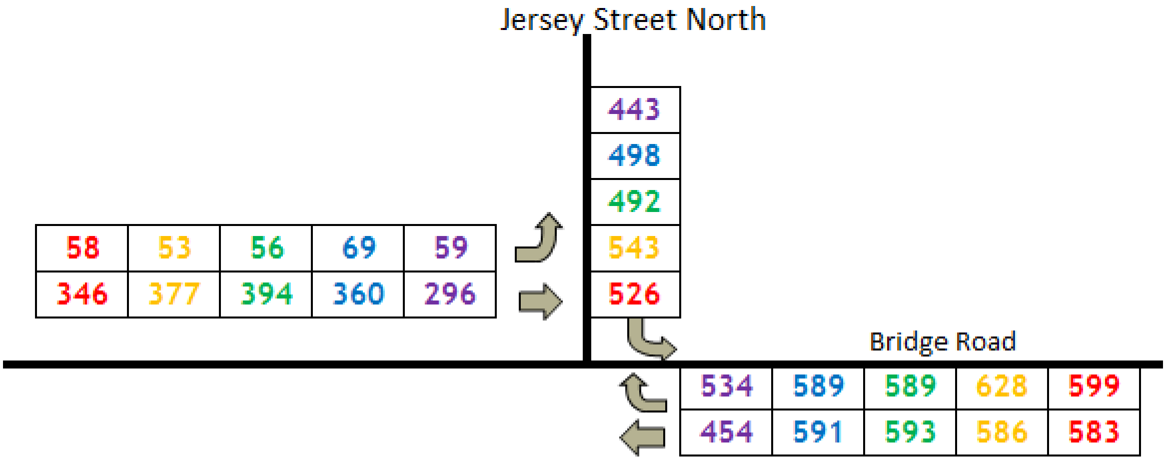
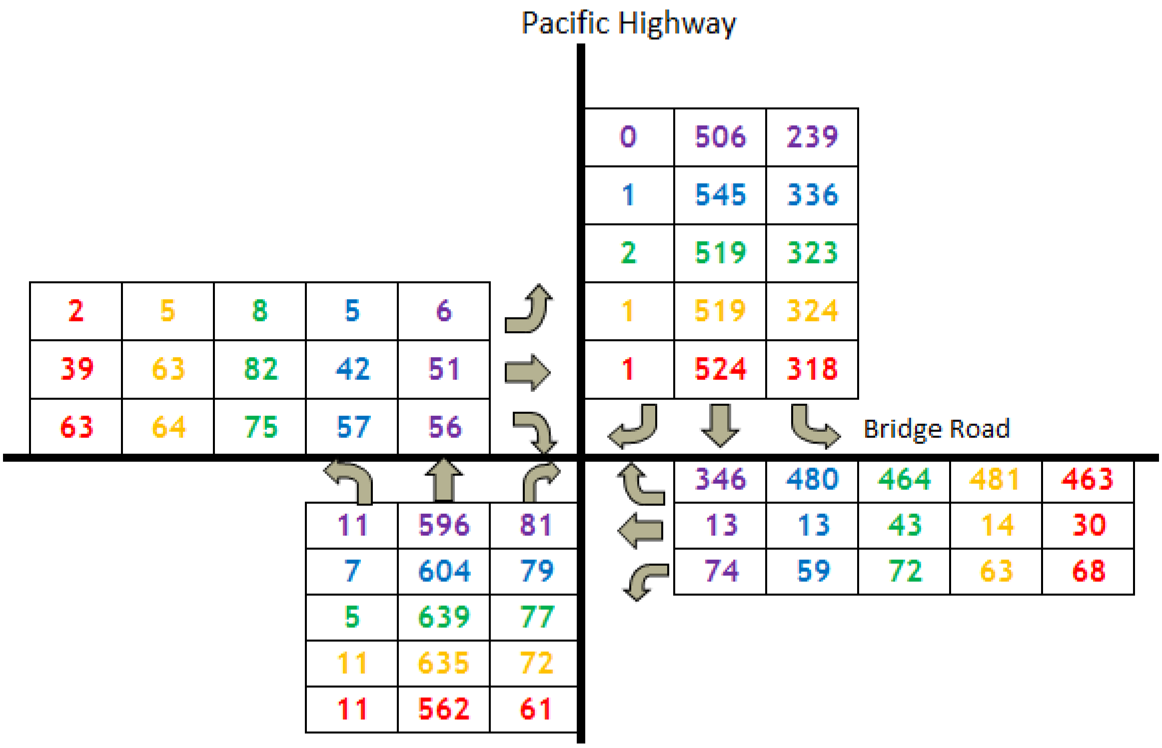


Figure 18 BP Peak Volumes (vehicles/hr) - Pacific Highway/Bridge Road



No.	Scenario Description
S1	2010 Base Model
S2	2021 Base Model
S3	2021 Base + Option 1
S4	2021 Base + Option 2
S5	2021 Base + Option 3

1.8 AM and BP Intersection Level of Service (LOS)

In an urban environment the performance of the road network is usually critical at intersections. The NSW Roads and Traffic Authority have adopted a method of assessing intersection performance using the level of service (LoS) criteria. LoS is a continuum from 'A' good operations to 'F' with unacceptable delays and queues. Table 5 provides a description of intersection level of service.

Table 5 Level of Service Criteria

LoS	Average Delay per Vehicle (secs/veh)	Traffic Signal
A	< 14	Good operation
B	15 to 28	Good with acceptable delays & spare capacity
C	29 to 42	Satisfactory
D	43 to 56	Operating near capacity
E	57 to 70	At capacity; at signals, incidents will cause excessive delays Roundabouts require other control mode

Level of service measurements were extracted from all models at the critical signalised junctions within the model network. Table 6 and Table 7 highlight the LoS differences between each of the AM and BP peak models respectively. It should be noted that the LoS extracted from Paramics Analyser is based on the United States Highway Capacity Manual method. We have taken this as being acceptable given Council's request for Paramics to be used in these analyses; in any event it is the relativities and impacts that are of concern here and these are illustrated clearly in the following tables.

Table 6 AM Peak LoS Comparisons

Intersection	Level of Service					
	S1	S2	S3	S4	S5	S6*
Pacific Highway/Bridge Road	A	A	B	B	B	B
Jersey Street North/Bridge Road	B	B	B	B	B	B
George Street/Bridge Road	A	A	A	A	A	B
Pedestrian Signals near Council	A	A	A	A	A	A
Pacific Highway/Coronation Road	A	A	A	A	A	B
Pacific Highway/Station Street	A	A	A	A	A	B
Pacific Highway/William Street	A	A	A	B	A	B
Pacific Highway/George Street	B	B	B	B	B	B
Pacific Highway/Edgeworth David Avenue	A	A	A	A	A	B

*LoS extracted from previous modelling testing with Quarry traffic in/out of William Street.

Table 7 BP Peak LOS Comparisons

Intersection	Level of Service					
	S1	S2	S3	S4	S5	S6*
Pacific Highway/Bridge Road	B	B	B	B	B	B
Jersey Street North/Bridge Road	A	A	A	A	A	B
George Street/Bridge Road	B	B	B	B	B	B
Pedestrian Signals near Council	A	A	A	A	A	B
Pacific Highway/Coronation Road	A	A	A	A	A	B
Pacific Highway/Station Street	A	A	A	A	A	A
Pacific Highway/William Street	A	A	A	A	B	B
Pacific Highway/George Street	B	C	C	C	C	C
Pacific Highway/Edgeworth David Avenue	B	B	B	B	B	B

*LoS extracted from previous modelling testing with Quarry traffic in/out of William Street.

It is noted that these LoS results are satisfactory even with some queuing observed in the model, as we are mainly concerned with the relativities between the Base and other scenarios. The LoS results from Paramics are in part due to Paramics counting cars that pass through an intersection in its calculations (when obtaining the junction inputs from Section 1.7). Paramics uses the Highway Capacity Manual formula for Degree of Saturation when calculating LoS and so considers the numbers of moving vehicles in that context.

All traffic signals within the modelled network along Pacific Highway have been set to a cycle time of 120 seconds in the model. This extended to coordinating the signals at these intersections in order to optimise the flow of vehicles.

Aside from providing this coordination in the Paramics model, it is also a capability that will be represented even more effectively in RMS's SCATS Traffic Signalling System, to be implemented in actuality. RMS can incorporate the linking together and coordination of these signals into their SCATS system along Pacific Highway, Bridge Road and George Street to optimise both routes into an overall system, as happens elsewhere in Sydney.

In the AM peak, the critical intersections within the model are operating satisfactorily at LoS A or B. In the BP peak, majority of the intersections are operating at LoS A or B. The intersection of Pacific Highway/George Street operates at a LoS C in 2021 due to high southbound traffic. Performance of the intersection remains consistent with the different options tested indicating little or no impacts from the additional quarry traffic.

1.9 CONCLUSION

The purpose of this technical note is to assess the operational effects that the quarry infill vehicles are likely to have on the surrounding road network based on the ingress and egress options proposed and determine a solution which is realistic operationally. Overall, the quantitative and visual analyses from the Paramics modelling undertaken indicate the following:

- Long queues for future southbound vehicles on Pacific Highway between Bridge Road and George Street in the 2021 Future Base scenario. The overall network operation is satisfactory based on the Levels of Service for each critical intersection in the study area.
- Option 1 with quarry trucks entering and exiting the quarry from Bridge Road via George Street did not significantly impact on the overall network operation. There are spare capacities along the proposed route on George Street and Bridge Road to accommodate the additional truck movements in the peak hours tested.
- Similarly with Option 2, quarry trucks entering via William Street and exiting from Bridge Road via George Street did not significantly impact on the overall network operation. Pacific Highway northbound, between George Street and William Street has adequate capacity to accommodate the entering quarry traffic.
- With Option 3, quarry trucks exiting via William Street to travel southbound has an impact on the already congested Pacific Highway (Southbound) as identified in the 2021 Future Base AM Peak scenario. The additional traffic results in queuing extending back to Bridge Road. Although these do clear, this option causes trucks to queue back along William Street with insufficient green time to release the right turning vehicles onto Pacific Highway.
- Previous modelling undertaken with trucks entering and exiting via William Street has also indicated queues extending back to Bridge Road for southbound Pacific Highway. Similar to Option 3, trucks queue back along William Street due to insufficient capacity on Pacific Highway for vehicles to turn right to exit the intersection.
- The quantitative assessment showed that the road network has sufficient capacity to amply cater the 8 year quarry fill scenario in 2021. When comparing this 8 year quarry infill scenario to the 2021 Base scenario (i.e. with no quarry infill), there are negligible impacts to the road network in terms of LoS with no significant reductions in level of service across the modelled area.

Based on the findings summarised above, all options are within acceptable limits in terms of traffic operation; and it is recommended that Option 1 or Option 2 be adopted from a capacity and operations perspective for the 8 year quarry infill operation. The results showed that when comparing the additional truck movements associated with an 8-year fill scenario in 2021, to the outputs from the Base scenario in the same year (i.e. same but without the quarry truck movements), the road network provides ample capacity for all road based vehicles, with negligible impacts to road and intersection operations.

APPENDIX

C

Noise Report

Noise Impact Assessment

Hornsby Quarry Infill

A025_LJ2888

Prepared for
Hornsby Shire Council

April 2013

Cardno
Shaping the Future

Document Information

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3	26/2/2013	Paul Lonard	PL	Julie McDonagh	JM
4	28/2/2013	Paul Lonard	PL	Julie McDonagh	JM
5	4/4/2013	Paul Lonard	PL	Julie McDonagh	JM

Executive Summary

Cardno were engaged by Hornsby Shire Council (HSC) to conduct an environmental noise impact assessment for the proposed infilling of Hornsby Quarry. The purpose of the assessment was to determine whether noise emissions will comply with the relevant statutory noise requirements and to identify relevant mitigation measures as appropriate.

The proposed infilling operation will include the delivery of offsite spoil by truck, and operation of plant within the quarry. Currently, the quarry pit is approximately RL 10, with infill works expected to be completed once RL 90 is reached. To account for an infill completion time period of 8 years, the site would require an average of 23 loads per hour (230 per day loads per day at an average of 25 tonne per load).

Unattended monitoring was conducted for a period of at least 7 days at 7 receiver locations to measure the existing noise environment. The monitoring locations north and south of the site, were characteristic of an area not significantly affected by main roads or commercial activity, with monitoring locations further to the east moderately affected by noise from the Pacific Highway.

Predicted noise impacts were based on the likely activities at the site, such as truck movements and quarry plant and equipment. The volume of vehicles accessing the site was determined from traffic generation rates provided by Cardno (Traffic and Transport). Two access arrangements were accounted for in the noise modelling. These were from Quarry Road on the southern boundary of the site, and Bridge Road on the eastern boundary of the site. Furthermore, the noise models accounted for an increase in source heights as the infill progresses from RL 10 to RL 90.

The noise assessment criteria for noise emissions from onsite equipment is referenced from the NSW Department of Environment, Climate Change and Water's (DECCW) *Industrial Noise Policy* (January 2000) (NSW INP). Noise generated by trucks on local roads (i.e. trucks entering and leaving the site) is referenced from the DECCW *Road Noise Policy* (July 2011) (NSW RNP). Therefore predicted noise levels for onsite activity and site generated traffic were required to be predicted separately to address these assessment requirements.

Assessment Conclusions

The noise impact assessment carried out for the Hornsby Quarry project indicates the following:

Quarry Plant Noise

The noise levels for onsite plant and equipment are predicted to significantly exceed the criteria at residents located on Manor Road, Fern Tree Close, Dural Lane, Roper Lane, Bridge Road, and the Pacific Highway.

Options for reducing onsite plant noise to within acceptable levels are limited. Acoustic barriers would not be a feasible option due to constraints from topography. An option to reduce noise may include restricting the number of onsite plant and equipment, although this option is unlikely to achieve strict compliance.

Noise impacts may progressively worsen as the infill will eventually increase to relative height of the noise sources operating in the quarry.

Truck Egress Noise

Based on noise impact alone, access from Bridge Road is recommended over access via Quarry Road, given that Bridge Road has less residential dwellings to pass between the Pacific Highway and the site. Furthermore, dwellings proximate to Bridge Road are already exposed to higher traffic noise levels from the Pacific Highway.

Provided the recommendations in Section 6 are implemented, noise impacts at neighbouring offsite receivers will be minimised, but the relevant statutory noise criteria is not likely to be achievable for the Quarry fill operations, with any available practical mitigation options.

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Tables

Figures

1 Project Description

1.1 Introduction

The Hornsby Quarry site is located at Quarry Road, Hornsby. This noise impact assessment was conducted on behalf of the proponent, Hornsby City Council.

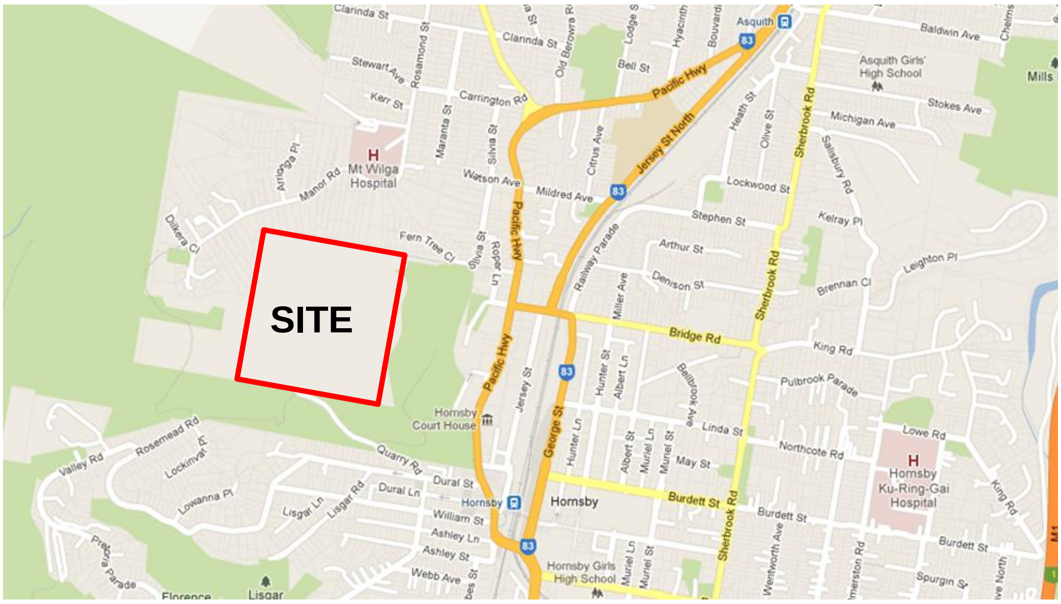
Unattended noise monitoring was conducted over a 7 day period to measure the existing noise environment at residents proximate to the site. Based on these measured noise levels, the NSW INP, and the NSW RNP, the applicable noise limits were determined.

Operational noise from the proposed quarry infill was predicted using SoundPLAN 7.1. The noise model takes into consideration onsite activity such as plant, equipment, and trucks. The predicted noise levels from these activities were compared to the applicable noise limits, to determine compliance.

1.2 Site Description

The quarry site is located at Quarry Road, Hornsby. Figure 1-1 shows the site location.

Figure 1-1 Site location



Currently, the quarry site is excavated from approximately RL 90 to a depth of RL 10, with a void area of 8-11 hectares. This volume of excavated material is approximately 3.3 million m^3.

The area surrounding the site comprises of predominately residential dwellings and multi-unit apartment buildings, which can be detailed as follows:

> Manor Road, Fern Tree Close and Summers Avenue are located north and northwest of the subject site. These roads carry local traffic and provide access to a number of residential dwellings that back onto the quarry site.

> Roper Lane and Bridge Road are located east of the subject site. These roads carry local traffic and provide access to a number of residential dwellings.

> The Pacific Highway runs in a north-south direction and is located east of the subject site. A number of residential dwelling and commercial premises front the highway in this area.

> A number of residential dwellings are situated to the south of the subject site on the following local roads:

- Dural Street;

- William Street;
- Frederick Street;
- Lowanna Place;
- Lockinvar Street;
- Rosemead Road;

Dwellings located in the above streets are included in the analysis of predicted noise impacts.

> Bushland is located to the west of the subject site.

1.3 Proposal

The proposal is to operate the former Hornsby quarry as an infill site for offsite spoil disposal. This assessment has taken into consideration a minimum fill time of 8 years, in line with the *Hornsby Quarry Additional Paramics Modelling Summary of Findings*, prepared by Cardno. Given that the minimum fill time would represent the most intensive use of the site in terms of traffic generation, the results of this study are therefore provide a conservative assessment of impacts.

The project will incorporate trucks entering the site and dumping spoil into the pit. Plant such as loaders, bulldozers, and compactors will be used to distribute spoil evenly throughout the quarry pit. The quarry is currently at RL 10. As infilling continues, this will progressively increase to a final RL of 90.

In line with the traffic impact assessment, the assumed hours of operation are as follows:

> 7am to 5pm Monday to Friday

> 8am-12pm Saturday

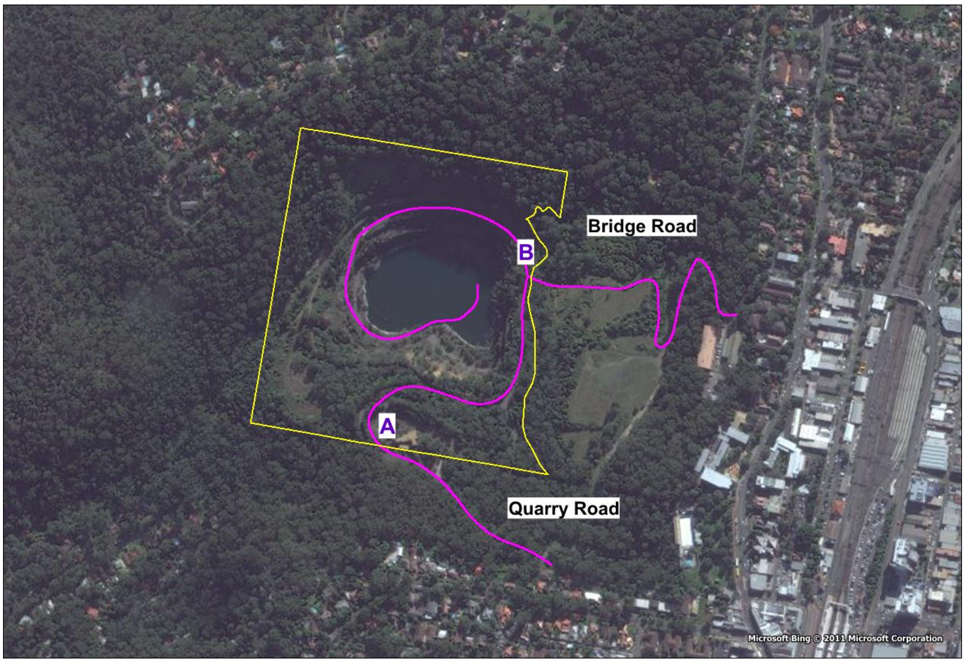
The above hours of operation are associated with the day period noise assessment criteria. Two truck access options are currently proposed as follows:

> Quarry Road, to the south of the site (Location A); and

> Bridge Road to the east of the site (Location B).

The above options are displayed in Figure 1-2.

Figure 1-2 Site access locations



2 Existing Noise Conditions

2.1 Unattended Noise Monitoring Methodology

Unattended noise monitoring was carried out between 8 and 19 August 2012 to measure the existing noise environment using seven Type 2 ARL EL215 environmental noise loggers. The noise monitors were positioned with the microphone approximately 1.4 metres above ground level. The sound measuring equipment was set to record noise levels as follows:

> "A" weighting
> "Fast" response
> 15 minute statistical interval

The noise monitoring program was conducted generally in accordance with Australian Standard *AS 1055-1997: Acoustics – Description and measurement of environmental noise (3 parts).*

2.1.1 Equipment Calibration

Calibration of the measuring equipment was carried out before and after the measurements, and was noted the maximum variation was by less than +/-0.3 dB(A) during the course of the monitoring for all equipment used.

2.1.2 Meteorological Conditions

The environmental conditions during the measurement period were obtained from the Bureau of Meteorology, Terrey Hills weather station (Bureau of Meteorology station reference: 066059):

Conditions:	Rain periods on the 11-12 August.
Wind:	4 - 26 km/h predominantly from the southwest
Humidity:	38-80%
Temperature:	4 - 21ºC

Weather data obtained at 15 minute intervals was used to determine whether noise data was affected by inclement conditions. Rainfall and wind speeds are included on the weekly noise monitoring charts presented in Section 2.3.

2.1.3 Measurement Parameters

As environmental noise varies with time, the use of statistical descriptors is necessary to understand and describe these variations. For environmental noise, the assessment period is split into daytime (7am – 6pm), evening (6pm – 10pm) and night-time (10pm – 7am). A-weighted statistical levels are used to describe ambient noise levels. The common descriptors used to describe environmental noise are described as follows:

L_{Amax}: the A-weighted maximum noise level measured during the measurement period.

L_{A1}: the A-weighted noise level exceeded for 1% of the measurement period.

L_{A10}: the noise A-weighted level exceeded for 10% of the measurement period, generally referred to as the average of the maximums.

L_{A90}: the A-weighted noise level exceeded for 90% of the measurement period, generally referred to as the average minimum sound pressure level or background noise level (refer AS 1055.1 – 1997).

L_{Aeq}: the equivalent continuous noise level over the measurement period, generally referred to as the energy averaged sound pressure level over the measurement period.

2.1.4 Noise Monitoring Locations

Monitoring was carried out at the following locations (Figure 2-1):

> Logger 1 (SN# 194677) – 2/11 William Street

> Logger 2 (SN# 194803) – 24 William Street

> Logger 3 (SN# 194662) – 30 Lowanna Place

> Logger 4 (SN# 194528) – Quarry Road

> Logger 5 (SN# 194574) – Roper Lane

> Logger 6 (SN# 194539) – 9 Fern Tree Close

> Logger 7 (SN# 194637) – 98 Manor Road

Figure 2-1 Noise monitoring locations

2.2 Noise Monitoring Results

The monitoring results were analysed to determine the Rating Background Level (RBL) and traffic noise levels. The RBL was determined to establish noise limits in accordance with statutory requirements outlined in Section 2.4. Traffic noise levels were calculated for inclusion in the traffic noise model and analysis conducted for this assessment.

2.2.1 Rating Background Level

The Rating Background Level (RBL) for each site was determined in accordance with the *Industrial Noise Policy* (NSW EPA 2000) (INP). Weather affected data (wind or rain) was excluded from the analysis. The RBL applicable to each site is detailed in Table 2-1.

Table 2-1 Rating Background Levels

Logger	Measurement Location	Rating Background Level, dB(A)		
		Day, 7am-10pm	Evening, 6pm-10pm	Night, 10pm-7am
1	2/11 William Street	42	40	34
2	24 William Street	39	37	33
3	30 Lowanna Place	35	34	33
4	Quarry Road	33	31	30 (28)*
5	Roper Lane	41	39	34
6	9 Fern Tree Close	33	32	31
7	98 Manor Road	32	32	30 (29)*

* INP Appendix B: *Where this level is found to be less than 30 dB(A), the rating background level is set to 30 dB(A).*

The RBLs from Table 2-1 are used to formulate the design benchmarks for onsite quarry activities as detailed in Section 4.2.

2.2.2 Measured Traffic Noise Levels

The measured traffic noise levels are shown in Table 2-2. Weekends and weather affected data (due to rain or wind) were excluded from the calculation of traffic noise levels.

The noise monitor at 11 William Street was the only location proximate to a roadway with sufficient traffic volumes to measure traffic noise.

Table 2-2 Measured traffic noise levels

Logger	Measurement Location	Traffic Noise Descriptor, dB(A)				
		$L_{A10\,(18\,hour)}$	Day $L_{Aeq\,(1\,hour)}$	Night $L_{Aeq\,(1\,hour)}$	$L_{Aeq\,(15\,hour)}$ 7am-10pm	$L_{Aeq\,(9\,hour)}$ 7am-10pm
1	2/11 William Street	60	63	53	58	52

2.3 Monitoring Results – Noise Charts

The noise charts provide a graphical representation of the measured noise levels. A 24 hour average chart provides a graphical representation of the noise level trend over a 24 hour period, with noise statistics shown at 1 hour intervals. Weather affected data was excluded from the analysis. A weekly chart displays the entire monitoring period (for whole days only), with noise statistics shown in 15 minute intervals.

2.3.1 Logger 1 – 2/11 William Street Measurement Results

The measured noise levels for 2/11 William Street are presented in Figure 2-2 (hourly average) and Figure 2-3 (week period).

Figure 2-2 Measured Noise Levels Logger Location 1 – Hourly Averages

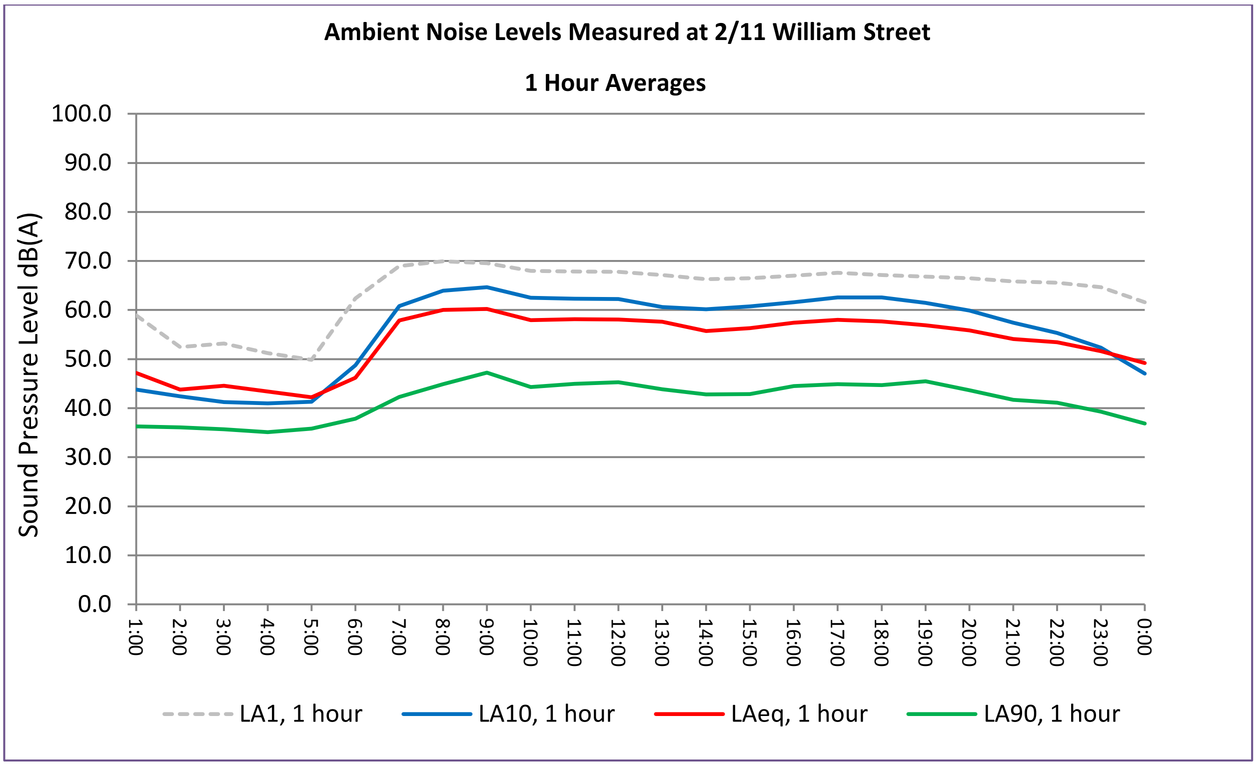
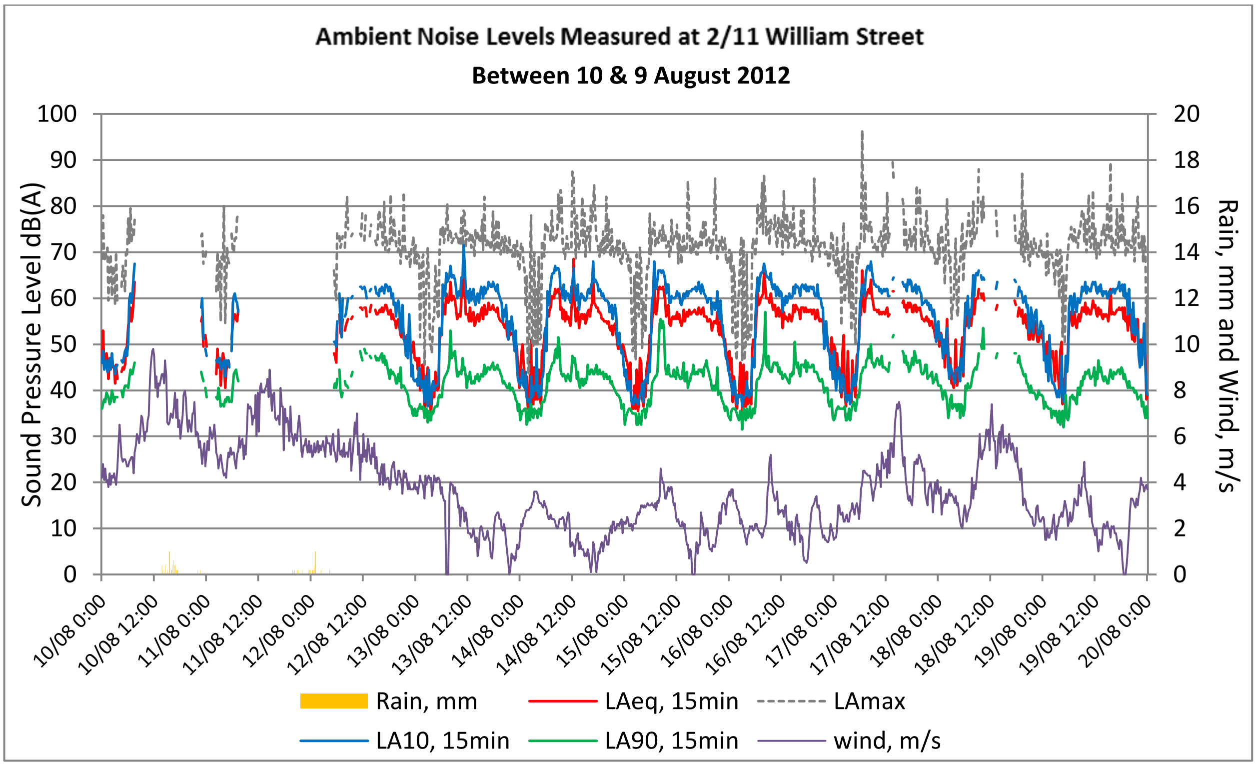


Figure 2-3 Measured Noise Levels Logger Location 1 – Week Period



2.3.2 Logger 2 – 24 William Street Measurement Results

The measured noise levels for 24 William Street are presented in Figure 2-4 (hourly average) and Figure 2-5 (week period).

Figure 2-4 Measured Noise Levels Logger Location 2 – Hourly Averages

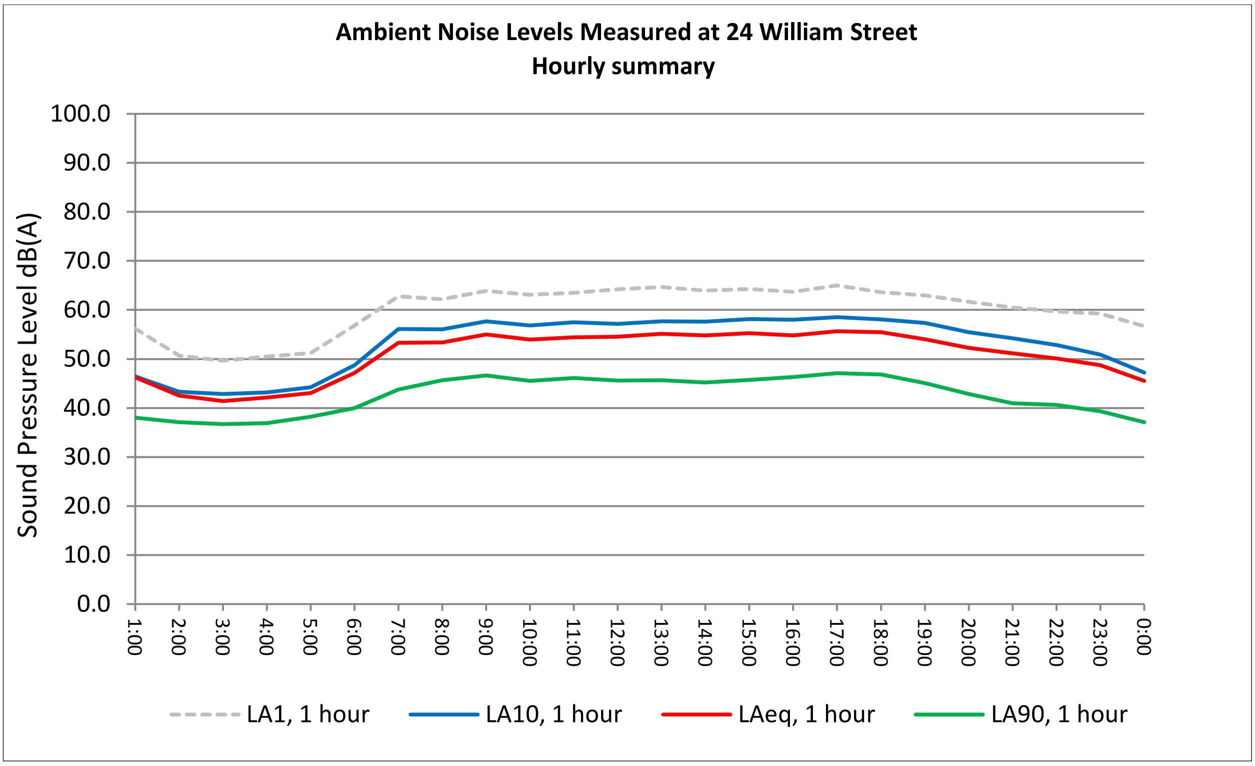
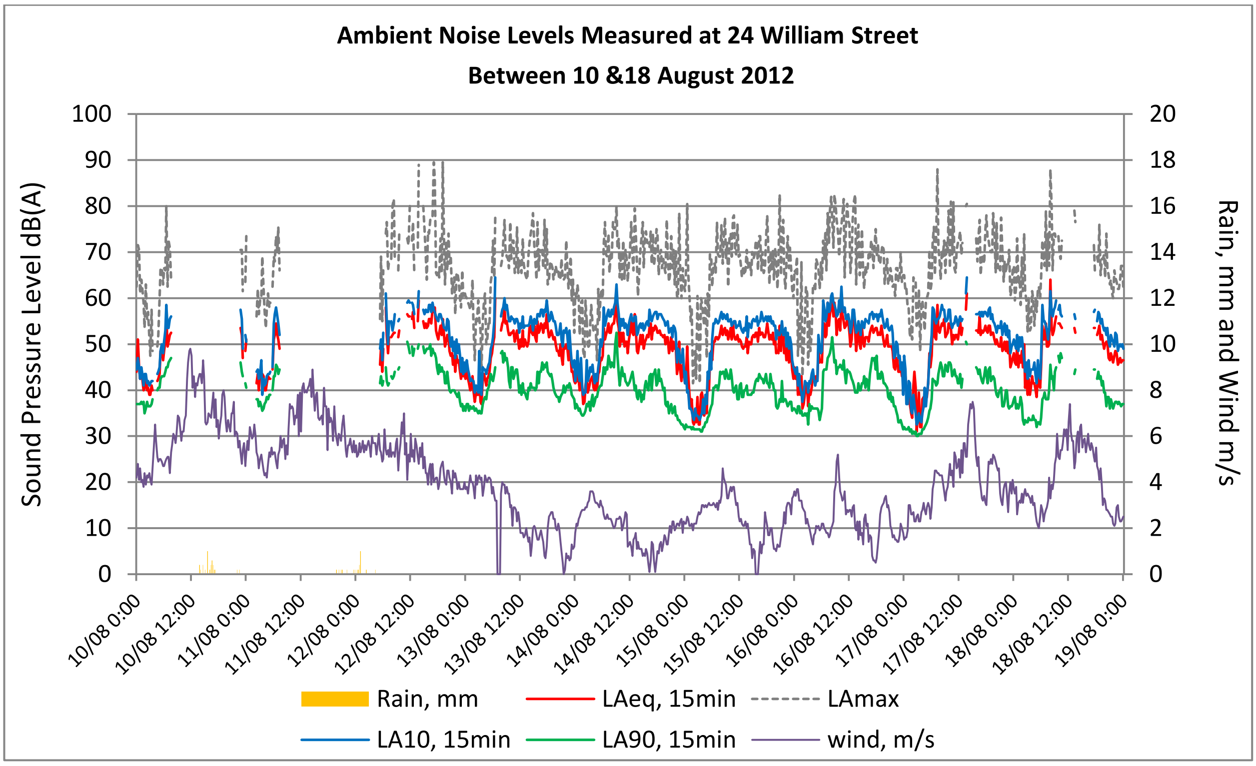


Figure 2-5 Measured Noise Levels Logger Location 2 – Week Period



2.3.3 Logger 3 – 30 Lowanna Place Measurement Results

The measured noise levels for 30 Lowanna Place are presented in Figure 2-6 (hourly average) and Figure 2-7 (week period).

Figure 2-6 Measured Noise Levels Logger Location 3 – Hourly Averages

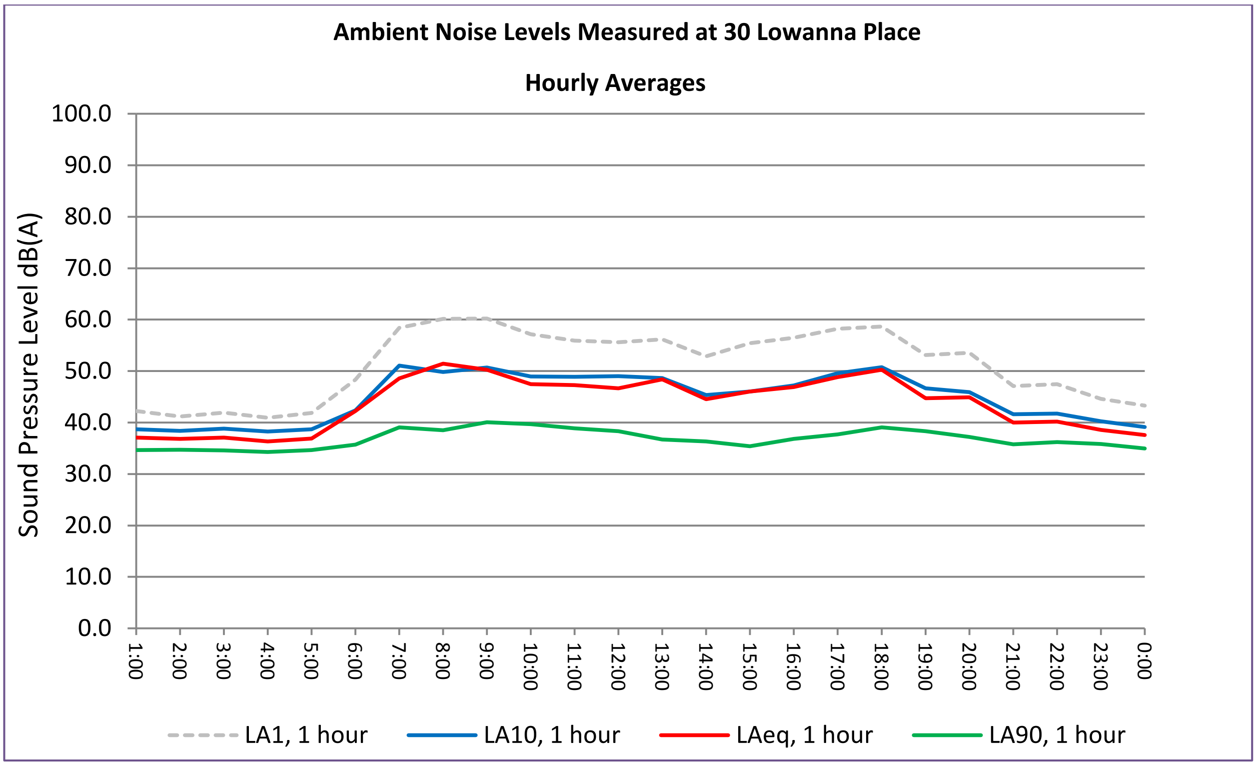
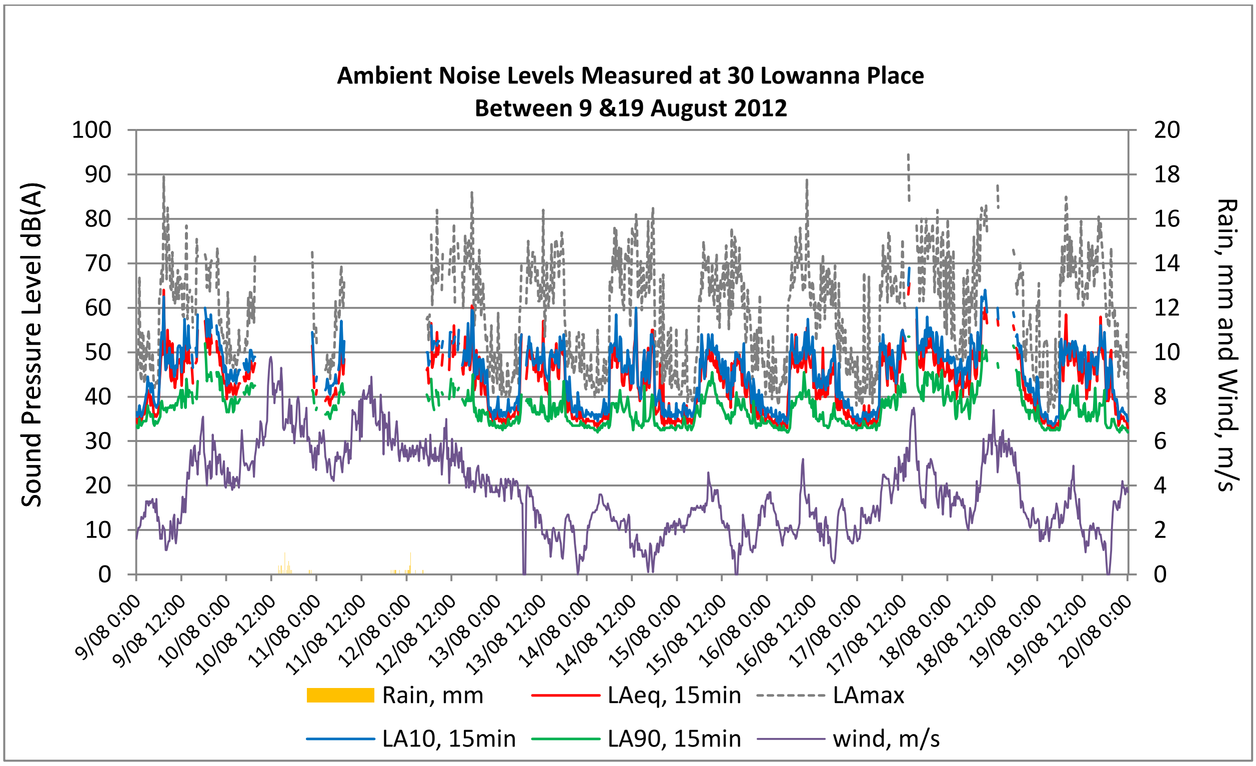


Figure 2-7 Measured Noise Levels Logger Location 3 – Week Period



2.3.4 Logger 4 – Quarry Road Measurement Results

The measured noise levels for Quarry Road are presented in Figure 2-8 (hourly average) and Figure 2-9 (week period).

Figure 2-8 Measured Noise Levels Logger Location 4 – Hourly Averages

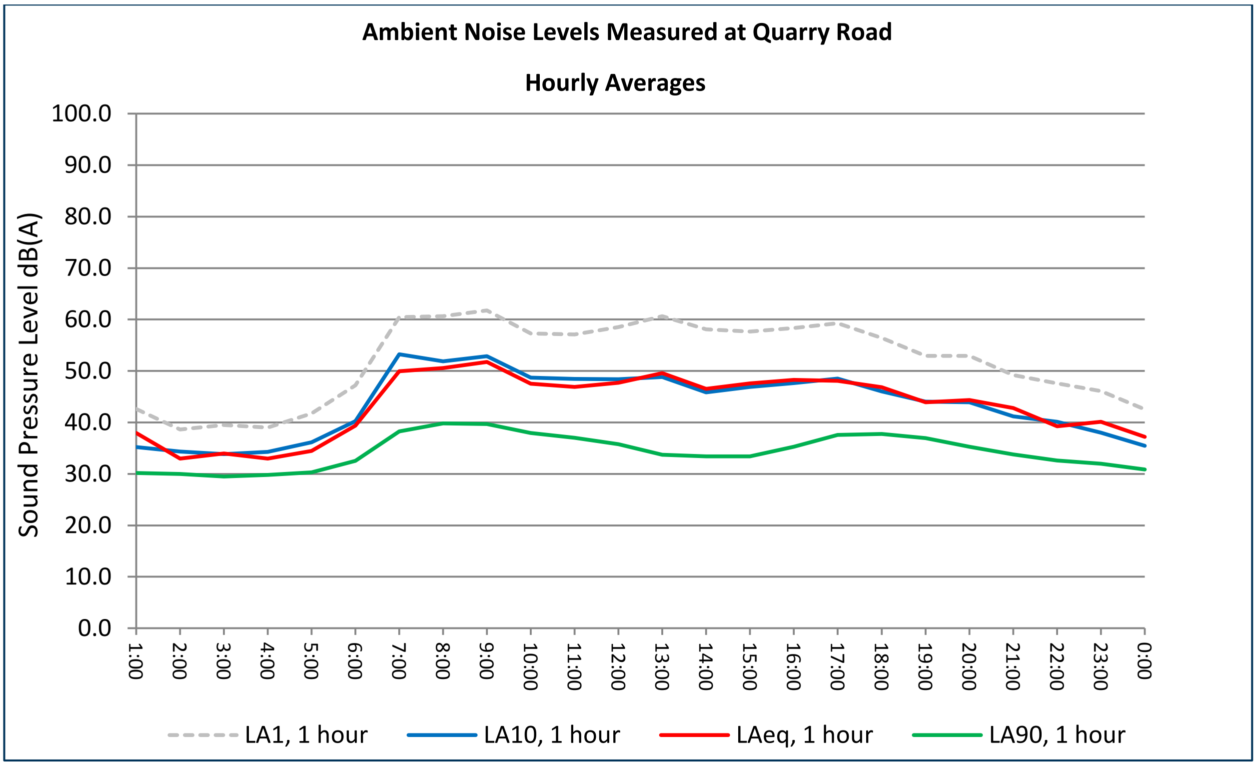
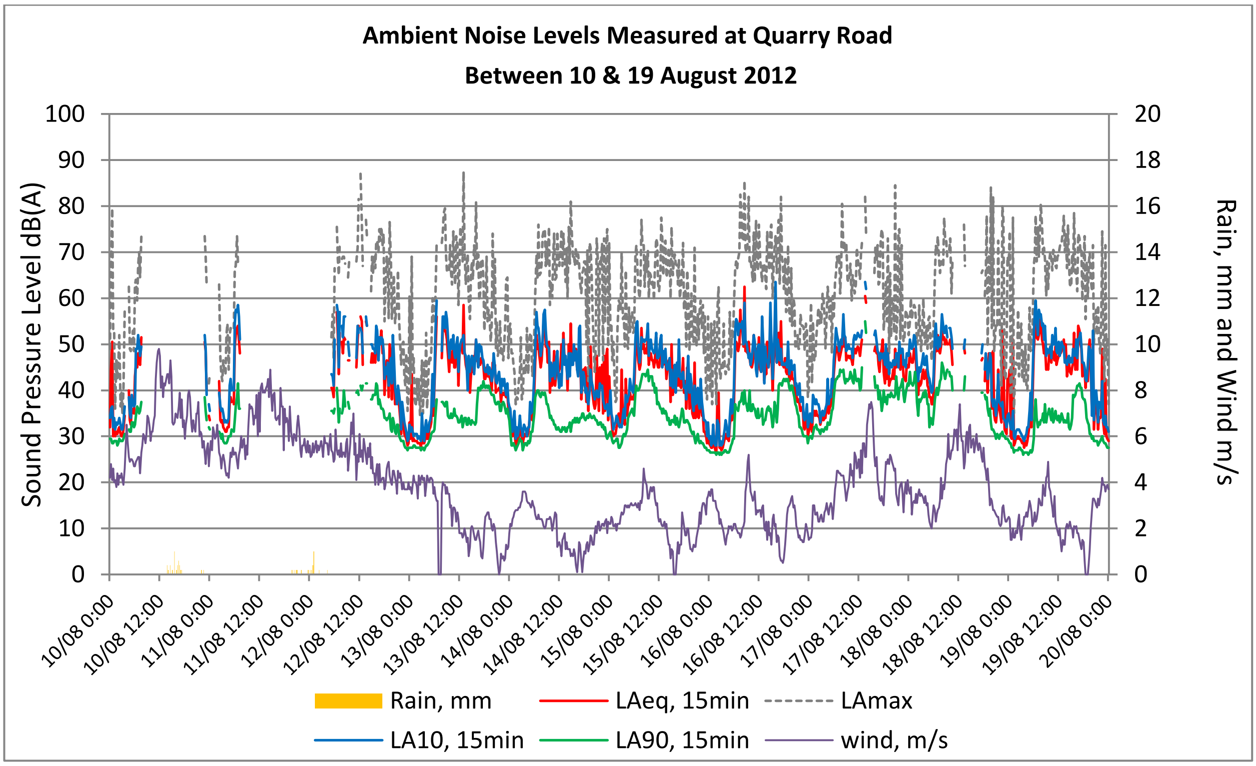


Figure 2-9 Measured Noise Levels Logger Location 4 – Week Period



2.3.5 Logger 5 – Roper Lane Measurement Results

The measured noise levels for Roper Lane are presented in Figure 2-10 (hourly average) and Figure 2-11 (week period).

Figure 2-10 Measured Noise Levels Logger Location 5 – Hourly Averages

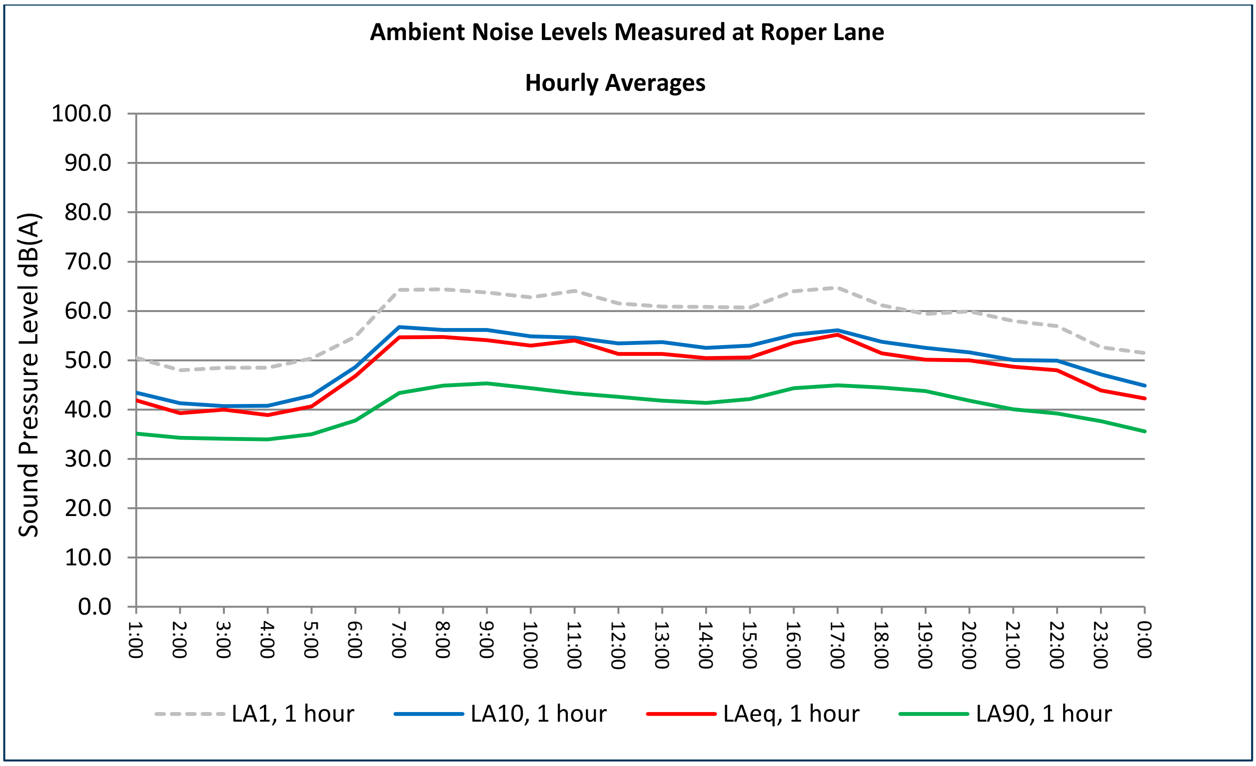
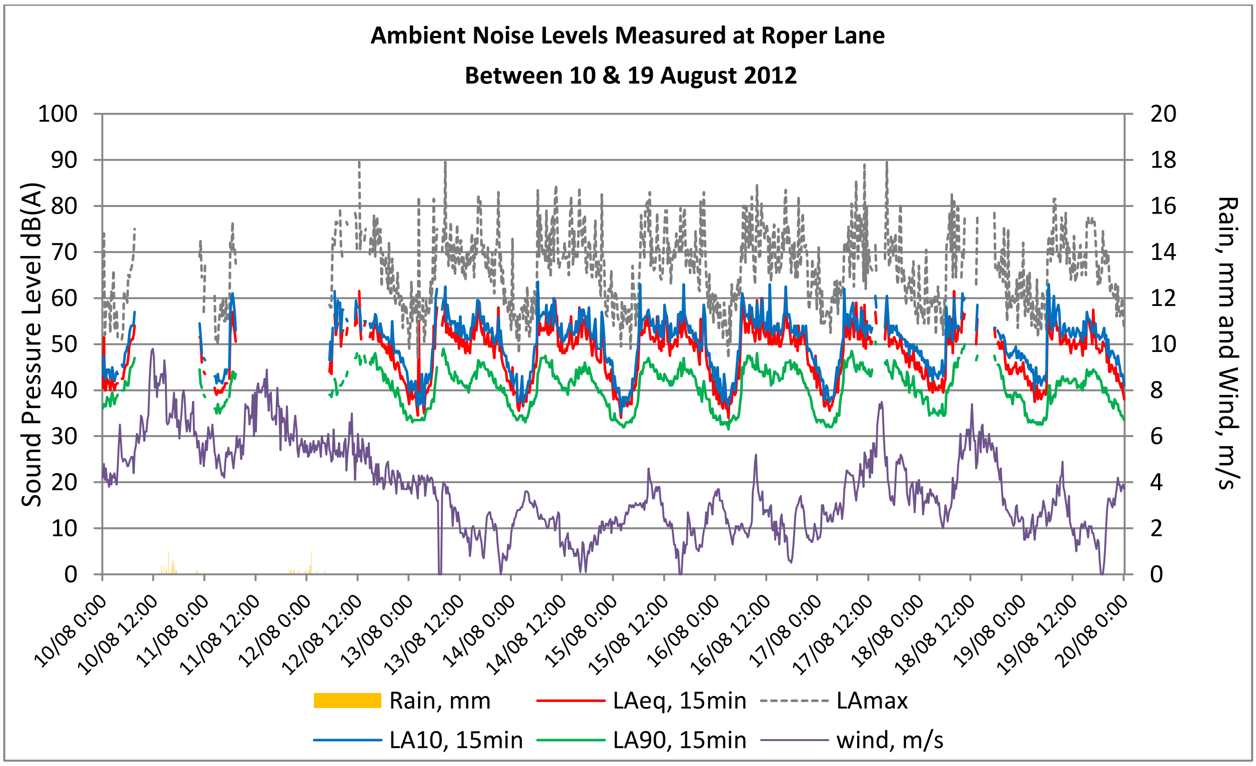


Figure 2-11 Measured Noise Levels Logger Location 5 – Week Period



2.3.6 Logger 6 – 9 Fern Tree Place Measurement Results

The measured noise levels for 9 Fern Tree Place are presented in Figure 2-12 (hourly average) and Figure 2-13 (week period).

Figure 2-12 Measured Noise Levels Logger Location 6 – Hourly Averages

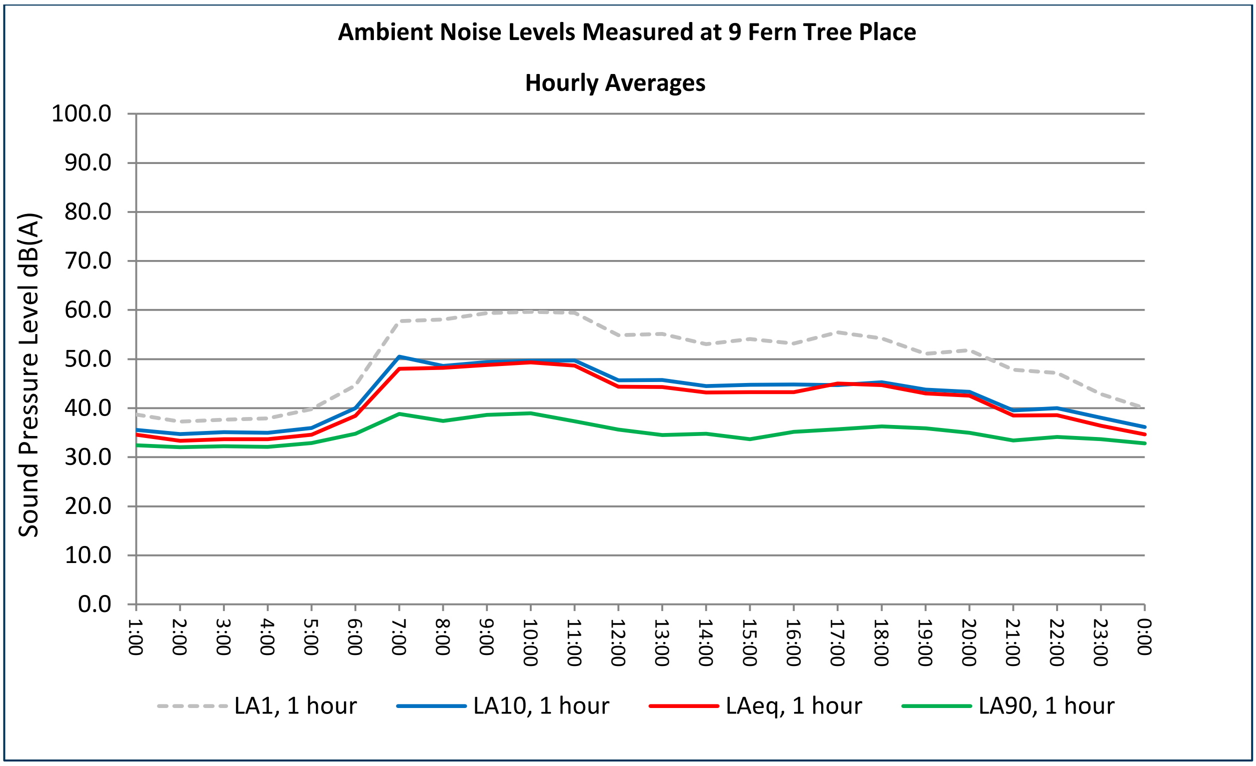
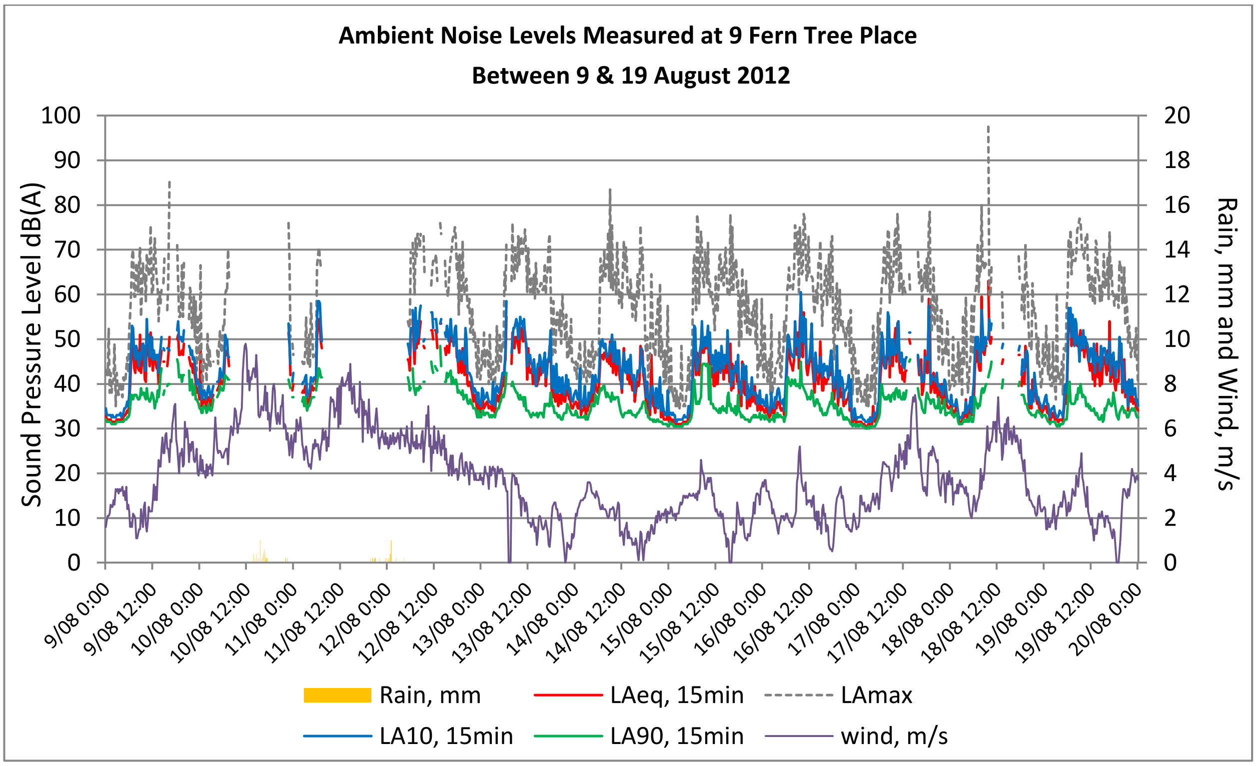


Figure 2-13 Measured Noise Levels Logger Location 6 – Week Period



2.3.7 Logger 7 – 98 Manor Road Measurement Results

The measured noise levels for 98 Manor Road are presented in Figure 2-14 (hourly average) and Figure 2-15 (week period).

Figure 2-14 Measured Noise Levels Logger Location 7 – Hourly Averages

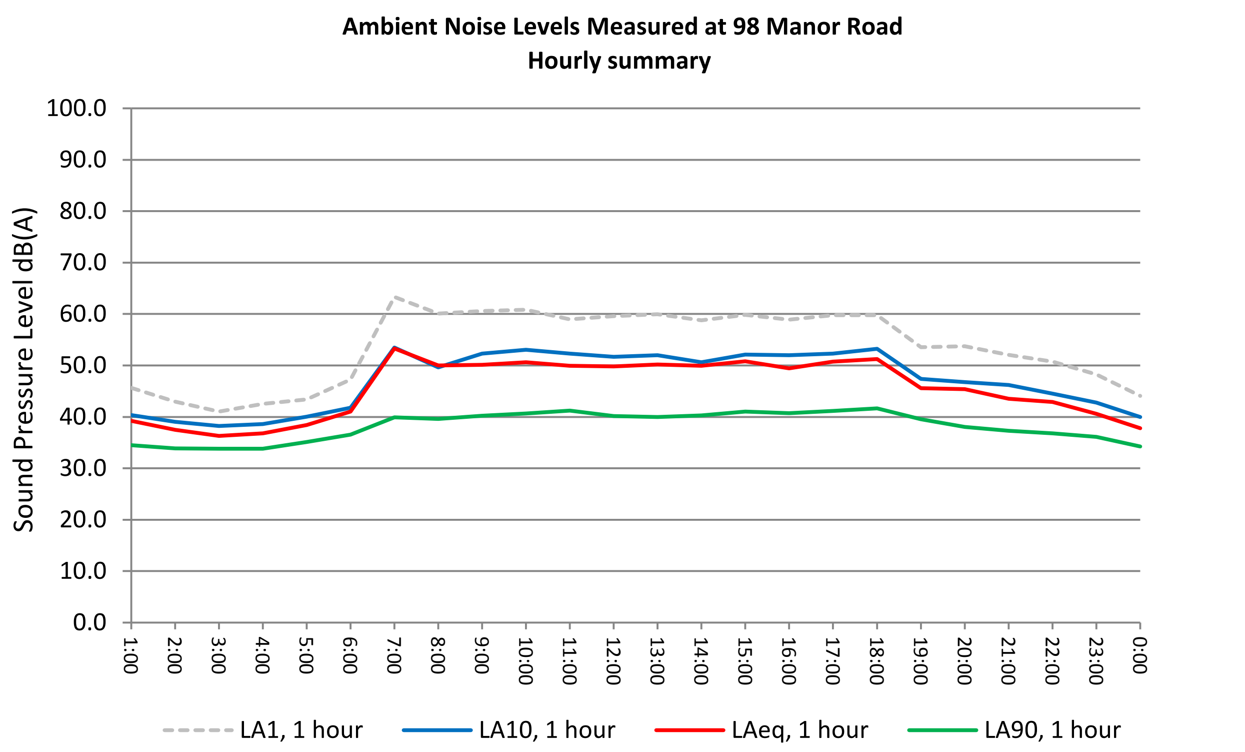
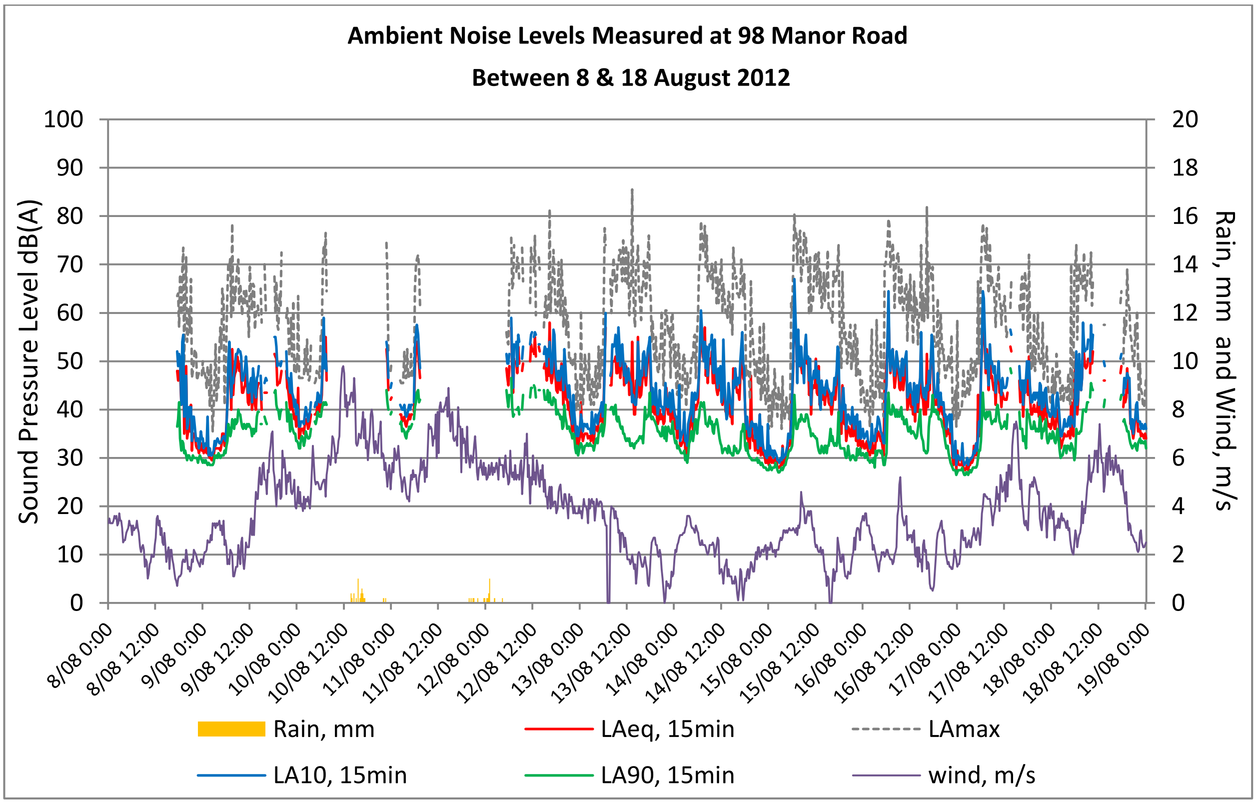


Figure 2-15 Measured Noise Levels Logger Location 7 – Week Period



2.4 Attended Noise Monitoring Methodology

Attended noise monitoring was carried out between on the 19th August 2012 to measure the existing noise environment using a Rion NA-28 sound level meter. The sound level meter was positioned with the microphone approximately 1.5 metres above ground level. The sound measuring equipment was set to record noise levels as follows:

> "A" weighting

> "Fast" response

> 15 minute statistical interval

The noise monitoring program was conducted generally in accordance with Australian Standard *AS 1055-1997: Acoustics – Description and measurement of environmental noise (3 parts).*

2.5 Attended Noise Measurement Results

The results of the attended noise monitoring and observations of acoustic environment are presented in Table 2-3.

Table 2-3 Attended Noise Monitoring Results

Monitoring Location	*Time*	L_{eq}	L_{90}	*Comments*
2/11 William Street	13:15-13.30, 20th August, 2012	53	42	Traffic from William Street Neighbourhood noise activity Birds in trees Cars across road moving away and honking horn
24 William Street	11:00-11.15, 20th August, 2012	50	40	Local traffic sources Birds People walking and talking along the footpath Distant activity at childcare centre Cars in Church car park Distant traffic noise from Pacific Highway Distant construction noise
Quarry Road	10:30-10:45, 20th August, 2012	50	35	Swimming pool construction activity, Bird noises both distant and close, domestic activity (whipper snipper), local traffic noises, Aircraft in distance, voices in nearby bushland (walkers/workmen)
30 Lowanna Place	11:00-11.15, 20th August, 2012	46	37	Loud Bird Noises (cockatoos) Intermittent chainsaw/leaf blower noise Distant aircraft noise Workmen unloading equipment in street Distant traffic source Wind in trees Distant lawn mower noise
Roper Lane	13:45-14.00, 20th August, 2012	48	41	Traffic from minor roads Local traffic sources along Roper Lane Music from car parked nearby Dog howling yelping Distant aircraft movement
9 Ferntree Close	14:15-14.30, 20th August, 2012	44	33	Birds in distance, Cockatoos Leaf mulcher in distance Distant aircraft movement
98 Manor Road	14:15-14.30,	41	34	Distant birds, cockatoos

Monitoring Location	*Time*	L_{eq}	L_{90}	*Comments*
	20th August, 2012			Distant construction machinery noise Neighbourhood activity on resident's balcony Distant mower/leaf shredder noise

3 Noise Assessment Criteria

3.1 NSW Road Noise Policy July 2011

The noise criteria applicable to site generated vehicle noise (including trucks) is addressed in the NSW Road Noise Policy, July 2011 (NSW RNP), which was produced by the Department of Environment, Climate Change, and Water (DECCW).

The applicable road traffic noise criteria at potentially affected residential receivers are shown in Table 3-1 below:

Table 3-1 Road traffic noise assessment criteria for residential land uses

Road category	*Type of project/land use*	*Assessment criteria – dB(A)*	
		Day (7 a.m.–10 p.m.)	*Night (10 p.m.–7 a.m.)*
Freeway/ arterial/ sub-arterial roads	3. Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	60 $L_{Aeq,\ 15\ hour}$ (external)	55 $L_{Aeq,\ 9\ hour}$ (external)
Local roads	6. Existing residences affected by additional traffic on existing local roads generated by land use developments	55 $L_{Aeq,\ 1\ hour}$ (external)	50 $L_{Aeq,\ 1\ hour}$ (external)

The noise limits for residents shall also apply to aged care facilities.

3.2 Department of Environment Climate Change and Water (DECCW)

The noise criteria for industrial noise emission within NSW are set by the guidelines in the DECCW's Industrial Noise Policy, January 2000 (NSW INP).

There are two objectives in the NSW INP. These are to preserve the amenity of the environment and to also protect against noise intrusion. To protect amenity of a given area, the existing noise from industrial sources is compared against acceptable levels for a particular land use. If the current levels are close to or approaching these acceptable levels then restrictions on the level of new noise emission may apply.

Noise intrusion is controlled by limiting the amount by which new development or significant plant item can increase noise levels above the existing noise levels.

During an assessment it is identified whether the intrusive criterion or the amenity criterion is more stringent. The most stringent becomes the project specific criterion within each time period for the development or upgrade.

Separate criteria are defined for the daytime (7am to 6pm), evening (6pm to 10pm) and night-time assessment periods (10pm to 7am) to reflect the change in ambient noise levels within a 24 hour period.

3.2.1 <u>Intrusive Noise Criteria</u>

The intrusive criteria are established from the ambient L_{A90} background noise level (in the absence of the noise source to be assessed) at the nearest sensitive receivers. The result of statistical analysis of background noise levels, as required by the INP (refer Appendix A for definitions) is termed the Rating Background Level (RBL). The intrusive criterion used to assess the predicted noise level associated with the project is then determined by adding 5 dB(A) to the RBL level.

The intrusive noise criteria for this site that are shown below in Table 3-2 are based upon the RBL's displayed in Table 2-1 of Section 2.2.1.

Table 3-2 Intrusive Criteria for Industrial Noise Emissions

Receiver	*Intrusive Noise Criteria ($L_{Aeq, 15minute}$) dB(A)*		
	Daytime (7am to 6pm)	*Evening (6pm to 10pm)*	*Night (10pm to 7am)*
2/11 William Street	47	45	39
24 William Street	44	42	38
30 Lowanna Place	40	39	38
Quarry Road	38	36	35
Roper Lane	46	44	39
9 Fern Tree Close	38	37	36
98 Manor Road	37	37	35

3.2.2 Amenity Noise Criteria

The amenity assessment is based upon the noise criteria specific to land use and associated activities, and is expressed in L_{Aeq} over specified time periods. The amenity criteria are set out in full in Table 2.1 of the NSW Industrial Noise Policy. Under the INP guidelines the site would be classified as "suburban", as the acoustic environment is generally dominated by local traffic with intermittent flows and some limited commerce or industry. In the evening it is generally dominated by the natural environment and infrequent human activity.

Note that the land use classification may not relate to Council planning definitions of land use. These are separate definitions within the INP that relate to the acoustic environment. The applicable amenity noise goals during the day, evening and night-time periods for residential receivers near the site are reproduced in Table 3-3.

Table 3-3 INP Recommended Amenity Criteria

Type of Receiver	*Indicative Noise Amenity Area*	*Time of Day*	*Acceptable L_{Aeq} noise level, dB(A)*	*Recommended Maximum $L_{Aeq,}$ dB(A)*
Residence	Rural	Day	50	55
		Evening	45	50
		Night	40	45
Residence	Suburban	Day	55	60
		Evening	45	50
		Night	40	45
Commercial	All	When in use	65	70

3.3 Australian Standards

The following Australian Standards have also been referenced for this assessment:

> AS 1055-1997: Acoustics – Description and measurement of environmental noise (3 parts);

> AS 2702-1984: Acoustics – Methods for the Measurement of Road Traffic Noise; and

> AS 3671 - 1989: Acoustics – Road Traffic Noise Intrusion - Building Siting & Construction.

4 Design Benchmarks

4.1 Road Traffic Noise

Table 4-1 summarises the adopted external road traffic noise criteria for this development.

Table 4-1 Summary of Adopted Road Traffic Noise Criteria

Noise Source	Assessment Descriptor	Measurement Location	Relevant External Noise Criteria
Pacific Highway Bridge Road (East of the Pacific Hwy), George Street	$L_{Aeq,\ 15\ hour}$ (Between 7am and 10pm)	One metre in front of the most exposed part of a proposed noise sensitive place	60 dB(A)
	$L_{Aeq,\ 9\ hour}$ (Between 10pm and 7am)	One metre in front of the most exposed part of a proposed noise sensitive place	55 dB(A)
Quarry Road, Frederick Street, William Street, Bridge Road (West of the Pacific Hwy)	$L_{Aeq,\ 1\ hour}$ (Maximum1hour period between 7am and 10pm)	One metre in front of the most exposed part of a proposed noise sensitive place	55 dB(A)
	$L_{Aeq,\ 1\ hour}$ (Maximum1hour period between 10pm and 7am)	One metre in front of the most exposed part of a proposed noise sensitive place	50 dB(A)

4.2 Environmental Noise

The noise limits for onsite quarry noise, as assessed inside the affected dwellings property boundary, are detailed in Table 4-2. The noise limits represent the more stringent of the intrusive criteria or the amenity criteria; however for all time periods the intrusive noise criteria was the determining factor.

Table 4-2 Adopted INP noise limits – Industrial and Commercial Noise

Receiver	Applicable Noise Criteria ($L_{Aeq\ 15minute}$) dB(A)		
	Daytime (7am to 10pm)	Evening (6pm to 10pm)	Night (10pm to 7am)
2/11 William Street	47	45	39
24 William Street	44	42	38
30 Lowanna Place	40	39	38
Quarry Road	38	36	35
Roper Lane	46	44	39
9 Fern Tree Close	38	37	36
98 Manor Road	37	37	35

5 Potential Noise Impacts

5.1 Site Generated Traffic Noise

5.1.1 Site Generated Traffic Noise Model Inputs and Assumptions

The prediction of onsite quarry was conducted with SoundPLAN 7.1, which applied Calculation of Road Traffic Noise 1988 (CoRTN) algorithms. The traffic noise model input and assumptions are displayed in Table 5-1.

Table 5-1 Noise model parameters

Input Parameter	*Input Date/Source Reference*
Ground Elevation Geometry	Provided by the Cardno design team
Existing Alignments	Provided by the Cardno design team
Existing and Future Traffic Flow Data	Refer to Section 5.1.2 and 5.1.3
Road Traffic Speeds	50km/h adopted for local roads including William Street, Bridge Road (west of Pacific Highway), Frederick Street, and Quarry Road
	60km per hour adopted for all remaining roads
Road Surface Type	Modelling has assumed a pavement surface of Dense Grade Asphalt indicating a correction factor of 0 dB(A) (with reference to the RTA *Environmental Noise Management Manual* (ENMM), 2001) to be applied to all modelling scenarios.
Ground Absorption	Assumed 100% soft ground absorption surfaces between road and receivers.
Facade Reflection	+2.5 dB(A) applied to existing and future prediction models only, where receivers were located at facades of buildings. Logger locations for the verification model were free-field and therefore facade correction was not applied.
Correction to CoRTN for Australian Conditions	Subtract 0.7 dB(A) for free field receivers (Logger locations) – this applies only to verification of logger results. Predicted results for residences have been considered façade corrected (as they are located within 1 metre of the building façade) with 1.7 dB(A) subtracted (with reference to the Austroads' Guide *An Approach to the Validation of Traffic Noise Models,*2002*)*
L_{A10} to L_{Aeq} conversion	Correction factors were based on measured data at 11 William Street (refer to Section 2.2.2).
Receiver Height	Assumed to be 1.2 metres above ground level as per noise logger microphone heights for the verification model and 1.5 metres above floor level for prediction models.

5.1.2 Traffic Volumes

Traffic volumes for the Hornsby local road network were obtained from Cardno (Traffic and Transport). The Annual Average Daily Traffic (AADT) volumes were extrapolated from AM peak hour counts. The traffic growth between 2010 and 2021 is predicted to range between 9-13%. This equates to an annual growth rate of approximately 0.8-1.1% per annum.

The traffic volumes of the local road network, excluding quarry traffic, are shown in Table 5-2.

Table 5-2 Predicted traffic volumes

Road Section	Annual Average Daily Traffic (AADT)		% Heavy Vehicles
	2010	2012	
Pacific Hwy, North of Bridge Rd	18,960	19,340	10.3
Pacific Hwy, Bridge Rd-William St	12,750	13,010	11.5
Pacific Hwy, William St-George St	10,620	10,830	12.0
Pacific Hwy, George St-Edgeworth David Ave	26,140	26,670	13.2
Pacific Hwy, South of Edgeworth David Ave	23,660	24,140	13.8
William St	2,900	2,960	9.0
Bridge Rd, West of Pacific Hwy	2,250	2,300	10.2
Bridge Rd, Pacific Hwy-Jersey St North	9,530	9,720	10.0
Bridge Rd, Jersey St North-George St	19,160	19,550	11.0
George St, Bridge Rd-Burdett St	13,310	13,580	12.9
George St, Burdett St-Pacific Hwy	17,350	17,700	13.8

5.1.3 Development Contribution to Traffic Volumes

In line with the *Hornsby Quarry Additional Paramics Modelling Summary of Findings* (Cardno, November 2012), the analysis of traffic generated by the site has taken into consideration an 8 year infill scenario. Based on this scenario, the predicted traffic volumes are presented in Table 5-3.

Table 5-3 Site generated traffic volumes for 8 year infill scenario

Years to fill	Cubic metres/annum	Loads/annum	Loads/hour
8	537,500	45,867	23

With a pass-by occurring for entering the site and another for leaving the site, a rate of 23 loads per hour would result in 46 truck pass-by events per hour.

The traffic noise modelling assumes that trip generation rates will remain the same throughout the lifespan of the infill operation.

5.1.4 Traffic Model Scenarios

The following traffic scenarios were assessed:

Scenario 1, Model verification. Existing traffic with no development contribution (year 2012) compared to measured levels on William Street (Logger 1);

Scenario 2, Existing Situation Existing traffic with no development contribution (year 2012) predicted across the surrounding area. The results from this analysis were used as baseline level for which site generated traffic noise level were added.

Scenario 3, Quarry Rd Option A The development contribution from access via the Pacific Highway, William Street and Quarry Road.

Scenario 4, Bridge Rd Option B The development contribution from access via George Street and Bridge Road.

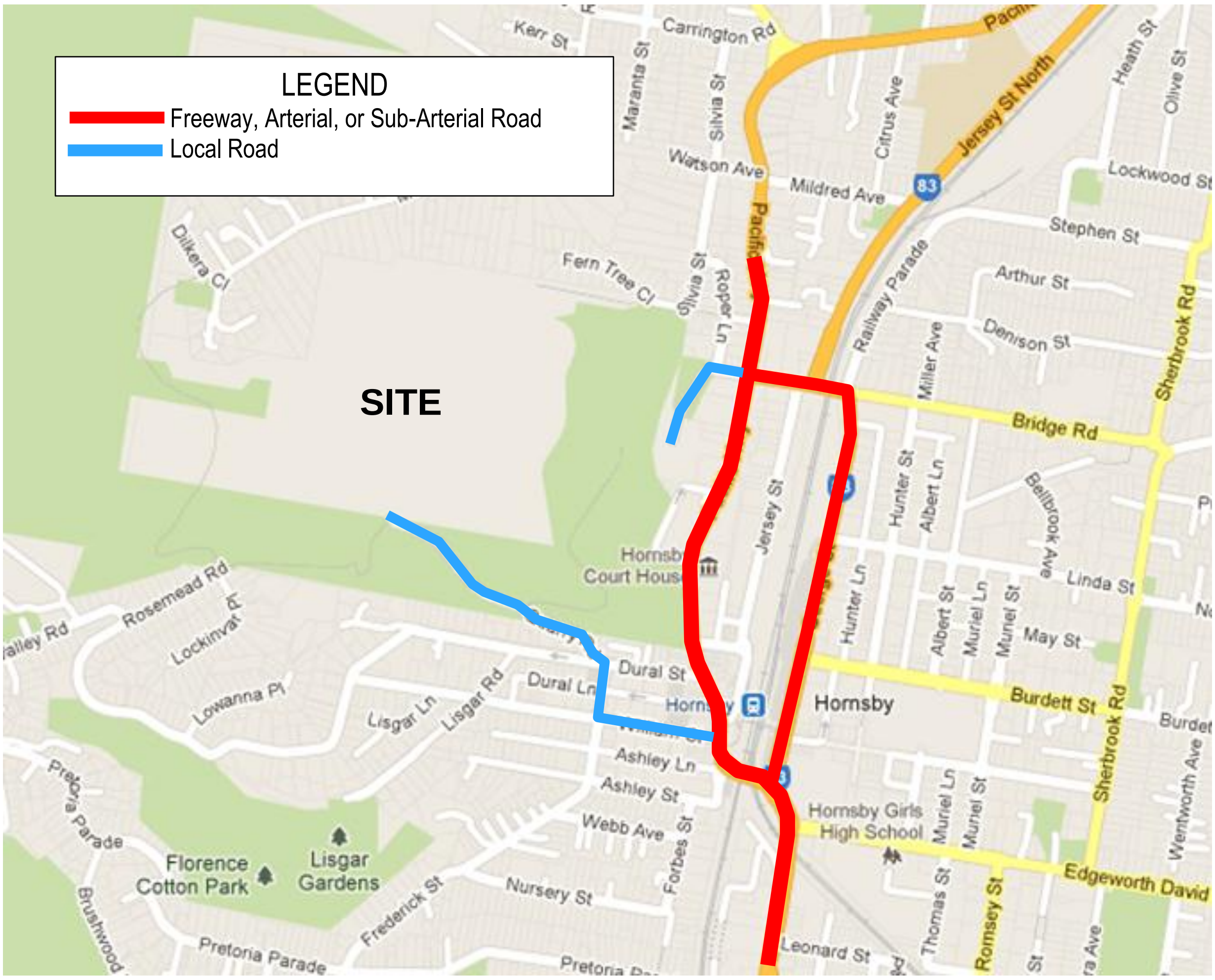
Scenario 5, Both Roads This model considers the traffic using the site as a loop, with entry via Quarry Road and Bridge Road as the exit, or entry via Bridge Road and Quarry road as the exit.

Noise emissions from trucks located on the quarry site, are addressed in Section 5.2.

Figure 5-1 Scenario Map

Traffic noise models also accounted for the road classification under the NSW RNP, to enable comparison of results to the applicable NSW RNP noise limit. The classifications are displayed in Figure 5-2.

Figure 5-2 NSW RNP Classification for Freeways, Arterial, Sub-Arterial, and Local Roads



5.1.5 Scenario 1 Model Verification, 11 William Street

11 William Street represents the only monitoring location proximate to a road of which reliable traffic data was provided. Therefore verification of the traffic noise model was conducted at this location only.

Verification of the modelling program, Sound Plan 7.1, was undertaken prior to the prediction of future traffic noise levels. An iteration of the model was developed using existing (2012) traffic data (refer to Table 5-4) and current site conditions to generate a predicted SPL ($L_{A10,\ 18\ hour}$) for comparison to the measured SPL ($L_{A10,\ 18\ hour}$) at 11 William Street.

Table 5-4 below shows the parameters applied in the verification:

Table 5-4 Modelling Parameters –William Street– Existing Traffic (2012)

Parameter	*Value*
Traffic Volume (24 hours)	2,900 vehicles
Percentage heavy vehicles	9.0 %
Road Surface	Dense Graded Asphalt (DGA)
Traffic Speed	50km/hr
Number of Lanes	1 lane in each direction

To reflect the free-field measurement location, the model verification was determined as a free-field level, with the results shown in Table 5-5.

Table 5-5 Modelling Verification Results

Measurement Parameter	*Predicted, dB(A) $L_{A10,\ 18\ hour}$*	*Measured, dB(A) $L_{A10,\ 18\ hour}$*	*Difference, dB(A)*
$L_{A10,\ 18\ hour}$	61.6	59.9	+1.7

As the NSW RMS allowable deviation is within +/-2.0 dB(A) tolerance, the model was considered to be verified.

5.1.6 Scenarios 2 and 3, Predicted Traffic Noise Levels

The predicted traffic noise levels are split to account for the different noise limits that apply for local roads and those that apply for Freeways, arterial, or sub arterial roads. For the purposes of Scenario 3 and the results presented in Table 5-7, NSW RNP classifications were applied as displayed in Table 5-6.

Table 5-6 NSW RNP Classifications and Applicable Design Benchmark

NSW RNP Road classification	*Applicable Roads – Scenario 3*	*Applicable noise limit*
Freeways, arterial, sub-arterial	Pacific Highway	60 dB(A) $L_{Aeq,\ 15\ hour}$
Local Roads	Quarry Road, Frederick Street, William Street	55 dB(A) $L_{Aeq,\ 1\ hour}$

The applicable noise limit changes as the vehicle turns from the Pacific Highway onto William Street, in the case of a truck approaching the site.

It should be noted that predicted noise levels for the existing scenario do not depict accurate results for noise emanating from local roads Quarry Road and Frederick Street because traffic data is unavailable for these roads.

Results of modelling for Scenarios 2 (existing) and 3 (site access via Quarry Road) are presented in Table 5-7.

Predicted exceedances of the applicable criteria are highlighted.

Table 5-7 Predicted traffic noise levels – Scenarios 2 and 3

Receiver	*Floor Level*	*Noise Levels from Freeways, arterial, sub-arterial Roads dB(A) $L_{Aeq,\ 15\ hour}$*				*Noise Levels from Local Roads, dB(A) $L_{Aeq,\ 1\ hour\ (Max)}$*			
		Scenario 2	*Scenario 3*	*Total (Scenario 2 + 3)*	*Predicted increase*	*Scenario 2*	*Scenario 3*	*Total (Scenario 2 + 3)*	*Predicted increase*
5-9 Dural St	ground	54	21	54	-	31	47	47	16
	first	56	24	56	-	33	48	48	15
	second	57	27	57	-	37	49	49	12
10-12 Dural St	ground	46	19	46	-	27	33	34	7
	first	47	21	47	-	29	35	36	7
	second	49	24	49	-	32	38	39	7
11-15 Dural St	ground	54	23	54	-	32	50	50	18
	first	55	26	55	-	35	51	51	16
	second	56	31	56	-	39	52	52	13
16 Dural St	ground	48	14	48	-	25	63	63	38
	first	48	14	48	-	25	63	63	38
	second	49	16	49	-	26	62	62	36
	third	50	17	50	-	27	62	62	35
	fourth	51	20	51	-	28	62	62	34
17 Dural St	ground	49	20	49	-	30	58	58	28
	first	51	22	51	-	32	59	59	27
	second	53	25	53	-	35	59	59	24
20 Dural St	ground	47	18	47	-	27	31	32	5
	first	47	20	47	-	28	34	35	7
21 Dural St	ground	50	23	50	-	32	55	55	23
22 Dural St	ground	42	17	42	-	27	44	44	17
	first	46	20	46	-	28	46	46	18
23 Dural St	ground	50	23	50	-	31	53	53	22
24 Dural St	ground	46	17	46	-	24	37	37	13

Receiver	Floor Level	Noise Levels from Freeways, arterial, sub-arterial Roads dB(A) $L_{Aeq,\ 15\ hour}$				Noise Levels from Local Roads, dB(A) $L_{Aeq,\ 1\ hour\ (Max)}$			
		Scenario 2	Scenario 3	Total (Scenario 2 + 3)	Predicted increase	Scenario 2	Scenario 3	Total (Scenario 2 + 3)	Predicted increase
	first	47	19	47	-	26	43	43	17
25 Dural St	ground	48	24	48	-	32	45	45	13
26 Dural St	ground	45	18	45	-	27	30	32	5
	first	47	21	47	-	28	34	35	7
27 Dural St	ground	47	23	47	-	31	46	46	15
29 Dural St	ground	47	20	47	-	28	43	43	15
	first	48	24	48	-	31	46	46	15
31 Dural St	ground	46	19	46	-	28	34	35	7
	first	47	24	47	-	31	37	38	7
16A Dural St	ground	49	20	49	-	28	63	63	35
	first	50	23	50	-	30	63	63	33
19A Dural St	ground	50	23	50	-	32	58	58	26
23A Dural St	ground	47	24	47	-	31	43	43	12
24A Dural St	ground	46	17	46	-	26	27	30	4
	first	47	19	47	-	27	29	31	4
29A Dural St	ground	43	22	43	-	29	33	34	5
8A Dural St	ground	36	20	36	-	30	38	39	9
	first	38	22	38	-	32	40	41	9
	second	42	25	42	-	34	45	45	11
Dural St Church	ground	48	21	48	-	31	60	60	29
1A Frederick St	ground	46	42	47	1	64	62	66	2
	first	48	43	49	1	65	63	67	2
	second	50	43	51	1	65	63	67	2
	third	51	44	52	1	65	62	67	2
8 William St	ground	50	45	51	1	66	62	67	1
	first	51	46	52	1	66	62	67	1

Receiver	Floor Level	Noise Levels from Freeways, arterial, sub-arterial Roads dB(A) $L_{Aeq, 15 hour}$				Noise Levels from Local Roads, dB(A) $L_{Aeq, 1 hour (Max)}$			
		Scenario 2	Scenario 3	Total (Scenario 2 + 3)	Predicted increase	Scenario 2	Scenario 3	Total (Scenario 2 + 3)	Predicted increase
	second	53	48	54	1	66	62	67	1
9-17 William St	ground	51	37	51	-	67	62	68	1
	first	53	39	53	-	67	63	68	1
	second	55	40	55	-	67	63	68	1
10-12 William St	ground	48	43	49	1	66	62	67	1
	first	50	45	51	1	66	62	67	1
	second	51	46	52	1	66	62	67	1
	third	53	47	54	1	66	62	67	1
14-18 William St	ground	48	44	49	1	66	62	67	1
	first	49	45	50	1	66	62	67	1
	second	51	46	52	1	66	62	67	1
19-21 William St	ground	47	34	47	-	67	62	68	1
	first	49	35	49	-	67	63	68	1
	second	50	36	50	-	67	63	68	1
20-22 William St	ground	47	41	48	1	66	62	67	1
	first	49	43	50	1	66	62	67	1
23-25 William St	ground	45	8	45	-	67	62	68	1
	first	47	9	47	-	67	62	68	1
	second	48	10	48	-	67	63	68	1
29 William St	ground	45	29	45	-	67	63	68	1
	first	47	30	47	-	67	63	68	1
	second	48	33	48	-	67	63	68	1
31 William St	ground	45	31	45	-	59	58	62	3

A summary of the above results is provided in Section 5.1.9.

5.1.7 Scenarios 2 and 4, Predicted Traffic Noise Levels

The predicted traffic noise levels are split to account for the different noise limits that apply for local roads and those that apply for Freeways, arterial, or sub arterial roads. For the purposes of Scenario 4 and the results presented in Table 5-9, NSW RNP classifications were applied as displayed in Table 5-8.

Table 5-8 NSW RNP Classifications and Applicable Design Benchmark

NSW RNP Road classification	*Applicable Roads – Scenario 4*	*Applicable noise limit*
Freeways, arterial, sub-arterial	Bridge Road (East of the Pacific Hwy) Pacific Highway, George Street	60 dB(A) $L_{Aeq,\ 15\ hour}$
Local Roads	Bridge Road (West of the Pacific Hwy) William Street, Quarry Road, Frederick Street, Dural Street.	55 dB(A) $L_{Aeq,\ 1\ hour}$

The applicable noise limit changes as the vehicle crosses the Pacific Highway whilst on Bridge Road, in the case of a truck approaching the site. Results of modelling for Scenarios 2 (existing) and 3 (site access via Quarry Road) are presented in Table 5-9.

Predicted exceedances of the applicable criteria are highlighted.

Table 5-9 Predicted traffic noise levels – Scenarios 2 and 4

Receiver	Floor Level	Noise Levels from Freeways, arterial, sub-arterial Roads dB(A) $L_{Aeq, 15 hour}$				Noise Levels from Local Roads, dB(A) $L_{Aeq, 1 hour (Max)}$			
		Scenario 2	Scenario 4	Total (Scenario 2 + 4)	Predicted increase	Scenario 2	Scenario 4	Total (Scenario 2 + 4)	Predicted increase
211 Pacific Hwy	ground	60	44	60	-	38	36	40	2
	first	65	47	65	-	40	38	42	2
	second	66	48	66	-	42	40	44	2
213 Pacific Hwy	ground	60	44	60	-	37	35	39	2
	first	64	48	64	-	39	37	41	2
215 Pacific Hwy	ground	61	46	61	-	42	39	44	2
	first	66	49	66	-	43	42	46	3
	second	67	50	67	-	45	43	47	2
	third	67	51	67	-	46	44	48	2
217 Pacific Hwy	ground	64	50	64	-	46	46	49	3
	first	66	52	66	-	49	48	52	3
	second	68	52	68	-	50	48	52	2
	third	67	53	67	-	51	49	53	2
219 Pacific Hwy	ground	64	52	64	-	51	50	54	3
	first	67	54	67	-	54	52	56	2
	second	68	55	68	-	55	53	57	2
221 Pacific Hwy	ground	66	55	66	-	59	57	61	2
	first	68	56	68	-	61	58	63	2
	second	69	56	69	-	62	58	63	1
223 Pacific Hwy	ground	59	52	60	1	64	62	66	2
	first	61	53	62	1	67	63	68	1
	second	62	53	63	1	66	63	68	2
227 Pacific Hwy	ground	61	51	61	-	47	46	50	3
229 Pacific Hwy	ground	66	49	66	-	41	41	44	3

Receiver	Floor Level	Noise Levels from Freeways, arterial, sub-arterial Roads dB(A) $L_{Aeq,\ 15\ hour}$				Noise Levels from Local Roads, dB(A) $L_{Aeq,\ 1\ hour\ (Max)}$			
		Scenario 2	Scenario 4	Total (Scenario 2 + 4)	Predicted increase	Scenario 2	Scenario 4	Total (Scenario 2 + 4)	Predicted increase
231 Pacific Hwy	ground	64	46	64	-	36	35	39	3
233 Pacific Hwy	ground	63	45	63	-	29	27	31	2
235 Pacific Hwy	ground	64	45	64	-	35	34	38	3
1 Roper Ln	ground	55	42	55	-	39	37	41	2
	ground	50	31	50	-	53	53	56	3
3 Roper Ln	ground	54	41	54	-	33	31	35	2
5 Roper Ln	ground	54	41	54	-	34	32	36	2
1 Summers Ave	ground	54	43	54	-	42	41	45	3
3 Summers Ave	ground	55	46	56	1	44	43	47	3

A summary of the above results is provided in Section 5.1.9.

5.1.8 Scenarios 2 and 5, Predicted Traffic Noise Levels

The predicted traffic noise levels are split to account for the different noise limits that apply for local roads and those that apply for Freeways, arterial, or sub arterial roads. For the purposes of Scenario 5 and the results presented in Table 5-10, NSW RNP classifications were applied as displayed in Table 5-6 and Table 5-8.

Predicted exceedances of the applicable criteria are highlighted.

Table 5-10 Predicted traffic noise levels – Scenarios 2 and 5

Receiver	Floor Level	Noise Levels from Freeways, arterial, sub-arterial Roads dB(A) $L_{Aeq, 15 hour}$				Noise Levels from Local Roads, dB(A) $L_{Aeq, 1 hour (Max)}$			
		Scenario 2	Scenario 5	Total (Scenario 2 + 5)	Predicted increase	Scenario 2	Scenario 5	Total (Scenario 2 + 5)	Predicted increase
5-9 Dural St	ground	54	36	54	-	31	44	44	13
	first	56	36	56	-	33	45	45	12
	second	57	38	57	-	37	46	47	10
10-12 Dural St	ground	46	29	46	-	27	30	32	5
	first	47	30	47	-	29	32	34	5
	second	49	31	49	-	32	35	37	5
11-15 Dural St	ground	54	35	54	-	32	47	47	15
	first	55	35	55	-	35	48	48	13
	second	56	38	56	-	39	49	49	10
16 Dural St	ground	48	30	48	-	25	60	60	35
	first	48	31	48	-	25	60	60	35
	second	49	32	49	-	26	59	59	33
	third	50	33	50	-	27	59	59	32
	fourth	51	34	51	-	28	59	59	31
17 Dural St	ground	49	33	49	-	30	55	55	25
	first	51	34	51	-	32	56	56	24
	second	53	37	53	-	35	56	56	21
20 Dural St	ground	47	30	47	-	27	29	31	4
	first	47	31	47	-	28	31	33	5
21 Dural St	ground	50	34	50	-	32	52	52	20
22 Dural St	ground	42	28	42	-	27	41	41	14
	first	46	30	46	-	28	43	43	15
23 Dural St	ground	50	35	50	-	31	50	50	19
24 Dural St	ground	46	29	46	-	24	34	34	10

Receiver	Floor Level	Noise Levels from Freeways, arterial, sub-arterial Roads dB(A) $L_{Aeq,\ 15\ hour}$				Noise Levels from Local Roads, dB(A) $L_{Aeq,\ 1\ hour\ (Max)}$			
		Scenario 2	Scenario 5	Total (Scenario 2 + 5)	Predicted increase	Scenario 2	Scenario 5	Total (Scenario 2 + 5)	Predicted increase
	first	47	31	47	-	26	40	40	14
25 Dural St	ground	48	34	48	-	32	42	42	10
26 Dural St	ground	45	30	45	-	27	28	31	4
	first	47	32	47	-	28	31	33	5
27 Dural St	ground	47	33	47	-	31	43	43	12
29 Dural St	ground	47	33	47	-	28	40	40	12
	first	48	34	48	-	31	43	43	12
31 Dural St	ground	46	32	46	-	28	31	33	5
	first	47	34	47	-	31	34	36	5
16A Dural St	ground	49	31	49	-	28	60	60	32
	first	50	32	50	-	30	60	60	30
19A Dural St	ground	50	34	50	-	32	55	55	23
23A Dural St	ground	47	33	47	-	31	40	41	10
24A Dural St	ground	46	30	46	-	26	25	29	3
	first	47	30	47	-	27	27	30	3
29A Dural St	ground	43	30	43	-	29	30	33	4
8A Dural St	ground	36	22	36	-	30	35	36	6
	first	38	24	38	-	32	37	38	6
	second	42	27	42	-	34	42	43	9
Dural St Church	ground	48	33	48	-	31	57	57	26
1A Frederick St	ground	46	40	47	1	64	59	65	1
	first	48	41	49	1	65	60	66	1
	second	50	42	51	1	65	60	66	1
	third	51	43	52	1	65	59	66	1
211 Pacific Hwy	ground	60	41	60	-	38	33	39	1
	first	65	44	65	-	40	36	41	1

Receiver	Floor Level	Noise Levels from Freeways, arterial, sub-arterial Roads dB(A) $L_{Aeq, 15 hour}$				Noise Levels from Local Roads, dB(A) $L_{Aeq, 1 hour (Max)}$			
		Scenario 2	Scenario 5	Total (Scenario 2 + 5)	Predicted increase	Scenario 2	Scenario 5	Total (Scenario 2 + 5)	Predicted increase
	second	66	45	66	-	42	38	43	1
213 Pacific Hwy	ground	60	41	60	-	37	33	38	1
	first	64	45	64	-	39	35	40	1
215 Pacific Hwy	ground	61	43	61	-	42	36	43	1
	first	66	46	66	-	43	39	44	1
	second	67	47	67	-	45	40	46	1
	third	67	48	67	-	46	41	47	1
217 Pacific Hwy	ground	64	47	64	-	46	43	48	2
	first	66	49	66	-	49	45	50	1
	second	68	49	68	-	50	45	51	1
	third	67	50	67	-	51	46	52	1
219 Pacific Hwy	ground	64	49	64	-	51	47	52	1
	first	67	51	67	-	54	49	55	1
	second	68	52	68	-	55	50	56	1
221 Pacific Hwy	ground	66	52	66	-	59	54	60	1
	first	68	53	68	-	61	55	62	1
	second	69	53	69	-	62	55	63	1
223 Pacific Hwy	ground	59	49	59	-	64	59	65	1
	first	61	50	61	-	67	60	68	1
	second	62	50	62	-	66	60	67	1
227 Pacific Hwy	ground	61	48	61	-	47	43	48	1
229 Pacific Hwy	ground	66	46	66	-	41	38	43	2
231 Pacific Hwy	ground	64	43	64	-	36	32	37	1
233 Pacific Hwy	ground	63	42	63	-	29	25	30	1
235 Pacific Hwy	ground	64	42	64	-	35	32	37	2
1 Roper Ln	ground	55	39	55	-	39	34	40	1

Receiver	Floor Level	Noise Levels from Freeways, arterial, sub-arterial Roads dB(A) $L_{Aeq,\ 15\ hour}$				Noise Levels from Local Roads, dB(A) $L_{Aeq,\ 1\ hour\ (Max)}$			
		Scenario 2	Scenario 5	Total (Scenario 2 + 5)	Predicted increase	Scenario 2	Scenario 5	Total (Scenario 2 + 5)	Predicted increase
	ground	50	28	50	-	53	50	55	2
3 Roper Ln	ground	54	38	54	-	33	28	34	1
5 Roper Ln	ground	54	38	54	-	34	30	35	1
1 Summers Ave	ground	54	40	54	-	42	38	43	1
3 Summers Ave	ground	55	43	55	-	44	40	45	1
8 William St	ground	50	43	51	1	66	59	67	1
	first	51	44	52	1	66	59	67	1
	second	53	46	54	1	66	59	67	1
9-17 William St	ground	51	37	51	-	67	59	68	1
	first	53	39	53	-	67	60	68	1
	second	55	41	55	-	67	60	68	1
10-12 William St	ground	48	41	49	1	66	59	67	1
	first	50	43	51	1	66	59	67	1
	second	51	44	52	1	66	59	67	1
	third	53	45	54	1	66	59	67	1
14-18 William St	ground	48	42	49	1	66	59	67	1
	first	49	43	50	1	66	59	67	1
	second	51	44	52	1	66	59	67	1
19-21 William St	ground	47	35	47	-	67	59	68	1
	first	49	36	49	-	67	60	68	1
	second	50	37	50	-	67	60	68	1
20-22 William St	ground	47	39	48	1	66	59	67	1
	first	49	42	50	1	66	59	67	1
23-25 William St	ground	45	31	45	-	67	59	68	1
	first	47	32	47	-	67	59	68	1
	second	48	33	48	-	67	60	68	1

Receiver	Floor Level	Noise Levels from Freeways, arterial, sub-arterial Roads dB(A) $L_{Aeq, 15 hour}$				Noise Levels from Local Roads, dB(A) $L_{Aeq, 1 hour (Max)}$			
		Scenario 2	Scenario 5	Total (Scenario 2 + 5)	Predicted increase	Scenario 2	Scenario 5	Total (Scenario 2 + 5)	Predicted increase
29 William St	ground	45	32	45	-	67	60	68	1
	first	47	34	47	-	67	60	68	1
	second	48	36	48	-	67	60	68	1
31 William St	ground	45	33	45	-	59	55	60	1

A summary of the above results is provided in Section 5.1.9.

5.1.9 Traffic Analysis Results Summary

Noise levels from site generated traffic are predicted to exceed the criteria on local roads in cases where dwellings are immediately adjacent to the haulage route. The local roads include William Street, Dural Lane, Frederick Street, and Bridge Road.

Given that the Bridge Road access would minimise the potential for traffic on local roads, this access point is the preferred option on the basis of minimising noise impact. However, the traffic noise levels for the existing situation and the site generated traffic (utilising the Bridge Road) situation, are both predicted to exceed the criteria at two locations (which are apartment buildings), and result in combined levels exceeding the criteria at 4 locations. The contribution from site generated traffic is predicted to increase traffic noise levels by 1-3 dB(A). In accordance with the NSW RNP, increases of more than 2 dB(A) would be considered discernible to the human ear.

By comparison, noise impact from the existing situation combined with the contribution from site generated traffic utilising the Quarry Road option is predicted to exceed the criteria at up to 15 locations (which includes a mixture of dwellings and apartment buildings). Up to 10 of these locations are predicted to have high existing traffic noise levels, with additional heavy vehicle traffic predicted to significantly increase noise levels at 5 locations, including apartment buildings and dwellings.

The option of splitting traffic between both Quarry Road and Bridge Road would reduce the predicted noise impact from trucks on these roads by approximately 3 dB(A). However the combined noise levels are still predicted to exceed the criteria at 17 locations, which include 14 locations located along Quarry Road and 3 locations located along the Bridge Road access. Existing levels are predicted to exceed the criteria at 11 of these locations; therefore site generated traffic is predicted to increase traffic noise to levels above the criteria at 6 locations.

Other options considered for reducing noise in this assessment, included upgrading of the road surface. However truck noise on local roads with speed limits of 50 km/h would be predominately caused by the truck engine and exhaust, rather than by the friction of the tyres and road surface. Acoustic barriers were considered, however these would not be practical for screening roads with residential driveways.

5.2 Onsite Quarry Noise

5.2.1 Onsite Quarry Noise Model Inputs and Assumptions

The prediction of onsite quarry was conducted with SoundPLAN 7.1, which applied calculation methodology in accordance with International Standard *IS0 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*. The noise model inputs and assumptions are displayed in Table 5-11.

Table 5-11 Noise model parameters

Input Parameter	*Input Date/Source Reference*
Ground Elevation Geometry	Provided by the Cardno design team
Quarry Geometry	Provided by the Cardno design team
Ground Absorption	Assumed 100% soft ground absorption surfaces (e.g. grass) between the quarry and receivers.
Wind	Calm Conditions
Temperature	Model default -10°C
Humidity	Model default -70%
Air Pressure	Model default -1013.25mbar
Facade Reflection	+2.5 dB(A) – applied to existing and future prediction models only, where receivers were located at facades of buildings.
Receiver Height	Assumed to be 1.5 metres above floor level.

5.2.2 Onsite Equipment and Plant

Construction equipment noise sources have been sourced from Industry references and supplemented with values referenced from Australian Standard AS 2436:2010 – "Guide to noise and vibration control on construction, demolition and maintenance sites". The noise levels that have been used as the basis for the noise assessment are summarised in Table 5-12.

Table 5-12 Proposed plant and equipment sound power levels

Plant	*Quantity*	*Sound Power Level, dB(A)*	*usage*	*Source Height*
Vibratory roller	1	111	daily	1
Loader	1	113	daily	3
4x4 ute	2-3	87	daily	1
Truck	23 (per hour)	99	daily	2
Water Cart	1	110	daily	2
Fuel truck	1	110	daily	2
Reverse beacon	1 per truck	98	daily	1
Wheel wash	1	108	daily	3
Large Padfoot roller	1	111	1 day per month	1
Bulldozer	1	108	1 day per month	3
Excavator	1	113	1 day per fortnight	3
Grader	1	108	1 day per month	2

The noise model has taken into consideration that several infrequently used items of plant (i.e. Large Padfoot Roller, Bulldozer, Excavator, and the Grader) are unlikely to be used simultaneously. Of the infrequently used plant, the excavator is the loudest and it was therefore the only item of plant included in the sound models in conjunction with the remaining items of plant used daily to provide a practical worst case scenario.

5.2.3 Modelled Quarry Noise Scenarios

The assessment of quarry filling operations has taken into consideration the following operational configurations:

> Site access via William Street and Quarry Road

> Site access via Bridge Road.

> Fill commencing in the quarry pit at RL10, with trucks dumping spoil from RL46.

> Fill nearing completion at RL90 in the year 2021.

The above operational configurations are incorporated into 4 model scenarios as follows:

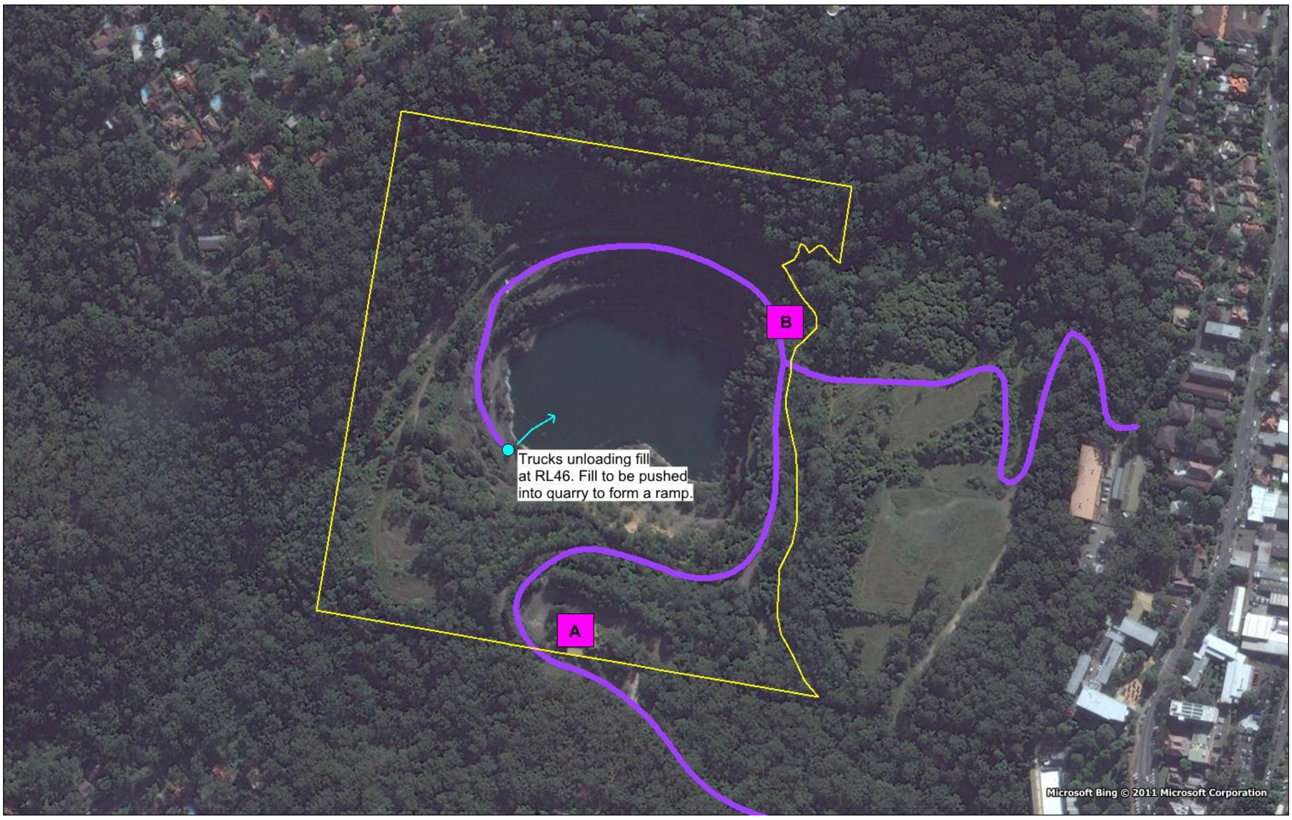
Scenario 1: Trucks dumping fill at RL46, with compactors operating at RL10. Site entry facilities are situated at location 'A' as shown in Figure 5-3.

Scenario 2: Trucks dumping fill at RL46, with compactors operating at RL10. Site entry facilities are situated at location 'B' as shown in Figure 5-3.

Scenario 3: Trucks dumping fill at RL90, with compactors operating at RL90. Site entry facilities are situated at location 'A' as shown in Figure 5-3.

Scenario 4: Trucks dumping fill at RL90, with compactors operating at RL90. Site entry facilities are situated at location 'B' as shown in Figure 5-3.

Figure 5-3 Site access locations



5.2.4 Predicted Noise Impact from Construction Activities

Predicted noise impacts for onsite quarry activities are displayed in Table 5-13. For comparison to the assessment criteria, predicted exceedances of the day criteria are highlighted.

Please note, where a prediction exceeds the daytime criterion, it will also exceed both the evening and night criteria.

Table 5-13 Predicted Noise Levels

Receiver	Floor	Criteria			Predicted Noise Level, dB(A) $L_{Aeq,\ 1\ hour}$ Modelled Scenario			
		Day	Evening	Night	1	2	3	4
5-9 Dural St	ground	47	45	39	46	33	46	39
	first	47	45	39	47	36	48	43
	second	47	45	39	47	41	48	46
10-12 Dural St	ground	47	45	39	49	46	51	49
	first	47	45	39	49	46	51	49
	second	47	45	39	50	47	51	49
11-15 Dural St	ground	47	45	39	47	36	47	41
	first	47	45	39	48	41	49	45
	second	47	45	39	48	43	49	47
16 Dural St	ground	38	36	35	52	47	52	49
	first	38	36	35	52	47	53	50
	second	38	36	35	52	47	53	50

Receiver	Floor	Criteria			Predicted Noise Level, dB(A) $L_{Aeq,\ 1\ hour}$ Modelled Scenario			
		Day	Evening	Night	1	2	3	4
	third	38	36	35	52	47	53	50
	fourth	38	36	35	53	48	53	50
17 Dural St	ground	47	45	39	45	43	45	43
	first	47	45	39	45	45	46	46
	second	47	45	39	46	46	47	48
20 Dural St	ground	38	36	35	55	48	55	49
	first	38	36	35	55	48	55	50
21 Dural St	ground	44	42	38	47	42	48	45
22 Dural St	ground	38	36	35	48	47	50	49
	first	38	36	35	49	47	51	49
23 Dural St	ground	44	42	38	50	36	50	44
24 Dural St	ground	38	36	35	53	40	53	41
	first	38	36	35	54	44	54	47
25 Dural St	ground	44	42	38	45	45	47	48
26 Dural St	ground	38	36	35	52	48	53	51
	first	38	36	35	54	48	54	50
27 Dural St	ground	44	42	38	51	46	51	49
28 Dural St	ground	38	36	35	56	48	57	50
	first	38	36	35	57	48	57	50
29 Dural St	ground	44	42	38	48	47	49	48
	first	44	42	38	49	47	50	48
30 Dural St	ground	38	36	35	55	47	55	48
	first	38	36	35	56	47	56	49
31 Dural St	ground	44	42	38	49	46	49	46
	first	44	42	38	49	46	50	48
32 Dural St	ground	38	36	35	56	48	56	50
	first	38	36	35	56	48	56	50
34 Dural St	ground	38	36	35	55	48	55	49
	first	38	36	35	55	48	56	49
36 Dural St	ground	38	36	35	58	48	58	50
	first	38	36	35	58	48	58	50
38 Dural St	ground	38	36	35	58	48	58	50
	first	38	36	35	58	48	58	50
40 Dural St	ground	38	36	35	58	48	58	50
42 Dural St	ground	38	36	35	58	48	58	50
44 Dural St	ground	38	36	35	59	48	58	50
46 Dural St	ground	38	36	35	57	47	57	48
48 Dural St	ground	38	36	35	55	47	55	47
50 Dural St	ground	38	36	35	55	46	55	47
52 Dural St	ground	38	36	35	56	47	56	47
56 Dural St	ground	38	36	35	55	44	54	46

Receiver	Floor	Criteria			Predicted Noise Level, dB(A) $L_{Aeq,\ 1\ hour}$ Modelled Scenario			
		Day	Evening	Night	1	2	3	4
58 Dural St	ground	38	36	35	57	44	56	45
60 Dural St	ground	38	36	35	55	42	54	43
16A Dural St	ground	38	36	35	49	47	51	50
	first	38	36	35	47	47	50	50
19A Dural St	ground	44	42	38	46	44	46	45
23A Dural St	ground	44	42	38	52	44	52	46
24A Dural St	ground	38	36	35	55	48	55	50
	first	38	36	35	55	48	55	50
29A Dural St	ground	38	36	35	49	46	50	48
8A Dural St	ground	47	45	39	50	43	51	48
	first	47	45	39	51	45	52	49
	second	47	45	39	51	46	52	49
1 Fern Tree Cl	ground	38	37	36	50	56	52	57
3 Fern Tree Cl	ground	38	37	36	51	55	53	57
5 Fern Tree Cl	ground	38	37	36	51	56	53	57
7 Fern Tree Cl	ground	38	37	36	50	57	49	57
9 Fern Tree Cl	ground	38	37	36	52	57	54	58
10 Fern Tree Cl	ground	38	37	36	50	54	52	55
	first	38	37	36	50	55	52	56
12 Fern Tree Cl	ground	38	37	36	50	54	52	56
	first	38	37	36	50	54	52	56
14 Fern Tree Cl	ground	38	37	36	50	55	52	56
	first	38	37	36	50	55	52	56
15 Fern Tree Cl	ground	38	37	36	52	58	53	59
16 Fern Tree Cl	ground	38	37	36	50	54	52	56
	first	38	37	36	50	55	52	56
17 Fern Tree Cl	ground	38	37	36	52	58	54	59
19 Fern Tree Cl	ground	38	37	36	52	55	55	57
20 Fern Tree Cl	ground	38	37	36	47	48	47	50
	first	38	37	36	49	50	49	53
22 Fern Tree Cl	ground	38	37	36	47	50	47	51
	first	38	37	36	49	52	49	54
24 Fern Tree Cl	ground	38	37	36	49	52	50	53
	first	38	37	36	49	54	51	55
26 Fern Tree Cl	ground	38	37	36	50	53	52	55
	first	38	37	36	50	54	53	56
28 Fern Tree Cl	ground	38	37	36	50	52	52	55
	first	38	37	36	51	53	53	55
30 Fern Tree Cl	ground	38	37	36	51	54	52	56
	first	38	37	36	51	55	53	57
32 Fern Tree Cl	ground	38	37	36	52	53	54	55

Receiver	Floor	Criteria			Predicted Noise Level, dB(A) $L_{Aeq,\ 1\ hour}$ Modelled Scenario			
		Day	Evening	Night	1	2	3	4
1A Fern Tree Cl	first	38	37	36	52	54	55	56
	ground	38	37	36	52	55	53	56
1A Frederick St	ground	47	45	39	30	28	31	28
	first	47	45	39	30	28	30	28
	second	47	45	39	30	28	30	29
	third	47	45	39	31	29	32	30
1 Lockinvar Pl	ground	37	37	35	48	33	46	35
3 Lockinvar Pl	ground	37	37	35	48	33	46	35
4 Lockinvar Pl	ground	37	37	35	42	30	42	30
5 Lockinvar Pl	ground	37	37	35	46	32	45	34
6 Lockinvar Pl	ground	37	37	35	41	29	41	29
7 Lockinvar Pl	ground	37	37	35	51	34	49	39
9 Lockinvar Pl	ground	37	37	35	36	30	35	30
11 Lockinvar Pl	ground	37	37	35	35	30	34	29
30 Lowanna Pl	ground	37	37	35	51	33	50	35
32 Lowanna Pl	ground	37	37	35	38	30	37	30
26A Lowanna Pl	ground	37	37	35	53	42	52	43
7 Manor Rd	ground	37	37	35	48	49	50	51
9 Manor Rd	ground	37	37	35	46	48	48	49
10 Manor Rd	ground	37	37	35	47	41	47	43
11 Manor Rd	ground	37	37	35	50	51	51	53
15 Manor Rd	ground	37	37	35	50	51	50	52
16 Manor Rd	ground	37	37	35	45	40	46	42
17 Manor Rd	ground	37	37	35	42	39	43	41
17A Manor Rd	ground	37	37	35	52	50	53	53
18 Manor Rd	ground	37	37	35	45	40	45	42
19 Manor Rd	ground	37	37	35	46	39	46	41
21 Manor Rd	ground	37	37	35	48	43	48	45
23 Manor Rd	ground	37	37	35	49	43	49	48
25 Manor Rd	ground	37	37	35	46	39	47	44
27 Manor Rd	ground	37	37	35	47	45	47	47
29 Manor Rd	ground	37	37	35	47	46	49	49
31 Manor Rd	ground	37	37	35	50	51	49	51
32 Manor Rd	ground	37	37	35	45	36	45	39
33 Manor Rd	ground	37	37	35	52	52	54	55
34-36 Manor Rd	ground	37	37	35	44	36	43	38
35 Manor Rd	ground	37	37	35	52	52	54	55
37 Manor Rd	ground	37	37	35	52	52	54	55
39 Manor Rd	ground	37	37	35	52	52	54	55
40 Manor Rd	ground	37	37	35	43	38	44	41
41 Manor Rd	ground	37	37	35	52	52	54	55

Receiver	Floor	Criteria			Predicted Noise Level, dB(A) $L_{Aeq, 1 hour}$ Modelled Scenario			
		Day	Evening	Night	1	2	3	4
43 Manor Rd	ground	37	37	35	52	52	54	55
44 Manor Rd	ground	37	37	35	44	38	44	40
45 Manor Rd	ground	37	37	35	51	50	54	54
46 Manor Rd	ground	37	37	35	42	38	43	40
47 Manor Rd	ground	37	37	35	49	50	53	53
48 Manor Rd	ground	37	37	35	37	35	38	37
49 Manor Rd	ground	37	37	35	51	45	53	52
50 Manor Rd	ground	37	37	35	44	39	44	39
51 Manor Rd	ground	37	37	35	52	52	54	54
52 Manor Rd	ground	37	37	35	47	41	47	43
53 Manor Rd	ground	37	37	35	53	52	54	54
54 Manor Rd	ground	37	37	35	46	42	46	43
55 Manor Rd	ground	37	37	35	52	52	54	54
57 Manor Rd	ground	37	37	35	51	50	54	54
59 Manor Rd	ground	37	37	35	51	49	54	53
60 Manor Rd	ground	37	37	35	46	41	46	43
61 Manor Rd	ground	37	37	35	51	50	53	54
63 Manor Rd	ground	37	37	35	48	50	53	54
64 Manor Rd	ground	37	37	35	48	44	49	45
65 Manor Rd	ground	37	37	35	50	41	50	45
66 Manor Rd	ground	37	37	35	45	41	45	44
67 Manor Rd	ground	37	37	35	50	43	51	46
68 Manor Rd	ground	37	37	35	44	44	45	45
69 Manor Rd	ground	37	37	35	48	42	49	46
71 Manor Rd	ground	37	37	35	45	36	46	40
73 Manor Rd	ground	37	37	35	49	46	51	50
74 Manor Rd	ground	37	37	35	46	37	45	38
75 Manor Rd	ground	37	37	35	50	48	52	52
76 Manor Rd	ground	37	37	35	48	35	47	36
77 Manor Rd	ground	37	37	35	51	49	53	53
78 Manor Rd	ground	37	37	35	42	33	42	33
80 Manor Rd	ground	37	37	35	47	33	47	33
82 Manor Rd	ground	37	37	35	47	38	47	39
84 Manor Rd	ground	37	37	35	51	34	51	45
86 Manor Rd	ground	37	37	35	52	47	54	53
88 Manor Rd	ground	37	37	35	50	35	50	39
90 Manor Rd	ground	37	37	35	52	38	51	43
92 Manor Rd	ground	37	37	35	52	48	54	53
94 Manor Rd	ground	37	37	35	52	50	55	55
96 Manor Rd	ground	37	37	35	53	51	56	55
98 Manor Rd	ground	37	37	35	55	54	56	56

Receiver	Floor	Criteria			Predicted Noise Level, dB(A) $L_{Aeq,\ 1\ hour}$			
					Modelled Scenario			
		Day	Evening	Night	1	2	3	4
17A Manor Rd	ground	37	37	35	51	50	52	53
19A Manor Rd	ground	37	37	35	50	48	52	52
19B Manor Rd	ground	37	37	35	48	47	49	49
21A Manor Rd	ground	37	37	35	51	48	53	52
23A Manor Rd	ground	37	37	35	52	49	53	52
25A Manor Rd	ground	37	37	35	50	49	52	52
27A Manor Rd	ground	37	37	35	48	48	50	50
27B Manor Rd	ground	37	37	35	52	51	54	54
29A Manor Rd	ground	37	37	35	52	52	53	54
31A Manor Rd	ground	37	37	35	51	52	53	55
31B Manor Rd	ground	37	37	35	53	54	55	56
42B Manor Rd	ground	37	37	35	44	36	44	39
47A Manor Rd	ground	37	37	35	52	52	55	55
56A Manor Rd	ground	37	37	35	46	40	46	42
57A Manor Rd	ground	37	37	35	53	53	55	55
59A Manor Rd	ground	37	37	35	54	53	55	55
61A Manor Rd	ground	37	37	35	54	53	56	55
63A Manor Rd	ground	37	37	35	49	51	54	55
211 Pacific Hwy	ground	46	44	39	49	52	51	53
	first	46	44	39	49	52	51	53
	second	46	44	39	50	52	51	53
213 Pacific Hwy	ground	46	44	39	49	51	51	52
	first	46	44	39	50	52	51	53
215 Pacific Hwy	ground	46	44	39	49	54	51	54
	first	46	44	39	49	54	51	55
	second	46	44	39	50	54	51	55
	third	46	44	39	50	54	51	55
217 Pacific Hwy	ground	46	44	39	49	54	51	55
	first	46	44	39	49	54	51	55
	second	46	44	39	49	54	51	55
	third	46	44	39	50	54	51	55
219 Pacific Hwy	ground	46	44	39	49	52	50	53
	first	46	44	39	49	54	50	54
	second	46	44	39	49	54	51	55
221 Pacific Hwy	ground	46	44	39	48	53	50	54
	first	46	44	39	49	54	50	54
	second	46	44	39	49	54	50	55
223 Pacific Hwy	ground	46	44	39	48	50	49	51
	first	46	44	39	48	51	49	52
	second	46	44	39	48	52	50	53
227 Pacific Hwy	ground	46	44	39	46	44	48	47

Receiver	Floor	Criteria			Predicted Noise Level, dB(A) $L_{Aeq,\ 1\ hour}$ Modelled Scenario			
		Day	Evening	Night	1	2	3	4
229 Pacific Hwy	ground	46	44	39	28	30	29	30
231 Pacific Hwy	ground	46	44	39	45	43	45	46
233 Pacific Hwy	ground	46	44	39	45	41	46	45
235 Pacific Hwy	ground	46	44	39	45	40	45	45
1 Roper Ln	ground	46	44	39	49	52	50	53
	ground	46	44	39	48	51	50	53
3 Roper Ln	ground	46	44	39	48	51	50	53
5 Roper Ln	ground	46	44	39	48	51	50	52
93 Rosemead Rd	ground	46	44	39	42	36	41	39
95 Rosemead Rd	ground	46	44	39	43	31	41	33
97 Rosemead Rd	ground	46	44	39	38	29	37	29
101 Rosemead Rd	ground	37	37	35	39	33	39	36
105 Rosemead Rd	ground	37	37	35	36	33	37	36
106 Rosemead Rd	ground	37	37	35	34	29	33	28
107 Rosemead Rd	ground	37	37	35	46	33	45	36
108 Rosemead Rd	ground	37	37	35	34	29	33	29
110 Rosemead Rd	ground	37	37	35	44	30	43	30
1 Summers Ave	ground	46	44	39	49	52	50	53
2-4 Summers Cl	ground	46	44	39	49	53	51	54
	first	46	44	39	49	53	51	54
3 Summers Ave	ground	46	44	39	49	52	50	54
6 Summers Cl	ground	46	44	39	50	54	51	55
	first	46	44	39	51	55	53	56
7 Summers Cl	ground	46	44	39	49	54	51	54
8 Summers Cl	ground	46	44	39	50	54	51	55
	first	46	44	39	50	54	51	55
8 William St	ground	47	45	39	28	31	28	31
	first	47	45	39	28	26	28	26
	second	47	45	39	28	26	28	26
9-17 William St	ground	47	45	39	33	30	34	31
	first	47	45	39	35	31	36	33
	second	47	45	39	37	33	37	35
10-12 William St	ground	47	45	39	29	28	29	28
	first	47	45	39	28	27	28	27
	second	47	45	39	28	27	28	27
	third	47	45	39	28	27	28	27
14-18 William St	ground	47	45	39	31	32	30	32
	first	47	45	39	31	32	30	32
	second	47	45	39	31	28	31	28
19-21 William St	ground	47	45	39	32	28	32	30
	first	47	45	39	33	29	34	32

Receiver	Floor	Criteria			Predicted Noise Level, dB(A) $L_{Aeq,\ 1\ hour}$ Modelled Scenario			
		Day	Evening	Night	1	2	3	4
	second	47	45	39	35	30	36	34
20-22 William St	ground	47	45	39	32	33	32	34
	first	47	45	39	32	32	33	33
23-25 William St	ground	47	45	39	35	31	35	32
	first	47	45	39	36	33	36	34
	second	47	45	39	38	35	38	36
29 William St	ground	47	45	39	38	37	39	38
	first	47	45	39	40	40	40	41
	second	47	45	39	42	41	42	41
31 William St	ground	44	42	38	36	36	37	37
Dural St Church	ground	44	42	38	38	46	41	46

5.2.5 Onsite Quarry Noise Results Summary

Non-compliance during the day, evening and night period is predicted at a number of residents. Noise modelling predicted lower noise levels with the quarry operating at RL10, when compared to results predicted at RL90. Therefore once operational, noise impact may progressively worsen until completion. This is understandable, as noise sources will gradually move closer to the receivers (in both a vertical and horizontal sense) and any natural screening afforded by the topography will reduce. Residents on Manor Road will be the most affected, as these residents would have direct line of sight to quarry activities. It should be noted that the modelling reflects on point in time. We have endeavoured to model the worst case but noise levels will vary from those predicted in the above sections during actual operation, depending on the number of plant operating and its location.

The noise model has taken into consideration calm wind conditions, however downwind locations may experience higher noise levels than those predicted. As a worst case scenario, prevailing afternoon winds at the site, which are predominately 20-30km/h from the south east, may have the potential to exacerbate noise levels at the worst affected receiver locations on Manor Road. Prevailing morning winds, which are generally below 10km/h from the west, may increase noise levels at residents located to the east of the site.

Options for acoustic treatment are limited due to the extensive area under consideration and topographical constraints. Strategies could be implemented to minimize noise and these could be as follows:

- Minimising the number of items of plant in use at any one time;
- Partial barriers at vehicle entry points.

Provision of acoustic barriers at the Quarry were considered, however to be effective a barrier in excess of 5m would be required around the entire perimeter of the quarry.

6 Recommendations

To minimize noise at neighbouring residential receivers, the following recommendations could be implemented:

> Minimize the number of plant and equipment operating on the site at any one time;

> Restrict operation of the site to the day period (7am to 6pm);

> Provide acoustic property treatments to affected residential receivers;

> Design access layout to minimize requirements for visiting trucks to reverse;

> Utilise Bridge Road for access.

It should be noted that adoption of some or all of the above recommendations, are likely to reduce noise emissions and improve amenity, but are not likely to result in compliance with either the quarry operations or truck noise assessment criteria.

7 Conclusions

A full acoustic assessment was conducted of the proposed infill of the Hornsby Quarry project, located at Quarry Road, Hornsby.

Provided the recommendations in Section 6 are implemented, noise impacts at neighbouring offsite receivers will be minimised, but the relevant statutory noise criteria is not likely to be achievable for the Quarry fill operations, with any available practical mitigation options.

APPENDIX A
TECHNICAL TERMS

APPENDIX A – TECHNICAL TERMS

A-weighted Level:
As per dB(A) defined below.

Ambient Sound:
Of an environment: the all-encompassing sound associated with that environment, being a composite of sounds from many sources, near and far.

Background Sound Level:
The average of the lowest levels of the sound levels measured in an affected area in the absence of noise from occupants and from unwanted external ambient noise sources.

Decibel, dB:
Unit of acoustic measurement. Measurements of power, pressure and intensity may be expressed in dB relative to standard reference levels.

dB(A):
Unit of acoustic measurement electronically weighted to approximate the sensitivity of human hearing to sound frequency.

L_{90}, L_{10}etc:
A statistical measurement giving the sound pressure level which is exceeded for the given percentile of an observation period, i.e. L_{90} is the level which is exceeded for 90 precent of an observation period. L_{90} is commonly referred to as a basis for measuring the background sound level.

$L_{Abg,}$:
The A-weighted background sound level measured over a time interval T.

$L_{Aeq,T}$:
Equivalent continuous A-weighted sound pressure level. This is the value of the A-weighted sound pressure level of a continuous steady sound that, within a measurement time interval T, has the same A-weighted sound energy as the actual time-varying sound.

Sound Pressure Level, Lp, dB, of a sound:
A measurement obtained directly obtained using a microphone and sound level meter. Sound pressure level varies with distance from a source and with changes to the measuring environment. Sound pressure level equals 20 times the logarithm to the base 10 of the ratio of the r.m.s. sound pressure to the reference sound pressure of 20 micro Pascals.

Sound Power Level, Lw, dB of a source:
Sound power level is a measure of the sound energy emitted by a source, does not change with distance, and cannot be directly measured. Sound power level of a machine may vary depending on the actual operating load and is calculated from sound pressure level measurements with appropriate corrections for distance and/or environmental conditions. Sound power level is equal to 10 times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power of 1 picoWatt.

Weighted Sound Reduction Index, Rw:
A single number rating of laboratory measurement of airborne sound reduction index. It is the typical measure of sound reduction achievable by a building construction element. The rating is determined in accordance with AS 1191-2002 – "Acoustics – Method for Laboratory Measurement of Airborne Sound Insulation of Building Elements" or EN ISO 717-1.

Assessment Background Noise Level, ABL:
The assessment background level (ABL) is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10th percentile (lowest 10 percent) background level (LA90) for each period.

Rating Background Noise Level, RBL:
The rating background level for each period is the median value of the assessment background level values for the period over all of the days measured. As such, there is a rating background level value for each period –daytime, evening and night time.

Hornsby Quarry Infill

APPENDIX B
NOISE CONTOUR MAPS

Figure 7-1 Predicted Quarry Noise Levels, Scenario 1

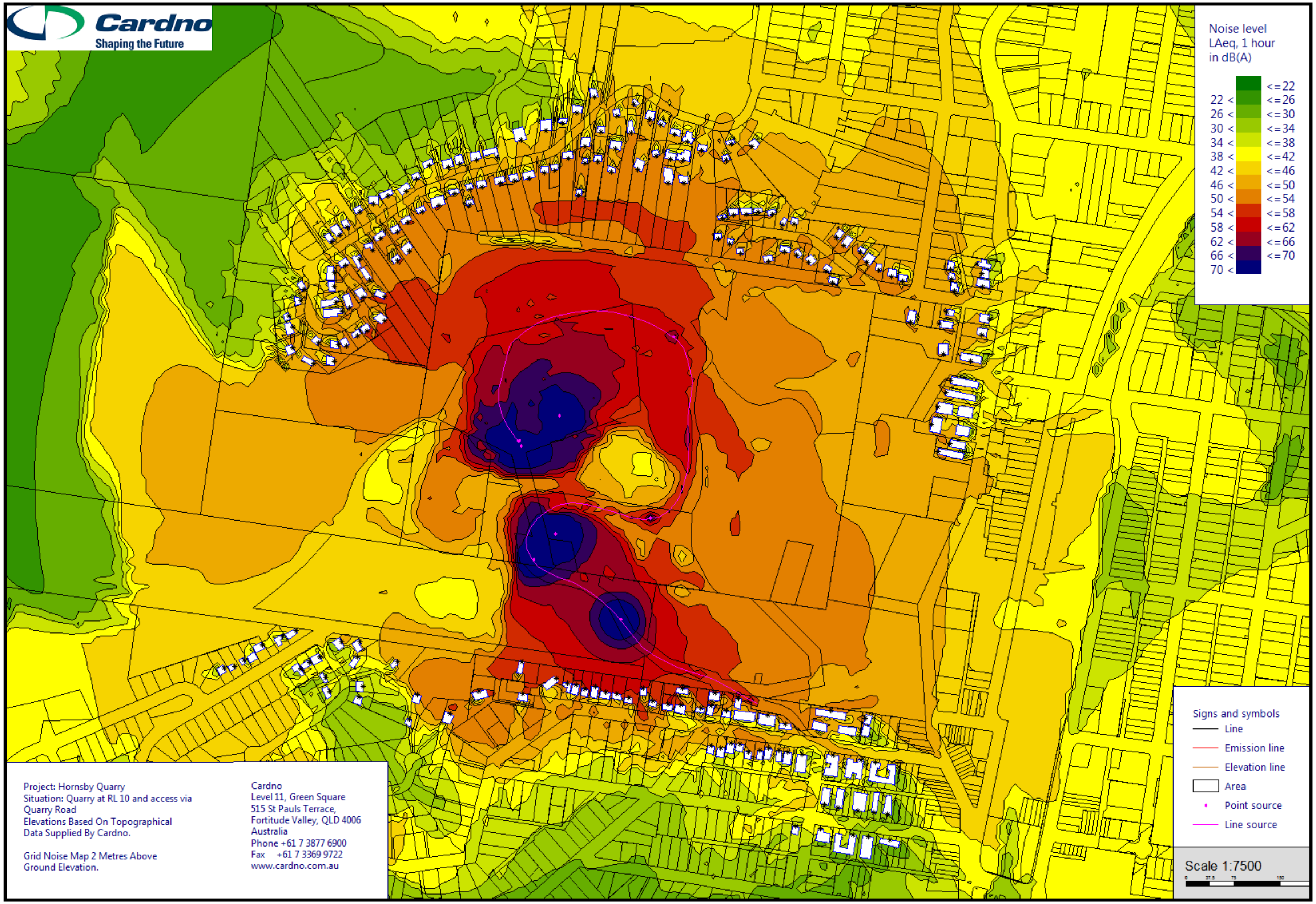


Figure 7-2 Predicted Quarry Noise Levels, Scenario 2

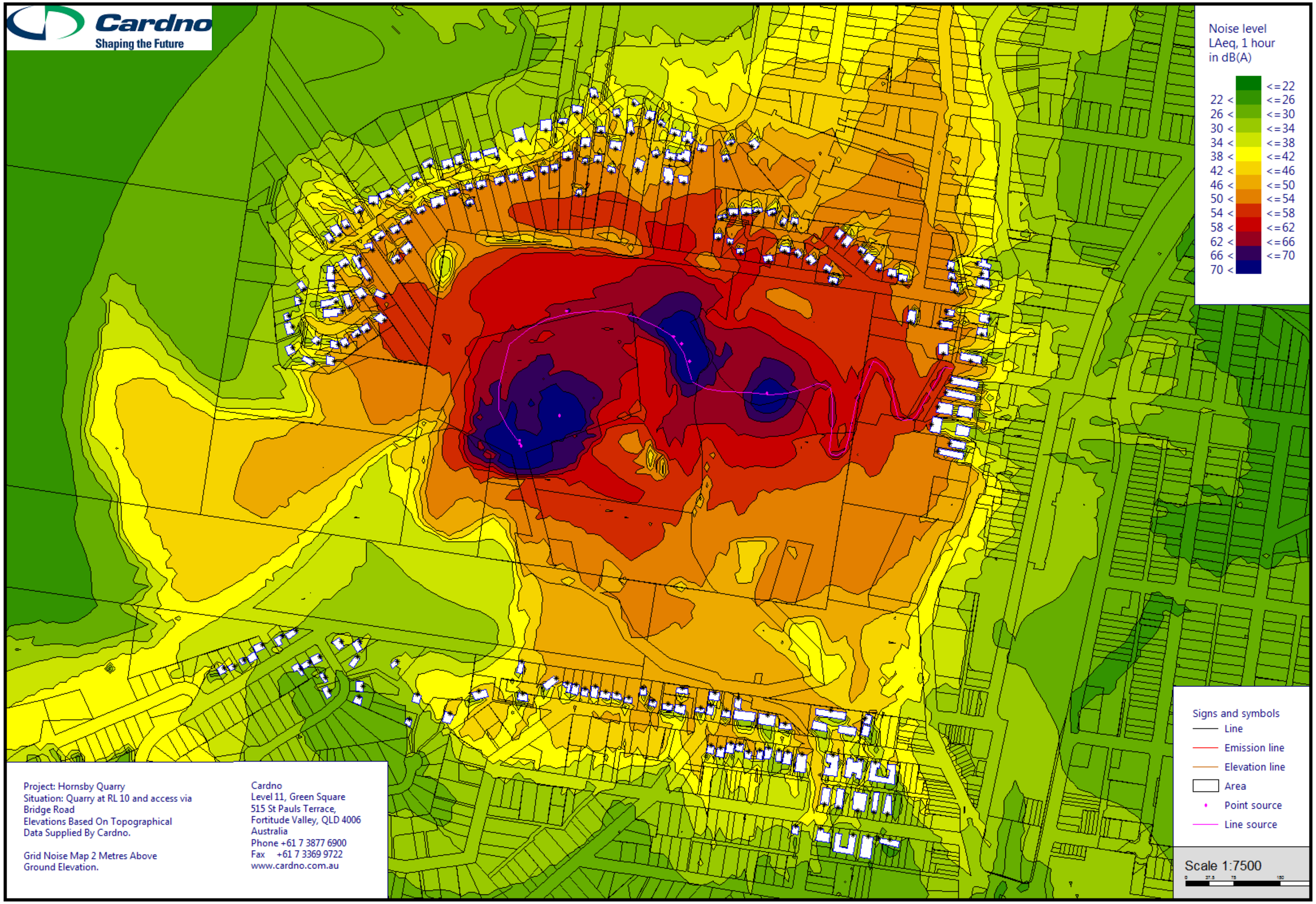


Figure 7-3 Predicted Quarry Noise Levels, Scenario 3

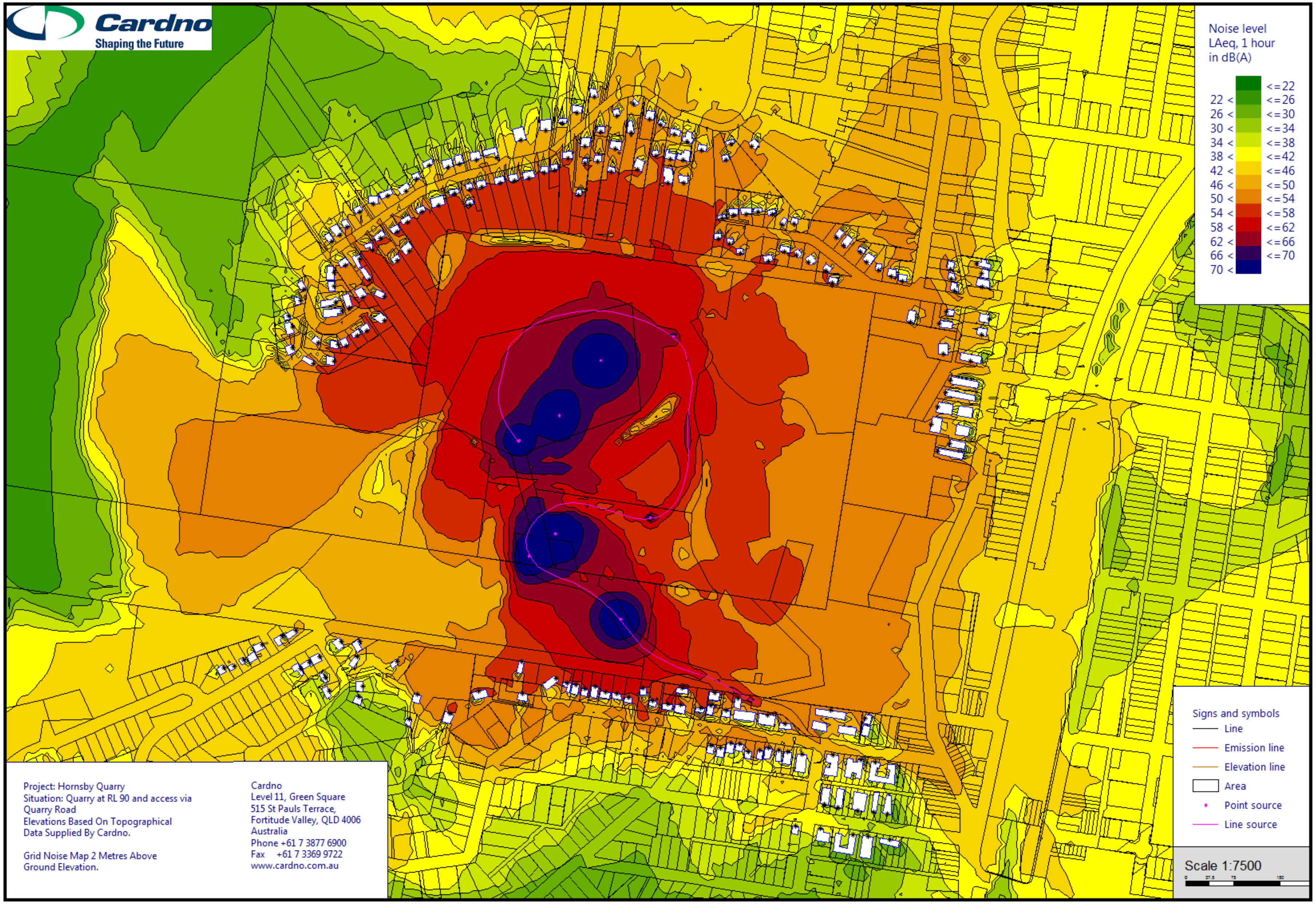
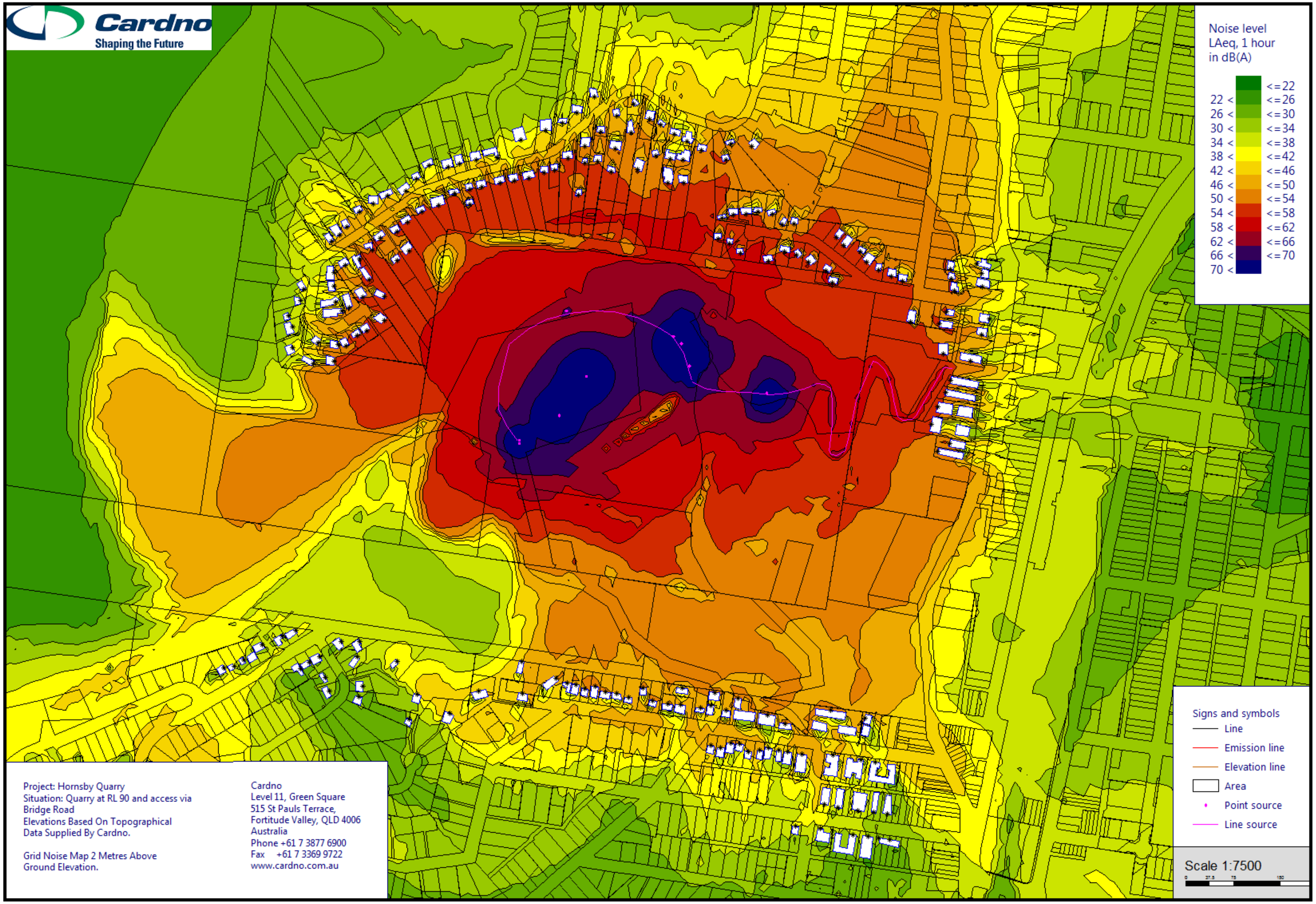


Figure 7-4 Predicted Quarry Noise Levels, Scenario 4



APPENDIX

D

Database Search Results

Table D-1 Threatened Fauna Species listed under the EPBC Act

Scientific Name	Common Name	Status
Anthochaera phrygia	Regent Honeyeater	E
Botaurus poiciloptilus	Australasian Bittern	E
Dasyornis brachypterus	Eastern Bristlebird	E
Erythrotriorchis radiatus	Red Goshawk	V
Lathamus discolor	Swift Parrot	E
Rostratula australis	Australian Painted Snipe	V
Macquaria australasica	Macquarie Perch	E
Prototroctes maraena	Australian Grayling	V
Heleioporus australiacus	Giant Burrowing Frog	V
Litoria aurea	Green and Golden Bell Frog	V
Litoria littlejohni	Littlejohn's Tree Frog, Heath Frog	V
Mixophyes balbus	Stuttering Frog	V
Mixophyes iteratus	Giant Barred Frog, Southern Barred Frog	E
Chalinolobus dwyeri	Large-eared Pied Bat, Large Pied Bat	V
Dasyurus maculatus maculatus	Spot-tailed Quoll, Spotted-tail Quoll	E
Isoodon obesulus obesulus	Southern Brown Bandicoot (Eastern)	E
Petrogale penicillata	Brush-tailed Rock-wallaby	V
Phascolarctos cinereus	Koala	V
Potorous tridactylus tridactylus	Long-nosed Potoroo	V
Pseudomys novaehollandiae	New Holland Mouse	V
Pteropus poliocephalus	Grey-headed Flying-fox	V
Hoplocephalus bungaroides	Broad-headed Snake	V
Apus pacificus	Fork-tailed Swift	-
Ardea alba	Great Egret, White Egret	-
Ardea ibis	Cattle Egret	-
Haliaeetus leucogaster	White-bellied Sea-Eagle	-
Hirundapus caudacutus	White-throated Needletail	-
Merops ornatus	Rainbow Bee-eater	-

Scientific Name	Common Name	Status
Monarcha melanopsis	Black-faced Monarch	-
Myiagra cyanoleuca	Satin Flycatcher	-
Rhipidura rufifrons	Rufous Fantail	-
Gallinago hardwickii	Latham's Snipe, Japanese Snipe	

E – Endangered
V – Vulnerable

Table D-2 Threatened Flora Species listed under the EPBC Act

Scientific Name	Common Name	Status
Acacia bynoeana	Bynoe's Wattle, Tiny Wattle	V
Asterolasia elegans		E
Cryptostylis hunteriana	Leafless Tongue-orchid	V
Darwinia biflora		V
Eucalyptus camfieldii	Camfield's Stringybark	V
Leptospermum deanei		V
Melaleuca deanei	Deane's Melaleuca	V
Pelargonium sp. Striatellum (G.W.Carr 10345)	Omeo Stork's-bill	E
Pimelea curviflora var. curviflora		V
Pimelea spicata		E
Streblus pendulinus	Siah's Backbone, Sia's Backbone, Isaac Wood	E
Tetratheca glandulosa	Glandular Pink-bell	V

E – Endangered
V – Vulnerable

Table D-3 Threatened Fauna Species Listed on the Bionet Database.

Scientific Name	Common Name	NSW Status	National Status
Heleioporus australiacus	Giant Burrowing Frog	V,P	V
Pseudophryne australis	Red-crowned Toadlet	V,P	
Litoria aurea	Green and Golden Bell Frog	E1,P	V
Varanus rosenbergi	Rosenberg's Goanna	V,P	
Ptilinopus superbus	Superb Fruit-Dove	V,P	
Apus pacificus	Fork-tailed Swift	P	C,J,K

Scientific Name	Common Name	NSW Status	National Status
Hirundapus caudacutus	White-throated Needletail	P	C,J,K
Haliaeetus leucogaster	White-bellied Sea-Eagle	P	C
Hieraaetus morphnoides	Little Eagle	V,P	
Falco hypoleucos	Grey Falcon	E1,P,2	
Haematopus fuliginosus	Sooty Oystercatcher	V,P	
Calidris acuminata	Sharp-tailed Sandpiper	P	C,J,K
Calidris ferruginea	Curlew Sandpiper	E1,P	C,J,K
Limicola falcinellus	Broad-billed Sandpiper	V,P	C,J,K
Callocephalon fimbriatum	Gang-gang Cockatoo	V,P,3	
Callocephalon fimbriatum	Gang-gang Cockatoo population in the Hornsby and Ku-ring-gai LGAs	E2,V,P,3	
Calyptorhynchus lathami	Glossy Black-Cockatoo	V,P,2	
Glossopsitta pusilla	Little Lorikeet	V,P	
Polytelis swainsonii	Superb Parrot	V,P,3	V
Cuculus saturates	Himalayan Cuckoo	P	C,J,K
Ninox connivens	Barking Owl	V,P,3	
Ninox strenua	Powerful Owl	V,P,3	
Tyto novaehollandiae	Masked Owl	V,P,3	
Tyto tenebricosa	Sooty Owl	V,P,3	
Anthochaera phrygia	Regent Honeyeater	E4A,P	E
Daphoenositta chrysoptera	Varied Sittella	V,P	
Petroica boodang	Scarlet Robin	V,P	
Petroica phoenicea	Flame Robin	V,P	
Stagonopleura guttata	Diamond Firetail	V,P	
Dasyurus maculatus	Spotted-tailed Quoll	V,P	E
Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	E1,P	E
Phascolarctos cinereus	Koala	V,P	V
Cercartetus nanus	Eastern Pygmy-possum	V,P	
Pteropus poliocephalus	Grey-headed Flying-fox	V,P	V

Scientific Name	Common Name	NSW Status	National Status
Mormopterus norfolkensis	Eastern Freetail-bat	V,P	
Chalinolobus dwyeri	Large-eared Pied Bat	V,P	V
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V,P	
Miniopterus australis	Little Bentwing-bat	V,P	
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V,P	

E – Endangered J – JAMBA
V – Vulnerable C – CAMBA
P – Protected K – ROKAMBA

Table D-4 Threatened Flora Species Listed on the Bionet Database.

Scientific Name	Common Name	NSW Status	National Status
Tetratheca glandulosa		V,P	V
Epacris purpurascens var. purpurascens		V,P	
Acacia bynoeana	Bynoe's Wattle	E1,P	V
Acacia gordonii		E1,P	E
Grammitis stenophylla	Narrow-leaf Finger Fern	E1,P,3	
Haloragodendron lucasii		E1,P	E
Callistemon linearifolius	Netted Bottle Brush	V,P,3	
Darwinia biflora		V,P	V
Darwinia peduncularis		V,P	
Eucalyptus camfieldii	Camfield's Stringybark	V,P	V
Eucalyptus scoparia	Wallangarra White Gum	E1,P	V
Leptospermum deanei		V,P	V
Melaleuca biconvexa	Biconvex Paperbark	V,P	V
Melaleuca deanei	Deane's Paperbark	V,P	V
Syzygium paniculatum	Magenta Lilly Pilly	E1,P	V
Genoplesium baueri	Bauer's Midge Orchid	V,P,2	
Genoplesium plumosum	Tallong Midge Orchid	E4A,P,2	E
Pterostylis nigricans	Dark Greenhood	V,P,2	
Grevillea caleyi	Caley's Grevillea	E1,P	E

Scientific Name	Common Name	NSW Status	National Status
Persoonia hirsuta	Hairy Geebung	E1,P	E
Persoonia mollis subsp. maxima		E1,P	E
Persoonia nutans	Nodding Geebung	E1,P	E
Galium australe	Tangled Bedstraw	E1,P	
Lasiopetalum joyceae		V,P	V

E – Endangered
V – Vulnerable
P – Protected

APPENDIX

E

Economic Analysis

Assumptions used in the Economic Analysis:

- The majority of the internal quarry road is wide enough to allow two-way traffic for large trucks, with the exception of a short stretch to the south of the intersection of the existing Quarry Road access and proposed Bridge Road access (on the eastern side of the quarry) and a 200m section on the western side of the quarry.
- The majority of the internal quarry road is less than 10 per cent grade, with the exception of a 200m section on the western side of the quarry. However, this section would be no more than 15 per cent grade and as such the entire internal quarry road is deemed appropriate for use by public road trucks.
- The road surface is suitable with only minimal upgrade and maintenance to allow public road trucks to travel on.
- Travelling beneath the southern face of the quarry is to be avoided as this is unstable, and there is potential for rock fall in this area.
- It is assumed that filling of the quarry will be undertaken in the first instance from a point at approximately RL46 at the south western corner of the quarry. This is to avoid traffic movements under the southern quarry wall, which has been identified as being unstable. There is room at this location for trucks to manoeuvre, tip, and turn. Filling will be "tipped" into the quarry pit from this point and ramped up via a batter slope to this location over time allowing access into the quarry pit on this fill.
- Works needed on the surrounding road network are included in Mitigation Costs.
- The site will not be suitable for tipper and dogs and semi-trailer tippers at the early stages for logistical reasons. This becomes less of an issue as the quarry fills up and the access improves to the filling floor.
- Material is delivered at no cost to Council and disposers are meeting all costs of testing and classification (i.e. material arrives on site as either VENM or ENM with certificates)
- The amount of VENM needed is in the order of 412,800,000 tonnes.
- Average load per VENM truck delivery is 25 tonnes.
- Operation is undertaken by an extension of the current HSC works department, staffed by Work personnel and has access to Works facilities and plant.
- Establishment works will take approximately 12 months (Year 1) to complete.
- No rehabilitation works (topsoil, landscaping, etc) have been assumed other than demolition of temporary structures (sheds, hardstands, etc).
- It is assumed that water balance is neutral.
- Prices are ex GST.

Table E-1 Summary of Infrastructure, Operational Costs and VENM price scenarios

Access Option	Access Option Description	Infrastructure and Operational Costs (including impact mitigation measures) ($)		Scenario 1: Total cost of VENM if Purchased at $15/tonne ($)	Scenario 2: Required Price of VENM per tonne to Achieve Cost Neutrality ($ / tonne)		Scenario 3: Neutral price for VENM revenue per tonne ($ / tonne) • 40% VENM purchased at $15/tonne. • 30% VENM at zero cost • 30% VENM as Revenue		Sensitivity on Scenario 3: Neutral price for VENM revenue per tonne. ($ / tonne) (50% increase in capital and operating costs) • 40% VENM purchased at $15/tonne. • 30% VENM at zero cost • 30% VENM as Revenue	
		8 Year	20 Year	8 and 20 Year	8 Year	20 Year	8 Year	20 Year	8 Year	20 Year
1	Entry and Exit via Bridge Road	$31.44M	$59.95M	$137.60M	$3	$6	$31	$40	$37	$50
2	One-way loop access via roads in Access Options 1 and 4. Entrance via Quarry Road.	$33.29M	$62.04M	$137.60M	$3	$6	$32	$40	$38	$50
3	One-way loop access via roads in Access Options 1 and 4. Entrance via Bridge Road.	$33.29M	$62.04M	$137.60M	$3	$6	$32	$40	$38	$50
4	Entry and Exit via Quarry Road	$26.30M	$55.05M	$137.60M	$2	$5	$29	$30	$34	$40

Hornsby Quarry

Preliminary Cost Estimate for the Backfilling of Quarry with VENM

Assumptions

Estimate is for works within the Quarry site only
The majority of the internal quarry road is wide enough to allow two-way traffic for large trucks, with the exception of a short stretch to the south of the intersection with the proposed Bridge Road access (on the eastern side of the quarry) and a 200m section on the western side of the quarry.
The majority of the internal quarry road is less than 10 per cent grade, with the exception of a 200m section on the western side of the quarry. However, this section would be no more than 15 per cent grade and as such the entire internal quarry road is deemed appropriate for use by public road trucks.
The road surface is suitable with only minimal upgrade to allow public road trucks to travel on.
Travelling beneath the southern face of the quarry is to be avoided as this is unstable, and there is potential for rock fall in this area.
It is understood that filling of the quarry will be undertaken in the first instance from a point at approximately RL46 at the south western corner of the quarry. This is to avoid traffic under the southern quarry wall, which has been identified at being unstable. There is room at this location for trucks to manoeuvre, tip, and turn. Filling will be "tipped" into the quarry pit from this point and ramped up via a batter slope to this location over time allowing access into the quarry pit on this fill.
No works to surrounding road network. Using existing roads and access points.
Site will not be that suitable for tipper and dogs and semi-trailer tippers at the early stages. This becomes less of an issue as the quarry fills up and the access improves to the filling floor.
Material is delivered at no cost and disposers are meeting all costs of testing and classification (material arrives on site as either VENM or ENM with certificates)
Operation is an extension of current HSC works department, staffed by Work personnel and has access to Works facilities and plant
Establishment works will take approximately 12 months (Year 1) to complete
No rehabilitation works (topsoil, landscaping, etc) have been assumed other than demolition of temporary structures (sheds, hardstands, etc)
Assume water balance is neutral
No cost assumed for additional insurances
No contingency added
Prices are ex GST

	Year											
	1	2	3	4	5	6	7	8	9	Total	Notes	Rate refernece
Item	**Establishment**	**Backfilling Operation**										
Site Establishment												
Reinstate security fence/gates/booms/etc	$75,000	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	**$95,000**	For security and monitoring truck movements with on site and off site monitoring	Nominal sum as not able to inspect the existing condittion or extent of fencing. Assuming majority of security fence is already in place and only requires repairs and adjustment to suit new accesses.
Utility connection	$150,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	**$190,000**	Assuming trunk mains to site exist and are of sufficient capacity. Some reticulation throughout site will also be reqired. Minor yearly cost for connection fees, maintenance and minor relocations. Assume there are no significant utilities relocations required.	Nominal sum based on re-establishment of connection points, DB's, water meters, etc and local reticulation within site to new facilitities (ie control room, fitters shed, acoustic shed, etc).
Install CCTV system	$102,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	**$182,000**	Assuming 12 cameras on site with a CCTV monitoring station in the Control Centre.	12 cameras @ $6k each (Rawlinsons $6k each including post and anti-vandal housing) + assume $5 for reticulation of power and data (~2km) + CCTV monitoring and off site data recording $25k. $5k per year for data logging + $5k per year for maintenance
Lighting	$25,000	$500	$500	$500	$500	$500	$500	$500	$500	**$29,000**		Nominal sum for flood lighting at entrance, carpark, Control Centres.
Car parking areas for personnel	$25,000									**$25,000**		Parking for say 8 vehicles located within the site security fence
2 way radios	$15,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	**$31,000**		Radios in all plant and vehicles + personnel radios for all personnel
Gaurdrails	$365,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	**$381,000**	Assuming Thriebeam given proximty to heavy vehicles with posts at 2m centers.	Approximatley 700m of gaurdrail ($300/m) will be required along the access roads open to public trucks (to tipping point at RL 46). Gaurdrail posts will need to be drilling into rock so a high rate is assumed. Posts at 2m centers ($300ea) + say 10 terminals ($5k each)
Signposting and delineation	$15,000	$500	$500	$500	$500	$500	$500	$500	$500	**$19,000**		Nominal sum for some custom signs and linemarking
Total	**$772,000**	**$22,500**	**$22,500**	**$22,500**	**$22,500**	**$22,500**	**$22,500**	**$22,500**	**$22,500**	**$952,000**		
Access Works												

	Year											
	1	2	3	4	5	6	7	8	9	Total	Notes	Rate refernece
Item	**Establishment**	**Backfilling Operation**										
Reinstate existing haul roads (access road from Quarry road) (not applicable for Option 1)	$200,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	**$360,000**	Some earthowroks required to stabilise fill areas in the ara of the crusher plant (PSM Report). Annual operating costs are assuming that maintenance works are undertaken by plant on site.	Discussed with HSC 21/1/13
Reinstate existing haul roads (internal road)	$50,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	**$210,000**	Assumed road in good condition and only requires patching and sealing prior to use. Annual operating costs are assuming that maintenance works are undertaken by plant on site.	Discussed with HSC 21/1/13
Stabilize batters for haul roads for public vehicles and establishing acces to pit base for personnel	$1,000,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	**$1,200,000**	Includes establishing access to quarry by public vehicles to dumping platform as well as access for quarry personnel from "dumping platform" down to quarry pit.	PSM (2012) pg 22 for capital cost to "establish temporary access quarry North and South Sides". Annual costs are included to this to provide the maintenanance for these access roads. As advised by HSC.
Construct tipping platforms	$450,000									**$450,000**	Concrete hardstand areas large enough for trucks to reverse, tip and pass each other. Should have a barrier at the tipping face to restrain errant reversng vehicles.	Based on WF JRCP rates (~$175/sq.m) assuming pad is ~50m x 50m and 300mm thick with $15k for a barrier.
Stormwater drainage	$150,000	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	**$170,000**	Nominal sum as condition and extent of existing drainage are not known.	$2.5k pa assumed for cleaning and minor maintenance
Total	**$1,850,000**	**$67,500**	**$67,500**	**$67,500**	**$67,500**	**$67,500**	**$67,500**	**$67,500**	**$67,500**	**$2,390,000**		
Entrance facility (Acoustic shed)												
Acoutstic shed	$300,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	**$340,000**	Shed assumed to 20m wide and 40m long to accommodate two semi-trailers, wheelwash and small reception office/ablutions. This will allow for vehicle inspection, document collection and whellwashing to be conducted undercover and with suppression of noise.	Ranbuild $230k + $70k for acoustic bats and fitout. $5k pa for maintenance.
Hardstand area	$280,000									**$280,000**	Assume 20m wide + 20m either end of shed (total length 80m) = 1,600sq.m	Based on WF JRCP rates (~$175/sq.m) assuming 300mm thick.
Weighbridge	$80,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	**$120,000**		Phone quote from Accuweigh ($60k) with extra for installation. $5k pa assumed for maintenance and calibration.
Automatic wheelwash (including pumps and recycled water system)	$150,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	**$230,000**		Interclean 120 $200k but advised this was too large. Assuming a smaller, less sophisticated model. $10k pa assumed for maintenance and operating costs.
Office/meal room/ablutions (1 x 12m temporary site shed)	$10,000	$500	$500	$500	$500	$500	$500	$500	$500	**$14,000**	Assumed purchased outright with minor fitout requirements	$0.5k pa assumed for maintenance.
Control Centre												
Office/meal room/ablutions (3 x 12m temporary site sheds)	$45,000	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	**$65,000**	Assumed purchased outright with major fitout requirements (CCTV dust proof room, offices, meeting rooms, change facilities, etc).	$2.5k pa assumed for maintenance.
Total	**$865,000**	**$23,000**	**$23,000**	**$23,000**	**$23,000**	**$23,000**	**$23,000**	**$23,000**	**$23,000**	**$1,049,000**		
Plant Maintenance Shed/Store												
Large shed/fitters workshop	$40,000	$1,000	$1,000	$1,000	$5,000	$1,000	$1,000	$1,000	$1,000	**$52,000**	For minor maintenance of on site plant (lubrication, tyre change, hoses, etc). Assume heavy maintenance is done off site. Shed will have to be moved at least once during the backfilling operation ($5k at Year 5)	Ranbuild 20 x 10m farm shed
Shipping container for secure storage	$3,000									**$3,000**		
Fitout of maintenance shed	$75,000									**$75,000**	Set up with work facilities, compressed air, tools, etc	Nominal sum
Hardstand area	$15,000				$15,000					**$30,000**	Nominal sum for crushed rock hardstand	Nomimal sum
Total	**$133,000**	**$1,000**	**$1,000**	**$1,000**	**$20,000**	**$1,000**	**$1,000**	**$1,000**	**$1,000**	**$160,000**		
Stormwater management												
Establish sedimentation ponds	$50,000	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	**$70,000**	Collected water shold be used for dust suppression/truck wash, etc	Nominal sum for installation and $5k pa assumed for cleaning out.
Construct sumps for collection of stormwater	$10,000									**$10,000**		Nominal sum
Establish large pumps		$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	**$40,000**	Assuming existing pump is sufficient.	Operating costs of $5pa assumed for existing pumps

	Year											
	1	2	3	4	5	6	7	8	9	Total	Notes	Rate refernece
Item	**Establishment**	**Backfilling Operation**										
Initial pump out of collected water	$10,000									**$10,000**	Assuming existing pump is sufficient. More intensive pump operation during first year to draw down water levels.	
Disposal of material from wheelwash										**$0**	Assume this material can be placed in the fill	
Total	**$70,000**	**$7,500**	**$7,500**	**$7,500**	**$7,500**	**$7,500**	**$7,500**	**$7,500**	**$7,500**	**$130,000**		
Plant Items											Assume fueling by mini-tankers (no fuel stored on site)	
Permanent plant based onsite												
Front end loader	$600,000	$102,457	$102,457	$102,457	$102,457	$102,457	$102,457	$102,457	$102,457	**$1,419,655**	Year 1 is purchase price. Years 2 - 9 are maintenance costs.	
CAT Compactor	$740,000	$121,853	$121,853	$121,853	$121,853	$121,853	$121,853	$121,853	$121,853	**$1,714,824**	Year 1 is purchase price. Years 2 - 9 are maintenance costs.	Westrac (see Plant Fuel & Maintenance Sheet)
Fuel		$427,433	$427,433	$427,433	$427,433	$427,433	$427,433	$427,433	$427,433	**$3,419,463**		CAT Performance Handbook (see Plant Fuel & Maintenance Sheet)
Minor plant maintence		$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	**$400,000**	Hydraulic hoses, tyres, windows, lights, etc (replaced by on site mechanic)	
Plant required from time to time but based off site												
Large padfoot roller (dry hire)		$35,520	$35,520	$35,520	$35,520	$35,520	$35,520	$35,520	$35,520	**$284,160**	Intermittent use only. Assume 1 day per month on site @ $120/hr for 8 hours + $1000 floatage each way	RMS project day rates
D9 Dozer (wet hire)		$79,200	$79,200	$79,200	$79,200	$79,200	$79,200	$79,200	$79,200	**$633,600**	Intermittent use only. Assume 1 day per month on site @ $200/hr for 8 hours + $2500 floatage each way	RMS project day rates
30t Excavator (wet hire)		$88,400	$88,400	$88,400	$88,400	$88,400	$88,400	$88,400	$88,400	**$707,200**	Intermittent use only. Assume 1 day per fortnight on site @ $175/hr for 8 hours + $1000 floatage each way	Based on rates provided by HSC 21/1/13
Grader (wet hire)		$37,440	$37,440	$37,440	$37,440	$37,440	$37,440	$37,440	$37,440	**$299,520**	Intermittent use only. Assume 1 day per month on site @ $140/hr for 8 hours + $1000 floatage each way	Based on rates provided by HSC 21/1/13
Water Truck (wet hire)		$115,200	$115,200	$115,200	$115,200	$115,200	$115,200	$115,200	$115,200	**$921,600**	Supplied on a hire arrangement. Assumed on site 4 hours per day for 6 days a week at $100/h for 48 weeks/year	Based on discounted water truck hire rate due to long term regular work.
Site Vehicles										**$0**		
Supervisors ute	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	**$225,000**	Toyota Hilux or similar	Assumed full service lease agreement (incl fuel)
Deputy Supervisors ute	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	**$225,000**	Toyota Hilux or similar	Assumed full service lease agreement (incl fuel)
Spare ute for transfering plant operators	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	**$225,000**	Toyota Hilux or similar	Assumed full service lease agreement (incl fuel)
Total	**$1,415,000**	**$1,132,503**	**$1,132,503**	**$1,132,503**	**$1,132,503**	**$1,132,503**	**$1,132,503**	**$1,132,503**	**$1,132,503**	**$10,475,022**		
Personnel												
Quarry Superintendent	$224,000	$224,000	$224,000	$224,000	$224,000	$224,000	$224,000	$224,000	$224,000	**$2,016,000**		Rawlinsons "Site Manager" - $140k + %60 overhead pa
Deputy Supervisor/Plant Operator	$192,000	$192,000	$192,000	$192,000	$192,000	$192,000	$192,000	$192,000	$192,000	**$1,728,000**		Rawlinsons "General Foreman" - $120k + %60 overhead pa
Control Centre Operator	$88,000	$88,000	$88,000	$88,000	$88,000	$88,000	$88,000	$88,000	$88,000	**$792,000**		Rawlinsons "Site Clerk" - $55k + %60 overhead pa
Plant Operator	$112,000	$112,000	$112,000	$112,000	$112,000	$112,000	$112,000	$112,000	$112,000	**$1,008,000**		Nominal salary $70k + %60 overhead pa (seek.com)
Mechanic/Storeman/Plant Operator	$136,000	$136,000	$136,000	$136,000	$136,000	$136,000	$136,000	$136,000	$136,000	**$1,224,000**		Nominal salary $85k + %60 overhead pa (seek.com)
Total	**$752,000**	**$752,000**	**$752,000**	**$752,000**	**$752,000**	**$752,000**	**$752,000**	**$752,000**	**$752,000**	**$6,768,000**		
Survey												
Initial survey establishment	$50,000									**$50,000**	Establishment of survey base, bench marks and laser scanner locations	
Laser scanner and data logger	$250,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	**$330,000**	Permanently mounted in security box on pole to allow regular scanning	Laser scanner used for MCG
Survey support		$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	**$160,000**	Part-time survye technican to monitor equipment, collate data, etc	
Total	**$300,000**	**$30,000**	**$30,000**	**$30,000**	**$30,000**	**$30,000**	**$30,000**	**$30,000**	**$30,000**	**$540,000**		
Geotech												
Initial geotech investigation to scope rehab works										**$0**	Included in stabilisation works above	

Item	Year											
	1	2	3	4	5	6	7	8	9	Total	**Notes**	**Rate refernece**
	Establishment	**Backfilling Operation**										
Geotechnical supervision of rehab works										**$0**	Included in stabilisation works above	
Geotechnical supervision of batters during works		$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	**$200,000**	Geotech coming to site once a month to inspect slopes, etc a write a report	
Compaction testing of placed fill material	$50,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	**$90,000**	Assume testing done by Quarry staff using nuclear densometer	$50k for purchase of equipment (nuclear densometer, etc) and training of staff in use. $5k pa for calibration
Total	**$50,000**	**$30,000**	**$30,000**	**$30,000**	**$30,000**	**$30,000**	**$30,000**	**$30,000**	**$30,000**	**$290,000**		
Preliminaries												
Security patrol	$65,000	$65,000	$65,000	$65,000	$65,000	$65,000	$65,000	$65,000	$65,000	**$585,000**		Cordells
Consumables	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	**$90,000**	Office, kitchen, ablutions, PPE, rubish collection, etc	Nominal sum
General maintenance of offices		$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	**$80,000**	Electrical tagging, repairs, IT support, etc	Nominal sum
Cleaning	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	**$270,000**	Assuming site sheds cleaned once a week by contract cleaners	Nominal sum of ~$500/week with some consumables
Total	**$105,000**	**$115,000**	**$115,000**	**$115,000**	**$115,000**	**$115,000**	**$115,000**	**$115,000**	**$115,000**	**$1,025,000**		
Demobilisation												
Demolition of sheds, hardstands and utility connections									$250,000	$250,000	Demolition of structures, hardstand, parking areas, utilities, etc.	Nominal sum
Total	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$250,000**	**$250,000**		

LJ2888 Hornsby Quarry	Fuel Price	1.592	dollars	(Source: mynrma)
Plant Fuel Consumption	*Date:*	*29/11/2012*		

Plant Items	Model	Fuel Consumption			% Time operating	Working year (hours)	Working Hours (hours)	1	2	3	4	5	6	7	8	9	Source
		Low	Medium	High													
Front end loader	CAT 980G	26	36	47	90%	2640	2376	$0	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	CAT Performance Handbook
CAT Compactor	CAT 825G	42	57	66	90%	2640	2376	$0	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	CAT Performance Handbook
							Subtotals per year		$ 427,432.90	$ 427,432.90	$ 427,432.90	$ 427,432.90	$ 427,432.90	$ 427,432.90	$ 427,432.90	$ 427,432.90	

Labour Cost	$ 110.00	/hour	Project Duration	8	years

Plant Items	Model	10 Year Maintenance Data				Pro-rata of Total Cost for Duration	1	2	3	4	5	6	7	8	9	Source
		10 Year Cost (parts and consumables)	Labour Hours	Labour Cost	Total Cost											
Front end loader	CAT 980G	$ 732,738.28	2653	$ 291,830.00	$ 1,024,568.28	$ 819,654.62	$0	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	10 year maintenance costs provided by Westrac
CAT Compactor	CAT 825G	$ 834,190.61	3494	$ 384,340.00	$ 1,218,530.61	$ 974,824.49	$0	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	10 year maintenance costs provided by Westrac
							Subtotals per year		$ 224,309.89	$ 224,309.89	$ 224,309.89	$ 224,309.89	$ 224,309.89	$ 224,309.89	$ 224,309.89	

Hornsby Quarry

Preliminary Cost Estimate for the Backfilling of Quarry with VENM

Assumptions

Estimate is for works within the Quarry site only
The majority of the internal quarry road is wide enough to allow two-way traffic for large trucks, with the exception of a short stretch to the south of the intersection with the proposed Bridge Road access (on the eastern side of the quarry) and a 200m section on
The majority of the internal quarry road is less than 10 per cent grade, with the exception of a 200m section on the western side of the quarry. However, this section would be no more than 15 per cent grade and as such the entire internal quarry road is deemed
The road surface is suitable with only minimal upgrade to allow public road trucks to travel on.
Travelling beneath the southern face of the quarry is to be avoided as this is unstable, and there is potential for rock fall in this area.
It is understood that filling of the quarry will be undertaken in the first instance from a point at approximately RL46 at the south western corner of the quarry. This is to avoid traffic under the southern quarry wall, which has been identified at being unstable. There is room at this location for trucks to manoeuvre, tip, and turn. Filling will be "tipped" into the quarry pit from this point and ramped up via a batter slope to this location over time allowing access into the quarry pit on this fill.
No works to surrounding road network. Using existing roads and access points.
Site will not be that suitable for tipper and dogs and semi-trailer tippers at the early stages. This becomes less of an issue as the quarry fills up and the access improves to the filling floor.
Material is delivered at no cost and disposers are meeting all costs of testing and classification (material arrives on site as either VENM or ENM with certificates)
Operation is an extension of current HSC works department, staffed by Work personnel and has access to Works facilities and plant
Establishment works will take approximately 12 months (Year 1) to complete
No rehabilitation works (topsoil, landscaping, etc) have been assumed other than demolition of temporary structures (sheds, hardstands, etc)
Assume water balance is neutral
No cost assumed for additional insurances
No contingency added
Prices are ex GST

	Year																								
	1	2	3	4	5	6	7	8	9	10	11	11	12	13	14	15	16	17	18	19	20	21	Total	Notes	Rate reference
Item	Establishment	Backfilling Operation									Continued Backfilling Operation	Overhaul / Replacement													
Site Establishment																									
Reinstate security fence/gates/booms/etc	$ 75,000	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 20,000	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	2500	$145,000.00	For security and monitoring truck movements with on site and off site monitoring. Assume overhaul of boom gate at year 11.	Nominal sum as not able to inspect the existing conditition or extent of fencing. Assuming majority of security fence is already in place and only requires repairs and adjustment to suit new accesses.
Utility connection	$ 150,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000		$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	5000	$250,000.00	Assuming trunk mains to site exist and are of sufficient capacity. Some reticulation throughout site will also be reqired. Minor yearly cost for connection fees, maintenance and minor relocations. Assume there are no significant utilities relocations required.	Nominal sum based on re-establishment of connection points, DB's, water meters, etc and local reticulation within site to new facilitities (ie control room, fitters shed, acoustic shed, etc).
Install CCTV system	$ 102,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 50,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	10000	$352,000.00	Assuming 12 cameras on site with a CCTV monitoring station in the Control Centre. Assume replacement of cameras at year 11.	12 cameras @ $6k each (Rawlinsons $6k each including post and anti-vandal housing) + assume $5 for reticulation of power and data (~2km) + CCTV monitoring and off site data recording $25k. $5k per year for data logging + $5k per year for maintenance
Lighting	$ 25,000	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500		$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	500	$35,000.00		Nominal sum for flood lighting at entrance, carpark, Control Centres.
Car parking areas for personnel	$ 25,000																						$25,000.00		Parking for say 8 vehicles located within the site security fence
2 way radios	$ 15,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 15,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	2000	$70,000.00	Assume replace all at year 11	Radios in all plant and vehicles + personnel radios for all personnel
Gaurdrails	$ 365,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000		$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	2000	$405,000.00	Assuming Thriebeam given proximty to heavy vehicles with posts at 2m centers.	Approximatley 700m of gaurdrail ($300/m) will be required along the access roads open to public trucks (to tipping point at RL 46). Gaurdrail posts will need to be drilling into rock so a high rate is assumed. Posts at 2m centers ($300ea) + say 10 terminals ($5k each)
Signposting and delineation	$ 15,000	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 5,000	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	500	$30,000.00	Assume new line marking and some signage at year11.	Nominal sum for some custom signs and linemarking
Total	**$ 772,000**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 90,000**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$ 22,500**	**$1,312,000.00**		
Access Works																									
Reinstate existing haul roads (access road from Quarry road) (not applicable for Option 1)	$200,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000		$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$600,000.00	Some earthowroks required to stabilise fill areas in the ara of the crusher plant (PSM Report). Annual operating costs are assuming that maintenance works are undertaken by plant on site.	Discussed with HSC 21/1/13
Reinstate existing haul roads (internal road)	$50,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000		$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$450,000.00	Assumed road in good condition and only requires patching and sealing prior to use. Annual operating costs are assuming that maintenance works are undertaken by plant on site.	Discussed with HSC 21/1/13
Stabilize batters for haul roads for public vehicles and establishing acces to pit base for personnel	$1,000,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000		$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$1,500,000.00	Includes establishing access to quarry by public vehicles to dumping platform as well as access for quarry personnel from "dumping platform" down to quarry pit.	PSM (2012) pg 22 for capital cost to "establish temporary access quarry North and South Sides". Annual costs are included to this to provide the maintenanance for these access roads. As advised by HSC.
Construct tipping platforms	$ 450,000																						$450,000.00	Concrete hardstand areas large enough for trucks to reverse, tip and pass each other. Should have a barrier at the tipping face to restrain errant reversng vehicles.	Based on WF JRCP rates (~$175/sq.m) assuming pad is ~50m x 50m and 300mm thick with $15k for a barrier.
Stormwater drainage	$ 150,000	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500		$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	2500	$200,000.00	Nominal sum as condition and extent of existing drainage are not known.	$2.5k pa assumed for cleaning and minor maintenance
Total	**$ 1,850,000**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ -**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$3,200,000.00**		
Entrance facility (Acoustic shed)																									
Acoutstic shed	$300,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000		$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	5000	$400,000.00	Shed assumed to 20m wide and 40m long to accommodate two semi-trailers, wheelwash and small reception office/ablutions. This will allow for vehicle inspection, document collection and whellwashing to be conducted undercover and with suppression of noise.	Ranbuild $230k + $70k for acoustic bats and fitout. $5k pa for maintenance.
Hardstand area	$ 280,000																						$280,000.00	Assume 20m wide + 20m either end of shed (total length 80m) = 1,600sq.m	Based on WF JRCP rates (~$175/sq.m) assuming 300mm thick.
Weighbridge	$ 80,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 80,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	5000	$260,000.00	Assume replacement at year 11	Phone quote from Accuweigh ($60k) with extra for installation. $5k pa assumed for maintenance and calibration.
Automatic wheelwash (including pumps and recycled water system)	$ 150,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 150,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	10000	$500,000.00	Assume replacement at year 11	Interclean 120 $200k but advised this was too large. Assuming a smaller, less sophisticated model. $10k pa assumed for maintenance and operating costs.
Office/meal room/ablutions (1 x 12m temporary site shed)	$ 10,000	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 10,000	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	500	$30,000.00	Assumed purchased outright with minor fitout requirements. Assume replacement at year 11	$0.5k pa assumed for maintenance.
Control Centre																									
Office/meal room/ablutions (3 x 12m temporary site sheds)	$ 45,000	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 45,000	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	2500	$140,000.00	Assumed purchased outright with major fitout requirements (CCTV dust proof room, offices, meeting rooms, change facilities, etc). Assume replacement at year 11	$2.5k pa assumed for maintenance.
Total	**$865,000**	**$23,000**	**$23,000**	**$ 23,000**	**$ 23,000**	**$ 23,000**	**$ 23,000**	**$ 23,000**	**$ 23,000**	**$ 23,000**	**$ 23,000**	**$ 285,000**	**$ 23,000**	**$ 23,000**	**$ 23,000**	**$ 23,000**	**$ 23,000**	**$ 23,000**	**$ 23,000**	**$ 23,000**	**$ 23,000**	**$ 23,000**	**$1,610,000.00**		
Plant Maintenance Shed/Store																							$0.00		
Large shed/fitters workshop	$ 40,000	$ 1,000	$ 1,000	$ 1,000	$ 5,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000		$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	1000	$64,000.00	For minor maintenance of on site plant (lubrication, tyre change, hoses, etc). Assume heavy maintenance is done off site. Shed will have to be moved at least once during the backfilling operation ($5k at Year 5)	Ranbuild 20 x 10m farm shed
Shipping container for secure storage	$ 3,000																						$3,000.00		
Fitout of maintenance shed	$75,000										$ 25,000												$100,000.00	Set up with work facilities, compressed air, tools, etc. Minor overhaul/replacement at year 11	Nominal sum
Hardstand area	$ 15,000				$ 15,000					$ 15,000						$ 15,000							$60,000.00	Nominal sum for crushed rock hardstand	Nomimal sum
Total	**$ 133,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$ 20,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$ 16,000**	**$ 26,000**	**$ -**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$ 16,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$227,000.00**		
Stormwater management																									
Establish sedimentation ponds	$ 50,000	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500		$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500	2500	$100,000.00	Collected water shold be used for dust suppression/truck wash, etc	Nominal sum for installation and $5k pa assumed for cleaning out.
Construct sumps for collection of stormwater	$ 10,000																						$10,000.00		Nominal sum
Establish large pumps		$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000		$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	5000	$100,000.00	Assuming existing pump is sufficient.	Operating costs of $5pa assumed for existing pumps
Initial pump out of collected water	$ 10,000																						$10,000.00	Assuming existing pump is sufficient. More intensive pump operation during first year to draw down water levels.	
Disposal of material from wheelwash																								Assume this material can be placed in the fill	
Total	**$ 70,000**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ -**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$ 7,500**	**$220,000.00**		
Plant Items																								Assume fueling by mini-tankers (no fule stored on site)	
Permanent plant based onsite																									
Front end loader	$ 600,000	$ 102,457	$ 102,457	$ 102,457	$ 102,457	$ 102,457	$ 102,457	$ 102,457	$ 102,457	$ 102,457	$ 102,457	$ 480,000	$ 102,457	$ 102,457	$ 102,457	$ 102,457	$ 102,457	$ 102,457	$ 102,457	$ 102,457	$ 102,457	$ 102,457	$3,129,136.56	Year 1 is purchase price. Years 2 - 21 are maintenance costs. Year 11 is assumed as replacement of plant item with original item sold for 20% of original price (therefore replacement price is 80% of original).	
CAT Compactor	$ 740,000	$ 121,853	$ 121,853	$ 121,853	$ 121,853	$ 121,853	$ 121,853	$ 121,853	$ 121,853	$ 121,853	$ 121,853	$ 592,000	$ 121,853	$ 121,853	$ 121,853	$ 121,853	$ 121,853	$ 121,853	$ 121,853	$ 121,853	$ 121,853	$ 121,853	$3,769,061.22	Year 1 is purchase price. Years 2 - 21 are maintenance costs. Year 11 is assumed as replacement of plant item with original item sold for 20% of original price (therefore replacement price is 80% of original).	Westrac (see Plant Fuel & Maintenance Sheet)
Fuel		$ 427,433	$ 427,433	$ 427,433	$ 427,433	$ 427,433	$ 427,433	$ 427,433	$ 427,433	$ 427,433	$ 427,433		$ 427,433	$ 427,433	$ 427,433	$ 427,433	$ 427,433	$ 427,433	$ 427,433	$ 427,433	$ 427,433	$ 427,433	$8,548,657.92		CAT Performance Handbook (see Plant Fuel & Maintenance Sheet)
Minor maintence		$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000		$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$1,000,000.00	Hydraulic hoses, tyres, windows, lights, etc (replaced by on site mechanic)	

Item	Year 1	2	3	4	5	6	7	8	9	10	11	11
	Establishment	Backfilling Operation									Continued Backfilling Operation	Overhaul / Replacement
Plant required from time to time but based off site												
Large padfoot roller (dry hire)		$35,520	$35,520	$35,520	$35,520	$35,520	$35,520	$35,520	$35,520	$35,520	$35,520	
D9 Dozer (wet hire)		$79,200	$79,200	$79,200	$79,200	$79,200	$79,200	$79,200	$79,200	$79,200	$79,200	
30t Excavator (wet hire)		$88,400	$88,400	$88,400	$88,400	$88,400	$88,400	$88,400	$88,400	$88,400	$88,400	
Grader (wet hire)		$37,440	$37,440	$37,440	$37,440	$37,440	$37,440	$37,440	$37,440	$37,440	$37,440	
Water Truck	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	
Site Vehicles												
Supervisors ute	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	
Deputy Supervisors ute	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	
Spare ute for transfering plant operators	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	
Total	**$ 1,530,000**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,072,000**
Personnel												
Quarry Superintendent	$ 224,000	$ 224,000	$ 224,000	$ 224,000	$ 224,000	$ 224,000	$ 224,000	$ 224,000	$ 224,000	$ 224,000	$ 224,000	
Deputy Supervisor/Plant Operator	$ 192,000	$ 192,000	$ 192,000	$ 192,000	$ 192,000	$ 192,000	$ 192,000	$ 192,000	$ 192,000	$ 192,000	$ 192,000	
Control Centre Operator	$ 88,000	$ 88,000	$ 88,000	$ 88,000	$ 88,000	$ 88,000	$ 88,000	$ 88,000	$ 88,000	$ 88,000	$ 88,000	
Plant Operator	$ 112,000	$ 112,000	$ 112,000	$ 112,000	$ 112,000	$ 112,000	$ 112,000	$ 112,000	$ 112,000	$ 112,000	$ 112,000	
Mechanic/storeman/plant operator	$ 136,000	$ 136,000	$ 136,000	$ 136,000	$ 136,000	$ 136,000	$ 136,000	$ 136,000	$ 136,000	$ 136,000	$ 136,000	
Total	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ -**
Survey												
Initial survey establishment	$ 50,000											
Laser scanner and data logger	$ 250,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 250,000
Survey support		$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	
Total	**$ 300,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 250,000**
Geotech												
Initial geotech investigation to scope rehab works												
Geotechnical supervision of rehab works												
Geotechnical supervision of batters during works		$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	
Compaction testing of placed fill material	$ 50,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	
Total	**$ 50,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ -**
Preliminaries												
Security patrol	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	
Consumables	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	
General maintenance of offices		$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	
Cleaning	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	
Total	**$ 105,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ -**
Demobilisation												
Demolition of sheds, hardstands and utility connections												
Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**

Item	12	13	14	15	16	17	18	19	20	21	Total	Notes	Rate reference
Plant required from time to time but based off site													
Large padfoot roller (dry hire)	$35,520	$35,520	$35,520	$35,520	$35,520	$35,520	$35,520	$35,520	$35,520	$35,520	**$710,400.00**	Intermittent use only. Assume 1 day per month on site @ $120/hr for 8 hours + $1000 floatage each way	RMS project day rates
D9 Dozer (wet hire)	$79,200	$79,200	$79,200	$79,200	$79,200	$79,200	$79,200	$79,200	$79,200	$79,200	**$1,584,000.00**	Intermittent use only. Assume 1 day per month on site @ $200/hr for 8 hours + $2500 floatage each way	RMS project day rates
30t Excavator (wet hire)	$88,400	$88,400	$88,400	$88,400	$88,400	$88,400	$88,400	$88,400	$88,400	$88,400	**$1,768,000.00**	Intermittent use only. Assume 1 day per fortnight on site @ $175/hr for 8 hours + $1000 floatage each way	Based on rates provided by HSC 21/1/13
Grader (wet hire)	$37,440	$37,440	$37,440	$37,440	$37,440	$37,440	$37,440	$37,440	$37,440	$37,440	**$748,800.00**	Intermittent use only. Assume 1 day per month on site @ $140/hr for 8 hours + $1000 floatage each way	Based on rates provided by HSC 21/1/13
Water Truck	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	115000	$2,415,000.00	Supplied on a hire arrangement. Assumed on site 4 hours per day for 6 days a week at $100/h for 48 weeks/year	Based on discounted water truck hire rate due to long term regular work.
Site Vehicles													
Supervisors ute	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	25000	$525,000.00	Toyota Hilux or similar	Assumed full service lease agreement (incl fuel)
Deputy Supervisors ute	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	25000	$525,000.00	Toyota Hilux or similar	Assumed full service lease agreement (incl fuel)
Spare ute for transfering plant operators	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	25000	$525,000.00	Toyota Hilux or similar	Assumed full service lease agreement (incl fuel)
Total	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$ 1,132,303**	**$25,248,055.70**		
Personnel													
Quarry Superintendent	$ 224,000	$ 224,000	$ 224,000	$ 224,000	$ 224,000	$ 224,000	$ 224,000	$ 224,000	$ 224,000	224000	$4,704,000.00		Rawlinsons "Site Manager" - $140k + %60 overhead pa
Deputy Supervisor/Plant Operator	$ 192,000	$ 192,000	$ 192,000	$ 192,000	$ 192,000	$ 192,000	$ 192,000	$ 192,000	$ 192,000	192000	$4,032,000.00		Rawlinsons "General Foreman" - $120k + %60 overhead pa
Control Centre Operator	$ 88,000	$ 88,000	$ 88,000	$ 88,000	$ 88,000	$ 88,000	$ 88,000	$ 88,000	$ 88,000	88000	$1,848,000.00		Rawlinsons "Site Clerk" - $55k + %60 overhead pa
Plant Operator	$ 112,000	$ 112,000	$ 112,000	$ 112,000	$ 112,000	$ 112,000	$ 112,000	$ 112,000	$ 112,000	112000	$2,352,000.00		Nominal salary $70k + %60 overhead pa (seek.com)
Mechanic/storeman/plant operator	$ 136,000	$ 136,000	$ 136,000	$ 136,000	$ 136,000	$ 136,000	$ 136,000	$ 136,000	$ 136,000	136000	$2,856,000.00		Nominal salary $85k + %60 overhead pa (seek.com)
Total	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$ 752,000**	**$15,792,000.00**		
Survey													
Initial survey establishment											$50,000.00	Establishment of survey base, bench marks and laser scanner locations	
Laser scanner and data logger	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$700,000.00	Permanently mounted in security box on pole to allow regular scanning. Assume replacement at year 11	Laser scanner used for MCG
Survey support	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$400,000.00	Part-time survye technican to monitor equipment, collate data, etc	
Total	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$1,150,000.00**		
Geotech													
Initial geotech investigation to scope rehab works												Included in stabilisation works above	
Geotechnical supervision of rehab works												Included in stabilisation works above	
Geotechnical supervision of batters during works	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$500,000.00	Geotech coming to site once a month to inspect slopes, etc a write a report	
Compaction testing of placed fill material	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$ 5,000	$150,000.00	Assume testing done by Quarry staff using nuclear densometer	$50k for purchase of equipment (nuclear densometer, etc) and training of staff in use. $5k pa for calibration
Total	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$650,000.00**		
Preliminaries													
Security patrol	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$1,365,000.00		Cordells
Consumables	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$210,000.00	Office, kitchen, ablutions, PPE, rubish collection, etc	Nominal sum
General maintenance of offices	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$200,000.00	Electrical tagging, repairs, IT support, etc	Nominal sum
Cleaning	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$630,000.00	Assuming site sheds cleaned once a week by contract cleaners	Nominal sum of ~$500/week with some consumables
Total	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$ 115,000**	**$2,405,000.00**		
Demobilisation													
Demolition of sheds, hardstands and utility connections										250000	$250,000.00	Demolition of structures, hardstand, parking areas, utilities, etc.	Nominal sum
Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 250,000**	**$250,000.00**		

LJ2888 Hornsby Quarry
Plant Fuel Consumption

Fuel Price	1.592	dollars	**(Source: mynrma)**
Date:	*29/11/2012*		

Plant Items	Model	Fuel Consumption			% Time operating	Working year (hours)	Working Hours (hours)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Source
		Low	Medium	High																									
Front end loader	CAT 980G	26	36	47	90%	2640	2376	$0	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	$ 177,781.82	CAT Performance Handbook
CAT Compactor	CAT 825G	42	57	66	90%	2640	2376	$0	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	$ 249,651.07	CAT Performance Handbook
							Subtotals per year		**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	**$ 427,432.90**	

Labour Cost	$ 110.00	/hour

	Project Duration	20	years

Plant Items	Model	10 Year Maintenance Data				Pro-rata of Total Cost for Duration		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Source
		10 Year Cost (parts and consumables)	Labour Hours	Labour Cost	Total Cost																								
Front end loader	CAT 980G	$ 732,738.28	2653	$ 291,830.00	$ 1,024,568.28	$2,049,136.56		$0	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	$ 102,456.83	10 year maintenance costs provided by Westrac
CAT Compactor	CAT 825G	$ 834,190.61	3494	$ 384,340.00	$ 1,218,530.61	$2,437,061.22		$0	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	$ 121,853.06	10 year maintenance costs provided by Westrac
								Subtotals per year		**$ 224,309.89**	**$ 224,309.89**	**$ 224,309.89**	**$ 224,309.89**	**$ 224,309.89**	**$ 224,309.89**	**$ 224,309.89**	**$224,309.89**	**$ 224,309.89**	**$ 224,309.89**	**$ 224,309.89**	**$ 224,309.89**	**$ 224,309.89**	**$ 224,309.89**	**$ 224,309.89**	**$ 224,309.89**	**$ 224,309.89**	**$ 224,309.89**	**$ 224,309.89**	

Table E-6 Mitigation Option Costs

		Capital Costs				Annual Costs				Demobilisation Costs	Comments
		Option				Option				Option	
Category	Mitigation Measure	1	2	3	4	1	2	3	4	All	
Traffic	A Traffic Management Plan must be prepared by the Contractor prior to the commencement of works to manage potential traffic impacts and issues. The TMP will improve general road safety and should include relevant warning and advisory signage, including speed limits and for maintenance purposes.	$15,000	$15,000	$15,000	$15,000	n/a	n/a	n/a	n/a	n/a	
Traffic	Coordinating the traffic signals at intersections in order to optimise the flow of vehicles.	$20,000	$20,000	$20,000	$20,000	$1,000	$1,000	$1,000	$1,000	n/a	
Traffic	Motorists need to be made aware of any changed traffic conditions and the provision of appropriate alternative access routes if necessary. Signs should be erected along any roads in the immediate area, warning motorists to be cautious of the trucks entering and leaving the quarry, and alerting them to any changed traffic conditions.	$20,000	$20,000	$20,000	$20,000	$2,000	$2,000	$2,000	$2,000	n/a	
Traffic	Maintenance of local roads to ensure surface quality for local road users. Additionally, maintenance of road during demobilisation for ongoing local use.	n/a	n/a	n/a	n/a	$50,000	$50,000	$50,000	$50,000	$100,000	
Traffic	Identification of alternate park areas for residents and businesses along affected routes.	$10,000	$10,000	$10,000	$10,000	$500	$500	$500	$500	n/a	
Traffic	All equipment and machinery at the works site will need to be contained within the s	nil	nil	nil	nil	n/a	n/a	n/a	n/a	n/a	
Traffic	Ongoing communication with negatively impacted residents.	n/a	n/a	n/a	n/a	$2,000	$2,000	$2,000	$2,000	n/a	
Noise	Minimising the number of plant items in use in the quarry area and surrounds at any one time.	nil	nil	nil	nil	n/a	n/a	n/a	n/a	n/a	
Noise	Partial barriers at vehicle entry points.	$5,000	$5,000	$5,000	$5,000	$500	$500	$500	$500	n/a	
Noise	Provide acoustic property treatments to affected residential receivers for: Option 1 route (Approximately 99 dwellings affected) (Cardno, 2012a) Option 2 route (Approximately 248 dwellings affected) (Cardno, 2012a) Option 3 route (Approximately 248 dwellings affected) (Cardno, 2012a) Option 4 route (Approximately 149 dwellings affected) (Cardno, 2012a)	$990,000	$2,480,000	$2,480,000	$1,490,000	n/a	n/a	n/a	n/a	n/a	
Noise	Limit quarry infilling to the proposed hours of operation (7am to 5pm - Monday to Friday, 8am to 12pm - Saturday).	nil	nil	nil	nil	n/a	n/a	n/a	n/a	n/a	
Noise	Installation of an acoustics shed at entry point	nil*	nil*	nil*	nil*	nil*	nil*	nil*	nil*	nil*	
Noise	Design access layout to minimise requirements for visiting trucks to reverse.	nil	nil	nil	nil	n/a	n/a	n/a	n/a	n/a	

		Capital Costs				Annual Costs				Demobilisation Costs	Comments
		Option				Option				Option	
Category	Mitigation Measure	1	2	3	4	1	2	3	4	All	
Air Quality	All loads arriving and departing the site should be covered	nil*	nil*	nil*	nil*	nil*	nil*	nil*	nil*	n/a	A policy can be implemented which states the Quarry will not accept uncovered loads. This should deter any uncovered loads arriving.
Air Quality	All vehicles leaving the site or moving from unsealed to sealed roads should use a rumble grid and pit prior to exiting, and a wheel wash facility should be implemented to remove excess mud or dirt as required.	$30,000	$30,000	$30,000	$30,000	$1,000	$1,000	$1,000	$1,000	n/a	
Air Quality	Any stockpiles should be in an appropriate location with respect to likely wind conditions, and should be maintained in a reasonable size so that covering may be more easily undertaken if needed.	nil*	nil*	nil*	nil*	nil*	nil*	nil*	nil*	n/a	
Air Quality	Where feasible, limit the area of exposed excavated materials on site.	nil*	nil*	nil*	nil*	nil*	nil*	nil*	nil*	n/a	
Air Quality	Regularly check weather conditions and forecasts and adjust work practices accordingly, particularly if high wind speeds are predicted or experienced.	nil	nil	nil	nil	n/a	n/a	n/a	n/a	n/a	
Air Quality	Use water sprays to reduce dust emissions during unloading activities.	nil	nil	nil	nil	n/a	n/a	n/a	n/a	n/a	
Air Quality	Cover stockpiled materials during times of rain or high winds.	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	n/a	
Air Quality	Vegetation removal should be minimised around the site. Screening vegetation is likely to reduce the impacts of dust in some locations with increasing distance from potential dust sources.	nil	nil	nil	nil	n/a	n/a	n/a	n/a	n/a	
Air Quality	On-site plant and machinery should not be left in idle. Engines should be turned off when parked.	nil	nil	nil	nil	n/a	n/a	n/a	n/a	n/a	
Air Quality	Ensure that equipment and machinery is adequately maintained.	nil*	nil*	nil*	nil*	nil*	nil*	nil*	nil*	n/a	
Groundwater	Dewatering of the quarry void prior to filling would be required. This would be a significant activity involving pumping approximately 450 ML of water from the void. Ongoing management would be required for the ongoing inflow of groundwater.	nil*	nil*	nil*	nil*	nil*	nil*	nil*	nil*	n/a	
Groundwater	Installation of septic, sewerage and stormwater facilities should be contained in a manner to avoid contact with the groundwater.	nil*	nil*	nil*	nil*	nil*	nil*	nil*	nil*	n/a	
Groundwater	Appropriate procedures, spill kits and response procedures should be in place to prevent / respond to petrol, oil and other chemical spills.	$1,000	$1,000	$1,000	$1,000	nil	nil	nil	nil	n/a	

		Capital Costs				Annual Costs				Demobilisation Costs	Comments
		Option				Option				Option	
Category	Mitigation Measure	1	2	3	4	1	2	3	4	All	
Topography and Geology	Rock bolts to support key blocks and defects. Mesh to support zones of weakness or loose blocks of rick. Drainage holes to control the build-up of groundwater pressure. Scaling of the rock faces to remove detached blocks and areas of significant blast damage.	nil*	nil*	nil*	nil*	nil*	nil*	nil*	nil*	n/a	
Topography and Geology	No access to the quarry within one week of heavy rainfall, establishment of defined access paths, limited time and number of visits to the quarry, only allow workers access to the quarry within the cabs of trucks, added protection provided to vehicle working in the quarry floor, ongoing monitoring of stability.	nil	nil	nil	nil	nil	nil	nil	nil	nil	
Topography and Geology	To minimise the amount of settlement, filling should involve spreading fill to layers of approximately 1 to 2m thickness and compacting. End use should consider settlement issues.	nil*	nil*	nil*	nil*	nil*	nil*	nil*	nil*	n/a	
Flora and Fauna	All native tree and plant species must be retained with the exception of those approved for removal in the final design.	nil	nil	nil	nil	n/a	n/a	n/a	n/a	n/a	
Flora and Fauna	Unless approval has been granted, threatened vegetation species and communities are not to be removed or harmed.	nil	nil	nil	nil	n/a	n/a	n/a	n/a	n/a	
Flora and Fauna	Any tree-trimming must be carried out responsibly and only the necessary portions of trees are to be removed.	nil	nil	nil	nil	n/a	n/a	n/a	n/a	n/a	
Flora and Fauna	In order to assist in the protection of trees to be retained, temporary fencing should be erected around trees where possible, in accordance with Council. This should extend to the trees which may be impacted by the access of work vehicles to and from the site.	$10,000	$10,000	$10,000	$10,000	$1,000	$1,000	$1,000	$1,000	n/a	
Flora and Fauna	In order to help reduce the likelihood of weed dispersal, erosion and sediment control measures should be implemented during the proposed construction. It is recommended that where appropriate, washing of trucks is undertaken to prevent contamination with weed species, particularly if trucks are coming from non-local areas. Any revegetation taking place on the site should be undertaken using species local to the area.	nil*	nil*	nil*	nil*	nil*	nil*	nil*	nil*	n/a	
Flora and Fauna	A *Vegetation Management Plan* should be prepared as part of the CEMP to ensure mitigation measures to protect existing native vegetation are observed.	$5,000	$5,000	$5,000	$5,000	n/a	n/a	n/a	n/a	n/a	
Flora and Fauna	Where possible, all native tree and plant species must be retained as they are likely to provide habitat for existing fauna.	nil	nil	nil	nil	n/a	n/a	n/a	n/a	n/a	

		Capital Costs				Annual Costs				Demobilisation Costs	Comments
		Option				Option				Option	
Category	**Mitigation Measure**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**All**	
Flora and Fauna	If an animal dwelling is discovered in or adjacent to a tree to be removed or trimmed, work must cease immediately so that appropriate management actions can be undertaken where necessary.	$5,000	$5,000	$5,000	$5,000	n/a	n/a	n/a	n/a	n/a	
Flora and Fauna	It is recommended a certified wildlife handler be present on site to assist in the safe removal of any displaced wildlife. If any native animals are injured during the construction process, the local wildlife rescue service (WIRES) should be contacted.	$5,000	$5,000	$5,000	$5,000	n/a	n/a	n/a	n/a	n/a	
Heritage	The contractors and all staff contracted to undertake construction works should be informed and made aware of their responsibilities in the event that any Aboriginal objects are identified. An unexpected finds protocol should be maintained and followed during the works in order to ensure that impacts on unknown items are minimised. If any Aboriginal objects and / or places are located during the construction phase, all work should cease in the vicinity of the find. Council's Project Manager and OEH should be contacted. If skeletal material is identified then NSW Police must be contacted.	$5,000	$5,000	$5,000	$5,000	n/a	n/a	n/a	n/a	n/a	
Heritage	Should any Aboriginal objects be uncovered during the works, an Aboriginal Heritage Impact Permit (AHIP) under Section 90 of the Act would need to be obtained if the object cannot be avoided.	$10,000	$10,000	$10,000	$10,000	n/a	n/a	n/a	n/a	n/a	
Heritage	It is recommended that a Heritage Impact Assessment be conducted to assess the impacts of the proposal on the two heritage items located at the quarry site (diatreme and cemetery). In addition, the HIA should also consider impacts on the house located at 3 Bridge Road, should any option that utilises this road be chosen.	$15,000	$15,000	$15,000	$15,000	n/a	n/a	n/a	n/a	n/a	
Heritage	Given the potential impacts on the volcanic diatreme, it is necessary for Council to investigate appropriate means of maintaining this heritage item or alternatively recording and covering it if this is deemed the most appropriate way to enable future public use of the site. It is recommended that video, photographs and written documentation of the item be recorded and archived prior to the item being covered with fill.	$15,000	$15,000	$15,000	$15,000	n/a	n/a	n/a	n/a	n/a	
Heritage	With regard to the Higgins Family Cemetery, create a buffer zone (50 metres) and fencing along the boundary of this buffer zone to prevent unauthorised access by vehicles or access on foot.	$2,000	$2,000	$2,000	$2,000	$500	$500	$500	$500	n/a	
Heritage	With regard to the Higgins Family Cemetery, establish signage to notify site operators and the public of the location of the item.	$1,000	$1,000	$1,000	$1,000	n/a	n/a	n/a	n/a	n/a	
Heritage	With regard to the Higgins Family Cemetery, provide onsite training so that contractors and personnel on site are made aware of the location and sensitivity of the heritage item.	$1,000	$1,000	$1,000	$1,000	n/a	n/a	n/a	n/a	n/a	

		Capital Costs				Annual Costs				Demobilisation Costs	Comments
		Option				Option				Option	
Category	**Mitigation Measure**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**All**	
Heritage	With regards to vibration impacts, traffic routes to access the works site and any restrictions to avoid heritage items in the vicinity of the works should be specified in a *Construction Traffic Management Plan*. Heavy vehicles should adhere to road speed limits at all times.	nil	nil	nil	nil	nil	nil	nil	nil	n/a	Included in the Traffic Management Plan outlined in the Traffic category above.
Heritage	All site personnel should be made aware of the presence of the heritage items in the general locality of the works, such that the potential for accidental damage to these heritage items is minimised.	$1,000	$1,000	$1,000	$1,000	n/a	n/a	n/a	n/a	n/a	
Heritage	If vibration impacts from nearby road traffic appear to be adversely affecting any heritage building or structures, works and traffic movements in the vicinity should be stopped immediately, and OEH (Heritage Branch) informed.	nil	nil	nil	nil	n/a	n/a	n/a	n/a	n/a	
Social	Do not allow trucks travelling to and from the quarry to park along the access roads.	nil	nil	nil	nil	nil	nil	nil	nil	nil	
Social and Visual Amenity	Complaints register, to record any community complaints received during the works.	n/a	n/a	n/a	n/a	$1,000	$1,000	$1,000	$1,000	n/a	
Visual Amenity	Construction of the access road should be undertaken in a manner that does not allow excessive site equipment, debris or waste to accumulate nearby. Once construction of the access roads is completed, all debris should be removed from the site and disposed of appropriately. Site equipment and any temporary facilities/amenities should also be removed.	nil*	nil*	nil*	nil*	nil*	nil*	nil*	nil*	n/a	
Visual Amenity	Plant new screenings in affected locations	$10,000	$10,000	$10,000	$10,000	n/a	n/a	n/a	n/a	n/a	
	Total (to nearest '$10,000)	$1,180,000	$2,670,000	$2,670,000	$1,680,000	$60,000	$60,000	$60,000	$60,000	$100,000	

* Costs are already included in Site Establishment and Backfilling cost estimates

APPENDIX

F

Access options report

Cardno
Shaping the Future

Cardno
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LJ2888 Filling of Hornsby Quarry Access Options Assessment

Prepared for Hornsby Shire Council

October 2012

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4	Final	October 2012	Christina Chiu Emma Maratea	CC ERM	Kester Boardman Jenny Smithson	IKB JS

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1 INTRODUCTION

Hornsby Shire Council (HSC) resolved to fill the Hornsby Quarry with Virgin Excavated Natural Material (VENM) in August 2009, and have commissioned Cardno to seek the necessary approvals to enable the quarry to be filled.

The location of the quarry, and the local geography of the area, means any filling of the quarry will require movement of fill material through both major roads and residential/commercial areas and will lead to some disruption for local residents. To assist in minimising disruption for local residents, an options assessment has been undertaken to identify and evaluate the most appropriate access route to the quarry to facilitate the transportation of fill to Hornsby Quarry, with the results presented in this report.

This document:

- Identifies the potential access options considered,
- Sets out criteria for project success (screening criteria),
- Compares each potential access option against the agreed screening criteria,
- Establishes a list of access options which satisfy the screening criteria and may be feasible,
- Compares access options which satisfy the screening criteria using a multi criteria analysis,
- Provides the results of the multi criteria analysis, and
- Identifies the access option for filling the quarry which is determined by the multi criteria analysis to have the lowest level of impact, and is therefore recommended as the preferred access option for future detailed evaluation.
- Identifies access options which are recommended for future detailed evaluation.

2 ACCESS OPTIONS CONSIDERED

The objectives of this report are to identify all feasible methods and routes for transporting VENM to the quarry rim and then, through a logical and documented process, determine a preferred option which will be subject to a more detailed assessment of environmental and social impact as part of a separate exercise.

The Cardno team identified the access options through:

- Review of local maps, aerial imagery and GIS data,
- Review of past documents and assessments provided to Cardno by Council,
- A workshop with the Cardno team, and discussions with Cardno staff familiar with the local area,
- Travelling the local road network,
- Desktop research and database searches,
- Review of the findings of traffic modelling of key sections of the study area, and
- Discussions with Council.

At this stage, no detailed consideration of how VENM fill material will be transported from the quarry rim to the active point of fill has been undertaken. This has been considered to be a common process to all options.

Table 2.1 identifies the complete list of potential access options identified by Cardno for the transport of VENM to the quarry rim. These 20 Access Options can be categorised into 3 delivery mechanisms as follows:

- Transportation of fill primarily by road (13 options),
- Transportation of fill primarily by rail (6 options), and
- Transportation of fill by air (1 option).

The local road access options to the quarry are shown in Figure 2.1.

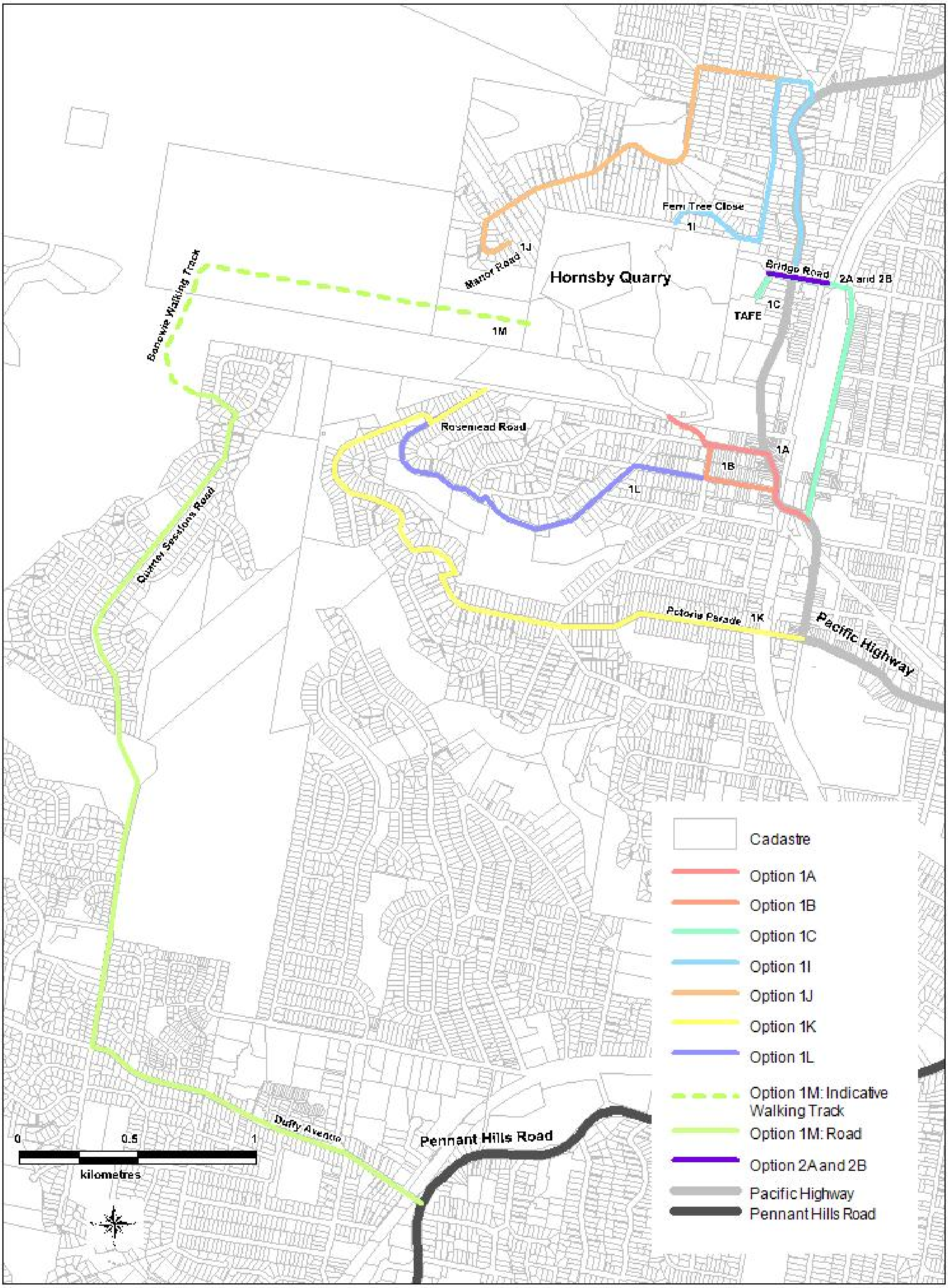

Figure 2.1 Access Route Options

Table 2.1 List of Access Options Considered

Option Number	Access Option
Scenario 1: Transportation of VENM by Road	
1A	Access via Quarry Road / Dural Street / Pacific Highway.
1B	Access via Quarry Road / Fredrick Street / William Street / Pacific Highway.
1C	Extension of Bridge Road to facilitate direct access to quarry.
1D	Creation of transfer station at the end of existing Bridge Road with tunnel access to quarry.
1E	Creation of transfer station at the end of existing Bridge Road with no tunnel access to quarry.
1F	Creation of transfer station from Pacific Highway with tunnel access to quarry.
1G	Creation of transfer station from Pacific Highway with no tunnel access to quarry.
1H	One-way loop access via two preferred route options (determined to be Options 1B and 1C – refer to Section 4.3.5).
1I	Access via Fern Tree Close / Silvia Street / Carrington Road / Galston Road / Pacific Highway.
1J	Access via Manor Road / Rosamond Street / Carrington Road / Galston Road / Pacific Highway.
1K	Access via Rosemead Road / Valley Road / Pretoria Parade the Pacific Highway.
1L	Access via Rosemead Road / William Street.
1M	Access via Benowie Walking Track / Quarter Sessions Road / Duffy Avenue / Pennant Hills Road.
Scenario 2: Transportation of VENM by Rail	
2A	Creation of rail spur along Bridge Road from main northern line extending to the quarry.
2B	Creation of conveyor along Bridge Road from main northern line extending to the quarry with transfer station.
2C	Creation of a tunnel from the existing rail line, with a transfer station at the tunnel entrance and a conveyor running through the tunnel.
2D	Creation of a tunnel from the existing rail line, with direct train access to the quarry through the tunnel.
2E	Creation of a tunnel from the existing rail line, with a transfer station and direct truck access to the quarry through the tunnel.
2F	Truck access to the quarry from the northern rail line utilising preferred Option 2 route.
Scenario 3: Transportation of VENM by Air	
3	Transport of VENM by helicopter from the material source direct to the quarry pit.

The subsequent sections of this report will:

- Consider each of the options in Table 2.1 in the context of known constraints to determine which of the options are (or may be) compatible with the stated Council objectives for filling the quarry, and
- Explain the reasons for discounting any option from further consideration.

3 SCREENING OF OPTIONS

In this analysis, Cardno identified three screening criteria against which each option was initially assessed, namely:

- Number of residential dwellings impacted;
- Site availability for any required associated infrastructure; and
- Compatibility with the Proposed Hornsby Westside Revitalisation Masterplan.

3.1 Number of Residential Dwellings Impacted

One of Council's key objectives is for the works associated with filling the quarry to affect the minimum number of residents in the community. Potential impacts will occur at the quarry site, and along the transport routes, and are expected to include:

- Noise,
- Vibration,
- Dust,
- Safety, and
- Amenity.

Analysis was undertaken to determine the number of dwellings located adjacent to each of the route options identified. Table 3.1 summarises the results of the assessment, and the analysis undertaken is presented in more detail in Appendix A.

The results in Table 3.1 show that options 1K, 1L and 1M pass a significantly higher number of dwellings than routes 1A to 1E, 1I and 1J.

In light of these findings, options 1K, 1L and 1M have been excluded from further assessment, noting that they do not exhibit significantly lower impacts in relation to any of the other criteria considered.

The outcome of applying this constraint is to minimise the disturbance to Hornsby Quarry's surrounding community.

It is also considered that a significant number of dwellings would be impacted, and that there is a significant health (noise) risk associated with the transportation of VENM to the quarry by air (ie the use of helicopter), particularly noting the close proximity of Hornsby Town Centre and residential properties. It is also likely to be cost prohibitive and pose possible safety concerns. As a result, access option 3 – transport to the quarry by air (helicopter) – was discounted from further assessment.

Table 3.1 Calculated Number of Dwellings Impacted by Route Access Options

Option Number	Access Option	Number of Dwellings Impacted
	Option 1: Transportation of VENM by Road	
1A	Access via Quarry Road / Dural Street / Pacific Highway.	131
1B	Access via Quarry Road / Fredrick Street / William Street / Pacific Highway.	149
1C	Extension of Bridge Road to facilitate direct access to quarry	99
1D	Creation of transfer station at the end of existing Bridge Road with tunnel access to quarry	104
1E	Creation of transfer station at the end of existing Bridge Road with no tunnel access to quarry	104
1F	Creation of transfer station from Pacific Highway with tunnel access to quarry	N/Q
1G	Creation of transfer station from Pacific Highway with no tunnel access to quarry	N/Q
1H	One-way loop access via two preferred route options (determined to be Options 1B and 1C – refer to Section 4.3.5).	N/Q
1I	Access via Fern Tree Close / Silvia Street / Carrington Road / Galston Road / Pacific Highway	157
1J	Access via Manor Road / Rosamond Street / Carrington Road / Galston Road / Pacific Highway.	208
1K	Access via Rosemead Road / Valley Road / Pretoria Parade the Pacific Highway.	**227**
1L	Access via Rosemead Road / William Street	**226**
1M	Access via Benowie Walking Track / Quarter Sessions Road / Duffy Avenue / Pennant Hills Road.	**287**
	Option 2: Transportation of VENM by Rail	
2A	Creation of rail spur along Bridge Road from the main northern line extending to the quarry	N/Q
2B	Creation of conveyor along Bridge Road from the main northern line extending to the quarry with transfer station	N/Q
2C	Creation of a tunnel from the existing rail line, with a transfer station at the tunnel entrance and a conveyor running through the tunnel.	N/Q
2D	Creation of a tunnel from the existing rail line, with direct train access to the quarry through the tunnel.	N/Q
2E	Creation of a tunnel from the existing rail line, with a transfer station and direct truck access to the quarry through the tunnel.	N/Q
2F	Truck access to the quarry from the northern rail line utilising preferred Option 2 route.	Truck access to the quarry TBC
	Option 3: Transportation of VENM by Air	
3	Transport of VENM by helicopter from the material source direct to the quarry pit	N/Q (>200)

N/Q = Not Quantified

3.2 Site Availability for Associated Infrastructure

A number of the options identified required ancillary infrastructure such as transfer stations or rail sidings to be developed. The likely availability of sites for these facilities is considered in this section. Transfer station requirements for the project have been considered in general terms only at this stage, however it is noted that the purpose of these facilities is to enable the fill material to be transferred from one mode of transport to another (for example from a train to a truck or a conveyor system). The facilities may be covered, partially covered or uncovered and are typically expected to contain a delivery area, loading and unloading machinery moving within the facility, a stockpile area, and staff facilities.

Options 1D through to 1G require the creation of a transfer station at either the end of the existing Bridge Street or from the Pacific Highway. Cardno undertook spatial analysis using available GIS data combined with local site knowledge in an attempt to identify any suitable locations for the transfer stations.

Options 1D and 1E require a transfer station to be established in the general vicinity of the existing end of Bridge Street. Part of this area is occupied by TAFE NSW – Northern Sydney Institute. However, the lot of land north of the TAFE is currently undeveloped, making it a possible site for a transfer station.

Options 1F and 1G require a transfer station to be established just off the Pacific Highway. Through the inspection of GIS data of the sites in the vicinity of Hornsby Quarry along the Pacific Highway, no available sites for a transfer station were identified, however it is noted that HSC has the option of acquisition of lots in order to facilitate this option.

In light of the findings on the need to secure sites for associated infrastructure, Options 1D-1G have been excluded from further assessment. However, it is noted that further consideration of these options may be warranted if suitable locations for the required infrastructure can be made available to HSC.

Options 2A to 2F all involve transport of VENM to Hornsby by rail and present associated logistical constraints. The infrastructure required for the transportation by rail includes:

- A rail spur between the location at which VENM is loaded onto trains and the existing freight rail line,
- A transfer station at the point of loading VENM onto trains,
- A transfer station at the point of offloading VENM from trains at Hornsby, and,
- A rail spur from the freight line to the transfer station at which VENM will be offloaded in Hornsby.

At the rail delivery point in Hornsby, a transfer station in the vicinity of the rail line would need to be established in order to unload the VENM from the freight train to the access point of the quarry.

Cardno understands that there has been a recent upgrade to Hornsby Railway Station, where an additional Platform (Platform 5) and pedestrian concourse were added and completed in 2009. Additionally, works were undertaken to widen tracks and construct 1.7 km of new tracks (PB, 2005), to accommodate the anticipated increase in demand for the Main Northern Rail Line for freight and passenger services to Newcastle (Railcorp, 2003 cited by PB, 2005). Hornsby Railway Station's upgrade was also used to increase the Main Northern Rail Line's terminating capacity. These upgrade works encroached upon the bus interchange and other sites within the Railway Corridor boundary which were reconfigured (PB, 2005).

Following these works, it is understood by Cardno that there is no available space at the station to accommodate the additional rail spurs or sidings that would be needed to deliver VENM to the quarry by rail. Additionally, inspection of aerial images and GIS data supplied by Council shows there is no appropriate site, unless Council is prepared to undertake property acquisitions, adding significantly to the overall cost of the project.

Due to the lack of suitable locations at which the required rail infrastructure could be located, it is considered that all options that involve delivery of VENM by rail are not practical. Therefore, Options 2A-2F have not been considered further in this assessment.

3.3 Compatibility with the Proposed Hornsby Westside Revitalisation Masterplan

A proposed Hornsby Westside Revitalisation Masterplan has been developed to provide a basis for a program of street upgrades to be designed and implemented over a number of years. The main elements of the Masterplan include:

- 40 km/h High Pedestrian Activity Area along Pacific Highway from William Street to Hornsby TAFE (Western Campus).
- One through lane each way for the entire length of the Pacific Highway between Dural Lane and Bridge Road.
- Dedicated right turn lane into William Street from the Pacific Highway.
- Dedicated right turn lane into Station Street from the Pacific Highway.
- Raised platforms on existing pedestrian crossings on the Pacific Highway at Station Street and Hornsby TAFE.
- Traffic signals at Pacific Highway/Coronation Street intersection (subject to 50:50 funding from RTA).
- Angle parking in front of Hornsby Park.
- Angle parking in front of Council Chambers and Courthouse.
- Introduction of street trees (species yet to be determined).
- Paving remaining footway areas in clay pavers.
- New street furniture.

Option 1A would result in trucks entering the 40km/h High Pedestrian Activity Area along Pacific Highway. Therefore this option has not been considered further in this assessment. All other options avoid truck movements through this zone.

3.4 Results of initial screening of Access Options

After applying the initial screening criteria and considering the constraints which have been outlined in earlier sections, the remaining access options considered to be potentially feasible are listed in Table 3.2. These options are assessed in more detail through multi criteria analysis in Section 4.

Table 3.2 Potentially Feasible Access Options Requiring Further Assessment

Option Number	Access Option
1B	Access via Quarry Road / Fredrick Street / William Street / Pacific Highway.
1C	Extension of Bridge Road to facilitate direct access to quarry.
1I	Access via Fern Tree Close / Silvia Street / Carrington Road / Galston Road / Pacific Highway.
1J	Access via Manor Road / Rosamond Street / Carrington Road / Galston Road / Pacific Highway.
1H	One-way loop access via two preferred route options (determined to be Options 1B and 1C).

Table 3.3 identifies additional options which would be considered to be viable only if a suitable site for associated infrastructure can be identified and made available to Council. No further assessment of these options has been made, however they could be evaluated using the multi criteria analysis framework described in Section 4 if suitable locations for the required infrastructure become available.

Table 3.3 Potentially Feasible Options if Sites for Infrastructure Are Available

Option	Description of Work Required
1D	Creation of transfer station at the end of existing Bridge Road with tunnel access to quarry.
1E	Creation of transfer station at the end of existing Bridge Road with no tunnel access to quarry.
1F	Creation of transfer station from Pacific Highway with tunnel access to quarry.
1G	Creation of transfer station from Pacific Highway with no tunnel access to quarry.

4 MULTI CRITERIA ANALYSIS OF FEASIBLE ACCESS ROUTE OPTIONS

The five potentially feasible access options identified in Table 3.2 all comprised road options accessed from the Pacific Highway. To determine the best access option, a multi-criteria assessment of the five options was conducted. This section of the report describes the assessment methodology utilised in the assessment which leads to the recommendation of a preferred access route.

4.1 ASSESSMENT METHODOLOGY AND CRITERIA

A set of criteria was developed to quantitatively analyse each access option (scenario). Each scenario was then scored against the criteria defined in Section 4.1.1. Scoring of the five options has been based on a range of 1 to 5, where 1 is the best performing option and 5 is the worst performing option with respect to the criterion being considered. As a result, a low score in an assessment category signifies a lower environmental or social impact and a better solution in general terms. An overall lower score indicates a higher preference for the route option.

It is noted that, using this approach, the total score for each criterion will always add up to 15 (1+2+3+4+5). Where options were determined to perform equally, equivalent scores were assigned at a value which preserved the total score of 15. (For example, if 2 options were determined to perform equally well, and better than all other options both options were scored as 1.5, being the average of 1 and 2).

4.1.1 Criteria

The assessment criteria considered are as follows:

- Number of dwellings on the route – this criterion considers the number of dwellings which are directly adjacent to or fronting the route. Routes with a higher number of dwellings can be expected to lead to greater nuisance impacts including increased traffic volumes, noise, vibration, dust generation and associated safety issues. The number of dwellings along each access option is shown in Table 3.1.
- Length of route – this criterion considers the distance a vehicle is required to travel from the common point at the southern Pacific Highway / George Street intersection to the quarry rim (with the exception of 1K and 1M which are measured along the routes as shown on Figure 2.1). A shorter distance can be expected to have lower impacts on the surrounding environment, involve less travel time and place less stress on the existing infrastructure. The length of each route to the quarry following the route shown on Figure 2.1 is shown in Table 4.1.
- Ease of getting the VENM from the quarry rim to the quarry base – the different access options lead to different points around the quarry rim. This criterion considers the ease at which the VENM would likely be transported from the quarry rim to the base of the quarry, and the relative level of additional environmental or social impacts which would be expected to result from this step of the quarry filling process.
- Technical challenges – this criterion considers the level of technical complexity associated with each access option. This includes consideration of factors such as steep gradients which must be overcome.

- Road Network Operation – This criterion considers the road network design and capacity along each route. An access option which has a greater traffic carrying capacity is generally expected to perform better, and receive a lower score.

Table 4.1 Calculated Length of Route to the Quarry for Access Options by Road

Option Number	Access Option	Length of Route (km) (shown on Figure 2.1)
Option 1: Transportation of VENM by Road		
1A	Access via Quarry Road / Dural Street / Pacific Highway.	0.68
1B	Access via Quarry Road / Fredrick Street / William Street / Pacific Highway.	0.71
1C	Extension of Bridge Road to facilitate direct access to quarry.	1.20
1D	Creation of transfer station at the end of existing Bridge Road with tunnel access to quarry.	1.20
1E	Creation of transfer station at the end of existing Bridge Road with no tunnel access to quarry.	1.20
1F	Creation of transfer station from Pacific Highway with tunnel access to quarry.	N/A
1G	Creation of transfer station from Pacific Highway with no tunnel access to quarry.	N/A
1H	One-way loop access via two preferred route options (determined to be Options 1B and 1C – refer to Section 4.3.5).	0.96[#]
1I	Access via Fern Tree Close / Silvia Street / Carrington Road / Galston Road / Pacific Highway.	2.77
1J	Access via Manor Road / Rosamond Street / Carrington Road / Galston Road / Pacific Highway.	3.44
1K	Access via Rosemead Road / Valley Road / Pretoria Parade the Pacific Highway.	2.69
1L	Access via Rosemead Road / William Street.	2.06
1M	Access via Benowie Walking Track / Quarter Sessions Road / Duffy Avenue / Pennant Hills Road.	5.86

[#] Calculated as the average of options 1B and 1C

4.1.2 Criteria Weighting

The criteria described above have been considered by this assessment to be of equal importance. No weightings have therefore been used in the assessment.

4.1.3 Overall Scoring

Scores were given to each route option for each criteria and summed to determine an overall score. The lower the overall score the better the option. The options are discussed in further detail below and include the assigned scoring for each criterion.

4.2 PRO's AND CON's OF EACH OPTION ANALYSED

Prior to applying the scoring a qualitative assessment was undertaken to consider key pro's and con's of each option analysed. These are further explained in Table 4.2 below.

Table 4.2 Pro's and Con's of Each Option

Option (refer to Figure 2.1)	Pro's	Con's
Option 1B Access via Quarry Road / Fredrick Street / William Street / Pacific Highway	Enables existing quarry roads to be used to transfer VENM to the quarry base, and provides a low level of technical challenge	Impacts to dwellings located along the route.
Option 1C Extension of Bridge Road to facilitate direct access to quarry. Access via Bridge Road / George Street.	Minimal use of local residential streets.	Technical challenges in moving VENM from the existing road network to the quarry base. Impacts to dwellings located along the route.
Option 1I Access via Fern Tree Close / Silvia Street / Carrington Road / Galston Road / Pacific Highway / George Street	No significant pros identified	Technical challenges in moving VENM from the existing road network to the quarry base. Length of route. Impacts to dwellings located along the route.
Option 1J Access via Manor Road / Rosamond Street / Carrington Road / Galston Road / Pacific Highway / George Street.	No significant pros identified	Technical challenges in moving VENM from the existing road network to the quarry base. Length of route. Impacts to dwellings located along the route.
Option 1H One-way loop access via two preferred route options (determined to be Options 1B and 1C – refer to Section 4.3.5).	Option to reduce impact at any one location by use of a one way loop, effectively halving traffic movements at any location.	Leads to an impact along two separate locations increasing the number of affected dwellings (although only subject to one way movements). Technical challenges in moving trucks between the existing road network at Bridge Road and the quarry base. Impacts to dwellings located along the route.

4.3 INDIVIDUAL OPTION SCORING

4.3.1 Option 1B - **Access via Quarry Road / Fredrick Street / William Street / Pacific Highway**

Option 1B provides a transport route from the Pacific Highway to the southeast side of the quarry, from where existing internal quarry roads can be used to transport VENM to the quarry base.

OVERVIEW

- Transport of VENM material will occur by road from the southern junction of Pacific Highway and George Street to the quarry along:
  - Pacific Highway,
  - William Street,
  - Frederick Street, and
  - Quarry Road.
- VENM transport from the quarry rim to the base could be undertaken using existing internal quarry roads.

Table 4.3 Option 1B Scores

Criteria	Scoring / Comments	
Number of dwellings on the route	3	149 dwellings have been determined to lie along the route. Many of these dwellings are part of multi-unit residential developments.
Length of route	1	At 0.71 km, the route from the common intersection (Pacific Hwy / George St) to the quarry rim is the shortest of the 5 options being considered.
Ease of getting the VENM from the quarry rim to the quarry base	1	This option provides the simplest means of transferring VENM from the quarry rim to the base, as there is an existing haul road inside the quarry with its origin at the end of Quarry Road.
Technical challenges	1	This option is considered to provide the least technical challenges. Roads to the quarry rim are generally close to horizontal, and the quarry face at this point is stable. Transfer of material into the quarry from the rim is relatively simple due to the presence of the existing haul road.
Road Network Operation	2	The majority of the route from the Pacific Highway to the quarry rim is on major roads, with key turns generally being made at signal controlled intersections. Options 1B, 1C and 1H were found to perform significantly better than options 1I and 1J, and have been scored equally for this criterion.
TOTAL SCORE	8	

4.3.2 Option 1C - **Extension of Bridge Road to Facilitate Direct Access to Quarry**

Option 1C provides a transport route from the Pacific Highway to the northeast side of the quarry. From this point, new infrastructure will be required to transport VENM to the quarry base, with either significant extension to Bridge Road, or a transfer station and conveyor system, being required.

OVERVIEW

- Transport of VENM material will occur by road from the southern junction of Pacific Highway and George Street to the quarry along:
  - George Street, and
  - Bridge Road.
- VENM transport from the quarry rim to the base could be undertaken using either a new road system which would need to be constructed, or by installing a transfer system to transfer VENM to a new conveyor system.

Table 4.4 Option 1C Scores

Criteria	Scoring / Comments	
Number of dwellings on the route	1	99 dwellings have been determined to lie along the route. Many of these dwellings are part of multi unit residential developments. This is fewer than the other four options being considered.
Length of route	3	At 1.2 km the route from the common intersection (Pacific Hwy / George St) to the quarry rim is the third shortest of the 5 options being considered.
Ease of getting the VENM from the quarry rim to the quarry base	2	There is no existing infrastructure to convey the VENM from the quarry rim to the quarry base at this location. This area of the quarry is relatively stable. There is a significant gradient between the existing Bridge Road and the quarry base.
Technical challenges	5	The topography and change in height between the end of Bridge Road and the quarry base, coupled with the horizontal distance, means that there are a number of technical challenges to be overcome if VENM is to be successfully transported to the base of the quarry. In particular, there is a constraint on the maximum gradient that trucks can climb or descend, which means construction of an access road from this point is technically challenging.
Road Network Operation	2	The majority of the route from the Pacific Highway to the quarry rim is on major roads, with key turns generally being made at signal controlled intersections. Options 1B, 1C and 1H were found to perform significantly better than Options 1I and 1J, and have been scored equally for this criterion.
TOTAL SCORE	13	

4.3.3 Option 1I - **Access via Fern Tree Close / Silvia Street / Carrington Road / Galston Road / Pacific Highway / George Street**

Option 1I provides a transport route from the Pacific Highway to the north side of the quarry. From this point, new infrastructure will be required to transport VENM to the quarry base.

OVERVIEW

- Transport of VENM material will occur by road from the southern junction of Pacific Highway and George Street to the quarry along:
  - George Street,
  - Pacific Highway,
  - Galston Road,
  - Carrington Road,
  - Silvia Street, and
  - Fern Tree Close.
- VENM transport from the quarry rim to the base could be undertaken using either a new road system, which would need to be constructed, or by installing a transfer station to transfer VENM to a new conveyor system.

Table 4.5 Option 1I Scores

Criteria	Scoring / Comments	
Number of dwellings on the route	4	157 dwellings have been determined to lie along the route. There is a combination of single dwelling and multi-unit dwellings (mostly on Pacific Highway) along this route.
Length of route	4	At 2.77 km, the route from the common intersection (Pacific Hwy / George St) to the quarry rim is the fourth shortest of the 5 options being considered.
Ease of getting the VENM from the quarry rim to the quarry base	4.5	There is no existing infrastructure to convey the VENM from the quarry rim to the quarry base at this location. This area of the quarry is described as having a moderate risk of instability (PSM, 2007). There is a significant gradient between the end of Fern Tree Close and the quarry base.
Technical challenges	2.5	The topography and change in height between the end of Fern Tree Close and the quarry base, coupled with the horizontal distance, means that there are a number of technical challenges to be overcome if VENM is to be successfully transported to the base of the quarry.
Road Network Operation	4	A significant length of the access route is on roads not well suited to heavy vehicle transport, and uses access roads through areas of low density housing.
TOTAL SCORE	19	

4.3.4 Option 1J - **Access via Manor Road / Rosamond Street / Carrington Road / Galston Road / Pacific Highway / George Street**

Option 1J provides a transport route from the Pacific Highway to the northwest side of the quarry. From this point, new infrastructure will be required to transport VENM to the quarry base.

OVERVIEW

- Transport of VENM material will occur by road from the southern junction of Pacific Highway and George Street to the quarry along:
  - George Street,
  - Pacific Highway,
  - Galston Road,
  - Carrington Road,
  - Rosamond Street, and
  - Manor Road.
- VENM transport from the quarry rim to the base could be undertaken using either a new road system, which would need to be constructed, or by installing a transfer system to transfer VENM to a new conveyor system.

Table 4.6 Option 1J Scores

Criteria	Scoring / Comments	
Number of dwellings on the route	5	208 dwellings have been determined to lie along the route. This is the greatest number of any of the five options being considered.
Length of route	5	At 3.44 km, the route from Pacific Highway to the quarry rim is the longest of the 5 options being considered.
Ease of getting the VENM from the quarry rim to the quarry base	4.5	There is no existing infrastructure to convey the VENM from the quarry rim to the quarry base at this location. This area of the quarry is described as having a moderate to high risk of instability (PSM, 2007).
Technical challenges	2.5	The topography and change in height between the end of Manor Road and the quarry base, coupled with the horizontal distance, means that there are a number of technical challenges to be overcome if VENM is to be successfully transported to the base of the quarry.
Road Network Operation	5	A significant length of the access route is on roads not well suited to heavy vehicle transport, and uses access roads through areas of low density housing.
TOTAL SCORE	22	

4.3.5 Option 1H - **One-way Loop Access via Two Preferred Route Options**

Option 1H provides a one way transport loop, with vehicles accessing and exiting the quarry at different locations. Based on the assessment above, the one way loop is assumed to combine Options 1B (southern access point) and 1C (the northern access point), which were shown to be the best performing two way options. Infrastructure enabling access at Quarry Road is available, however an egress road will need to be provided at Bridge Road.

OVERVIEW

- Transport of VENM material will occur by road from the southern junction of Pacific Highway and George Street to the quarry along:
  - Pacific Highway,
  - Dural Street,
  - Quarry Road,
  - Internal quarry movement,
  - Bridge Street (new infrastructure), and
  - George Street.
- VENM transport from the quarry rim to the base would be undertaken using a road system part of which is present and part of which would require construction.

Table 4.7 Option 1H Scores

Criteria	Scoring / Comments	
Number of dwellings on the route	2	149 dwellings have been determined to lie along the entry route. 99 dwellings have been determined to lie along the exit route. (Vehicle movements past each dwelling will occur in only one direction, whereas for all other access options considered impact will occur as traffic moves in both directions).
Length of route	2	At 0.96km the route from Pacific Highway to the quarry rim is one of the shortest of the 5 options being considered. (To give a fair comparison with other options, this distance has been calculated as the average of the route lengths of Options 1B and 1C).
Ease of getting the VENM from the quarry rim to the quarry base	3	It will be relatively easy to get VENM to the quarry base from Quarry Road due to the presence of the existing internal haul road. However, there is currently no infrastructure present at Bridge Road to allow the trucks to exit the quarry at this point.
Technical challenges	4	The topography and change in height between the end of Bridge Road and the quarry base, coupled with the horizontal distance, means that there are a number of technical challenges to be overcome if a route for trucks to exit the quarry at this location is to be provided.
Road Network Operation	2	The majority of the route from the Pacific Highway to the quarry rim is on major roads, with key turns generally being made at signal controlled intersections. Options 1B, 1C and 1H were found to perform significantly better than Options 1I and 1J, and have been scored equally for this criterion.
TOTAL SCORE	13	

4.4 SUMMARY OF SCORES

The scores from the evaluation applied to each of the five access route options are summarised in Table 4.8.

Table 4.8 Summary of Scores (Summary Evaluation of Options)

Criteria	Route Option Score*				
	1B	1C	1I	1J	1H
Number of dwellings on the route	3	1	4	5	2
Length of route	1	3	4	5	2
Ease of getting the VENM from the quarry rim to the quarry base	1	2	4.5	4.5	3
Technical challenges	1	5	2.5	2.5	4
Road Network Operation	2	2	4	5	2
TOTAL SCORE	8	13	19	22	13
RANK	1	2	4	5	2

* Best Rated Option = 1, Poorest Rated Option = 5.

It can be seen from Table 4.8 that, based on the multi-criteria analysis undertaken, the preferred option would be Option 1B which proposes access to the quarry from the Pacific Highway via Dural Street and Quarry Road and had the total lowest score of 8.

The next best options were Options 1C and 1H, which both scored 13.

5 CONCLUSIONS

This report has considered a total of 20 potential route access options to fill Hornsby Quarry. Of the 20 options:

- 1 option (Option 3) for filling by air has been determined not to be feasible due to a number of reasons, but primarily the inherent health and safety risks and noise associated with this method of filling.
- 6 options (options 2A-2F) included a significant rail transport component and have therefore been determined not to be feasible for a number of reasons including:
  - The requirement for ancillary infrastructure to be provided including transfer stations and rail sidings, and the fact that no suitable sites could be readily identified for this purpose;
  - The current rail infrastructure at Hornsby does not allow for retrofitting of additional sidings or rail lines to accommodate the VENM transport into Hornsby Railway Station; and
  - Although not discussed within this report, rail transfer of the material is not practical where the VENM will be sourced from multiple locations (noting that the VENM source is not yet known, and this constraint will not apply in all cases), and that transport of VENM over short distances will be more expensive by rail than by road.
- 3 Options (Options 1K-1M) for transport of VENM by road were discounted from more detailed consideration, as they will result in significantly greater disturbance of local residents than other routes.
- 1 Option (Option 1A) was found to be incompatible with the proposed Hornsby Westside Revitalisation Masterplan. This option was therefore not investigated further.
- 4 Options (1D-1G) for transport of VENM by road may warrant further investigation, only if suitable locations for a transfer station can be identified in the vicinity of Bridge Road or Pacific Highway to allow transfer of VENM from road trailers to a local transport system. These options were not assessed in the multi-criteria analysis.
- Following a screening of the options, five options for transport of VENM by road were found to warrant further investigation, and have been the subject of a multi-criteria analysis. These options are:
  - Option 1B: Access via Quarry Road / Fredrick Street / William Street / Pacific Highway.
  - Option 1C: Extension of Bridge Road to facilitate direct access to the quarry. Access via George Street / Bridge Road.
  - Option 1H: One-way loop access via two preferred route options (determined to be Options 1B and 1C).
  - Option 1I: Access via Fern Tree Close / Silvia Street / Carrington Road / Galston Road / Pacific Highway / George Street.
  - Option 1J: Access via Manor Road / Rosamond Street / Carrington Road / Galston Road / Pacific Highway / George Street.

Based on the multi-criteria analysis, it has been determined that Option 1B will have the lowest overall social and environmental impact. This scenario which routes trucks from the Pacific Highway to the quarry via William Street, Fredrick Street and Quarry Road is the shortest of the five routes evaluated by the analysis, and enables existing internal quarry access roads to be used to convey VENM to the quarry base. It receives the best scores for both technical feasibility and operation of the road network.

Despite the Option 1B route being relatively short compared to most other options and the preferred route based on the multi-criteria analysis, it will still pass approximately 149 dwellings, the residents of which are likely to be subject to disruption, noise, minor local air pollution, and some health and safety risks. Cardno therefore recommends that further, more detailed investigations of the impacts associated with this preferred route option be undertaken in order to determine if the level of impact is justified and acceptable prior to the granting of approval to proceed with the quarry filling.

The Council may also consider undertaking more detailed analysis of the access options ranked second and third best (Options 1C and 1H) and/or those options which may be feasible and more environmentally acceptable if sites for associated required additional infrastructure become available.

Table 5.1 provides a summary of the overall assessment outlined in this report and shows for each option considered whether they satisfied the initial screening criteria and, for those that did, the results of the multi-criteria analysis. The table also provides reasons for the exclusion of options from further consideration following the initial screening.

Table 5.1 Overall Summary of Options

		Screening Criteria			
Option ID	Access Option	Residential Dwellings Impacted	Site Availability for Associated Infrastructure	Compatibility with Hornsby Westside Masterplan	Comment
Scenario 1: Transportation of VENM by Road					
1A	Access via Quarry Road / Dural Street / Pacific Highway.				Not compatible with the proposed Hornsby Westside Revitalisation Masterplan.
1B	Access via Quarry Road / Fredrick Street / William Street / Pacific Highway.				The most feasible access option determined through multi-criteria analysis and therefore the preferred access option with a score of 8.
1C	Extension of Bridge Road to facilitate direct access to quarry. Access via George Street / Bridge Road.				A feasible option determined through multi-criteria analysis to be the equal second ranked access option with a score of 13.
1D	Creation of transfer station at the end of existing Bridge Road with tunnel access to quarry.		Further Assessment Required		Potentially feasible but requires further consideration of suitable sites and their feasibility for the construction of infrastructure.
1E	Creation of transfer station at the end of existing Bridge Road with no tunnel access to quarry.		Further Assessment Required		

Option ID	Access Option	Screening Criteria: Residential Dwellings Impacted	Site Availability for Associated Infrastructure	Compatibility with Hornsby Westside Masterplan	Comment
1F	Creation of transfer station from Pacific Highway with tunnel access to quarry.		Further Assessment Required		Potentially feasible but requires further consideration of suitable sites and their feasibility for the construction of infrastructure.
1G	Creation of transfer station from Pacific Highway with no tunnel access to quarry.		Further Assessment Required		
1H	One-way loop access via two preferred route options (determined to be Options 1B and 1C).				A feasible option determined through multi-criteria analysis to be the equal second ranked access option with a score of 13.
1I	Access via Fern Tree Close / Silvia Street / Carrington Road / Galston Road / Pacific Highway / George Street.				A feasible option determined through multi-criteria analysis to be the forth ranked access option with a score of 19.
1J	Access via Manor Road / Rosamond Street / Carrington Road / Galston Road / Pacific Highway / George Street.				A feasible Option determined through multi-criteria analysis to be the fifth ranked (least preferred) access option with a score of 22.
1K	Access via Rosemead Road, Valley Road, Pretoria Parade the Pacific Highway.				In comparison with Options 1A-1E, significantly greater number of dwellings are subject to increased disturbance while little difference with respect to any other constraints.
1L	Access via Rosemead Road / William Street.				In comparison with Options 1A-1E, significantly greater number of dwellings are subject to increased disturbance while little difference with respect to any other constraints.
1M	Access via Benowie Walking Track / Quarter Sessions Road / Duffy Avenue / Pennant Hills Road.				In comparison with Options 1A-1E, significantly greater number of dwellings are subject to increased disturbance while little difference with respect to any other constraints.
Scenario 2: Transportation of VENM by Rail					
2A	Creation of rail spur along Bridge Road from main northern line extending to the quarry.				Not viable due to inability to install required rail infrastructure.
2B	Creation of conveyor along Bridge Road from main northern line extending to the quarry.				Not viable due to inability to install required rail infrastructure.

		Screening Criteria			
Option ID	Access Option	Residential Dwellings Impacted	Site Availability for Associated Infrastructure	Compatibility with Hornsby Westside Masterplan	Comment
2C	Creation of a tunnel from the existing rail line, with a transfer station at the tunnel entrance and a conveyor running through the tunnel.				Not viable due to inability to install required rail infrastructure.
2D	Creation of a tunnel from the existing rail line, with direct train access to the quarry through the tunnel.				Not viable due to inability to install required rail infrastructure.
2E	Creation of a tunnel from the existing rail line, with direct truck access to the quarry through the tunnel.				Not viable due to inability to install required rail infrastructure.
2F	Truck access to the quarry from the northern rail line utilising preferred Option 2 route.				Not viable due to inability to install required rail infrastructure.
Option 3: Transportation of VENM by Air					
3	Transport of VENM by helicopter from the material source direct to the quarry pit.				Significant health and safety risk due to close proximity of Hornsby town centre and other areas of habitation.

Key

	Satisfied constraint
	Did not satisfy constraint or further assessment required

6 RECOMMENDATIONS

Based on a multi-criteria analysis, it has been determined that Option 1B is likely to have the least overall environmental and social impact.

Option 1B – comprising access via William Street, Fredrick Street and Quarry Road from Pacific Highway – is therefore considered to be the preferred option.

It is noted however, that the preferred option still passes 149 dwellings, the residents of which are likely to be subject to disruption, noise, minor local air pollution, and additional health and safety risks. Cardno therefore recommends that further more detailed investigations of the impacts associated with this preferred route option are undertaken in order to determine if the level of impact is justified and acceptable prior to the granting of approval to proceed with the quarry filling.

Such an assessment should include a consideration of the following factors:

1. Environment,
2. Heritage,
3. Safety and risk,
4. Traffic,
5. Noise,
6. Costs / Economics (to determine if the stated objective of cost neutrality can be achieved),
7. Logistical constraints, and
8. Project lifetime.

This report also notes that Option 1C was the second ranking stand-alone access option (second to Option 1H, which is the combination of 1B and 1C). This access option (involving the extension of Bridge Road to facilitate direct access to the quarry) scored well with respect to most criteria, but scored poorly (fifth of five) with respect to technical challenges. These challenges should be further explored through detailed design should Option 1B not prove suitable as a result of more detailed investigations of impacts.

7 REFERENCES

ARTC (2008), *New research shows rail is cheaper than trucks*, Media Release, Accessed at http://www.artc.com.au/library/news_140508.pdf.

BITRE (2009), *Information Sheet 34: Road and rail freight: competitors or complements?* Department of Transport, Infrastructure, Regional Development and Local Government: Bureau of Transport, Infrastructure and Regional Economics.

Cardno (2011), Paramics Modelling Documentation Draft Report, Prepared for Hornsby Shire Council.

DECCW (2008), *Waste Classification Guidelines Part 1: Classifying Waste*, Department of Environment Climate Change and Water (NSW).

DEC (1996), *Landfill Waste Classification and Waste Definitions 1996* (As amended December 2009), Department of Environment and Conservation (WA).

Hornsby Shire Council (2008), *Hornsby Westside Revitalisation Proposed Masterplan Plan and Stage 1 – Coronation Street Upgrade*, Executive Manager's Report No. WK54/08.

Parsons Brinckerhoff (2005), *Hornsby Platform 5 and Stabling Project Summary: Review of Environmental Factors*, Prepared for Department of Transport Infrastructure: Development Corporation.

PSM (2007), *Geotechnical and hydrogeological constraints relevant to the land use options within Hornsby Quarry*, Pells Sullivan Meynink Pty Ltd. Prepared for Hornsby Shire Council.

Rawlinsons (2011) *Australia's Construction Handbook: 2011*, Edition 29, Rawlhouse Publishing, Sydney.

Appendix A

Assessment of Number of Residential Dwellings Impacted

This appendix provides an assessment of the number of residential dwellings which will be affected along each identified route option should the works proceed. The assessment is based on data provided by Council, which was modified by Cardno following analysis and review of the data provided. It is important to note that the analysis was undertaken for the number of 'dwellings' rather than number of 'lots', reflecting the fact that multiple dwellings can be present on a single lot.

Dwelling data provided by Council, consisted of all addresses which have street addresses on the route options and addresses thought to be adjacent to the route options. The addresses consisted of parent addresses and any strata addresses of each parent address. Strata addresses occur when there is more than one dwelling on a lot of land. For example, the parent address on a lot of land can be an apartment block and its strata addresses are for each individual apartment.

Council data was reviewed by Cardno using available aerials, cadastre and street imagery as references. Council data was refined as follows:

1. Council data was checked for duplicate addresses. Duplicates were removed from data.
2. Additional dwellings which were found to be present by Cardno, but which were not listed in the Council data were added to the dwelling count.
3. Cross checking addresses provided by Council with local maps, identified addresses which were not directly adjacent to the route (for example they were set well back from the road, or were shielded by other structures from the expected impacts). These dwellings were discounted as addresses affected.
4. It was noted that due to the layout and street naming convention of the local road network, some dwellings were affected, even though their street address was on a road which was not part of the route option being considered. Such dwellings were added by Cardno to the affected dwelling count.

The following table identifies the number of dwellings which Cardno identified as being affected on each of the route options considered in this study.

Option	Total Number of Residential Dwellings Affected	Route Description	Route Section	Residential Dwellings affected on Route Section	Issues and Resolutions
1A	131	Access via Quarry Road / Dural Street / Pacific Highway	Dural	110	
			Quarry Road	21	
1B	149	Access via Quarry Road / Fredrick Street / William Street / Pacific Highway.	William Street	101	Frederick Street 1A was missing from Council data. This address is an apartment block and will affect the number of dwellings significantly if omitted. Using available street imagery, Cardno estimated 12 additional street facing dwellings.
			Frederick Street	27	
			Quarry Road	21	
1C	99	Extension of Bridge Road to facilitate direct access to quarry. Access via George Street / Bridge Road.	Bridge Road	99	
1D	104	Creation of transfer station at the end of existing bridge street w/ tunnel access to quarry	Bridge Road	104	75-79 Jersey Street North (9 Bridge Road) is a relatively large lot, however, using available street imagery it was estimated that there are only 12 dwellings directly adjacent Bridge Road. The majority of 67-71 Jersey Street (2a Bridge Rd) is located behind another lot. The street front on Bridge road is a pool according to available street imagery. This address was not included in dwelling count.
1I	157	Access via Fern Tree Close / Silvia Street / Carrington Road / Galston Road / George Street / Pacific Highway	Pacific Highway	81	
			Galston Road	1	
			Carrington Road	4	
			Silvia Street	48	
			Fern Tree Close	23	
1J	208	Access via Manor Road / Rosamond Street / Carrington Road / Galston Road / George Street / Pacific Highway.	Pacific Highway	81	
			Galston Road	1	
			Carrington Road	28	
			Rosamond Street	21	
			Manor Road	77	

Option	Total Number of Residential Dwellings Affected	Route Description	Route Section	Residential Dwellings affected on Route Section	Issues and Resolutions
1K	227	Access via Rosemead Road / Valley Road / Pretoria Parade the Pacific Highway.	Rosemead Road	19	
			Valley Road	37	
			Pretoria Parade	171	
1L	226	Access via Rosemead Road / William Street	William Street	150	
			Rosemead Street	76	
1M	287	Access via Benowie Walking Track / Quarter Sessions Road / Duffy Avenue / Pennant Hills Road.	Duffy Avenue	125	1 Settlers Way and 38 Quarter Sessions Road, both adjacent to Quarter Sessions Road are not included in data from Council - street imagery shows one residential house for both these addresses. These two dwellings have been included in the dwelling count.
			Quarter Sessions Road	162	