THE CITY OF OTTAWA

King Edward Avenue Lane Reduction Impact Study

Final Report - August 14, 2009

DILLON CONSULTING

Acacia Consulting & Research

August 14, 2009

The City of Ottawa
Community Sustainability Department
110 Laurier Avenue West, 4th Floor East
Ottawa, Ontario K1P 1J1

Attention: Michael Murr, Director of Community Sustainability

Re: King Edward Avenue Lane Reduction Impact Study
Final Report

Dear Mr. Murr:

Enclosed, please find our Final Report for the King Edward Lane Reduction Impact Study.

We have enjoyed collaborating with you and members of the King Edward Avenue Task Force on this challenging assignment.

We look forward to presenting the findings at Transportation Committee.

Should you have any questions, please do not hesitate to contact the undersigned.

Yours sincerely,

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Executive Summary

King Edward Avenue is a six lane arterial roadway which currently serves multiple roles in the transportation network in central Ottawa. The Lowertown community has long felt that the interprovincial and mobility functions on King Edward Avenue have overshadowed the needs of the local residents and businesses.

The corridor is presently undergoing a program of infrastructure renewal. During this period of construction, the six-lane roadway cross-section has been operating as a four-lane roadway due to construction activities. While congestion has been evident in the corridor, the King Edward Avenue Task Force ("Task Force") believes that traffic demands are fundamentally being served. Given the community's perceived effectiveness of King Edward Avenue during construction, a request was made to consider the feasibility of permanently reducing the cross-section on this segment of King Edward Avenue to four lanes.

There are two principal objectives for this study:

1. Identify the transportation system impacts of reducing the cross-section of King Edward Avenue from Rideau Street to Sussex Drive from a six lane to a potential four lane cross-section; and,

2. Identify the effects on the community of reducing the cross-section of King Edward Avenue from Rideau Street to Sussex Drive from a six lane to a potential four lane cross-section.

The consulting team, City Staff and members of the Task Force developed the criteria to understand the transportation, community, and safety impacts. These criteria are summarized in *Table 4-1*. The consulting team, City Staff and members of the Task Force also identified the alternative scenarios for King Edward, as follows (the study was limited to three scenarios):

- Scenario 1: Six-lane configuration
- Scenario 2: Six-lane hybrid configuration
- Scenario 3: Four-lane configuration

The configuration of the lanes in these scenarios is fully described in Section 4.3.

A review of case studies of lane reductions from other jurisdictions has provided insight to the conditions, rationale and results of these lane reductions. Modelling of transportation, air quality and noise impacts has been undertaken to quantify these measures under the scenarios. A summary of the community impacts and the transportation impacts are provided on the following pages.

This project was initiated to determine whether alternative roadway configurations might be feasible for King Edward Avenue and to analyze the potential transportation and community impacts. The study's comparative assessment of the three scenarios provides an understanding of the relative differences between each. We conclude from this comparative assessment that the lane reduction scenarios have sufficient merit to be considered further.

It should be noted that public engagement has been focussed on members of the Task Force and Lowertown. The project's mandate did not include an evaluation of the impacts or recommending a specific lane configuration. Further to our conclusion, we offer the following recommendations for advancing forward beyond this project's analysis:

- Report to be received by Transportation Committee: This report needs to be submitted to Transportation Committee for their review and discussion since their feedback and support is important.

- Broader consultation be undertaken: There are a wide range of other stakeholders including adjacent neighbourhoods, transit operators, the goods movement industry, various agencies, commuters, and the public at-large that have not yet been consulted. There is a need to broaden the range of those consulted to ensure that their input is considered and documented.

- Complete an evaluation and submit a recommendation: An evaluation framework would define the weighting of the impacts and ensure that the impacts of the alternative lane configurations for King Edward Avenue are properly assessed. It would provide the technical justification for a potential lane reduction, at which point a recommendation could be submitted to Transportation Committee for their consideration.

Table ES-1: Summary of Community Impact Analysis

	Roadway Configuration		
	Scenario 1 **6 Lane**	**Scenario 2** **6 Lane Hybrid**	**Scenario 3** **4 Lane**
Air Quality			
Average emissions – CO concentrations (ppm)	5.0 - 9.7	4.8 - 10.2	4.6 - 8.3
Average emissions – NOx concentrations (ppm)	0.2 - 0.8	0.2 - 0.8	0.4 - 0.6
Average emissions – $PM_{2.5}$ concentrations (micrograms)	7 - 13	7 - 13	6 - 10
Average emissions – SO_2 concentrations (ppb)	1.1 - 2.3	1.0 - 2.4	1.0 - 1.9
Noise			
Predicted noise levels	68.4 - 72.9	67.9 - 74.3	66.0 - 73.6
Economic Prosperity			
If the land use planning framework is changed to encourage (re)development, will the roadway's configuration contribute to the likelihood of new residential development?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive
If the land use planning framework is changed to encourage (re)development, will the roadway's configuration contribute to the likelihood of new office or retail investment?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive
Urban design / streetscape / identity / place-making			
Can a higher quality of night-time lighting of sidewalks be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes
Can new street furniture be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes
Can increased sidewalk width be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes
Can on-street parking be achieved?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive
Can new/increased medians be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes
Can new/increased vegetation be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes
Can new/increased urban braille be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes
Can improved corridor height-to-width ratio be achieved?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive
Neighbourhood cohesion			
Can a wider mix of land uses vs. concentration of social service agencies be achieved?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive
Can better access to public services such as schools, parks, and community facilities be achieved?	n/a – status quo	No evidence in the case studies that offer insight	No evidence in the case studies that offer insight
Can broader socio-economic diversity be achieved?	n/a – status quo	No evidence in the case studies that offer insight	No evidence in the case studies that offer insight
Neighbourhood connectivity			
Can greater opportunities for pedestrian crossings be achieved?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive
Can additional bicycle lanes be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes; depending on the ultimate design, this scenario may provide more space than the 6 Lane Hybrid to accommodate bike lanes.
Can better way-finding for community and surrounding destinations be achieved?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive
Can improved linkages with multiple transportation modes be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes
If on-street parking is provided, can a greater sense of pedestrian safety be achieved?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive; depending on the ultimate design, this scenario may provide more space than the 6 Lane Hybrid to accommodate on-street parking which might possibly provide a greater sense of pedestrian safety.
Note			Depending on the ultimate design, this scenario may provide more space than the 6 Lane Hybrid to accommodate streetscaping.

Table ES-2: Summary of Transportation Impact Assessment

TRANSPORTATION IMPACT ASSESSMENT EVALUATION CRITERIA				Scenario 1: 6 Lane Configuration				Scenario 2: 6 Lane Hybrid Configuration				Scenario 3: 4 Lane Configuration			
				AM Peak		PM Peak		AM Peak		PM Peak		AM Peak		PM Peak	
				Hour	Period	Hour	Period	Hour	Period	Hour	Period	Hour	Period	Hour	Period
Motorists															
Criteria 1	Traffic volume in corridor	Peak direction flow between	NB	550	1300	1750	4300	550	1300	1750	4350	550	1250	1450	3700
		St. Patrick & Murray	SB	1900	4550	1550	3650	1900	4600	1450	3650	1950	4650	1400	3450
Criteria 2	Corridor congestion [mm:ss] [1.6km travel route]	NB average travel time		3:58	3:52	3:47	3:43	3:58	3:54	3:59	3:48	4:05	3:59	7:03	6:23
		SB average travel time		2:21	2:21	2:49	2:45	2:21	2:21	2:56	3:11	2:34	2:32	4:01	4:29
Criteria 3	Impacts on alternative routes [#]	Vehicles redirecting		(neg)	(neg)	(neg)	(neg)	(neg)	(neg)	(neg)	(neg)	(neg)	(neg)	(neg)	(neg)
Criteria 4	Ability to accommodate on-street parking [parking stall hrs 7am to 7pm]						740[#]				556				0
Pedestrians															
Criteria 5A	Pedestrian walking time along primary pedestrian route (incl. delay) [min]	Sussex to Rideau		18	18	18	18	18	18	18	18	18	18	18	18
		MacKenzie to Vanier		24	24	24	24	24	24	24	24	24	24	24	24
Criteria 5B	Average pedestrian waiting + crossing time at a key intersection [sec]	St. Patrick		73	73	87	83	77	73	90	87	70	71	80	84
		Murray		42	42	55	54	43	42	56	55	42	41	61	58
Cyclists															
Criteria 6	Cycling travel time for commuter cyclists* [min]	Sussex to Rideau		8	8.5	9.5	9	8	8.5	9.5	9	8.5	8.5	8.5	8.5
		MacKenzie to Vanier		10.5	10.5	11	11	10.5	10.5	11	11	10.5	10.5	11	11
Criteria 7	Effect on cycling network connectivity**			Qualitative discussion to be addressed in the report											
Transit															
Criteria 8	Transit travel time [mm:ss]	Average time		-	-	4:24	4:18	-	-	4:22	4:24	-	-	5:44	5:58
Criteria 9	Travel time reliability [mm:ss]	90th percentile time		-	-	5:02	4:54	-	-	5:00	5:11	-	-	7:08	10:30
Criteria 10	Transit vehicle volume [# buses/period]			-	-	130	288	-	-	122	300	-	-	118	266
Goods Movement															
Criteria 11	Truck corridor travel time [mm:ss] [1.8km travel route]	Northbound time		4:11	4:00	4:00	3:57	4:09	4:04	4:23	4:08	4:14	4:05	7:29	6:40
		Southbound time		2:34	2:33	2:36	2:34	2:34	2:34	2:47	3:06	2:52	2:49	4:01	4:40
Criteria 12	Peak truck flow [# trucks/period]	Northbound flow		77	182	58	136	81	191	63	151	79	183	58	150
		Southbound flow		113	271	55	125	113	272	51	126	111	262	53	125
Impacts on Other Communities															
Criteria 13	External impacts on other communities due to traffic displacement			(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	300	600
Criteria 14	Duration of impact on other communities due to dispersed traffic [hours]			(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	>2.5	>2.5

[#] On-street parking is not formally included in the 6-lane scenario but has been estimated for comparison purposes
*Approximate; Calculation based on pedestrian waiting times at intersections and typical cycling speed
**Could permit curb lanes to stay and have parking instead of streetscaping

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1. Introduction

King Edward Avenue is a six lane arterial roadway which currently serves multiple roles in the transportation network in central Ottawa. King Edward Avenue provides local neighbourhood access to Lowertown, an interprovincial link for commuters and commercial traffic to the Macdonald-Cartier Bridge, a public transit corridor for STO buses, and facilities for pedestrians and cyclists. As the primary connection to one of only two interprovincial bridges permitted to carry truck traffic, King Edward Avenue has evolved into perhaps the primary interprovincial economic artery in Ottawa.

King Edward Avenue is also a prominent corridor in the City of Ottawa. In the Official Plan (2003), the segment from Sussex Drive/Macdonald Cartier Bridge to Rideau Street is designated as a Central Area Gateway. As a Central Area Gateway, the Plan envisions that the street will be enhanced to improve the image of the Central Area and assist in visitor orientation [Section 3.6.6.5c].

The Lowertown community has long felt that the interprovincial and mobility functions on King Edward Avenue have overshadowed the needs of the local residents and businesses. The King Edward Avenue Task Force ("Task Force") was formed specifically to lobby the City to implement measures to mitigate the impact of King Edward Avenue operations on the community, including implementing design changes and/or reducing the cross-section of the road to four lanes.

The corridor is presently undergoing a program of infrastructure renewal. Construction activity on King Edward Avenue began in 2005 following completion of an Environmental Assessment (EA) study in 2002. The four phases of the construction program include a variety of subsurface infrastructure works, roadway reconstruction, construction of a structure to enable bridge access and landscape architecture. Construction is anticipated to be completed to south of Rideau Street by end of 2009.

During this period of construction, the six-lane roadway cross-section has been operating as a four-lane roadway due to construction activities. While congestion has been evident in the corridor, the Task Force believes that traffic demands are fundamentally being served.

2. Purpose of the Study

Given the community's perceived effectiveness of King Edward Avenue during construction, a request was made to consider the feasibility of permanently reducing the cross-section on this segment of King Edward Avenue to four lanes. Transportation Committee directed staff to undertake a feasibility study to consider this network change in October 2008, consistent with direction from Council during approval of 2002 Environmental Study Report to look at this issue after a number of future milestones.

In response to the community request, Dillon Consulting Limited was retained by the City of Ottawa to undertake a feasibility study that would investigate the transportation and community impacts of reducing the cross-section on King Edward Avenue from six lanes to potentially four lanes between Rideau Street and Sussex Drive.

There are two principal objectives for this study:

3. Identify the transportation system impacts of reducing the cross-section of King Edward Avenue from Rideau Street to Sussex Drive from a six lane to a potential four lane cross-section; and,

4. Identify the effects on the community of reducing the cross-section of King Edward Avenue from Rideau Street to Sussex Drive from a six lane to a potential four lane cross-section.

This study is primarily a technical evaluation of transportation system and community impacts that would result from reducing the cross-section of King Edward Avenue from six lanes to potentially four lanes between Rideau Street and Sussex Drive. The project's mandate did not include an evaluation of the impacts or recommending a specific lane configuration.

This report describes the analytical framework for this feasibility study, describes the results of the analysis, provides a summary of the public consultation conducted, and recommendations for next steps.

3. Study Context

3.1 Location and Study Area

King Edward Avenue is located in central Ottawa, near to the Byward Market, and bisects both the Lowertown and Sandy Hill neighbourhoods. It is within Ward 12, Rideau-Vanier.

In 2004 when the ward boundary review was conducted, the population of Ward 12 was 45,550 persons which is expected to grow to approximately 50,000 persons by 2015. Both the ward and the neighbourhood immediate to the King Edward Avenue corridor have a wide range of residential and non-residential land uses, and a diverse population.

The study area encompasses the King Edward Avenue corridor portion in Lowertown, from Sussex Drive in the north to Rideau Street in the south. A map of the study area is below.

Figure 3-1: King Edward Avenue - Study Area

Due to the nature of the issues analyzed in this study, a secondary study area was defined to capture the broader transportation and environmental impacts. The secondary study area is shown in *Figure 3-2* on the following page.

Figure 3-2: King Edward Avenue – Secondary Study Area

King Edward Avenue serves a range of roles – from a local road for the immediate community to an interregional arterial connecting Ontario and Quebec – and there are a variety of interests resulting from their geographic, functional, or jurisdictional relationship to the corridor. These interests include, but are not limited to:

- Lowertown neighbourhood
- Sandy Hill neighbourhood
- New Edinburgh neighbourhood
- Byward Market BIA
- Rideau Street BIA

- OC Transpo
- Société de Transport de l'Outaouais
- The trucking industry
- City of Ottawa
- City of Gatineau
- Province of Ontario (Ministry of Transportation)
- Province of Québec (Ministère des Transports du Québec)
- Transit users, motorists, cyclists, and pedestrians

It should be noted that this feasibility study involved consultation with members of the Task Force and the immediate neighbourhood. Comments regarding involving other stakeholders in the process of considering the feasibility of permanent lane reduction(s) on King Edward are provided in Section 9 of this report.

3.2 Social Context

An overview of social and crime indicators is provided to gain a full appreciation of the broader, non-transportation issues that impact Lowertown.

3.2.1 Social Indicators

At the time this report was being prepared, the City of Ottawa was updating its neighbourhood profiles and information specifically for Lowertown was not readily available. However, in November 2008, the Social Planning Council of Ottawa prepared a social profile for the city based on the 2006 Census titled, "This is Who We Are." Specific data is not reported but highlights can be interpreted from the comprehensive mapping provided in the report. The relevant social indicators as depicted in the census tract-based mapping are summarized below:

- 22% to 48% of families in the area are lone-parent families;
- 35% to 67% of seniors in the area are living alone;
- 14% to 25% of persons aged 15 or more have no certificate, diploma or degree;
- The median household income ranges from $0 to $58,793, with the median household income ranging from $0 to $36,186 in one of the area's census tracts; and,
- 35% to 73% of tenant households are spending more than 30% of their household income on gross rent.

There are also a variety of public health issues in Ward 12 as noted in the City's Public Health Ward Profile[1], which include:

- 33.4% of the households are low income, as compared to the city-wide average of 15%;
- 5.5% of live births in Ward 12 were to teenage mothers which is more than double the City of Ottawa average;
- 7.4% of live births in Ward 12 were of low birth weight which is higher than the City of Ottawa average of 5.8%;
- 17.3% of births in Ward 12 were to women who smoked during pregnancy which is triple the City of Ottawa average of 5.7%; and;
- 21.2% of Ward 12 citizens are daily smokers which is above the City of Ottawa average of 15.9%.

A wide range of agencies and the City of Ottawa are working to improve many of the social issues in Ward 12. However, the Task Force has expressed concern that there is a high concentration of social service agencies in the area.

The above summary confirms that there are social issues in Lowertown which do have an impact on quality of life in the neighbourhood.

3.2.2 Crime Indicators

The City of Ottawa Police Service's 2007-2008 profiles for the City and Ward 12 examines all criminal offences. Some of the key measures in the reports are summarized below.

Summary of Crime Trends, City of Ottawa and Ward 12[2]				
	2008 Crime Rate (rate per 100,000 population)		% change (2007-2008)	
	City of Ottawa	Ward 12	City of Ottawa	Ward 12
Crimes Against the Person	672.2	1,899.1	-8.3%	-17.7%
Crimes Against Property	3,427.2	8,956.4	-8.3%	-3.3%
Traffic Offences	311.5	520.4	5.0%	11.7%
Drug Offences	202.0	1,374.5	13.2%	21.7%
Other Offences	471.9	2,747.7	-3.5%	18.9%

[1] http://www.ottawa.ca/residents/health/publications/ward_profiles/ward12_en.html

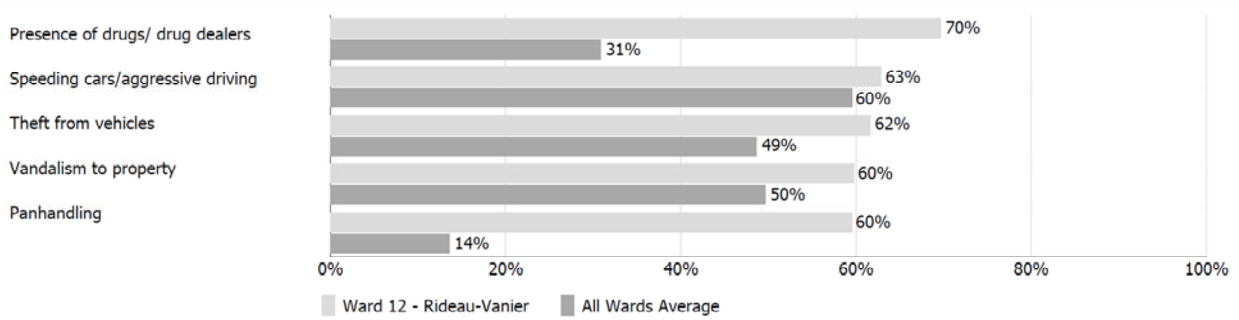
[2] Ottawa Police Service. 2009, May 20. "2007-2008 Ward Profile for Ward 12 – Rideau-Vanier" and "2007-2008 Crime Trends for the City of Ottawa".

On all key indicators, the absolute crime rate in Ward 12 is higher than the average crime rate across the City. Although the change in number of crimes against the person between 2007 and 2008 in Ward 12 was better than the entire City, crimes against property did not decrease as much as it had city-wide, and the incidents of crime increased for all other indicators (most notably in the 'other offences' category which included increases in the number of bail violations, breach of probation, and prostitution offences).

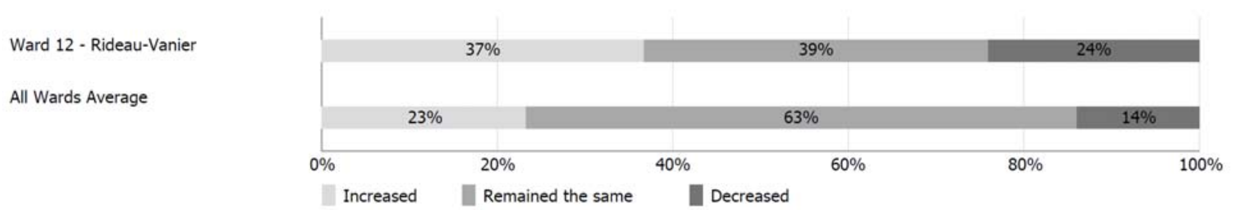
Of the 50,658 calls for service in 2008 identified in the profile for Ward 12, it should be noted that 12,856 (25.4%) of these calls were in the Priority 1 category meaning that there was actual or potential danger for bodily injury or death, an officer requiring immediate assistance, or a crime was in progress or imminent. This is higher than the City-wide average of 21.1% of calls for service being Priority 1 calls.

Through their Public Survey, the Ottawa Police Service and the Ottawa Police Services Board regularly seeks input on residents' perception of safety and security in their communities, concerns about crime, priorities for the police, and citizen's satisfaction with police services. A summary of the results for Ward 12 compared with city-wide results is provided below (note: the information represents the opinions and perceptions of respondents by ward and is not based on official crime figures or reports).

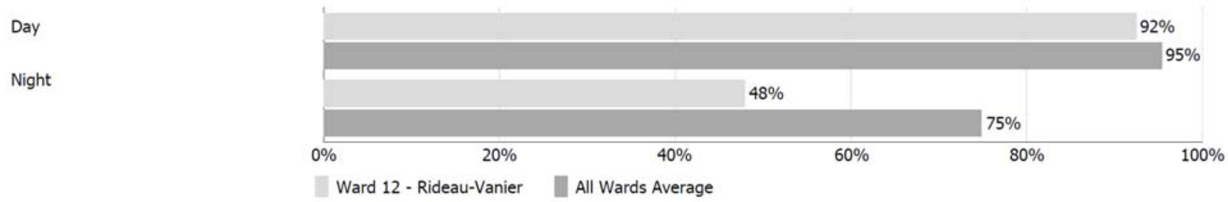
Top Five Ward Concerns



Level of Crime



Feeling Safe When Walking Alone



The top five perceived concerns in Ward 12 are all higher that the city-wide average. It is interesting to note that a greater proportion of citizens in Ward 12 (as compared to the city-wide average) hold the opinion that crime has increased, although there are also some citizens that feel that crime decreased. While a similar proportion of citizens in Ward 12 feel safe walking alone during the day as citizens city-wide, there is a noteworthy decrease in confidence walking alone during the night in Ward 12.

This summary of crime illustrates the significant real crime that occurs in Lowertown and the perceptions about crime which together have an impact on quality of life in the neighbourhood.

4. Scope of Study and Analysis Framework

The feasibility analysis was conducted as a dual transportation and community impact assessment. This section of the report discusses the scope and design of the impact assessment.

4.1 Scope of Study

To determine the impacts of a potential lane reduction, it was important that the analysis of the transportation system address:

- Mobility for interprovincial commuter traffic;
- Mobility for interprovincial goods movement;
- Mobility within Lowertown;
- Mobility and access for vehicular traffic to and between Lowertown and the Byward Market;
- Linkages in the surface transit system for STO;
- Vehicle, bicycle, and pedestrian access to and between Lowertown and the Byward Market; and,
- Connectivity between Lowertown and the Byward Market.

The approach used to understand the transportation impacts was a quantitative analysis approach that relied on computer modelling using the VISSIM software package. Further details on the transportation modelling approach are provided later in this section of the report.

Additionally, it was important that the analysis of the community impacts address:

- Air quality;
- Noise;
- Economic prosperity;
- Streetscape / urban design / urban form;
- Effect of roadway design on neighbourhood cohesion, place-making, and connectivity; and,
- The ability of the roadway's design to retain / improve the corridor's identity.

The approach used to understand many of the community impacts was a qualitative analysis approach that incorporated a review of case studies from other jurisdictions where similar study or implementation of lane reduction had occurred. However, impacts such as air quality and noise were determined using computer modelling, and therefore have quantitative results.

Lastly, safety considerations also needed to be factored into the impact analysis. The concept of safety is relevant to both the transportation system (i.e., safe movement of vehicles) and community (i.e., residents' perceived safety in the corridor). The approach used to understand safety impacts incorporated a blend of quantitative and qualitative measures.

4.2 Analysis Framework

A series of criteria were required to properly complete the assessment and ensure that specific impacts from a potential lane reduction would be clearly identified and measured.

A variety of considerations were made when identifying criteria. First, the criteria had to respond to the scope of the study and the issues in the corridor. All quantitative measures needed to be output from a recognized model and/or viable methodology. All qualitative measures would ideally be demonstrated in a relevant case study, and allow for a clear 'yes' or 'no' opinion to be rendered.

The consulting team developed an initial set of criteria to address the transportation, community, and safety impacts. This initial set of criteria was discussed with City Staff and members of the Task Force, and revised. After further discussion at a community meeting, the evaluation criteria were finalized. The criteria that resulted from this process are summarized in *Table 4-1*.

Table 4-1: Analysis Framework

Community Impact Assessment Evaluation Criteria	Transportation Impact Assessment Evaluation Criteria
Air Quality • Criteria 1: Average emissions from truck, car and bus[3] traffic during peak period, including emissions from vehicles while stopped/idling [#] • Criteria 2: Estimated dispersion of emissions during peak period [#] • Methodology: Emissions are forecasted based on customary approach[4]	**Motorists** • Criteria 1: Capacity in corridor [#] • Methodology: Forecasted vehicles/hour for peak hour and for peak period • Criteria 2: Corridor congestion [#] • Methodology: Estimated average speed or travel time of vehicles in corridor, peak hour and peak period • Criteria 3: Impacts on alternative routes [#] • Methodology: Estimated number of vehicles infiltrating on the few alternative routes (Nelson/York, Rideau/Cumberland/Murray) other than King Edward Avenue • Criteria 4: Ability to accommodate on-street parking [#] • Methodology: Number of hour-spaces per day
Noise • Criteria 3: Average noise from traffic during peak period [#] • Methodology: Noise is forecasted based on customary approach	**Pedestrians** • Criteria 5A: Pedestrian walking time along a primary pedestrian route [#] • Criteria 5B: Pedestrian waiting time at a key intersection [#] • Methodology: Estimated number of minutes per pedestrian; regard will be given to the cycle time of traffic signals for different widths of King Edward

[3] Only travelling buses are factored in; idling buses on lay-by are excluded.

[4] Data from the City's portable air quality monitoring station was to originally be used but was it not available when this report was prepared

Table 4-1: Analysis Framework

Community Impact Assessment Evaluation Criteria	Transportation Impact Assessment Evaluation Criteria
Economic Prosperity • Criteria 4: If the land use planning framework is changed to encourage (re)development, will the roadway's configuration contribute to the likelihood of new residential investment? [YES/NO] • Criteria 5: If the land use planning framework is changed to encourage (re)development, will the roadway's configuration contribute to the likelihood of new office or retail investment? [YES/NO] • Methodology: Reference will be made to any relevant case studies • A map of existing property values will be provided as anecdotal information • A map of existing abandoned buildings will be provided as anecdotal information	**Cyclists** • Criteria 6: Cycling travel time for commuter cyclists [#] • Methodology: Estimated number of minutes per cyclist along a primary cycling route; reference will be made to the City's new cycling plan and crossing at St. Andrew • Criteria 7: Is there an appreciable positive effect on cycling network connectivity? [YES/NO] • Methodology: Reference will be made to the City's new cycling plan
Streetscape / urban design / urban form; Retain/improvement of corridor's identity; Place-making • Criteria 6: Can a higher quality of night-time lighting of sidewalks be achieved [YES/NO] • Criteria 7A to 7G: Can specific streetscape elements (street furniture, sidewalk width, on-street parking, medians, vegetation, urban braille, corridor height-to-width ratio) be achieved [YES/NO] • Methodology (applies to #7): Reference will be made to any relevant case studies; the future four-lane configuration will be compared to the road typologies for which the City of Ottawa has prepared road corridor design guidelines; the analysis anticipates that the streetscape design of King Edward as a four-lane road would, at minimum, meet these guideline requirements	**Transit** • Criteria 8: Transit travel time [#] • Methodology: Cumulative hours of bus travel time per hour, for southbound a.m. and p.m. peak periods; regard will be given to STO bus usage of the Union terminus • Criteria 9: Travel time reliability[5] [#] • Methodology: 90th percentile travel time per bus during peak hour, peak period • Criteria 10: Transit vehicle capacity [#] • Methodology: Number of buses per hour, during the peak hour
Neighbourhood cohesion • Criteria 8A to 8C: Can greater neighbourhood cohesion (wider mix of land uses vs concentration of social service agencies; access to public services such as schools, parks, and community facilities; socio-economic diversity) be achieved [YES/NO] • Methodology: Reference will be made to any relevant case studies	**Goods Movement** • Criteria 11: Corridor travel time [#] • Methodology: Minutes of time per truck[6] through the corridor • Criteria 12: Truck capacity [#] • Methodology: Trucks per hour, during peak hour and peak period

[5] Improved transit reliability can reduce automobile trips in the corridor because transit buses are operating efficiently

[6] Trucks are defined as over 3,000 kg (i.e., cube vans or bigger)

Table 4-1: Analysis Framework

Community Impact Assessment Evaluation Criteria	Transportation Impact Assessment Evaluation Criteria
Neighbourhood connectivity • Criteria 9A to 9D: Can greater connectivity (opportunities for pedestrian crossings of King Edward, bicycle lanes on King Edward, way-finding information for community and surrounding destinations, linkages multiple transportation modes) be achieved [YES/NO] • Methodology: Reference will be made to any relevant case studies	**Impacts on Other Communities** • Criteria 13: External impacts on other communities due to traffic displacement [#] • Methodology: Vehicles per hour, during peak hour and peak period • Criteria 14: Duration of impact on other communities due to dispersed traffic [#] • Methodology: Number of vehicle hours of additional peak period time
Safety (common to both CIA and TIA)[7] • Criteria S1: The time, in seconds, that a pedestrian is exposed to traffic while crossing King Edward Avenue [#] • Methodology: Pedestrian exposure is calculated based on average walking speed and the width of the crossing, and existence of a median • Criteria S2a and S2b: Estimated operating speed of vehicles, southbound and northbound [#] • The operating speed of vehicles on the ramp will be included as anecdotal information • Criteria S3: If on-street parking is provided, can a greater sense of pedestrian safety be achieved? [YES/NO]	

[7] A previous version of this framework included the "Safety Index of Bicycles and Pedestrians" but insufficient information and resources were available for the consulting team to calculate this index

4.3 Roadway Scenarios

A number of alternative roadway configurations were considered for comparative purposes in this study, which was limited to evaluating a total of three scenarios. The two primary configurations consisted of a six-lane cross-section as per the current construction contract for King Edward Avenue, and a four-lane cross-section, as suggested by the community.

For evaluation purposes, the six-lane configuration was considered to be the "status quo" or baseline condition since it was selected through the Environmental Assessment (EA) process and is currently being constructed. The four-lane configuration is essentially the same cross-section that was proposed in the EA study. A third option was developed as a variation on the six-lane design that included designation of a bus lane in the southbound direction and designation of a "right-turn only" lane into the neighbourhood north of St. Patrick Street.

The development of the roadway scenarios involved discussions with City Staff, members of the Task Force, and the consulting team. A variety of scenarios were considered, and consensus was reached that the options described below would provide the best insight for the transportation and community impact assessment and were the ones agreed to be the most appropriate to carry forward for analysis.

Scenario 1: Six-lane Configuration

The Six-lane Configuration is currently being constructed and includes three "through lanes" in the southbound direction, double left turn lanes are in place at St. Patrick Street and Murray Street and shared through-right lanes are in place at all intersections except Rideau Street where the third through lane becomes an exclusive right-turn lane. In the northbound direction, a third through lane is developed immediately north of Rideau Street and is carried through the entire corridor up to Boteler Street where the third lane becomes a ramp to Sussex Drive.

Scenario 2: Six-lane Hybrid Configuration

The Six-lane hybrid Configuration includes three "through lanes" in the southbound direction with the curb lane (between Bruyère Street and York Street) being designated for "transit vehicles only" during the afternoon peak period and parking during all other periods. As with Scenario 1, this configuration also includes double left turn lanes at St. Patrick Avenue and Murray Street and shared through-right lanes at all intersections except Rideau Street where the third through lane becomes an exclusive right-turn lane. In the northbound direction, a third through lane is developed immediately north of Rideau Street and is carried through to St. Andrew Street at which point the curb lane is designated as a "right-turn only" lane to facilitate access into the neighbourhood and to prevent motorists from using the curb lane as a queue jump lane to gain faster access to the bridge. A bulb out, pavement markings or other measures located north of Cathcart Street would further encourage motorists destined for the bridge to remain in the two through lanes after which point motorists could access the Sussex Drive ramp.

Scenario 3: Four-lane Configuration

The Four-lane Configuration is essentially the same cross-section as was proposed in the previous EA study; two "through lanes" are maintained in both southbound and northbound directions from Rideau Street to the MacDonald-Cartier Bridge ramp with auxiliary turn lanes at key locations (southbound double left turn lanes at St. Patrick Street, an exclusive southbound right turn lane at St. Patrick Street, a southbound right turn lane at Rideau Street, and a northbound lane to access the Sussex Drive ramp developing north of Cathcart Street, all other right turns are shared with a through lane).

4.4 Case Studies Approach

By reviewing lane reductions from other jurisdictions, it was intended that the case studies would provide insight to the conditions, rationale and the result(s) of the lane reduction. This insight would be used to help provide the qualitative input needed for the community impact assessment.

At the outset, it was determined that the case studies should be relevant to the issues facing King Edward Avenue (e.g., urban municipality with large population, urban arterial roadway, truck traffic, etc.). Mega-projects such as the burying of Boston's Central Artery were not considered relevant.

The case study research was undertaken by searching the websites of:

- All major Canadian cities;
- The provincial ministries of transportation that have jurisdiction in the major Canadian cities;
- Major American cities that have a reputation for progressive urbanization (e.g., Chicago, Seattle, Portland, Atlanta, etc.);
- The Department of Transportation for many American states, including those states in which the progressive American cities are located;
- Canadian and American federal transportation agency websites; and,
- Canadian and American transportation organization websites.

As well, a general search of the Internet was undertaken using keywords that would relate to a lane reduction project.

Based on the search that was conducted for appropriate case studies, it became apparent that lane reductions are common in many parts of North America on collector and local roads; this practice is referred to as "road diets." However, lane reductions on arterial roads, while they do exist, are not as prevalent as the road diets occurring on collector and local roads.

Of the approximately 80 cases that were found relating to a lane reduction project, we identified 13 projects that were considered relevant to King Edward Avenue due to their context, traffic characteristics, class of road in the overall transportation hierarchy, existing cross-section, and/or proposed/final cross-section. It is not surprising that there were relatively few situations that reflect the exact circumstances of King Edward Avenue, given the complex characteristics and challenges of the corridor. The case studies are:

- El Camino Real, Palo Alto, California
- Jarvis Streetscape, Toronto
- Kings Highway, Myrtle Beach, South Carolina
- Lakeshore Avenue, Oakland, California
- Ninth Avenue, New York
- Broadway Boulevard, New York
- Potrero Avenue, San Francisco
- Bridgeport Way, University Place, Washington
- Edgewater Drive, Orlando, Florida
- North Alameda Street, Los Angeles, California
- Pasadena + Broadway, Los Angeles, California
- Front Street (Union Station), Toronto
- Boulevard Strandvejen, Hellerup, Denmark

The documentation that was obtained for the case studies included any combination of environmental assessment / technical studies, planning / design studies, staff reports to municipal authorities, and/or public consultation materials. The analysis of the case studies is based exclusively on the material that was obtained and reviewed. We recognize that there may be other case studies from other jurisdictions; however, it is important to note that we only considered case studies where we could obtain documentation for our own independent review and analysis.

It should also be noted that the case studies range in status. They may be in a planning stage, an environmental assessment stage, and others have been implemented. Regardless of their status, the case studies do provide insight on what has been achieved and what is intended to be achieved.

Full details of the case studies are included in *Appendix A*. A summary of the observations from the case studies are provided in *Table 4-2*.

Overall, the case studies demonstrate that a lane reduction in these jurisdictions provides the propensity to achieve the desired change for many of the urban design and streetscaping improvements anticipated by members of the Task Force. Since many of the case study jurisdictions have given up roadway to promote cycling and transit ridership, then the case studies support these elements of improved connectivity.

The case studies do not provide definitive insight on other matters such as economic prosperity or neighbourhood cohesion. Additional discussion on this finding is provided in Section 7 of this report.

Table 4-2: Case Study Results

		1	2	3	4	5	6	7	8	9	10	11	12	13	
		El Camino Real, Palo Alta, California	Jarvis Steetscape, Toronto	Kings Highway, Myrtle Beach, South Carolina	Lakeshore Avenue, Oakland, California	Ninth Avenue, New York	Broadway Boulevard, New York	Potrero Avenue, San Francisco	Bridgeport Way, Unvirsity Place, Washington	Edgewater Drive, Orlando, Florida	North Alameda Street, Los Angeles, California	Pasadena + Broadway, Los Angeles, California	Front Street (Union Station), Toronto	Boulevard Strandvejen, Hellerup, Denmark	
	Total number of all lanes before	6	5	6/5	4	6	6	8	5	4	7/8	6,7	6	4	
	Total number of all lanes after/proposed	5/4	4	4	3	5	4	6	4	3	5/7	5,5	4	2	
	Number of car through-traffic lanes before	6	5	6/5	4	4	4	6	4	4	6/5	4,4	4	4	
	Number of car through-traffic lanes after	4	4	4	2	3	2	4	4	2	4/4	2,2	2	2	
COMMUNITY IMPACT ASSESSMENT CRITIERA															
Category	**Criterion**														**Propensity of the lane reduction to achieve desired change**
Economic Prosperity	New residential investment			P							P	P			Not conclusive
	New office/retail investment			P		P	P		Y		P	P			Not conclusive
Streetscape	Higher quality of night-time sidewalk lighting	P	P	P		Y			Y				Y		Medium/High (where this element did not previously exist)
	Street furniture	Y	Y			Y	Y		Y						High (where this element did not previously exist)
	Sidewalk width	Y	Y	Y		Y	Y		Y				Y	Y	High
	On-street parking	Y								Y					Not conclusive
	Medians	Y	Y	Y		Y	Y	Y	Y			P	N[1]	Y	High (where this element did not previously exist)
	Vegetation	Y	Y	Y		Y	Y		Y			P	N[1]	Y	High (where this element did not previously exist)
	Urban braille	Y	P			Y					Y	Y		Y	Medium/High (where this element did not previously exist)
	Height-to-width ratio	P		P		P	P		P						Low (by visually dividing the width of the corridor; no material change to H:W ratio)
Neighbourhood cohesion	Wider mix of land uses			P							P	P			Not conclusive
	Access to public amenities														No evidence
	Socio-economic diversity														No evidence
Neighbourhood connectivity	New pedestrian crossing opportunities								Y					Y	Not conclusive
	Bicycle lanes	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	High (where this element did not previously exist)
	Way-finding		Y	Y		Y									Not conclusive
	Multi-model trans. linkages	Y			Y	Y	Y	Y	Y		Y	Y			High (by providing bike lanes and bus lanes / lay-bys where they did not previously exist)
Safety	On-street parking > ped. safety	Y								P					Not conclusive[2]
TRANSPORTATION IMPACT ASSESSMENT CRITERIA															
Category	**Criterion**														**Propensity of the lane reduction to achieve desired change**
Cyclists	Appreciable postive effect on connectivity	P		P	Y	Y	P	P	P	Y	P	P		Y	Medium/High

Legend: Y = Yes P = Potential

Notes

1. The lane reduction concept illustrates the removal of an existing landscaped centre median.

2. Although extensive studies can be found that suggest the provision of on-street parking creates an improved sense of pedestrian safety, new on-street parking was only proposed in two case studies; therefore, it is difficult to draw a reasonable conclusion based on the case studies alone.

4.5 Transportation Modeling Approach

4.5.1 Baseline and Trends

Dillon used all available City of Ottawa intersection count data (up to and including 2008) and bridge count data (up to 2007 was available when we initiated our analysis) in order to generate traffic volumes for a "baseline" 2008 traffic model. It is important to recognize that the traffic volume counts in recent years are affected by the fact that the corridor has been under construction. Traffic volume sources are identified in *Appendix B*, but generally the baseline volumes for our 2008 model are a collection of different sources, adjusted so that traffic volumes are consistent throughout the study area (e.g. inbound volumes to one intersection match outbound volumes from the previous intersection).

Traffic volumes generally fluctuate from day to day and year to year. Those used in our analysis were adjusted (i.e. “balanced”) to account for these and other potential differences in traffic flows resulting from counts being carried out on Mondays, Fridays, near a national holiday or during years other than in 2008. These “balanced” traffic volumes are also included in *Appendix B*.

Once an acceptable 2008 baseline was established, historical traffic volume growth on the MacDonald-Cartier Bridge was examined. The City of Ottawa annually collects traffic data on all five inter-provincial bridges on an hour-by-hour basis. Based on historical analysis for a 2.5 hour peak period, trends for the MacDonald-Cartier Bridge were established for inbound (i.e. from Gatineau into Ottawa) and outbound (i.e. from Ottawa into Gatineau) traffic flows.

The trend analysis was carried out for the years between 1995 and 2007. *Appendix C* includes the trend analysis data. Generally, the following traffic trends were observed:

- AM Peak period inbound trend: -0.7% per annum
- AM Peak period outbound trend: -0.1% per annum
- PM Peak period inbound trend: -1.4% per annum
- PM Peak period outbound trend: +1.5% per annum

The declining trend of traffic is in part related to lower available capacity on King Edward (i.e. since construction started in 2005). Lack of capacity has lead to reductions in traffic volumes but not necessarily a reduction in demand, as indicated by the City’s traffic operations group. It was not possible to determine, based on interprovincial bridge traffic data, whether traffic demands had increased at other locations as a result of capacity constraints caused by construction activity within the King Edward Avenue corridor.

The historical trends were used to adjust the 2008 balanced traffic volumes to a 2010 horizon year (e.g. volumes inbound in AM Peak Period reduced by approximately 0.7% per year; volumes outbound in PM Peak Period were increased by 1.5% per year, etc.).

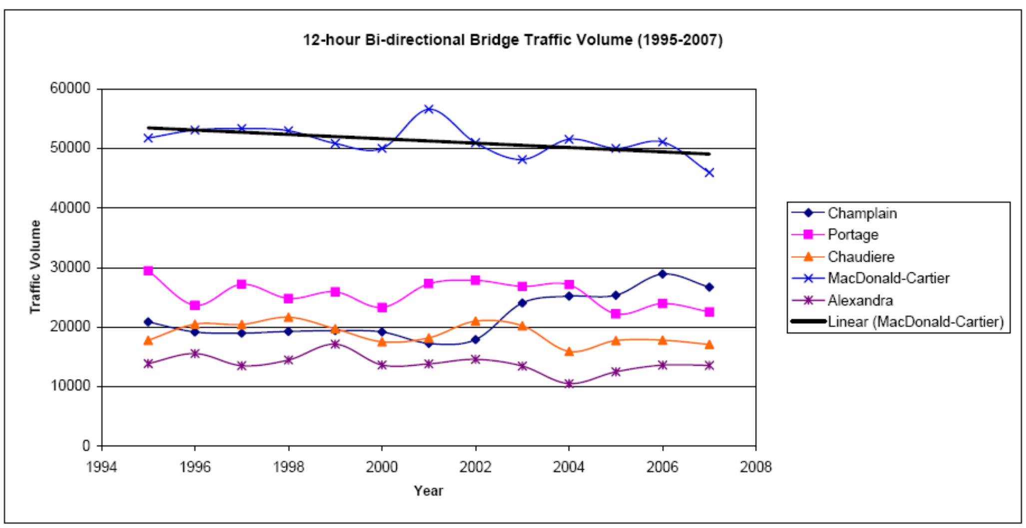
The City's longer-term travel demand projections for growth across the Ottawa River are included below to confirm the validity of this approach. The latest version of the Ottawa Transportation Master Plan's projects the following travel demand for the interprovincial screenline:

Projected Interprovincial Travel Demand (morning peak hour peak direction person-trips by motorized modes)			
Year	**Transit**	**Auto**	**Total**
2005	5,100	14,200	19,300
2031	11,800	15,800	27,600
Growth	**132%**	**11%**	**43%**

As shown in the above table, significant growth in travel is expected across the interprovincial screenline. Much of this growth will occur within the transit travel mode with an expected increase in passengers of 132%. Only 11% growth in auto travel is expected.

4.5.2 Other Traffic Trends

Peak period (i.e. 2.5 hours) analysis was used to model traffic conditions in the corridor, as described in more detail below. In addition, a review of 12-hour traffic volume counts for the five interprovincial bridges was carried out as part of this study. Raw data and associated graphics are included in *Appendix B*. The trend shows that bi-directional, 12-hour traffic volumes have generally been decreasing on the MacDonald-Cartier Bridge.



From a local perspective, a 12-hour trend appears to be a valid comparison period in order to characterize a potential trend toward less traffic in the corridor. However, it must be noted that trends in 12-hour counts can be influenced by fluctuations in travel during non-peak periods and/or in non-peak directions. As such, a 12-hour period is not a very good gauge of the overall "capacity" of a given transportation link. For the purposes of managing city-wide mobility (e.g. traffic operations), peak periods are the most critical time frames making peak period trends an important consideration.

The MacDonald-Cartier Bridge has excess capacity and as such, was considered for modelling purposes to be an unconstrained source of traffic. As indicated above, the traffic trends were used to bring the 2008 baseline traffic volumes to a 2010 horizon year for a "2.5 hour period" for both the AM and PM.

Traffic growth trend analysis was carried out using a 2.5 hour peak (e.g. 6:15 AM to 8:45 AM and 3:15 PM to 5:45 PM) because it was considered that a one hour assessment would not show any "peaking". Such a short period would make it difficult to discern differences between the alternative scenarios/ roadway configurations. That is, an intersection that was considered to be at capacity would present similar "peak hour" level of service results under all scenarios, whereas if a longer assessment time (e.g. 2.5 hours) was considered it would be possible to measure a difference between scenarios for traffic, air quality and other related criteria.

Transportation data (e.g. mixed traffic, goods movement, transit, cycling and pedestrians) were analyzed using PTV's VISSIM software to conduct microscopic simulation and to model travel for all modes based on driver behaviour, routing, etc. VISSIM is capable of tracking individual vehicles through the network and compiling statistics based on simulations of different roadway configurations.

An outline of the basic VISSIM transportation modelling process is provided below:

- An electronic map was imported and scaled to real life proportions (e.g. 100 metres in real life represents 100 metres in the model).
- Study area roads and pedestrian crossings were drawn in on top of the map.
- Traffic signal timing plans (i.e., how many seconds allocated to each traffic signal phase) for each signalized intersection were coded into the program. Current traffic signal information was obtained from the City in January, 2009.
- The number of vehicles was input into the model at each extremity of the defined study area which represents a starting or ending point of the study corridor (e.g. Rideau Street, MacDonald-Cartier Bridge).
- Three different sets of traffic counts (bridge counts, City of Ottawa Automatic Traffic Recorder (ATR) counts, City of Ottawa turning-movement counts) were used to establish

vehicle turning volumes at specific intersections. Vehicle volumes were balanced so the model would be representative of traffic flows during a typical weekday (i.e. not Fridays or holidays).

- Calibration was carried out to refine the model and address any inconsistencies with the real world (e.g. traffic volume queues, vehicle lane change behaviour in advance of an intersection, etc.).
- Data collection points were defined in the traffic simulation model. These data points were used to measure such data as traffic volume and speed for all corridor vehicles or for isolated vehicle classes (e.g. buses or trucks). Pedestrian information was also incorporated into the model and simulated (e.g. number of pedestrians, intersection crossing time).

Specific Measures of Effectiveness (MOE) were used to assess the different scenarios in the VISSIM simulation. An MOE is a measurement that can provide an indication of how well the transportation system is performing under certain conditions. For this analysis, MOEs include the quantifiable data outlined in the Evaluation Criteria, such as vehicle and pedestrian travel time through the corridor, vehicles and trucks processed per peak period, and average vehicle speed.

The merits of each scenario can more easily be compared by examining the various MOEs across the three scenarios and identifying the differences. Data collected from the VISSIM model was utilized for analysis purposes and is presented within the appropriate section for each of the study criteria.

5. Community Impact Assessment of the Scenarios

5.1 Introduction

King Edward Avenue is a prominent street in Lowertown and plays a role in the community's sense of place, prosperity, and diversity. Aside from its obvious transportation function, there is also a relationship with land use fronting and near to the corridor.

Other jurisdictions have explored and implemented lane reductions of major roads resulting in a sense of community improvement. The Task Force, Lowertown community and City of Ottawa is trying to determine if the same is possible for Lowertown with a potential lane reduction of King Edward Avenue. To help achieve this, the feasibility of reducing the cross-section of King Edward Avenue from six lanes to potentially four lanes is being investigated. A principal objective of this study was to identify specific community impacts of reducing the cross-section from a six lane to a potential four lane cross-section.

The results are described in detail in the following subsections and summarized on *Table 5-1* at the end of this section.

5.2 Air Quality

There is a relationship between public health and the quality of air in cities, and efforts are being made to improve urban air quality. The Task Force has expressed concern about air quality in the corridor; it is not certain if a lane reduction would improve air quality due to less volume of traffic or worsen air quality due to longer periods of traffic congestion. The objective of the air quality assessment was to predict the ambient air contaminant levels in the vicinity of King Edward Avenue due to vehicular emissions under each scenario for the year 2010. The following pollutants are the key conventional air contaminants associated with vehicular traffic and were assessed for this study:

- Carbon monoxide (CO);
- Oxides of nitrogen (NO_x);
- Respirable particulate matter ($PM_{2.5}$); and
- Sulphur dioxide (SO_2).

The gaseous emissions (i.e. CO, NO_x and SO_2) are associated with tailpipe emissions only, whereas particulate matter ($PM_{2.5}$) emissions are associated with re-suspension of road dust, vehicular braking and tailpipe emissions. Ten points of reception were selected along King Edward Avenue between Cathcart Street and Rideau Street, including single and multi unit residential buildings, places of worship, a school and a small park. This comparative study considered the worst-case meteorological conditions for the dispersion of air contaminants. This provided a conservative assessment of the air quality impacts of the three scenarios.

The air quality impacts were assessed using the U.S. EPA model MOBILE 6.2 and the U.S. EPA model CAL3QHC (Lakes Environmental CALRoads View) models. The City of Ottawa had a portable air quality monitoring station near King Edward Avenue but the study team was not able to use it at the time this report was prepared. The study team therefore relied on the data from the Wurtemburg Air Quality Station for the air quality analysis. Full details about the air quality methodology and approach, including information on ambient background air quality and Ministry of Environment standards are provided in *Appendix D*.

Two criteria were used to formulate an understanding of this community impact:

Criteria 1: Average emissions from truck, car and bus traffic during peak PM period

Criteria 2: Estimated dispersion of emissions during peak PM period

The table below illustrates the emissions from traffic determined by the modelling.

	Roadway Configuration											
	Scenario 1 6 Lane				**Scenario 2 6 Lane Hybrid**				**Scenario 3 4 Lane**			
Receptors[8]	**CO** ppm	**NOx** ppm	**$PM_{2.5}$** ug/m³	**SO_2** ppb	**CO** ppm	**NOx** ppm	**$PM_{2.5}$** ug/m³	**SO_2** ppb	**CO** ppm	**NOx** ppm	**$PM_{2.5}$** ug/m³	**SO_2** ppb
156 King Edward Avenue	5.7	0.5	8	1.4	5.4	0.5	7	1.4	4.6	0.4	6	1.1
244 Bruyère	6.9	0.6	10	1.6	7.1	0.5	10	1.7	5.9	0.5	8	1.4
174 King Edward Avenue	7.4	0.5	9	1.6	7.4	0.5	9	1.6	5.8	0.4	7	1.2
175 King Edward Avenue	9.7	0.8	13	2.3	10.2	0.8	13	2.4	7.0	0.5	10	1.8
233 King Edward Avenue	9.0	0.6	11	2.2	8.1	0.5	7	2.1	7.2	0.5	9	1.7
237 King Edward Avenue	6.9	0.5	9	1.7	6.8	0.5	9	1.6	4.9	0.4	7	1.3
231 Clarence Street	8.1	0.5	10	2.0	7.0	0.3	9	1.8	8.3	0.6	10	1.9
277 King Edward Avenue	6.6	0.4	9	1.6	6.5	0.4	9	1.6	5.1	0.4	7	1.3
195 St. George Street	5.1	0.2	7	1.1	4.8	0.2	7	1.0	7.8	0.5	9	1.4
375 King Edward Avenue	5.0	0.2	7	1.2	4.8	0.2	7	1.2	5.0	0.4	6	1.0

This analysis indicates that the Six-lane Configuration (Scenario 1) generally results in higher ambient concentrations of CO, NOx, $PM_{2.5}$ and SO_2 than the Six-lane Hybrid Configuration (Scenario 2). This is due to the marginally higher volumes (approximately 2% greater) predicted under Scenario 1 than under Scenario 2. Due to the lower volumes predicted for Scenario 3's Four-lane Configuration, the estimated ambient concentrations of the air contaminants are generally lower than the concentrations predicted under either Scenario 1

[8] Refer to Appendix D for additional details on the specific location of the receptors.

or 2. However there are receptors (typically receptors 7, 9 and 10) that have been predicted to be impacted by higher concentrations of air contaminants under Scenario 3 than under Scenarios 1 and 2. This is a result of higher traffic volume per lane under Scenario 3 than under Scenarios 1 and 2 and the impact of the worst case meteorological conditions on dispersion.

When ambient background air quality data is taken into account, only NOx is found to exceed the provincial standard of the four contaminants considered. This is attributable to vehicular traffic since the background NOx concentration is only 0.026 ppm while the predicted NOx concentration due to vehicular traffic is approximately 0.8 ppm.

5.3 Noise

The amount of noise in a neighbourhood plays a factor in localized quality of life. The Task Force has expressed concern about noise in the corridor and believes that a lane reduction would slow down traffic during peak periods and help reduce noise. The objective of the noise assessment was to predict the noise levels in the vicinity of King Edward Avenue due to vehicular traffic under each scenario for the year 2010.

The noise impact of traffic on King Edward Avenue was modelled using the CADNA/A software and the German RLS 90 protocol which predicts noise better than the Ministry of Environment (MOE) STAMSON/ORNAMENT methods for source-receiver distances closer than 15 metres. The analysis was based on two centrelines (one for the northbound lane and one for the southbound lane) which was a suitable approach for understanding the difference in noise between the scenarios. Full details about the noise methodology and approach, including information on Ministry of Environment standards are provided in *Appendix E*.

One criterion was used to formulate an understanding of this community impact:

Criteria 3: Average noise from traffic during peak period

The following table shows the predicted one-hour A-weighted equivalent sound level (Leq) at the selected locations under each of the three road laneway configuration scenarios.

	Roadway Configuration		
	Scenario 1 6 Lane	Scenario 2 6 Lane Hybrid	Scenario 3 4 Lane
Receptors[9]	Sound level (dBA)	Sound level (dBA)	Sound level (dBA)
156 King Edward Avenue	68.4	67.9	67.5
244 Bruyère	71.9	71.4	71.0
174 King Edward Avenue	72.0	71.6	71.1
175 King Edward Avenue	72.9	74.3	73.6
233 King Edward Avenue	68.4	68.2	67.2
237 King Edward Avenue	69.6	69.5	68.5
277 King Edward Avenue	69.9	69.7	68.2
231 Clarence St	70.5	70.4	68.6
375 King Edward Avenue	68.8	68.6	66.0
195 St George	70.0	69.9	66.7

The predicted one-hour equivalent sound level ranged from 68.4 to 72.9 dBA under Scenario 1 (Six-lane Configuration), from 67.9 to 74.3 dBA under Scenario 2 (Six-lane Hybrid Configuration), and from 66.0 to 73.6 dBA under Scenario 3 (Four-lane Configuration). Based on the predicted results the variation in vehicle speed for each of the scenarios is the primary differentiator for sound levels at each of the selected receptors.

In general, the Four-lane Configuration results in slightly lower predicted sound levels. It is important to note that none of the sound levels differs by more than three dB in any of the scenarios. A differential of 3 dB would not be perceptible by most people located at the indentified receptors.

5.4 Economic Prosperity

Economic prosperity is a concern for all neighbourhoods. It is not limited solely to the prosperity of existing businesses or the potential to establish and sustain new businesses, but also relates to neighbourhood property values and the benefits that can be reaped from property values that increase over time. The Task Force has expressed concern about economic prosperity, in particular that the proximity of property to the corridor negatively impacts property value. This aspect of the study attempted to understand the impact that the roadway configurations might have on economic prosperity.

Two criteria were used to formulate an understating of this community impact when reviewing the case studies:

[9] Refer to Appendix E for additional details on the specific location of the receptors.

Criteria 4: If the land use planning framework is changed to encourage (re)development, will the roadway's configuration contribute to the likelihood of new residential investment?

Criteria 5: If the land use planning framework is changed to encourage (re)development, will the roadway's configuration contribute to the likelihood of new office or retail investment?

	Roadway Configuration		
	Scenario 1 **6 Lane**	**Scenario 2** **6 Lane Hybrid**	**Scenario 3** **4 Lane**
If the land use planning framework is changed to encourage (re)development, will the roadway's configuration contribute to the likelihood of new residential development?	n/a	Case study results are not conclusive	Case study results are not conclusive
If the land use planning framework is changed to encourage (re)development, will the roadway's configuration contribute to the likelihood of new office or retail investment?	n/a	Case study results are not conclusive	Case study results are not conclusive

There are no conclusive findings from other jurisdictions that suggest a lane reduction would contribute to the likelihood of new residential, office, or retail investment, if the land use planning framework is changed to encourage (re)development. We anticipate that a change in the land use planning framework may be the more likely catalyst for (re)development in the corridor rather than a potential lane reduction.

5.5 Urban Design / Streetscape

Urban design is a critical aspect in creating liveable places. It encompasses a range of elements including urban form and streetscaping, and bridges elements of land use, architecture, and landscaping. The City of Ottawa defines urban design as "the process of applying desired functional and aesthetic parameters to the design of the city and its parts."[10] Urban design helps to provide an identity to neighbourhoods, makes neighbourhoods and streets attractive, contributes to place-making, and encourages human-space interaction in cities. Streetscape refers to the specific set of urban design elements such as lighting, vegetation, and street furniture which come together to address the visual image of a road

[10] http://www.ottawa.ca/residents/planning/design_plan_guidelines/urban_design/index_en.html

corridor. The Task Force has expressed concern about the urban design / streetscape in the corridor and believes that a lane reduction might provide room for streetscaping improvements.

Eight criteria were used to formulate an understating of this community impact when reviewing the case studies:

Criteria 6: Can a higher quality of night-time lighting of sidewalks be achieved?

Criteria 7A: Can new street furniture be achieved?

Criteria 7B: Can increased sidewalk width be achieved?

Criteria 7C: Can on-street parking be achieved?

Criteria 7D: Can new/increased medians be achieved?

Criteria 7E: Can new/increased vegetation be achieved?

Criteria 7F: Can new/increased urban braille be achieved?

Criteria 7G: Can improved corridor height-to-width ratio be achieved?

The City of Ottawa has prepared urban design guidelines for various road typologies. In addition to the case studies, we reviewed those design guidelines which we believed would be the most applicable to a future King Edward Avenue – the *Regional Road Corridor Design Guidelines* and the *Urban Design Guidelines for Development Along Arterial Mainstreets* – to further understand what streetscaping elements might be possible.

	Roadway Configuration		
	Scenario 1 **6 Lane**	**Scenario 2** **6 Lane Hybrid**	**Scenario 3** **4 Lane**
Can a higher quality of night-time lighting of sidewalks be achieved?	n/a	Case study results suggest yes	Case study results suggest yes
Can new street furniture be achieved?	n/a	Case study results suggest yes	Case study results suggest yes
Can increased sidewalk width be achieved?	n/a	Case study results suggest yes	Case study results suggest yes
Can on-street parking be achieved?	n/a	Case study results are not conclusive	Case study results are not conclusive
Can new/increased	n/a	Case study results suggest yes	Case study results suggest yes

medians be achieved?			
Can new/increased vegetation be achieved?	n/a	Case study results suggest yes	Case study results suggest yes
Can new/increased urban braille be achieved?	n/a	Case study results suggest yes	Case study results suggest yes
Can improved corridor height-to-width ratio be achieved?	n/a	Case study results are not conclusive	Case study results are not conclusive
Notes			Depending on the ultimate design, this scenario may provide more space than the 6 Lane Hybrid to accommodate streetscaping.

A reduction in the number of lanes is expected to contribute to higher-quality of night-time lighting of sidewalks, new street furniture, increased sidewalk width, new/increased medians, new/increased vegetation, and new/increased urban Braille.[11] Practically, we recognize that the extent of these improvements in the corridor depends on how a lane reduction is configured. We also recognize that some of these elements might compete with each other (e.g., vegetation might compete with new street furniture within the additional space gained by the lane reduction).

There is was no information from our research that allows us to determine if a lane reduction would lead to more on-street parking or improved corridor height-to-width ratio. If on-street parking was desired, we anticipate that it could be facilitated by designing it into the reconfigured roadway. If improved corridor height-to-width ratio was desired, we anticipate that it could be facilitated by a change in the land use planning framework to promote buildings of a certain scale and massing relative to the corridor.

5.6 Cohesion

Neighbourhood cohesion is an aspect of city-building that creates a sense of community and belonging among residents. Neighbourhood cohesion is supported by factors such as mix of land uses, access to public services, and socio-economic characteristics. Neighbourhood cohesion is achieved when citizens feel united because of their commonalities while simultaneously embracing aspects of their diversity. The Task Force has expressed concern about community cohesion and has suggested that the corridor might have a divisive impact on community cohesion.

Three criteria were used to formulate an understating of this community impact when reviewing the case studies:

[11] The case studies involved streetscaping treatments in corridors that had little existing streetscaping. The implications of this are discussed in Section 7 of this report.

Criteria 8A: Can a wider mix of land uses vs. concentration of social service agencies be achieved?

Criteria 8B: Can better access to public services such as schools, parks, and community facilities be achieved?

Criteria 8C: Can broader socio-economic diversity be achieved?

	Roadway Configuration		
	Scenario 1 6 Lane	Scenario 2 6 Lane Hybrid	Scenario 3 4 Lane
Can a wider mix of land uses vs. concentration of social service agencies be achieved?	n/a	Case study results are not conclusive	Case study results are not conclusive
Can better access to public services such as schools, parks, and community facilities be achieved?	n/a	No evidence in the case studies that offer insight	No evidence in the case studies that offer insight
Can broader socio-economic diversity be achieved?	n/a	No evidence in the case studies that offer insight	No evidence in the case studies that offer insight

Based on the research conducted by our team, there are no conclusive findings from other jurisdictions that suggest a lane reduction in the corridor might address issues with mix of land uses, access to public facilities, or broader socio-economic diversity. If the community aims to address these issues, there may be other methods that might lead to suitable outcomes.[12]

5.7 Connectivity

Neighbourhood connectivity helps knit different parts of a City together and supports mobility within, around, and through neighbourhoods. Neighbourhood connectivity is supported by pedestrian linkages, cycling linkages, way-finding signage, and access to multiple modes of transportation. When neighbourhood connectivity is achieved, it helps minimize the isolation of a neighbourhood from the rest of the city. The Task Force feels that a lane reduction in the corridor might provide opportunities to improve neighbourhood connectivity.

Four criteria were used to formulate an understating of this community impact when reviewing the case studies:

[12] A discussion of the alternative methods is provided in Section 7 of this report.

Criteria 9A: Can greater opportunities for pedestrian crossings [of King Edward] be achieved?

Criteria 9B: Can additional bicycle lanes [on King Edward] be achieved?

Criteria 9C: Can better way-finding information for community and surrounding destinations be achieved?

Criteria 9D: Can improved linkages with multiple transportation modes be achieved?

	Roadway Configuration		
	Scenario 1 **6 Lane**	**Scenario 2** **6 Lane Hybrid**	**Scenario 3** **4 Lane**
Can greater opportunities for pedestrian crossings be achieved?	n/a	Case study results are not conclusive	Case study results are not conclusive
Can additional bicycle lanes be achieved?	n/a	Case study results suggest yes	Case study results suggest yes Depending on the ultimate design, this scenario may provide more space than the 6 Lane Hybrid to accommodate bike lanes.
Can better way-finding for community and surrounding destinations be achieved?	n/a	Case study results are not conclusive	Case study results are not conclusive
Can improved linkages with multiple transportation modes be achieved?	n/a	Case study results suggest yes	Case study results suggest yes

The analysis of the case studies, when applied to the alternative scenarios, suggests that additional bicycle lanes and improved linkages with multiple transportation modes can be achieved. This finding is not surprising since the lane reduction in the case study jurisdictions has allowed space to be allocated to dedicated cycling trails, dedicated bus lanes, or a combination of both. For King Edward Avenue, if there is a lane reduction, the ability to dedicate some of the roadway to an on-street bicycle lane will have to be determined through a design exercise that also balances the space demands for streetscaping and possibly on-street parking.

There are no conclusive findings from other jurisdictions that suggest a lane reduction might provide opportunities for pedestrian crossings or better way-finding for the community and surrounding area. In the matter of way-finding, which could be considered a matter of improved signage, there are methods by which improved way-finding signage could be achieved for Lowertown that does not depend on a lane reduction in the corridor.[13]

[13] A discussion of improved signage is provided in Section 7 of this report.

5.8 Safety Considerations

Real and perceived safety is a consideration in the planning of good neighbourhoods and streets that are intended to be supportive of pedestrian and cycling modes of travel. A variety of factors influence pedestrian and cyclist perception of safety such as the number of lanes, the speed of adjacent automobile traffic, and the existence of on-street parking. The Task Force believes that a lane reduction in the corridor might contribute to increased safety.

One criterion was used to formulate an understating of this community impact[14] when reviewing the case studies:

Criteria S3: If on-street parking is provided, can a greater sense of pedestrian safety be achieved?

	Roadway Configuration		
	Scenario 1 **6 Lane**	**Scenario 2** **6 Lane Hybrid**	**Scenario 3** **4 Lane**
If on-street parking is provided, can a greater sense of pedestrian safety be achieved?	n/a	Case study results are not conclusive (see discussion below)	Case study results are not conclusive (see discussion below) Depending on the ultimate design, this scenario may provide more space than the 6 Lane Hybrid to accommodate on-street parking which might possibly provide a greater sense of pedestrian safety.

Many of the case studies did not discuss safety issues so it was difficult to draw a conclusive observation about safety from the case studies. However, the consulting team is aware of substantial planning literature that supports on-street parking as a means to buffer pedestrians from traffic.[15] Public feedback documented during the preparation of the City's Pedestrian Plan notes that, "Several respondents felt that more on-street parking helps to slow cars and enhance pedestrian safety."[16] For this particular criterion, it is anticipated that some greater sense of pedestrian safety can be achieved if on-street parking is provided. As noted in the Transportation Impact Assessment portion of this study, only the Six-lane scenarios are able to accommodate on-street parking; Scenario 3 does not allow for parking.

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[14] Refer to Section 6 of this report regarding safety criteria related to transportation impacts.

[15] http://www.walkinginfo.org/engineering/parking.cfm

[16] Ottawa, City of. 2009 (DRAFT). *Ottawa Pedestrian Plan*. P. 54.

5.9 Summary of Results

Table 5-1: Summary of Community Impact Analysis

	Roadway Configuration		
	Scenario 1 6 Lane	Scenario 2 6 Lane Hybrid	Scenario 3 4 Lane
Air Quality			
Average emissions – CO concentrations (ppm)	5.0 - 9.7	4.8 - 10.2	4.6 - 8.3
Average emissions – NOx concentrations (ppm)	0.2 - 0.8	0.2 - 0.8	0.4 - 0.6
Average emissions – $PM_{2.5}$ concentrations (micrograms)	7 - 13	7 - 13	6 - 10
Average emissions – SO_2 concentrations (ppb)	1.1 - 2.3	1.0 - 2.4	1.0 - 1.9
Noise			
Predicted noise levels	68.4 - 72.9	67.9 - 74.3	66.0 - 73.6
Economic Prosperity			
If the land use planning framework is changed to encourage (re)development, will the roadway's configuration contribute to the likelihood of new residential development?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive
If the land use planning framework is changed to encourage (re)development, will the roadway's configuration contribute to the likelihood of new office or retail investment?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive
Urban design / streetscape / identity / place-making			
Can a higher quality of night-time lighting of sidewalks be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes
Can new street furniture be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes
Can increased sidewalk width be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes
Can on-street parking be achieved?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive
Can new/increased medians be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes
Can new/increased vegetation be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes
Can new/increased urban braille be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes
Can improved corridor height-to-width ratio be achieved?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive
Neighbourhood cohesion			
Can a wider mix of land uses vs. concentration of social service agencies be achieved?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive
Can better access to public services such as schools, parks, and community facilities be achieved?	n/a – status quo	No evidence in the case studies that offer insight	No evidence in the case studies that offer insight
Can broader socio-economic diversity be achieved?	n/a – status quo	No evidence in the case studies that offer insight	No evidence in the case studies that offer insight
Neighbourhood connectivity			
Can greater opportunities for pedestrian crossings be achieved?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive
Can additional bicycle lanes be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes; depending on the ultimate design, this scenario may provide more space than the 6 Lane Hybrid to accommodate bike lanes.
Can better way-finding for community and surrounding destinations be achieved?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive
Can improved linkages with multiple transportation modes be achieved?	n/a – status quo	Case study results suggest yes	Case study results suggest yes
If on-street parking is provided, can a greater sense of pedestrian safety be achieved?	n/a – status quo	Case study results are not conclusive	Case study results are not conclusive; depending on the ultimate design, this scenario may provide more space than the 6 Lane Hybrid to accommodate on-street parking which might possibly provide a greater sense of pedestrian safety.
Note			Depending on the ultimate design, this scenario may provide more space than the 6 Lane Hybrid to accommodate streetscaping.

6. Traffic Impact Assessment of the Scenarios

6.1 Introduction

The Transportation Impact Assessment (TIA) combined both empirical and qualitative criteria to capture the impact of lane reductions on multimodal transportation users in the study area. The TIA criteria are identified and described throughout this section including relevant results stemming from the analysis.

The results are described in detail in the following subsections and summarized in *Table 6-1* at the end of this section.

6.2 Motorists

An assessment of impacts on motorists was conducted as part of the TIA to determine the impacts under each of the three roadway scenarios would have on traffic volumes in the corridor. Metrics were included related to ability to accommodate traffic, corridor congestion, neighbourhood infiltration and availability of parking.

Four main criteria were used to measure motorist transportation impacts:

Criteria 1: Traffic volume in corridor, measured by the number of vehicles travelling in the AM and PM peak period and peak hour, determined for the northbound and southbound directions between St. Patrick Street and Murray Street

Criteria 2: Corridor congestion, measured by the estimated travel time of vehicles in corridor, for a 1.6 kilometre distance in each of northbound and southbound flows (e.g. from south, east and west of the intersection of Rideau Street and King Edward Avenue to a point 1.6 kilometres north, on the MacDonald-Cartier Bridge)

Criteria 3: Impacts on alternative routes, measured by the estimated number of vehicles infiltrating the local neighbourhood streets by using alternative routes

Criteria 4: Ability to accommodate on-street parking, measured by the number of parking stall-hours per day

Refer to *Table 6-1* for the detailed measures describing this impact.

Traffic volume in the corridor measured directional flow (i.e. northbound and southbound) for the AM and PM peaks for two intervals: one-hour and 2.5-hour peak periods. It should be noted that traffic volumes were reported for the most congested segment of the King Edward Avenue corridor: mid-block between Murray Street and St. Patrick Street. Other locations were considered to be under "free flow" conditions and as such would not provide sufficient means to distinguish performance between the different roadway configuration scenarios.

Traffic volumes were fairly consistent across all three scenarios for the AM period (i.e., 1300 and 4600 vehicle range for southbound flow in peak hour and period). The Six-lane and Six-lane Hybrid configurations exhibited similar traffic flow characteristics in PM peak (i.e. 1750 and 4300 vehicle range for northbound flow in peak hour and period). The Four-lane Configuration exhibited a significant reduction (approximately 20%) in the number of vehicles able to flow through the corridor in the PM peak hour and period (i.e. 1400 and 3450 range for northbound flow in peak hour and period).

Corridor congestion measured the average northbound and southbound travel time (in minutes) estimated by the VISSIM model. Northbound AM peak travel times were consistent across all scenarios. The Four-lane Configuration saw increased congestion for northbound and southbound PM peak periods, with an estimated increase in travel time of 3.0 minutes for northbound direction and 1.5 minutes for southbound direction.

The difference in travel times between northbound and southbound directions is due in large part to northbound queues which were often simulated to be longer than southbound queues. In addition, at the intersection of King Edward Avenue and Murray Street all southbound through vehicles have a green signal display for the full length of the north-south signal phase. In contrast, the northbound vehicles are allocated a much smaller portion of this phase as they are required to stop during the phase for southbound left turning vehicles, a significant movement. The effect is a higher travel time in the northbound direction.

It is possible that retiming of traffic signals would have an effect on corridor performance. Signal timing plans were obtained from the City of Ottawa in January, 2009. These were carried through all scenarios with modifications made to pedestrian crossing time in Scenario 3, the Four-lane Configuration.

The impacts on alternative routes criterion attempted to measure the number of vehicles that might reroute to other streets (i.e. neighbourhood infiltration) to assess the potential impact on adjacent neighbourhoods. Due to software limitations, it was not possible to quantify this through traffic modelling. It was only possible to estimate the level of traffic that would no longer be processed in the study corridor but not to determine where traffic was being diverted to. The traffic on King Edward Avenue could largely be presumed to be regional travellers attempting to reach destinations beyond the study area. As such, neighbourhood infiltration could be considered to be negligible under each of the three scenarios.

The potential for additional traffic congestion in the short-term is possible. However, based on research conducted for this study, it is believed that the dynamics of traffic flow is highly variable and it is therefore difficult to predict the long-term effects on other routes and the severity of the effects.

The ability to accommodate on-street parking was considered under each given scenario, being mindful of peak direction parking restrictions that could likely be enforced. For each scenario, the potential availability of parking stalls over the course of a 12-hour period (7 am-7 pm) was measured to determine total "parking stall hours" available. Scenario 1 has the ability to accommodate 740 parking space hours[17] and Scenario 2 has the ability to accommodate 556 parking space hours. Scenario 3 is not able to accommodate any parking space hours under the configuration assumed; however, if curb lanes were maintained in this scenario, on-street parking in certain locations could be included as a trade-off to wider boulevards and streetscaping.

6.3 Pedestrians

The length pedestrians need to travel to get to a destination is a primary factor when considering a choice between walking and driving. When assessing a new roadway configuration for King Edward Avenue consideration must be taken to ensure pedestrian walking time is not increased.

Two main criteria were used to measure impacts on pedestrians:

Criteria 5A: Pedestrian walking time along a primary pedestrian route (including delay), measured by the number of minutes per pedestrian (estimated)

Criteria 5B: Pedestrian waiting and crossing time at a key intersection, measured by the number of minutes per pedestrian (estimated)

Refer to *Table 6-1* for the detailed measures describing this impact.

Pedestrian walking time along two pedestrian routes was measured in minutes to estimate the time it might take pedestrians to walk from Sussex Drive to Rideau Street (north to south) and from Mackenzie Avenue to Vanier Parkway (west to east). Calculated walking time included waiting time at intersections. Route distances were approximately 2 km from Sussex Drive to Rideau Street and approximately 2.5 km from Mackenzie Avenue to Vanier Parkway. The results did not vary significantly between the three scenarios.

[17] Although not specifically part of the alternative described in Section 4.3, a potential number of on-street parking stall-hours was estimated to facilitate comparison.

Pedestrian waiting time at a key intersection measured the amount of time in seconds it took pedestrians to cross St. Patrick and Murray Streets, including pedestrian wait time at the intersection before being granted right of way. These were calculated as a function of the 2008 traffic volumes and were recorded as a weighted average based on the distances pedestrians had to travel while crossing each intersection. For both "pedestrian routes", the sum of pedestrian wait and crossing times were in the same range across all three scenarios. Crossing times for the Four-lane Configuration were the shortest because of the narrower intersection crossing distance in the east-west direction, however, due to traffic signal timing allocation the wait times between crossing opportunities offset this benefit.

6.4 Cyclists

In 2008 the City of Ottawa introduced the *Ottawa Cycling Plan (OCP)*, which outlines a long-term strategy for expanding the cycling network in the urban and rural areas of Ottawa. Cycling is a popular travel mode in the City and there are many pre-existing cycling routes.

A major goal of the *OCP* is to expand the cycling network by proposing a new system that includes "Spine" and "Community" cycling routes. A Spine route is designed to provide a direct link between destinations and rural communities and is intended for use by more experienced frequent commuters and recreational cyclists. Community routes will feed into the Spine system and will provide opportunities for commuter or recreational cycling along streets with less traffic.

Presently, existing cycling routes within the study corridor include two "Shared-Use" lanes along St. Andrew Street and along Rideau Street. Both of these routes cross King Edward Avenue at their respective intersections. Signage is displayed on these routes and cyclists share the roadway with other vehicles.

Within the King Edward Avenue Study Area there are two existing and two proposed Spine routes and one proposed Community route all of which do, or will in future, intersect with King Edward Avenue. As mentioned above, St. Andrew Street and Rideau Street are existing cycling routes on the Spine network and future Spine routes will intersect King Edward Avenue at St. Patrick Street and Murray Street. A Community route is proposed to intersect at York Street.

The proposed cycling network with Spine and Community routes highlighted is shown in the figure below. The routes along St. Patrick and Murray are identified as "Proposed Bicycle Lanes" and the one along York is designated as a "Proposed Shared Use Lane".

Figure 6-1: Study Area Cycling Routes

The *Ottawa Cycling Plan* and technical analyses were used to assess the effect each configuration would have on the cycling network in the community.

Two main criteria were used:

Criteria 6: Cycling travel time for commuter cyclists, measured by the estimated number of minutes per cyclist along a primary cycling route

Criteria 7: Is there an appreciable positive effect on cycling network connectivity?

Refer to *Table 6-1* for the detailed measures describing this impact.

Cycling travel time for commuter cyclists was calculated using typical cycling speed combined with a proxy to gauge signal delay (pedestrian waiting times at intersections was used). Travel time (in minutes) was approximated for the north to south route of Sussex Drive to Rideau Street and the east to west route of Mackenzie Avenue to Vanier Parkway. Results indicate that there is no distinct difference for cycling travel time across scenarios during the AM peak period. In the PM period, cyclists travelling in the north-south direction benefit from a modified signal timing (i.e., reduced east-west pedestrian crossing distance), incurring 0.5 to 1.0 minute less signal delay at the St. Patrick Street and Murray Street intersections with King Edward.

There is little effect on cycling network connectivity due to changes in configurations since King Edward Avenue is not part of the OCP network. We recognize that there is potential for reallocation of road space within Scenario 3, the Four-lane Configuration, which could enable the creation of cycling lanes on King Edward Avenue. If this occurred, it would augment the OCP Spine network and improve connectivity.

6.5 Transit

The ability of residents and commuters to have efficient and effective alternative transportation choices is necessary to ensure a good quality of life for community members. An effective transit system will reduce the reliance on the single-occupancy vehicle and reduce congestion along major arterial corridors, such as King Edward Avenue.

To assess the effectiveness of transit in the four scenarios, three main criteria[18] were used:

Criteria 8: Transit travel time, measured by average bus travel time in minutes (PM period only) for a 1.6 kilometre distance in the southbound direction (e.g. from the MacDonald-Cartier Bridge to the intersection of Rideau Street and King Edward Avenue)

Criteria 9: Travel time reliability, measured by the 90th percentile travel time per bus (which is the time below which 90% of all buses travel)

Criteria 10: Transit vehicle volume, measured by the number of buses per period

Refer to *Table 6-1* **for the detailed measures describing this impact.**

Transit travel time measured the average time it took Société des transports de l'Outaouais (STO) buses to travel the corridor from a starting point on the MacDonald-Cartier Bridge to their route starting point at the intersection of Rideau Street and King Edward Avenue. The route measured replicates existing STO travel and begins just north of Sussex Drive on the MacDonald-Cartier Bridge, exits the bridge onto Boteler Street and turns right onto Sussex Drive from Boteler Street. It then follows Sussex to King Edward Avenue, where it turns right and heads south down King Edward Avenue. The travel time is measured up to Rideau Street.

Transit travel time for Scenarios 1 and 2 was consistent, and the Four-lane Configuration (Scenario 3) exhibited an increase of approximately 1.5 minutes of travel time per bus for

[18] STO buses travel to Ottawa empty in order to start their afternoon transit routes and as such, no passenger delay calculations were included in the criteria set.

both the PM peak hour and the peak period. This was an increase from 4:20 minutes to 5:45 minutes of travel time.

In comparing the Four-lane Configuration (Scenario 3) with the other scenarios, this increase in travel time for transit vehicles is significant given that approximately 120 buses per hour start their routes at the corner of Rideau Street and King Edward Avenue. Many of these buses are "deadheading" (i.e. travelling without passengers) between routes. A 1.5 minute delay along King Edward Avenue means a delay in arriving at Rideau Street at the very start of their route which then results in a delay for passengers and the potential need to increase the fleet size in order to compensate for the system-wide effect of this delay or travel time variability.

The additional travel time modelled for transit vehicles in the southbound direction is related to traffic signals being coordinated for northbound and northbound-left-turning vehicles at the very congested intersections of St. Patrick Street and Murray Street with King Edward Avenue. Traffic counts show that southbound volumes are high in the PM peak period (1400 vehicles per hour) even though the northbound direction is the most congested in the PM Peak period.

It should be noted that as a result of different routing being employed in the VISSIM model for transit vehicles, travel time measurements for buses can not be directly compared to motorist or truck travel times.

Transit time reliability was measured using the 90th percentile transit travel time, that is, the time below which 90% of buses travel a given route. This is a valid measurement used in the transit industry which provides an indication of how well transit vehicles are adhering to a schedule. It stands that if the 90th percentile is substantially higher than the average time (as calculated in Criteria 8) it may be difficult for a transit service provider to maintain service and scheduling commitments. In other words, if reliability is poor then additional buses may be required, at increased operating cost, to ensure that the route schedules are followed. A lower level of service can also be offered to improve reliability however this works against goals of maintaining and/or increasing transit ridership. In the case of King Edward Avenue, because Rideau Street and King Edward Avenue is the starting point for the PM transit service it is critical that buses arrive on time and start their routes on time.

In the Four-lane Configuration (Scenario 3) the 90th percentile time was over 10 minutes for the PM peak period. This means that 90 percent of all buses would complete their route in 10 minutes or less. As such, the STO may require that additional time be added to all buses scheduled within the PM peak period. Starting buses on time at the beginning of a route is critical to ensuring that transit route schedules are adhered to.

The 90th percentile time for Scenarios 1 and 2 was comparable to their average transit travel time. This indicates that it is less likely that additional time would have to be added to bus schedules under these scenarios.

Transit vehicle volume measured the number of buses that were able to travel their route in the PM peak hour and peak period. It measured how well transit vehicles were able to negotiate the corridor under congested conditions. The model used for analysis assumed that 120 buses per hour were travelling south on King Edward Avenue. If that number of buses did not arrive at the identified route end point within the traffic simulation period, it signified that additional buses would have to be put in service to maintain the existing number of scheduled route starts at Rideau Street and King Edward in the PM peak.

The Four-lane Configuration allowed for the fewest transit vehicles to complete their route in the PM peak hour and peak period. Of the 120 STO buses scheduled per hour in the PM peak, 118 buses were shown to complete their route in the modelling software, as compared to 130 and 122 respectively for Scenarios 1 and 2. In the peak period, the number of buses processed within the corridor was expected to be 300 which dropped to 266 for Scenario 3 as compared to 288 and 300 respectively for Scenarios 1 and 2.

6.6 Goods Movement

Goods movement is central to an urban area's economic vitality. The King Edward Avenue corridor is a designated truck route, used for transporting goods. As an interregional transportation corridor any reconfiguration of King Edward Avenue should consider the impacts on truck travel.

The measured truck route distance is 1.8 kilometres (from Waller Street to the MacDonald-Cartier Bridge). It should be noted that the motorist route distance used to assess Criteria 2 was 1.6 kilometres (from Rideau Street to the MacDonald-Cartier Bridge). As such, truck travel time should not be compared against general motorist travel time.

Truck volumes were obtained from City of Ottawa vehicle classification surveys and generally range from 55 to 110 trucks per hour, per direction in the peak periods. The southbound direction in the AM period is heaviest for truck traffic (110 trucks per hour) as compared to the PM (55 trucks per hour) and/or the northbound direction of travel (75 trucks per hour in the AM and 60 trucks per hour in the PM).

To assess the impact of reducing lanes on goods movement two main criteria were used:

Criteria 11: Truck corridor travel time, measured as the minutes of time per truck through the corridor in northbound and southbound directions

Criteria 12: Peak truck flow, measured as the number of trucks per period

Refer to *Table 6-1* for the detailed measures describing this impact.

Truck corridor travel time measured the average northbound and southbound travel time (in minutes) for the truck route as estimated by the VISSIM model. For the aforementioned route, truck travel times for the AM peak hour and peak period were consistent across all scenarios with an average northbound time of approximately 4 minutes and an average southbound time of approximately 2.5 minutes. Truck travel times for the PM peak hour and peak period were consistent across Scenario 1 and 2, but were higher for Scenario 3 at roughly 7 minutes and 4 minutes for the southbound and northbound directions, respectively.

Peak truck flow measured the number of trucks that the VISSIM traffic simulation estimated to travel through the King Edward corridor in each scenario. Results for this criterion were fairly consistent across all scenarios in the northbound and southbound direction for all time periods, and no discernable differences were noted. This may in part be due to how the truck route was defined. Whereas routes and travel times measured for motorists included traffic signal delays on either King Edward Avenue (south of Rideau Street) or Rideau Street (east and west of King Edward Avenue), the truck route was defined as starting (or ending) at Waller Street. Given the defined study area used for the VISSIM model, lower traffic volumes were defined at Waller Street as compared to King Edward Avenue and Rideau Street and as such, the modelled truck travel times may be shorter than in reality.

6.7 Impacts on other Communities

Bridge traffic was analyzed for the five interprovincial bridges: Champlain, Chaudiere, Portage, Alexandra and MacDonald-Cartier in an attempt to quantify traffic impacts on other communities resulting from King Edward Avenue construction. Historical trend analysis was carried out for the five bridges from hourly, peak period and 12-hour perspectives. The analysis was carried out to determine whether any traffic volume fluctuations could be discerned during construction on King Edward Avenue since it began in 2005 (e.g. volume decreases on MacDonald-Cartier occurring at the same time as increases on the Alexandra or Portage Bridges). No such trends were evident.

The VISSIM traffic simulation was carried out using “unconstrained” traffic volume inputs for a 2.5 hour peak period. This duration of analysis allowed traffic to build over time and, for the higher-capacity configuration, to also dissipate. This produced traffic volume estimates for each scenario that could then be directly compared in terms of traffic throughput.

The following criteria were used to determine impacts on other communities:

Criteria 13: External impacts on other communities due to traffic displacement, measured as the number of vehicles per hour in the peak period

Criteria 14: Duration of impact on other communities due to dispersed traffic, measured as the number of vehicle hours of additional peak period time

Refer to *Table 6-1* for the detailed measures describing this impact.

External impacts on other communities due to traffic displacement measured the number of vehicles per hour during the peak period and peak hour that could reroute to other, neighbouring communities due to congested conditions on King Edward Avenue. The Six-lane and Six-lane Hybrid Configurations were found to have negligible impacts on other neighbourhoods since all assigned traffic was able to flow through the corridor within the peak period.

The Four-lane Configuration is forecast to require a rerouting of 300 vehicles for the peak hour and 600 vehicles for the peak period (since these vehicles were not able to "clear" the study area during the 2.5 hour simulation period). While it could be expected that these motorists will chose alternate routes instead of waiting in congestion on the MacDonald-Cartier Bridge or on King Edward Avenue, it is possible that the "relocated" traffic will not manifest itself because motorists would choose alternative modes of travel, hours of travel, defer discretionary trips, etc. resulting in a phenomenon of traffic evaporation that has occurred in other jurisdictions where lane reductions have been implemented.[19]

To further understand externalities the traffic volume was input into MOBILE 6.2, the U.S. EPA vehicular emissions model, to predict the potential greenhouse gas impacts. If traffic reroutes, then approximately 170 kg CO2 equivalent would be generated along the alternate routes. If the traffic expected to reroute does not manifest, then the volume of CO2 reduced in the corridor may be reduced by a similar volume of CO2 equivalent. The volume of CO2 equivalent is comparable to approximately 900 kilometres of commuting in a small car[20]. Additional information on the greenhouse gas estimate is provided in *Appendix F*.

The duration of impact on other communities due to dispersed traffic measured the number of vehicle hours that dispersed traffic rerouted through neighbouring communities. Based on the peak period traffic modelling, it is anticipated that the duration of impact on other

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[19] Cairns, Sally, et. al. 1998. Traffic Impact of Highway Capacity Reductions: Assessment of the Evidence. P. 54.

[20] Safe Climate calculator, based on U.S. EPA and Energy Information Administration information: http://www.safeclimate.net/calculator/ind_calc_form1.php

communities due to dispersed traffic will be for at least 2.5 hours during the PM peak period. No impacts are forecasted during the AM peak period for the three scenarios assessed.

6.8 Safety Considerations

Pedestrian exposure to traffic while crossing an intersection was used as a method to quantify pedestrian safety. The most congested intersections within the study area are the intersections of King Edward Avenue with St. Patrick Street, Murray Street and Rideau Street. The criteria used included:

Criteria S1: Time in seconds that pedestrians would be exposed to traffic while crossing King Edward Avenue, based on average walking speed compared to width of crossing, and existence of a median

Criteria S2: Estimated operating speed of vehicles, southbound and northbound during the peak period

Refer to *Table 6-1* for the detailed measures describing this impact.

The pedestrian exposure to traffic was assessed for all scenarios. Under both the Six-lane and Six-lane Hybrid Configurations (Scenarios 1 and 2) the lane arrangements remain essentially the same at both intersections. Under the Four-lane Configuration (Scenario 3) the width of King Edward Avenue is reduced by two lanes and as such, the pedestrian crossing time in the east-west direction of crossing would be reduced by approximately 4 metres (one lane equivalent). For the average pedestrian, this translates to a reduction of walking time or reduced “exposure to traffic” of 3 seconds (i.e. total of 37 seconds to cross vs. 40 seconds under the other two scenarios).

Estimated operating speeds were captured during VISSIM traffic simulations. It was predicted that Scenario 1 will experience operating speeds in the range of 32 to 48 km/h with a weighted average of 42 km/h. Scenario 2 will experience speeds in the range of 31 to 48 km/h with a weighted average of 41 km/h. Scenario 3 will experience speeds in the range of 24 to 48 km/h with a weighted average of 39 km/h. As a result of estimated speeds in the study area, Scenario 3 demonstrates the lowest operating speeds.

6.9 Summary of Results

Table 6-1: Summary of Transportation Impact Assessment

TRANSPORTATION IMPACT ASSESSMENT EVALUATION CRITERIA				Scenario 1: 6 Lane Configuration				Scenario 2: 6 Lane Hybrid Configuration				Scenario 3: 4 Lane Configuration			
				AM Peak		PM Peak		AM Peak		PM Peak		AM Peak		PM Peak	
				Hour	Period	Hour	Period	Hour	Period	Hour	Period	Hour	Period	Hour	Period
Motorists															
Criteria 1	Traffic volume in corridor	Peak direction flow between St. Patrick & Murray	NB	550	1300	1750	4300	550	1300	1750	4350	550	1250	1450	3700
			SB	1900	4550	1550	3650	1900	4600	1450	3650	1950	4650	1400	3450
Criteria 2	Corridor congestion [mm:ss] [1.6km travel route]	NB average travel time		3:58	3:52	3:47	3:43	3:58	3:54	3:59	3:48	4:05	3:59	7:03	6:23
		SB average travel time		2:21	2:21	2:49	2:45	2:21	2:21	2:56	3:11	2:34	2:32	4:01	4:29
Criteria 3	Impacts on alternative routes [#]	Vehicles redirecting		(neg)	(neg)	(neg)	(neg)	(neg)	(neg)	(neg)	(neg)	(neg)	(neg)	(neg)	(neg)
Criteria 4	Ability to accommodate on-street parking [parking stall hrs 7am to 7pm]						740#				556				0
Pedestrians															
Criteria 5A	Pedestrian walking time along primary pedestrian route (incl. delay) [min]	Sussex to Rideau		18	18	18	18	18	18	18	18	18	18	18	18
		MacKenzie to Vanier		24	24	24	24	24	24	24	24	24	24	24	24
Criteria 5B	Average pedestrian waiting + crossing time at a key intersection [sec]	St. Patrick		73	73	87	83	77	73	90	87	70	71	80	84
		Murray		42	42	55	54	43	42	56	55	42	41	61	58
Cyclists															
Criteria 6	Cycling travel time for commuter cyclists* [min]	Sussex to Rideau		8	8.5	9.5	9	8	8.5	9.5	9	8.5	8.5	8.5	8.5
		MacKenzie to Vanier		10.5	10.5	11	11	10.5	10.5	11	11	10.5	10.5	11	11
Criteria 7	Effect on cycling network connectivity**			Qualitative discussion to be addressed in the report											
Transit															
Criteria 8	Transit travel time [mm:ss]	Average time		-	-	4:24	4:18	-	-	4:22	4:24	-	-	5:44	5:58
Criteria 9	Travel time reliability [mm:ss]	90th percentile time		-	-	5:02	4:54	-	-	5:00	5:11	-	-	7:08	10:30
Criteria 10	Transit vehicle volume [# buses/period]			-	-	130	288	-	-	122	300	-	-	118	266
Goods Movement															
Criteria 11	Truck corridor travel time [mm:ss] [1.8km travel route]	Northbound time		4:11	4:00	4:00	3:57	4:09	4:04	4:23	4:08	4:14	4:05	7:29	6:40
		Southbound time		2:34	2:33	2:36	2:34	2:34	2:34	2:47	3:06	2:52	2:49	4:01	4:40
Criteria 12	Peak truck flow [# trucks/period]	Northbound flow		77	182	58	136	81	191	63	151	79	183	58	150
		Southbound flow		113	271	55	125	113	272	51	126	111	262	53	125
Impacts on Other Communities															
Criteria 13	External impacts on other communities due to traffic displacement			(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	300	600
Criteria 14	Duration of impact on other communities due to dispersed traffic [hours]			(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	>2.5	>2.5

#On-street parking is not formally included in the 6-lane scenario but has been estimated for comparison purposes
*Approximate; Calculation based on pedestrian waiting times at intersections and typical cycling speed
**Could permit curb lanes to stay and have parking instead of streetscaping

7. Anecdotal Information and Additional Discussion

There are some challenges that face the King Edward Avenue corridor and the Lowertown community that could not be incorporated in the Analysis Framework. To ensure that these concerns were not overlooked, we have provided observations on specific issues that members of the Task Force asked to be included.

The subsection on anecdotal information describes issues from one perspective and does not include any alternative perspectives. It is considered one point of view and has not been factored into any professional observations on corridor issues made by the consulting team elsewhere in this report.

The subsection of additional discussion expands on some of the matters touched on in the community impact analysis and traffic impact analysis. It recognizes the complexity of the King Edward Avenue corridor and provides further commentary on the challenges and change that characterizes this part of Ottawa.

7.1 Anecdotal Information

7.1.1 Community Concerns about Vibration

Members of the Task Force have expressed a concern about the vibration caused by the vehicles in the corridor and suggested that a potential lane reduction might reduce vehicle speed and provide additional separation distance from land uses, which would have a mitigating effect on the impacts of vibration. Since no viable methodology exists to quantify vibration impacts resulting from a potential lane reduction, then, at the request of Task Force members, we contacted Richard Lebel, General Director of La Nouvelle Scène theatre at 333 King Edward Avenue, and Ian Burgess, resident at 244 Bruyère, to document their anecdotal evidence of vibration impacts.

We were advised that vibration is noticeable at the theatre and there is vibration that occurs with each passing truck. La Nouvelle Scène's offices are located in the front 10 metres of the building and before construction they were experiencing "shaking of their desks and computers." During last winter and in the beginning of spring, we were advised that there seemed to be less vibration. However, with the recent construction on-going, it is now difficult to say if the vibration effects have changed since pre-construction conditions. [21]

[21] Lebel, Richard. 2009, May 21. Telephone communication.

We were advised that there are a variety of vibration impacts at Mr. Burgess's residence including "glass clinking because the wine glass cabinet would shake," vibrations in various rooms in the residence, dust shaking off the windowsills, vibrations in the basement, and basement window security bars shaking when a truck passes by. We were also advised that there are vibration impacts at the residence when trucks stop and start at the St. Andrew intersection, and vibration can be perceived when standing on the sidewalk. Approximately three years ago the vibrations seemed more intense but now they seem less intense, although there is still vibration in the basement. When King Edward Avenue was reduced to four lanes, we were advised that there might have been less vibration because traffic was moving slower, but it was hard to discern since construction equipment was also causing vibration.

7.1.2 Operating Speed of Vehicles on the Ramp

The Task Force has expressed concern that the vehicle speeds on the bridge ramps have an impact to the traffic characteristics in the King Edward Avenue corridor. We note the following discussion from the Planning and Environmental Study Report prepared for the current reconstruction project:

> In 1997, a speed survey was conducted by the City of Ottawa along King Edward Avenue immediately north of Bruyère Street. The result of the survey indicated that the 85th percentile speeds were in the order of 75 km/h in both the northbound and southbound directions. Compliance with the posted 50 km/h speed limit was very low at approximately 3%.[22]

Shortly before this report was released, Council approved the following measures:

- Reduction of the speed limit on the Macdonald Cartier Bridge on the Ontario side reduced from 60K/hour to 50K/hour;
- Reduction of the speed limit at the entry curve to King Edward Avenue be reduced from 40K/hour to 30K/hour;
- Reduction of the speed limit on KEA be reduced from 50K/hour to 40K/hour from Sussex to Mann Avenue; and,
- That the City of Ottawa aggressively pursue the Province of Ontario to permit the City of Ottawa to install on an exceptional basis photo radar technology on KEA to reduce the excessive speeding on the road.

[22] Ottawa, City of. 2002. *King Edward Avenue Renewal: Planning and Environmental Study Report*. Page 3-8.

7.1.3 Previous Traffic Collision Information

The Task Force has expressed concern about the traffic collisions in the corridor. The analysis framework could not include estimating the change in potential traffic collisions that might occur with a potential lane reduction since traffic collisions are based on a variety of complex, unique factors that lead to each collision happening. To illustrate the Task Force's concerns, the following is a chronology of collisions resulting in serious injuries or deaths in the King Edward Avenue corridor[23,24]:

- April 6, 2009: Man, 58, struck by a school bus and seriously injured at King Edward and St. Patrick.
- March 12, 2009: Woman, 49, dies after her car is hit by truck at King Edward and St. Patrick.
- Oct. 14, 2008: Wheelchair occupant seriously hurt after being hit on King Edward at Laurier.
- July 2007: Truck hits car at King Edward and St. Patrick; 65-year-old killed.
- March 2007: 20-year-old woman is hit as she attempts to cross King Edward.
- September 2006: Truck hits and kills elderly male pedestrian at King Edward and Rideau.
- November 2005: Woman, 53, is hit at King Edward and Rideau, suffers life-threatening injuries.
- June 2003: Man, 81, is hit by a truck at King Edward and Rideau and dragged several metres, but survives.
- October 2002: Courier driver, 22, dies when a car hits his parked vehicle on King Edward.
- June 2002: Bus crashes into doughnut shop at King Edward and St. Patrick, injuring two.
- May 1997: Woman, 86, is struck and killed by a vehicle on King Edward.

7.1.4 Data from Portable Air Quality Monitoring Station

The City of Ottawa had a portable air quality monitoring station near King Edward Avenue and at the request of Task Force members, the consulting team was asked to summarize the information gathered from the unit. The intention was to use the station but the study team was not able to use it at the time this report was prepared. The study team therefore relied on the data from the Wurtemburg Air Quality Station.

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[23] Nugent-Bowman, Daniel. 2009, March 13. "Accident revives King Edward traffic debate," *Ottawa Citizen*.

[24] Canadian Broadcasting Corporation. 2009, April 7. "Speed dangerous on King Edward, councillor says," *CBC News*. http://www.cbc.ca/canada/ottawa/story/2009/04/07/ot-090407-king-edward.html

7.1.5 Vibration Checks from the Reconstruction Study

We understand that the City of Ottawa has been undertaking vibration checks as part of the on-going reconstruction work in the corridor. The data was not available to be incorporated into this study at the time this report was prepared.

7.2 Additional Discussion

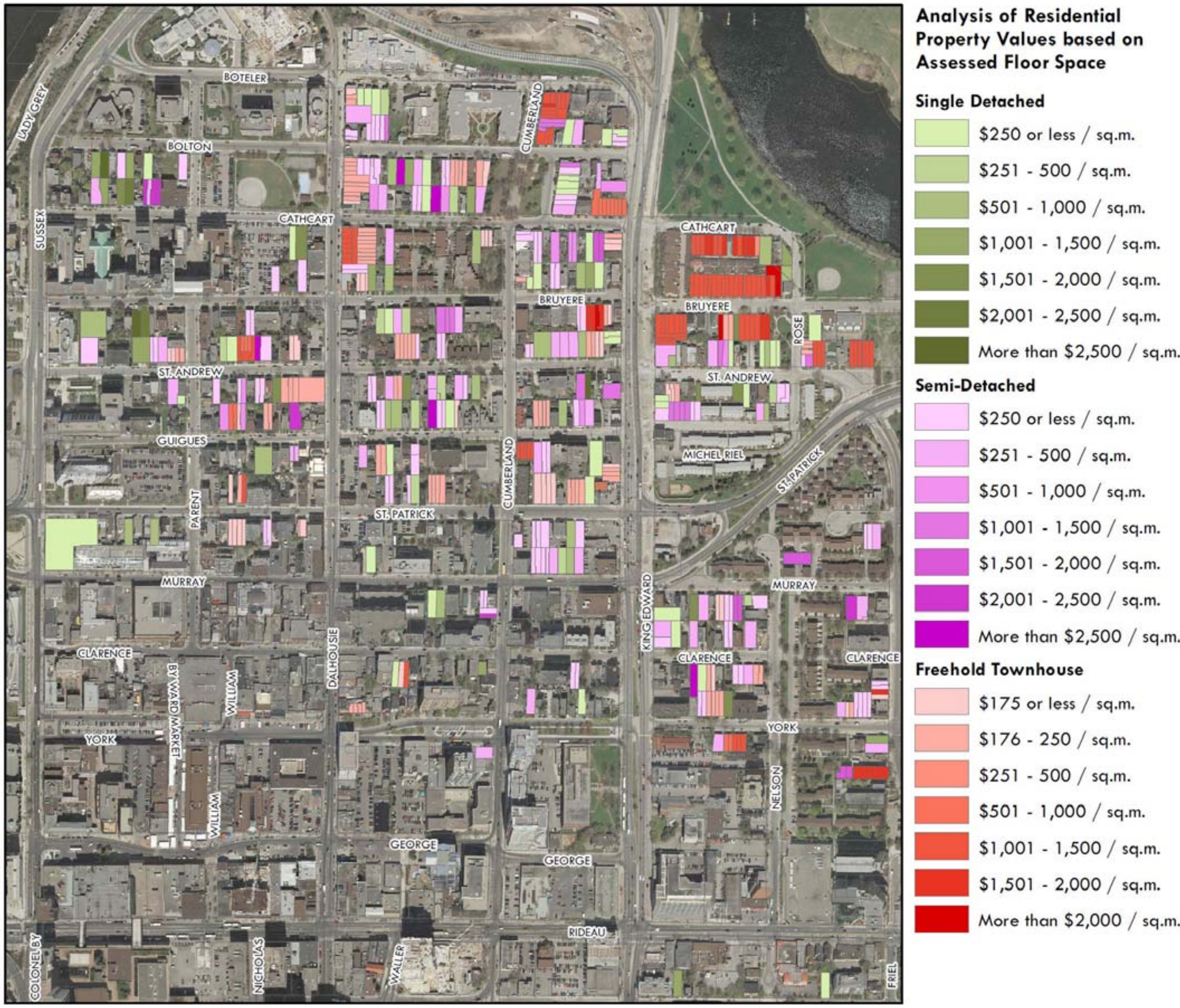
7.2.1 Existing Property Values

The Task Force has expressed concern about property values near the corridor but since no viable methodology existed to quantify changes in property value with a potential lane reduction we have documented existing property value. Using municipal property assessment data and mapping obtained from the City of Ottawa, we conducted thematic mapping of residential property value per square metre of assessed floor space by housing type. The results are depicted in *Figure 7-1*.

Property values appear to vary considerably throughout the neighbourhood and there does not appear to be a clear spatial relationship between the proximity of a residence to King Edward Avenue and property value.

It should be noted that the Municipal Property Assessment Corporation does factor in proximity of a property to heavy traffic patterns when undertaking assessments. It should also be noted that this MPAC variable for a property might not change if the lanes on King Edward Avneue were reduced since the street would remain a major urban artery and properties abutting or near King Edward Avenue could still have the variable "Traffic Pattern (heavy)" applied to them.

Figure 7-1: Existing Property Values



7.2.2 Abandoned Buildings

The Task Force expressed concern about abandoned buildings in Lowertown and in response to this issue we conducted a field survey of the neighbourhood on April 25, 2009 to identify existing abandoned buildings. The abandoned buildings identified were:

- 78 Bolton Street
- 222 Cumberland Street
- 287 Cumberland Street
- 174 King Edward Avenue
- 143 Murray Street
- 207 Murray Street
- 209 Murray Street
- 260 Murray Street
- 454 Old St. Patrick Street
- 167 St. Andrew Street

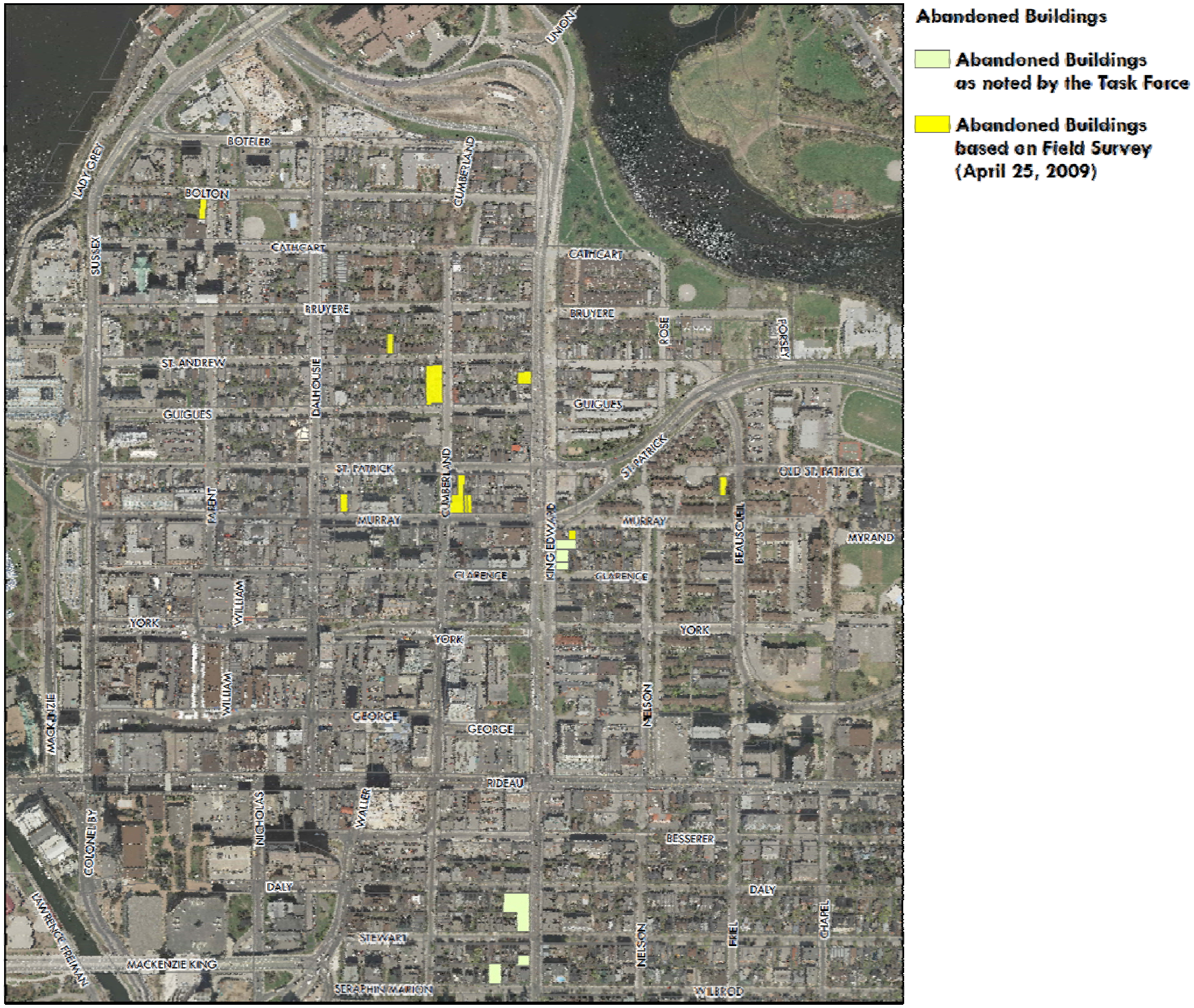
The inventory also includes the following other buildings that Task Force members identified as abandoned:

- 195-199 Guigues Avenue
- 199 Wilbrod Street
- 263-265 King Edward Avenue
- 269-275 King Edward Avenue
- 277-279 King Edward Avenue
- 460 King Edward Avenue
- 484 King Edward Avenue

The results are depicted in *Figure 7-2*.

Although not an abandoned building, it should be noted there is a large empty lot on the south-east corner of St. Patrick Street and King Edward Avenue which the Task Force believes represents part of the urban blight along the street.

Figure 7-2: Abandoned Buildings



There does not appear to be a clear spatial relationship between the proximity of any abandoned buildings to King Edward Avenue.

7.2.3 Urban Heat Island and Microclimate Effects

Urbanized areas experience a phenomenon of warming referred to as the "urban heat island" due to the concentration of development and population. In summertime, the urban heat island effect can be exacerbated due to the absorption of the sun's rays on dark surfaces, such as rooftops and asphalted roadways.

Appropriate landscaping that manages solar gain is one way of mitigating urban heat island impacts for microclimates (i.e., the sun/shade, temperature, and wind in a specific area or location).[25] If the lane reduction provides an opportunity for the planning of additional trees that offer shade, it is anticipated that there might be some positive benefit to summertime microclimate (although the extent of the positive benefit is unknown).

7.2.4 Potential Air Quality Impact of Additional Trees

The air quality in major road corridors is impacted by vehicular emissions and particulate matter. Further to the discussion above about mitigating urban heat island microclimate impacts, the planting of trees also offers air quality benefits since trees draw in carbon dioxide and help sequester particulate matter.[26]

Members of the Task Force have suggested that 350 to 450 additional trees could be accommodated with a reduction from six lanes to four lanes, and that the total amount of pollution absorbed by these additional trees could be 9,000 kg/year. Determining the number of trees and measuring their specific air quality benefit was outside of the scope of this study; however, we believe that the addition of trees in the corridor, where practicable, has some merit.

Therefore, if Council decides to implement a lane reduction, it would be appropriate to engage a qualified professional to properly consider and design any additional tree plantings that might be suitable.

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[25] Ottawa, City of. 2004. *Air Quality and Climate Change Management Plan*. P.10.

[26] Region of Ottawa-Carleton. July 2000. *Regional Road Corridor Design Guidelines*. P. 11.

7.2.5 Mitigating Noise Impacts with Additional Trees

Members of the Task Force anticipated that additional trees might mitigate some of the noise from King Edward Avenue. Given the short separation distances between the noise source and receptors and the height of some of the receptors (i.e., apartment buildings) it is difficult to mitigate noise emissions. Trees and other such "buffering" would not provide any abatement given the situation. Noise barriers would also not provide all receptors with noise abatement since there are apartment buildings which could not be fully shielded by such noise barriers.

7.2.6 Community Concerns Regarding the Truck Route

The Task Force expressed concern that King Edward Avenue, as a designated truck route, is a corridor in which certain trucks carrying hazardous materials pass. They have further expressed a concern about the impact of a spill, during which the Task Force suggested that a substantial number of residents would have to be evacuated.

In the short-term, we understand that King Edward Avenue will remain designated as a truck route due to its role (in conjunction with the MacDonald-Cartier Bridge) as an interprovincial link. If Council opts to proceed with a lane reduction (before a new interprovincial link is established and before trucks are directed away from King Edward Avenue), then it should be recognized that trucks will still be present in the corridor and we do not expect that the lane configuration would alter the type of goods trucked through the corridor.

7.2.7 Interprovincial Crossings Environmental Assessment Study

The federal, Ontario and Quebec governments launched an Environmental Assessment that evaluates existing and projected interprovincial transportation capacity in the National Capital Region within the next 20 years. The study has concluded that "a new interprovincial crossing of the Ottawa River is the best solution." A recommended east-end crossing has been identified at Kettle Island.

In the analysis conducted for the Environmental Assessment, it was noted that the City of Ottawa would remove Rideau Street and King Edward Avenue from the City's identified truck route system and that the NCC supports the relocation of heavy truck transport from the core area, in the context of new interprovincial crossings in the National Capital Region.[27] The transportation system modelling that supported the preferred option demonstrated that a new interprovincial crossing would have a dual benefit: to improve the overall traffic flow for

[27] Genivar (Taylor, S.). 2008, December 17. "Current and Projected Traffic Demands memorandum," Interprovincial Crossings EA Study. Ottawa, ON.

interprovincial crossings and to relieve the volume of traffic on other interprovincial crossing routes. The illustrations of the differential traffic forecasts for the 2031 AM peak period suggests that there would be a noticeable reduction of automobile and commercial vehicle traffic in the King Edward Avenue Corridor and across the Macdonald Cartier Bridge.

7.2.8 Current BRT Plans by STO

One of the dynamic relationships in the King Edward Avenue corridor is the combination of commuter traffic and transit buses. In automobile congested areas, it is believed that increasing transit service and providing transit priority is most effective at reducing the degree of congestion delay.[28] If higher-order transit service can be provided for commuters between Gatineau and Ottawa, then the Task Force has suggested that this higher order transit service could relieve the corridor of some automobile congestion, thereby supporting the rationale for a potential lane reduction.

The Société de transport de l'Outaouais (STO) is proposing a bus rapid transit system with a dedicated route that will run along the existing Quebec-Gatineau Railway right-of-way in a two-way, 15-kilometre corridor reserved exclusively for buses. Some of the Rapibus stations will have new incentive parking facilities that will encourage the use of public transportation. The STO believes that Rapibus will encourage greater public transit use in the Outaouais and this transfer of trips on to the bus will help reduce traffic congestion, especially on weekdays during peak periods. The concept anticipates that Rapibus would cross at the Pont Noir Bridge and would help relieve pressure on other bridges in the region.[29]

7.2.9 Margin of Urban Design Improvements

The case studies demonstrated that significant improvement can be achieved for urban design and streetscaping through a lane reduction. However, all of the case studies proposed new urban design and streetscaping in corridors which previously did not have substantial place-making elements (it was clear that part of the impetus for these lane reductions was to improve the urban design and streetscaping of the corridor).

In the case of King Edward Avenue, the renewal project that is currently underway has led to the installation of many new streetscape elements such as landscaped medians and themed light fixtures. As a result, if a lane reduction is contemplated for King Edward Avenue, the urban design and streetscaping improvements would represent further upgrades to those already planned. Since none of the case studies involved improvements on an existing

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[28] http://www.vtpi.org/tdm/tdm96.htm

[29] http://www.sto.ca/rapibus/index_e.html

corridor that already had extensive streetscaping, the case studies can not offer insight on how substantial the margin of improvement might be for King Edward Avenue.

Therefore, if Council decides to implement a lane reduction, it would be appropriate to engage the community, city staff, and qualified professionals to properly design any additional streetscaping that might be possible given less roadway in the King Edward Avenue cross-section. This would ensure that the margin of benefits from any additional streetscaping would be maximized.

7.2.10 The Role of Government in Enacting Lane Reductions

During the review of the case studies, we noted that government played an important role in helping lane reductions become a reality. Some of the lane reductions were supported by transportation professionals – the traffic modelling suggested that a lane reduction was feasible – and were then supported by decision-makers. There were other jurisdictions that experience significant traffic congestion – most notably New York, Palo Alto, and Los Angeles, and to a lesser extent San Francisco and Denmark – with no obvious place for traffic to go elsewhere and where customary traffic modelling might suggest that traffic chaos would result if the number of traffic lanes was reduced. In these jurisdictions, leadership among municipal officials and government decision-makers has led to the lane reductions.

Based on our review of the case studies in New York, we understand that Mayor Bloomberg has a very strong agenda to make New York sustainable. The head of the City's Transportation department has been empowered to pilot lane reductions with the use of temporary barricades and then follow up with actual lane reductions, widening sidewalks, and creation of transit and bike lanes. The message is that less cars and more liveable streets supports a sustainable New York.

In reviewing the case studies for Palo Alto and Los Angeles, we found that the State of California has a strong agenda for improving the transportation system through context-sensitive design, reducing automobile trips, and advancing public use of transit, cycling and walking as key travel modes. The municipalities have accepted this agenda and are putting forward the lane reduction proposals described in the case studies.

Lastly, the lane reduction for Boulevard Strandvejen in Denmark further demonstrates how government took leadership to implement a lane reduction. It is the earliest example, as well, dating back to the mid-1980s. Since then, Denmark has developed a reputation for "liberation of the street from the supremacy of the automobile" and its cities continue to create bike lanes, reduce traffic lanes, and close off streets to traffic in order to create pedestrian zones.[30]

7.2.11 Supporting Approaches and Methods to Address Community Issues

The case studies did not provide sufficient or conclusive evidence that a lane reduction had directly contributed to certain community improvements, and based on professional planning practice, we are not certain that there would be a strong causal relationship (e.g., a lane reduction would not necessarily cause new investment in office space). There are other approaches and methods that members of the Task Force and Lowertown Community could consider, as follows:

- Neighbourhood Plan: To address quality of life matters, a Neighbourhood Plan that creates strong partnerships between citizens and local stakeholders, would serve Lowertown well. It would help stakeholders organize themselves as a collective and work with City Departments to implement various programs and projects for the betterment of the area.

- Community Improvement Plan: To provide incentives for (re)development and to encourage the (re)development of underutilized sites, a Community Improvement Plan with appropriate programs might provide the impetus for investment and subsequent economic prosperity.

- Community Design Plan: To address elements of land use mix, urban design and streetscape design, and improved signage the City's Community Design Plan process would be undertaken for Lowertown to create a common vision for future development and streetcaping for King Edward Avenue.

8. Summary of Consultation

This project was undertaken with consultation focussed with members of the King Edward Avenue Task Force and Lowertown, due to the limited timeframe for the study and the well-organized Task Force. Members of the Task Force acted as the primary liaison for the community during the project's progress. Presentations were also made at the Lowertown Community Association meetings.

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[30] Turner, Chris. 2008, December 18. "Copenhagen, Melbourne & The Reconquest of the City," *WorldChanging Canada*. http://www.worldchanging.com

The liaison for this project has resulted in a positive working relationship between members of the Task Force, City Staff, and the consultants. It should be recognized that members of the Task Force played an important role with staff and the consultants in defining the project, designing the analytical framework, and reviewing outputs.

The following provides a summary of the key meetings and principal outcomes of the consultation.

November 14, 2008: A meeting was held with City Staff and members of the Task Force to discuss the initial Analysis Framework and the overall schedule for the project. Important criteria for understanding community and transportation impacts were suggested by City Staff and the Task Force members, and integrated into the framework. General support was expressed for the timing of the work and consultation in the overall schedule.

November 20, 2008: City Staff met with members of the Lowertown Community Association and members of the Task Force as a kick-off to the study. Specific discussion points included the study objectives, timing and overall approach to be used to conduct the study. Attendees were supportive of the approach and looked forward to further involvement and updates.

December 1, 2008: A meeting was held with City Staff and members of the Task Force to discuss refinements to the Analysis Framework before seeking broader feedback. The meeting resulted in some fine-tuning of the Analysis Framework.

December 4, 2008: A meeting was held with members of the Lowertown Community Association and members of the Task Force to discuss the Analysis Framework. The feedback received was integrated and resulted in the final version of the Analysis Framework that guided the consulting team's research and analysis through the course of the project.

January 23, 2009: A meeting was held with City Staff and members of the Task Force to discuss the configuration of lanes on King Edward in order to appropriately build the traffic model. Consensus was reached on the three scenarios that the consulting team analyzed.

March 31, 2009: A meeting was held with City Staff and members of the Task Force to discuss the initial results of the case studies. The case studies were confirmed to be relevant and suitable for incorporation as findings.

May 4, 2009: A meeting was held with City Staff and members of the Task Force to discuss the initial results of the transportation, noise, and air quality modelling. Staff and the Task Force members asked questions about some of the assumptions and measures, and explanations were provided to assist with interpretation of the modelling results.

May 14, 2009: A meeting was held with members of the Lowertown Community Association and members of the Task Force to review of the draft findings. Members of the community raised some questions about the assumptions used and interpreting the measures. Explanations were provided during the meeting and have been subsequently addressed in the report.

9. Conclusions / Next Steps

This project was initiated to determine whether alternative roadway configurations might be feasible for King Edward Avenue and to analyze the potential transportation and community impacts. The study's comparative assessment of the three scenarios provides an understanding of the relative differences between each. We conclude from this comparative assessment that the lane reduction scenarios have sufficient merit to be considered further.

It should be noted that public engagement has been focussed on members of the Task Force and Lowertown. The project's mandate did not include an evaluation of the impacts or recommending a specific lane configuration. Further to our conclusion, we offer the following recommendations for advancing forward beyond this project's analysis:

- Report to be received by Transportation Committee: This report needs to be submitted to Transportation Committee for their review and discussion since their feedback and support is important.
- Broader consultation be undertaken: There are a wide range of other stakeholders including adjacent neighbourhoods, transit operators, the goods movement industry, various agencies, commuters, and the public at-large that have not yet been consulted. There is a need to broaden the range of those consulted to ensure that their input is considered and documented.
- Complete an evaluation and submit a recommendation: An evaluation framework would define the weighting of the impacts and ensure that the impacts of the alternative lane configurations for King Edward Avenue are properly assessed. It would provide the

technical justification for a potential lane reduction, at which point a recommendation could be submitted to Transportation Committee for their consideration.

Appendix A: Case Studies

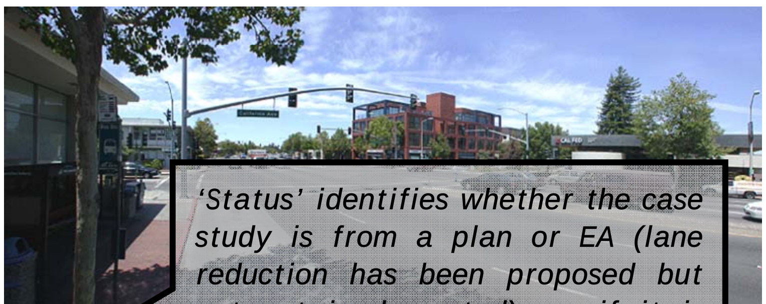
Lane Reduction Case Studies

Introduction to the Case Studies

- We found few situations that reflect the exact circumstances of King Edward Avenue
- Case studies were considered for their context, traffic characteristics, class of road in the overall transportation hierarchy, existing cross-section, and proposed/final cross-section; mega-projects such as the burying of Boston's Central Artery or the removal of Toronto's Gardiner Expressway were not considered relevant
- There are thirteen case studies in this package
- The evidence provided in each case study (i.e., description of improvements or impacts) emanates from the documentation obtained
- Documentation we reviewed includes a variety of environmental assessment / technical studies, planning / design studies, staff reports to municipal authorities, and/or public consultation materials
- We recognize that there may be other case studies from other jurisdictions; however, we only considered case studies where we could obtain documentation for our own independent review / analysis
- A summary table with our preliminary analysis is provided at the end of this package

How to Read the Case Studies

Case Study 1	El Camino Real, Palo Alto, California

Before	After or Proposed
	

'Status' identifies whether the case study is from a plan or EA (lane reduction has been proposed but not yet implemented), or if it is currently existing

Status	Plan	Date	Planning started in 2002

Relevance to King Edward Avenue	Insights Gained from this Case Study
✓ **Six lane urban arterial reduced to five or four lanes in key zones** ✓ Regionally-important road (State Highway 86) ✓ Traffic volume ranges from 45,000 to 55,000 ADT ✓ Street has high levels of traffic during peak travel times ✓ Street's character has distinct urban/suburban segments ✓ Aim to make it a multi-modal transportation corridor ✓ Aim to increase the aesthetic character of the street o State, not the city, has jurisdiction over the road	✓ Where four lanes are proposed, it is expected to produce "relatively higher benefits for pedestrians, bicyclists and transit users" (shorter crossing, traffic speed management, increased sidewalk space for pedestrians and business activity, trees for shade) ✓ Proposed urban design features include curb extensions, striping of pedestrian crosswalks, special paving, pedestrian refuges in centre medians, public art, and street furniture ✓ Additional boulevard space allows for extensive planting of new street trees o Six lanes are still planned at the intersections to maintain traffic flow

'Relevance' summarizes why this case study is considered valid (checkmarks); caveats to interpreting the validity of the case study are shown with a round bullet

'Insights' summarizes what can be learned from this case study (checkmarks); caveats to interpreting the success of reducing the lanes are shown with a round bullet

Case Study

1

El Camino Real, Palo Alto, California

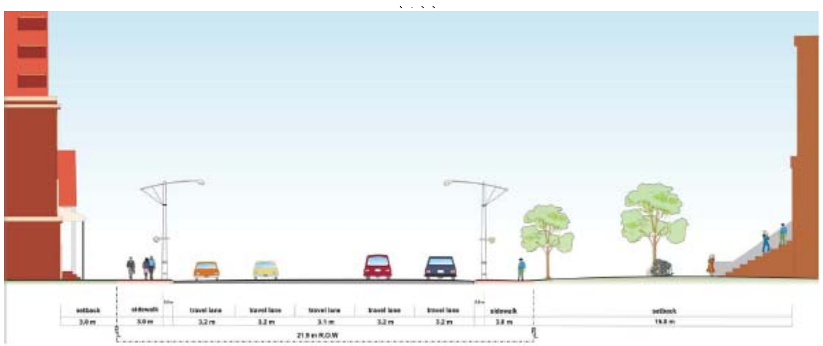
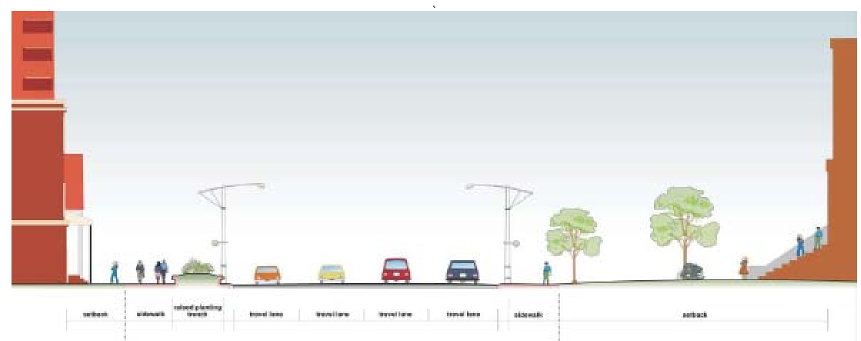
Before	After or Proposed
	

Status	Plan	**Date**	Planning started in 2002

Relevance to King Edward Avenue	**Insights Gained from this Case Study**
✓ **Six lane urban arterial reduced to five or four lanes in key zones** ✓ Regionally-important road (State Highway 86)	✓ Where four lanes are proposed, it is expected to produce "relatively higher benefits for pedestrians, bicyclists and transit users" (shorter crossing, traffic speed management,

✓ Traffic volume ranges from 45,000 to 55,000 ADT ✓ Street has high levels of traffic during peak travel times ✓ Street's character has distinct urban/suburban segments ✓ Aim to make it a multi-modal transportation corridor ✓ Aim to increase the aesthetic character of the street o State, not the city, has jurisdiction over the road	increased sidewalk space for pedestrians and business activity, trees for shade) ✓ Proposed urban design features include curb extensions, striping of pedestrian crosswalks, special paving, pedestrian refuges in centre medians, public art, and street furniture ✓ Additional boulevard space allows for extensive planting of new street trees o Six lanes are still planned at the intersections to maintain traffic flow

Case Study 2	Jarvis Streetscape, Toronto

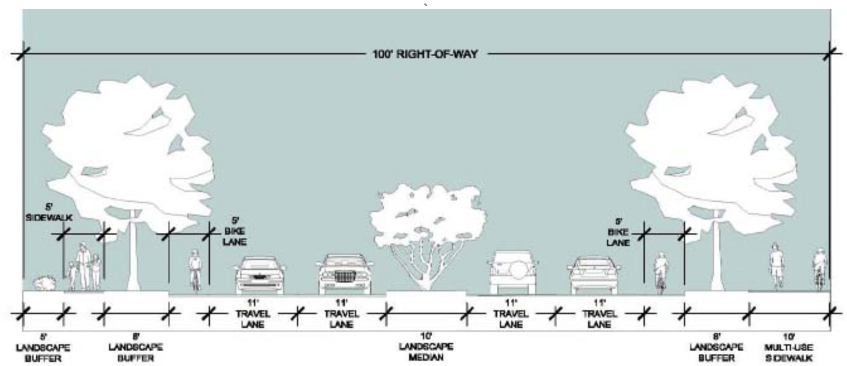
Before	After or Proposed
	

Status	Environmental Assessment	Date	Study started in 2008

Relevance to King Edward Avenue	Insights Gained from this Case Study
✓ **Five lane urban arterial (with variable direction centre lane) reduced to four lanes**	✓ Boulevard widening: more space for pedestrian amenities, trees, landscaping; “greater opportunities for place-making

✓ Historically important and prominent commuter route ✓ Street has high levels of traffic during peak travel times ✓ Traffic speeds are in excess of municipal limits ✓ Many heritage properties front on to the street ✓ Aim to enhance the public realm and attractiveness, pedestrian environment and safety, improve traffic, and support economic development ✓ Aim to balance the needs of pedestrians, cyclists, transit, and vehicles	and creating areas of emphasis" ✓ Addresses heritage, such as: restoring original configuration, allowing for signage and art, public realm improvements to enhance heritage experience, and streetscape improvements ✓ Anticipated benches, street lighting, and sidewalk markers are expected to improve the pedestrian realm of the street ✓ Flexibility for certain treatment such as on-street parking bays to serve businesses, median treatments for pedestrian refuge

Case Study 3	Kings Highway, Myrtle Beach, South Carolina

Before	After or Proposed
	

Status	Plan	**Date**	Plan started in 2008

Relevance to King Edward Avenue	**Insights Gained from this Case Study**
✓ **Five/six lane urban and suburban arterial reduced to four**	✓ Traffic projected to decrease by 20,000 to 25,000 vehicles

lanes (in the downtown district of the 20 mile road) ✓ Former local street evolved into regional arterial (US #17) ✓ Street has high levels of traffic, with peak seasonal traffic ✓ Area is mix of downtown commercial and strip mall, with densely populated residential neighbourhoods nearby ✓ Aim to enhance aesthetics, introduce viable transportation options, and provide function facilities that are safe for all ✓ Aim to redesign the roadway back to serve local needs through both land use and transportation improvements ✓ No dedicated bicycle facilities currently exist o Lane reduction was feasible since new capacity was provided in the adjacent highway network	per day ✓ Level of service at the intersections "projected to be roughly the same" ✓ Traffic model indicates "an ability to reduce the posted speed limit by 10 miles per hour" (15 kph), from 45 mph to 35 mph (75 kph to 60 kph) ✓ Limited directional and wayfinding signage to be enhanced ✓ Zoning ordinance (i.e., urban design guidelines) to be updated with strict controls for streetscaping and buildings in the corridor ✓ Limited curb cuts are "expected to reduce potential for vehicle to pedestrian conflicts and accidents"

Case Study

4 Lakeshore Avenue, Oakland, California

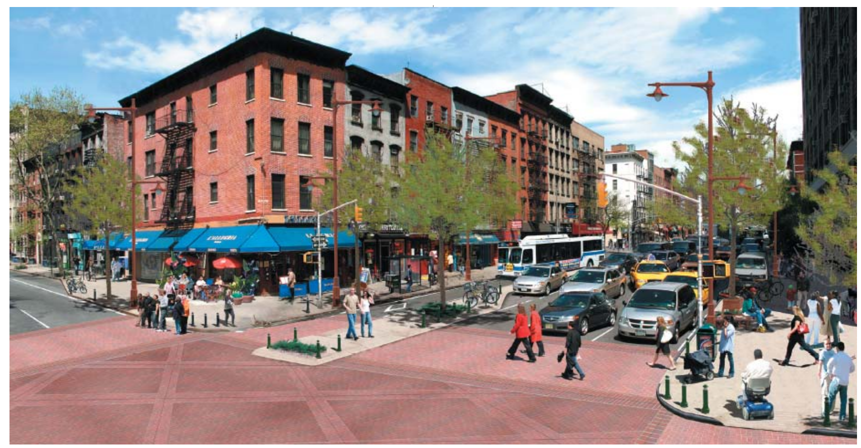
Before	After or Proposed
	

Status	Currently exists	**Date**	Approved for installation in 2007

Relevance to King Edward Avenue	Insights Gained from this Case Study
✓ **Four lane urban roadway reduced to two travel lanes**	✓ Expected to encourage cycling to the Farmers Market

✓ Local residents lobbied for traffic calming ✓ Police have confirmed traffic speeding on the road ✓ Aim to provide bike lanes on both sides of the street within the expanded boulevards ✓ Solution involves repainting the lines in the road and demarcating the new automobile and bike lanes o Residential neighbourhood, with low daily traffic o Lane reduction only affecting 0.4 mile (0.6 km) length of road	✓ Expected to encourage cycling to bus stations and rapid transit stations ✓ Believed to support social equity by offering area residents to "try transportation options that reduce vehicular impacts on other Oakland neighbourhoods" ✓ Expected that "fewer cars will potentially… [result] in less noise and other vehicular impacts" ✓ Bike lanes also expected to "be used by seniors and persons with disabilities" ✓ Reducing the number of automobile lanes is expected to "improve pedestrian safety by minimizing conflict points with vehicles"

Case Study 5	Ninth Avenue, New York

Before	After or Proposed
	

Status	Plan, moved into the assessment phase	Date	Plan completed in 2006/7; assessment nearing end

Relevance to King Edward Avenue	Insights Gained from this Case Study

✓ **Six lane urban roadway reduced to five lanes** (four through-traffic lanes reduced to three) ✓ Heavily congested regional roadway that is connected to inter-regional infrastructure (Lincoln Tunnel) ✓ Heavy truck and bus traffic impacting Ninth Avenue ✓ Area is mixed use and recently rezoned for major growth ✓ Significant issues with pedestrian safety and public health ✓ Area has 2nd lowest proportion of open space in the city ✓ Community trying to make Ninth Avenue a destination, rather than a thoroughfare ✓ Various issues with drug addicts and vagrancy ✓ Citizens value the area for its diversity, proximity to the city's centre, and social capital; "Clinton / Hell's Kitchen" is a well-known and historic neighbourhood in New York ✓ Aim to undertake short-term and long-term improvements to address vehicular travel / congestion, maintain access, improve pedestrian and other road users' safety, and improve and enhance residents quality of life o Planning process involves the Port Authority of New York and New Jersey (the principal stakeholder for inter-regional infrastructure)	✓ More street trees are possible ✓ Support businesses with tailored on-street meter parking ✓ Wider boulevard allows for new and reorganized street furniture that "guide[s] pedestrian flows rather than prohibit them" ✓ Median provide refuge for pedestrians ✓ Pedestrian crossing time expected to reduce by 33% (crossing distance reduced from the existing 72 feet to potentially 48 feet) o Initial improvements accepted by the New York Department of Transportation and considered for implementation involve changes to signage to direct buses and trucks to existing alternative routes o Complex on-street parking issues require further study

Case Study 6	Broadway Boulevard, New York

Before	After or Proposed
	

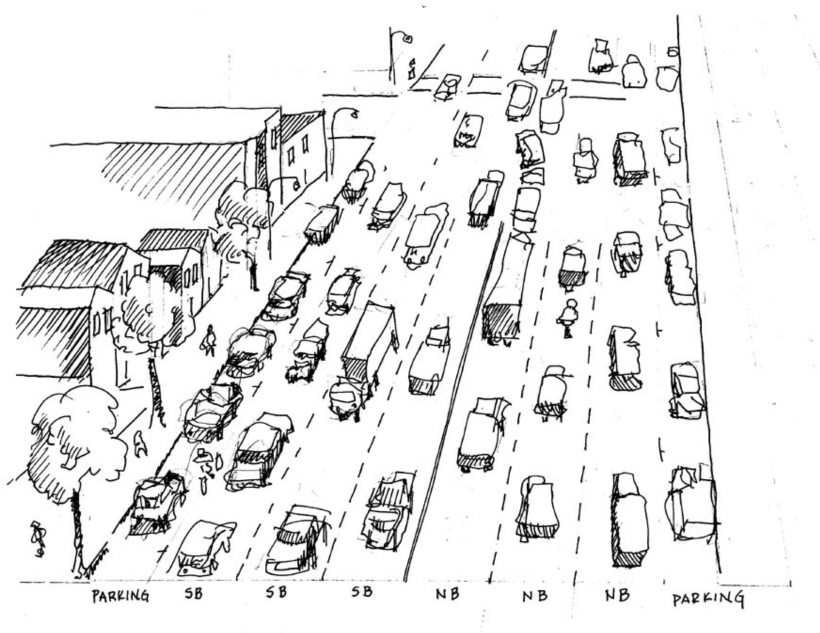
Status	Existing	**Date**	Completion date unknown

Relevance to King Edward Avenue	Insights Gained from this Case Study
✓ **Six lane urban roadway reduced to four lanes** (four through-traffic lanes reduced to two) ✓ Usually congested major roadway ✓ Trucks consistently in the mix of traffic ✓ Existing underutilized bike path ✓ Area is mixed use ✓ Aim to reduce negative impacts of traffic, improve pedestrian and other road users' safety, and improve and enhance quality of life	✓ Significant increase in overall vibrancy ✓ Positive economic development (e.g., restaurants, cafés) ✓ Able to provide dedicated bike lane, and resultant improvement in bike lane usage and cyclist safety ✓ Able to provide extensive street furniture; some enhancements to landscaping using potted planters ✓ Pedestrian refuge provided by median ✓ Crossing distance and time reduced

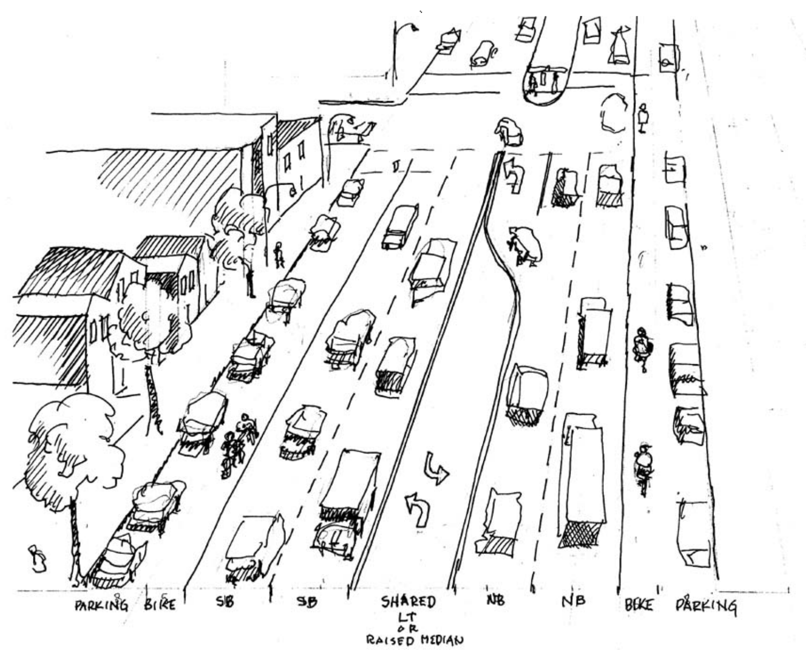
Case Study 7

Potrero Avenue, San Francisco

Before



After or Proposed



Status	Existing	**Date**	Completed in 2006

Relevance to King Edward Avenue	Insights Gained from this Case Study
✓ **Eight lane urban roadway reduced to six lanes** (six through-traffic lanes reduced to four + centre turn lane / median) ✓ Major urban arterial with access to inter-regional highway (US #101) ✓ Area is mix of residential and small commercial buildings; San Francisco General Hospital fronts on to the street ✓ Major bus route on the street o Potrero Avenue handles traffic volumes well below its capacity; however, about two or three days per week, as congestion on the parallel freeway increases, traffic volumes can increase significantly on Potrero Avenue	✓ The solution is "low-cost, pavement marking" re-striping ✓ The new configuration "balances the needs of the Potrero Avenue community without unduly interfering with the needs of many motorists who rely on Potrero Avenue to reach their final destinations in and out of the City" ✓ Able to accommodate new dedicated bike lanes (pavement markings) ✓ Did not negatively impact planned regional bus rapid transit improvements ✓ Pedestrian refuge created in the median

Case Study

8

Bridgeport Way, University Place, Washington

Before	After or Proposed
	

Status	Existing	Date	Completed between 1999 and 2002

Relevance to King Edward Avenue	Insights Gained from this Case Study
✓ **Five lane urban roadway reduced to four lanes with planted median** ✓ Total of 1.5 miles (2.5 kilometres) was reconfigured ✓ Major urban arterial that serves local and regional traffic; often a bypass when I-5 freeway is heavily congested ✓ Highest transit volume corridor in Pierce County ✓ Major bus route on the street ✓ Viewed as the "main street" of the neighbourhood ✓ Aim to address safety concerns, improve quality of life, increase mobility and cohesiveness of the community, and enhance aesthetics ✓ Aim was to also create a multi-modal link to facilitate development of a town centre	✓ Facilitated new streetscaping, including new streetlights and planting strips ✓ Facilitated bike lanes along the entire length of the corridor ✓ Mid-block pedestrian crossings have been provided (pedestrian traffic signals), with pedestrian refuge in the medians ✓ "A recently completed before and after study indicates that there has been an increase in business revenues due to the project" ✓ "Significant activity in redevelopment due to the Bridgeport Way project has also been observed with new businesses recently relocating to the area and others are applying for redevelopment and relocation" ✓ Traffic collisions have been reduced by up to 60% for some areas; speeds have been reduced by 6% o Flared intersections were necessary to accommodate turns for long vehicles (i.e., trucks)

Case Study 9	Edgewater Drive, Orlando, Florida

Before	After or Proposed
	

Status	Existing	**Date**	Completed in 2002

Relevance to King Edward Avenue	**Insights Gained from this Case Study**
✓ **Four lane urban roadway reduced to two through-traffic lanes** ✓ Total of 1.5 miles (2.5 kilometres) was reconfigured in the central business district ✓ Major urban arterial that averages 20,000 vehicle trips per day; peaks at nearly 28,000 local and regional traffic ✓ Aim was to avoid increasing traffic on neighbourhood streets, reduce speeding and crashes, make bike lanes continuous to increase cycling volumes, widen sidewalks and improve streetscape to increase pedestrian volumes, and a more pedestrian friendly commercial district o Edgewater serves mostly local traffic	✓ Changes facilitated by a re-striping of the lanes ✓ Traffic collisions reduced by 34% and injuries reduced by 68% ✓ Overall traffic speeds reduced; 10% reduction in speeding achieved in the south end where speeding was most problematic ✓ 12% reduction in traffic volume in the corridor ✓ 12% increase in utilization of on-street parking ✓ 23% increase in pedestrian counts ✓ 30% increase in bicycle counts ✓ "Pedestrians are finding it easier to cross" ✓ Positive results led to an extension of the lane reduction through restriping to other sections of Edgewater Drive o No quantifiable short-term change in property value

Case Study

10

North Alameda Street, Los Angeles, California

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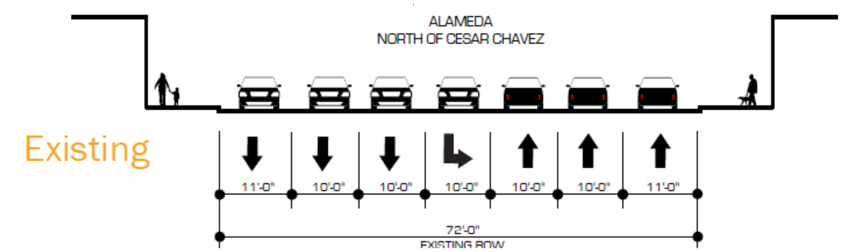
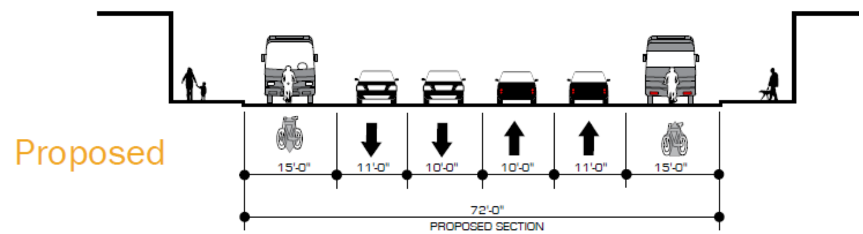
<tr><td>
</td><td>
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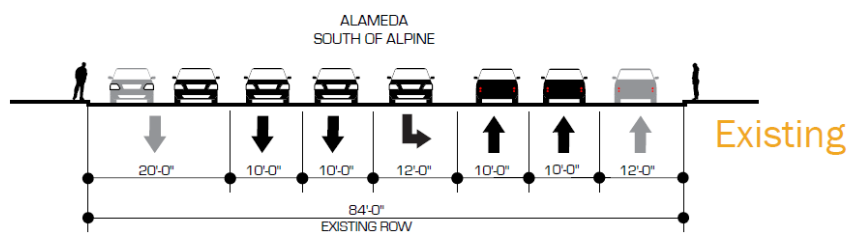
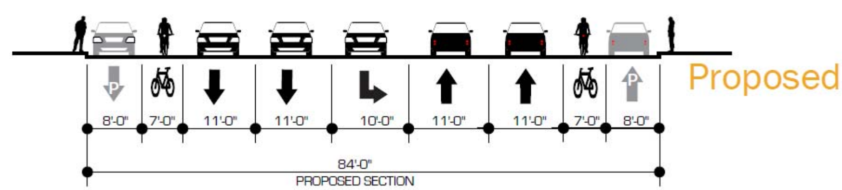
<tr><td>
</td><td>
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Status	Plan	**Date**	2008

Relevance to King Edward Avenue	Insights Gained from this Case Study
✓ **Seven lane urban roadway reduced to five lanes** (six traffic travel lanes reduced to four) ✓ **Eight lane urban roadway reduced to seven** (five traffic travel lanes reduced to four) ✓ Located in downtown Los Angeles (near Chinatown) ✓ Current asphalt width ranges from 72 feet to 90 feet (18 metres to 23 metres) ✓ Currently served by buses mixed with general traffic ✓ Aim is to make the street conductive to walking and cycling, calm traffic, and provide landscaped medians and islands ✓ Aim is foster neighbourhood development that has been stimulated by the recent Metro Gold Line and some initial industrial redevelopment to residential uses o Street serves a largely industrial area, although it fronts on Union Station and many popular resident and tourist hubs	✓ Bulb-outs at the intersections will reduce pedestrian crossing time ✓ Tactile devices (urban Braille) to be installed at all intersection bulb-outs ✓ Curb ramps for accessibility to be installed at all intersection bulb-outs ✓ Landscaped medians and islands are expected to “reclaim public space” ✓ Continuous provision of bike lanes expected to encourage cycling

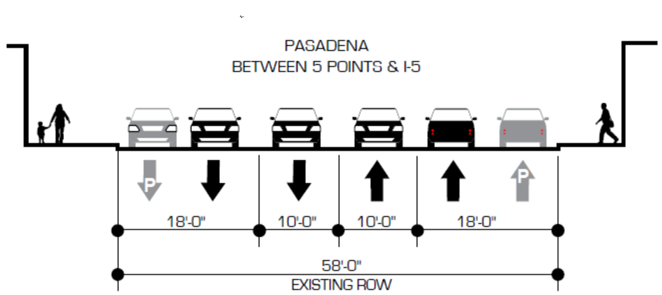
Case Study

11

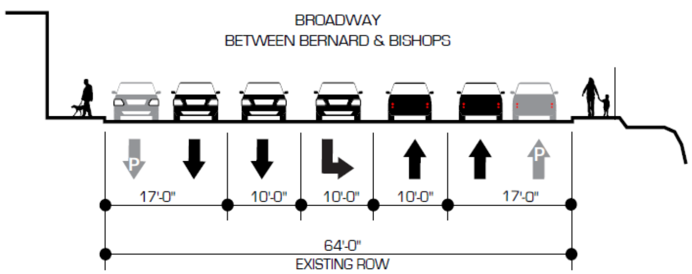
Pasadena + Broadway, Los Angeles, California

Before

Existing

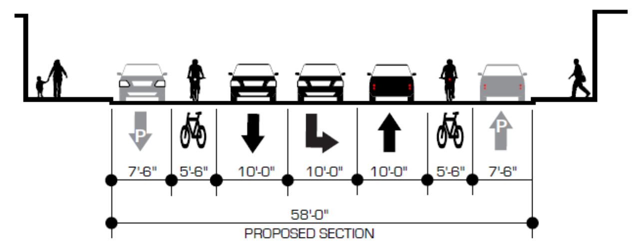


Existing

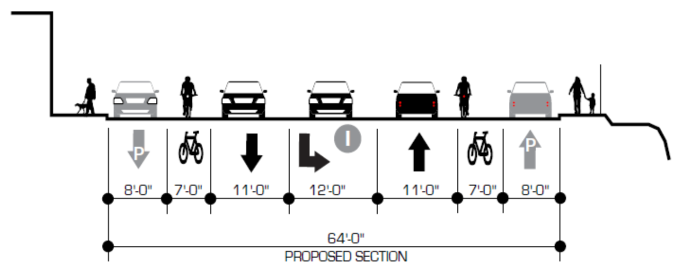


After or Proposed

Proposed



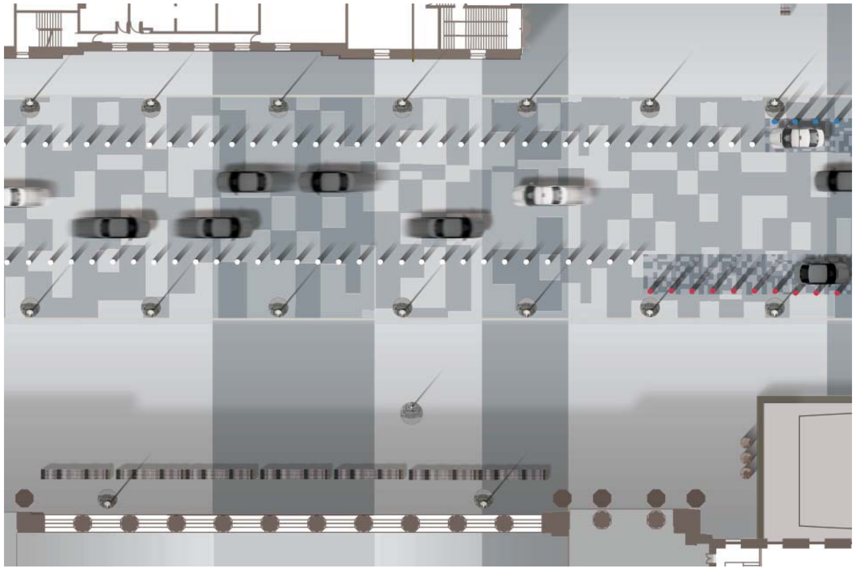
Proposed



Status	Plan	Date	2008

Relevance to King Edward Avenue	Insights Gained from this Case Study
✓ **Pasadena - Six lane urban roadway reduced to five** (four traffic travel lanes reduced to two) ✓ **Broadway - Seven lane urban roadway reduced to five** (four traffic travel lanes reduced to two) ✓ Located in downtown Los Angeles (near Chinatown) ✓ Current asphalt width ranges from 56 feet to 63 feet (14 metres to 16 metres) ✓ Area is mixed use (although mainly commercial) ✓ Aim is to make the street conductive to walking and cycling, calm traffic, and provide landscaped medians and islands ✓ Aim is to also introduce new modes of travel	✓ Bulb-outs at the intersections will reduce pedestrian crossing time ✓ Tactile devices (urban Braille) to be installed at all intersection bulb-outs ✓ Curb ramps for accessibility to be installed at all intersection bulb-outs ✓ Potential to install landscaped centre median in certain locations ✓ Continuous provision of bike lanes expected to encourage cycling

Case Study 12	Front Street (Union Station), Toronto

Before		After or Proposed	
			
Status	Plan	**Date**	2006

Relevance to King Edward Avenue	Insights Gained from this Case Study
✓ **Six lane urban roadway reduced to four** (four traffic travel lanes proposed to be reduced to two) ✓ Aim is to expand pedestrian realm, enhance heritage qualities of Front Street, and accommodate cyclists, taxi queuing, passenger pick-up / drop-off, and maintenance and emergency vehicle access ✓ Automobile traffic is significant o Street serves a largely commercial area and the bus/train station o Street is already landscaped with a centre median o As a concept of the Union Station District Plan, the lane reduction has to be evaluated through an Environmental Assessment	✓ Greater sidewalk space anticipated for pedestrian flow ✓ Pedestrian presence can be given "primary importance" ✓ Design is expected to "essentially maintain[s] the present flow of vehicles" ✓ Required space for taxi queuing and pick-up/drop-off can be provided

Case Study

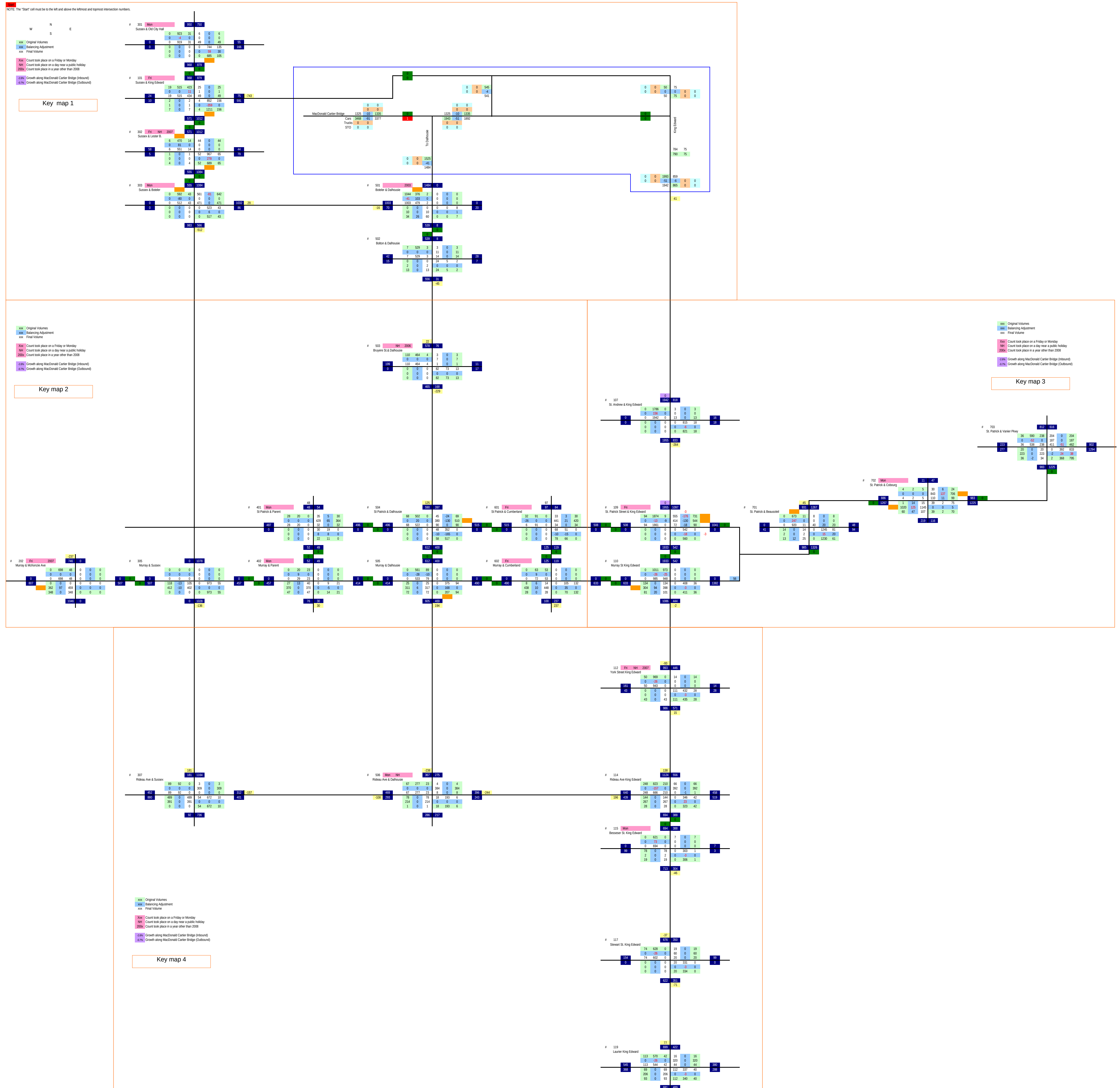
13 Boulevard Strandvejen, Hellerup, Denmark

Before	After or Proposed
	

			
Status	Existing	**Date**	Implemented in the 1980's

Relevance to King Edward Avenue	**Insights Gained from this Case Study**
✓ **Four lane urban roadway reduced to two** (four traffic travel lanes reduced to two) ✓ Major 2.4 km thoroughfare with heavy traffic ✓ Area includes one of the most important shopping corridors, and mixed use with residential ✓ In 1978, there were 20,000 vehicles per day and 1,600 bicycles/mopeds per day ✓ Aim was to improve pedestrian safety, reduce traffic accidents, and give priority to "light" road users o Road width varies from 18.6 metres to 26.5 metres	✓ Changes in the southern portion facilitated with re-striping ✓ Other portions included wider sidewalks and new centre medians for pedestrian refuge ✓ New pedestrian crossings were facilitated, where feasible ✓ Trees planted to improve the streetscape and demarcate pedestrian crossing ✓ Fewer traffic accidents have been recorded o "Establishment of a bypass" as an initial solution was unrealistic o Even on the widest section, the option was for a "two lane solution so as not to attract more cars than could be led through the narrowest part of the road"

Appendix B: Baseline 2008 Traffic Model Volumes


Key map 1
Key map 2
Key map 3
Key map 4

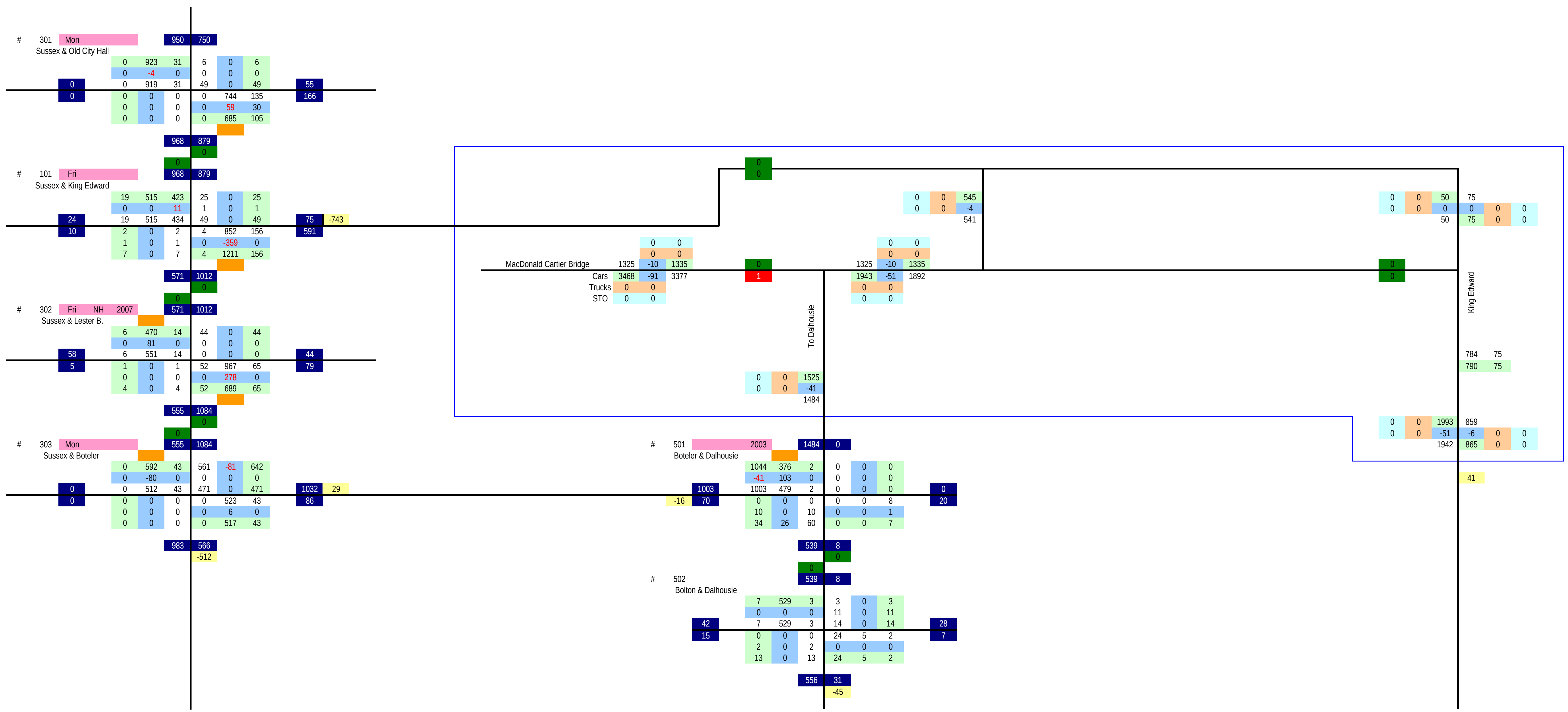
N

W E

S

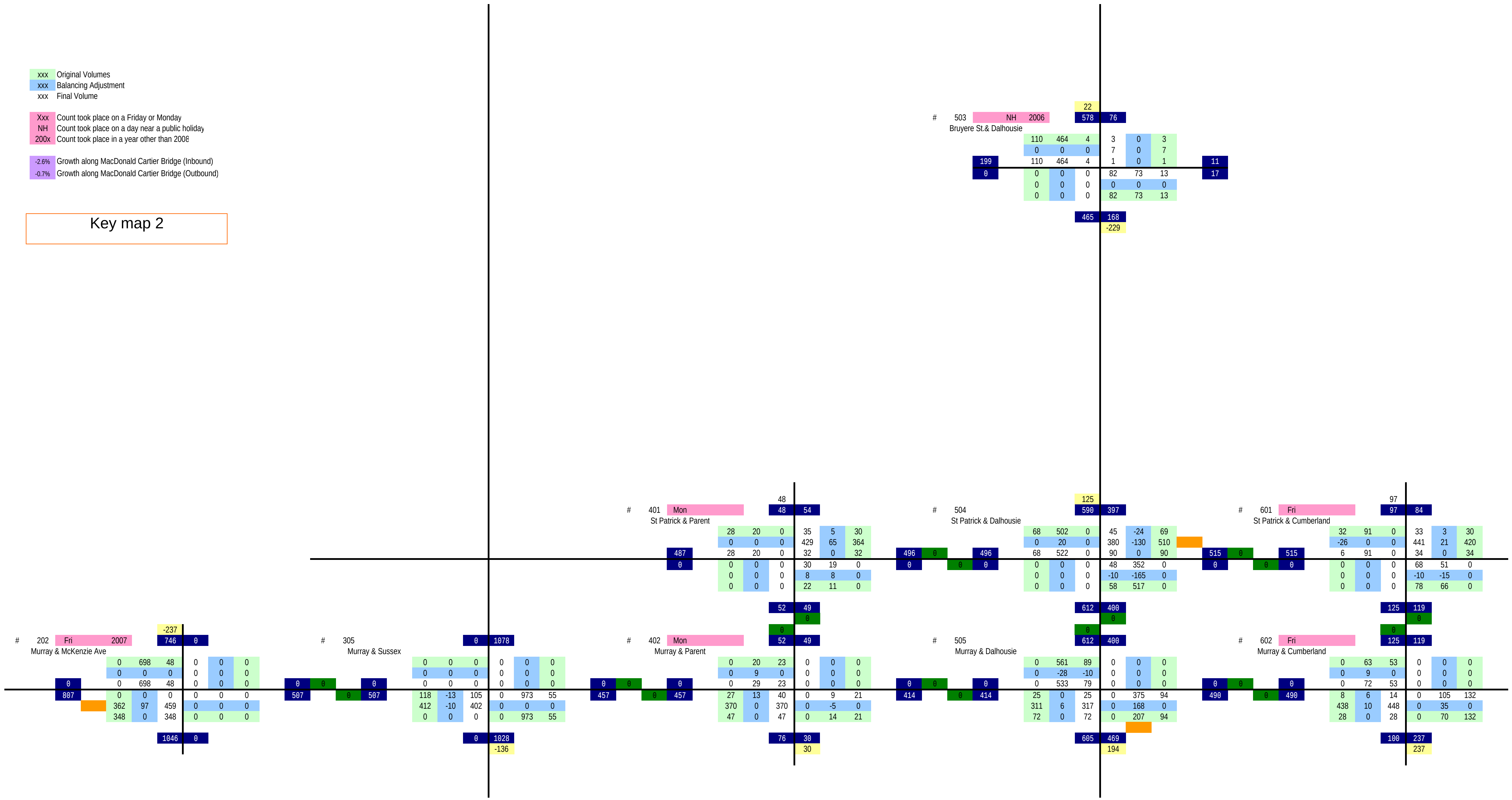
xxx	Original Volumes
xxx	Balancing Adjustment
xxx	Final Volume
Xxx	Count took place on a Friday or Monday
NH	Count took place on a day near a public holiday
200x	Count took place in a year other than 2008
-2.6%	Growth along MacDonald Cartier Bridge (Inbound)
-0.7%	Growth along MacDonald Cartier Bridge (Outbound)

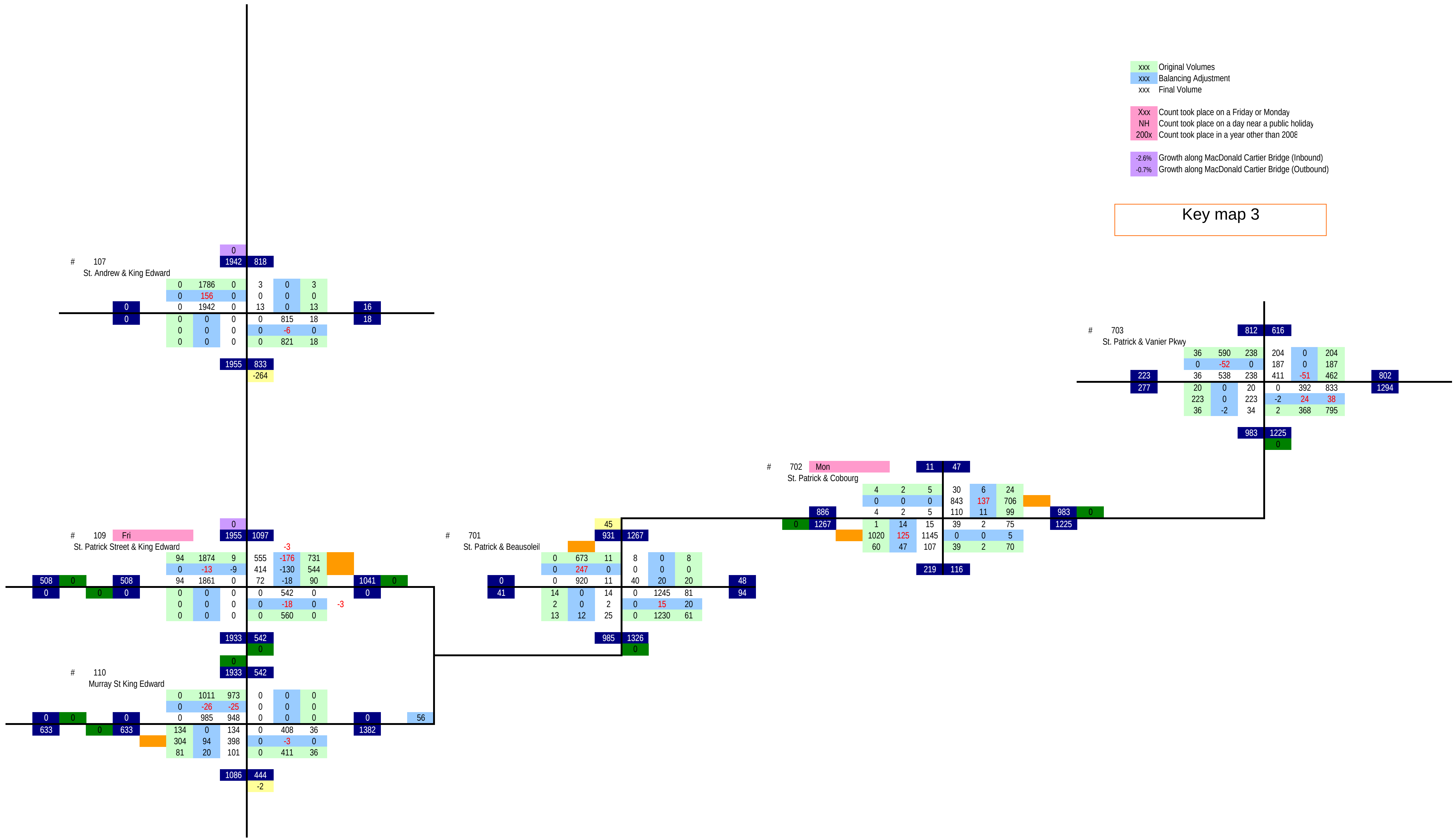
Key map 1



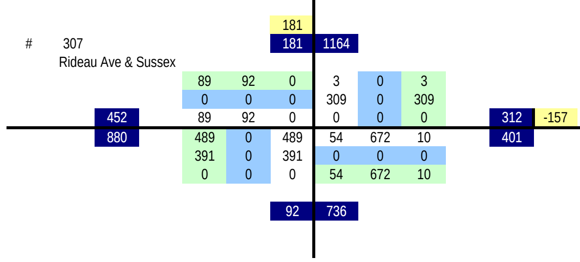
xxx	Original Volumes
xxx	Balancing Adjustment
xxx	Final Volume
Xxx	Count took place on a Friday or Monday
NH	Count took place on a day near a public holiday
200x	Count took place in a year other than 2008
-2.6%	Growth along MacDonald Cartier Bridge (Inbound)
-0.7%	Growth along MacDonald Cartier Bridge (Outbound)

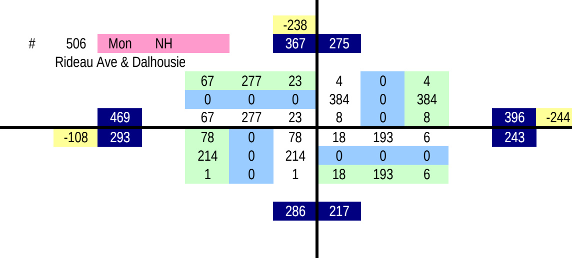
Key map 2

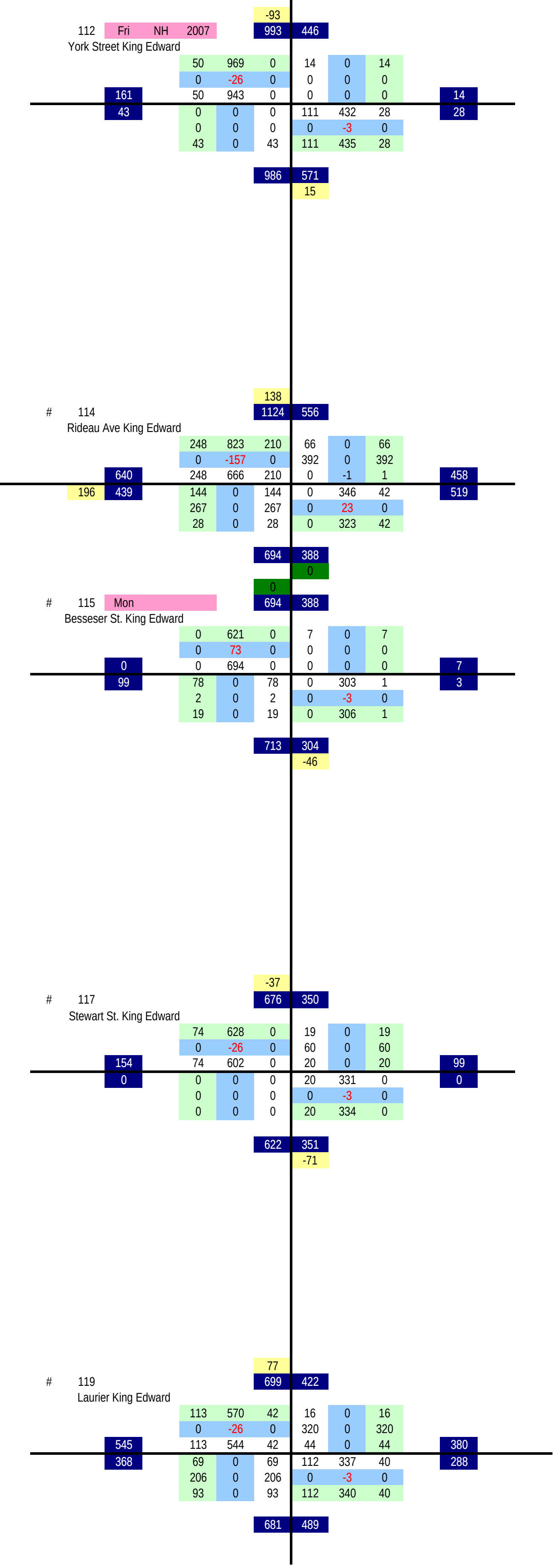




xxx Original Volumes
xxx Balancing Adjustment
xxx Final Volume
Xxx Count took place on a Friday or Monday
NH Count took place on a day near a public holiday
200x Count took place in a year other than 2008
-2.6% Growth along MacDonald Cartier Bridge (Inbound)
-0.7% Growth along MacDonald Cartier Bridge (Outbound)
Key map 3
107
St. Andrew & King Edward
109 Fri
St. Patrick Street & King Edward
110
Murray St King Edward
701
St. Patrick & Beausoleil
702 Mon
St. Patrick & Cobourg
703
St. Patrick & Vanier Pkwy





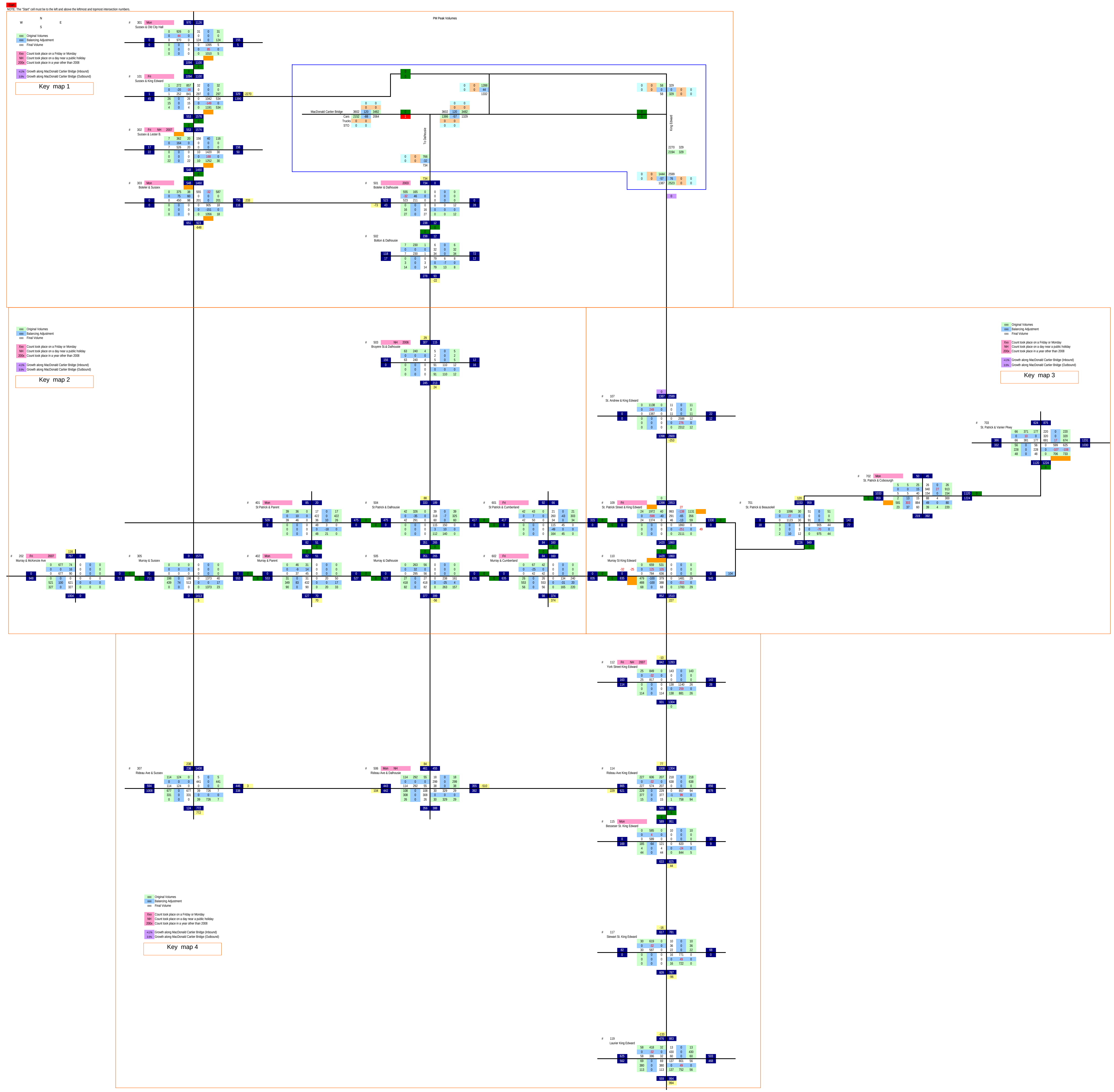


xxx Original Volumes
xxx Balancing Adjustment
xxx Final Volume

Xxx Count took place on a Friday or Monday
NH Count took place on a day near a public holiday
200x Count took place in a year other than 2008

-2.6% Growth along MacDonald Cartier Bridge (Inbound)
-0.7% Growth along MacDonald Cartier Bridge (Outbound)

Key map 4


Start
NOTE: The "Start" cell must be to the left and above the leftmost and topmost intersection numbers.
N
W
E
S
xxx Original Volumes
xxx Balancing Adjustment
xxx Final Volume
Xxx Count took place on a Friday or Monday
NH Count took place on a day near a public holiday
200x Count took place in a year other than 2008
-4.1% Growth along MacDonald Cartier Bridge (Inbound)
3.5% Growth along MacDonald Cartier Bridge (Outbound)
Key map 1
Key map 2
Key map 3
Key map 4
PM Peak Volumes
301 Mon Sussex & Old City Hall
101 Fri Sussex & King Edward
302 Fri NH 2007 Sussex & Lester B.
303 Mon Boteler & Sussex
501 Boteler & Dalhousie
502 Bolton & Dalhousie
503 Bruyere St & Dalhousie
MacDonald Cartier Bridge
Cars
Trucks
STO
To Dalhousie
King Edward
107 St. Andrew & King Edward
703 St. Patrick & Vanier Pkwy
702 Mon St. Patrick & Cobourgh
701 St. Patrick & Beausoleil
401 Mon St Patrick & Parent
504 St Patrick & Dalhousie
601 Fri St Patrick & Cumberland
108 Fri St. Patrick Street & King Edward
202 Fri 2007 Murray & McKenzie Ave
305 Murray & Sussex
402 Mon Murray & Parent
505 Murray & Dalhousie
602 Fri Murray & Cumberland
110 Murray St King Edward
112 Fri NH 2007 York Street King Edward
307 Rideau Ave & Sussex
506 Mon NH Rideau Ave & Dalhousie
114 Rideau Ave King Edward
115 Mon Besserer St. King Edward
117 Stewart St. King Edward
118 Laurier King Edward

Start

NOTE: The "Start" cell must be to the left and above the leftmost and topmost intersection numbers

N

W E

S

xxx Original Volumes

xxx Balancing Adjustment

xxx Final Volume

Xxx Count took place on a Friday or Monday

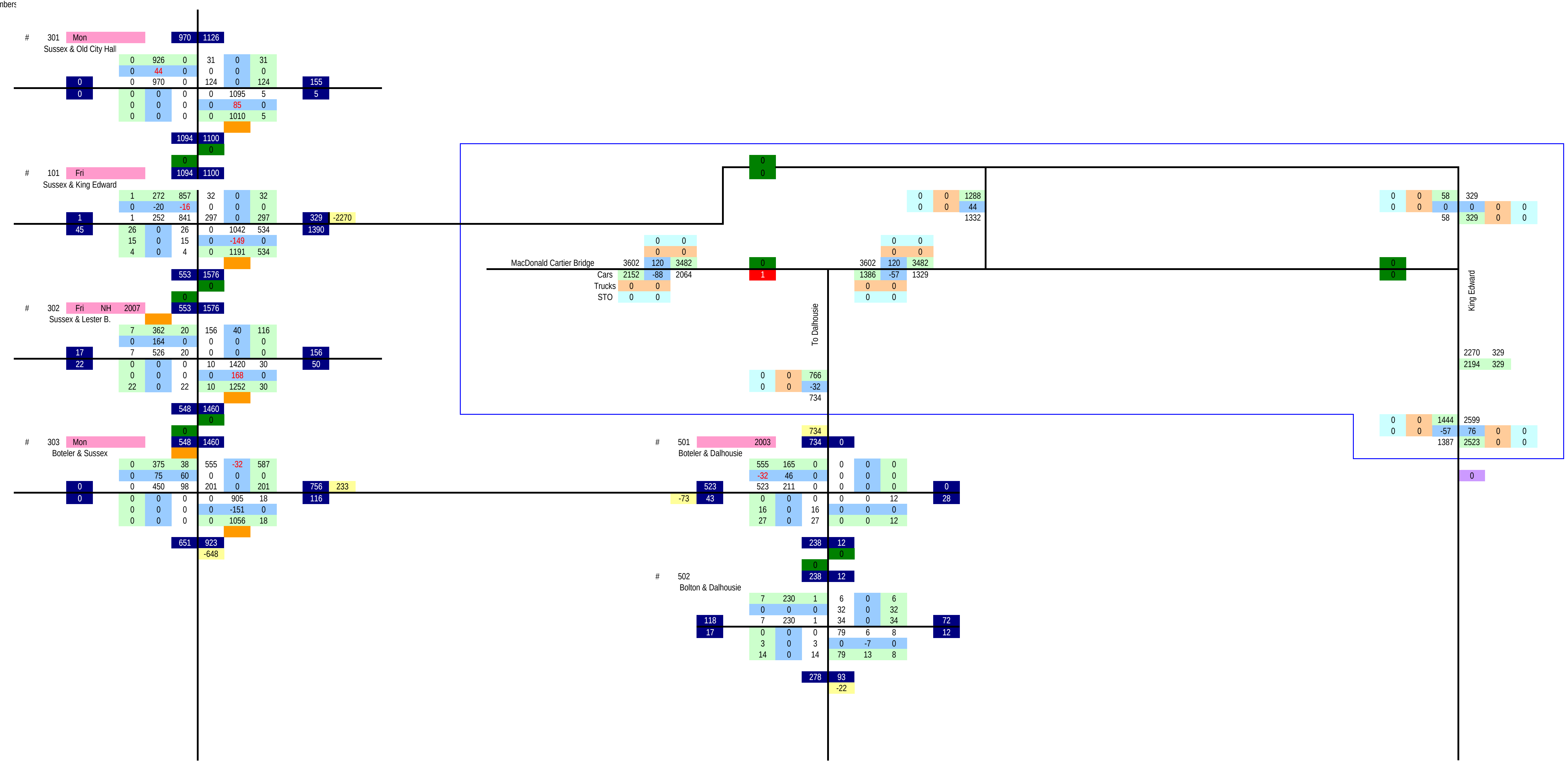
NH Count took place on a day near a public holiday

200x Count took place in a year other than 2008

-4.1% Growth along MacDonald Cartier Bridge (Inbound)

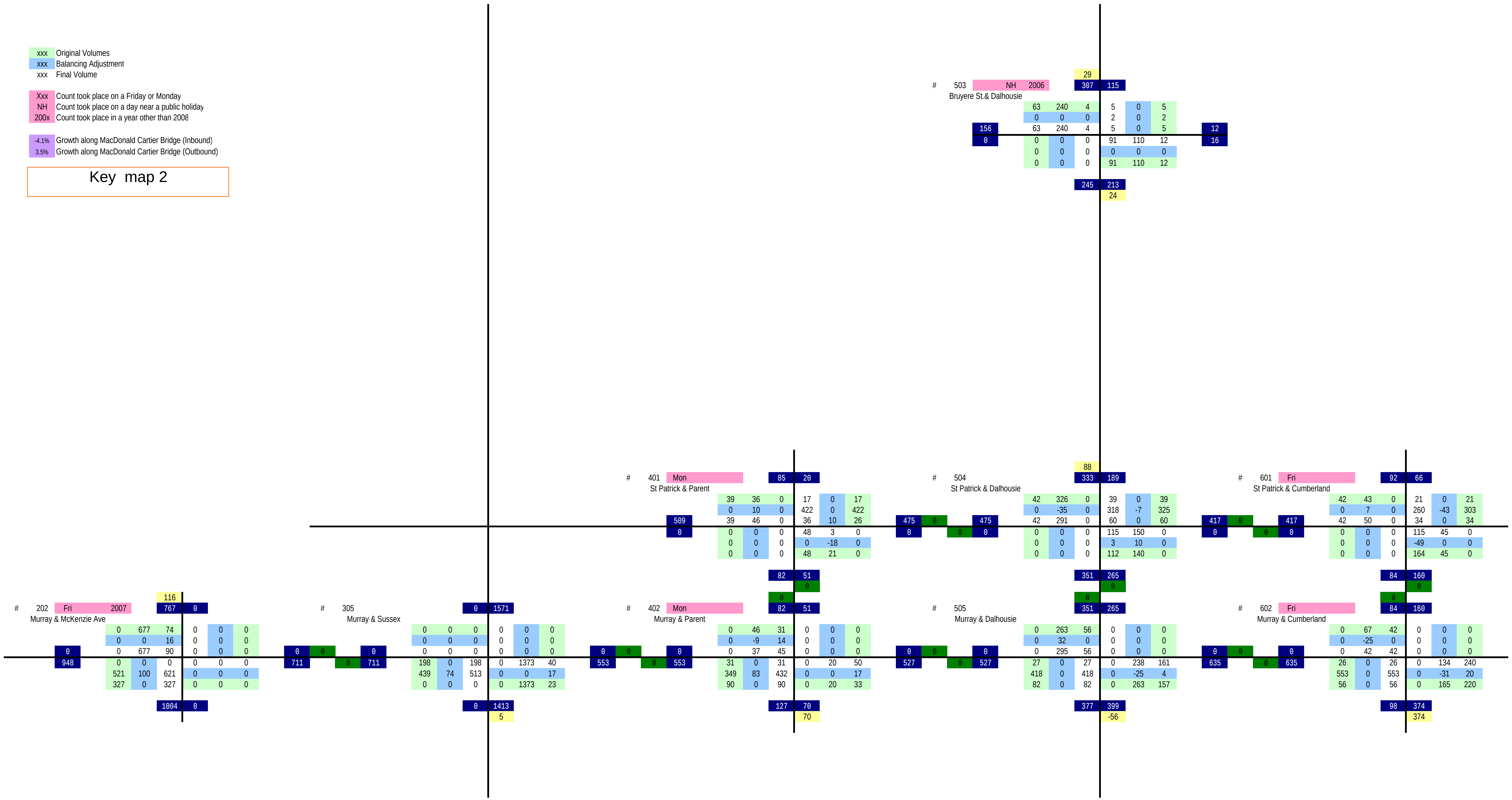
3.5% Growth along MacDonald Cartier Bridge (Outbound)

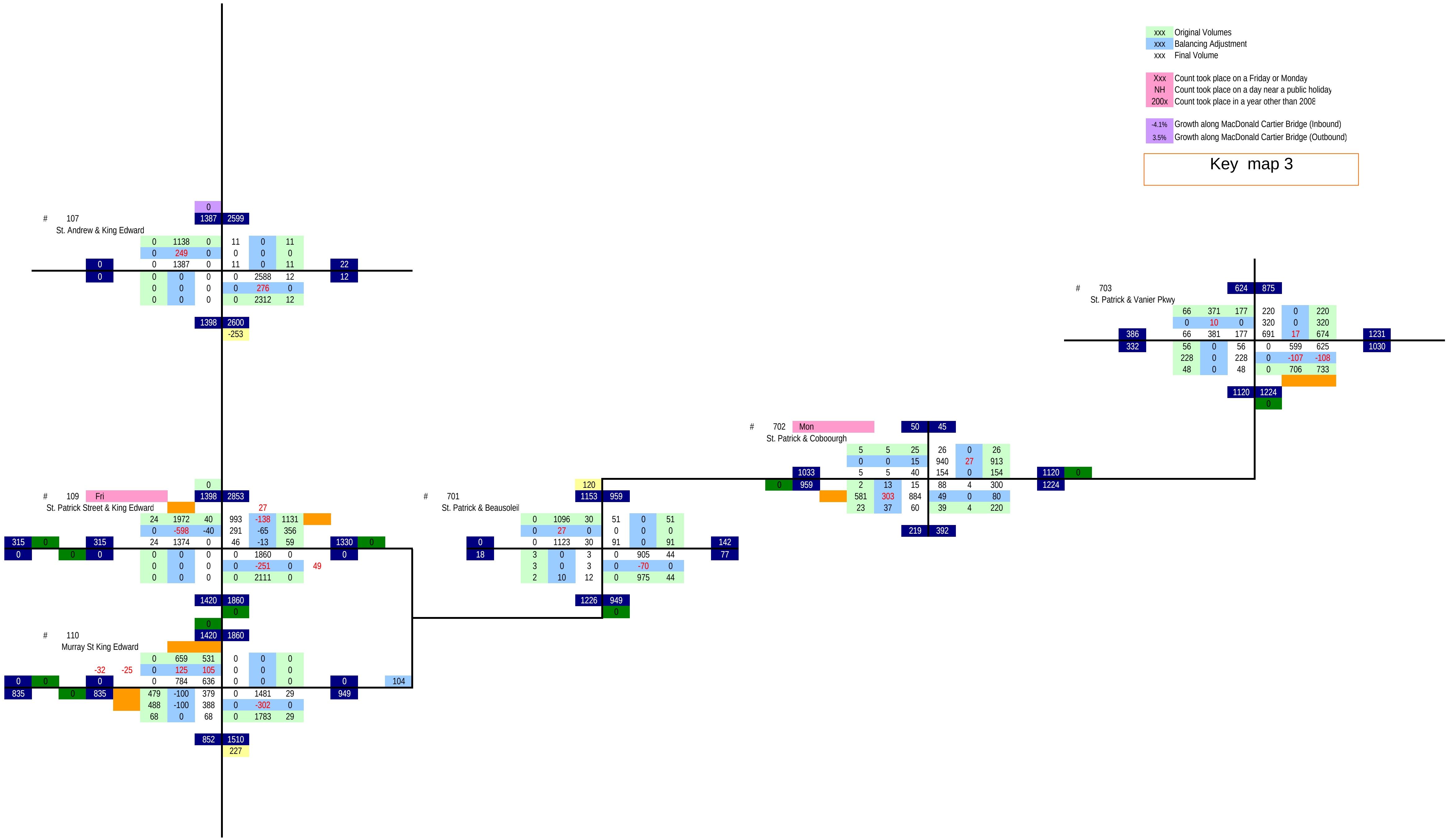
Key map 1

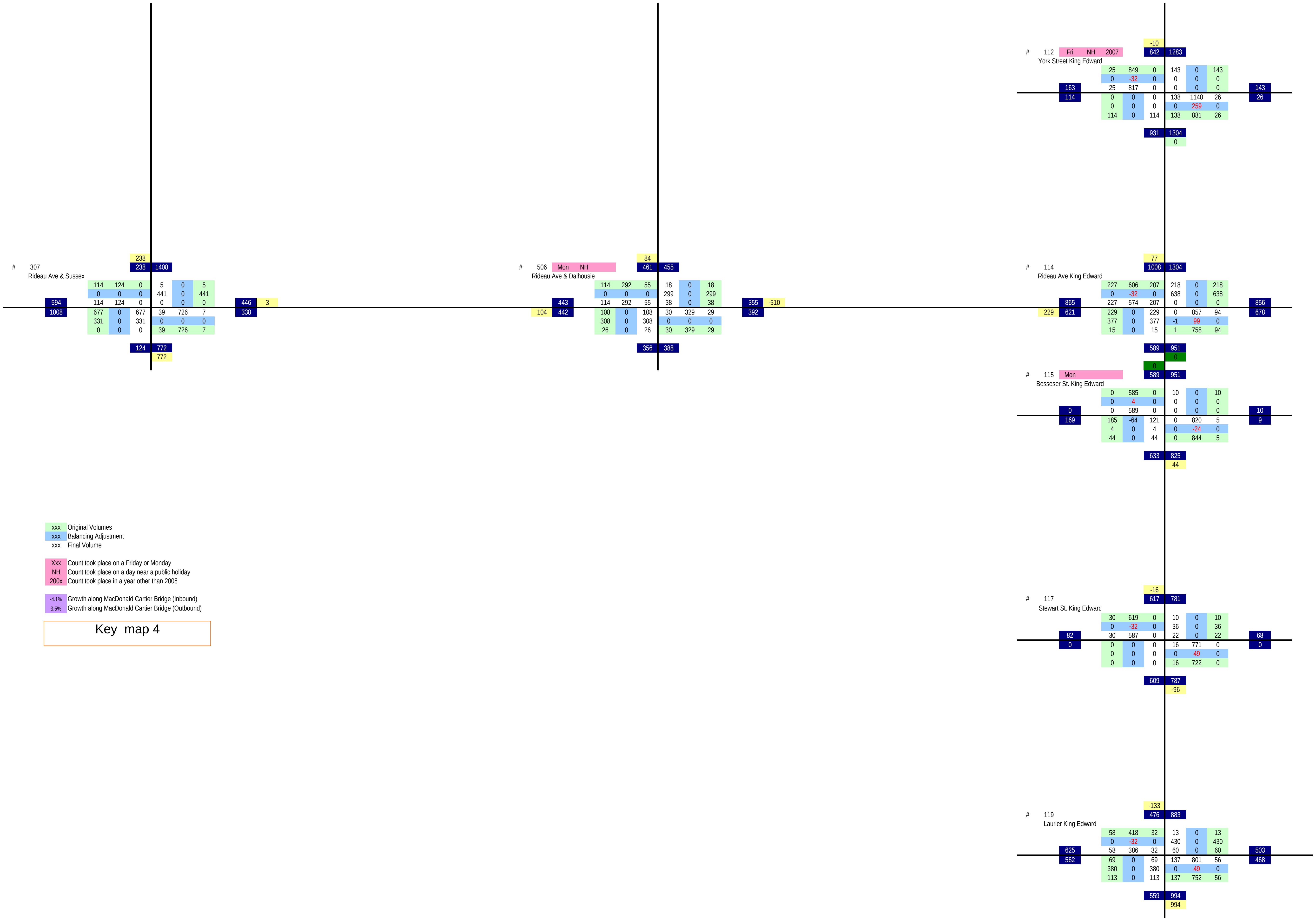


xxx	Original Volumes
xxx	Balancing Adjustment
xxx	Final Volume
Xxx	Count took place on a Friday or Monday
NH	Count took place on a day near a public holiday
200x	Count took place in a year other than 2008
-4.1%	Growth along MacDonald Cartier Bridge (Inbound)
3.5%	Growth along MacDonald Cartier Bridge (Outbound)

Key map 2




Key map 3
xxx Original Volumes
xxx Balancing Adjustment
xxx Final Volume
Xxx Count took place on a Friday or Monday
NH Count took place on a day near a public holiday
200x Count took place in a year other than 2008
-4.1% Growth along MacDonald Cartier Bridge (Inbound)
3.5% Growth along MacDonald Cartier Bridge (Outbound)
107
St. Andrew & King Edward
109
Fri
St. Patrick Street & King Edward
110
Murray St King Edward
701
St. Patrick & Beausoleil
702
Mon
St. Patrick & Coboourgh
703
St. Patrick & Vanier Pkwy



xxx Original Volumes
xxx Balancing Adjustment
xxx Final Volume

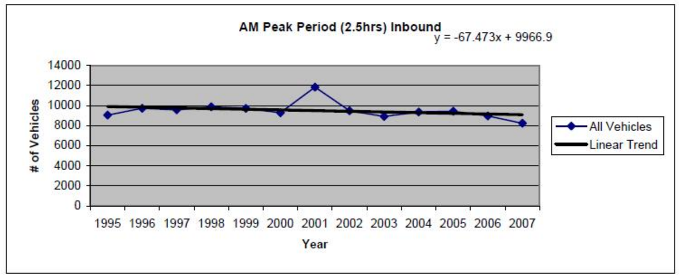
Xxx Count took place on a Friday or Monday
NH Count took place on a day near a public holiday
200x Count took place in a year other than 2008

-4.1% Growth along MacDonald Cartier Bridge (Inbound)
3.5% Growth along MacDonald Cartier Bridge (Outbound)

Key map 4

Appendix C: Trend Analysis

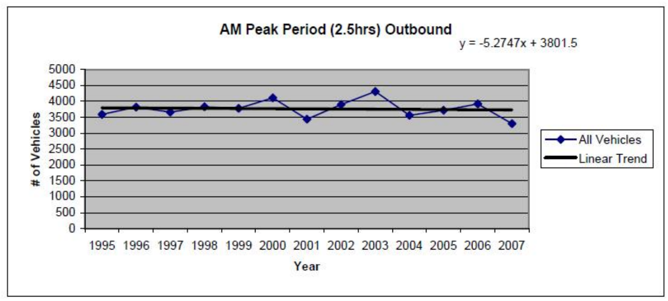
	AM Peak Period (2.5 hours) Inbound (South)			
Year	Auto Vehicle	LT Vehicle	HT Vehicle	Vehicle Totals
1995	8494	346	210	9050
1996	9150	390	190	9730
1997	8898	422	250	9570
1998	9130	540	200	9870
1999	9048	472	200	9720
2000	8630	420	230	9280
2001	11074	556	210	11840
2002	8742	508	230	9480
2003	8162	508	240	8910
2004	8480	560	320	9360
2005	8612	538	280	9430
2006	8142	548	270	8960
2007	7810	250	170	8230



Trend Per Annum
-0.74%

	Estimated Values		
Year	2008	2009	2010
Total	8169	8108	8048

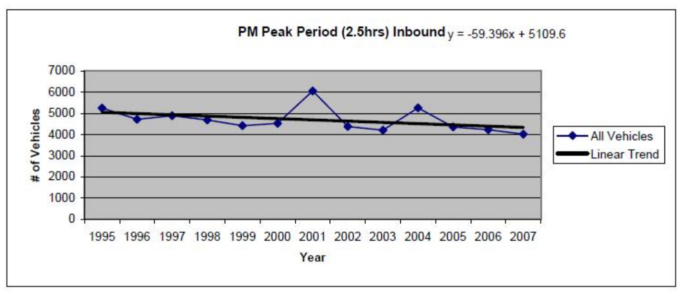
	AM Peak Period (2.5 hours) Outbound (North)			
Year	Auto Vehicle	LT Vehicle	HT Vehicle	Vehicle Totals
1995	3266	134	190	3590
1996	3440	170	210	3820
1997	3268	172	220	3660
1998	3432	188	210	3830
1999	3400	190	190	3780
2000	3702	188	220	4110
2001	3018	212	210	3440
2002	3470	220	210	3900
2003	3836	224	250	4310
2004	3386	174	0	3560
2005	3296	204	220	3720
2006	3422	238	260	3920
2007	2960	150	190	3300



Trend Per Annum
-0.14%

	Estimated Values		
Year	2008	2009	2010
Total	3295	3291	9286

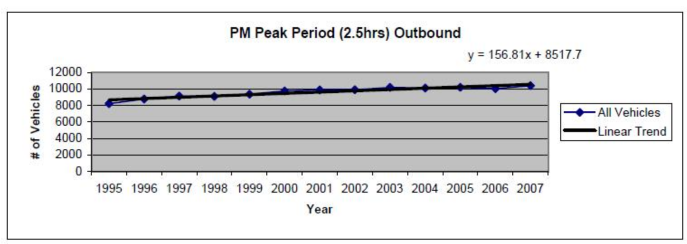
	PM Peak Period (2.5 hours) Inbound (South)			
Year	Auto Vehicle	LT Vehicle	HT Vehicle	Vehicle Totals
1995	4908	182	160	5250
1996	4386	184	150	4720
1997	4506	204	180	4890
1998	4308	232	150	4690
1999	4078	202	140	4420
2000	4204	186	140	4530
2001	5680	230	150	6060
2002	4022	208	150	4380
2003	3814	246	150	4210
2004	4976	214	70	5260
2005	3972	228	160	4360
2006	3838	252	140	4230
2007	3740	140	140	4020



Trend Per Annum
-1.37%

	Estimated Values		
Year	2008	2009	2010
Total	3965	3911	3857

	PM Peak Period (2.5 hours) Outbound (North)			
Year	Auto Vehicle	LT Vehicle	HT Vehicle	Vehicle Totals
1995	7438	572	200	8210
1996	8380	240	150	8770
1997	8414	556	160	9130
1998	8438	542	110	9090
1999	8608	582	170	9360
2000	9058	492	200	9750
2001	9082	638	160	9880
2002	9128	582	190	9900
2003	9384	626	170	10180
2004	9388	532	180	10100
2005	9422	598	180	10200
2006	9532	338	160	10030
2007	9708	532	160	10400



Trend Per Annum
1.49%

	Estimated Values		
Year	2008	2009	2010
Total	10554	10711	10870

Appendix D: Air Quality Analysis Details

Community Air Quality Impact Assessment of Reducing Cross-Section to Four Lanes (Cathcart Street to Rideau Street) – Preliminary Assessment

Introduction

The objective of this assessment was to provide a preliminary analysis of the air quality impact on the community surrounding King Edward Avenue from vehicle traffic as a result of three (3) potential lane re-configurations on King Edward Avenue. The three lane configurations are:

- Scenario 1 – Six-lane Configuration;
- Scenario 2 – Six-lane Hybrid Configuration; and
- Scenario 3 – Four-lane Configuration.

The resulting impact of each scenario was modeled based on predicted traffic volume and ambient air quality.

Air Quality Assessment Objectives

The objective of the air quality assessment was to predict the ambient air contaminant levels in the vicinity of King Edward Avenue due to vehicular emissions under each scenario for the year 2010. The air quality impacts were assessed using the following predictive models for the three scenarios under investigation:

- U.S. EPA model MOBILE 6.2 - Vehicle emission modelling software used for predicting emission factors for various types of vehicles and for different vehicle-related emissions; and

- U.S. EPA model CAL3QHC (Lakes Environmental CALRoads View) - designed for modelling dispersion of roadway emissions, including those from idling vehicles queued at intersections.

The following pollutants are the key conventional air contaminants associated with vehicular traffic and were assessed for this study:

- Carbon monoxide (CO);
- Oxides of nitrogen (NO_x);
- Respirable particulate matter ($PM_{2.5}$); and
- Sulphur dioxide (SO_2).

The gaseous emissions (i.e. CO, NO_x and SO_2) are associated with tailpipe emissions only whereas particulate matter ($PM_{2.5}$) emissions are associated with re-suspension of road dust, vehicular braking and tailpipe emissions.

Study Area and Sensitive Air Quality Receptors

This study considered the impact of the three road lane configurations at selected points of reception along Kind Edward Avenue between Cathcart Street and Rideau Street. Ten sensitive receptors were selected and these included single and multi unit residential buildings, places of worship, a school and a small park. These receptors are identified in the table below.

Receptors West of King Edward Avenue				Receptors East of King Edward Avenue			
Receptor	**Address**	**Location**	**Height (m)**	**Receptor**	**Address**	**Location**	**Height (m)**
R1	156 King Edward Avenue	back yard corner	1.8	R2	244 Bruyère	mid backyard	1.8
R3	174 King Edward Avenue	front	1.8	R4	175 King Edward Avenue	2nd storey front	6
R5	233 King Edward Avenue (Shepherds of Good Hope Church)	front	1.8	R6	237 King Edward Avenue (City of Ottawa)	mid of park	1.8
R7	231 Clarence St (Clarence & King Edward Avenue) (City of Ottawa Social Housing)	middle of front 2nd storey	6	R8	277 King Edward Avenue	middle of front 2nd storey	6

Receptors West of King Edward Avenue				Receptors East of King Edward Avenue			
Receptor	**Address**	**Location**	**Height (m)**	**Receptor**	**Address**	**Location**	**Height (m)**
R9	195 St George (St. George & King Edward Avenue) (Ottawa Day Nursery)	front on King Edward Avenue	1.8	R10	375 King Edward Avenue (Seventh Day Adventist Church)	front on King Edward Avenue	1.8

Air Quality Assessment Methodology

Traffic Data and Assumptions

Dillon used all available City of Ottawa intersection count data (up to and including 2008) and bridge count data (up to 2007 was available when we initiated our analysis) in order to generate traffic volumes for a "baseline" 2008 traffic model. Baseline volumes for our 2008 model are a collection of different sources, adjusted so that traffic volumes are consistent throughout the study area (e.g. inbound volumes to one intersection match outbound volumes from the previous intersection).

Transportation data (e.g. mixed traffic, goods movement, transit, cycling and pedestrians) were analyzed using PTV's VISSIM software to conduct microscopic simulation and to model travel for all modes based on driver behaviour, routing, etc. VISSIM is capable of tracking individual vehicles through the network and compiling statistics based on simulations of different roadway configurations.

The air quality impact assessment used the peak hourly afternoon volumes as these were typically higher than the peak morning hourly volumes under all three scenarios. The following table list the hourly peak southbound and northbound volumes and the mean traffic speeds for the afternoon at five intersections along King Edward Avenue. These intersections on King Edward Avenue represent the mid-block locations of five road segments along the King Edward Avenue study route. These five road segments are:

- Cathcart Street to St. Andrew Street;
- St. Andrew Street to St. Patrick Street;
- St. Patrick Street to Murray Street;

- Murray Street to York Street; and
- York Street to Rideau Street.

It must be noted that the mean traffic speeds indicated are not the posted speed limits for the road segments along King Edward Avenue but rather the predicted average speed based on the VISSIM traffic simulation which considered congestion along the study route.

King Edward Avenue Intersection	Direction	Scenario 1		Scenario 2		Scenario 3	
		Total Vehicles	Average (km/h)	Total Vehicles	Average (km/h)	Total Vehicles	Average (km/h)
Bruyère St.	SB	1521	43	1458	39	1354	38
	NB	2514	46	2497	43	2125	46
Guigues Ave	SB	1529	43	1456	38	1331	38
	NB	2517	44	2502	43	2110	43
Mid-St. Patrick & Murray Sts	SB	1541	39	1466	38	1328	35
	NB	1767	39	1764	38	1401	38
Clarence St.	SB	924	46	864	46	766	40
	NB	1205	32	1213	31	837	29
Mid-Rideau & York Sts.	SB	1015	44	949	44	813	33
	NB	1204	45	1229	44	794	27

SB – southbound; NB – northbound

For the purposes of the air quality modelling, the average speeds were rounded to the nearest 5 kilometres per hour as there was no significant difference in the predicted emission rate for the pollutants under consideration when the vehicular speeds differed by less than a few kilometres per hour.

The traffic signal timing was based on the traffic modelling conducted for this study. It was assumed that the signal timing was the same under all road laneway configurations/scenarios. The following table lists the signal timing at the intersections along King Edward Avenue.

Intersection	Travel Direction	Cycle Time (s)	Red Time (s)
King Edward and St. Andrew	SB	100	70
	NB	100	70
King Edward and St. Patrick	SB	100	59

Intersection	Travel Direction	Cycle Time (s)	Red Time (s)
	NB	100	39
King Edward and Murray	SB	100	59
	NB	100	39
King Edward and York	SB	100	61
	NB	100	61
King Edward and Rideau	SB	100	48
	NB	100	36

SB – southbound; NB – northbound

Meteorological Data

This comparative study considered the worst-case meteorological conditions for the dispersion of air contaminants. This provided a conservative assessment of the air quality impacts of the three scenarios defined above. The characteristics of the meteorological condition used in all modelling scenarios are described in the table below. These meteorological parameters were calculated from the five year meteorological data set provided by the MOE for air quality impact assessments and dispersion modelling purposes in Ontario. The data has been processed by the MOE for the Ottawa, Belleville and Cornwall region.

Meteorological Conditions	
Wind Speed	1.53 m/s
Stability Class	F – Moderately Stable
Surface roughness	4 m (urban core)
Background Concentration	0 ppm
Multiple Wind Directions	Yes
Wind Direction Increment Angle	2 degrees
Start Angle	0 degrees
End Angle	360 degrees

Predicted Air Quality Impacts

The following table present the predicted CO, NOx, $PM_{2.5}$ and SO_2 concentrations at the selected sensitive receptors along the study route under the three road laneway configuration scenarios.

Receptor	CO (ppm)			NOx (ppm)			$PM_{2.5}$ (ug/m^3)			SO_2 (ppb)		
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3
1	5.7	5.4	4.6	0.5	0.5	0.4	8	7	6	1.4	1.4	1.1
2	6.9	7.1	5.9	0.6	0.5	0.5	10	10	8	1.6	1.7	1.4
3	7.4	7.4	5.8	0.5	0.5	0.4	9	9	7	1.6	1.6	1.2
4	9.7	10.2	7.0	0.8	0.8	0.5	13	13	10	2.3	2.4	1.8
5	9.0	8.1	7.2	0.6	0.5	0.5	11	7	9	2.2	2.1	1.7
6	6.9	6.8	4.9	0.5	0.5	0.4	9	9	7	1.7	1.6	1.3
7	8.1	7.0	8.3	0.5	0.3	0.6	10	9	10	2.0	1.8	1.9
8	6.6	6.5	5.1	0.4	0.4	0.4	9	9	7	1.6	1.6	1.3
9	5.1	4.8	7.8	0.2	0.2	0.5	7	7	9	1.1	1.0	1.4
10	5.0	4.8	5.0	0.2	0.2	0.4	7	7	6	1.2	1.2	1.0

S1 – Scenario 1, S2 – Scenario 2, S3 – Scenario 3.

The predicted CO concentrations at the selected sensitive receptors ranged from 5.0 to 9.7 ppm under Scenario 1 (Six-lane Configuration), from 4.8 to 10.2 ppm under Scenario 2 (Six-lane Hybrid Configuration), and from 4.6 to 8.3 ppm under Scenario 3 (Four-lane Configuration). For NOx, the predicted concentrations ranged from 0.2 to 0.8 ppm under Scenarios 1 and 2, and 0.4 to 0.6 ppm under Scenario 3. $PM_{2.5}$ concentrations were predicted to range from 7 to 13 ug/m^3 under Scenarios 1 and 2, and from 6 to 10 ug/m^3 under Scenario 3. SO2 concentrations were predicted to range from 1.1 to 2.3 ppb under Scenario 1, 1.0 to 2.4 ppb under Scenario 2 and from 1.0 to 1.9 ppb under Scenario 3.

The predicted concentrations were added to the background concentrations and the cumulative concentrations are presented in the following table. Since the background concentration for NOx (1-hr 90th percentile) is only 0.026 ppm (26 ppb), it does not significantly impact the cumulative (predicted + background) concentrations at the selected receptors.

Receptor	CO (ppm)			NOx (ppm)			$PM_{2.5}$ (ug/m^3)			SO_2 (ppb)		
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3
1	6.1	5.8	5.0	0.5	0.5	0.4	21	20	19	3.4	3.4	3.1
2	7.3	7.5	6.3	0.6	0.5	0.5	23	23	21	3.6	3.7	3.4
3	7.8	7.8	6.2	0.5	0.5	0.4	22	22	20	3.6	3.6	3.2
4	10.1	10.6	7.4	0.8	0.8	0.5	26	26	23	3.3	4.4	3.8
5	9.4	8.5	7.6	0.6	0.5	0.5	24	20	22	4.2	4.1	3.7
6	7.3	7.3	5.3	0.5	0.5	0.4	22	22	20	3.7	3.6	3.3
7	8.5	7.4	8.7	0.5	0.3	0.6	23	22	23	4.0	3.8	3.9
8	7.0	6.9	5.5	0.4	0.4	0.4	22	22	20	3.6	3.6	3.3
9	5.5	5.2	8.2	0.2	0.2	0.5	20	20	22	3.1	3.0	3.4
10	5.4	5.2	5.4	0.2	0.2	0.4	20	20	19	3.2	3.2	3.0

S1 – Scenario 1, S2 – Scenario 2, S3 – Scenario 3.

The scenarios were compared against each other to determine their relative impact with respect to a given contaminant (see table below). This preliminary assessment indicates that the Six-lane Configuration (Scenario 1) generally results in higher ambient concentrations of CO, NOx, $PM_{2.5}$ and SO_2 than the Six-lane Hybrid Configuration (Scenario 2). This is due to the marginally higher volumes (approximately 2% greater) predicted under Scenario 1 than under Scenario 2. Due to the lower volumes predicted for Scenario 3's Four-lane Configuration, the estimated ambient concentrations of the air contaminants are generally lower than the concentrations predicted under either Scenario 1 or 2. However there are receptors (typically receptors 7, 9 and 10) that have been predicted to be impacted by higher concentrations of air contaminants under Scenario 3 than under Scenarios 1 and 2. This is a result of higher traffic volume per lane under Scenario 3 than under Scenarios 1 and 2 and the impact of the worst case meteorological conditions on dispersion.

Receptor	CO			NOx			$PM_{2.5}$			SO_2		
	S1/S3	S2/S3	S1/S2	S1/S3	S2/S3	S1/S2	S1/S3	S2/S3	S1/S2	S1/S3	S2/S3	S1/S2
1	124%	117%	106%	125%	125%	100%	133%	117%	114%	127%	127%	100%
2	117%	120%	97%	120%	100%	120%	125%	125%	100%	114%	121%	94%
3	128%	128%	100%	125%	125%	100%	129%	129%	100%	133%	133%	100%
4	139%	146%	95%	160%	160%	100%	130%	130%	100%	128%	133%	96%
5	125%	113%	111%	120%	100%	120%	122%	78%	157%	129%	124%	105%
6	141%	139%	101%	125%	125%	100%	129%	129%	100%	131%	123%	106%
7	98%	84%	116%	83%	50%	167%	100%	90%	111%	105%	95%	111%
8	129%	127%	102%	100%	100%	100%	129%	129%	100%	123%	123%	100%
9	65%	62%	106%	40%	40%	100%	78%	78%	100%	79%	71%	110%
10	100%	96%	104%	50%	50%	100%	117%	117%	100%	120%	120%	100%
Average	117%	113%	104%	105%	98%	111%	119%	112%	108%	119%	117%	102%

S1 – Scenario 1, S2 – Scenario 2, S3 – Scenario 3.

Ambient (Background) Concentrations

The Ministry of Environment (MOE) and Environment Canada (EC) own and operate many ambient air quality monitoring stations across Ontario. A summary of ambient measurements for the year 2007, obtained from MOE station No. 51001 (Ottawa, Rideau/Wurtemburg), is presented below. The 90th percentile ambient measurements were used in the assessment because it provides a reasonable worst-case level that does not include extreme emission events such as fires or nearby idling vehicles in the immediate vicinity of the study area, or monitoring station equipment irregularities.

Summary of Ambient Measurements from MOE Station No. 51001		
Contaminant	**Statistic**	**2007**
CO (ppm)	1-hr Max	1.5
	24-hr Max	0.79
	Annual Mean	0.30
	1-hr 90th Percentile	0.44
NOx (ppb)	1-hr Max	213
	24-hr Max	79
	Annual Mean	12

Summary of Ambient Measurements from MOE Station No. 51001		
Contaminant	**Statistic**	**2007**
	1-hr 90th Percentile	26
$PM_{2.5}$ (µg/m^3)	1-hr Max	57
	24-hr Max	37
	Annual Mean	5.9
	24-hr 90th Percentile	13
SO_2 (ppb)	1-hr Max	28
	24-hr Max	6.6
	Annual Mean	0.85
	1-hr 90th Percentile	2.0

Comparison to Existing Standards

For each contaminant, the highest cumulative concentration at any of the ten selected receptors was compared to the existing standard. This is illustrated below.

Cumulative Concentrations versus Existing Standards					
Contaminant	**Highest Concentration**	**Background Concentration**	**Cumulative Concentration**	**Existing Standard**	**Percent of Standard**
CO (ppm)	10.2	0.4	10.6	30	35 %
NOx (ppm)	0.8	0.026	0.83	0.2	413 %
$PM_{2.5}$ (µg/m^3)	13	13	26	30	87 %
SO_2 (ppb)	2.4	2.0	4.4	250	2 %

Notes: For CO, NOx and SO_2, the concentrations indicated are for 1-hour averaging time

For $PM_{2.5}$, the concentrations indicated are for 24-hour averaging time

Of the four contaminants considered, only NOx is found to exceed the provincial standard. This exceedance is attributable to vehicular traffic since the background NOx concentration is only 0.026 ppm while the predicted NOx concentration due to vehicular traffic is approximately 0.8 ppm.

Ministry of Environment Air Quality Guidelines

The Ontario Ministry of Environment air quality guidelines were used in this assessment. See table below.

MOE Air Quality Criteria for Relevant Air Contaminants (1-hour & 24-hour)		
Contaminant	**Ministry of the Environment AAQC 1-hr Standards**	**Ministry of the Environment AAQC 24-hr Standards**
CO (µg/m³)	36,200	15,700 (1)
CO (ppm)	30	13 (1)
NO_x (µg/m³)	400	200
NO_x (ppb)	200	100
$PM_{2.5}$ (µg/m³)	N/A	30 (2)

Notes: (1) 8-hour carbon monoxide standard

(2) CCME Canada Wide Standard for the fine fraction of Particulate Matter $PM_{2.5}$

N/A – Not applicable; guideline not established

Appendix E: Noise Analysis Details

King Edward Avenue Preliminary Noise Impact Assessment

Introduction

The objective of this assessment was to provide a preliminary analysis of the noise impact on the community surrounding King Edward Avenue from vehicle traffic as a result of three (3) potential lane re-configurations on King Edward Avenue. The three lane re-configuration scenarios include:

- Scenario 1 –Six-lane Configuration;
- Scenario 2 – Six-lane Hybrid Configuration; and
- Scenario 3 – Four-lane Configuration

The resulting impact of each scenario was modeled based upon predicted traffic volume and vehicle speeds for the year 2010.

Study Area and Noise Sensitive Receptors

This study considered the impact of the three road lane configurations at selected points of reception along Kind Edward Avenue between Cathcart Street and Rideau Street. Ten sensitive receptors were selected and these included single and multi unit residential buildings, places of worship, a school and a small park. These receptors are identified in the table below.

Receptors West of King Edward Avenue				Receptors East of King Edward Avenue			
Receptor	**Address**	**Location**	**Height (m)**	**Receptor**	**Address**	**Location**	**Height (m)**
R1	156 King Edward Avenue	Back yard OLA	1.5	R2	244 Bruyère	Backyard OLA	1.5
R3	174 King Edward Avenue	Front yard OLA	1.5	R4	175 King Edward Avenue	Front balcony 2nd storey front	6

Receptors West of King Edward Avenue				Receptors East of King Edward Avenue			
Receptor	Address	Location	Height (m)	Receptor	Address	Location	Height (m)
R5	233 King Edward Avenue (Shepherds of Good Hope Church)	Front yard OLA	1.5	R6	237 King Edward Avenue (City of Ottawa)	Side yard OLA	1.5
R7	231 Clarence St (Clarence & King Edward Avenue) (City of Ottawa Social Housing)	Front balcony 2nd storey	6	R8	277 KEA	Front 2nd storey balcony	6
R9	195 St George (St. George & King Edward Avenue) (Ottawa Day Nursery)	Front yard OLA on King Edward Avenue	1.5	R10	375 KEA (Seventh Day Adventist Church)	Front yard on King Edward Avenue	1.5

OLA – Outdoor Living Area – Commonly defined as a location at the midpoint in the rear yard, 3.0 metres from the rear façade. Front and side yard OLAs were also used in the noise impact analysis.

Noise Impact Assessment Methodology and Assumptions

The noise impact of traffic on King Edward Avenue was modelled using the CADNA/A software program from DataKustik GmbH. The CADNA program utilizes the German RLS 90 protocol for propagating noise impact from traffic sources. The RLS 90 protocol was selected over the Ministry of Environment (MOE) STAMSON/ORNAMENT methods commonly used in Ontario to predict noise from traffic sources as the MOE method underestimates the impact from traffic at source-receiver distance closer than 15 metres.

The noise impact was determined based upon the one-hour peak afternoon volumes. The afternoon volumes were typically higher than the peak morning hourly volumes under all three scenarios. As only the daytime traffic volumes were used, the noise impact was assessed only at the outdoor living areas, which is consistent with MOE and City of Ottawa methodology for assessing daytime traffic impacts. The following table lists the hourly peak southbound and northbound volumes and the mean traffic speeds for the afternoon at five intersections along King Edward Avenue that were used in the noise modelling. These intersections on King Edward Avenue represent the mid-block locations of five road segments along the King Edward Avenue study route. These five road segments are:

- Cathcart Street to St. Andrew Street;
- St. Andrew Street to St. Patrick Street;
- St. Patrick Street to Murray Street;
- Murray Street to York Street; and
- York Street to Rideau Street.

It must be noted that the mean traffic speeds indicated are not the posted speed limits for the road segments along King Edward Avenue but rather the predicted average speed based on the VISSIM traffic simulation, which considered congestion along the study route.

King Edward Avenue Intersection	Direction	Scenario 1		Scenario 2		Scenario 3	
		Total Vehicles	Average (km/h)	Total Vehicles	Average (km/h)	Total Vehicles	Average (km/h)
Bruyère St.	SB	1521	43	1458	39	1354	38
	NB	2514	46	2497	43	2125	46
Guigues Ave	SB	1529	43	1456	38	1331	38
	NB	2517	44	2502	43	2110	43
Mid-St. Patrick & Murray Sts	SB	1541	39	1466	38	1328	35
	NB	1767	39	1764	38	1401	38
Clarence St.	SB	924	46	864	46	766	40
	NB	1205	32	1213	31	837	29
Mid-Rideau & York Sts.	SB	1015	44	949	44	813	33
	NB	1204	45	1229	44	794	27

SB – southbound; NB – northbound

The following assumptions were incorporated in the noise impact model:

- Traffic noise sources were assumed to originate from the centre line of the proposed roadway alignments;
- The noise impact was assessed at the OLA of the noise sensitive receptors (typically 3.0 metres from building façade);
- No adjustments were made to account for reflection from adjacent buildings
- Screening from adjacent laneways and roadway dividers was not incorporated in the model;

- The receptors were assumed to have direct line of sight to each of the finite roadway segments defined in the model. Shielding from adjacent buildings was not included in the model.
- Predicted vehicle speeds rather than posted speeds were incorporated into the model.

Predicted Noise Impacts

The following table shows the predicted one-hour A-weighted equivalent sound level (Leq) at the selected sensitive receptors along the study route under each of the three road laneway configuration scenarios.

Receptor ID	Receptor Description	Predicted One-hour Leq (dBA)		
		Scenario 1 Six-lane Configuration	Scenario 2 Six-lane Configuration	Scenario 3 Four-lane Configuration
R1	156 King Edward Avenue	68.4	67.9	67.5
R2	244 Bruyère	71.9	71.4	71.0
R3	174 King Edward Avenue	72.0	71.6	71.1
R4	175 King Edward Avenue	72.9	74.3	73.6
R5	233 King Edward Avenue (Shepherds of Good Hope Church)	68.4	68.2	67.2
R6	237 King Edward Avenue (City of Ottawa)	69.6	69.5	68.5
R7	277 King Edward Avenue	69.9	69.7	68.2
R8	231 Clarence St (Clarence & King Edward Avenue) (City of Ottawa Social Housing)	70.5	70.4	68.6
R9	375 King Edward Avenue (Seventh Day Adventist Church)	68.8	68.6	66.0
R10	195 St George (St. George & King Edward Avenue) (Ottawa Day Nursery)	70.0	69.9	66.7

The predicted one-hour Leqs at the selected sensitive receptors ranged from 68.4 to 72.9 dBA under Scenario 1 (Six-lane Configuration), from 67.9 to 74.3 dBA under Scenario 2 (Six-lane Hybrid Configuration), and from 66.0 to 73.6 dBA under Scenario 3 (Four-lane Configuration). Based on the predicted results the variation in vehicle speed for each of the scenarios is the primary differentiator for sound levels at each of the selected receptors. In general, the Four-lane Configuration results in slightly lower predicted sound levels. None of the sound levels differs by more than three dB in any of the scenarios. A differential of 3 dB would not be perceptible by most people located at the indentified receptors.

Noise Guidelines

Both the Ministry of Transportation Ontario (2006) and the Ministry of Environment (1997) provide guidance on the noise levels to be generated by road traffic. The City of Ottawa also provides noise guidelines on the noise impact of transportation corridors on noise sensitive receptors in its Environmental Noise Control Guidelines (2006).

The guidelines are as follows and are taken from reports we have prepared:

The Ministry of Transportation Ontario (MTO) provides guidance on the assessment and mitigation of highway generated noise on noise sensitive land use areas. This guidance document is entitled *Environmental Guide for Noise* (MTO, 2006). The noise impact is determined by comparing the future sound levels with and without the proposed road improvements for the Outdoor Living Areas (OLA) of noise sensitive areas. *Table 2-1* below summarises the mitigation efforts that are to be applied for the predicted change in noise levels above the ambient and the projected noise level with the proposed improvements.

Table 2-1. Outdoor Living Area Criterion for Road Traffic Noise – Mitigation Effort Required for Projected Noise Level with Proposed Improvements above the Ambient

Change in Noise Level Above Ambient/ Projected Noise Levels with Proposed Improvements	Mitigation Effort Required
< 5 dBA change and < 65 dBA	None
≥ 5 dBA change OR ≥ 65 dBA	▪ Investigate noise control measures on right-of-way; ▪ Introduce noise control measures within right-of-way and mitigate to ambient if technically feasible; and ▪ Noise control measures, where introduced, should achieve a minimum of 5 dBA attenuation, over first row of receivers.

Table 2.1 in MTO (2006).

The *Environmental Guide for Noise* (MTO, 2006) notes that mitigation measures must attempt to achieve noise levels as close to, or lower than, the future predicted ambient without the proposed improvements as is technically, economically, and administratively feasible. Mitigation measures within the right-of-way include:

- Acoustical barriers;
- Berms;
- Vertical and horizontal alignments; and
- Pavement surfaces.

The *Environmental Guide for Noise* (MTO, 2006) also provides guidance on minimizing the noise generated by highway construction. Construction operations must also abide by municipal noise control bylaws. Where activities contravene the bylaw, exemptions must be obtained prior to construction. The municipal noise control bylaws of the respective municipalities are discussed in their relevant sections below.

The Ontario Ministry of Environment (MOE) provides guidance under its existing legislation, i.e. the *Environmental Protection Act* (EPA) and the *Environmental Assessment Act* (EAA), on the noise criteria for planning of **proposed new** sensitive land uses adjacent but not limited to industrial, aggregate, commercial, sewage and waste management facilities, airports, and road and rail transportation corridors (MOE, 1997a, b, and c).

The Noise Assessment Criteria in Land Use Planning guidance document prepared by the MOE (MOE, 1997a) identifies noise sensitive land uses as:

- residential developments;
- seasonal residential developments;
- hospitals, nursing/retirement homes;
- schools, day-care centres, etc.

In order to determine whether proposed new noise sensitive land uses are impacted by a noise source such as a transportation corridor, the MOE requires that a feasibility or detailed noise impact study be carried out as outlined in the *Noise Assessment Criteria in Land Use Planning: Requirements, Procedures and Implementation* (MOE, 1997b). *Table 2-2* summarises the MOE (1997a) outdoor living area criterion for daytime and night-time.

Table 2-2. Outdoor Living Area Criterion for Road Traffic Noise

Time Period	Leq	Assessment
07:00 – 23:00	Leq (16), 55 dBA	Outdoor Living Area and Plane of Bedroom Window
23:00 – 07:00	Leq (8), 50 dBA	Plane of Bedroom Window

The guideline (MOE, 1997b) further outlines the outdoor living area daytime and night-time noise criteria for new residences and the recommended noise control measures. These control measures include outdoor minimum noise control, ventilation, and building code requirements for road, rail and aircraft noise (Tables 1, 2, 3 and 4 in MOE, 1997b). For outdoor living areas during daytime hours (07:00 – 23:00 h), when the Leq (16 h) is greater than 55 dBA warning clauses of *Type A* and *B* are required of new residential developments. These warning clauses indicate to purchasers or tenants that sound levels may on occasion interfere with activities of the dwelling occupants. These warning clauses are defined in the MOE (1997b) guideline. Noise mitigation measures (barriers) are also required if the sound levels are predicted to be greater than 60 dBA. This measure should reduce the Leq (16 h) to below 60 dBA and as close as possible to 55 dBA as is technically, economically and administratively feasible. At the plane of the bedroom window, if the Leq (16 h) exceeds 55 dBA control measures are not required however, developers are required to have the dwellings fitted to accommodate and/or installed central air systems with clauses noting this, and buildings built to the latest Ontario building code.

Appendix F: Greenhouse Gas Analysis

Greenhouse Gas Impact Assessment of Reducing Cross-Section to Four Lanes (Cathcart Street to Rideau Street) – Preliminary Assessment

Objectives

Under the four-lane scenario, it has been estimated that approximately 300 southbound vehicles destined toward the MacDonald-Cartier Bridge during the afternoon peak hour would be redirected from King Edward Avenue. For the peak afternoon period (2.5-hours), approximately 600 northbound vehicles would be redirected.

The objective of the preliminary greenhouse gas (GHG) assessment was to predict the GHG emissions from the redirected vehicles for the year 2010. The GHG emissions were estimated using the U.S. EPA vehicular emissions model MOBILE 6.2.

Modelling Assumptions

The worst-case peak vehicular volume was considered. This is the 300 vehicles per hour that was estimated for the peak PM hour.

The following vehicular make up of the traffic was assumed for this preliminary assessment where the “Class” classification is based on the convention used by the traffic model:

- Motorcycles: 1.3% (Class 1);
- Passenger cars: 72.7% (Class 2);
- Light duty trucks: 9.5% (Class 3); and
- Heavy duty trucks: 16.6% (Class 4 to 12).

There is a modelling limitation of MOBILE 6.2 for carbon dioxide (CO_2) emissions in that the vehicular speed does not affect CO_2 emissions. Therefore there is no distinction between the CO_2 emissions under idling or free-flow traveling.

MOBILE 6.2 does not predict methane (CH_4) emissions. In order to estimate CH_4 emissions, the difference in the estimated total hydrocarbon (THC) emissions and the non-methane hydrocarbon (NMHC) emissions was assumed to be representative of the CH_4 emissions.

MOBILE 6.2 does not predict nitrous oxide emissions.

The predicted average speed of traffic on King Edward Ave. at Bruyère St. was approximately 38 km/h. It was assumed that without further information on the typical travel speeds on alternate routes taken by the redirected vehicles, this traffic speed was considered to be a reasonable assumption. Note that this average speed may include idling.

MOBILE 6.2 cannot predict emissions during idling. The minimum speed from which emissions can be predicted is 4 km/h. In estimating the emissions due to idling, it was assumed that the vehicles were idling (i.e. travelling at 4 km/h) over an entire 1 km length of roadway. This is a conservative worst-case scenario.

GHG Emissions of Redirected Southbound Vehicles

The GHG emissions of the 300 vehicles during the PM peak hour is given in the tables below. The GHG emission factors presented in the tables below can be used to estimate carbon impact of the redirected vehicles based on their travel distance and stop-go conditions in the study area.

Pollutant	Idling Vehicles - Northbound				
	Emission Factor (g/km/vehicle)	# vehicles	Emission Factor (g/km)	Global Warming Potential	Emission Factor (kg CO2eq./km)
Carbon Dioxide (CO_2)	350.0	300	105003	1	**105.0**
Methane (CH_4)	0.154	300	46	21	**1.0**
Total					**106.0**

Pollutant	Free-Flow Vehicles (38 km/h) - Northbound				
	Emission Factor (g/km/vehicle)	# vehicles	Emission Factor (g/km)	Global Warming Potential	Emission Factor (kg CO2eq./km)
Carbon Dioxide (CO_2)	350.0	300	105003	1	**105.0**
Methane (CH_4)	0.035	300	11	21	**0.2**
Total					**105.2**

The King Edward Avenue corridor measures approximately 1.6 kilometres within the study area. As such, the total Greenhouse Gas emissions estimate for the 300 vehicles that, in Scenario 3, are re-directed to other locations would be 170 kilograms of carbon dioxide equivalent if a similar distance was travelled along an alternative route (e.g. at a different bridge crossing). To get a sense of scale, this is comparable to approximately 900 kilometres of commuting in a small car[31].

[31] Safe Climate calculator, based on U.S. EPA and Energy Information Administration information: http://www.safeclimate.net/calculator/ind_calc_form1.php

Appendix G: Synchro Analysis

MEMO

TO: Tom Fitzgerald, Leng Ha

FROM: Dillon Consulting

DATE: July 20, 2009

SUBJECT: King Edward Avenue – Synchro Modelling

FILE NO.: 08-9959

Traffic operations analysis was undertaken using Synchro software to supplement the planning level VISSIM modelling results for King Edward Avenue. This memo presents the analysis process, discussion of limitations of the Synchro model and results. Appendix A outlines base assumptions used in the modelling as reviewed by City of Ottawa staff.

MODELLING PROCESS

The Synchro model covered the primary study area from the intersection of King Edward Avenue and Rideau Street to the intersection of King Edward Avenue and Cathcart Street. While this area is slightly larger than that outlined in the assumptions memo, this area was selected to ensure that all changes to lane geometry between model scenarios would be represented.

Six separate Synchro models were created. One model each for AM and PM peak hours for each of three modelling scenarios. These scenarios were:

- Scenario 1 – 6 Lane Configuration
- Scenario 2 – 6 Lane Hybrid Configuration
- Scenario 3 – 4 Lane Configuration

Traffic volumes used in all modelling files were the same as those entered for the VISSIM model. While City staff has raised concerns that the volumes used are lower than past traffic counts have shown, the volumes used are based on the most recent counts available and were vetted by the Steering Committee earlier in the study.

Traffic signal timing values for the corridor were entered based on timing plans provided by City of Ottawa staff. The signal timing used in the analysis was optimized using the optimization feature of Synchro software to reflect new traffic volume inputs. Due to the timing restraint of the pedestrian crossing at the intersection of King Edward Avenue and St. Patrick Street there were limitations on the optimization at this signal controller. Likewise, the optimization process did not properly account for the "pedestrian advance phases" at the intersection of King Edward Avenue and Rideau Street. This was manually adjusted after the optimization of signal timing.

As stated in Appendix A, average delay times and queue lengths have been reported from Synchro's SimTraffic module. These results have been gathered after "seeding" the network for half an hour and subsequently recording traffic operations for one hour. Five random seeds were used and the resulting values for 95th percentile queue, average queue and delay time were used and averaged for reporting purposes. Values for intersection level of service (LOS) were based on volume to capacity ratios (V/C) as outlined in the *City of Ottawa Transportation Impact Assessment Guidelines*.

LIMITATIONS OF MODELLING SOFTWARE

King Edward Avenue is a complex corridor to model using traffic software. A number of issues were raised over the course of the Synchro analysis as discussed below.

King Edward Avenue & St. Andrew Street

The existing timing at the intersection of King Edward Avenue and St. Andrew Street contains a bicycle phase designed to allow cyclists to cross King Edward Avenue. This phase runs concurrent with the westbound turn movement phase and the east-west pedestrian phase. As bicycles are not modelled by Synchro this phase was omitted from the timing. Due to the concurrent nature of the phase this omission has no effect on the modelling results as agreed with City of Ottawa staff.

King Edward Avenue & St. Patrick Street / Murray Street

The westbound right turn movement at the intersection of King Edward Avenue and St. Patrick Street is currently timed with two contiguous protected phases. One phase is displayed during the southbound left turn movement at the intersection of King Edward Avenue and Murray Street while the other phase is displayed during the east-west through phases. However, this second contiguous phase is not displayed when there is a pedestrian call on the north side crossing of King Edward Avenue. This is known as a negative overlap and Synchro is not capable of modelling it under these conditions. To account for this the second right turn phase has been coded as a permissive turn rather than protected with an appropriate number of conflicting pedestrians. As a result, the analysis may understate the delay and queueing experienced by this turning movement for all three scenarios.

The intersection of King Edward Avenue and St. Patrick Street as well as the intersection of King Edward Avenue and Murray Street are operated using the same signal controller. These intersections combined have three east-west pedestrian crossings. The current signal control scheme calls for a different split time to be assigned to the east-west signal phases depending on which (if any) pedestrian calls are activated. Synchro is not able to model these conditional phase split times. To account for this, a weighted average of the applicable split times was taken (based on pedestrian crossing volumes) and an average cycle length was found. This means that each signal cycle at this intersection represents an average cycle rather than a model accounting for the variation within a dynamic signal timing plan.

King Edward Avenue & Rideau Street

At the intersection of King Edward Avenue and Rideau Street there is a bus lane in both the eastbound and westbound directions. While this lane is available for general traffic at some times, during the peak hours they are reserved for buses only. To account for this in the Synchro model the eastbound and westbound approaches of Rideau Street have been coded with only one through lane for use by general traffic (i.e. one lane in each direction has been omitted).

RESULTS

The results of the Synchro analysis are included in the attached tables, one for each Synchro file. Summarized at each of the five signalized intersections are volume to capacity (V/C), level of service (LOS), average delay, average queues and 95th percentile queues. As indicated previously these were obtained from Synchro's SimTraffic module or calculated based on the *City of Ottawa Transportation Impact Assessment Guidelines*. For example, in any case where the maximum V/C for an intersection was greater than 0.90 a volume weighted average V/C has been calculated (i.e. V/C = 0.95 and 0.86 with volumes 1860 and 993 respectively yields a weighted V/C of 0.92). Only those movements that were both critical and experienced a V/C of within 15% of the maximum V/C were considered in this weighting process.

The most prominent difference between scenarios is in the PM peak hour. In Scenarios 1 and 2 only the intersection of Rideau Street and King Edward Avenue experiences a level of service of "F". However, in Scenario 3, three of the five signalized intersections fail (LOS of F) with the remaining two at "E". Queues, particularly at the intersection of King Edward Avenue and Murray Street showed a marked increase in Scenario 3 (on the order of 30 metres on the eastbound approach) and delays are significantly higher (average delay totalled across all intersections is over a minute higher in Scenario 3 as compared to Scenario 1).

The intersection of King Edward Avenue and Rideau Street experiences particularly intense queueing in the PM peak hour with eastbound queues extending several hundred metres (>150 WB, >100 SB and >400 EB). Delays in the PM peak hour also increase significantly at this intersection. This intersection experiences significant capacity difficulties in the PM peak hour under all scenarios. It acts as a bottleneck restricting flow on King Edward Avenue.

In general these results support the findings of the VISSIM analysis. At a corridor level all scenarios perform more or less adequately during the AM peak hour. In the PM peak hour the lane configurations in Scenarios 1 and 2 are able to process all traffic along King Edward Avenue that makes it through the intersection of Rideau Street and King Edward Avenue. However, Scenario 3 (4 Lane Configuration) demonstrates an inability to process this traffic and travel in the study area is constricted even further.

Scenario 1 - 6 Lane Configuration - AM *(Optimized Timing Plan)*

Intersection #	Intersection Name	Max v/c	Weighted v/c (If Max > 0.90)	LOS	Average Delay	Queue (m) [Avg (95th)] EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
107	St. Andrew Street & Kind Edward Avenue	0.74		C	12.9	-	-	4.0 (12.4)	-	-	21.5 (30.7)	-	88.5 (106.7)
109	St. Patrick Street & King Edward Avenue	0.52		A	10.4	-	-	43.5 (63.6)	38.5 (59.8)	-	13.2 (21.3)	-	9.6 (20.2)
110	Murray Street & King Edward Avenue	0.80		C	15.2	21.1 (35.0)	39.7 (58.9)	-	-	-	39.2 (62.3)	57.3 (75.1)	9.0 (21.6)
112	York Street & King Edward Avenue	0.54		A	15.2	-	-	-	-	10.0 (21.2)	12.5 (27.5)	-	91.4 (63.9)
114	Rideau Street & King Edward Avenue	0.74		C	24.3	37.4 (67.1)	28.3 (54.9)	-	76.0 (125.5)	-	32.8 (51.0)	25.7 (53.9)	24.7 (46.7)

Scenario 2 - 6 Lane Hybrid Configuration - AM *(Optimized Timing Plan)*

Intersection #	Intersection Name	Max v/c	Weighted v/c (If Max > 0.90)	LOS	Average Delay	Queue (m) [Avg (95th)] EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
107	St. Andrew Street & Kind Edward Avenue	0.74		C	12.7	-	-	3.2 (10.4)	-	-	29.1 (43.4)	-	88.6 (101.8)
109	St. Patrick Street & King Edward Avenue	0.52		A	10.4	-	-	43.8 (64.9)	37.7 (60.0)	-	14.5 (22.8)	-	9.9 (19.1)
110	Murray Street & King Edward Avenue	0.80		C	15.6	21.4 (37.5)	39.7 (58.5)	-	-	-	42.3 (67.6)	54.3 (73.6)	10.5 (23.3)
112	York Street & King Edward Avenue	0.54		A	15.7	-	-	-	-	10.8 (22.8)	14.3 (29.4)	-	64.0 (89.5)
114	Rideau Street & King Edward Avenue	0.74		C	24.0	37.1 (67.7)	28.7 (55.4)	-	73.9 (121.5)	-	34.7 (53.9)	23.3 (49.8)	24.0 (42.3)

Scenario 3 - 4 Lane Configuration - AM *(Optimized Timing Plan)*

Intersection #	Intersection Name	Max v/c	Weighted v/c (If Max > 0.90)	LOS	Average Delay	Queue (m) [Avg (95th)] EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
107	St. Andrew Street & Kind Edward Avenue	0.91	0.91	E	9.1	-	-	3.5 (11.0)	-	-	19.1 (43.4)	-	86.7 (104.2)
109	St. Patrick Street & King Edward Avenue	0.57		A	11.2	-	-	39.0 (57.2)	39.0 (57.2)	-	15.5 (25.5)	-	34.4 (60.5)
110	Murray Street & King Edward Avenue	0.87		D	21.4	38.8 (58.0)	38.8 (58.0)	-	-	-	57.1 (83.7)	65.0 (81.2)	14.0 (27.9)
112	York Street & King Edward Avenue	0.68		B	8.8	-	-	-	-	11.7 (23.4)	19.5 (38.0)	-	29.8 (56.8)
114	Rideau Street & King Edward Avenue	0.69		B	23.4	34.5 (64.7)	30.8 (66.7)	-	69.4 (117.4)	-	32.2 (50.5)	29.5 (58.4)	25.4 (43.6)

NOTES:

Average Delay and Queue values based on SimTraffic Results.
SimTraffic network seeded for 30 minutes and recorded for 60 minutes, data gathered over five simulation runs.
Maximum v/c and Weighted v/c values based on HCM Signalized intersection results from Synchro 6.

Scenario 1 - 6 Lane Configuration - PM **(Optimized Timing Plan)**

Intersection #	Intersection Name	Max v/c	Weighted v/c (If Max > 0.90)	LOS	Average Delay	Queue (m) [Avg (95th)]							
						EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
107	St. Andrew Street & Kind Edward Avenue	0.85		D	7.7	-	-	4.7 (13.4)	-	-	53.9 (67.3)	-	70.4 (100.9)
109	St. Patrick Street & King Edward Avenue	0.95	0.92	E	18.2	-	-	31.2 (47.0)	97.2 (161.2)	-	31.7 (44.5)	-	17.0 (45.9)
110	Murray Street & King Edward Avenue	0.94	0.93	E	25.9	49.3 (70.3)	52.1 (72.2)	-	-	-	54.9 (74.9)	65.2 (82.5)	8.0 (19.2)
112	York Street & King Edward Avenue	0.57		A	12.6	-	-	-	-	15.7 (28.4)	18.4 (36.8)	-	45.3 (69.7)
114	Rideau Street & King Edward Avenue	1.12	1.10	F	484.7	87.6 (114.5)	240.7 (438.7)	-	153.8 (155.4)	-	72.5 (74.7)	76.7 (103.3)	48.8 (72.6)

Scenario 2 - 6 Lane Hybrid Configuration - PM **(Optimized Timing Plan)**

Intersection #	Intersection Name	Max v/c	Weighted v/c (If Max > 0.90)	LOS	Average Delay	Queue (m) [Avg (95th)]							
						EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
107	St. Andrew Street & Kind Edward Avenue	0.85		D	11.3	-	-	4.6 (13.1)	-	-	62.5 (72.0)	-	71.8 (101.7)
109	St. Patrick Street & King Edward Avenue	0.95	0.92	E	20.1	-	-	29.5 (45.6)	113.6 (150.0)	-	36.6 (53.4)	-	15.0 (41.3)
110	Murray Street & King Edward Avenue	0.94	0.93	E	26.5	51.7 (73.0)	51.1 (73.0)	-	-	-	69.8 (88.4)	62.9 (81.4)	8.9 (19.2)
112	York Street & King Edward Avenue	0.57		A	17.4	-	-	-	-	12.5 (24.9)	21.0 (32.6)	-	65.1 (89.8)
114	Rideau Street & King Edward Avenue	1.12	1.10	F	509.2	88.1 (113.1)	230.8 (435.5)	-	153.9 (156.0)	-	72.6 (74.7)	72.4 (102.7)	29.6 (53.2)

Scenario 3 - 4 Lane Configuration - PM **(Optimized Timing Plan)**

Intersection #	Intersection Name	Max v/c	Weighted v/c (If Max > 0.90)	LOS	Average Delay	Queue (m) [Avg (95th)]							
						EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
107	St. Andrew Street & Kind Edward Avenue	1.09	1.09	F	9.0	-	-	6.0 (15.8)	-	-	61.3 (70.7)	-	75.9 (104.0)
109	St. Patrick Street & King Edward Avenue	1.13	1.10	F	33.6	-	-	37.4 (57.9)	121.0 (133.4)	-	62.6 (84.5)	-	52.0 (115.8)
110	Murray Street & King Edward Avenue	1.03	1.00	E	40.9	77.3 (103.2)	77.3 (103.2)	-	-	-	80.9 (85.8)	71.4 (78.6)	5.4 (14.8)
112	York Street & King Edward Avenue	0.91	0.91	E	20.4	-	-	-	-	16.0 (47.7)	76.9 (120.0)	-	44.1 (92.8)
114	Rideau Street & King Edward Avenue	1.23	1.13	F	519.2	95.1 (99.6)	322.2 (396.2)	-	153.9 (155.7)	-	72.7 (75.2)	73.4 (103.8)	43.1 (69.1)

NOTES:
Average Delay and Queue values based on SimTraffic Results.
SimTraffic network seeded for 30 minutes and recorded for 60 minutes, data gathered over five simulation runs.
Maximum v/c and Weighted v/c values based on HCM Signalized intersection results from Synchro 6.

Appendix A – Synchro Modelling Assumptions for King Edward Avenue

In an effort to ensure that the Synchro modelling process is reflective of traffic conditions in the King Edward Avenue corridor Dillon prepared a list of base assumptions which were reviewed by City staff and used throughout the analysis.

The following assumptions were made:

1. **Saturation flow rate:**
   As per the City of Ottawa guidelines a saturation flow rate of 1800 vphpl was carried though all analysis.

2. **Lane width:**
   An assumed lane width of 3.5 meters was applied to all lanes.

3. **Peak Hour Factor:**
   An review of traffic counts for the corridor indicated a peak hour factor of approximately 0.94. This is an average value and was assumed to apply to all hourly volumes used.

4. **Analysis Period:**
   A 15 minute analysis period within each peak hour was used. This allows the peaking in traffic within the hour to be accounted for.

5. **Heavy Vehicle %:**
   An average rate of 2% heavy vehicles was applied to all volumes with exceptions as noted below. The heavy vehicle percentages along the following corridors will be increased to reflect truck routes.
   a. EBL at Rideau Street and NBT along King Edward Avenue
   b. SBT along King Edward Avenue and SBR at Rideau Street
   Transit vehicles travelling southbound along King Edward Avenue have also been included as heavy vehicles. However, in Scenario 2, transit vehicles were not included in the heavy vehicle percentage over the length of the exclusive transit lane. The values in the following table indicate the heavy vehicle percentages used (excluding transit vehicles).

Area Range	**AM Truck %**		**PM Truck %**	
	SB	**NB**	**SB**	**NB**
EBL and SBR Turns at Rideau	46%	55%	26%	29%
Through movements Rideau to Murray/St. Patrick	13% - 15%	16% - 21%	8% - 9%	6% - 7%
Through movements Murray to MacDonald Cartier Bridge	8%	8% - 11%	6%	4% - 5%

   Buses will be added to the PM SB heavy vehicle percentages as necessary for the three scenarios.

6. **Signal Timing:**
   Signal timing (Total Split, Amber+Red, Walk, Flashing Don't Walk, Offsets, and Cycle Lengths) used were from the timing plans provided to Dillon by the

City of Ottawa in June of 2009. These plans have cycle lengths that are typically 100 or 120 seconds. The Synchro optimize feature for intersection cycle lengths, splits and offsets was used to adjust timings for scenario specific conditions.

7. **Pedestrian Signals:**
   Pedestrian flashing don't walk (FDW) times at intersections were reduced in Scenario 3 to accommodate the shorter crossing distance. This reduction was based on 1.0m/s walking speed and 3.5m lane widths. A minimum FDW time of 5 seconds was maintained.

8. **Minimum Green Time:**
   Main street minimums of 20 seconds, side street minimums of 10 seconds and left turn minimums of 5 seconds were applied as per City of Ottawa guidelines.

9. **Area Type:**
   The area type was assumed as "Other" and not as "CBD" which indicates normal traffic conditions.

10. **Travel Speed:**
    An operating speed of 40 km/h was assumed for the entire corridor.

11. **Other Synchro Factors:**
    The default values for all other Synchro factors (including lane utilization) was used.

12. **Traffic Volumes:**
    For Scenario 1 and Scenario 2 the 2010 volumes entered into the VISSIM model as traffic demand (the "Demand Volumes") will be used. The VISSIM analysis indicated that the volume that Scenario 3 is able to serve (the "Served Volume") is lower than the "Demand Volumes". Despite this, through discussions with City staff it was determined that for Scenario 3 the "Demand Volumes" should be entered as for Scenarios 1 and 2.

13. **Pedestrian Volumes:**
    Pedestrian calls per hour were entered using the same volumes used in the VISSIM model which were obtained from recent (2008) City of Ottawa counts.

14. **Study Area:**
    The analysis focused on the primary study area intersections. Namely, those along King Edward Avenue between Rideau Street and St. Andrew Street inclusively.

15. **Lane arrangements:**
    Lane arrangements are based on Figures 7-9 and 7-11 (see attached figures) from the 2002 Environmental Assessment prepared by Delcan. Storage lengths for auxiliary lanes have been scaled off these figures. Changes to these arrangements have been highlighted in the text of the report (see attached excerpt).

16. **Transit Modelling:**
    As Synchro does not have transit modelling capabilities the exclusive transit

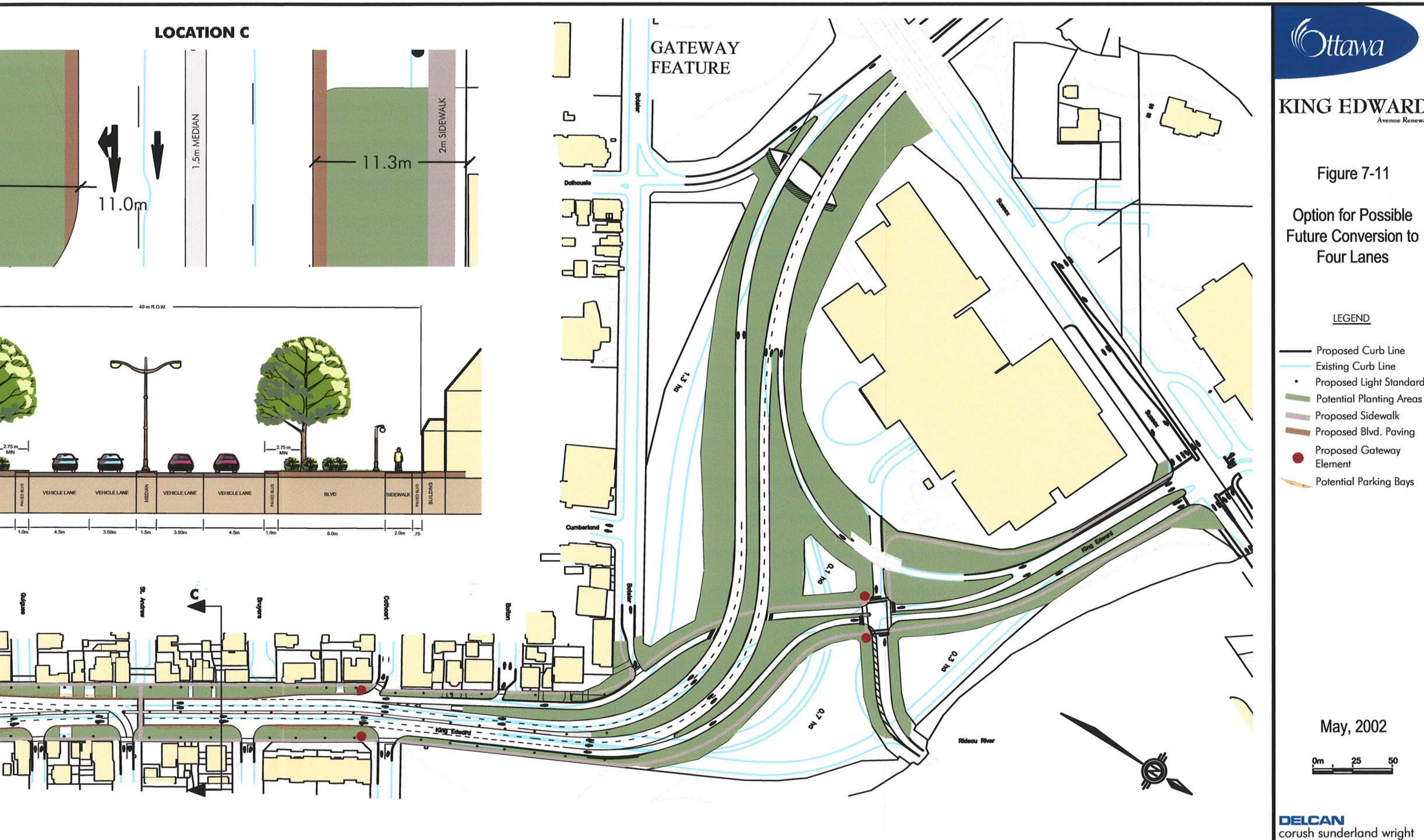
lane included in Scenario 2 was modelled by eliminating one through lane and subtracting the bus volumes from the through volumes. Shared through transit / right lanes were modelled by using an exclusive right turn with an appropriate number of "Bus Blockages" per hour.

Note: There are 120 buses scheduled to travel through the corridor in the PM peak hour. It is assumed that on average half of them would create a blockage in the shared through transit / right lane. As such 60 "Bus Blockages" per hour was used. A review of this method showed that the "Bus Blockages" did not significantly impact right turn levels of services.

17. Data collection:

Delay times and queue lengths were reported from SimTraffic results. These results were gathered after seeding the network for half an hour and subsequently recording for one hour. Five random seeds were used and the resulting values for 95th percentile queue, average queue and delay time were averaged for reporting purposes.

Figure 7-11



LOCATION C
11.0m
1.5m MEDIAN
11.3m
2m SIDEWALK
40 m R.O.W.
VEHICLE LANE
MEDIAN
PAVED BLVD
BLVD
SIDEWALK
BUILDING
GATEWAY
FEATURE
Dalhousie
Cumberland
Sussex
King Edward
Rideau River
Ottawa
KING EDWARD
Avenue Renewal
Figure 7-11
Option for Possible Future Conversion to Four Lanes
LEGEND
Proposed Curb Line
Existing Curb Line
Proposed Light Standard
Potential Planting Areas
Proposed Sidewalk
Proposed Blvd. Paving
Proposed Gateway Element
Potential Parking Bays
May, 2002
0m
25
50
DELCAN
corush sunderland wright

Figure 7-11

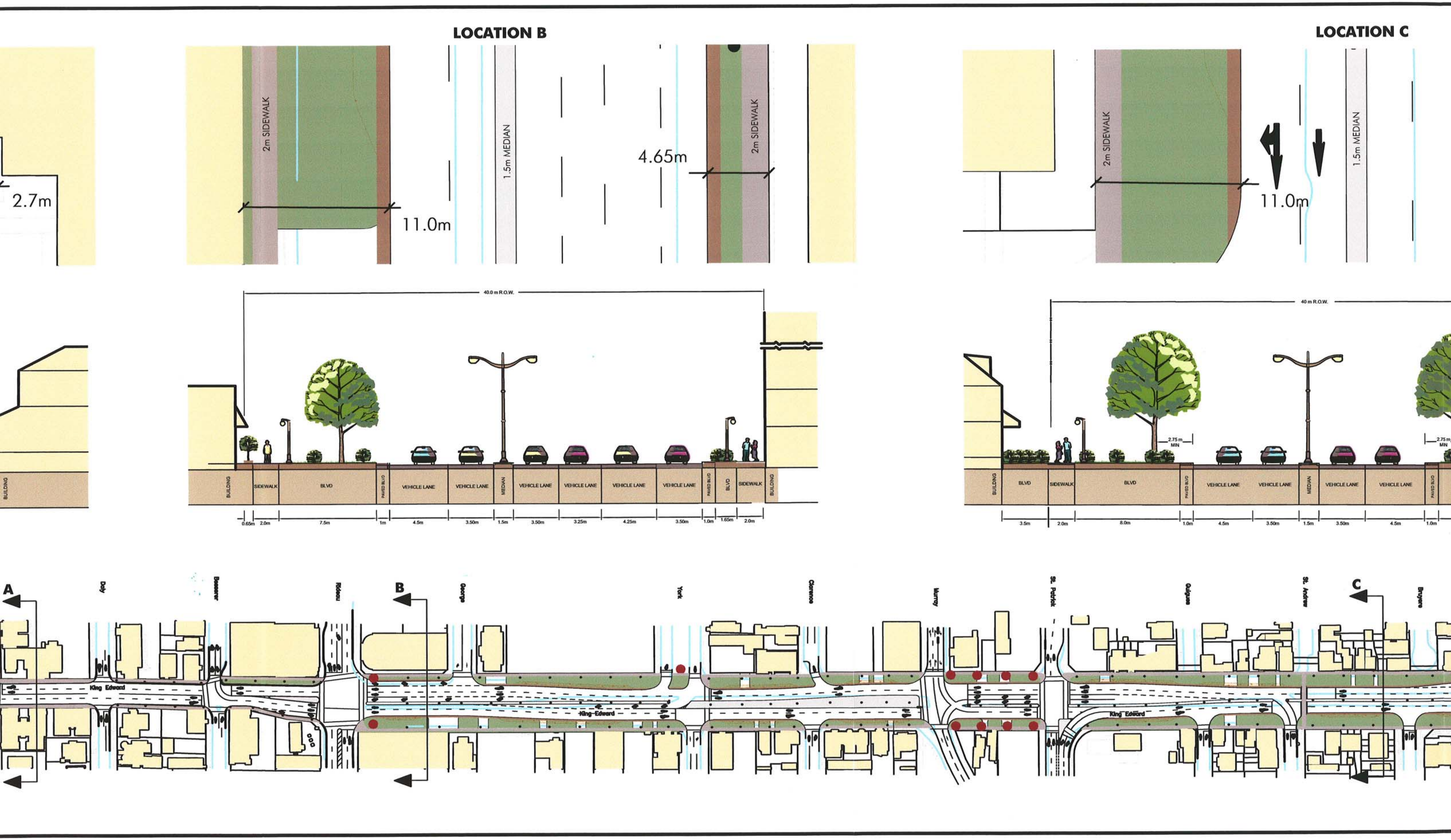
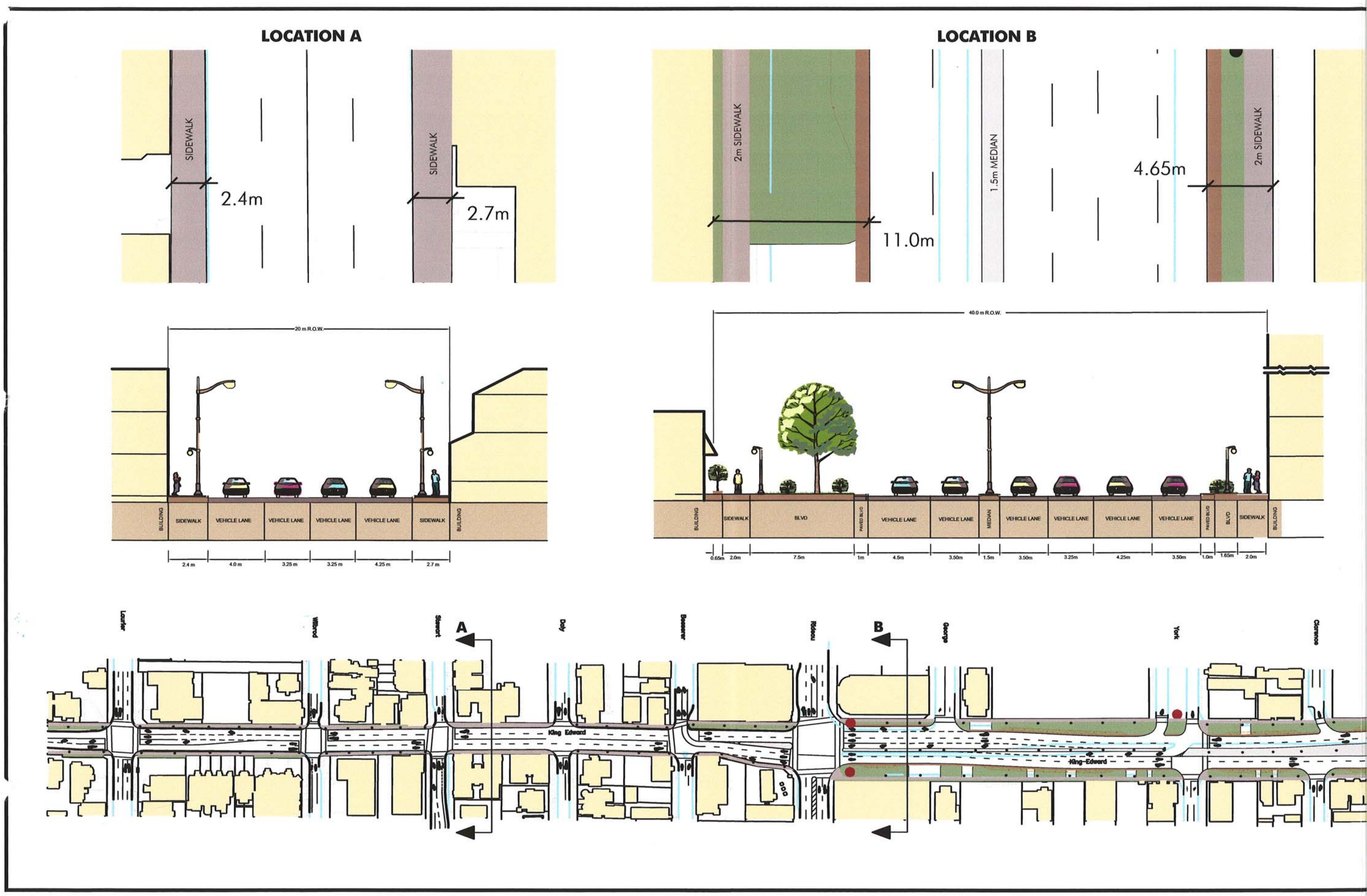

LOCATION B
LOCATION C
2.7m
2m SIDEWALK
11.0m
1.5m MEDIAN
4.65m
2m SIDEWALK
2m SIDEWALK
11.0m
1.5m MEDIAN
40.0 m R.O.W.
40 m R.O.W.
BUILDING
SIDEWALK
BLVD
PAVED BLVD
VEHICLE LANE
MEDIAN
A
B
C
Daly
Besserer
Rideau
George
York
Clarence
Murray
St. Patrick
Guigues
St. Andrew
Bruyere
King Edward

Figure 7-11



LOCATION A
SIDEWALK
2.4m
SIDEWALK
2.7m
20 m R.O.W.
BUILDING
SIDEWALK
VEHICLE LANE
VEHICLE LANE
VEHICLE LANE
VEHICLE LANE
SIDEWALK
BUILDING
LOCATION B
2m SIDEWALK
11.0m
1.5m MEDIAN
4.65m
2m SIDEWALK
40.0 m R.O.W.
Laurier
Wilbrod
Stewart
A
Daly
Besserer
Rideau
B
George
York
Clarence
King Edward
King Edward

Figure 7-9

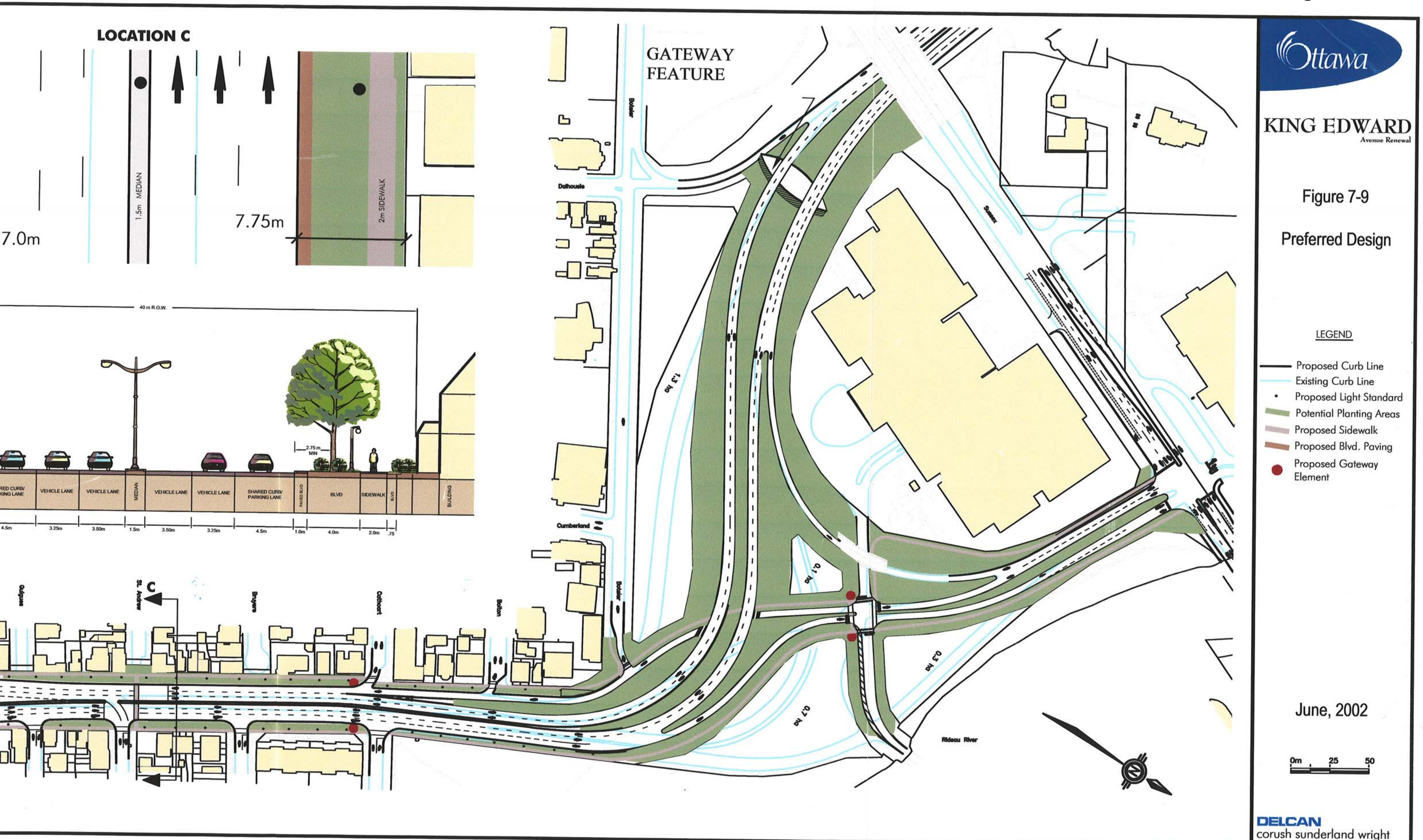

LOCATION C
7.0m
7.75m
1.5m MEDIAN
2m SIDEWALK
40 m R.O.W.
GATEWAY
FEATURE
Dalhousie
Cumberland
Sussex
Guigues
St. Andrew
Bruyere
Cathcart
Bolton
1.3 ha
0.1 ha
0.3 ha
0.7 ha
Rideau River
Ottawa
KING EDWARD
Avenue Renewal
Figure 7-9
Preferred Design
LEGEND
Proposed Curb Line
Existing Curb Line
Proposed Light Standard
Potential Planting Areas
Proposed Sidewalk
Proposed Blvd. Paving
Proposed Gateway Element
June, 2002
0m 25 50
DELCAN
corush sunderland wright

Figure 7-9

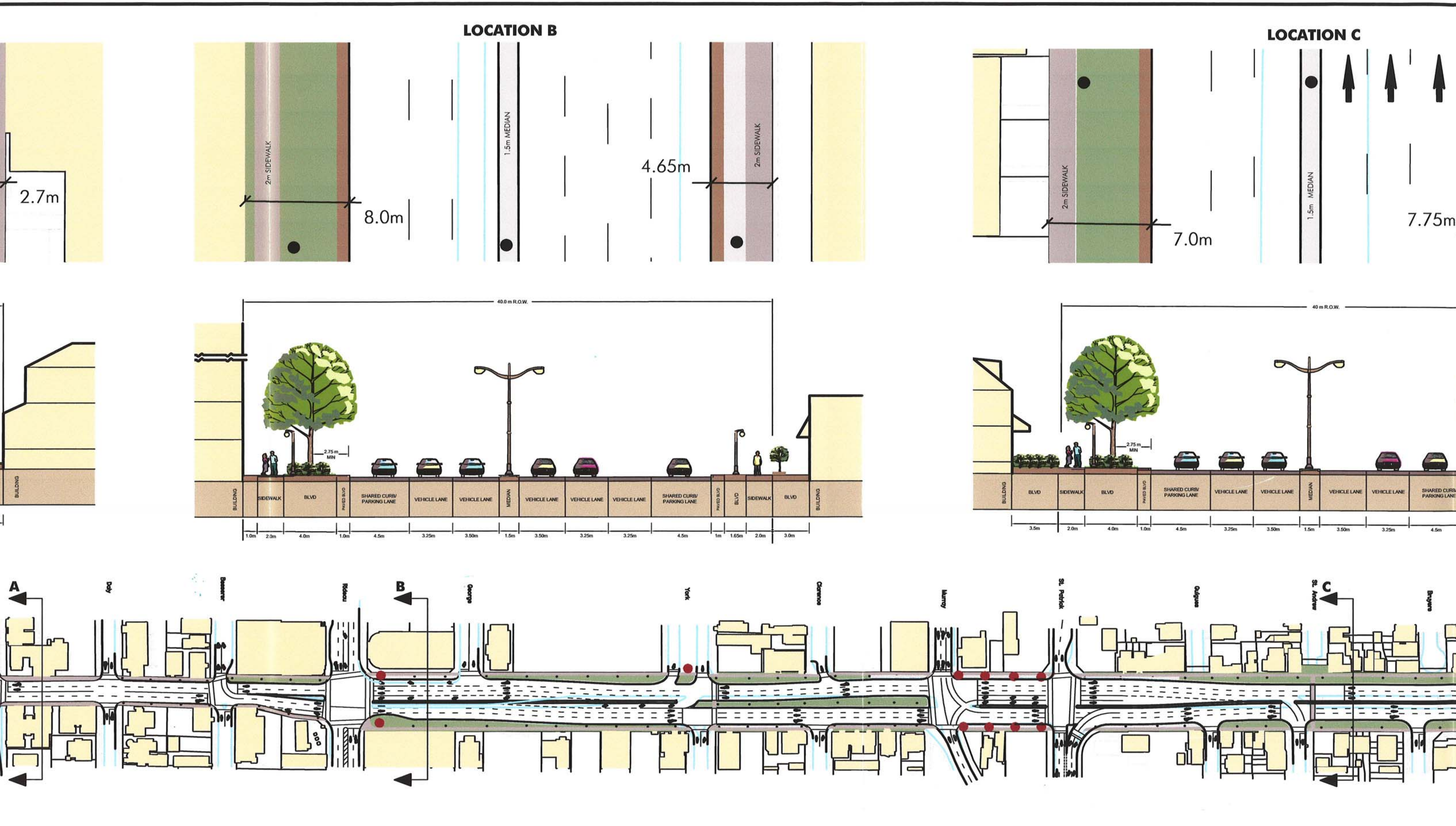
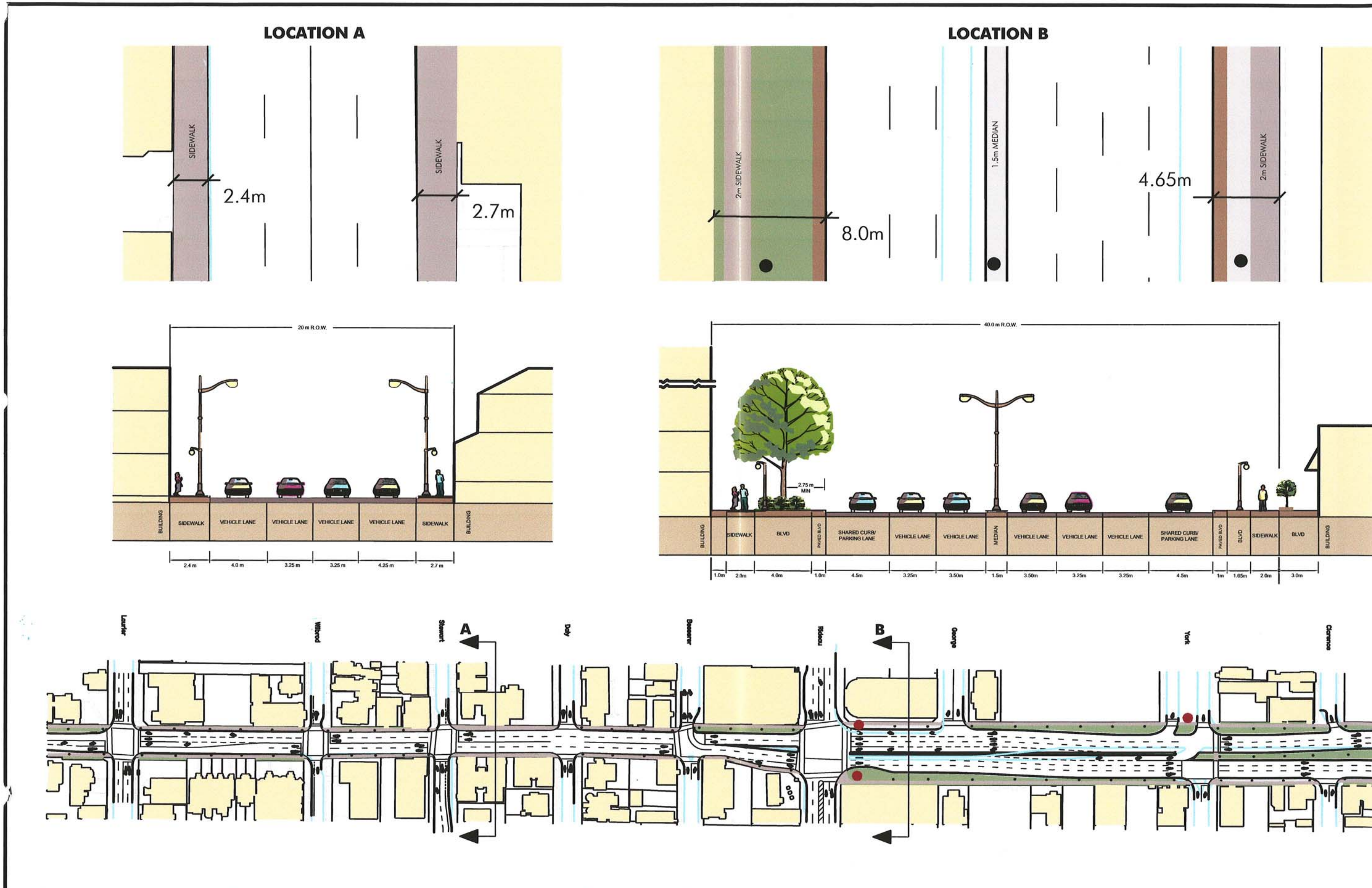

LOCATION B
LOCATION C
2.7m
8.0m
4.65m
7.0m
7.75m
2m SIDEWALK
1.5m MEDIAN
1.5m MEDIAN
40.0 m R.O.W.
40 m R.O.W.
BUILDING
SIDEWALK
BLVD
PAVED BLVD
SHARED CURB/ PARKING LANE
VEHICLE LANE
MEDIAN
A
B
C
Daly
Besserer
Rideau
George
York
Clarence
Murray
St. Patrick
Guigues
St. Andrew
Bruyere

Figure 7-9



LOCATION A
SIDEWALK
2.4m
SIDEWALK
2.7m
20 m R.O.W.
BUILDING
SIDEWALK
VEHICLE LANE
VEHICLE LANE
VEHICLE LANE
VEHICLE LANE
SIDEWALK
BUILDING
2.4 m
4.0 m
3.25 m
3.25 m
4.25 m
2.7 m
LOCATION B
2m SIDEWALK
8.0m
1.5m MEDIAN
4.65m
2m SIDEWALK
40.0 m R.O.W.
2.75 m MIN
BUILDING
SIDEWALK
BLVD
PAVED BLVD
SHARED CURB/ PARKING LANE
VEHICLE LANE
VEHICLE LANE
MEDIAN
VEHICLE LANE
VEHICLE LANE
VEHICLE LANE
SHARED CURB/ PARKING LANE
PAVED BLVD
BLVD
SIDEWALK
BLVD
BUILDING
1.0m
2.0m
4.0m
1.0m
4.5m
3.25m
3.50m
1.5m
3.50m
3.25m
3.25m
4.5m
1m
1.65m
2.0m
3.0m
Laurier
Wilbrod
Stewart
A
Daly
Besserer
Rideau
B
George
York
Clarence

King Edward Avenue Study
Scenario Listing

A number of alternative roadway configurations were considered for comparative purposes in this study. The two primary configurations consisted of a six-lane cross-section as per the current construction contract for King Edward Avenue, and a four-lane cross-section, as suggested by the community.

For evaluation purposes, the six-lane configuration was considered to be the "status quo" or baseline condition since it was selected through the Environmental Assessment (EA) process and is currently being constructed. The four-lane configuration is essentially the same four lane cross-section that was proposed in the EA study. A third option was developed as a variation on the six-lane design that included designation of a bus lane in the southbound direction and designation of a "right-turn only" lane into the neighbourhood north of St. Patrick Street.

Scenario 1: Six-lane Configuration
The six-lane configuration is currently being constructed and includes three "through lanes" in the southbound direction, double left turn lanes are in place at St. Patrick Avenue and Murray Street and shared through-right lanes are in place at all intersections except Rideau Street where the third through lane becomes an exclusive right-turn lane. In the northbound direction, a third through lane is developed immediately north of Rideau Street and is carried through the entire corridor up to Boteler Street where the third lane becomes a ramp to Sussex Drive.

Scenario 2: Six-lane Hybrid Configuration
The five-lane configuration includes three "through lanes" in the southbound direction with the curb lane (between Bruyere Street and York Street) being designated for "transit vehicles only" during the afternoon peak period and parking during all off-peak periods. As with Scenario 1, this configuration also includes double left turn lanes at St. Patrick Avenue and Murray Street and shared through-right lanes at all intersections except Rideau Street where the third through lane becomes an exclusive right-turn lane. In the northbound direction, a third through lane is developed immediately north of Rideau Street and is carried through to St. Andrew Street at which point the curb lane is designated as a "right-turn only" lane to facilitate access into the neighbourhood and to prevent motorists from using the curb lane as a queue jump lane to gain faster access to the bridge. A bulb out, pavement markings or other measures located north of Cathcart Street would further encourage motorists destined for the bridge to remain in the two through lanes after which point motorists could access the Sussex Drive ramp.

Scenario 3: Four-lane Configuration
The four-lane configuration is essentially the same cross-section as was proposed in the previous EA study; two "through lanes" are maintained in both southbound and northbound directions from Rideau Street to the MacDonald-Cartier bridge ramp with auxiliary turn lanes at key locations (southbound double left turn lanes at St. Patrick Street, an exclusive southbound right turn lane at St. Patrick Street, a southbound right turn lane at Rideau Street, and a northbound lane to access the Sussex Drive ramp developing north of Cathcart Street, all other right turns are shared with a through lane).

Appendix B – Synchro Modelling Output

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0		4.0			4.0
Lane Util. Factor	1.00		0.91			0.91
Frpb, ped/bikes	0.99		1.00			1.00
Flpb, ped/bikes	1.00		1.00			1.00
Frt	0.98		1.00			1.00
Flt Protected	0.96		1.00			1.00
Satd. Flow (prot)	1627		4366			4499
Flt Permitted	0.96		1.00			1.00
Satd. Flow (perm)	1627		4366			4499
Volume (vph)	13	3	815	18	0	1942
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	14	3	867	19	0	2066
RTOR Reduction (vph)	2	0	2	0	0	0
Lane Group Flow (vph)	15	0	884	0	0	2066
Confl. Peds. (#/hr)		20		19		
Heavy Vehicles (%)	2%	2%	11%	2%	2%	8%
Turn Type						
Protected Phases			2			6
Permitted Phases	8					
Actuated Green, G (s)	30.0		63.4			63.4
Effective Green, g (s)	31.9		65.1			65.1
Actuated g/C Ratio	0.30		0.62			0.62
Clearance Time (s)	5.9		5.7			5.7
Lane Grp Cap (vph)	494		2707			2789
v/s Ratio Prot			0.20			c0.46
v/s Ratio Perm	c0.01					
v/c Ratio	0.03		0.33			0.74
Uniform Delay, d1	25.7		9.5			14.0
Progression Factor	1.00		0.39			1.00
Incremental Delay, d2	0.1		0.3			1.8
Delay (s)	25.8		4.0			15.8
Level of Service	C		A			B
Approach Delay (s)	25.8		4.0			15.8
Approach LOS	C		A			B

Intersection Summary			
HCM Average Control Delay	12.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	59.6%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)					4.0	4.0		4.0			4.0	
Lane Util. Factor					0.95	0.88		0.91			0.81	
Frpb, ped/bikes					1.00	0.98		1.00			1.00	
Flpb, ped/bikes					1.00	1.00		1.00			1.00	
Frt					1.00	0.85		1.00			0.99	
Flt Protected					0.99	1.00		1.00			1.00	
Satd. Flow (prot)					3284	2565		4189			6640	
Flt Permitted					0.99	1.00		1.00			1.00	
Satd. Flow (perm)					3284	2565		4189			6640	
Volume (vph)	0	0	0	72	414	555	0	542	0	0	1861	94
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	77	440	590	0	577	0	0	1980	100
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	8	0
Lane Group Flow (vph)	0	0	0	0	517	590	0	577	0	0	2072	0
Confl. Peds. (#/hr)				14		12						1
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	16%	2%	2%	8%	2%
Turn Type				Perm		custom						
Protected Phases					4	1		2			6	
Permitted Phases				4		4						
Actuated Green, G (s)					30.8	41.6		45.2			58.3	
Effective Green, g (s)					33.4	45.9		47.1			63.6	
Actuated g/C Ratio					0.32	0.44		0.45			0.61	
Clearance Time (s)					6.6	5.7		5.9			9.3	
Lane Grp Cap (vph)					1045	1219		1879			4022	
v/s Ratio Prot						c0.06		0.14			c0.31	
v/s Ratio Perm					0.16	0.17						
v/c Ratio					0.49	0.48		0.31			0.52	
Uniform Delay, d1					29.0	21.1		18.5			11.9	
Progression Factor					0.98	0.97		0.33			0.19	
Incremental Delay, d2					1.7	1.4		0.4			0.3	
Delay (s)					30.1	21.9		6.5			2.6	
Level of Service					C	C		A			A	
Approach Delay (s)		0.0			25.7			6.5			2.6	
Approach LOS		A			C			A			A	

Intersection Summary			
HCM Average Control Delay	10.0	HCM Level of Service	A
HCM Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	4.0
Intersection Capacity Utilization	75.0%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0	4.0						4.0		4.0	4.0	
Lane Util. Factor	0.91	0.91						0.91		0.97	0.91	
Frpb, ped/bikes	1.00	0.99						1.00		1.00	1.00	
Flpb, ped/bikes	1.00	1.00						1.00		1.00	1.00	
Frt	1.00	0.97						0.99		1.00	1.00	
Flt Protected	0.95	1.00						1.00		0.95	1.00	
Satd. Flow (prot)	1509	3054						4000		3216	4226	
Flt Permitted	0.95	1.00						1.00		0.95	1.00	
Satd. Flow (perm)	1509	3054						4000		3216	4226	
Volume (vph)	134	398	101	0	0	0	0	408	36	948	985	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	143	423	107	0	0	0	0	434	38	1009	1048	0
RTOR Reduction (vph)	0	20	0	0	0	0	0	10	0	0	0	0
Lane Group Flow (vph)	143	510	0	0	0	0	0	462	0	1009	1048	0
Confl. Peds. (#/hr)			29						19	19		
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	21%	2%	2%	15%	2%
Turn Type	Split									Prot		
Protected Phases	4	4						10		9	14	
Permitted Phases												
Actuated Green, G (s)	30.8	30.8						13.3		38.7	61.3	
Effective Green, g (s)	33.4	33.4						18.6		41.0	63.6	
Actuated g/C Ratio	0.32	0.32						0.18		0.39	0.61	
Clearance Time (s)	6.6	6.6						9.3		6.3	6.3	
Lane Grp Cap (vph)	480	971						709		1256	2560	
v/s Ratio Prot	0.09	c0.17						c0.12		c0.31	0.25	
v/s Ratio Perm												
v/c Ratio	0.30	0.53						0.65		0.80	0.41	
Uniform Delay, d1	27.0	29.3						40.2		28.4	10.9	
Progression Factor	1.00	1.00						0.57		0.50	0.10	
Incremental Delay, d2	1.6	2.0						4.5		4.8	0.4	
Delay (s)	28.6	31.3						27.6		18.9	1.5	
Level of Service	C	C						C		B	A	
Approach Delay (s)		30.8			0.0			27.6			10.0	
Approach LOS		C			A			C			B	

Intersection Summary			
HCM Average Control Delay	17.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	75.0%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)			4.0			4.0	4.0	4.0			4.0	
Lane Util. Factor			1.00			1.00	1.00	0.91			0.91	
Frpb, ped/bikes			0.99			0.97	1.00	1.00			0.99	
Flpb, ped/bikes			1.00			1.00	1.00	1.00			1.00	
Frt			0.86			0.86	1.00	0.99			0.99	
Flt Protected			1.00			1.00	0.95	1.00			1.00	
Satd. Flow (prot)			1489			1459	1656	4037			4231	
Flt Permitted			1.00			1.00	0.20	1.00			1.00	
Satd. Flow (perm)			1489			1459	344	4037			4231	
Volume (vph)	0	0	43	0	0	14	111	432	28	0	943	50
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	46	0	0	15	118	460	30	0	1003	53
RTOR Reduction (vph)	0	0	0	0	0	0	0	7	0	0	5	0
Lane Group Flow (vph)	0	0	46	0	0	15	118	483	0	0	1051	0
Confl. Peds. (#/hr)			5			74	76		30	30		76
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	20%	2%	2%	14%	2%
Turn Type			custom			custom	pm+pt					
Protected Phases							7	2			6	
Permitted Phases			6 7			2 7	2					
Actuated Green, G (s)			105.0			105.0	93.6	46.6			46.6	
Effective Green, g (s)			105.0			105.0	97.0	48.4			48.4	
Actuated g/C Ratio			1.00			1.00	0.92	0.46			0.46	
Clearance Time (s)							5.6	5.8			5.8	
Lane Grp Cap (vph)			1489			1459	925	1861			1950	
v/s Ratio Prot							c0.06	0.12			c0.25	
v/s Ratio Perm			0.03			0.01	0.06					
v/c Ratio			0.03			0.01	0.13	0.26			0.54	
Uniform Delay, d1			0.0			0.0	1.2	17.3			20.3	
Progression Factor			1.00			1.00	15.43	0.39			0.93	
Incremental Delay, d2			0.0			0.0	0.3	0.3			1.0	
Delay (s)			0.0			0.0	18.5	7.1			19.8	
Level of Service			A			A	B	A			B	
Approach Delay (s)		0.0			0.0			9.3			19.8	
Approach LOS		A			A			A			B	

Intersection Summary			
HCM Average Control Delay	15.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.33		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	44.0%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00		1.00	1.00		0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.91		1.00	0.83		1.00	0.88	1.00	1.00	0.90
Flpb, ped/bikes	0.96	1.00	1.00		1.00	1.00		1.00	1.00	0.95	1.00	1.00
Frt	1.00	1.00	0.85		1.00	0.85		1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00		1.00	1.00		1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1053	1745	1355		1745	1231		3316	1309	1578	3316	931
Flt Permitted	0.32	1.00	1.00		1.00	1.00		1.00	1.00	0.51	1.00	1.00
Satd. Flow (perm)	356	1745	1355		1745	1231		3316	1309	846	3316	931
Volume (vph)	144	267	28	0	392	66	0	346	42	210	666	248
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	153	284	30	0	417	70	0	368	45	223	709	264
RTOR Reduction (vph)	0	0	15	0	0	25	0	0	30	0	0	178
Lane Group Flow (vph)	153	284	15	0	417	45	0	368	15	223	709	86
Confl. Peds. (#/hr)	270		128	128		270			65	65		54
Heavy Vehicles (%)	55%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	46%
Turn Type	custom		custom			custom			custom	custom		custom
Protected Phases	11	10			14			12		13	16	
Permitted Phases	1		1			3			5	7		7
Actuated Green, G (s)	51.5	56.5	51.5		32.5	51.5		20.0	32.9	32.9	36.6	32.9
Effective Green, g (s)	52.8	57.8	52.8		33.8	52.8		22.6	34.2	34.2	39.2	34.2
Actuated g/C Ratio	0.50	0.55	0.50		0.32	0.50		0.22	0.33	0.33	0.37	0.33
Clearance Time (s)	5.3	5.3	5.3		5.3	5.3		6.6	5.3	6.6	6.6	5.3
Lane Grp Cap (vph)	312	961	681		562	619		714	426	363	1238	303
v/s Ratio Prot	c0.09	0.16			c0.24			0.11		0.07	c0.21	
v/s Ratio Perm	0.15		0.01			0.04			0.01	0.13		0.09
v/c Ratio	0.49	0.30	0.02		0.74	0.07		0.52	0.03	0.61	0.57	0.28
Uniform Delay, d1	26.3	12.7	13.1		31.7	13.5		36.4	24.1	31.7	26.2	26.3
Progression Factor	1.00	1.00	1.00		1.00	1.00		1.00	1.00	0.27	0.26	0.47
Incremental Delay, d2	5.4	0.8	0.1		8.6	0.2		2.6	0.2	6.9	1.8	2.1
Delay (s)	31.8	13.5	13.2		40.3	13.7		39.0	24.3	15.4	8.5	14.5
Level of Service	C	B	B		D	B		D	C	B	A	B
Approach Delay (s)		19.4			36.5			37.4			11.1	
Approach LOS		B			D			D			B	

Intersection Summary			
HCM Average Control Delay	21.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	76.5%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

105: Cathcart Street & King Edward Avenue Performance by movement

Movement	WBR2	NBT	SBT	SER	All
Delay / Veh (s)	6.3	0.5	66.1	5262.4	83.1

106: Bruyere Street & King Edward Avenue Performance by movement

Movement	NBT	SBT	All
Delay / Veh (s)	0.8	15.4	11.0

107: St. Andrew Street & King Edward Avenue Performance by movement

Movement	WBL	WBR	NBT	NBR	SBT	All
Delay / Veh (s)	36.6	5.9	3.5	2.0	16.9	12.9

108: Guigues Ave & King Edward Avenue Performance by movement

Movement	NBT	NBR	SBT	All
Delay / Veh (s)	1.2	1.8	1.7	1.6

109: St. Patrick Street & King Edward Avenue Performance by movement

Movement	WBL	WBT	WBR	NBT	SBT	SBR	All
Delay / Veh (s)	36.7	30.4	20.2	6.4	3.4	2.4	10.4

110: Murray Street & King Edward Avenue Performance by movement

Movement	EBL	EBT	EBR	NBT	NBR	SBL	SBT	All
Delay / Veh (s)	27.3	29.2	20.3	26.6	4.3	14.6	3.4	15.2

111: Clarence Street & King Edward Avenue Performance by movement

Movement	NBT	NBR	SBT	SBR	All
Delay / Veh (s)	0.8	0.4	1.5	1.4	1.3

112: York Street & King Edward Avenue Performance by movement

Movement	EBR	WBR	NBL	NBT	NBR	SBT	SBR	All
Delay / Veh (s)	2.3	0.8	7.0	12.1	3.9	18.9	12.3	15.2

113: George Street & King Edward Avenue Performance by movement

Movement	EBR	WBR	NBT	SBT	All
Delay / Veh (s)	8.9	2.8	1.5	3.0	2.9

114: Rideau Street & King Edward Avenue Performance by movement

Movement	EBL	EBT	EBR	WBT	WBR	NBT	NBR	SBL	SBT	SBR	All
Delay / Veh (s)	36.6	16.1	10.8	38.1	20.1	39.6	12.0	25.9	15.5	9.6	24.3

700: St. Patrick Street & Murray Street Performance by movement

Movement	NBL	NBT	SBR	All
Delay / Veh (s)	2.9	1.9	1.2	1.6

Total Network Performance

Delay / Veh (s)			94.0

Intersection: 105: Cathcart Street & King Edward Avenue

Movement	WB	SB	SB	SE
Directions Served	>	T	T	R
Maximum Queue (m)	18.2	51.5	51.0	42.8
Average Queue (m)	8.0	43.0	35.6	37.4
95th Queue (m)	15.3	61.1	63.9	47.0
Link Distance (m)	96.8	41.1	41.1	38.7
Upstream Blk Time (%)		24	4	95
Queuing Penalty (veh)		0	0	0
Storage Bay Dist (m)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 106: Bruyere Street & King Edward Avenue

Movement	SB	SB	SB
Directions Served	T	T	T
Maximum Queue (m)	118.8	114.8	120.8
Average Queue (m)	111.8	69.0	27.9
95th Queue (m)	125.2	113.3	96.6
Link Distance (m)	68.9	68.9	68.9
Upstream Blk Time (%)	37	4	0
Queuing Penalty (veh)	240	26	1
Storage Bay Dist (m)			
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 107: St. Andrew Street & King Edward Avenue

Movement	WB	NB	NB	NB	SB	SB	SB
Directions Served	LR	T	T	TR	T	T	T
Maximum Queue (m)	17.4	29.7	33.0	33.7	89.9	89.9	84.9
Average Queue (m)	4.0	11.9	21.5	16.6	88.5	72.5	49.0
95th Queue (m)	12.4	25.8	30.7	30.0	90.1	106.7	79.5
Link Distance (m)	215.7	43.2	43.2	43.2	67.5	67.5	67.5
Upstream Blk Time (%)				0	39	10	1
Queuing Penalty (veh)				0	255	65	8
Storage Bay Dist (m)							
Storage Blk Time (%)							
Queuing Penalty (veh)							

Intersection: 108: Guigues Ave & King Edward Avenue

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 109: St. Patrick Street & King Edward Avenue

Movement	WB	WB	WB	WB	NB	NB	NB	SB	SB	SB	SB	SB
Directions Served	LT	T	R	R	T	T	T	T	T	T	T	TR
Maximum Queue (m)	70.8	66.5	64.2	63.3	21.9	21.7	22.3	10.7	20.4	14.9	24.7	31.5
Average Queue (m)	43.5	38.5	37.1	33.3	13.2	9.9	8.6	2.3	9.6	3.0	9.5	9.6
95th Queue (m)	63.6	59.8	56.4	53.2	21.3	20.3	19.8	7.9	17.9	9.5	20.2	22.4
Link Distance (m)	87.2	87.2			69.0	69.0	69.0			71.8	71.8	71.8
Upstream Blk Time (%)		0										
Queuing Penalty (veh)		0										
Storage Bay Dist (m)			75.0	75.0				55.0	55.0			
Storage Blk Time (%)		0	0	0								
Queuing Penalty (veh)		0	0	0								

Intersection: 110: Murray Street & King Edward Avenue

Movement	EB	EB	EB	NB	NB	NB	SB	SB	SB	SB	SB
Directions Served	L	LT	TR	T	T	TR	L	L	T	T	T
Maximum Queue (m)	39.6	65.6	66.6	65.2	60.8	53.7	69.1	72.2	21.4	28.2	22.8
Average Queue (m)	20.1	39.7	37.4	39.2	34.9	28.9	46.9	57.3	8.2	9.0	4.2
95th Queue (m)	35.0	58.9	58.5	62.3	55.2	48.2	66.5	75.1	18.4	21.6	15.4
Link Distance (m)	131.1	131.1	131.1	60.3	60.3	60.3	69.0	69.0	69.0	69.0	69.0
Upstream Blk Time (%)				1	0	0	0	1			
Queuing Penalty (veh)				1	0	0	0	5			
Storage Bay Dist (m)											
Storage Blk Time (%)											
Queuing Penalty (veh)											

Intersection: 111: Clarence Street & King Edward Avenue

Movement	SB	SB	SB
Directions Served	T	T	TR
Maximum Queue (m)	21.1	32.7	32.5
Average Queue (m)	1.0	3.2	2.2
95th Queue (m)	9.2	16.5	14.5
Link Distance (m)	60.3	60.3	60.3
Upstream Blk Time (%)			0
Queuing Penalty (veh)			0
Storage Bay Dist (m)			
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 112: York Street & King Edward Avenue

Movement	EB	WB	NB	NB	NB	NB	SB	SB	SB
Directions Served	R	R	L	T	T	TR	T	T	TR
Maximum Queue (m)	14.7	8.9	27.3	30.9	27.6	26.9	83.0	87.7	83.8
Average Queue (m)	1.9	0.4	10.0	12.5	12.4	10.1	57.0	64.2	55.1
95th Queue (m)	8.9	3.4	21.2	27.5	25.9	23.1	81.0	91.4	80.1
Link Distance (m)	123.4	145.6		139.4	139.4	139.4	63.9	63.9	63.9
Upstream Blk Time (%)							3	6	3
Queuing Penalty (veh)							10	21	9
Storage Bay Dist (m)			65.0						
Storage Blk Time (%)									
Queuing Penalty (veh)									

Intersection: 113: George Street & King Edward Avenue

Movement	EB	WB	SB	SB
Directions Served	R	R	T	TR
Maximum Queue (m)	34.6	9.1	20.7	8.5
Average Queue (m)	14.7	3.7	0.7	0.3
95th Queue (m)	26.5	11.0	14.6	3.9
Link Distance (m)	61.8	42.4	139.4	139.4
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (m)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 114: Rideau Street & King Edward Avenue

Movement	EB	EB	EB	WB	WB	NB	NB	NB	SB	SB	SB	SB
Directions Served	L	T	R	T	R	T	T	R	L	T	T	R
Maximum Queue (m)	80.3	71.8	33.2	140.3	32.8	60.4	57.9	30.9	62.4	50.3	62.2	64.6
Average Queue (m)	37.4	28.3	4.6	76.0	11.4	32.8	27.9	6.3	25.7	18.6	24.7	21.0
95th Queue (m)	67.1	54.9	19.2	125.5	33.3	51.0	47.8	18.7	53.9	38.2	46.5	49.6
Link Distance (m)		333.4		149.1		67.9	67.9		63.5	63.5	63.5	63.5
Upstream Blk Time (%)				0		0	0		0	0	0	1
Queuing Penalty (veh)				0		0	0		1	0	1	2
Storage Bay Dist (m)	85.0		25.0		25.0			22.0				
Storage Blk Time (%)	0	9	0	41	0		16	0				
Queuing Penalty (veh)	0	16	0	27	0		7	0				

Intersection: 700: St. Patrick Street & Murray Street

Movement	NB	SB
Directions Served	LT	R
Maximum Queue (m)	16.4	10.1
Average Queue (m)	0.9	0.6
95th Queue (m)	6.7	5.8
Link Distance (m)	119.5	173.9
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (m)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Nework Summary

Network wide Queuing Penalty: 696

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0		4.0			4.0
Lane Util. Factor	1.00		0.91			0.91
Frpb, ped/bikes	0.99		1.00			1.00
Flpb, ped/bikes	1.00		1.00			1.00
Frt	0.98		1.00			1.00
Flt Protected	0.96		1.00			1.00
Satd. Flow (prot)	1627		4366			4499
Flt Permitted	0.96		1.00			1.00
Satd. Flow (perm)	1627		4366			4499
Volume (vph)	13	3	815	18	0	1942
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	14	3	867	19	0	2066
RTOR Reduction (vph)	2	0	2	0	0	0
Lane Group Flow (vph)	15	0	884	0	0	2066
Confl. Peds. (#/hr)		20		19		
Heavy Vehicles (%)	2%	2%	11%	2%	2%	8%
Turn Type						
Protected Phases			2			6
Permitted Phases	8					
Actuated Green, G (s)	30.0		63.4			63.4
Effective Green, g (s)	31.9		65.1			65.1
Actuated g/C Ratio	0.30		0.62			0.62
Clearance Time (s)	5.9		5.7			5.7
Lane Grp Cap (vph)	494		2707			2789
v/s Ratio Prot			0.20			c0.46
v/s Ratio Perm	c0.01					
v/c Ratio	0.03		0.33			0.74
Uniform Delay, d1	25.7		9.5			14.0
Progression Factor	1.00		0.39			1.00
Incremental Delay, d2	0.1		0.3			1.8
Delay (s)	25.8		4.0			15.8
Level of Service	C		A			B
Approach Delay (s)	25.8		4.0			15.8
Approach LOS	C		A			B

Intersection Summary			
HCM Average Control Delay	12.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	59.6%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)					4.0	4.0		4.0			4.0	
Lane Util. Factor					0.95	0.88		0.91			0.81	
Frpb, ped/bikes					1.00	0.98		1.00			1.00	
Flpb, ped/bikes					1.00	1.00		1.00			1.00	
Frt					1.00	0.85		1.00			0.99	
Flt Protected					0.99	1.00		1.00			1.00	
Satd. Flow (prot)					3284	2565		4189			6640	
Flt Permitted					0.99	1.00		1.00			1.00	
Satd. Flow (perm)					3284	2565		4189			6640	
Volume (vph)	0	0	0	72	414	555	0	542	0	0	1861	94
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	77	440	590	0	577	0	0	1980	100
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	8	0
Lane Group Flow (vph)	0	0	0	0	517	590	0	577	0	0	2072	0
Confl. Peds. (#/hr)				14		12						1
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	16%	2%	2%	8%	2%
Turn Type				Perm		custom						
Protected Phases					4	1		2			6	
Permitted Phases				4		4						
Actuated Green, G (s)					30.8	41.6		45.2			58.3	
Effective Green, g (s)					33.4	45.9		47.1			63.6	
Actuated g/C Ratio					0.32	0.44		0.45			0.61	
Clearance Time (s)					6.6	5.7		5.9			9.3	
Lane Grp Cap (vph)					1045	1219		1879			4022	
v/s Ratio Prot						c0.06		0.14			c0.31	
v/s Ratio Perm					0.16	0.17						
v/c Ratio					0.49	0.48		0.31			0.52	
Uniform Delay, d1					29.0	21.1		18.5			11.9	
Progression Factor					0.98	0.97		0.33			0.19	
Incremental Delay, d2					1.7	1.4		0.4			0.3	
Delay (s)					30.1	21.9		6.5			2.6	
Level of Service					C	C		A			A	
Approach Delay (s)		0.0			25.7			6.5			2.6	
Approach LOS		A			C			A			A	

Intersection Summary			
HCM Average Control Delay	10.0	HCM Level of Service	A
HCM Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	4.0
Intersection Capacity Utilization	75.0%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0	4.0						4.0		4.0	4.0	
Lane Util. Factor	0.91	0.91						0.91		0.97	0.91	
Frpb, ped/bikes	1.00	0.99						1.00		1.00	1.00	
Flpb, ped/bikes	1.00	1.00						1.00		1.00	1.00	
Frt	1.00	0.97						0.99		1.00	1.00	
Flt Protected	0.95	1.00						1.00		0.95	1.00	
Satd. Flow (prot)	1509	3054						4000		3216	4226	
Flt Permitted	0.95	1.00						1.00		0.95	1.00	
Satd. Flow (perm)	1509	3054						4000		3216	4226	
Volume (vph)	134	398	101	0	0	0	0	408	36	948	985	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	143	423	107	0	0	0	0	434	38	1009	1048	0
RTOR Reduction (vph)	0	20	0	0	0	0	0	10	0	0	0	0
Lane Group Flow (vph)	143	510	0	0	0	0	0	462	0	1009	1048	0
Confl. Peds. (#/hr)			29						19	19		
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	21%	2%	2%	15%	2%
Turn Type	Split									Prot		
Protected Phases	4	4						10		9	14	
Permitted Phases												
Actuated Green, G (s)	30.8	30.8						13.3		38.7	61.3	
Effective Green, g (s)	33.4	33.4						18.6		41.0	63.6	
Actuated g/C Ratio	0.32	0.32						0.18		0.39	0.61	
Clearance Time (s)	6.6	6.6						9.3		6.3	6.3	
Lane Grp Cap (vph)	480	971						709		1256	2560	
v/s Ratio Prot	0.09	c0.17						c0.12		c0.31	0.25	
v/s Ratio Perm												
v/c Ratio	0.30	0.53						0.65		0.80	0.41	
Uniform Delay, d1	27.0	29.3						40.2		28.4	10.9	
Progression Factor	1.00	1.00						0.57		0.50	0.10	
Incremental Delay, d2	1.6	2.0						4.5		4.8	0.4	
Delay (s)	28.6	31.3						27.6		18.9	1.5	
Level of Service	C	C						C		B	A	
Approach Delay (s)		30.8			0.0			27.6			10.0	
Approach LOS		C			A			C			B	

Intersection Summary			
HCM Average Control Delay	17.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	75.0%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)			4.0			4.0	4.0	4.0			4.0	
Lane Util. Factor			1.00			1.00	1.00	0.91			0.91	
Frpb, ped/bikes			0.99			0.97	1.00	1.00			0.99	
Flpb, ped/bikes			1.00			1.00	1.00	1.00			1.00	
Frt			0.86			0.86	1.00	0.99			0.99	
Flt Protected			1.00			1.00	0.95	1.00			1.00	
Satd. Flow (prot)			1489			1459	1656	4037			4231	
Flt Permitted			1.00			1.00	0.20	1.00			1.00	
Satd. Flow (perm)			1489			1459	344	4037			4231	
Volume (vph)	0	0	43	0	0	14	111	432	28	0	943	50
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	46	0	0	15	118	460	30	0	1003	53
RTOR Reduction (vph)	0	0	0	0	0	0	0	7	0	0	5	0
Lane Group Flow (vph)	0	0	46	0	0	15	118	483	0	0	1051	0
Confl. Peds. (#/hr)			5			74	76		30	30		76
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	20%	2%	2%	14%	2%
Turn Type			custom			custom	pm+pt					
Protected Phases							7	2			6	
Permitted Phases			6 7			2 7	2					
Actuated Green, G (s)			105.0			105.0	93.6	46.6			46.6	
Effective Green, g (s)			105.0			105.0	97.0	48.4			48.4	
Actuated g/C Ratio			1.00			1.00	0.92	0.46			0.46	
Clearance Time (s)							5.6	5.8			5.8	
Lane Grp Cap (vph)			1489			1459	925	1861			1950	
v/s Ratio Prot							c0.06	0.12			c0.25	
v/s Ratio Perm			0.03			0.01	0.06					
v/c Ratio			0.03			0.01	0.13	0.26			0.54	
Uniform Delay, d1			0.0			0.0	1.2	17.3			20.3	
Progression Factor			1.00			1.00	15.43	0.39			0.93	
Incremental Delay, d2			0.0			0.0	0.3	0.3			1.0	
Delay (s)			0.0			0.0	18.5	7.1			19.8	
Level of Service			A			A	B	A			B	
Approach Delay (s)		0.0			0.0			9.3			19.8	
Approach LOS		A			A			A			B	

Intersection Summary			
HCM Average Control Delay	15.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.33		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	44.0%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00		1.00	1.00		0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.91		1.00	0.83		1.00	0.88	1.00	1.00	0.90
Flpb, ped/bikes	0.96	1.00	1.00		1.00	1.00		1.00	1.00	0.95	1.00	1.00
Frt	1.00	1.00	0.85		1.00	0.85		1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00		1.00	1.00		1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1053	1745	1355		1745	1231		3316	1309	1578	3316	931
Flt Permitted	0.32	1.00	1.00		1.00	1.00		1.00	1.00	0.51	1.00	1.00
Satd. Flow (perm)	356	1745	1355		1745	1231		3316	1309	846	3316	931
Volume (vph)	144	267	28	0	392	66	0	346	42	210	666	248
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	153	284	30	0	417	70	0	368	45	223	709	264
RTOR Reduction (vph)	0	0	15	0	0	25	0	0	30	0	0	178
Lane Group Flow (vph)	153	284	15	0	417	45	0	368	15	223	709	86
Confl. Peds. (#/hr)	270		128	128		270			65	65		54
Heavy Vehicles (%)	55%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	46%
Turn Type	custom		custom			custom			custom	custom		custom
Protected Phases	11	10			14			12		13	16	
Permitted Phases	1		1			3			5	7		7
Actuated Green, G (s)	51.5	56.5	51.5		32.5	51.5		20.0	32.9	32.9	36.6	32.9
Effective Green, g (s)	52.8	57.8	52.8		33.8	52.8		22.6	34.2	34.2	39.2	34.2
Actuated g/C Ratio	0.50	0.55	0.50		0.32	0.50		0.22	0.33	0.33	0.37	0.33
Clearance Time (s)	5.3	5.3	5.3		5.3	5.3		6.6	5.3	6.6	6.6	5.3
Lane Grp Cap (vph)	312	961	681		562	619		714	426	363	1238	303
v/s Ratio Prot	c0.09	0.16			c0.24			0.11		0.07	c0.21	
v/s Ratio Perm	0.15		0.01			0.04			0.01	0.13		0.09
v/c Ratio	0.49	0.30	0.02		0.74	0.07		0.52	0.03	0.61	0.57	0.28
Uniform Delay, d1	26.3	12.7	13.1		31.7	13.5		36.4	24.1	31.7	26.2	26.3
Progression Factor	1.00	1.00	1.00		1.00	1.00		1.00	1.00	0.27	0.26	0.47
Incremental Delay, d2	5.4	0.8	0.1		8.6	0.2		2.6	0.2	6.9	1.8	2.1
Delay (s)	31.8	13.5	13.2		40.3	13.7		39.0	24.3	15.4	8.5	14.5
Level of Service	C	B	B		D	B		D	C	B	A	B
Approach Delay (s)		19.4			36.5			37.4			11.1	
Approach LOS		B			D			D			B	

Intersection Summary			
HCM Average Control Delay	21.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	105.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	76.5%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

105: Cathcart Street & King Edward Avenue Performance by movement

Movement	WBR2	NBT	SBT	SER	All
Delay / Veh (s)	9.0	0.7	31.4	2366.8	48.1

106: Bruyere Street & King Edward Avenue Performance by movement

Movement	NBT	SBT	All
Delay / Veh (s)	1.1	14.4	10.4

107: St. Andrew Street & King Edward Avenue Performance by movement

Movement	WBL	WBR	NBT	NBR	SBT	All
Delay / Veh (s)	23.2	1.4	4.1	1.2	16.5	12.7

108: Guigues Ave & King Edward Avenue Performance by movement

Movement	NBT	NBR	SBT	All
Delay / Veh (s)	1.3	1.5	1.6	1.5

109: St. Patrick Street & King Edward Avenue Performance by movement

Movement	WBL	WBT	WBR	NBT	SBT	SBR	All
Delay / Veh (s)	34.5	29.8	21.3	6.6	3.3	2.3	10.4

110: Murray Street & King Edward Avenue Performance by movement

Movement	EBL	EBT	EBR	NBT	NBR	SBL	SBT	All
Delay / Veh (s)	28.7	30.1	19.5	30.8	4.7	13.8	3.7	15.6

111: Clarence Street & King Edward Avenue Performance by movement

Movement	NBT	NBR	SBT	SBR	All
Delay / Veh (s)	0.9	1.2	1.5	1.3	1.3

112: York Street & King Edward Avenue Performance by movement

Movement	EBR	WBR	NBL	NBT	NBR	SBT	SBR	All
Delay / Veh (s)	2.4	0.6	7.0	13.6	3.5	19.0	11.9	15.7

113: George Street & King Edward Avenue Performance by movement

Movement	EBR	WBR	NBT	SBT	All
Delay / Veh (s)	10.3	4.2	1.5	2.9	3.1

114: Rideau Street & King Edward Avenue Performance by movement

Movement	EBL	EBT	EBR	WBT	WBR	NBT	NBR	SBL	SBT	SBR	All
Delay / Veh (s)	35.9	16.2	13.8	37.7	20.7	39.3	12.9	24.7	15.2	9.9	24.0

700: St. Patrick Street & Murray Street Performance by movement

Movement	NBL	NBT	SBR	All
Delay / Veh (s)	2.8	1.9	1.1	1.6

Total Network Performance

Delay / Veh (s)	75.1

Intersection: 105: Cathcart Street & King Edward Avenue

Movement	WB	SB	SB	SE
Directions Served	>	T	T	R
Maximum Queue (m)	14.0	49.9	49.8	43.3
Average Queue (m)	5.3	38.0	32.1	32.0
95th Queue (m)	11.7	62.3	61.7	50.8
Link Distance (m)	96.2	39.5	39.5	38.7
Upstream Blk Time (%)		20	4	77
Queuing Penalty (veh)		0	0	0
Storage Bay Dist (m)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 106: Bruyere Street & King Edward Avenue

Movement	SB	SB	SB
Directions Served	T	T	T
Maximum Queue (m)	117.8	118.1	122.0
Average Queue (m)	110.0	69.3	36.2
95th Queue (m)	128.6	119.7	114.1
Link Distance (m)	68.9	68.9	68.9
Upstream Blk Time (%)	33	4	1
Queuing Penalty (veh)	214	25	4
Storage Bay Dist (m)			
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 107: St. Andrew Street & King Edward Avenue

Movement	WB	NB	NB	NB	SB	SB	SB
Directions Served	LR	T	T	TR	T	T	T
Maximum Queue (m)	13.7	39.2	49.3	28.6	91.6	91.3	88.9
Average Queue (m)	3.2	19.9	29.1	8.0	88.6	69.6	48.8
95th Queue (m)	10.4	36.9	43.4	23.2	90.4	101.8	79.4
Link Distance (m)	215.7	43.2	43.2	43.2	67.5	67.5	67.5
Upstream Blk Time (%)		0	0	0	39	8	2
Queuing Penalty (veh)		0	1	0	251	53	10
Storage Bay Dist (m)							
Storage Blk Time (%)							
Queuing Penalty (veh)							

Intersection: 108: Guigues Ave & King Edward Avenue

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 109: St. Patrick Street & King Edward Avenue

Movement	WB	WB	WB	WB	NB	NB	NB	SB	SB	SB	SB	SB
Directions Served	LT	T	R	R	T	T	T	T	T	T	T	TR
Maximum Queue (m)	73.0	67.1	72.0	63.2	26.9	24.2	23.3	11.6	17.9	19.9	21.8	25.5
Average Queue (m)	43.8	37.7	41.3	30.4	14.5	10.0	8.6	2.5	9.0	4.2	9.9	8.5
95th Queue (m)	64.9	60.0	65.0	54.2	22.8	21.2	19.2	8.6	16.2	13.1	19.1	19.9
Link Distance (m)	87.2	87.2			69.0	69.0	69.0			71.8	71.8	71.8
Upstream Blk Time (%)			0									
Queuing Penalty (veh)			0									
Storage Bay Dist (m)			75.0	75.0				55.0	55.0			
Storage Blk Time (%)		0	0	0								
Queuing Penalty (veh)		0	0	0								

Intersection: 110: Murray Street & King Edward Avenue

Movement	EB	EB	EB	NB	NB	NB	SB	SB	SB	SB	SB
Directions Served	L	LT	TR	T	T	TR	L	L	T	T	T
Maximum Queue (m)	44.0	65.0	62.0	71.1	68.2	61.1	67.6	72.3	25.4	27.5	24.1
Average Queue (m)	21.4	39.7	35.8	42.3	39.0	29.7	45.9	54.3	8.8	10.5	5.3
95th Queue (m)	37.5	58.5	56.8	67.6	63.1	54.8	65.2	73.6	20.2	23.3	17.0
Link Distance (m)	131.1	131.1	131.1	60.3	60.3	60.3	69.0	69.0	69.0	69.0	69.0
Upstream Blk Time (%)				2	1	0	0	1			
Queuing Penalty (veh)				3	2	0	0	4			
Storage Bay Dist (m)											
Storage Blk Time (%)											
Queuing Penalty (veh)											

Intersection: 111: Clarence Street & King Edward Avenue

Movement	NB	SB	SB	SB
Directions Served	T	T	T	TR
Maximum Queue (m)	1.5	15.5	25.5	24.0
Average Queue (m)	0.1	0.8	2.4	1.5
95th Queue (m)	1.1	7.2	13.1	11.2
Link Distance (m)	63.9	60.3	60.3	60.3
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (m)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 112: York Street & King Edward Avenue

Movement	EB	WB	NB	NB	NB	NB	SB	SB	SB
Directions Served	R	R	L	T	T	TR	T	T	TR
Maximum Queue (m)	15.6	8.4	30.0	34.4	35.6	25.3	85.5	87.0	86.0
Average Queue (m)	2.2	0.6	10.8	14.3	14.1	9.5	58.7	64.0	56.3
95th Queue (m)	9.2	4.1	22.8	29.4	29.4	21.3	82.8	89.5	81.9
Link Distance (m)	123.4	145.6		139.4	139.4	139.4	63.9	63.9	63.9
Upstream Blk Time (%)							3	6	3
Queuing Penalty (veh)							11	18	10
Storage Bay Dist (m)			65.0						
Storage Blk Time (%)									
Queuing Penalty (veh)									

Intersection: 113: George Street & King Edward Avenue

Movement	EB	WB	SB
Directions Served	R	R	T
Maximum Queue (m)	35.9	12.7	1.9
Average Queue (m)	16.4	3.4	0.1
95th Queue (m)	28.5	10.9	1.3
Link Distance (m)	61.8	42.4	
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (m)			24.0
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 114: Rideau Street & King Edward Avenue

Movement	EB	EB	EB	WB	WB	NB	NB	NB	SB	SB	SB	SB
Directions Served	L	T	R	T	R	T	T	R	L	T	T	R
Maximum Queue (m)	77.9	78.3	32.5	131.1	34.0	61.1	60.5	29.8	63.8	40.9	52.3	58.5
Average Queue (m)	37.1	28.7	6.4	73.9	10.6	34.7	29.5	7.3	23.3	17.7	24.0	21.1
95th Queue (m)	67.7	55.4	22.1	121.5	32.2	53.9	51.7	22.1	49.8	34.6	42.3	49.0
Link Distance (m)		333.4		149.1		67.9	67.9		63.5	63.5	63.5	63.5
Upstream Blk Time (%)				0		0	0		0		0	1
Queuing Penalty (veh)				0		0	0		1		0	1
Storage Bay Dist (m)	85.0		25.0		25.0			22.0				
Storage Blk Time (%)	0	10	0	40	0		17	0				
Queuing Penalty (veh)	0	17	0	27	0		7	0				

Intersection: 700: St. Patrick Street & Murray Street

Movement	NB	SB
Directions Served	LT	R
Maximum Queue (m)	7.3	1.2
Average Queue (m)	0.4	0.0
95th Queue (m)	3.8	0.8
Link Distance (m)	119.5	173.9
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (m)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Nework Summary

Network wide Queuing Penalty: 661

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0		4.0			4.0
Lane Util. Factor	1.00		0.95			0.95
Frpb, ped/bikes	0.99		1.00			1.00
Flpb, ped/bikes	1.00		1.00			1.00
Frt	0.98		1.00			1.00
Flt Protected	0.96		1.00			1.00
Satd. Flow (prot)	1624		3039			3131
Flt Permitted	0.96		1.00			1.00
Satd. Flow (perm)	1624		3039			3131
Volume (vph)	13	3	815	18	0	1942
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	14	3	867	19	0	2066
RTOR Reduction (vph)	2	0	2	0	0	0
Lane Group Flow (vph)	15	0	884	0	0	2066
Confl. Peds. (#/hr)		20		19		
Heavy Vehicles (%)	2%	2%	11%	2%	2%	8%
Turn Type						
Protected Phases			2			6
Permitted Phases	8					
Actuated Green, G (s)	16.0		67.4			67.4
Effective Green, g (s)	17.9		69.1			69.1
Actuated g/C Ratio	0.19		0.73			0.73
Clearance Time (s)	5.9		5.7			5.7
Lane Grp Cap (vph)	306		2210			2277
v/s Ratio Prot			0.29			c0.66
v/s Ratio Perm	c0.01					
v/c Ratio	0.05		0.40			0.91
Uniform Delay, d1	31.6		5.0			10.4
Progression Factor	1.00		0.28			1.00
Incremental Delay, d2	0.3		0.5			6.7
Delay (s)	31.9		1.9			17.1
Level of Service	C		A			B
Approach Delay (s)	31.9		1.9			17.1
Approach LOS	C		A			B

Intersection Summary			
HCM Average Control Delay	12.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.73		
Actuated Cycle Length (s)	95.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	76.7%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)					4.0	4.0		4.0			4.0	4.0
Lane Util. Factor					0.95	0.88		0.95			0.86	1.00
Frpb, ped/bikes					1.00	0.97		1.00			1.00	0.99
Flpb, ped/bikes					1.00	1.00		1.00			1.00	1.00
Frt					1.00	0.85		1.00			1.00	0.85
Flt Protected					0.99	1.00		1.00			1.00	1.00
Satd. Flow (prot)					3284	2536		2916			5670	1462
Flt Permitted					0.99	1.00		1.00			1.00	1.00
Satd. Flow (perm)					3284	2536		2916			5670	1462
Volume (vph)	0	0	0	72	414	555	0	542	0	0	1861	94
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	77	440	590	0	577	0	0	1980	100
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	39
Lane Group Flow (vph)	0	0	0	0	517	590	0	577	0	0	1980	61
Confl. Peds. (#/hr)				14		12						1
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	16%	2%	2%	8%	2%
Turn Type				Perm		custom						Perm
Protected Phases					4	1		2			6	
Permitted Phases				4		4						6
Actuated Green, G (s)					26.4	37.3		39.5			52.7	52.7
Effective Green, g (s)					29.0	41.6		41.4			58.0	58.0
Actuated g/C Ratio					0.31	0.44		0.44			0.61	0.61
Clearance Time (s)					6.6	5.7		5.9			9.3	9.3
Lane Grp Cap (vph)					1002	1217		1271			3462	893
v/s Ratio Prot						c0.06		0.20			c0.35	
v/s Ratio Perm					0.16	0.17						0.04
v/c Ratio					0.52	0.48		0.45			0.57	0.07
Uniform Delay, d1					27.2	19.1		18.9			11.1	7.5
Progression Factor					0.98	0.97		0.28			0.42	0.53
Incremental Delay, d2					1.9	1.4		0.8			0.3	0.1
Delay (s)					28.6	19.9		6.2			5.0	4.1
Level of Service					C	B		A			A	A
Approach Delay (s)		0.0			24.0			6.2			4.9	
Approach LOS		A			C			A			A	

Intersection Summary			
HCM Average Control Delay	10.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.53		
Actuated Cycle Length (s)	95.0	Sum of lost time (s)	4.0
Intersection Capacity Utilization	73.8%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0	4.0						4.0		4.0	4.0	
Lane Util. Factor	0.91	0.91						0.95		0.97	0.95	
Frpb, ped/bikes	1.00	0.99						1.00		1.00	1.00	
Flpb, ped/bikes	1.00	1.00						1.00		1.00	1.00	
Frt	1.00	0.97						0.99		1.00	1.00	
Flt Protected	0.95	1.00						1.00		0.95	1.00	
Satd. Flow (prot)	1509	3053						2785		3216	2941	
Flt Permitted	0.95	1.00						1.00		0.95	1.00	
Satd. Flow (perm)	1509	3053						2785		3216	2941	
Volume (vph)	134	398	101	0	0	0	0	408	36	948	985	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	143	423	107	0	0	0	0	434	38	1009	1048	0
RTOR Reduction (vph)	0	22	0	0	0	0	0	7	0	0	0	0
Lane Group Flow (vph)	143	508	0	0	0	0	0	465	0	1009	1048	0
Confl. Peds. (#/hr)			29						19	19		
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	21%	2%	2%	15%	2%
Turn Type	Split									Prot		
Protected Phases	4	4						10		9	14	
Permitted Phases												
Actuated Green, G (s)	26.4	26.4						14.4		32.0	55.7	
Effective Green, g (s)	29.0	29.0						19.7		34.3	58.0	
Actuated g/C Ratio	0.31	0.31						0.21		0.36	0.61	
Clearance Time (s)	6.6	6.6						9.3		6.3	6.3	
Lane Grp Cap (vph)	461	932						578		1161	1796	
v/s Ratio Prot	0.09	c0.17						c0.17		c0.31	0.36	
v/s Ratio Perm												
v/c Ratio	0.31	0.54						0.80		0.87	0.58	
Uniform Delay, d1	25.3	27.5						35.8		28.3	11.2	
Progression Factor	1.00	1.00						1.05		0.53	0.15	
Incremental Delay, d2	1.7	2.3						11.0		7.6	1.2	
Delay (s)	27.1	29.8						48.6		22.4	2.8	
Level of Service	C	C						D		C	A	
Approach Delay (s)		29.2			0.0			48.6			12.4	
Approach LOS		C			A			D			B	

Intersection Summary			
HCM Average Control Delay	21.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.74		
Actuated Cycle Length (s)	95.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	73.8%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)			4.0			4.0	4.0	4.0			4.0	
Lane Util. Factor			1.00			1.00	1.00	0.95			0.95	
Frpb, ped/bikes			0.99			0.97	1.00	1.00			1.00	
Flpb, ped/bikes			1.00			1.00	1.00	1.00			1.00	
Frt			0.86			0.86	1.00	0.99			0.99	
Flt Protected			1.00			1.00	0.95	1.00			1.00	
Satd. Flow (prot)			1489			1459	1656	2810			2946	
Flt Permitted			1.00			1.00	0.18	1.00			1.00	
Satd. Flow (perm)			1489			1459	320	2810			2946	
Volume (vph)	0	0	43	0	0	14	111	432	28	0	943	50
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	46	0	0	15	118	460	30	0	1003	53
RTOR Reduction (vph)	0	0	0	0	0	0	0	5	0	0	4	0
Lane Group Flow (vph)	0	0	46	0	0	15	118	485	0	0	1052	0
Confl. Peds. (#/hr)			5			74	76		30	30		76
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	20%	2%	2%	14%	2%
Turn Type			custom			custom	pm+pt					
Protected Phases							7	2			6	
Permitted Phases			6 7			2 7	2					
Actuated Green, G (s)			95.0			95.0	83.6	48.1			48.1	
Effective Green, g (s)			95.0			95.0	87.0	49.9			49.9	
Actuated g/C Ratio			1.00			1.00	0.92	0.53			0.53	
Clearance Time (s)							5.6	5.8			5.8	
Lane Grp Cap (vph)			1489			1459	815	1476			1547	
v/s Ratio Prot							c0.06	0.17			c0.36	
v/s Ratio Perm			0.03			0.01	0.08					
v/c Ratio			0.03			0.01	0.14	0.33			0.68	
Uniform Delay, d1			0.0			0.0	2.2	12.9			16.7	
Progression Factor			1.00			1.00	11.21	0.57			0.36	
Incremental Delay, d2			0.0			0.0	0.3	0.5			2.0	
Delay (s)			0.0			0.0	24.9	7.9			8.0	
Level of Service			A			A	C	A			A	
Approach Delay (s)		0.0			0.0			11.2			8.0	
Approach LOS		A			A			B			A	

Intersection Summary			
HCM Average Control Delay	8.9	HCM Level of Service	A
HCM Volume to Capacity ratio	0.45		
Actuated Cycle Length (s)	95.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	52.8%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱		↑	↱		↑↑	↱	↰	↑↑	↱
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00		1.00	1.00		0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.90		1.00	0.81		1.00	0.89	1.00	1.00	0.91
Flpb, ped/bikes	0.96	1.00	1.00		1.00	1.00		1.00	1.00	0.95	1.00	1.00
Frt	1.00	1.00	0.85		1.00	0.85		1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00		1.00	1.00		1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1049	1745	1342		1745	1204		3316	1322	1580	3316	939
Flt Permitted	0.36	1.00	1.00		1.00	1.00		1.00	1.00	0.53	1.00	1.00
Satd. Flow (perm)	397	1745	1342		1745	1204		3316	1322	886	3316	939
Volume (vph)	144	267	28	0	392	66	0	346	42	210	666	248
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	153	284	30	0	417	70	0	368	45	223	709	264
RTOR Reduction (vph)	0	0	16	0	0	27	0	0	29	0	0	169
Lane Group Flow (vph)	153	284	14	0	417	43	0	368	16	223	709	95
Confl. Peds. (#/hr)	270		128	128		270			65	65		54
Heavy Vehicles (%)	55%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	46%
Turn Type	custom		custom			custom			custom	custom		custom
Protected Phases	11	10			14			12		13	16	
Permitted Phases	1		1			3			5	7		7
Actuated Green, G (s)	41.5	46.5	41.5		31.5	41.5		20.0	32.9	32.9	36.6	32.9
Effective Green, g (s)	42.8	47.8	42.8		32.8	42.8		22.6	34.2	34.2	39.2	34.2
Actuated g/C Ratio	0.45	0.50	0.45		0.35	0.45		0.24	0.36	0.36	0.41	0.36
Clearance Time (s)	5.3	5.3	5.3		5.3	5.3		6.6	5.3	6.6	6.6	5.3
Lane Grp Cap (vph)	254	878	605		602	542		789	476	411	1368	338
v/s Ratio Prot	c0.07	0.16			c0.24			0.11		0.07	c0.21	
v/s Ratio Perm	0.20		0.01			0.04			0.01	0.12		0.10
v/c Ratio	0.60	0.32	0.02		0.69	0.08		0.47	0.03	0.54	0.52	0.28
Uniform Delay, d1	27.5	14.0	14.5		26.8	14.9		31.0	19.7	26.0	20.8	21.6
Progression Factor	1.00	1.00	1.00		1.00	1.00		1.00	1.00	0.49	0.44	0.15
Incremental Delay, d2	10.2	1.0	0.1		6.4	0.3		2.0	0.1	4.2	1.2	1.7
Delay (s)	37.7	15.0	14.6		33.2	15.1		33.0	19.8	17.0	10.4	4.9
Level of Service	D	B	B		C	B		C	B	B	B	A
Approach Delay (s)		22.4			30.6			31.6			10.4	
Approach LOS		C			C			C			B	

Intersection Summary			
HCM Average Control Delay	19.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.58		
Actuated Cycle Length (s)	95.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	76.5%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

105: Cathcart Street & King Edward Avenue Performance by movement

Movement	WBR2	NBT	SBT	SER	All
Delay / Veh (s)	5.8	0.7	5.1	365.4	10.6

106: Bruyere Street & King Edward Avenue Performance by movement

Movement	NBT	SBT	All
Delay / Veh (s)	0.9	7.9	5.8

107: St. Andrew Street & King Edward Avenue Performance by movement

Movement	WBL	WBR	NBT	NBR	SBT	All
Delay / Veh (s)	37.7	8.0	4.1	2.2	11.2	9.1

108: Guigues Ave & King Edward Avenue Performance by movement

Movement	NBT	NBR	SBT	All
Delay / Veh (s)	1.6	1.7	1.9	1.8

109: St. Patrick Street & King Edward Avenue Performance by movement

Movement	WBL	WBT	WBR	NBT	SBT	SBR	All
Delay / Veh (s)	33.0	27.8	19.2	6.3	6.2	2.4	11.2

110: Murray Street & King Edward Avenue Performance by movement

Movement	EBL	EBT	EBR	NBT	NBR	SBL	SBT	All
Delay / Veh (s)	25.7	28.8	22.2	59.6	30.4	18.4	4.6	21.4

111: Clarence Street & King Edward Avenue Performance by movement

Movement	NBT	NBR	SBT	SBR	All
Delay / Veh (s)	2.8	0.9	1.8	1.7	2.1

112: York Street & King Edward Avenue Performance by movement

Movement	EBR	WBR	NBL	NBT	NBR	SBT	SBR	All
Delay / Veh (s)	4.7	0.7	7.6	15.1	10.9	6.5	5.5	8.8

113: George Street & King Edward Avenue Performance by movement

Movement	EBR	WBR	NBT	SBT	All
Delay / Veh (s)	10.5	3.8	1.2	2.4	2.6

114: Rideau Street & King Edward Avenue Performance by movement

Movement	EBL	EBT	EBR	WBT	WBR	NBT	NBR	SBL	SBT	SBR	All
Delay / Veh (s)	41.1	18.7	12.4	34.8	19.9	32.9	11.3	27.9	15.0	10.4	23.4

700: St. Patrick Street & Murray Street Performance by movement

Movement	NBL	NBT	SBR	All
Delay / Veh (s)	3.0	2.0	1.2	1.7

Total Network Performance

Delay / Veh (s)	52.5

Intersection: 105: Cathcart Street & King Edward Avenue

Movement	WB	SB	SB	SE
Directions Served	>	T	T	R
Maximum Queue (m)	15.5	48.6	45.8	45.6
Average Queue (m)	7.8	13.4	10.4	20.2
95th Queue (m)	14.8	44.8	37.8	47.9
Link Distance (m)	100.3	39.5	39.5	38.7
Upstream Blk Time (%)		3	1	31
Queuing Penalty (veh)		0	0	0
Storage Bay Dist (m)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 106: Bruyere Street & King Edward Avenue

Movement	SB	SB
Directions Served	T	T
Maximum Queue (m)	117.6	122.7
Average Queue (m)	78.5	46.1
95th Queue (m)	139.6	109.1
Link Distance (m)	68.9	68.9
Upstream Blk Time (%)	11	3
Queuing Penalty (veh)	107	26
Storage Bay Dist (m)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 107: St. Andrew Street & King Edward Avenue

Movement	WB	NB	NB	SB	SB
Directions Served	LR	T	TR	T	T
Maximum Queue (m)	13.7	48.6	47.5	89.9	93.6
Average Queue (m)	3.5	19.1	18.3	86.7	74.8
95th Queue (m)	11.0	43.4	37.5	100.6	104.2
Link Distance (m)	219.2	43.2	43.2	67.5	67.5
Upstream Blk Time (%)		0	0	23	8
Queuing Penalty (veh)		1	1	227	82
Storage Bay Dist (m)					
Storage Blk Time (%)					
Queuing Penalty (veh)					

Intersection: 108: Guigues Ave & King Edward Avenue

Movement	NB	SB	SB
Directions Served	T	T	T
Maximum Queue (m)	3.2	8.1	7.9
Average Queue (m)	0.2	0.3	0.3
95th Queue (m)	2.6	3.7	4.3
Link Distance (m)	71.7	43.2	43.2
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (m)			
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 109: St. Patrick Street & King Edward Avenue

Movement	WB	WB	WB	WB	NB	NB	SB	SB	SB	SB	SB
Directions Served	LT	T	R	R	T	T	T	T	T	T	R
Maximum Queue (m)	63.0	60.4	62.7	59.4	29.1	29.2	36.8	39.5	61.5	75.2	29.5
Average Queue (m)	39.0	33.5	35.0	31.7	15.5	13.7	15.7	21.6	26.4	34.4	1.6
95th Queue (m)	57.2	51.4	53.2	49.7	25.5	25.5	28.8	33.0	50.1	60.5	14.3
Link Distance (m)	90.7	90.7			69.2	69.2			71.7	71.7	
Upstream Blk Time (%)									0	0	
Queuing Penalty (veh)									0	1	
Storage Bay Dist (m)			75.0	75.0			55.0	55.0			60.0
Storage Blk Time (%)		0	0	0					0	0	0
Queuing Penalty (veh)		0	0	0					0	0	0

Intersection: 110: Murray Street & King Edward Avenue

Movement	EB	EB	EB	NB	NB	SB	SB	SB	SB
Directions Served	L	LT	TR	T	TR	L	L	T	T
Maximum Queue (m)	38.4	69.6	66.1	81.6	80.1	76.1	76.0	28.6	31.0
Average Queue (m)	19.4	38.8	36.9	56.2	57.1	58.6	65.0	11.7	14.0
95th Queue (m)	33.5	58.0	56.9	83.7	83.0	77.0	81.2	24.6	27.9
Link Distance (m)	134.6	134.6	134.6	60.3	60.3	69.2	69.2	69.2	69.2
Upstream Blk Time (%)				14	15	2	5		
Queuing Penalty (veh)				32	33	8	24		
Storage Bay Dist (m)									
Storage Blk Time (%)									
Queuing Penalty (veh)									

Intersection: 111: Clarence Street & King Edward Avenue

Movement	NB	NB	SB	SB
Directions Served	T	TR	T	TR
Maximum Queue (m)	27.4	25.8	16.8	31.0
Average Queue (m)	2.5	2.3	0.6	1.5
95th Queue (m)	17.3	17.0	7.7	17.7
Link Distance (m)	63.8	63.8	60.3	60.3
Upstream Blk Time (%)	0	0		0
Queuing Penalty (veh)	0	0		0
Storage Bay Dist (m)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 112: York Street & King Edward Avenue

Movement	EB	WB	NB	NB	NB	SB	SB
Directions Served	R	R	L	T	TR	T	TR
Maximum Queue (m)	16.6	8.2	30.6	40.7	47.4	67.0	76.2
Average Queue (m)	4.0	0.6	11.7	18.4	19.5	22.7	29.8
95th Queue (m)	12.2	3.9	23.4	33.4	38.0	45.8	56.8
Link Distance (m)	126.9	149.1		139.4	139.4	63.8	63.8
Upstream Blk Time (%)						0	0
Queuing Penalty (veh)						1	2
Storage Bay Dist (m)			65.0				
Storage Blk Time (%)							
Queuing Penalty (veh)							

Intersection: 113: George Street & King Edward Avenue

Movement	EB	WB	SB
Directions Served	R	R	T
Maximum Queue (m)	44.8	13.2	7.0
Average Queue (m)	14.2	3.9	0.2
95th Queue (m)	28.4	11.7	3.9
Link Distance (m)	61.2	45.9	
Upstream Blk Time (%)	0		
Queuing Penalty (veh)	0		
Storage Bay Dist (m)			24.0
Storage Blk Time (%)			0
Queuing Penalty (veh)			0

Intersection: 114: Rideau Street & King Edward Avenue

Movement	EB	EB	EB	WB	WB	NB	NB	NB	SB	SB	SB	SB
Directions Served	L	T	R	T	R	T	T	R	L	T	T	R
Maximum Queue (m)	74.2	97.9	21.6	132.4	32.8	54.2	52.5	26.1	67.1	53.0	50.5	57.1
Average Queue (m)	34.5	30.8	3.4	69.4	11.9	32.2	24.6	5.9	29.5	21.0	25.4	24.7
95th Queue (m)	64.7	66.7	12.5	117.4	33.6	50.5	44.0	17.0	58.4	40.2	43.6	48.9
Link Distance (m)		333.4		149.1		67.9	67.9		63.7	63.7	63.7	63.7
Upstream Blk Time (%)				0			0		1	0	0	0
Queuing Penalty (veh)				0			0		2	0	0	1
Storage Bay Dist (m)	85.0		25.0		25.0			22.0				
Storage Blk Time (%)	0	11		39	0		9	0				
Queuing Penalty (veh)	0	19		26	0		4	0				

Intersection: 700: St. Patrick Street & Murray Street

Movement	NB	SB
Directions Served	LT	R
Maximum Queue (m)	10.5	4.9
Average Queue (m)	0.7	0.2
95th Queue (m)	5.0	2.1
Link Distance (m)	123.0	173.9
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (m)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Nework Summary

Network wide Queuing Penalty: 598

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0		4.0			4.0
Lane Util. Factor	1.00		0.91			0.91
Frpb, ped/bikes	0.97		1.00			1.00
Flpb, ped/bikes	1.00		1.00			1.00
Frt	0.93		1.00			1.00
Flt Protected	0.98		1.00			1.00
Satd. Flow (prot)	1533		4669			4226
Flt Permitted	0.98		1.00			1.00
Satd. Flow (perm)	1533		4669			4226
Volume (vph)	11	11	2588	12	0	1387
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	12	12	2753	13	0	1476
RTOR Reduction (vph)	4	0	0	0	0	0
Lane Group Flow (vph)	20	0	2766	0	0	1476
Confl. Bikes (#/hr)		58		23		
Heavy Vehicles (%)	2%	2%	4%	2%	2%	15%
Turn Type						
Protected Phases			2			6
Permitted Phases	8					
Actuated Green, G (s)	23.0		75.1			75.1
Effective Green, g (s)	24.9		77.1			77.1
Actuated g/C Ratio	0.23		0.70			0.70
Clearance Time (s)	5.9		6.0			6.0
Lane Grp Cap (vph)	347		3273			2962
v/s Ratio Prot			c0.59			0.35
v/s Ratio Perm	c0.01					
v/c Ratio	0.06		0.85			0.50
Uniform Delay, d1	33.4		12.1			7.6
Progression Factor	1.00		0.45			1.00
Incremental Delay, d2	0.3		1.0			0.6
Delay (s)	33.7		6.4			8.2
Level of Service	C		A			A
Approach Delay (s)	33.7		6.4			8.2
Approach LOS	C		A			A

Intersection Summary			
HCM Average Control Delay	7.2	HCM Level of Service	A
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	63.9%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)					4.0	4.0		4.0			4.0	
Lane Util. Factor					0.95	0.88		0.91			0.81	
Frpb, ped/bikes					1.00	0.99		1.00			1.00	
Flpb, ped/bikes					1.00	1.00		1.00			1.00	
Frt					1.00	0.85		1.00			1.00	
Flt Protected					0.99	1.00		1.00			1.00	
Satd. Flow (prot)					3291	2581		4628			6265	
Flt Permitted					0.99	1.00		1.00			1.00	
Satd. Flow (perm)					3291	2581		4628			6265	
Volume (vph)	0	0	0	46	291	993	0	1860	0	0	1374	24
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	49	310	1056	0	1979	0	0	1462	26
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	3	0
Lane Group Flow (vph)	0	0	0	0	359	1056	0	1979	0	0	1485	0
Confl. Peds. (#/hr)				4		5				1		
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	5%	2%	2%	15%	2%
Turn Type				Perm		custom						
Protected Phases					4	1		2			6	
Permitted Phases				4		4						
Actuated Green, G (s)					28.7	44.1		47.7			65.4	
Effective Green, g (s)					31.3	48.4		49.6			70.7	
Actuated g/C Ratio					0.28	0.44		0.45			0.64	
Clearance Time (s)					6.6	5.7		5.9			9.3	
Lane Grp Cap (vph)					936	1229		2087			4027	
v/s Ratio Prot						c0.13		c0.43			0.24	
v/s Ratio Perm					0.11	0.28						
v/c Ratio					0.38	0.86		0.95			0.37	
Uniform Delay, d1					31.6	27.7		29.0			9.2	
Progression Factor					0.97	0.96		0.18			0.27	
Incremental Delay, d2					1.2	7.9		5.6			0.2	
Delay (s)					31.8	34.6		10.9			2.7	
Level of Service					C	C		B			A	
Approach Delay (s)		0.0			33.9			10.9			2.7	
Approach LOS		A			C			B			A	

Intersection Summary			
HCM Average Control Delay	15.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.90		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	84.0%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0	4.0						4.0		4.0	4.0	
Lane Util. Factor	0.91	0.91						0.91		0.97	0.91	
Frpb, ped/bikes	1.00	0.99						1.00		1.00	1.00	
Flpb, ped/bikes	1.00	1.00						1.00		1.00	1.00	
Frt	1.00	0.98						1.00		1.00	1.00	
Flt Protected	0.95	0.99						1.00		0.95	1.00	
Satd. Flow (prot)	1509	3058						4528		3216	3919	
Flt Permitted	0.95	0.99						1.00		0.95	1.00	
Satd. Flow (perm)	1509	3058						4528		3216	3919	
Volume (vph)	379	388	68	0	0	0	0	1481	29	636	784	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	403	413	72	0	0	0	0	1576	31	677	834	0
RTOR Reduction (vph)	0	9	0	0	0	0	0	2	0	0	0	0
Lane Group Flow (vph)	291	588	0	0	0	0	0	1605	0	677	834	0
Confl. Peds. (#/hr)			65						16	16		61
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	7%	2%	2%	24%	2%
Turn Type	Split									Prot		
Protected Phases	4	4						10		9	14	
Permitted Phases												
Actuated Green, G (s)	28.7	28.7						36.3		22.8	68.4	
Effective Green, g (s)	31.3	31.3						41.6		25.1	70.7	
Actuated g/C Ratio	0.28	0.28						0.38		0.23	0.64	
Clearance Time (s)	6.6	6.6						9.3		6.3	6.3	
Lane Grp Cap (vph)	429	870						1712		734	2519	
v/s Ratio Prot	c0.19	0.19						c0.35		c0.21	0.21	
v/s Ratio Perm												
v/c Ratio	0.68	0.68						0.94		0.92	0.33	
Uniform Delay, d1	34.9	34.9						32.9		41.5	8.9	
Progression Factor	1.00	1.00						0.25		0.79	0.34	
Incremental Delay, d2	8.4	4.2						10.5		18.1	0.3	
Delay (s)	43.3	39.0						18.8		51.1	3.4	
Level of Service	D	D						B		D	A	
Approach Delay (s)		40.4			0.0			18.8			24.8	
Approach LOS		D			A			B			C	

Intersection Summary			
HCM Average Control Delay	25.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.85		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	84.0%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)			4.0			4.0	4.0	4.0			4.0	
Lane Util. Factor			1.00			1.00	1.00	0.91			0.91	
Frpb, ped/bikes			0.99			0.97	1.00	1.00			1.00	
Flpb, ped/bikes			1.00			1.00	1.00	1.00			1.00	
Frt			0.86			0.86	1.00	1.00			1.00	
Flt Protected			1.00			1.00	0.95	1.00			1.00	
Satd. Flow (prot)			1489			1461	1654	4526			3941	
Flt Permitted			1.00			1.00	0.25	1.00			1.00	
Satd. Flow (perm)			1489			1461	442	4526			3941	
Volume (vph)	0	0	114	0	0	143	138	1140	26	0	817	25
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	121	0	0	152	147	1213	28	0	869	27
RTOR Reduction (vph)	0	0	0	0	0	0	0	2	0	0	3	0
Lane Group Flow (vph)	0	0	121	0	0	152	147	1239	0	0	893	0
Confl. Peds. (#/hr)			5			68	78		23			78
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	7%	2%	2%	23%	2%
Turn Type			custom			custom	pm+pt					
Protected Phases							7	2			6	
Permitted Phases			6 7			2 7	2					
Actuated Green, G (s)			110.0			110.0	98.3	50.3			50.3	
Effective Green, g (s)			110.0			110.0	102.0	52.4			52.4	
Actuated g/C Ratio			1.00			1.00	0.93	0.48			0.48	
Clearance Time (s)							5.6	6.1			6.1	
Lane Grp Cap (vph)			1489			1461	956	2156			1877	
v/s Ratio Prot							c0.07	c0.27			0.23	
v/s Ratio Perm			0.08			0.10	0.07					
v/c Ratio			0.08			0.10	0.15	0.57			0.48	
Uniform Delay, d1			0.0			0.0	0.8	20.8			19.5	
Progression Factor			1.00			1.00	9.18	0.30			0.88	
Incremental Delay, d2			0.1			0.1	0.1	0.3			0.8	
Delay (s)			0.1			0.1	7.5	6.4			18.0	
Level of Service			A			A	A	A			B	
Approach Delay (s)		0.1			0.1			6.5			18.0	
Approach LOS		A			A			A			B	

Intersection Summary			
HCM Average Control Delay	9.9	HCM Level of Service	A
HCM Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	47.2%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00		1.00	1.00		0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.89		1.00	0.69		1.00	0.83	1.00	1.00	0.77
Flpb, ped/bikes	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85		1.00	0.85		1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00		1.00	1.00		1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1311	1745	1314		1745	1021		3316	1238	1658	3316	649
Flt Permitted	0.10	1.00	1.00		1.00	1.00		1.00	1.00	0.15	1.00	1.00
Satd. Flow (perm)	144	1745	1314		1745	1021		3316	1238	268	3316	649
Volume (vph)	229	377	15	0	638	218	0	857	94	207	574	227
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	244	401	16	0	679	232	0	912	100	220	611	241
RTOR Reduction (vph)	0	0	6	0	0	48	0	0	27	0	0	156
Lane Group Flow (vph)	244	401	10	0	679	184	0	912	73	220	611	85
Confl. Peds. (#/hr)	534		169	169		534			104	104		152
Heavy Vehicles (%)	29%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	79%
Turn Type	custom		custom			custom			custom	custom		custom
Protected Phases	11	10			14			12		13	16	
Permitted Phases	1		1			3			5	7		7
Actuated Green, G (s)	52.1	57.1	52.1		38.1	52.1		24.4	37.3	37.3	41.0	37.3
Effective Green, g (s)	53.4	58.4	53.4		39.4	53.4		27.0	38.6	38.6	43.6	38.6
Actuated g/C Ratio	0.49	0.53	0.49		0.36	0.49		0.25	0.35	0.35	0.40	0.35
Clearance Time (s)	5.3	5.3	5.3		5.3	5.3		6.6	5.3	6.6	6.6	5.3
Lane Grp Cap (vph)	229	926	638		625	496		814	434	253	1314	228
v/s Ratio Prot	c0.15	0.23			c0.39			c0.28		c0.10	0.18	
v/s Ratio Perm	0.37		0.01			0.18			0.06	0.20		0.13
v/c Ratio	1.07	0.43	0.02		1.09	0.37		1.12	0.17	0.87	0.46	0.37
Uniform Delay, d1	43.9	15.7	14.7		35.3	17.8		41.5	24.6	44.0	24.6	26.6
Progression Factor	1.00	1.00	1.00		1.00	1.00		1.00	1.00	0.90	1.02	3.42
Incremental Delay, d2	77.9	1.5	0.0		61.7	2.1		70.1	0.8	29.5	1.1	4.3
Delay (s)	121.8	17.2	14.7		97.0	19.9		111.6	25.5	69.1	26.3	95.5
Level of Service	F	B	B		F	B		F	C	E	C	F
Approach Delay (s)		55.7			77.4			103.1			50.6	
Approach LOS		E			E			F			D	

Intersection Summary			
HCM Average Control Delay	72.7	HCM Level of Service	E
HCM Volume to Capacity ratio	0.99		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	99.3%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

105: Cathcart Street & King Edward Avenue Performance by movement

Movement	NBT	SBT	SER	All
Delay / Veh (s)	1.2	1.3	11.6	1.4

106: Bruyere Street & King Edward Avenue Performance by movement

Movement	NBT	SBT	All
Delay / Veh (s)	1.4	1.4	1.4

107: St. Andrew Street & King Edward Avenue Performance by movement

Movement	WBL	WBR	NBT	NBR	SBT	All
Delay / Veh (s)	38.2	11.7	6.8	5.6	9.1	7.7

108: Guigues Ave & King Edward Avenue Performance by movement

Movement	NBT	NBR	SBT	All
Delay / Veh (s)	2.4	2.9	1.3	2.1

109: St. Patrick Street & King Edward Avenue Performance by movement

Movement	WBL	WBT	WBR	NBT	SBT	SBR	All
Delay / Veh (s)	34.0	28.6	46.4	6.4	9.4	2.1	18.2

110: Murray Street & King Edward Avenue Performance by movement

Movement	EBL	EBT	EBR	NBT	NBR	SBL	SBT	All
Delay / Veh (s)	35.1	37.3	24.2	26.8	9.0	40.7	3.1	25.9

111: Clarence Street & King Edward Avenue Performance by movement

Movement	WBR	NBT	SBT	SBR	All
Delay / Veh (s)	10.2	1.6	0.8	0.4	2.2

112: York Street & King Edward Avenue Performance by movement

Movement	EBR	WBR	NBL	NBT	NBR	SBT	SBR	All
Delay / Veh (s)	2.8	1.9	12.3	4.5	1.3	25.7	16.8	12.6

113: George Street & King Edward Avenue Performance by movement

Movement	EBR	NBT	SBT	All
Delay / Veh (s)	1465.8	1.6	21.0	47.3

114: Rideau Street & King Edward Avenue Performance by movement

Movement	EBL	EBT	EBR	WBT	WBR	NBT	NBR	SBL	SBT	SBR	All
Delay / Veh (s)	304.5	198.5	216.1	1042.3	1021.4	725.3	703.7	205.2	41.8	29.3	484.7

700: St. Patrick Street & Murray Street Performance by movement

Movement	NBL	NBT	SBR	All
Delay / Veh (s)	6.0	3.4	34.4	20.2

Total Network Performance

Delay / Veh (s)	304.5

Intersection: 105: Cathcart Street & King Edward Avenue

Movement	SB	SB	SE
Directions Served	T	T	R
Maximum Queue (m)	21.7	10.0	15.4
Average Queue (m)	0.9	0.7	2.4
95th Queue (m)	9.9	5.2	9.1
Link Distance (m)	41.1	41.1	38.7
Upstream Blk Time (%)	0		
Queuing Penalty (veh)	0		
Storage Bay Dist (m)			
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 106: Bruyere Street & King Edward Avenue

Movement	SB	SB
Directions Served	T	T
Maximum Queue (m)	57.8	26.8
Average Queue (m)	9.2	1.4
95th Queue (m)	35.8	13.7
Link Distance (m)	68.9	68.9
Upstream Blk Time (%)	0	0
Queuing Penalty (veh)	1	0
Storage Bay Dist (m)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 107: St. Andrew Street & King Edward Avenue

Movement	WB	NB	NB	NB	SB	SB	SB
Directions Served	LR	T	T	TR	T	T	T
Maximum Queue (m)	16.5	59.4	64.1	64.4	88.8	81.2	55.9
Average Queue (m)	4.7	37.6	53.9	57.0	70.4	41.6	23.6
95th Queue (m)	13.4	53.4	67.3	72.5	100.9	73.6	47.3
Link Distance (m)	215.7	43.2	43.2	43.2	67.5	67.5	67.5
Upstream Blk Time (%)		2	11	14	8	0	0
Queuing Penalty (veh)		15	96	120	39	1	0
Storage Bay Dist (m)							
Storage Blk Time (%)							
Queuing Penalty (veh)							

Intersection: 108: Guigues Ave & King Edward Avenue

Movement	NB	NB	NB	SB	SB
Directions Served	T	T	TR	T	T
Maximum Queue (m)	9.5	34.6	39.5	11.3	5.8
Average Queue (m)	0.8	6.0	10.3	1.3	0.2
95th Queue (m)	6.2	22.6	29.8	14.0	4.1
Link Distance (m)	71.8	71.8	71.8	43.2	43.2
Upstream Blk Time (%)				1	
Queuing Penalty (veh)				3	
Storage Bay Dist (m)					
Storage Blk Time (%)					
Queuing Penalty (veh)					

Intersection: 109: St. Patrick Street & King Edward Avenue

Movement	WB	WB	WB	WB	NB	NB	NB	SB	SB	SB	SB	SB
Directions Served	LT	T	R	R	T	T	T	T	T	T	T	TR
Maximum Queue (m)	48.6	123.8	85.9	82.8	48.3	46.9	52.2	40.2	43.5	46.7	23.6	18.2
Average Queue (m)	31.2	97.2	82.1	78.1	31.7	27.7	28.6	13.6	17.0	8.7	5.9	2.5
95th Queue (m)	47.0	161.2	96.3	93.0	44.4	42.1	44.5	43.2	45.9	38.0	17.8	10.7
Link Distance (m)	87.2	87.2			69.0	69.0	69.0			71.8	71.8	71.8
Upstream Blk Time (%)		20	8	0						1		
Queuing Penalty (veh)		135	0	0						5		
Storage Bay Dist (m)			75.0	75.0				55.0	55.0			
Storage Blk Time (%)		0	27	15				1	2	0		
Queuing Penalty (veh)		2	39	22				3	6	1		

Intersection: 110: Murray Street & King Edward Avenue

Movement	EB	EB	EB	NB	NB	NB	SB	SB	SB	SB	SB
Directions Served	L	LT	TR	T	T	TR	L	L	T	T	T
Maximum Queue (m)	76.7	82.2	75.0	81.3	81.2	81.3	74.2	75.8	21.2	22.7	14.8
Average Queue (m)	49.3	52.1	44.6	48.9	54.9	59.0	61.7	65.2	8.0	7.6	2.7
95th Queue (m)	70.3	72.2	66.9	75.8	79.8	82.4	81.2	82.5	17.8	19.2	10.9
Link Distance (m)	131.1	131.1	131.1	60.3	60.3	60.3	69.0	69.0	69.0	69.0	69.0
Upstream Blk Time (%)				2	3	7	9	12			
Queuing Penalty (veh)				8	15	34	25	35			
Storage Bay Dist (m)											
Storage Blk Time (%)											
Queuing Penalty (veh)											

Intersection: 111: Clarence Street & King Edward Avenue

Movement	WB	NB	NB	NB	SB	SB	SB
Directions Served	R	T	T	TR	T	T	TR
Maximum Queue (m)	43.0	16.2	17.2	26.2	4.5	10.7	2.8
Average Queue (m)	19.8	1.1	1.1	1.9	0.2	0.4	0.1
95th Queue (m)	36.3	8.2	8.2	12.9	3.2	4.4	1.5
Link Distance (m)	148.7	63.9	63.9	63.9	60.3	60.3	60.3
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (m)							
Storage Blk Time (%)							
Queuing Penalty (veh)							

Intersection: 112: York Street & King Edward Avenue

Movement	EB	WB	NB	NB	NB	NB	SB	SB	SB
Directions Served	R	R	L	T	T	TR	T	T	TR
Maximum Queue (m)	19.3	23.1	31.3	46.2	41.6	25.9	67.2	78.7	70.2
Average Queue (m)	5.5	5.8	15.7	18.4	17.4	8.4	41.8	45.3	45.7
95th Queue (m)	15.4	16.9	28.4	36.8	31.0	20.9	60.9	69.7	70.1
Link Distance (m)	123.4	145.6		139.4	139.4	139.4	63.9	63.9	63.9
Upstream Blk Time (%)							0	1	3
Queuing Penalty (veh)							1	4	10
Storage Bay Dist (m)			65.0						
Storage Blk Time (%)									
Queuing Penalty (veh)									

Intersection: 113: George Street & King Edward Avenue

Movement	EB	SB	SB	SB	SB
Directions Served	R	T	T	T	TR
Maximum Queue (m)	67.5	33.4	109.0	96.6	43.5
Average Queue (m)	41.1	21.6	48.1	35.6	7.6
95th Queue (m)	80.1	44.5	130.3	111.8	30.6
Link Distance (m)	61.8		139.4	139.4	139.4
Upstream Blk Time (%)	48		1	0	
Queuing Penalty (veh)	0		3	0	
Storage Bay Dist (m)		24.0			
Storage Blk Time (%)		44	0		
Queuing Penalty (veh)		103	1		

Intersection: 114: Rideau Street & King Edward Avenue

Movement	EB	EB	EB	WB	WB	NB	NB	NB	SB	SB	SB	SB
Directions Served	L	T	R	T	R	T	T	R	L	T	T	R
Maximum Queue (m)	98.5	330.6	22.0	157.2	34.0	76.0	77.1	29.8	84.8	70.7	80.3	86.8
Average Queue (m)	87.6	240.7	3.0	153.8	19.8	72.5	72.5	10.2	76.7	44.3	48.8	57.8
95th Queue (m)	114.5	438.7	15.9	155.4	41.6	74.7	75.5	28.5	103.3	64.5	72.6	89.5
Link Distance (m)		333.4		149.1		67.9	67.9		63.5	63.5	63.5	63.5
Upstream Blk Time (%)		27		55		67	68		70	2	4	11
Queuing Penalty (veh)		0		0		0	0		177	4	10	27
Storage Bay Dist (m)	85.0		25.0		25.0			22.0				
Storage Blk Time (%)	47	27	0	60	2		73	0				
Queuing Penalty (veh)	184	65	0	132	10		68	1				

Intersection: 700: St. Patrick Street & Murray Street

Movement	NB	NB	SB	SB
Directions Served	LT	T	R	R
Maximum Queue (m)	66.8	63.6	129.8	181.7
Average Queue (m)	21.6	11.1	9.0	111.4
95th Queue (m)	57.6	42.9	70.0	232.0
Link Distance (m)	119.5	119.5	173.9	173.9
Upstream Blk Time (%)			0	15
Queuing Penalty (veh)			0	0
Storage Bay Dist (m)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Nework Summary

Network wide Queuing Penalty: 1406

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0		4.0			4.0
Lane Util. Factor	1.00		0.91			0.95
Frpb, ped/bikes	0.96		1.00			1.00
Flpb, ped/bikes	1.00		1.00			1.00
Frt	0.93		1.00			1.00
Flt Protected	0.98		1.00			1.00
Satd. Flow (prot)	1518		4668			3191
Flt Permitted	0.98		1.00			1.00
Satd. Flow (perm)	1518		4668			3191
Volume (vph)	11	11	2588	12	0	1387
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	12	12	2753	13	0	1476
RTOR Reduction (vph)	3	0	0	0	0	0
Lane Group Flow (vph)	21	0	2766	0	0	1476
Confl. Peds. (#/hr)		58		23		
Heavy Vehicles (%)	2%	2%	4%	2%	2%	6%
Turn Type						
Protected Phases			2			6
Permitted Phases	8					
Actuated Green, G (s)	23.0		75.1			75.1
Effective Green, g (s)	24.9		77.1			77.1
Actuated g/C Ratio	0.23		0.70			0.70
Clearance Time (s)	5.9		6.0			6.0
Lane Grp Cap (vph)	344		3272			2237
v/s Ratio Prot			c0.59			0.46
v/s Ratio Perm	c0.01					
v/c Ratio	0.06		0.85			0.66
Uniform Delay, d1	33.4		12.1			9.2
Progression Factor	1.00		0.49			1.00
Incremental Delay, d2	0.3		1.0			1.5
Delay (s)	33.7		6.9			10.7
Level of Service	C		A			B
Approach Delay (s)	33.7		6.9			10.7
Approach LOS	C		A			B

Intersection Summary			
HCM Average Control Delay	8.4	HCM Level of Service	A
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	73.1%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)					4.0	4.0		4.0			4.0	4.0
Lane Util. Factor					0.95	0.88		0.91			0.86	1.00
Frpb, ped/bikes					1.00	0.99		1.00			1.00	1.00
Flpb, ped/bikes					1.00	1.00		1.00			1.00	1.00
Frt					1.00	0.85		1.00			1.00	0.85
Flt Protected					0.99	1.00		1.00			1.00	1.00
Satd. Flow (prot)					3291	2579		4628			5777	1127
Flt Permitted					0.99	1.00		1.00			1.00	1.00
Satd. Flow (perm)					3291	2579		4628			5777	1127
Volume (vph)	0	0	0	46	291	993	0	1860	0	0	1374	24
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	49	310	1056	0	1979	0	0	1462	26
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	9
Lane Group Flow (vph)	0	0	0	0	359	1056	0	1979	0	0	1462	17
Confl. Peds. (#/hr)				4		6				1		
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	5%	2%	2%	6%	2%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	60
Turn Type				Perm		custom						Perm
Protected Phases					4	1		2			6	
Permitted Phases				4		4						6
Actuated Green, G (s)					28.7	44.1		47.7			65.4	65.4
Effective Green, g (s)					31.3	48.4		49.6			70.7	70.7
Actuated g/C Ratio					0.28	0.44		0.45			0.64	0.64
Clearance Time (s)					6.6	5.7		5.9			9.3	9.3
Lane Grp Cap (vph)					936	1229		2087			3713	724
v/s Ratio Prot						c0.13		c0.43			0.25	
v/s Ratio Perm					0.11	0.28						0.02
v/c Ratio					0.38	0.86		0.95			0.39	0.02
Uniform Delay, d1					31.6	27.7		29.0			9.4	7.1
Progression Factor					0.97	0.96		0.18			0.22	0.04
Incremental Delay, d2					1.2	7.9		5.6			0.2	0.0
Delay (s)					31.8	34.6		10.9			2.3	0.4
Level of Service					C	C		B			A	A
Approach Delay (s)		0.0			33.9			10.9			2.2	
Approach LOS		A			C			B			A	

Intersection Summary			
HCM Average Control Delay	14.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.90		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	84.0%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0	4.0						4.0		4.0	4.0	
Lane Util. Factor	0.91	0.91						0.91		0.97	0.95	
Frpb, ped/bikes	1.00	0.99						1.00		1.00	1.00	
Flpb, ped/bikes	1.00	1.00						1.00		1.00	1.00	
Frt	1.00	0.98						1.00		1.00	1.00	
Flt Protected	0.95	0.99						1.00		0.95	1.00	
Satd. Flow (prot)	1509	3058						4528		3216	3103	
Flt Permitted	0.95	0.99						1.00		0.95	1.00	
Satd. Flow (perm)	1509	3058						4528		3216	3103	
Volume (vph)	379	388	68	0	0	0	0	1481	29	636	784	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	403	413	72	0	0	0	0	1576	31	677	834	0
RTOR Reduction (vph)	0	9	0	0	0	0	0	2	0	0	0	0
Lane Group Flow (vph)	291	588	0	0	0	0	0	1605	0	677	834	0
Confl. Peds. (#/hr)			65				61		16	16		61
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	7%	2%	2%	9%	2%
Turn Type	Split									Prot		
Protected Phases	4	4						10		9	14	
Permitted Phases												
Actuated Green, G (s)	28.7	28.7						36.3		22.8	68.4	
Effective Green, g (s)	31.3	31.3						41.6		25.1	70.7	
Actuated g/C Ratio	0.28	0.28						0.38		0.23	0.64	
Clearance Time (s)	6.6	6.6						9.3		6.3	6.3	
Lane Grp Cap (vph)	429	870						1712		734	1994	
v/s Ratio Prot	c0.19	0.19						c0.35		c0.21	0.27	
v/s Ratio Perm												
v/c Ratio	0.68	0.68						0.94		0.92	0.42	
Uniform Delay, d1	34.9	34.9						32.9		41.5	9.6	
Progression Factor	1.00	1.00						0.31		0.77	0.32	
Incremental Delay, d2	8.4	4.2						10.5		18.0	0.6	
Delay (s)	43.3	39.0						20.8		49.7	3.7	
Level of Service	D	D						C		D	A	
Approach Delay (s)		40.4			0.0			20.8			24.3	
Approach LOS		D			A			C			C	

Intersection Summary			
HCM Average Control Delay	26.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.85		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	84.0%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)			4.0			4.0	4.0	4.0			4.0	4.0
Lane Util. Factor			1.00			1.00	1.00	0.91			0.95	1.00
Frpb, ped/bikes			0.99			0.97	1.00	1.00			1.00	0.90
Flpb, ped/bikes			1.00			1.00	1.00	1.00			1.00	1.00
Frt			0.86			0.86	1.00	1.00			1.00	0.85
Flt Protected			1.00			1.00	0.95	1.00			1.00	1.00
Satd. Flow (prot)			1489			1461	1654	4526			3103	1016
Flt Permitted			1.00			1.00	0.23	1.00			1.00	1.00
Satd. Flow (perm)			1489			1461	406	4526			3103	1016
Volume (vph)	0	0	114	0	0	143	138	1140	26	0	817	25
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	121	0	0	152	147	1213	28	0	869	27
RTOR Reduction (vph)	0	0	0	0	0	0	0	2	0	0	0	8
Lane Group Flow (vph)	0	0	121	0	0	152	147	1239	0	0	869	19
Confl. Peds. (#/hr)			5			68	78		23			78
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	7%	2%	2%	9%	2%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	60
Turn Type			custom			custom	pm+pt					Perm
Protected Phases							7	2			6	
Permitted Phases			6 7			2 7	2					6
Actuated Green, G (s)			110.0			110.0	98.3	51.3			51.3	51.3
Effective Green, g (s)			110.0			110.0	102.0	53.4			53.4	53.4
Actuated g/C Ratio			1.00			1.00	0.93	0.49			0.49	0.49
Clearance Time (s)							5.6	6.1			6.1	6.1
Lane Grp Cap (vph)			1489			1461	928	2197			1506	493
v/s Ratio Prot							c0.07	0.27			c0.28	
v/s Ratio Perm			0.08			0.10	0.08					0.02
v/c Ratio			0.08			0.10	0.16	0.56			0.58	0.04
Uniform Delay, d1			0.0			0.0	1.8	20.1			20.2	14.8
Progression Factor			1.00			1.00	10.27	0.18			1.46	1.86
Incremental Delay, d2			0.1			0.1	0.1	0.2			1.5	0.1
Delay (s)			0.1			0.1	18.1	3.8			31.1	27.7
Level of Service			A			A	B	A			C	C
Approach Delay (s)		0.1			0.1			5.3			31.0	
Approach LOS		A			A			A			C	

Intersection Summary			
HCM Average Control Delay	13.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.38		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	47.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00		1.00	1.00		0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.89		1.00	0.69		1.00	0.83	1.00	1.00	0.77
Flpb, ped/bikes	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85		1.00	0.85		1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00		1.00	1.00		1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1311	1745	1314		1745	1021		3316	1238	1658	3316	649
Flt Permitted	0.10	1.00	1.00		1.00	1.00		1.00	1.00	0.15	1.00	1.00
Satd. Flow (perm)	144	1745	1314		1745	1021		3316	1238	268	3316	649
Volume (vph)	229	377	15	0	638	218	0	857	94	207	574	227
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	244	401	16	0	679	232	0	912	100	220	611	241
RTOR Reduction (vph)	0	0	6	0	0	48	0	0	27	0	0	156
Lane Group Flow (vph)	244	401	10	0	679	184	0	912	73	220	611	85
Confl. Peds. (#/hr)	534		169	169		534			104	104		152
Heavy Vehicles (%)	29%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	79%
Turn Type	custom		custom			custom			custom	custom		custom
Protected Phases	11	10			14			12		13	16	
Permitted Phases	1		1			3			5	7		7
Actuated Green, G (s)	52.1	57.1	52.1		38.1	52.1		24.4	37.3	37.3	41.0	37.3
Effective Green, g (s)	53.4	58.4	53.4		39.4	53.4		27.0	38.6	38.6	43.6	38.6
Actuated g/C Ratio	0.49	0.53	0.49		0.36	0.49		0.25	0.35	0.35	0.40	0.35
Clearance Time (s)	5.3	5.3	5.3		5.3	5.3		6.6	5.3	6.6	6.6	5.3
Lane Grp Cap (vph)	229	926	638		625	496		814	434	253	1314	228
v/s Ratio Prot	c0.15	0.23			c0.39			c0.28		c0.10	0.18	
v/s Ratio Perm	0.37		0.01			0.18			0.06	0.20		0.13
v/c Ratio	1.07	0.43	0.02		1.09	0.37		1.12	0.17	0.87	0.46	0.37
Uniform Delay, d1	43.9	15.7	14.7		35.3	17.8		41.5	24.6	44.0	24.6	26.6
Progression Factor	1.00	1.00	1.00		1.00	1.00		1.00	1.00	0.62	0.63	1.79
Incremental Delay, d2	77.9	1.5	0.0		61.7	2.1		70.1	0.8	28.5	1.1	4.1
Delay (s)	121.8	17.2	14.7		97.0	19.9		111.6	25.5	55.9	16.5	51.7
Level of Service	F	B	B		F	B		F	C	E	B	D
Approach Delay (s)		55.7			77.4			103.1			32.5	
Approach LOS		E			E			F			C	

Intersection Summary			
HCM Average Control Delay	67.4	HCM Level of Service	E
HCM Volume to Capacity ratio	0.99		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	99.3%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

105: Cathcart Street & King Edward Avenue Performance by movement

Movement	NBT	SBT	SER	All
Delay / Veh (s)	2.0	1.2	8.7	1.8

106: Bruyere Street & King Edward Avenue Performance by movement

Movement	NBT	SBT	All
Delay / Veh (s)	4.4	2.8	3.8

107: St. Andrew Street & King Edward Avenue Performance by movement

Movement	WBL	WBR	NBT	NBR	SBT	All
Delay / Veh (s)	38.6	9.3	12.2	5.0	10.0	11.5

108: Guigues Ave & King Edward Avenue Performance by movement

Movement	NBT	NBR	SBT	All
Delay / Veh (s)	5.4	2.2	1.3	3.8

109: St. Patrick Street & King Edward Avenue Performance by movement

Movement	WBL	WBT	WBR	NBT	SBT	SBR	All
Delay / Veh (s)	27.7	20.7	61.4	8.8	6.7	1.9	20.0

110: Murray Street & King Edward Avenue Performance by movement

Movement	EBL	EBT	EBR	NBT	NBR	SBL	SBT	All
Delay / Veh (s)	36.3	35.6	25.9	26.5	9.9	37.1	3.5	25.4

111: Clarence Street & King Edward Avenue Performance by movement

Movement	WBR	NBT	SBT	SBR	All
Delay / Veh (s)	9.4	2.1	2.4	1.6	3.0

112: York Street & King Edward Avenue Performance by movement

Movement	EBR	WBR	NBL	NBT	NBR	SBT	SBR	All
Delay / Veh (s)	3.0	1.5	10.9	9.8	3.4	37.0	19.3	19.1

113: George Street & King Edward Avenue Performance by movement

Movement	EBR	NBT	SBT	All
Delay / Veh (s)	1303.5	1.6	15.8	41.9

114: Rideau Street & King Edward Avenue Performance by movement

Movement	EBL	EBT	EBR	WBT	WBR	NBT	NBR	SBL	SBT	SBR	All
Delay / Veh (s)	272.6	164.3	184.3	1064.4	1057.4	707.3	674.4	181.1	25.3	19.9	474.6

700: St. Patrick Street & Murray Street Performance by movement

Movement	NBL	NBT	SBR	All
Delay / Veh (s)	6.8	3.6	471.0	239.9

Total Network Performance

Delay / Veh (s)	379.0

Intersection: 105: Cathcart Street & King Edward Avenue

Movement	SB	SB	SE
Directions Served	T	T	R
Maximum Queue (m)	0.4	6.2	11.8
Average Queue (m)	0.0	0.4	2.0
95th Queue (m)	0.3	5.8	7.4
Link Distance (m)	39.5	39.5	38.7
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (m)			
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 106: Bruyere Street & King Edward Avenue

Movement	NB	NB	NB	SB	SB
Directions Served	T	T	TR	T	T
Maximum Queue (m)	65.9	90.2	82.5	79.2	53.4
Average Queue (m)	8.4	28.3	11.1	14.0	5.1
95th Queue (m)	42.7	88.6	50.9	51.7	29.0
Link Distance (m)	67.5	67.5	67.5	68.9	68.9
Upstream Blk Time (%)	0	2	0	0	0
Queuing Penalty (veh)	0	15	2	3	0
Storage Bay Dist (m)					
Storage Blk Time (%)					
Queuing Penalty (veh)					

Intersection: 107: St. Andrew Street & King Edward Avenue

Movement	WB	NB	NB	NB	SB	SB
Directions Served	LR	T	T	TR	T	T
Maximum Queue (m)	16.9	65.0	66.1	65.4	88.8	87.0
Average Queue (m)	4.9	58.5	62.6	48.0	74.8	49.7
95th Queue (m)	13.3	72.4	68.0	71.2	102.0	82.9
Link Distance (m)	215.7	43.2	43.2	43.2	67.5	67.5
Upstream Blk Time (%)		21	33	10	10	1
Queuing Penalty (veh)		179	285	89	72	9
Storage Bay Dist (m)						
Storage Blk Time (%)						
Queuing Penalty (veh)						

Intersection: 108: Guigues Ave & King Edward Avenue

Movement	NB	NB	NB
Directions Served	T	T	TR
Maximum Queue (m)	58.6	64.7	40.1
Average Queue (m)	19.3	25.6	6.2
95th Queue (m)	51.8	58.1	25.4
Link Distance (m)	71.8	71.8	71.8
Upstream Blk Time (%)	0	0	0
Queuing Penalty (veh)	0	2	0
Storage Bay Dist (m)			
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 109: St. Patrick Street & King Edward Avenue

Movement	WB	WB	WB	WB	NB	NB	NB	SB	SB	SB	SB	SB
Directions Served	LT	T	R	R	T	T	T	T	T	T	T	R
Maximum Queue (m)	53.9	123.9	86.9	82.7	61.8	66.0	50.5	34.0	32.8	24.8	25.1	1.6
Average Queue (m)	28.1	118.3	85.7	79.4	36.5	35.0	25.2	8.3	10.9	6.6	6.7	0.1
95th Queue (m)	47.2	131.6	86.7	94.5	53.1	55.8	43.4	25.9	27.6	18.2	19.2	1.1
Link Distance (m)	87.2	87.2			69.1	69.1	69.1			71.8	71.8	
Upstream Blk Time (%)		41	17	1	0	0	0					
Queuing Penalty (veh)		273	0	0	0	1	0					
Storage Bay Dist (m)			75.0	75.0				55.0	55.0			25.0
Storage Blk Time (%)		0	46	6				0	0		0	
Queuing Penalty (veh)		2	67	8				0	0		0	

Intersection: 110: Murray Street & King Edward Avenue

Movement	EB	EB	EB	NB	NB	NB	SB	SB	SB	SB
Directions Served	L	LT	TR	T	T	TR	L	L	T	T
Maximum Queue (m)	80.7	74.6	68.9	83.3	82.2	81.1	75.1	73.1	24.4	29.7
Average Queue (m)	52.7	50.6	43.1	67.7	67.8	55.4	59.3	63.6	9.8	8.7
95th Queue (m)	75.0	69.9	64.3	87.6	85.9	80.7	79.9	81.8	21.4	23.3
Link Distance (m)	134.6	134.6	134.6	60.2	60.2	60.2	69.1	69.1	69.1	69.1
Upstream Blk Time (%)				9	10	5	5	9		
Queuing Penalty (veh)				47	52	23	18	31		
Storage Bay Dist (m)										
Storage Blk Time (%)										
Queuing Penalty (veh)										

Intersection: 111: Clarence Street & King Edward Avenue

Movement	WB	NB	NB	NB	SB	SB
Directions Served	R	T	T	TR	T	T
Maximum Queue (m)	46.0	35.9	29.9	17.1	35.0	35.3
Average Queue (m)	19.6	5.6	4.1	1.1	4.8	7.5
95th Queue (m)	36.3	22.3	17.9	8.5	20.8	26.5
Link Distance (m)	148.7	63.8	63.8	63.8	60.2	60.2
Upstream Blk Time (%)						
Queuing Penalty (veh)						
Storage Bay Dist (m)						
Storage Blk Time (%)						2
Queuing Penalty (veh)						0

Intersection: 112: York Street & King Edward Avenue

Movement	EB	WB	NB	NB	NB	NB	SB	SB	SB
Directions Served	R	R	L	T	T	TR	T	T	R
Maximum Queue (m)	23.6	20.4	35.0	42.2	39.8	29.0	85.8	88.8	34.0
Average Queue (m)	5.9	4.9	15.1	19.9	19.5	11.0	70.7	75.4	5.6
95th Queue (m)	16.8	14.5	29.0	34.4	32.7	23.9	93.1	94.5	22.1
Link Distance (m)	123.4	145.6		139.4	139.4	139.4	63.8	63.8	
Upstream Blk Time (%)							20	26	
Queuing Penalty (veh)							82	109	
Storage Bay Dist (m)			65.0						25.0
Storage Blk Time (%)								47	
Queuing Penalty (veh)								12	

Intersection: 113: George Street & King Edward Avenue

Movement	EB	SB	SB	SB	SB
Directions Served	R	T	T	T	TR
Maximum Queue (m)	62.3	34.2	99.0	78.7	58.8
Average Queue (m)	42.0	21.5	45.4	31.9	4.5
95th Queue (m)	81.6	44.8	124.9	104.4	28.8
Link Distance (m)	61.8		139.4	139.4	139.4
Upstream Blk Time (%)	51		3	0	
Queuing Penalty (veh)	0		9	0	
Storage Bay Dist (m)		24.0			
Storage Blk Time (%)		37	1		
Queuing Penalty (veh)		85	1		

Intersection: 114: Rideau Street & King Edward Avenue

Movement	EB	EB	EB	WB	WB	NB	NB	NB	SB	SB	SB	SB
Directions Served	L	T	R	T	R	T	T	R	L	T	T	R
Maximum Queue (m)	98.5	316.5	32.0	156.6	34.0	78.0	78.3	29.8	86.1	61.0	65.3	82.0
Average Queue (m)	84.9	193.5	3.1	153.8	21.0	72.4	72.7	9.5	72.7	29.2	32.2	42.8
95th Queue (m)	113.2	404.8	16.2	155.4	42.5	75.1	75.2	27.5	108.5	53.3	55.3	78.3
Link Distance (m)		333.4		149.1		67.9	67.9		63.5	63.5	63.5	63.5
Upstream Blk Time (%)		20		55		68	69		66	0	1	5
Queuing Penalty (veh)		0		0		0	0		168	1	2	13
Storage Bay Dist (m)	85.0		25.0		25.0			22.0				
Storage Blk Time (%)	39	24	0	61	2		73	1				
Queuing Penalty (veh)	152	60	0	132	10		68	3				

Intersection: 700: St. Patrick Street & Murray Street

Movement	NB	NB	SB	SB
Directions Served	LT	T	R	R
Maximum Queue (m)	64.8	56.4	176.8	183.1
Average Queue (m)	26.8	13.3	18.6	177.1
95th Queue (m)	58.7	45.4	103.2	196.9
Link Distance (m)	119.5	119.5	173.9	173.9
Upstream Blk Time (%)			0	51
Queuing Penalty (veh)			0	0
Storage Bay Dist (m)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Nework Summary

Network wide Queuing Penalty: 2088

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0		4.0			4.0
Lane Util. Factor	1.00		0.95			0.95
Frpb, ped/bikes	0.94		1.00			1.00
Flpb, ped/bikes	1.00		1.00			1.00
Frt	0.93		1.00			1.00
Flt Protected	0.98		1.00			1.00
Satd. Flow (prot)	1497		3249			2941
Flt Permitted	0.98		1.00			1.00
Satd. Flow (perm)	1497		3249			2941
Volume (vph)	11	11	2588	12	0	1387
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	12	12	2753	13	0	1476
RTOR Reduction (vph)	7	0	0	0	0	0
Lane Group Flow (vph)	17	0	2766	0	0	1476
Confl. Peds. (#/hr)		58		23		
Heavy Vehicles (%)	2%	2%	4%	2%	2%	15%
Turn Type						
Protected Phases			2			6
Permitted Phases	8					
Actuated Green, G (s)	23.0		115.1			115.1
Effective Green, g (s)	24.9		117.1			117.1
Actuated g/C Ratio	0.17		0.78			0.78
Clearance Time (s)	5.9		6.0			6.0
Lane Grp Cap (vph)	249		2536			2296
v/s Ratio Prot			c0.85			0.50
v/s Ratio Perm	c0.01					
v/c Ratio	0.07		1.09			0.64
Uniform Delay, d1	52.8		16.5			7.2
Progression Factor	1.00		0.59			1.00
Incremental Delay, d2	0.5		41.5			1.4
Delay (s)	53.3		51.2			8.6
Level of Service	D		D			A
Approach Delay (s)	53.3		51.2			8.6
Approach LOS	D		D			A

Intersection Summary			
HCM Average Control Delay	36.5	HCM Level of Service	D
HCM Volume to Capacity ratio	0.91		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	95.9%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)					4.0	4.0		4.0			4.0	4.0
Lane Util. Factor					0.95	0.88		0.95			0.86	1.00
Frpb, ped/bikes					1.00	0.98		1.00			1.00	1.00
Flpb, ped/bikes					1.00	1.00		1.00			1.00	1.00
Frt					1.00	0.85		1.00			1.00	0.85
Flt Protected					0.99	1.00		1.00			1.00	1.00
Satd. Flow (prot)					3290	2563		3221			5325	1483
Flt Permitted					0.99	1.00		1.00			1.00	1.00
Satd. Flow (perm)					3290	2563		3221			5325	1483
Volume (vph)	0	0	0	46	291	993	0	1860	0	0	1374	24
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	0	49	310	1056	0	1979	0	0	1462	26
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	7
Lane Group Flow (vph)	0	0	0	0	359	1056	0	1979	0	0	1462	19
Confl. Peds. (#/hr)				4		5						
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	5%	2%	2%	15%	2%
Turn Type				Perm		custom						Perm
Protected Phases					4	1		2			6	
Permitted Phases				4		4						6
Actuated Green, G (s)					28.7	52.0		79.8			105.4	105.4
Effective Green, g (s)					31.3	56.3		81.7			110.7	110.7
Actuated g/C Ratio					0.21	0.38		0.54			0.74	0.74
Clearance Time (s)					6.6	5.7		5.9			9.3	9.3
Lane Grp Cap (vph)					687	1030		1754			3930	1094
v/s Ratio Prot						c0.17		c0.61			0.27	
v/s Ratio Perm					0.11	0.24						0.01
v/c Ratio					0.52	1.03		1.13			0.37	0.02
Uniform Delay, d1					52.7	46.9		34.1			7.1	5.2
Progression Factor					0.98	0.97		0.25			0.37	0.38
Incremental Delay, d2					2.8	34.6		58.5			0.2	0.0
Delay (s)					54.3	80.1		67.2			2.9	2.0
Level of Service					D	F		E			A	A
Approach Delay (s)		0.0			73.5			67.2			2.8	
Approach LOS		A			E			E			A	

Intersection Summary			
HCM Average Control Delay	49.4	HCM Level of Service	D
HCM Volume to Capacity ratio	1.08		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	127.4%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0	4.0						4.0		4.0	4.0	
Lane Util. Factor	0.91	0.91						0.95		0.97	0.95	
Frpb, ped/bikes	1.00	0.99						1.00		1.00	1.00	
Flpb, ped/bikes	1.00	1.00						1.00		1.00	1.00	
Frt	1.00	0.98						1.00		1.00	1.00	
Flt Protected	0.95	0.99						1.00		0.95	1.00	
Satd. Flow (prot)	1509	3048						3150		3216	2727	
Flt Permitted	0.95	0.99						1.00		0.95	1.00	
Satd. Flow (perm)	1509	3048						3150		3216	2727	
Volume (vph)	379	388	68	0	0	0	0	1481	29	636	784	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	403	413	72	0	0	0	0	1576	31	677	834	0
RTOR Reduction (vph)	0	7	0	0	0	0	0	1	0	0	0	0
Lane Group Flow (vph)	291	590	0	0	0	0	0	1606	0	677	834	0
Confl. Peds. (#/hr)			65						16	16		61
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	7%	2%	2%	24%	2%
Turn Type	Split									Prot		
Protected Phases	4	4						10		9	14	
Permitted Phases												
Actuated Green, G (s)	28.7	28.7						69.0		30.1	108.4	
Effective Green, g (s)	31.3	31.3						74.3		32.4	110.7	
Actuated g/C Ratio	0.21	0.21						0.50		0.22	0.74	
Clearance Time (s)	6.6	6.6						9.3		6.3	6.3	
Lane Grp Cap (vph)	315	636						1560		695	2013	
v/s Ratio Prot	0.19	c0.19						c0.51		c0.21	0.31	
v/s Ratio Perm												
v/c Ratio	0.92	0.93						1.03		0.97	0.41	
Uniform Delay, d1	58.2	58.2						37.9		58.4	7.4	
Progression Factor	1.00	1.00						0.61		0.87	0.15	
Incremental Delay, d2	34.5	21.7						27.2		27.4	0.6	
Delay (s)	92.7	80.0						50.3		78.0	1.7	
Level of Service	F	E						D		E	A	
Approach Delay (s)		84.1			0.0			50.3			35.9	
Approach LOS		F			A			D			D	

Intersection Summary			
HCM Average Control Delay	52.4	HCM Level of Service	D
HCM Volume to Capacity ratio	0.99		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	127.4%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)			4.0			4.0	4.0	4.0			4.0	
Lane Util. Factor			1.00			1.00	1.00	0.95			0.95	
Frpb, ped/bikes			0.99			0.97	1.00	1.00			1.00	
Flpb, ped/bikes			1.00			1.00	1.00	1.00			1.00	
Frt			0.86			0.86	1.00	1.00			1.00	
Flt Protected			1.00			1.00	0.95	1.00			1.00	
Satd. Flow (prot)			1489			1461	1655	3150			2742	
Flt Permitted			1.00			1.00	0.21	1.00			1.00	
Satd. Flow (perm)			1489			1461	363	3150			2742	
Volume (vph)	0	0	114	0	0	143	138	1140	26	0	817	25
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	0	0	121	0	0	152	147	1213	28	0	869	27
RTOR Reduction (vph)	0	0	0	0	0	0	0	2	0	0	3	0
Lane Group Flow (vph)	0	0	121	0	0	152	147	1239	0	0	893	0
Confl. Peds. (#/hr)			5			68	78		23			78
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	7%	2%	2%	23%	2%
Turn Type			custom			custom	pm+pt					
Protected Phases							7	2			6	
Permitted Phases			6 7			2 7	2					
Actuated Green, G (s)			75.0			75.0	63.3	30.3			30.3	
Effective Green, g (s)			75.0			75.0	67.0	32.4			32.4	
Actuated g/C Ratio			1.00			1.00	0.89	0.43			0.43	
Clearance Time (s)							5.6	6.1			6.1	
Lane Grp Cap (vph)			1489			1461	920	1361			1185	
v/s Ratio Prot							c0.07	c0.39			0.33	
v/s Ratio Perm			0.08			0.10	0.07					
v/c Ratio			0.08			0.10	0.16	0.91			0.75	
Uniform Delay, d1			0.0			0.0	1.6	19.9			17.9	
Progression Factor			1.00			1.00	1.00	1.00			0.84	
Incremental Delay, d2			0.1			0.1	0.4	10.6			4.1	
Delay (s)			0.1			0.1	2.0	30.6			19.1	
Level of Service			A			A	A	C			B	
Approach Delay (s)		0.1			0.1			27.5			19.1	
Approach LOS		A			A			C			B	

Intersection Summary			
HCM Average Control Delay	21.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	57.5%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00		1.00	1.00		0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.88		1.00	0.69		1.00	0.84	1.00	1.00	0.77
Flpb, ped/bikes	1.00	1.00	1.00		1.00	1.00		1.00	1.00	0.99	1.00	1.00
Frt	1.00	1.00	0.85		1.00	0.85		1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00		1.00	1.00		1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1305	1745	1307		1745	1016		3316	1241	1649	3316	652
Flt Permitted	0.11	1.00	1.00		1.00	1.00		1.00	1.00	0.17	1.00	1.00
Satd. Flow (perm)	155	1745	1307		1745	1016		3316	1241	302	3316	652
Volume (vph)	229	377	15	0	638	218	0	857	94	207	574	227
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	244	401	16	0	679	232	0	912	100	220	611	241
RTOR Reduction (vph)	0	0	6	0	0	53	0	0	29	0	0	151
Lane Group Flow (vph)	244	401	10	0	679	179	0	912	71	220	611	90
Confl. Peds. (#/hr)	534		169	169		534			104	104		152
Heavy Vehicles (%)	29%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	79%
Turn Type	custom		custom			custom			custom	custom		custom
Protected Phases	11	10			14			12		13	16	
Permitted Phases	1		1			3			5	7		7
Actuated Green, G (s)	45.1	50.1	45.1		35.1	45.1		21.4	34.3	34.3	38.0	34.3
Effective Green, g (s)	46.4	51.4	46.4		36.4	46.4		24.0	35.6	35.6	40.6	35.6
Actuated g/C Ratio	0.46	0.51	0.46		0.36	0.46		0.24	0.36	0.36	0.41	0.36
Clearance Time (s)	5.3	5.3	5.3		5.3	5.3		6.6	5.3	6.6	6.6	5.3
Lane Grp Cap (vph)	198	897	606		635	471		796	442	277	1346	232
v/s Ratio Prot	c0.14	0.23			c0.39			c0.28		c0.10	0.18	
v/s Ratio Perm	c0.43		0.01			0.18			0.06	0.18		0.14
v/c Ratio	1.23	0.45	0.02		1.07	0.38		1.15	0.16	0.79	0.45	0.39
Uniform Delay, d1	40.4	15.3	14.5		31.8	17.5		38.0	22.0	38.7	21.6	24.0
Progression Factor	1.00	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	140.4	1.6	0.1		55.7	2.3		80.1	0.8	20.5	1.1	4.8
Delay (s)	180.8	16.9	14.5		87.5	19.8		118.1	22.8	59.2	22.7	28.8
Level of Service	F	B	B		F	B		F	C	E	C	C
Approach Delay (s)		77.4			70.2			108.7			31.6	
Approach LOS		E			E			F			C	

Intersection Summary			
HCM Average Control Delay	70.8	HCM Level of Service	E
HCM Volume to Capacity ratio	1.08		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	99.3%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

105: Cathcart Street & King Edward Avenue Performance by movement

Movement	NBT	SBT	SER	All
Delay / Veh (s)	1.6	2.9	55.2	2.9

106: Bruyere Street & King Edward Avenue Performance by movement

Movement	NBT	SBT	All
Delay / Veh (s)	1.6	5.9	3.3

107: St. Andrew Street & King Edward Avenue Performance by movement

Movement	WBL	WBR	NBT	NBR	SBT	All
Delay / Veh (s)	73.1	28.0	7.0	5.2	11.4	9.0

108: Guigues Ave & King Edward Avenue Performance by movement

Movement	NBT	NBR	SBT	All
Delay / Veh (s)	6.6	6.1	4.9	6.0

109: St. Patrick Street & King Edward Avenue Performance by movement

Movement	WBL	WBT	WBR	NBT	SBT	SBR	All
Delay / Veh (s)	66.7	60.6	92.1	10.0	25.1	1.2	33.6

110: Murray Street & King Edward Avenue Performance by movement

Movement	EBL	EBT	EBR	NBT	NBR	SBL	SBT	All
Delay / Veh (s)	65.9	70.9	60.7	33.5	28.8	69.1	2.2	40.9

111: Clarence Street & King Edward Avenue Performance by movement

Movement	WBR	NBT	SBT	SBR	All
Delay / Veh (s)	603.8	18.9	1.6	1.2	67.6

112: York Street & King Edward Avenue Performance by movement

Movement	EBR	WBR	NBL	NBT	NBR	SBT	SBR	All
Delay / Veh (s)	4.1	14.6	11.9	28.2	27.0	15.9	14.1	20.4

113: George Street & King Edward Avenue Performance by movement

Movement	EBR	NBT	SBT	All
Delay / Veh (s)	257.9	1.5	13.0	16.0

114: Rideau Street & King Edward Avenue Performance by movement

Movement	EBL	EBT	EBR	WBT	WBR	NBT	NBR	SBL	SBT	SBR	All
Delay / Veh (s)	734.2	579.4	503.9	906.2	903.7	708.9	682.8	155.8	26.6	21.0	519.2

700: St. Patrick Street & Murray Street Performance by movement

Movement	NBL	NBT	SBR	All
Delay / Veh (s)	6.2	3.8	1183.2	550.8

Total Network Performance

Delay / Veh (s)	557.8

Intersection: 105: Cathcart Street & King Edward Avenue

Movement	SB	SB	SE
Directions Served	T	T	R
Maximum Queue (m)	28.1	31.0	20.3
Average Queue (m)	5.9	4.7	5.2
95th Queue (m)	29.7	26.3	21.9
Link Distance (m)	39.5	39.5	38.7
Upstream Blk Time (%)	3	1	6
Queuing Penalty (veh)	0	0	0
Storage Bay Dist (m)			
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 106: Bruyere Street & King Edward Avenue

Movement	SB	SB
Directions Served	T	T
Maximum Queue (m)	94.0	91.3
Average Queue (m)	32.5	18.2
95th Queue (m)	101.2	76.4
Link Distance (m)	68.9	68.9
Upstream Blk Time (%)	7	2
Queuing Penalty (veh)	52	15
Storage Bay Dist (m)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 107: St. Andrew Street & King Edward Avenue

Movement	WB	NB	NB	SB	SB
Directions Served	LR	T	TR	T	T
Maximum Queue (m)	19.7	64.1	64.4	89.9	90.1
Average Queue (m)	6.0	61.3	61.0	75.9	55.4
95th Queue (m)	15.8	70.6	70.7	104.0	88.4
Link Distance (m)	219.2	43.2	43.2	67.5	67.5
Upstream Blk Time (%)		19	18	18	3
Queuing Penalty (veh)		242	234	126	18
Storage Bay Dist (m)					
Storage Blk Time (%)					
Queuing Penalty (veh)					

Intersection: 108: Guigues Ave & King Edward Avenue

Movement	NB	NB	SB	SB
Directions Served	T	TR	T	T
Maximum Queue (m)	85.2	82.9	41.9	31.8
Average Queue (m)	57.0	55.1	22.0	5.3
95th Queue (m)	97.5	95.5	67.1	28.2
Link Distance (m)	71.7	71.7	43.2	43.2
Upstream Blk Time (%)	4	4	15	0
Queuing Penalty (veh)	60	57	103	1
Storage Bay Dist (m)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 109: St. Patrick Street & King Edward Avenue

Movement	WB	WB	WB	WB	NB	NB	SB	SB	SB	SB	SB
Directions Served	LT	T	R	R	T	T	T	T	T	T	R
Maximum Queue (m)	66.4	127.5	86.0	82.7	76.7	79.6	57.3	61.1	85.0	60.9	15.6
Average Queue (m)	37.4	121.0	85.4	79.9	62.6	58.3	42.0	45.9	52.0	26.3	0.5
95th Queue (m)	57.9	133.4	87.3	86.2	84.5	84.1	79.3	84.2	115.8	53.0	9.3
Link Distance (m)	90.7	90.7			69.2	69.2			71.7	71.7	
Upstream Blk Time (%)	0	49	13		5	3		0	19	0	
Queuing Penalty (veh)	0	328	0		42	28		0	136	0	
Storage Bay Dist (m)			75.0	75.0			55.0	55.0			60.0
Storage Blk Time (%)		0	52	32			15	25	0	0	
Queuing Penalty (veh)		0	76	46			52	85	0	0	

Intersection: 110: Murray Street & King Edward Avenue

Movement	EB	EB	EB	NB	NB	SB	SB	SB	SB
Directions Served	L	LT	TR	T	TR	L	L	T	T
Maximum Queue (m)	100.8	107.3	105.4	86.5	84.2	75.7	75.5	20.0	23.2
Average Queue (m)	69.6	77.3	71.0	79.9	80.9	70.1	71.4	5.4	4.1
95th Queue (m)	97.8	103.2	98.7	85.8	84.5	78.6	77.5	14.8	14.4
Link Distance (m)	134.6	134.6	134.6	60.3	60.3	69.2	69.2	69.2	69.2
Upstream Blk Time (%)				36	43	35	38		
Queuing Penalty (veh)				274	324	126	135		
Storage Bay Dist (m)									
Storage Blk Time (%)									
Queuing Penalty (veh)									

Intersection: 111: Clarence Street & King Edward Avenue

Movement	WB	NB	NB	SB	SB
Directions Served	R	T	TR	T	TR
Maximum Queue (m)	160.2	71.7	72.0	30.0	44.4
Average Queue (m)	141.7	54.6	57.3	2.6	5.2
95th Queue (m)	191.2	76.4	78.9	15.6	24.3
Link Distance (m)	152.2	63.8	63.8	60.3	60.3
Upstream Blk Time (%)	60	10	14	0	0
Queuing Penalty (veh)	0	62	89	0	0
Storage Bay Dist (m)					
Storage Blk Time (%)					
Queuing Penalty (veh)					

Intersection: 112: York Street & King Edward Avenue

Movement	EB	WB	NB	NB	NB	SB	SB
Directions Served	R	R	L	T	TR	T	TR
Maximum Queue (m)	29.4	49.7	72.4	134.0	125.2	87.3	88.1
Average Queue (m)	8.0	16.5	16.0	75.3	76.9	44.1	58.1
95th Queue (m)	20.2	38.7	47.7	120.0	118.3	76.3	92.8
Link Distance (m)	126.9	149.1		139.3	139.3	63.8	63.8
Upstream Blk Time (%)				1	0	2	7
Queuing Penalty (veh)				3	3	8	31
Storage Bay Dist (m)			65.0				
Storage Blk Time (%)				11			
Queuing Penalty (veh)				15			

Intersection: 113: George Street & King Edward Avenue

Movement	EB	NB	SB	SB	SB
Directions Served	R	T	T	T	TR
Maximum Queue (m)	59.2	3.5	33.7	111.8	115.9
Average Queue (m)	29.1	0.1	15.1	31.2	31.0
95th Queue (m)	69.5	2.5	38.9	100.8	98.5
Link Distance (m)	61.2	63.6		139.3	139.3
Upstream Blk Time (%)	24			1	0
Queuing Penalty (veh)	0			4	0
Storage Bay Dist (m)			24.0		
Storage Blk Time (%)			23	2	
Queuing Penalty (veh)			71	6	

Intersection: 114: Rideau Street & King Edward Avenue

Movement	EB	EB	EB	WB	WB	NB	NB	NB	SB	SB	SB	SB
Directions Served	L	T	R	T	R	T	T	R	L	T	T	R
Maximum Queue (m)	98.5	343.8	32.8	158.4	32.8	76.8	78.3	29.9	86.8	83.2	76.6	84.2
Average Queue (m)	95.1	322.2	4.0	153.9	19.5	72.7	72.7	10.6	73.4	40.9	43.1	48.3
95th Queue (m)	99.6	396.2	19.0	155.7	42.0	74.7	75.2	30.3	103.8	68.9	69.1	79.4
Link Distance (m)		333.4		149.1		67.9	67.9		63.6	63.6	63.6	63.6
Upstream Blk Time (%)		53		55		72	66		57	1	2	4
Queuing Penalty (veh)		0		0		0	0		144	3	4	11
Storage Bay Dist (m)	85.0		25.0		25.0			22.0				
Storage Blk Time (%)	71	23	0	60	1		74	1				
Queuing Penalty (veh)	277	55	0	131	8		69	4				

Intersection: 700: St. Patrick Street & Murray Street

Movement	NB	NB	SB	SB
Directions Served	LT	T	R	R
Maximum Queue (m)	78.0	68.0	163.6	181.9
Average Queue (m)	23.2	9.5	10.1	178.5
95th Queue (m)	61.9	42.5	72.4	180.6
Link Distance (m)	123.0	123.0	173.9	173.9
Upstream Blk Time (%)			0	59
Queuing Penalty (veh)			0	0
Storage Bay Dist (m)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Nework Summary

Network wide Queuing Penalty: 3560