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Agreement No. CE 31/2016 (TT) Toll Rationalisation Study of Three Road Harbour Crossings and Three Land Tunnels between Kowloon and Sha Tin - Feasibility Study

Final Report

November 2018

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Toll Rationalisation Study of Three Road Harbour Crossings and Three Land Tunnels between Kowloon and Sha Tin – Feasibility Study

Final Report

Prepared for:

Transport Department

Prepared by:

AECOM Asia Company Limited

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Abbreviations

BOT	build-operate-transfer
CHT	Cross Harbour Tunnel
CJTS	Car journey time survey
CWB	Central and Wanchai Bypass
EB	Eastbound
EHC	Eastern Harbour Crossing
GV	Goods Vehicle
HGV	Heavy Goods Vehicle
LGV	Light Goods Vehicle
LRT	Lion Rock Tunnel
LTs	Land Tunnels
MGV	Medium Goods Vehicle
MC	Motorcycle
NB	Northbound
NENT	Northeast New Territories
RHC	Road Harbour Crossing
R8K	Route 8 (between Cheung Sha Wan and Sha Tin)
SB	Southbound
SP	Stated Preference
STM	Strategic Transport Model
TDM	Toll Diversion Model
TCT	Tate's Cairn Tunnel
TD	Transport Department
TQS	Traffic Queue Survey
VoT	Value of Time
WB	Westbound
WHC	Western Harbour Crossing

EXECUTIVE SUMMARY

Introduction

1. Traffic problems associated with queues at the road harbour crossings ("RHCs") and the land tunnels between Sha Tin and the urban area have been in existence for many years and studied a few times previously. There is a degree of symmetry between these two sets of tunnels, in that the pair of Cross Harbour Tunnel ("CHT") and Lion Rock Tunnel ("LRT") are in centralised locations and both heavily overloaded, resulting in long traffic queues almost all day long. The other pair of tunnels: Eastern Harbour Crossing ("EHC") and Tate's Cairn Tunnel ("TCT") are overloaded during peak hours. The third pair of Western Harbour Crossing ("WHC") and Route 8 between Cheung Sha Wan and Sha Tin ("R8K") both have spare road capacity but connecting roads with insufficient spare road capacity.

2. Compared to previous studies, this Study has the advantages of the following changes in circumstances, viz. the EHC and TCT are now owned by the Government, and the Central and Wanchai Bypass will be opened shortly. The former means that Government can set tolls at five of the six tunnels, subject to LegCo approval, and needs to negotiate only with the WHC franchisee regarding a proposed toll rationalisation plan. The latter will allow a much better distribution of traffic in Hong Kong Island meaning that the spare road capacity of WHC can be utilised for alleviating the traffic congestion at CHT and EHC.

Study Process

3. Traffic analysis in the Study was undertaken based on the traffic forecast of a two-tier transport model. The first-tier model is a strategic transport demand model which is compatible with the Government's Comprehensive Transport Study Model. The model uses various data input and assumptions, e.g. economic growth, socio-economic developments (population, employment places, school places, etc), transport infrastructure and transport policies, to assess the usage of highways and public transport services for different vehicle types and periods of the day. The second-tier model is a toll diversion logit model which uses the total tunnel demands projected by the first-tier model to estimate the flows at each tunnel according to the likely response of tunnel users to different toll rationalisation schemes.

4. The two-tier transport model was developed and supported by a wide variety and enormous amount of data. Traffic flow data were assembled from the Annual Traffic Census that is published annually by the Transport Department for decades. Moreover, extensive traffic counts were conducted at connecting roads to RHCs and land tunnels to collect data under the existing traffic conditions. In addition, queue lengths by time of the day were recorded at the connecting roads to each of the tunnels. The queuing situation coupled with journey times for crossing each tunnel provided a complete picture of the tunnel traffic conditions.

5. In order to collect traffic data for developing the second-tier model, a stated-preference survey was conducted. In the survey, sufficient numbers of potential tunnel users belonging to different market segments were asked a series of choice questions to collect statistically significant data for calibrating their reaction to different levels of toll against journey times. The simulated results of the model were checked against the measured queue lengths and journey time data to vindicate the validity of the model.

6. The Study recognised that public transport ("PT") vehicles are efficient carriers which are operated in fixed routes and service schedules. Any adjustments to PT tolls will not help rationalise traffic demands at tunnels. Similarly, adjustments to goods vehicle tolls will not be effective in rationalising tunnel traffic demands because the tolls will form a small proportion of the costs of goods deliveries. Therefore, the Study focussed on adjusting the tolls of the less efficient transport modes, viz. private cars, motorcycles and taxis. These three modes constitute about 75% of all tunnel traffic.

7. A very wide range of toll options was derived based on the findings of previous studies, and views and opinions collected during the public consultation exercise carried out at the early stage of the Study. The Study examines the toll options on whether: (a) the option may make the best use of the spare road capacity at the WHC; (b) the impact of tunnel traffic queues on the movements of non-traffic traffic may be minimised; and (c) the community at large (including PT passengers) may benefit from savings in journey time and distance.

8. The toll options were tested using the 2-tier transport model to develop various toll rationalisation schemes for detailed evaluation. Better performing options were compared to short list a few toll rationalisation schemes for detailed testing and evaluation. The Study compares the toll schemes, especially on the following considerations: (a) any reduction in traffic queue lengths and crossing times at CHT

and EHC, thus accruing savings in journey times and distances; (b) any release in traffic junctions previously affected by cross-harbour traffic queues, thus reducing traffic impact on non-tunnel traffic; (c) any induction of additional cross-harbour traffic demand, thus worsening traffic situation; and (d) any new traffic junctions that non-tunnel traffic would be affected by cross-harbour traffic queues, thus deteriorating the traffic congestion of non-tunnel traffic. The scheme that would produce the best rationalisation results was identified as the Recommended Scheme.

Study Findings

9. It was found that, for the RHCs, traffic needed to be diverted away from the CHT by increasing its tolls substantially so that CHT-bound traffic would not interfere with other non-tunnel traffic, and the queue length and journey time of CHT traffic would be reduced. The Study results indicated that EHC tolls should be increased to the same level as those of CHT to avoid increasing the queue length and journey time of EHC traffic. To make full use of the CWB in distributing traffic through the WHC, its tolls should be reduced to attract traffic from the other tunnels. However, if WHC tolls are reduced to the same level of CHT and EHC, too many private cars would be diverted to WHC and cause congestion at the WHC connecting roads in West Kowloon and Sai Ying Pun.

10. The private car tolls that worked best were $40 for CHT and EHC, and $50 for WHC. Similar adjustment to the tolls of motorcycles and taxis should be made.

11. For the land tunnels, there is little scope for improvement until the widening of Tai Po Road (Sha Tin section) is completed, making R8K more accessible and allowing the diversion of LRT and TCT traffic to R8K. The Study found that a major toll reduction at TCT would lead to widespread congestion in the Ma On Shan area.

12. Traffic situation for the land tunnels is different on Sundays and general holidays with much lower traffic demands. Therefore it would be possible to lower the TCT tolls to match the flat toll of $8 at LRT and R8K on the foregoing days.

13. It is recommended that the toll for empty taxi should be equalised at all three RHCs at $15 so that empty taxis can use the shortest route to cross the harbour instead of concentrating on using the CHT.

14. Preliminary economic assessments indicate that the Recommended Scheme would engender social cost savings of some $880 million a year from reduced travel time and

journey distances. The emission of greenhouse gases would also be reduced with savings in journey distances.

Conclusions

15. The Recommended Scheme would effectively rationalise the cross-harbour traffic demands through the use of the spare road capacity at WHC, and would accrue social cost savings. For subsequent refinement of the Recommended Scheme, it is recommended that the improvement to the cross-harbour traffic situation by the scheme should be reviewed by undertaking traffic observations before and after the scheme implementation.

1 INTRODUCTION

1.1 Background

1.1.1 The three existing road harbour crossings ("RHCs"), namely the Cross Harbour Tunnel ("CHT"), the Eastern Harbour Crossing ("EHC") and the Western Harbour Crossing ("WHC") are road links connecting Hong Kong Island and Kowloon. These three tunnels were constructed at different times adopting a build-operate-transfer ("BOT") model. The ownership of CHT and EHC was transferred to Government upon the expiry of the franchises in 1999 and 2016 respectively. The franchise for WHC will expire in 2023.

1.1.2 To address the undesirable traffic distribution among the three RHCs and the long standing congestion problem at the CHT, the Government commissioned a "Consultancy Study on Rationalising the Utilisation of Road Harbour Crossings" ("RHC Consultancy") in November 2008.

1.1.3 During the three-month public consultation exercise conducted from November 2010 to February 2011 on the findings and recommendations of the RHC Consultancy, various views and suggestions were received from different sectors of the community, including the Legislative Council, District Councils, professional institutions, transport trades, and members of the public. These views and suggestions included various toll adjustment strategies (e.g. toll levels and structures) to achieve a more desirable traffic distribution, as well as options to implement the toll adjustments and other relevant comments.

1.1.4 In May 2011, the Government commissioned another consultancy study, Detailed Traffic Assessment of Toll Arrangements for Road Harbour Crossings, to carry out a detailed traffic assessment and formulate toll scenarios for the three RHCs, based on the findings and recommendations of the RHC Consultancy.

1.1.5 In February 2013, the Government launched another three-month public consultation exercise to invite views on the proposed measures involving the adjustments of CHT and EHC tolls to improve traffic distribution among the three RHCs. In February 2014, in view of the then traffic situations at the CHT and the EHC, and having regard to the views of the public and concerns of the relevant districts (such as the potential traffic impact on the local road network in Kwun Tong), the Government decided to put in abeyance the implementation of a toll adjustment trial scheme.

1.1.6 Besides the three RHCs, there are three existing traffic tunnels between Kowloon and Sha Tin ("the land tunnels"), viz. the Tate's Cairn Tunnel ("TCT"), Lion Rock Tunnel ("LRT") and Route 8 (between Cheung Sha Wan and Sha Tin) ("R8K"). The Tate's Cairn Tunnel Company Limited was granted a 30-year franchise in 1988 to operate the TCT until 2018. Both LRT and R8K are Government toll-tunnels.

1.1.7 The existing total average daily traffic flow of the RHCs and the land tunnels are about 260,000 vehicles/day and 210,000 vehicles/day. According to an assessment by the Transport Department in 2017, at present about 15% (or about 39,000 vehicles) of the cross-harbour road traffic will also use one of the land tunnels, while the above-mentioned traffic flow will be about 20% of the total land tunnel traffic.

1.1.8 To prepare for taking over the EHC in August 2016, the Government undertook to study the toll adjustment strategy and options for the rationalisation of traffic distribution among the three RHCs. Given the rationalisation of the traffic flows at the RHCs will affect the usage of the land tunnels, the study examined, in a holistic manner, the possible toll options for all these six tunnels so that the traffic congestion at the tunnels could be minimised.

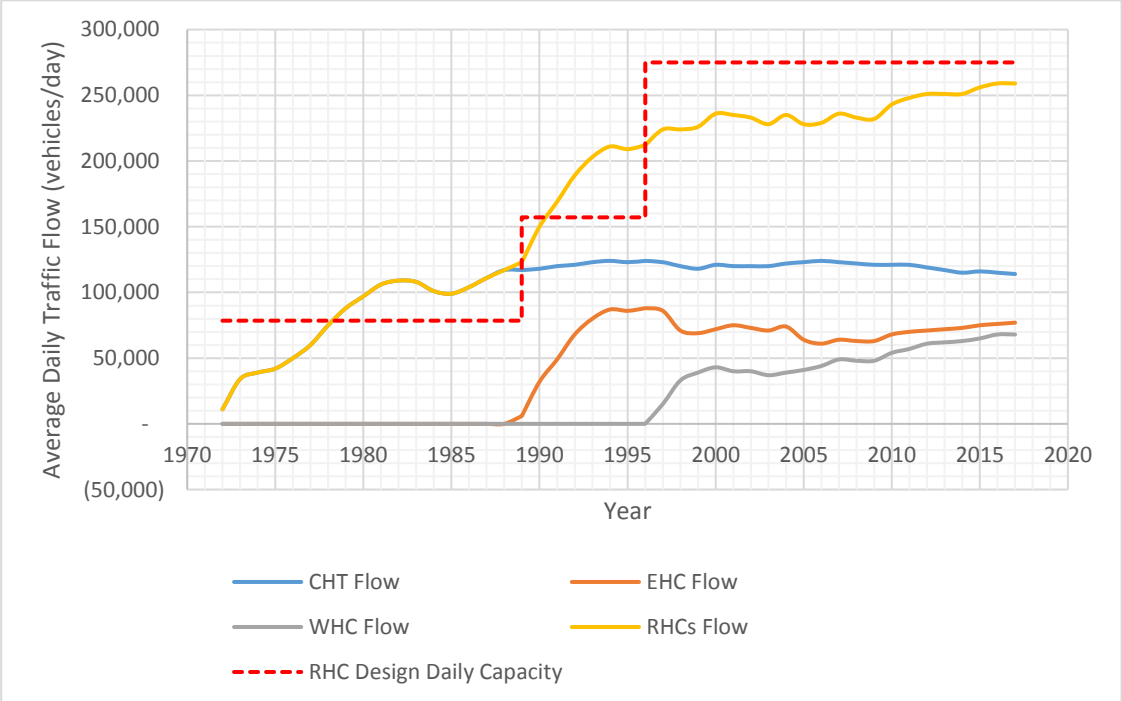
1.1.9 Against the above background, the Transport Department ("TD") commissioned AECOM Asia Company Limited to undertake the Toll Rationalisation Study of Three Road Harbour Crossings and Three Land Tunnels between Kowloon and Sha Tin – Feasibility Study ("the Study") to examine possible options to regulate the flow and distribution of traffic among the six tunnels. The Study commenced on 6 January 2017 for completion in 2018.

1.2 Traffic and Toll History of the RHCs

1.2.1 **Figure 1.1** presents the trends of average daily traffic flows of the RHCs. In the 1980s, traffic increased at an average rate of around 5% per year. Total daily cross-harbour traffic increased by more than 50% in 10 years, from 97,000 vehicles/day in 1980 to 150,000 vehicles/day in 1990. Similar strong growth rates were recorded in the 1990s and total daily traffic in 2000 increased to 235,000 vehicles/day which was 57% more than the 1990 figure.

1.2.2 In the 2000s, the traffic growth for the RHCs slowed down and the annual average growth rate was less than 0.5%, possibly due to the economic downturn. Since 2010, the cross-harbour traffic growth has picked up with an annual growth rate of around 1%.

Figure 1.1 Trends of Average Daily Cross-Harbour Traffic Flows



CHT

1.2.3 **Table 1.1** shows the CHT toll history. There have been two increases in tolls at the CHT since it was opened in 1972 when the car toll was $5. A Passage Tax was introduced in 1984 in order to restrain traffic for most vehicle types, but with no increase for buses. This resulted in a decrease in CHT traffic of about 8.5% between 1983 and 1985. There had been no further toll adjustments since the last increase in 1999.

Table 1.1: CHT Toll History

Types of Vehicles	Aug 1972	Jun 1984	Sep 1999
Car	5	10	20
Taxi	5	10	10
M.C.	2	4	8
PLB	8	10	10
LGV	10	15	15
MGV	15	20	20
HGV	20	25	30
SD Bus	10	10	10
DD Bus	15	15	15
Extra Axle	5	5	10

1.2.4 In 1999, the car toll was raised from $10 to $20 with only small or no changes for the other vehicle types. This resulted in a drop of 1.8% in traffic between 1998 and 1999, but by 2000 the traffic flow surpassed the 1998 level. In 1999 the CHT had a higher car toll than EHC, but lower for all other vehicle types. Thus, some car traffic was diverted away from the CHT, whereas for other vehicle types, some traffic was shifted towards the CHT.

EHC

1.2.5 **Table 1.2** shows the EHC toll history. When EHC was opened in 1989 it had the same car toll as CHT, but was higher for other vehicle types. It recorded 32,000 vehicles/day in its first full year of operation in 1990 rising rapidly to 88,000 vehicles/day in 1996. Traffic at these levels caused considerable congestion in East Kowloon and the eastern part of HK Island. However, there was no apparent relief to the CHT, revealing that there had been significant suppressed cross-harbour traffic demand at the time of EHC opening.

Table 1.2: EHC Toll History

Types of Vehicles	Sep 1989	Jan 1998	May 2005
Car	10	15	25
Taxi	10	15	25
M.C.	5	8	13
PLB	15	23	38
LGV	15	23	38
MGV	20	30	50
HGV	30	45	75
SD Bus	20	30	50
DD Bus	30	45	75
Extra Axle	10	15	25

1.2.6 At the start of 1998 the EHC car toll was raised to $15 with proportional increases for other vehicle types, making it more expensive than the CHT. There was a drop in traffic at EHC of 17% between 1997 and 1998. As the WHC was opened in 1997, some traffic was also diverted away from the CHT to the WHC, thus freeing space in the former to accommodate the diverted traffic from EHC.

1.2.7 In May 2005 the EHC car toll was raised from $15 to $25 with proportional increases for other vehicle types. The traffic flow dropped by 17% largely due to the 67% increase in tolls, but limited by the congestion at CHT and the much higher tolls at the WHC. There were no further toll adjustments to EHC since the last increase in 2005.

WHC

1.2.8 **Table 1.3** shows the WHC toll history. When the WHC was opened in 1997, its daily traffic was about 22,000 vehicles. The WHC experienced exponential traffic growth from 1998 to 2000 with an annual growth rate at more than 14%. Since 2000, the WHC company started to increase tolls regularly. The concessionary toll of car was increased from $35 in 2000 to $70 in 2018 with increases also for other vehicle types.

1.2.9 Despite the continual increase in tolls in 2000s, WHC daily traffic increased moderately from 43,000 vehicles in 2000 to 54,000 vehicles in 2010. The market share for the WHC amongst the RHCs had increased from 18% to 22% during those ten years.

1.2.10 Since year 2010, the WHC has continued to increase its share of cross-harbour traffic. WHC traffic in 2017 constituted 26% of the total. In the same period, increase in traffic at the WHC contributed to almost 90% of the total cross-harbour traffic increase.

Table 1.3: WHC Toll History (Concessionary Toll)

Vehicle Type	Apr 1997	Dec 2000	Feb 2003	Jul 2004	Jan 2008	Aug 2010	Jan 2013	Feb 2015	Jan 2017	May 2018
Car	30	35	37	40	45	50	55	60	65	70
Taxi	30	35	35	35	40	45	50	55	60	65
M.C.	15	20	20	22	22	23	25	25	25	25
PLB	40	45	47	50	55	60	65	70	75	80
LGV	45	50	50	55	55	60	65	70	75	80
MGV	65	70	70	80	80	85	90	95	100	105
HGV	95	100	100	110	110	115	120	125	130	135
SD Bus	40	50	60	70	80	90	100	110	120	130
DD Bus	55	70	85	100	115	128	140	155	170	185
Extra Axle	30									

Impact of Car Toll Changes

1.2.11 During the whole of 1998, the car toll was $10 at CHT, $15 at EHC and $30 at WHC. In September 1999 the CHT car toll was raised to $20 and the motorcycle ("MC") toll increased from $4 to $8, but all other tolls on all tunnels remained the same until the end of 2000. Therefore a comparison of the traffic flows in 1998 and 2000 revealed the impact of raising private vehicle tolls only. The increase in CHT car toll in 1999 of $10 is roughly equivalent to $14 in 2017 prices.

Table 1.4: Impact of 1999 Toll Increase at CHT

Types of Vehicles	1998				2000				% Change			
	CHT	EHC	WHC	Total	CHT	EHC	WHC	Total	CHT	EHC	WHC	Total
Car & M.C.	65,000	38,000	20,000	123,000	52,000	42,000	26,000	120,000	-20%	11%	30%	-2.4%
Others	55,000	33,000	13,000	101,000	68,000	30,000	17,000	115,000	24%	-9%	31%	13.9%
Total	120,000	71,000	33,000	224,000	120,000	72,000	43,000	235,000	0%	1%	30%	4.9%

1.2.12 Between the two years, the total cross-harbour traffic grew by 4.9%, and car/MC traffic decreased by 2.4%. In 1998 the CHT was the cheapest tunnel for cars at $10, with the others at $15 and $30. By 2000, the CHT car toll was at $20, which was more expensive than that of EHC (i.e. $15) and $10 cheaper than that of WHC. There was a 20% drop in CHT car/MC traffic. However, this space was filled by other vehicle types, notably taxi and goods vehicle. This would seem to indicate that scenarios which only adjust car tolls are unlikely to reduce total CHT traffic by much, unless they reach a level where total cross-harbour car traffic is significantly reduced and there is no release of suppressed demand for other vehicle types.

Growth in Total Cross Harbour Traffic

1.2.13 Since the 2008 global economic crisis, total cross-harbour traffic in 2017 has grown at an average rate of 1.4% per year. Should this rate continued, the total daily cross-harbour traffic will increase from 259,000 vehicles/day in 2017 to 281,000 vehicles/day in 2023. In terms of peak hour traffic, the AM peak cross-harbour southbound demand in 2017 has reached about 12,000 vehicles/hour which exceeds the RHCs practical capacity. Hence, measures are necessary to rationalise the traffic flows or even restrain the cross-harbour traffic through direct toll increases.

Balancing Traffic between Tunnels

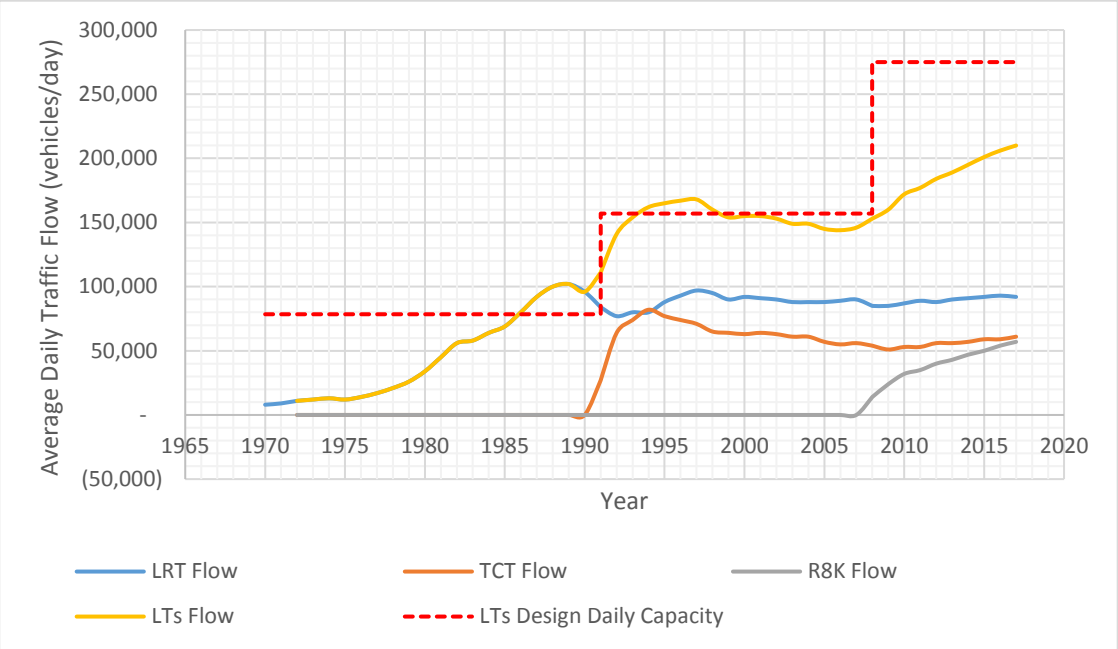
1.2.14 The Government can adjust the tolls of CHT and EHC through amending the relevant subsidiary legislation, which is subject to negative vetting by the Legislative Council. This is not the case for WHC which will only be returned to the Government in August 2023. It is part of WHC's duty to its shareholders to maximise profits and this means tolls will be raised despite its traffic level is below a tolerable level. The WHC company has freedom to increase tolls substantially because the actual tolls charged are well below the statutory values. This will increase the pressure on the other two tunnels.

1.2.15 If the Government wants to make full use of the capacity of all three RHCs, then there would need to be an agreement with the WHC operator to maintain a lower toll and be compensated in some way.

1.3 Traffic and Toll History of the Land Tunnels

1.3.1 **Figure 1.2** shows the traffic history of the land tunnels ("LTs"). Similar to the RHCs, there was strong traffic growth for the land tunnels in the 1980s and 1990s. Land tunnel traffic increased from 96,000 vehicles/day in 1990 to 155,000 vehicles/day in 2000 with an annual growth rate of about 5%, showing a small downturn in 1990 but reaching a peak in 1997. Then the airport relocation and the opening of Route 3 in 1998 caused an abrupt drop in land tunnel traffic and then a more gentle decline until the opening of the R8K in 2008.

Figure 1.2: Trends of Average Daily Land Tunnel Traffic Flows



1.3.2 From 2000 to 2010, the average traffic growth rate was reduced to 1% per year. After 2008, the momentum of traffic increase at LTs is picking up again at a rate of about 3% per year. The rapid increase during the 1990s was made possible by the opening of TCT and the more recent one by the R8K.

1.3.3 **Table 1.5** shows the toll history of TCT. Unlike those of the RHCs, where there have been many toll increases for financial reasons on the WHC and EHC, and for traffic control reasons on the CHT, the tolls of LTs have been relatively stable. Both LRT and Route 8K have a fixed toll for all vehicle classes, currently $8. TCT has had many toll increases but they were small, and has a toll tariff varying by vehicle type. The current car toll is $20, so there is a large differential and larger still for other vehicle types.

Table 1.5: TCT Toll History

Types of Vehicles	Jun 1991	May 1995	Nov 1996	Jan 2000	Aug 2005	Nov 2008	Dec 2010	Aug 2013	Jan 2016
Car	4	6	8	10	12	14	15	17	20
Taxi	4	6	8	10	12	14	15	17	20
M.C.	4	6	8	10	10	11	12	13	15
LB (Public)	7	10	13	17	18	21	21	23	23
LB (Private)	7	10	13	17	18	21	22	24	24
LGV	7	10	13	17	18	21	22	24	24
MGV	8	15	20	20	23	25	26	28	28
HGV	8	15	20	20	23	25	26	28	28
SD Bus	8	15	20	20	24	28	29	31	32
DD Bus	8	15	20	20	26	31	32	34	35
Extra Axle	5	5	7	13	15	18	19	21	24

1.4 Impact on Non-tunnel traffic

1.4.1 During peak periods, long queues of traffic are observed on the connecting roads to the RHCs and land tunnels. The traffic queues frequently cause obstruction to the passage of non-tunnel traffic. For example, the queue of southbound TCT sometimes extends to the Shek Mun Roundabout during morning peak hour and adversely affects the westbound movements of Ma On Shan traffic towards Sha Tin Town Centre and beyond. Similarly, the eastbound traffic on Gloucester Road towards Causeway Bay and Happy Valley is frequently obstructed by the queue of northbound CHT traffic during evening peak hour. Moreover, the northbound traffic on Aberdeen Tunnel is blocked by the northbound CHT traffic on Canal Road Flyover during peak periods and this causes the intermittent closure of northbound Aberdeen Tunnel when the CHT traffic queue extends close to the tunnel portal. As a result of the traffic congestion in the connecting roads to the tunnels, non-tunnel traffic using the connecting roads to other places is also delayed.

1.4.2 The adverse effects of the traffic queues of tunnel traffic on non-tunnel traffic are illustrated in **Plates 1.1 and 1.2**.

Plate 1.1 - Long queue of southbound Cross Harbour Tunnel traffic on Ferry Street Flyover causing slip road traffic tailing back to the junction of Ferry Street and Waterloo Road and obstructing its operation

Plate 1.2 - Long queue of southbound Eastern Harbour Crossing traffic on Lei Yue Mun Road at its junction with Tseung Kwan O Road adversely affecting the junction operation

1.5 Study Objectives

1.5.1 The aim of the Study is to formulate a toll plan to influence the choice of motorists through adjusting the tolls of different tunnels in order to rationalise traffic distribution among the six tunnels, thus alleviating the traffic congestion in the connecting roads to the tunnels and thus reducing traffic delay to the tunnel traffic and non-tunnel traffic.

1.5.2 Traffic assessment for the three RHCs with a view to achieving a better distribution of traffic have been addressed in several studies in the past, most recently in a study reporting in 2013. That study only examined the harbour tunnels. This Study will take advantage of the following changes in circumstances since the previous study has been conducted:

- The Central and Wanchai Bypass ("CWB") will be opened before any toll changes will be in effect. Previously the CWB would not have been available at the time that the toll changes would have occurred. The CWB will relieve several bottlenecks in Hong Kong Island, thereby allowing more use of the available capacity at WHC, and lessen the amount of traffic needing to use Gloucester Road and conflicting with the CHT queues.
- The EHC franchise has since expired giving the Government effective control over two of the three RHCs.
- The WHC franchise will expire in August 2023, thus providing a clearer timeframe for the Government to negotiate with the WHC operator on the amount of subsidies needed if tolls are to be maintained at their current levels or reduced.

2 EXISTING TRAFFIC SITUATION

2.1 Traffic surveys

2.1.1 In order to identify and assess the existing traffic flows and traffic conditions at the three RHCs and the three land tunnels, including their connecting roads, information from available data source / report including Annual Traffic Census and Traffic Queue Survey ("TQS"), and TD's Journey Time Indication System were gathered and reviewed. The major connecting roads of the RHCs and land tunnels are shown in **Table 2.1**

Table 2.1: Major Connecting Roads of the RHCs and land tunnels

Tunnel Traffic	Approach Road
CHT AM Southbound ("SB")	Gascoigne Road Flyover eastbound ("EB")
	Gascoigne Road at-grade EB
	Princess Margaret Road SB
	Chatham Road North westbound ("WB")
CHT PM Northbound ("NB")	Canal Road Flyover NB
	Gloucester Road EB
	Island Eastern Corridor WB
	Queen's Road East EB
	Wong Nai Chung Road NB
EHC AM SB	Kwun Tong Bypass EB
	Lei Yue Mun Road SB
	Lei Yue Mun Road Slip Road
EHC PM NB	Island Eastern Corridor EB
	Island Eastern Corridor WB
WHC AM SB	West Kowloon Highway SB
WHC PM NB	Connaught Road West Flyover WB
	Connaught Road West Flyover EB
	Connaught Road West at-grade EB
LRT AM SB	Lion Rock Tunnel Road SB
LRT PM NB	Waterloo Road NB
	Lung Cheung Road WB
	Lung Cheung Road EB
TCT AM SB	Tate's Cairn Highway SB
	Sha Lek Highway EB
	Siu Lek Yuen Road SB
TCT PM NB	Kwun Tong Bypass NB
	Lung Cheung Road WB
	Lung Cheung Road EB
R8K AM SB	Tsing Sha Highway SB
R8K PM NB	Tsing Sha Highway NB

2.1.2 To supplement the information collected, the following surveys were carried out to collect the necessary traffic data:

- Traffic counting surveys;
- Additional TQSs; and
- Car journey time surveys ("CJTSs").

Traffic Counting Surveys

2.1.3 Traffic counts at the three RHCs and the three land tunnels were obtained by collecting hourly traffic flow information from TD. For connecting roads to the tunnels a large part of the traffic flow information was only Coverage (C) stations of ATC with limited information available. Classified traffic counts similar to those for ATC Core or Coverage (B) stations were therefore done to remedy the data shortfall.

Traffic Queues Surveys

2.1.4 TQSs were conducted to provide information on the traffic queues along the connecting roads to the RHCs and land tunnels during the morning and evening peak periods on weekdays. Traffic CAM Online on the TD website was also used to supplement the information collected in the TQS for estimating the existing traffic situation on the connecting roads to the three RHCs and the three land tunnels. For road sections on highways or elevated levels where there are no convenient points for observing queues, TQSs were done during the CJTSs.

Car Journey Time Surveys

2.1.5 CJTSs were conducted along routes in the connecting roads to the three RHCs and the three land tunnels for the same time period as traffic was counted in order to capture similar traffic conditions. The CJTSs consisted of a series of car journeys from one point (origin) to another (destination) at 30-minute intervals. Each survey involved 4 car trips from each origin to each destination over a two-hour duration. The journey times for crossing the tunnels were recorded from the start of a traffic queue of a tunnel until the exit portal of the tunnel.

2.2 Existing Traffic Condition

2.2.1 Currently, several trunk routes are seriously congested during peak hours. Generally, the traffic volume is higher in the southbound direction of the tunnels mentioned above than the northbound direction during AM peak, while the traffic volume for the northbound direction of the tunnels is larger during PM peak. Because of the high traffic demand, most of the RHCs and land tunnels are overloaded so that a considerable length of traffic queue can be observed. **Table 2.2** summarises the existing queuing situation in the connecting roads of each tunnel. Figures showing the queuing situation are also shown in **Appendix A**.

2.2.2 All traffic flows in this chapter and subsequent chapters are shown as weekday average daily and weekday AM and PM peak hour values.

Table 2.2: Existing Tunnel Traffic Flows, Queues and Crossing Time

Tunnel / Daily Traffic Demand (Vehicles)	Peak / Direction	Hourly Tunnel Capacity (Vehicles/ hour)	Hourly Tunnel Traffic Demand (Vehicles)	Approach Road	Observed Queue Length* (m)	Surveyed Crossing Time** (Min)
CHT / 114,100	AM S/B	2,600	4,600	Gascoigne Road Flyover EB	2,900	31
				Princess Margaret Road SB	2,100	
				Chatham Road North WB	1,900	
				Gascoigne Road at-grade EB	1,800	
	PM N/B	2,600	4,400	Canal Road Flyover NB	1,600	36
				Gloucester Road EB	3,000	
				Island Eastern Corridor WB	1,700	
				Queen's Road East EB	1,500	
				Wong Nai Chung Road NB	1,800	
EHC / 82,400	AM S/B	2,600	3,600	Kwun Tong Bypass EB	1,300	14
				Lei Yue Mun Road SB	1,200	
				Lei Yue Mun Road Slip Road	500	
	PM N/B	2,600	3,600	Island Eastern Corridor EB	1,000	14
				Island Eastern Corridor WB	800	
WHC / 75,500	AM S/B	4,200	3,800	West Kowloon Highway SB	-	3
	PM N/B	4,200	3,600	Connaught Road West Flyover WB	-	3
				Connaught Road West Flyover EB	-	
				Connaught Road West at-grade EB	-	
LRT / 93,400	AM S/B	2,600	3,500	Lion Rock Tunnel Road SB	1,800	17
	PM N/B	2,600	3,800	Waterloo Road NB	1,500	13
				Lung Cheung Road WB	1,200	
				Lung Cheung Road EB	700	
TCT / 62,600	AM S/B	2,600	3,600	Tate's Cairn Highway SB	1,900	26
				Sha Lek Highway EB	400	
				Siu Lek Yuen Road SB	400	
	PM N/B	2,600	3,200	Kwun Tong Bypass NB	1,200	14
				Lung Cheung Road WB	500	
				Lung Cheung Road EB	400	
R8K / 61,900	AM S/B	4,700	3,700	Tsing Sha Highway SB	-	5
	PM N/B	4,700	3,000	Tsing Sha Highway NB	-	5

Notes
* - Queue measured from tunnel entrance to the end of queue

** - Average journey time for crossing the tunnel counted from the start of traffic queue to the exit portal of the tunnel

CHT Tunnel Traffic Condition

2.2.3 It was observed that the problem was more serious for southbound traffic in CHT during AM peak and northbound traffic during PM peak. In AM peak, a long traffic queue was observed in all four approach roads of CHT on Kowloon side. Gascoigne Road Flyover recorded approximately 2.9 km of traffic queue which reached Yau Ma Tei beyond Prosperous Garden. About 2.1 km and 1.9 km of traffic queues were observed in Princess Margaret Road and Chatham Road North respectively, in which the two queues reached Hung Hom Police Station and Ko Shan Theatre respectively. The long traffic queues along the foregoing connecting road comprised non-tunnel trips between North Kowloon and Central Kowloon, and between the East and West Kowloon respectively.

2.2.4 For the northbound traffic of CHT during PM peak, the longest traffic queue, which was 3 km, was recorded in Gloucester Road/ Connaught Road Central and extended beyond the Exchange Square. About 1.7 km of traffic queue was recorded in Gloucester Road/ Island Eastern Corridor, reaching its down ramp to the Victoria Park Road. The traffic queue of Canal Road Flyover was 1.6 km long, extending to the exit portal of Aberdeen Tunnel northbound. Since Route 4 is an important east-west route in Hong Kong Island, the traffic queues in Gloucester Road/ Connaught Road Central and Gloucester Road/ Island Eastern Corridor adversely affect traffic movements in Hong Kong Island North.

EHC Tunnel Traffic Condition

2.2.5 During AM peak, approximately 1.3 km and 1.2 km of traffic queues were observed in Kwun Tong Bypass and Lei Yue Mun Road respectively. As the traffic queue in Kwun Tong Bypass reaches Kwun Tong Police Station, any possible lengthening of the queue will block the traffic heading to Tseung Kwan O Road and cause delay to the Tseung Kwan O traffic. Moreover, the queue will also obstruct the traffic travelling to Kwun Tong commercial and industrial area via Lei Yue Mun Road.

2.2.6 For PM peak, about 1.0 km and 0.8 km of traffic queues were observed in eastbound and westbound direction of Island Eastern Corridor respectively, with the ends of the queues reaching North Point Fire Station and Tai Koo Shing respectively. The foregoing traffic queues in Island Eastern Corridor adversely affect traffic movements in Hong Kong Island East.

LRT Tunnel Traffic Condition

2.2.7 During AM peak, the queue length in southbound Lion Rock Tunnel Road was about 1.8 km. The traffic queue extended from Lion Rock Tunnel Road near Sun Tin Wai Estate. As a result, the traffic in Sha Tin, especially those trips heading to Tai Wai, was affected.

2.2.8 During the PM peak, the queue along Waterloo Road with length around 1.5 km, blocked the traffic movements in central Kowloon. On the other hand, the eastbound and westbound of Lung Cheung Road recorded 0.7 km and 1.2 km of traffic queues respectively. The queue reached Morse Park for westbound Lung Cheung Road. The traffic queues in the Lung Cheung Road, which is the major part of Route 7, blocked the traffic going to and from the east Kowloon, central Kowloon and Kwai Tsing District.

Tate's Cairn Tunnel Traffic Condition

2.2.9 Traffic queue of about 1.9 km long was observed for southbound TCT traffic during the AM peak, stretching from the Tate's Cairn Highway to Shek Mun Roundabout. As Shek Mun Roundabout is the main route for the Ma On Shan traffic, whenever the traffic queue from TCT tunnel portal reached and blocked the roundabout at times, Ma On Shan traffic was severely delayed.

2.2.10 Traffic queue of about 1.2 km long was observed for northbound TCT in Kwun Tong Bypass with the tail of the queue reaching Richland Gardens. As Kwun Tong Bypass is a vital part of Route 2, the traffic queue adversely affected the non-tunnel traffic in east Kowloon. For Lung Cheung Road and Tai Hom Road, 0.5 km and 0.4 km of queue lengths were recorded respectively with the tails of the queues reaching Choi Hung Estate and Diamond Hill Station respectively.

2.3 Stated Preference Surveys

2.3.1 A Logit-based discrete choice model was developed to reflect the motorists' choice of using toll road facilities across Victoria Harbour (using WHC, CHT, or EHC) and between Kowloon and Shatin (using R8K, LRT or TCT). The Logit Model adopts the concept of utility in econometric theory to estimate the probability of tunnel choices of the motorists, and is commonly used in the field of transport choice modelling.

2.3.2 The utility is expressed as a function of travel time, distance and monetary cost paid on toll levies, distinguished by different market segments. Each segment of travellers has a different perception of the value of time and choice behaviour. Applying the probability formulation, vehicles are distributed to particular routes or toll road facilities based on generalized cost consideration.

2.3.3 In order to derive the model parameters for the Logit-based assignment model, stated preference ("SP") surveys were conducted from March to April 2017. Only the goods vehicle drivers, private car/motorcycle drivers, and taxi passengers who have experience in using the concerned tunnels in the past 3 months were invited to participate in this study. The SP surveys collected information from sufficient number of respondents so that a Logit-based assignment model could be developed for producing simulation results that were statistically significant.

2.3.4 In the SP surveys, participants were requested to provide the following information:

(a) the origin and destination (according to defined geographical sectors) of their most frequent trip that routed through a RHC, land tunnel or both;

(b) the travel time period (peak, inter-peak or off-peak) of their trip; and

(c) their choice (one out of a maximum of four alternatives) of travel routing or/and tunnel tolls under different scenarios of travel conditions (different travel time, travel distance and toll level) as a GV driver, private car driver or taxi passenger.

2.3.5 The SP surveys were undertaken through the following three ways in which participants were only asked once:

(a) On-street interview: Face-to-face interview surveys were conducted at Transport Department Licensing Offices, and on-street to randomly interview car-owners and taxi passengers.

(b) Mail-back questionnaire survey: Questionnaires were distributed on-street or mail boxes of selected residential estates. The target respondents (GV drivers, private car drivers and taxi passengers) were requested to return the completed questionnaire using a mail-back envelop.

(c) Questionnaire survey at toll plaza: Questionnaires were distributed to GV and private car drivers at toll plazas of government tunnels (including Tsing Sha Highway, Lion Rock Tunnel, Cross Harbour Tunnel and Eastern Harbour Crossing) for drivers to complete and post back.

3 MODELLING METHODOLOGY AND INPUT ASSUMPTIONS

3.1 Modelling Methodology

3.1.1 A two-tier transport modelling approach has been used for the Study, which comprises a strategic transport model ("STM") as the upper tier and a logit toll diversion model ("TDM") as the lower tier. The upper tier STM is a conventional trip-based, 4-stage demand model which is compatible with the established Comprehensive Transport Study Model of TD that was developed in 1999 and last enhanced in 2015.

3.1.2 The STM is a set of four-step transport demand models developed based on a proven approach for forecasting weekday travel demand in the HKSAR. The models were constructed based on aggregated demographic and socio-economic data, and travel behaviour parameters derived from the 2011 Travel Characteristics Survey undertaken by TD.

3.1.3 The STM has been used in many projects of strategic transport planning in Hong Kong. The four-step process involved in the STM is summarised as follows -

(a) Trip End Model: estimating the trips generated in different traffic zones in the HKSAR, the trip ends, based on assumptions of future land use development and socio-economic situation;

(b) Distribution Model: calculating the trip movements between the traffic zones in the form of trip matrices based on the estimated zonal trip ends and the journey time and cost for travelling between each pair of traffic zones;

(c) Mode Choice Model: deriving the proportions of the total trips between each pair of traffic zones that will be made using different transport modes; and

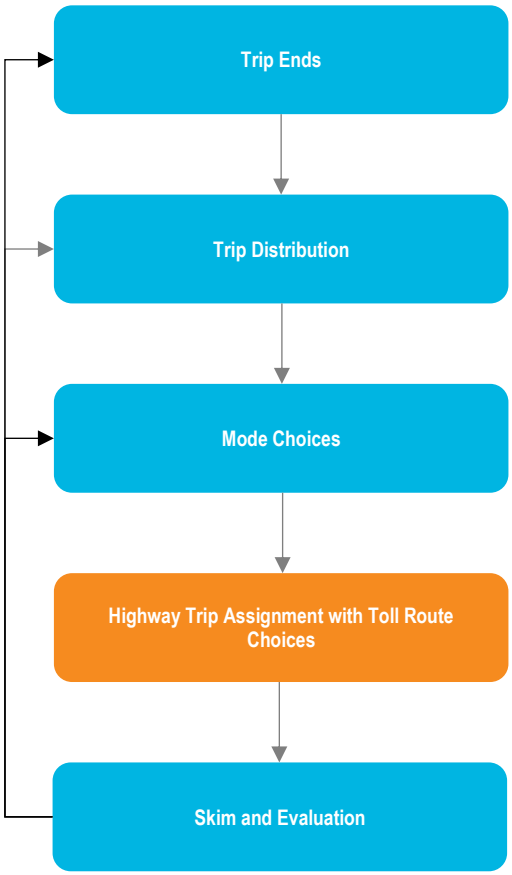
(d) Assignment Model: simulating the route choice of the trips between each pair of traffic zones using different transport modes to project the trips in each section of the highway and public transport networks, thus forecasting the congestion levels and operating speeds of different sections of the road network in Hong Kong.

3.1.4 Following the mode choice and distribution processes in the STM, the different market demand segments, defined by trip purpose, are combined by vehicle class and assigned to the highway network using a multi-class equilibrium approach based on a generalised cost consideration under the Wardrop's principle. In order to better reflect the motorists' route choice of using different tunnels in the highway assignment process, an additional traffic modeling process involving a logit model (i.e. adopting a probabilistic approach) was developed for simulating different perceptions of the value of time ("VoT") and route choice behaviour of each market demand segment. In other words, the logit model subdivides the demand matrices by vehicle type from the STM into several "market segments" as required by the analytical need of the Study.

3.1.5 The core work of the TDM is to refine the route choice of the vehicle demand matrices forecast by the STM in consideration of the tolls levied at different RHCs and land tunnels. In other words, demand matrices of different vehicle types are assigned onto the road network to reflect the consideration of tunnel tolls when route choice is made by motorists. In doing so, trips for each mode or market segment are divided into choices of "toll and toll-free" or "preferred path and other paths" to facilitate traffic analysis in the Study. The TDM allows the model results to be sensitive to the

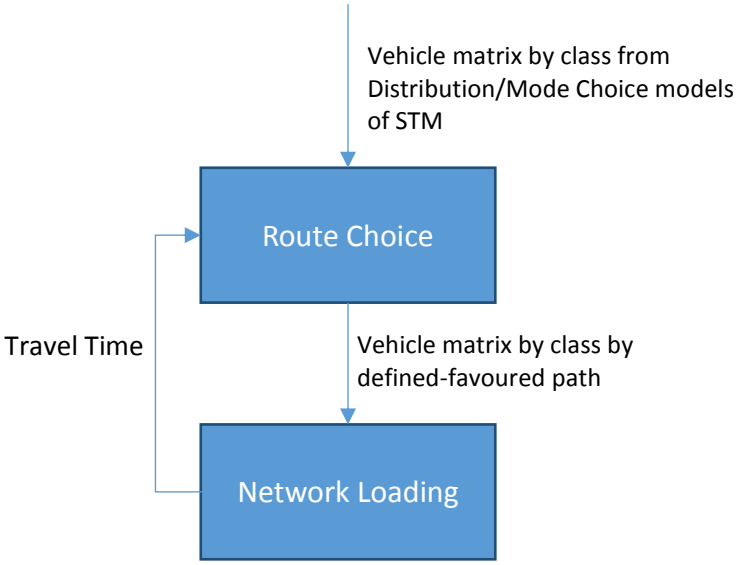
socioeconomic choices of commuters. The process of the TDM is illustrated in **Figure 3.1**.

Figure 3.1: Process of the TDM



3.1.6 The TDM partitions the trips between the best tolled route and the other tolled routes for a given origin-destination zonal pair in each iteration of the equilibrium highway assignment process The consideration of toll choice in the highway assignment step of TDM is determined using a binary logit approach for each of the vehicle classes. The probability of selecting a toll road would be based on a utility function that estimates the trade-off between travel time savings and the associated toll costs, taking into account travellers' characteristics that vary by vehicle class and route. **Figure 3.2** illustrates the process of the highway assignment step in the TDM.

Figure 3.2: The Highway Assignment Step in TDM



3.2 Input assumptions for Base Year and Design Year

3.2.1 The transport model was validated to the traffic conditions of the base year of 2017 using the latest land use and planning data, and assumptions on transport infrastructure, transport networks, socio-economic situations and transport policies.

Strategic Planning Data

3.2.2 The planning dataset, 2014-based Territorial Population and Employment Data Matrix developed by Planning Department, was adopted as the basis of the territorial planning data input. Base year planning data were derived by linear interpolation of the data for 2014 and 2021.

3.2.3 For population in base year, however, the Study has made reference to the projections of population distribution for 2015-2024 compiled by the Working Group on Population Distribution Projections of Planning Department. The projection was completed in December 2015, and adopted the latest Census and Statistics Department's projections of territorial population released in September 2015 as control totals. Forecast housing supply data adopted by those projections has taken into account all planning information of housing development proposals that were known up to the first quarter of 2015 and other assumptions.

Highway Network and Railway Network

3.2.4 All strategic highways and railways which were completed in or before 2016 have been taken into account for the base year model. Committed/planned highway and railway projects were incorporated into the design years of STM.

3.2.5 The latest values of other model inputs have been obtained from the concerned Government Department. The inputs include -

(a) Highway Tolls - assumed to remain constant in real terms over time as a working assumption for future design years;

(b) Port Related Data - the port cargo forecasts and assumptions of new port facilities given in the "Study of the Strategic Development Plan for Hong Kong Port 2030", released by the Transport and Housing Bureau in December 2014, were adopted;

(c) Airport Related Data – the latest design year airport usage forecasts by the Airport Authority were adopted;

(d) Vehicle Fleet Size Data - average growth rates of 3% and 2% per year for private car were adopted for the years 2018 to 2021 and 2021 to 2026 respectively; and

(e) GDP Data – 3% and 2.8% per year GDP growth was adopted for years 2018 to 2021 and 2021 to 2026 respectively.

4 BASELINE TRAFFIC SITUATION

4.1 Traffic forecast

4.1.1 The transport models developed in the Study were used for the comparative evaluation of various toll schemes which took into account of the imminent opening of the Central – Wan Chai Bypass ("CWB"). The CWB will substantially increase the capacity of the road corridor for the east-west traffic movements in Hong Kong Island North, viz. Island Eastern Corridor, Gloucester Road, Harcourt Road and Connaught Road Central. This will affect the route choice of motorists in Hong Kong Island North. The CWB will divert the non-tunnel traffic from the connecting roads to the WHC and alleviate the traffic congestion in the road corridor during peak hours. Therefore, the use of WHC will be encouraged despite its tolls are much higher than those of CHT and EHC. As a result, the distribution of cross-harbour traffic among the three RHCs will change. The diversion of traffic from CHT to WHC will shorten the CHT traffic queue on the Gloucester Road/Harcourt Road. However, the possible increase in WHC tolls will tend to encourage motorists to use CHT and EHC instead of WHC.

4.1.2 The 2014-based Territorial Population Employment Data Matrix adopted in the Study provides population and employment figures for 2014 and 2021 based on which the figures for 2017 were derived and the year 2017 was adopted as the base year for the calibration and validation of the transport models. As it would take some time to implement a toll rationalisation plan, the year 2021 was adopted as the design year for forecasting the traffic situations under different toll schemes.

4.1.3 In the traffic analyses of toll schemes, the traffic situations of the schemes were compared with that of the Baseline case, i.e. no toll rationalisation plan would be implemented in 2021. Under the Baseline case, it was assumed that there would not be any changes to the CHT and EHC tolls but WHC tolls would increase throughout the remainder of the franchise period according to the historical trend.

4.1.4 Currently, congestion is more severe in the southbound direction of the connecting roads to the RHCs and land tunnels during the AM peak period but congestion is more severe in the northbound in the PM peak. This is mainly due to the heavy commuter traffic travelling between the New Territories, Kowloon and Hong Kong Island. Traffic statistics showed that, in 2017, the southbound traffic of RHCs was 25% more than the northbound traffic in the AM peak while northbound traffic was about 17% more than the southbound traffic in the evening peak. Therefore traffic demand analysis in this Study has been focused on southbound traffic in the AM peak and northbound traffic in the PM peak. **Table 4.1** shows the traffic demand forecasts of the RHCs and land tunnels under the Baseline case in 2021.

4.1.5 The overall daily traffic demand at RHCs and land tunnels will continue to increase from 2017 to 2021 due to demographic and economic growth. Traffic demand for RHCs will increase by 1.8%, while that of the land tunnels will increase by 5.4%. One of the reasons for persistent growth in traffic demand is the continual growth in

population in the New Territories. The population growth in the non-metro areas[1] is 10.4%, whereas the growth rate in the metro areas is 1.7%. The ratio of employment places to working population in the non-metro areas remains at a low level of 0.45 in 2021. This leads to a high level of commuter traffic demand in the AM and PM peaks.

Table 4.1: 2021 Baseline Traffic Forecasts (Vehicles)

Scenario	Demand	EHC	CHT	WHC	Total RHCs	TCT	LRT	R8K	Total Land Tunnels
2017 Existing	Daily	82,400	114,100	75,500	**272,000**	62,600	93,400	61,900	**217,900**
	AM Peak SB	3,600	4,600	3,800	**12,000**	3,600	3,500	3,700	**10,800**
	PM Peak NB	3,600	4,400	3,600	**11,600**	3,200	3,800	3,000	**10,000**
2021 Baseline	Daily	85,800	114,900	76,300	**277,000**	66,900	98,300	64,500	**229,700**
	AM Peak SB	3,600	4,500	4,400	**12,500**	3,600	3,600	4,200	**11,400**
	PM Peak NB	3,700	4,300	4,100	**12,100**	3,300	3,800	3,400	**10,500**

4.1.6 The opening of the North South Line as part of the Shatin to Central Link will provide extra options for passengers to cross the harbour. However, rail links generally diverts passengers from other modes of public transport, which has little impact on traffic loadings, rather than from private cars, motorcycles or taxis. Commercial vehicles, which make up an increasing proportion of cross-harbour traffic, cannot be diverted to rail.

4.2 Traffic Analysis

4.2.1 The queues and journey times in 2021 AM and PM Peaks under the Baseline case are shown in **Table 4.2**, in comparison with the existing situations. Detail presentations of the queues are shown in **Appendix B**. Appendix B also presents the traffic junctions where non-cross-harbour traffic may be blocked by cross-harbour traffic queues.

[1]Metro areas refer to Hong Kong Island, Kowloon, Tsuen Wan, Kwai Chung and Tsing Yi. Non-metro areas refer to other parts of the New Territories.

Table 4.2: Existing and 2021 Traffic Queues and Journey Times

Scenario	AM SB Queue (m) and Journey Time (Min)						PM NB Queue (m) and Journey Time (Min)					
	EHC	CHT	WHC	TCT	LRT	R8K	EHC	CHT	WHC	TCT	LRT	R8K
Existing	1,300	2,900	-	1,900	1,800	-	1,000	3,000	-	1,200	1,500	-
	14	31	3	26	17	5	14	36	3	14	13	5
2021 Baseline	1,300	2,900	-	1,900	2,200	-	1,200	2,300	-	1,600	1,600	-
	14	31	3	26	19	5	15	33	3	16	13	5

4.2.2 As discussed above, the opening of the CWB will result in some CHT traffic diverting to WHC, reducing in a shortening of the CHT traffic queue during the peak hours. With the increase in cross-harbour traffic demand in the Baseline case, the CHT traffic queues on Gloucester Road/Harcourt Road will lengthen back to their existing levels.

4.2.3 Traffic queuing at the connecting roads to the RHCs and land tunnels in 2021 will be similar to the existing situation. Even longer queues of traffic will be formed at EHC, TCT and LRT but there will not be traffic queues at the WHC and R8K because of the high toll level for the former and the bottleneck at Tai Po Road (Shatin Section) for the latter.

4.3 Scope for toll rationalisation

4.3.1 The aforementioned traffic queuing situation indicates that any worthwhile toll rationalisation scheme should be aimed to divert traffic from CHT to WHC. The road space in CHT freed up in the diversion may allow EHC traffic to use CHT. The end result will be an increase in traffic at WHC but a decrease at the other two tunnels.

4.3.2 The spare capacity of WHC may be utilised through increasing tolls to suppress traffic demands at the CHT and EHC while reducing the WHC tolls to divert the original CHT and EHC traffic demands.

4.3.3 For the land tunnels, there is currently no scope for making use of the spare available capacity at R8K until the works to widen Tai Po Road (Shatin Section) are completed in 2023.

4.3.4 For both the RHCs and land tunnels, the daily traffic demands are less than the daily design capacities. This means that the consideration of toll adjustments to rationalise traffic demands should focus on the traffic situation during peak periods instead of other time periods.

5 PUBLIC CONSULTATION AND DEVELOPMENT OF THE RECOMMENDED TOLL RATIONALISATION SCHEME

5.1 Public consultation findings

5.1.1 There have been many discussions in the community of Hong Kong on issues relating to the rationalisation of the tolls and traffic distribution of RHCs and land tunnels since 2000. Major opinions expressed and discussed in the community include:

(a) The main cause of uneven traffic distribution among the three RHCs was the BOT mode of construction for harbour crossing. Therefore the Government should refrain from adopting the BOT model to deliver roads and tunnels in future;

(b) The Government should examine the feasibility of establishing a Tunnels and Bridges Authority to own and manage all tunnels and bridges, including the BOT tunnels;

(c) The Government should examine the feasibility of constructing a fourth road harbour crossing or a cross-harbour bridge;

(d) The Government should take a macro approach in formulating measures to rationalise traffic of the three RHCs, and that the toll levels of other tunnels should be taken into consideration;

(e) The Government should consider the option of buying back WHC as this would provide greater flexibility for the Government to implement traffic management measures;

(f) There are concerns on whether the Government could comprehensively review the tolls and traffic flow of the six tunnels, as the BOT franchise of WHC would not expire until 2023;

(g) The Government should, upon the takeover of EHC, lower the tolls of EHC on a par with CHT to attract more vehicles to use EHC;

(h) Vehicles could be charged differently during peak hours and non-peak hours in order to distribute the traffic rationally; and

(i) The Government should consider rationalise the tolls of the three land tunnels to facilitate redistribution of the tunnel traffic.

5.1.2 Most of the opinions, such as items (a) to (f) in paragraph 5.1.1 are opinions on constraints / obstacles to implement toll adjustment, rather than toll options / strategies. Therefore public consultation was conducted during this Study to collect public's comments and views on toll strategies with a view to formulating various proposals to influence the choice of motorists through raising or lowering the tolls of different tunnels in order to rationalise traffic distribution among the six tunnels.

5.1.3 A technical workshop was held on 13 July 2017 to collect the views/opinions from some members of the academia, professional bodies, Transport Advisory Committee, Road Safety Council and Road Safety Research Committee. The views collected are summarised in **Table 5.1**.

Table 5.1: Views on Tolling Strategies Collected from the Technical Workshop

Vehicle type	Views on Tolling Strategies
Private Car	• Increase for private car toll at the CHT should be high
	• Focus of toll schemes should be put on private car
Taxi	• The value of time of taxi users is high, hence small increase of taxi toll at the CHT will not be effective
	• Increase of taxi toll will be absorbed by passengers hence it may not be effective to rationalise taxi movements at the tunnels by toll adjustments
Motorcycle	• Not mentioned at the workshop
Goods vehicle	• Traffic patterns of GVs may not be affected much by toll changes because GV drivers tend to stay using their usual routes
	• Reducing the tailpipe emissions of GVs will be more effective than other vehicle types to improve air quality
Bus and Light Bus	• Bus toll at the CHT is too low and should be increased
	• Bus routing is fixed, hence toll increase will not reduce bus movements
	• If bus toll at the WHC is reduced, more empty bus may be routed to use it instead of the CHT
	• Toll schemes should be evaluated based on the benefits to bus passengers
	• More use of bus should be encouraged to reduce private car usage
	• Subsidies funded by the additional revenue collected from increased car toll should be provided to cross-harbour buses to reduce their fares

5.1.4 Other views expressed at the workshop are summarised as follows.

(a) Clear objectives should be set for the toll rationalisation study;

(b) Different toll levels should be implemented to address the uneven traffic distribution in peak and non-peak periods;

(c) Evaluation of proposed toll rationalisation schemes should be based on the possible changes in journey time to cross the tunnels instead of queue lengths in the connecting roads;

(d) Tolls should only be increased but not decreased to avoid inducing additional traffic demands;

(e) Toll collection at the tunnels should be done automatically by electronic means to avoid toll booths becoming bottlenecks;

(f) Extra revenue obtained from raising tolls should be spent on subsiding public transport through a scheme of "dedicated fund for dedicated use"; and

(g) Environmental assessment of proposed toll rationalisation plan should be carried out.

5.1.5 The Government consulted LegCo Panel on Transport in November 2017 to present the preliminary findings of Toll Rationalisation Study and to collect the views of LegCo members on toll rationalisation. The views collected are summarised as follows:

(a) Lower EHC tolls to align with CHT tolls;

(b) Unify the tolls of the three land tunnels by lowering TCT tolls to align with LRT and Route 8K tolls;

(c) Unify the tolls of three RHCs by raising CHT tolls and lowering WHC tolls to align with those of EHC;

(d) Unify the tolls of three RHCs by raising CHT tolls and lowering WHC and EHC tolls;

(e) Lower the tolls of all six tunnels; and

(f) Remove toll booths, such as completely waiving tunnel tolls, and adding Autotoll lanes or mandating electronic tolling, to eradicate traffic congestion at toll booths caused by manual toll collection.

5.1.6 A forum for members of District Council ("DC") was held on 14 Dec 2017 to discuss the issues and approach to toll rationalisation at the RHCs and land tunnels. About two-thirds of DC members attending the forum supported Strategies (a), (b) and (c), as shown below -

(a) Increase toll

(b) Increase toll for specific vehicle types

(c) Differential tolling by time period

(d) Decrease toll

(e) Toll free

(f) Flat toll

5.1.7 Other issues and concerns expressed by DC members in the forum include -

(a) Measures to improve the capacity of the RHCs or to build a fourth road harbour crossing;

(b) Urban planning to alleviate traffic congestion in trunk roads between Northeast New Territories and Kowloon;

(c) Automatic toll collection through electronic payment to reduce queuing time in toll plaza;

(d) Other demand management measures should be explored such as park-and-ride and increased usage of public transport services;

(e) Control the growth of private car or private light bus;

(f) Study objectives and evaluation criteria of toll rationalisation schemes should be clearly presented to the public; and

(g) A mechanism for reviewing tunnel tolls should be proposed.

5.2 Framework of the development of a toll rationalisation scheme

5.2.1 During the public consultation exercise, the following framework, developed in the Study for formulating a toll rationalisation scheme, was presented -

(a) Toll adjustment plans should not only cover individual tunnels;

(b) Tunnel tolls should not be waived;

(c) Appropriate toll increase in CHT and LRT is necessary;

(d) The toll schemes should focus on the tolls of motorcycles, private cars and taxis;

(e) Tolls of public transport vehicles with fixed routes should not be increased;

(f) Different tolls at different times could be explored; and

(g) Toll adjustment mechanisms could be explored.

5.2.2 Based on the foregoing framework and the views of the public, toll rationalisation schemes were drawn up and assessed in the Study.

5.2.3 The option to build a fourth road harbour crossing would provide additional capacity to the cross-harbour traffic. However, it requires a long time from planning to construction which the congestion of tunnel crossings cannot be addressed in short to medium terms. Identification of land is also required in order to choose a suitable landing point for the fourth tunnel to effectively divert the traffic. This subject should be studied separately in other studies such as the "Strategic Studies on Railways and Major Roads beyond 2030".

5.3 Identification of the recommended toll rationalisation scheme

5.3.1 At present, private cars, taxis and motorcycles constitute about 75% of the total traffic volume of RHCs. These types of vehicles are not efficient road users considering that they are private in nature and can carry only a few passengers. Franchised buses are efficient road carriers as they carry large number of passengers. They are running on fixed routes, and thus their choice of RHCs will not be affected by their toll level. Goods vehicles tend to be inelastic to toll changes since tunnel tolls form a very small part of the total value of carrying out their business, and they generally have a contribution to benefits of the economy. As a result, the Study recommends focusing on better distribution of cross-harbour traffic movements of private cars, taxis and motorcycles via toll rationalisation.

Stage 1

5.3.2 As an initial stage, the following list of toll schemes for both the RHCs and land tunnels was drew up to gauge the possible changes in traffic demands under different levels of tunnel tolls -

(a) All EHC tolls will be the same as CHT tolls with no change at WHC
(b) All CHT tolls will be the same as EHC tolls with no change at WHC
(c) Car and taxi tolls at both CHT and EHC will be $40 and $25 respectively with no change at WHC
(d) Two variant schemes of car, taxi and goods vehicle tolls at both CHT and EHC with no change at WHC: the GV tolls set to existing CHT or EHC level
(e) Same as (d), but with LRT increased to $20 for car and taxi.
(f) Same as (d), but with LRT increased to $20 for car and taxi, and TCT goods vehicle tolls dropped to $8
(g) Tolls of CHT and WHC set to existing EHC levels
(h) Same as (g), but with car tolls of CHT and EHC set to $40
(i) Same as (g), but with car tolls of CHT and EHC set to $40, and EHC goods vehicle tolls set to CHT levels
(j) TCT levying a flat toll equal to LRT toll ($8), with no changes at other tunnels
(k) Car and taxi tolls of LRT increased to $20, with no changes at other tunnels
(l) LRT tolls will be the same as TCT

5.3.3 The toll schemes incorporating the views collected in the public consultation were added to the foregoing list to increase the spectrum of toll levels. With the transport models developed in this Study, traffic forecasts were made for all the schemes and the results were compared against that of the Baseline case for developing potential toll rationalisation schemes. The findings of the aforementioned analysis are summarised below.

5.3.4 It was found that toll schemes with reduced tolls at either CHT or EHC performed very badly, resulting in drastic increase in traffic queues and journey times at one or both of the tunnels. They were therefore discarded from further consideration.

5.3.5 Some schemes would improve traffic conditions at CHT through diverting traffic demand to WHC, while some would worsen the queuing situation at EHC. The analysis results show that the optimum level for CHT toll for private car to divert to WHC would be in the order of $40, and EHC private car toll should increase with an increase in CHT toll to avoid CHT traffic switching to use EHC and worsening its congested situation during peak hours. The results also indicate that raising the private car toll of CHT and EHC to a level beyond $40 would result in a slight reduction in their traffic demand.

5.3.6 Traffic analysis results revealed that a high proportion of trips using the RHCs or land tunnels, or both, would involve long-distance travel and motorists making those trips would consider a reduction of travel time an important factor besides toll when deciding on using which tunnel. Motorists choosing WHC, especially after the opening of CWB, would do so for its connecting roads permitting high traffic speed despite its high toll level. Reducing WHC tolls to the same levels as CHT and EHC would attract traffic from these two tunnels and would lengthen the traffic queue, causing problems to non-tunnel traffic on the WHC connecting roads to Central

Kowloon in the AM peak and to Sai Ying Pun/Kennedy Town in the PM peak. At the same time, reduction of WHC tolls would generate additional traffic demand, resulting in small reduction of traffic at CHT and EHC.

5.3.7 Traffic demand of goods vehicles were found to be largely inelastic with regard to toll charges, since the tunnel tolls form a very small part of the total transport costs. Traffic analysis results showed that goods vehicle travel demand would not change significantly as a result of toll adjustments. In addition, raising goods vehicle tolls will increase the transport costs of the community. Hence, the Study did not consider any changes in goods vehicle tolls.

5.3.8 For the land tunnels, only those travelling from the most northern parts of the Northeast New Territories ("NENT") have the opportunity to avoid traffic queues at the three land tunnels by selecting Route 3 to Kowloon, Hong Kong Island or Lantau Island. For the southbound traffic coming from other parts of NENT, it will use Tolo Highway and will experience delay at Tai Po Road (Shatin Section) near New Town Plaza because of high traffic demand and reduced road capacity due to heavy cross-weaving of traffic. The foregoing road section is the bottleneck to the traffic using R8K, making it not a viable alternative to TCT and LRT. To remove the foregoing bottleneck, a road-widening project, planned to complete in 2023, is being undertaken to increase the road capacity of Tai Po Road (Shatin Section) and reduce its high cross-weaving traffic.

5.3.9 For reasons as discussed above, the Study found that none of the alternative land tunnel tolling schemes would produce significantly better results than the existing tolls. As a result, the existing land tunnel tolls were taken forward to the next stage of the analyses.

Stage 2

5.3.10 Based on the above findings, a more refined set of toll schemes were considered based on their forecasts and subsequent traffic analysis. These schemes were centered around those that had been found to work best in Stage 1 -

(a) Setting motorcycle, car and taxi tolls to \$16, \$40 and \$20 respectively for CHT and EHC with all other tolls unchanged, and WHC tolls same as the Baseline case.
(b) Same as (a), but with motorcycle, car and taxi tolls set to \$21, \$55 and \$44 for WHC
(c) Same as (a), but with motorcycle, car and taxi tolls set to \$20, \$50 and \$36 for WHC
(d) Same as (a), but with motorcycle, car and taxi tolls set to \$18, \$45 and \$28 for WHC
(e) Same as (a), but with motorcycle, car and taxi tolls set to \$16, \$40 and \$20 for WHC
(f) Setting motorcycle, car and taxi tolls to \$16, \$35 and \$18 respectively for CHT, EHC and WHC with all other tolls unchanged
(g) Setting motorcycle, car and taxi tolls to \$16, \$35 and \$20 respectively for CHT and EHC, and WHC motorcycle, car and taxi tolls set to \$20, \$50 and \$36 respectively

(h) Same as (g), but with car tolls set to $30 for CHT and EHC
(i) Setting motorcycle, car and taxi tolls to $16, $30 and $20 respectively for CHT and EHC, and WHC motorcycle, car and taxi tolls set to $16, $40 and $20 respectively

5.3.11 Based on the transport model results of the foregoing schemes, seven toll scenarios, as shown in **Table 5.2**, were shortlisted for detailed analysis. **Table 5.2** also summarises the key modelled results of the toll schemes, viz. total peak hour demand of the three RHCs, traffic queue length at EHC and CHT, the number of junctions released for non-tunnel traffic and the number of junctions that non-tunnel traffic will be affected due to the toll scheme..

Table 5.2: Traffic Situations under Different Toll Levels at the RHCs

Toll level in terms of private car	Peak hour demand (veh/hr)		Traffic queue length (km)		No. of traffic junctions released	No. of traffic junctions newly affected
(WHC/CHT/EHC)	AM	PM	AM	PM	AM &PM	AM &PM
Baseline	12,500	12,100	9.7	7.6	-	-
$50/$20/$25	12,900	12,500	9.5	7.0	3	2
$50/$30/$30	12,800	12,300	9.0	6.1	7	3
$50/$35/$35	12,700	12,200	8.3	5.5	8	3
$50/$40/$25	12,800	12,300	8.3	5.6	9	4
$50/$40/$40	12,500	12,000	7.1	4.7	10	0
$40/$40/$40	12,700	12,200	4.8	3.4	12	4

5.3.12 The terminology used in **Table 5.2** is as follows:

(a) Peak hour demand – the total peak hour demand of the three RHCs
(b) traffic queue lengths – the total length of the traffic queues on the connecting roads to EHC and CHT;
(c) no. of traffic junctions released – the traffic junctions that non-cross-harbour traffic will not be obstructed by cross-harbour traffic queue upon the implementation of the concerned toll scheme, as compared with the baseline scheme; and
(d) no. of traffic junctions newly affected – the traffic junctions that non-cross-harbour traffic will become obstructed by cross-harbour traffic queue upon the implementation of the concerned toll scheme, as compared with the baseline scheme.

5.3.13 It was found that at a car toll of $40 would achieve pushing away sufficient car trips from CHT and EHC to WHC so that the CHT and EHC traffic queues would reduce substantially. Mild increase of CHT and EHC tolls will not be effective in encouraging motorists to use WHC. It was also found that the EHC car toll should be set to the same level of $40 as CHT to prevent the diversion of CHT car trips to EHC as well as to WHC. At the same time, the differential in car toll of CHT and EHC against WHC should be small enough to encourage CHT traffic to divert to WHC, thus sparing road space for EHC car traffic to shift to CHT. In other words, if the toll differential between CHT/EHC and WHC is large, CHT car users will not tend to use WHC but will use EHC instead because CHT tends to be more congested than EHC but both tunnels will charge the same car toll. This would cause traffic queues on the EHC connecting roads to be longer than the Baseline situation.

5.3.14 It was found that the WHC car toll should be reduced to $50 to achieve an effective pulling effect for diverting CHT and EHC car trips to WHC. However, it was also found that further reduction of WHC car tolls to levels below $50 would tend to divert too much traffic to WHC from CHT and would cause problems to non-tunnel traffic on the WHC connecting roads to Central Kowloon in the AM peak and to Sai Ying Pun/Kennedy Town in the PM peak. At the same time, the corresponding reduction in CHT and EHC car demand would shorten the traffic queues on their connecting roads but the reduction would not be significant in alleviating the congestion to the non-tunnel traffic on the roads.

5.3.15 Table 5.2 shows that some of the toll schemes should not be pursued because some traffic junctions will be affected by the lengthening of EHC/CHT traffic queue arising from the toll schemes. Even though the $40/$40/$40 scheme will achieve a shorter traffic queue at EHC/CHT as compared with the $50/$40/$40 scheme, the former will be newly-affected traffic junctions and increased traffic demand during the peak hours.

5.3.16 In view of the above, car tolls of $40 at CHT and EHC, and $50 at the WHC were considered the optimal levels, achieving an effective re-distribution of traffic from CHT to WHC, freeing up road capacity of CHT to accommodate diverted traffic from EHC which would otherwise observe further overloading of tunnel traffic, hence causing further adverse impact to the connecting roads in its vicinity. In the same vein, motorcycle tolls of $16 at CHT and EHC, and $20 at the WHC; and taxi tolls of $20 at CHT and EHC, and $36 at the WHC were recommended.

5.4 Time-Varying Tolling

Tolls varying on weekdays

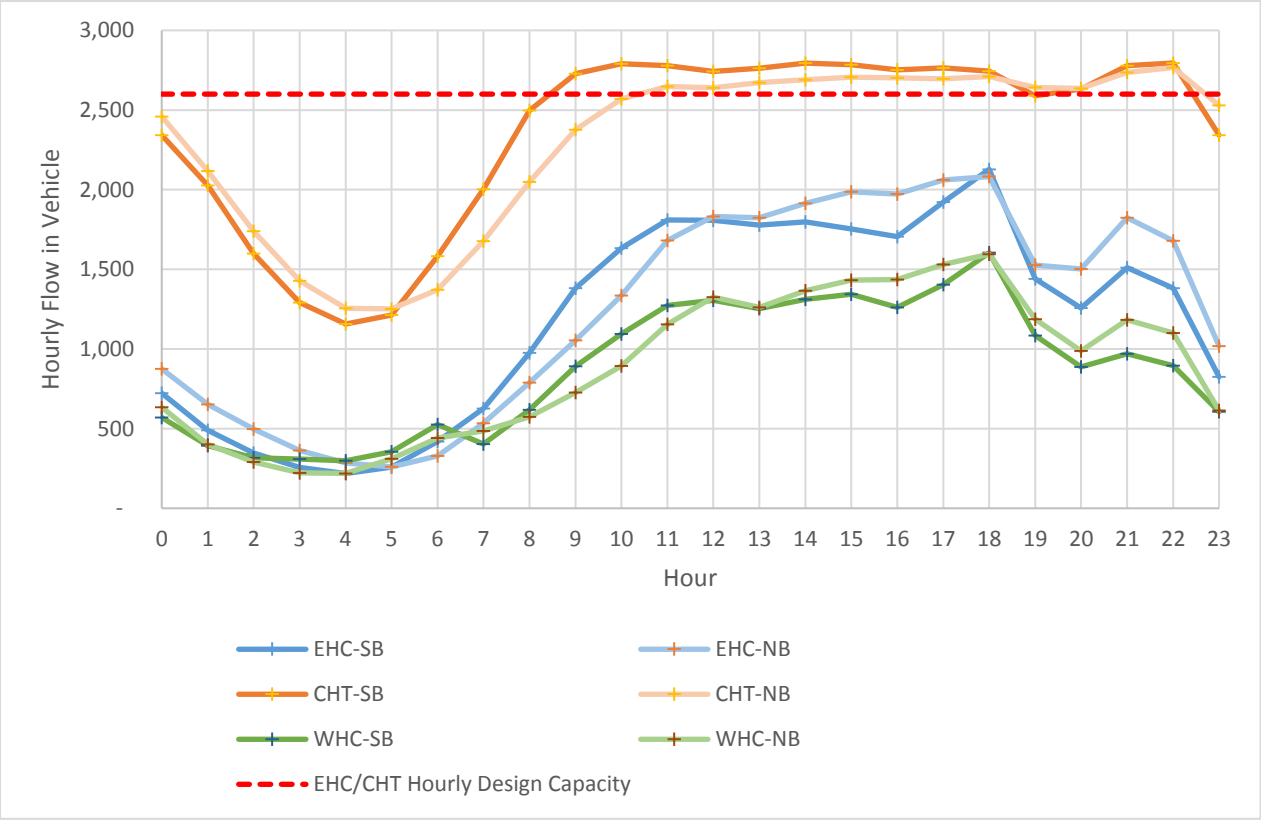
5.4.1 As traffic congestion associated with peak travel demand may not occur during other time periods such as inter-peak or off-peak, the idea of varying tunnel tolls by the time of the day would be justified from the point of view of traffic demand management. However, a sudden, substantial change in tolls would cause safety and operational problems. In Singapore, in the early days of road pricing in the central area, vehicles were found slowing down or waiting for the time-varying toll to reduce and they caused road blockage and congestion. At the same time, vehicles were also found to speed up to reach the tolling point before tolls were raised. These caused safety issues to the traffic reaching the tolling point. Hence, it is desirable for toll changes to be

made at several small increments over a well-defined period. This is not practicable with the existing toll facilities at the moment, but could be further explored with future progress in toll collection methodologies. Hence, this Study did not consider time-varying tolling on weekdays.

Tolls varying on Sundays and general holidays

5.4.2 An analysis of the daily traffic profile at the RHCs for Sundays and general holidays are shown in **Figure 5.1**. At car toll level of $40 for CHT and EHC, and $50 for WHC, the cross-harbour traffic demand will be similar to the existing situation. In particular, CHT will be operating above its design capacity from 9am to 11pm while EHC will also be close to saturation from noon to 7pm. Therefore, there will not be any scope for reducing the car toll at CHT or EHC on Sundays and general holidays because any toll reduction will tend to induce additional traffic demand that will overload CHT and EHC.

Figure 5.1: 2017 Observed Hourly Flows at the RHCs on Sundays & General Holidays

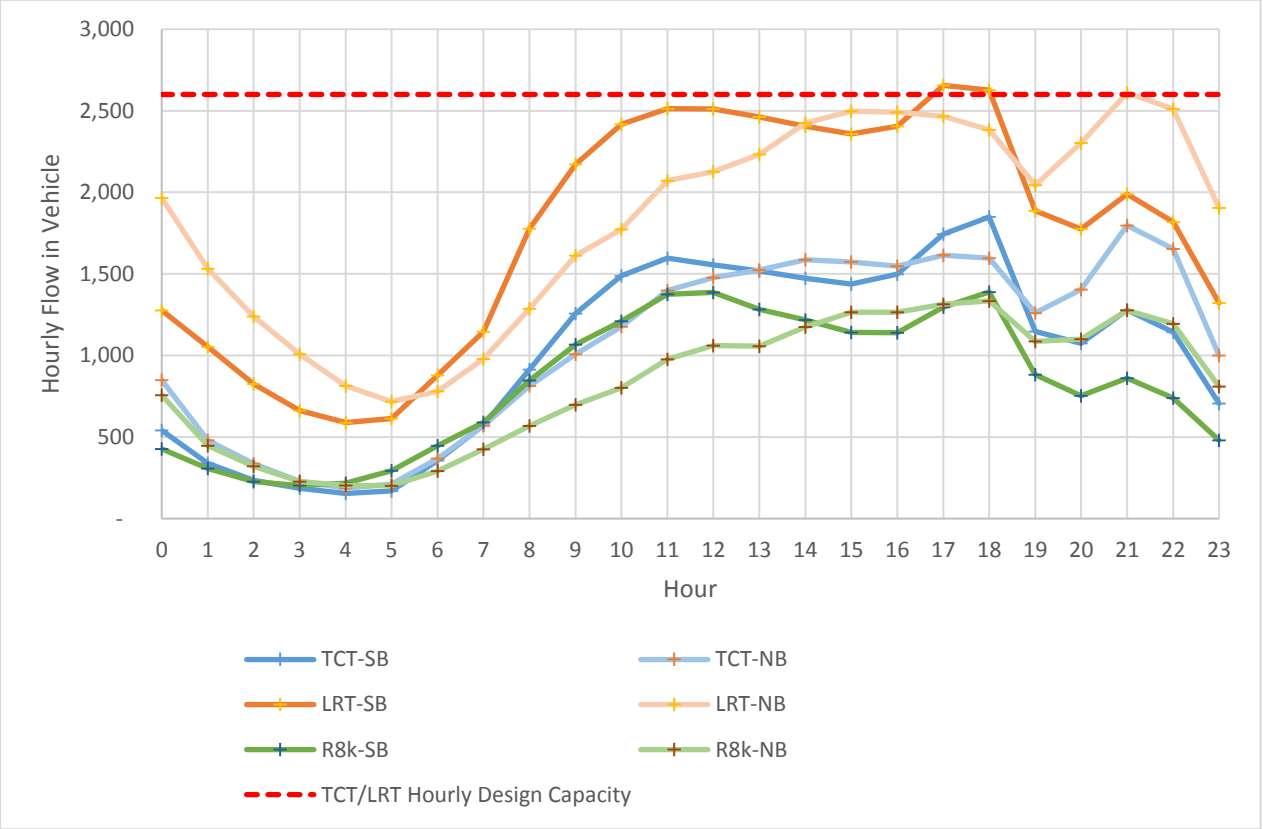


5.4.3 Existing observed daily traffic profile at the land tunnels for Sundays and general holidays are shown in **Figure 5.2**. Average traffic flows for LRT southbound and northbound from 10am to 10pm are about 2,400 and 2,300 vehicles/hour respectively. The traffic flow recorded is close to the hourly design capacity of 2600 vehicles. During the peak hours, LRT traffic flow observed is over the design capacity. On the

contrary, average traffic flows at both directions of TCT from 10am to 10pm are about 1,500 vehicles/hour and are far below the design capacity.

5.4.4 Noting that Sunday traffic level varies more gently during different times of the day than weekdays and displays less severe peak traffic situations, there may be scope for setting lower tunnel tolls for Sundays and general holidays than weekdays. It was found that the road capacity of TCT would be able to cope with the diversion of LRT and TCT traffic on Sundays and general holidays if a flat of $8 – the same as R8K and LRT – is set. This will lead to an improved traffic situation for the land tunnels. In comparison, it was found that the traffic demand for EHC during Sundays and general holidays would be too high for considering any lowering of tunnel tolls.

Figure 5.2: 2017 Observed Hourly Flows at the Land Tunnels on Sundays & General Holidays



5.5 Recommended toll rationalisation scheme

5.5.1 Based the traffic analyses of the toll schemes described above, it was concluded that a scheme with car tolls set at $40/$40/$50 for EHC, CHT and WHC respectively, with corresponding motorcycle and taxi tolls would give the best results in rationalising the traffic demands at the RHCs. Also in this case, it is proposed that empty taxi tolls should be set at $15 for all the three RHCs to rationalise the empty taxi demand for the RHCs.

5.5.2 Taxi trips were found to be less elastic with regard to toll charges, since the VoT for taxi trips is significantly higher than that of car trips. The comparatively inelasticity of taxi trips to toll is more evident in the peak hours of RHC traffic. The market shares of WHC for RHC taxi demand are 44% and 32% for the peak and daily respectively. The market shares of WHC for car traffic in the peak and daily are about 32% and 29% respectively. In addition, it was found that taxi only contributes to 14% of total RHC traffic in the peak whereas the market share of car is 55%. Also, taxis are providing a public transport service for movements that usually cannot be accomplished in any other way, and their usage should be promoted over the use of car. Therefore, cross-harbour movements taxi tolls have been set lower than car tolls. Nevertheless, with the proposed $20 toll at CHT/EHC and $36 at WHC, the difference of taxi tolls between using WHC and EHC/CHT will be $16 which is still higher than the toll difference of $10 between using WHC and EHC/CHT for car. This change of toll difference shall be sufficient to divert taxi traffic from CHT/EHC to WHC.

5.5.3 The recommended toll scheme is shown in **Table 5.3**. For 2021, no changes were recommended for the land tunnels apart from the flat toll for TCT on Sundays and general holidays.

Table 5.3: Recommend Toll Scheme for 2021

Car Type	Recommended Toll Scheme					
	EHC	CHT	WHC	TCT	LRT	R8K
Motorcyles	$16	$16	$20	$15	$8	$8
PC	$40	$40	$50	$20		
Taxis (with passengers)	$20	$20	$36	$20		
Taxis (w/o passengers)	$15	$15	$15	$20		
PLB	$38	$10	$80	$23		
Private LB	$38	$10	$80	$24		
Light GV	$38	$15	$80	$24		
Medium GV	$50	$20	$105	$28		
Heavy GV	$75	$30	$135	$28		
PB (SD)	$50	$10	$130	$32		
PB (DD)	$75	$15	$185	$35		

Note: the proposed new tolls are underlined

6 ASSESSMENT OF THE RECOMMENDED TOLL RATIONALISATION SCHEME

6.1 Traffic demand forecast

6.1.1 **Table 6.1** shows the traffic demand forecasts for the RHCs and land tunnels in the 2021 recommended scheme case. Compared with the Baseline case, total daily traffic at WHC is increased by about 34,000 vehicles. Most of the increased traffic at WHC has been diverted from CHT. The daily traffic at CHT and EHC is reduced by 30,100 and 3,600 vehicles/day respectively.

Table 6.1: 2021 Toll Scheme Traffic Forecasts (Vehicles)

Scenario	Demand	EHC	CHT	WHC	Total RHC	TCT	LRT	R8K	Total Land Tunnels
2021 Baseline	Daily	85,800	114,900	76,300	**277,000**	66,900	98,300	64,500	**229,700**
	AM SB	3,600	4,500	4,400	**12,500**	3,600	3,600	4,200	**11,400**
	PM NB	3,700	4,300	4,100	**12,100**	3,300	3,800	3,400	**10,500**
2021 Scheme	Daily	82,200	84,800	110,300	**277,300**	66,200	96,300	67,100	**229,600**
	AM SB	3,500	3,900	5,100	**12,500**	3,600	3,500	4,300	**11,400**
	PM NB	3,500	3,700	4,800	**12,000**	3,300	3,700	3,500	**10,500**

6.1.2 The change of RHC traffic confirms two major considerations set for the toll scheme development:

- In order to take advantage of the spare capacity of WHC, it will be necessary to change the balance of tolls between the RHCs. At the moment the very low CHT tolls, combined with its central location, attract the greatest amount of traffic. By increasing CHT car toll from $20 to $40, it effectively increases the generalised costs of the trips using CHT and encourages those trips to use other alternative paths.
- The EHC traffic has to be carefully handled but there is no spare capacity at EHC to accommodate any diversion of CHT traffic. The high WHC tolls are currently pushing traffic to the other two tunnels and would continue to do so after the opening of the CWB, thereby partially nullifying its benefits. By applying the same magnitude of toll increase at EHC as CHT, most of the traffic diverted from CHT will go to WHC, and not EHC.

6.1.3 The results also indicate the natural pairing effect between the harbour crossings and the land tunnels. Traffic demand for LRT is reduced by 2,000 vehicles/day while R8K is increased by 2,600 vehicles/day. The change of traffic at the land tunnels, however, is minimal.

6.2 Traffic analysis

6.2.1 The queues and journey times for 2021 under the scheme toll assumptions are shown in **Table 6.2** for the AM Peak and PM Peak, in comparison with the Baseline case. The locations of the queues are shown in **Appendix B** and in comparison with the queues resulting from the Baseline scheme.

Table 6.2: Traffic Queue Lengths and Journey Times – Scheme Case

Scenario	AM Southbound Queue Length (m) and Journey Time (min)						PM Northbound Queue Length (m) and Journey Time (min)					
	EHC	CHT	WHC	TCT	LRT	R8K	EHC	CHT	WHC	TCT	LRT	R8K
2021 Baseline	1,300	2,900	-	1,900	2,200	-	1,200	2,300	-	1,600	1,600	-
	14	31	3	26	19	5	15	33	3	16	13	5
2021 Scheme	1,200	2,100	1,400	1,900	1,900	-	900	1,200	1,000	1,600	1,400	-
	14	24	10	26	18	5	13	27	8	16	12	5

6.2.2 CHT queue lengths will substantially reduce by 800m and 1,100m in the AM peak southbound and PM peak northbound traffic. Traffic queues at the EHC in AM peak southbound and PM peak northbound traffic will shorten by 100m and 300m respectively. Traffic queues at the WHC will lengthen and reach 1,400m and 1,000m in the AM and PM peaks respectively.

6.2.3 Traffic queues on the WHC connecting roads start to affect non-tunnel traffic under the peak of the peak situation. At westbound of Rumsey Street Flyover during PM peak, the 1,000m queues will interfere the non-tunnel traffic going to Kennedy Town under such circumstances.

6.2.4 It was found in the scheme results that the optimum level for CHT tolls for private cars at $40. If same car toll is set at EHC, there will not be any net diversion of car traffic from CHT to EHC so the EHC queues will not change. However, the freed capacity at CHT will attract commercial vehicles from EHC to CHT. In summary, the scheme improves conditions at CHT as well as EHC though to a lesser extent, while at the same time does not extend WHC queues to worsen the non-tunnel traffic.

6.2.5 The queue length at LRT is marginally reduced while there is a minimal change of traffic queue at TCT.

6.3 Potential Social Benefits

6.3.1 Road pricing analysis suggests that savings in travel time and related resources could be achieved if drivers are directed to travel along minimum marginal time routes. Equivalently, tolls based on the difference between marginal and average travel times might induce drivers to shift to routes closer to a societal optimal. Therefore, it calls for an economic evaluation exercise in order to assess the benefits of the toll scheme based on a system optimal objective.

6.3.2 In this Study, a preliminary assessment was undertaken on the user benefit estimate of the recommended toll rationalisation scheme by comparing the forecast traffic results of the scheme with those of the Baseline case. The essential measure of benefits to users is consumer surplus, that is, the excess of consumers willing to pay over the cost of a trip in reaction to the implementation of the recommended toll rationalisation scheme.

6.3.3 **Figure 6.1** shows the general principle of economic analysis for transport system. To measure the change of transport costs between the Baseline and Scheme cases, the 'rule of half' was adopted to estimate the Consumer Surplus, which assumes implicitly that there is a linear relationship between the cost of travel and demand.

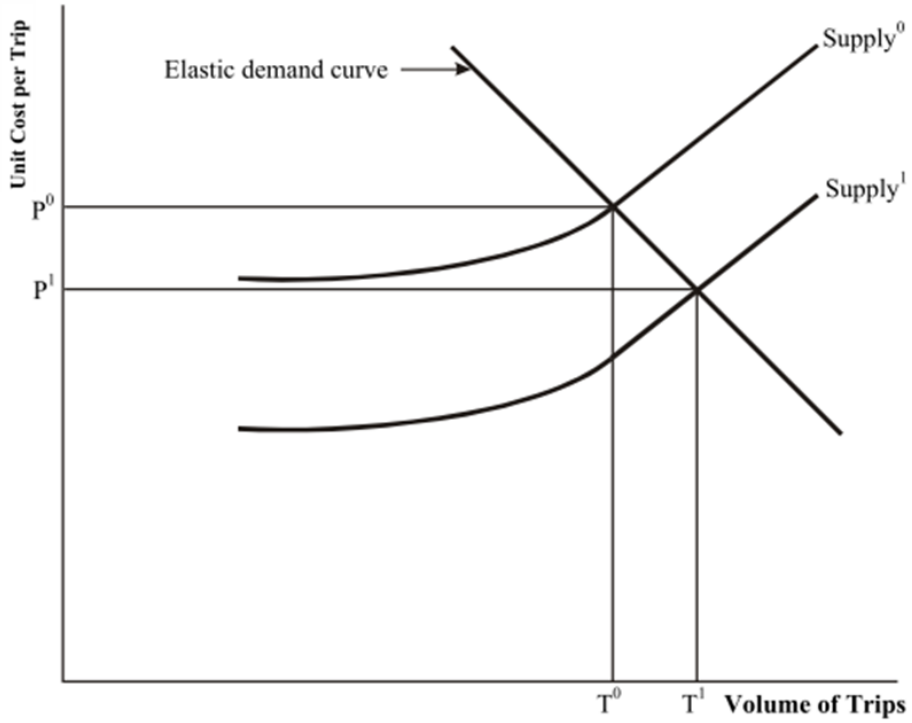
*Consumer Surplus = (change in cost * do-minimum demand) + (half change in costs * change in demand)*

$$= (P^0-P^1)*T^0+½(P^0-P^1)*(T^1-T^0)$$

$$= ½ (T^0+T^1)*(P^0-P^1)$$

where Pi is the perceived cost of travel (note that the superscript i is used to denote the scenario - 0 for Baseline case, 1 for Scheme case), and T is the number of travellers.

Figure 6.1: Measuring the Consumer Surplus for Transport Projects



Reference: TAG Unit 3.5.3 (Transport User Benefit Calculation), Department for Transport, UK

6.3.4 Zone to zone (Origin to destination) traffic demand and costs from the model runs for Baseline and Scheme cases are extracted to compare. The generalised costs were compared by type of costs – time cost and vehicle operation cost ("VOC"). **Table 6.3** shows the comparison of generalised costs between Baseline and Scheme cases.

Table 6.3: Comparison of Operation and Time Cost (Million HKD in 2017 price)

Scenario	VOC Annual Cost	VoT Annual Cost	Total Annual Cost
Baseline	20,178.7	47,011.7	67,190.3
Scheme	20,158.3	46,153.9	66,312.3
Scheme - Baseline	-20.3	-857.7	-878.1

6.3.5 Traffic analysis revealed that 16% of the people making cross-harbour trips (cars, MCs and taxis using WHC, and taxis using EHC) will pay less toll, 13% (cars and MCs using CHT and EHC, and taxis using CHT) will pay more and 71% (vehicles other than cars, MCs and taxis) will pay the same. With the toll rationalisation scheme, traffic at the CHT, EHC and their connecting roads will experience journey time savings of 19,400 hours on a weekday though the traffic diverted to WHC will result in some increase in journey time. It is worth noting that the time savings in CHT and EHC will be enjoyed by public transport and goods vehicle users whose toll remain unchanged in the recommended scheme. It was estimated that that public transport users of EHC would save 5,500 hours of journey time on a weekday.

6.4 Other Potential Benefits

6.4.1 For the recommended toll rationalisation scheme, further preliminary assessments were conducted in order to evaluate the performance of the toll scenario regarding the aspects other than traffic and economic benefits. The first assessment conducted was the environment assessment, which mainly focused on the emissions of Greenhouse Gases (i.e. carbon dioxide, CO_2) from vehicles to help understand the potential environmental benefits from the toll rationalisation scheme.

6.4.2 The approach for estimating the change of Greenhouse Gases emissions between the Baseline and Scheme cases is shown below.

Change of Emission = Saving in distance traveled from transport model runs

× Emission factors of greenhouse gases from Environmental Protection Department (weight of gases emitted per volume of fuel consumed)

× Energy Utilisation Index for different types of vehicles from Electrical and Mechanical Services Department (volume of fuel consumed per distance travelled)

6.4.3 The daily vehicle-kilometre ("vkm") saving for the recommended scheme comparing to the Baseline is about 23,000. The calculated CO_2 reduction, expressed annually, is about 3,800 tonnes in a year. This amount is equivalent to the carbon dioxide absorbed by more than 160,000 trees in a year.

7 CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

7.1.1 At present, private cars, taxis and motorcycles contribute to about 75% of the total traffic volume of the road harbour crossings. These types of vehicles are not efficient road users considering that they are private in nature and have a relatively low number of passengers to carry. For buses and minibuses, they are efficient road users as they carry higher number of passengers. They also have fixed routes and their choice of road harbour crossings would not be affected by toll levels. Other vehicles such as commercial vehicles are also inelastic to toll changes since the tunnel tolls form a very small part of the total value of carrying out their business, and they generally have a contribution to benefits of the economy. As a result, the Study recommends focusing on better distribution of cross-harbour traffic movements of private cars, taxis and motorcycles via toll rationalisation.

7.1.2 To make effective use of the spare WHC capacity, it will be necessary to change the balance of tolls between the RHCs in order to rationalise the tunnel traffic. At present, CHT with its tolls and centralised location, attracts the greatest amount of cross-harbour traffic. The EHC is congested during peak hours when its traffic demand exceeds its road capacity. Therefore, EHC does not have spare capacity to shoulder any traffic demand of CHT during peak hours but its road capacity can cope with its traffic demand during other times of the day. The high WHC tolls are pushing traffic to the other two tunnels and would continue to do so after the opening of the CWB, thereby partially nullifying its benefits. The traffic situations of CHT and EHC will worsen if the WHC tolls will be raised by its operator.

7.1.3 Traffic analysis results indicated that any toll schemes likely to achieve a desirable distribution and reductions in aggregate queue lengths will have to set CHT car toll much higher than at present in order to push some of that traffic away. Schemes which either keep, lower or not to increase CHT tolls considerably would not help to reduce the queues substantially. However, if only the CHT toll is to be increased, the queues at EHC would increase to unacceptable levels, blocking the Kwun Tong Bypass and causing serious congestion problems on the Island East Corridor. Therefore, it is also necessary to increase EHC tolls so that the traffic could be pushed from CHT to WHC rather than to EHC. Any schemes which do not increase the tolls of EHC would aggravate the current traffic congestion at EHC as well as its adjoining road network.

7.1.4 It was also found from the Study that in the test results the optimum level for CHT tolls for private cars was in the region of $40. Also, if same car toll is set at EHC, there will not be any net diversion of car traffic from CHT to EHC so the EHC queues will not change. The resultant effect will be pushing the CHT and EHC traffic to WHC.

7.1.5 Those who choose WHC, especially after the opening of CWB, will be doing it for its greater speed and the high level of toll is less important to them. Reducing WHC tolls to the same levels as CHT and EHC will attract too much CHT traffic and generate additional cross-harbour traffic demand. This will cause problems to non-tunnel traffic on access roads to Central Kowloon in the AM peak and to Sai Ying Pun/Kennedy Town and has to be avoided. The traffic analysis results show that

suitable reduction of WHC car toll to $50 will help pull marginal traffic from CHT and EHC.

7.1.6 The adjustments of the motorcycle tolls will follow the car tolls at the RHCs.

7.1.7 Taxi toll at the CHT should be increased to encourage taxi users to use EHC and WHC with the reduction in taxi tolls at EHC and WHC. Similar to the car toll, the taxi toll at CHT and EHC should be equal to avoid taxi trips diverting from CHT to EHC because of a toll differential. At the same time, taxi toll at WHC should be set to a level higher than that at CHT and EHC to avoid over-diversion of taxi trips.

7.1.8 The recommended toll scheme will improve conditions at CHT and help contain or shorten the queues at EHC, while at the same time do not induce WHC queues into neighbouring road network. The users of EHC and CHT, especially the daily 452,000 public transport passengers who are the majority, will enjoy time savings when traffic congestion in the connecting roads is alleviated. Reduction in traffic congestion will also help road users to plan better their trips with less fluctuations in their journey times, and to reduce making accelerations and decelerations during their journeys. Moreover, the recommended toll scheme will encourage motorists to make more direct routes and save their journey distance. This will reduce fuel consumption and tailpipe emissions, thus improving the environment.

7.1.9 Only those travelling from the most northern parts of the NENT have the opportunity to avoid traffic queues at the three land tunnels by selecting Route 3 to Kowloon and Hong Kong Island, and rather more if heading to Lantau Island. During the AM peak period, all of the others only have the choice of joining the queue on Tai Po Road (Shatin section) to reach R8K, or the queues to LRT or TCT. As a result, none of the alternative tolling schemes gave significantly better results than the existing tolls, as R8K cannot be an alternative to LRT and TCT.

7.1.10 The pairing effect between R8K and WHC will mean that as flows on WHC increase, more vehicles will choose to join the queue of Tai Po Road (Sha Tin section) which will give a very marginal benefit to LRT and TCT. Nevertheless, this marginal improvement may, in due course, attract more of the northern traffic from Route 3 and generate additional traffic demand currently suppressed by the congestion at LRT and TCT.

7.1.11 In the light of above constraints, rationalisation of traffic distribution among the three land tunnels by toll adjustment will not provide an effective solution for the time being. Therefore, no toll scheme for the three land tunnels is recommended, pending the expected completion of the widening works of Tai Po Road (Sha Tin Section) in 2023 which will resolve the capacity constraint to Route 8K.

7.2 Recommendations

7.2.1 The roads of Hong Kong are highly congested and the congestion problem is worsening. Much of the congestion in Kowloon and on the north shore of Hong Kong Island arises from the queues at the tunnel portals of the CHT. These extend far back from the tunnel itself and block other movements. The traffic growth is and will continue to take place, adversely affecting large and increasing numbers of traffic

movements, which should be managed and tackled to maintain Hong Kong's reputation as a world-class city.

7.2.2 It is recommended that Hong Kong can make the best use of its available highway infrastructure by implementing the Recommended Toll Rationalisation Scheme, in order to effectively rationalise the cross-harbour traffic and to give an overall benefits to the community. It is also advised that, for subsequent refinement of the scheme, the impact on cross-harbour traffic by the Recommended Scheme should be reviewed by traffic observations before and after the implementation once the change in traffic patterns have been stabilised with time.

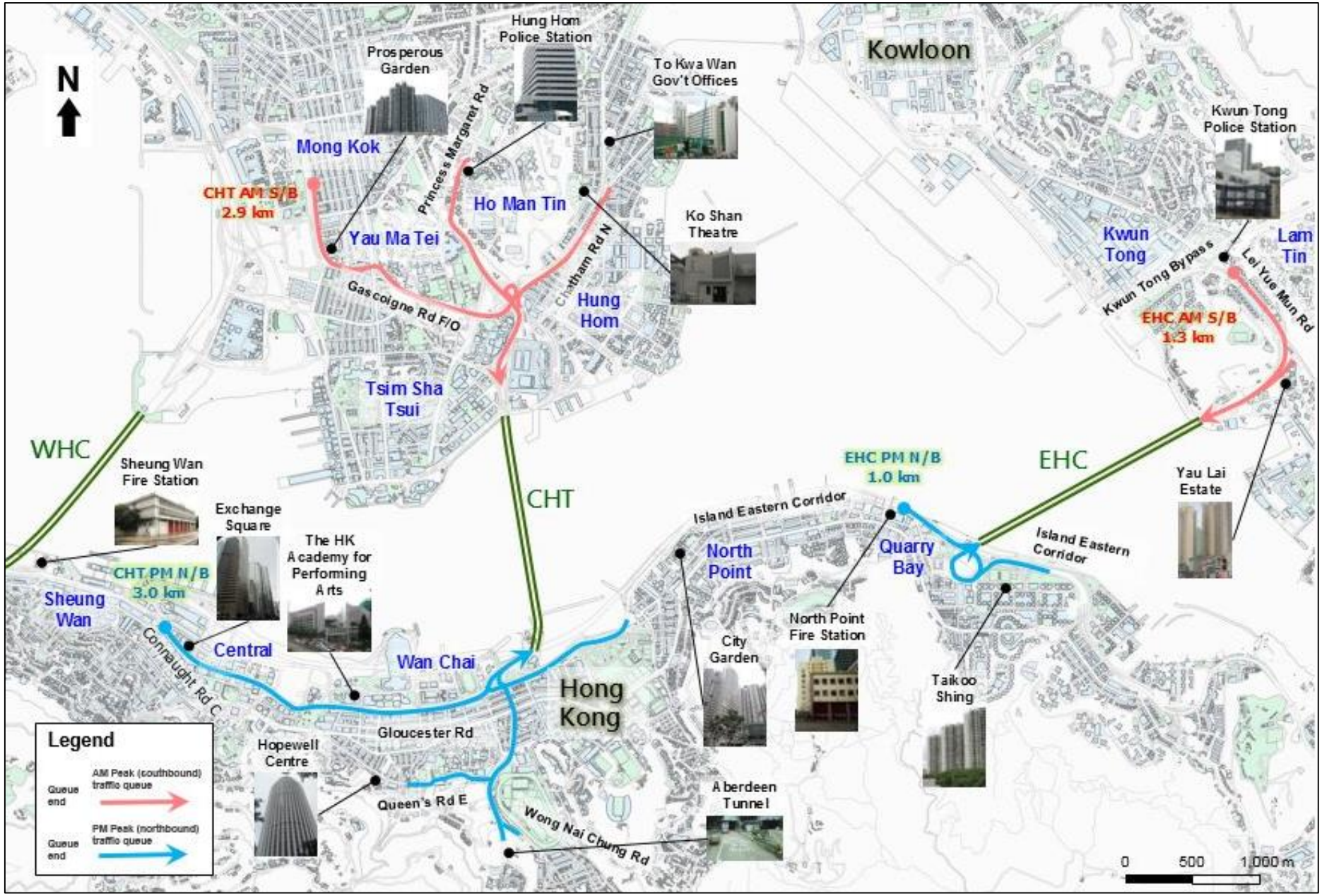
7.2.3 As mentioned earlier, there are advantages for varying the tolls by time during the day. However, due to the current toll collection methodologies available, only a unified toll can be applied throughout the day. The varying toll method could be applied by small incremental toll changes that could be made over extended periods, and this can only be done electronically. The details of such methodologies should be investigated and taken forward when the concept of electronic toll collection has been proven for implementation.

7.2.4 The widening works of Tai Po Road (Shatin section) will allow greater use of R8K and WHC. The tolling regimes of the land tunnels should be re-examined to dovetail with the completion of the widening works.

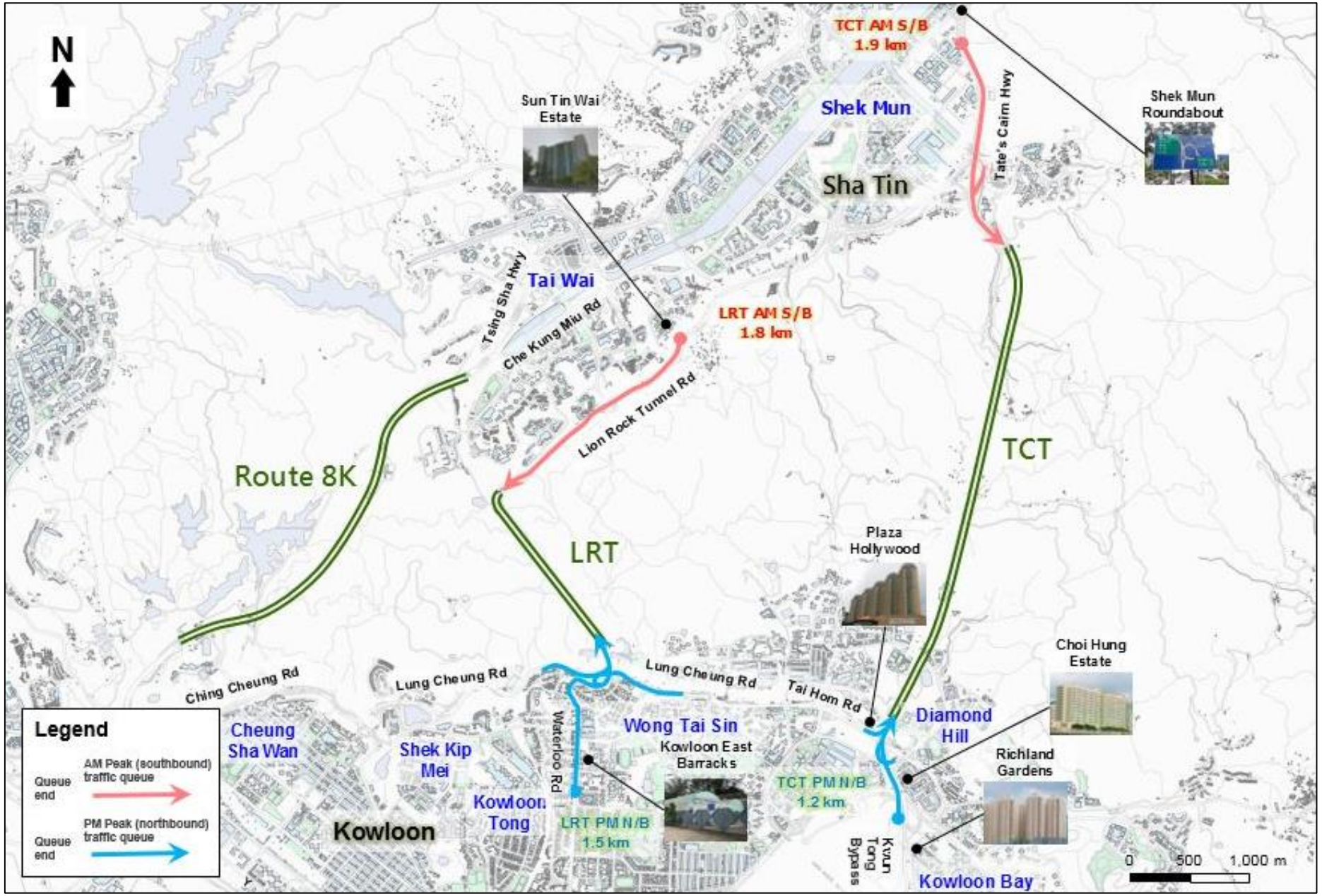
APPENDICES

Appendix A – Queuing Situation at the Approach Roads to the Tunnels – Existing Condition

APPENDIX A1- Existing traffic queues along connecting roads of the three Road Harbour Crossings

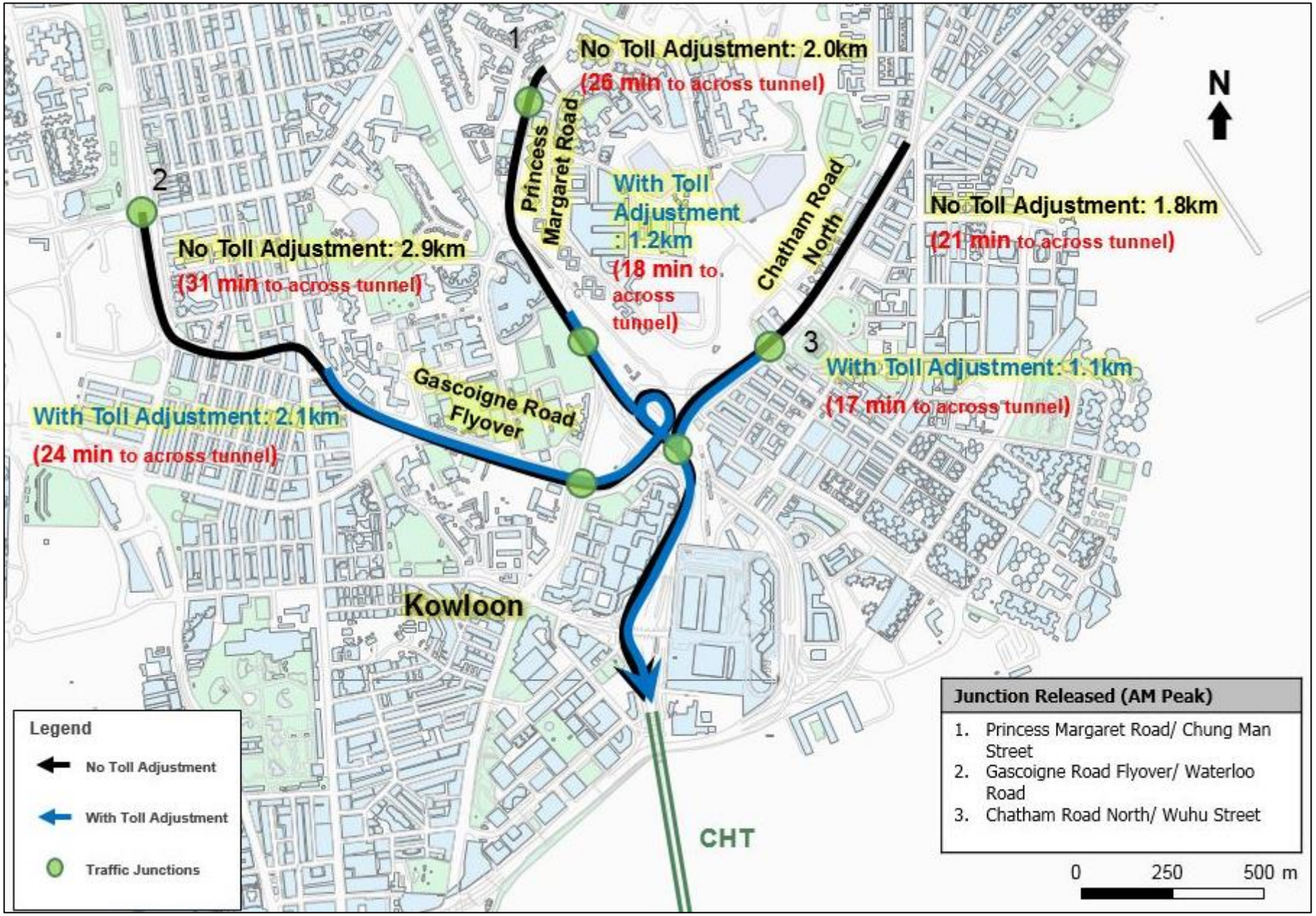


APPENDIX A2- Existing traffic queues along connecting roads of the three Land Tunnels

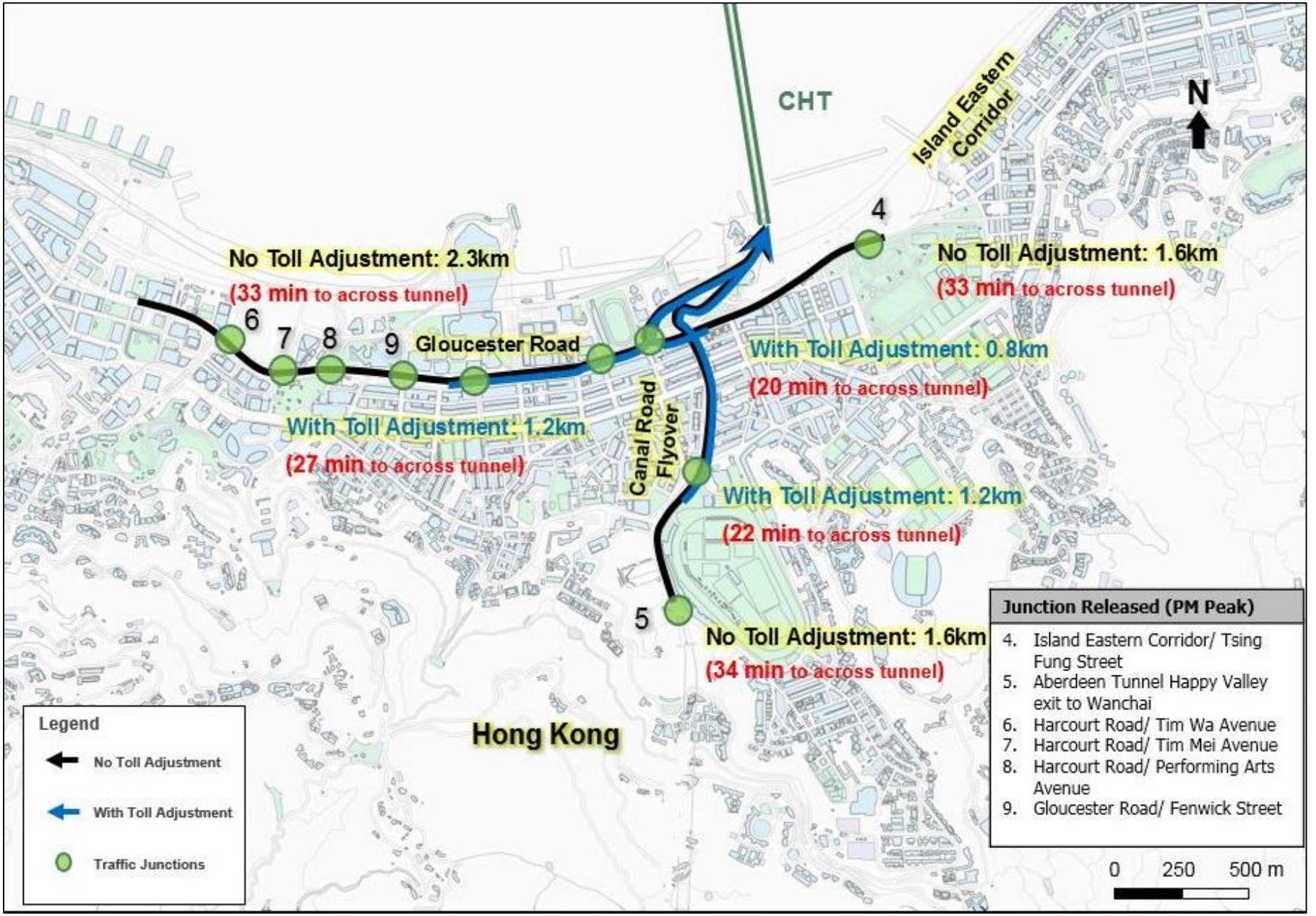


Appendix B – Queuing Situation at the Approach Roads to the Tunnels – Baseline and Scheme Conditions

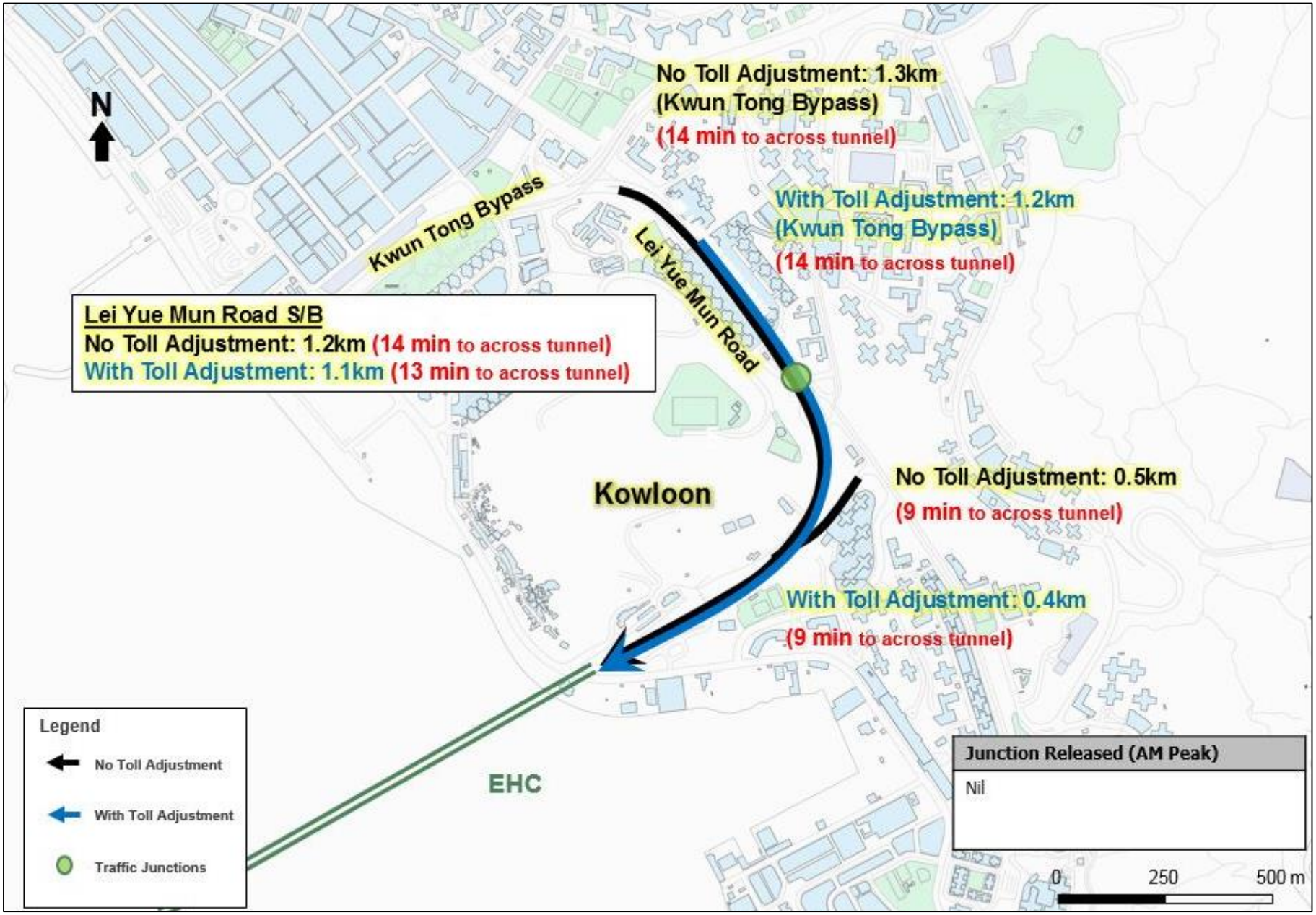
APPENDIX B1 - Forecast AM Peak (southbound) traffic queues along connecting roads of CHT in 2021



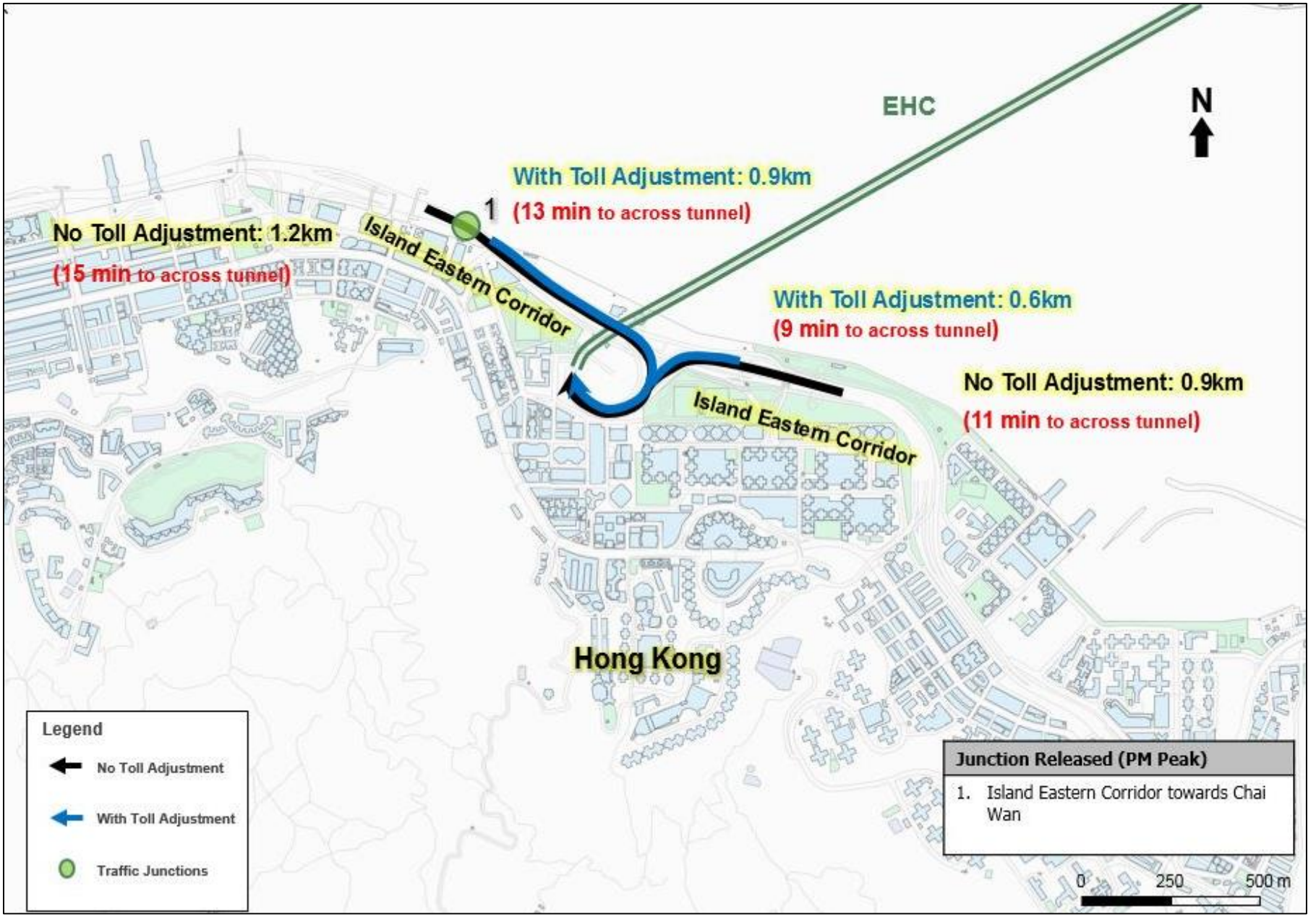
APPENDIX B2 - Forecast PM Peak (northbound) traffic queues along connecting roads of CHT in 2021



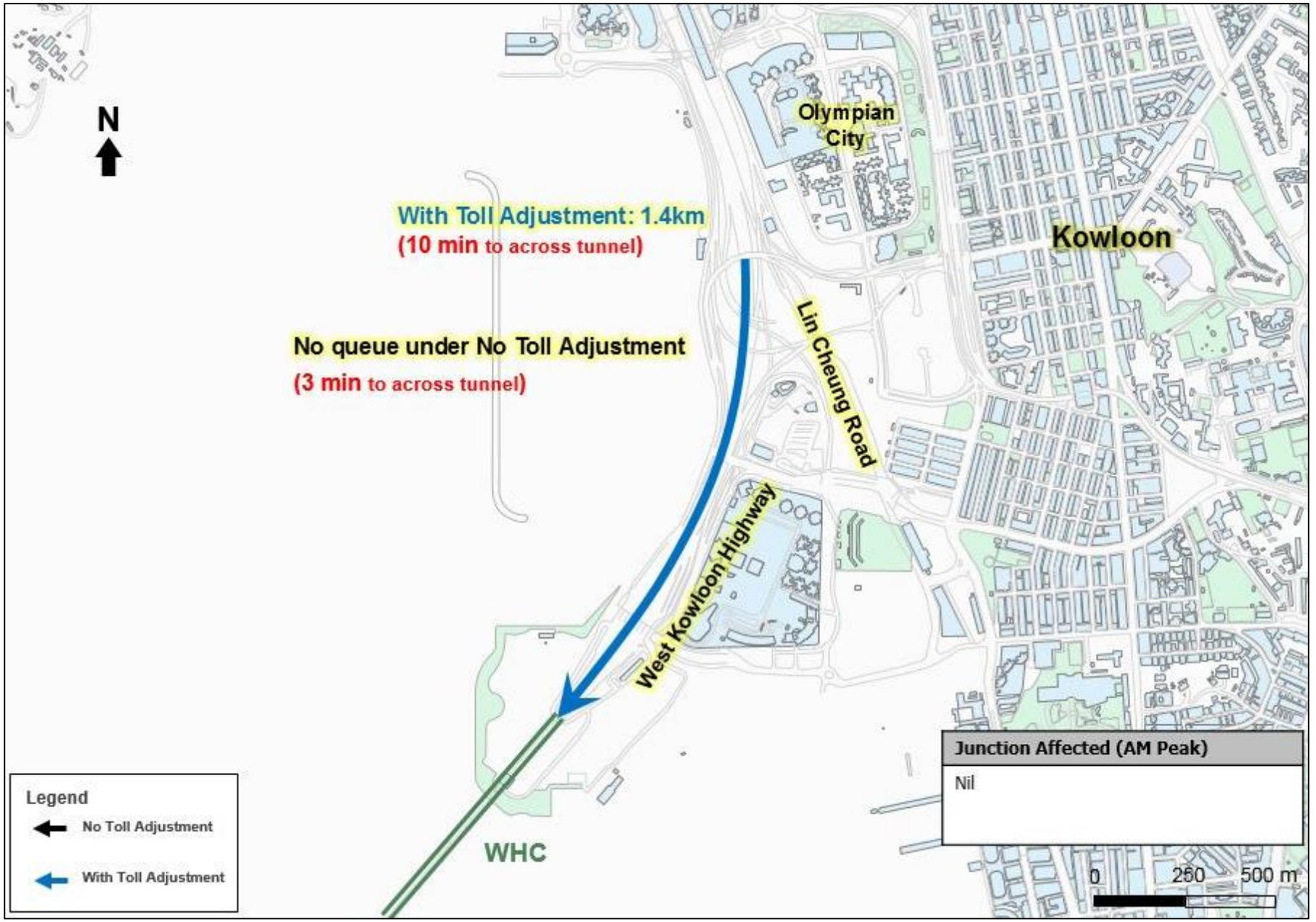
APPENDIX B3 - Forecast AM Peak (southbound) traffic queues along connecting roads of EHC in 2021



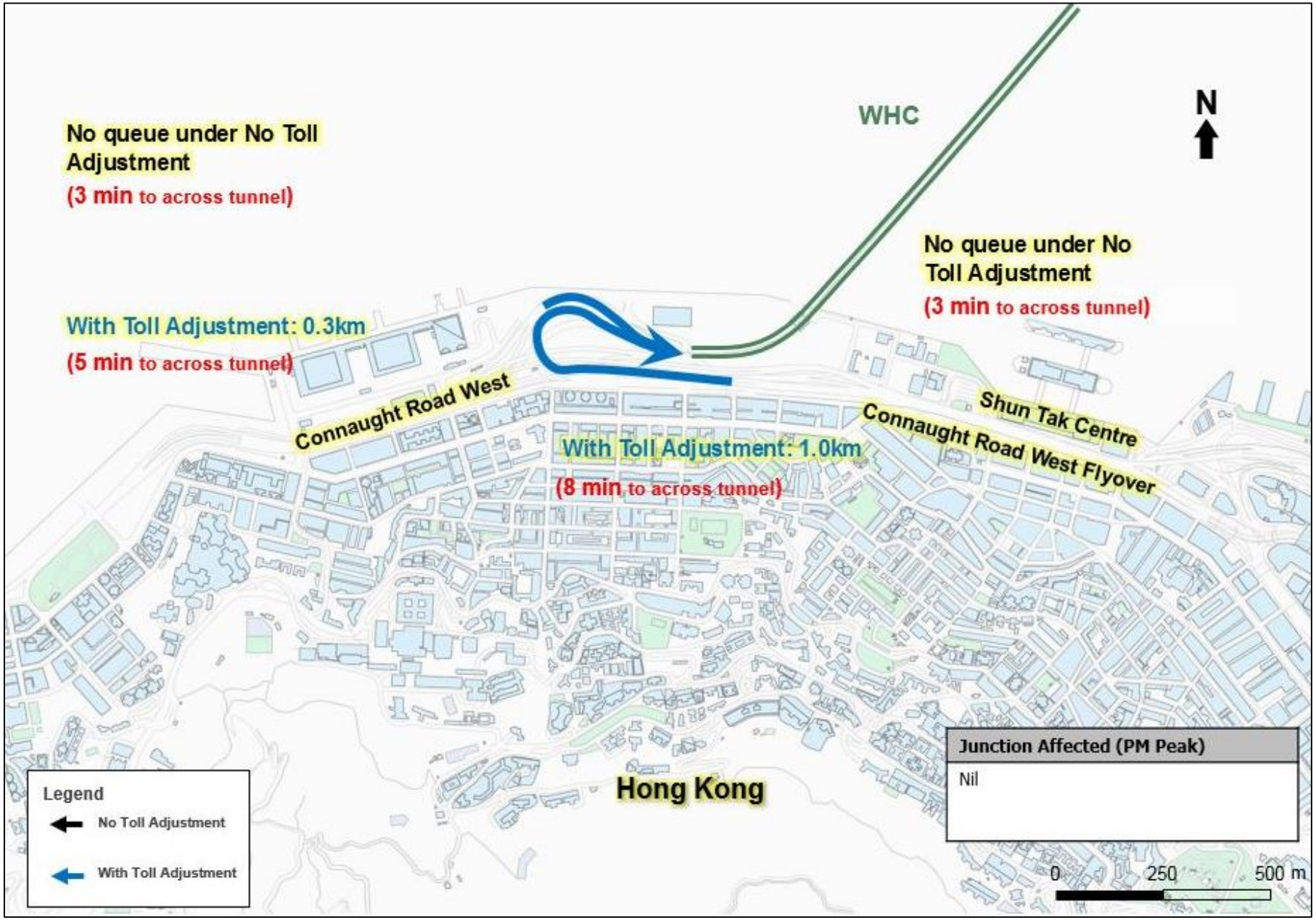
APPENDIX B4 - Forecast PM Peak (northbound) traffic queues along connecting roads of EHC in 2021



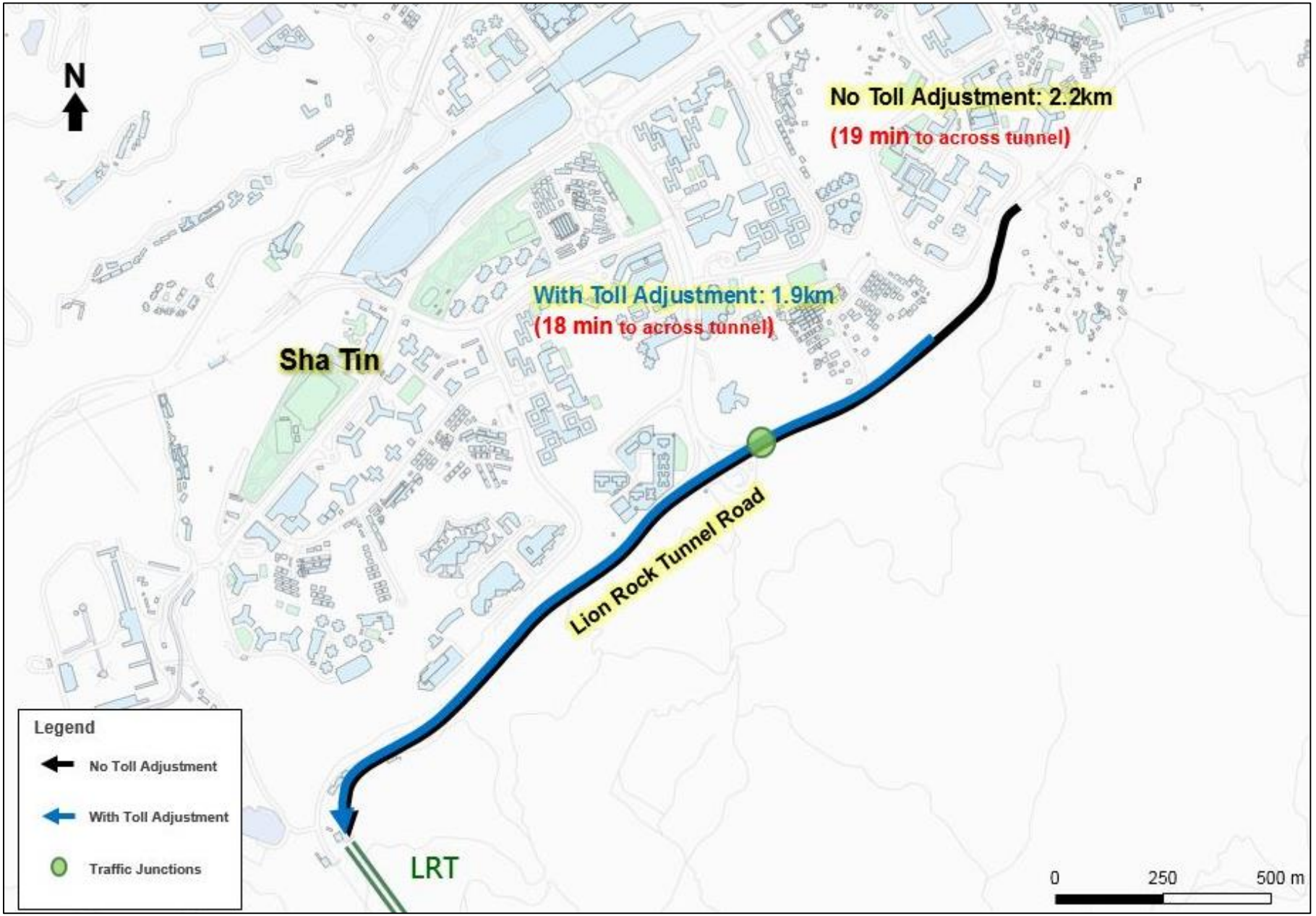
APPENDIX B5 - Forecast AM Peak (southbound) traffic queues along connecting roads of WHC in 2021



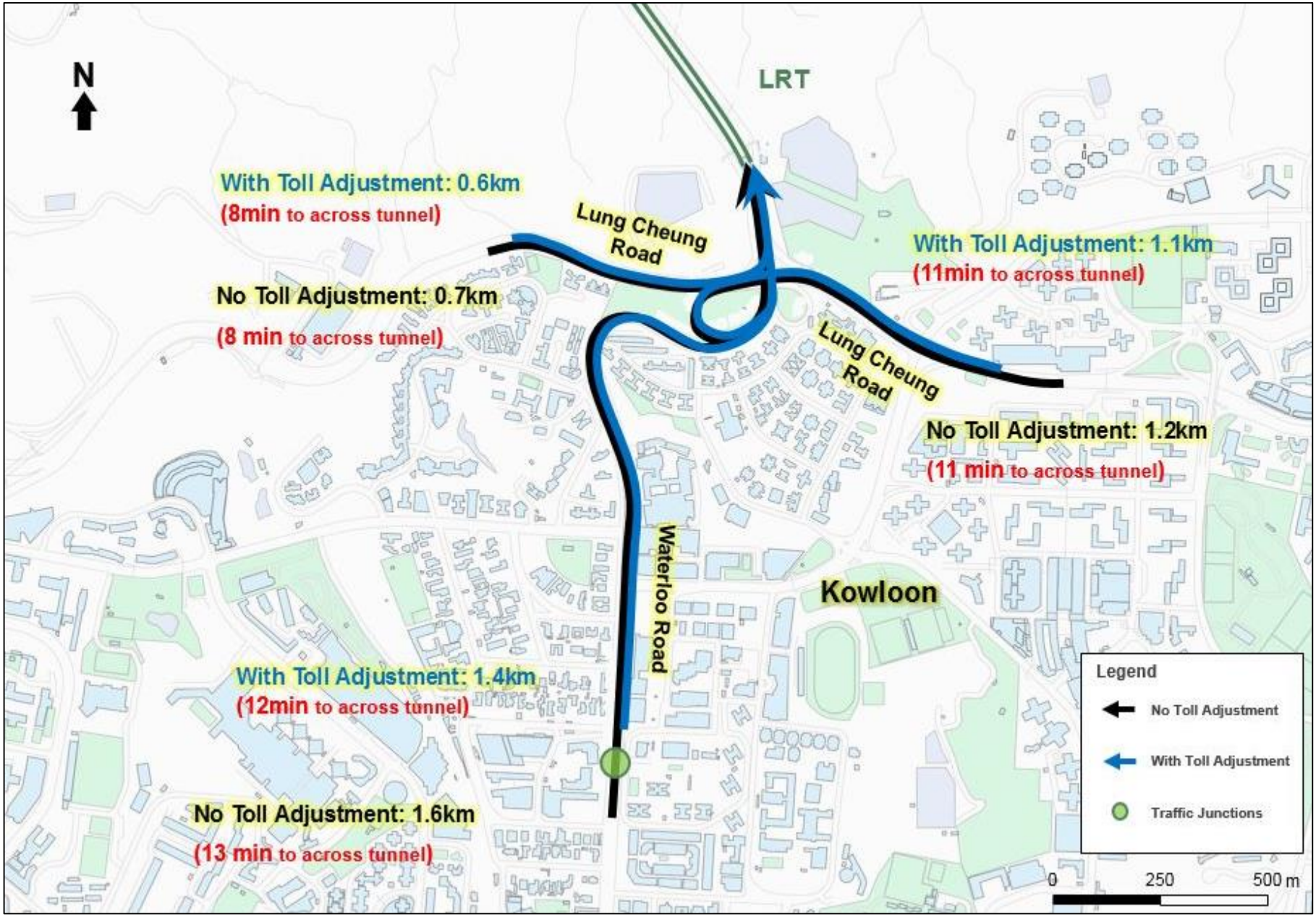
APPENDIX B6 - Forecast PM Peak (northbound) traffic queues along connecting roads of WHC in 2021



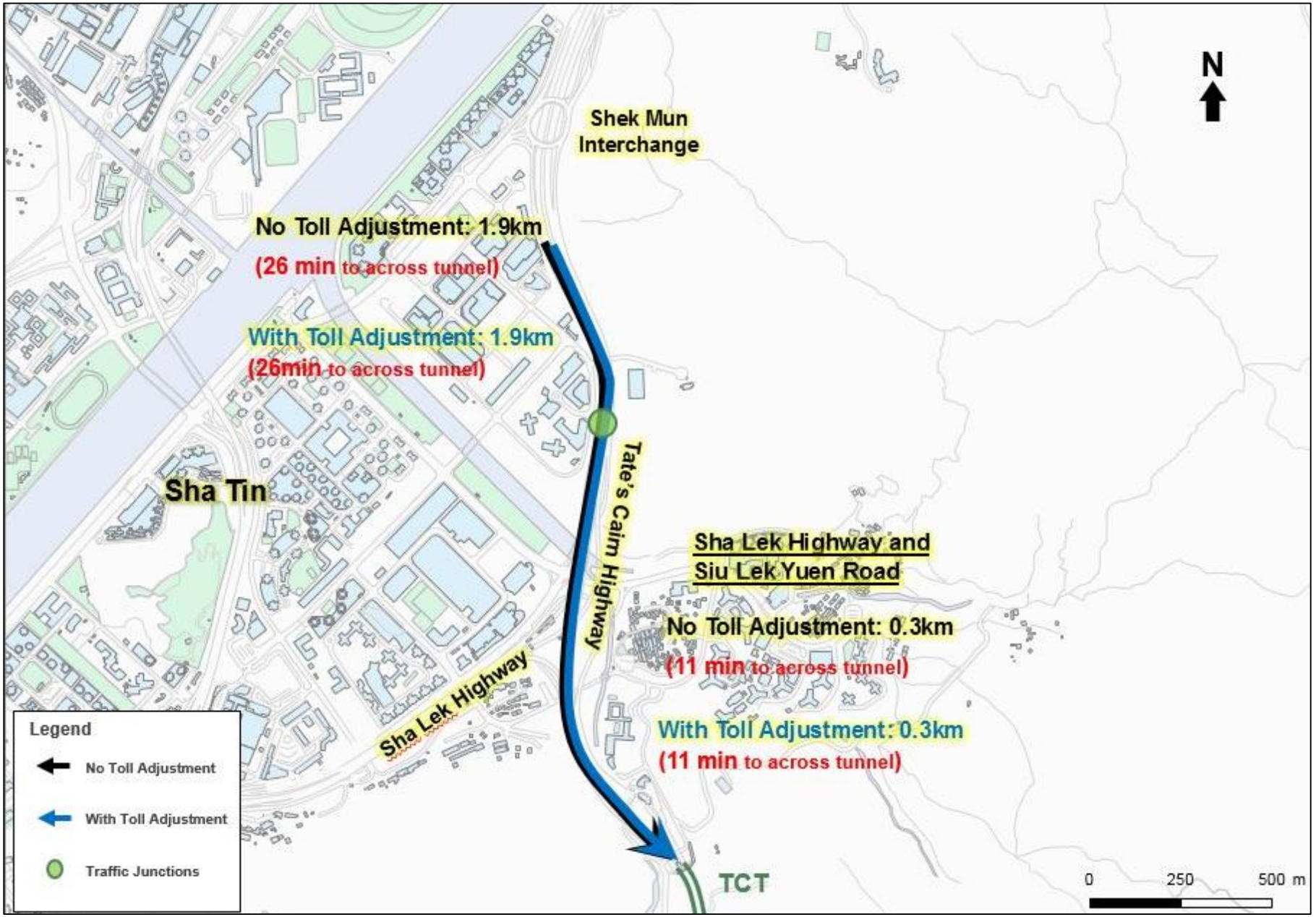
APPENDIX B7 - Forecast AM Peak (southbound) traffic queues along connecting roads of LRT in 2021



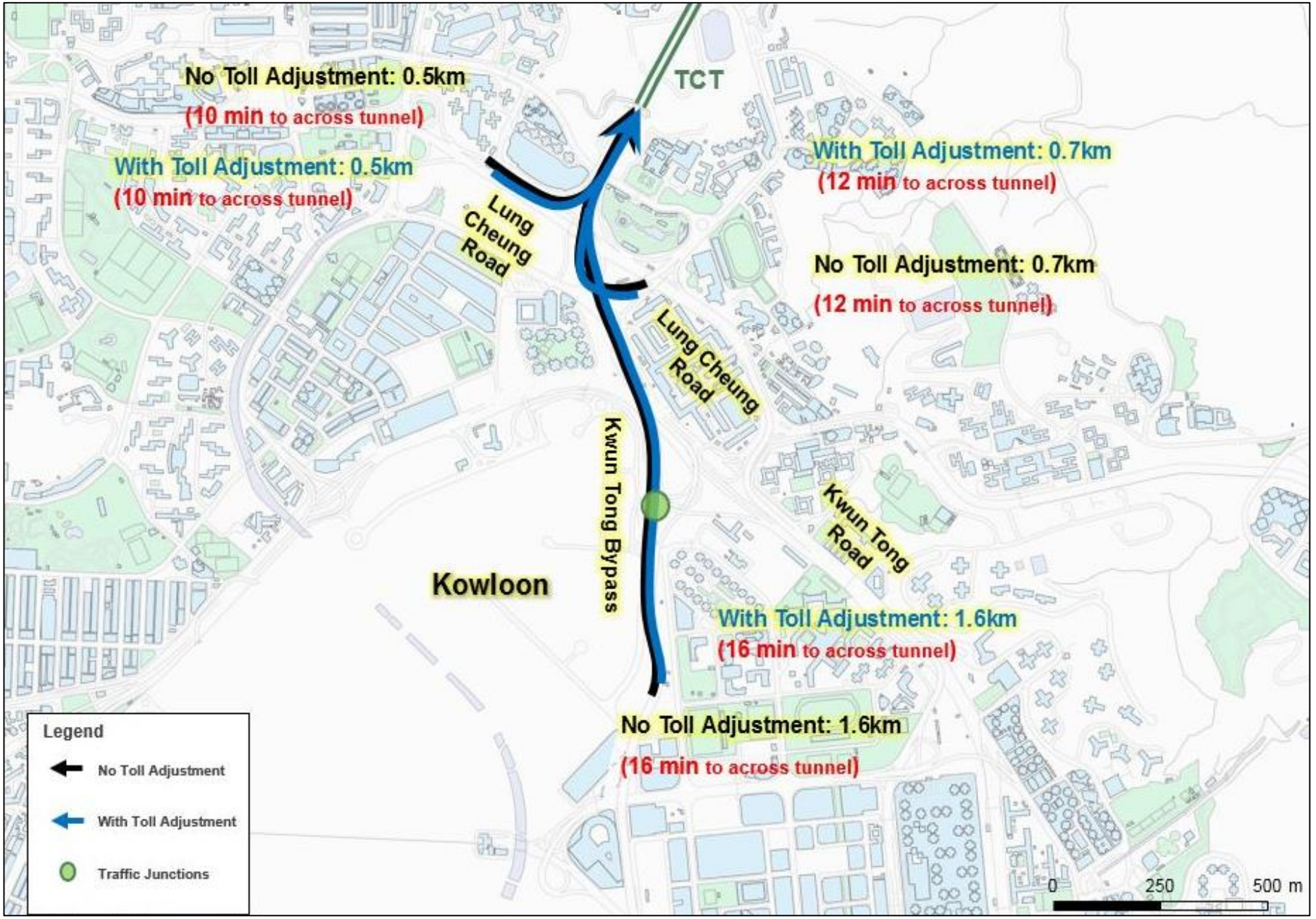
APPENDIX B8 - Forecast PM Peak (northbound) traffic queues along connecting roads of LRT in 2021



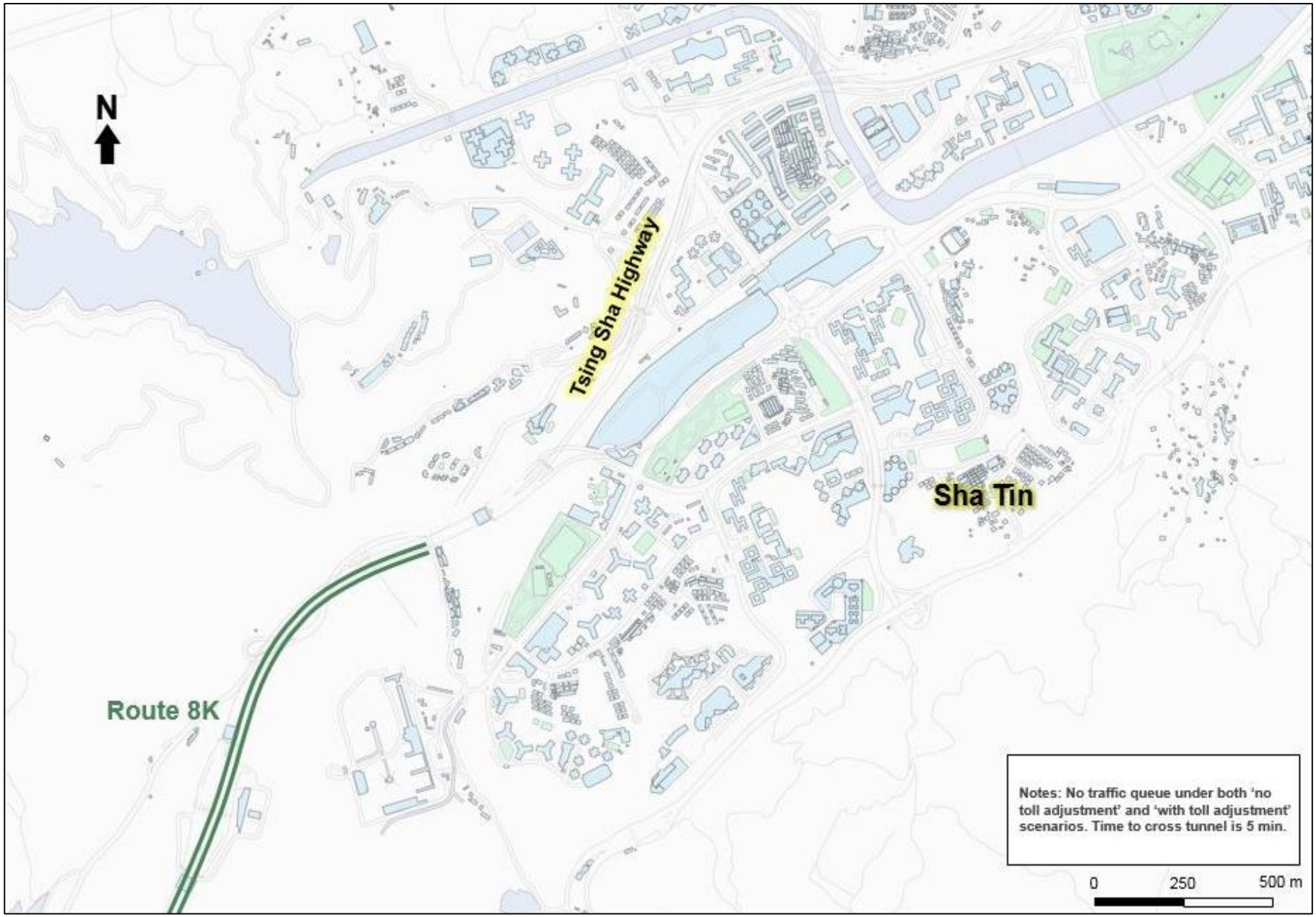
APPENDIX B9 - Forecast AM Peak (southbound) traffic queues along connecting roads of TCT in 2021



APPENDIX B10 - Forecast PM Peak (northbound) traffic queues along connecting roads of TCT in 2021



APPENDIX B11 - Forecast AM Peak (southbound) traffic queues along connecting roads of R8K in 2021



APPENDIX B12 - Forecast PM Peak (northbound) traffic queues along connecting roads of R8K in 2021