Future Deficiency Report

Technical Note 19

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1. INTRODUCTION

The purpose of this report is to present transport network deficiencies in the Waikato Region in 2021 and 2041. The report provides evidence of model convergence and a detailed account of predicted deficiencies within the region.

The report includes traffic volume plots covering the entire study area for all 3 years (2006, 2021 and 2041) and all 3 periods, level of service plots which highlight deficiencies across the region and traffic activity indicators are reported to indicate traffic growth and changes in network delays and speed. Also included is a summary of key points identified in the modelling.

2. MODEL CONVERGENCE

Assignment and Validation Loop

Time and distance matrices are required as inputs for trip distribution. As assigning the trips to the network generates these matrices, after each assignment the trip distribution needs to be re-run and the trips re-assigned until the time and distances matrices converge.

In practice, it is unlikely that absolute convergence occurs. The assignment and distribution steps are run iteratively until the totals of both the time and distance matrices between successive runs remain close to each other and relatively constant.

The totals for the time and distance matrices for two successive Assignment/Distribution Loops (after many previous runs) are shown below in **Table 1** where:

TVM = Total Vehicle Minutes

TVK = Total Vehicle Kilometres

The percentage change in generalised user cost between consecutive loops should be less than 1%. As the total vehicle minutes and total vehicle kilometres change less than 1% between runs (shown above), and unit time and distance costs are constant between runs, generalised user cost also changes less than 1% between runs.

Link Flow Convergence

The EEM requirement for link flow stability details that 95% of all links should not change by more than 5% between the ultimate and penultimate distribution/assignment convergence loops. The percentage of total links with changes of less than 5% for the three modelled periods is shown in **Table 2** below. These results confirm that convergence conditions have been exceeded in all cases.

Time and Distance Convergence Totals						Table 1
PERIOD	AM Peak		Interpeak		PM Peak	
	TVM	TVK	TVM	TVK	TVM	TVK
2006						
Last Run	2,594,648	2,583,117	2,395,296	2,522,879	3,302,800	3,237,754
Previous Run	2,594,509	2,582,985	2,395,029	2,522,776	3,302,961	3,237,997
Absolute Difference	139.63	132.29	267.26	103.59	-160.26	-243.65
% Diff	0.01%	0.01%	0.01%	0.00%	0.00%	-0.01%
2021						
Last Run	3,456,619	3,329,047	3,291,140	3,370,635	4,186,271	4,055,518
Previous Run	3,458,013	3,329,908	3,292,330	3,371,689	4,186,797	4,056,204
Absolute Difference	-1394.08	-861.2	-1190.14	-1053.6	-526.43	-686.39
% Diff	-0.04%	-0.03%	-0.04%	-0.03%	-0.01%	-0.02%
2041						
Last Run	4,403,511	3,929,222	4,091,478	4,035,150	5,043,457	4,726,161
Previous Run	4,401,209	3,931,245	4,088,638	4,035,178	5,037,180	4,725,036
Absolute Difference	2301.74	-2022.86	2840.43	-28.51	6276.87	1124.68
% Diff	0.05%	-0.05%	0.07%	0.00%	0.12%	0.02%

Works included in the 2021 and 2041 Do Minimum model are listed on page 10 of Future Model Preparation - Technical Note 18- Version 1 (4 December 2009). The reporting in subsequent sections of this technical note present outputs relating to the do minimum networks.

In developing the future models, it was found that the do minimum networks did no have sufficient capacity to permit the models to converge. As such a stable future trip matrix was not attainable. In order to address this the following works were also included in the 2021 network model in order to achieve convergence.

- The following links were 4 laned:
  - Victoria Street (Queen Street to Hamilton Rd, Cambridge)
  - Wairere Drive (Pukete Rd to Tramway Rd)
  - E1 (Crosby Rd to Clyde Rd)
  - Onion Rd extension
  - Expressway in full

Once convergence was achieved, the do minimum network was assigned to the resultant 'converged' trip matrix. Note that the additional convergence works are not included in the model reported on in this deficiency report – only the do minimum works are included in the assessment for both 2021 and 2041.

Link Flow Convergence				Table 2
Period	**Criteria**	**Links**	**Percentage**	**Less than 5%**
2006				
AMP	0% - 2.5%	17564	98.49	99.0
	2.5% - 5%	88	0.49	
	> 5%	182	1.02	
Total		**17834**	**100.00**	
INP	0% - 2.5%	17710	99.30	99.5
	2.5% - 5%	40	0.22	
	> 5%	84	0.47	
Total		**17834**	**100.00**	
PMP	0% - 2.5%	17128	96.04	97.7
	2.5% - 5%	293	1.64	
	> 5%	413	2.32	
Total		**17834**	**100.00**	
2021				
AMP	0% - 2.5%	17939	97.24	98.6
	2.5% - 5%	247	1.34	
	> 5%	263	1.43	
Total		**18449**	**100.00**	
INP	0% - 2.5%	18092	98.06	99.02
	2.5% - 5%	177	0.96	
	> 5%	180	0.98	
Total		**18449**	**100.00**	
PMP	0% - 2.5%	18135	98.30	99.22
	2.5% - 5%	169	0.92	
	> 5%	145	0.79	
Total		**18449**	**100.00**	
2041				
AMP	0% - 2.5%	17888	95.70	97.7
	2.5% - 5%	380	2.03	
	> 5%	423	2.26	
Total		**18691**	**100.00**	
INP	0% - 2.5%	18287	97.84	98.7
	2.5% - 5%	167	0.89	
	> 5%	237	1.27	
Total		**18691**	**100.00**	
PMP	0% - 2.5%	18307	97.95	98.9
	2.5% - 5%	177	0.95	
	> 5%	207	1.11	
Total		**18691**	**100.00**	

Similarly, in 2041 convergence was not achievable. In addition to the "convergence-only" works listed above for 2021, the following works were added to the 2041 network model in order to achieve convergence:

- Double circulating roundabouts were added at the following intersections:
  - Domain Rd/Papamoa Beach Rd
  - Golf Rd/Marine Parade
  - Concord Ave/Marine Parade
  - Ocean Beach Rd/Girven Rd
  - Concord Ave/Maunganui Rd
  - Kairua Rd/SH2
  - Papamoa Beach Rd/Parton Rd
  - Sh2/Bell rd
  - Welcome Bay Rd/Ohauiti Rd
  - Ohauiti Rd/Poike Rd
  - Domain Rd/Tara Rd
  - Fifteenth Ave/Grace Rd
- The following links were 4-laned:
  - E1 (Clyde Rd to Cobham Drive)
  - Avalon Drive bypass
  - Te Totara river crossing
  - Papamoa Beach Rd/Marine Parade from Papamoa Beach settlement to north of Tay St, Mt Maunganui
  - SH2 from the bridge to Fraser St
  - Cameron Rd from south of SH2 to 2 km south on Pyes Pa Rd
  - Domain Rd
  - SH2 from Domain Rd to Maunganui Rd
- A 3rd approach lane was added from the north at the roundabout at the intersection of Welcome Bay Rd and SH29
- The cycle time of the signals at the intersection of Hewletts Rd and Tasman Quay was increased to 180 seconds
- The intersection of Moffat Rd and Carmichael Rd was restricted to ban traffic turning right into Moffat Rd and left out of Moffat Rd.

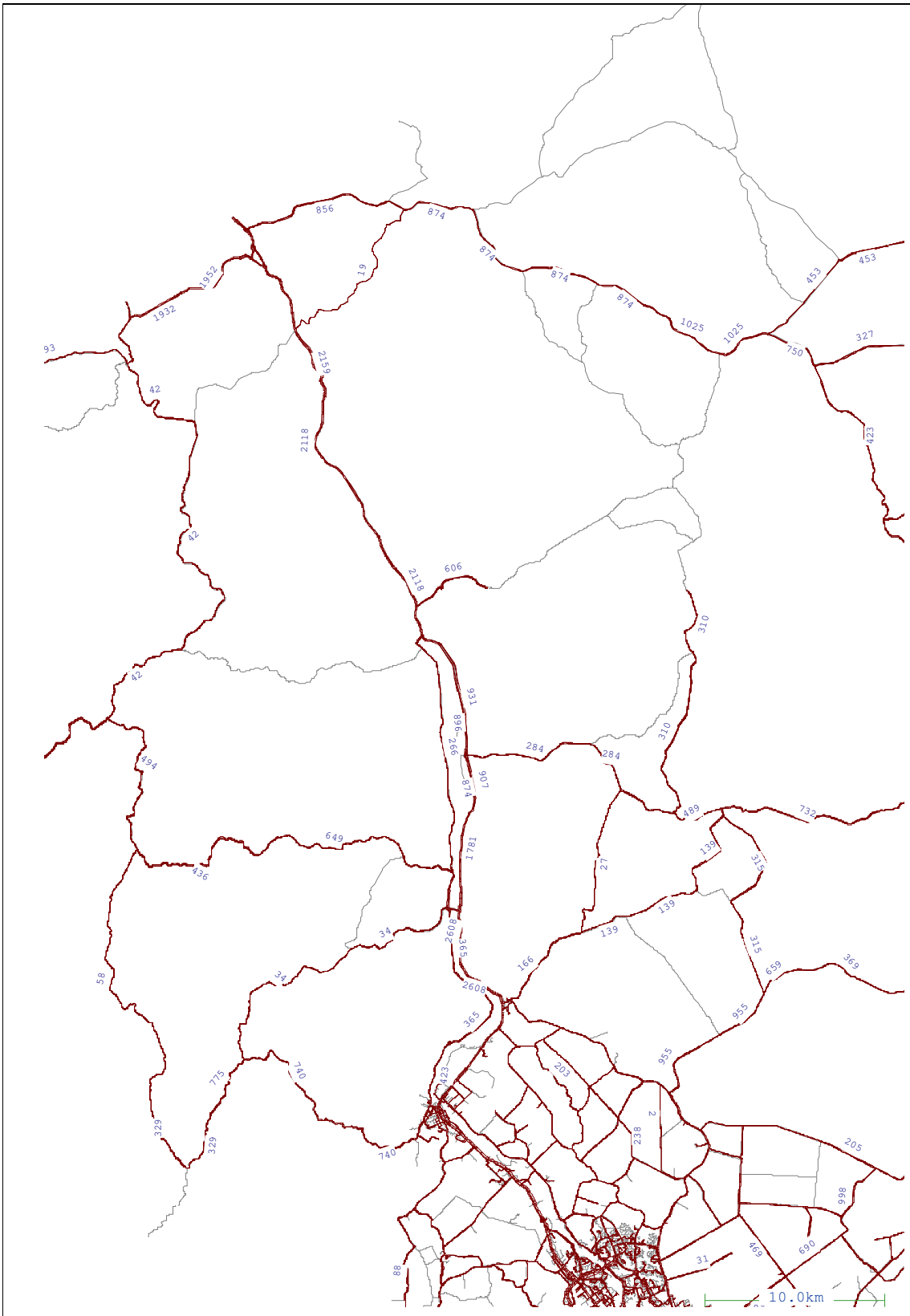
3. MODEL FUTURE SCENARIOS DEVELOPMENT

Introduction

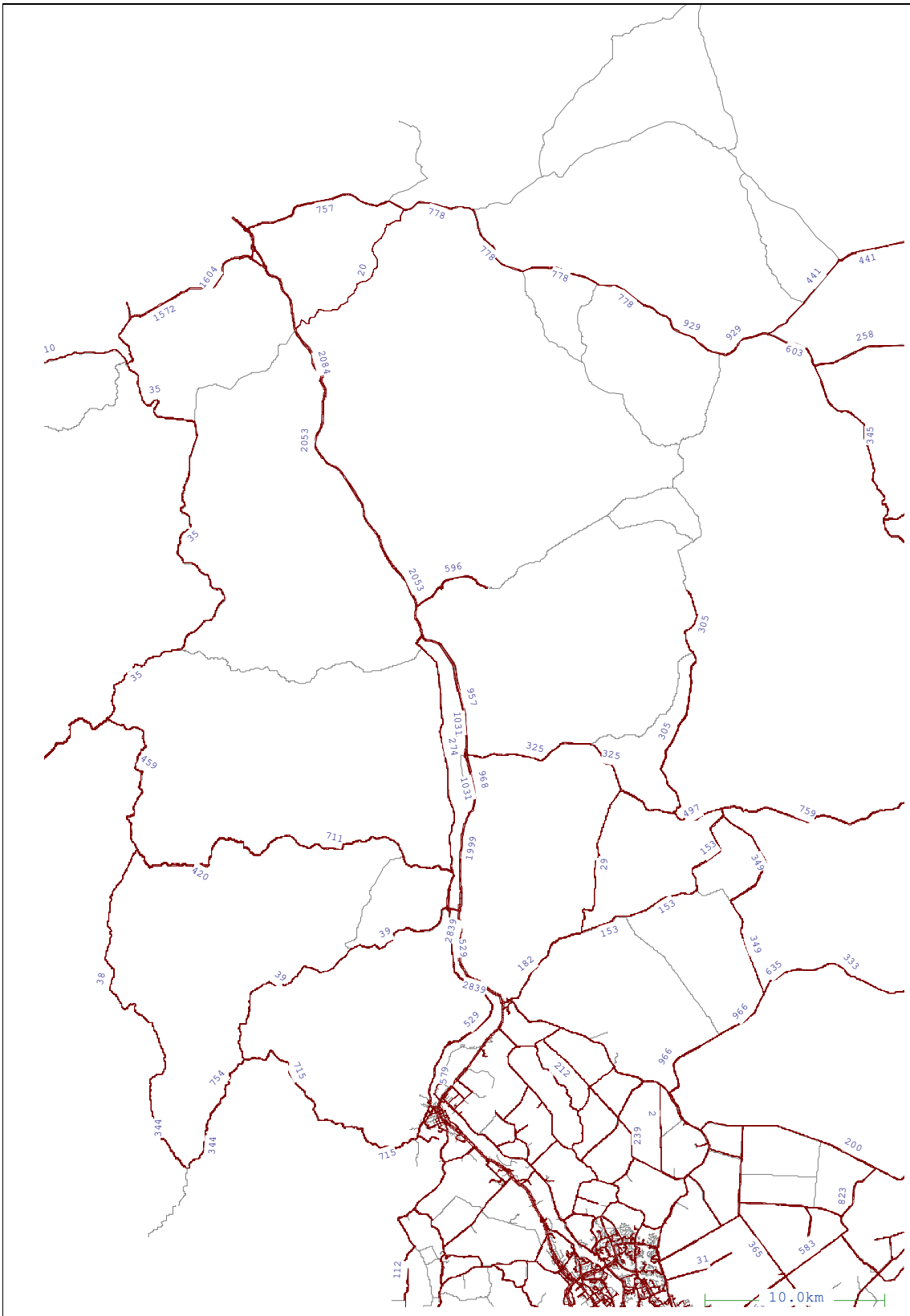
Refer to Future Model Preparation - Technical Note 18- Version 1 (4 December 2009) for landuse information. Technical Note 18 can be found in the Waikato\Reports\ Technical Notes\Tech Note 18 Future Model Prep folder.

Period Model Traffic Volumes

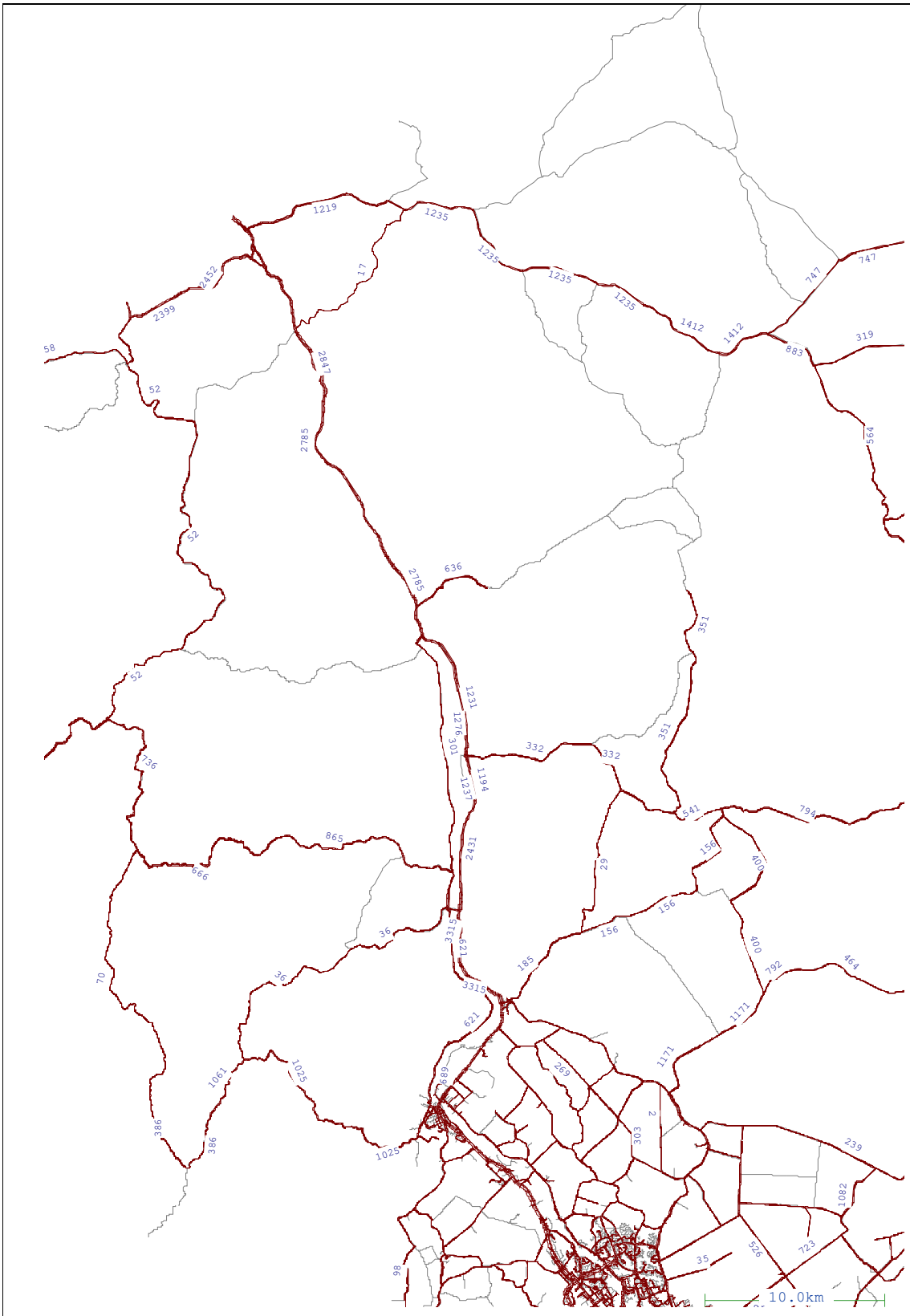
Two way traffic volumes for the morning and evening peak periods (2006, 2021 and 2041) are shown in **Figure 1** to **Figure 54** below for Waipa, Hamilton, Rotorua, Taupo and Tauranga along with a northern overview of Waikato.



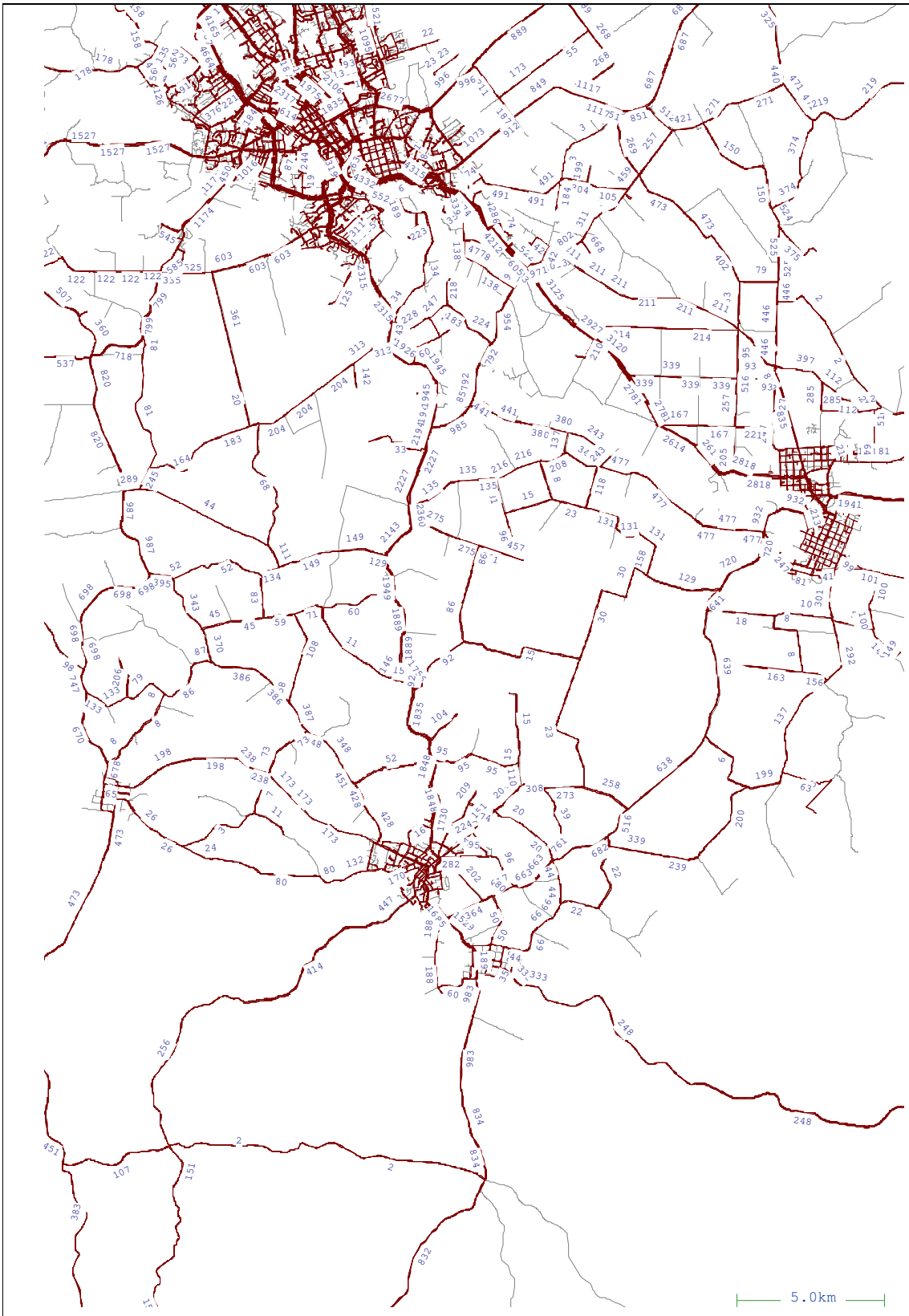
Traffic Design Group	**2006 AM Peak Two-Way Traffic volumes North Waikato**	**Figure 1**
Gabites Porter		



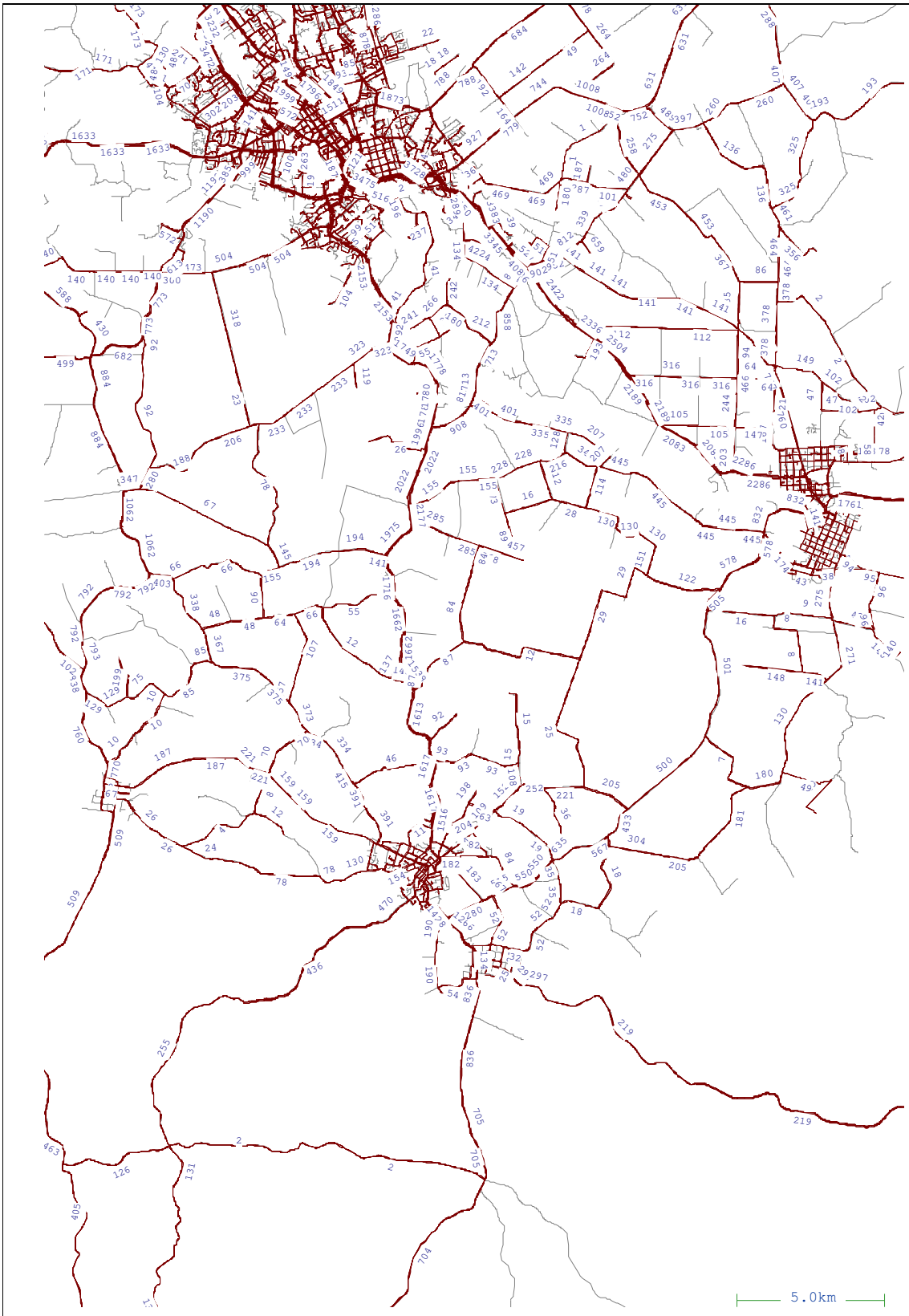
Traffic Design Group	**2006 Inter Peak Two-Way Traffic volumes North Waikato**	**Figure 2**
Gabites Porter		



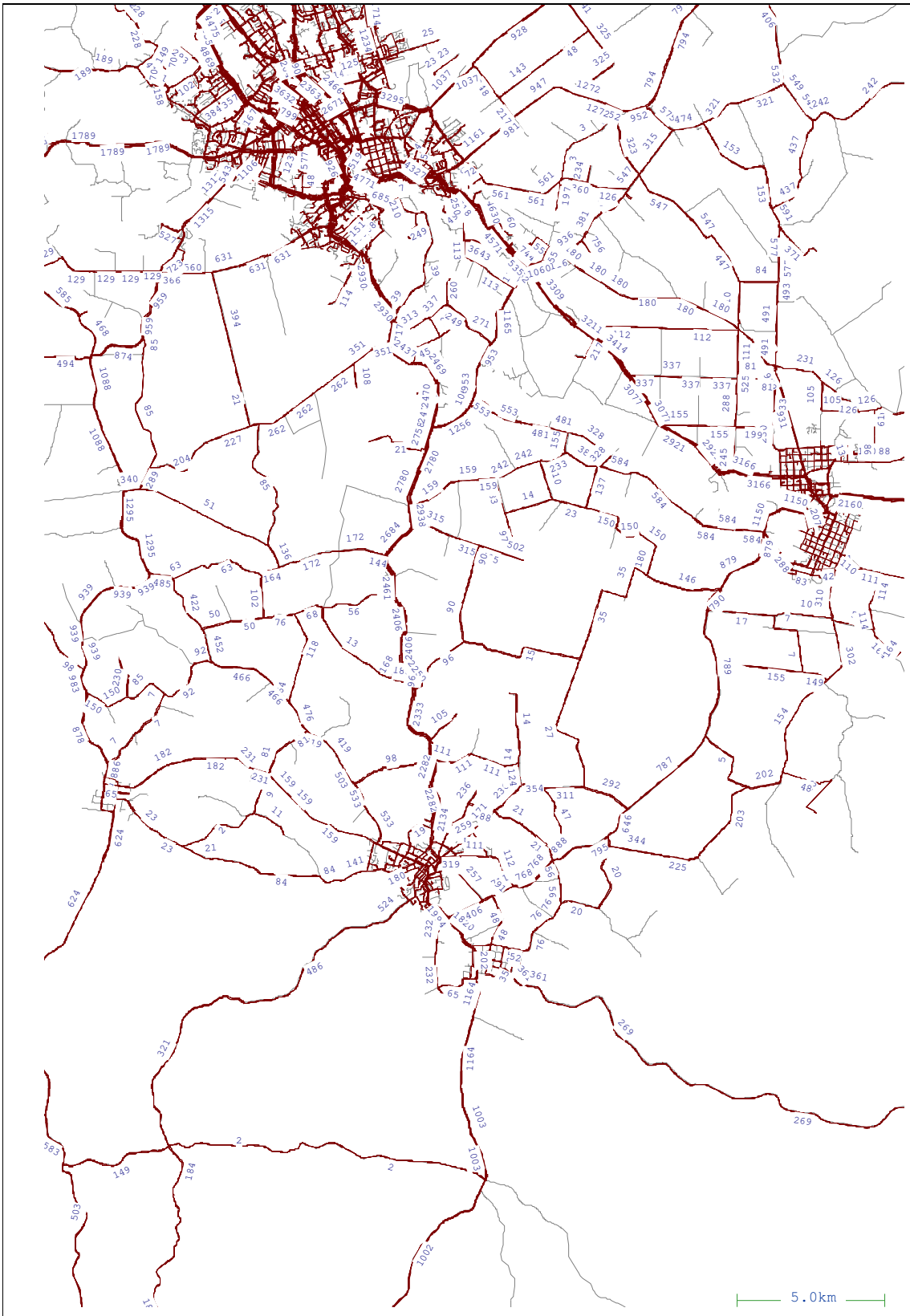
Traffic Design Group Gabites Porter	**2006 PM Peak Two-Way Traffic volumes North Waikato**	**Figure 3**



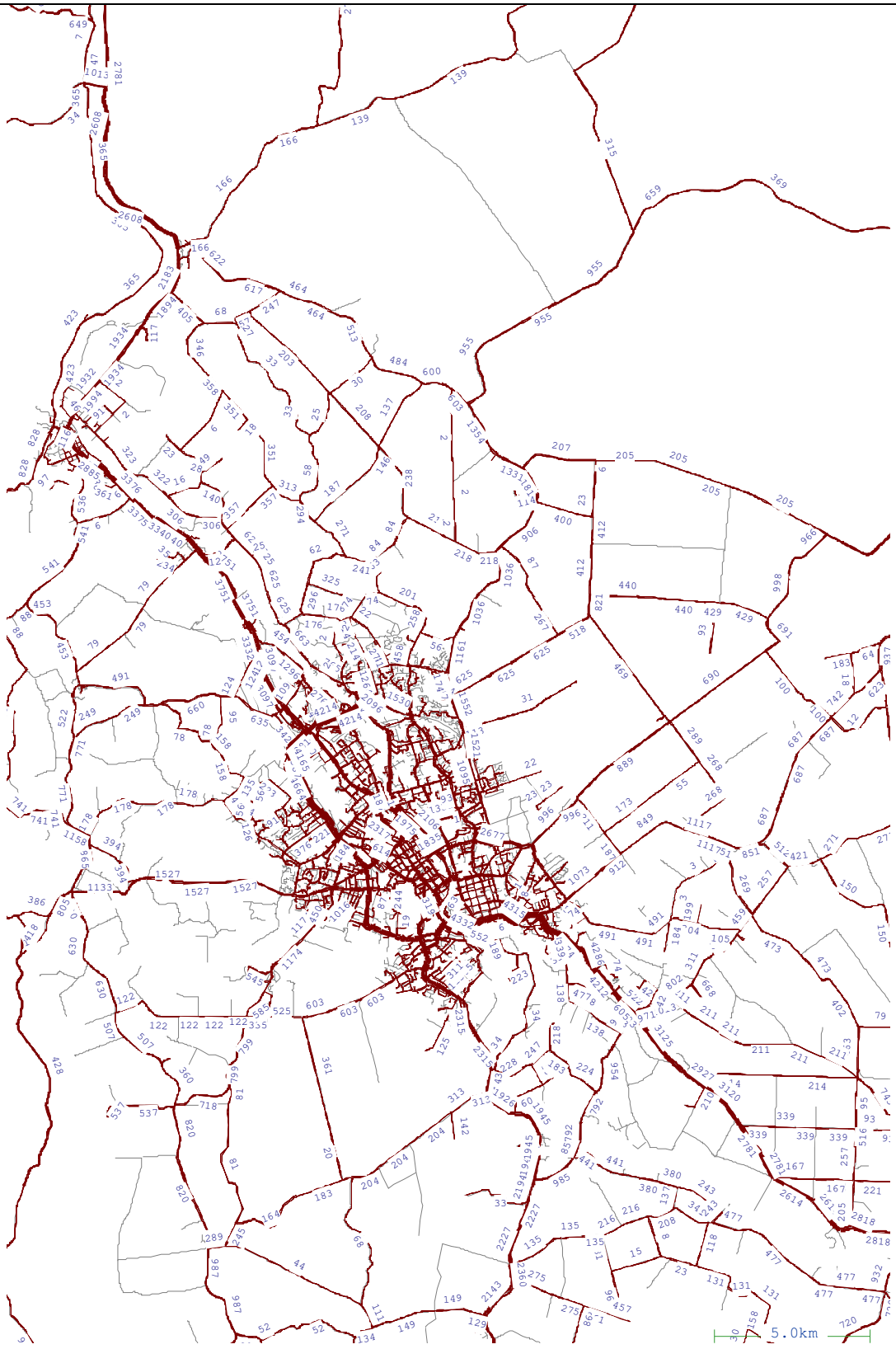
Traffic Design Group	**2006 AM Peak Two-Way Traffic volumes Waipa**	**Figure 4**
Gabites Porter		



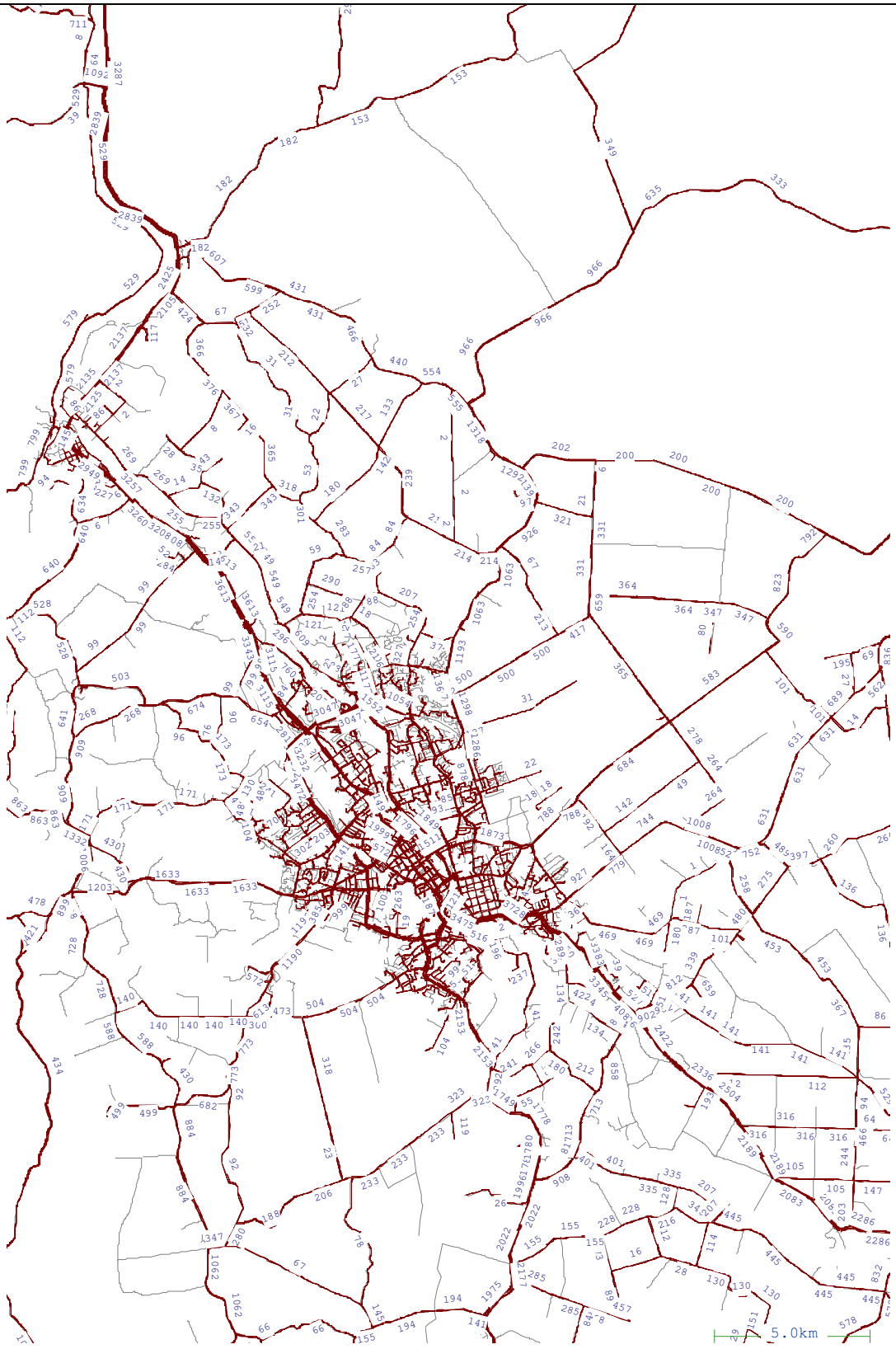
Traffic Design Group	**2006 Inter Peak Two-Way Traffic volumes Waipa**	**Figure 5**
Gabites Porter		



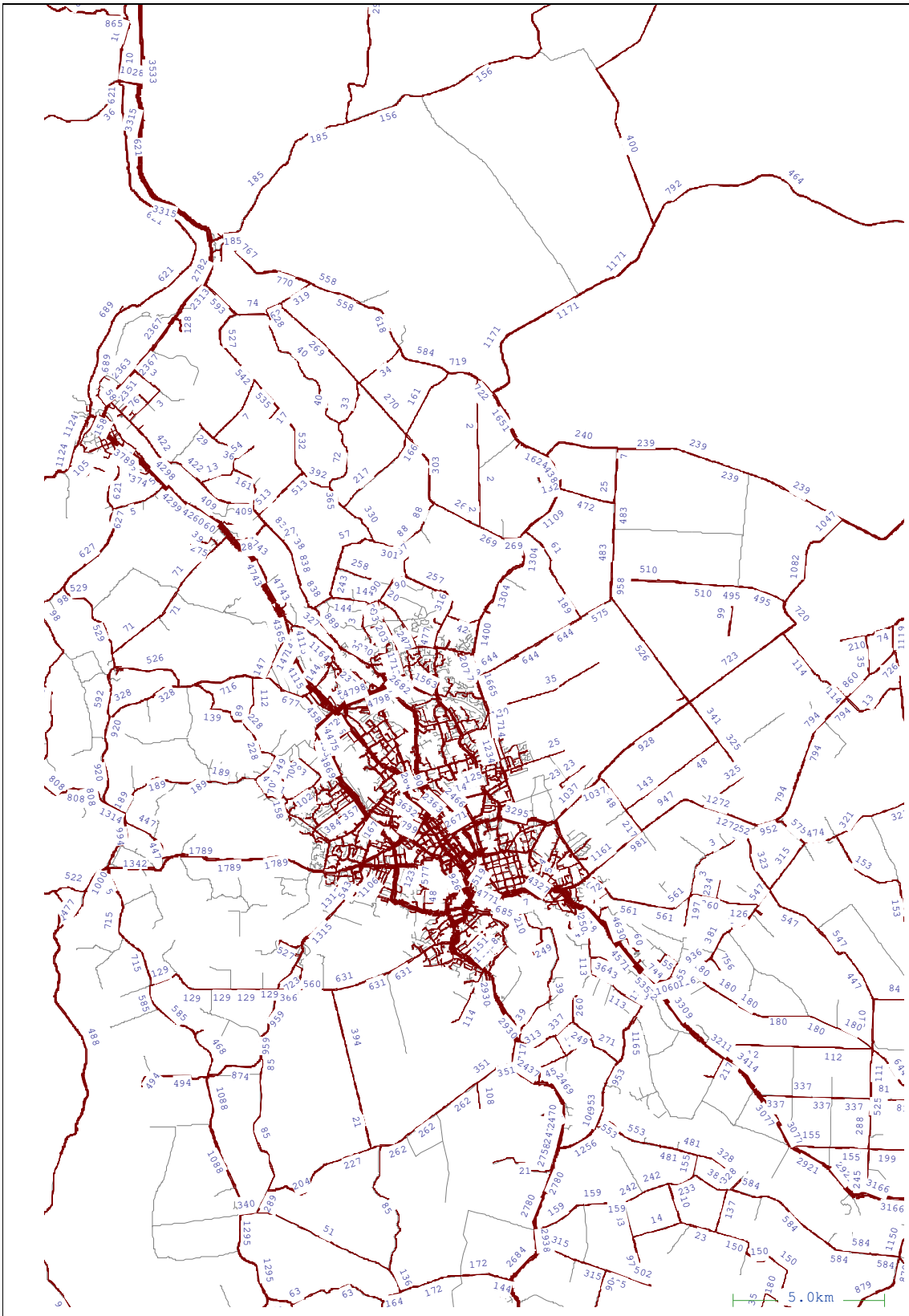
Traffic Design Group	**2006 PM Peak Two-Way Traffic volumes Waipa**	**Figure 6**
Gabites Porter		



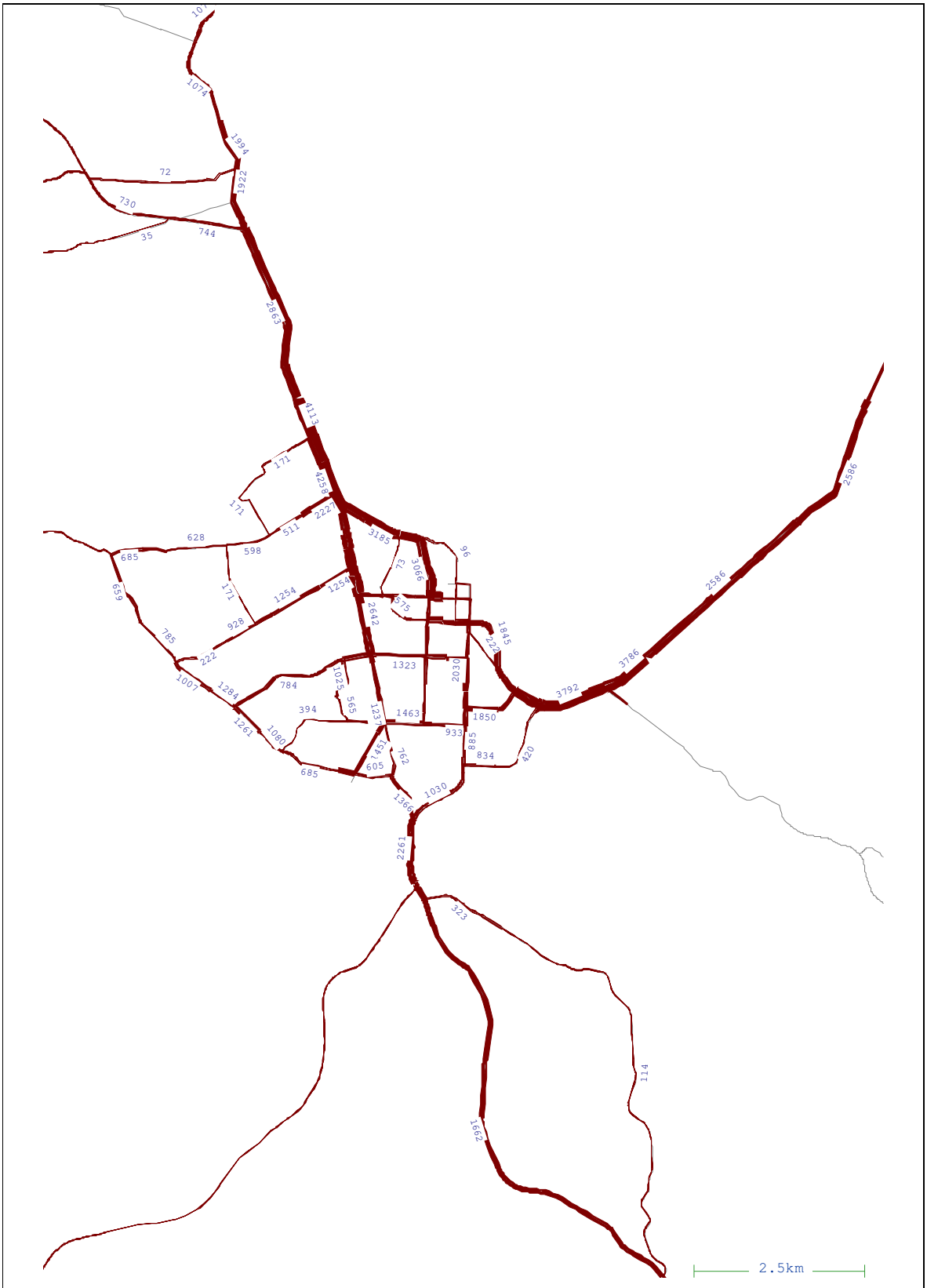
Traffic Design Group	**2006 AM Peak Two-Way Traffic volumes Hamilton**	**Figure 7**
Gabites Porter		



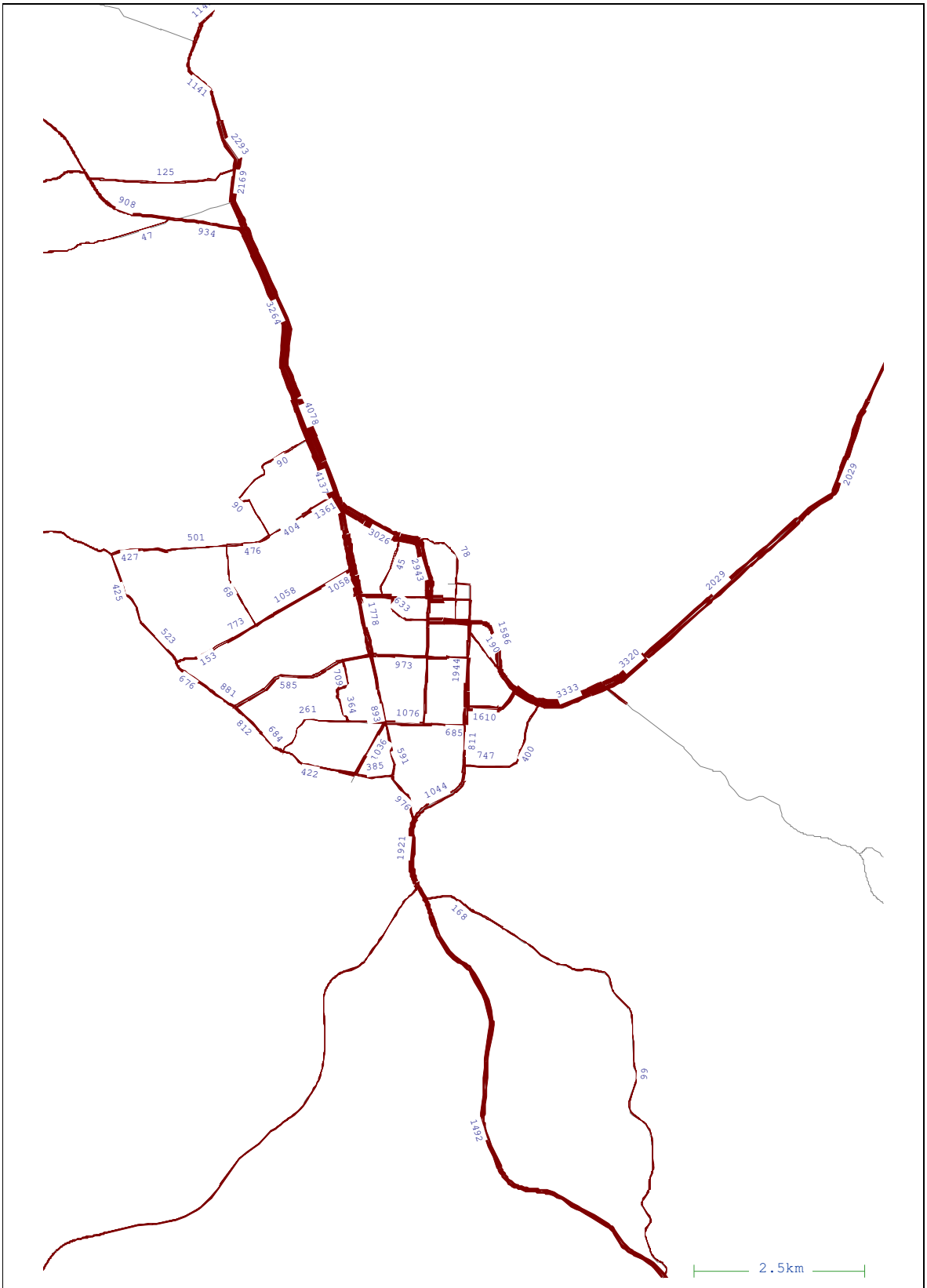
Traffic Design Group	**2006 Inter Peak Two-Way Traffic volumes Hamilton**	**Figure 8**
Gabites Porter		



Traffic Design Group Gabites Porter	**2006 PM Peak Two-Way Traffic volumes Hamilton**	**Figure 9**



Traffic Design Group Gabites Porter	**2006 AM Peak Two-Way Traffic volumes Rotorua**	**Figure 10**



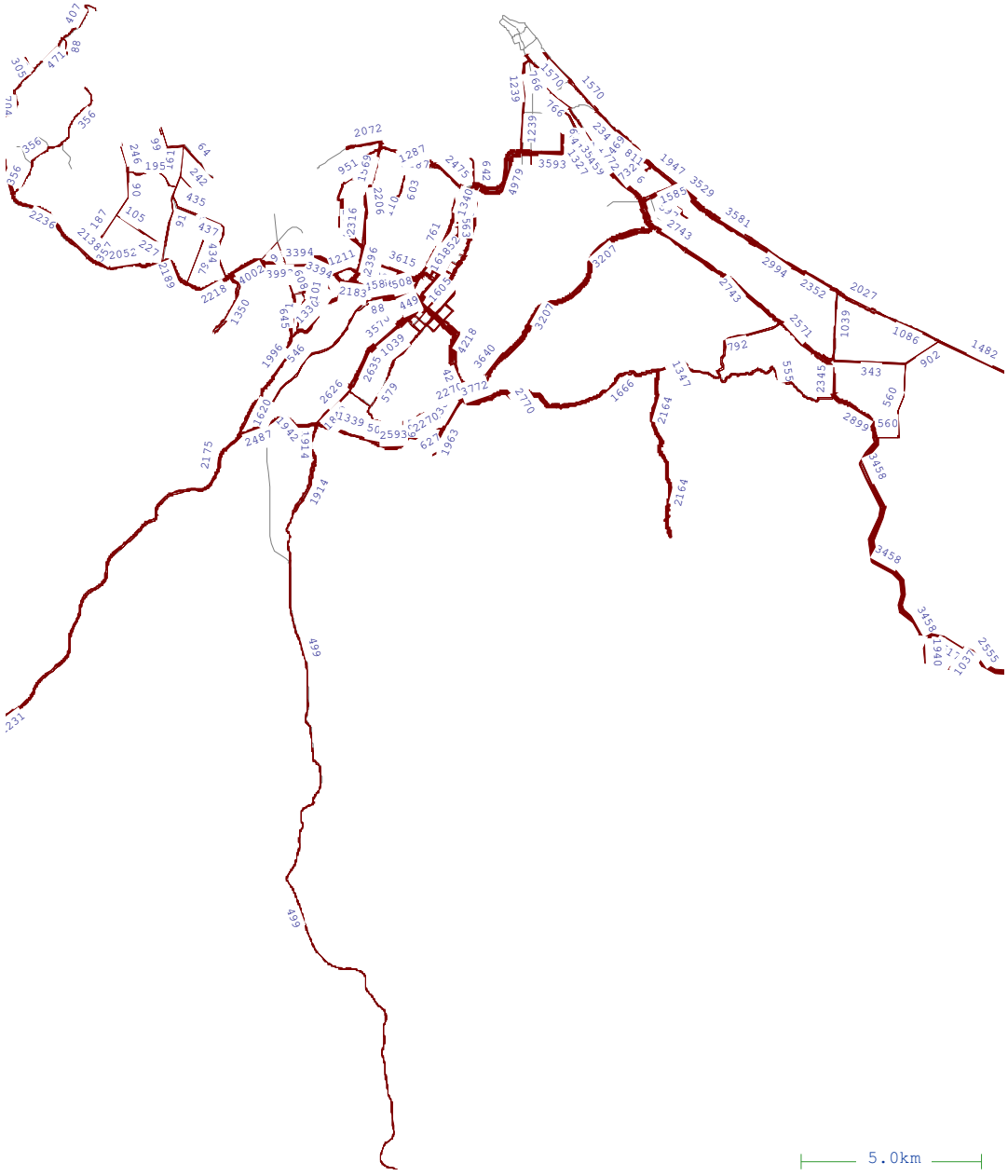
Traffic Design Group Gabites Porter	**2006 Inter Peak Two-Way Traffic volumes Rotorua**	**Figure 11**

Traffic Design Group Gabites Porter	**2006 PM Peak Two-Way Traffic volumes Rotorua**	**Figure 12**

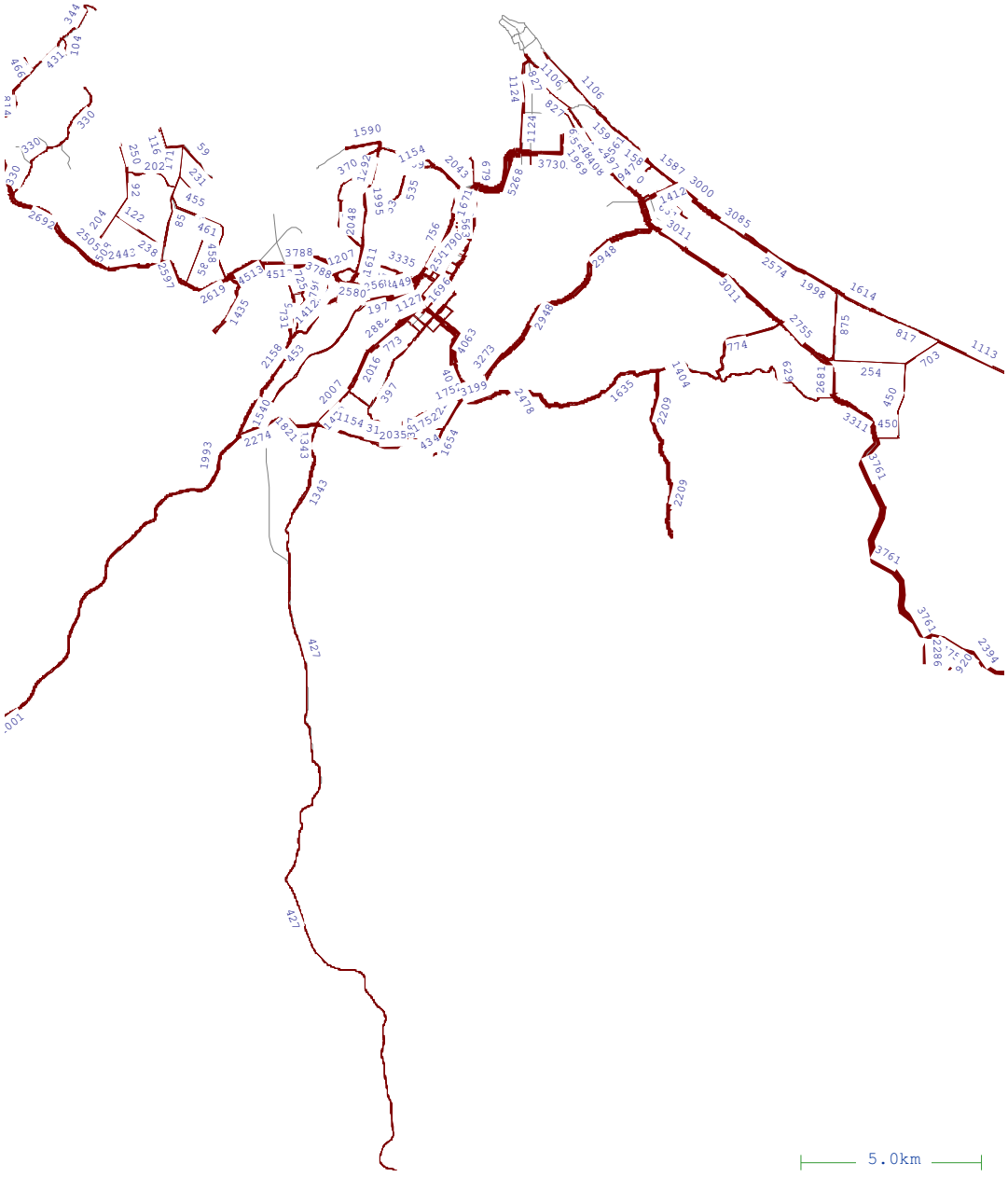
Traffic Design Group Gabites Porter	**2006 AM Peak Two-Way Traffic volumes Taupo**	**Figure 13**

Traffic Design Group	**2006 Inter Peak Two-Way Traffic volumes Taupo**	**Figure 14**
Gabites Porter		

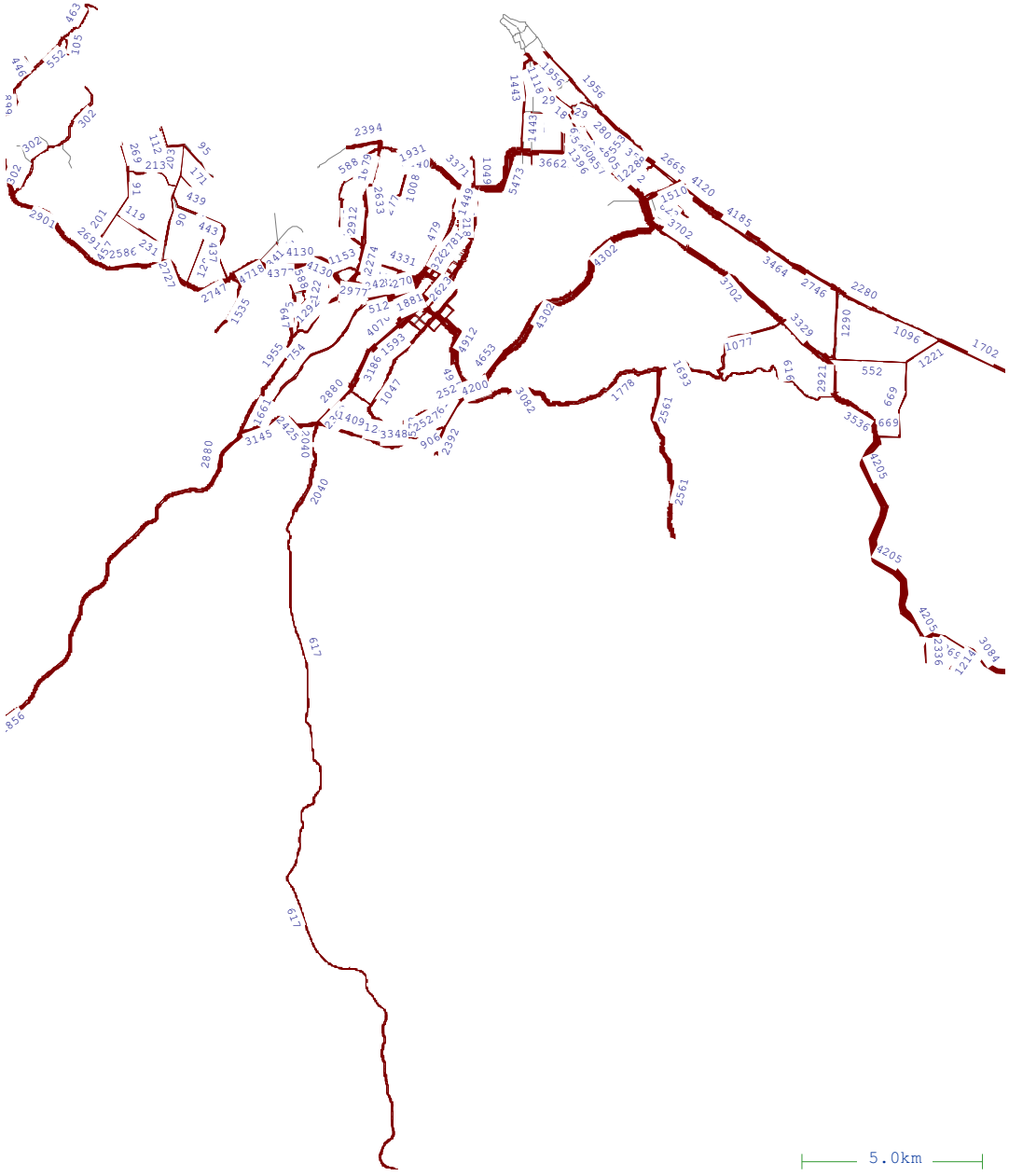
Traffic Design Group Gabites Porter	**2006 PM Peak Two-Way Traffic volumes Taupo**	**Figure 15**



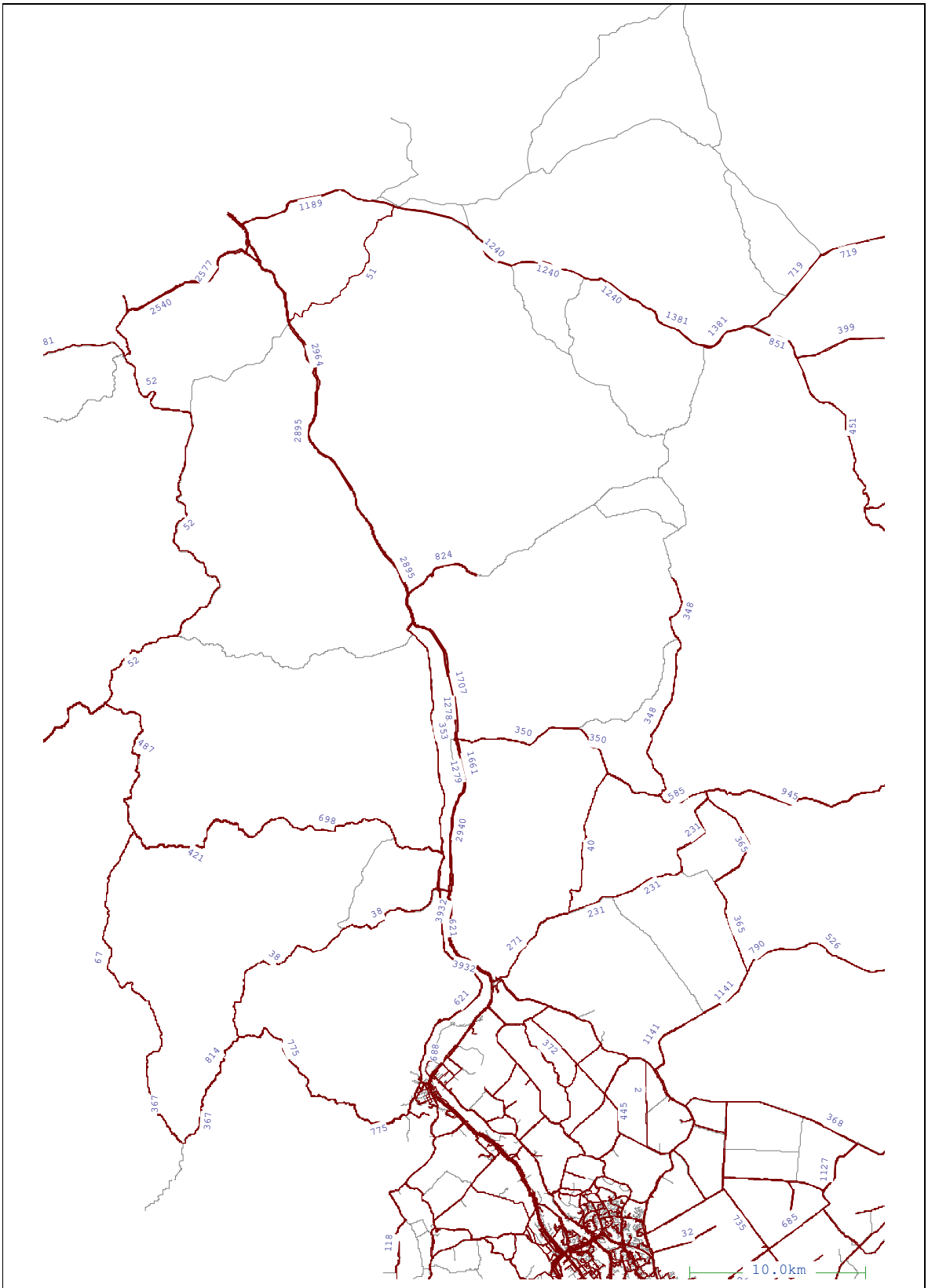
Traffic Design Group Gabites Porter	**2006 AM Peak Two-Way Traffic volumes Tauranga**	**Figure 16**



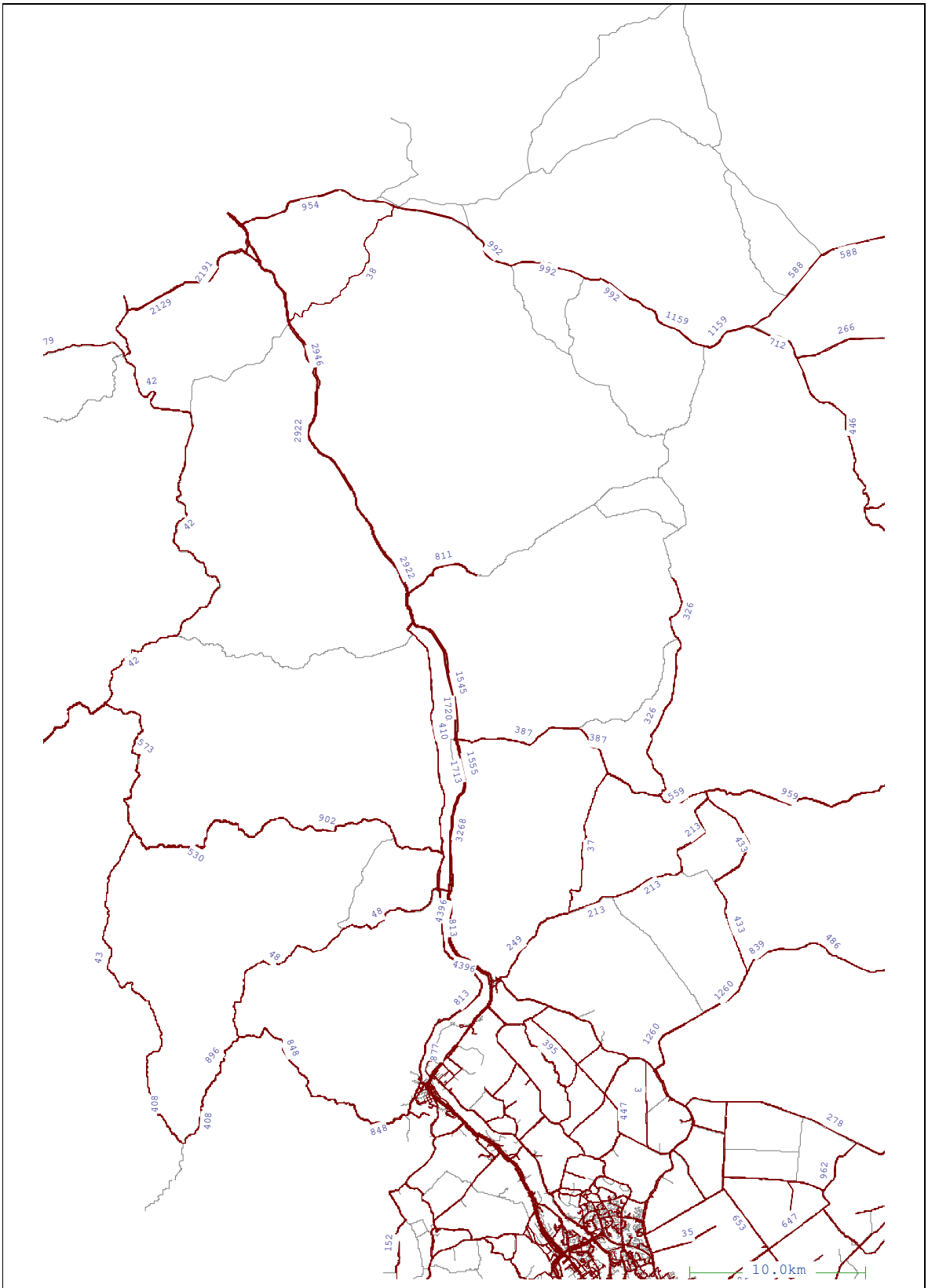
Traffic Design Group Gabites Porter	**2006 Inter Peak Two-Way Traffic volumes Tauranga**	**Figure 17**



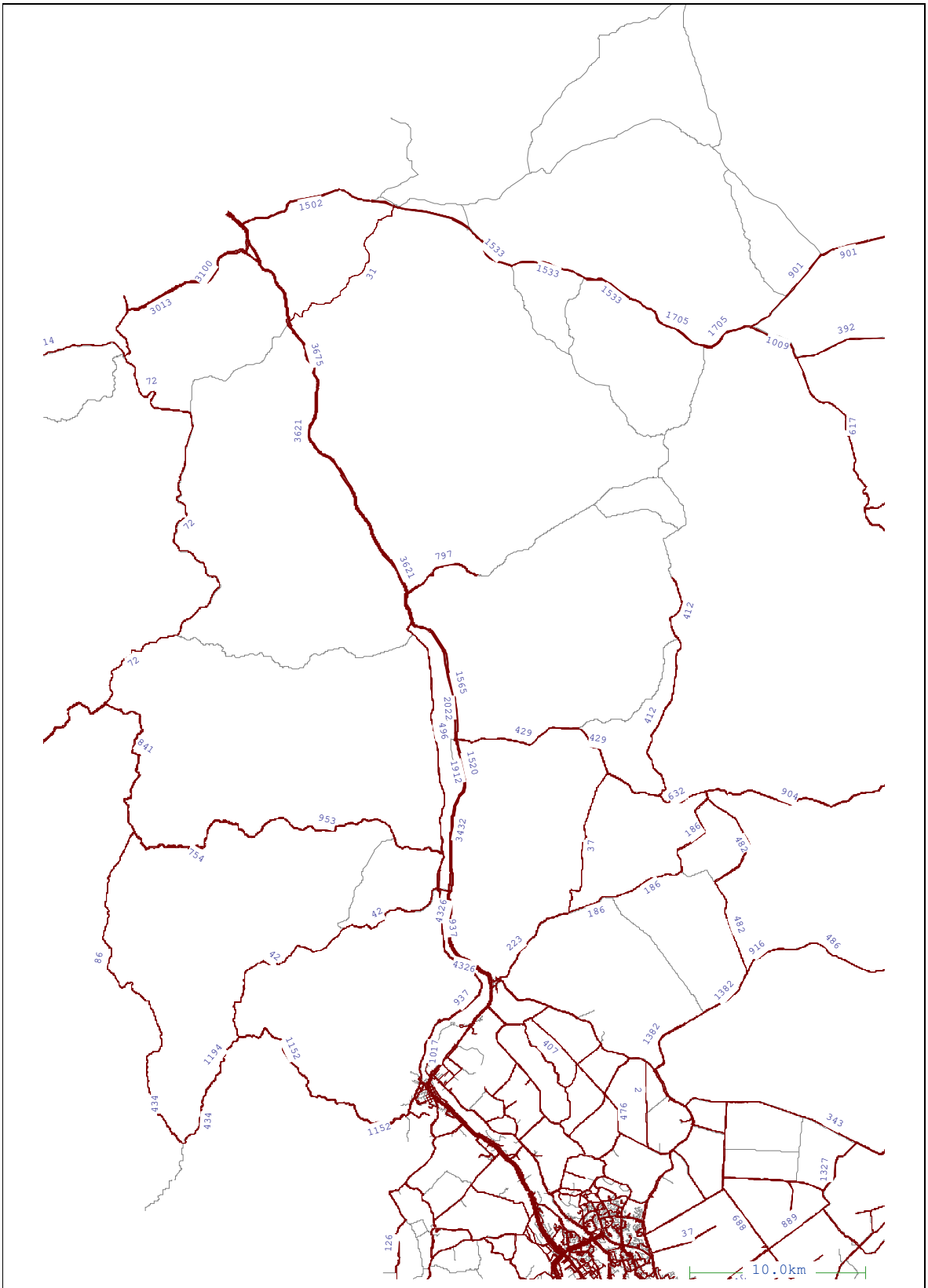
Traffic Design Group Gabites Porter	**2006 PM Peak Two-Way Traffic volumes Tauranga**	**Figure 18**



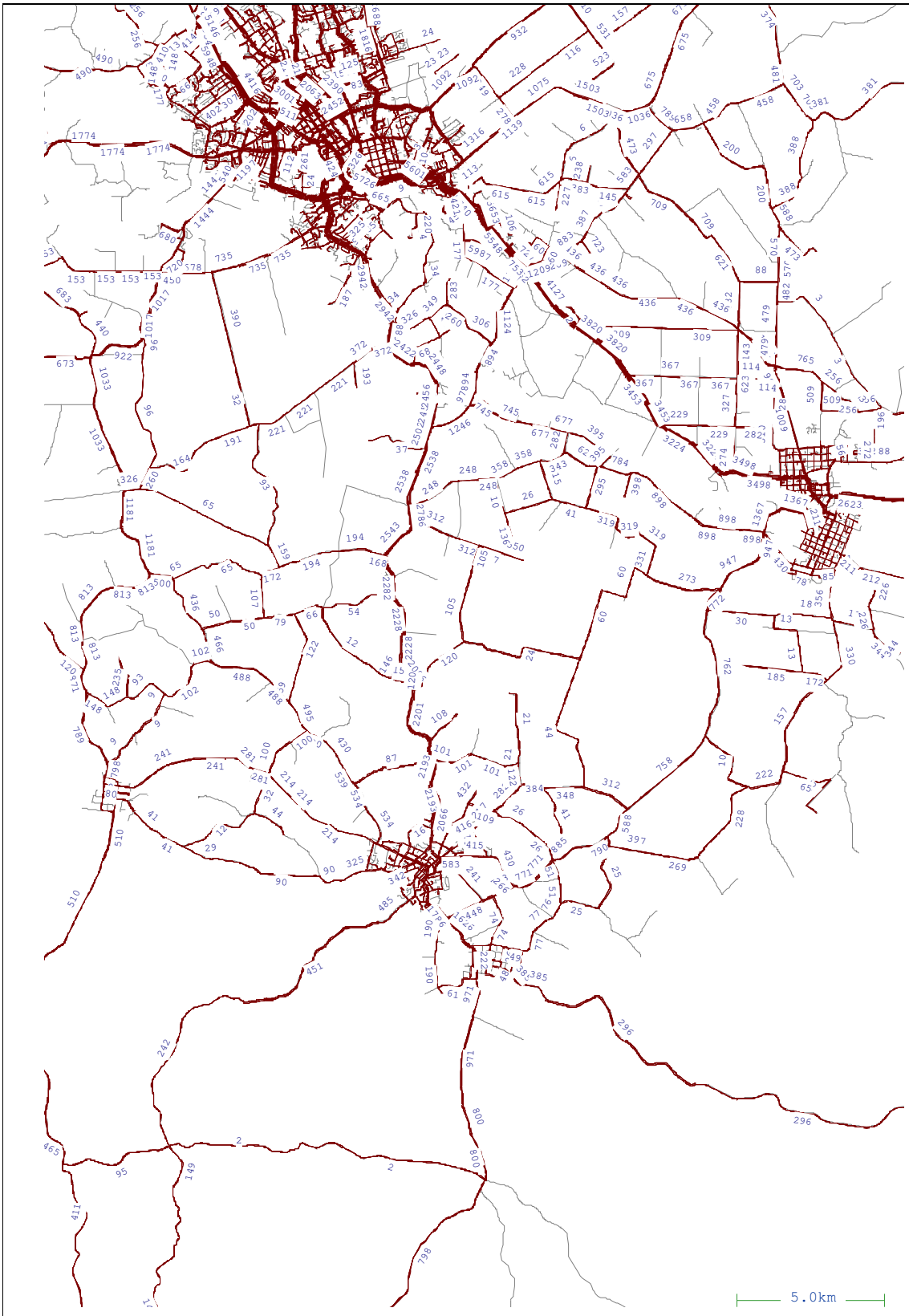
Traffic Design Group Gabites Porter	**2021 AM Peak Two-Way Traffic volumes North Waikato**	**Figure 19**



Traffic Design Group	**2021 Inter Peak Two-Way Traffic volumes North Waikato**	**Figure 20**
Gabites Porter		

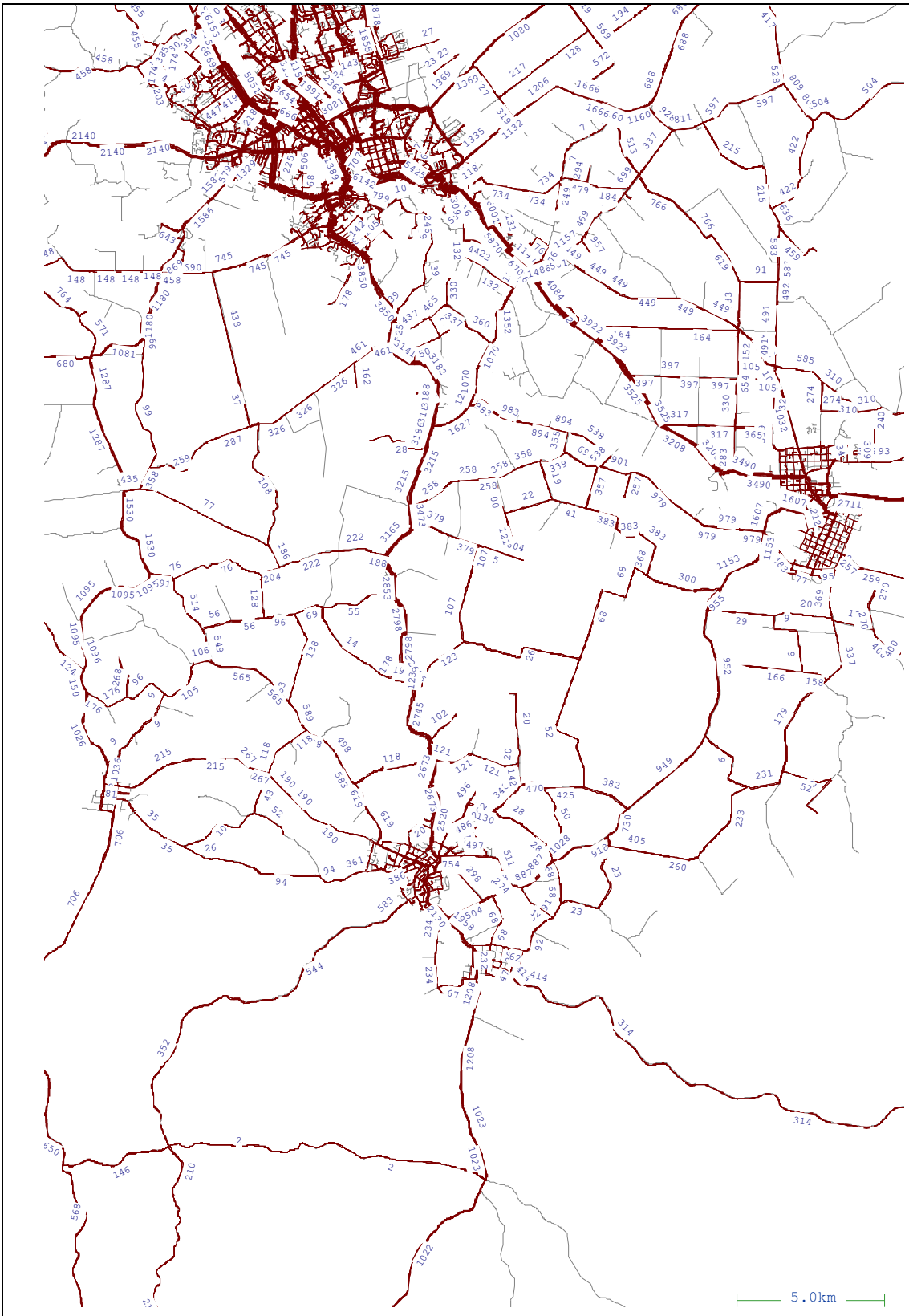


Traffic Design Group Gabites Porter	**2021 PM Peak Two-Way Traffic volumes North Waikato**	**Figure 21**

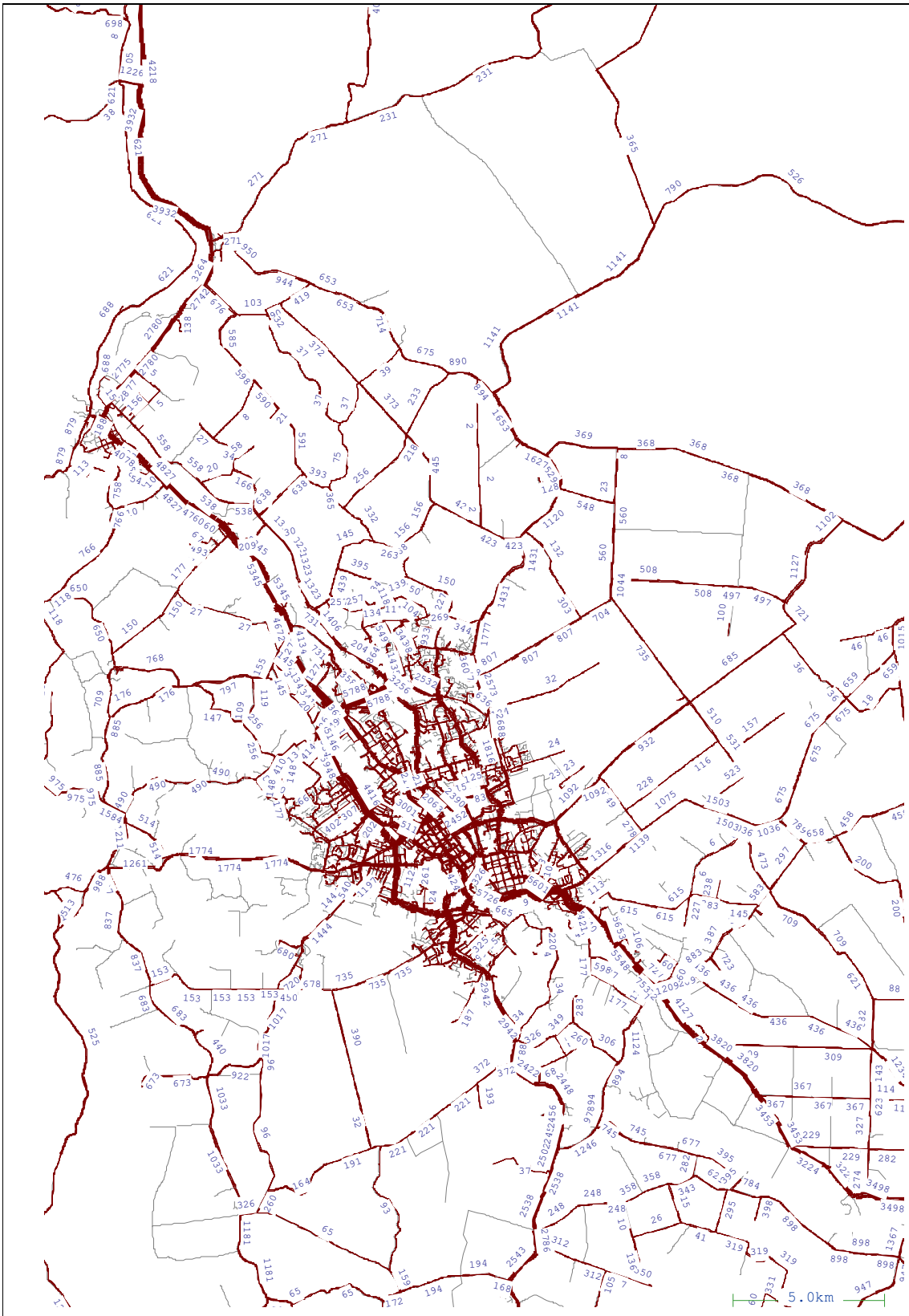


Traffic Design Group	**2021 AM Peak Two-Way Traffic volumes Waipa**	**Figure 22**
Gabites Porter		

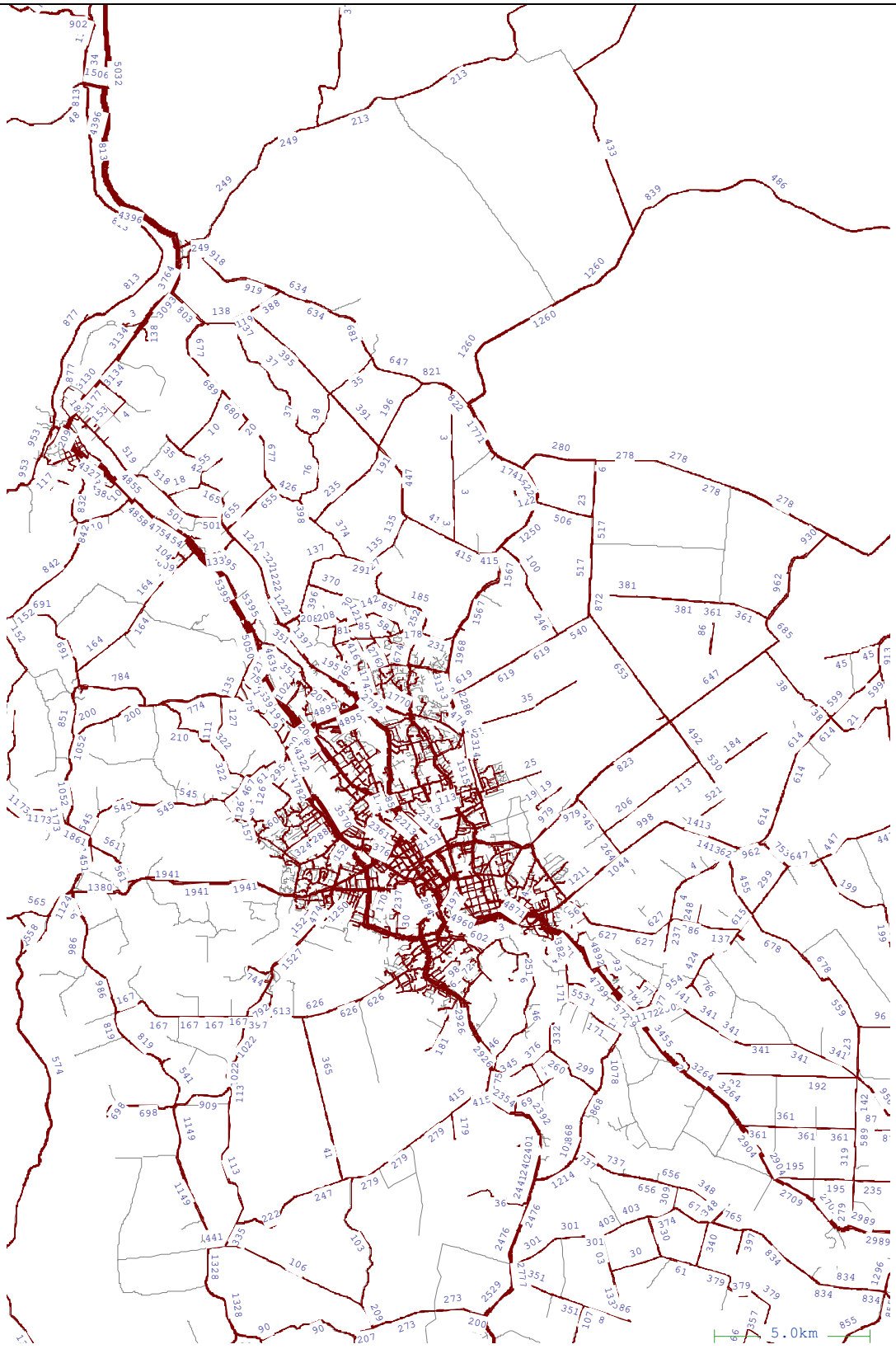
Traffic Design Group	**2021 Inter Peak Two-Way Traffic volumes Waipa**	**Figure 23**
Gabites Porter		



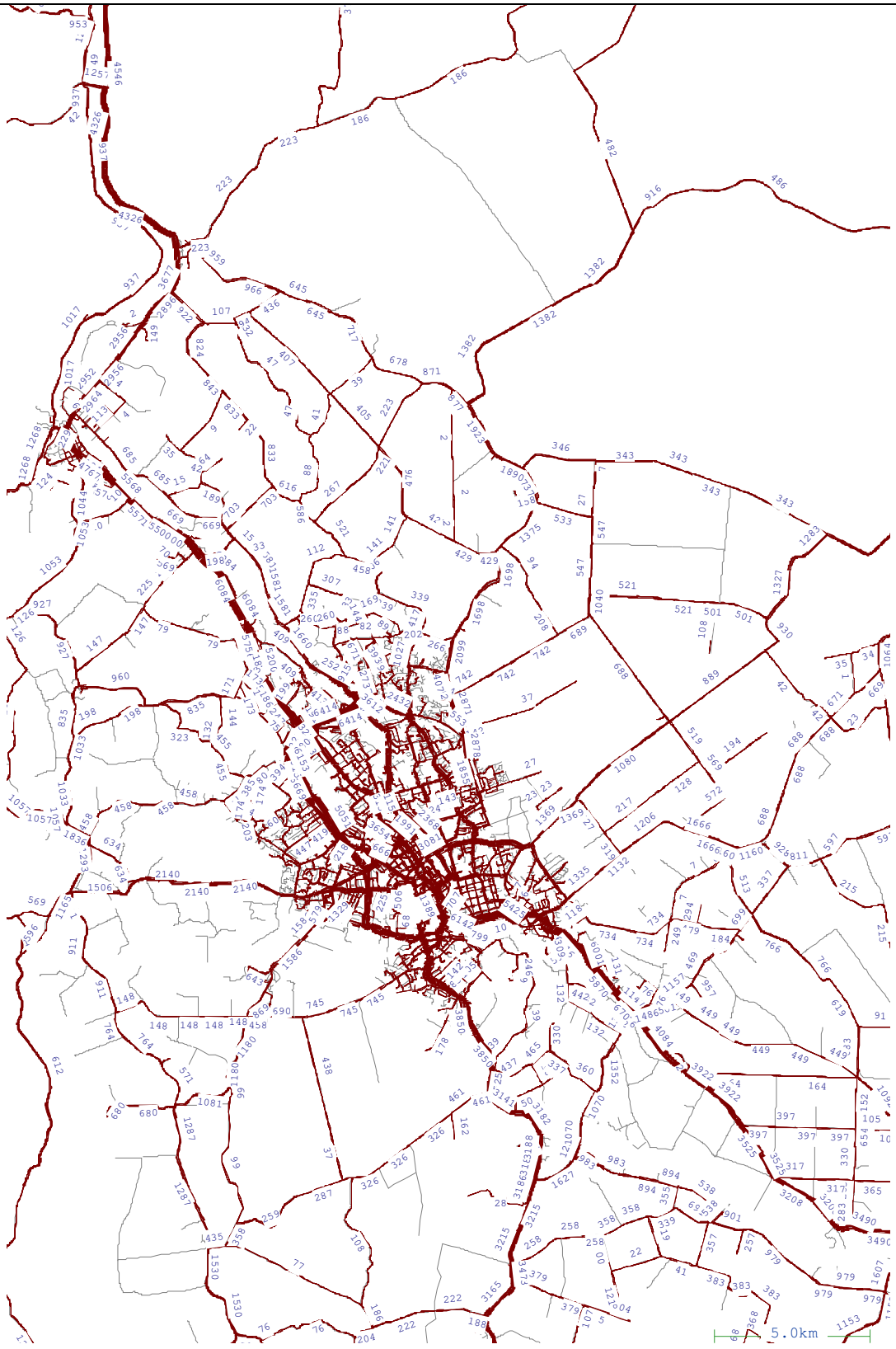
Traffic Design Group Gabites Porter	**2021 PM Peak Two-Way Traffic volumes Waipa**	**Figure 24**



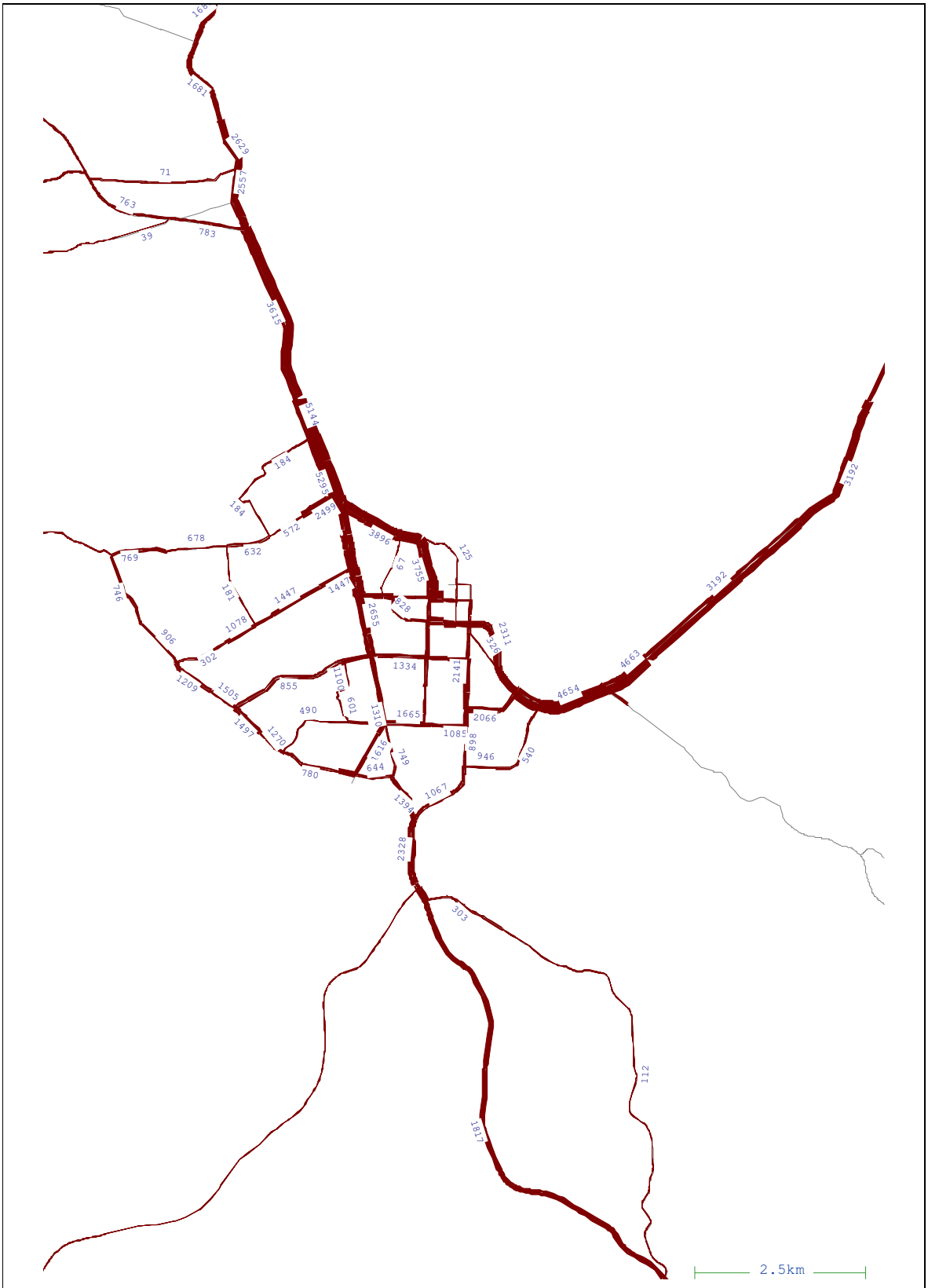
Traffic Design Group Gabites Porter	**2021 AM Peak Two-Way Traffic volumes Hamilton**	**Figure 25**



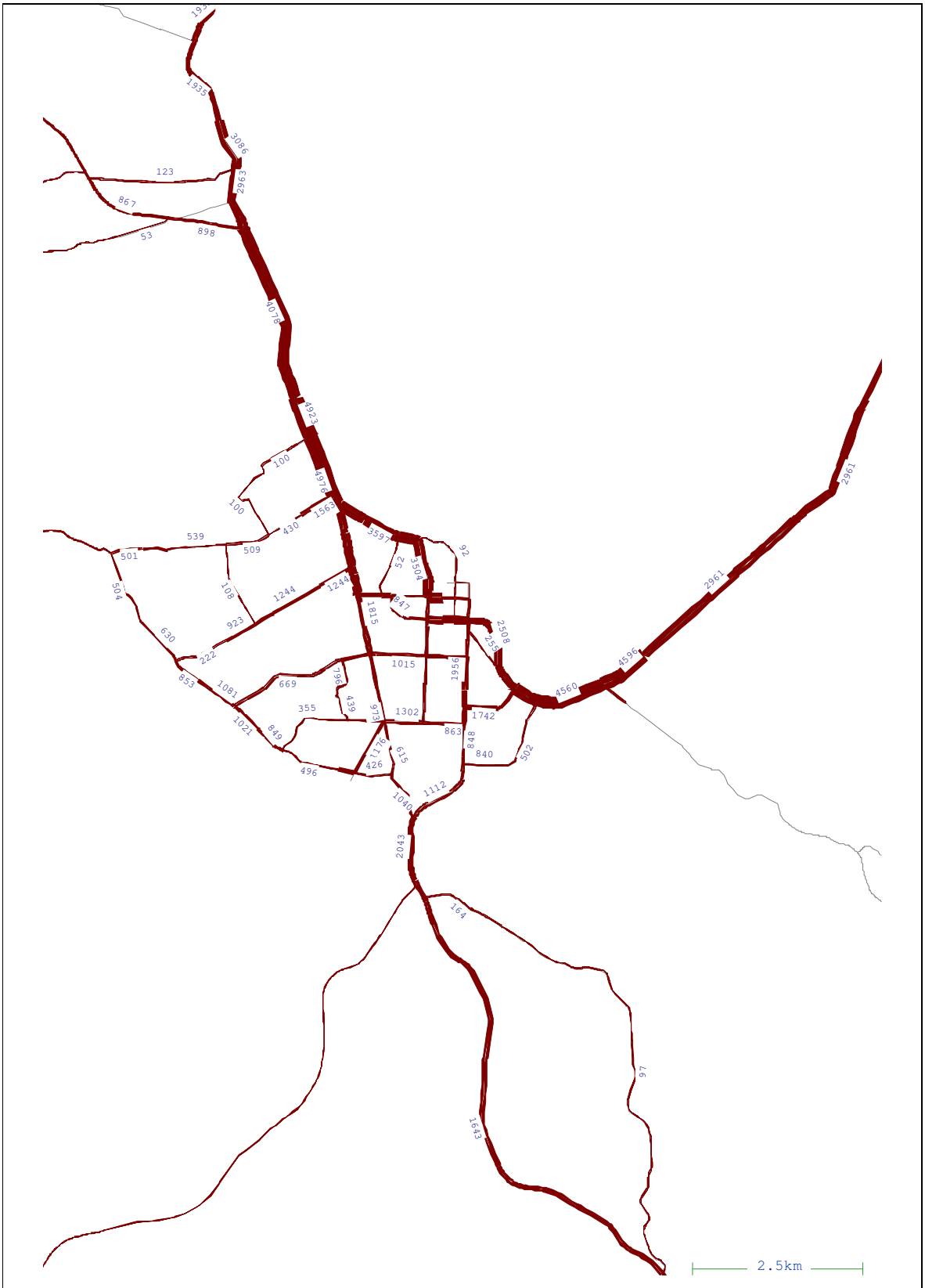
Traffic Design Group	**2021 Inter Peak Two-Way Traffic volumes Hamilton**	**Figure 26**
Gabites Porter		



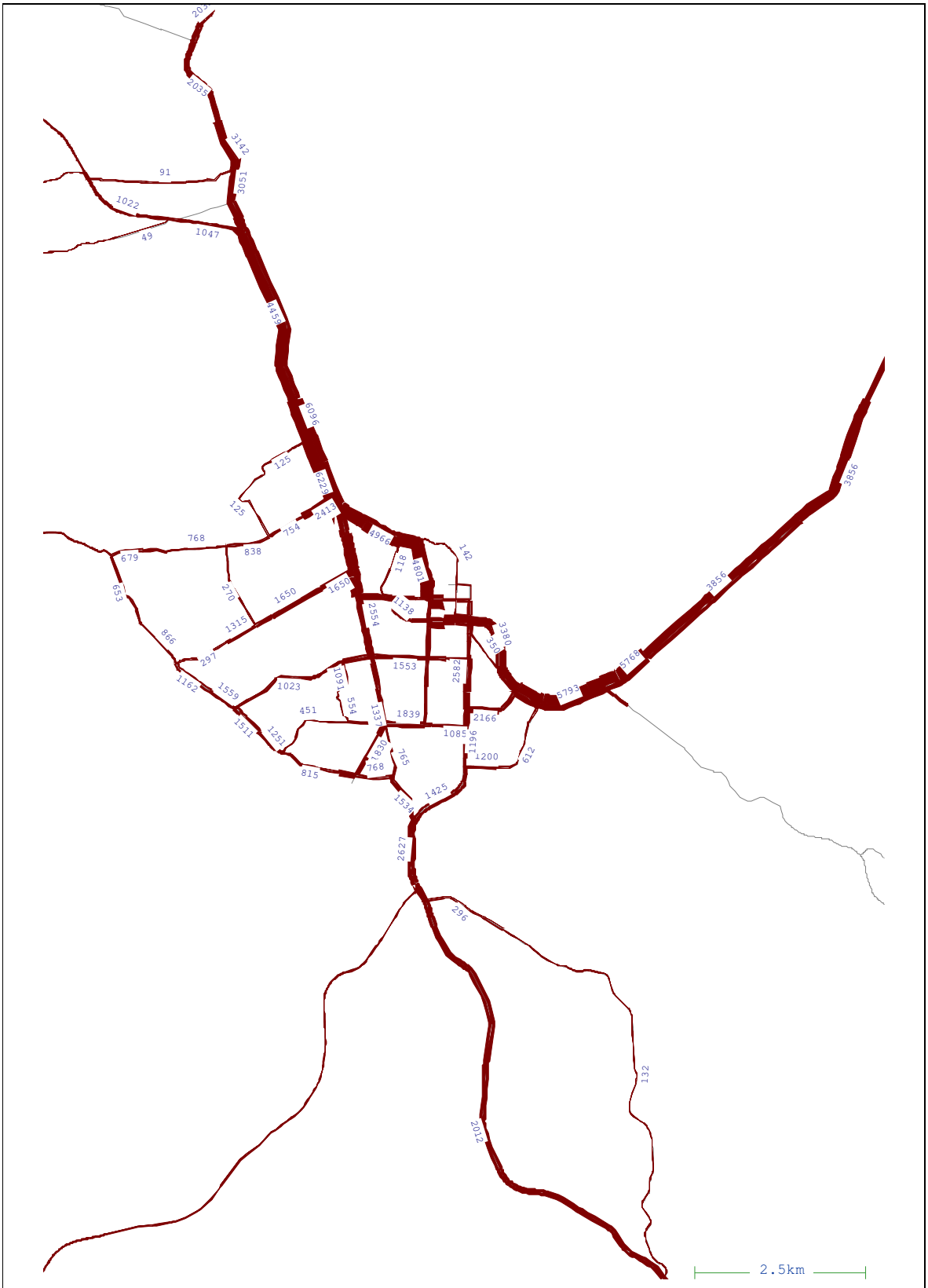
Traffic Design Group Gabites Porter	**2021 PM Peak Two-Way Traffic volumes Hamilton**	**Figure 27**



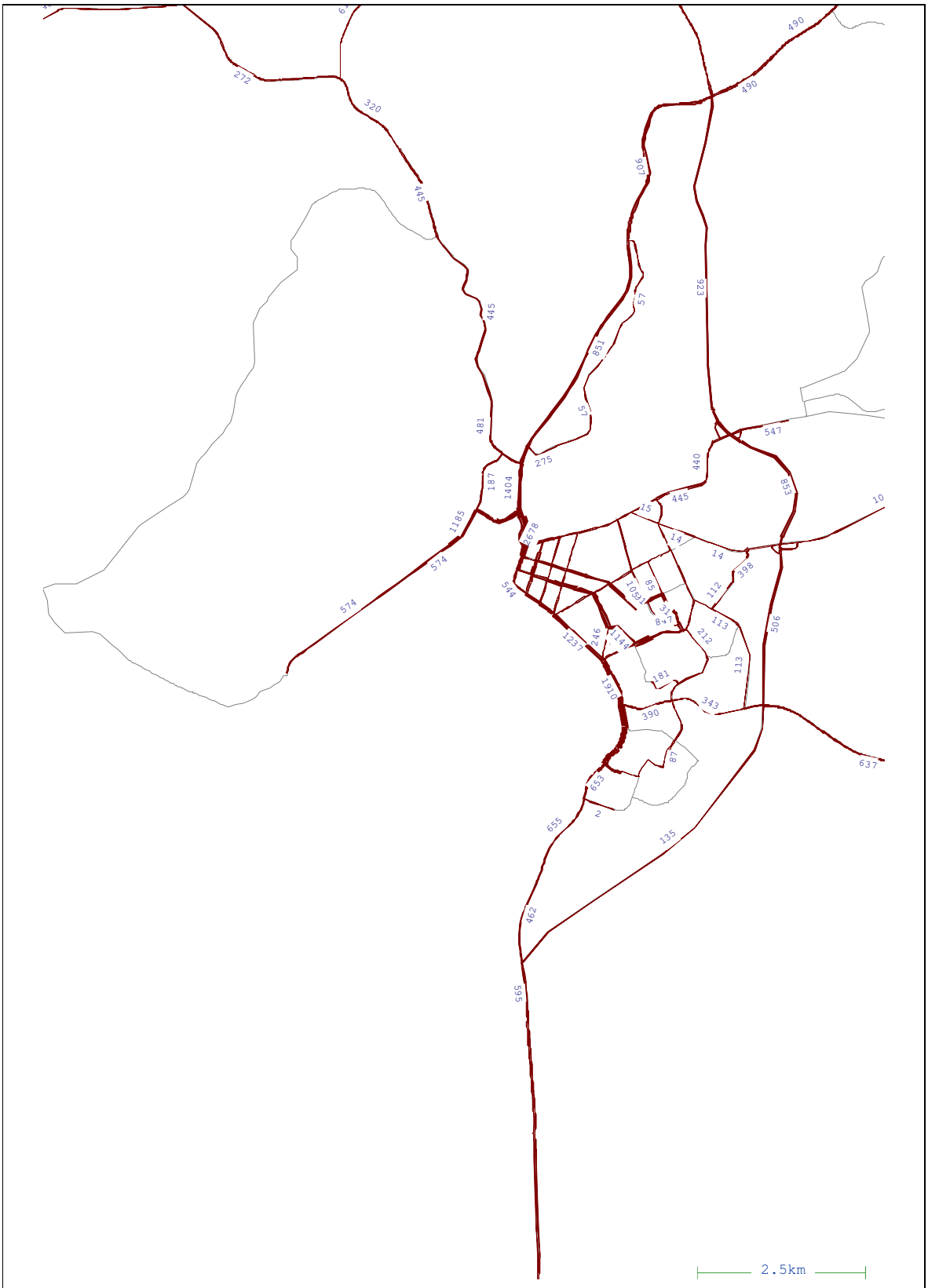
Traffic Design Group Gabites Porter	**2021 AM Peak Two-Way Traffic volumes Rotorua**	**Figure 28**



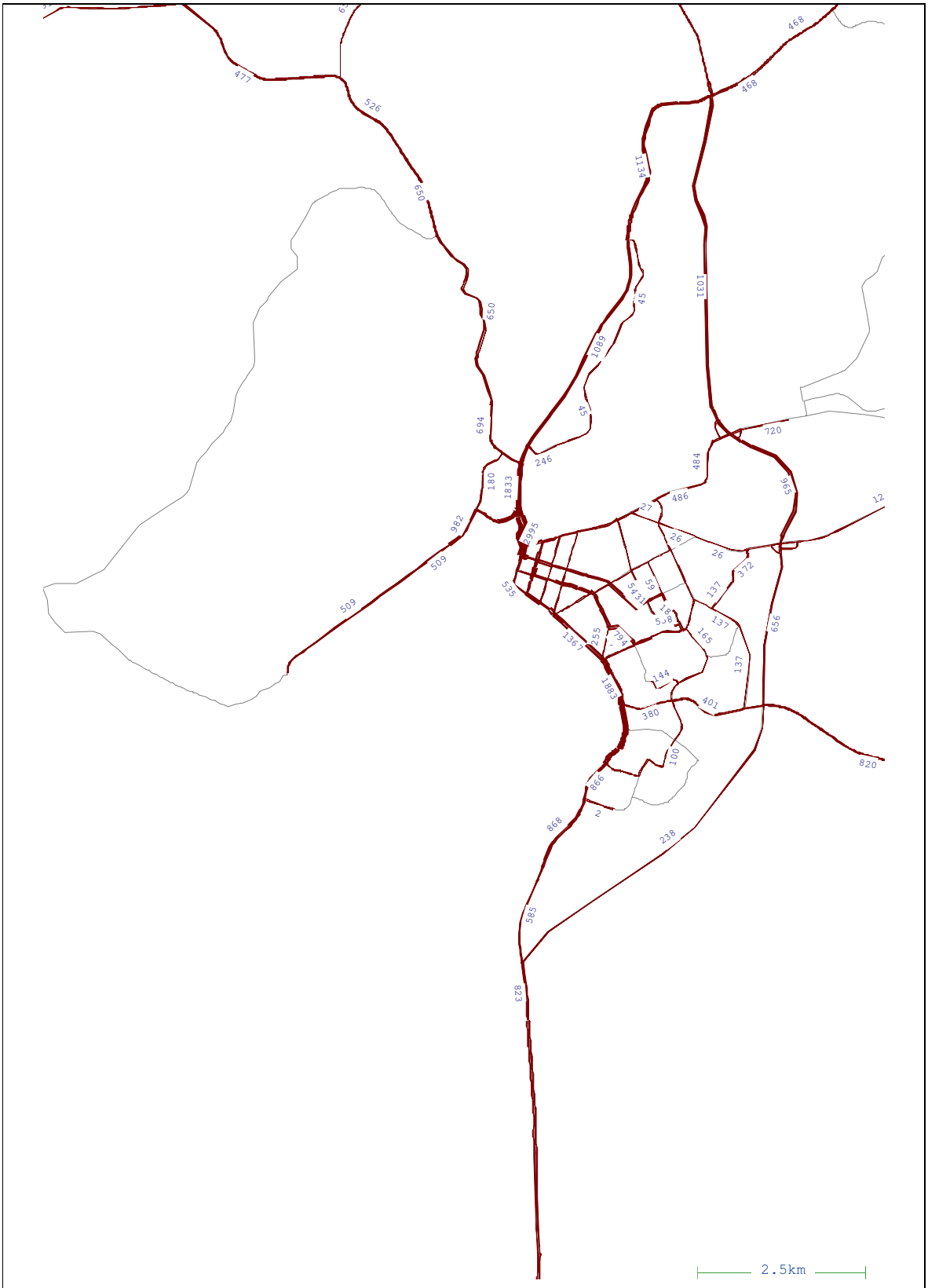
Traffic Design Group	**2021 Inter Peak Two-Way Traffic volumes Rotorua**	**Figure 29**
Gabites Porter		



Traffic Design Group Gabites Porter	**2021 PM Peak Two-Way Traffic volumes Rotorua**	**Figure 30**

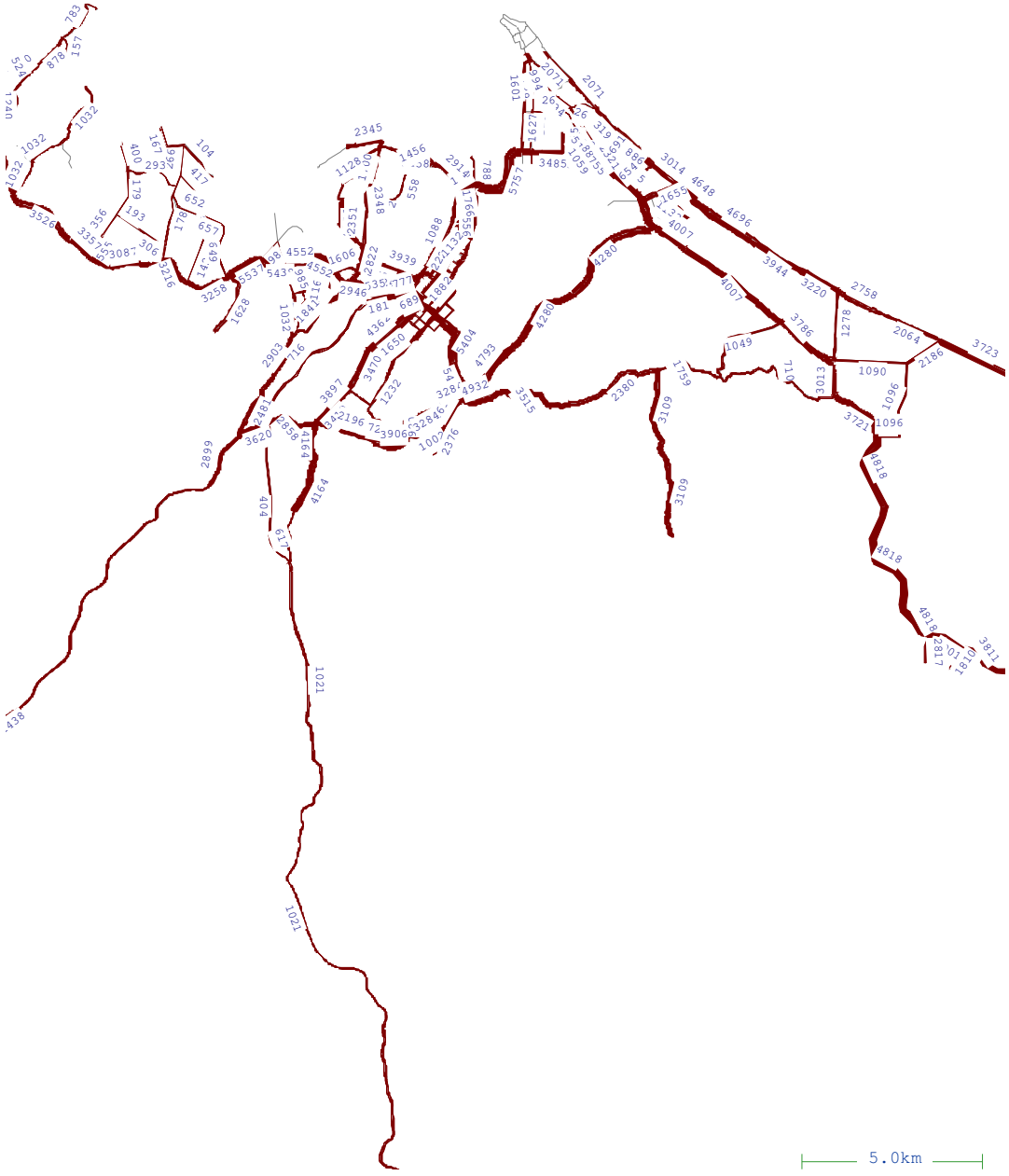


Traffic Design Group Gabites Porter	**2021 AM Peak Two-Way Traffic volumes Taupo**	**Figure 31**

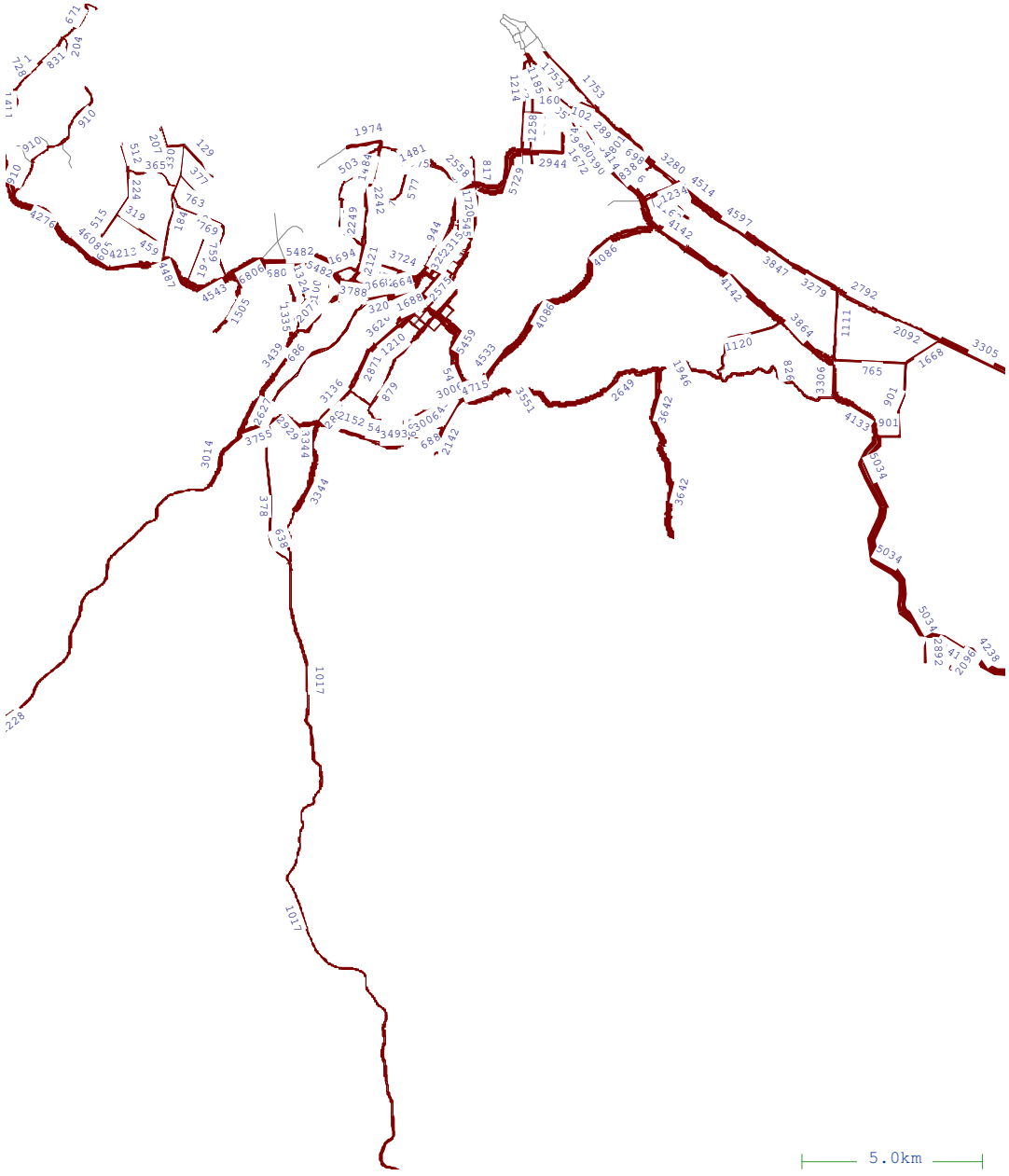


Traffic Design Group Gabites Porter	**2021 Inter Peak Two-Way Traffic volumes Taupo**	**Figure 32**

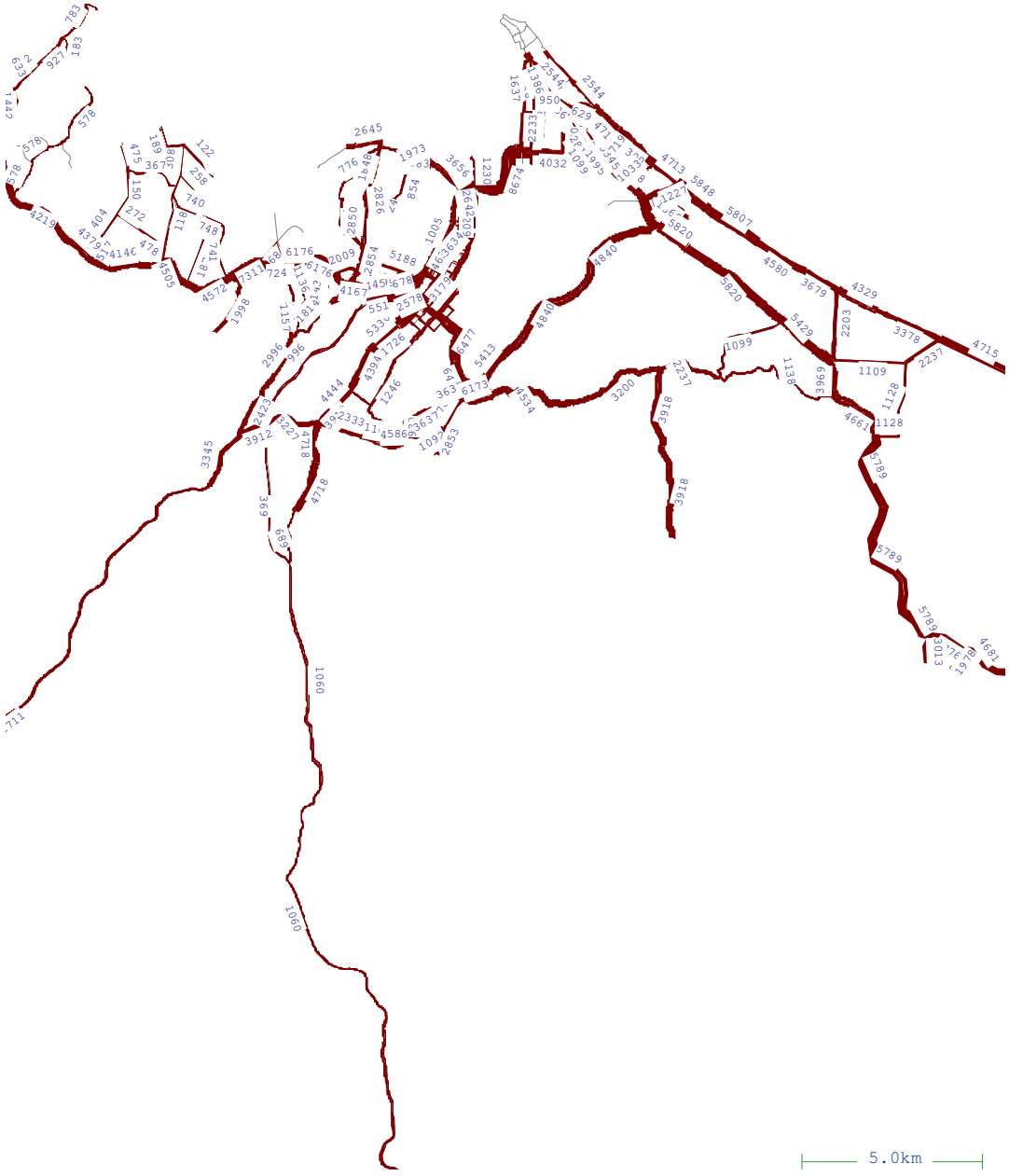
Traffic Design Group	**2021 PM Peak Two-Way Traffic volumes Taupo**	**Figure 33**
Gabites Porter		



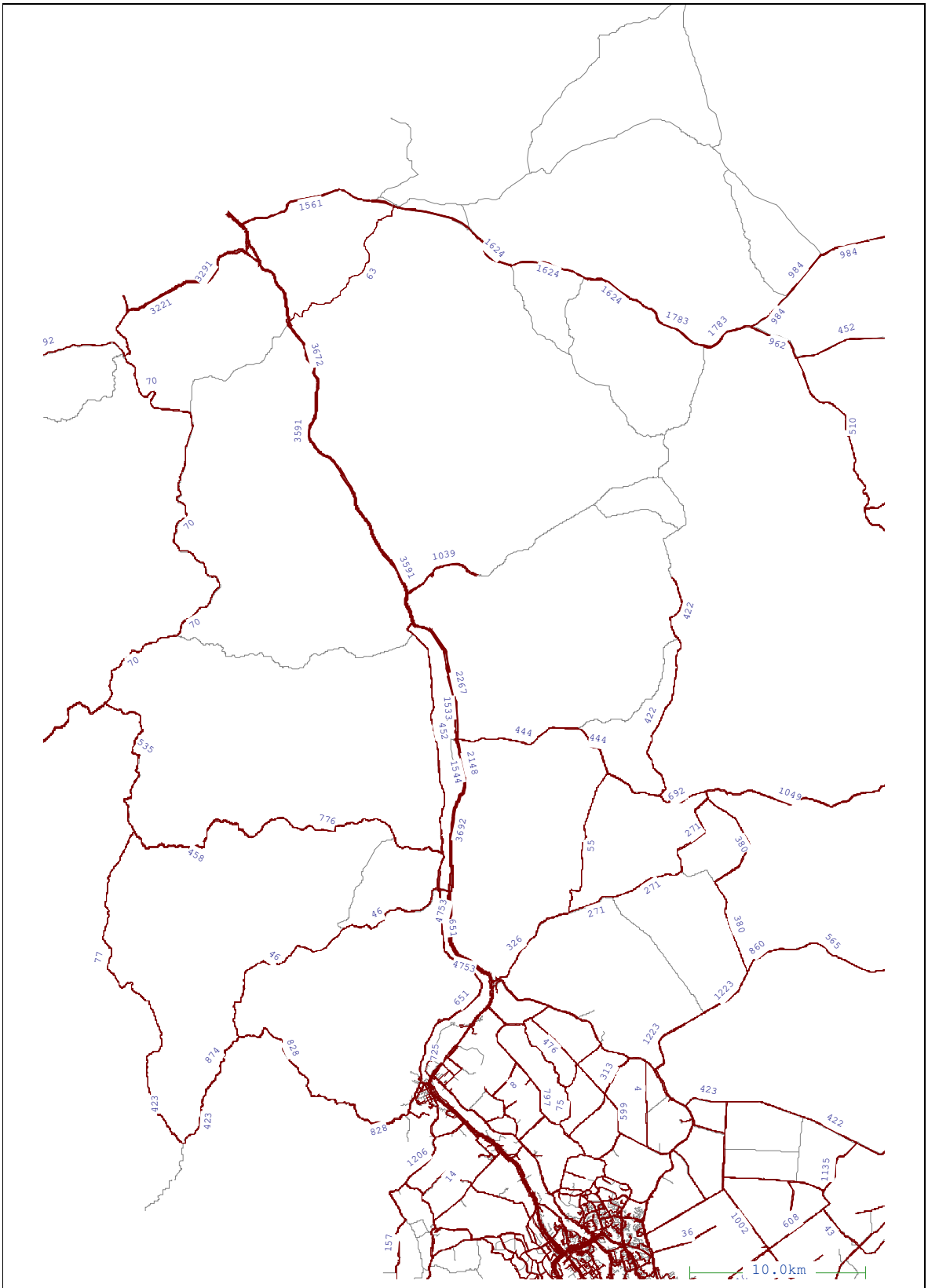
Traffic Design Group Gabites Porter	**2021 AM Peak Two-Way Traffic volumes Tauranga**	**Figure 34**



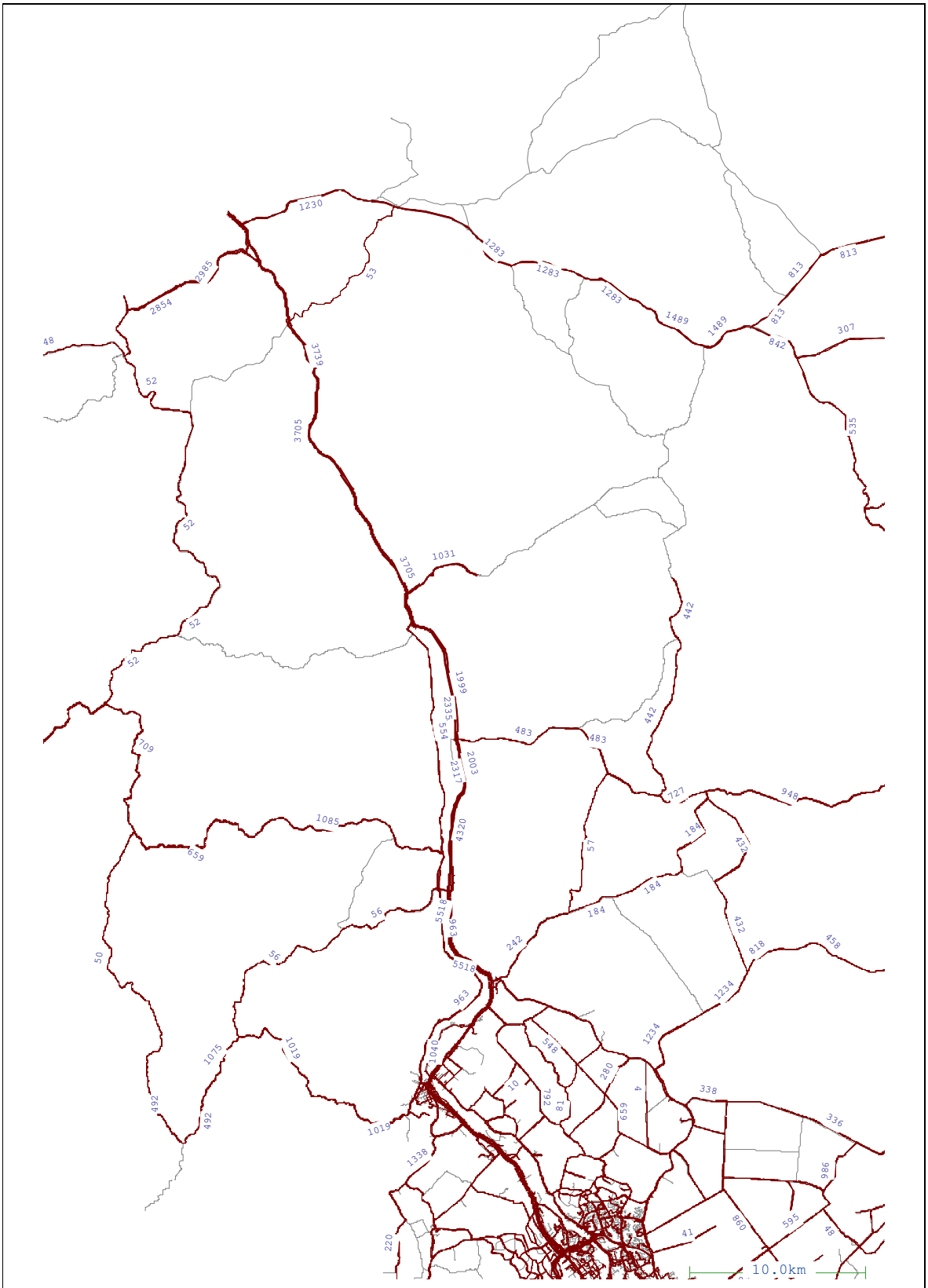
Traffic Design Group Gabites Porter	**2021 Inter Peak Two-Way Traffic volumes Tauranga**	**Figure 35**



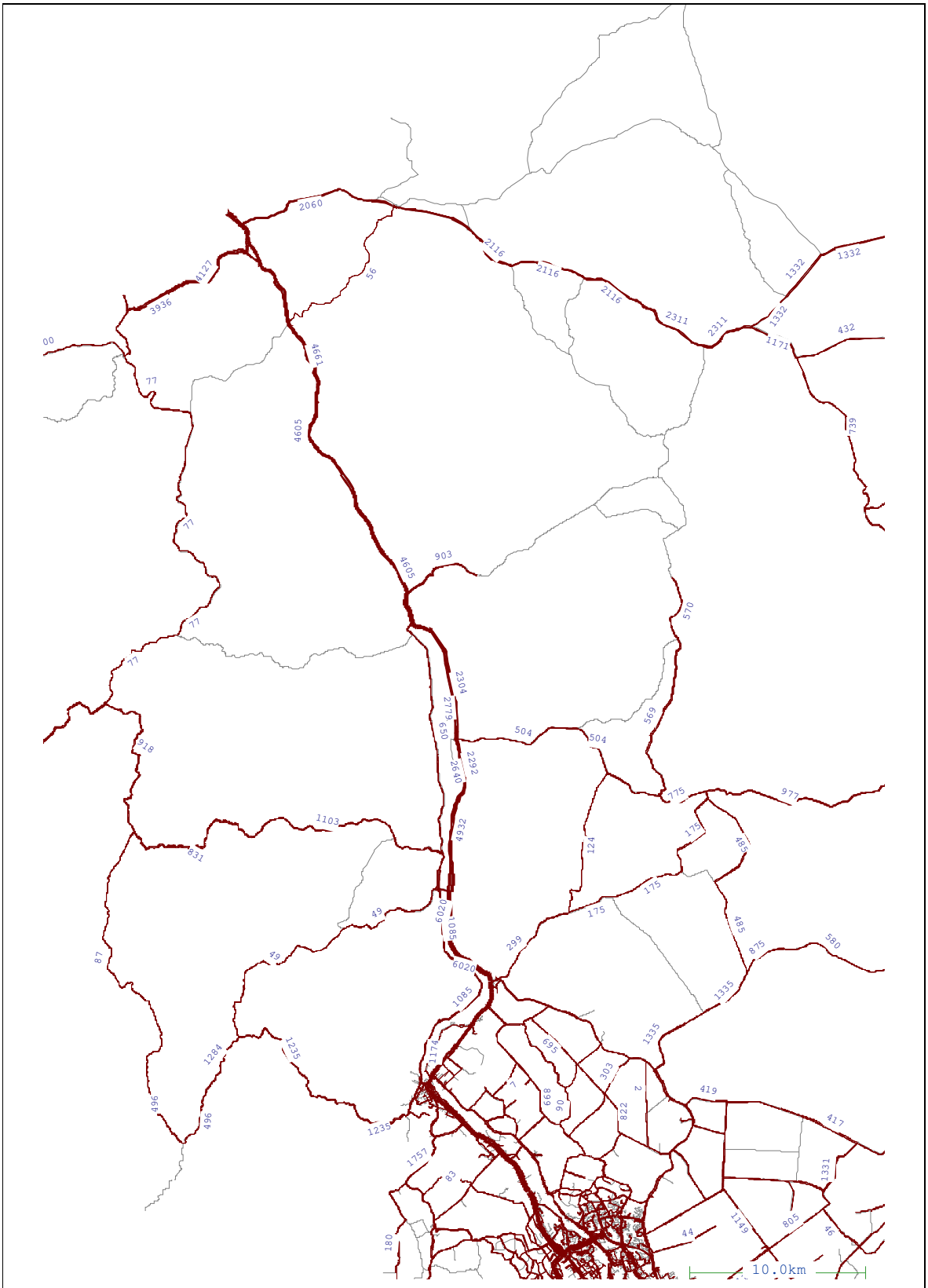
Traffic Design Group Gabites Porter	**2021 PM Peak Two-Way Traffic volumes Tauranga**	**Figure 36**



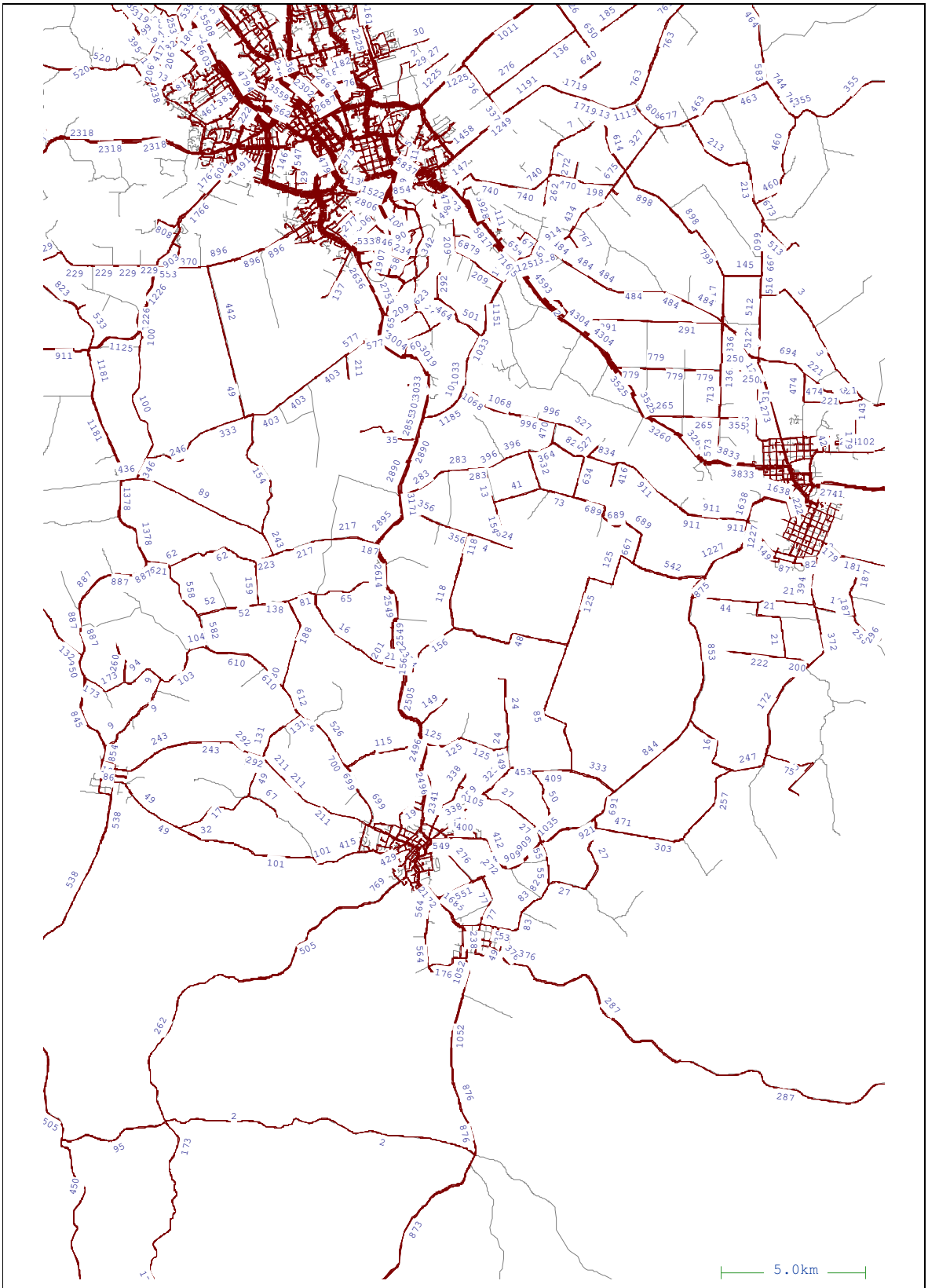
Traffic Design Group Gabites Porter	**2041 AM Peak Two-Way Traffic volumes North Waikato**	**Figure 37**



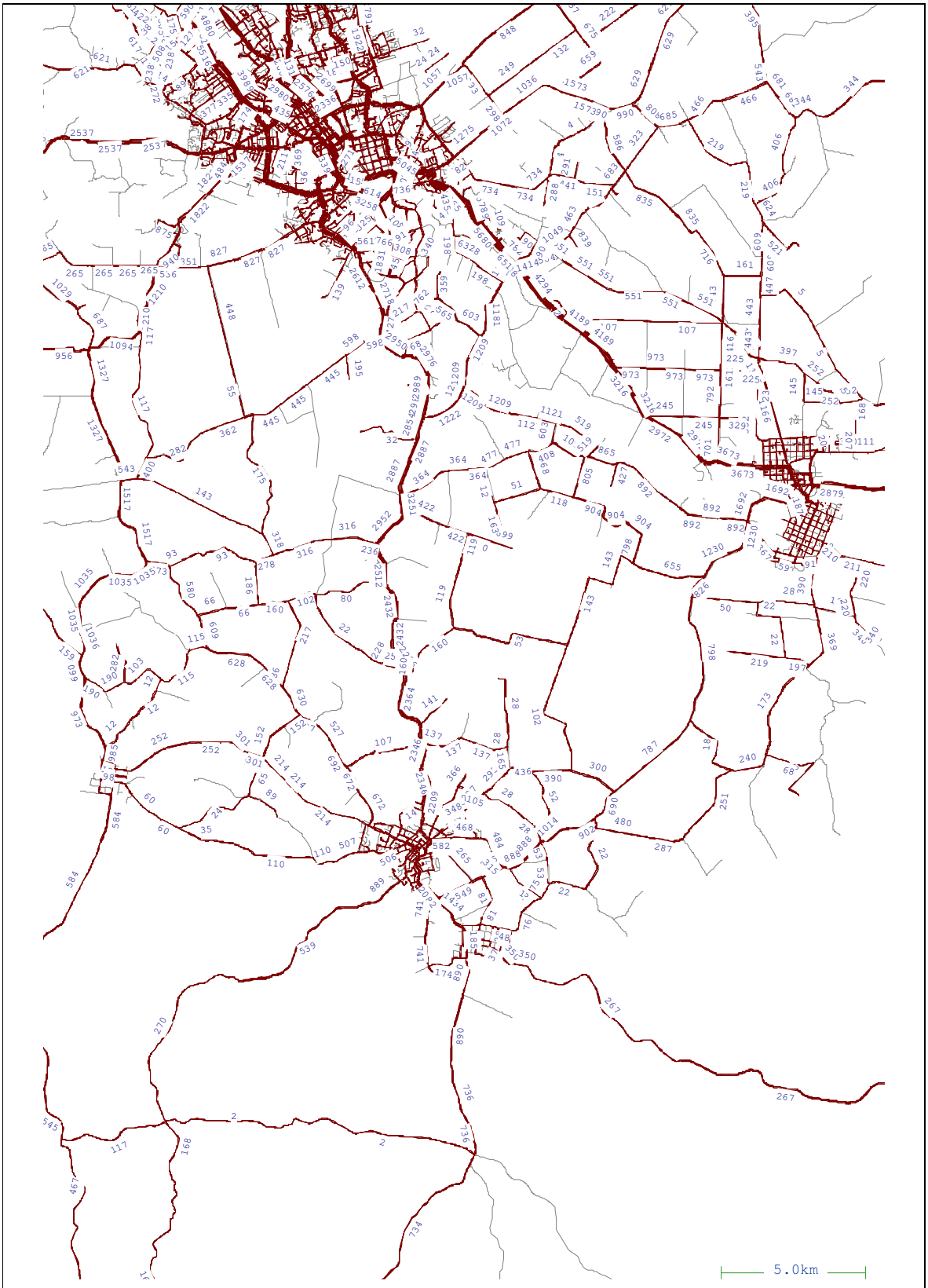
Traffic Design Group	**2041 Inter Peak Two-Way Traffic volumes North Waikato**	**Figure 38**
Gabites Porter		



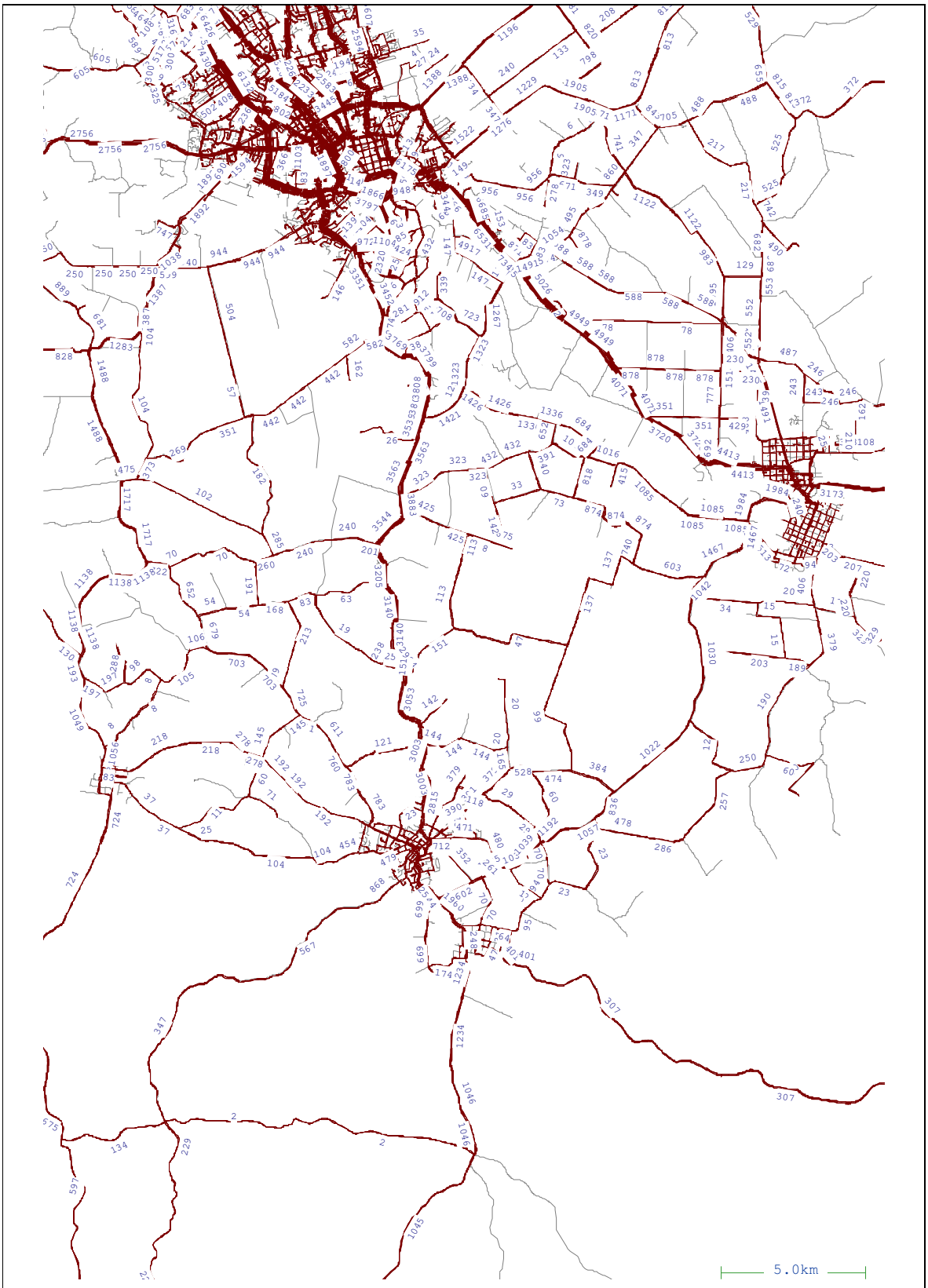
Traffic Design Group Gabites Porter	**2041 PM Peak Two-Way Traffic volumes North Waikato**	**Figure 39**



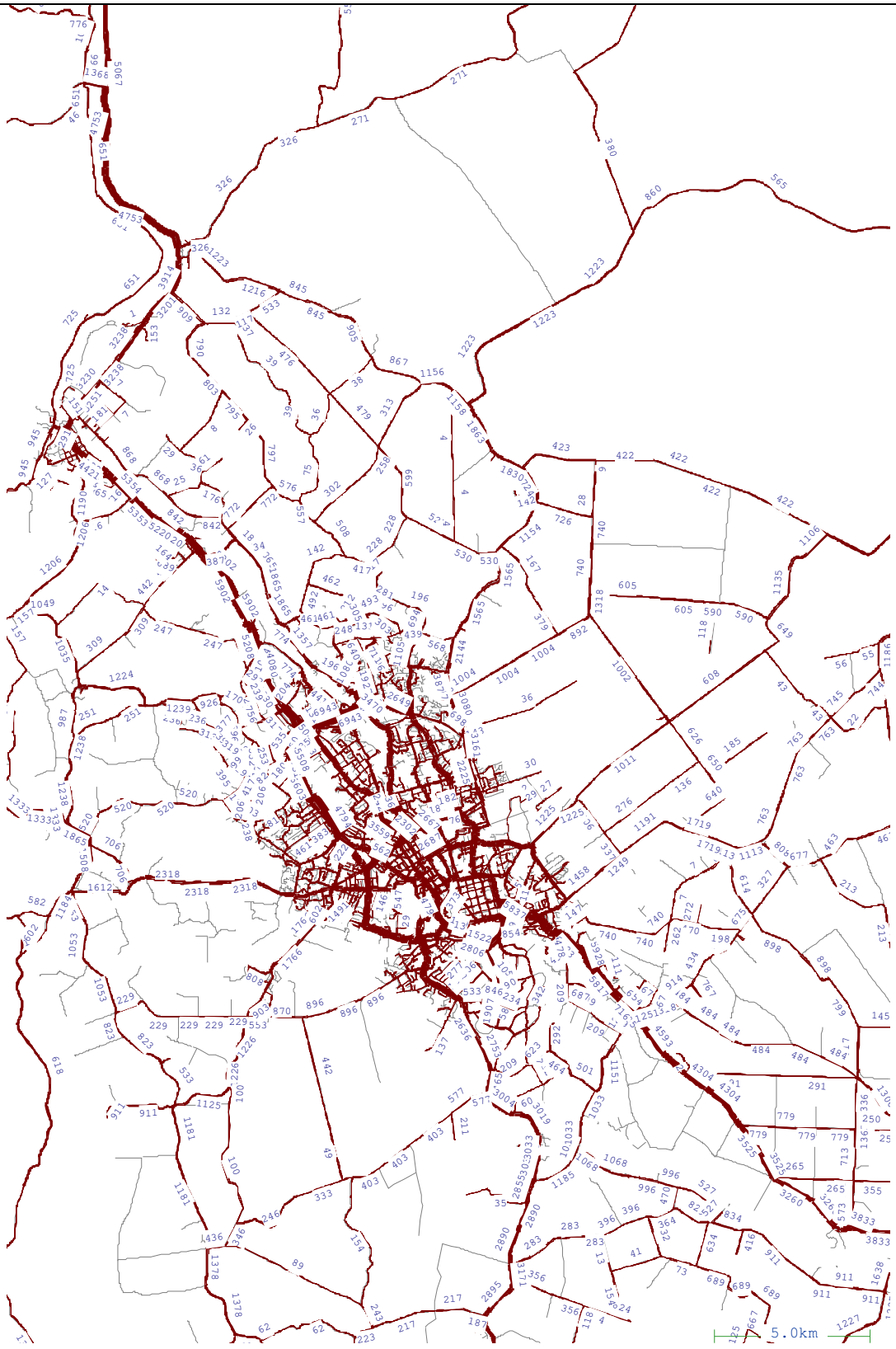
Traffic Design Group	**2041 AM Peak Two-Way Traffic volumes Waipa**	**Figure 40**
Gabites Porter		



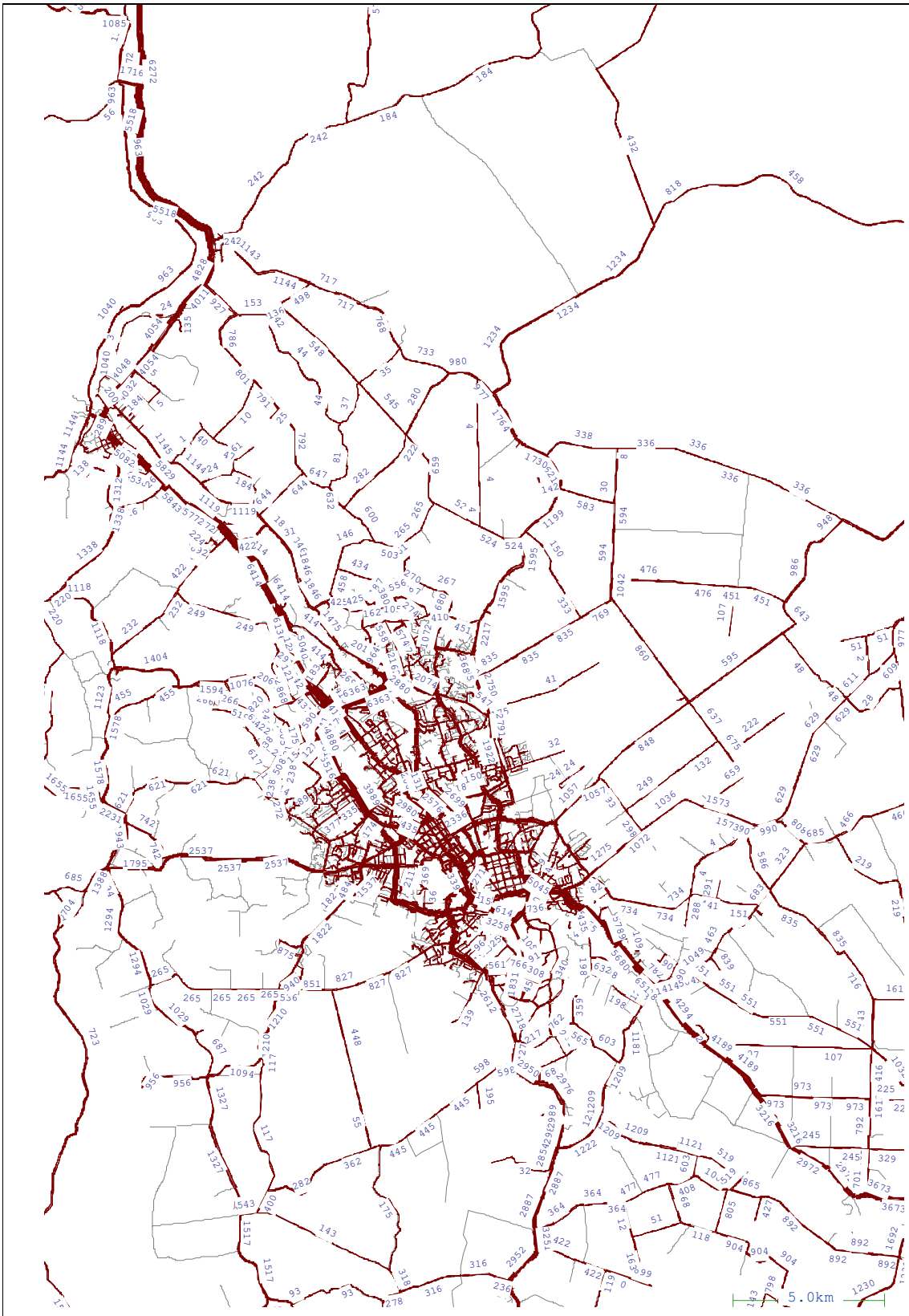
Traffic Design Group	**2041 Inter Peak Two-Way Traffic volumes Waipa**	**Figure 41**
Gabites Porter		



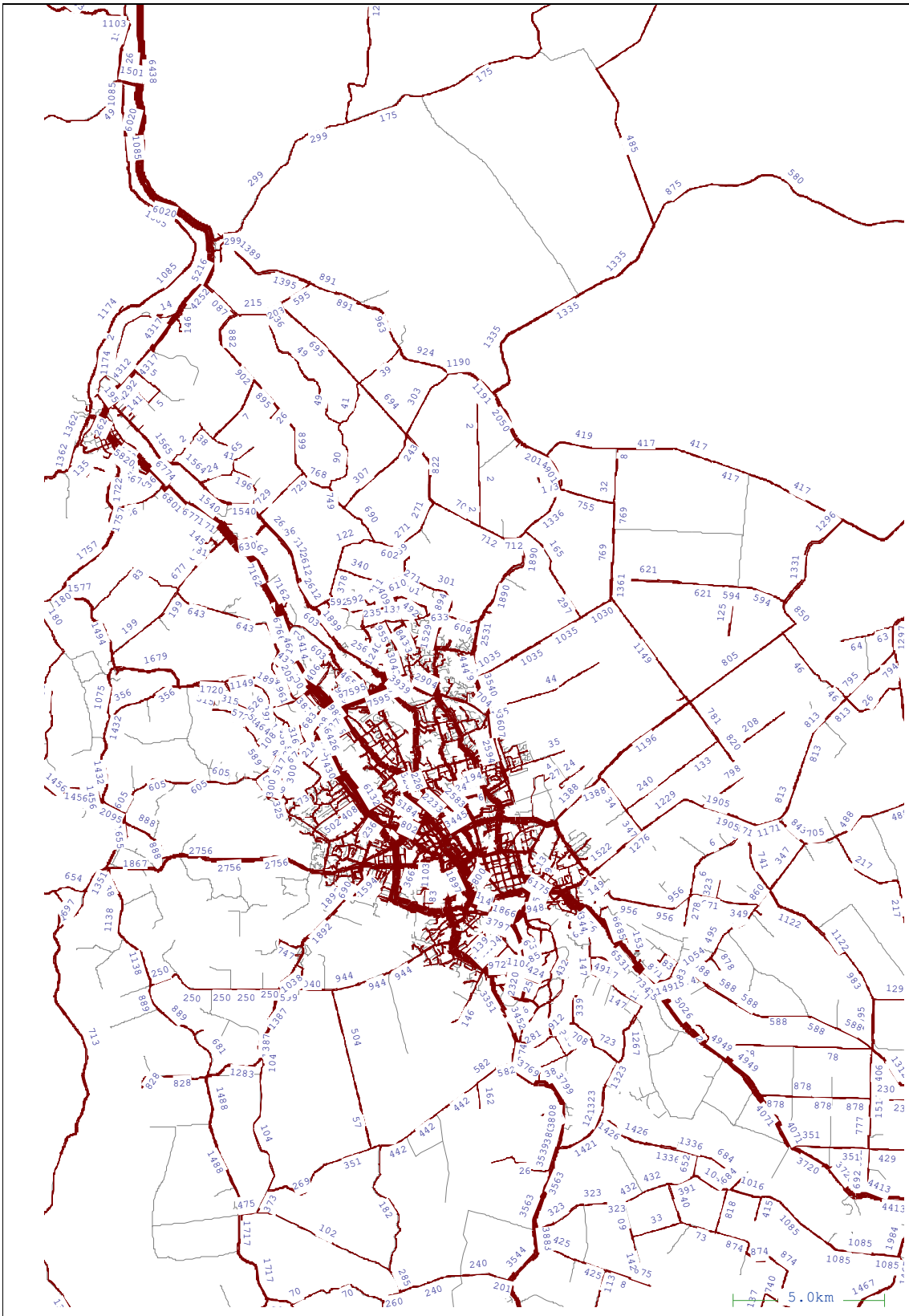
Traffic Design Group Gabites Porter	**2041 PM Peak Two-Way Traffic volumes Waipa**	**Figure 42**



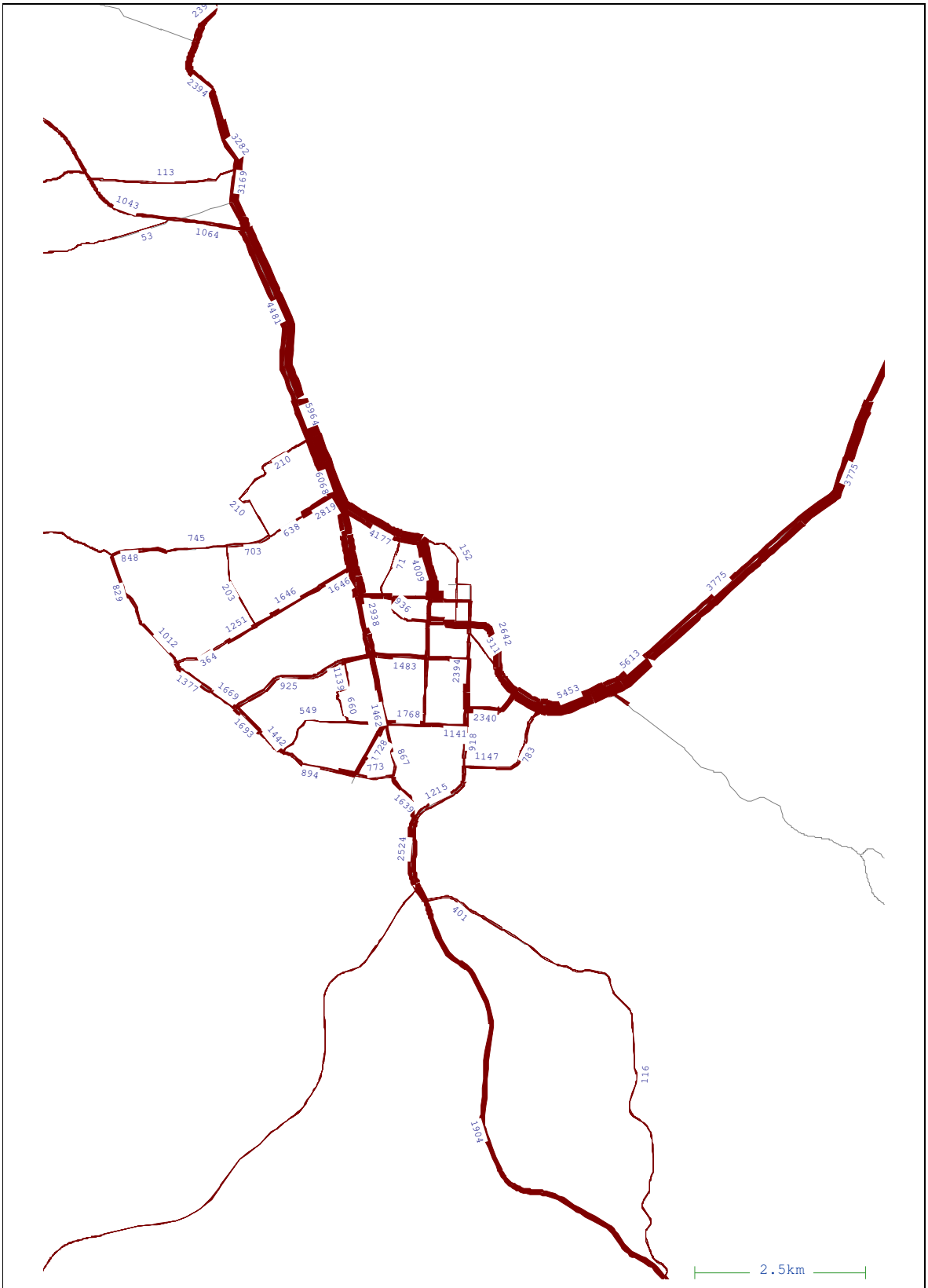
Traffic Design Group Gabites Porter	**2041 AM Peak Two-Way Traffic volumes Hamilton**	**Figure 43**



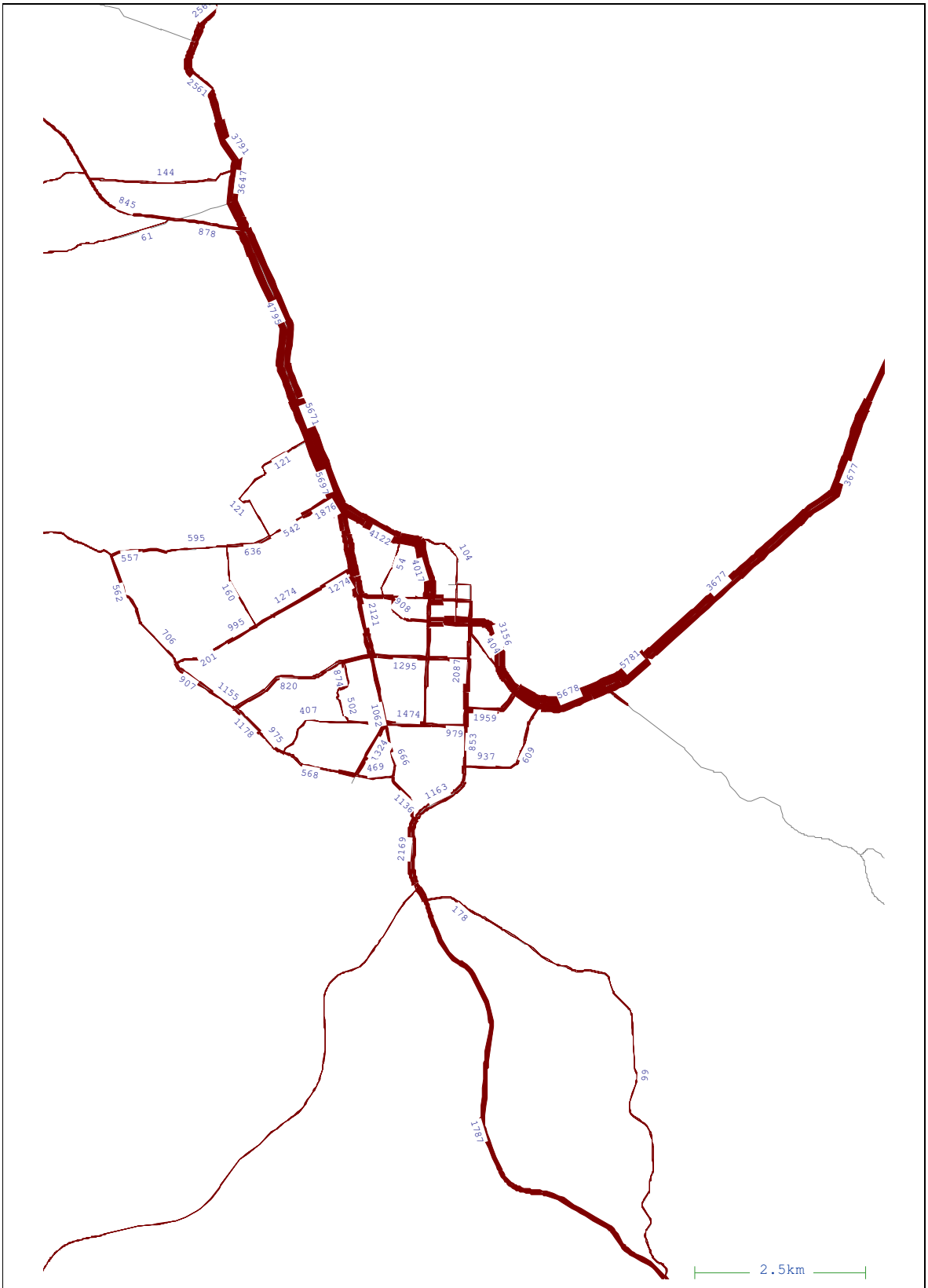
Traffic Design Group	**2041 Inter Peak Two-Way Traffic volumes Hamilton**	**Figure 44**
Gabites Porter		



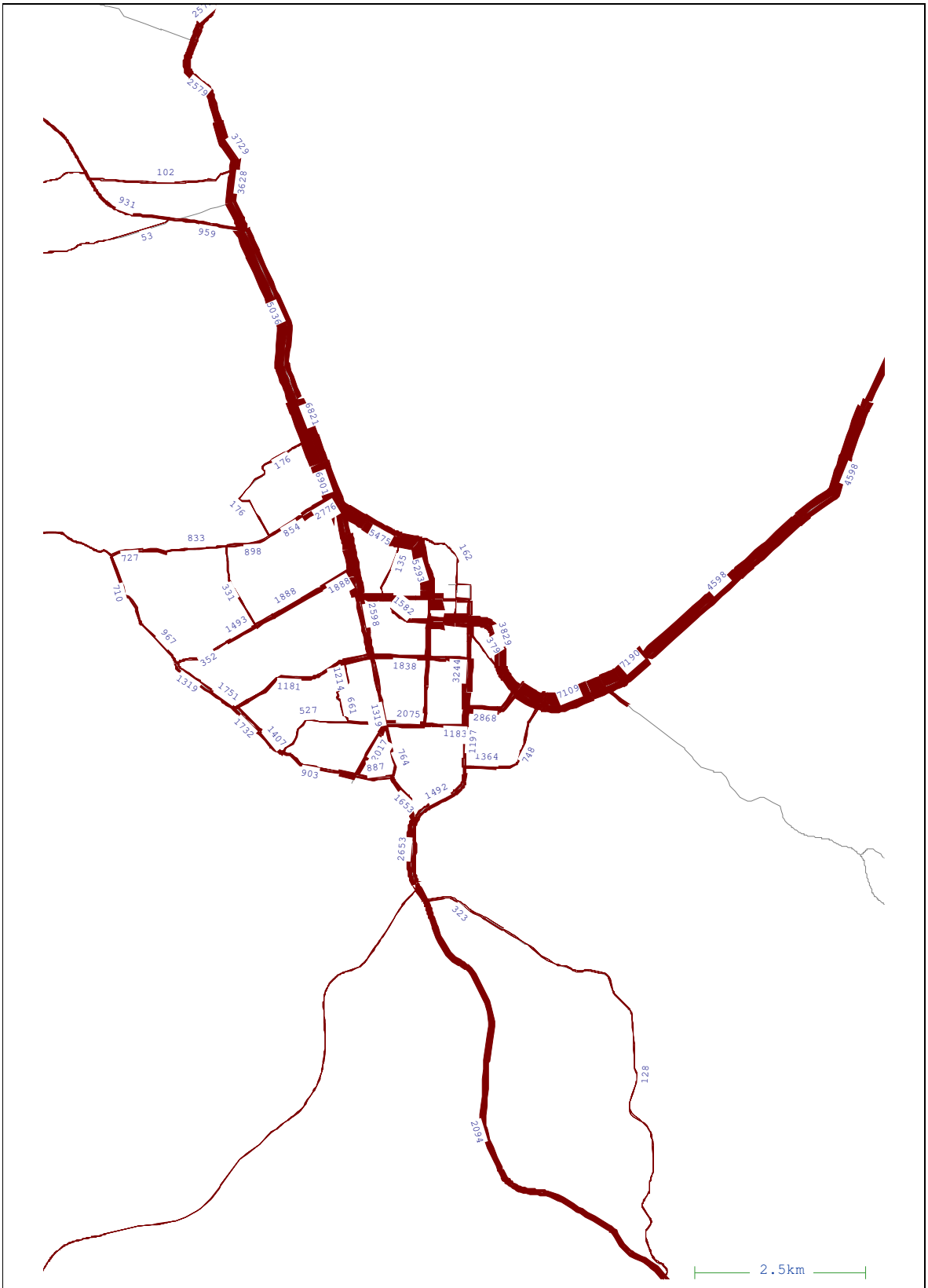
Traffic Design Group	**2041 PM Peak Two-Way Traffic volumes Hamilton**	**Figure 45**
Gabites Porter		



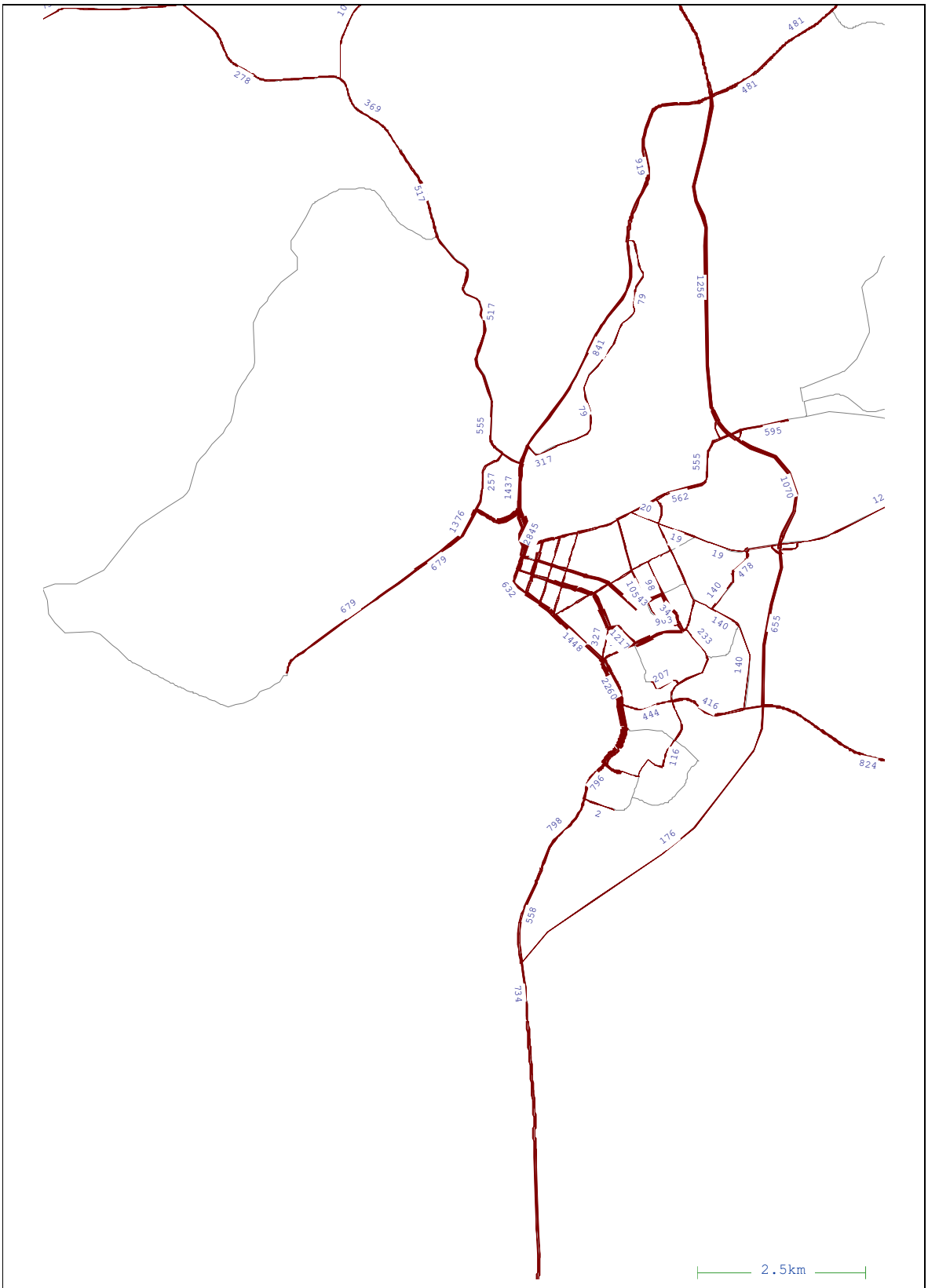
Traffic Design Group Gabites Porter	**2041 AM Peak Two-Way Traffic volumes Rotorua**	**Figure 46**



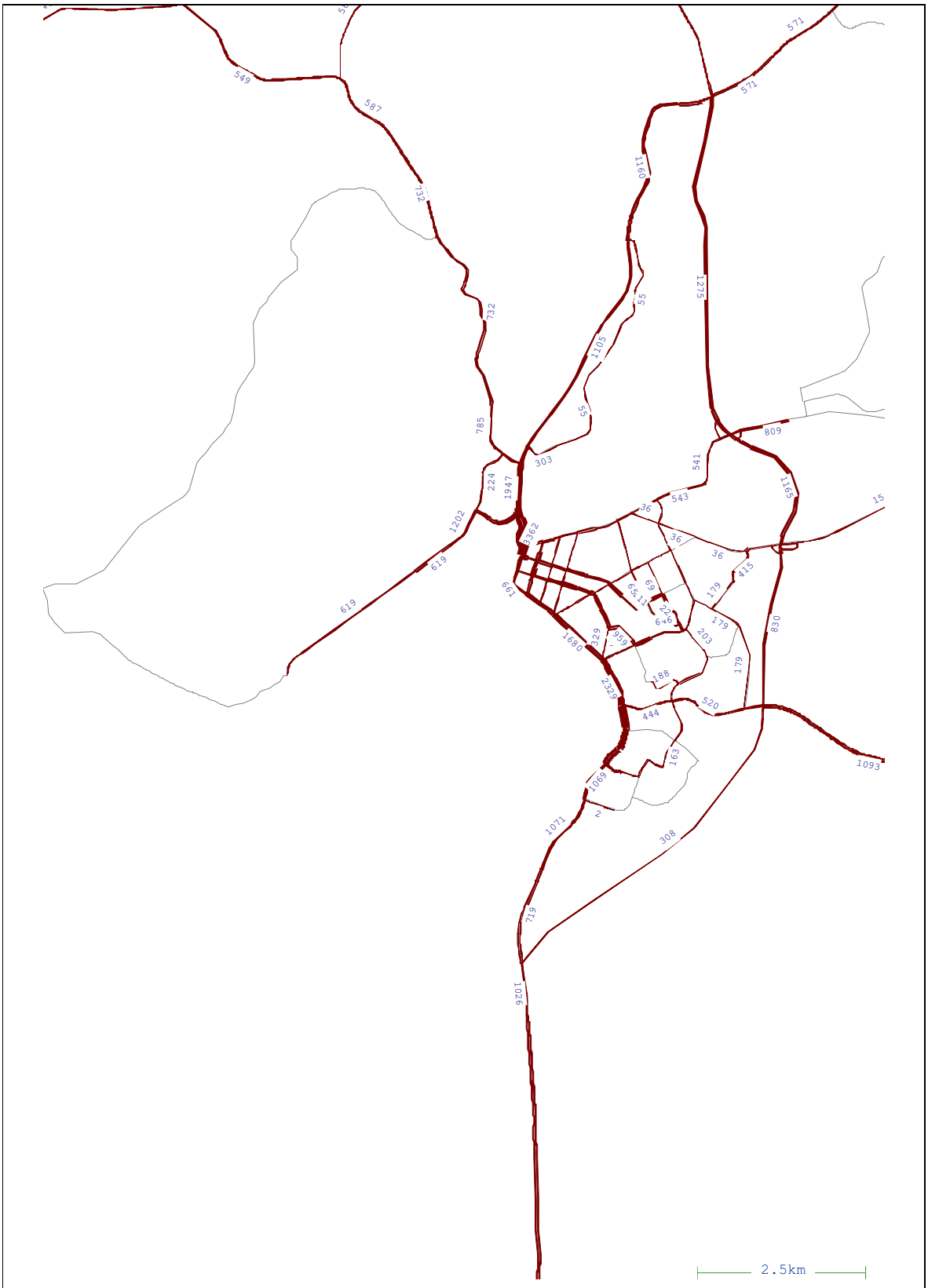
Traffic Design Group	**2041 Inter Peak Two-Way Traffic volumes Rotorua**	**Figure 47**
Gabites Porter		



Traffic Design Group Gabites Porter	**2041 PM Peak Two-Way Traffic volumes Rotorua**	**Figure 48**

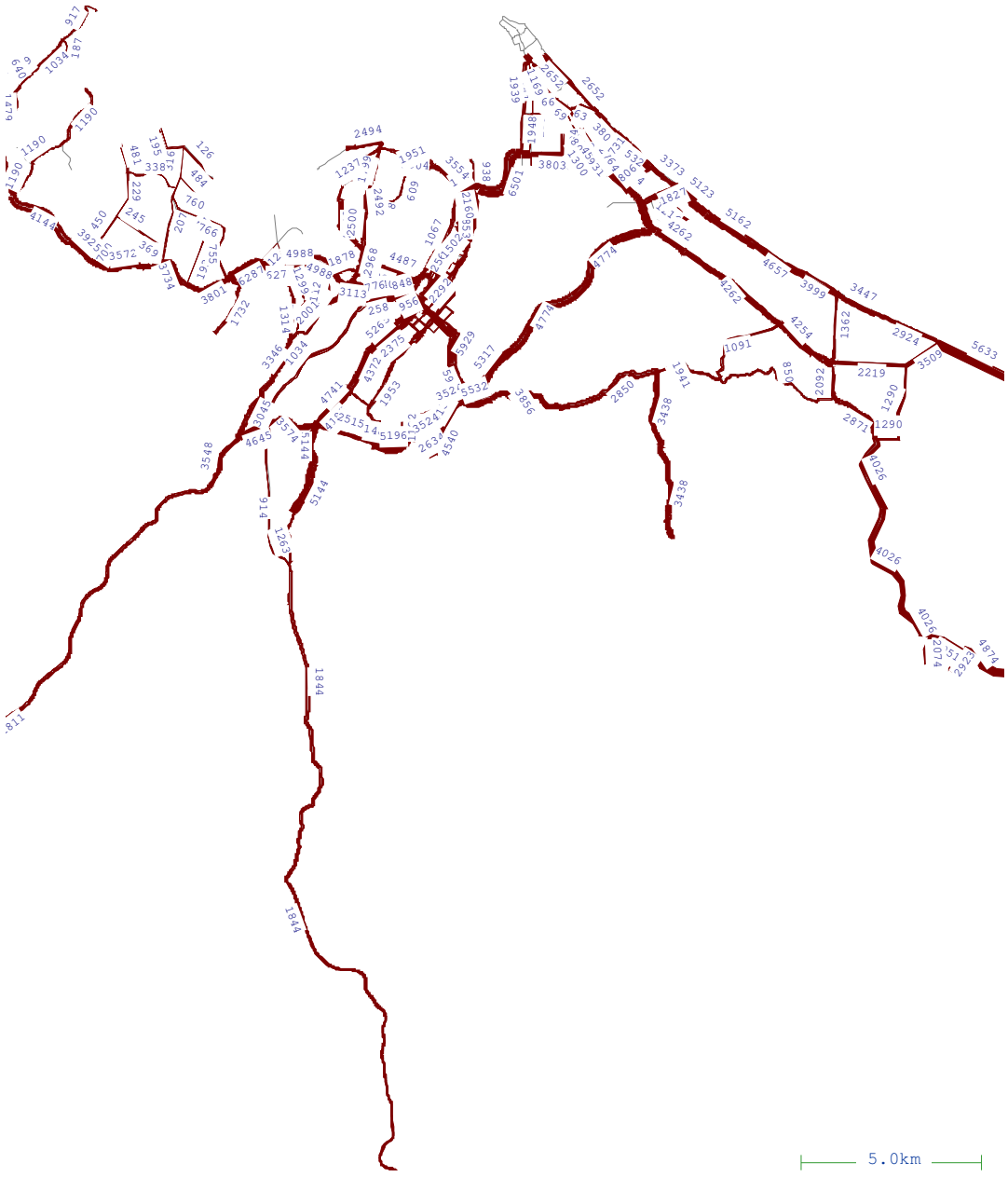


Traffic Design Group	**2041 AM Peak Two-Way Traffic volumes Taupo**	**Figure 49**
Gabites Porter		

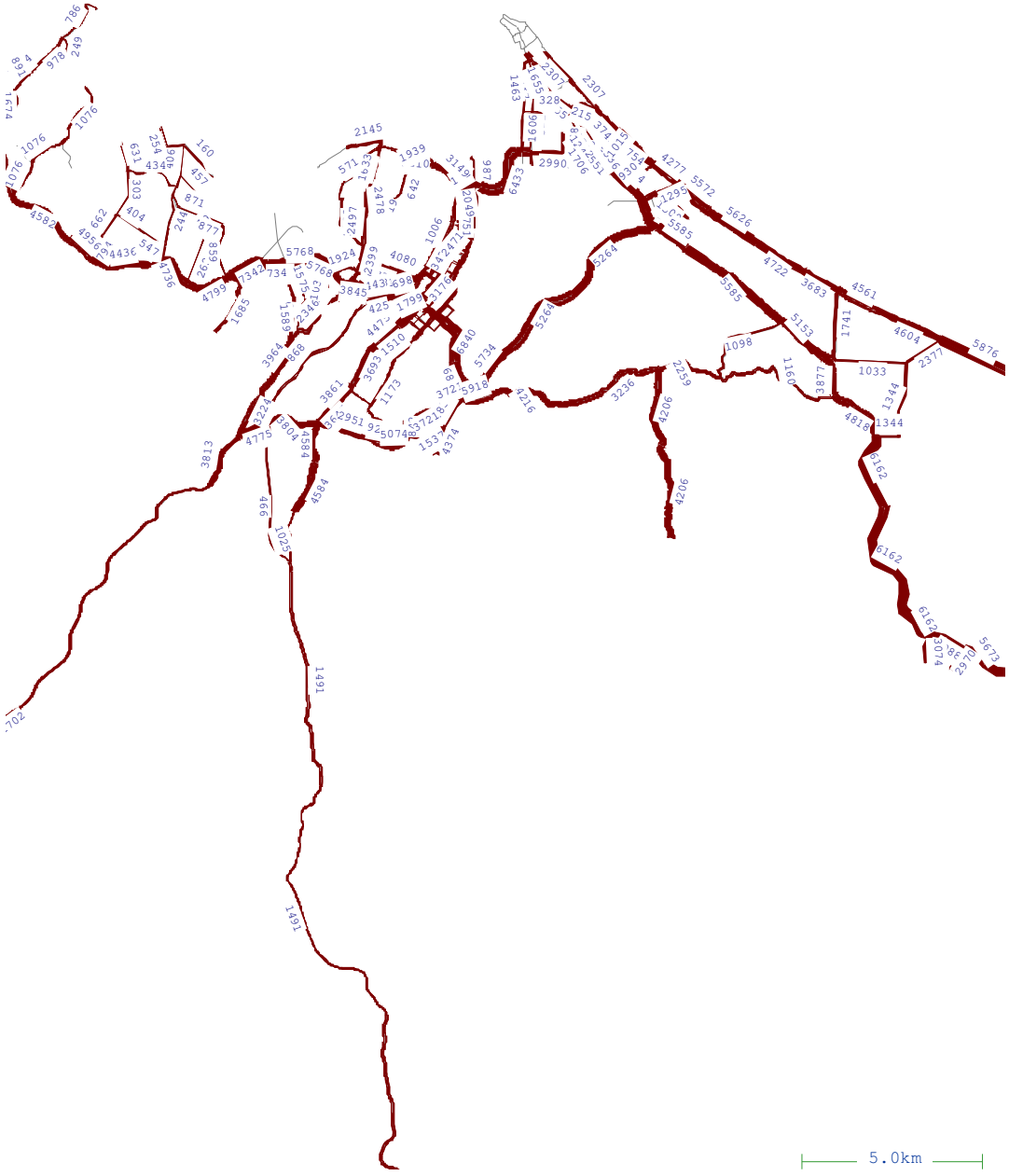


Traffic Design Group	**2041 Inter Peak Two-Way Traffic volumes Taupo**	**Figure 50**
Gabites Porter		

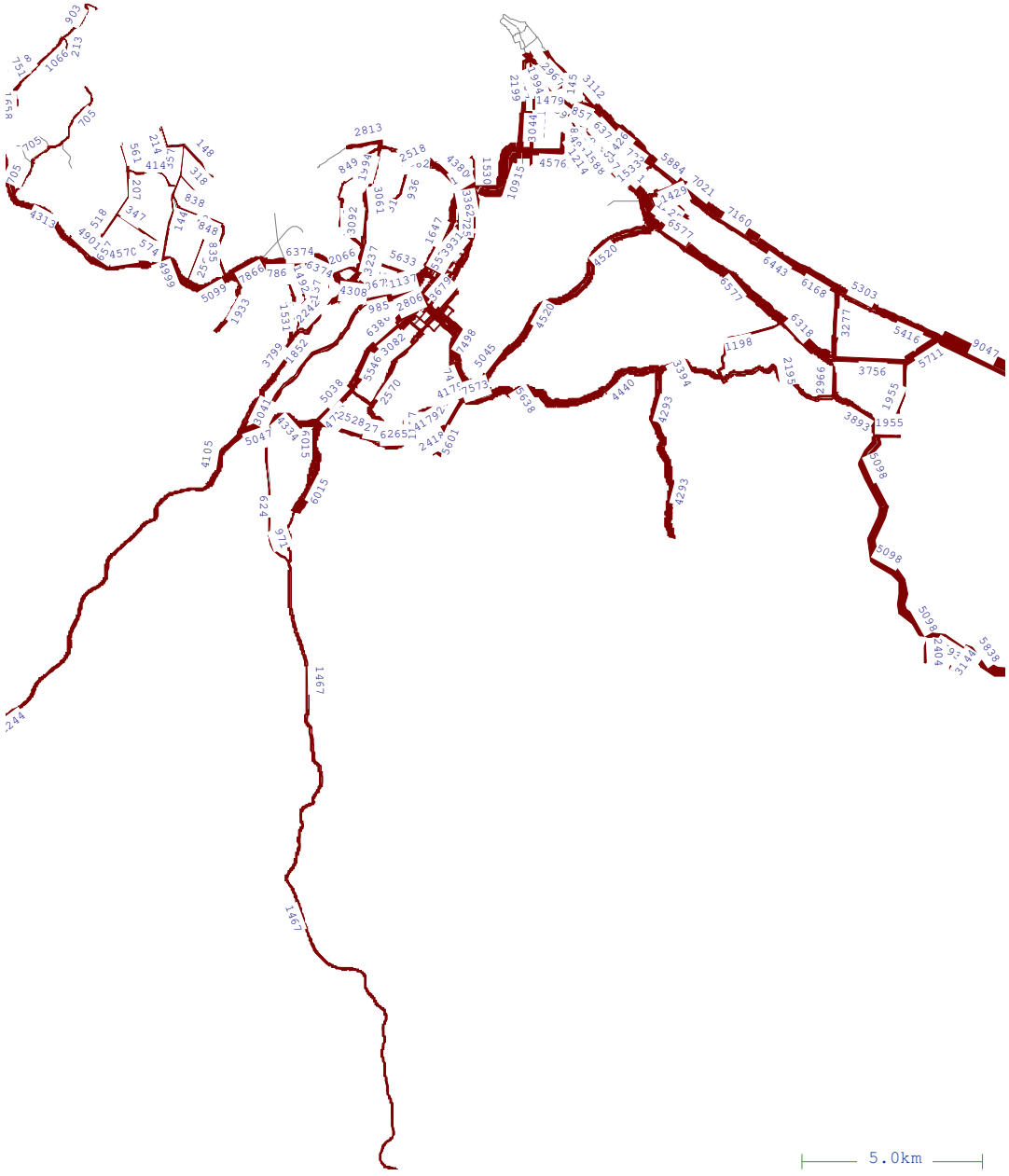
Traffic Design Group Gabites Porter	**2041 PM Peak Two-Way Traffic volumes Taupo**	**Figure 51**



Traffic Design Group Gabites Porter	**2041 AM Peak Two-Way Traffic volumes Tauranga**	**Figure 52**



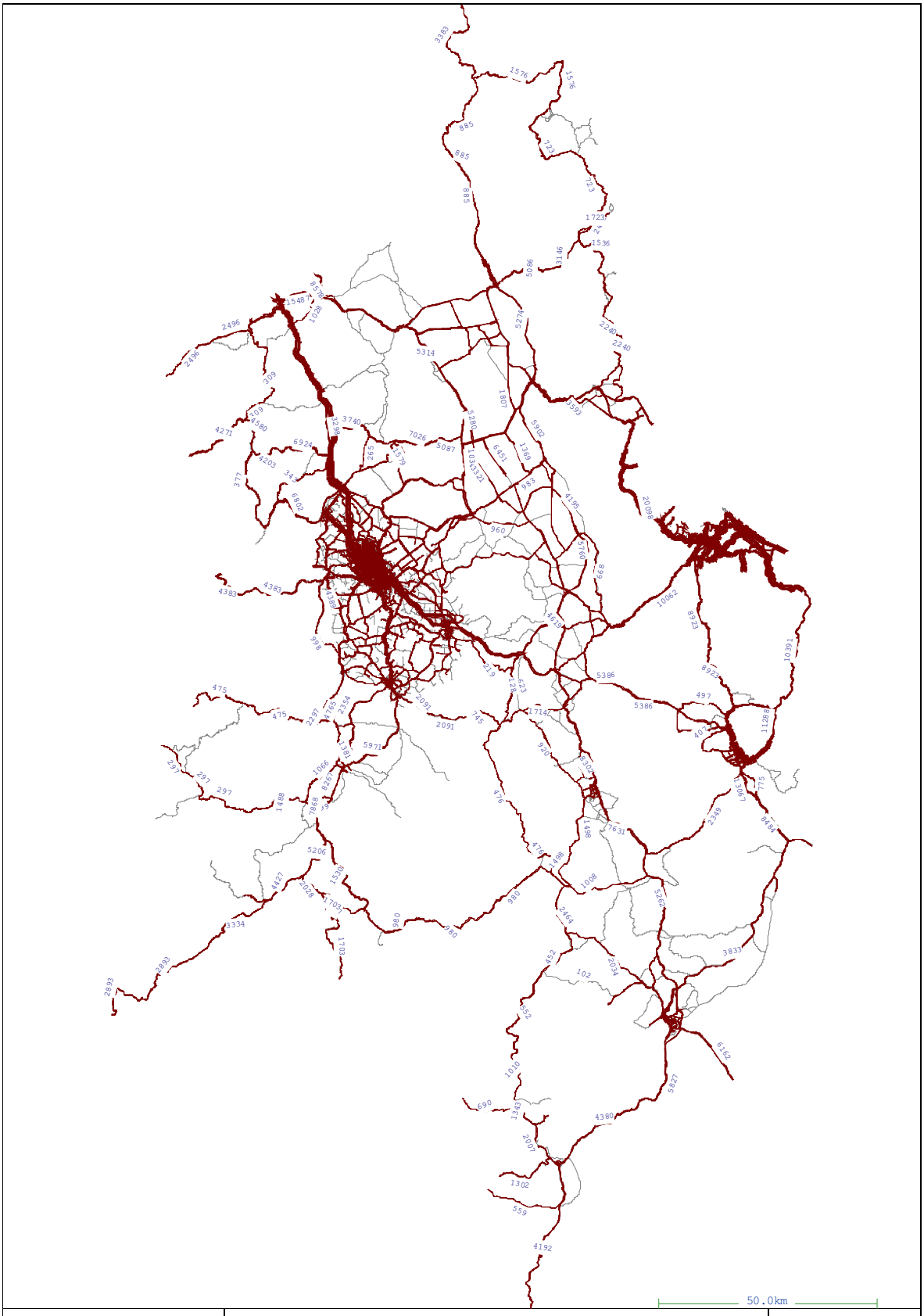
Traffic Design Group	**2041 Inter Peak Two-Way Traffic volumes Tauranga**	**Figure 53**
Gabites Porter		



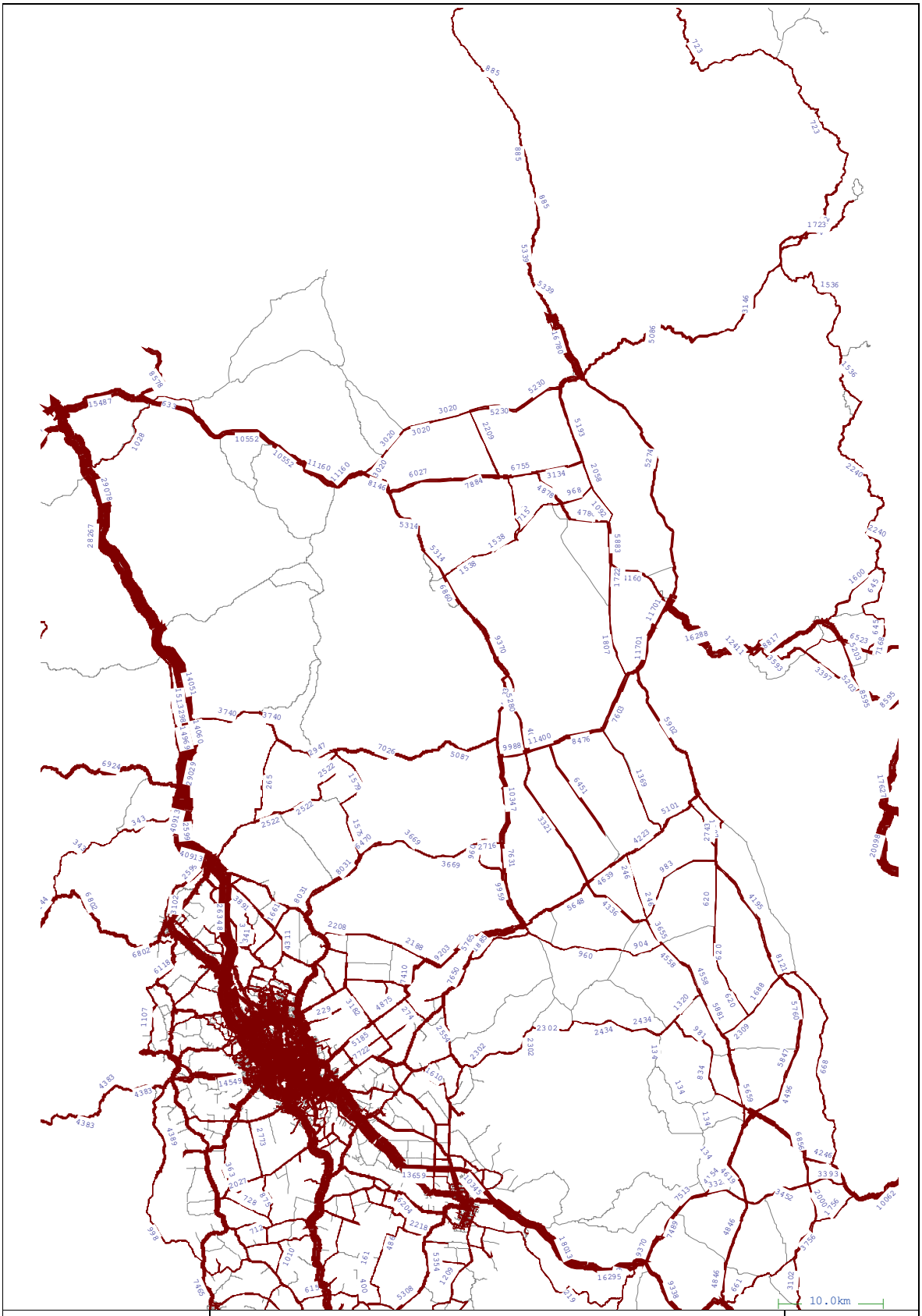
Traffic Design Group Gabites Porter	**2041 PM Peak Two-Way Traffic volumes Tauranga**	**Figure 54**

24 Hour Model Traffic Volumes

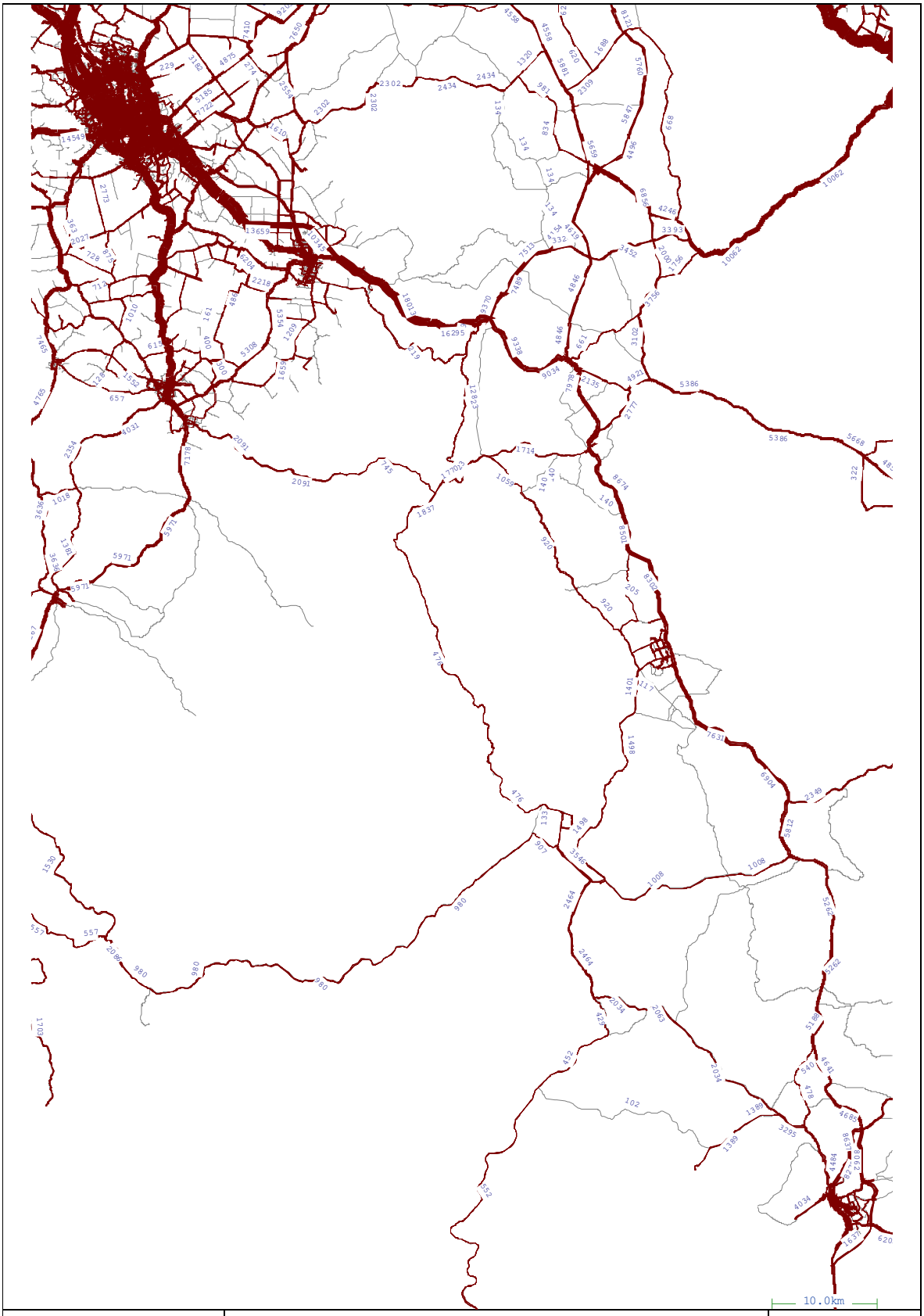
All day traffic volumes for 2021 and 2041 are shown in **Figure 55** to **Figure 60** below for the whole study area along with closer up views of North and South Waikato. These are an overview of AADT volumes using the expansion factors presented in Table 1 of Technical Note 9.



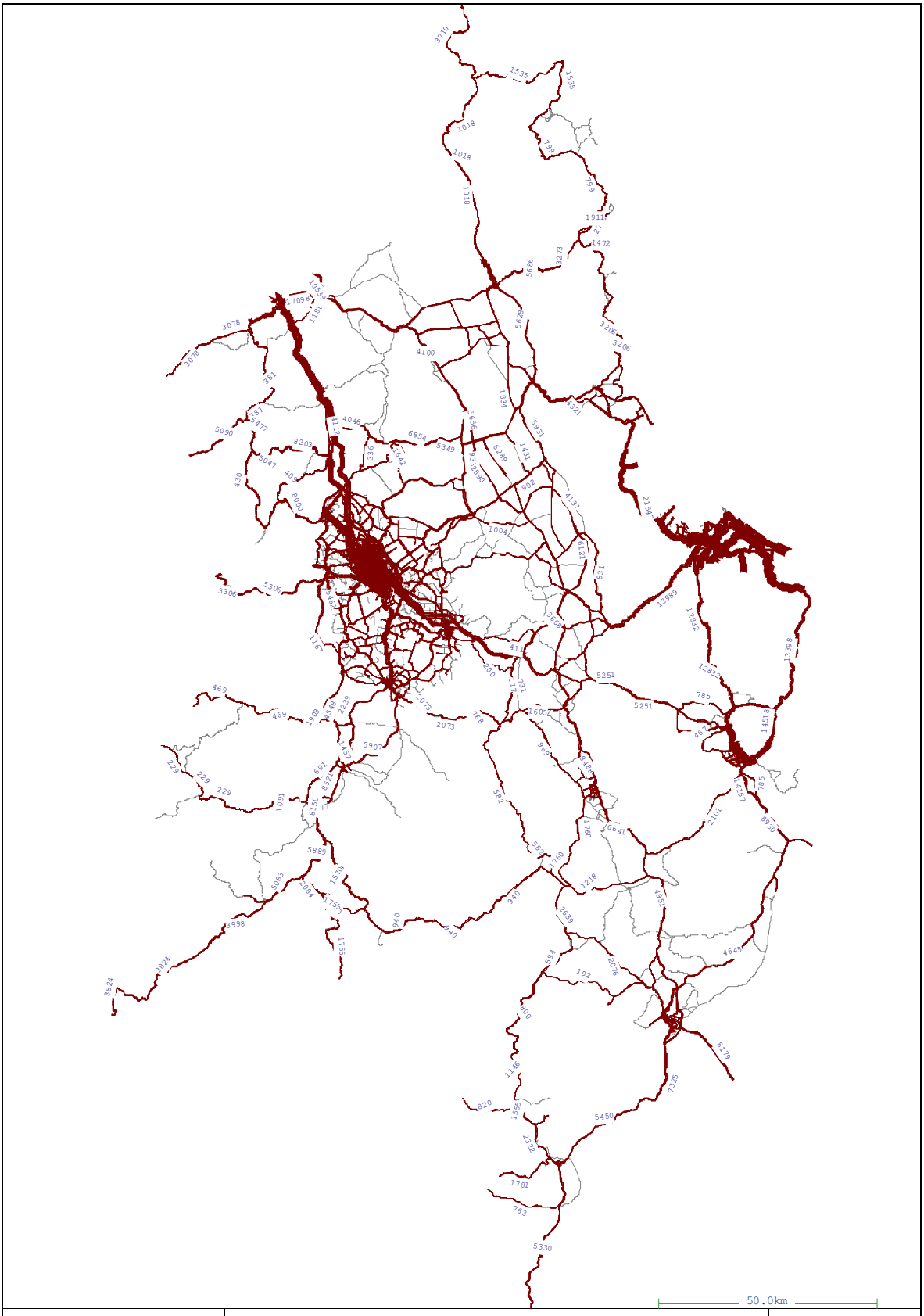
Waikato RLTS Modelling	**24hr Traffic Volumes 2021**	**Figure 55**
Gabites Porter		



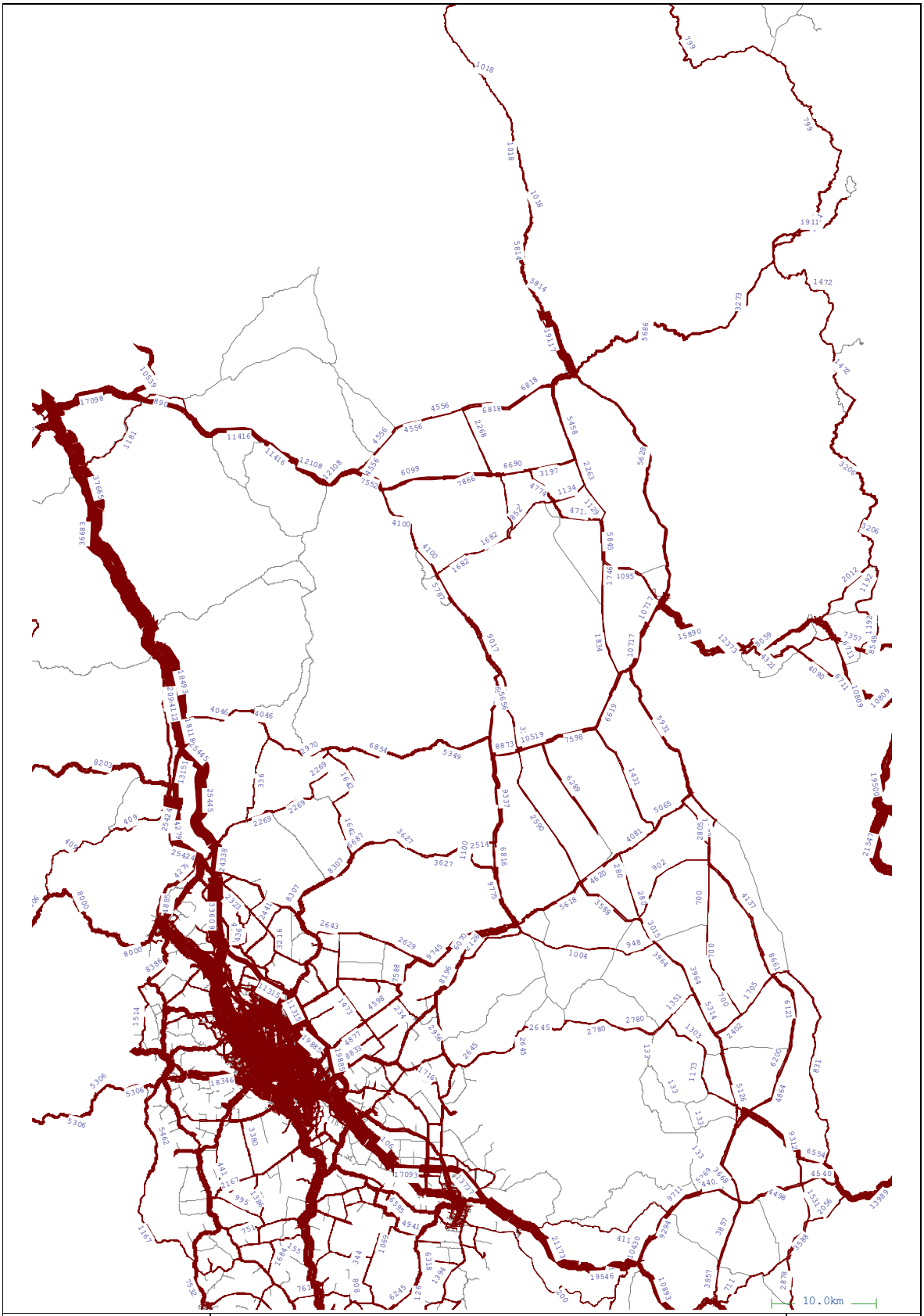
Waikato RLTS Modelling	**24hr Traffic Volumes** **2021** **North Waikato**	**Figure 56**
Gabites Porter		



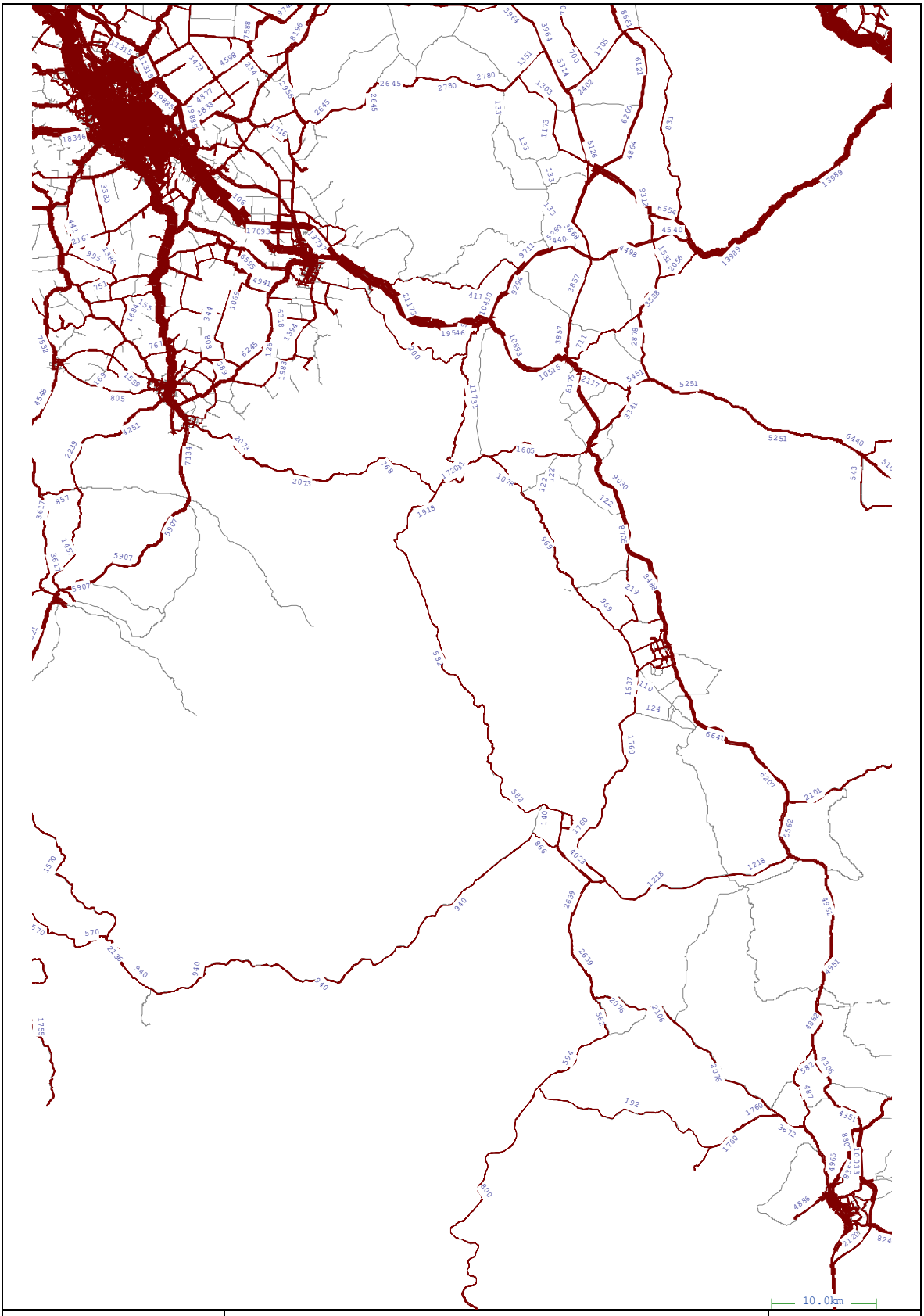
Waikato RLTS Modelling	**24hr Traffic Volumes 2021 South Waikato**	**Figure 57**
Gabites Porter		



Waikato RLTS Modelling	**24hr Traffic Volumes 2041**	**Figure 58**
Gabites Porter		



Waikato RLTS Modelling	**24hr Traffic Volumes** **2041** **North Waikato**	**Figure 59**
Gabites Porter		



Waikato RLTS Modelling	**24hr Traffic Volumes** **2041** **South Waikato**	**Figure 60**
Gabites Porter		

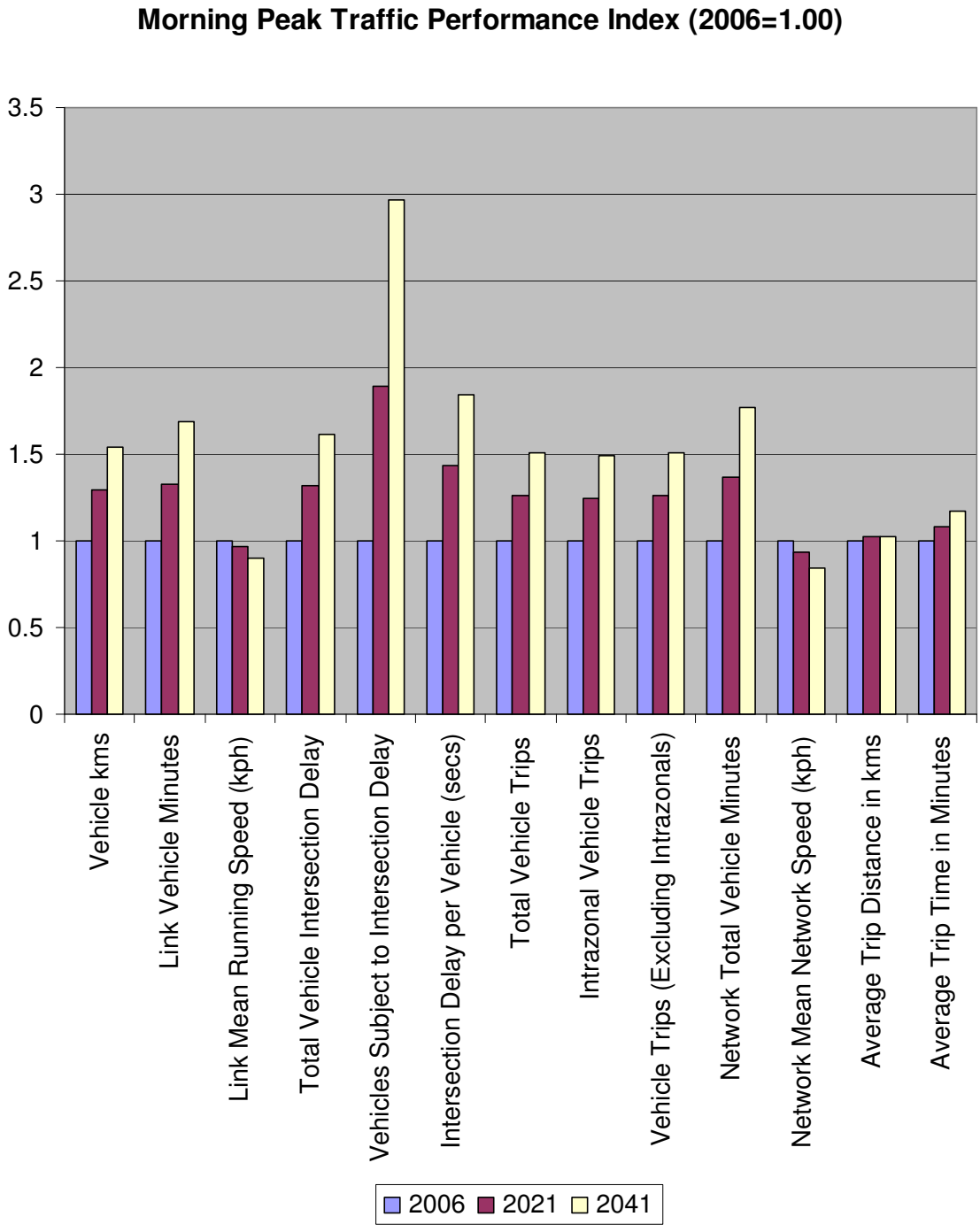
Some key outputs of the transport model are summarised below to give a brief overview of traffic activity in the Waikato regional Model. The indicators are as follows:

- Vehicle kms (VKT) is a measure of vehicle kilometres travelled for all road vehicles considered in this study. It is derived by multiplying vehicle trips by the distance travelled by each vehicle. The Ministry for the Environment uses VKT as a direct indicator of the pressure from road transport on the environment and as a basis for the calculation of vehicle emissions when combined with levels of service;
- Link Vehicle Minutes (VMT) is an aggregate measure of how long people are spending travelling in their cars along links. It does not include time spent by vehicles waiting at intersections. It is derived by multiplying vehicle trips by the time taken from origin to destination for each vehicle trip.
- Total Vehicle Trips is a measure of how many trips are being made by people in vehicles each model period.
- Link Mean Running Speed is a measure of the average speed of vehicles travelling along a link. It does not take into account delays encountered by vehicles at intersections.
- Vehicles subject to intersection delay is a measure of how many vehicles experience any kind of delay at intersections. It is used to help calculate the average intersection delay per vehicle across the whole network.
- Total intersection vehicle delay in minutes is a measure of the total amount of intersection delay experienced by all vehicles on the network. It is used to help calculate the average intersection delay per vehicle across the whole network.
- Intersection Delay per Vehicle is a measure of average delay experienced by all vehicles at all intersections. This indicator provides a way to measure vehicle conflicts. As the number of vehicles increase on a network the number of gaps available to vehicles wanting make a conflicting movement are reduced which leads to increased delay.
- Network Total Vehicle Minutes is a measure of the total amount of time vehicles spend on the network. This includes time spent waiting at intersections.
- Network Mean Network Speed is a measure of the average speed of vehicles travelling through the network. It includes delays experienced by vehicles at intersections.
- Average Trip Distance is a measure of the length of each vehicle trip. It is derived from trip 'length' and 'trip' matrices. This has been used as an indicator of the level of spread in the study area as it means people locating their trip origins further from their trip destinations e.g. people are living further from their work and shopping places.
- Average Trip Minutes is closely related to Average Trip Distances in that the greater the trip distance the greater amount of time spent on the trip.

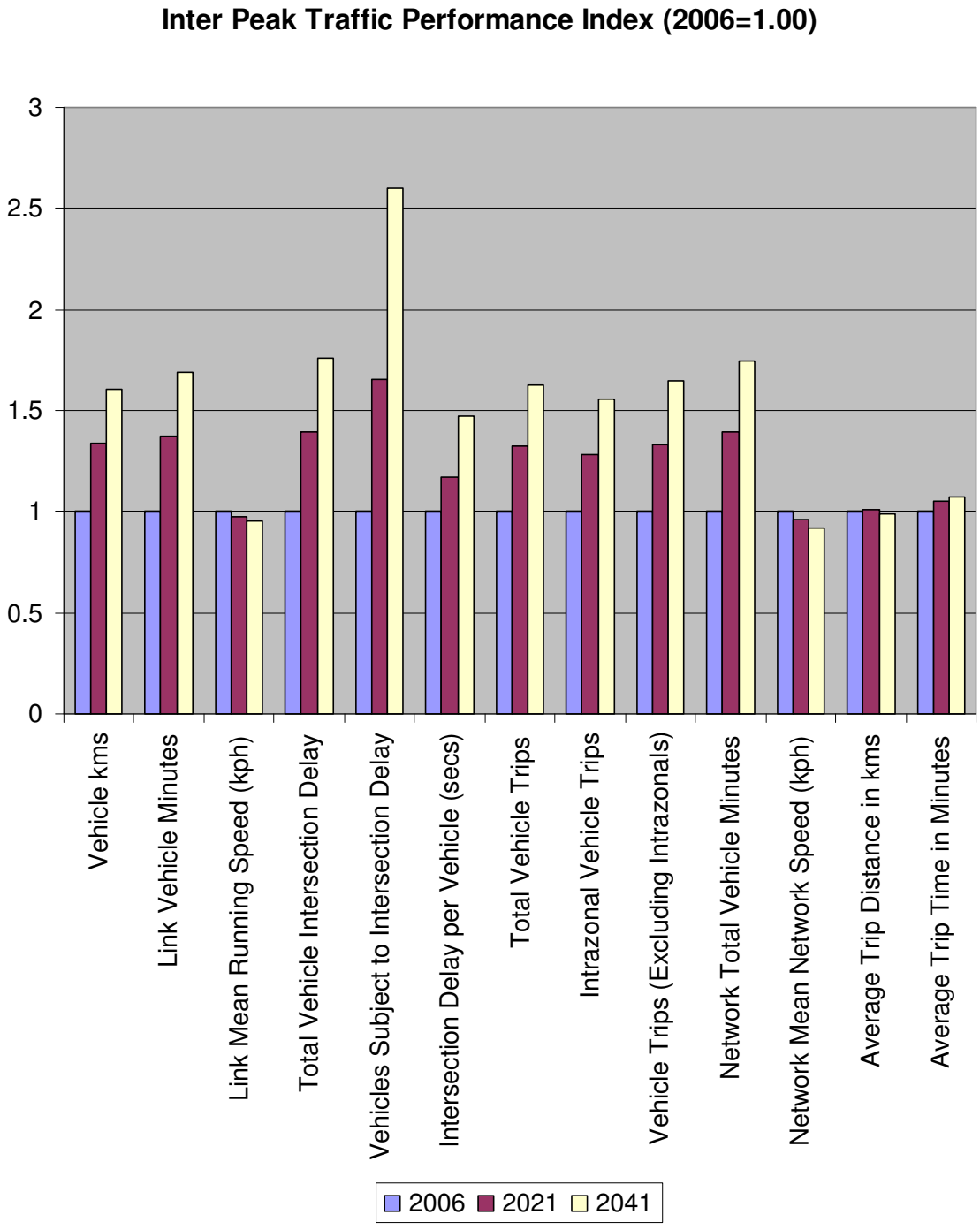
Results

The raw traffic results are shown in **Table 3** and illustrated in **Figure 61**, **Figure 62**, and **Figure 63**. They show how the networks are expected to perform in each of the model years to a base index equal to one according to each of the performance measures listed above.

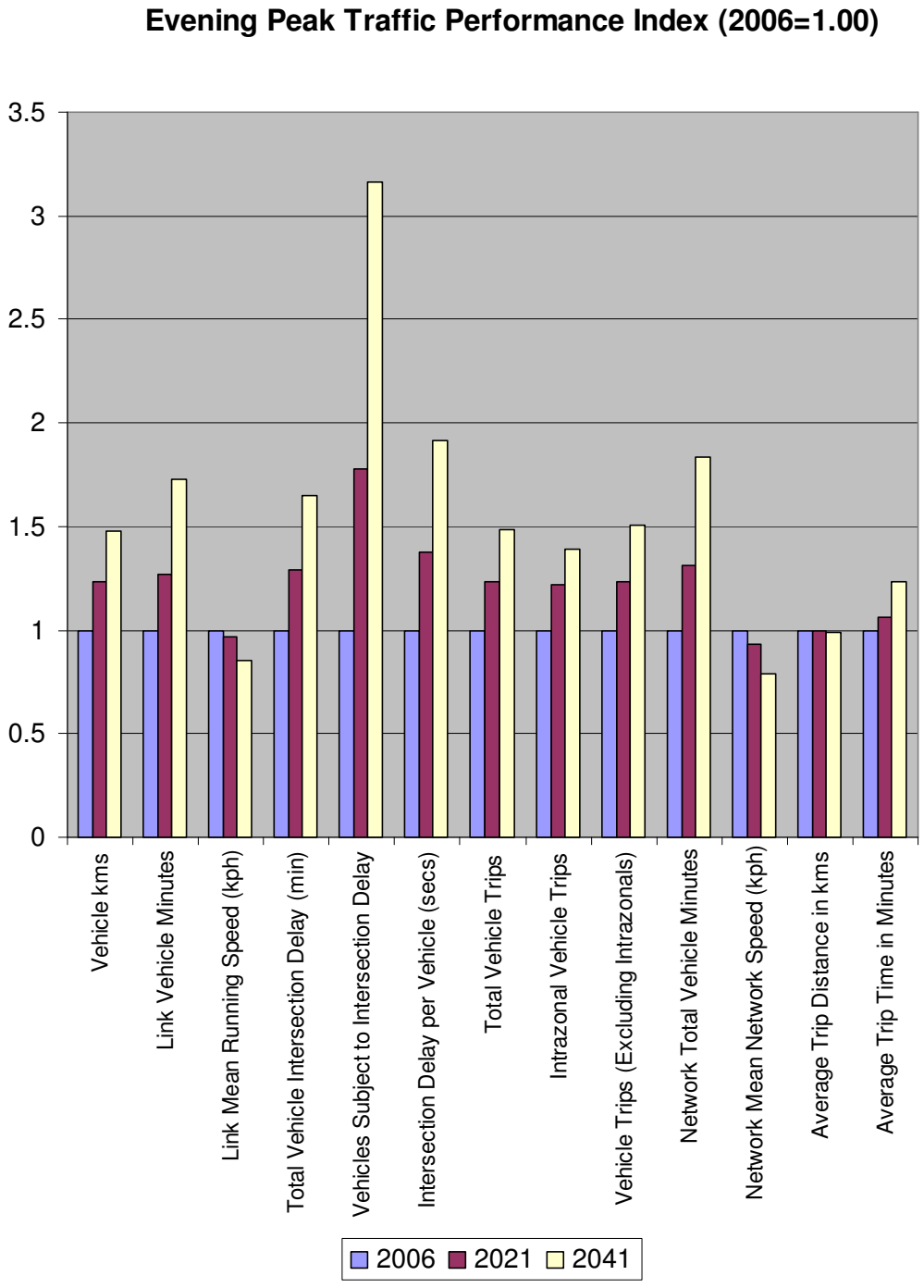
Traffic Activity Indicators				Table 3
Traffic Activity Indicator	**Morning Peak**			
	2006	**2021**	**2041**	**06 to 41 % Δ**
Vehicle kms	2,573,054	3,340,563	3,961,505	53.96%
Link Vehicle Minutes	2,364,126	3,146,571	3,995,720	69.01%
Link Mean Running Speed (kph)	65.3	63.2	58.7	-10.11%
Vehicles subject to Intersection Delay	1,992,082	2,635,696	3,215,495	61.41%
Total Vehicle Intersection Delay (min)	239,588	453,976	710,224	196.44%
Intersection Delay per Vehicle (sec)	7.2	10.3	13.3	84.72%
Total Vehicle Trips	221,769	280,173	334,073	50.64%
Intra Zonal Vehicle Trips	37,208	46,492	55,471	49.08%
Vehicle Trips (excluding intrazonals)	184,561	233,681	278,602	50.95%
Network Total Vehicle Minutes	2,594,648	3,552,550	4,590,575	76.92%
Network Mean Network Speed (kph)	59.3	55.2	49.8	-15.93%
Average Trip Distance in kms	11.60	11.92	11.86	2.20%
Average Trip Time in Minutes	11.70	12.68	13.74	17.45%
	Inter Peak			
Vehicle kms	2,522,879	3,375,849	4,045,437	60.35%
Link Vehicle Minutes	2,220,233	3,054,151	3,742,888	68.58%
Link Mean Running Speed (kph)	68.1	66.3	64.8	-4.85%
Vehicles subject to Intersection Delay	1,674,943	2,336,024	2,943,789	75.75%
Total Vehicle Intersection Delay (min)	177,915	293,834	462,518	159.97%
Intersection Delay per Vehicle (sec)	6.4	7.5	9.4	46.88%
Total Vehicle Trips	201,969	267,138	328,718	62.76%
Intra Zonal Vehicle Trips	41196	52766	63998	55.35%
Vehicle Trips (excluding intrazonals)	160,773	214,372	264,720	64.65%
Network Total Vehicle Minutes	2,395,296	3,342,013	4,185,140	74.72%
Network Mean Network Speed (kph)	63.1	60.5	57.7	-8.52%
Average Trip Distance in kms	12.49	12.64	12.31	-1.48%
Average Trip Time in Minutes	11.86	12.51	12.73	7.35%
	Evening Peak			
Vehicle kms	3,237,754	3,995,121	4,780,111	47.64%
Link Vehicle Minutes	3,003,129	3,820,866	5,201,420	73.20%
Link Mean Running Speed (kph)	64.6	62.6	55.0	-14.86%
Vehicles subject to Intersection Delay	2,399,147	3,093,410	3,960,528	65.08%
Total Vehicle Intersection Delay (min)	319362	568,915	1,010,473	216.40%
Intersection Delay per Vehicle (sec)	8.0	11.0	15.3	91.25%
Total Vehicle Trips	258,463	319,132	384,438	48.74%
Intra Zonal Vehicle Trips	39,078	47,747	54,287	38.92%
Vehicle Trips (excluding intrazonals)	219,385	271,385	330,151	50.49%
Network Total Vehicle Minutes	3,302,800	4,331,066	6,053,465	83.28%
Network Mean Network Speed (kph)	58.4	54.5	46.1	-21.17%
Average Trip Distance in kms	12.53	12.52	12.43	-0.74%
Average Trip Time in Minutes	12.78	13.57	15.75	23.22%



Traffic Design Group	**Morning Peak Traffic Indicators 2006-2041**	**Figure 61**
Gabites Porter		



Traffic Design Group	**Inter Peak Traffic Indicators 2006-2041**	**Figure 62**
Gabites Porter		



Traffic Design Group	**Evening Peak Traffic Indicators 2006-2041**	**Figure 63**
Gabites Porter		

The Morning peak traffic performance indicators illustrated in **Figure 61** show that total trips increase by 50% by 2041. This has associated impacts on total vehicle kilometres, total vehicle minutes and total intersection delay which all increase between 54% and 196%. Related to this, are the increases by 2.2% and 17.5% respectively in average trip distance and time. This indicates that the network is becoming more congested in the future.

The Inter peak traffic performance indicators illustrated in **Figure 62** show that total trips increase by 63% by 2041. This has associated impacts on total vehicle kilometres, total vehicle minutes and total intersection delay which all increase between 60% and 160%. Related to this is the increase in average trip times of 7% despite a slight decrease in the average trip distance. Again this indicates that the network is becoming more congested in the future.

The Evening peak traffic performance indicators illustrated in **Figure 63** show that total trips increase by 49%. This has associated impacts on total vehicle kilometres and total vehicle minutes which increase between 48% and 83%. Total intersection delay has increased by 216% by 2041. Related to this is the increase by 23% in average trip time. This indicates that the network is likely to become significantly more congested in the future.

General observations:

- Total Trip numbers are expected to increase in the order of 160 to 220% by 2041. Total vehicle minutes increase by 7% to 23%, which indicates that the network is becoming more congested.
- Total intersection delay is expected to increase two to three fold by 2041;
- The morning peak experiences an increase in average trip distance with the interpeak period and evening peak experiencing slight decreases in average trip distances.
- The interpeak period experiences less than half the growth in average trip times as the morning and evening peak periods.

Overall, it is clear that the Waikato Network will be put under increasing pressure as we move into the future. The exact nature of both pressures and the constraints will become clear in the next section, which focuses on network Levels of Service.

4. LEVEL OF SERVICE

Level of Service is a subjective measure of the way in which a network is operating, given the traffic demands that are placed on it. It is a concept developed by American engineers, and has been generally internationally adopted. It is being used in this study to measure the performance of both roads and intersections.

This section begins with a description of the LOS criteria used and follows with LOS. The network is then divided into sections to make it easier to understand the changes. In each section the LOS for different network component are both tabulated and illustrated to show where and when LOS issues are likely to arise.

LOS Descriptions

Because it is subjective, individual regions have a local perception of how individual roads and intersections are operating and that affects the local interpretation of the LOS values. It is important to note that level of service tends to be much worse during the morning and evening peaks. The interval between these periods usually generates fewer trips and the trips tend to be shorter resulting much in a much better LOS. For the Waikato Regional Transport Model the boundaries have been derived from the United States Transportation Research Board Highway Capacity Manual.

The results presented here focus on LOS F, E, D and C with particular attention paid to LOS F and E. The LOS boundaries are described in **Table 4**, which provides a description of:

- LOS definitions describing the type of conditions a driver faces under each level
- Link LOS boundaries that describe the performance of traffic moving along a section of road and a function of traffic volume and link free flow speed.
- Intersection LOS boundaries, which are based on two different criteria: Worst approach delay for priority controlled intersections; and weighted average delay across all approaches for signalised intersections and roundabouts.

Figure 64 shows how Link LOS varies depending on link type. It shows that the higher the vehicle volume and the lower the free speed the worse the LOS becomes. Link types are defined as follows:

- Link type 1 equates to road speeds of 10km/hr
- Link type 2 and 12 equate to road speeds of 20km/hr and 25km/hr
- Link type 3 and 13 equate to road speeds of 30km/hr and 35km/hr
- Link type 4 and 14 equate to road speeds of 40km/hr and 45km/hr
- Link type 5 and 15 equate to road speeds of 50km/hr and 55km/hr
- Link type 6 and 16 equate to road speeds of 60km/hr and 65km/hr
- Link type 7 and 17 equate to road speeds of 70km/hr and 75km/hr
- Link type 8 and 18 equate to road speeds of 80km/hr and 85km/hr
- Link type 9 and 19 equate to road speeds of 90km/hr and 95km/hr
- Link type 10 and 11 equate to road speeds of 100km/hr and 105km/hr

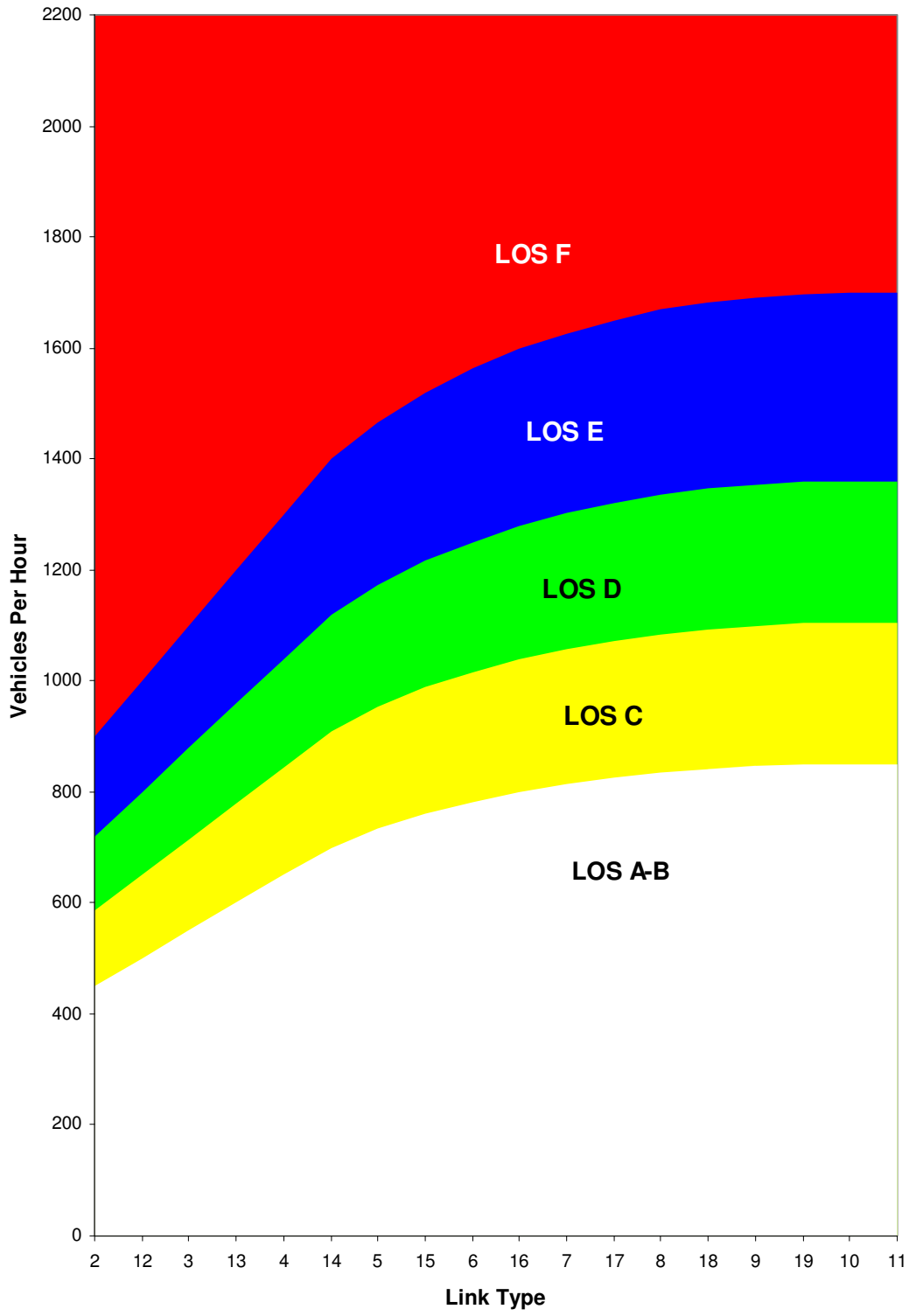
Please note that the Waikato model uses 2 hour assigned periods. Consequently the 1 hour criteria in **Table 4** and **Figure 64** have been factored up to produce hourly values.

This present day Level of Service provides a measure by which future network performance (and any resultant deficiencies) can be assessed, given knowledge and experience of current conditions.

Definitions of LOS				Table 4
LOS	AustRoads Description	Waikato Regional Transport Model LOS criteria		
		Link (vehicles per lane per hour)	Intersection delay (seconds/veh)	
			Priority*	Signal/Rotary**
LOS F	Forced flow. The amount of traffic approaching a point exceeds that which can pass it. Flow breakdowns occur, and queuing and delays occur.	In excess of **900-1700** depending on link type	In excess of 50 sec	In excess of 80 sec
LOS E	Traffic volumes are at or close to *capacity and there is virtually no freedom* to select desired speed and to manoeuvre within the traffic stream. Flow is unstable and *minor disturbances within the traffic stream will cause breakdowns in operation*.	Between **720-900** and **1360-1700** depending on link type	35 - 50 sec	55 - 80 sec
LOS D	Approaching unstable flow where *all drivers are severely restricted* in their freedom to select desired speed and to manoeuvre within the traffic stream. The general level of *comfort and convenience is poor* and small increases in traffic flow will cause operational problems.	Between **585-720** and **1105-1360** depending on link type	25 - 35 sec	35 - 55 sec
LOS C	Stable flow but most drivers *are restricted to some extent* in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of *comfort and convenience has declined noticeably*.	Between **450-585** and **850-1105** depending on link type	15 - 25 sec	20 - 35 sec
LOS B	Stable flow where drivers still *have reasonable freedom* to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience is less than LOS A.	Between **0** and **450-850** depending on link type	0 - 15 sec	0 - 20 sec
LOS A	Free flow in which drivers are *virtually unaffected* by the presence of others in the traffic stream. Freedom to select desired speeds and to manoeuvre within the traffic stream is extremely high and the general level of *comfort and convenience is excellent*.			

* Relates to delay at worst approach

** Relates average delay to weighted average delay across all approaches



Traffic Design Group Gabites Porter	**Waikato Regional Transport Model Link LOS Criteria (Per Hour)**	**Figure 64**

5. RESULTS

The following sections illustrate when and where transport deficiencies are expected to occur on the network in 2021 and 2041. Section 0 and section 0 present the results for the morning peak and evening peak periods respectively. Within each of these two sections Level of Service (LOS) plots are included which depict the location of the deficiencies by year. The analysis is then divided further into subsections that focus on different parts of the transport network.

In the Level of Service figures, three separate measures are shown as follows:

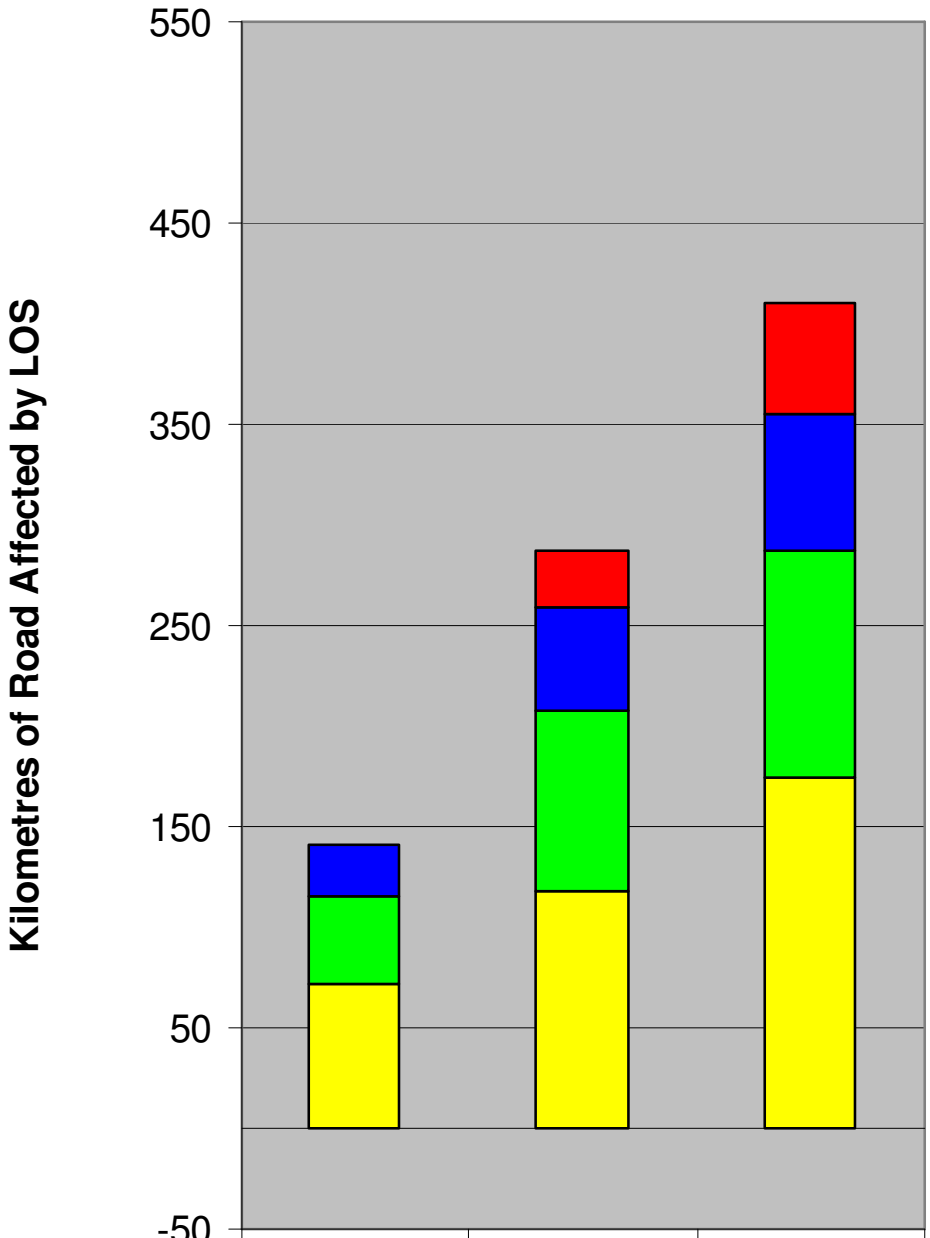
- Overall Intersection LOS is displayed as various coloured circles,
- LOS circles show the number of vehicles affected i.e. larger circle equates to more vehicles, and,
- Link LOS is displayed as different coloured lines along the length of the link affected.

AM Peak Transport Deficiencies

The kilometres of road falling into each LOS category are shown in **Figure 65** and the Number of Intersections falling into each LOS category (based on worst approach) are shown in **Figure 66**.

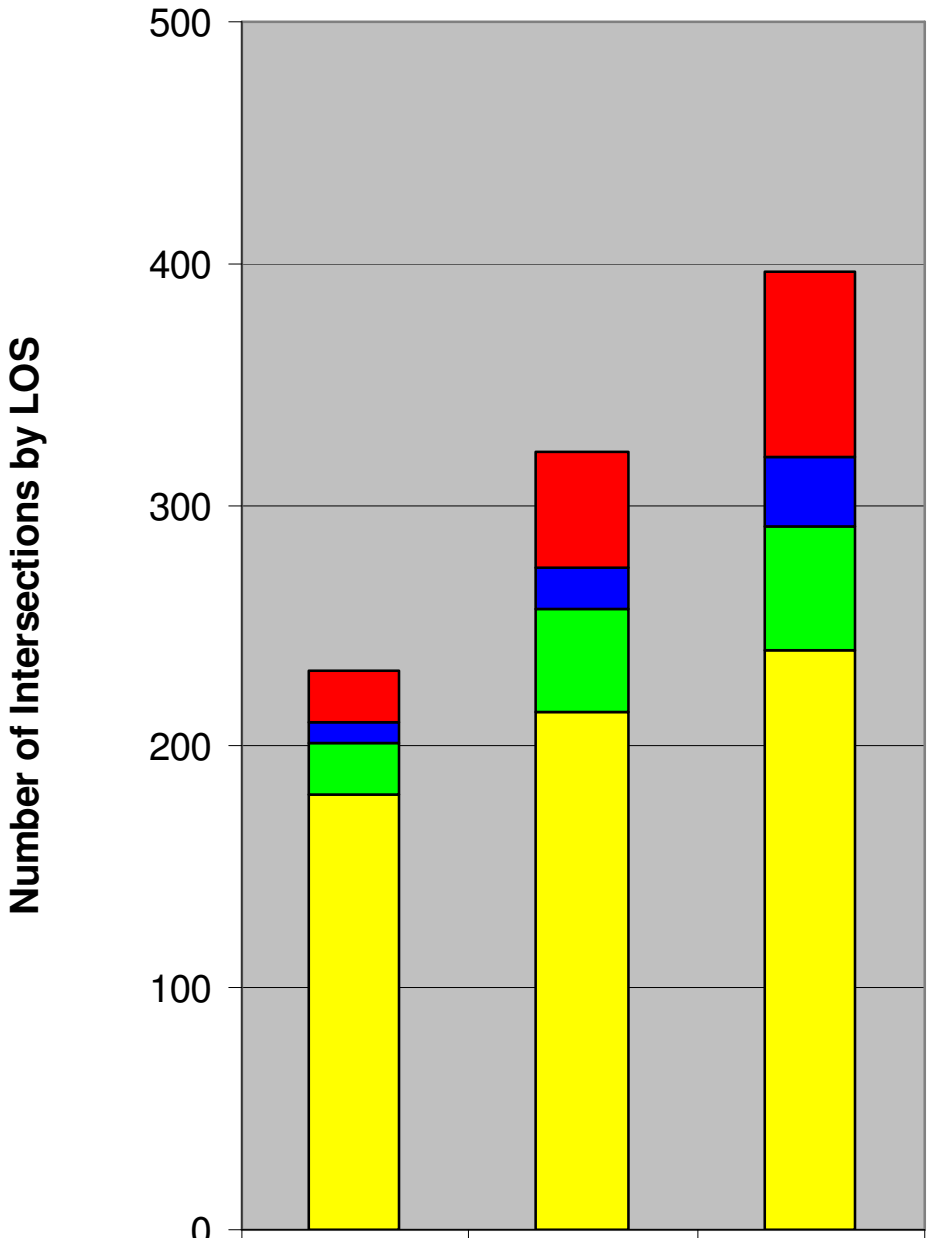
Level Of Service (LOS) plots depicting the location and severity of deficiencies across the Waikato Regional Transport Model study area are included as follows:

- Morning Peak LOS North Waikato (2006, 2021 and 2041) in **Figure 67**, **Figure 68** and **Figure 69**,
- Morning Peak LOS in Waipa (2006, 2021 and 2041) in **Figure 70**, **Figure 71** and **Figure 72**
- Morning Peak LOS in Hamilton (2006, 2021 and 2041) in **Figure 73**, **Figure 74** and **Figure 75**
- Morning Peak LOS in Rotorua (2006, 2021 and 2041) in **Figure 76**, **Figure 77** and **Figure 78**
- Morning Peak LOS in Taupo (2006, 2021 and 2041) in **Figure 79**, **Figure 80** and **Figure 81**
- Morning Peak LOS in Tauranga (2006, 2021 and 2041) in **Figure 82**, **Figure 83**, and **Figure 84**



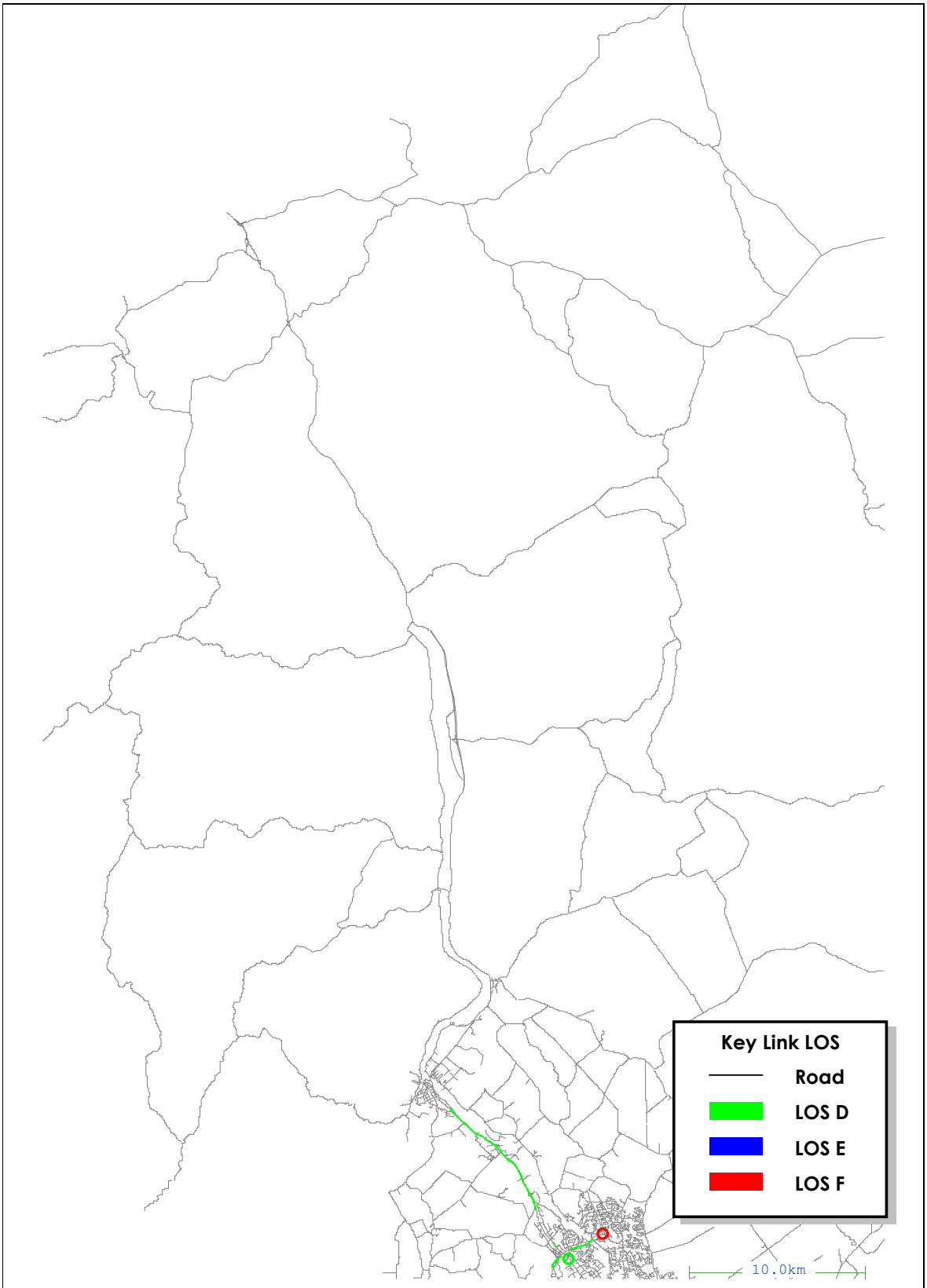
	2006	2021	2041
LOS F	0.2	28.5	55
LOS E	25.7	50.9	68.6
LOS D	43	89.7	112
LOS C	72	118.1	174.6

Traffic Design Group Gabites Porter	**Kilometres of Road Affected by LOS AM Peak**	**Figure 65**

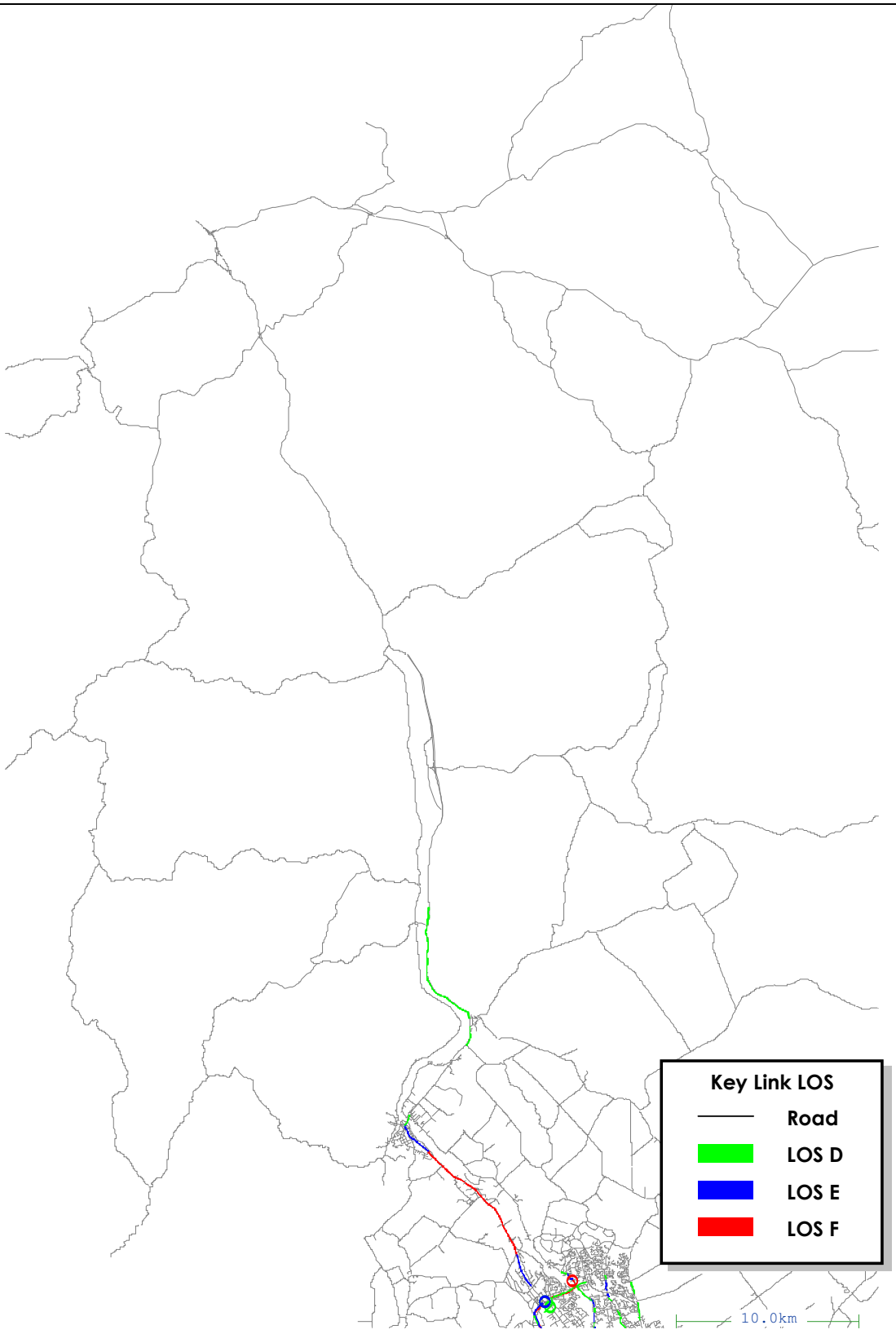


	2006	2021	2041
LOS F	21	48	77
LOS E	8	17	29
LOS D	22	43	51
LOS C	180	214	240

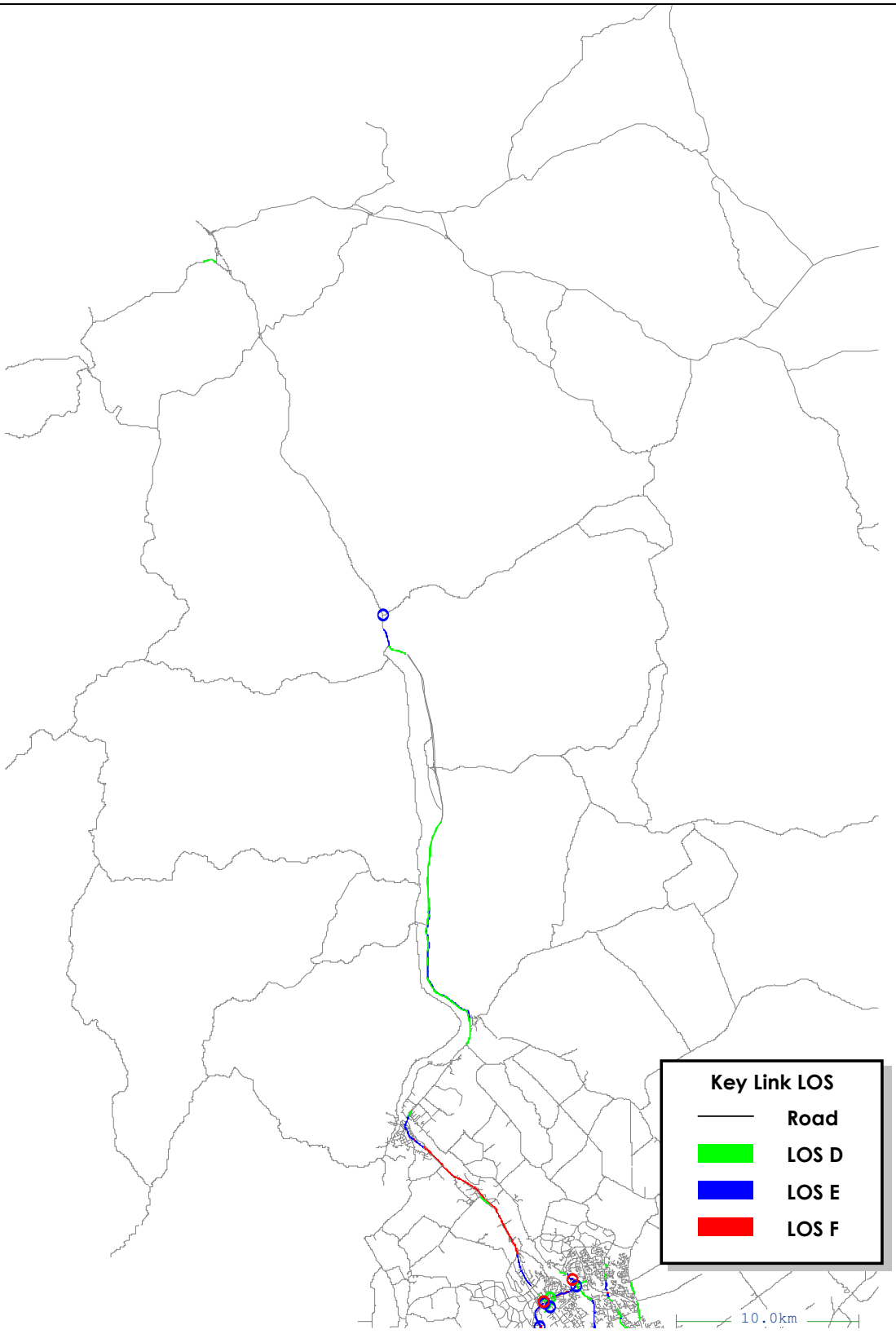
Traffic Design Group Gabites Porter	**Number of Intersections by LOS AM Peak**	**Figure 66**



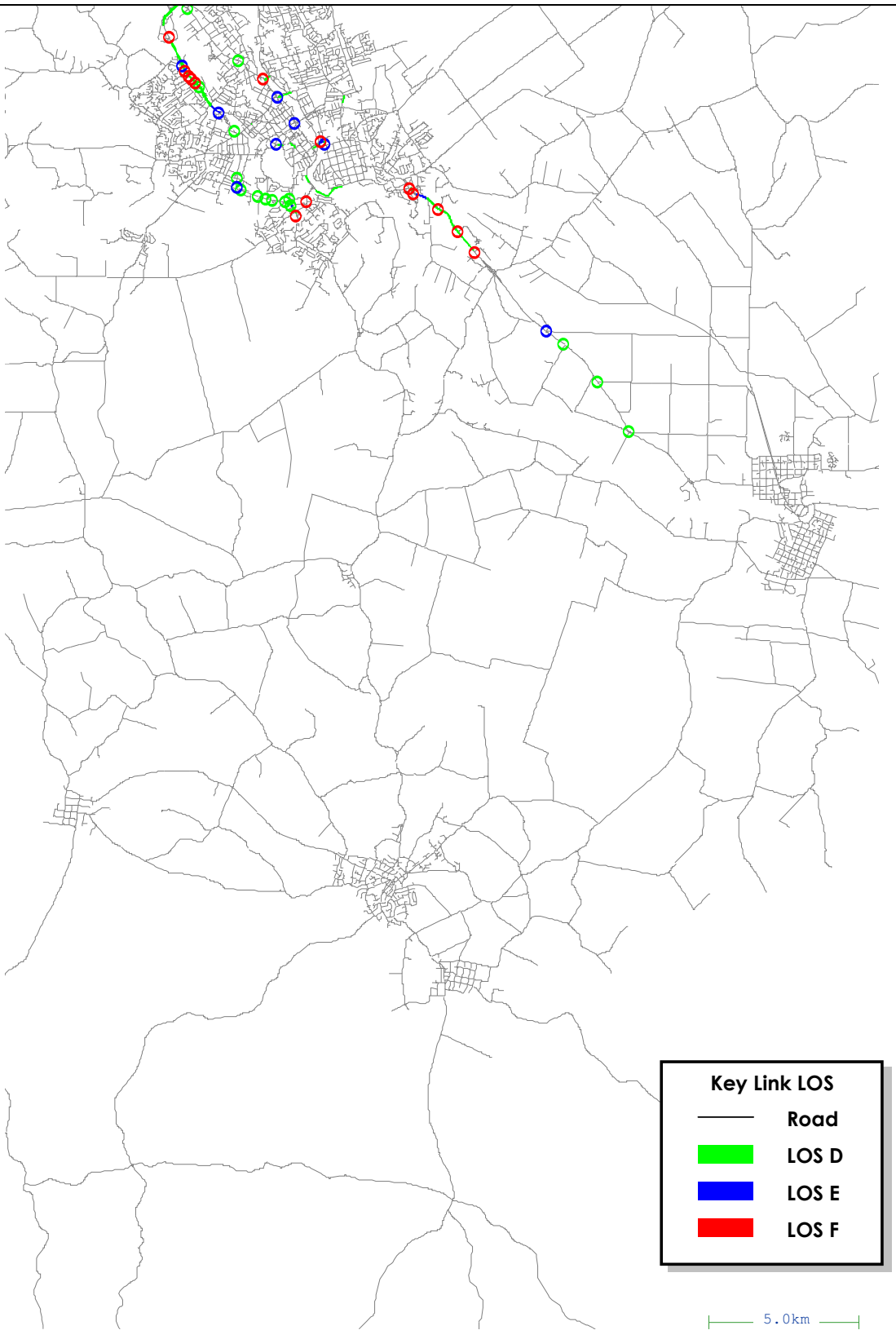
Traffic Design Group	**2006 Morning Peak LOS**	**Figure 67**
Gabites Porter	**North Waikato**	



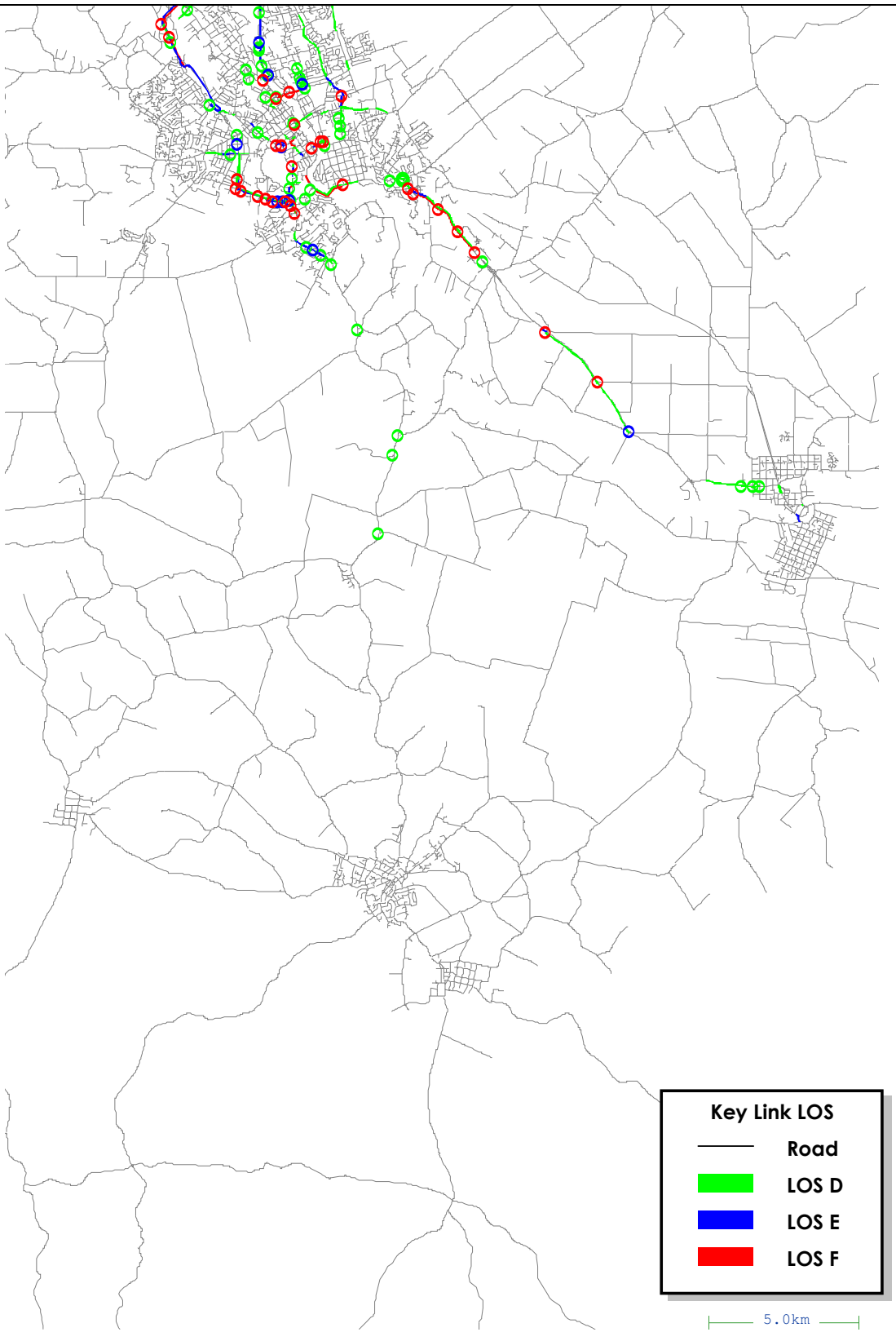
Traffic Design Group	**2021 Morning Peak LOS North Waikato**	**Figure 68**
Gabites Porter		



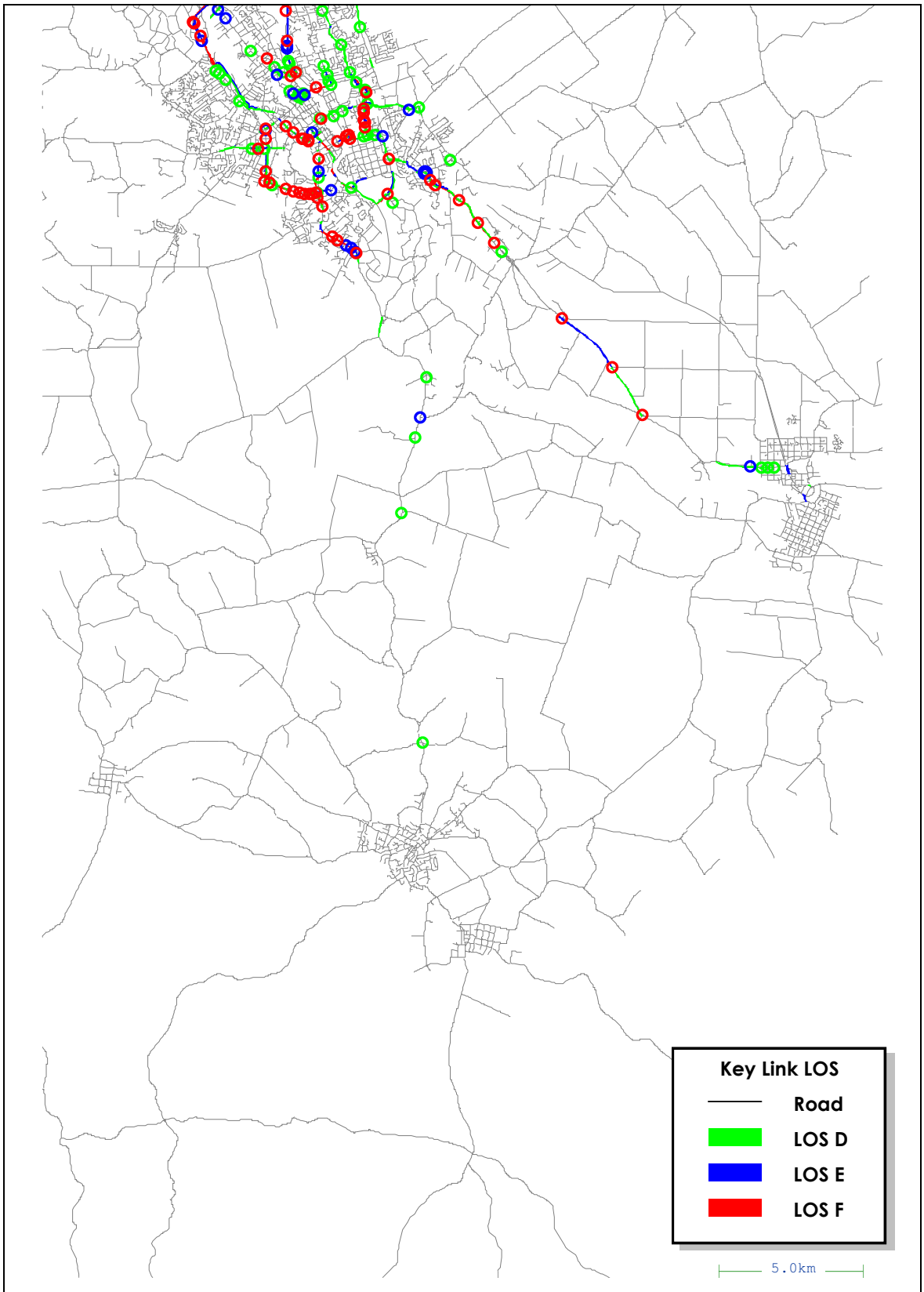
Traffic Design Group	**2041 Morning Peak LOS North Waikato**	**Figure 69**
Gabites Porter		



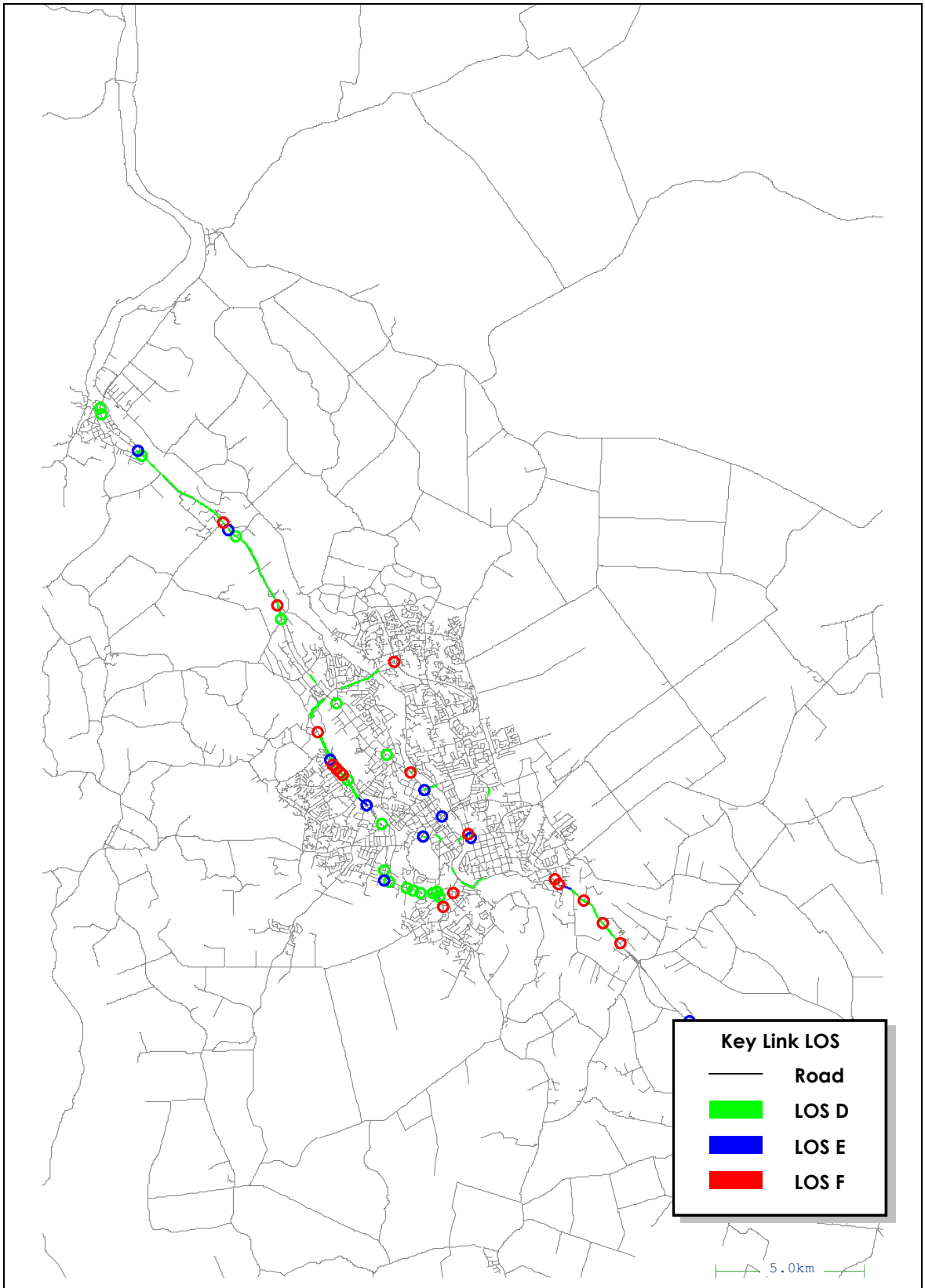
Traffic Design Group	**2006 Morning Peak LOS Waipa**	**Figure 70**
Gabites Porter		



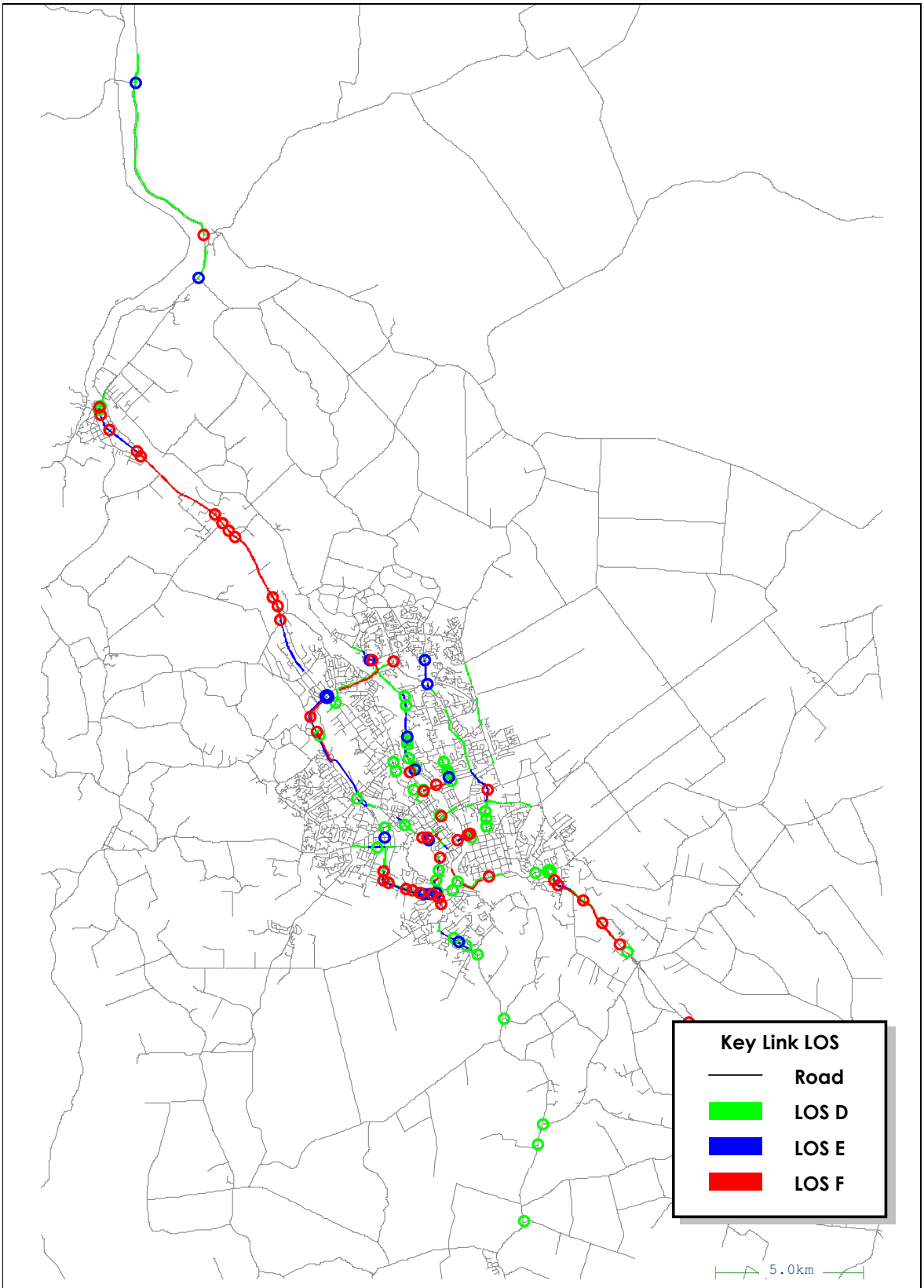
Traffic Design Group	**2021 Morning Peak LOS Waipa**	**Figure 71**
Gabites Porter		



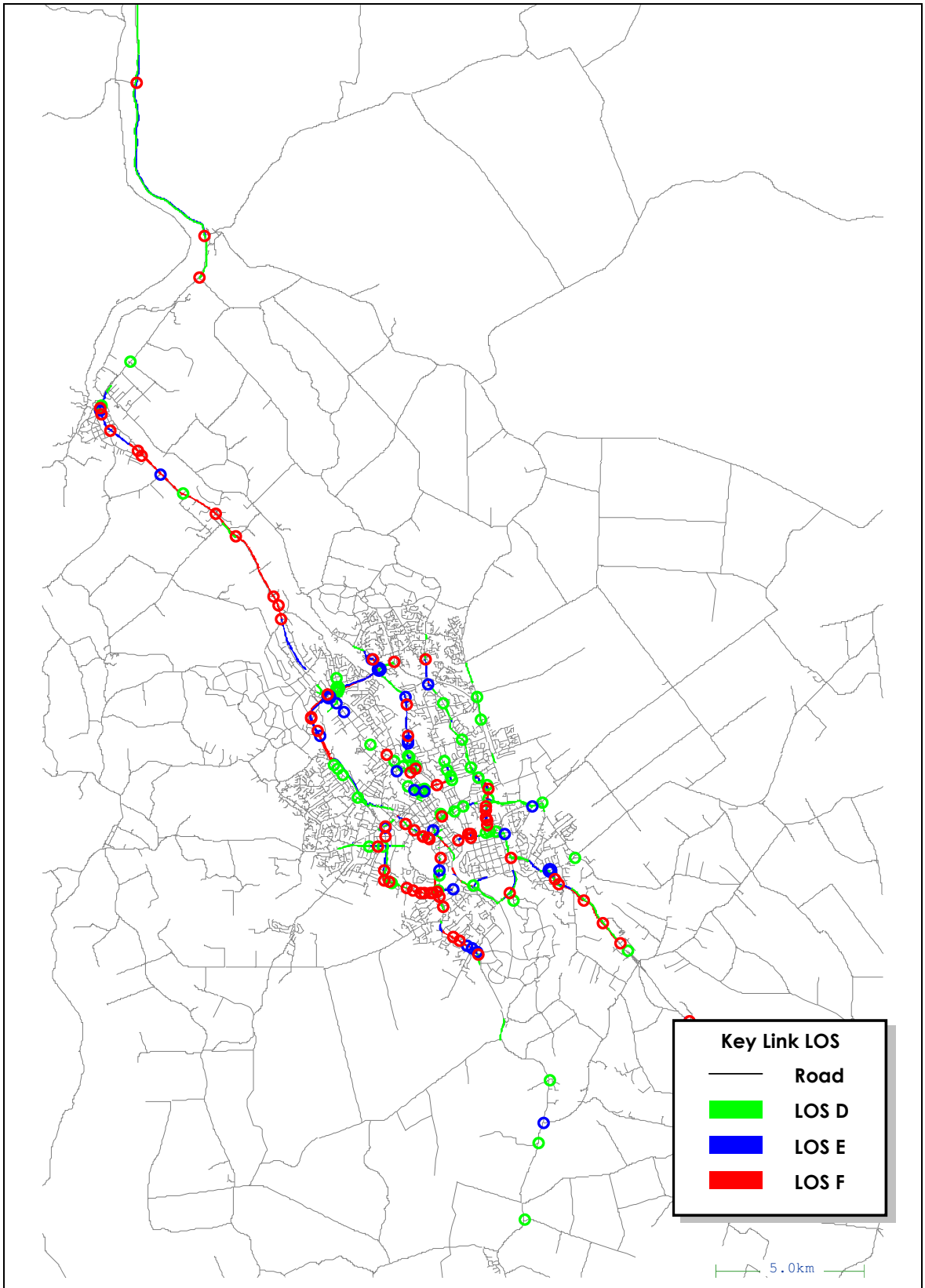
Traffic Design Group	**2041 Morning Peak LOS Waipa**	**Figure 72**
Gabites Porter		



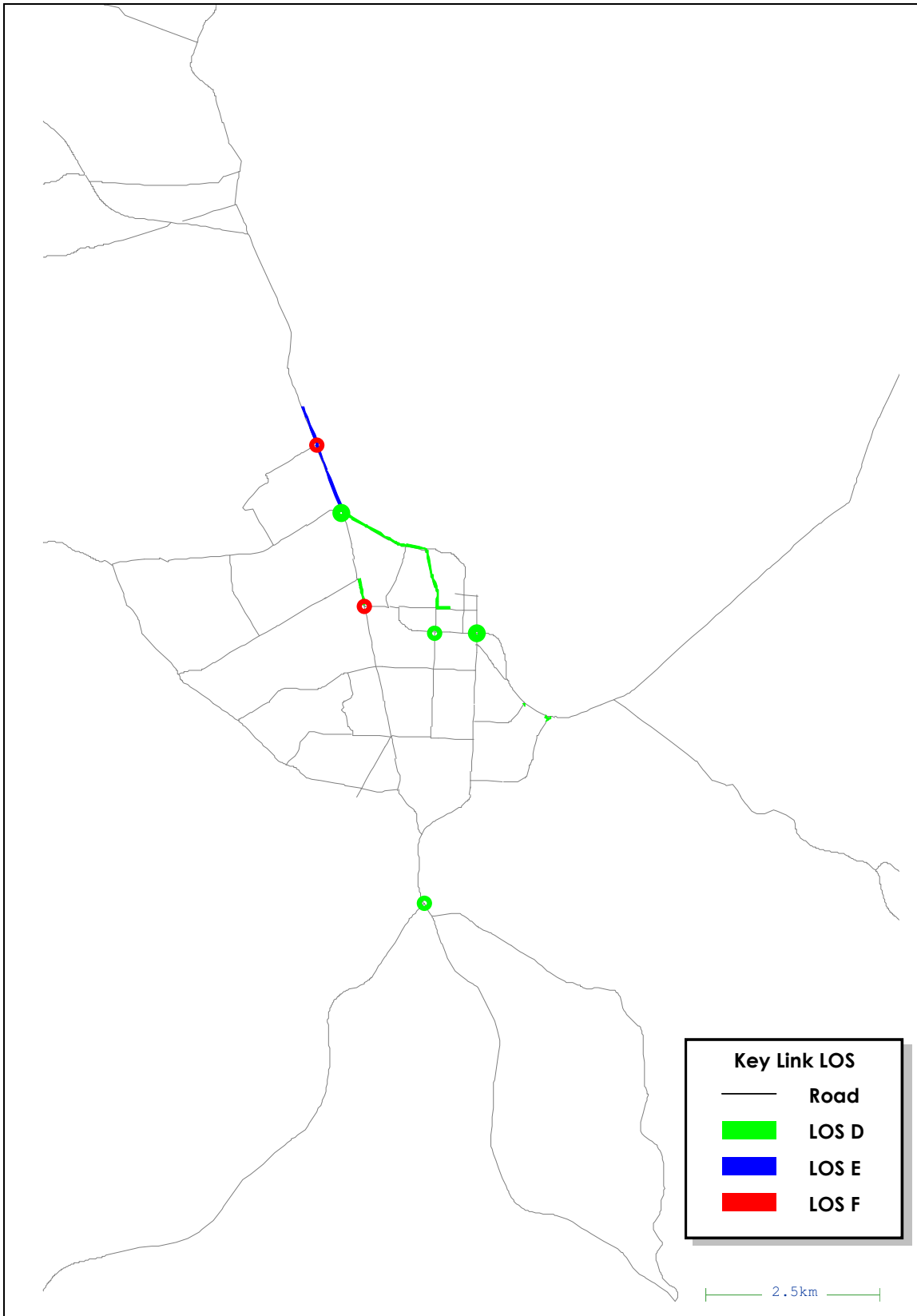
Traffic Design Group	**2006 Morning Peak LOS Hamilton**	**Figure 73**
Gabites Porter		



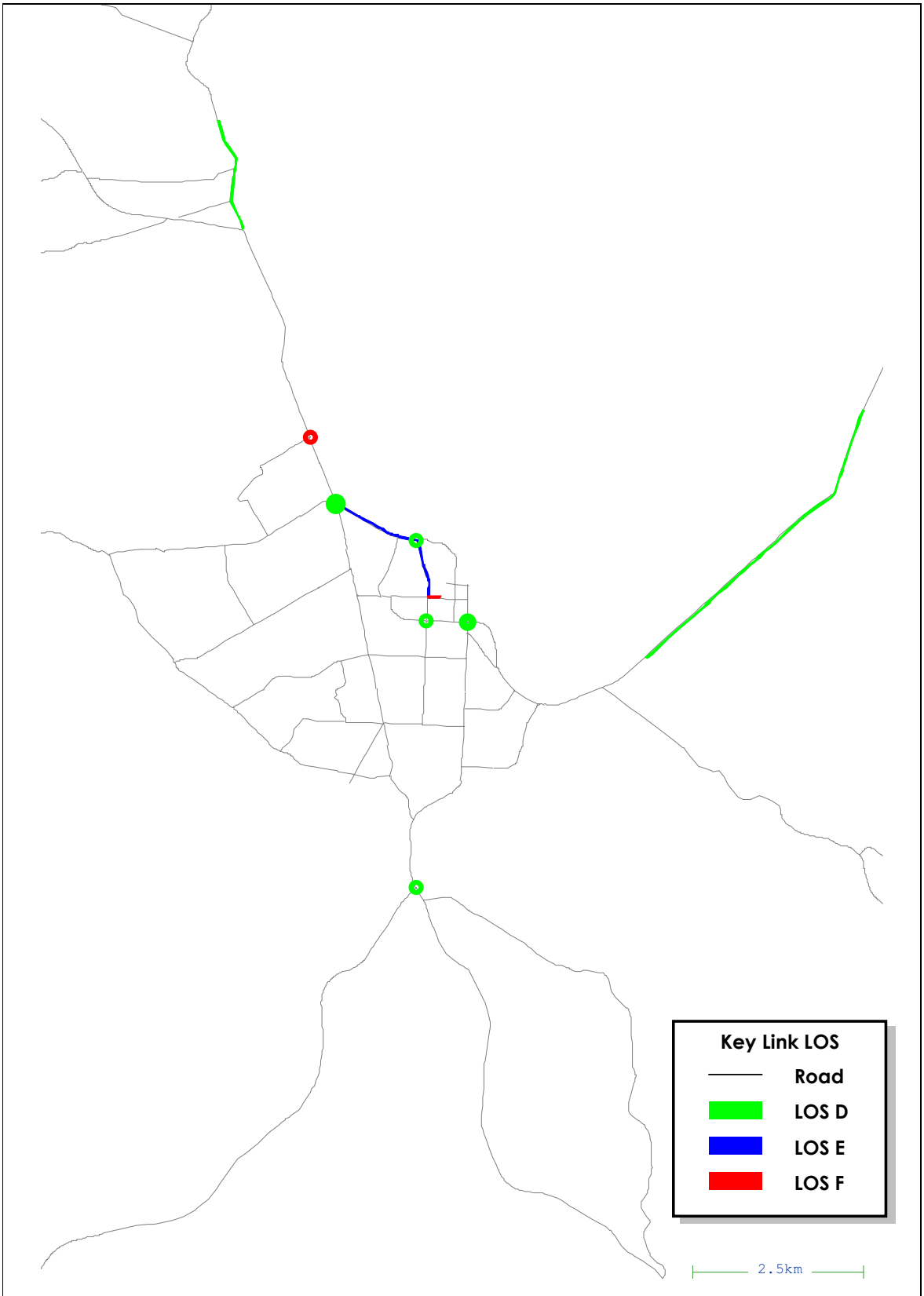
Traffic Design Group	**2021 Morning Peak LOS Hamilton**	**Figure 74**
Gabites Porter		



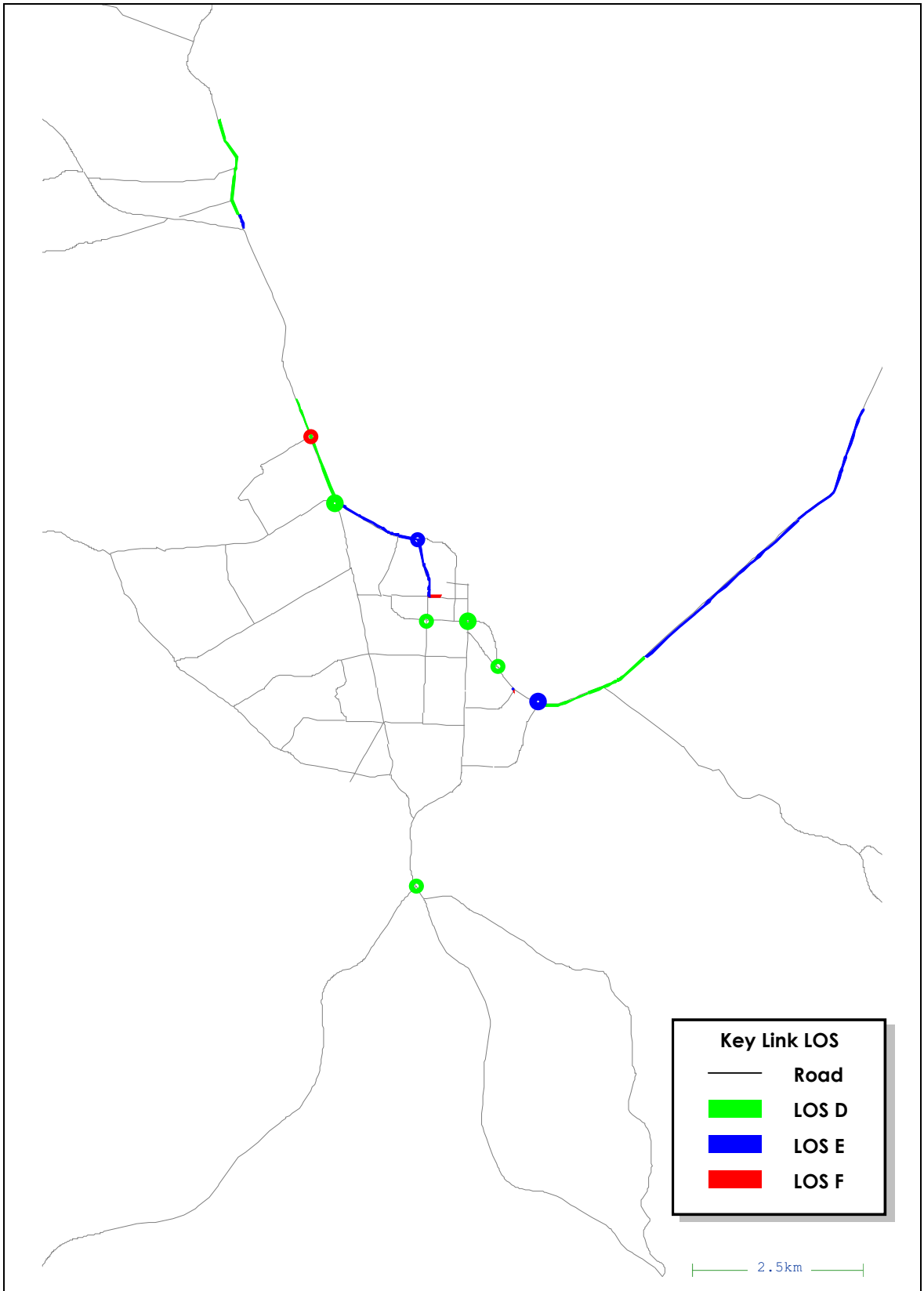
Traffic Design Group	**2041 Morning Peak LOS Hamilton**	**Figure 75**
Gabites Porter		



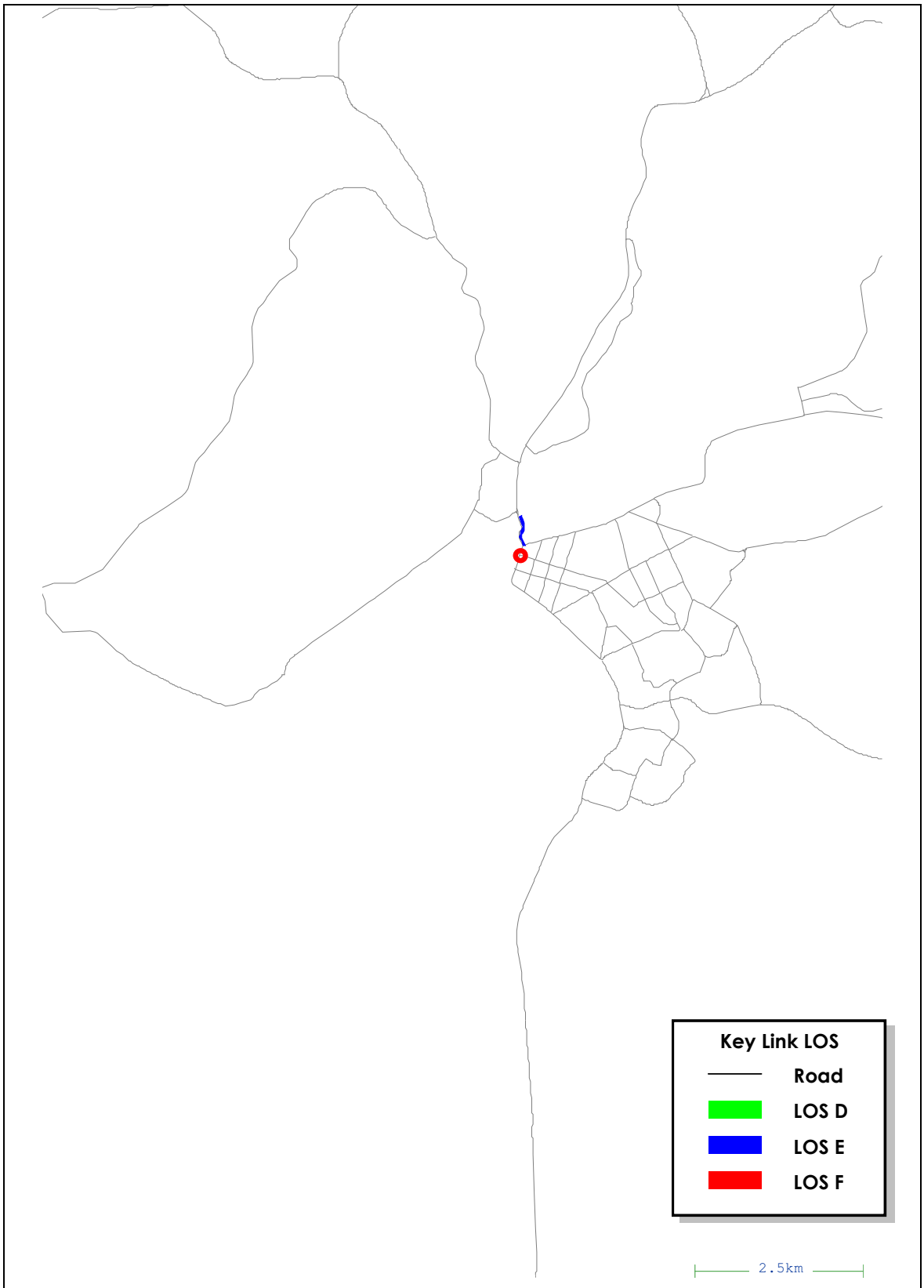
Traffic Design Group	**2006 Morning Peak LOS Rotorua**	**Figure 76**
Gabites Porter		



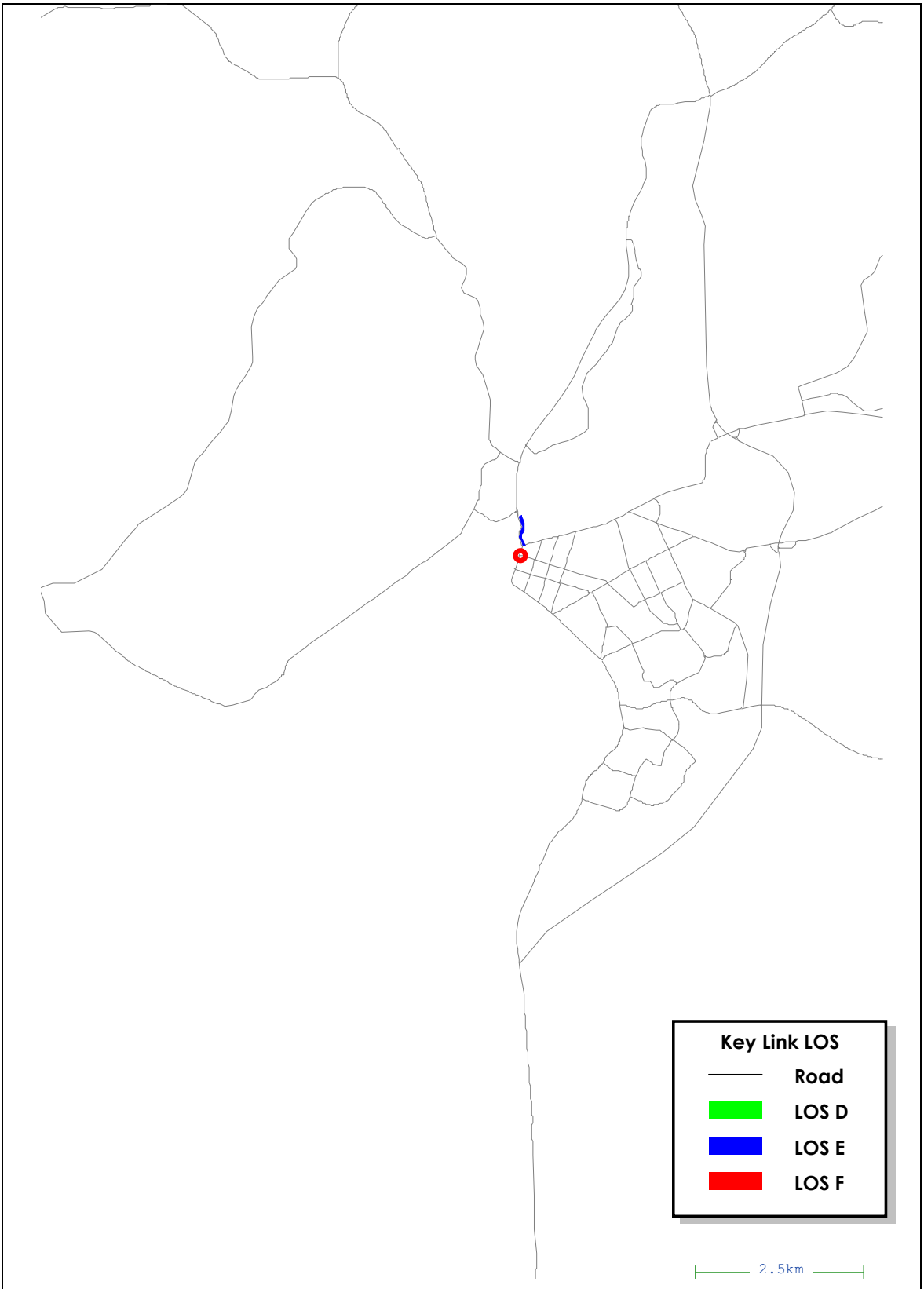
Traffic Design Group	**2021 Morning Peak LOS Rotorua**	**Figure 77**
Gabites Porter		



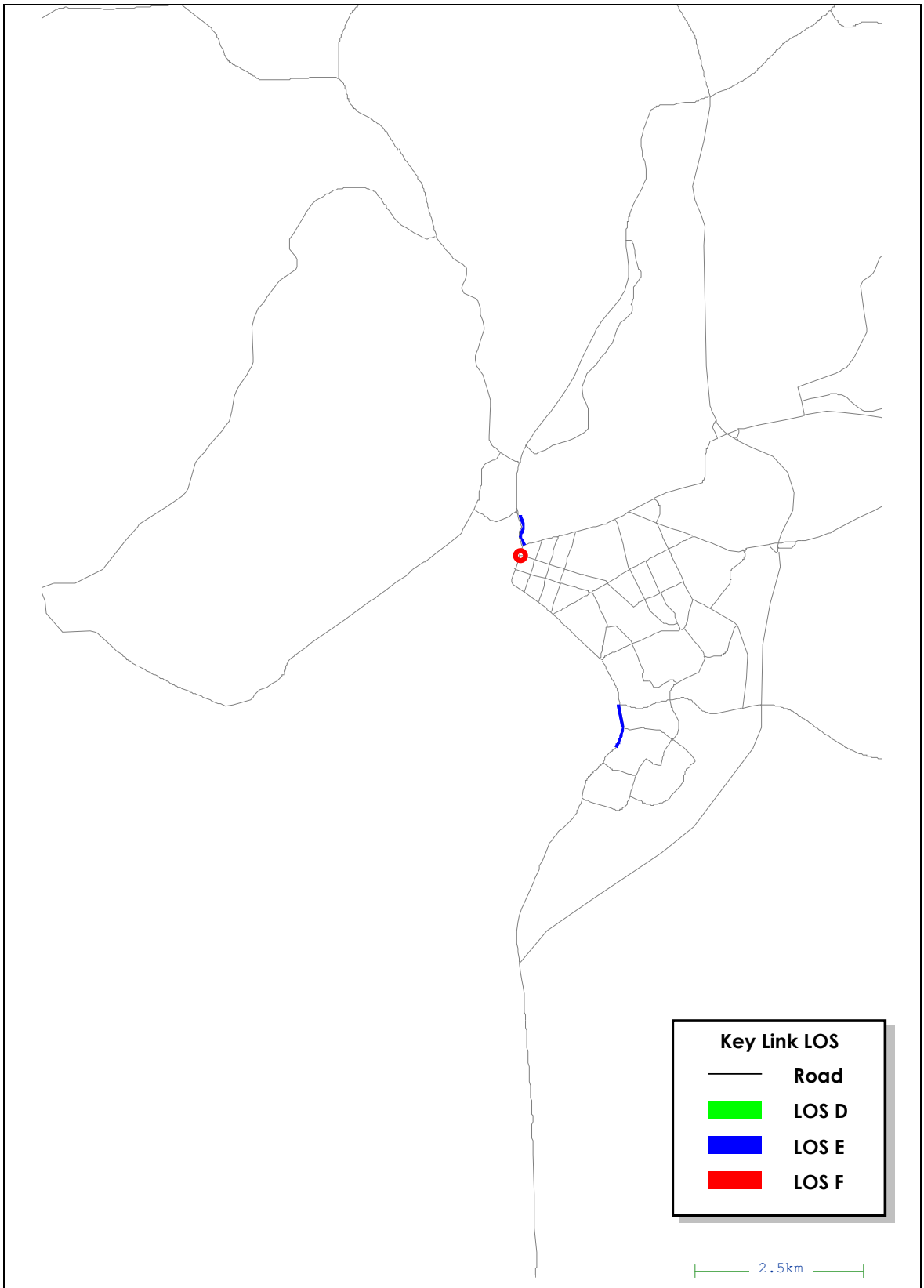
Traffic Design Group	**2041 Morning Peak LOS Rotorua**	**Figure 78**
Gabites Porter		



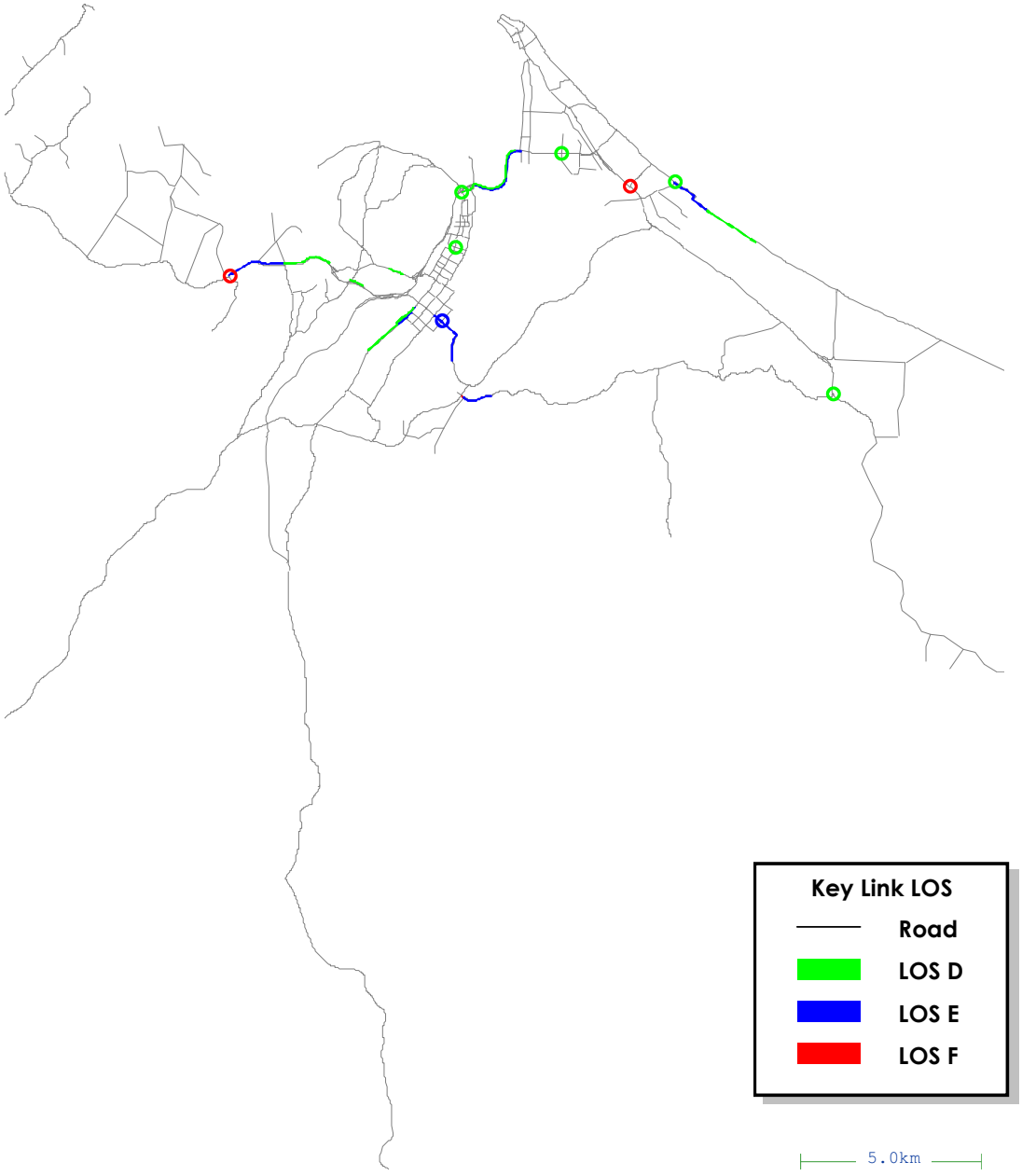
Traffic Design Group	**2006 Morning Peak LOS Taupo**	**Figure 79**
Gabites Porter		



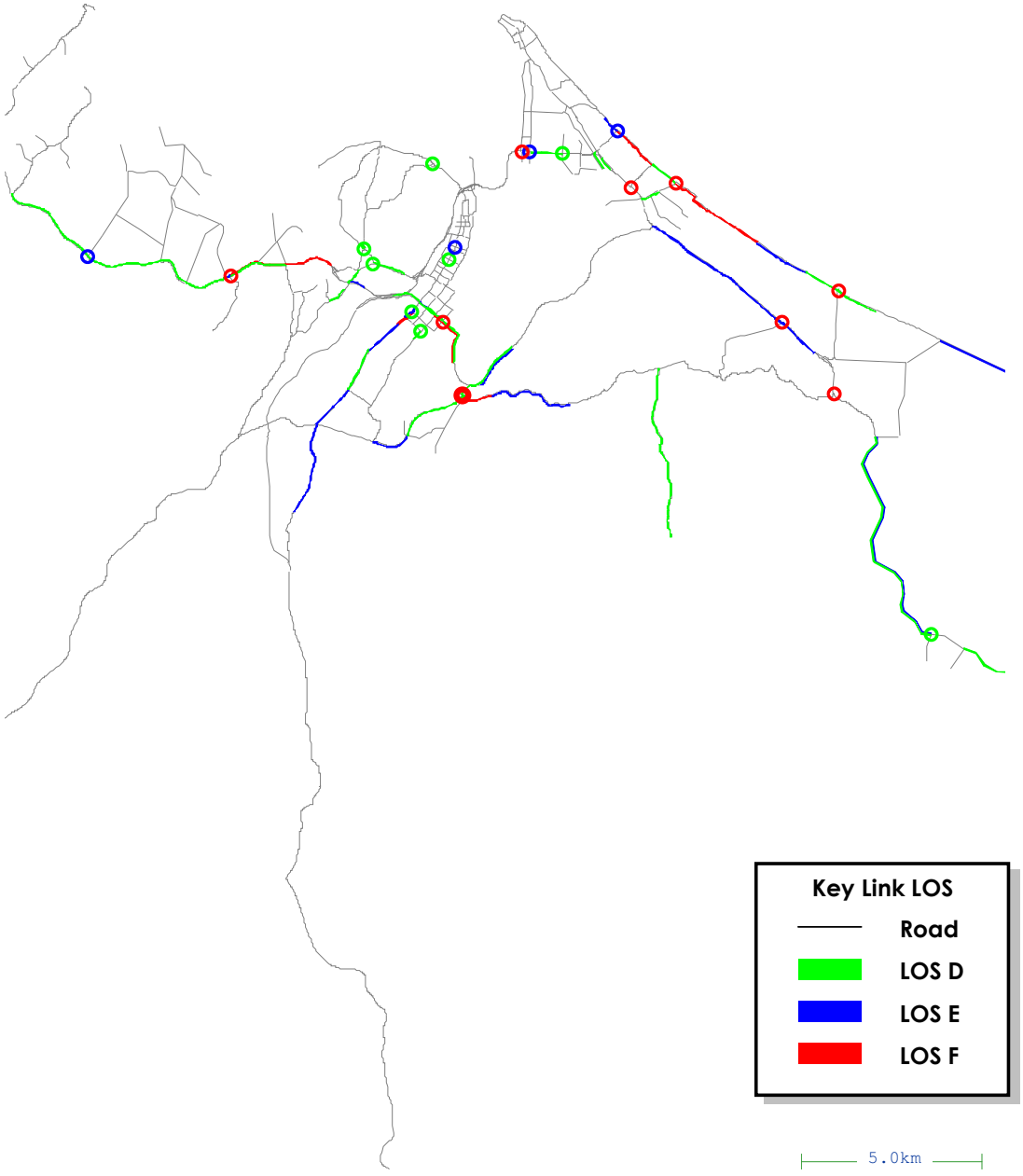
Traffic Design Group	**2021 Morning Peak LOS Taupo**	**Figure 80**
Gabites Porter		



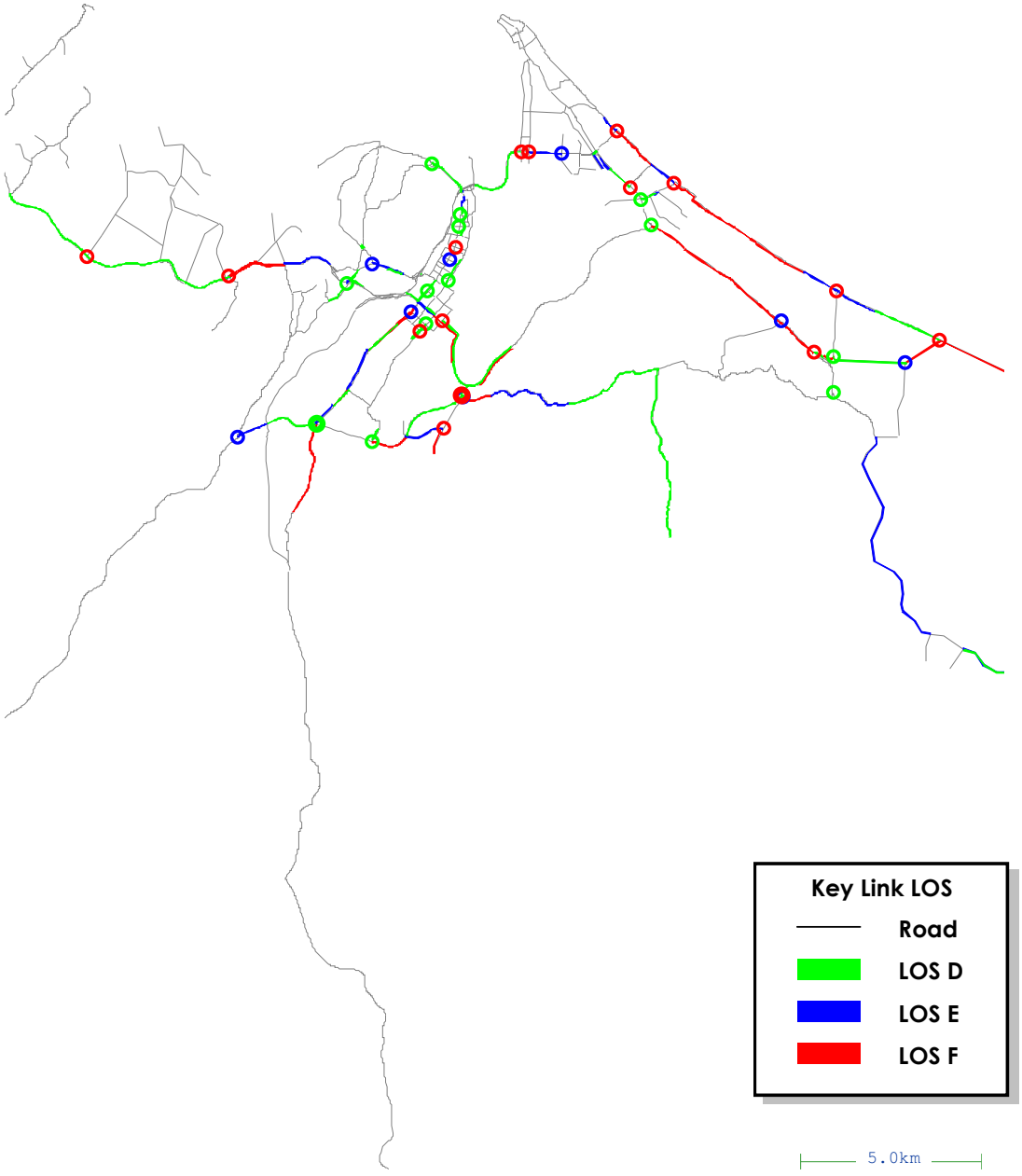
Traffic Design Group	**2041 Morning Peak LOS Taupo**	**Figure 81**
Gabites Porter		



Traffic Design Group	**2006 Morning Peak LOS Tauranga**	**Figure 82**
Gabites Porter		



Traffic Design Group	**2021 Morning Peak LOS Tauranga**	**Figure 83**
Gabites Porter		



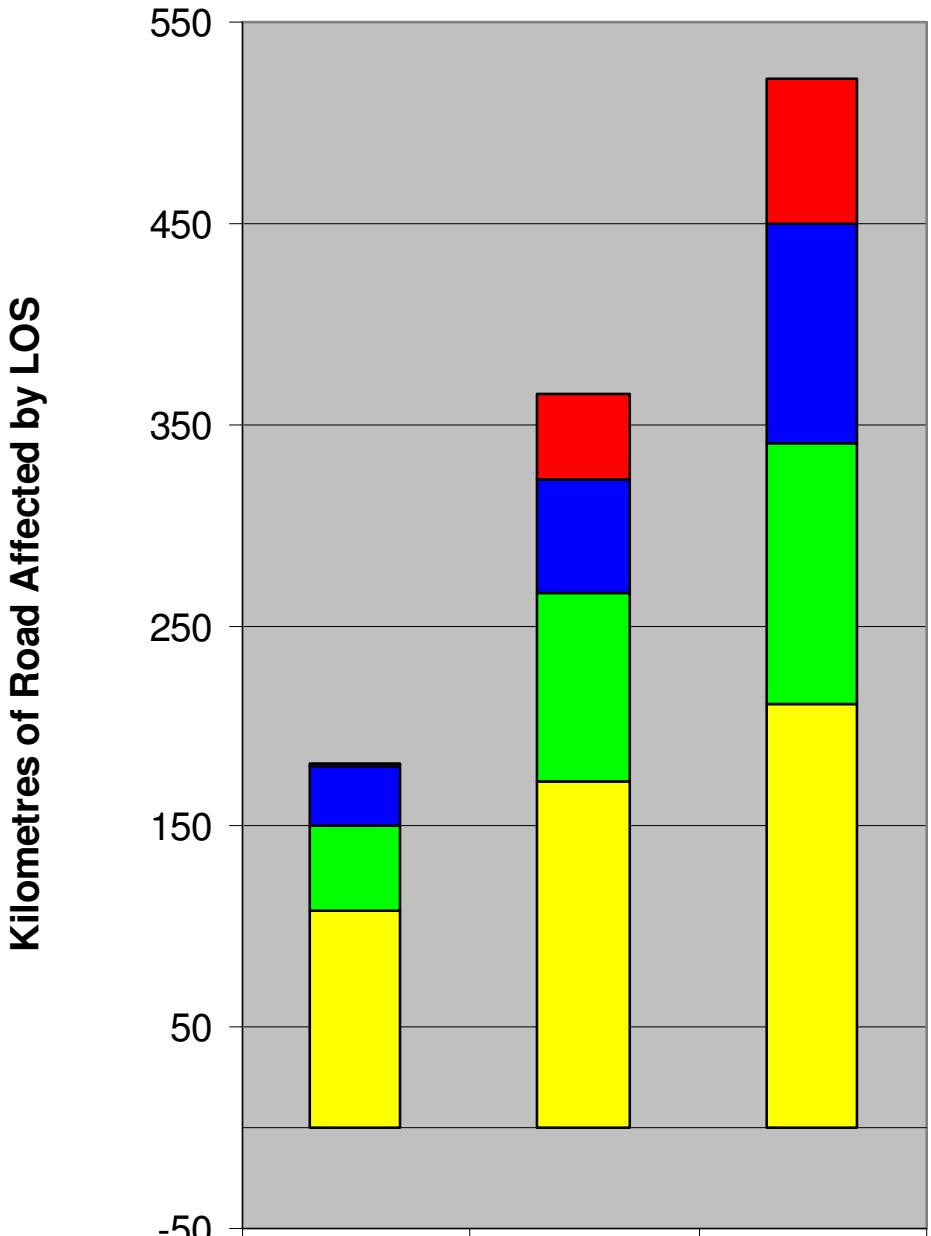
Traffic Design Group	**2041 Morning Peak LOS Tauranga**	**Figure 84**
Gabites Porter		

PM Peak Transport Deficiencies

The kilometres of road falling into each LOS category are shown in **Figure 85** and the Number of Intersections falling into each LOS category (based on worst approach) are shown in **Figure 86.**

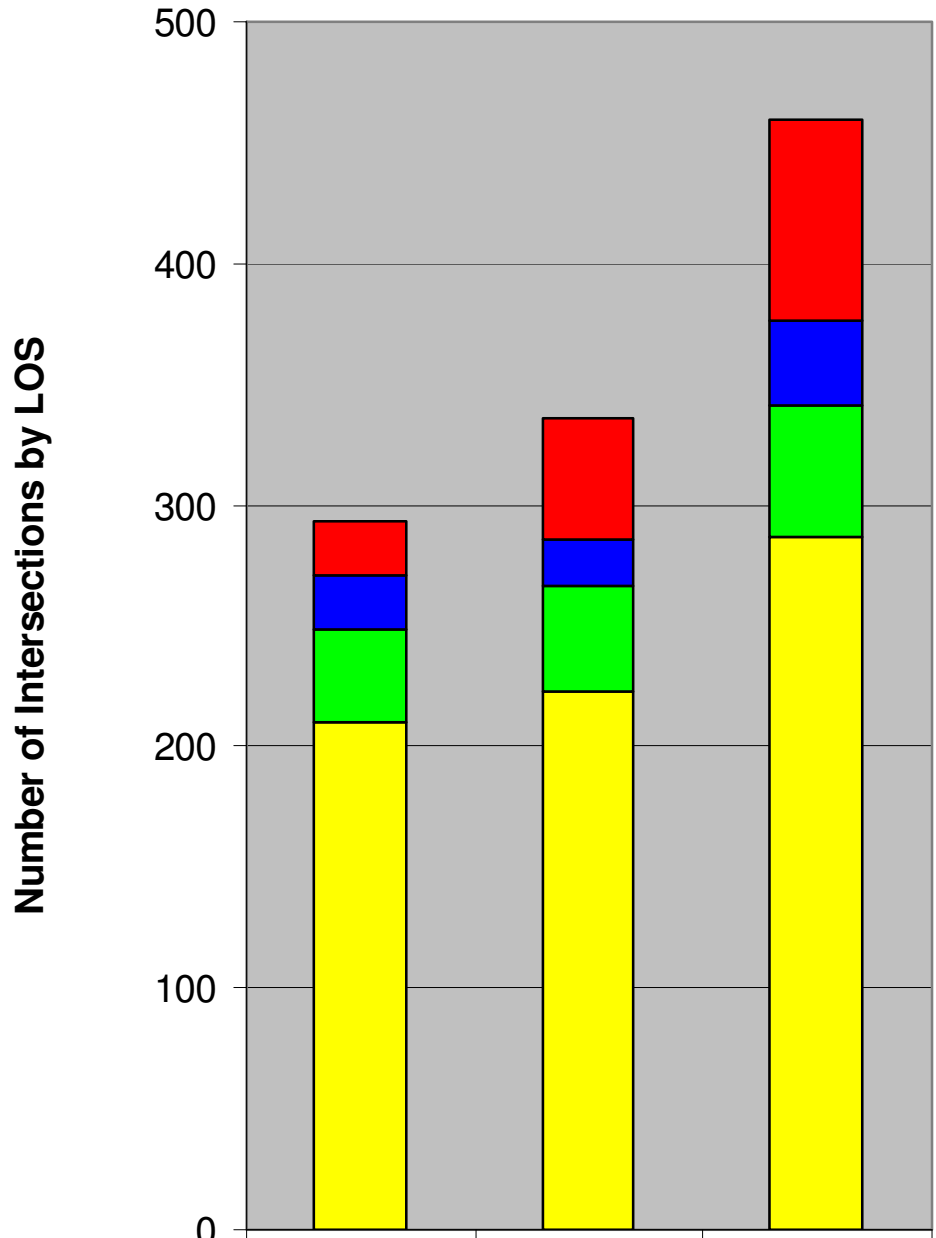
Level Of Service (LOS) plots depicting the location and severity of deficiencies across the Waikato Regional Transport Model study area are included as follows:

- Evening Peak LOS North Waikato (2006, 2021 and 2041) in **Figure 87**, **Figure 88** and **Figure 89**
- Evening Peak LOS in Waipa (2006, 2021 and 2041) **in Figure 90, Figure 91** and **Figure 92**
- Evening Peak LOS in Hamilton (2006, 2021 and 2041) in **Figure 93**, **Figure 94** and **Figure 95**
- Evening Peak LOS in Rotorua (2006, 2021 and 2041) in **Figure 96**, **Figure 97** and **Figure 98**
- Evening Peak LOS in Taupo (2006, 2021 and 2041) in **Figure 99**, **Figure 100** and **Figure 101**
- Evening Peak LOS in Tauranga (2006, 2021 and 2041) in **Figure 102**, **Figure 103** and **Figure 104**



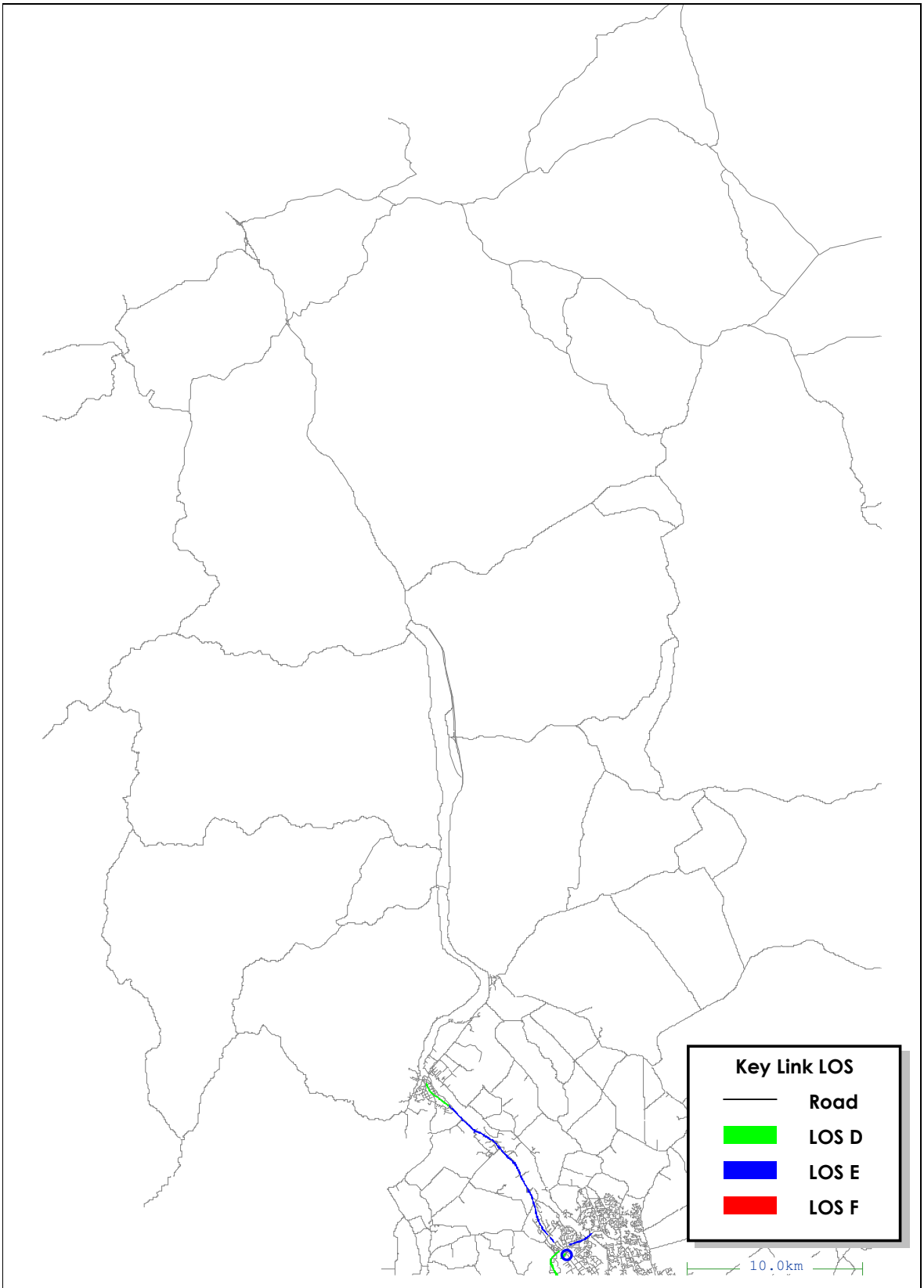
	2006	2021	2041
LOS F	0.9	43.6	72.1
LOS E	30.2	56.5	109.6
LOS D	42.8	93.7	129.8
LOS C	107.5	171.8	210.7

Traffic Design Group Gabites Porter	**Kilometres of Road Affected by LOS** PM Peak	**Figure 85**

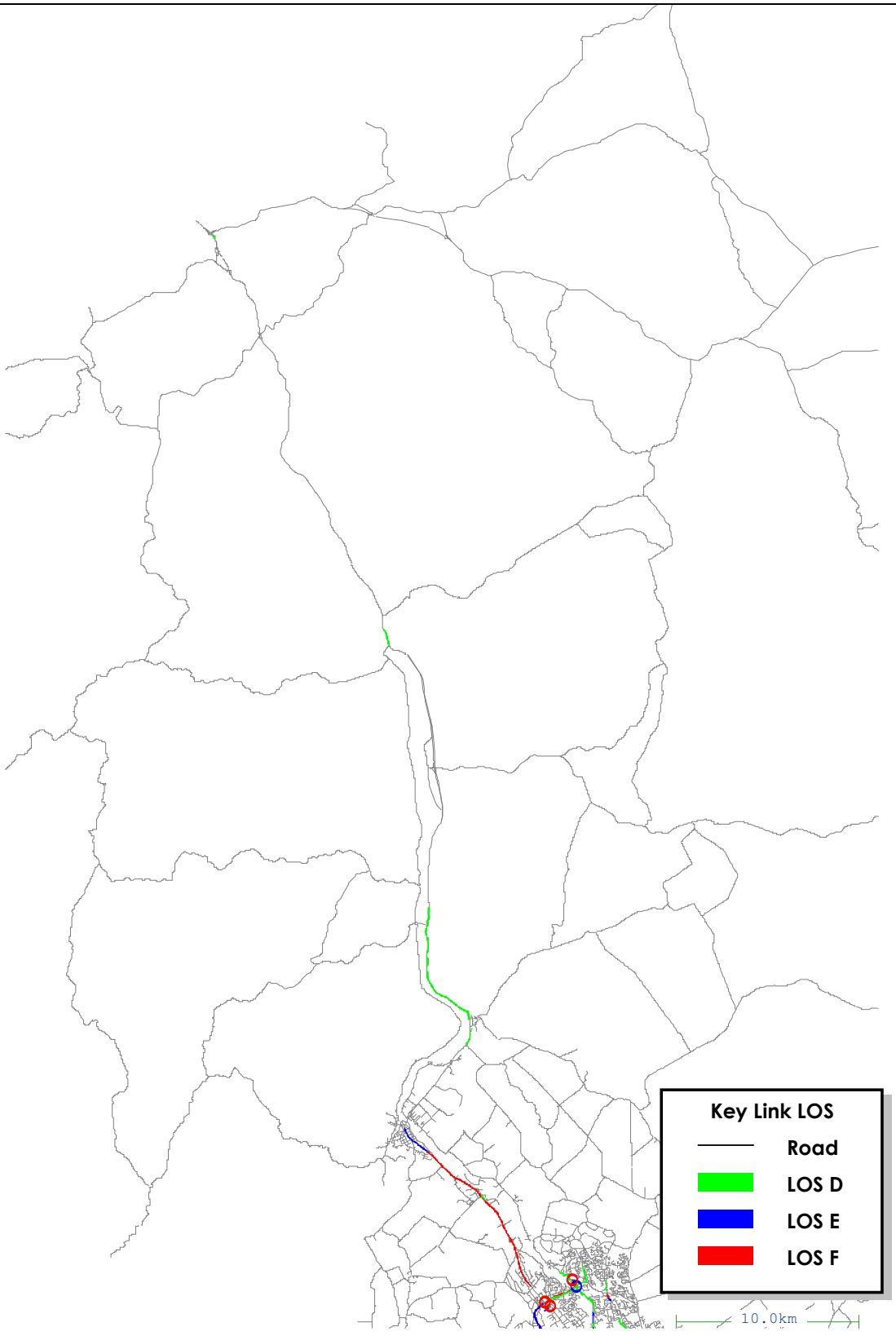


	2006	2021	2041
LOS F	22	50	83
LOS E	23	19	35
LOS D	38	44	54
LOS C	210	223	287

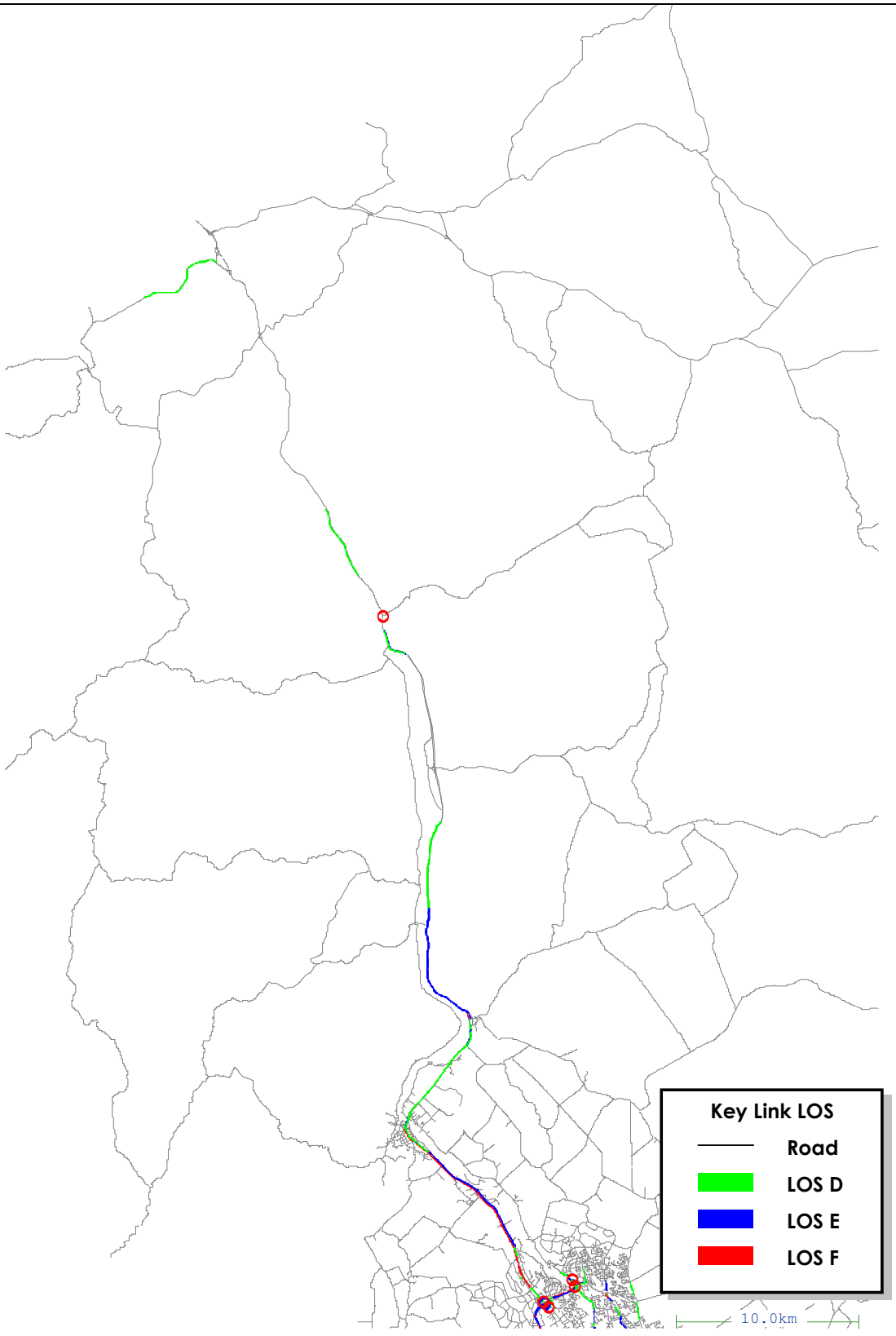
Traffic Design Group Gabites Porter	**Number of Intersections by LOS** PM Peak	**Figure 86**



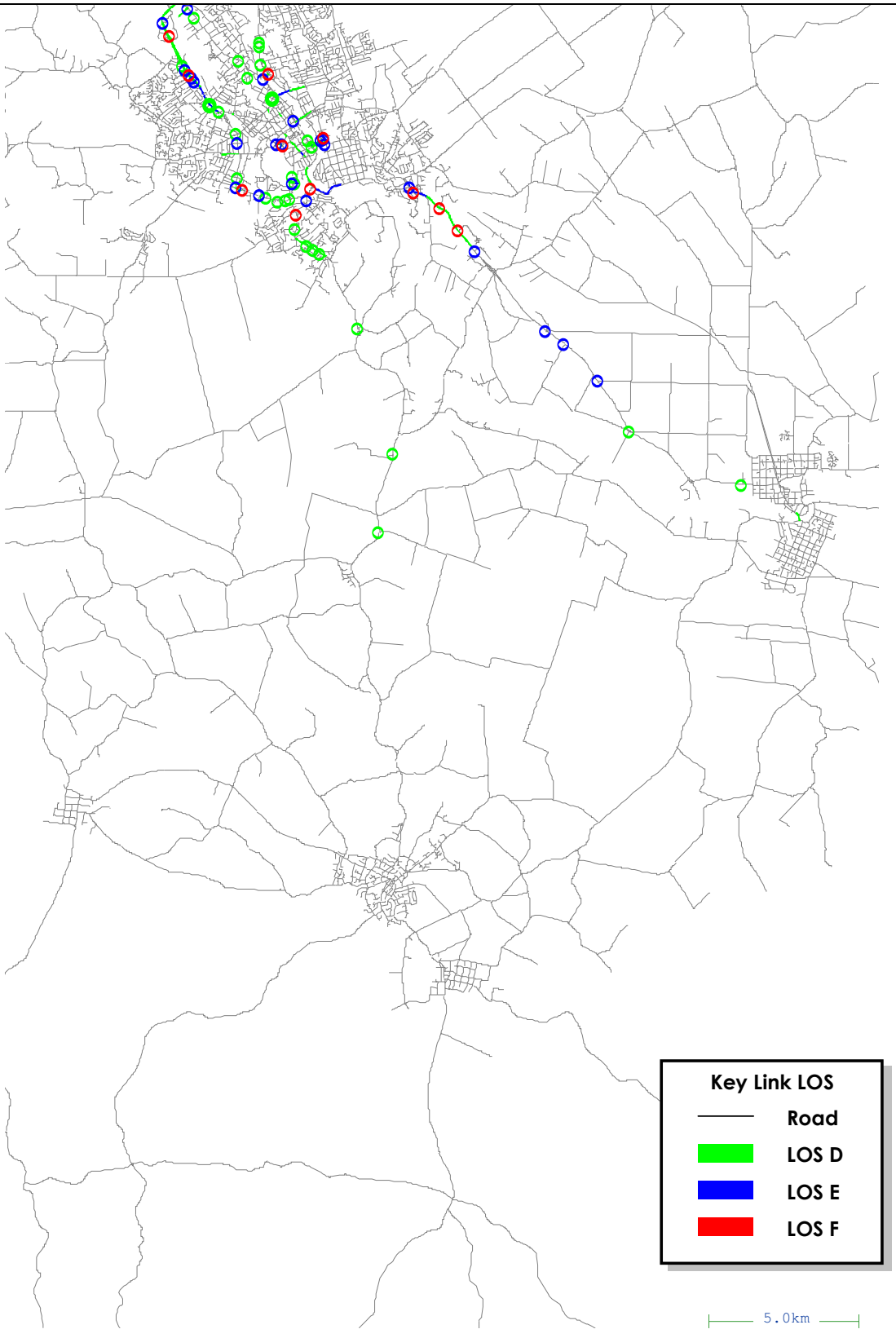
Traffic Design Group	**2006 Evening Peak LOS North Waikato**	**Figure 87**
Gabites Porter		



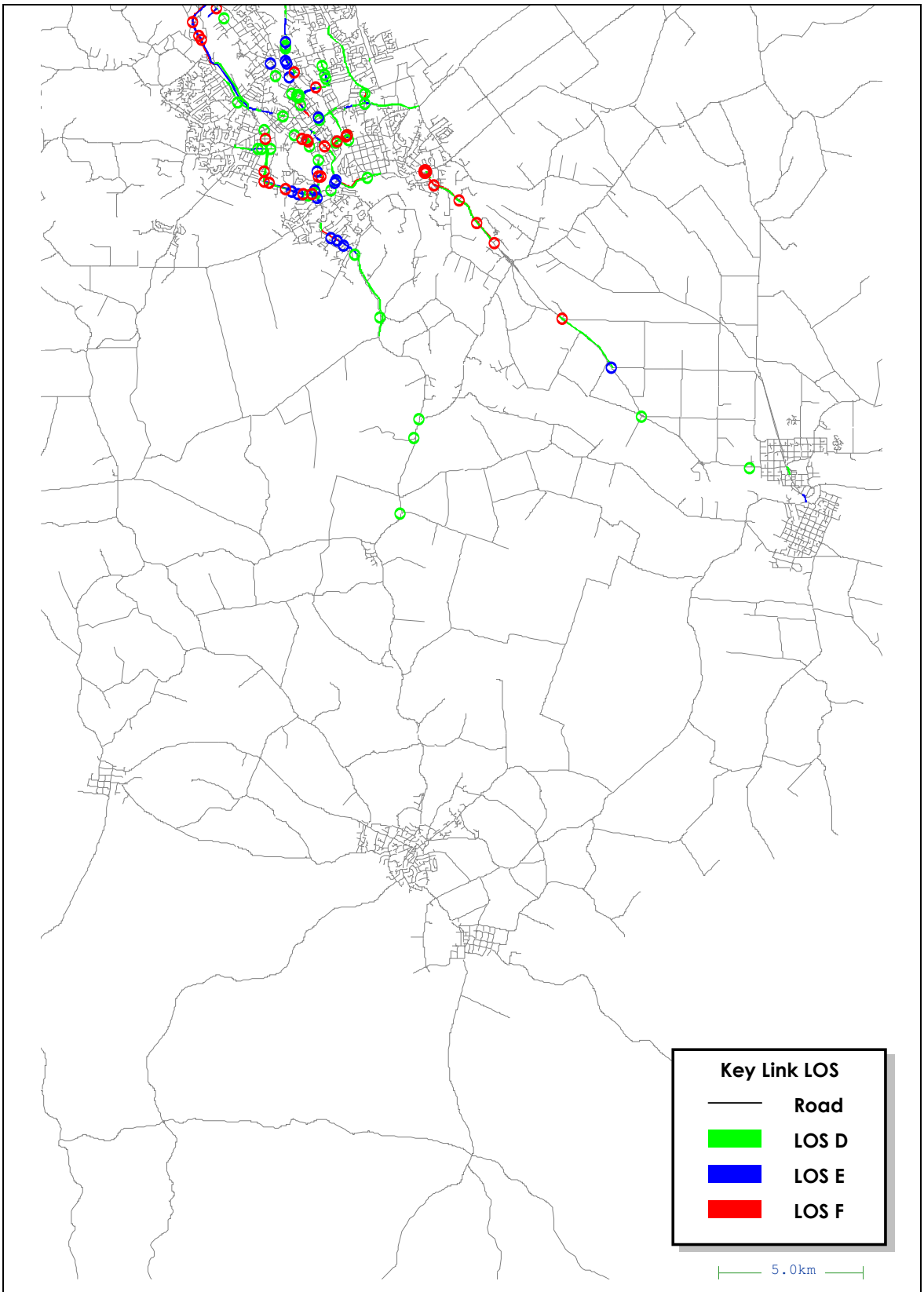
Traffic Design Group	**2021 Evening Peak LOS North Waikato**	**Figure 88**
Gabites Porter		



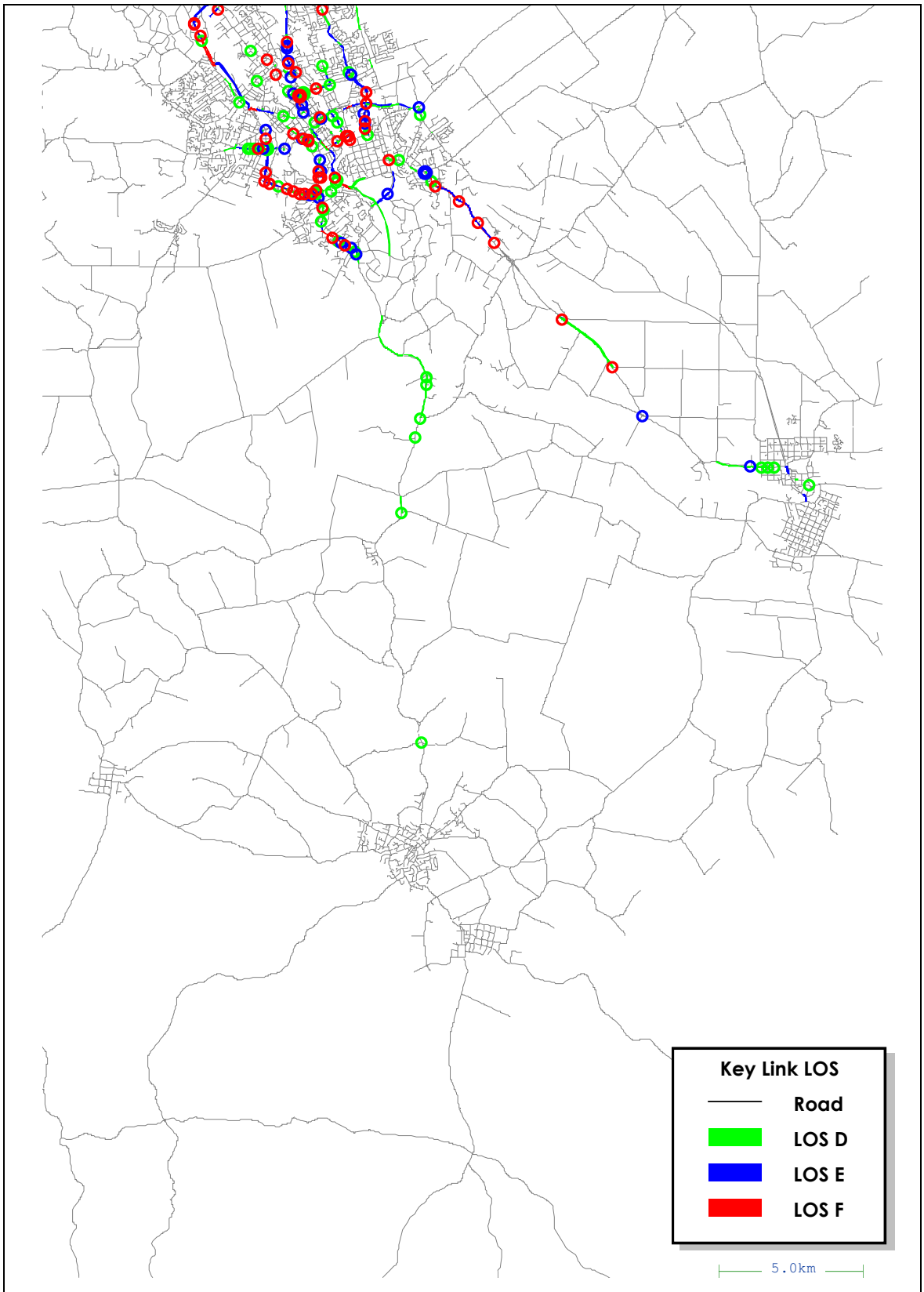
Traffic Design Group	**2041 Evening Peak LOS North Waikato**	**Figure 89**
Gabites Porter		



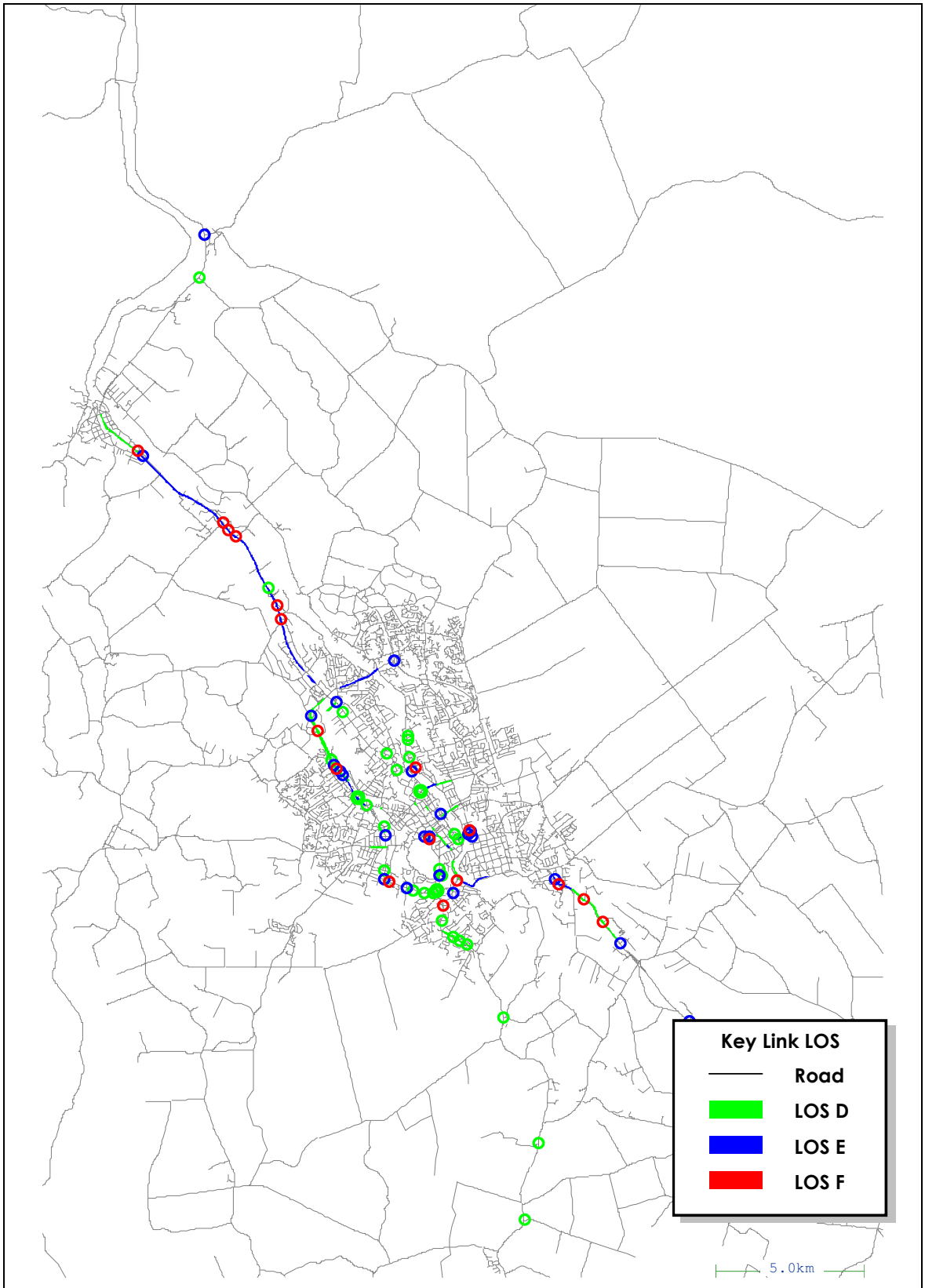
Traffic Design Group	**2006 Evening Peak LOS Waipa**	**Figure 90**
Gabites Porter		



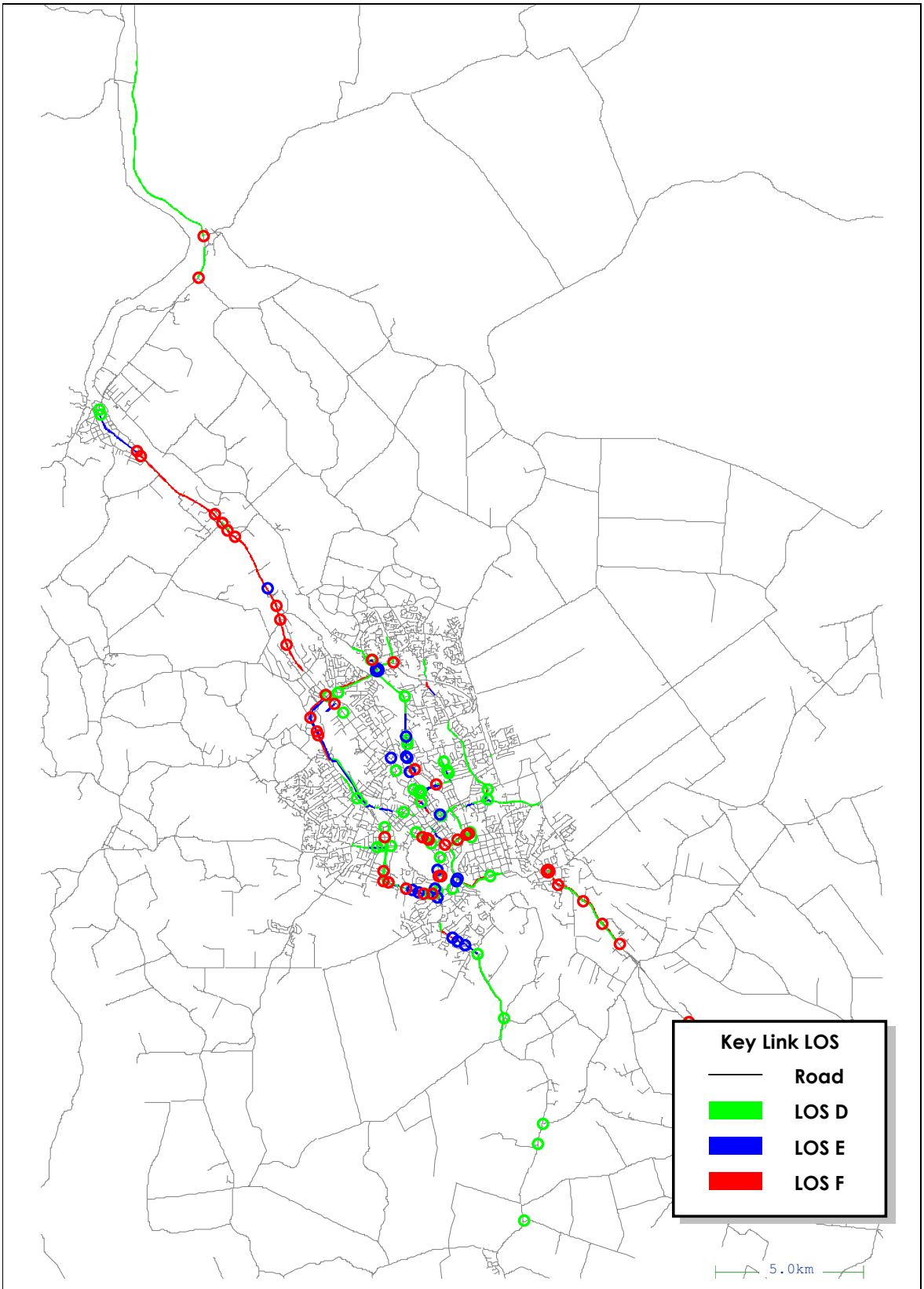
Traffic Design Group	**2021 Evening Peak LOS Waipa**	**Figure 91**
Gabites Porter		



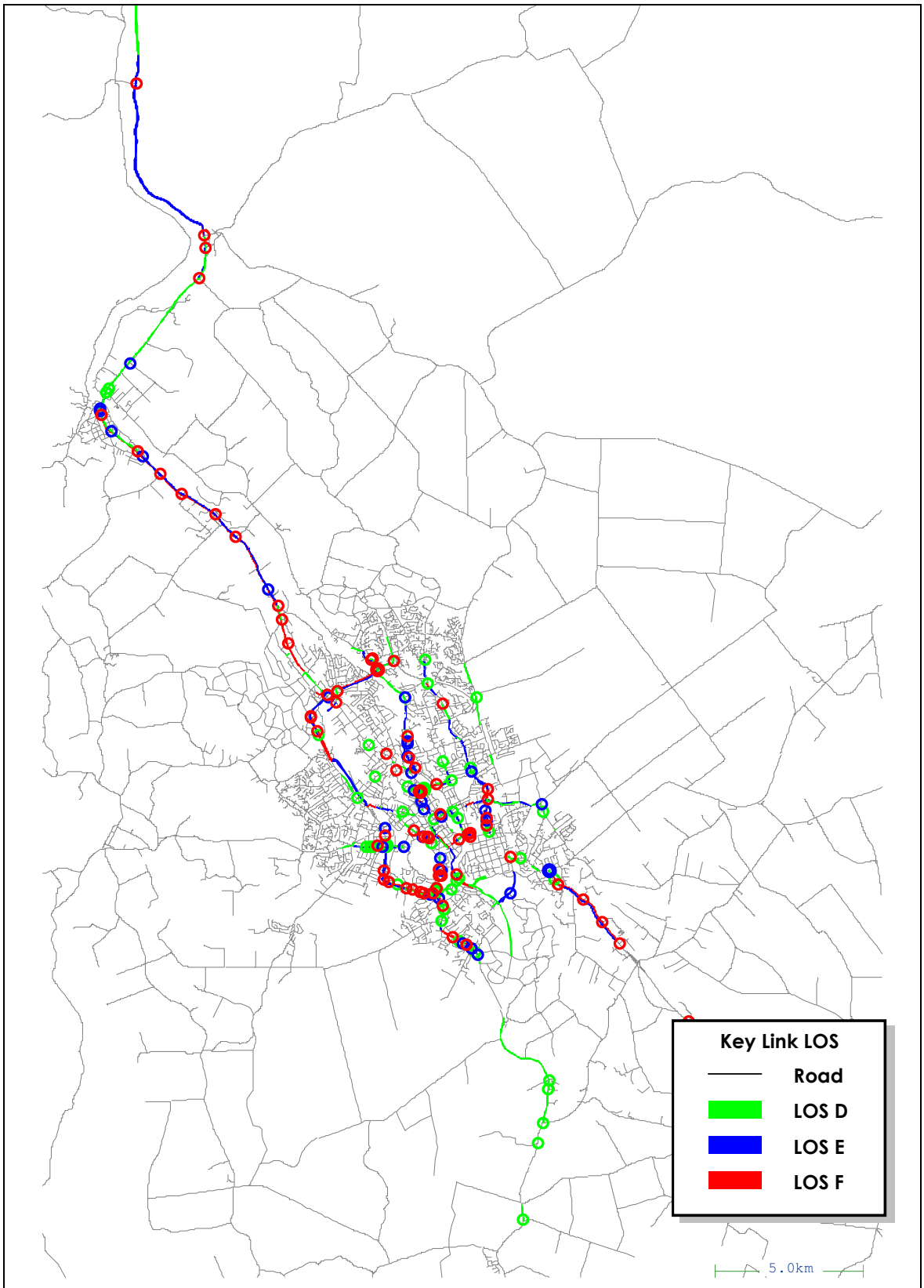
Traffic Design Group	**2041 Evening Peak LOS Waipa**	**Figure 92**
Gabites Porter		



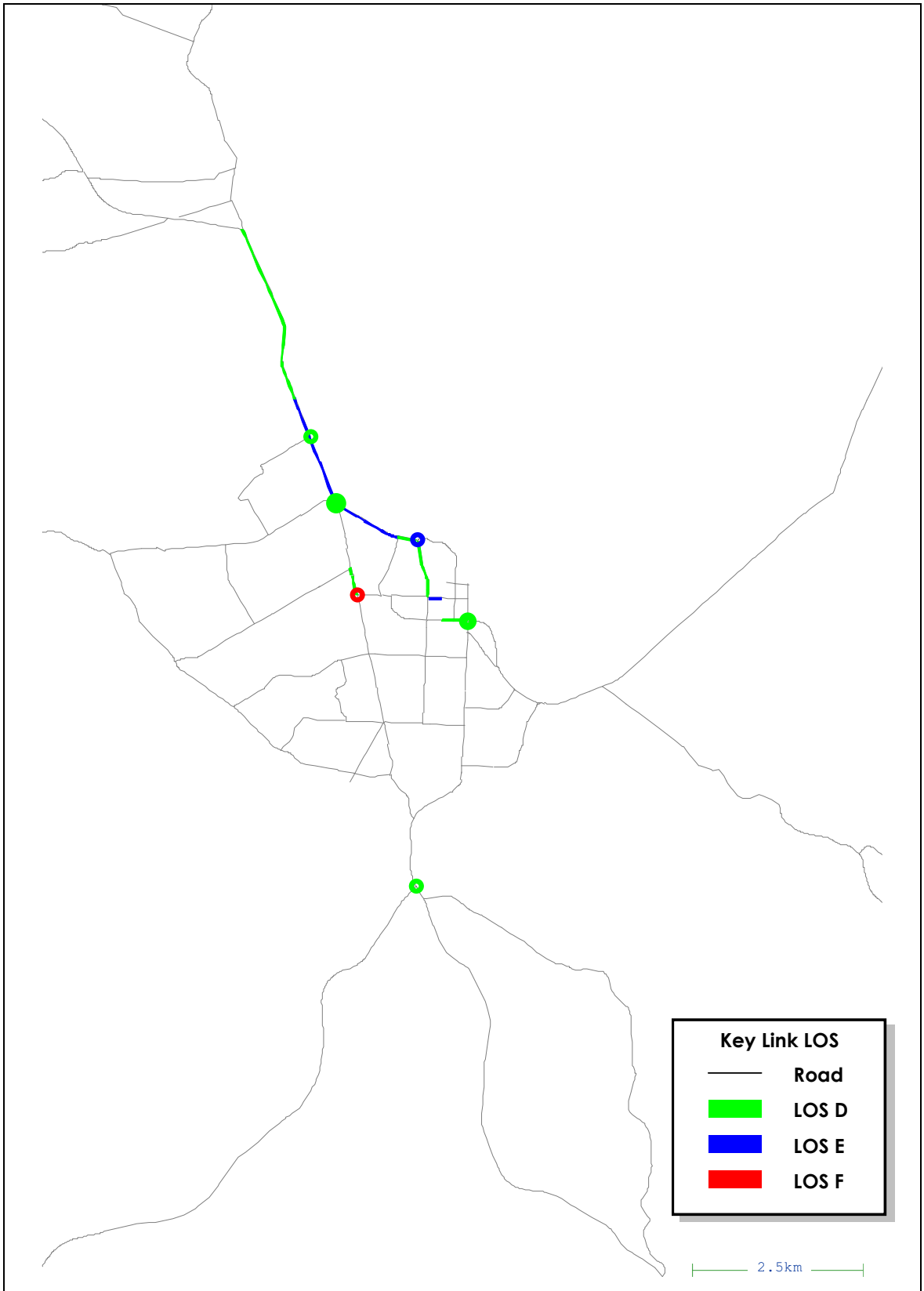
Traffic Design Group	**2006 Evening Peak LOS Hamilton**	**Figure 93**
Gabites Porter		



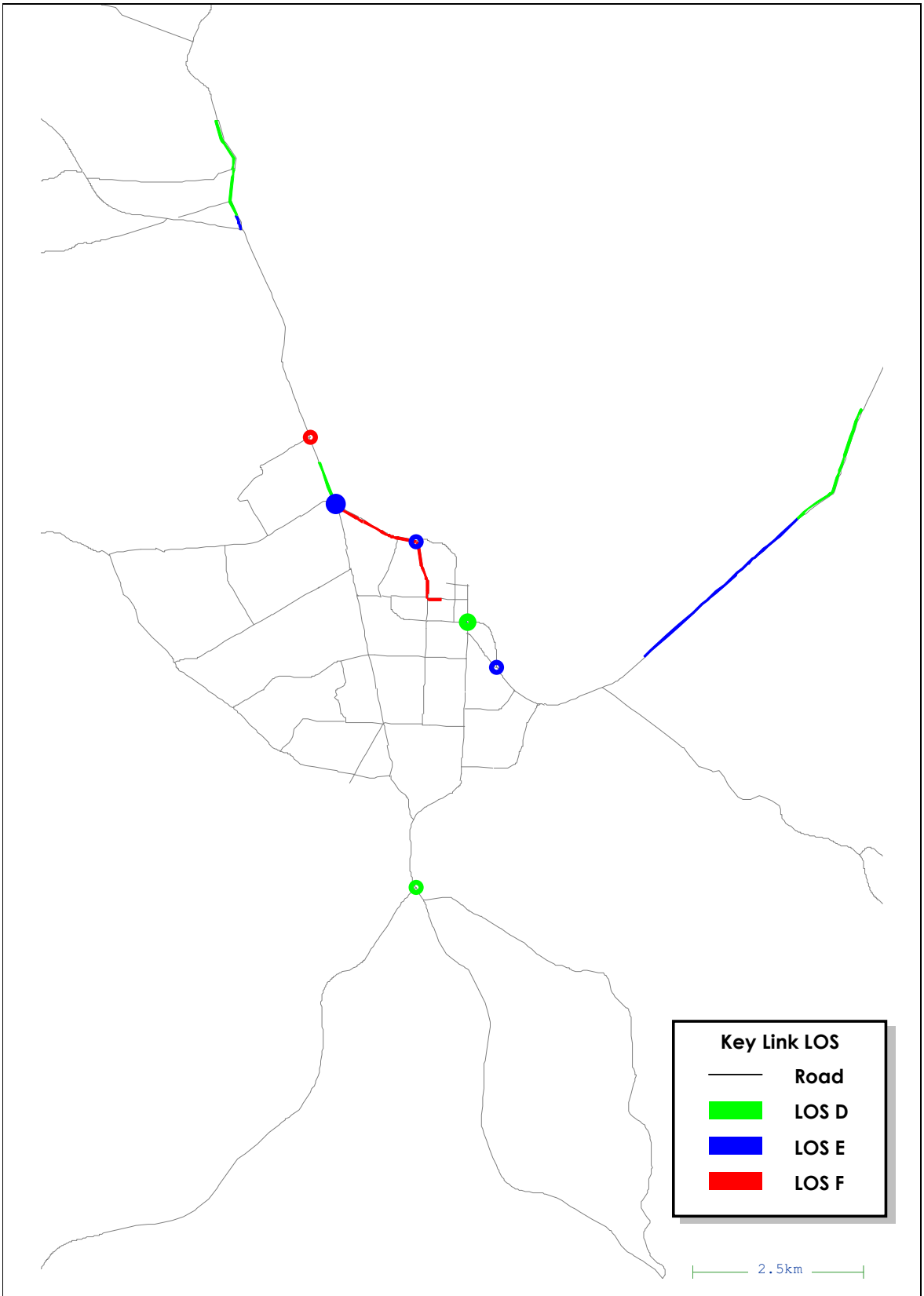
Traffic Design Group	**2021 Evening Peak LOS Hamilton**	**Figure 94**
Gabites Porter		



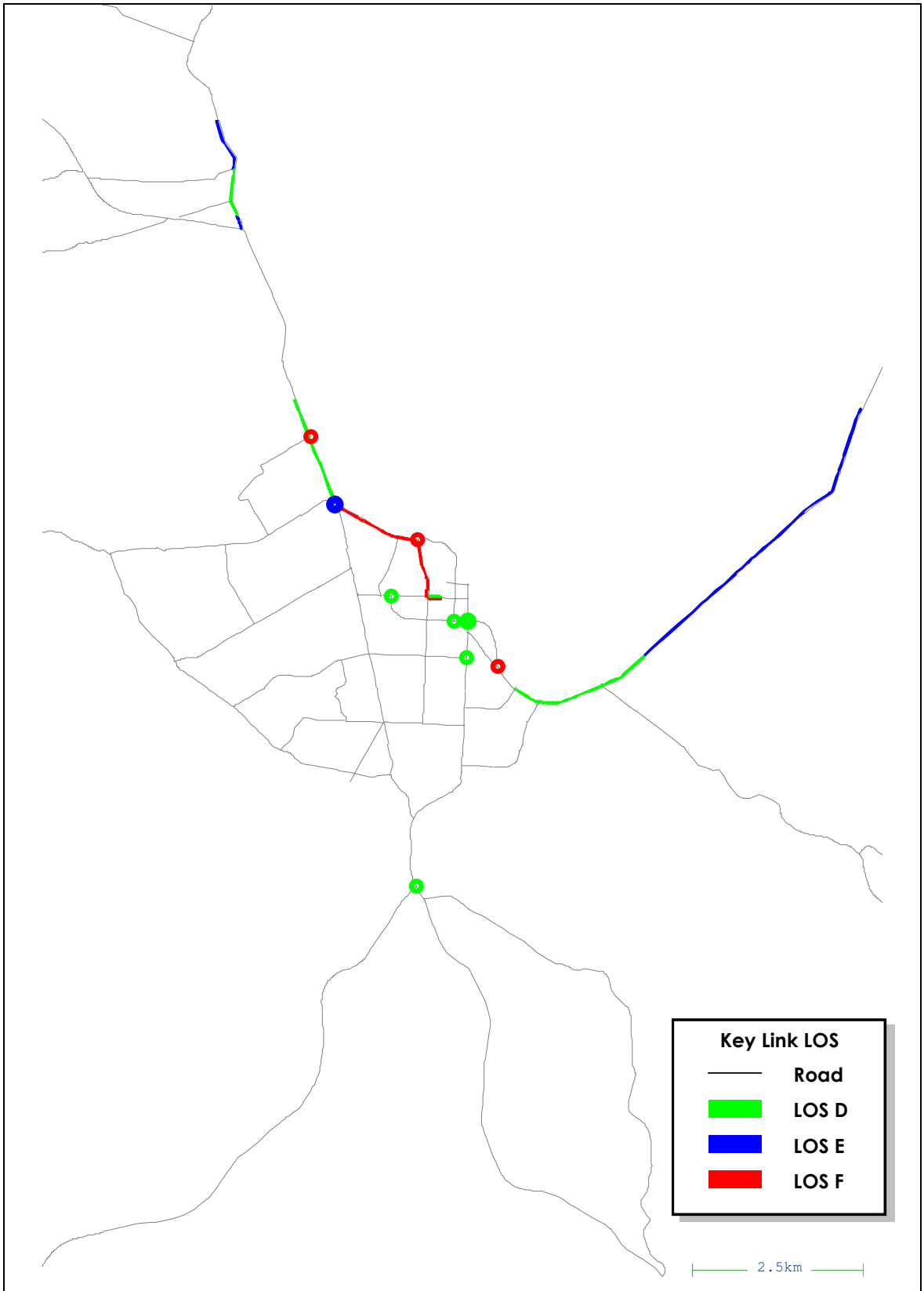
Traffic Design Group	**2041 Evening Peak LOS Hamilton**	**Figure 95**
Gabites Porter		



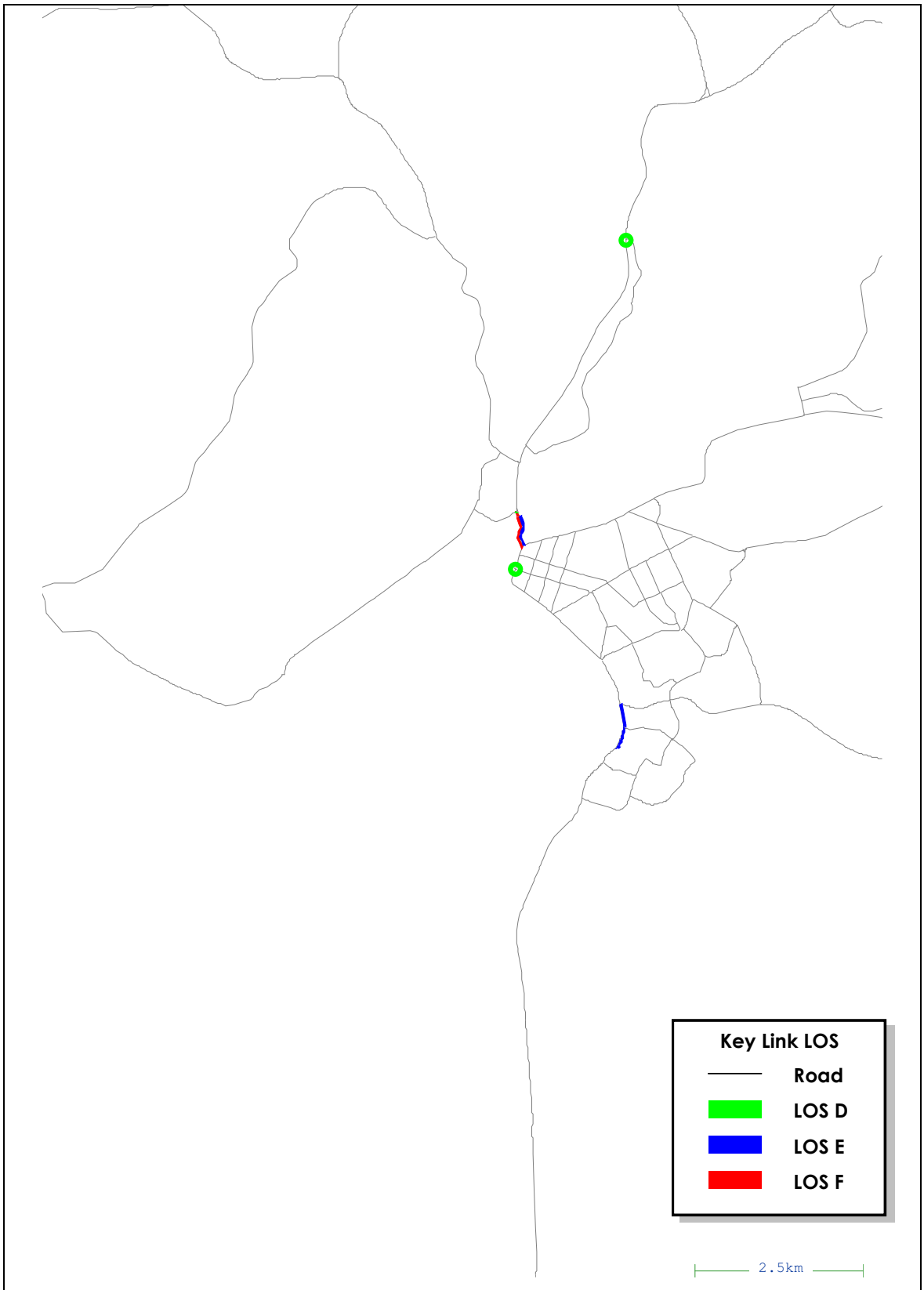
Traffic Design Group	**2006 Evening Peak LOS Rotorua**	**Figure 96**
Gabites Porter		



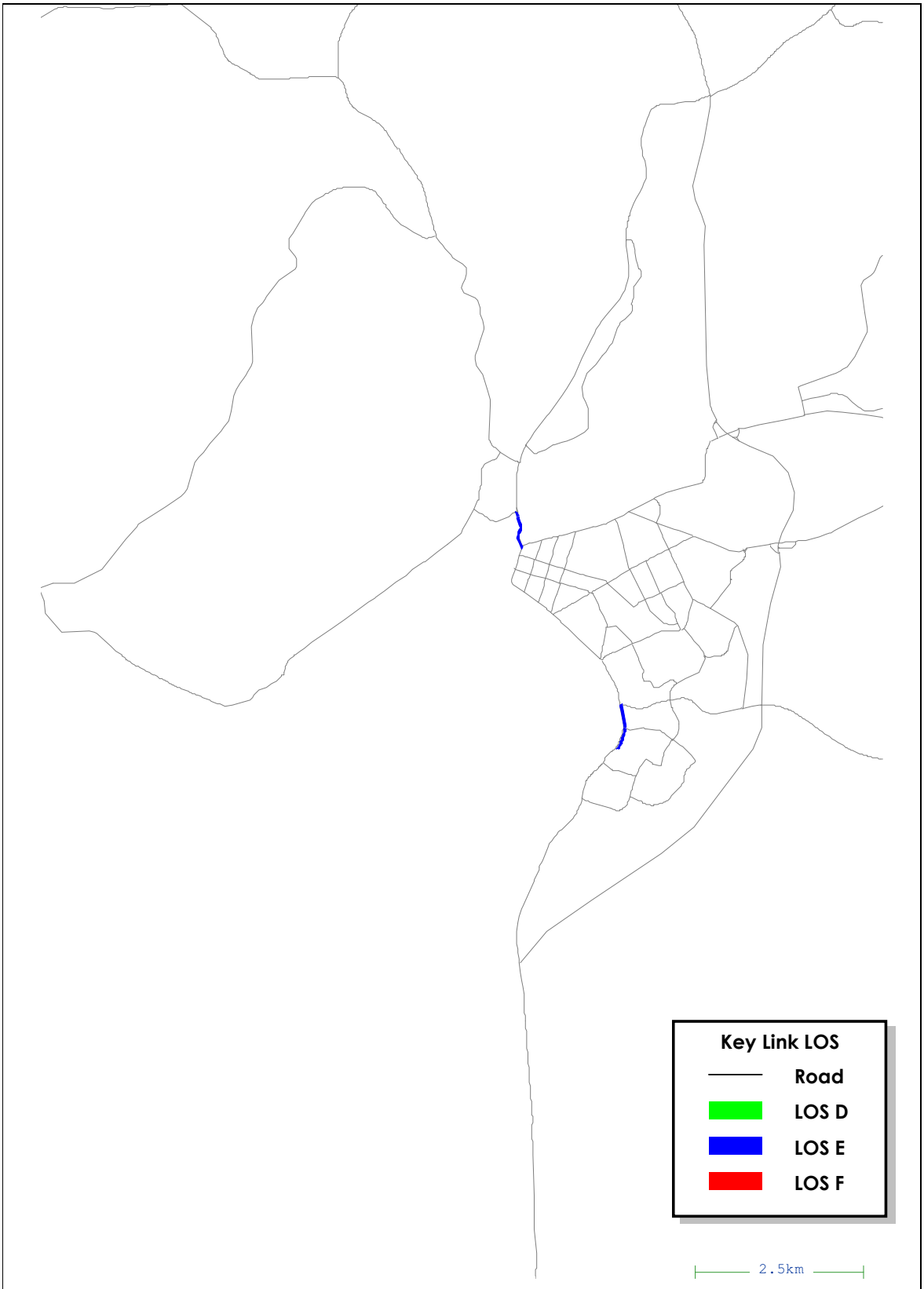
Traffic Design Group	**2021 Evening Peak LOS Rotorua**	**Figure 97**
Gabites Porter		



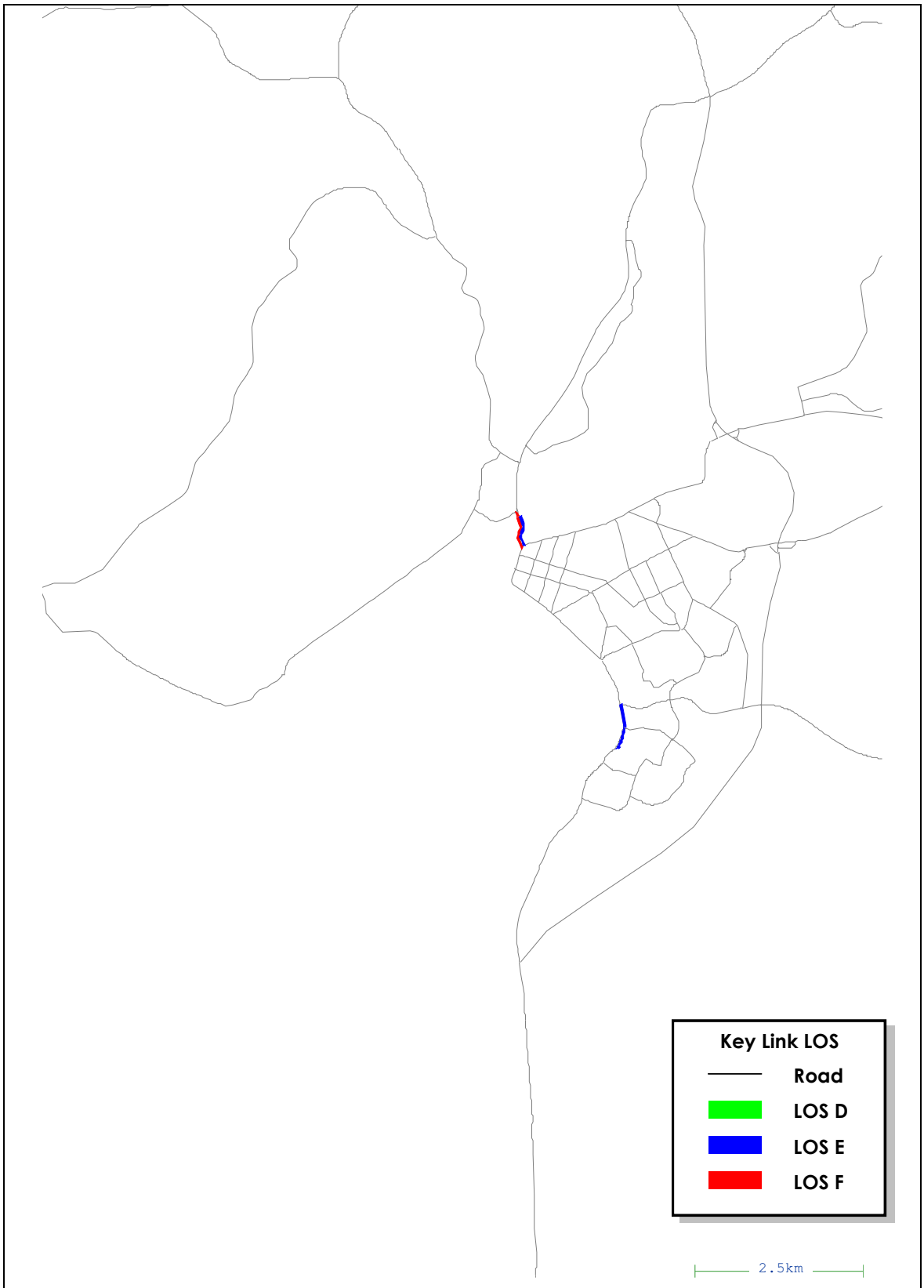
Traffic Design Group	**2041 Evening Peak LOS Rotorua**	**Figure 98**
Gabites Porter		



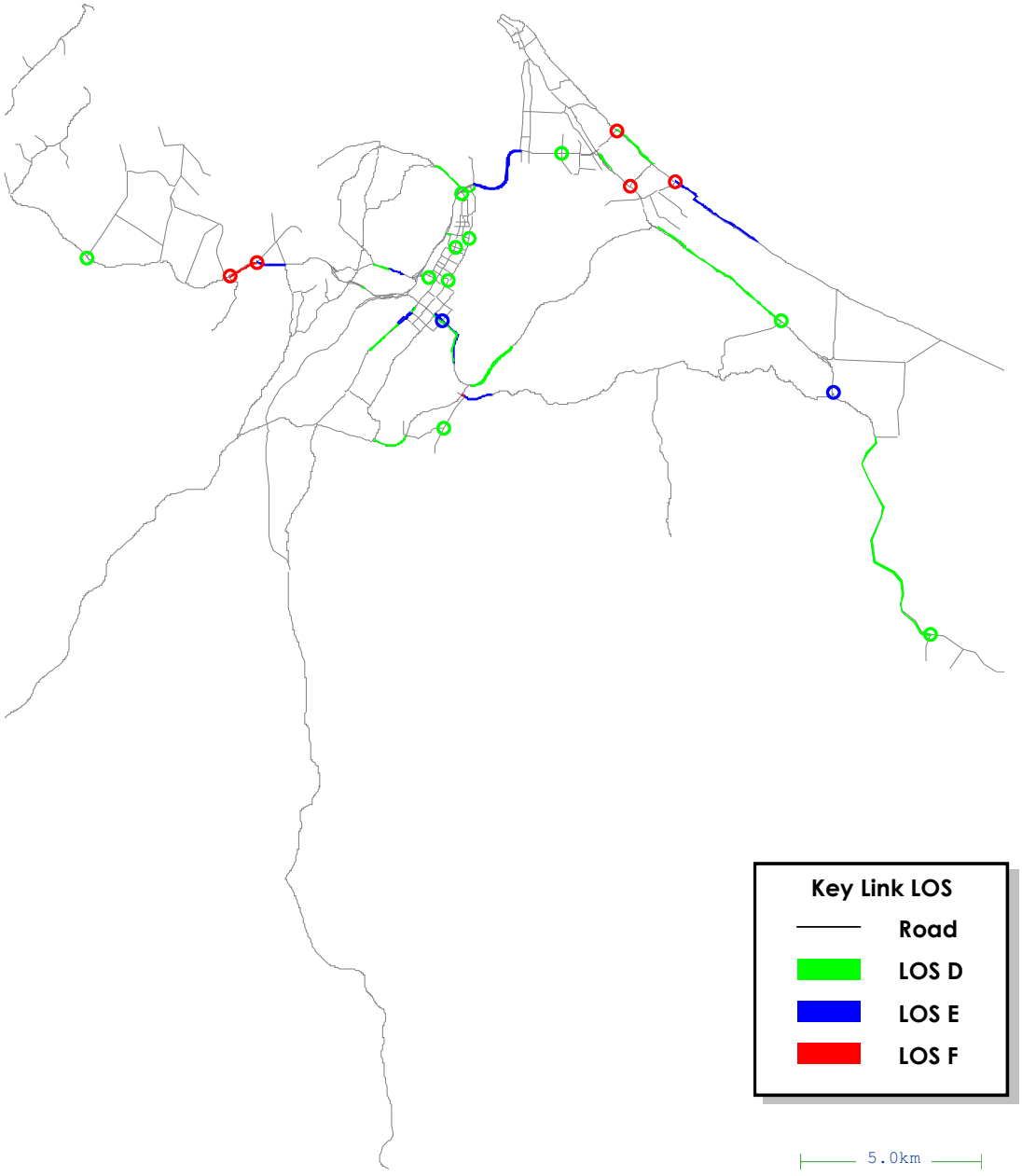
Traffic Design Group	**2006 Evening Peak LOS Taupo**	**Figure 99**
Gabites Porter		



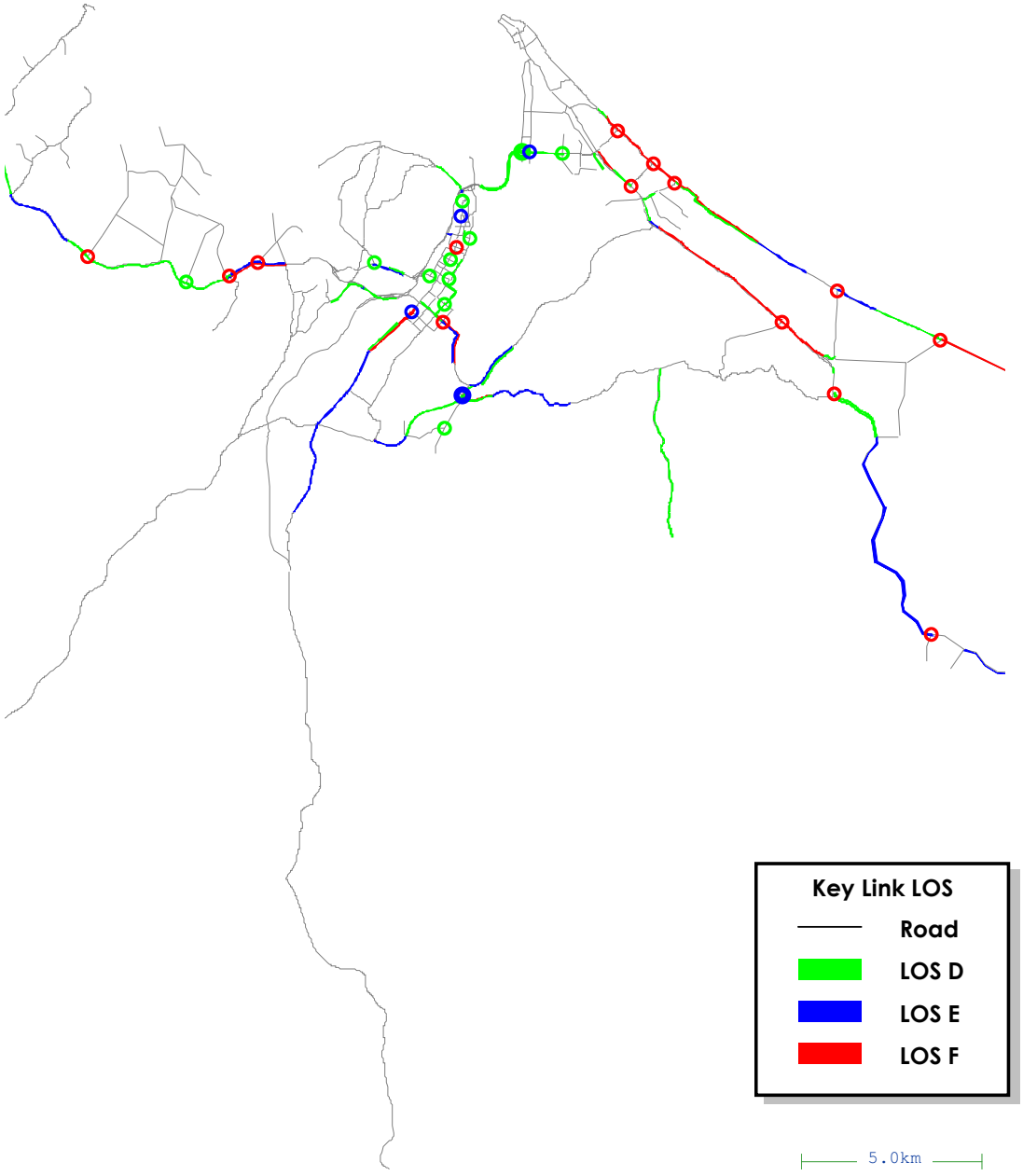
Traffic Design Group	**2021 Evening Peak LOS Taupo**	**Figure 100**
Gabites Porter		



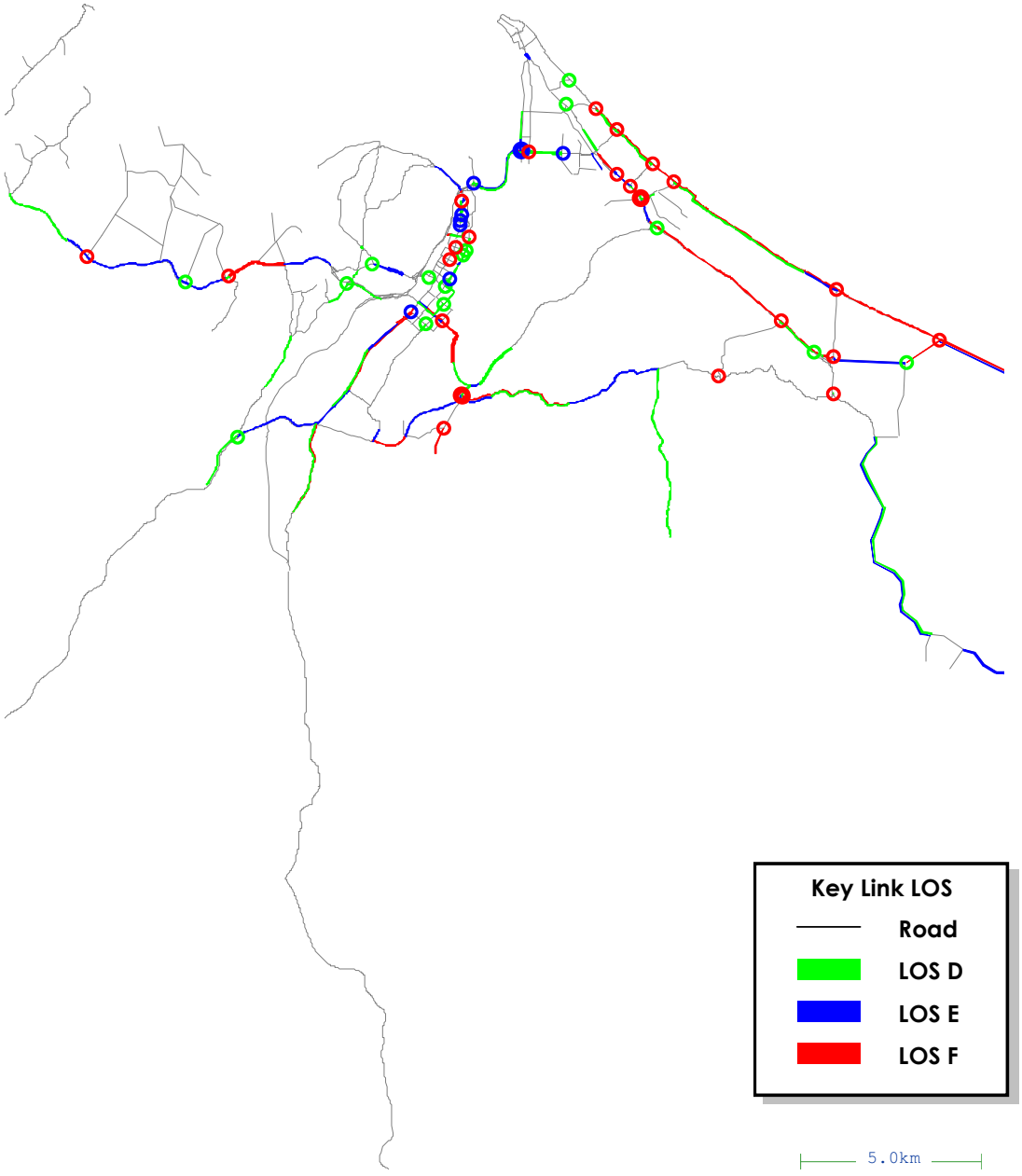
Traffic Design Group	**2041 Evening Peak LOS Taupo**	**Figure 101**
Gabites Porter		



Traffic Design Group	**2006 Evening Peak LOS Tauranga**	**Figure 102**
Gabites Porter		



Traffic Design Group	**2021 Evening Peak LOS Tauranga**	**Figure 103**
Gabites Porter		



Traffic Design Group	**2041 Evening Peak LOS Tauranga**	**Figure 104**
Gabites Porter		

6. SUMMARY

The Waikato network is under significant pressure. Without additional works it is likely to deteriorate significantly over time resulting in considerable congestion and delays to network traffic.

Analysis of the model shows traffic levels will increase significantly over the next 30 years. This will have important implications for the planning of the Waikato transport system.

Over the next 30 years:

- Total trips are expected to increase by 50 to 60%
- Total vehicle kms are also expected to increase by 50 to 60%
- Total intersection delay is expected to increase by up to 220%
- Average trip distances are expected to remain fairly constant

There are a number of bottlenecks on main routes and these are set to grow:

- The Morning Peak experiences a link LOS with a total of 68.9 km affected by LOS D or worse in 2006. This increases rapidly to 2021 to 169.1 km and by 2041 it has reached 235.6 km (242% growth).
- The Evening Peak experiences a link LOS with a total of 73.9 km affected by LOS D or worse in 2006. This increases by 2021 to 193.8 km and by 2041 it has more than tripled to 311.5 km (322% growth).
- The number of intersections affected by LOS D or worse is set to more than double in both periods over the next 30 years.
- In the Morning Peak 51 intersections are affected by LOS D and worse in 2006 and this increases to 108 by 2021 and to 157 by 2041 (207% growth).
- In the Evening Peak 83 intersections are affected by LOS D and worse. By 2021 this increases to 113 and by 2041 to 172 (107% growth).

Modelling suggests that the growth rate in the deficiencies is significantly higher than the growth in the traffic volumes.