Quarry Hills PSP

CITY OF WHITTLESEA

Transport Modelling Report

Revision A

25 August 2014

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Quarry Hills PSP

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Project manager:	Craig McPherson
Author:	Naomi Langdon and Trent Ekanayake
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Jacobs Group (Australia) Pty Limited
ABN 37 001 024 095
Floor 11, 452 Flinders Street
Melbourne VIC 3000
PO Box 312, Flinders Lane
T +61 3 8668 3000
F +61 3 8668 3001
www.jacobs.com

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The sole purpose of this report and the associated services performed by Jacobs is to estimate future road network requirements for the Quarry Hills Precinct Structure Plan in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

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1. Introduction

The City of Whittlesea, in partnership with the GAA, is managing the production of the Quarry Hills Precinct Structure Plan (PSP 1094). Located in the Northern Growth Corridor, about 25 kilometres north of Melbourne's CBD, the Quarry Hills area has considerable development potential with access to strategic transport links such as the M80 Ring Road and the Hume Freeway. Ultimately this 285 hectare site is expected to be transformed into a new community of around 6,500 people.

The Quarry Hills site is one of a number of proposed precincts located in the Northern Growth Corridor for which structure planning, including understanding the transport requirements, is currently underway. In 2012 Jacobs[1] developed the Northern Growth Corridor transport model for GAA. This model is a refinement of the Victorian Integrated Transport Model (VITM) and is presently assisting future planning in Hume, Whittlesea and Mitchell (Wallan).

This report describes the assumptions used in the strategic transport modelling process and provides traffic and public transport forecasts for several land use and infrastructure scenarios in 2026 and 2046. Estimated traffic volumes have been applied in a more detailed analysis of several key intersections in the PSP, which has identified the likely future intersection configurations needed to accommodate future traffic demand.

1.1 Glossary

The following terms and acronyms have been used in this report:

AM Peak: The AM peak represents the weekday period from 7:00am to 9:00am

Number of lanes: The quoted number of lanes on a link generally refers to the total number of lanes in both directions. A two-lane two-way road therefore has a single lane in each direction.

PM Peak: The PM peak represents the weekday period from 3:00pm to 6:00pm.

Select-link analysis: A method of analysing traffic movements by showing only the routes of trips that pass through a nominated link. A select-link analysis effectively shows the traffic catchment area for a given link.

V/C ratio: Volume-capacity ratio. This is the ratio of the traffic volume to the theoretical capacity of the road. A value close to 0.8 indicates the road is congested and the traffic on that road is expected to suffer significant delays. Technically, values greater than 1.0 should not be permitted, however if no other suitable routes are available, the transport model will still allocate traffic to congested roads, resulting in V/C ratios greater than 1.0.

veh/day: vehicles per day using a particular road link, reported as two-way volumes unless otherwise noted.

Acronyms

- COW – City of Whittlesea
- DTPLI – Department of Transport, Planning and Local Infrastructure
- MPA – Metropolitan Planning Authority
- NGC – Northern Growth Corridor
- OMR – Outer Metropolitan Ring Road
- PSP – Precinct Structure Plan
- PTV – Public Transport Victoria
- VIF – Victoria in Future population forecasts
- VITM – Victorian Integrated Transport Model

[1] Jacobs was formerly known as Sinclair Knight Merz (SKM), and earlier reports have been published under the SKM name.

2. Transport Model Development

2.1 Background

In 2012 Jacobs developed the Northern Growth Corridor (NGC[2]) transport model for the Metropolitan Planning Authority (MPA). The model is based on the Victorian Integrated Transport Model (VITM), which covers the entire Melbourne metropolitan area, including the NGC.

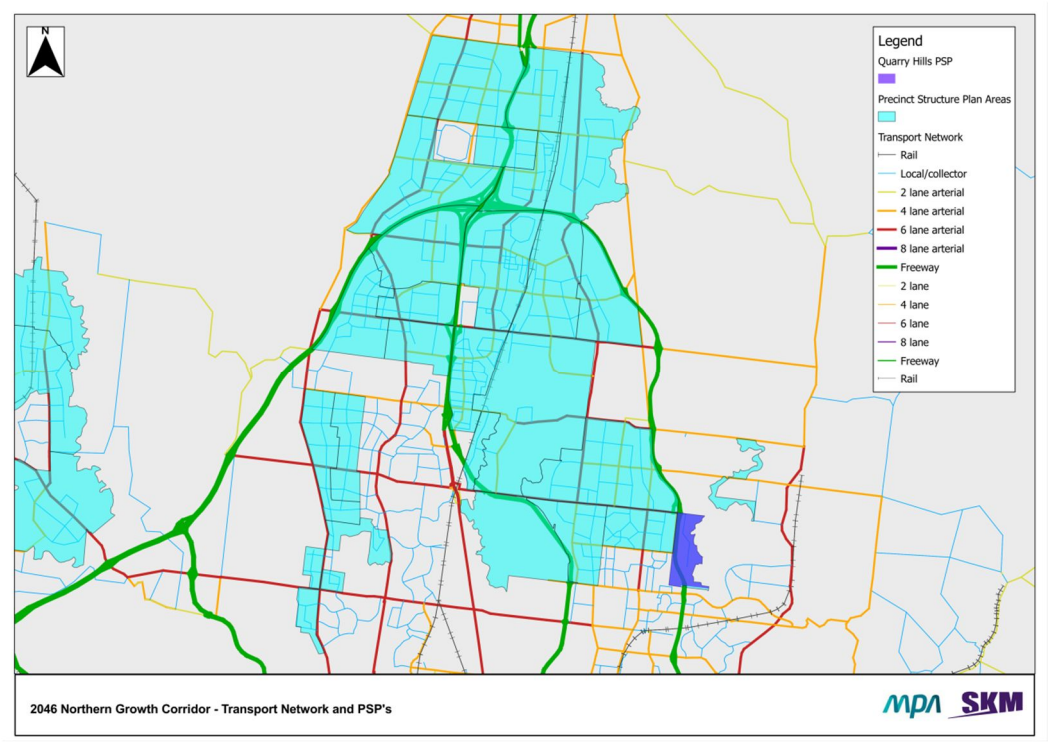
The NGC version of the VITM model includes greater detail in the municipalities of Hume, Whittlesea and parts of Mitchell Shire. The purpose of the model is to provide a tool for investigating the impacts of land use development on transport infrastructure and to test transport infrastructure options to serve forecast future demand.

The NGC model includes land use and transport network assumptions for two reference case years: **2026**, representing an interim build-out scenario, and **2046**, representing the ultimate build-out of the growth areas.

2.2 Base Model

The version of the model used for the Quarry Hills PSP study represents the most up to date version of the NGC model at the time of writing. This version of the model includes additional detail around the Craigieburn North and English Street PSPs (collectively PSP 25), which was undertaken in mid-2013 by Jacobs. The extent of the NGC is shown in Figure 2.1.

Figure 2.1: 2046 Northern Growth Corridor Base Model



Several updates were made to the base version of the 2046 model to make it suitable for modelling the Quarry Hills PSP. The updates included refining the land use zoning system, incorporating the latest land use estimates and improving the detail of the transport network. These updates are described in further detail below.

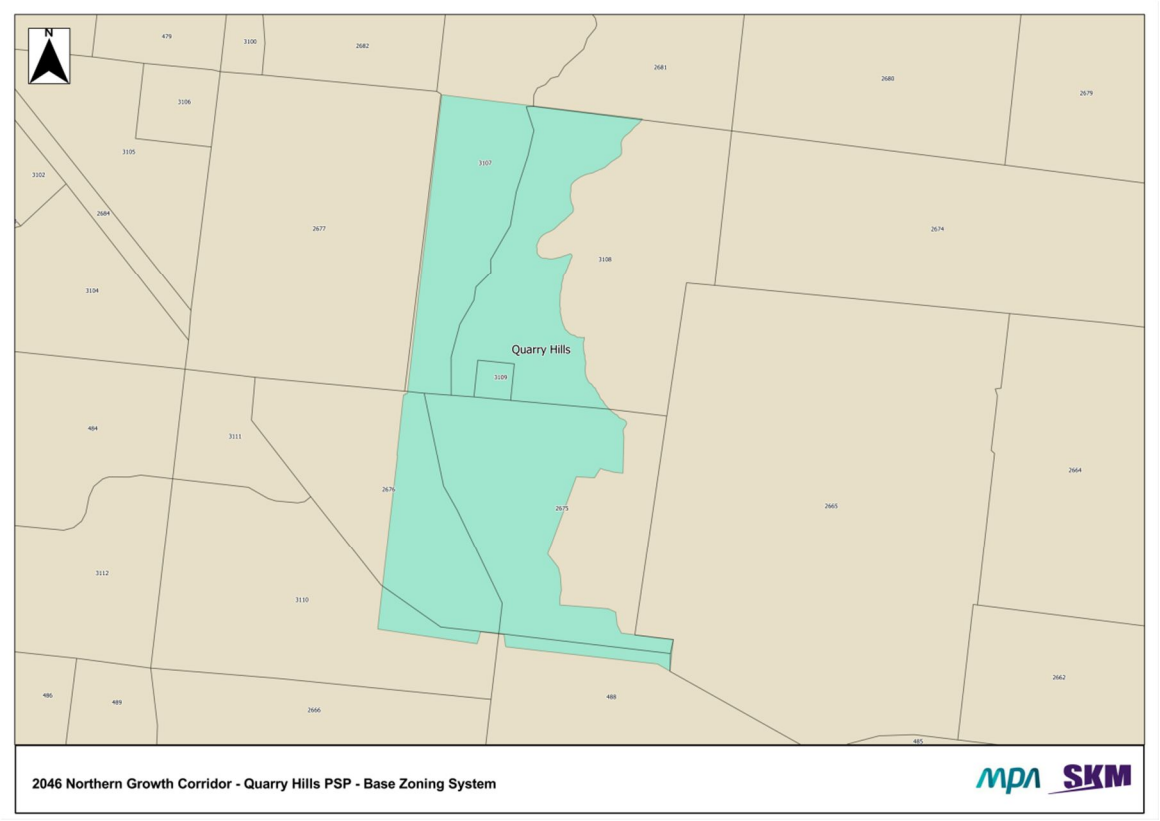
[2] The model is based on the Department of Transport's Victorian Integrated Transport Model (VITM). Further information on the validation of the model can found in a separate report titled "*Northern Growth Corridor Transport Model Validation – Final Report*" and details of the 2046 model updates and inputs in "*Northern Growth Corridor – 2046 Strategic Transport Model*".

2.3 Zoning System

The existing system of land use zones in the Quarry Hills PSP area was sparse, with portions of five zones collectively representing the entire Quarry Hills PSP as shown in Figure 2.2. This coarse representation of land use was considered to be insufficient to model the transport impacts of Quarry Hills in sufficient detail.

In addition, the Eucalypt Estate to the West of Quarry Hills was represented by only one zone. Since the Eucalypt Estate has direct connecting roads to Quarry Hills, this area was also updated to allow a more detailed representation of traffic through this area.

Figure 2.2: 2046 Northern Growth Corridor base model – old zoning system

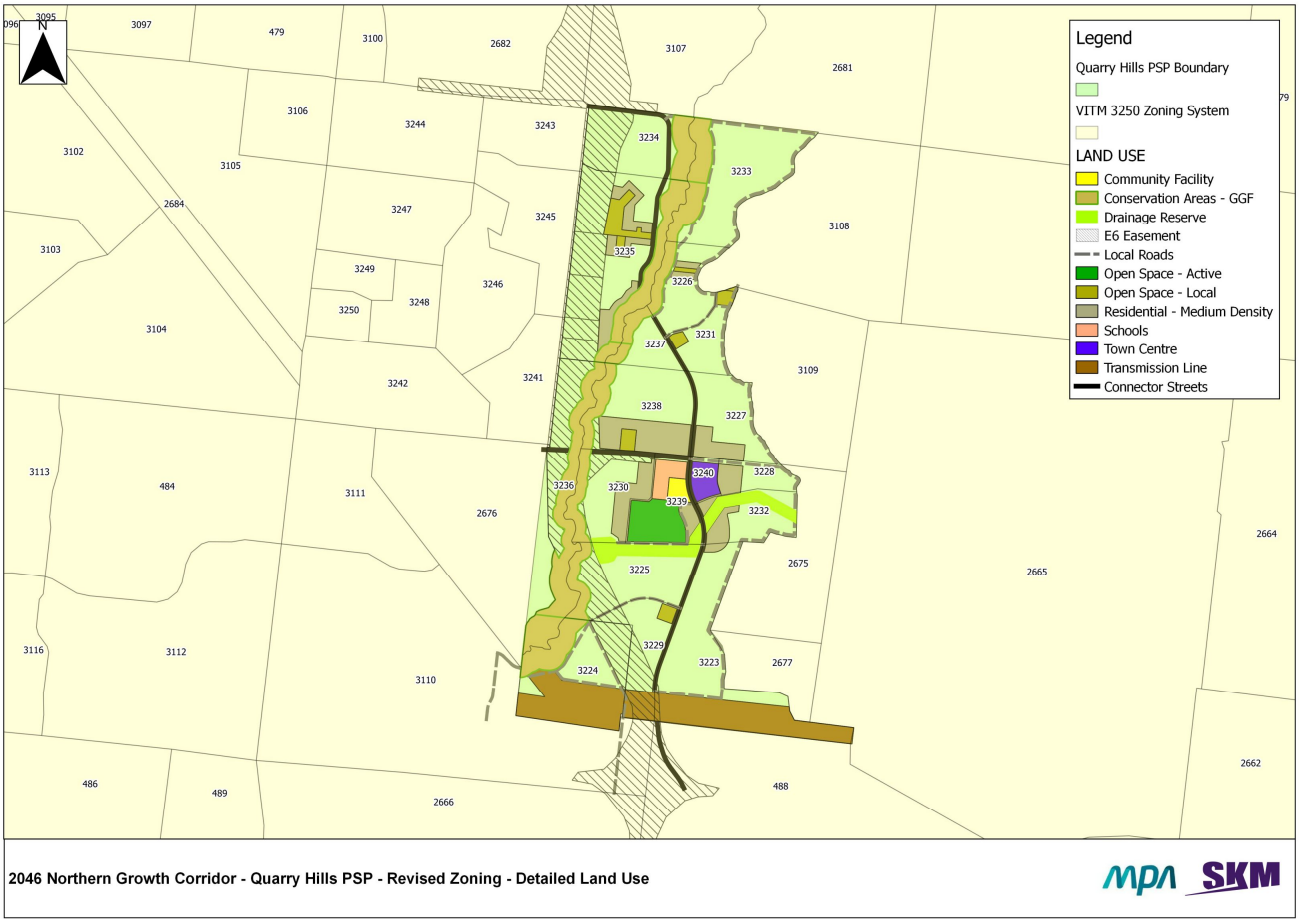


To provide better detail in the Quarry Hills and Eucalypt Estate areas, the zones were disaggregated into more detailed areas to better represent the different types of land use and their spatial distribution. The finer zoning system enables the model to adopt a more detailed road network and estimate traffic volumes more accurately.

Travel into and out of each zone is allocated to a link called a **centroid connector**. The centroid connector feeds travel that is assumed to originate from the centroid of a zone to adjacent links on the road network. In effect, the centroid connectors are an abstraction of the detailed local street network within a zone. In choosing the locations of centroid connectors, it is important that the links from each zone centroid are made to appropriate places on the surrounding road network, as the connectors effectively act as the “sources” and “sinks” of traffic.

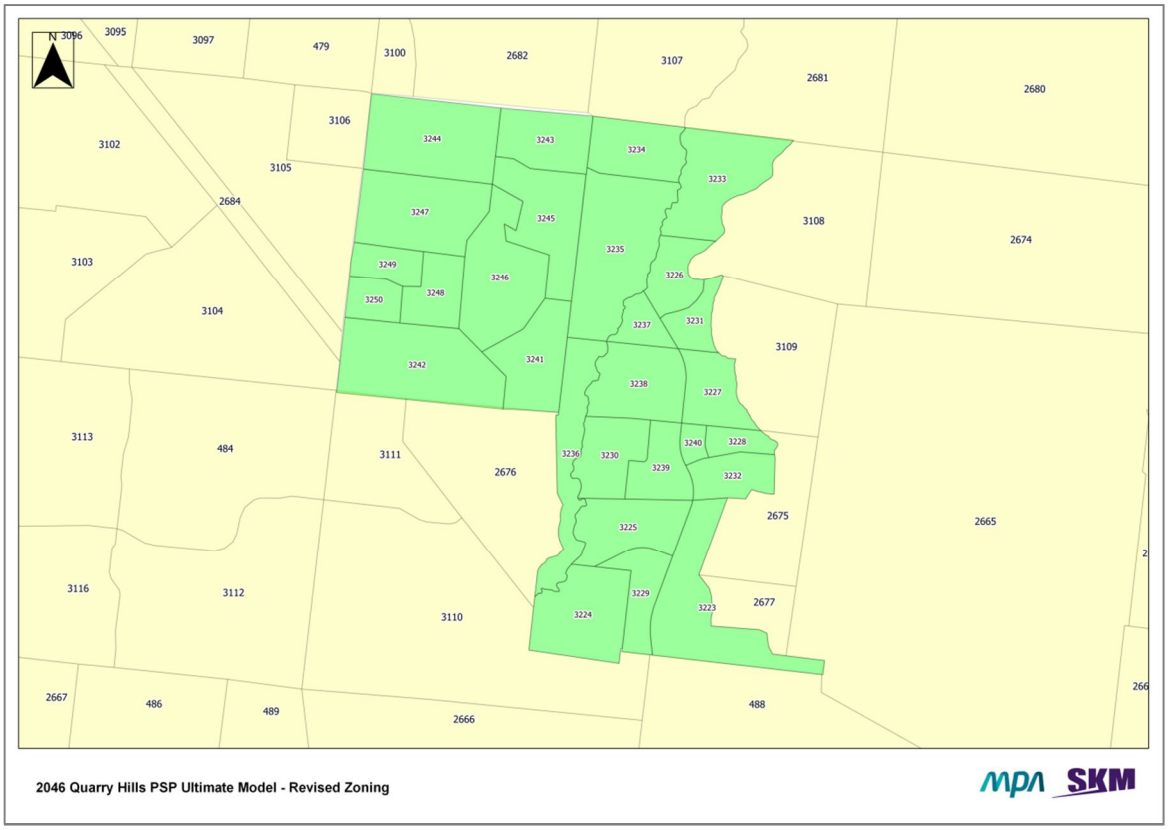
A systematic process of land use categorisation was used to disaggregate zones in Quarry Hills and the Eucalypt Estate. This ensured that zones were disaggregated in a logical manner and reflected particular types of land use such as residential areas, commercial areas and community centres. The revised zoning system was also designed to align with the proposed lot boundaries for Quarry Hills provided by the City of Whittlesea. The primary land uses proposed for the Quarry Hills area are shown in Figure 2.3.

Figure 2.3: Quarry Hills proposed land uses



The revision to the zoning system resulted in 18 zones for the Quarry Hills area and a further 10 zones for the Eucalypt Estate as shown in Figure 2.4. The zones were numbered from 3223 to 3250 in the model, with the zones adjusted to align with the PSP boundary. Separate zones were allocated to the school and retail town centre.

Figure 2.4: Final disaggregated zoning system



2.4 Land Use

The land use inputs to the model comprise demographic information for each zone. These include information on the number of households, population by age group, household structure (number of dependants), number of jobs and educational enrolments for each zone. The old demographic information for Quarry Hills (prior to update) is summarised in Table 1.

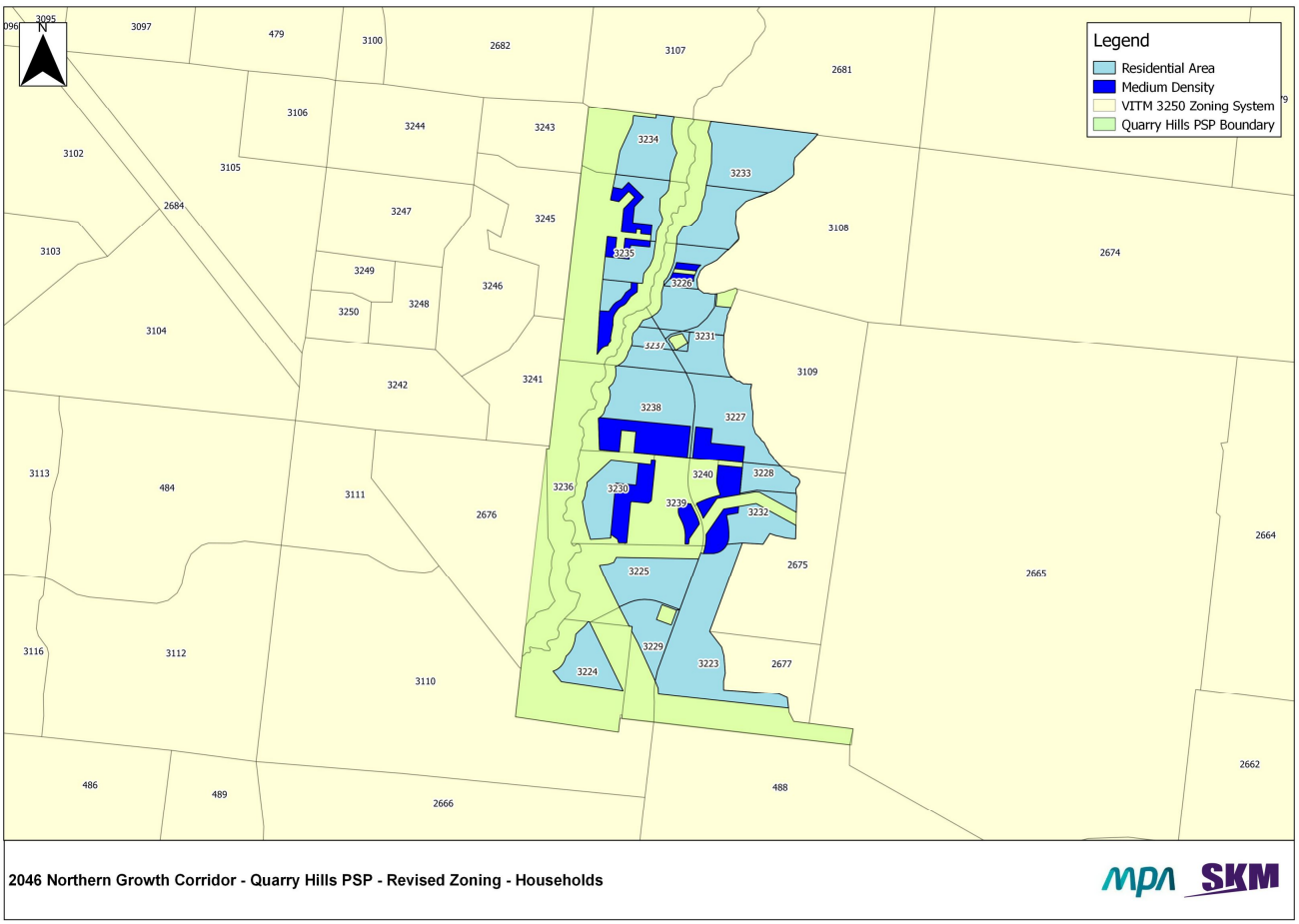
Table 1: 2046 Northern Growth Corridor Model – old demographic information for Quarry Hills

Zone	Population	Households	Employment		Enrolment		
			Retail	Total	Primary	Secondary	Tertiary
2675	2,947	1,081	0	148	450	0	0
3107	898	329	0	33	0	0	0
3108	2,631	965	0	97	0	0	0
3109	0	0	267	267	0	0	0

2.4.1 Households

Two types of residential dwellings are proposed for Quarry Hills. These consist of conventional density dwellings (14 dwellings/hectare) and medium density dwellings (25 dwellings/hectare). The distribution of both types of dwellings is shown in Figure 2.5.

Figure 2.5: Quarry Hills PSP residential distribution by type



Estimates of the number of dwellings for each lot were provided by the City of Whittlesea and are given in Table 2. A total of 2,404 dwellings are proposed for Quarry Hills comprising 76% conventional density dwellings and 24% medium density dwellings.

Table 2: Dwellings per Lot

Lot Number	Conventional Density Dwellings	Medium Density Dwellings
1	268	0
2	140	47
3	79	44
4	112	24
5	30	15
6	91	4
7	273	221
8	751	219
9	86	0
Total	**1830**	**574**

Using the areas of each revised zone, the dwellings for each zone were calculated. The results of this are given in Table 3, with each type of dwelling and the total households for each of the zones.

Table 3: Dwellings per revised zone

Zone Number	Conventional Density Dwellings	Medium Density Dwellings	Total Households
3223	299	10	309
3224	86	0	86
3225	140	0	140
3226	111	16	127
3227	135	66	201
3228	53	43	96
3229	81	0	81
3230	90	107	197
3231	82	0	82
3232	88	25	113
3233	186	0	186
3234	173	0	173
3235	107	118	225
3236	0	0	0
3237	61	0	61
3238	138	155	293
3239	0	31	31
3240	0	3	3
Total	**1830**	**574**	**2404**

The land use forecasts for the Eucalypt Estate were developed from the total number of households in the estate that were present in the existing VITM NGC model. This total number was then apportioned into zones based on the number of lots in each of the new zones. For the northern section of the model, detailed maps with lot outlines were provided, so households within each zone could be counted. For the remainder of the area, the remaining unallocated households were split into zones based on the developable land area.

Table 4: Household numbers for Eucalypt Estate

Zone Number	Total Households
3241	204
3242	346
3243	242
3244	250
3245	143

Zone Number	Total Households
3246	372
3247	234
3248	0
3249	72
3250	68

2.4.2 Population

The population was estimated for each zone within Quarry Hills and the Eucalypt Estate based on the number of households in the zone. This was further revised to incorporate different types of dwellings, by using different factors for the number of people per household for both types of dwellings. The factors used are given in Table 5.

Table 5: Residents per household assumed for each dwelling type

Dwelling Type	Residents per Household
Conventional Density	2.80
Medium Density	2.79

Using these factors and the number of households for each zone, estimates of the forecast population per zone were made. A total population of 6,723 was forecast for Quarry Hills and 5,413 for the Eucalypt Estate. The assumed population per zone is given in Table 6 and Table 7.

Table 6: Assumed population for Quarry Hills zones

Zone Number	Population
3223	866
3224	241
3225	392
3226	355
3227	563
3228	268
3229	227
3230	550
3231	230
3232	315
3233	520
3234	483
3235	628
3236	0
3237	172
3238	817
3239	87
3240	7
Total	**6,723**

Table 7: Assumed population for Eucalypt Estate zones

Zone Number	Population
3241	571
3242	970
3243	678
3244	700
3245	400
3246	1,043
3247	656
3248	0
3249	203
3250	192
Total	**5,413**

In addition to the total population of each zone, the strategic modelling requires the population to be split into age groups and family structure (number of dependants).

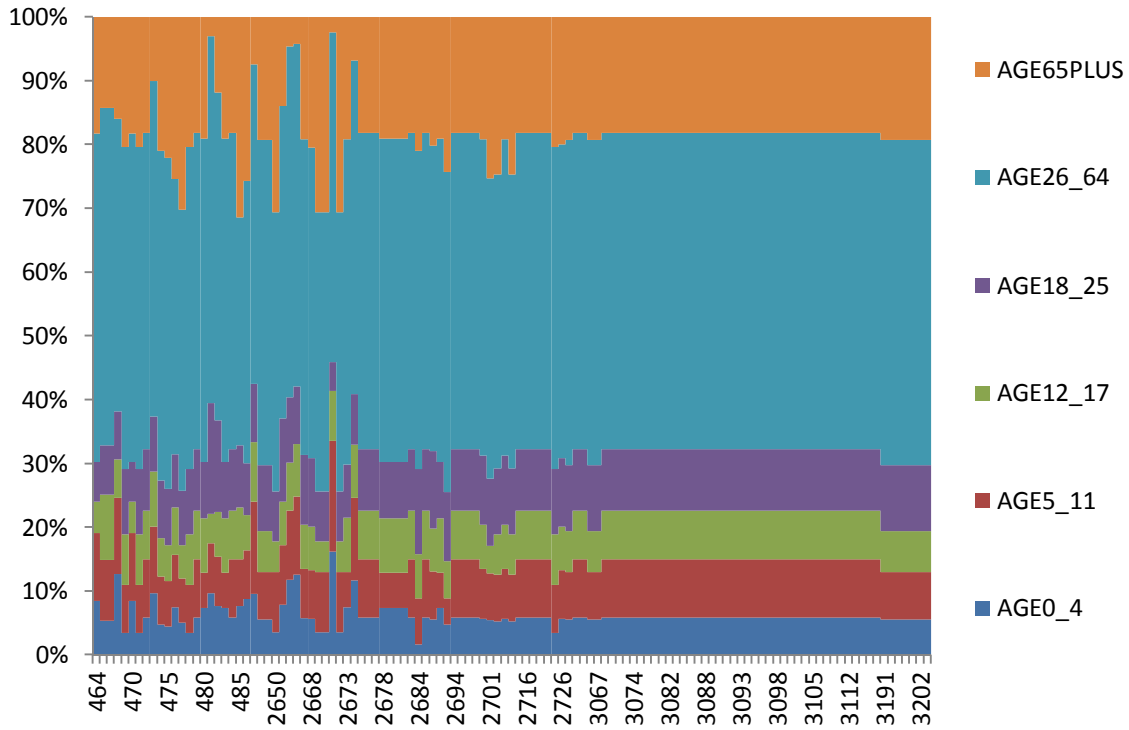
2.4.2.1 Age Group Split

Six age groups are modelled in VITM to reflect the distinctive trip-making patterns at different stages in a typical lifetime:

- 0 – 4 years old
- 5 – 11 years old
- 12 – 17 years old
- 18 – 25 years old
- 26 – 64 years old
- 65 years plus

To estimate the proportions of each age group in Quarry Hills and the Eucalypt Estate, the future age group split assumed in the five former zones representing Quarry Hills was examined. In addition, the proportional split of age groups was assessed for the entire municipality. Figure 2.6 shows the proportions of each age group for each of the zones in Whittlesea. This indicates that the proportional splits within each zone are generally consistent across the municipality, with the exception of a few zones containing larger numbers of the 65+ age group. These zones typically correspond to zones containing retirement villages.

Figure 2.6: Age group stacked proportional splits for all zones in Whittlesea



The analysis produced the following age group proportional splits as given in Table 8.

Table 8: Age group proportional splits for old Quarry Hills zones and the entire City of Whittlesea

Age Group	Existing Quarry Hills	City of Whittlesea
0 - 4	6%	7%
5 - 11	9%	9%
12 - 17	8%	7%
18 - 25	10%	9%
26 - 64	50%	49%
65 +	18%	18%

Given the negligible differences between the proportions, the proportional splits for the City of Whittlesea were adopted for the new Quarry Hills. Table 9 summarises the assumed number of people in each age group for Quarry Hills.

Table 9: Population in Quarry Hills by Age Group

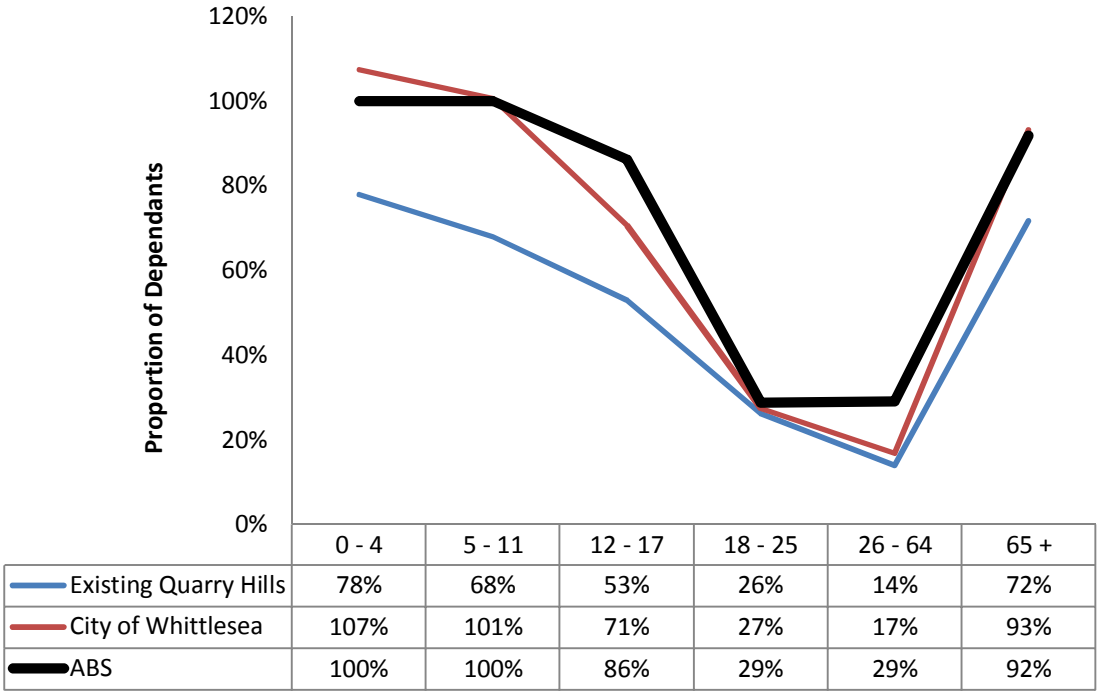
Age Group	Population
0 - 4	443
5 - 11	612
12 - 17	493
18 - 25	639
26 - 64	3327
65 +	1210

2.4.2.2 Household Structure

The model also takes into account the number of dependants (i.e. non-working family members) in each household. This attribute is split by the six aforementioned age groups.

A similar analysis was conducted for each of these groups for the Quarry Hills zones and the City of Whittlesea as a whole, examining the proportion of dependants in each age group. Data was also sourced from the Australian Bureau of Statistics (ABS) 2011 Census for the Hume, Mitchell and Whittlesea areas for the purposes of comparison. The results are presented in Figure 2.7.

Figure 2.7: Proportion of dependants by age group



The ABS and Whittlesea profiles are fairly similar, and the ABS profile was adopted for the model, consistent with other similar projects undertaken with the Northern Growth Corridor Model.

2.4.3 Employment

Employment figures for the Quarry Hills precinct were estimated for three categories of employment. These were retail employment, school employment and general household employment. Household employment refers to the small proportion of employment undertaken from home businesses and as such is a very small proportion. The figures in Table 10 supplied by MPA were used to calculate employment for each zone.

Table 10: Employment generation rates

Category	Employment Generation Rate
Household	1 job per 10 households
Retail	40 jobs per 1000m^2 in the town centre (zone 3240)
Primary School (Government)	40 jobs (based on a 450-student school)
Community Centre	5 retail jobs

Using the number of households and retail area in the town centre (zone 3240), the estimated employment for each zone was calculated for Quarry Hills (see Table 11).

Table 11: Employment assumptions for Quarry Hills

Zone Number	Household Employment	Retail Employment	School Employment
3223	31	0	0
3224	9	0	0
3225	14	0	0
3226	13	0	0
3227	20	0	0
3228	10	0	0
3229	8	0	0
3230	20	0	0
3231	8	0	0
3232	11	0	0
3233	19	0	0
3234	17	0	0
3235	22	0	0
3236	0	0	0
3237	6	0	0
3238	29	0	0
3239	3	5	40
3240	0	844	0
Sub-total	**240**	**849**	**40**
TOTAL	**1,129**		

As for the population and households, the overall number of employees in the Eucalypt Estate was maintained at the level in the original Northern Growth Corridor Model, with the jobs distributed among the disaggregated zones. No retail centre is planned for the Eucalypt Estate. A single primary school containing 450 students and 40 staff was placed in zone 3248, with the remainder of the local employment distributed through the estate. The final employment estimates for Eucalypt Estate are given in Table 12.

Table 12: Employment assumptions for Eucalypt Estate

Zone Number	Household Employment	Retail Employment	School Employment
3241	26	0	0
3242	44	0	0
3243	30	0	0
3244	31	0	0
3245	18	0	0
3246	47	0	0
3247	29	0	0
3248	0	0	40
3249	9	0	0
3250	9	0	0
Sub-total	**243**	**0**	**40**
TOTAL	**283**		

2.4.4 Education

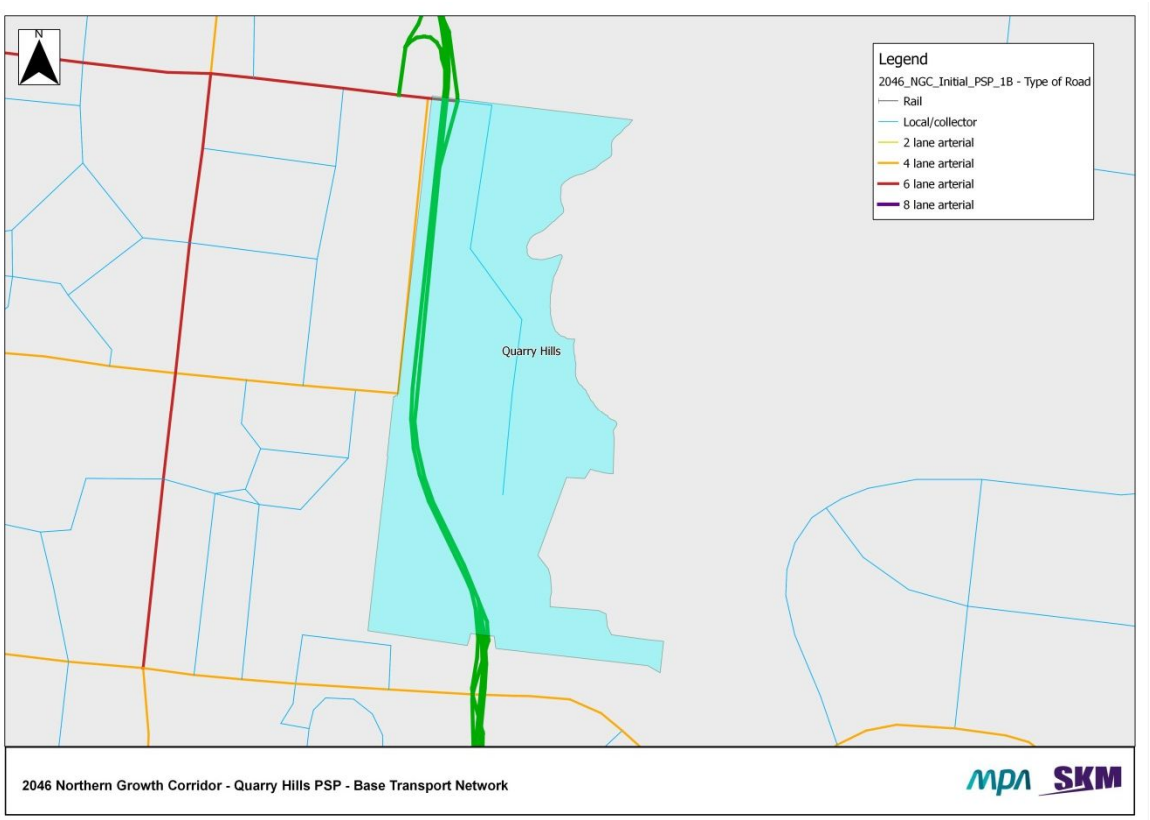
A government primary school is proposed as the only educational institution within Quarry Hills. This school is to be located in zone 3239 and anticipated to have an enrolment of 450 students. In the Eucalypt Estate, a single primary school containing 450 was placed in zone 3248.

2.5 Transport Network

2.5.1 Road Network

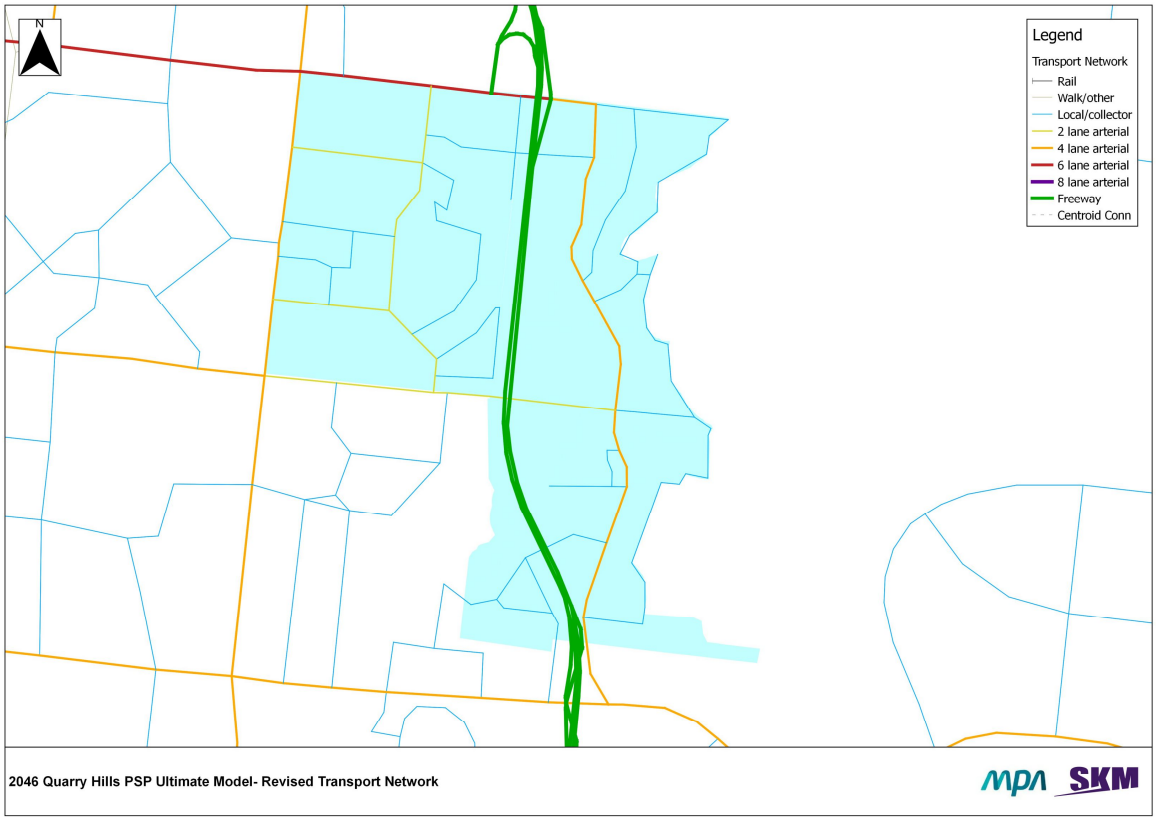
The road network within the Quarry Hills PSP in the old 2046 Northern Growth Corridor Base Model is virtually non-existent, with one single lane road running longitudinally though the PSP as shown in Figure 2.8.

Figure 2.8: Road network in the old 2046 Northern Growth Corridor Model



In order to model the PSP with a greater degree of accuracy, including conducting SIDRA analyses, a revised road network was coded. This network includes a major north south connector running through Quarry Hills, as well as an east west connector linking from the new connector towards the west into the existing arterial and its residential development. A number of local roads are also provided giving internal accessibility to the inner areas of the PSP and around the borders of Quarry Hills. This revised network is shown in Figure 2.9.

Figure 2.9: Revised road network in the 2046 Quarry Hills model

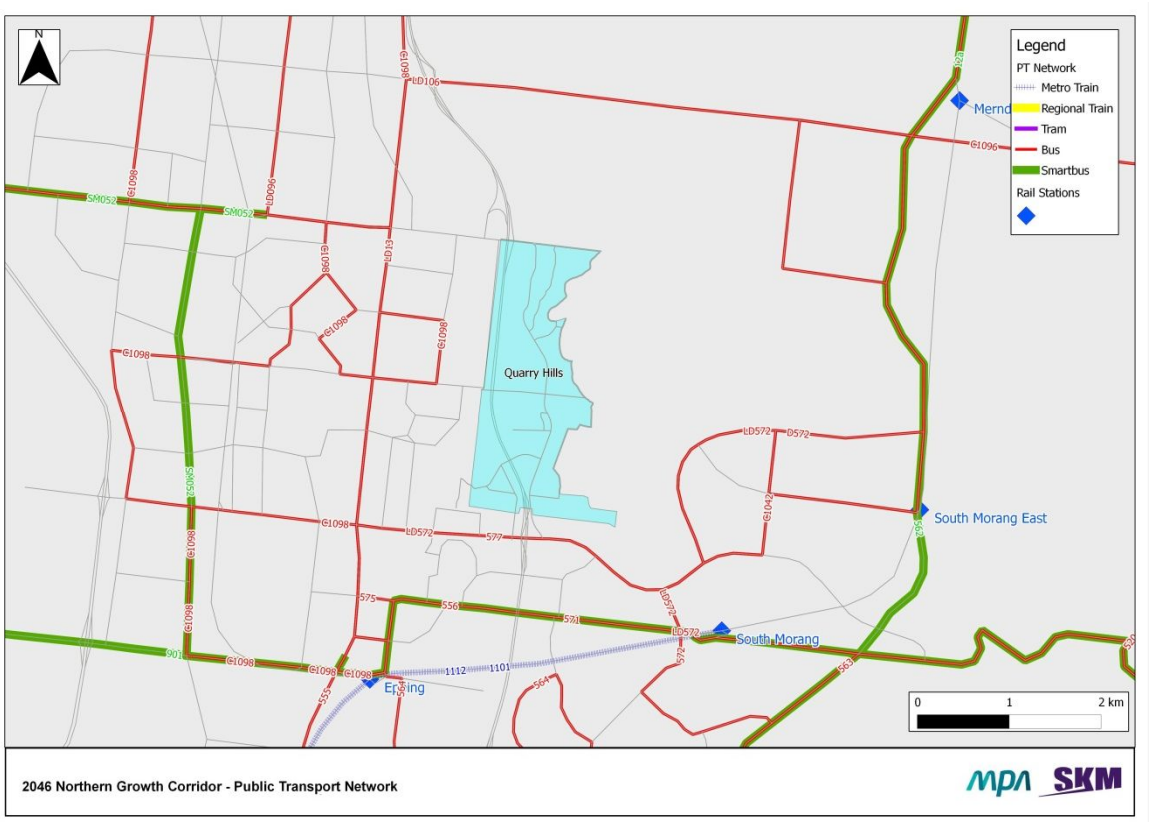


The major connectors are assumed to have two lanes in each direction and have a speed limit of 60 km/h, whilst the local roads will be one lane in each direction and have a speed limit of 50 km/h. Local access roads are not usually modelled in VITM due to the broad-brush nature of strategic modelling; these are approximated by centroid connectors.

2.5.2 Public Transport Network

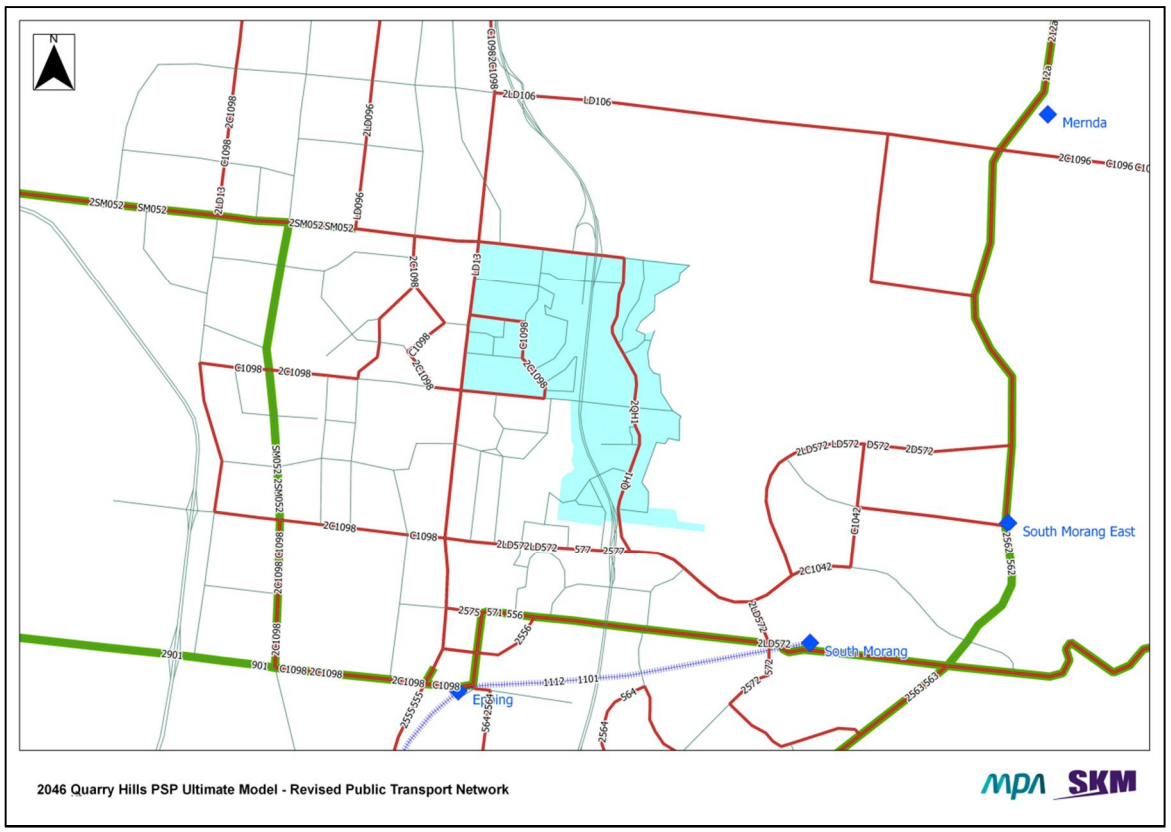
The current public transport network in the Northern Growth Corridor Model does not include any internal public transport routes within Quarry Hills, as shown in Figure 2.10. A number of bus routes do circumnavigate the precinct, with a number of rail stations including Epping and South Morang also in close proximity.

Figure 2.10: Public transport network in the old 2046 Northern Growth Corridor Model



With the further development of the internal road network in Eucalyptus Estate, rerouting of the buses within the estate was undertaken to ensure they followed the new road network. In addition to this, another bus route (QH1) was included in the Quarry Hills precinct that traverses the entire length of the major north-south connector street and provides for access to South Morang station to the south, as well as other bus services to the north and west. This service is a bidirectional service operating with a 30-minute headway.

Figure 2.11: Revised public transport network in the 2046 Quarry Hills model



2.6 2026 Model Updates

2.6.1 Base Model

The 2026 modelling was again based on the Northern Growth Corridor Model, incorporating up to and including the Craigieburn and English Street PSP work (collectively PSP 25), which was undertaken in mid-2013 by SKM. During this work a 2026 scenario was developed.

2.6.2 Zoning System

The disaggregated zoning system adopted for the 2046 modelling (see Section 2.3) was applied to the base 2026 model.

2.6.3 Land use

Outside of the Quarry Hills and Eucalypt Estate areas, the land use remained as per the 2026 Northern Growth Corridor. Within the study area, the following was assumed:

- **Eucalypt Estate:** Assume fully developed in 2026, so adopt land use from 2046.
- **Quarry Hills Town Centre:** Assume 50% of 2046 build out
- **Quarry Hills School:** Assume at 70% of 2046 capacity for students and employees
- **Quarry Hills Residential Development:** Assume at 80% of 2046 build out across the entire PSP

Figure 2.12 : 2026 Population

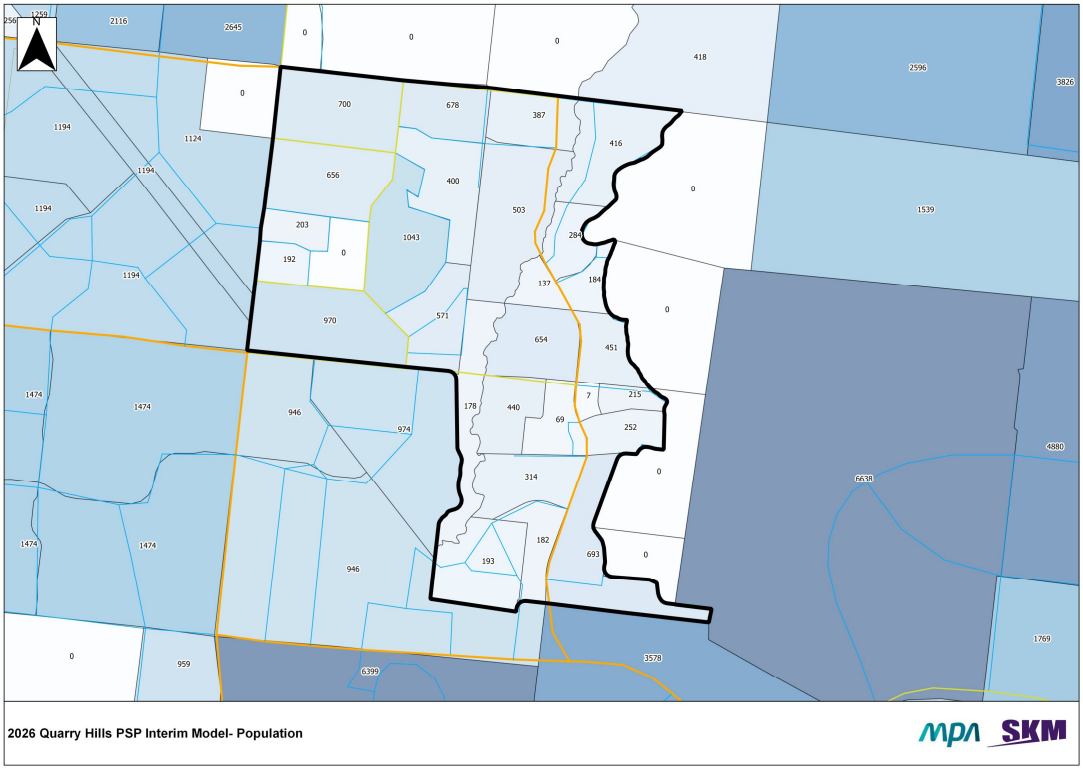


Figure 2.13 : 2026 Total Employment

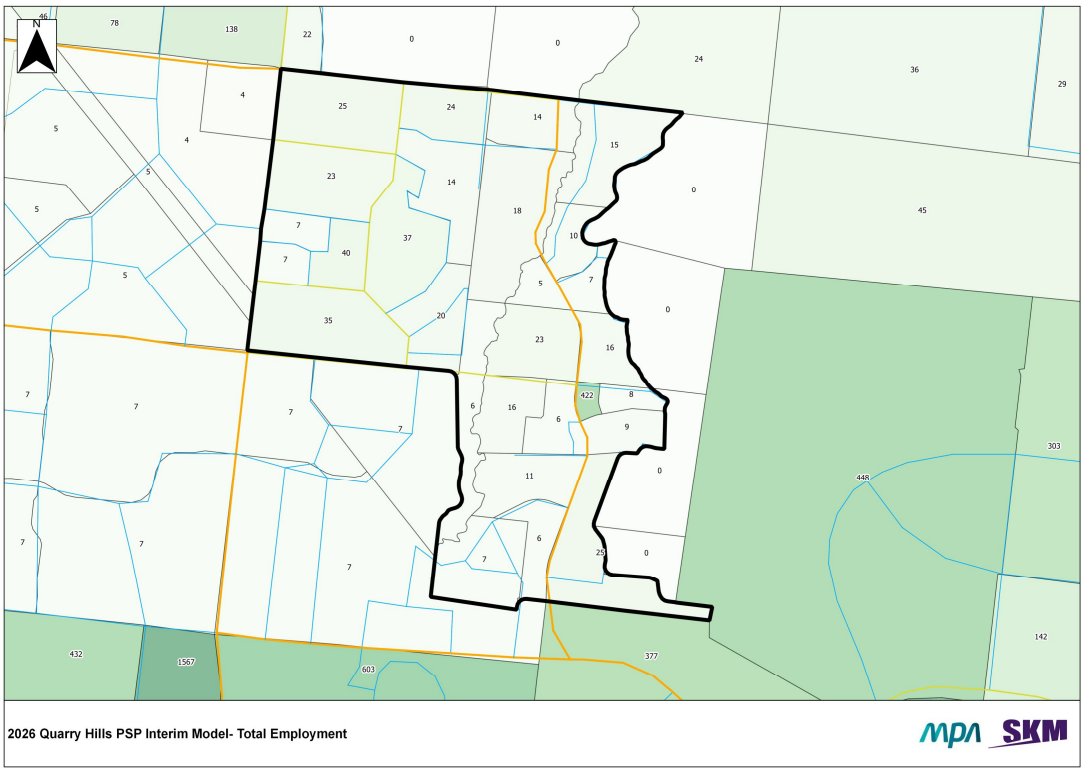
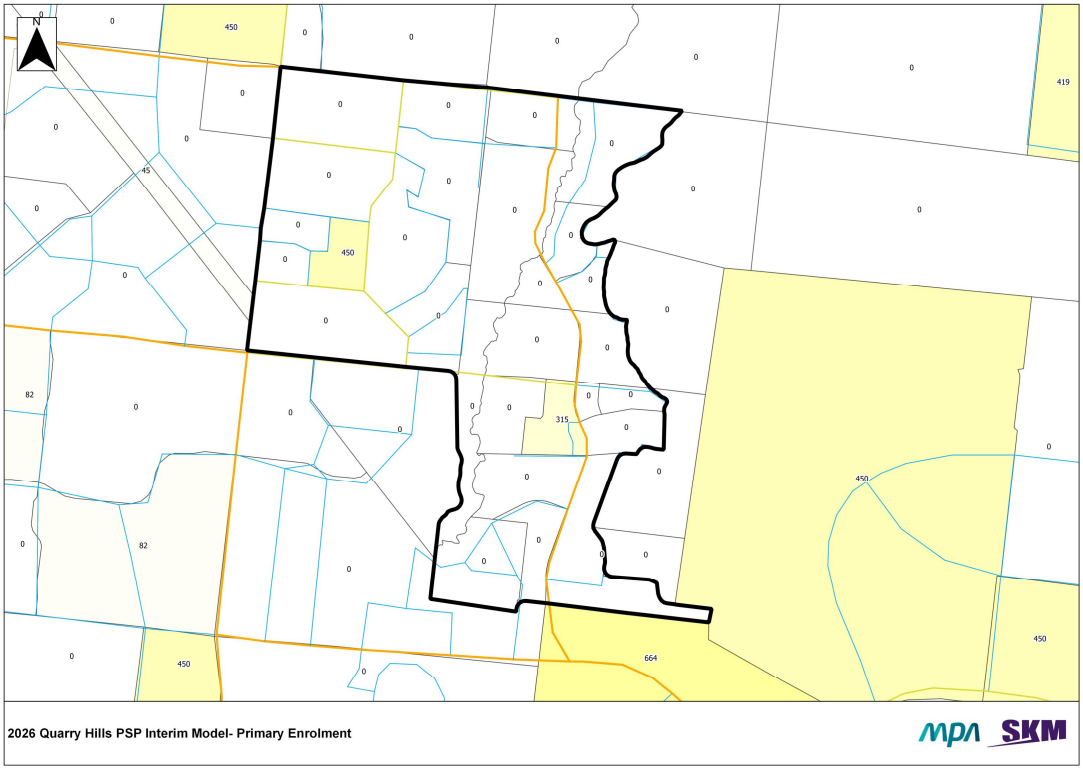


Figure 2.14 : 2026 Primary Enrolment



3. Scenario Testing

The following scenarios were modelled:

- **2046 Ultimate Model Base**: as described in sections 2.2 to 2.5.
- **2046 Ultimate Model Scenario 1:** As per Ultimate Model Base, but without the Outer Metropolitan Ring Road and the E6.
- **2046 Ultimate Model Scenario 2**: As per the Ultimate Model Base, but with the North-South Connector moved to the east of the Town Centre.
- **2026 Interim Model Scenario Base**: as described in Section 2.6.

The road networks for each scenario are shown in Figure 3.1 to Figure 3.4 below.

Figure 3.1 : Transport Network, 2046 Ultimate Model Base

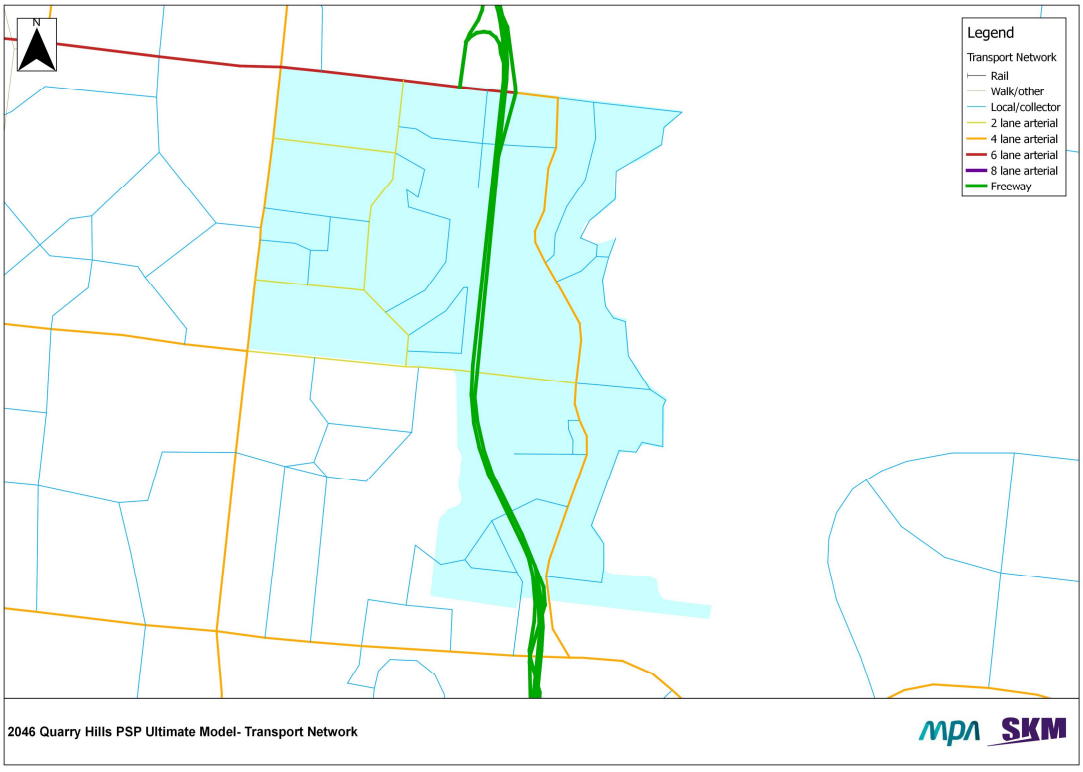


Figure 3.2 : Transport Network, 2046 Ultimate Model Scenario 1

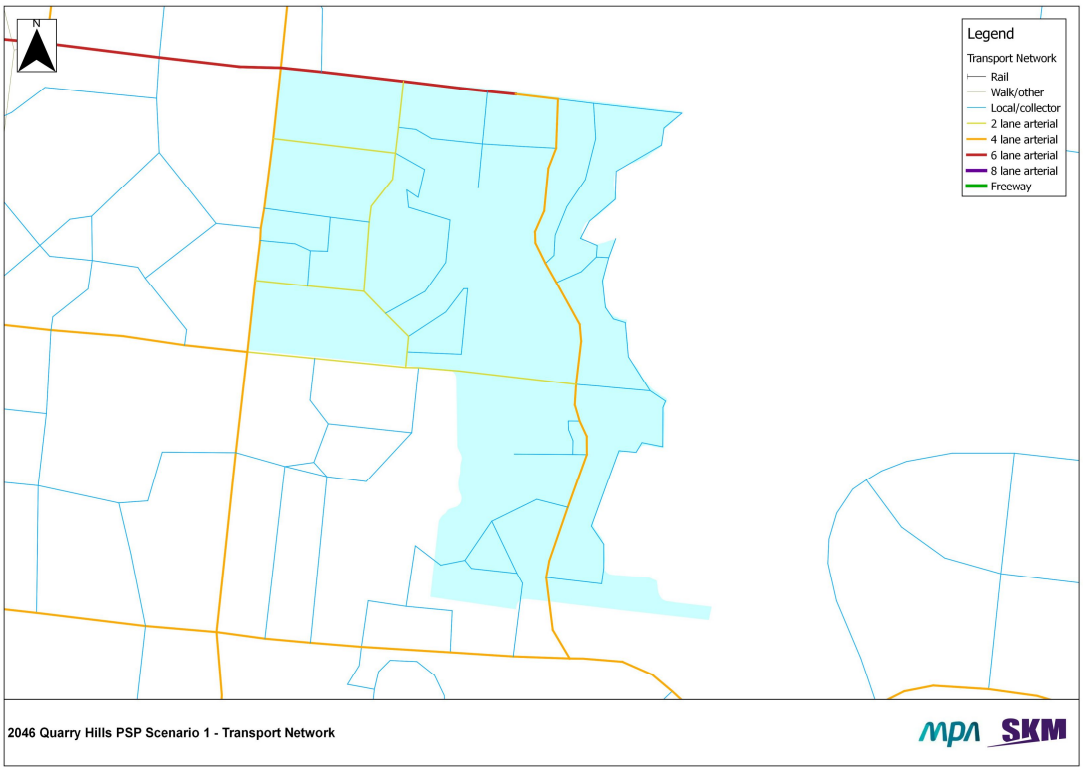


Figure 3.3 : Transport Network, 2046 Ultimate Model Scenario 2

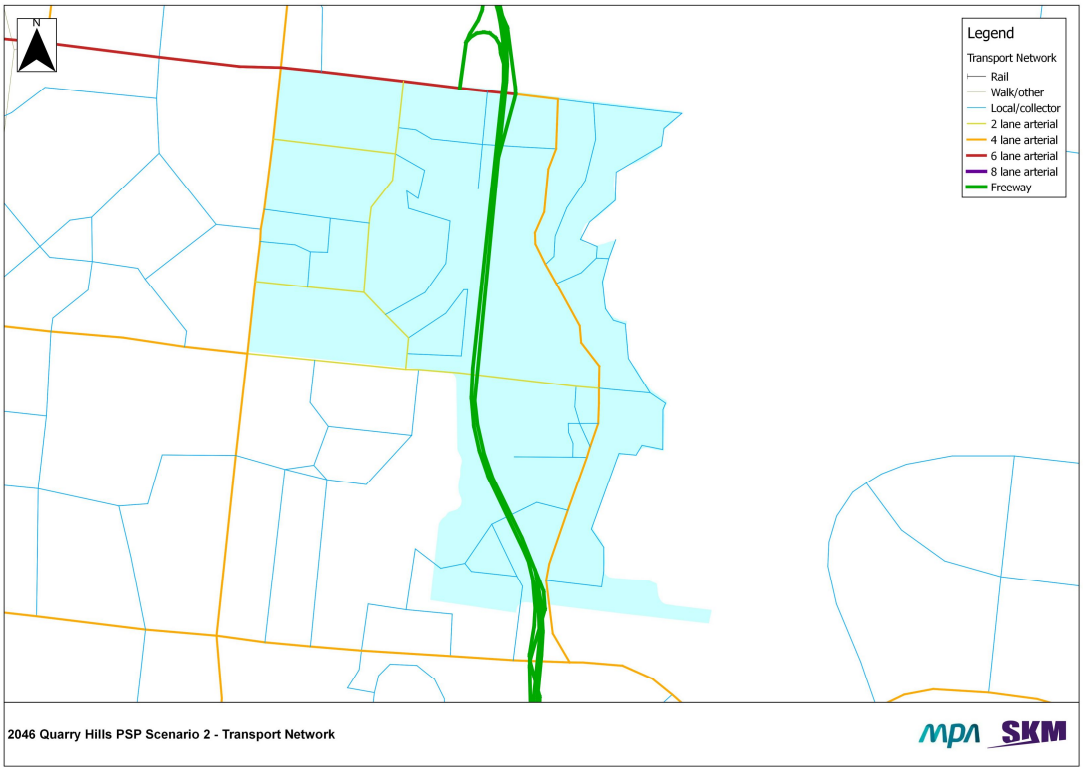
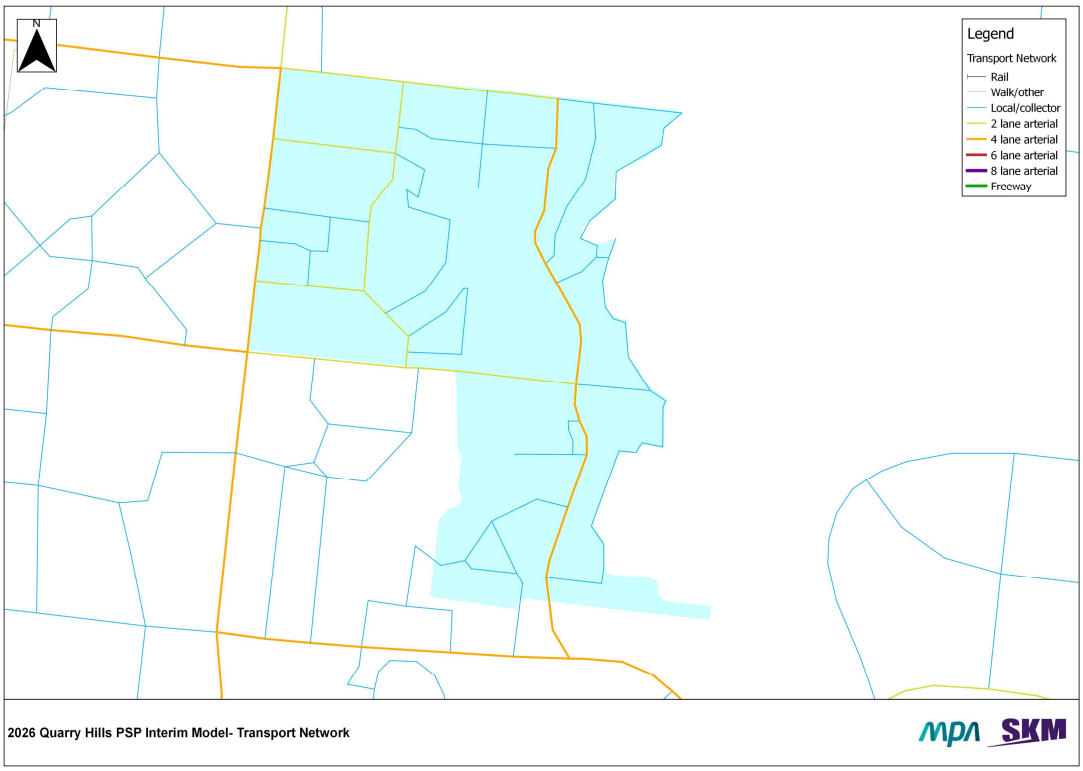


Figure 3.4 : Transport Network, 2026 Interim Model Scenario Base



3.1 Traffic Volumes

Figure 3.5 to Figure 3.8 show the daily traffic volumes forecast for each scenario in the Quarry Hills area. Note that the traffic volumes on the E6 have been excluded from these plots as the large volumes tend to obscure the traffic volumes in the study area. Traffic volumes by AM and PM Peak Hour and plots which show the volume on all roads can be seen in Appendix A.

It can be seen in all of the 2046 scenarios that the highest volumes in the study area are highest on the southern section of the North-South Connector. Daily volumes do not exceed 5,500 vehicles on this road in each direction (with peak hourly volumes less than 800 vehicles), leading to the conclusion that a single lane in each direction would have sufficient capacity for these levels of traffic.

Traffic volumes are higher in Quarry Hills in Scenario 1 when the OMR and E6 are not in place. As will be explored in Section 0, this higher volume is due to some non-Quarry Hills related traffic travelling through the study area in the absence of the E6.

It can be seen that the re-routing of the North-South Connector in Scenario 2 has very little impact on traffic volumes in comparison to the Base model. This indicates that either of the layouts of the connector will be acceptable in terms of traffic volumes.

Traffic volumes in 2026 are, as expected, lower than those in 2046. This is due to both lower numbers of households, less development of the school and town centre, and also the lower volume of background traffic.

Figure 3.5: Daily modelled volumes , 2046 Ultimate Model Base

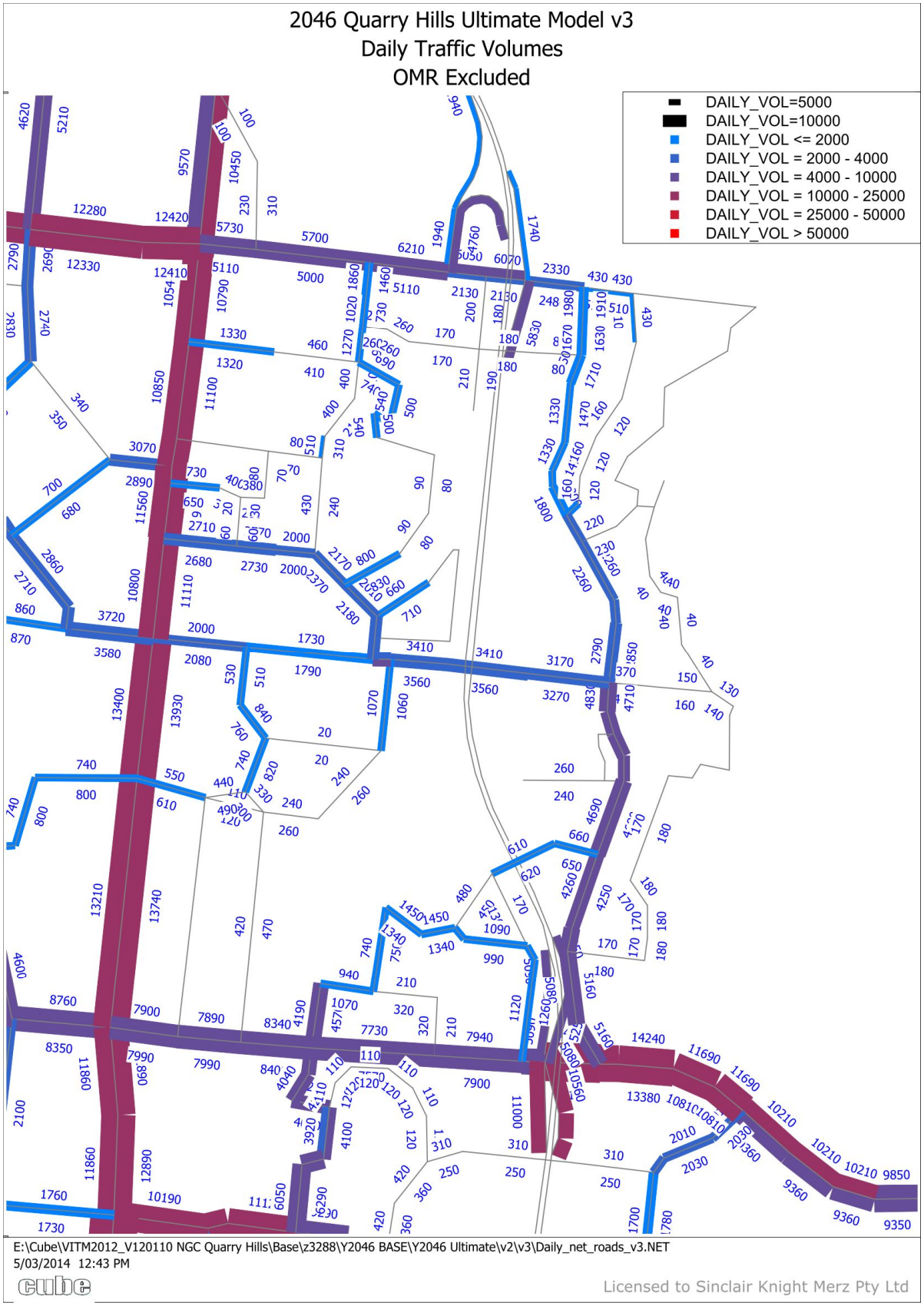


Figure 3.6: Daily modelled volumes , 2046 Scenario 1

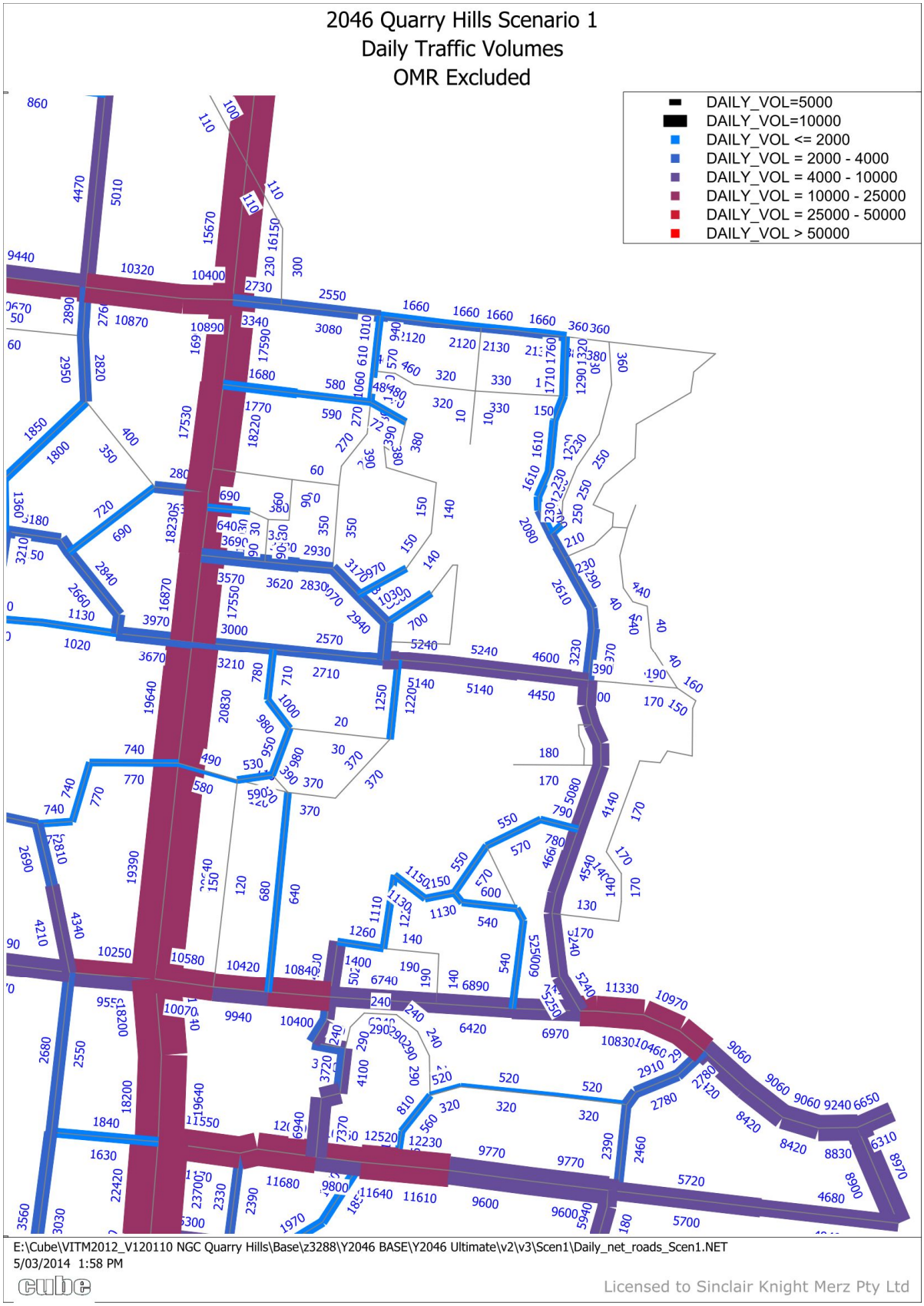


Figure 3.7: Daily modelled volumes , 2046 Scenario 2

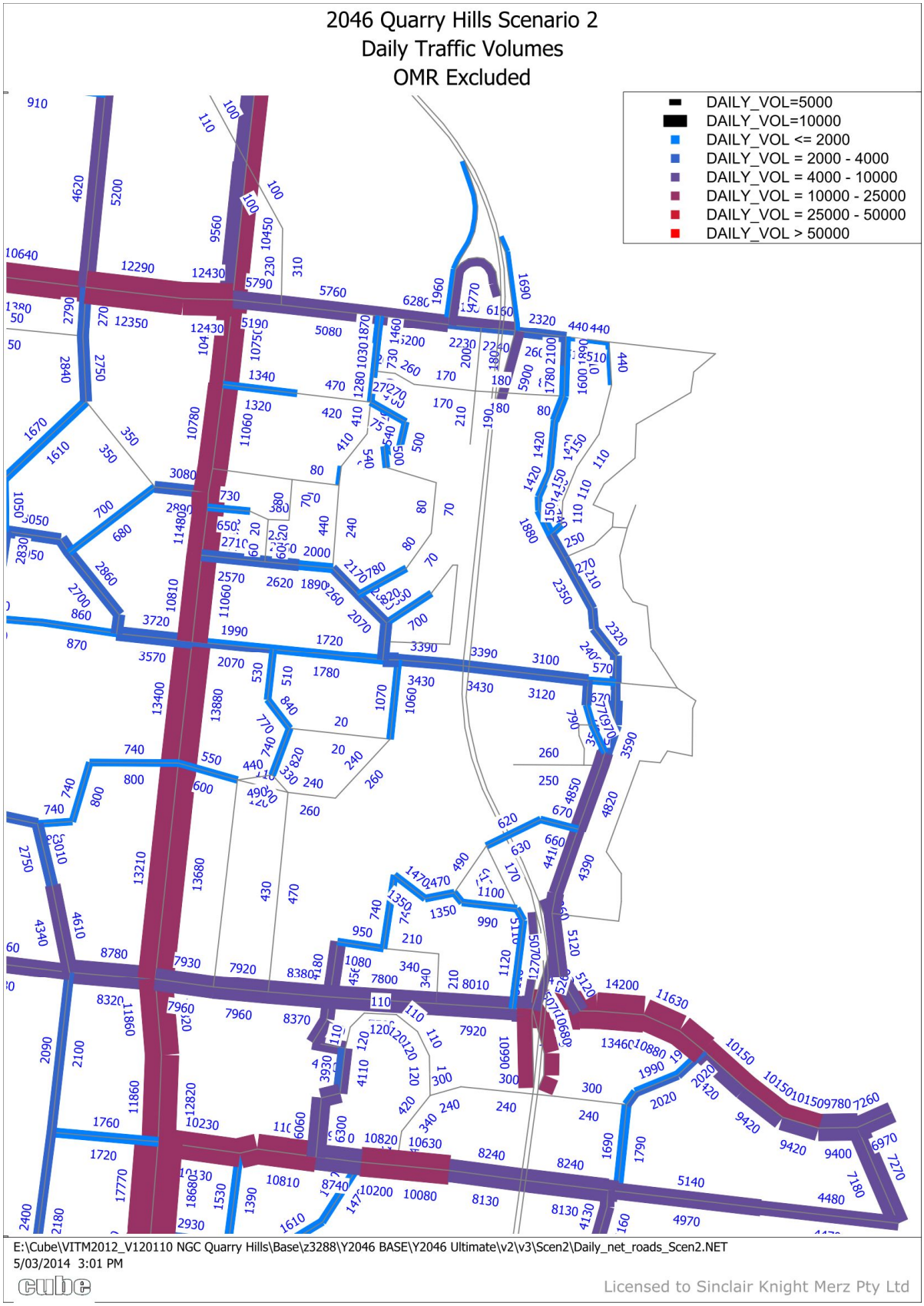
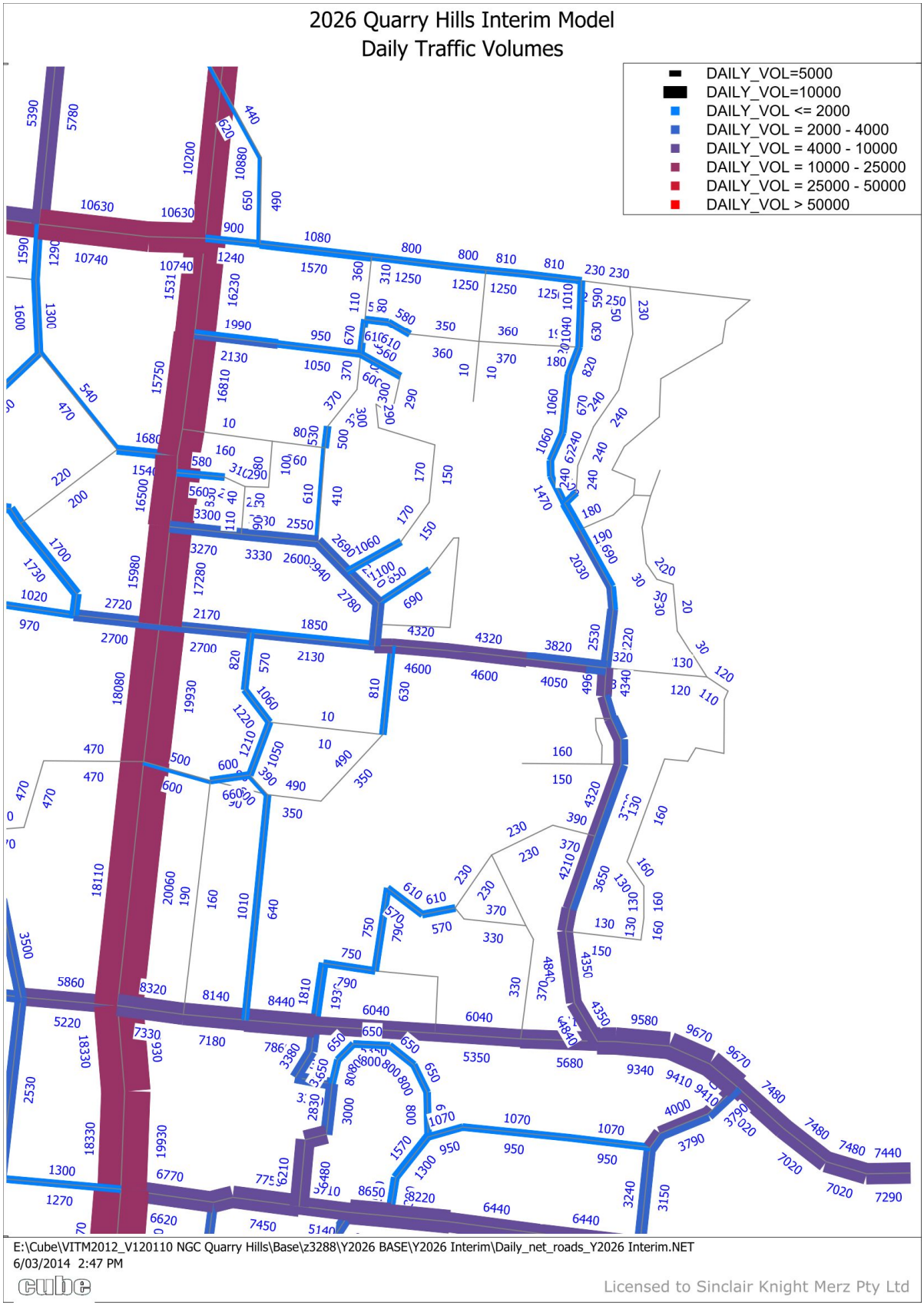


Figure 3.8: Daily modelled volumes , 2026 Interim Model Base



3.2 Road Capacity

The level of congestion on each road is approximated by the ratio of volume to capacity. The **volume to capacity** (**V/C) ratio** measures the proportion of the road's capacity that is used by traffic. A value close to 0.8 is normally assumed to indicate that the road is becoming congested and the traffic on that road will experience significant delays during peak periods. Technically, values greater than 1.0 should not be permitted (i.e. volume being greater than capacity); however, if no other suitable routes are available, the model will be forced to allocate traffic to congested roads, resulting in V/C ratios greater than 1.0.

Volume to capacity plots have been produced for the AM and PM peak periods (see Figure 3.9 to Figure 3.16). All of the local arterial roads within the Quarry Hills PSP area have forecast V/C ratios under 0.6, indicating there is sufficient capacity on these roads during all time periods.

3.2.1 North-South Connector

The North-South Connector, which was modelled as a four-lane road (i.e. two lanes in each direction), appears to have ample capacity. The analysis indicates that a two-lane road would be sufficient to accommodate forecast traffic volumes. In the concept design and costing stages of the Quarry Hills study, we have therefore treated the North-South Connector as being a two-lane road with additional turning lanes at signalised intersections.

3.2.2 E6 Freeway

In the scenarios containing the E6 freeway, the E6 is forecast to be moderately congested in the peak periods, with predominantly southbound flows in the AM peak and northbound flows in the PM peak. The V/C plots also indicate that the E6 helps to reduce congestion on Epping Road, which would otherwise attract significant volumes of traffic as shown in Figure 3.11 and Figure 3.12.

3.2.3 Findon Road

Some capacity constraints were observed in the 2046 model results for Findon Road where it meets the North-South Connector. This was especially the case in the eastern sections of Findon Road where there only a single lane has been modelled in each direction. Although this is outside the Quarry Hills PSP area, these results suggest that additional capacity may be needed for Findon Road by 2050.

Figure 3.9: AM peak (7-9am) volume to capacity ratios, 2046 Ultimate Model Base

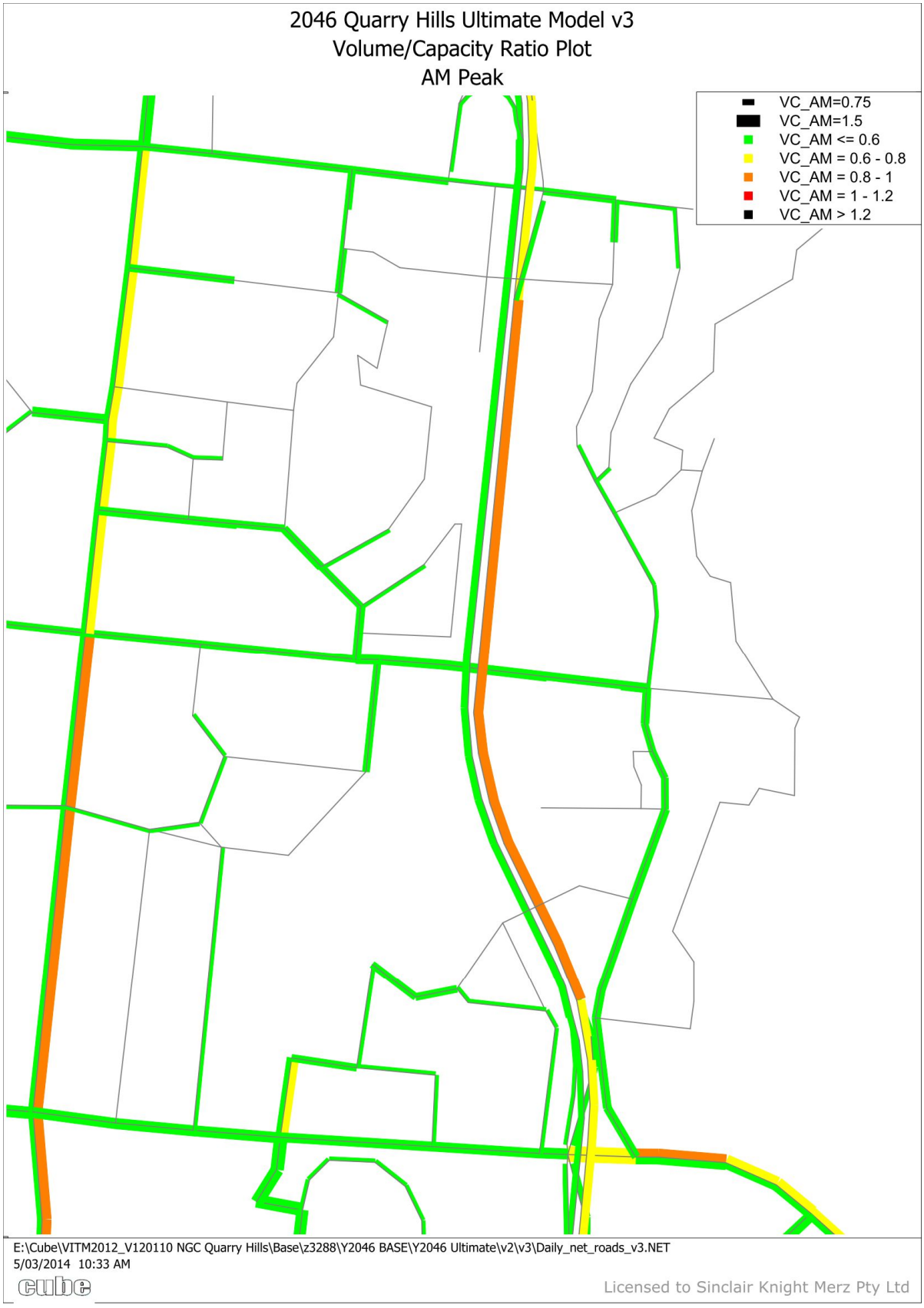


Figure 3.10: PM peak (4-6pm) volume to capacity ratios, 2046 Ultimate Model Base

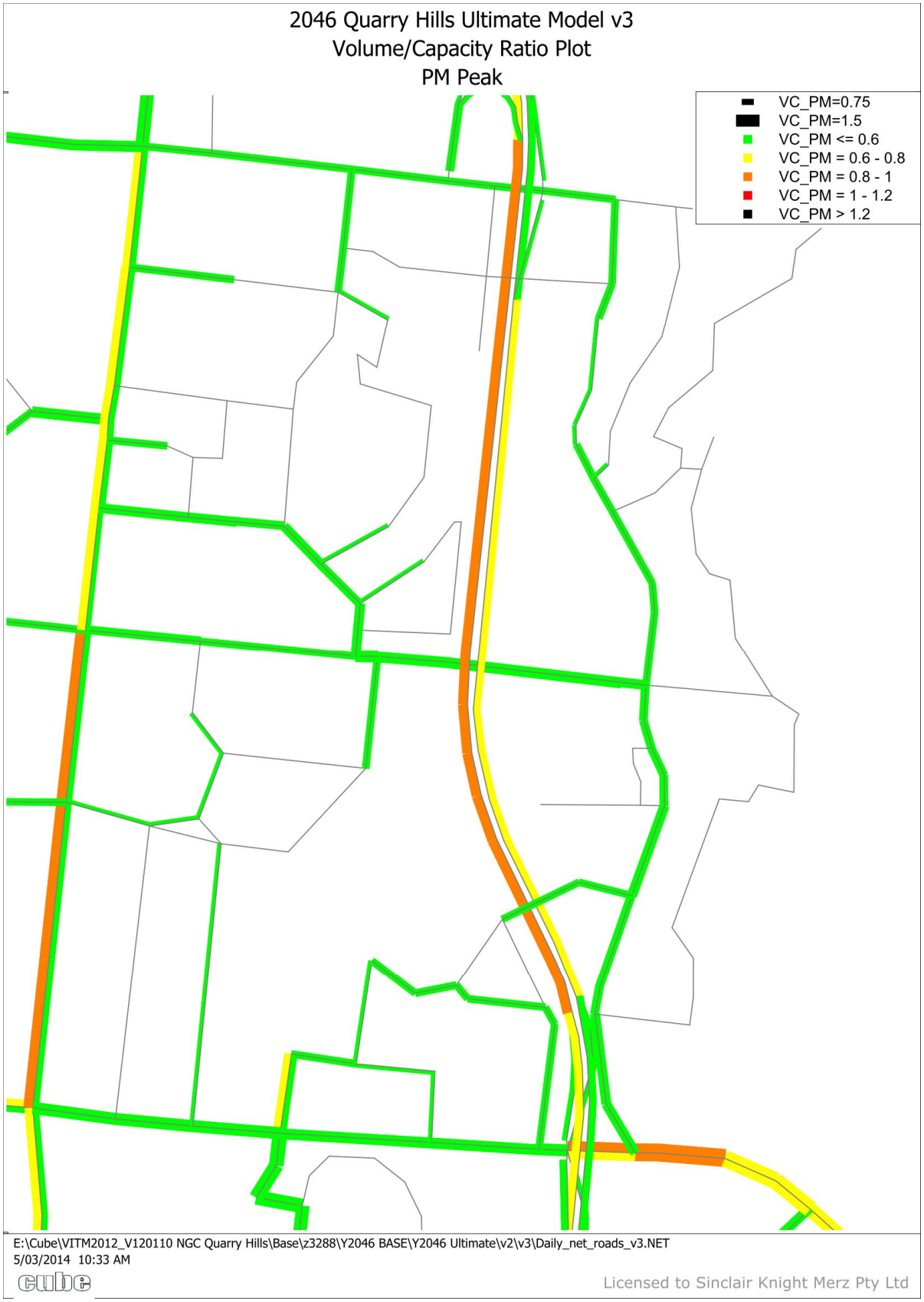


Figure 3.11: AM peak (7-9am) volume to capacity ratios, 2046 Scenario 1

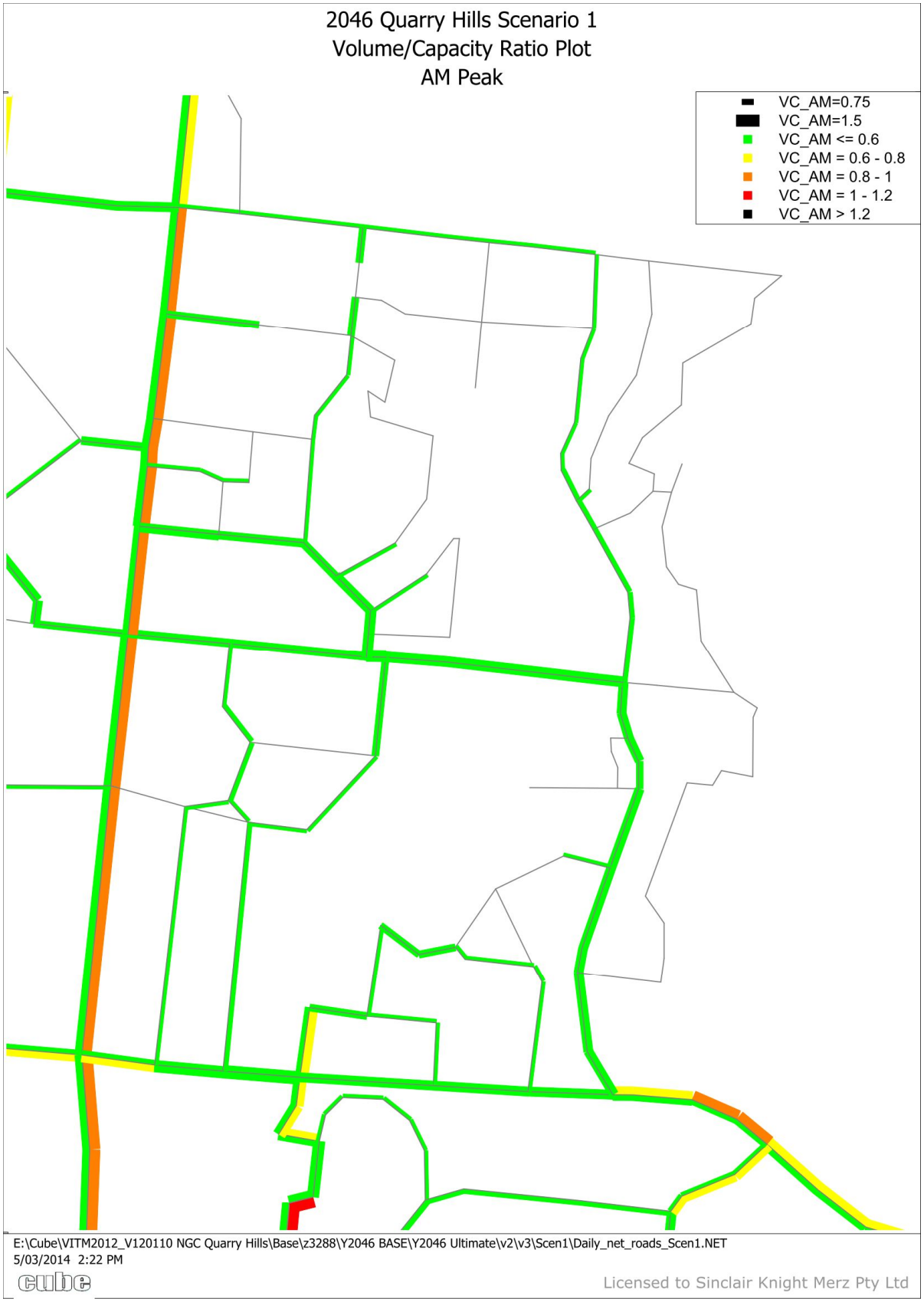


Figure 3.12: PM peak (4-6pm) volume to capacity ratios, 2046 Scenario 1

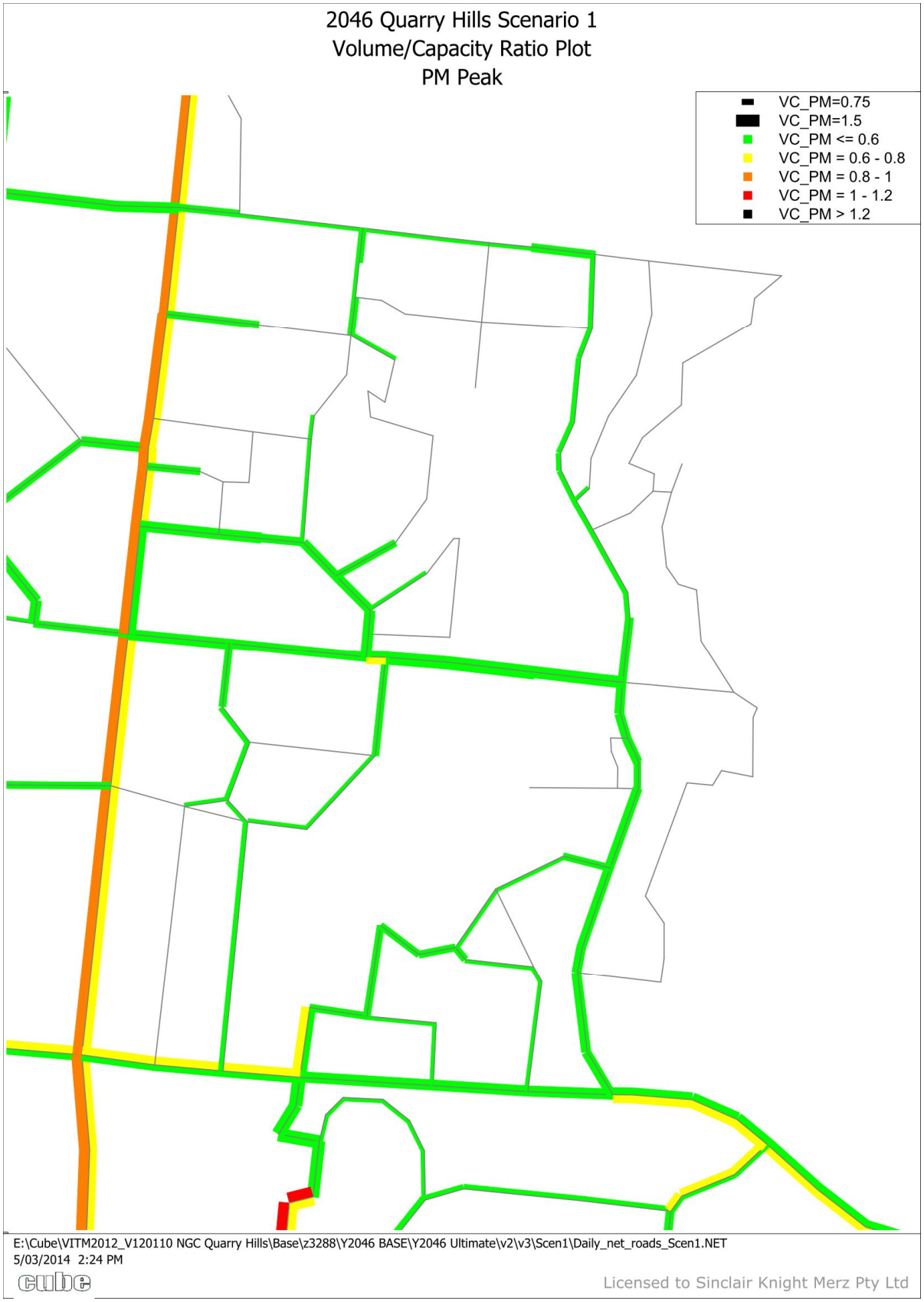


Figure 3.13: AM peak (7-9am) volume to capacity ratios, 2046 Scenario 2

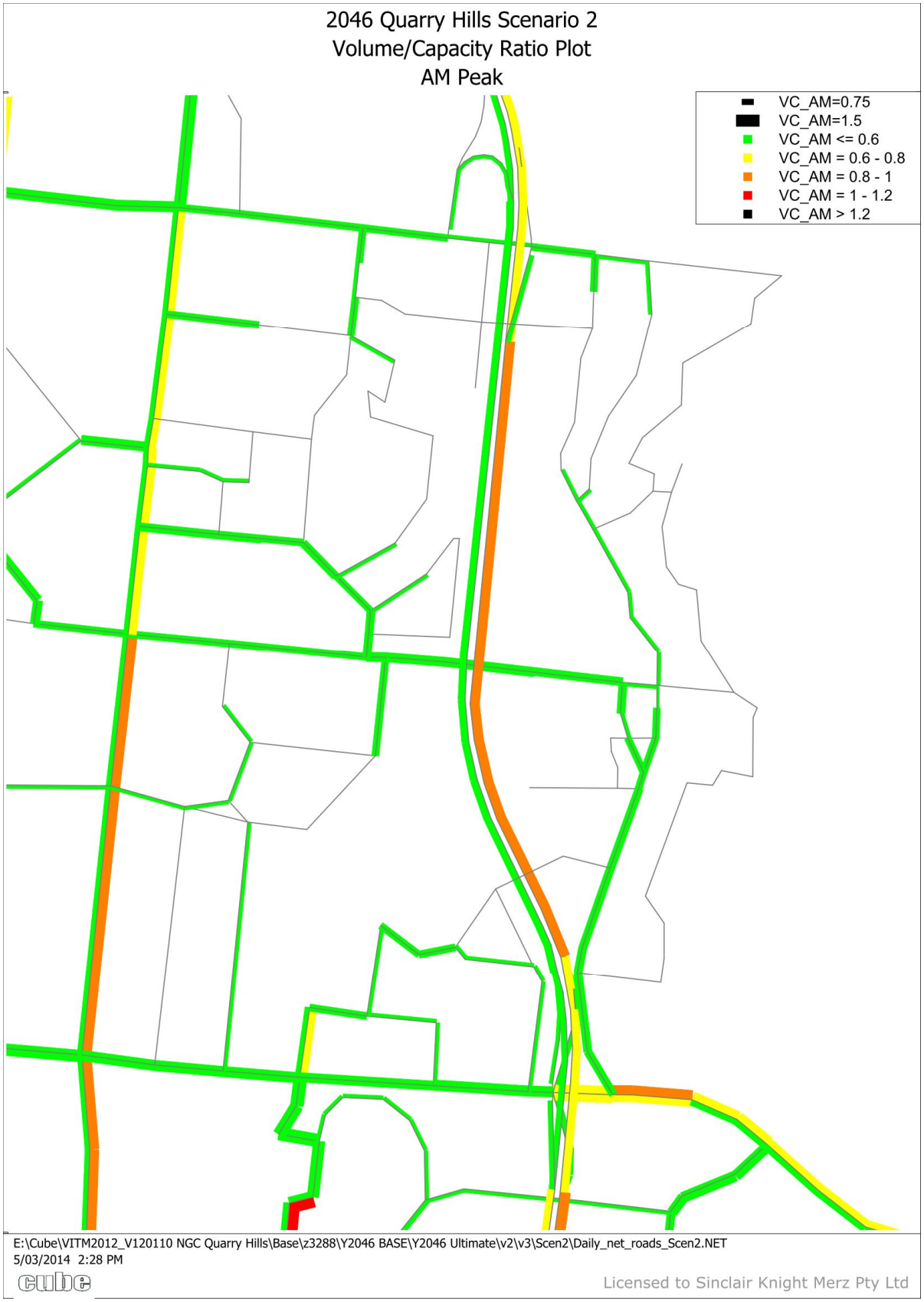


Figure 3.14: PM peak (4-6pm) volume to capacity ratios, 2046 Scenario 2

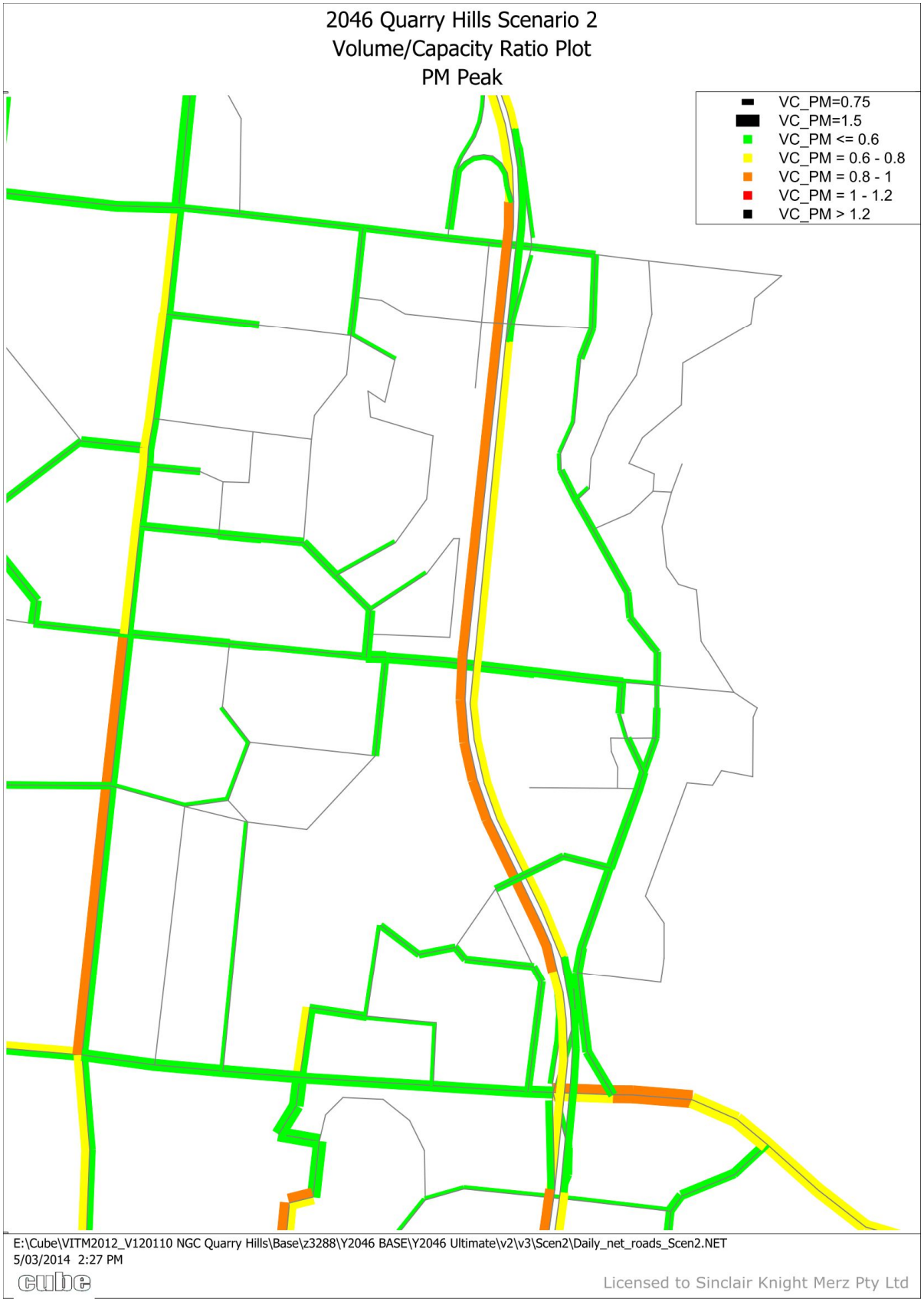


Figure 3.15: AM peak (7-9am) volume to capacity ratios, 2026 Interim Model Base

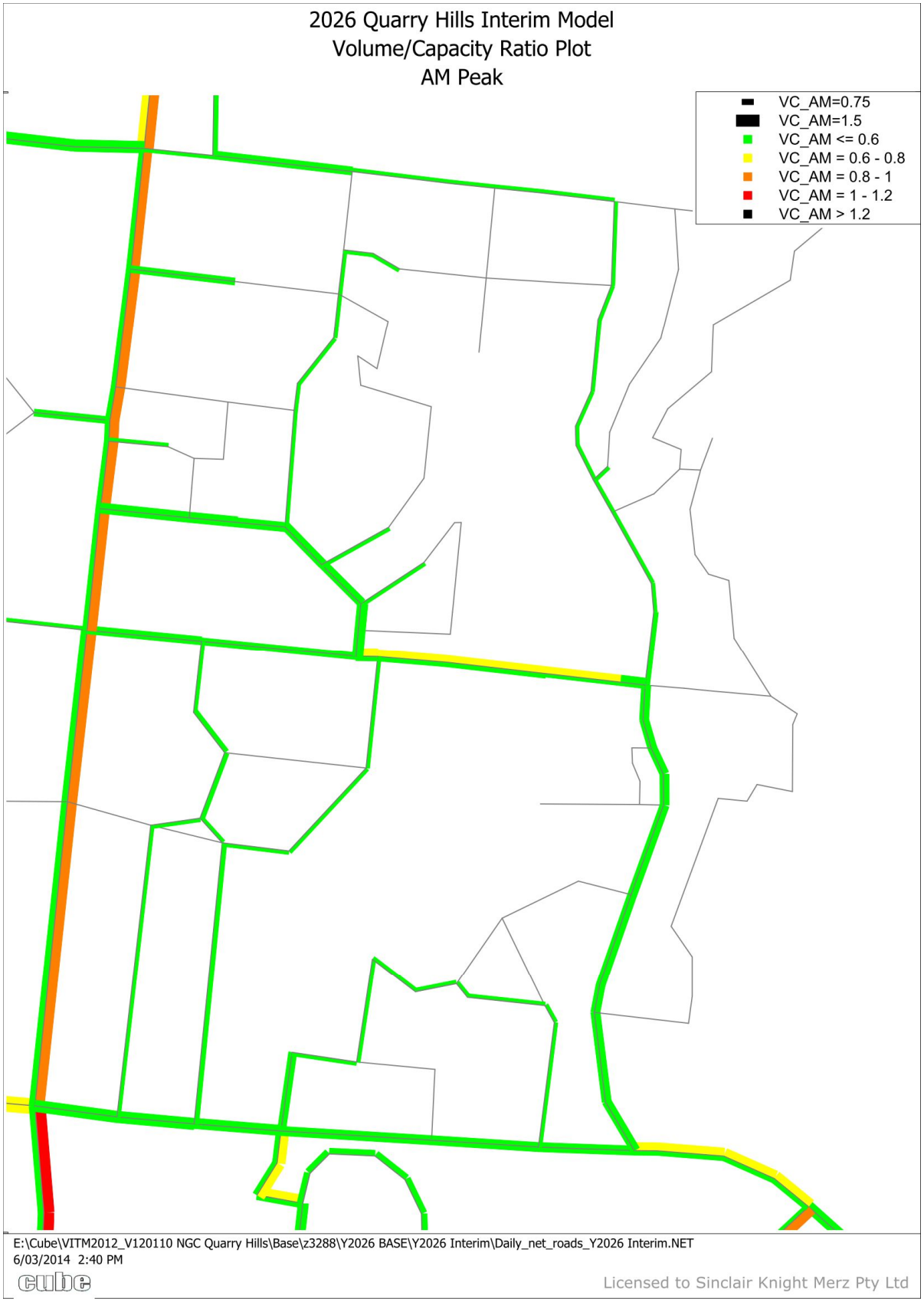
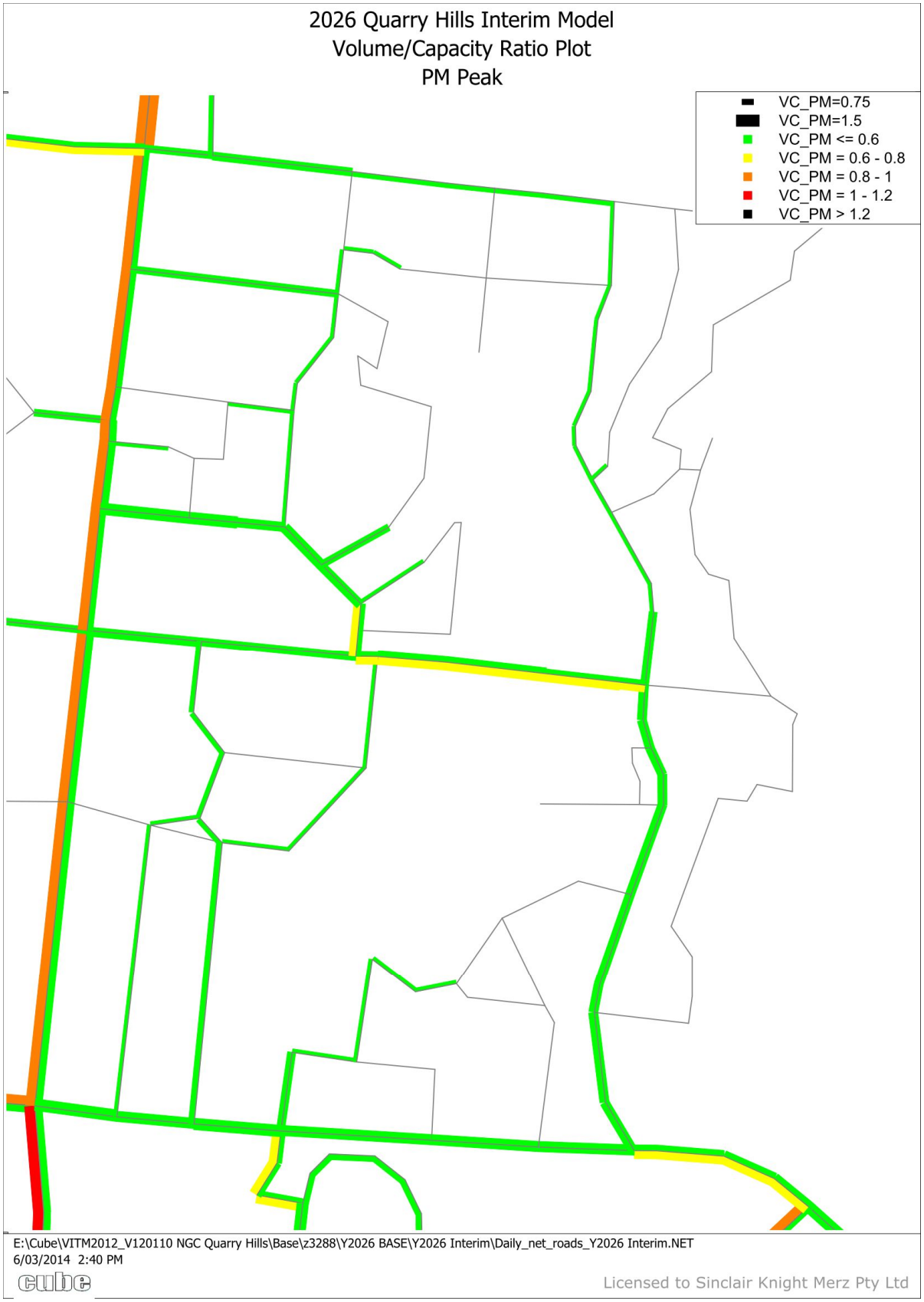


Figure 3.16: PM peak (4-6pm) volume to capacity ratios, 2026 Interim Model Base



3.3 Select-Link Analysis

To investigate the routes of traffic travelling to and from the Quarry Hills PSP, a set of select-link analyses were carried out for several major roads in the PSP. A **select-link analysis** is a method of analysing traffic movements by showing only the routes of trips that travel along a nominated link. This effectively allows the traffic catchment area for each link to be mapped.

Figure 3.17 to Figure 3.20 show select-link plots for sections of the North-South Connector, Harvest Home Road and one of the east-west collector roads for the 2046 base case. The location of the selected links are shown in red on the plots, with the widths of the links indicating the relative volumes of traffic. For clarity, low volumes have been omitted from the plots.

A complete set of plots for all scenarios are provided in Appendix A.

The select-link plots suggest the following routing impacts:

- The North-South Connector primarily caters for through traffic (Figure 3.17), and also provides an important access spine for local traffic in the Quarry Hills area.
- The southern section of the North-South Connector provides an important link between Harvest Home Road and Findon Road (Figure 3.18 and Figure 3.19).
- Most traffic movements on Harvest Home Road are to and from the west (Figure 3.19).

Figure 3.17: Select Link Plots – Daily - North-South Connector North of Harvest Home Road, 2046 Base

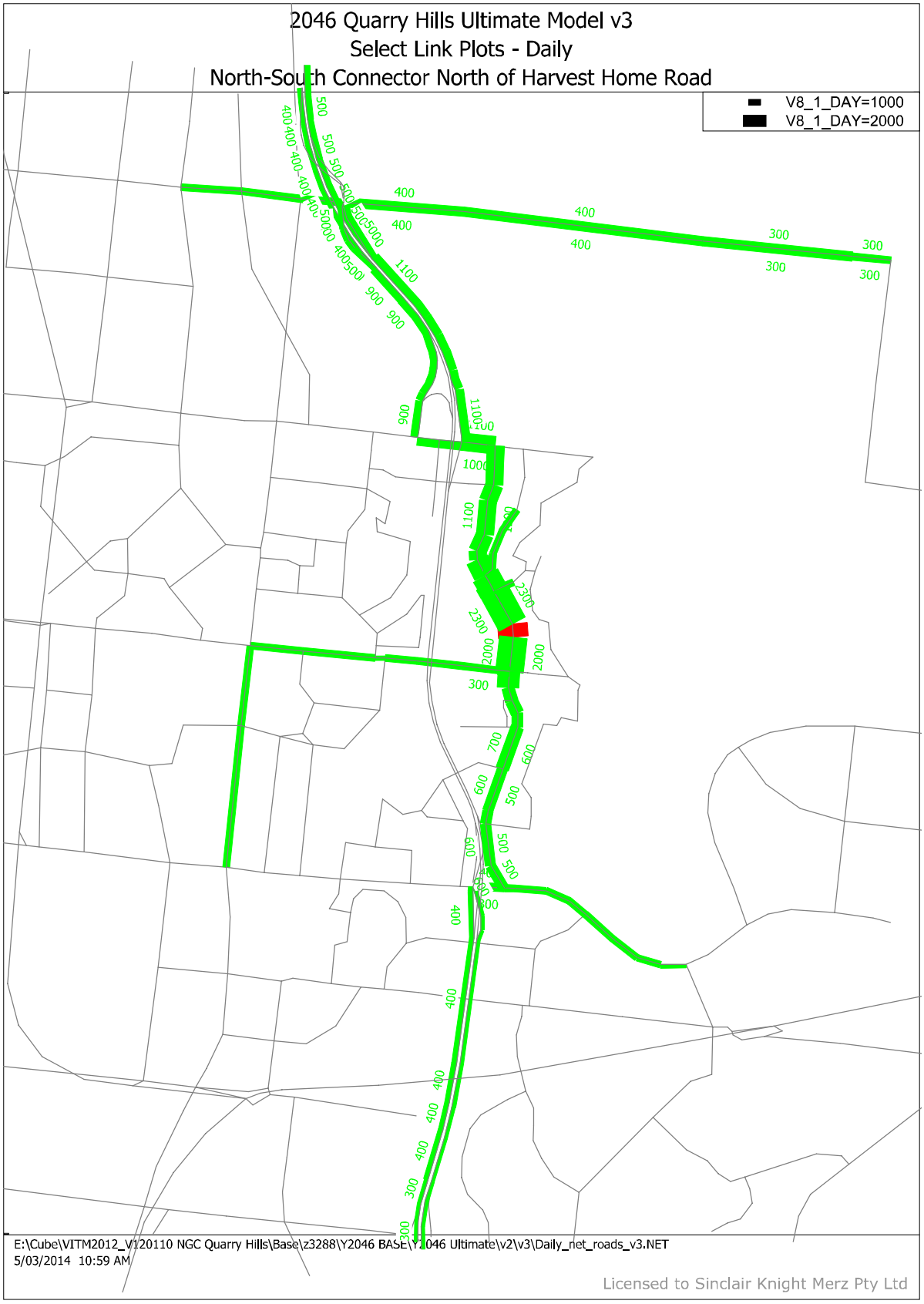


Figure 3.18: Select Link Plots – Daily - North-South Connector South of Harvest Home Road, 2046 Base

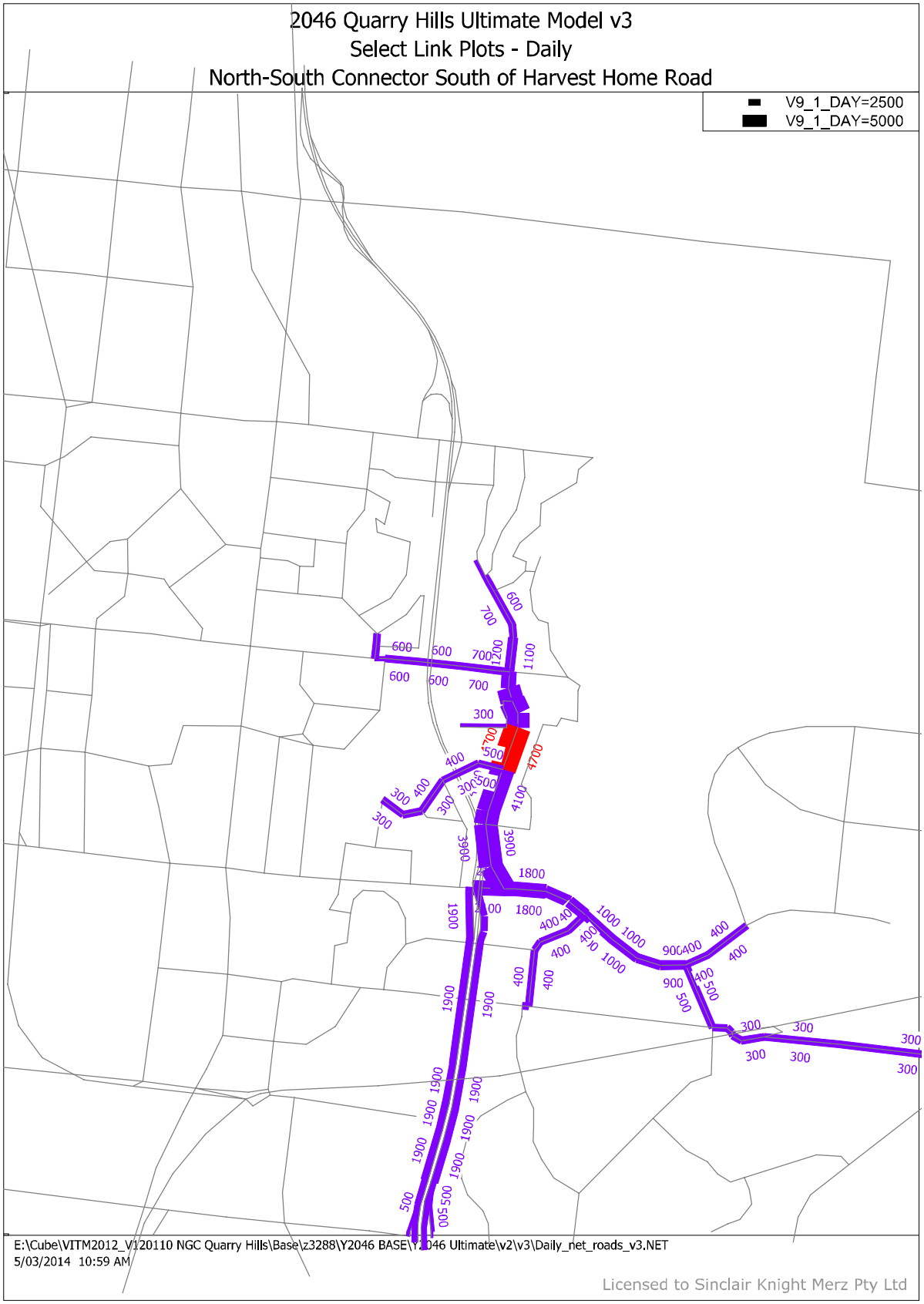


Figure 3.19: Select Link Plots – Daily - Harvest Home Road, 2046 Base

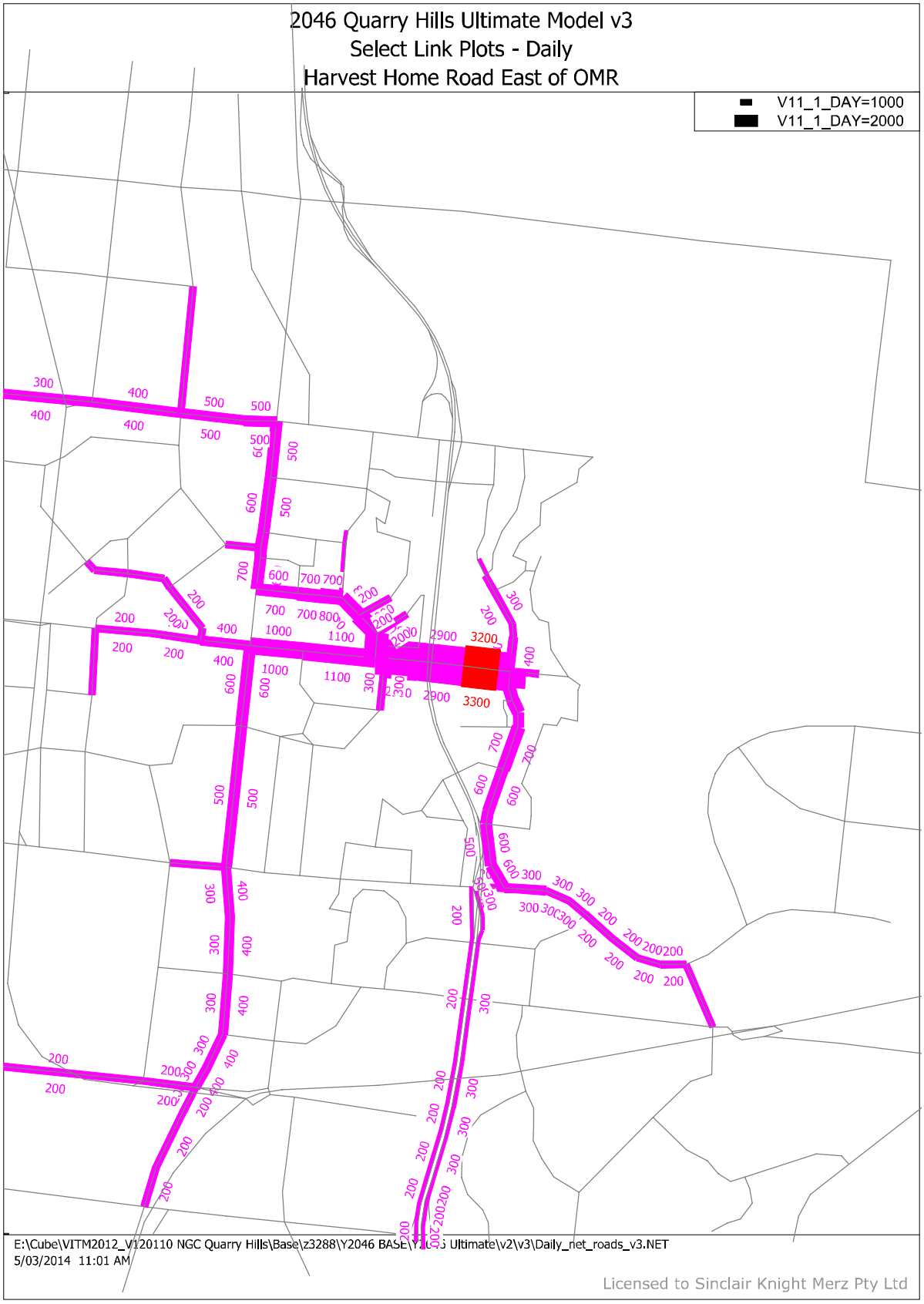
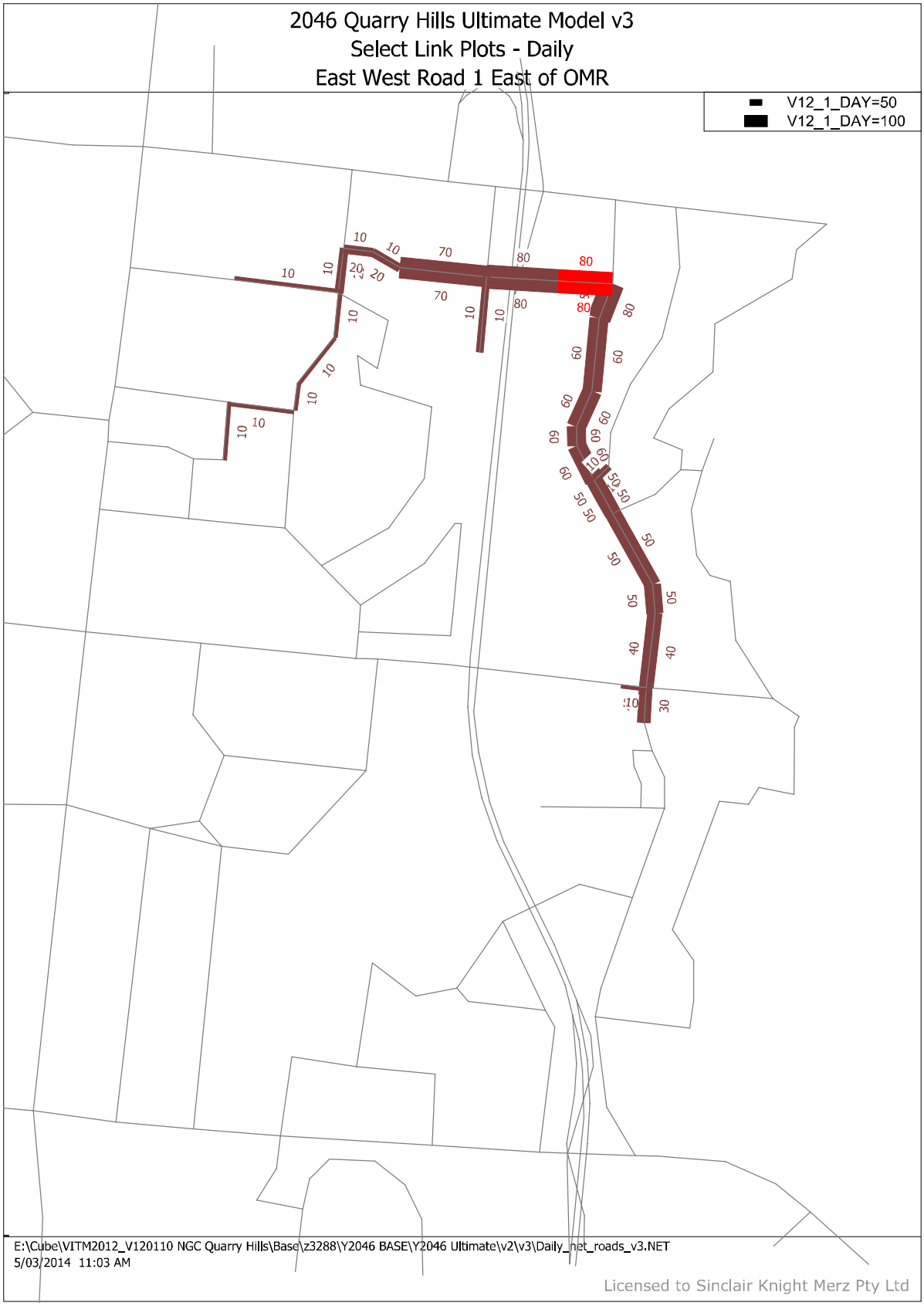


Figure 3.20: Select Link Plots – Daily – East-West Collector Road, 2046 Base



3.4 Public Transport

Figure 3.21 shows the assumed future bus routes and railway stations in the vicinity of Quarry Hills.

Figure 3.22 to Figure 3.29 show the forecast public transport patronage for services near Quarry Hills. Bus and train boardings are very similar across the 2046 scenarios. Boardings are generally lower in 2026 than 2046, reflecting the lower population assumed in 2026.

The main bus route that is proposed for Quarry Hills (QH1) is forecast to carry approximately 1000 passengers (two-way) per day.

Figure 3.21: Public transport network (2046)

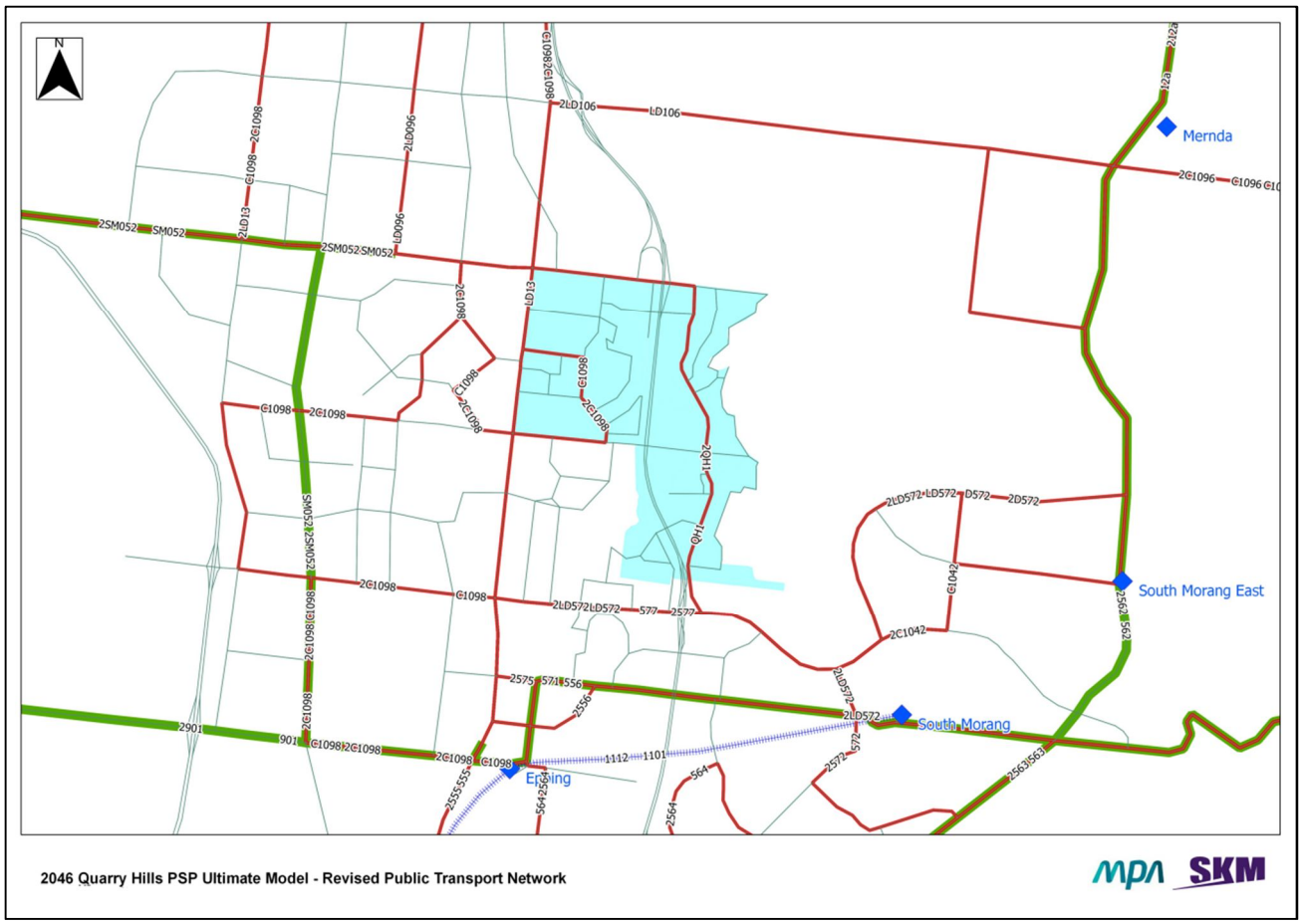


Figure 3.22 : 2046 Base – train boardings

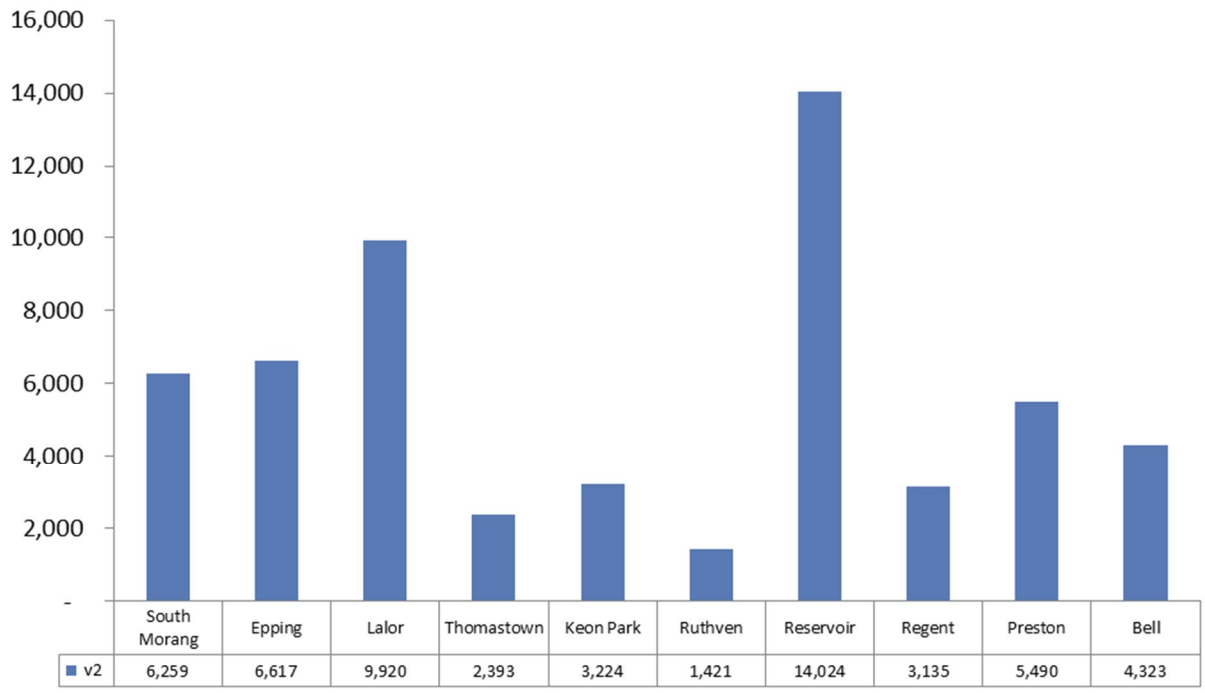


Figure 3.23 : 2046 Base – bus boardings

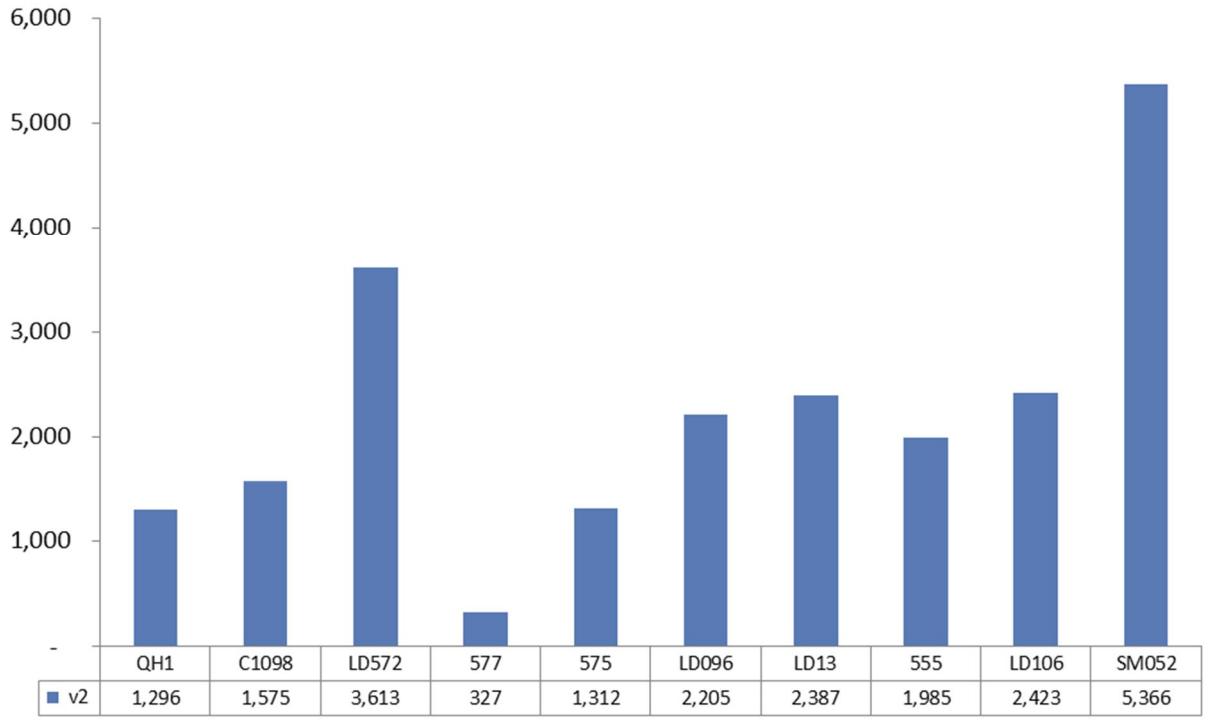


Figure 3.24 : 2046 Scenario 1 – train boardings

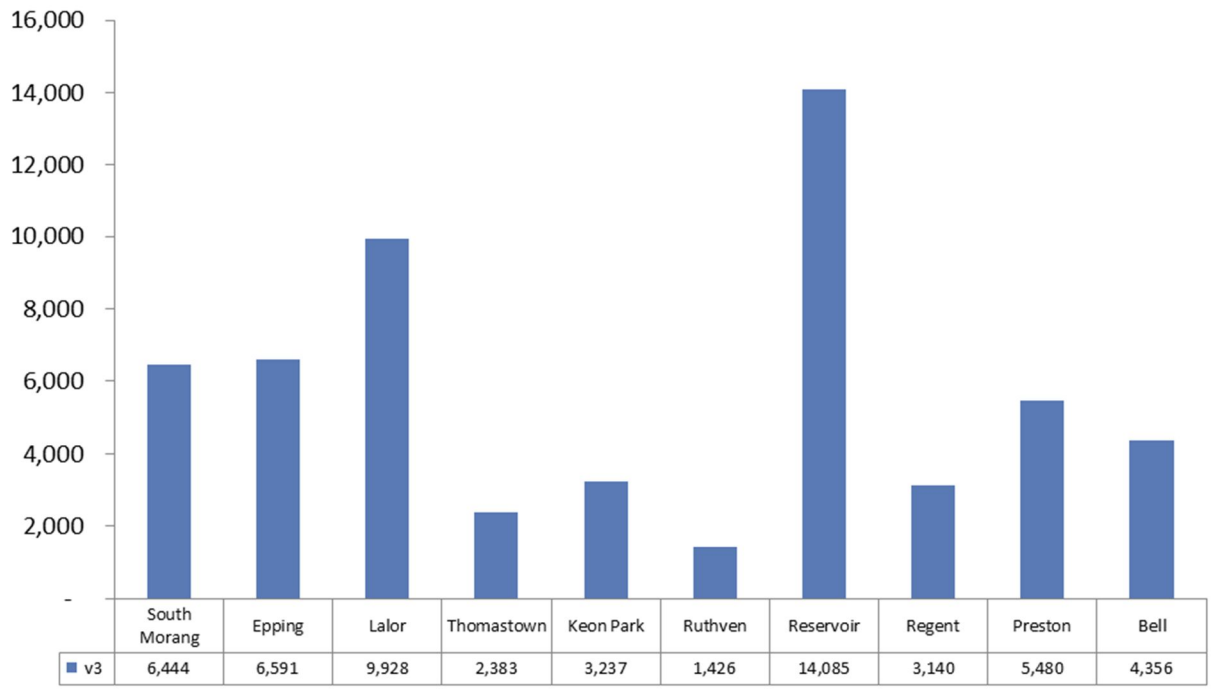


Figure 3.25 : 2046 Scenario 1 – bus boardings

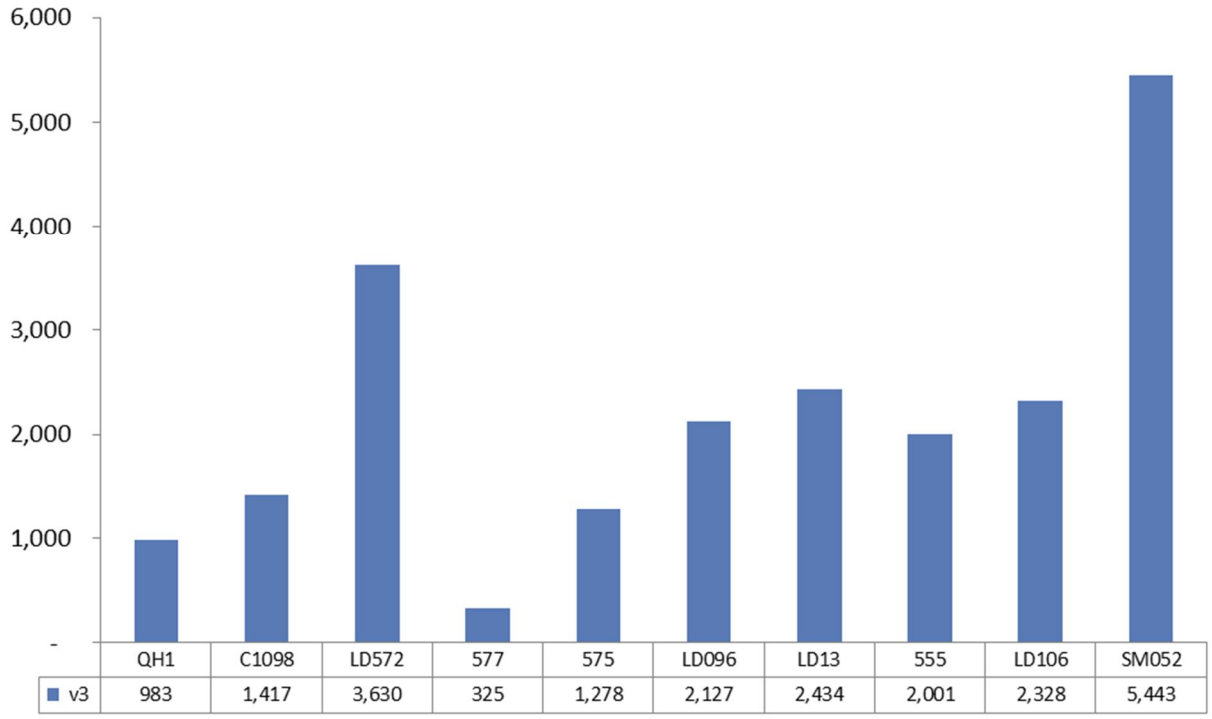


Figure 3.26 : 2046 Scenario 2 – train boardings

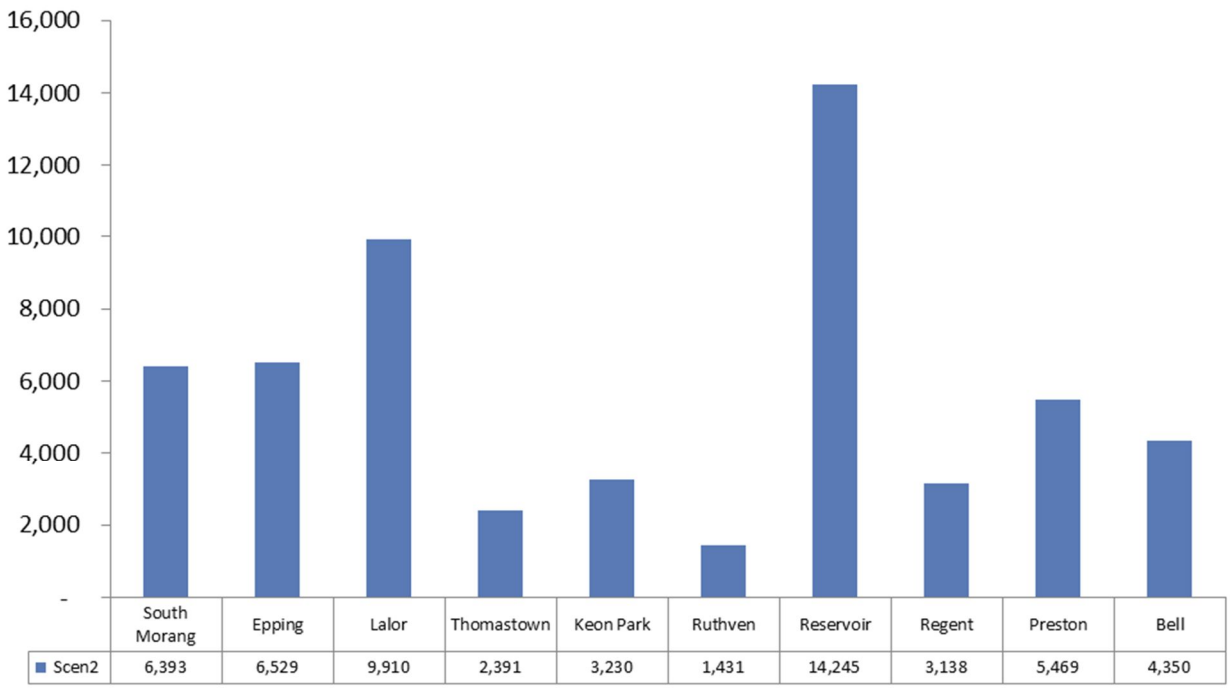


Figure 3.27 : 2046 Scenario 2 – bus boardings

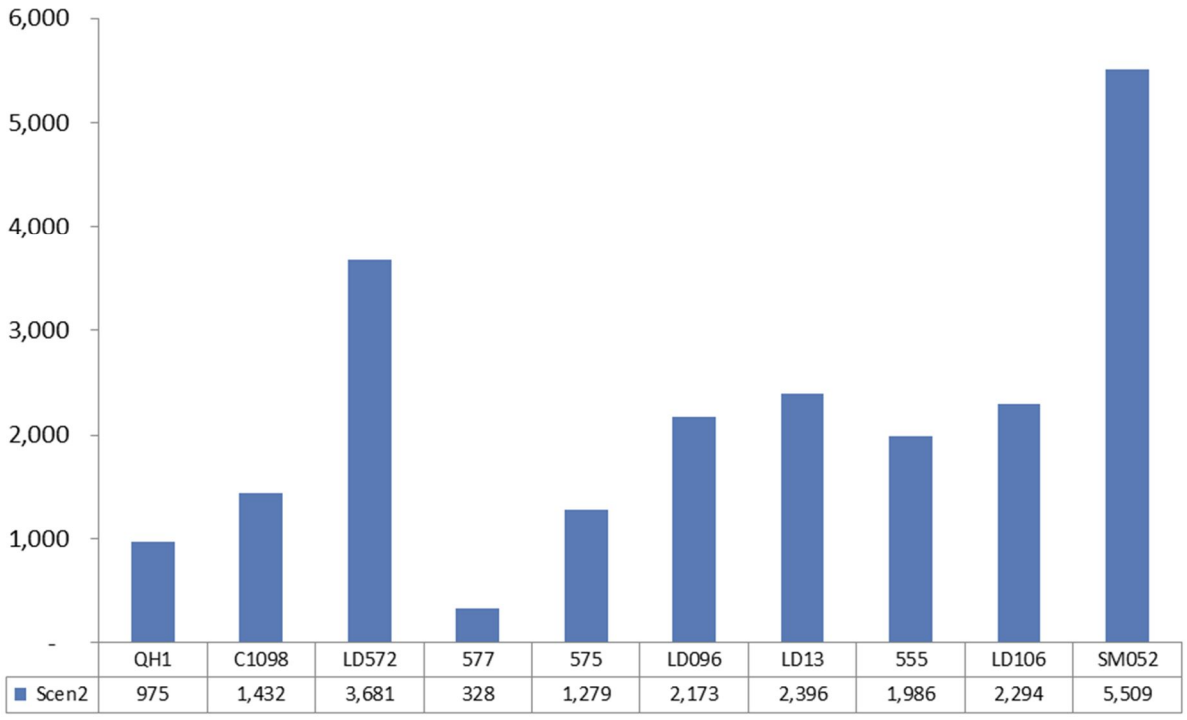
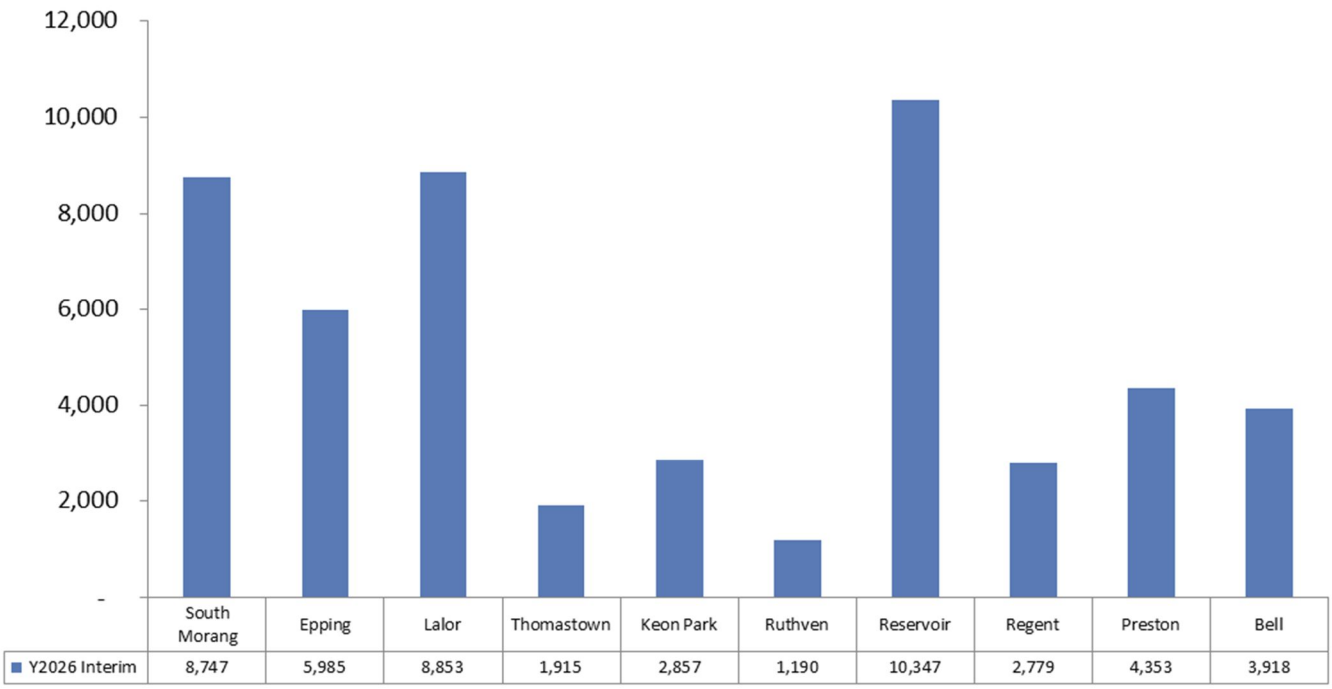
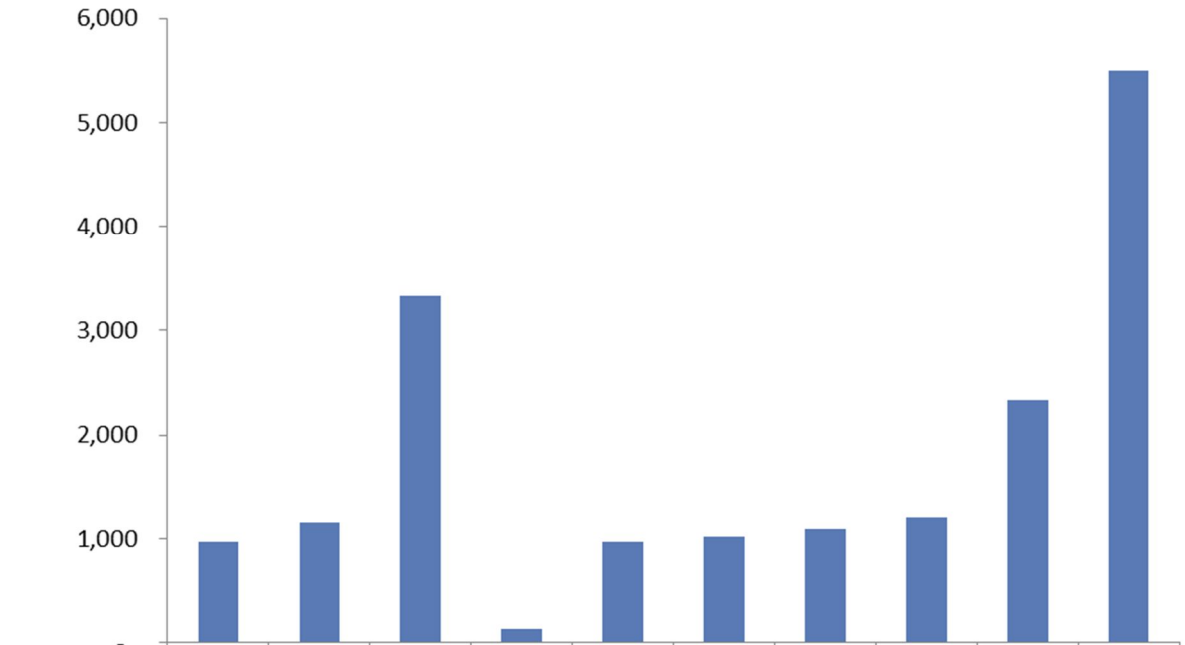


Figure 3.28 : 2026 Base – train boardings



	South Morang	Epping	Lalor	Thomastown	Keon Park	Ruthven	Reservoir	Regent	Preston	Bell
Y2026 Interim	8,747	5,985	8,853	1,915	2,857	1,190	10,347	2,779	4,353	3,918

Figure 3.29 : 2026 Base – bus boardings



	QH1	C1098	LD572	577	575	LD096	LD13	555	LD106	SM052
Y2026 Interim	969	1,156	3,333	136	971	1,016	1,090	1,209	2,330	5,495

4. Intersection Analysis

This chapter presents an overview of the forecast turning volumes and capacity requirements for three key intersections in Quarry Hills for the 2026 interim build-out scenario and 2046 Scenario 1. Scenario 1, without the E6 and OMR, was chosen as representing a potential worst case (maximum traffic volumes) for these intersections.

The three intersections are shown in Figure 4.1 and are numbered as follows:

- Intersection 1: Harvest Home Road and North-South Connector
- Intersection 2: Local access road and North-South Connector
- Intersection 3: Findon Road and North-South Connector

Figure 4.1 : Modelled intersections in Quarry Hills PSP

4.1 Turning Volumes

4.1.1 Assumptions

The raw volumes obtained from the strategic modelling component of this study were generally reasonable on most arterial roads, such as Findon Road and Harvest Home Road, but were less reliable on local and collector roads.

On some minor roads, turning movements occasionally had zero flows on the minor approaches of intersections serving local developments. This was due to the coarse nature of the road network assumed in the strategic model and is common for citywide models such as VITM.

This issue was dealt with by setting the zero turning flows to an appropriate minimum flow, which we have judged to be 10 vehicles per hour per movement. All flows were adjusted systematically; no ad-hoc adjustments were made.

4.1.2 Turning volume summaries

The following diagrams summarise the adjusted turning movements for the AM and PM peak periods for the 2026 base and 2046 Scenario 1. The results are expressed as hourly volumes and have been rounded to the nearest multiple of five vehicles.

Figure 4.2 : 2026 Base Turning Movements

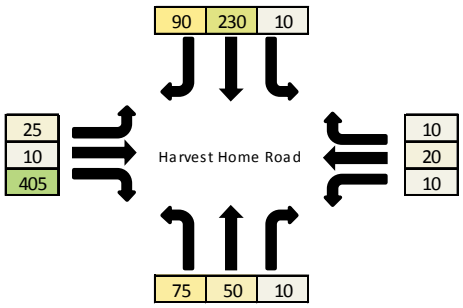
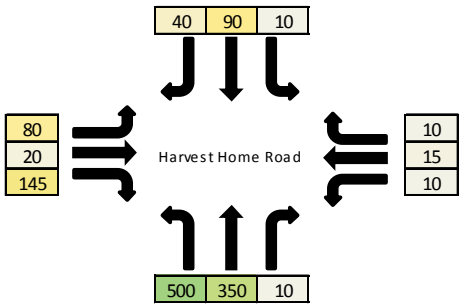
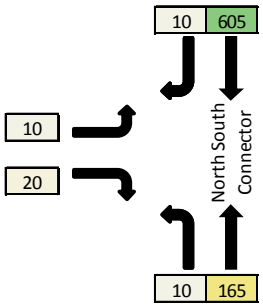
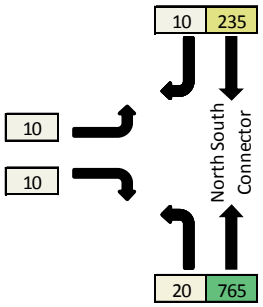
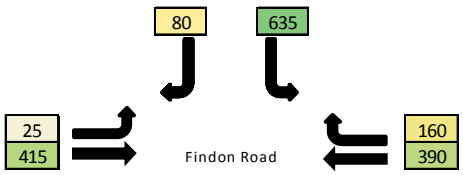
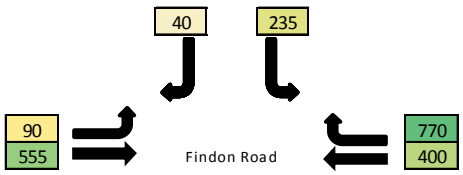
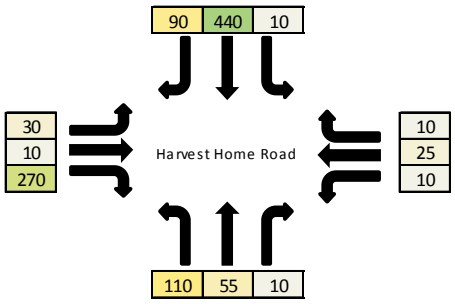
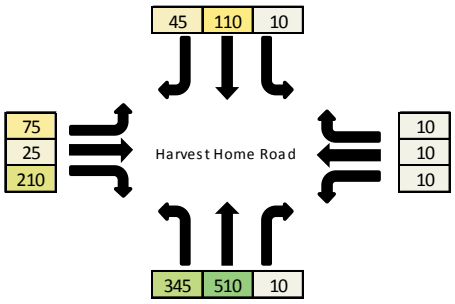
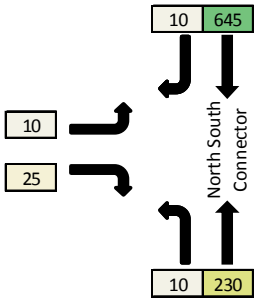
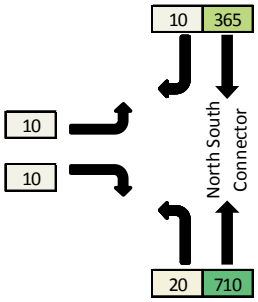
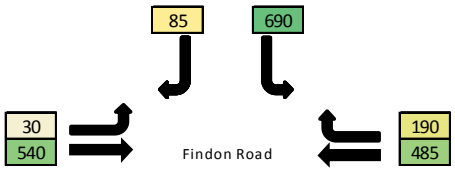
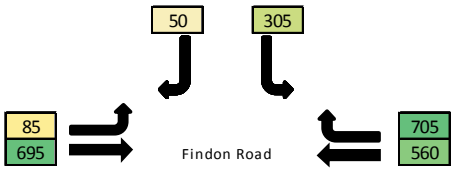
<table>
<tr><th colspan="3">2026 BASE HOURLY TURNING MOVEMENT VOLUMES</th></tr>
<tr><th rowspan="2">Intersection</th><th>AM PEAK (7-9am)</th><th>PM PEAK (3-6pm)</th></tr>
<tr><th>HOURLY TURNING MOVEMENT VOLUMES</th><th>HOURLY TURNING MOVEMENT VOLUMES</th></tr>
<tr><td>Intersection 1</td><td> 
</td><td> 
</td></tr>
<tr><td>Intersection 2</td><td> 
</td><td> 
</td></tr>
<tr><td>Intersection 3</td><td> 
</td><td> 
</td></tr>
</table>

Figure 4.3 : 2026 Base Turning Movements

2046 SCENARIO 1 HOURLY TURNING MOVEMENT VOLUMES		
Intersection	AM PEAK (7-9am) HOURLY TURNING MOVEMENT VOLUMES	PM PEAK (3-6pm) HOURLY TURNING MOVEMENT VOLUMES
Intersection 1		
Intersection 2		
Intersection 3		

4.2 SIDRA Intersection Modelling

SIDRA Intersection analysis software was used to calculate the levels of service at each intersection and to help optimise the intersection layouts.

4.2.1 Assessment Criteria

The criteria used to determine the configuration of lanes on each approach were as follows:

- A minimum level of service D, corresponding to average intersection delays of less than 55 seconds per vehicle.
- Degree of saturation generally less than 0.9 (i.e. volumes should be less than 90% of each movement's capacity);
- 95th percentile queue lengths generally less than 150 metres;
- Effective stop rates less than 1.0 (i.e. each vehicle can proceed through the signals within a single signal cycle);
- Intersection layout should generally conform to VicRoads design practice (for example, ensuring that the number of departure lanes match the number of approach lanes; using indented turning lanes on divided arterial roads).

Full SIDRA output summaries are provided in Appendix B.

4.2.2 Intersection Layouts

The intersection layouts were modelled in tandem with the engineering design work undertaken as part of this study. The same geometric design was adopted for the 2026 and 2046 scenarios.

The recommended intersection layouts (for capacity purposes) are shown in Figure 4.4 to Figure 4.6 on the following pages. The recommended layouts show the minimum configurations that would be required to provide acceptable levels of service in 2046. In some cases, such as at Harvest Home Road (Intersection 1), the engineering design provides additional lanes to allow for bus priority.

Figure 4.4 : Intersection 1 recommended layout – North South Connector and Harvest Home Road

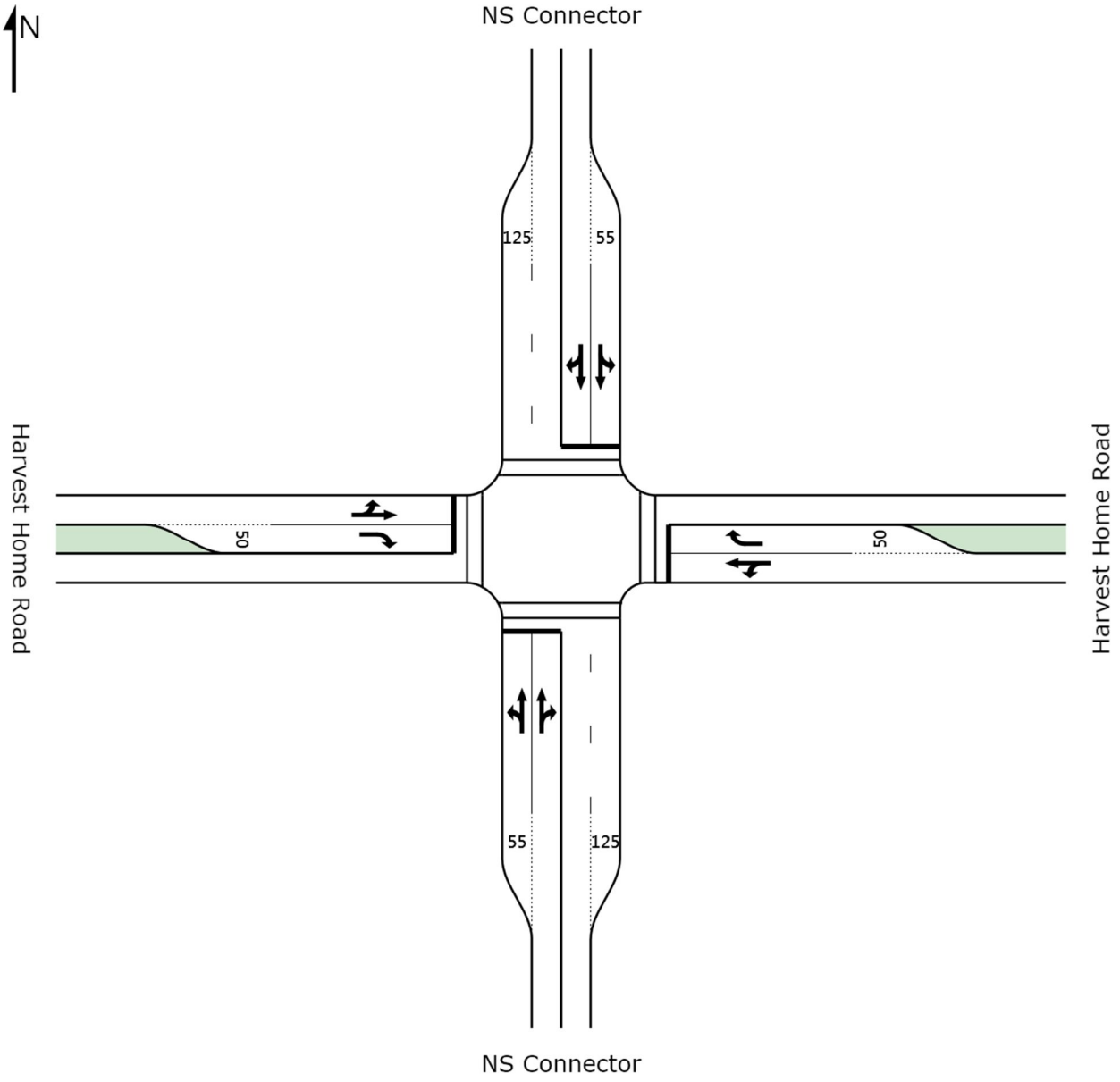


Figure 4.5 : Intersection 2 recommended layout – North South Connector and local town centre access

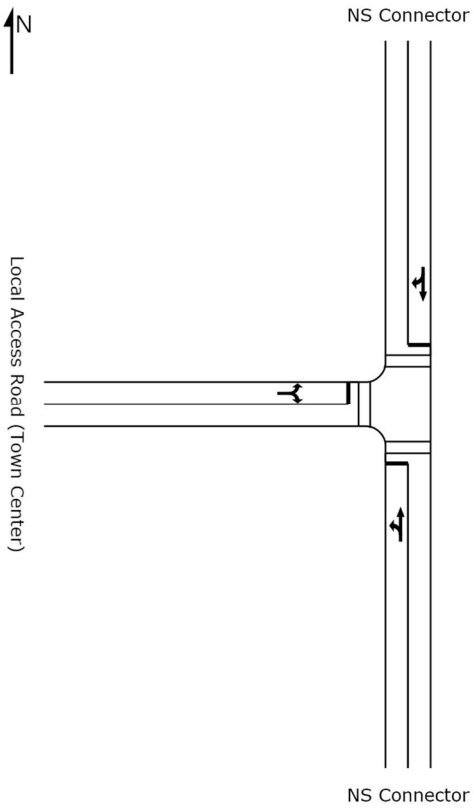
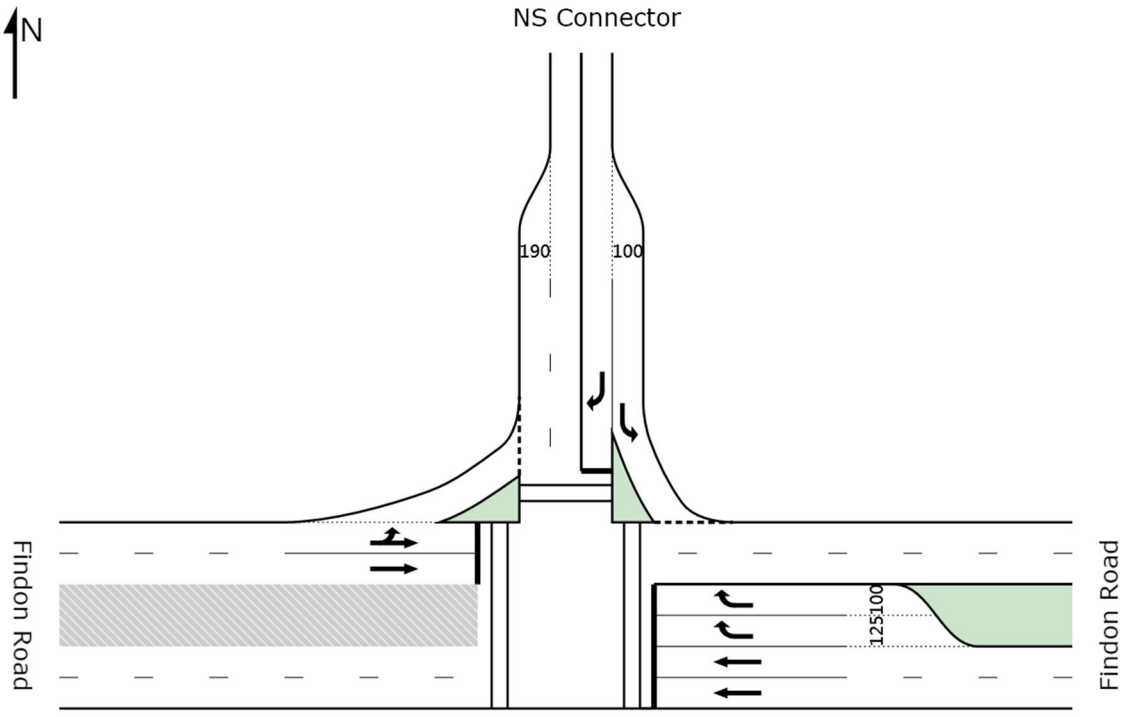


Figure 4.6 : Intersection 3 – North South Connector and Findon Road



4.2.3 Summary of Results

The following tables provide a summary of the performance indicators for each intersection with the layouts as shown in the previous section. These show that all performance criteria have been met while not overproviding intersection infrastructure.

Table 4.1 : 2026 Base AM Peak Summary Results

Intersection	LOS	Average Delay (sec/veh)	DOS	Highest DOS	95th %ile Queue (m)	Longest queue	Effective Stop Rate
1 - North South Connector and Harvest Home Road	C	23	0.77	West	60	West	0.75
2 - North South Connector and Town Center	A	8	0.67	North	67	North	0.64
3 - North South Connector and Findon Road	B	18	0.61	North	65	North	0.70

LOS = Level of Service DOS= Degree of Saturation

Table 4.2 : 2026 Base PM Peak Summary Results

Intersection	LOS	Average Delay (sec/veh)	DOS	Highest DOS	95th %ile Queue (m)	Longest queue	Effective Stop Rate
1 - North South Connector and Harvest Home Road	B	20	0.70	South	99	South	0.65
2 - North South Connector and Town Center	A	8	0.78	South	99	South	0.69
3 - North South Connector and Findon Road	C	26	0.79	East	100	East	0.78

LOS = Level of Service DOS= Degree of Saturation

Table 4.3 : 2046 Base AM Peak Summary Results

Intersection	LOS	Average Delay (sec/veh)	DOS	Highest DOS	95th %ile Queue (m)	Longest queue	Effective Stop Rate
1 - North South Connector and Harvest Home Road	C	24	0.69	West	87	North	0.73
2 - North South Connector and Town Center	A	8	0.68	North	74	North	0.63
3 - North South Connector and Findon Road	B	19	0.70	North	88	North	0.73

LOS = Level of Service DOS= Degree of Saturation

Table 4.4 : 2046 Base PM Peak Summary Results

Intersection	LOS	Average Delay (sec/veh)	DOS	Highest DOS	95th %ile Queue (m)	Longest queue	Effective Stop Rate
1 - North South Connector and Harvest Home Road	B	20	0.70	South	96	South	0.75
2 - North South Connector and Town Center	A	8	0.72	South	87	South	0.64
3 - North South Connector and Findon Road	C	25	0.74	East	91	East	0.78

LOS = Level of Service DOS= Degree of Saturation

5. Conclusion

This report has described the strategic modelling process and results for the Quarry Hills PSP for several scenarios in 2026 and 2046.

The modelling indicates that the proposed road network within Quarry Hills will have sufficient capacity to accommodate forecast traffic volumes in 2026 and 2046. Further findings are summarised in the sections below.

5.1.1 North-South Connector

Most traffic forecast within the Quarry Hills PSP is expected to be local to the area, although the North-South Connector will attract some additional through traffic if the OMR and E6 are not constructed. The analysis indicates that a two-lane road would be sufficient to accommodate forecast traffic volumes.

The alternative routing of the North-South Connector within Quarry Hills (Scenario 2) does not have a material effect on traffic volumes or patterns through the area.

5.1.2 Harvest Home Road

Harvest Home Road will provide a key connection between Quarry Hills and areas to the west of the PSP area. The analysis indicates that Harvest Home Road may attract some east-west traffic moving between Epping and Findon Road, but otherwise serves an access function for the town centre.

5.1.3 E6 Freeway

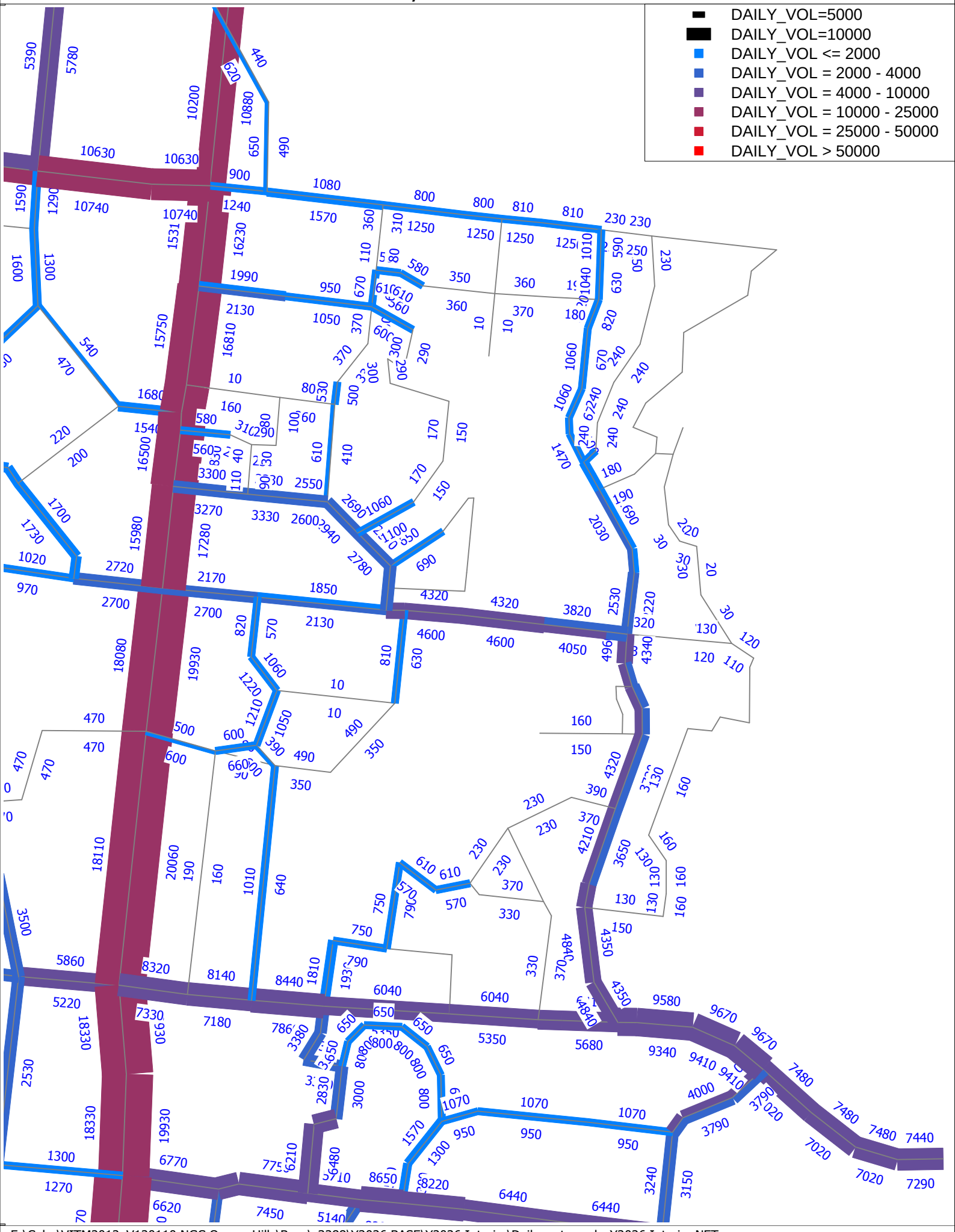
In the scenarios containing the E6 freeway, the E6 is forecast to be moderately congested in the peak periods, with predominantly southbound flows in the AM peak and northbound flows in the PM peak. The E6 is expected to help reduce congestion on Epping Road.

5.1.4 Findon Road

Some capacity constraints were observed in the 2046 model results for Findon Road where it meets the North-South Connector. This was especially the case in the eastern sections of Findon Road where there only a single lane has been modelled in each direction. Although this is outside the Quarry Hills PSP area, these results suggest that additional capacity may be needed for Findon Road by 2050.

Appendix A. Scenario Results

2026 Quarry Hills Interim Model
Daily Traffic Volumes



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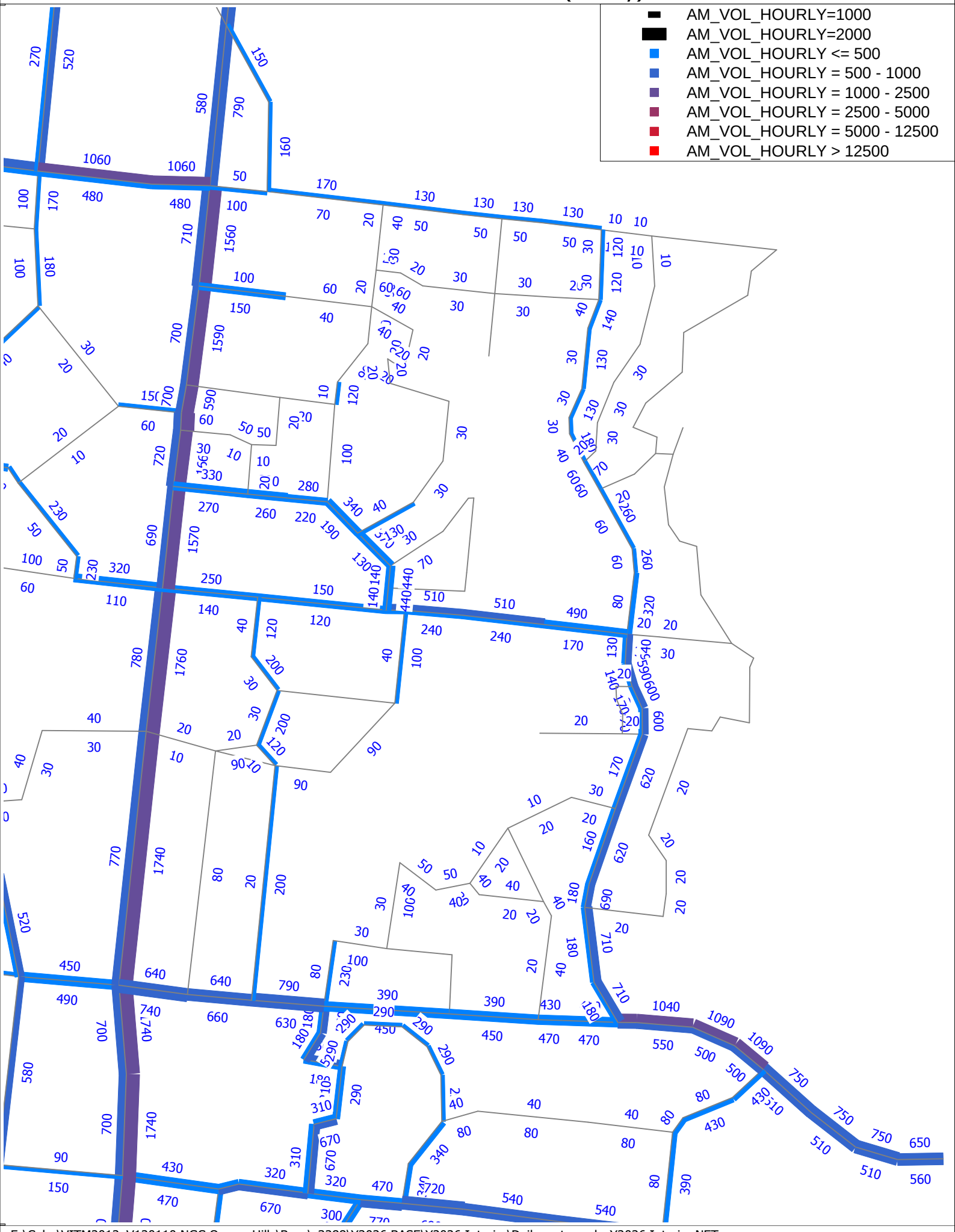
2026 Quarry Hills Interim Model
AM Peak Traffic Volumes (Hourly)



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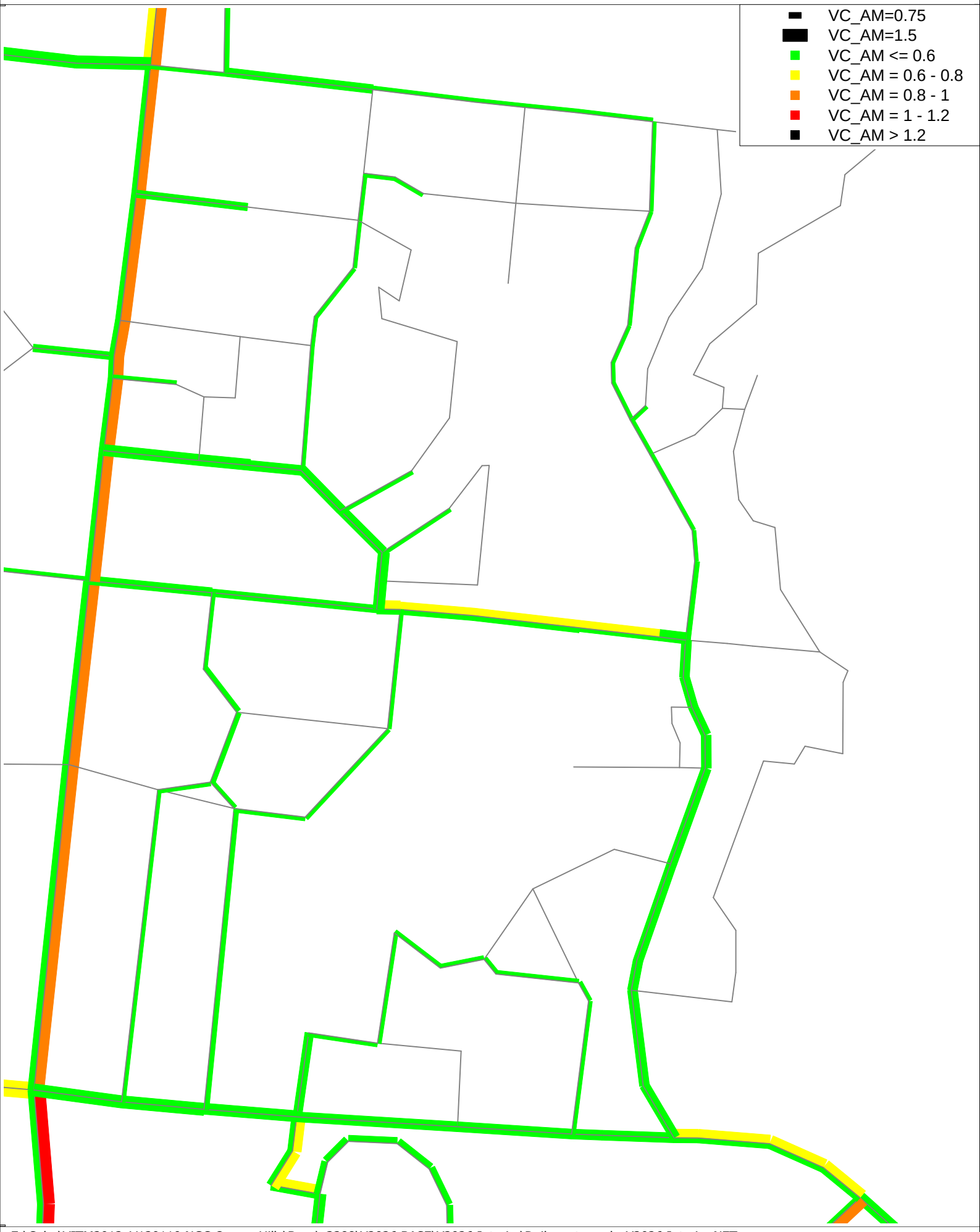
2026 Quarry Hills Interim Model
Volume/Capacity Ratio Plot
AM Peak



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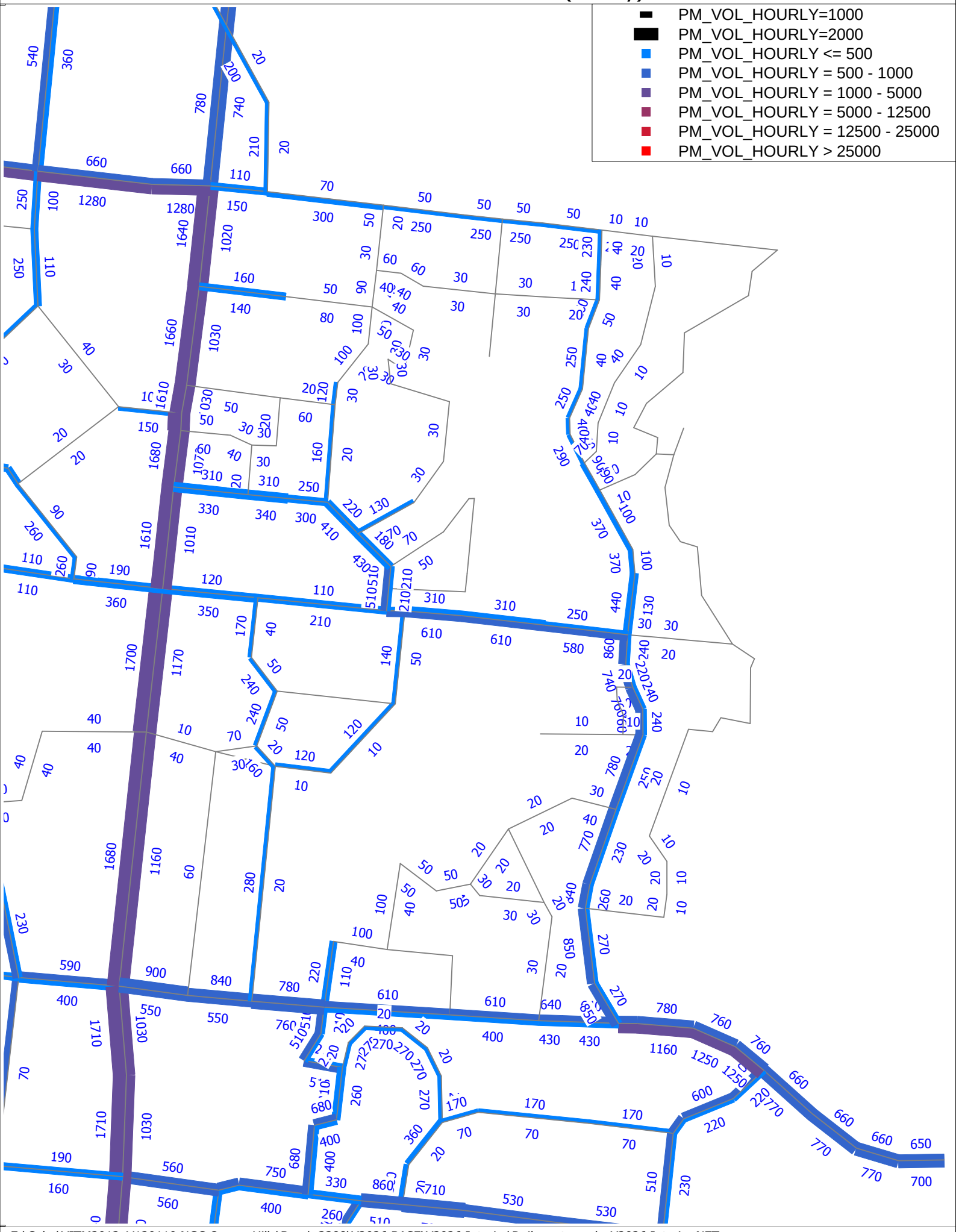
2026 Quarry Hills Interim Model
PM Peak Traffic Volumes (Hourly)



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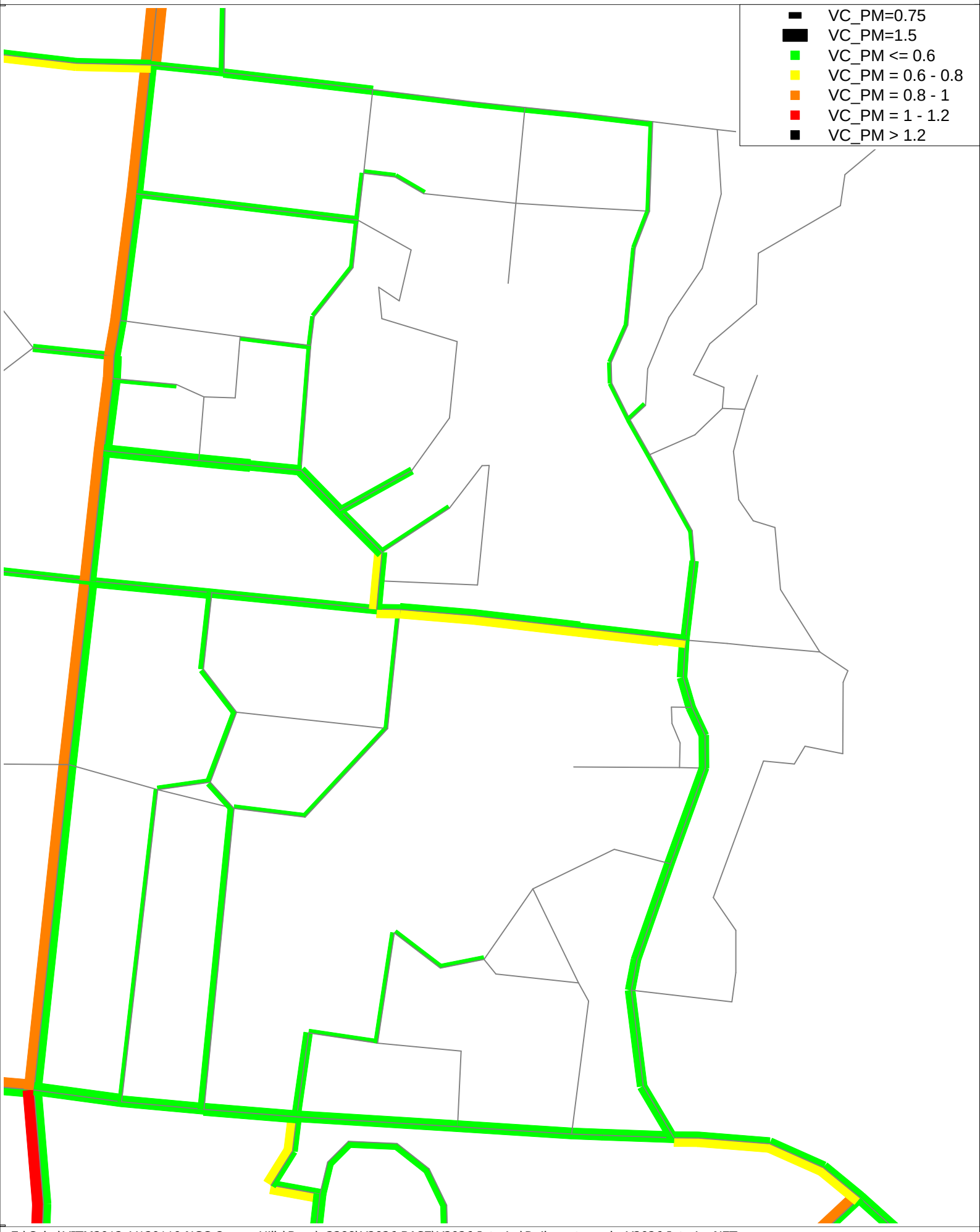
2026 Quarry Hills Interim Model
Volume/Capacity Ratio Plot
PM Peak



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2026 Quarry Hills Interim Model
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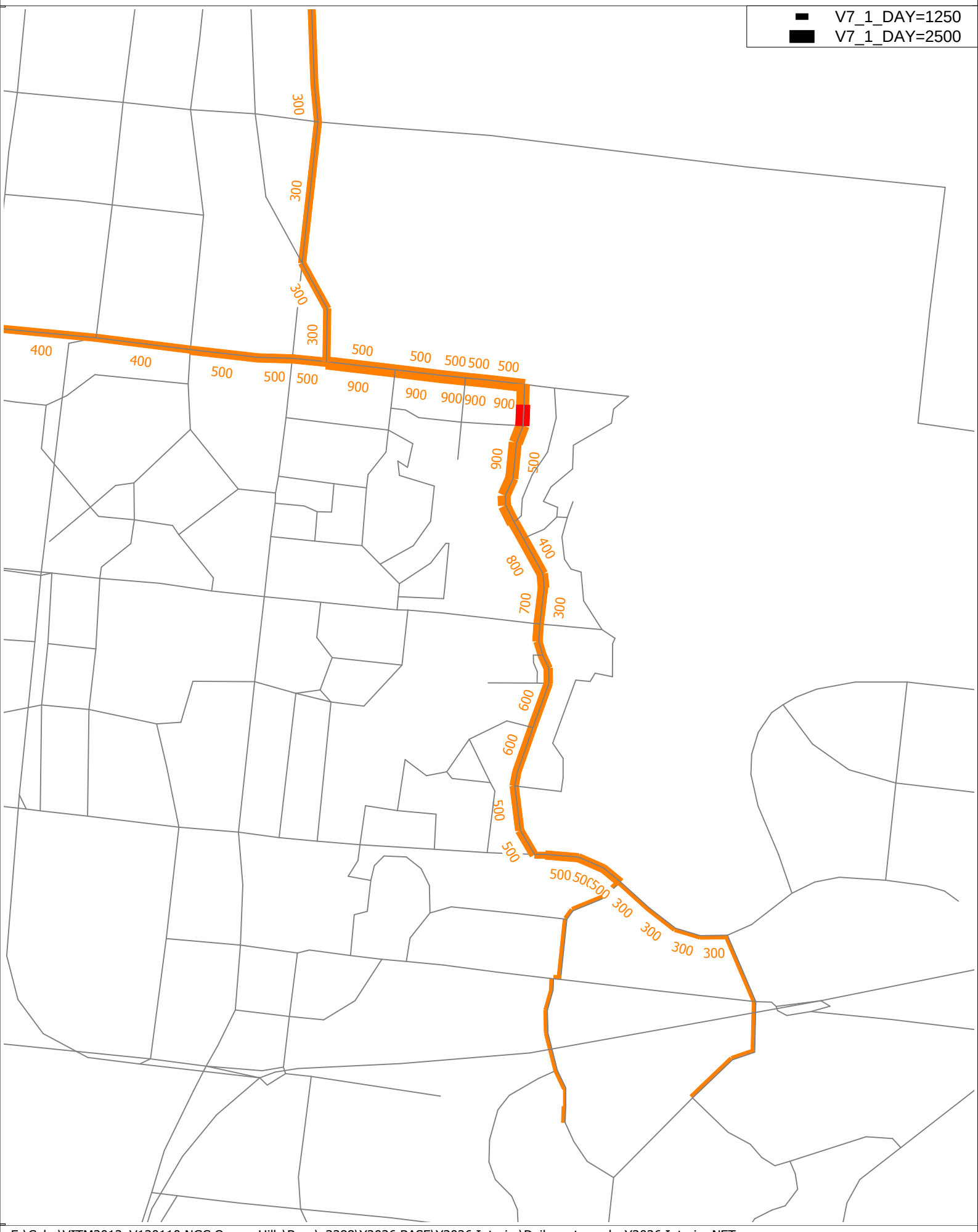
North South Connector South of Lehmans Road



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2026 Quarry Hills Interim Model
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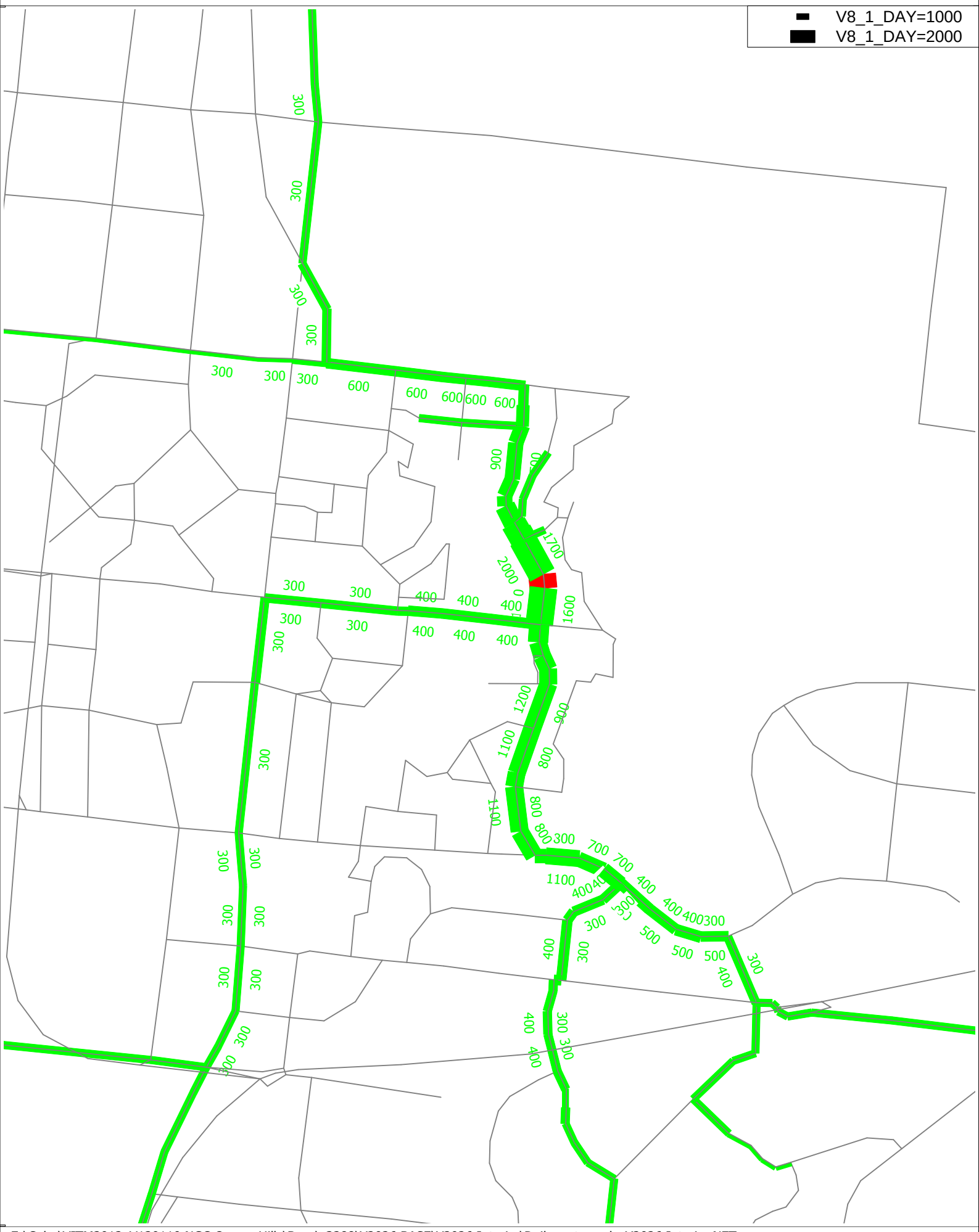
North South Connector North of Harvest Home Road



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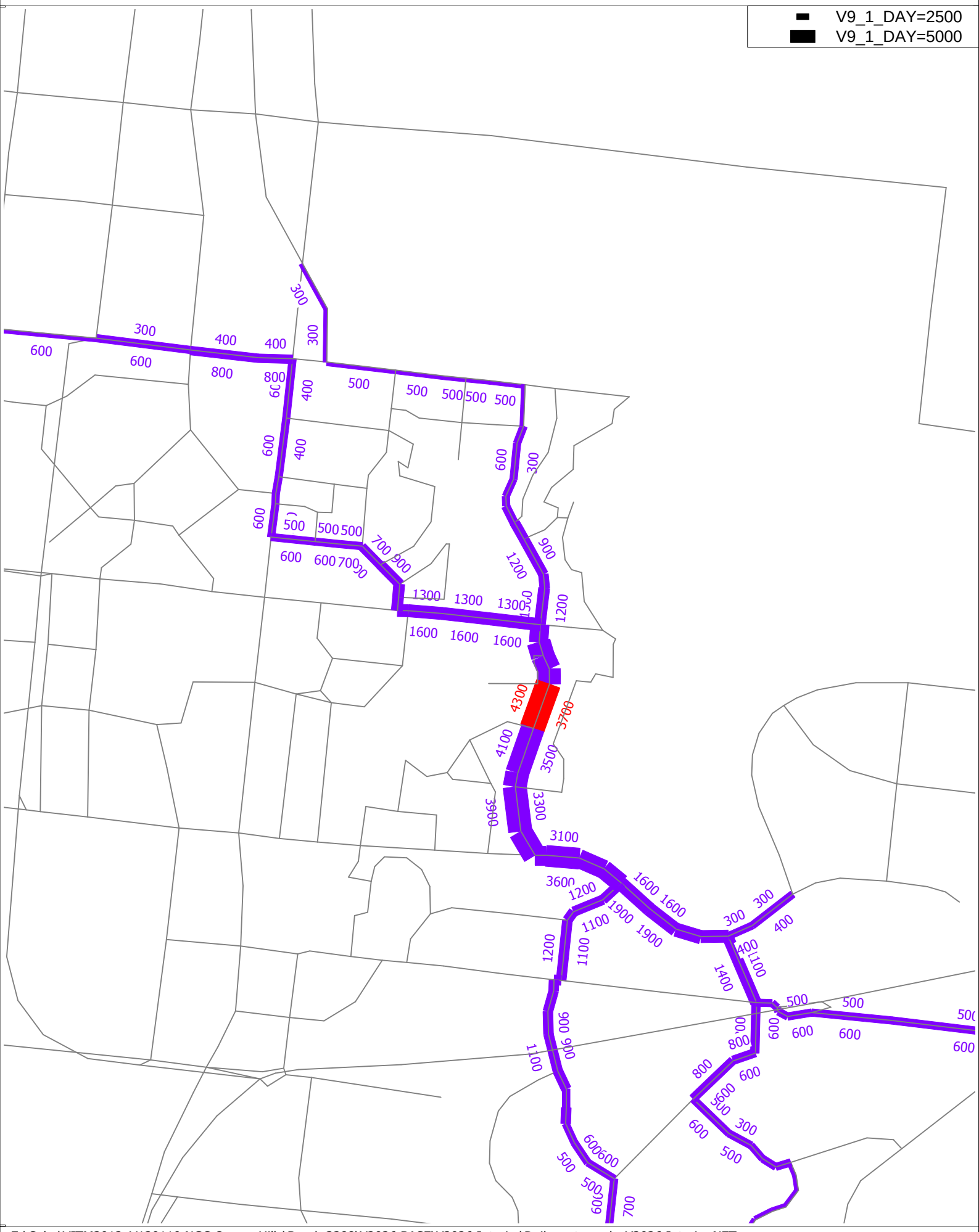
2026 Quarry Hills Interim Model
Select Link Plots - Daily
North South Connector South of Harvest Home Road



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2026 Quarry Hills Interim Model
Select Link Plots - Daily
North South Connector North of Findon Road

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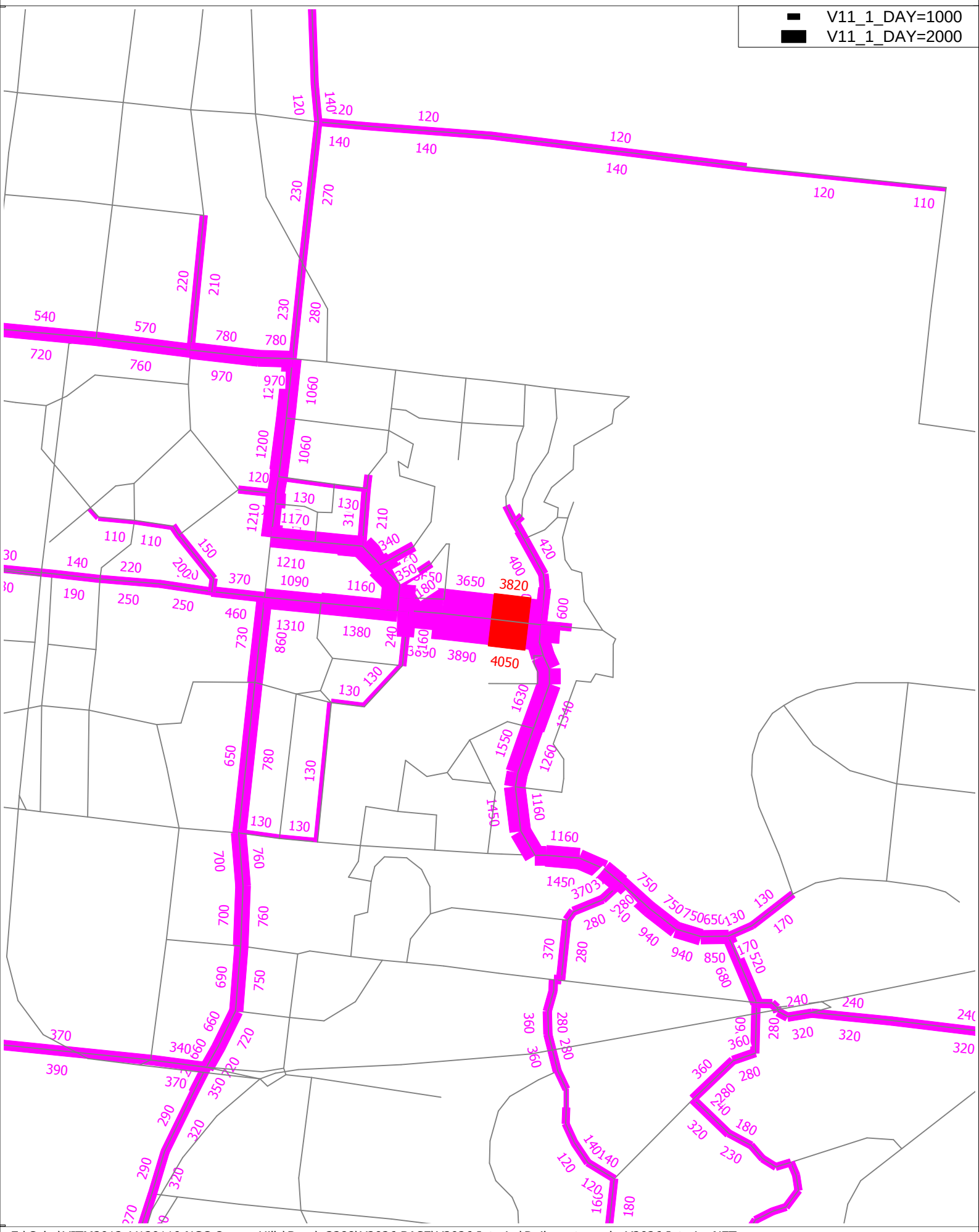
Harvest Home Road East of OMR



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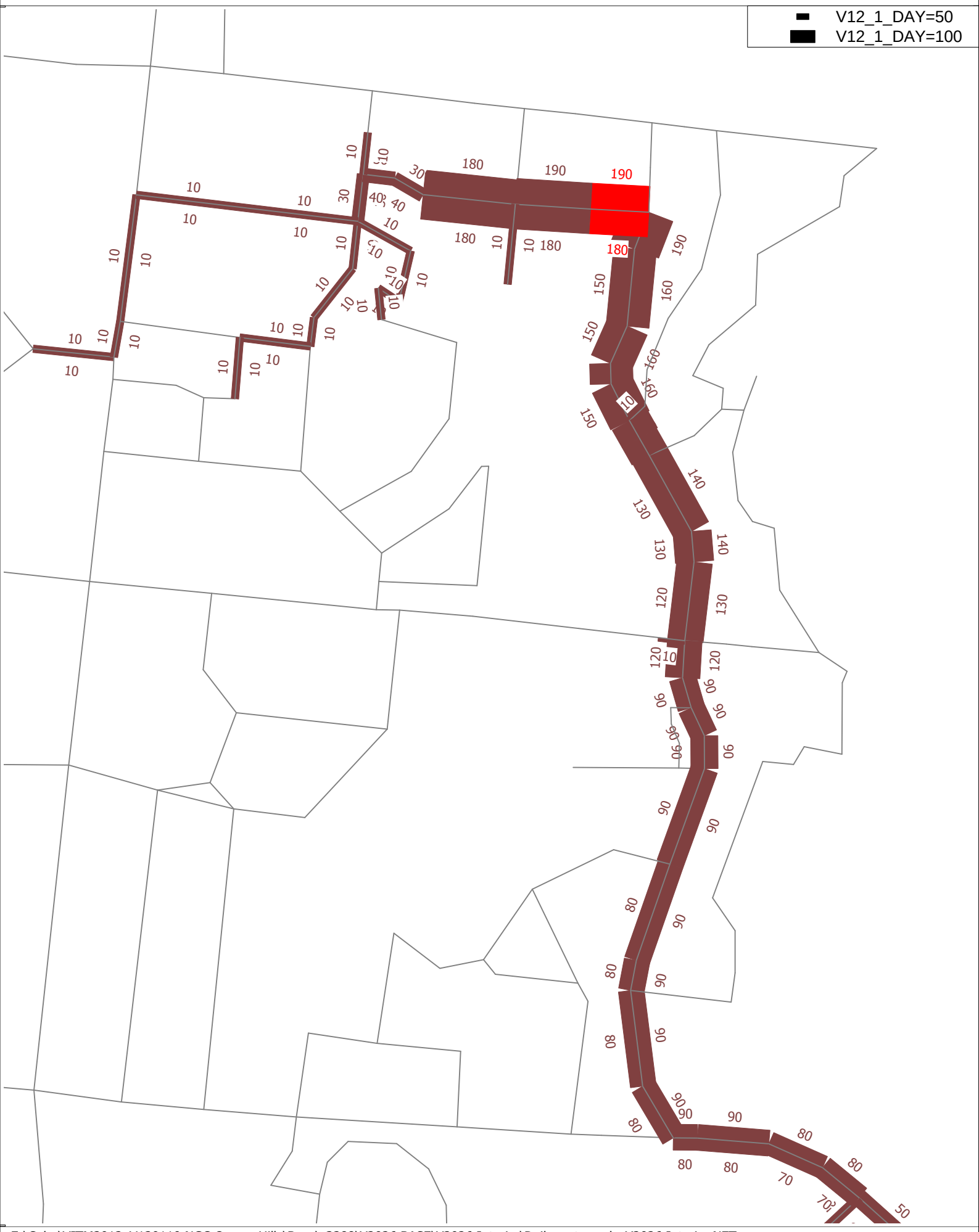
2026 Quarry Hills Interim Model
Select Link Plots - Daily
East West Road 1 East of OMR



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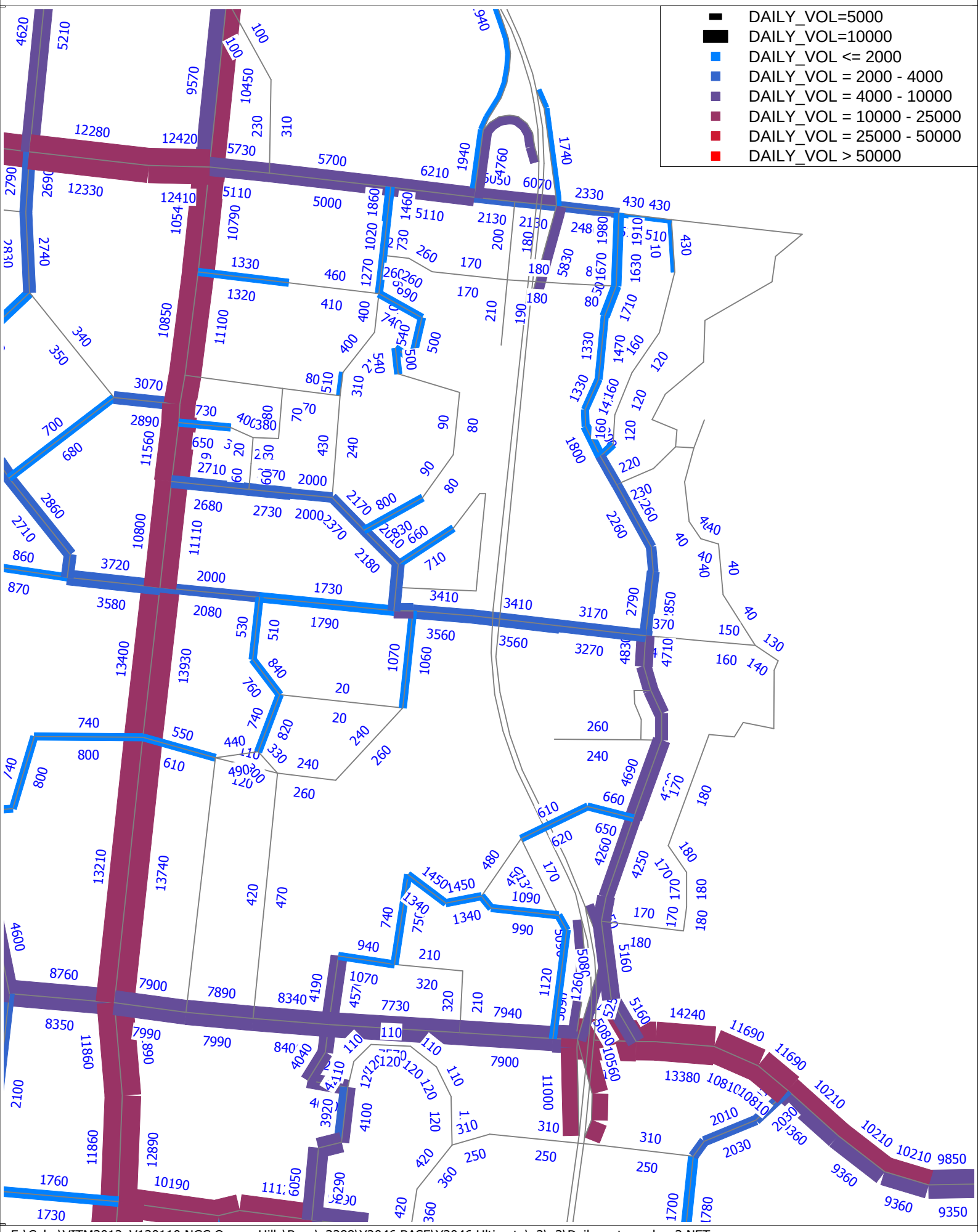
2046 Quarry Hills Ultimate Model v3
Daily Traffic Volumes
OMR Excluded



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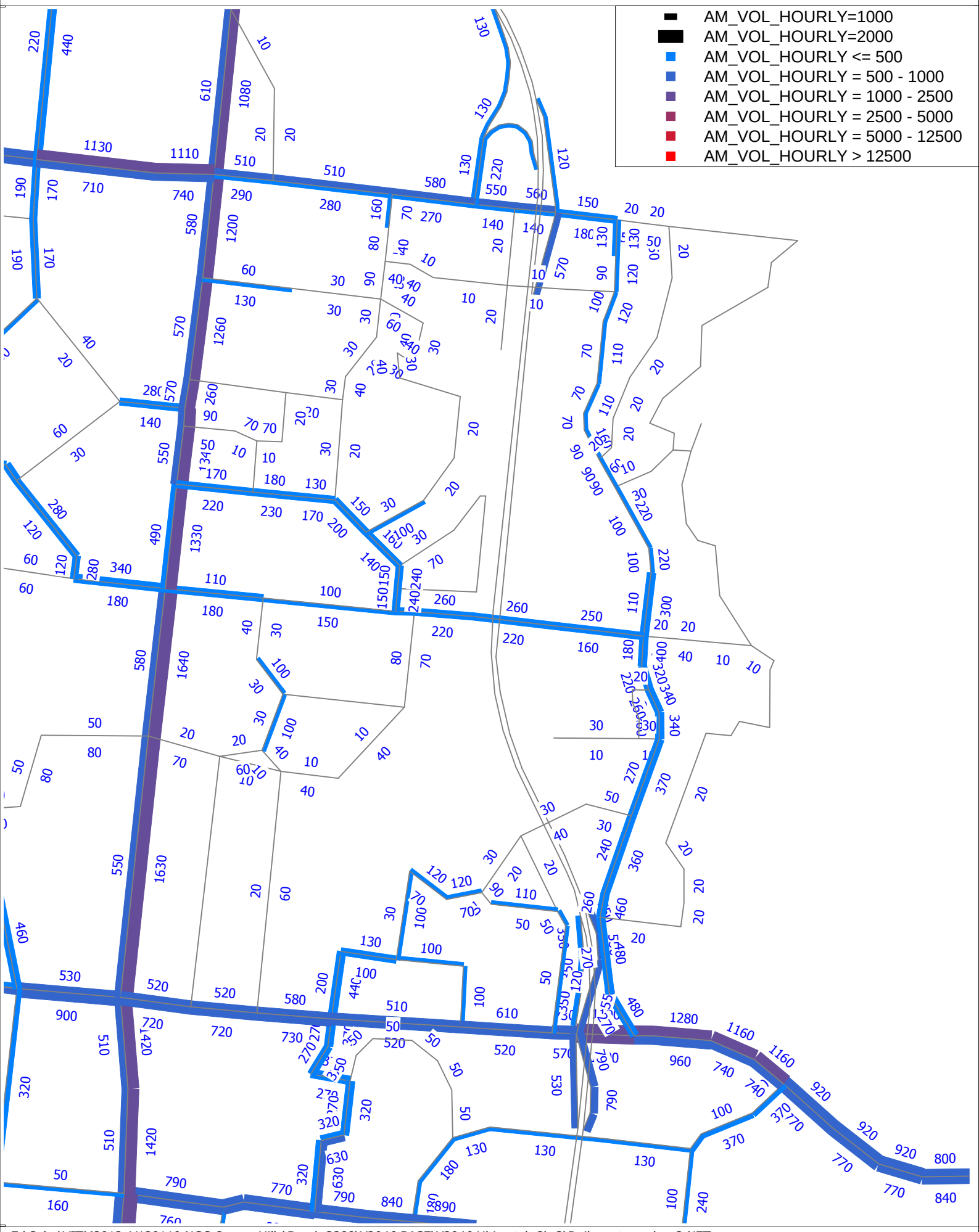
2046 Quarry Hills Ultimate Model v3
AM Peak Traffic Volumes (Hourly)
OMR Excluded



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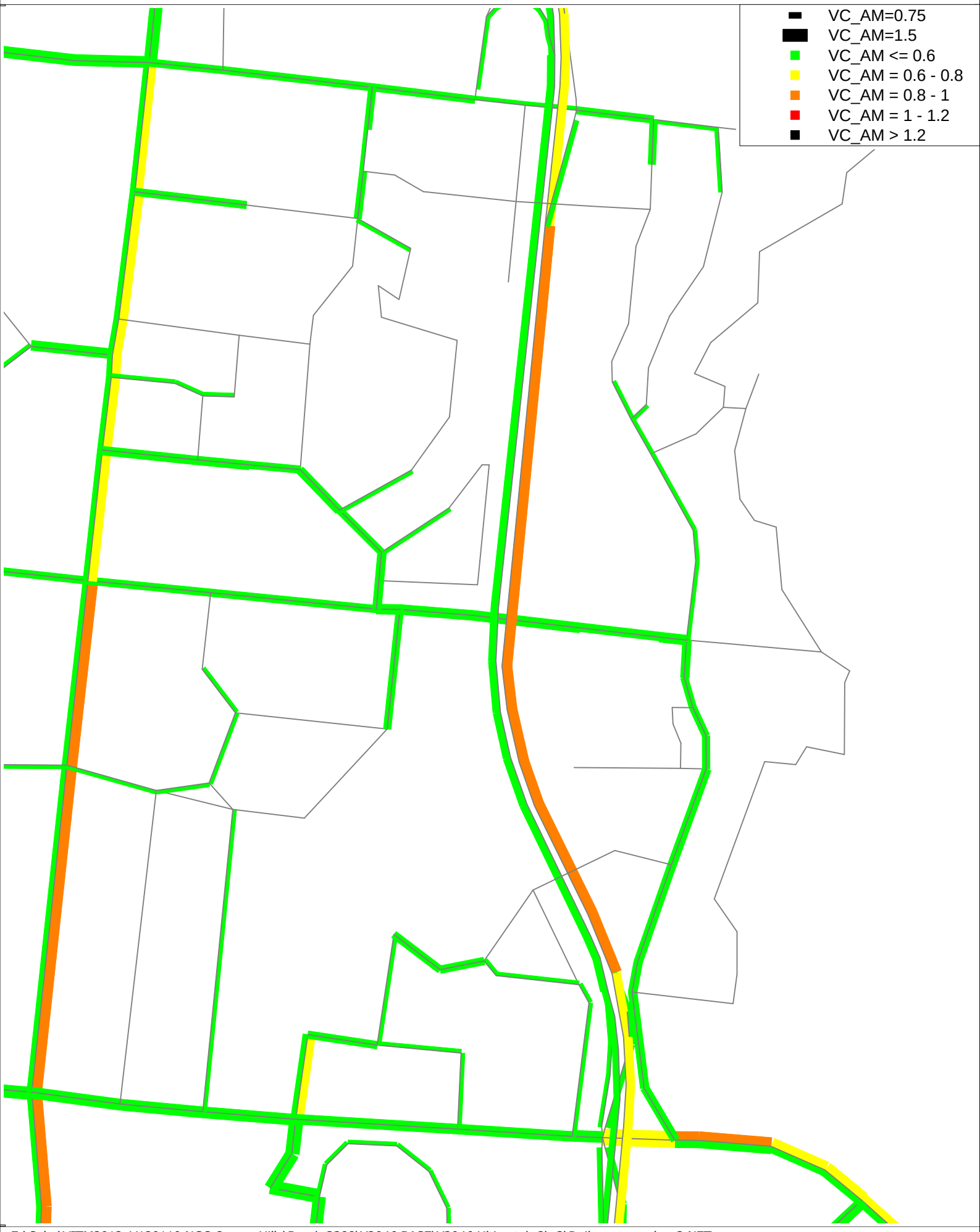
2046 Quarry Hills Ultimate Model v3
Volume/Capacity Ratio Plot
AM Peak



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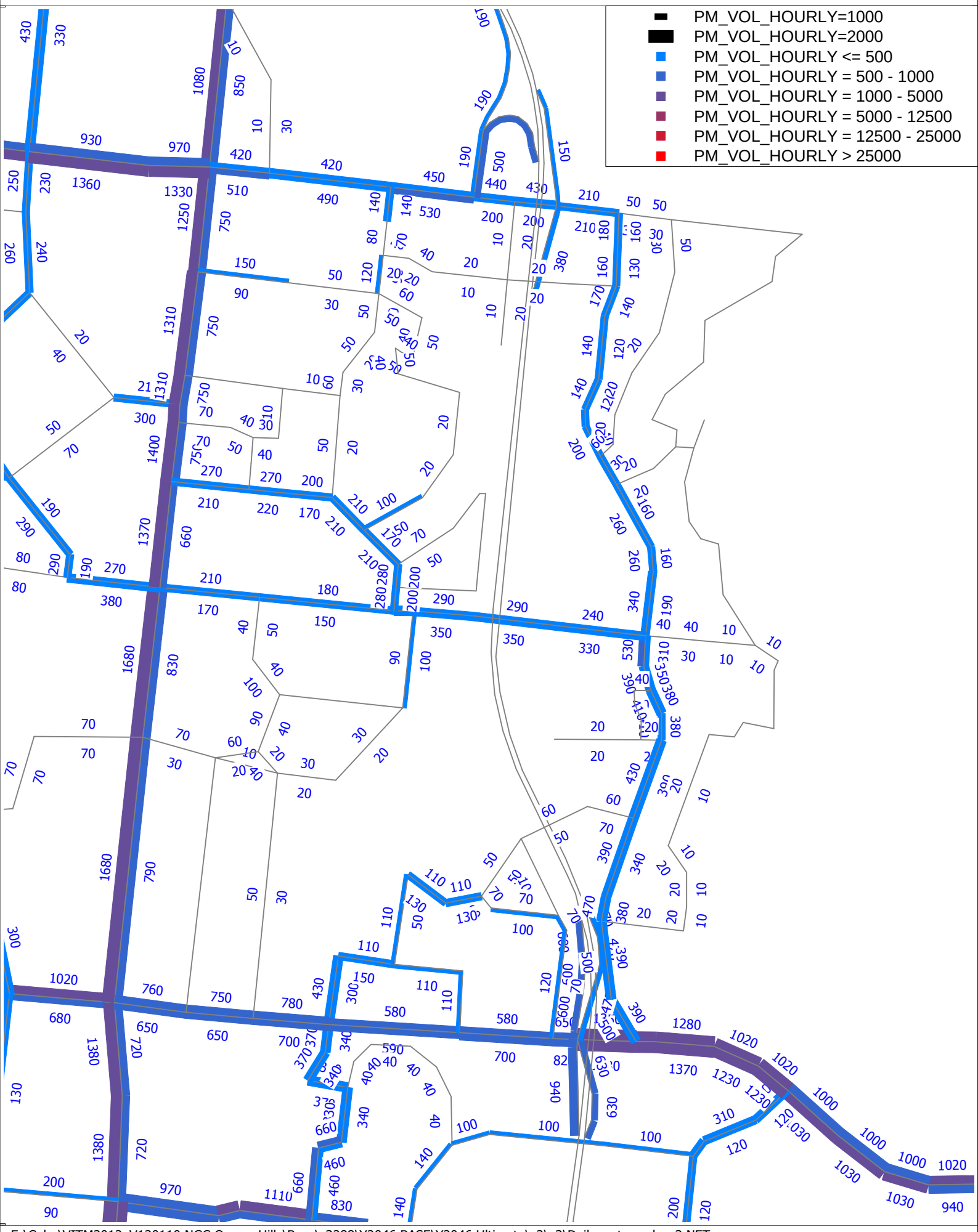
2046 Quarry Hills Ultimate Model v3
PM Peak Traffic Volumes (Hourly)
OMR Excluded



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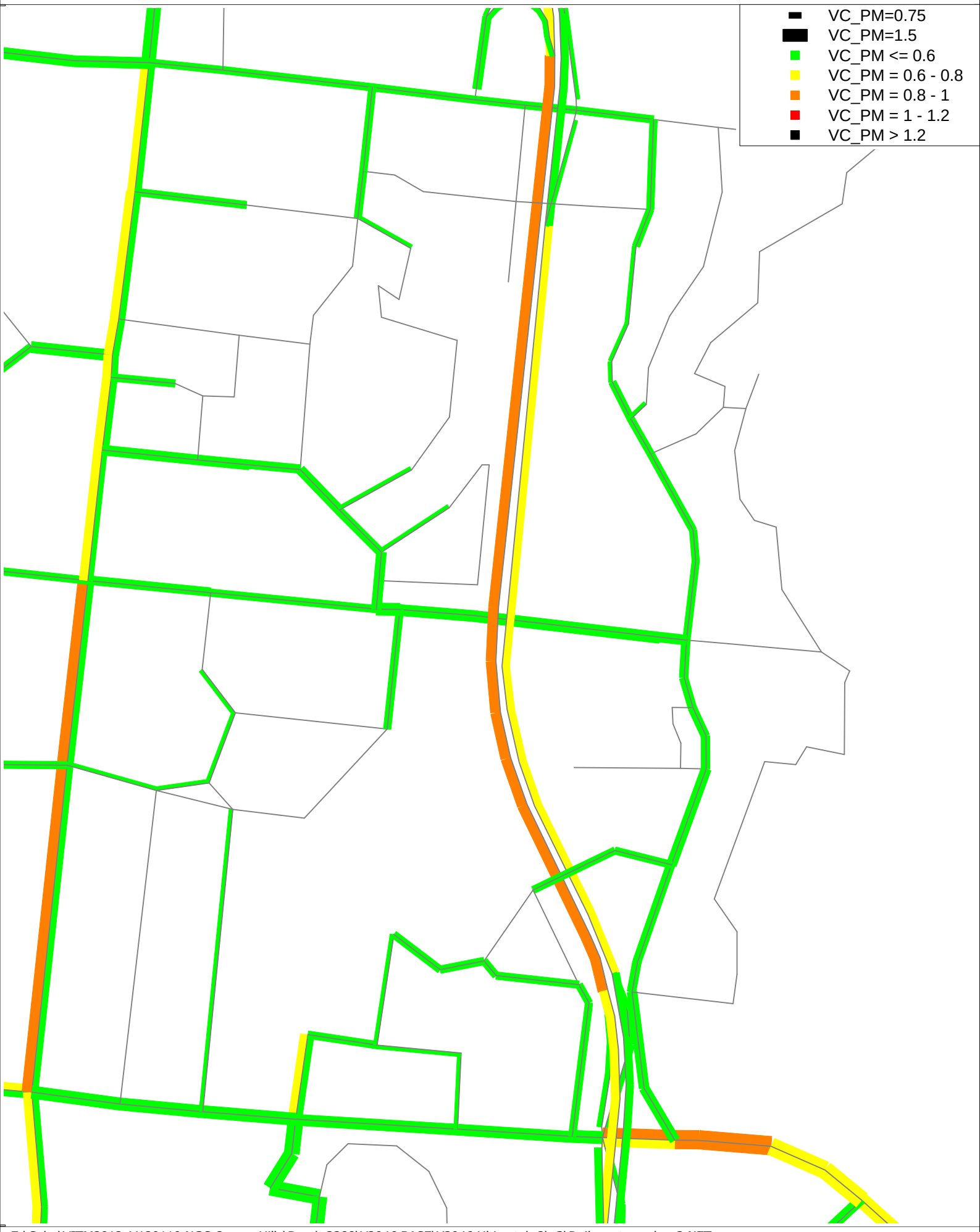
2046 Quarry Hills Ultimate Model v3
Volume/Capacity Ratio Plot
PM Peak



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2046 Quarry Hills Ultimate Model v3
Select Link Plots - Daily
North-South Connector South of Lehmans Road

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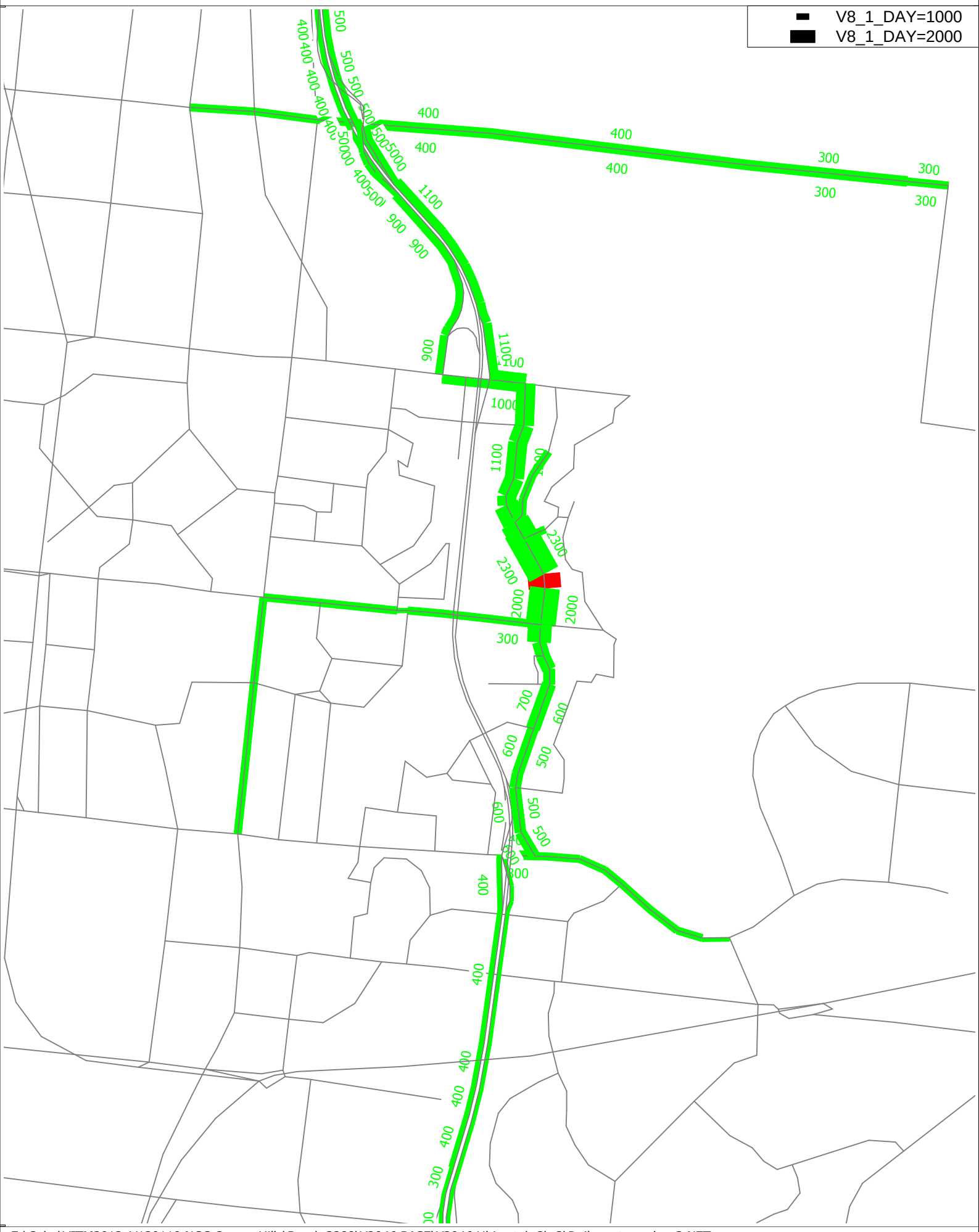
2046 Quarry Hills Ultimate Model v3
Select Link Plots - Daily
North-South Connector North of Harvest Home Road



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2046 Quarry Hills Ultimate Model v3
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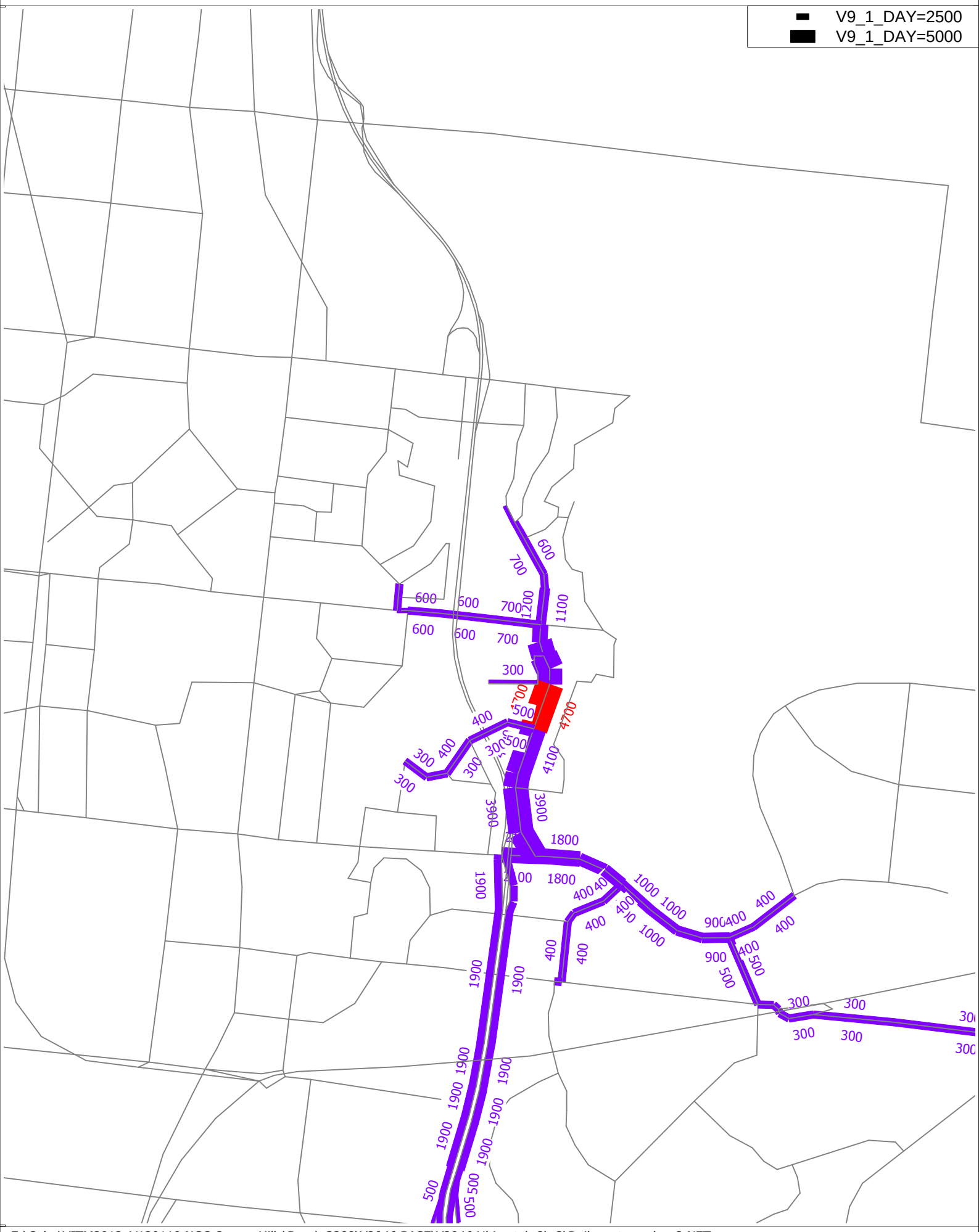

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2046 Quarry Hills Ultimate Model v3
Select Link Plots - Daily
North-South Connector North of Findon Road

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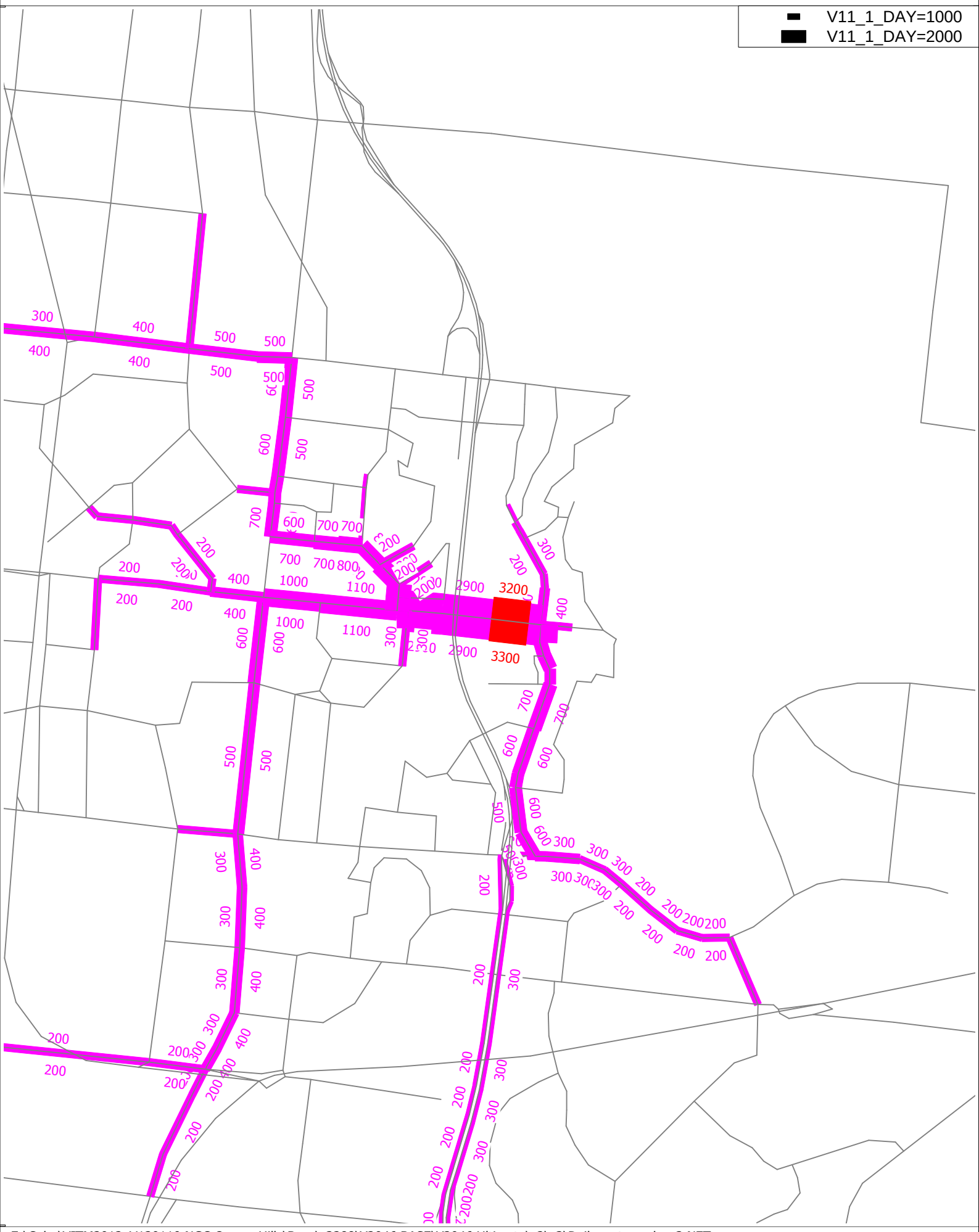
2046 Quarry Hills Ultimate Model v3
Select Link Plots - Daily
Harvest Home Road East of OMR



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2046 Quarry Hills Ultimate Model v3
Select Link Plots - Daily
East West Road 1 East of OMR

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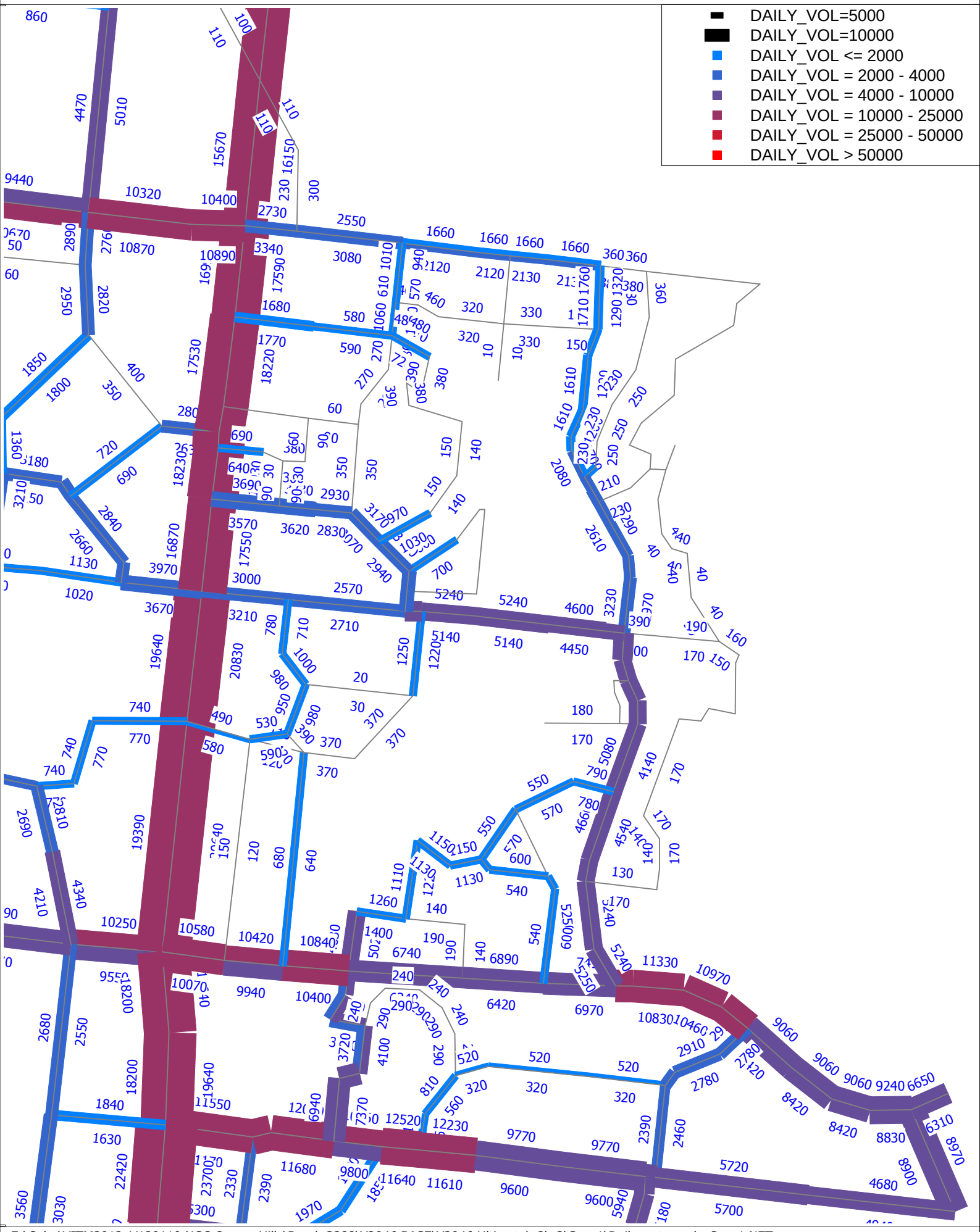
2046 Quarry Hills Scenario 1
Daily Traffic Volumes
OMR Excluded



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2046 Quarry Hills Scenario 1
AM Peak Traffic Volumes (Hourly)
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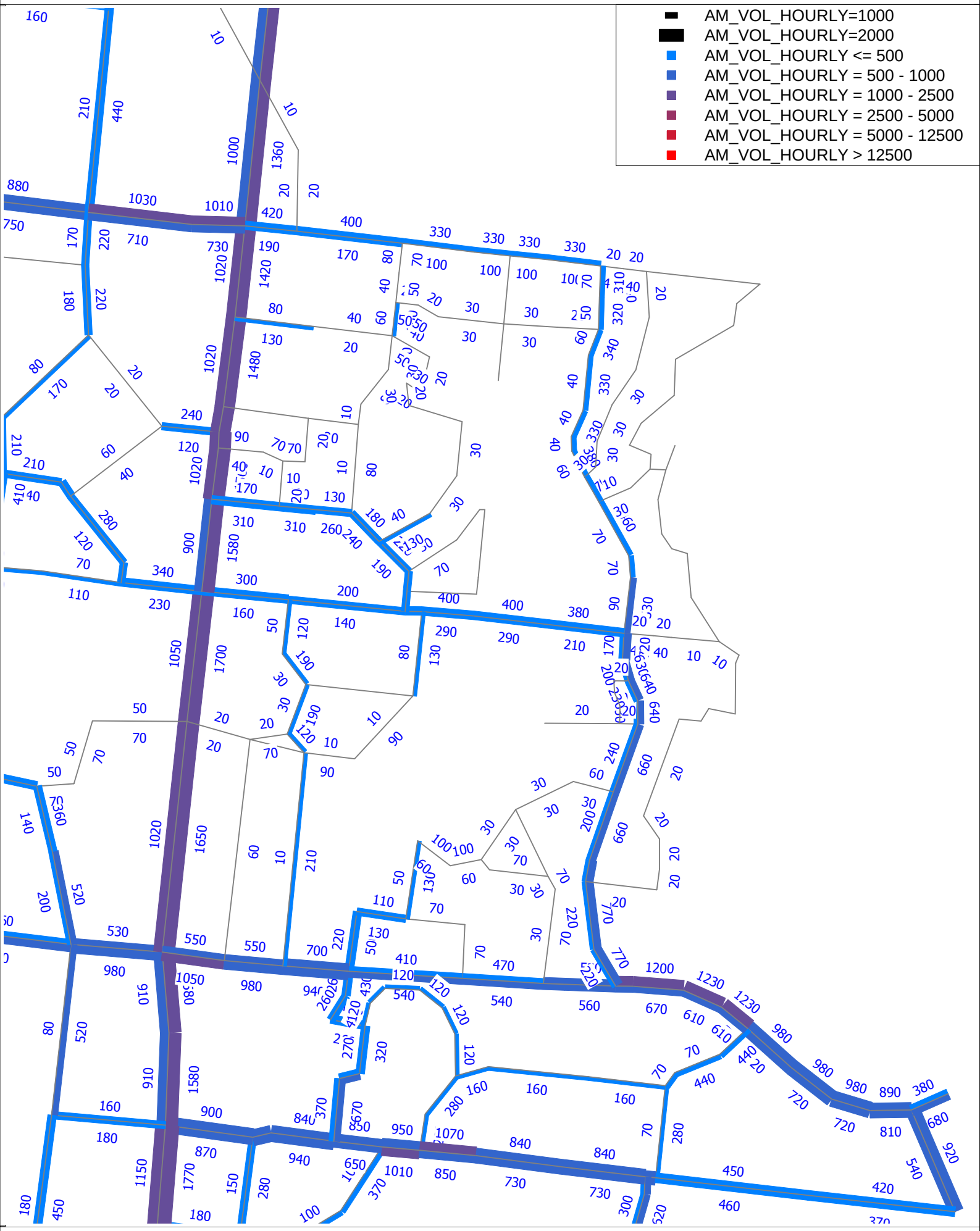

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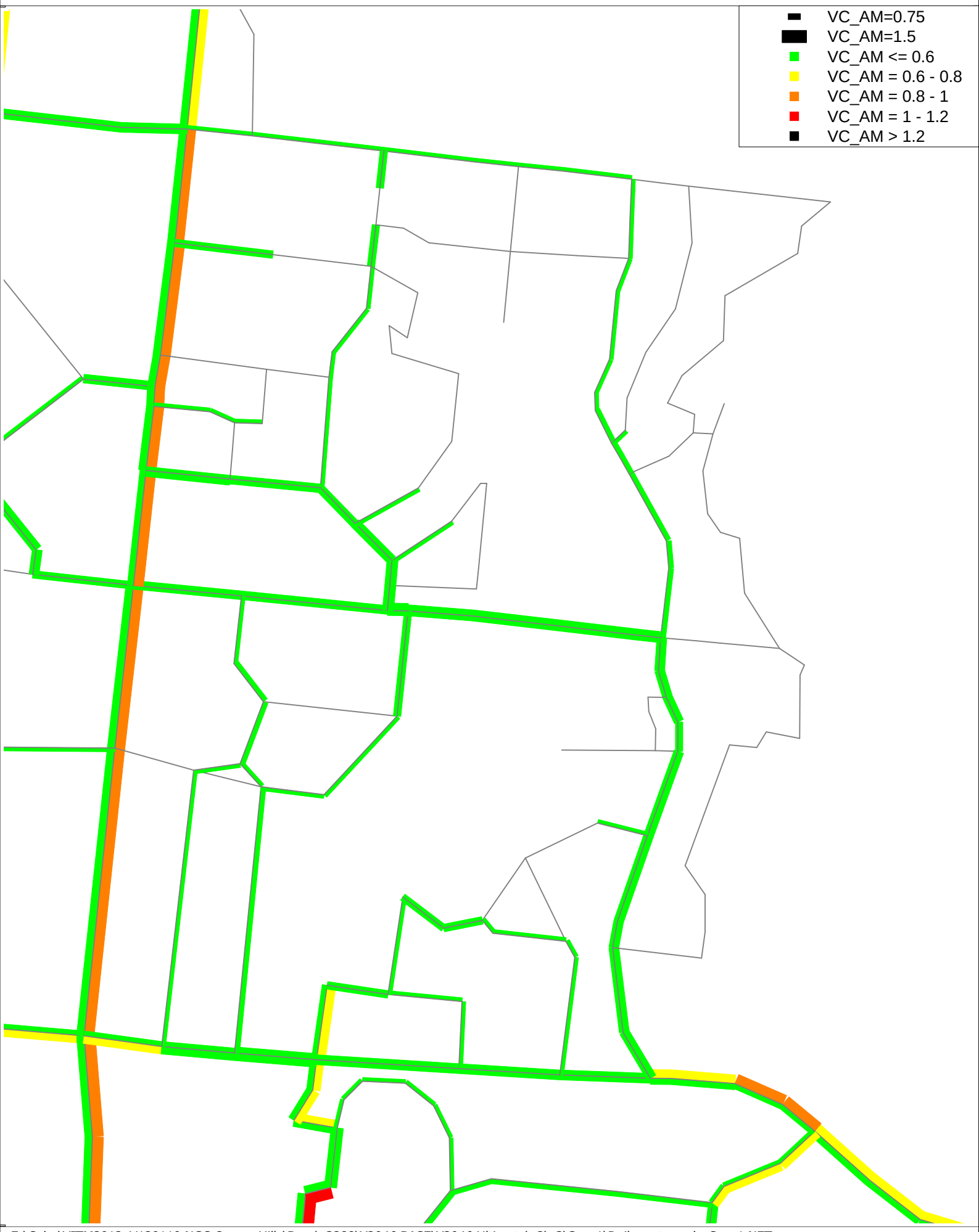
2046 Quarry Hills Scenario 1
Volume/Capacity Ratio Plot
AM Peak



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2046 Quarry Hills Scenario 1
PM Peak Traffic Volumes (Hourly)
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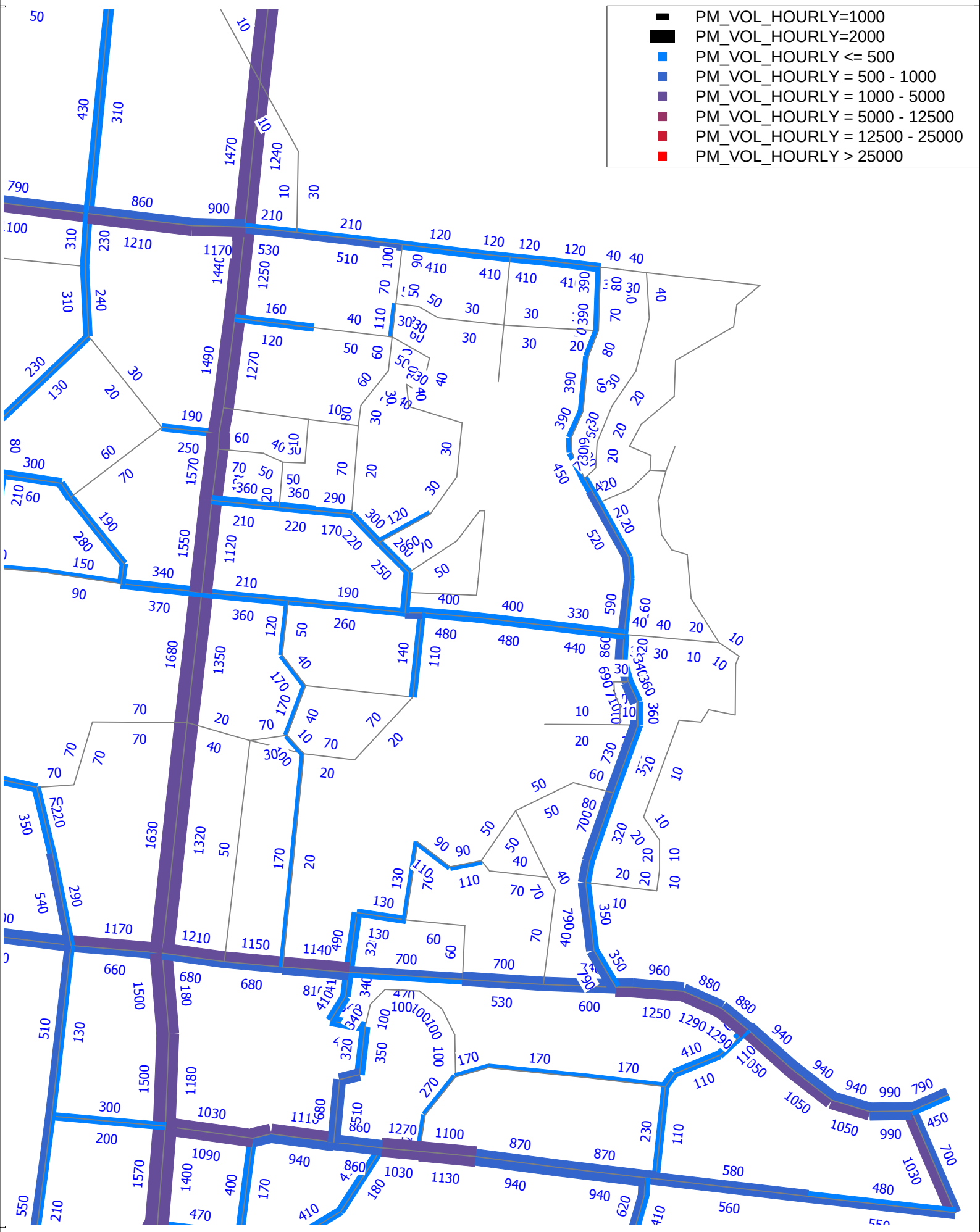

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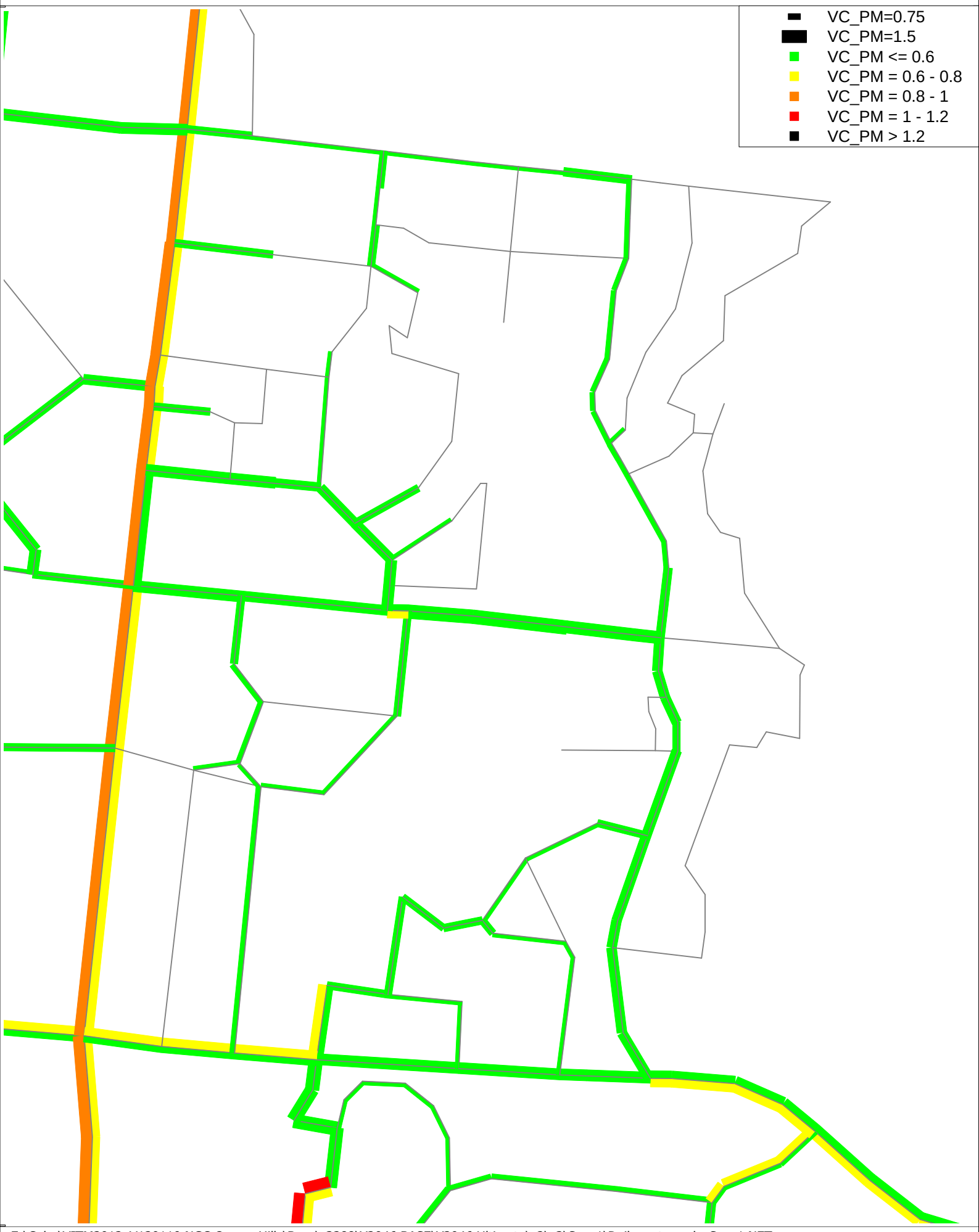
2046 Quarry Hills Scenario 1
Volume/Capacity Ratio Plot
PM Peak



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2046 Quarry Hills Scenario 1
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North-South Connector South of Lehmans Road

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2046 Quarry Hills Scenario 1
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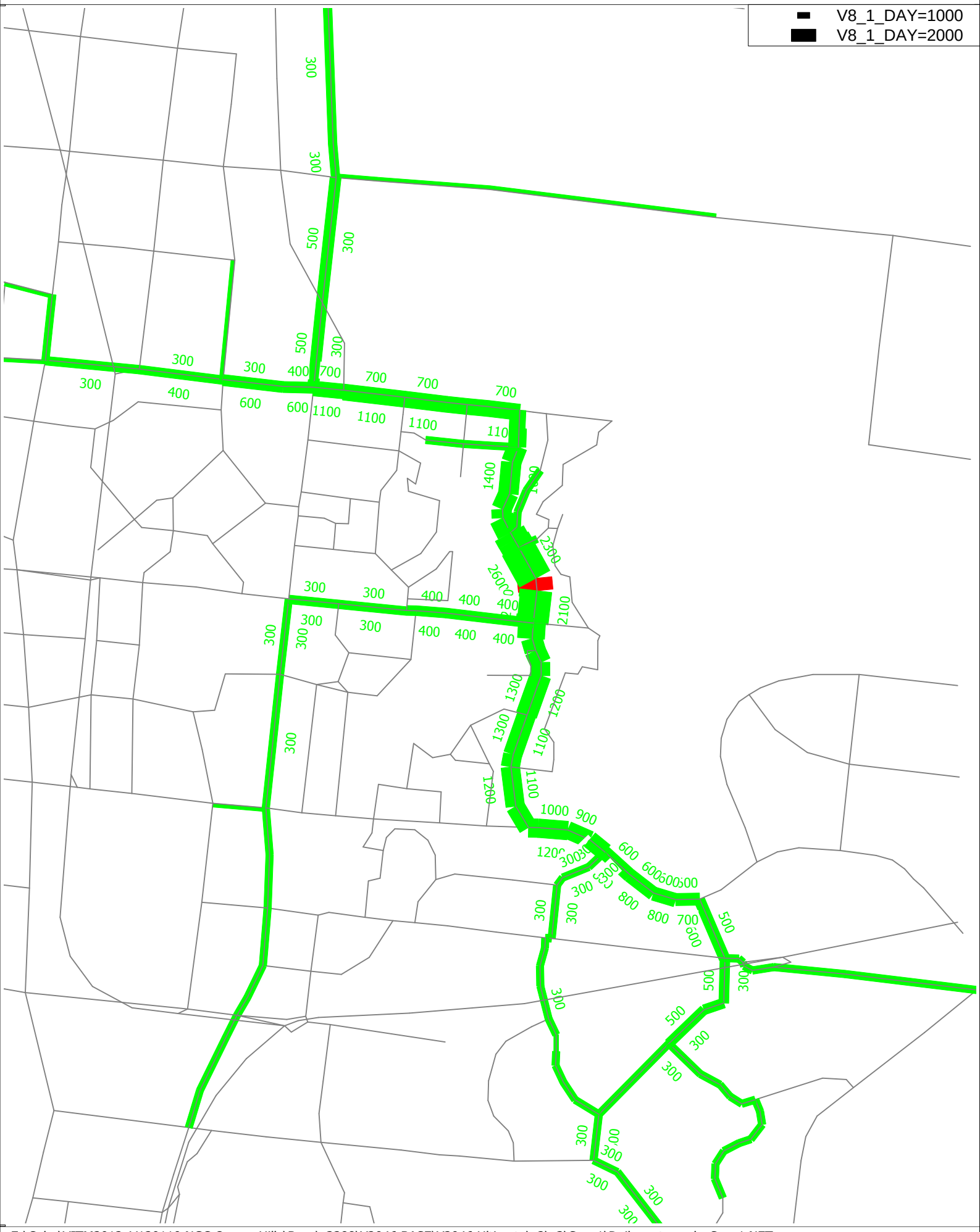
North-South Connector North of Harvest Home Road



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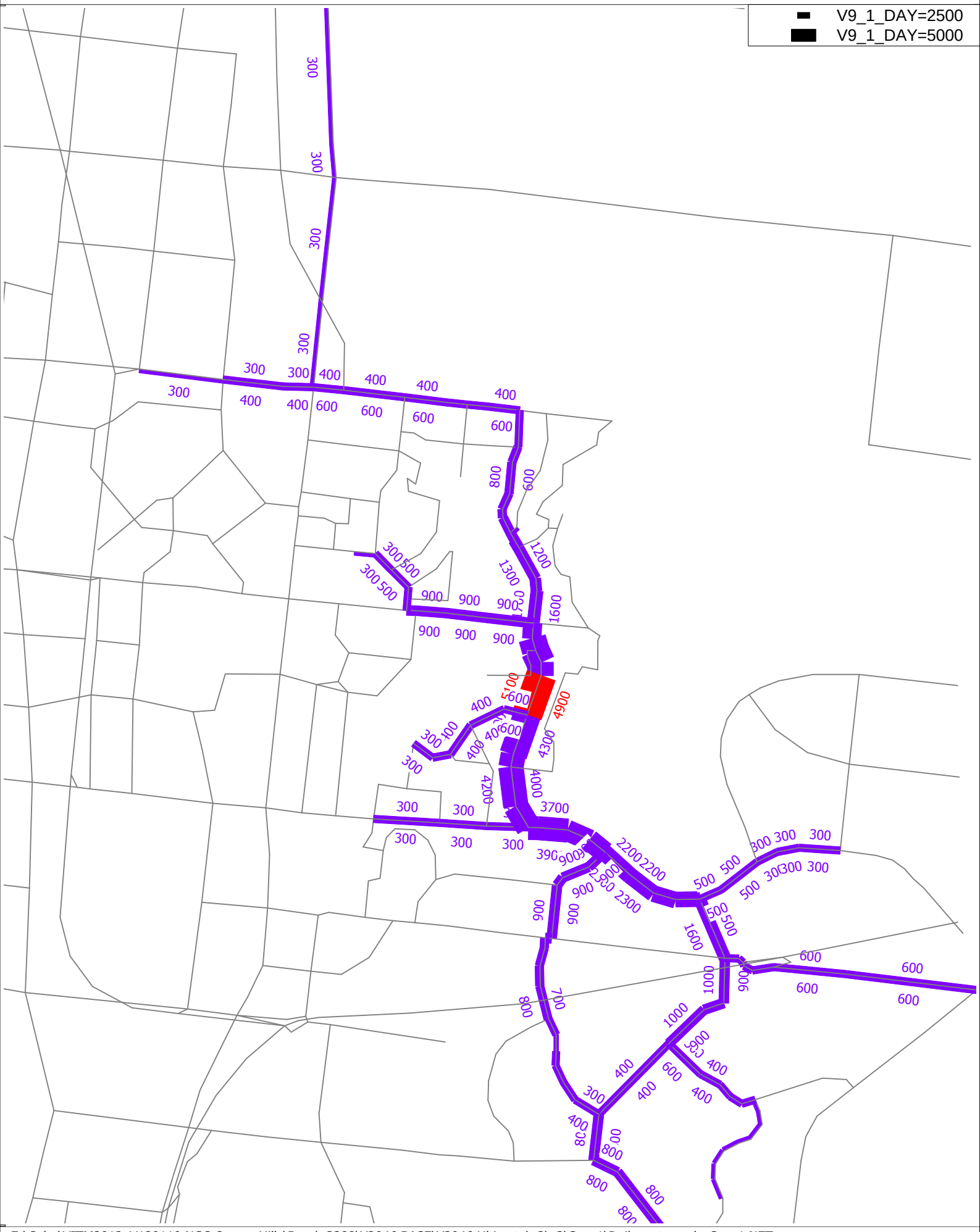
2046 Quarry Hills Scenario 1
Select Link Plots - Daily
North-South Connector South of Harvest Home Road



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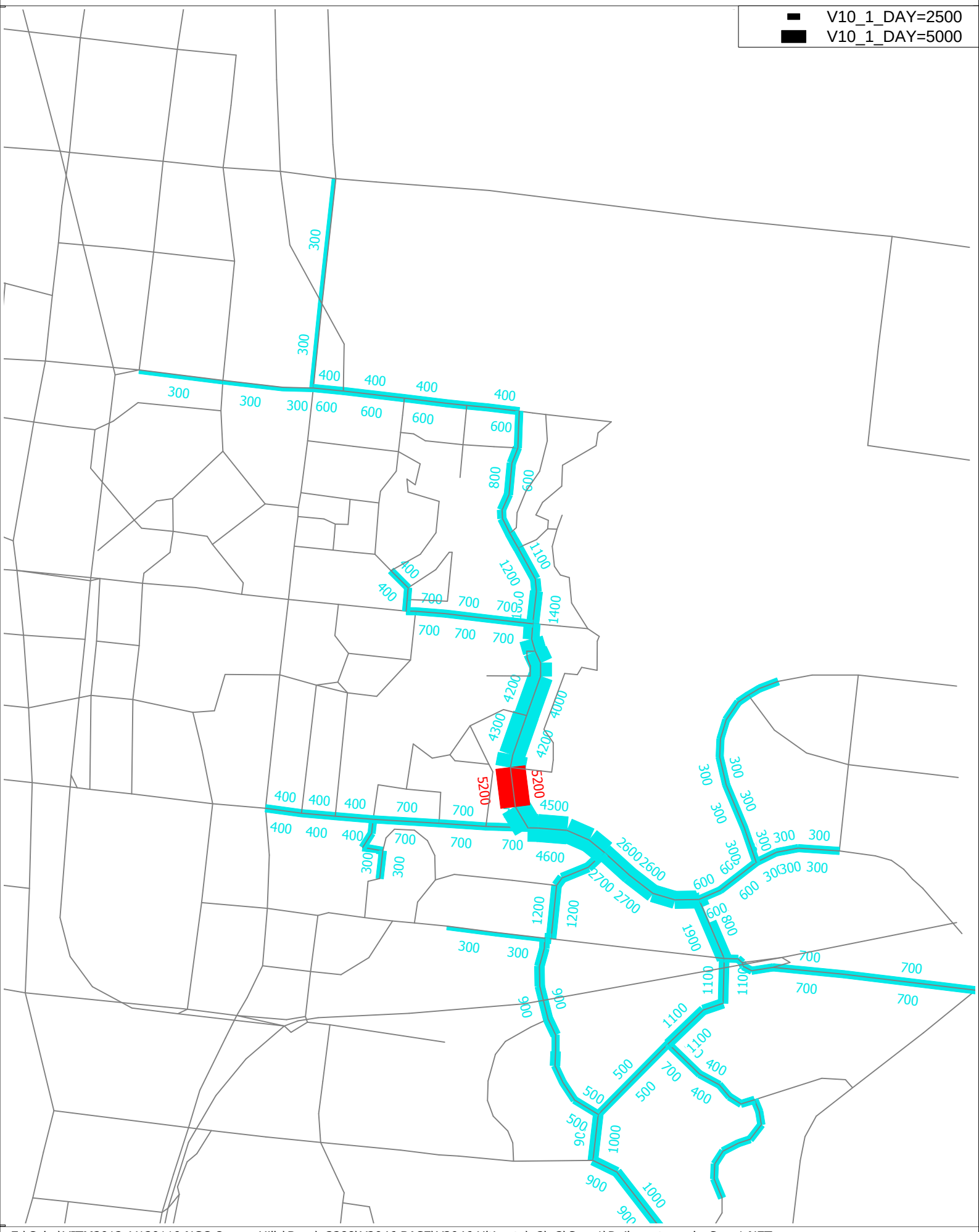
2046 Quarry Hills Scenario 1
Select Link Plots - Daily
North-South Connector North of Findon Road



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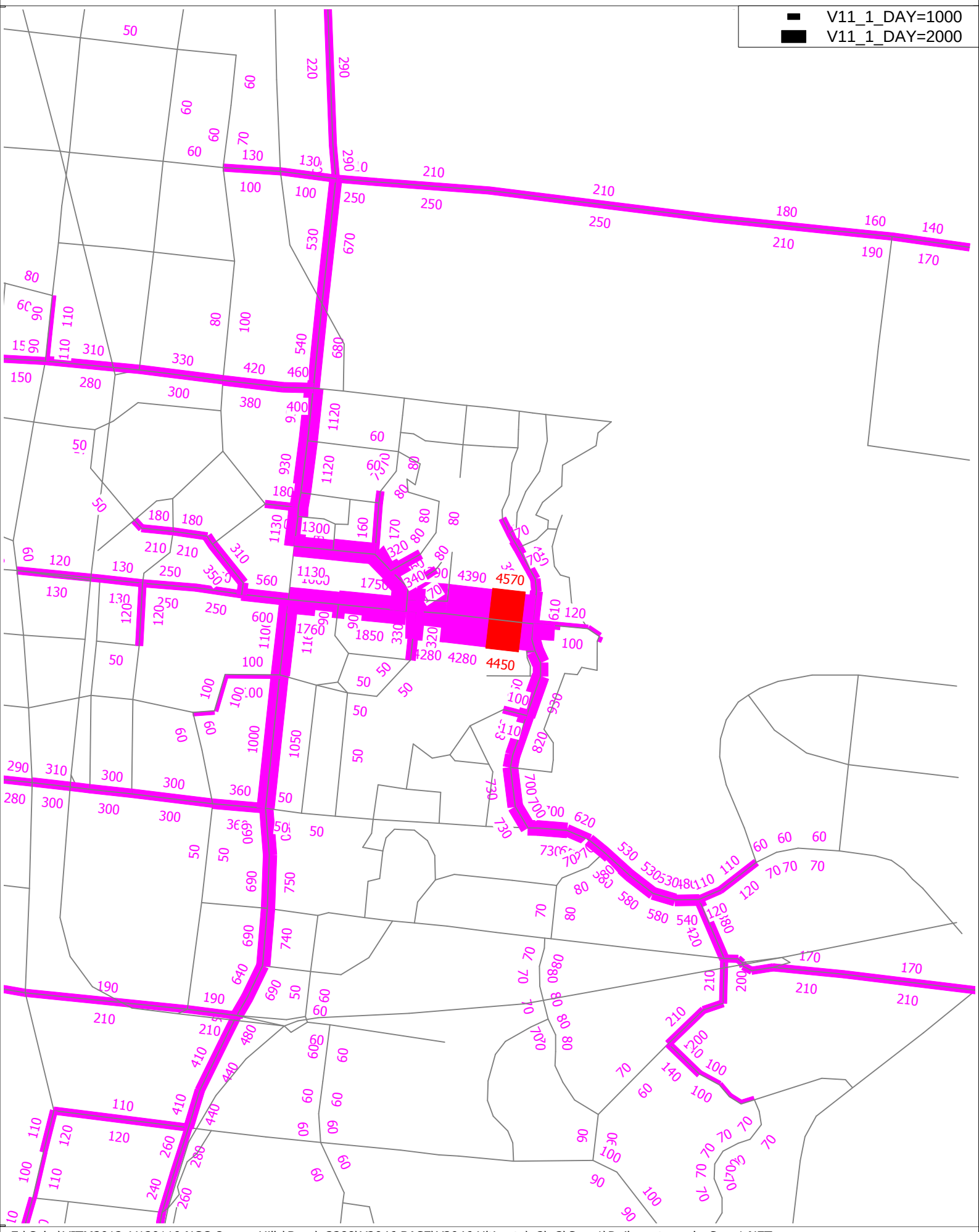
2046 Quarry Hills Scenario 1
Select Link Plots - Daily
Harvest Home Road East of OMR



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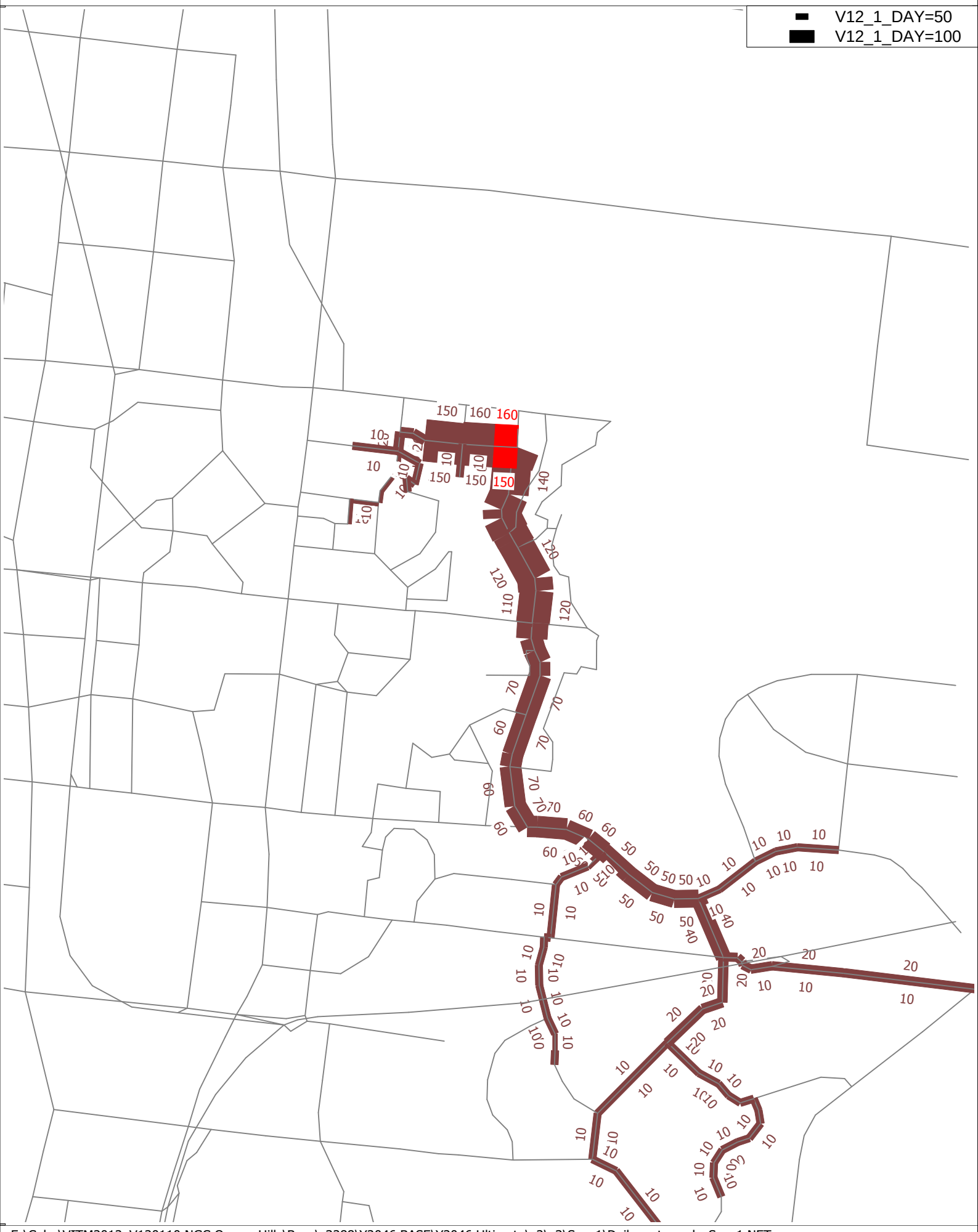
5/03/2014 2:40 PM

2046 Quarry Hills Scenario 1
Select Link Plots - Daily
East West Road 1 East of OMR



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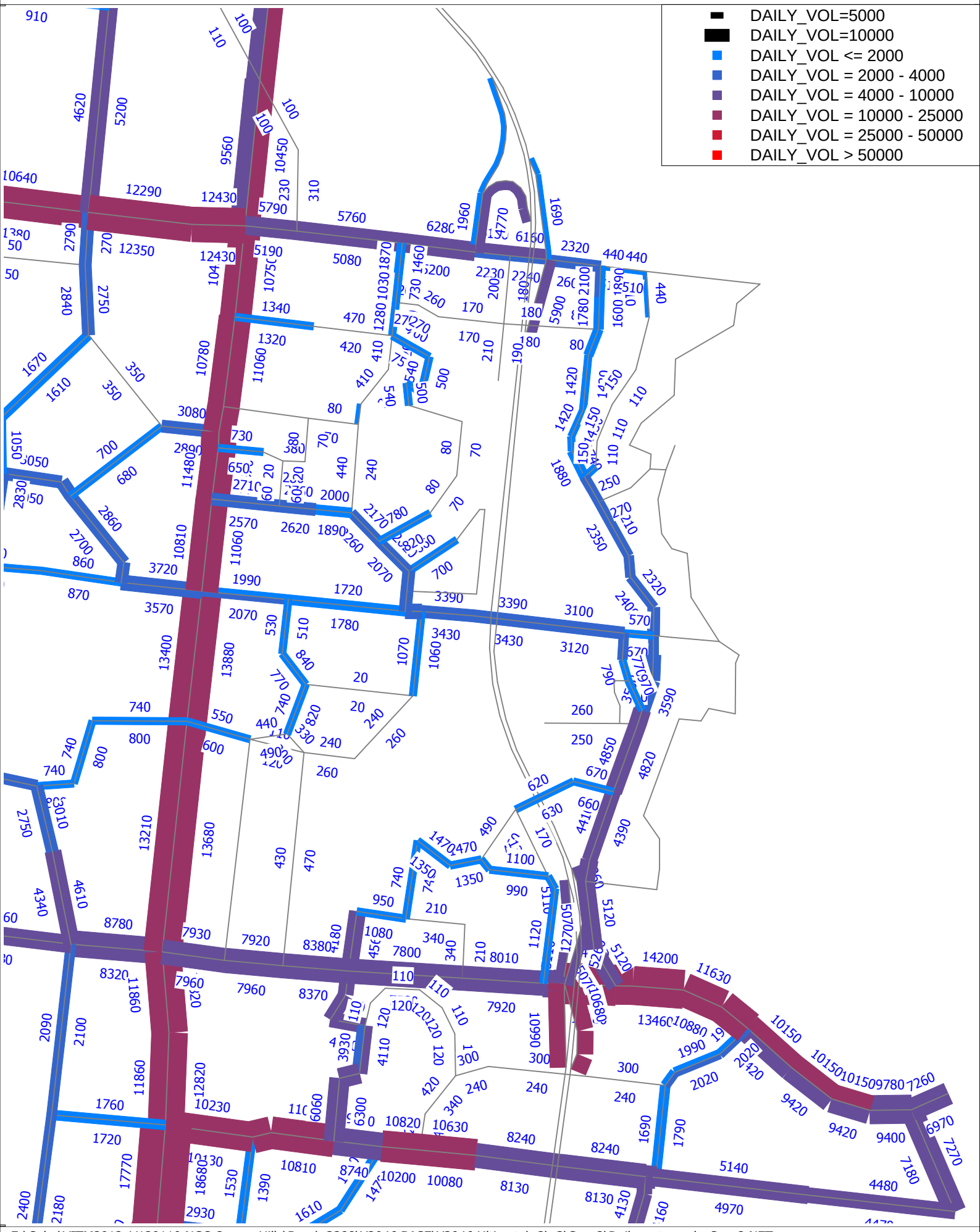
2046 Quarry Hills Scenario 2
Daily Traffic Volumes
OMR Excluded



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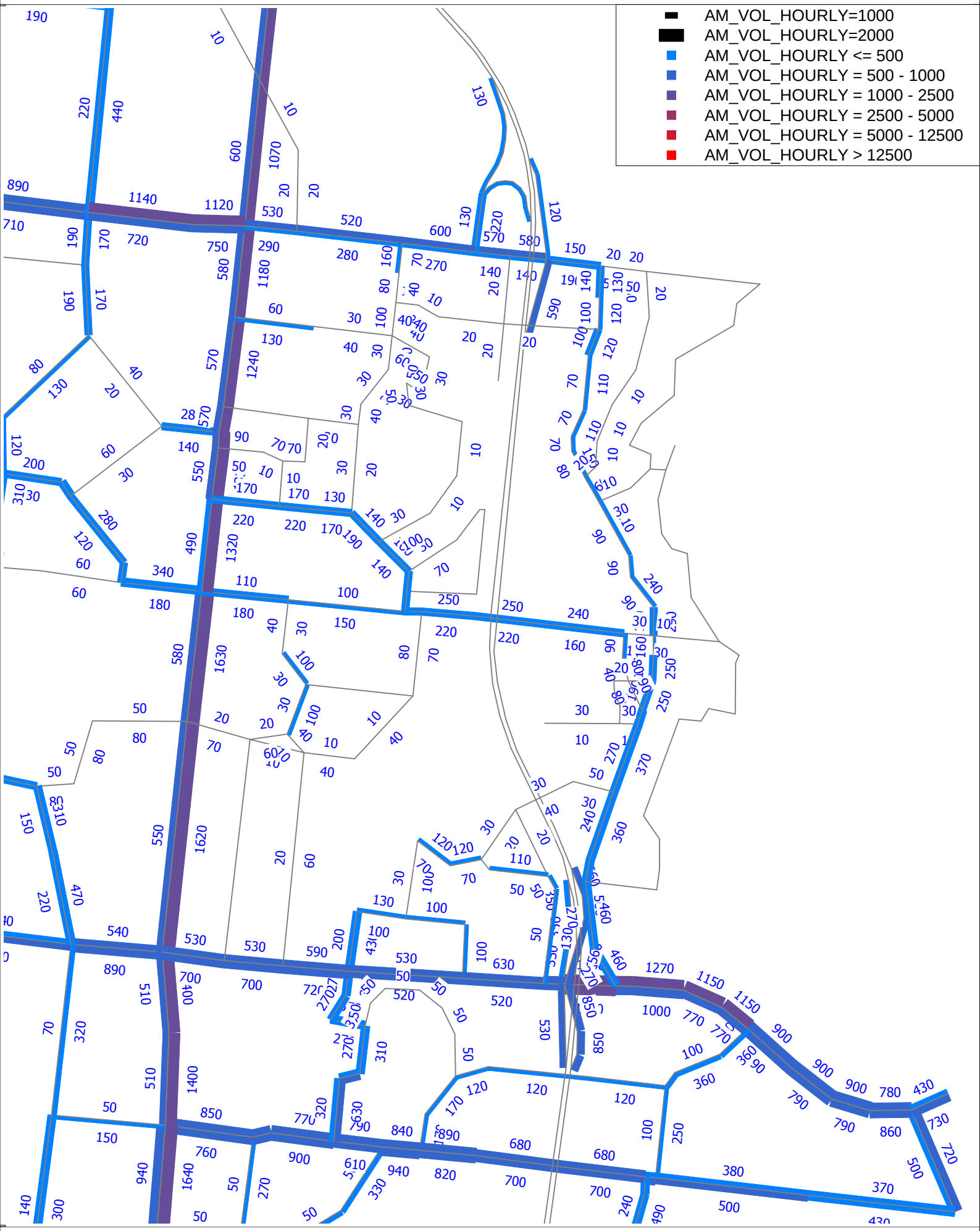
5/03/2014 3:01 PM

2046 Quarry Hills Scenario 2
AM Peak Traffic Volumes (Hourly)
OMR Excluded



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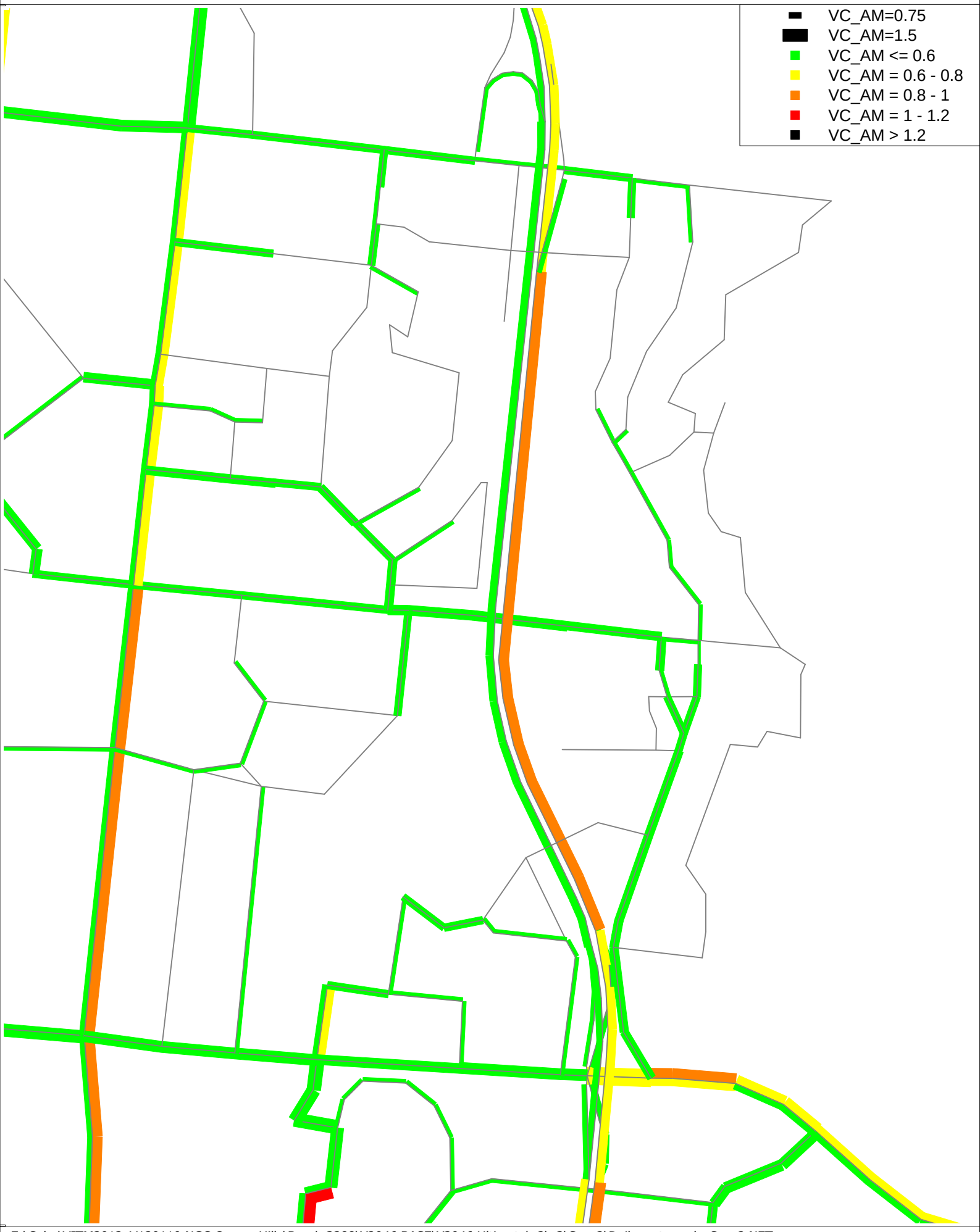
5/03/2014 2:52 PM

2046 Quarry Hills Scenario 2
Volume/Capacity Ratio Plot
AM Peak



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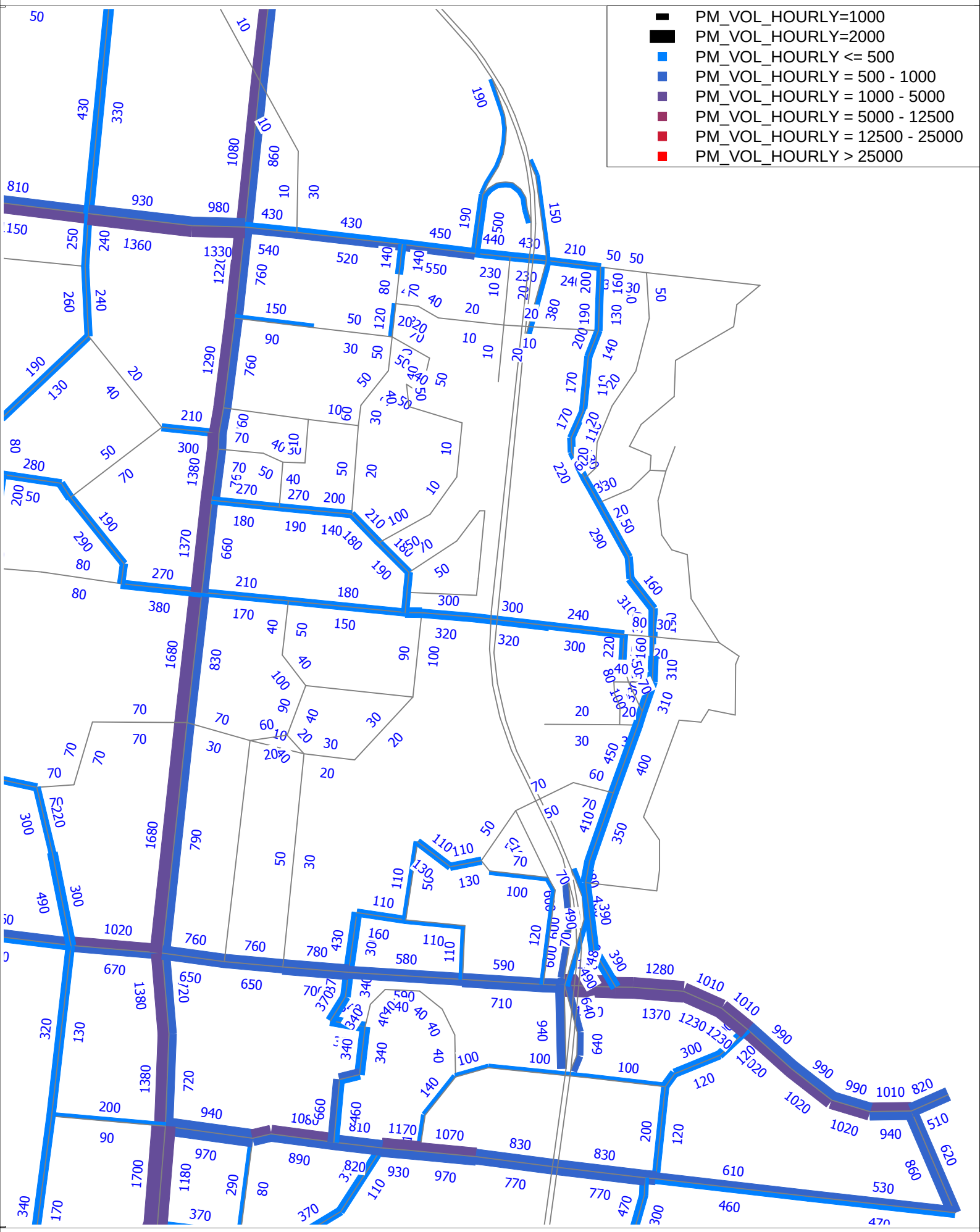
5/03/2014 2:28 PM

cube

2046 Quarry Hills Scenario 2
PM Peak Traffic Volumes (Hourly)
OMR Excluded



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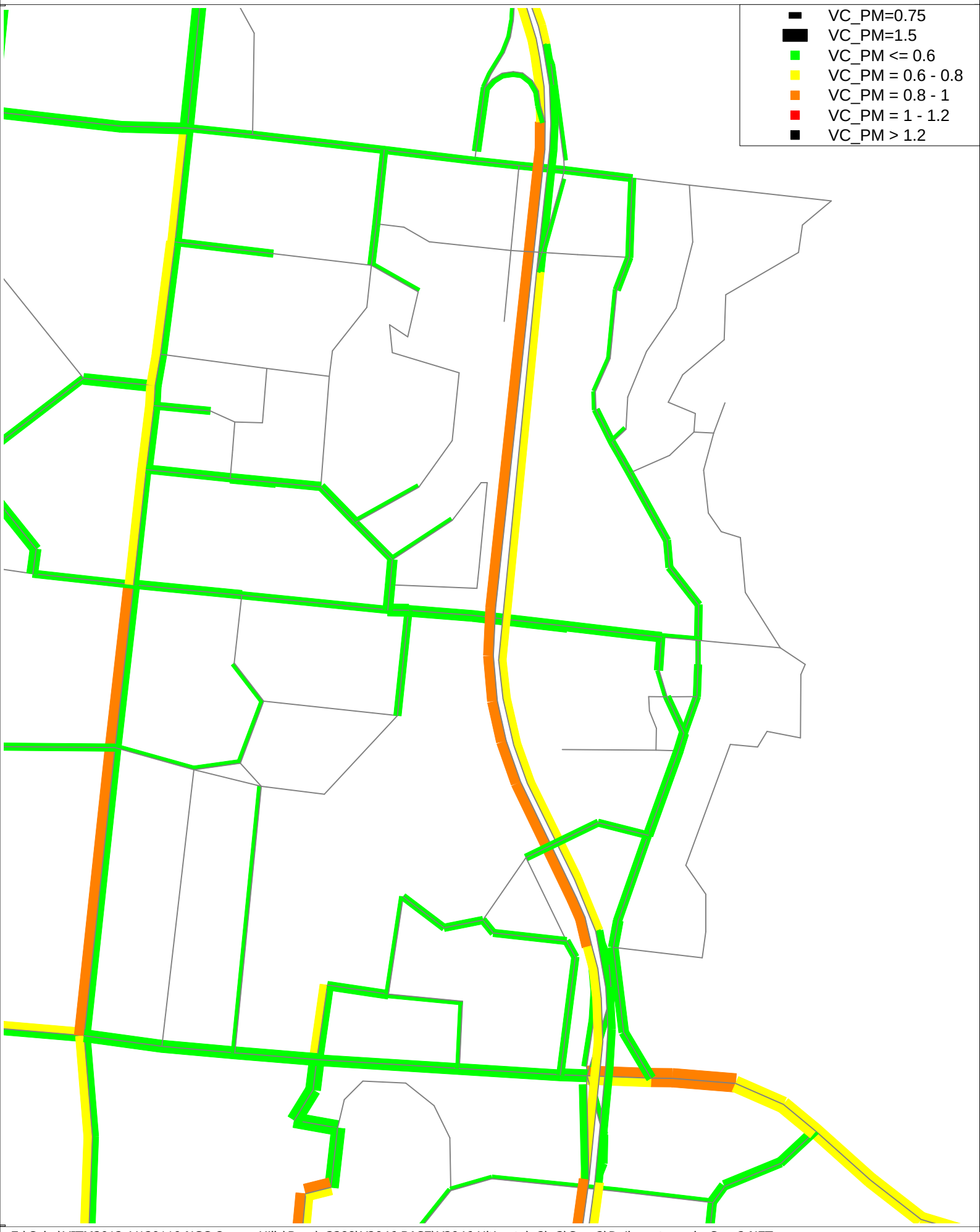
2046 Quarry Hills Scenario 2
Volume/Capacity Ratio Plot
PM Peak



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5/03/2014 2:27 PM

cube

2046 Quarry Hills Scenario 2
Select Link Plots - Daily
North-South Connector South of Lehman Road

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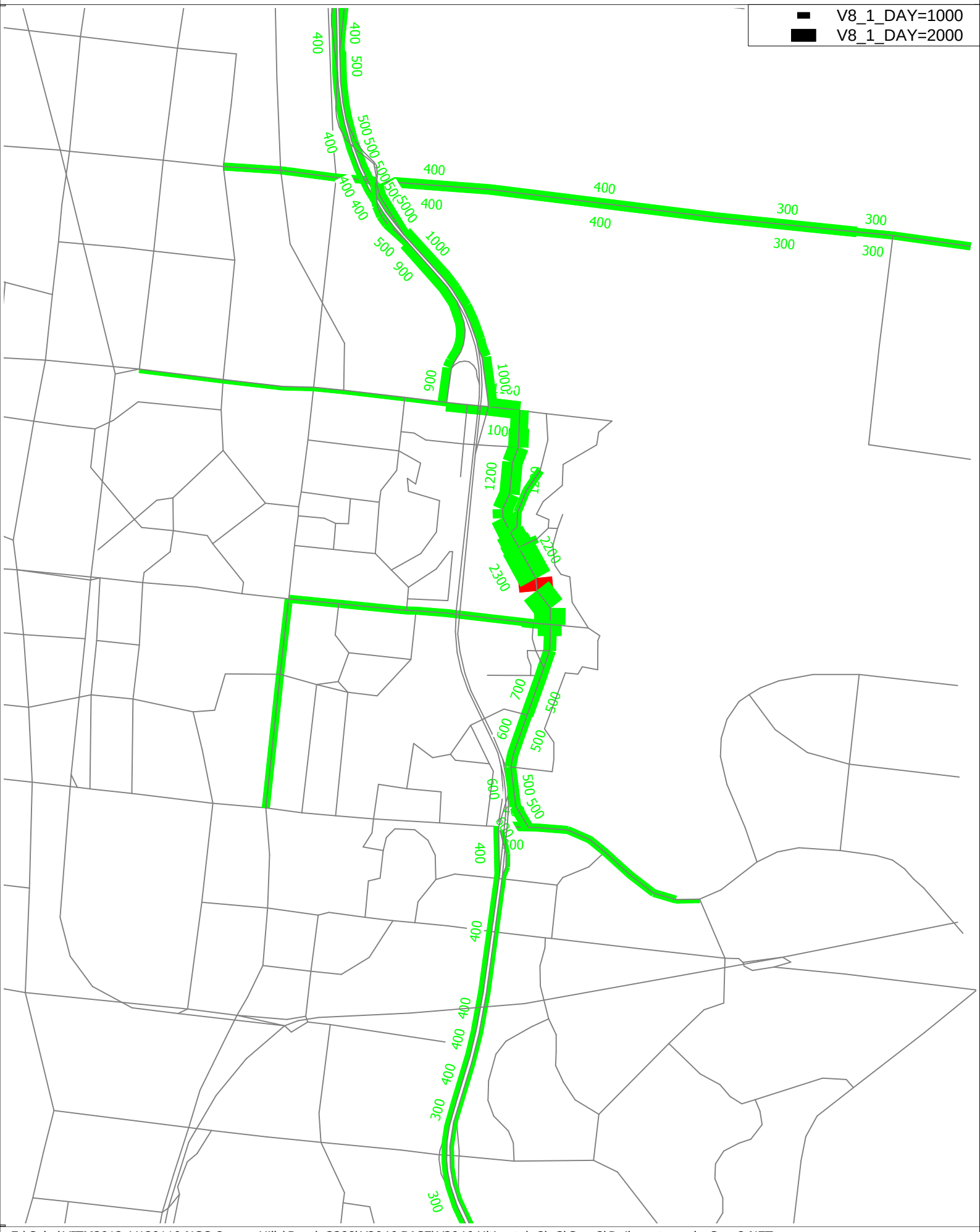
5/03/2014 2:31 PM

cube

2046 Quarry Hills Scenario 2
Select Link Plots - Daily
North-South Connector North of Harvest Home Road



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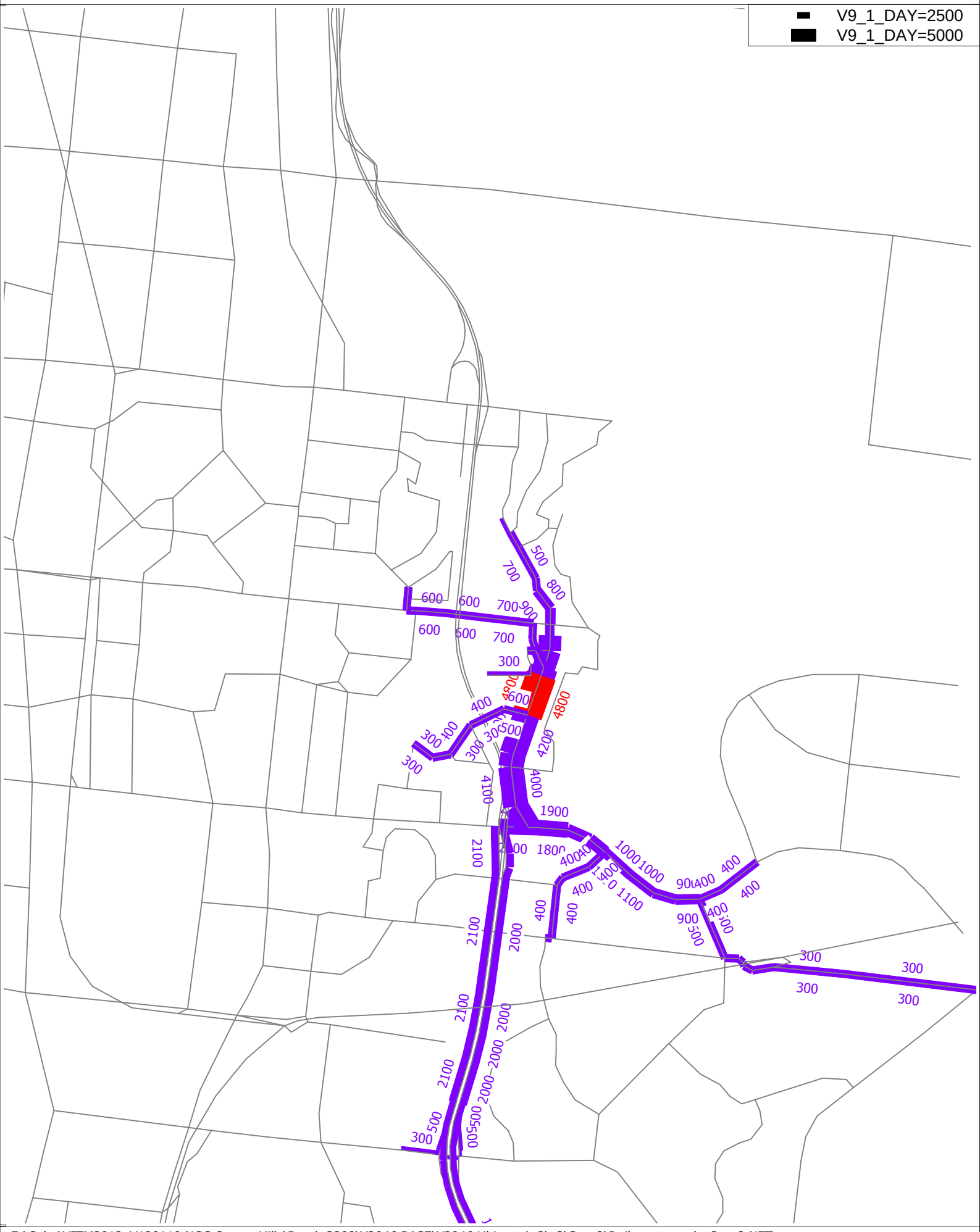
5/03/2014 2:33 PM

2046 Quarry Hills Scenario 2
Select Link Plots - Daily
North-South Connector South of Harvest Home Road



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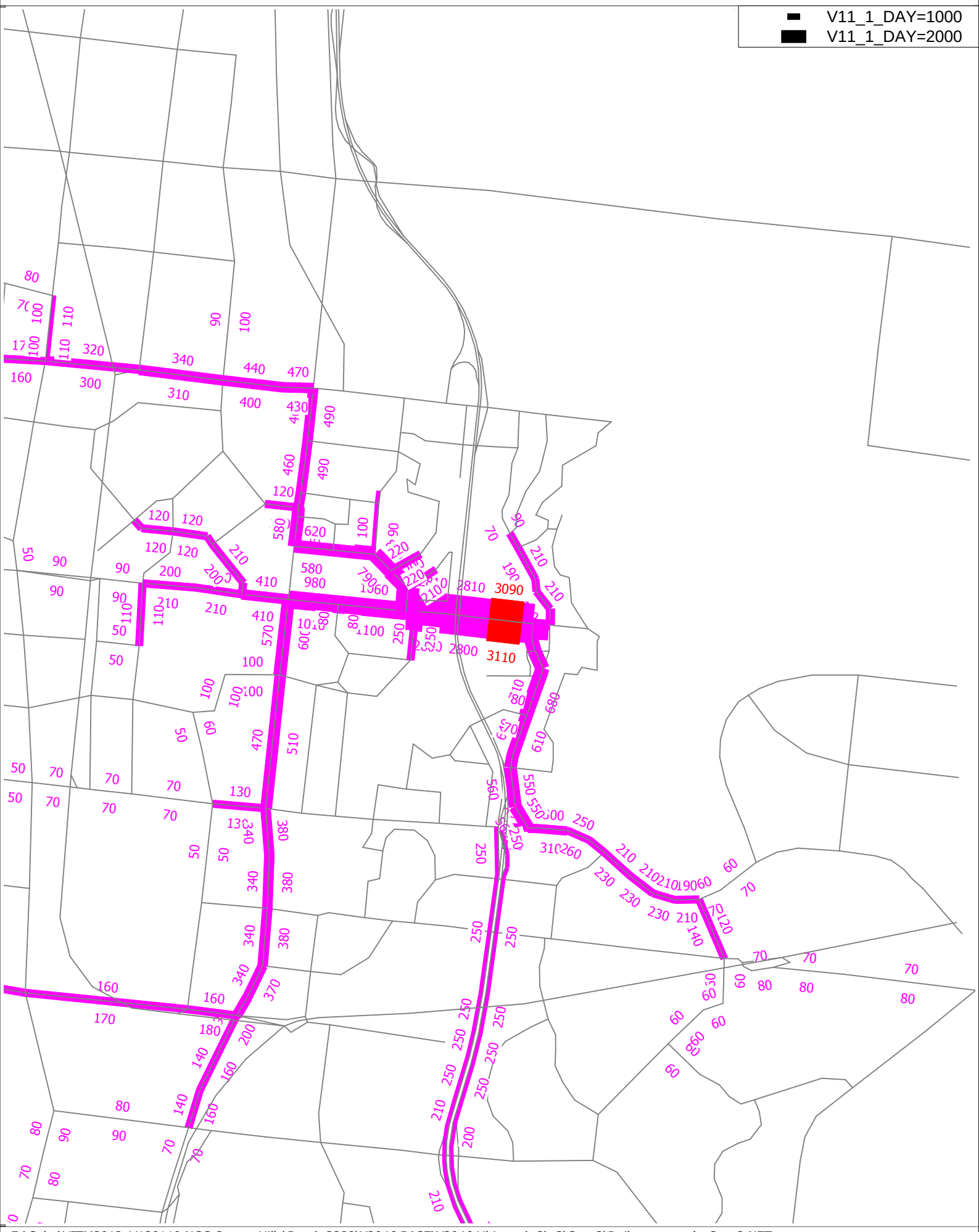
5/03/2014 2:34 PM

2046 Quarry Hills Scenario 2
Select Link Plots - Daily
North-South Connector North of Findon Road

E:\Cube\VITM2012_V120110 NGC Quarry Hills\Base\z3288\Y2046 BASE\Y2046 Ultimate\v2\v3\Scen2\Daily_net_roads_Scen2.NET
5/03/2014 2:36 PM

cube

2046 Quarry Hills Scenario 2
Select Link Plots - Daily
Harvest Home Road East of OMR



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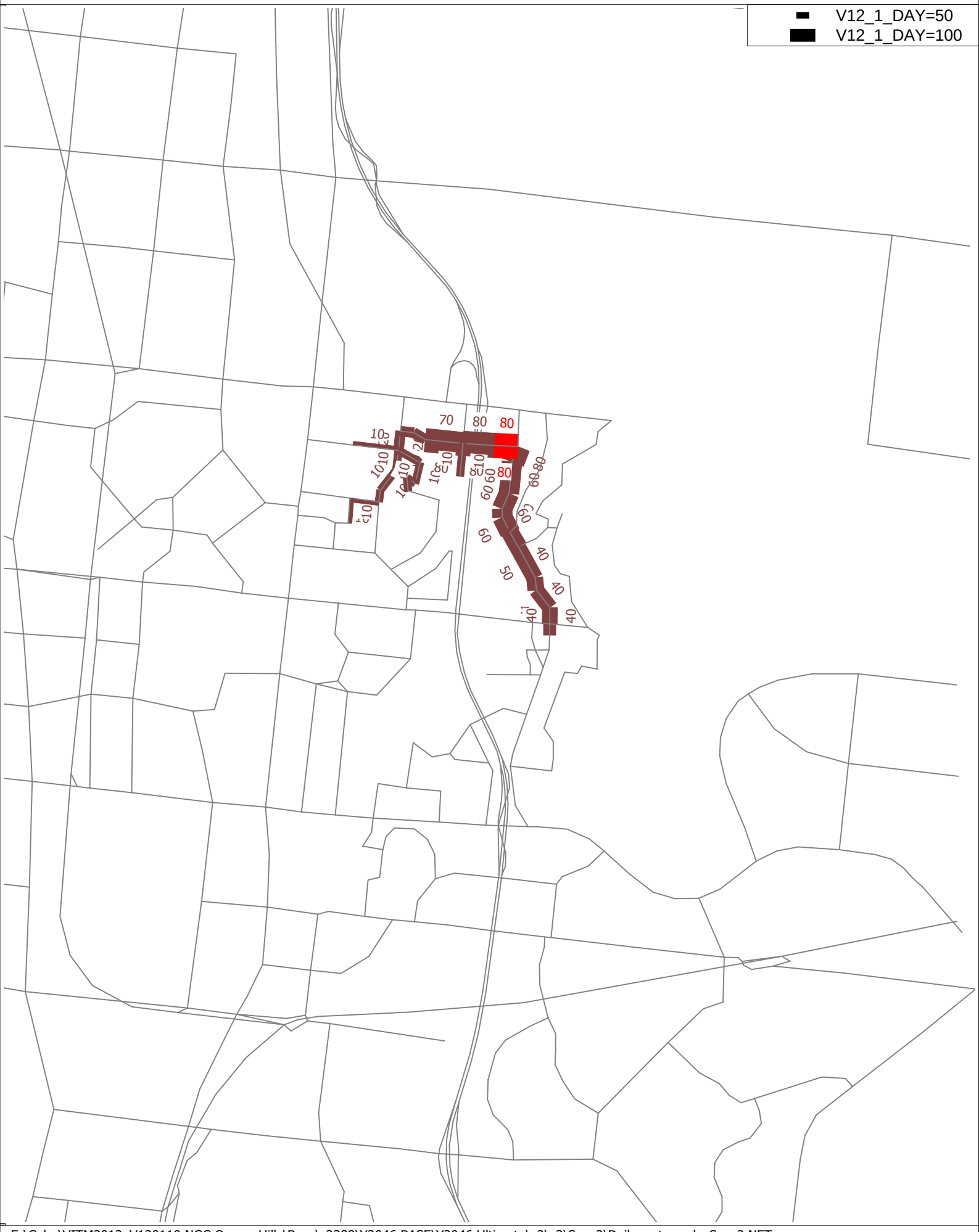
5/03/2014 2:38 PM

2046 Quarry Hills Scenario 2
Select Link Plots - Daily
East West Road 1 East of OMR



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5/03/2014 2:43 PM

Appendix B. SIDRA Results

B.1 2026 Scenario 1 AM Peak

VOLUMES
UTILITY APPLICATION FOR SIDRA INTERSECTION 5.1

MOVEMENT OUTPUT

*Use the **Control** sheet to create output data in this sheet. For detailed information, refer to the **Intro** sheet.*

2026 - Scenario BASE - AM Peak
Title: 1 - North South Connector and Harvest Home Road
Type: Signals

Movement Performance - Vehicles

Turn	Demand Flow veh/h	HV %	Deg. Satn. v/c	Average Delay sec	Total Delay veh-h/h	Level of Service	95th percentile Back of Queue Vehicles veh	95th percentile Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h	Tot. Travel Time veh-h/h	Perf. Index
South													
Left	79	7.0	0.200	27.4	0.60	LOS C	2.0	14.6	0.75	0.74	31.2	1.5	3.1
Through	53	7.0	0.134	20.0	0.29	LOS C	1.6	11.7	0.75	0.58	32.3	0.9	1.9
Right	11	9.7	0.134	26.6	0.08	LOS C	1.6	11.7	0.75	0.79	31.5	0.2	0.4
Approach	142	7.2	0.200	24.6	0.97	LOS C	2.0	14.6	0.75	0.69	31.6	2.7	5.4
East													
Left	11	9.7	0.119	35.6	0.11	LOS D	1.0	7.1	0.88	0.74	27.6	0.2	0.5
Through	21	7.0	0.119	29.0	0.17	LOS C	1.0	7.1	0.88	0.64	28.5	0.4	0.9
Right	11	9.7	0.022	15.6	0.05	LOS B	0.2	1.3	0.58	0.66	36.4	0.2	0.3
Approach	43	8.4	0.119	27.3	0.32	LOS C	1.0	7.1	0.80	0.67	29.8	0.8	1.7
North													
Left	11	9.7	0.328	27.3	0.08	LOS C	3.3	24.9	0.78	0.82	31.3	0.2	0.4
Through	242	7.0	0.493	21.8	1.47	LOS C	6.2	45.7	0.82	0.67	31.1	4.5	9.2
Right	95	7.0	0.493	30.3	0.80	LOS C	6.2	45.7	0.85	0.83	30.5	1.9	4.0
Approach	348	7.1	0.493	24.3	2.35	LOS C	6.2	45.7	0.82	0.72	31.0	6.5	13.6
West													
Left	26	7.0	0.141	36.8	0.27	LOS D	1.1	8.4	0.88	0.74	29.3	0.5	1.1
Through	11	9.7	0.141	30.4	0.09	LOS C	1.1	8.4	0.88	0.66	29.6	0.2	0.4
Right	426	7.0	0.767	19.2	2.27	LOS B	8.1	59.9	0.66	0.81	38.2	6.4	13.2
Approach	463	7.1	0.767	20.4	2.63	LOS C	8.1	59.9	0.68	0.80	37.3	7.1	14.8
ll Vehicles	996	7.1	0.767	22.7	6.28	LOS C	8.1	59.9	0.75	0.75	33.7	17.2	35.4

VOLUMES UTILITY APPLICATION FOR SIDRA INTERSECTION 5.1

MOVEMENT OUTPUT

*Use the **Control** sheet to create output data in this sheet. For detailed information, refer to the **Intro** sheet.*

2026 - Scenario BASE - PM Peak

Title: 2 - North South Connector and Town Center

Type: Signals

Movement Performance - Vehicles

Turn	Demand Flow veh/h	HV %	Deg. Satn. v/c	Average Delay sec	Total Delay veh-h/h	Level of Service	95th percentile Back of Queue Vehicles veh	95th percentile Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h	Tot. Travel Time veh-h/h	Perf. Index
South													
Left	21	7.0	0.776	14.5	0.09	LOS B	13.4	99.3	0.82	0.90	38.9	0.3	0.6
Through	805	7.0	0.776	8.0	1.79	LOS A	13.4	99.3	0.82	0.74	39.9	11.6	22.3
Approach	826	7.0	0.776	8.2	1.87	LOS A	13.4	99.3	0.82	0.74	39.8	11.9	23.0
North													
Through	247	7.0	0.285	6.4	0.44	LOS A	3.0	22.7	0.58	0.49	41.7	3.4	5.7
Right	12	17.7	0.285	13.6	0.04	LOS B	3.0	22.7	0.58	0.93	39.4	0.2	0.3
Approach	259	7.5	0.285	6.7	0.49	LOS A	3.0	22.7	0.58	0.51	41.6	3.6	6.1
West													
Left	12	17.7	0.101	25.3	0.08	LOS C	0.5	3.7	0.88	0.70	31.1	0.2	0.4
Right	12	17.7	0.101	25.7	0.09	LOS C	0.5	3.7	0.88	0.71	31.1	0.2	0.4
Approach	24	17.7	0.101	25.5	0.17	LOS C	0.5	3.7	0.88	0.70	31.1	0.4	0.8
ll Vehicles	1109	7.3	0.776	8.2	2.53	LOS A	13.4	99.3	0.76	0.69	40.0	15.9	29.8

VOLUMES UTILITY APPLICATION FOR SIDRA INTERSECTION 5.1 © 2000-2011 Akcelik & Associates Pty Ltd

MOVEMENT OUTPUT

*Use the **Control** sheet to create output data in this sheet. For detailed information, refer to the **Intro** sheet.*

2026 - Scenario BASE - PM Peak

Title: 3 - North South Connector and Findon Road

Type: Signals

Movement Performance - Vehicles

Turn	Demand Flow veh/h	HV %	Deg. Satn. v/c	Average Delay sec	Total Delay veh-h/h	Level of Service	95th percentile Back of Queue Vehicles veh	95th percentile Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h	Tot. Travel Time veh-h/h	Perf. Index
East													
Through	421	7.0	0.354	20.5	2.40	LOS C	5.5	41.1	0.79	0.66	36.6	7.0	15.0
Right	811	7.0	0.790	35.1	7.89	LOS D	13.5	100.3	0.96	0.88	29.6	15.8	36.2
Approach	1232	7.0	0.790	30.1	10.29	LOS C	13.5	100.3	0.90	0.80	31.7	22.8	51.2
North													
Left	247	7.0	0.242	9.7	0.67	LOS A	2.6	19.1	0.40	0.67	41.9	3.6	6.2
Right	42	7.0	0.183	38.5	0.45	LOS D	1.3	9.8	0.90	0.73	26.9	0.9	1.9
Approach	289	7.0	0.242	13.9	1.12	LOS B	2.6	19.1	0.47	0.68	38.8	4.6	8.2
West													
Left	95	7.0	0.557	31.4	0.83	LOS C	9.3	69.4	0.84	0.92	32.5	1.7	3.8
Through	584	7.0	0.557	23.1	3.75	LOS C	9.4	70.1	0.85	0.76	34.7	10.2	22.1
Approach	679	7.0	0.557	24.3	4.58	LOS C	9.4	70.1	0.85	0.78	34.4	11.9	25.9
ll Vehicles	2200	7.0	0.790	26.2	15.99	LOS C	13.5	100.3	0.83	0.78	33.3	39.3	85.2

B.2 2026 Scenario 1 PM Peak

VOLUMES
UTILITY APPLICATION FOR SIDRA INTERSECTION 5.1 © 2000-2011 Akcelik & Associates Pty Ltd

MOVEMENT OUTPUT

*Use the **Control** sheet to create output data in this sheet. For detailed information, refer to the **Intro** sheet.*

2026 - Scenario BASE - PM Peak

Title: 1 - North South Connector and Harvest Home Road

Type: Signals

Movement Performance - Vehicles

Turn	Demand Flow veh/h	HV %	Deg. Satn. v/c	Average Delay sec	Total Delay veh-h/h	Level of Service	95th percentile Back of Queue Vehicles veh	95th percentile Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h	Tot. Travel Time veh-h/h	Perf. Index
South													
Left	347	7.0	0.665	20.4	1.97	LOS C	7.1	52.4	0.72	0.79	34.7	6.0	12.0
Through	368	7.0	0.698	15.2	2.32	LOS B	13.3	98.8	0.85	0.75	34.4	6.1	13.4
Right	12	17.7	0.698	22.0	0.07	LOS C	13.3	98.8	0.85	0.87	33.8	0.2	0.4
Approach	907	7.1	0.698	19.5	4.90	LOS B	13.3	98.8	0.79	0.77	34.5	12.4	25.9
East													
Left	12	17.7	0.103	31.7	0.10	LOS C	0.7	5.5	0.87	0.73	29.1	0.2	0.5
Through	16	7.0	0.103	24.9	0.11	LOS C	0.7	5.5	0.87	0.63	30.0	0.3	0.6
Right	12	17.7	0.035	22.2	0.07	LOS C	0.2	1.9	0.81	0.67	32.7	0.2	0.4
Approach	40	13.4	0.103	26.1	0.29	LOS C	0.7	5.5	0.85	0.67	30.5	0.8	1.5
North													
Left	12	17.7	0.171	17.7	0.06	LOS B	1.5	11.5	0.60	0.82	36.3	0.2	0.4
Through	95	7.0	0.258	13.0	0.34	LOS B	1.5	11.5	0.64	0.50	36.3	1.5	2.8
Right	42	7.0	0.258	30.8	0.36	LOS C	1.5	11.3	0.86	0.76	30.0	0.8	1.7
Approach	149	7.9	0.258	18.5	0.76	LOS B	1.5	11.5	0.70	0.60	34.2	2.5	4.9
West													
Left	84	7.0	0.386	34.1	0.80	LOS C	2.9	21.5	0.92	0.78	30.3	1.6	3.4
Through	21	7.0	0.386	27.7	0.16	LOS C	2.9	21.5	0.92	0.73	30.5	0.4	0.8
Right	153	7.0	0.358	24.4	1.04	LOS C	3.1	23.2	0.77	0.76	34.8	2.5	5.1
Approach	258	7.0	0.386	27.9	2.00	LOS C	3.1	23.2	0.83	0.76	32.8	4.5	9.3
ll Vehicles	1353	7.4	0.698	19.7	7.41	LOS B	13.3	98.8	0.80	0.65	34.0	20.2	41.5

VOLUMES
UTILITY APPLICATION FOR SIDRA INTERSECTION 5.1

MOVEMENT OUTPUT

*Use the **Control** sheet to create output data in this sheet. For detailed information, refer to the **Intro** sheet.*

2026 - Scenario BASE - PM Peak
Title: 2 - North South Connector and Town Center
Type: Signals

Movement Performance - Vehicles

Turn	Demand Flow veh/h	HV %	Deg. Satn. v/c	Average Delay sec	Total Delay veh-h/h	Level of Service	ercentile Back of Queu Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h	Tot. Travel Time veh-h/h	Perf. Index
South													
Left	21	7.0	0.776	14.5	0.09	LOS B	13.4	99.3	0.82	0.90	38.9	0.3	0.6
Through	805	7.0	0.776	8.0	1.79	LOS A	13.4	99.3	0.82	0.74	39.9	11.6	22.3
Approach	826	7.0	0.776	8.2	1.87	LOS A	13.4	99.3	0.82	0.74	39.8	11.9	23.0
North													
Through	247	7.0	0.285	6.4	0.44	LOS A	3.0	22.7	0.58	0.49	41.7	3.4	5.7
Right	12	17.7	0.285	13.6	0.04	LOS B	3.0	22.7	0.58	0.93	39.4	0.2	0.3
Approach	259	7.5	0.285	6.7	0.49	LOS A	3.0	22.7	0.58	0.51	41.6	3.6	6.1
West													
Left	12	17.7	0.101	25.3	0.08	LOS C	0.5	3.7	0.88	0.70	31.1	0.2	0.4
Right	12	17.7	0.101	25.7	0.09	LOS C	0.5	3.7	0.88	0.71	31.1	0.2	0.4
Approach	24	17.7	0.101	25.5	0.17	LOS C	0.5	3.7	0.88	0.70	31.1	0.4	0.8
ll Vehicles	1109	7.3	0.776	8.2	2.53	LOS A	13.4	99.3	0.76	0.69	40.0	15.9	29.8

VOLUMES
UTILITY APPLICATION FOR SIDRA INTERSECTION 5.1 © 2000-2011 Akcelik & Associates Pty Ltd

MOVEMENT OUTPUT

*Use the **Control** sheet to create output data in this sheet. For detailed information, refer to the **Intro** sheet.*

2026 - Scenario BASE - PM Peak
Title: 3 - North South Connector and Findon Road
Type: Signals

Movement Performance - Vehicles

Turn	Demand Flow veh/h	HV %	Deg. Satn. v/c	Average Delay sec	Total Delay veh-h/h	Level of Service	ercentile Back of Queu Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h	Tot. Travel Time veh-h/h	Perf. Index
East													
Through	421	7.0	0.354	20.5	2.40	LOS C	5.5	41.1	0.79	0.66	36.6	7.0	15.0
Right	811	7.0	0.790	35.1	7.89	LOS D	13.5	100.3	0.96	0.88	29.6	15.8	36.2
Approach	1232	7.0	0.790	30.1	10.29	LOS C	13.5	100.3	0.90	0.80	31.7	22.8	51.2
North													
Left	247	7.0	0.242	9.7	0.67	LOS A	2.6	19.1	0.40	0.67	41.9	3.6	6.2
Right	42	7.0	0.183	38.5	0.45	LOS D	1.3	9.8	0.90	0.73	26.9	0.9	1.9
Approach	289	7.0	0.242	13.9	1.12	LOS B	2.6	19.1	0.47	0.68	38.8	4.6	8.2
West													
Left	95	7.0	0.557	31.4	0.83	LOS C	9.3	69.4	0.84	0.92	32.5	1.7	3.8
Through	584	7.0	0.557	23.1	3.75	LOS C	9.4	70.1	0.85	0.76	34.7	10.2	22.1
Approach	679	7.0	0.557	24.3	4.58	LOS C	9.4	70.1	0.85	0.78	34.4	11.9	25.9
ll Vehicles	2200	7.0	0.790	26.2	15.99	LOS C	13.5	100.3	0.83	0.78	33.3	39.3	85.2

B.3 2046 Scenario 1 AM Peak

VOLUMES
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MOVEMENT OUTPUT

*Use the **Control** sheet to create output data in this sheet. For detailed information, refer to the **Intro** sheet.*

2046 - Scenario 1 - AM Peak

Title: 1 - North South Connector and Harvest Home Road

Type: Signals

Movement Performance - Vehicles

Turn	Demand Flow veh/h	HV %	Deg. Satn. v/c	Average Delay sec	Total Delay veh-h/h	Level of Service	95th percentile Back of Queue Vehicles veh	95th percentile Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h	Tot. Travel Time veh-h/h	Perf. Index
South													
Left	116	7.0	0.276	23.8	0.76	LOS C	2.7	20.3	0.67	0.74	32.9	2.1	4.3
Through	58	7.0	0.125	19.1	0.31	LOS B	1.7	12.9	0.70	0.55	32.9	1.0	2.0
Right	11	9.7	0.125	25.7	0.08	LOS C	1.7	12.9	0.70	0.80	31.9	0.2	0.4
Approach	185	7.2	0.276	22.4	1.15	LOS C	2.7	20.3	0.68	0.69	32.9	3.3	6.8
East													
Left	11	9.7	0.215	43.0	0.13	LOS D	1.3	9.8	0.93	0.74	25.2	0.2	0.5
Through	26	7.0	0.215	36.3	0.27	LOS D	1.3	9.8	0.93	0.68	25.9	0.6	1.3
Right	11	9.7	0.026	19.8	0.06	LOS B	0.2	1.7	0.66	0.67	33.9	0.2	0.4
Approach	48	8.2	0.215	34.1	0.45	LOS C	1.3	9.8	0.87	0.69	27.2	1.0	2.1
North													
Left	11	9.7	0.423	23.6	0.07	LOS C	4.4	32.4	0.69	0.84	33.0	0.2	0.4
Through	463	7.0	0.636	19.9	2.56	LOS B	11.8	87.2	0.80	0.68	32.2	8.2	17.6
Right	95	7.0	0.636	28.9	0.76	LOS C	11.8	87.2	0.85	0.86	31.4	1.8	4.1
Approach	569	7.1	0.636	21.4	3.39	LOS C	11.8	87.2	0.80	0.71	32.1	10.3	22.1
West													
Left	32	7.0	0.251	44.2	0.39	LOS D	1.5	11.3	0.94	0.74	26.5	0.7	1.5
Through	11	9.7	0.251	37.8	0.11	LOS D	1.5	11.3	0.94	0.70	26.6	0.2	0.5
Right	284	7.0	0.692	23.8	1.88	LOS C	7.0	51.7	0.80	0.80	35.2	4.6	10.1
Approach	327	7.1	0.692	26.2	2.38	LOS C	7.0	51.7	0.82	0.79	33.8	5.6	12.1
ll Vehicles	1128	7.1	0.692	23.5	7.37	LOS C	11.8	87.2	0.79	0.73	32.4	20.2	43.2

VOLUMES UTILITY APPLICATION FOR SIDRA INTERSECTION 5.1

MOVEMENT OUTPUT

*Use the **Control** sheet to create output data in this sheet. For detailed information, refer to the **Intro** sheet.*

2046 - Scenario 1 - AM Peak

Title: 2 - North South Connector and Town Center

Type: Signals

Movement Performance - Vehicles

Turn	Demand Flow veh/h	HV %	Deg. Satn. v/c	Average Delay sec	Total Delay veh-h/h	Level of Service	95th percentile Back of Queue Vehicles veh	95th percentile Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h	Tot. Travel Time veh-h/h	Perf. Index
South													
Left	11	9.7	0.247	12.0	0.04	LOS B	2.6	19.5	0.54	0.87	40.2	0.2	0.3
Through	242	7.0	0.247	5.3	0.36	LOS A	2.6	19.5	0.54	0.45	42.7	3.2	5.3
Approach	253	7.1	0.247	5.6	0.40	LOS A	2.6	19.5	0.54	0.47	42.6	3.4	5.6
North													
Through	679	7.0	0.682	7.5	1.41	LOS A	10.0	74.1	0.76	0.68	40.4	9.6	17.8
Right	11	9.7	0.682	14.5	0.04	LOS B	10.0	74.1	0.76	0.93	39.1	0.2	0.3
Approach	690	7.0	0.682	7.6	1.46	LOS A	10.0	74.1	0.76	0.68	40.4	9.8	18.1
West													
Left	11	9.7	0.141	24.1	0.07	LOS C	0.7	5.1	0.88	0.71	31.6	0.2	0.4
Right	26	7.0	0.141	24.4	0.18	LOS C	0.7	5.1	0.88	0.72	31.5	0.5	0.9
Approach	37	7.8	0.141	24.4	0.25	LOS C	0.7	5.1	0.88	0.72	31.5	0.7	1.2
ll Vehicles	980	7.1	0.682	7.7	2.10	LOS A	10.0	74.1	0.71	0.63	40.5	13.9	24.9

VOLUMES UTILITY APPLICATION FOR SIDRA INTERSECTION 5.1 © 2000-2011 Akcelik & Associates Pty Ltd

MOVEMENT OUTPUT

*Use the **Control** sheet to create output data in this sheet. For detailed information, refer to the **Intro** sheet.*

2046 - Scenario 1 - AM Peak

Title: 3 - North South Connector and Findon Road

Type: Signals

Movement Performance - Vehicles

Turn	Demand Flow veh/h	HV %	Deg. Satn. v/c	Average Delay sec	Total Delay veh-h/h	Level of Service	95th percentile Back of Queue Vehicles veh	95th percentile Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h	Tot. Travel Time veh-h/h	Perf. Index
East													
Through	511	7.0	0.378	18.4	2.61	LOS B	6.4	47.8	0.76	0.64	38.0	8.2	17.5
Right	200	7.0	0.279	34.4	1.91	LOS C	2.9	21.9	0.86	0.77	29.9	3.9	8.3
Approach	711	7.0	0.378	22.9	4.52	LOS C	6.4	47.8	0.79	0.68	35.3	12.0	25.8
North													
Left	726	7.0	0.699	12.0	2.43	LOS B	11.9	87.9	0.67	0.82	40.2	11.1	21.9
Right	89	7.0	0.291	36.1	0.90	LOS D	2.7	20.3	0.89	0.76	27.7	1.9	4.0
Approach	816	7.0	0.699	14.7	3.33	LOS B	11.9	87.9	0.69	0.81	38.3	13.1	26.0
West													
Left	32	7.0	0.441	28.5	0.25	LOS C	7.9	58.4	0.77	0.91	34.3	0.5	1.2
Through	568	7.0	0.441	20.1	3.17	LOS C	7.9	58.4	0.78	0.68	36.7	9.4	20.1
Approach	600	7.0	0.441	20.5	3.42	LOS C	7.9	58.4	0.78	0.69	36.6	9.9	21.3
ll Vehicles	2126	7.0	0.699	19.1	11.27	LOS B	11.9	87.9	0.75	0.73	36.8	35.0	73.1

B.4 2046 Scenario 1 PM Peak

VOLUMES
UTILITY APPLICATION FOR SIDRA INTERSECTION 5.1 © 2000-2011 Akcelik & Associates Pty Ltd

MOVEMENT OUTPUT

*Use the **Control** sheet to create output data in this sheet. For detailed information, refer to the **Intro** sheet.*

2046 - Scenario 1 - PM Peak
Title: 1 - North South Connector and Harvest Home Road
Type: Signals

Movement Performance - Vehicles

Turn	Demand Flow veh/h	HV %	Deg. Satn. v/c	Average Delay sec	Total Delay veh-h/h	Level of Service	ercentile Back of Queu Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h	Tot. Travel Time veh-h/h	Perf. Index
South													
Left	363	7.0	0.697	20.6	2.08	LOS C	7.5	55.6	0.73	0.80	34.6	6.3	12.7
Through	537	7.0	0.679	15.1	2.25	LOS B	12.9	95.6	0.84	0.74	35.1	8.8	18.3
Right	12	17.7	0.679	21.9	0.07	LOS C	12.9	95.6	0.84	0.89	34.4	0.2	0.4
Approach	912	7.1	0.697	17.4	4.40	LOS B	12.9	95.6	0.80	0.76	34.9	15.3	31.4
East													
Left	12	17.7	0.092	31.6	0.10	LOS C	0.6	5.0	0.87	0.72	29.0	0.2	0.5
Through	12	17.7	0.092	24.9	0.08	LOS C	0.6	5.0	0.87	0.62	29.9	0.2	0.5
Right	12	17.7	0.035	22.2	0.07	LOS C	0.2	1.9	0.81	0.67	32.7	0.2	0.4
Approach	36	17.7	0.092	26.2	0.26	LOS C	0.6	5.0	0.85	0.67	30.5	0.7	1.3
North													
Left	12	17.7	0.194	17.7	0.06	LOS B	1.8	13.2	0.61	0.83	36.3	0.2	0.4
Through	116	7.0	0.292	13.3	0.43	LOS B	1.8	13.6	0.66	0.52	36.1	1.8	3.4
Right	47	7.0	0.292	29.3	0.39	LOS C	1.8	13.6	0.84	0.78	30.7	0.9	1.9
Approach	175	7.7	0.292	17.9	0.87	LOS B	1.8	13.6	0.70	0.61	34.4	3.0	5.7
West													
Left	79	7.0	0.385	34.1	0.75	LOS C	2.9	21.5	0.92	0.78	30.4	1.5	3.2
Through	26	7.0	0.385	27.7	0.20	LOS C	2.9	21.5	0.92	0.73	30.6	0.5	1.0
Right	221	7.0	0.516	25.3	1.55	LOS C	5.2	38.4	0.88	0.79	34.3	3.7	7.8
Approach	326	7.0	0.516	27.6	2.50	LOS C	5.2	38.4	0.89	0.78	33.0	5.7	12.0
ll Vehicles	1449	7.4	0.697	20.0	8.03	LOS B	12.9	95.6	0.81	0.75	34.2	24.7	50.4

VOLUMES II
UTILITY APPLICATION FOR SIDRA INTERSECTION 5.1

MOVEMENT OUTPUT

*Use the **Control** sheet to create output data in this sheet. For detailed information, refer to the **Intro** sheet.*

2046 - Scenario 1 - PM Peak
Title: 2 - North South Connector and Town Center
Type: Signals

Movement Performance - Vehicles

Turn	Demand Flow veh/h	HV %	Deg. Satn. v/c	Average Delay sec	Total Delay veh-h/h	Level of Service	ercentile Back of Queu Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h	Tot. Travel Time veh-h/h	Perf. Index
South													
Left	21	7.0	0.722	14.1	0.08	LOS B	11.8	87.4	0.77	0.90	39.1	0.3	0.6
Through	747	7.0	0.722	7.6	1.57	LOS A	11.8	87.4	0.77	0.69	40.3	10.6	20.0
Approach	768	7.0	0.722	7.7	1.65	LOS A	11.8	87.4	0.77	0.70	40.3	10.9	20.7
North													
Through	384	7.0	0.408	6.3	0.68	LOS A	4.8	36.0	0.61	0.52	41.7	5.3	9.1
Right	12	17.7	0.408	13.5	0.04	LOS B	4.8	36.0	0.61	0.94	39.5	0.2	0.3
Approach	396	7.3	0.408	6.6	0.72	LOS A	4.8	36.0	0.61	0.54	41.6	5.5	9.4
West													
Left	12	17.7	0.101	25.3	0.08	LOS C	0.5	3.7	0.88	0.70	31.1	0.2	0.4
Right	12	17.7	0.101	25.7	0.09	LOS C	0.5	3.7	0.88	0.71	31.1	0.2	0.4
Approach	24	17.7	0.101	25.5	0.17	LOS C	0.5	3.7	0.88	0.70	31.1	0.4	0.8
ll Vehicles	1188	7.3	0.722	7.7	2.54	LOS A	11.8	87.4	0.72	0.64	40.5	16.8	30.9

VOLUMES II
UTILITY APPLICATION FOR SIDRA INTERSECTION 5.1 © 2000-2011 Akcelik & Associates Pty Ltd

MOVEMENT OUTPUT

*Use the **Control** sheet to create output data in this sheet. For detailed information, refer to the **Intro** sheet.*

2046 - Scenario 1 - PM Peak
Title: 3 - North South Connector and Findon Road
Type: Signals

Movement Performance - Vehicles

Turn	Demand Flow veh/h	HV %	Deg. Satn. v/c	Average Delay sec	Total Delay veh-h/h	Level of Service	ercentile Back of Queu Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h	Tot. Travel Time veh-h/h	Perf. Index
East													
Through	589	7.0	0.467	21.0	3.44	LOS C	8.2	60.6	0.81	0.69	36.2	9.9	21.7
Right	742	7.0	0.745	34.9	7.19	LOS C	12.3	90.9	0.95	0.86	29.6	14.4	32.9
Approach	1332	7.0	0.745	28.8	10.64	LOS C	12.3	90.9	0.89	0.78	32.3	24.3	54.5
North													
Left	321	7.0	0.335	11.1	0.99	LOS B	4.4	32.3	0.48	0.70	40.8	4.8	8.9
Right	53	7.0	0.235	39.9	0.58	LOS D	1.7	12.8	0.91	0.74	26.5	1.2	2.5
Approach	374	7.0	0.335	15.2	1.58	LOS B	4.4	32.3	0.54	0.71	37.9	6.0	11.4
West													
Left	89	7.0	0.641	32.0	0.80	LOS C	11.8	87.5	0.87	0.93	32.4	1.6	3.7
Through	732	7.0	0.641	23.6	4.80	LOS C	12.1	89.5	0.88	0.78	34.4	12.9	28.4
Approach	821	7.0	0.641	24.6	5.60	LOS C	12.1	89.5	0.87	0.80	34.2	14.5	32.1
ll Vehicles	2526	7.0	0.745	25.4	17.81	LOS C	12.3	90.9	0.83	0.78	33.7	44.9	98.0