APPENDIX A. PORTAGE AND MAIN TRANSPORTATION STUDY

DILLON
CONSULTING

CITY OF WINNIPEG

Portage and Main Transportation Study

PROVINCE OF MANITOBA
08-Sept-2017
D. B.
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Member
22480
REGISTERED PROFESSIONAL ENGINEER

Certificate of Authorization
Dillon Consulting Limited (MB)
No. 1789 Date: September 8, 2017

ENGINEERS
GEOSCIENTISTS
MANITOBA

September 2017 – FINAL – 16-3623

September 8, 2017

City of Winnipeg
1155 Pacific Avenue
Winnipeg, Manitoba
R3E 3P1

Attention: Mr. Stephen Chapman, P.Eng.
Traffic Management Engineer, Public Works Department

Portage and Main Transportation Study

Dear Mr. Chapman:

Dillon Consulting Limited is proud to submit this final report detailing the microsimulation analysis of the impacts of restoring the pedestrian crossings to the intersection of Portage Avenue and Main Street.

The report includes; the approach to the technical investigation; microsimulation model creation and calibration; analysis of all tested alternatives; sensitivity analysis of pedestrian volume forecasts; conceptual design alternatives; and a Class 4 cost estimate. Note the rough schedule for completion of design and construction assumed a start date of November 1, 2016. The schedule would need to be revisited when project funding is obtained.

As requested, eight hard copies of the report are attached. Also attached are four DVD's containing a .pdf of the report, meeting minutes, site photos, and VISSIM model files.

We trust that the report meets all of your needs and look forward to collaborating again in the future.

Sincerely,

DILLON CONSULTING LIMITED

David Wiebe, P.Eng.
Project Manager, Partner

DBW:jef
Our file: 16-3623

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1.0 Introduction

The intersection of Portage Avenue and Main Street is the literal and symbolic heart of the City of Winnipeg. This is where the residents of the city gather together to celebrate, mark special occasions, and experience their city. The current intersection is almost exclusively on moving cars and trucks; and with the removal of the at-grade crosswalks in the late 1970's, pedestrians have been forced to use underground spaces to move across the intersection.

Similar situations can be seen across North America, where development throughout the 20th century focused pretty much exclusively on improving the ease and speed of moving about via cars. Cities across North America are coming to the same realisations as Winnipeg, recognising the importance of walking, biking, and transit to a sustainable and equitable city. The major challenge, of course, is repurposing, modifying, or removing large and expensive infrastructure that is important to the functioning of a busy, modern city that has grown up around it.

Within the above context, the City of Winnipeg engaged Dillon Consulting Limited (Dillon) to examine the transportation operations at Portage and Main and analyse the effects of restoring pedestrian crossings to the surface. Key City of Winnipeg staff members were assembled to work alongside Dillon in moving through the transportation analysis of a variety of options for restoration of pedestrian crossings at the intersection.

Dillon's approach to the assignment was to create a detailed and accurate transportation microsimulation model of the area surrounding Portage and Main and work with the City of Winnipeg in creating meaningful analyses of all transportation modes when pedestrians are restored to the intersection. The model and its outputs gave structure to the conversation around how best to serve the needs of all of the users of the intersection – pedestrians, autos/trucks, and buses. Results from each of the tested alternatives were discussed with City of Winnipeg's key staff members (consolidated into a Technical Steering Committee (TSC) for the project) and a preferred approach to modifying the physical layout and controls on the intersection was determined.

2.0 Existing Conditions

2.1 Description

The intersection of Portage Avenue and Main Street (Portage and Main) has been an important focal point for transportation since Portage and Main were cart trails in the 1800's. Many of Winnipeg's different street grids converge at this corner and the three tallest buildings in the city ring the intersection. The current configuration of Portage and Main dates from the late 1970's with the construction of the underground pedestrian concourse and the closing of the intersection to pedestrian crossings at ground level in 1979. Much of the existing infrastructure is almost four decades old and in need of renewal.

Portage Avenue and Main Street are both major arterial streets and regional mixed-use corridors in Winnipeg. Main Street has nine lanes north of the intersection and eight lanes south of the intersection. Portage Avenue has eight lanes west of the intersection and five lanes east of the intersection. Both streets have narrow concrete medians. Curb lanes along Main Street are diamond lanes reserved for transit and cyclists during peak periods. Right turns are permitted at Portage and Main in all four directions, but the only left turn movement permitted is from eastbound Portage turning north on to Main. The other three left turn movements are prohibited.

There are currently no pedestrian crossings permitted across any of the four legs of the intersection. This is indicated by signage and reinforced by the presence of concrete barriers between the sidewalks and the streets.

2.2 Site Visits

The project team performed three site visits to Portage and Main. The first visit was on April 13, 2016 to familiarize the team with the entire network of pedestrian and vehicular infrastructure in, around, and under the intersection. The second set of site visits took place in early June. These visits were performed to groundtruth the parking regulations on streets surrounding Portage and Main. The lengths of pedestrian paths through the underground concourse were also measured. A final site visit was performed on August 22, 2016 to groundtruth the infrastructure to be modified as part of the recommended alternative design. Selected photos from the various site visits are included on the enclosed CD and have previously been provided to the client digitally.

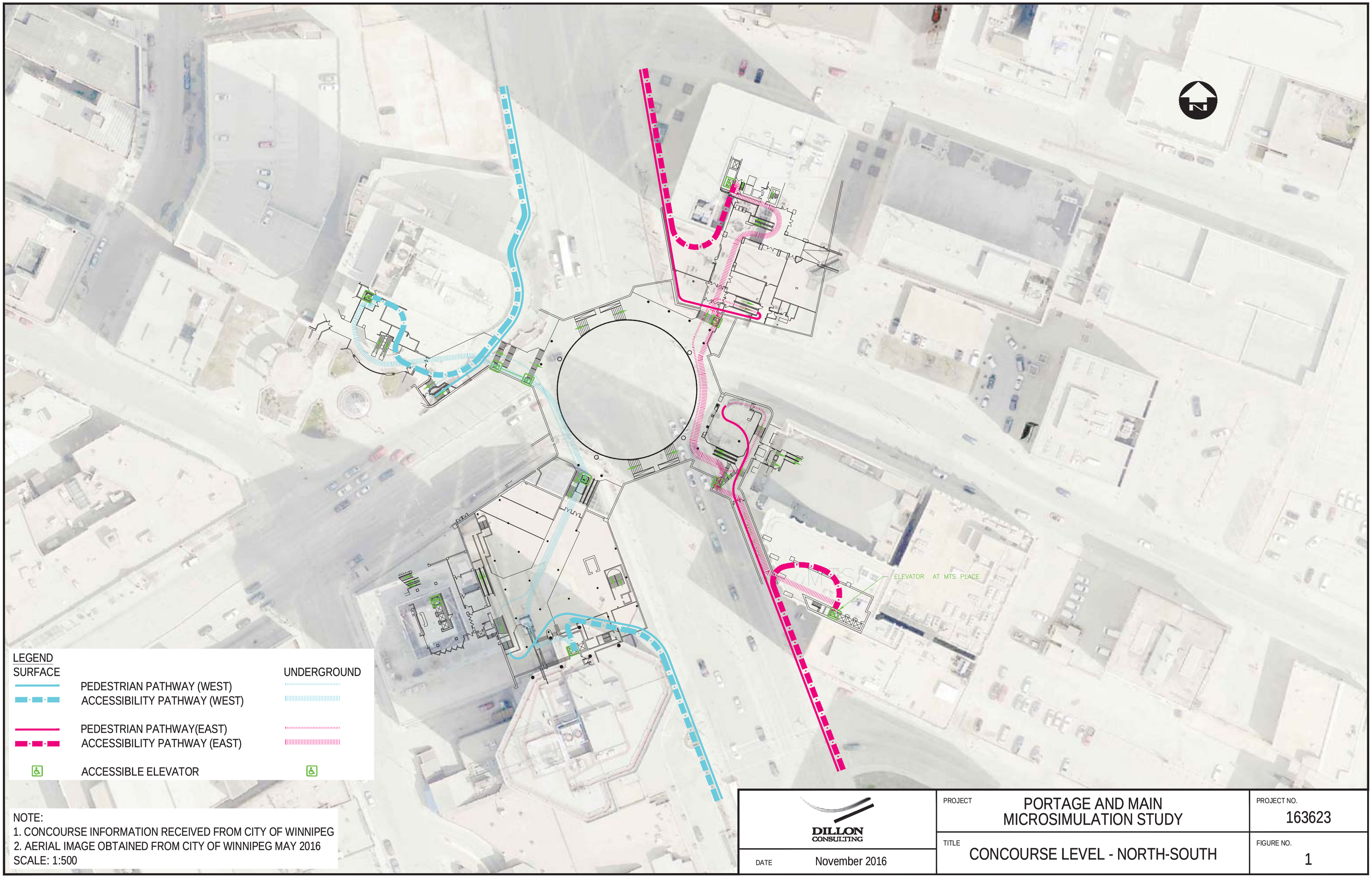
2.3 Data Sources

The project team used the following data sources provided by the City of Winnipeg and incorporated them into the VISSIM model, recommended alternative, and conclusions as appropriate:

- Municipal Accommodations Branch procured drawings – digitized hardcopies of what appears to be the circa 1976 construction plans for the concourse, as well as 360 Main Street (Winnipeg Square). They do not appear to be record drawings from after construction, so some changes may have been made during construction. Some CAD files were also present. These drawings were invaluable in determining the structure and foundation of the barrier walls, and the walking paths used in the pedestrian
- LBIS - CAD files for location of right-of-way, selected City underground utilities such as watermain/sewermain horizontal geometry
- Underground Structures Branch procured record drawings – mainly digitized hard copies of projects constructed in the public right-of-way. This also included a few CAD based drawings of various levels of detail. Note that these drawings generally had no information on the underground concourse or barrier wall construction.
- Vehicle and pedestrian counts
- Forecasts of pedestrian volumes at Portage and Main
- Traffic signal timing plans
- Transit routes and schedules
- Parking regulations (groundtruthing by Dillon)
- VISUM model of road network
- Synchro model of road network
- MioVision Camera Video of Portage and Main

2.4 Pedestrian Pathfinding

Pedestrian travel time was measured by selecting at-grade start and end points in each quadrant of the intersection. The most direct route available was determined using plans of both the public (concourse) and private infrastructure (buildings) and groundtruthed for accuracy. These paths are visible on **Figure 1** to **Figure 4**, below. All require a start point at surface grade, travel along public sidewalks, then entering the concourse, either by stairs for able bodied persons or elevators/lifts for wheelchair access. After traveling through the concourse, the pedestrians exit in the same manner, and proceed along public sidewalk to the end point.



NOTE:
1. CONCOURSE INFORMATION RECEIVED FROM CITY OF WINNIPEG
2. AERIAL IMAGE OBTAINED FROM CITY OF WINNIPEG MAY 2016
SCALE: 1:500

DILLON CONSULTING	PROJECT: PORTAGE AND MAIN MICROSIMULATION STUDY		PROJECT NO. 163623
DATE: November 2016	TITLE: CONCOURSE LEVEL - NORTH-SOUTH		FIGURE NO. 1

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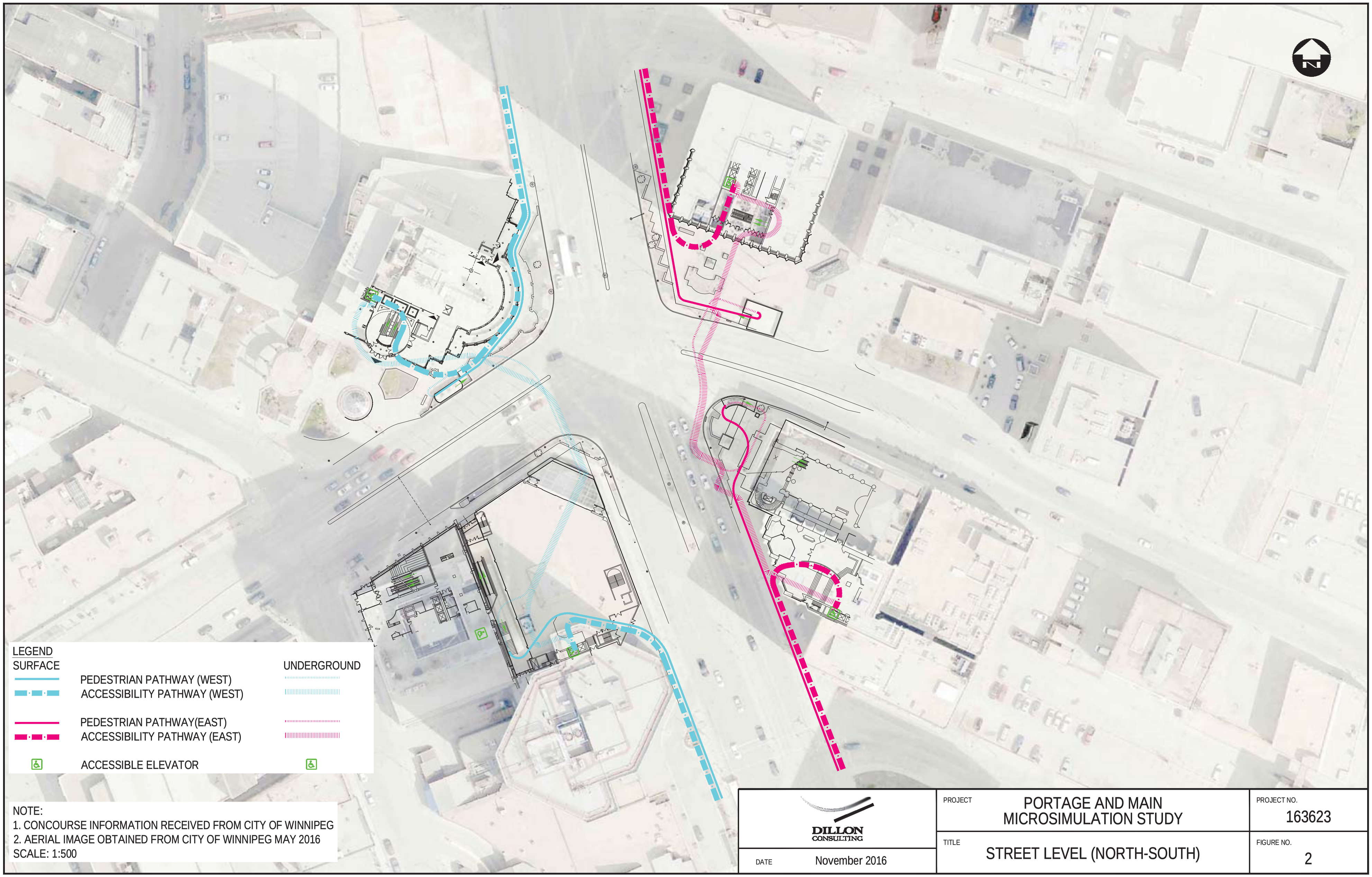

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DILLON CONSULTING	PROJECT: PORTAGE AND MAIN MICROSIMULATION STUDY	PROJECT NO. 163623
DATE: November 2016	TITLE: STREET LEVEL (NORTH-SOUTH)	FIGURE NO. 2

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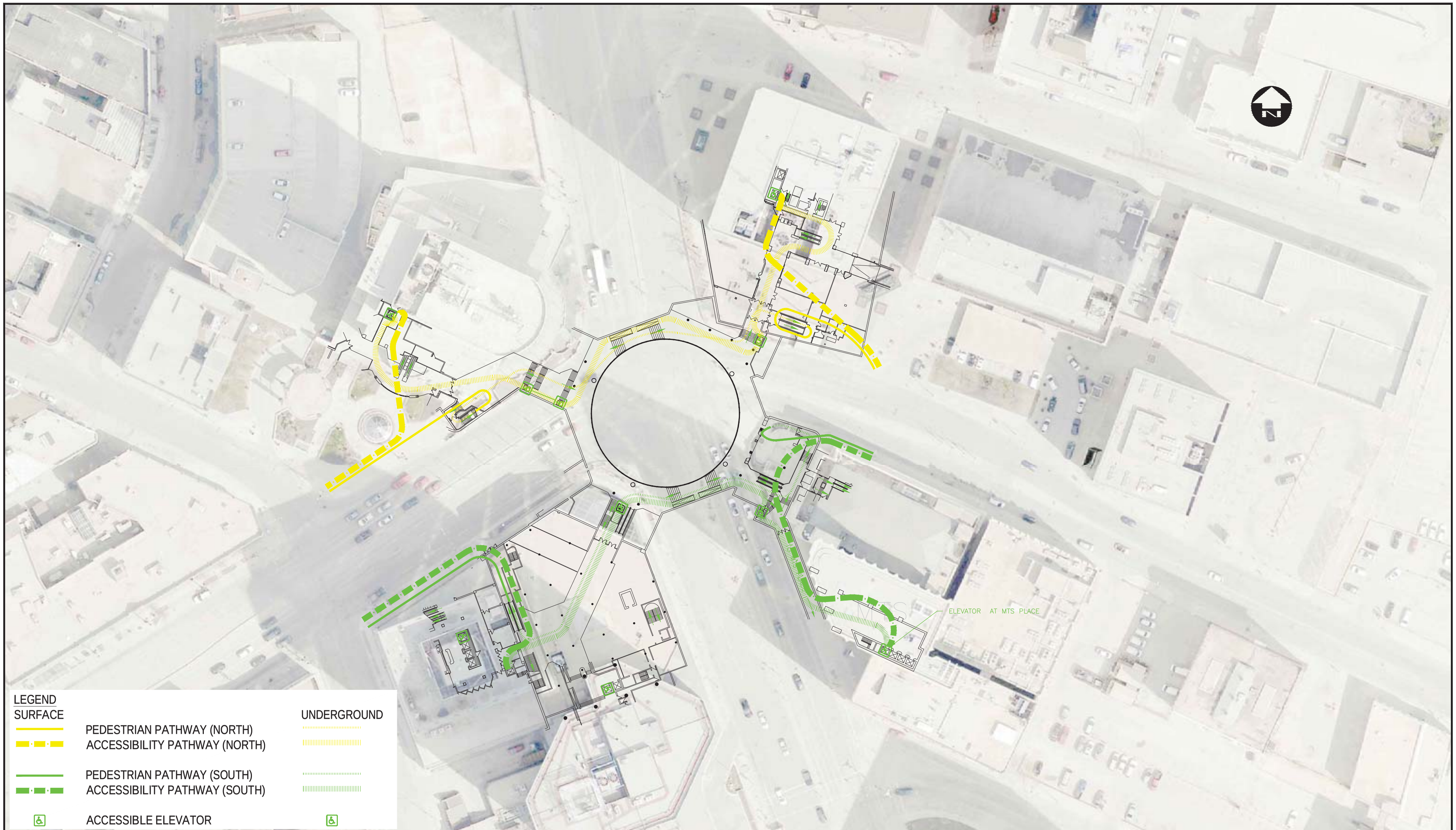

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DILLON CONSULTING

DATE November 2016	PROJECT PORTAGE AND MAIN MICROSIMULATION STUDY	PROJECT NO. 163623
	TITLE CONCOURSE LEVEL - EAST-WEST	FIGURE NO. 3

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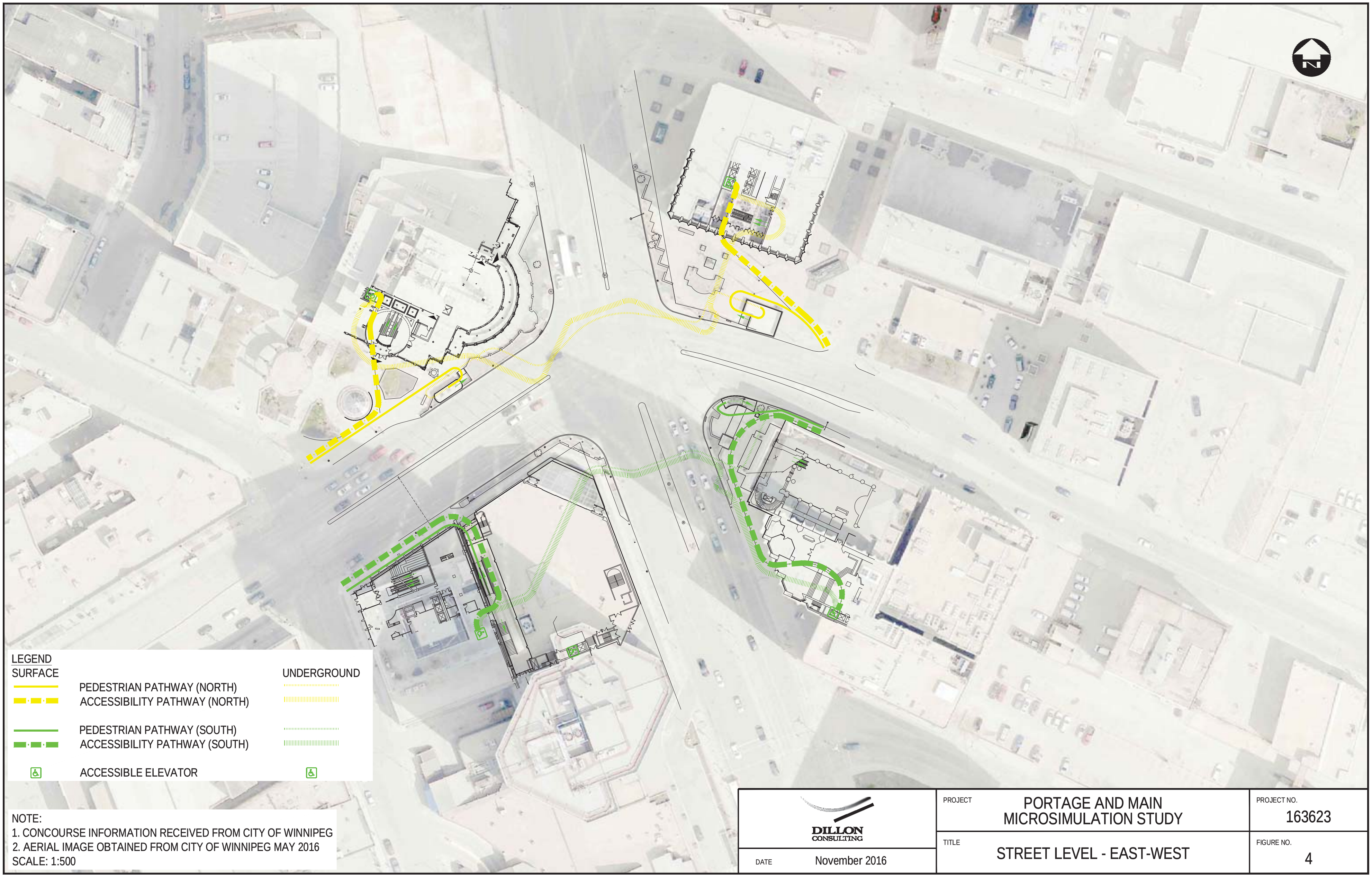

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SCALE: 1:500

DILLON CONSULTING

DATE	November 2016
PROJECT	PORTAGE AND MAIN MICROSIMULATION STUDY
TITLE	STREET LEVEL - EAST-WEST
PROJECT NO.	163623
FIGURE NO.	4

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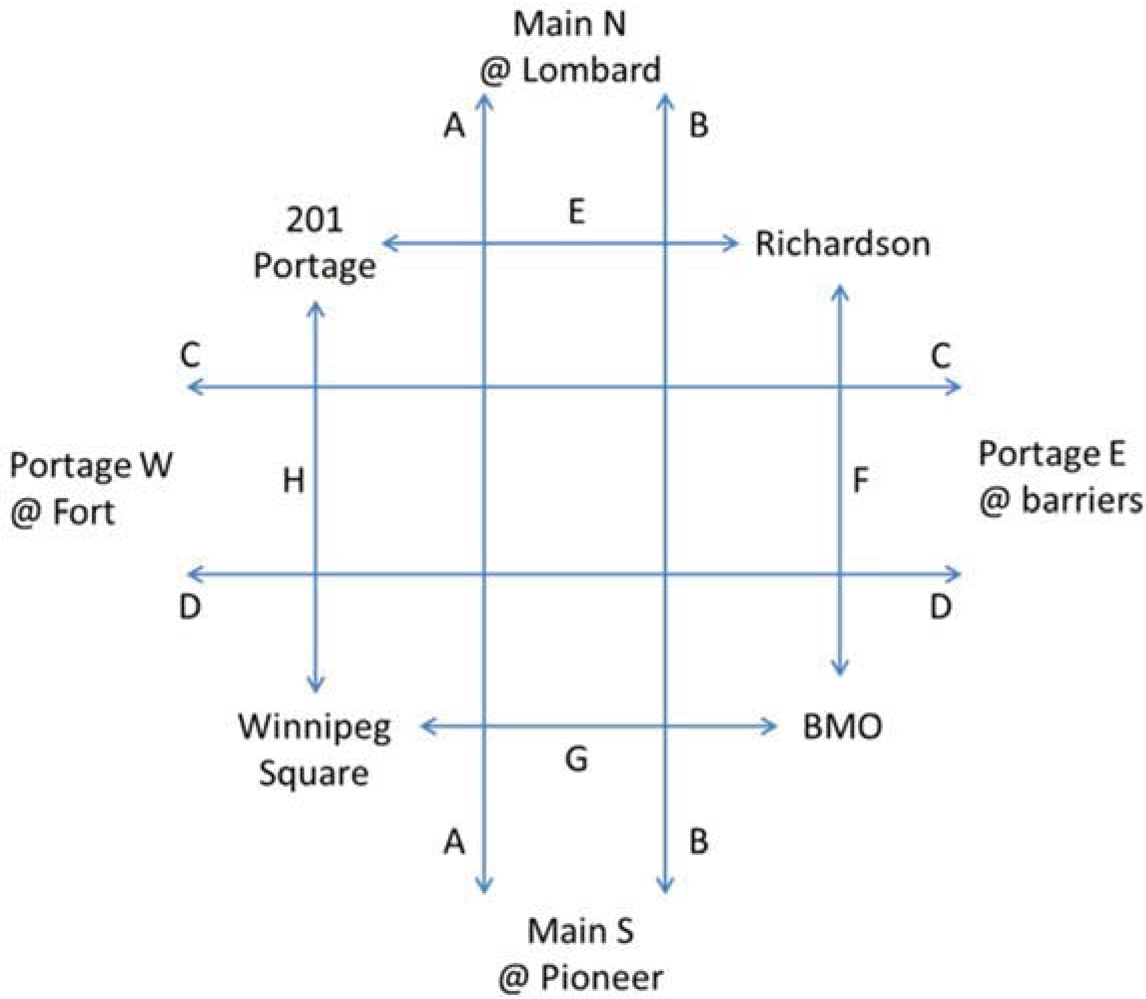
The travel times for pedestrians with the existing infrastructure at Portage and Main results in significantly more circuitous routes for pedestrians using wheelchairs or other mobility aids that cannot navigate on stairs or escalators. Current guidance from the Institute of Transportation Engineers (ITE) Toolbox on Intersection Safety and Design recommends the use of 1.07 metre per second (m/s) for wheelchair users. However, a travel speed of 1.00 m/s was assumed in calculation of travel times, as it is the crossing speed recommended by the City of Winnipeg in design of their signals. The average time for each elevator trip was estimated to be about 45 seconds from the site visits. The additional time required to navigate through the intersection by wheelchair is shown in **Table 1** (and **Figure 5**) and ranges from 69% to 208% more time than that for able-bodied pedestrians.

It should be noted that there is built-in assumption in the tables that pedestrians and wheelchair users are intimately familiar with the routes, access/egress points and lift locations and would take the most direct and efficient route. We did not use test subjects or track actual users to gauge travel time. It should be acknowledged that users who are unfamiliar with the concourse often take significant additional time to navigate from one corner to another due to the unique pedestrian infrastructure at Portage and Main.

Table 1 – Existing Pedestrian Travel Times at Portage and Main

Crossing (see Figure 5)	Mode	Length of Path	Walking Speed	Elevators	Total Average Travel Time		Additional Time for Wheelchair Users over Able-Bodied Pedestrians
		[m]	[m/s]	[#]	[sec]	[min]	[%]
A	Able-bodied	237.6	1.00	0	238	4.0	
A	Wheelchair	319.1	1.00	5	544	9.1	129%
B	Able-bodied	285.3	1.00	0	285	4.8	
B	Wheelchair	300.8	1.00	4	481	8.0	69%
C	Able-bodied	230.8	1.00	0	231	3.8	
C	Wheelchair	323.0	1.00	5	548	9.1	137%
D	Able-bodied	215.4	1.00	0	215	3.6	
D	Wheelchair	316.8	1.00	4	497	8.3	131%
E	Able-bodied	179.7	1.00	0	180	3.0	
E	Wheelchair	217.7	1.00	5	443	7.4	146%
F	Able-bodied	129.7	1.00	0	130	2.2	
F	Wheelchair	219.1	1.00	4	399	6.7	208%
G	Able-bodied	159.9	1.00	0	160	2.7	
G	Wheelchair	230.7	1.00	4	411	6.8	157%
H	Able-bodied	181.1	1.00	0	181	3.0	
H	Wheelchair	187.8	1.00	5	413	6.9	128%

Figure 5 – Illustration of all potential pedestrian paths at Portage and Main quantified in Table 1



3.0 Microsimulation Model

3.1 Approach

Analysis of the future operations of the intersection of Portage and Main and the surrounding roadways was performed via the application of a transportation microsimulation model created in the VISSIM software package.

Microsimulation provides the greatest flexibility in representing the unique operational conditions of real-world transportation facilities. Microsimulation takes an approach that is very different from traditional analyses, providing an enhanced ability to forecast and simulate the interaction of all transportation modes using the transportation system – not just cars. The differentiators for microsimulation that make it the most appropriate tool for this analysis are as follows:

- **Unique behaviour for every travel mode** – Microsimulation establishes detailed and unique "agent" behaviour as they move through the transportation network. An agent is any user of the system – pedestrian, cyclist, bus, car, or truck. Each class of agent (or mode) has unique behaviour or a set of rules that allow it to react (or they can be taught to react) to any infrastructure situation in a realistic manner. This is different to traditional analysis that applies static formulas based on empirical observation, which limits its applicability or validity in complex situations. Microsimulation allows the analyst the flexibility to best represent the real-world operations for any situation.
- **Individual User Behaviour** – In addition to the different types of modes behaving independently, every agent within a microsimulation model is an individual with a specified origin, destination, and set of behaviour parameters that control their awareness, aggressiveness, and path selection through the model. This allows the model to simulate behaviour that varies from one agent to the next and how this behaviour influences the efficiency of transportation infrastructure.
- **Connected environment** – Each agent in the system must physically move through the model from their origin to their destination. Traditional analysis typically treats each intersection movement or conflict point as a separate "island" with no interaction between upstream or downstream elements. This connected environment allows the effects of queuing and interaction between different modes to play into the analysis as users move through the model. This is important for this project, as the interactions between vehicles and pedestrians will be new to the location and will be a significant change to existing conditions.
- **Stochastic Processes** – The distribution of agent behaviour, flow rates entering the model, and other parameters are governed by a set of stochastic processes, which provide a controlled randomness to their distribution. These processes are governed by a 'random seed'. Maintaining the same random seed value (a simple integer value) across runs ensures that they will produce consistent results, while varying the seed value will distribute these items slightly differently and produce a different result. It is important in microsimulation to run the model with various random seeds to ensure an accurate average condition is reached. The simplified concept is to consider the typical weekday work

commute where the same amount of people need to travel to work during the morning every day, but leave their house at a slightly different time or behave slightly differently from one day to the next. Varying the random seed allows the analyst to take an average of this variance across a number of "Tuesdays" and "Wednesdays" from the same dataset.

As the intersection has been closed to pedestrians for close to 40 years, the experience of pedestrians and the interaction between pedestrians and drivers was especially important to this analysis. To best represent the behaviour and experience of pedestrians, the VISWALK add-on for VISSIM was employed. This add-on allows the software to realistically simulate the behaviour for individual pedestrians and their interaction with each other and the vehicles on the road.

The creation and application of the microsimulation model can be broken into several phases:

- Model Construction – the creation of the physical elements (roadway, traffic controls, origin/destination tables, etc.) that make up the model.
- Model Calibration – the adjustment of model parameters and coding to best represent the field data and observations of the existing condition.
- Alternatives Analysis – application of the model in the analysis of several different physical or traffic control-related alternatives.
- Sensitivity Analysis – varying certain characteristics of the model to judge the effects on each of the travel modes.

3.2 Model Construction

3.2.1 Study Area

Figure 6 below shows the area covered by the microsimulation model. The study area covers Portage Avenue between Donald Street and Westbrook Street; Main Street between St. Mary and James; Graham Avenue between Donald Street and Main Street; and Fort Street between St Mary Avenue and Portage Avenue. All streets that cross the major corridors listed here are represented as short intersecting sections with accurate geometry and traffic control at the intersections.

Figure 6 – Model Coverage

3.2.2 Network Elements

The physical elements of the model were created based on the data received, as applicable. Information regarding the number of lanes, exact roadway geometry, and any idiosyncrasies in the use of the transportation environment was obtained through a combination of detailed CAD drawings, internet mapping and street view data, the Downtown Synchro Model, local knowledge, and field visit confirmation.

At the majority of study area intersections, the pedestrian space is represented simply as the crosswalks with a small landing on either side of the roadway. Pedestrians are loaded into the model and cross the street, based on observed crossing volumes. Within the vicinity of the Portage/Main intersection, the pedestrian space includes the crosswalks as well as the sidewalk area, as illustrated by the blue area on **Figure 7**. The red area in the figure shows the obstacles that the pedestrians must navigate when moving through the space, such as planters, poles, barriers, and other solid objects. Some of the red areas represent existing barrier walls and planters. While the alternatives modelled generally remove most of these planters, they could be replaced with street furniture, street lights, bus stops, or even snow windrows in winter. Therefore the walking space is conservative in the model.

Figure 7 – Pedestrian Space Layout at Portage Avenue and Main Street

3.2.3 Transportation Demand Calculations

As transportation microsimulation models create users (automobiles, trucks, pedestrians) that move physically through a space, it is necessary to convert turning movement count data and predicted crossing volumes into origin/destination tables that describe where the users begin and end their journey through the model. This knowledge, combined with their individual behaviour, allows them to navigate their way through the model from origin to destination, as people do in reality.

As a result, it was necessary to create a network of balanced turning movement counts for vehicles (cars and trucks) in the model. This allowed for logical assignment of vehicles through the model with no "gaps" due to inconsistencies between adjacent counts. Dillon extracted the data for the AM and PM peak hours from the count data received from the City and processed the data through a proprietary method to create a balanced network of turning movement data for cars and trucks for the year 2016. The resultant turning movement counts for each intersection, both peak hours, and both modes (car, truck) are shown in **Appendix A**.

The final step in creation of vehicular demands in the model was to convert the balanced volume into origin/destination tables. These tables describe the number of vehicles moving between each of the zones in the model, as shown on **Figure 8**. This was accomplished via use of the built in matrix estimation tool in VISUM, known as TFlowFuzzy. TFlowFuzzy iterates the travel patterns for vehicles in the model until the modelled volume reasonably matches that observed in reality. The resulting origin and destination tables for the AM and PM peak hours for cars and trucks were applied in the modelling exercise.

Figure 8 – Vehicle Loading Zones

Similarly, for pedestrian volumes, it was necessary to convert the crossing volumes at existing crosswalks and the forecasted crossing volumes for Portage/Main into useable data for the model. For existing crosswalks, the crossing demand was simply coded to take the pedestrians across the intersection, as observed in reality. For the pedestrians crossing Portage and Main, it was necessary to convert the forecasted crossing volume into an origin/destination matrix that expanded the crossing volume into trips from and to the extents of the pedestrian area (the northern, southern, western, and eastern tips of blue area along both Portage and Main), represented by the green areas on **Figure 9**. These are the loading points for pedestrians crossing Portage and Main in the model. In the absence of data describing the destinations for the pedestrians in the area, the crossing volume for each crosswalk was simply distributed proportionally to each zone. **Table 2** shows the forecasted crossing volumes, as provided by City of Winnipeg staff. These forecasted volumes are based on volumes observed at other intersections on Portage Avenue in downtown, notably Portage and Fort, Portage and Donald, and Portage and Memorial.

Figure 9 – Pedestrian Loading Zones

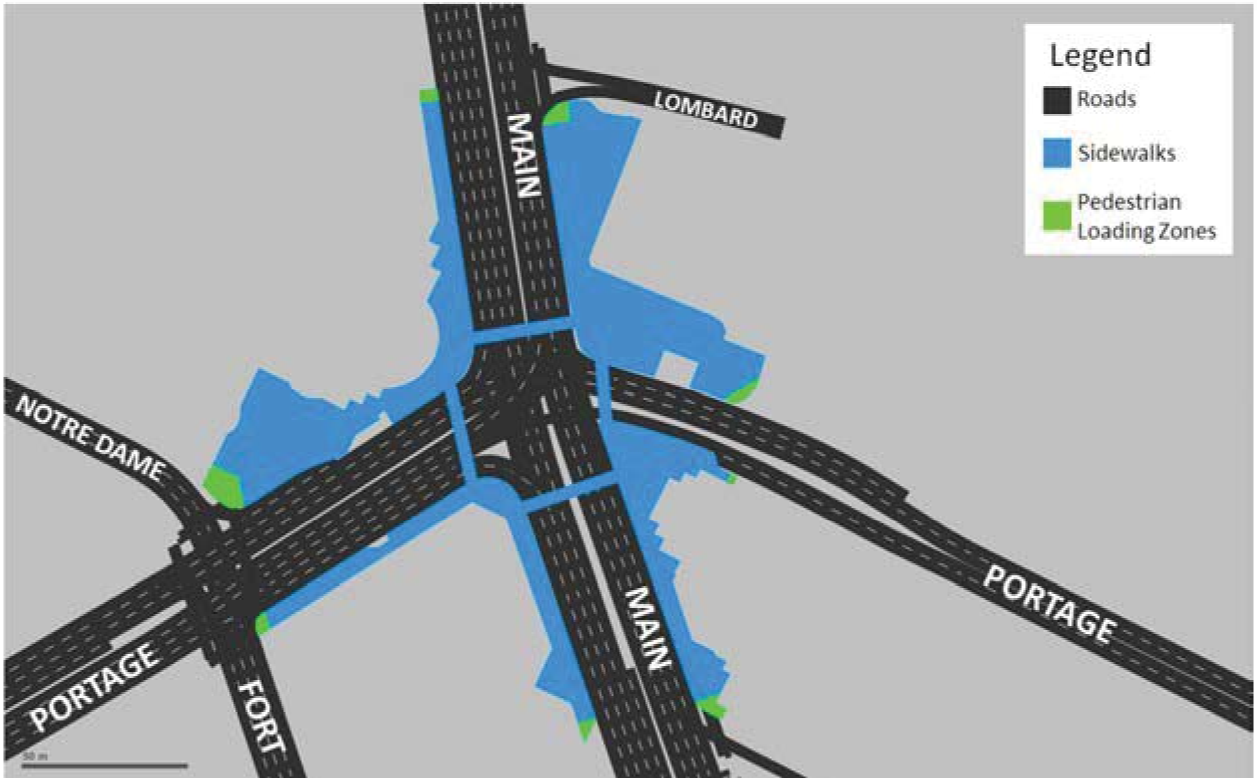


Table 2 – Forecasted Pedestrian Crossing Volumes at Portage Avenue and Main Street

Crossing	Peak Hour	
	AM	PM
North	400	500
South	400	500
East	300	500
West	300	500

Transit vehicles in the model were coded according to the schedules and routes provided by City of Winnipeg. These vehicles are produced in the model according to the specified schedule and follow their route to each stop where they stop to allow passenger boarding and alighting and proceed until they complete the route and depart from the model.

3.3 Model Calibration and Validation

Model calibration is simply the modification of inputs, settings, or geometry in the model to ensure that it matches certain sets of data related to the performance of the network in reality within a reasonable tolerance. Validation is the confirmation of the model's applicability for application in the required analysis via data sources not applied in calibration, variation of parameters to test model sensitivity, and/or visual performance review.

There are currently no mandated standards for model calibration. The FHWA's Traffic Analysis Toolbox lists criteria used by the Wisconsin Department of Transportation, an agency that concerns itself greatly with the use of microsimulation models, as shown in **Table 3** below. These criteria were based on guidelines developed in the United Kingdom[1].

Table 3 – FHWA Criteria for Model Calibration

Criteria and Measures	Calibration Acceptance Targets
Hourly Flows, Model Versus Observed	
Individual Link Flows	
Within 15%, for 700 veh/h < Flow < 2700 veh/h	> 85% of cases
Within 100 veh/h, for Flow < 700 veh/h	> 85% of cases
Within 400 veh/h, for Flow > 2700 veh/h	> 85% of cases
Sum of All Link Flows	Within 5% of sum of all link counts
GEH Statistic < 5 for Individual Link Flows*	> 85% of cases
GEH Statistic for Sum of All Link Flows	GEH < 4 for sum of all link counts
Travel Times, Model Versus Observed	
Journey Times, Network	
Within 15% (or 1 min, if higher)	> 85% of cases
Visual Audits	
Individual Link Speeds	
Visually Acceptable Speed-Flow relationship	To analyst's satisfaction
Bottlenecks	
Visually Acceptable Queuing	To analyst's satisfaction

The criteria presented in **Table 3** was applied to the model at both the link and turning movement count level to ensure adequate agreement at the most detailed level for the vehicular volume. At the turning movement level, the limiting criteria for volume flow were reduced to better represent the scale of typical turning movement flow.

The AM and PM Peak Hour models were adjusted and recoded until they met the specified calibration criteria. This represented the model's initial calibration and the model was progressed to validation.

[1] Federal Highway Administration, Traffic Analysis Toolbox: Volume III, http://ops.fhwa.dot.gov/trafficanalysistools/index.htm

The model was validated via two different approaches. In the absence of a significant source of other field data not applied in the calibration of the model, the model was validated through visual confirmation of study area operations by Dillon's local professional staff with extensive knowledge of traffic operations in the study area. This review provided insight into typical queuing and operational idiosyncrasies observed in reality and also served to provide a quality assurance review of the model.

The model was subsequently shared with City of Winnipeg transportation staff for review prior to beginning analysis. City of Winnipeg staff provided several comments on coding and operations in the model. These comments were acknowledged and changes were effected in the model, as applicable. Calibration of the model was again confirmed and is shown above in the prior tables.

Table 4 and **Table 5** show a summary of the final calibration results for the 2016 AM and PM peak hour after review and validation by City of Winnipeg staff. Detailed calibration results are provided in **Appendix B.**

Table 4 – 2016 AM Peak Hour Calibration Summary

LINKS	*Passed 6 of 6*							
*Criteria**	*Flow Range*		*Criteria*		*Goal*	*Current*	*Count*	*Model*
Within 100 veh/h, for Flow < 700 veh/h > 85% of cases	0	700	100	veh	85%	100%	19	19
Within 15%, for 700 veh/h < Flow < 2700 >85% of cases	700	2700	15	%	85%	100%	40	40
Within 400 veh/h, for Flow > 2700 veh/h > 85% of cases	2700		400	veh	85%	--	0	0
Sum of All Link Flows within 5% of sum of all link counts	Overall		5	%	5%	1%	66800	65885
GEH < 5 for individual Link Flows, > 85% of cases	Overall		5	GEH	85%	100%	59	59
GEH < 10 for individual link flows, 95% of cases	Overall		10	GEH	95%	100%	59	59
GEH < 4 for sum of all link counts	Overall		4	GEH	4.0	3.6	66800	65885

**Source: FHWA Traffic Toolbox Vol 3 'Calibration of Microsimulation Models', Table 4 "Wisconsin DOT Freeway Model Calibration Criteria"*

TURNS	*Passed 7 of 7*							
Criteria	*Flow Range*		*Criteria*		*Goal*	*Current*	*Count*	*Model*
Within 50 veh/h, for Flow < 400 veh/h > 85% of cases	0	400	50	veh	85%	98%	62	61
Within 10%, for 400 veh/h < Flow < 1200 >85% of cases	400	1200	10	%	85%	100%	21	21
Within 200 veh/h, for Flow > 1200 veh/h > 85% of cases	1200		200	veh	85%	100%	26	26
Sum of all turn flows within 5% of sum of all turn counts	Overall		5	%	5%	1%	66800	65885
GEH < 5 for individual turn Flows > 85% of cases	Overall		5	GEH	85%	99%	110	109
GEH < 10 for individual turn flows, 95% of cases	Overall		10	GEH	95%	100%	110	110
GEH < 4 for sum of all turn counts	Overall		4	GEH	4.0	3.6	66800	65885

Table 5 – 2016 PM Peak Hour Calibration Summary

LINKS	Passed 6 of 6							
Criteria*	Flow Range		Criteria		Goal	Current	Count	Model
Within 100 veh/h, for Flow < 700 veh/h > 85% of cases	0	700	100	veh	85%	95%	20	19
Within 15%, for 700 veh/h < Flow < 2700 >85% of cases	700	2700	15	%	85%	100%	39	39
Within 400 veh/h, for Flow > 2700 veh/h > 85% of cases	2700		400	veh	85%	--	0	0
Sum of All Link Flows within 5% of sum of all link counts	Overall		5	%	5%	0%	69800	69617
GEH < 5 for Individual Link Flows, > 85% of cases	Overall		5	GEH	85%	97%	59	57
GEH < 10 for individual link flows, 95% of cases	Overall		10	GEH	95%	98%	59	58
GEH < 4 for sum of all link counts	Overall		4	GEH	4.0	0.7	69800	69617

*Source: FHWA Traffic Toolbox Vol 3 'Calibration of Microsimulation Models', Table 4 "Wisconsin DOT Freeway Model Calibration Criteria"

TURNS	Passed 7 of 7							
Criteria	Flow Range		Criteria		Goal	Current	Count	Model
Within 50 veh/h, for Flow < 400 veh/h > 85% of cases	0	400	50	veh	85%	97%	62	60
Within 10%, for 400 veh/h < Flow < 1200 >85% of cases	400	1200	10	%	85%	96%	24	23
Within 200 veh/h, for Flow > 1200 veh/h > 85% of cases	1200		200	veh	85%	96%	23	22
Sum of all turn flows within 5% of sum of all turn counts	Overall		5	%	5%	0%	69800	69617
GEH < 5 for Individual turn Flows > 85% of cases	Overall		5	GEH	85%	99%	110	109
GEH < 10 for individual turn flows, 95% of cases	Overall		10	GEH	95%	100%	110	110
GEH < 4 for sum of all turn counts	Overall		4	GEH	4.0	0.7	69800	69617

It can be seen in the above tables that model performance compared to the balanced turning movement volumes for both the AM and PM peak hours is exemplary. All of the calibration criteria were passed and match very closely to the observed data.

4.0 Measures of Effectiveness

The performance measures used to represent the operations of the model were selected based on the aims of the project and the goals of the City for the study area. This aspect was critical to understanding the real effects of the proposed changes and how the various alternatives relate to each other. By their very nature, micro-simulation models can provide an overabundance of data and it was up to the modelling team and the Technical Steering Committee (TSC) to be clear in understanding what these statistics meant relative to the goals of the project. This section examines the measures resultant from discussions between Dillon and the TSC.

It was primarily important for measures to be selected for all travel modes in the model (vehicular, pedestrian, and transit) to allow for the effects of the alternatives on each mode to be well understood. The sections below break down the important measures selected for each mode.

4.1 Vehicles

As they have been by far the dominant form of travel in cities across North America for nearly a century, analysis of vehicular traffic is well understood by modern transportation planners and engineers. And specific to Winnipeg, the intersection of Portage Avenue and Main Street represents a very busy intersection in the city with respect to vehicular traffic. It was important, therefore, to select criteria for vehicles that communicated the overall effects on performance in the study area, performance of the Portage/Main intersection itself, and the overall travel time for vehicles moving through the model. The measures of effectiveness selected were as follows.

4.1.1 Overall Model Performance

Average Travel Speed (km/h) – This is the overall average travel speed for cars and trucks in the model. This provides a simple and understandable point of comparison between alternatives.

Unmet Demand (vehicles) – This is a measurement of the number of vehicles that were unable to enter the model at the end of the simulation period due to congestion and queuing. This is a representation of the extent of congestion in the study area as vehicles that were once able to enter the model under existing conditions are now “frustrated” at the end of the simulation period. In reality, these motorists will need to complete their trip outside of the peak hour or via a different route or mode.

Person Hours of Delay (hours) – The delay experienced by each vehicle is multiplied by a representative average occupancy (1.24 persons per vehicle, as provided by City of Winnipeg) to calculate the delay experienced by the average person travelling by vehicle in the study area. This provides an important benchmark versus other modes with differing occupancies (e.g., public transit).

4.1.2 Portage/Main Performance

Intersection Level of Service – Level of Service (LOS) is the classic measurement of intersection performance that translates a numerical measure (e.g., vehicle delay, volume to capacity ratio) into an easily understood letter grade from A to F. These letter grades represent the changes to the user's experience as congestion is encountered.

Intersection Average Vehicle Delay (seconds) – This is simply the average delay experienced by vehicles moving through the selected intersection or along a section of roadway. In this case, this value represents the delay experienced at the Portage/Main intersection. This is used to assign the Level of Service to the Portage/Main intersection, as recommended by the Highway Capacity Manual 2010 (HCM2010), as shown in **Table 6.**

Table 6 – Level of Service Definitions for Signalised and Unsignalised Intersections

LOS	Signalised	Unsignalised
A	≤10 sec	≤10 sec
B	10-20 sec	10-15 sec
C	20-35 sec	15-25 sec
D	35-55 sec	25-35 sec
E	55-80 sec	35-50 sec
F	>80 sec	>50 sec

4.1.3 Average Travel Time

It was important to understand the overall travel time for vehicles through the model, as this presents an easily understood and comparable metric. Travel time for vehicles was measured from the edges of the model on Portage Avenue and Main Street to each of the other model edges, noting limitations such as turning restrictions at the Portage/Main intersection. This provides a thorough examination of movements through the area to assess the effects of each alternative.

4.2 Pedestrians

For almost 40 years, pedestrians have not been able to cross the street at the intersection of Portage Avenue and Main Street. They are a point of focus for this analysis as they must be able to safely and efficiently cross the intersection and their experience must be understood.

4.2.1 Safety

Microsimulation models are not able to directly assess the safety of a roadway or intersection. Therefore, one element of safety that was used to differentiate between alternatives was simply the presence of permitted dual right turns at the Portage/Main intersection. This provided a simple binary measurement of an important element of safety at a large intersection. A permitted right turn means that vehicles and pedestrians move through the intersection at the same time and vehicles must wait for appropriate gaps in the stream of pedestrians to complete the movement. This is a concern for typical right turning vehicles that interact with a pedestrian crosswalk, but is of particular concern for dual right turning movements due to the decreased sight distance and potentially higher travel speeds for vehicles on the inner lane of the turn.

4.2.2 Average Travel Time

As with vehicular traffic, it was important to understand the travel time for pedestrians between their origin and destination zones in the model. This measurement illustrates the effects of the various alternatives on the pedestrian experience as they move through the space.

4.3 Transit

Public transit is an increasingly important element of transportation in most North American cities and especially in Winnipeg with its significant ongoing improvements to transit service across the city. The Graham Transit Mall resides within the study area for this analysis and forms a critical portion of the transit network for the entire city, as it is a central transit-only hub for movement throughout the city and the northern end of the south-west bus rapid transit line. It was important to understand the effects on transit overall in the study area, as well as the performance of the Graham Transit Mall.

4.3.1 Overall Model Performance

Average Travel Speed (km/h) - This is the overall average travel speed for transit vehicles in the model. This provides a simple and understandable point of comparison between alternatives. Travel speeds are naturally slower for transit vehicles than for cars, as they must stop to allow passengers to board and alight.

Person Hours of Delay (hours) – Identical to the Person Hours of Delay for vehicles, the delay experienced by each vehicle is multiplied by a representative average occupancy (20 persons per transit bus, as provided by City of Winnipeg) to calculate the delay experienced by the average person travelling by vehicle in the study area. As transit vehicles typically carry many more passengers than automobiles, each second of delay experienced by the vehicle is multiplied by the number of occupants. This provides perspective on the significance of maintaining optimal performance for transit vehicles to greatly reduce the delay for a larger portion of the travelling public.

4.3.2 Average Travel Time

Travel time is a key metric for transit vehicles, as they must perform well to maintain their tight schedules and reduce delays for a large number of people who rely on the quality of the service. For this analysis, the travel time is separated into the performance of the Graham Transit Mall (travelling to and from the cardinal points at the model's edges) as well as the travel between the model's cardinal points themselves. For example, the row "Eastbound Left" reports on routes that enter the model on Portage at Donald, travel eastbound to the Portage and Main intersection, turn left (north) and exit the model on Main at James. This provides a thorough examination of the effects of the alternatives on transit service in the area.

4.4 Evaluation Structure

The measures of effectiveness listed above were selected based on discussions with the TSC during the course of the project. The goal in selecting the criteria was to create a thorough but not excessively detailed list of criteria that could be summarised on a single page for easy comparison and discussion throughout the project. The criteria were arranged in tables based on the sections laid out above.

For each section, professional judgement was applied in selecting from the tested alternatives the preferred, neutral, and least preferred for each category. For ease of understanding, these were coloured in the tables as green (preferred), yellow (neutral), and red (least preferred). This allowed Dillon and the TSC to judge the tradeoffs in each alternative, as each alternative had its own strengths and weaknesses for each travel mode and MOE. The comparison between alternatives was not necessarily straightforward when examining the more detailed results, as some values were seen to improve, while others were degraded.

In addition, where possible, the criteria are ranked by the amount of volume performing the movement. This allows for an improved understanding of the importance of each movement and the effects of the alternative. For example, increased travel time of two minutes for a particular movement through the model may seem significant, but if this movement serves very few vehicles, this may not be a significant change at the intersection.

This approach to the evaluation allowed for discussion of the overall preferred alternatives for each mode and subcategory with sufficient additional detail to examine particularly important relationships when necessary.

5.0 Alternatives Analysis

5.1 Approach

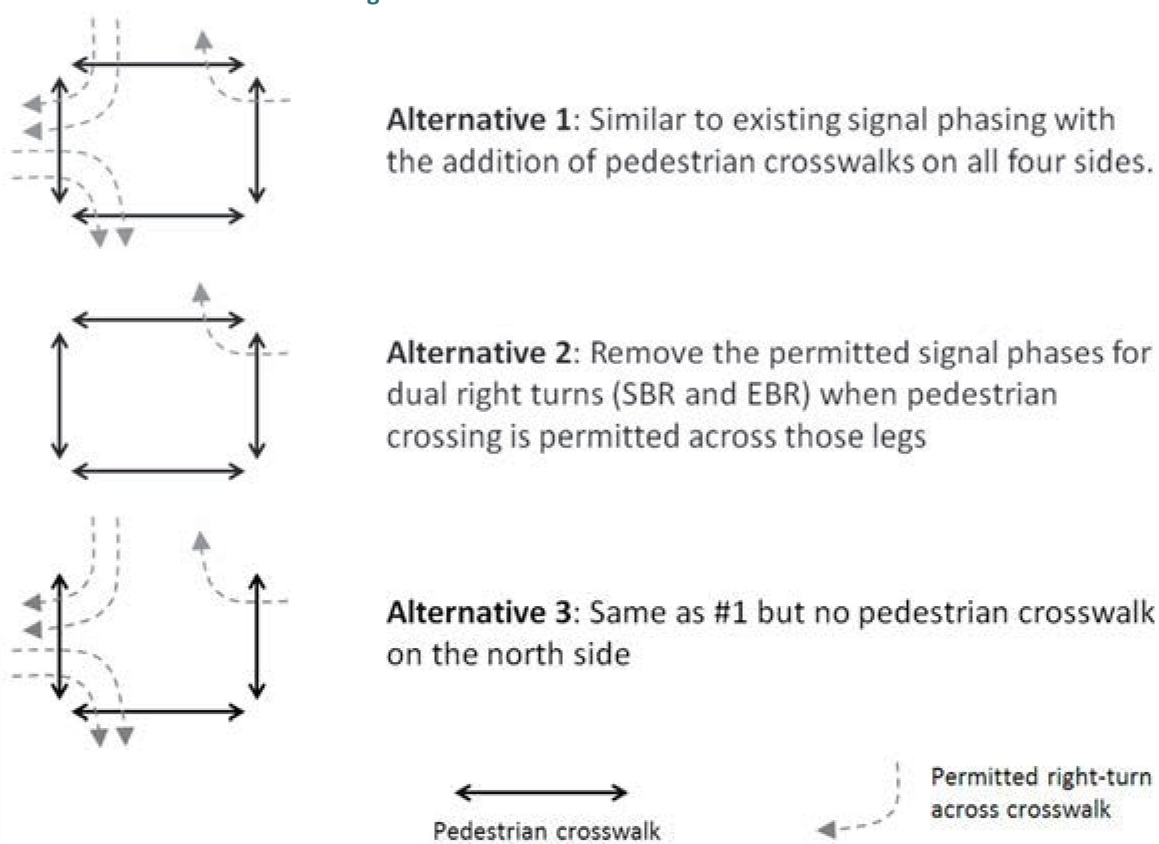
A total of five alternatives were tested in the course of the project. These were broken into two separate phases, as requested by the City.

- Phase 1 – Testing of three City-proposed alternatives that vary the signal timing and phasing at the Portage/Main intersection.
- Phase 2 – Testing of two Dillon-proposed alternatives that built upon the preferred alternative from Phase 1. These alternatives also varied the signal timing and phasing at the intersection, but also investigated physical modifications to the intersection to further enhance the intersection performance for vehicles, pedestrians, and transit vehicles.

5.2 Phase 1 Alternatives

City of Winnipeg staff proposed three alternatives for testing in Phase 1 as part of the request for proposals document. **Figure 10** provides a schematic representation of the alternatives for simplified comparison between each.

Figure 10 – Phase 1 Alternative Schematics



The three alternatives tested as part of Phase 1 each vary a single parameter from the existing condition or each other to test the validity of three separate concepts. Alternative 1 simply adds in pedestrian crossings to the existing condition. Alternative 2 builds upon Alternative one, but eliminates permitted right turns for southbound and eastbound traffic. This is in an effort to improve safety for pedestrians. Alternative 3 is identical to Alternative 1, with the exception of the removal of the northern crossing for pedestrians. Removing the northern crossing eliminates the need to accommodate pedestrian crossing time for that crossing outside of the eastbound left turn phase. This was intended to improve vehicle performance.

Each alternative was constructed in the calibrated base models for the AM and PM peak hours. The prescribed changes were implemented in the models. Controls at adjacent intersections were adjusted as possible to suit the impacts resulting from the changes.

It should be noted that previous analyses performed by the City of Winnipeg eliminated an alternative of a “scramble phase” at the Portage/Main intersection. A “scramble phase” is where all vehicular approaches are shown a red light and pedestrians are allowed to enter the intersection and cross in any direction (including diagonally). In some cases, this can provide more efficient use of the space when compared to separating each movement or groupings of movements into distinct phases. The footprint of the Portage/Main intersection is simply too large to allow a scramble phase to be a practical consideration. The very large crossing distances for pedestrians would require very long pedestrian-only phases and result in very poor vehicular operations. Therefore, a scramble phase is not a practical solution for this location and was not considered for further analysis as part of this microsimulation study.

5.2.1 Analysis

Table 7 and **Table 8** present the evaluation results for the Phase 1 alternatives. Existing conditions results are presented as a baseline comparison. All models have been run with 10 random seeds and their results averaged to present a true average condition.

It can be seen from the tables that in all cases, the introduction of at-grade pedestrian crossings to the intersection will have a negative impact on vehicular traffic. In all cases the Level of Service (and by extension the average vehicle delay) is worsened by the introduction of pedestrians. This is logical and to be expected as the traffic controls must be adjusted to provide safe crossing for pedestrians of all levels of mobility, whereas existing conditions prohibit crossings by pedestrians and prioritises efficiency of vehicle movement over everything else. The Timing Standards Memo provided by the City of Winnipeg for this project dictates that a walking speed of 1 m/s be applied when establishing the minimum crossing time for signal controls. This provides sufficient crossing time for those with mobility issues and provides a more comfortable and safe experience for all pedestrians, but will have a limiting effect on the ability to provide sufficient signal time to vehicular demands.

One point of emphasis for the operations in Alternative 3 is the performance of the northbound right turn movement. It has by far the least amount of turning volume of all of the movements at the intersection. However, it can be seen to affect the overall performance of the northbound approach quite clearly in this alternative. In Alternative 3, the northern pedestrian crossing has been eliminated to allow more efficient use of the intersection by vehicles making eastbound left turning movements. This, however, forces pedestrians wishing to cross the northern side of the intersection to make at least two (if not three, depending on destination) crossings of the intersection instead of one, thereby increasing the effective pedestrian volume on each crossing by 200-400 in the AM peak hour and 250-500 in the PM peak hour. This is of particular concern for the northbound right turn as it sees quite significant increases in travel time due to conflicts with pedestrians using the eastern crosswalk. The resultant queuing for this movement also shows an impact on the travel time for the northbound through movement, which is the movement with the second highest volume in both peak hours. Therefore, the northbound right – by all accounts a very minor movement at the intersection – affects performance of a major movement due to conflicts with pedestrians.

Vehicular operations in Alternative 2 are degraded in particular, as this alternative prevents the use of permitted dual right turns on the eastbound and southbound approaches. From the perspective of right turning motorists, this will create significant delays as they must wait to receive a protected green right turn arrow to proceed through the intersection. The southbound right and eastbound right turn carry significant volume in both the AM and PM peak hours and see dramatic increases in travel time through the model in the range of 7 to 20 minutes. This will logically create significant vehicle queues along both Portage Avenue and Main Street throughout the peak hours.

The trade-off for increased delays for vehicles at the intersection in Alternative 2 is a significant increase in the safety of pedestrians. Removal of permitted dual right turns at the intersection would mean that pedestrians would be able to cross the intersection with greatly reduced conflicts with turning vehicles. This would provide significantly more comfort and safety to all pedestrians crossing the west and south legs of the intersection.

The experience for pedestrians in terms of comfort, ease of navigation, and travel time while crossing the intersection is greatly improved in all of the tested alternatives when compared to existing conditions. Reintroduction of pedestrian crossings to the intersection greatly reduces the distance required for pedestrians to simply cross the road. Interestingly, the decreased distance required for crossing is, in many cases, balanced by the delay introduced to able-bodied pedestrians by requiring them to wait at the signal for their phase.

Table 7 – Phase 1 Alternative Evaluation Summary – 2016 AM Peak Hour

		Volume[1]	Existing		Alt 1	Alt 2	Alt 3
Automobiles	**Overall Model Performance**						
	Average Travel Speed (km/h)	-	21.3		17.2	14.4	17.0
	Unmet Demand	-	0		1,116	1,886	607
	Person Hours of Delay [2]		340		518	502	469
	Portage / Main Performance						
	Intersection Level of Service	-	C		D	E	D
	Intersection Avg Vehicle Delay (sec)	-	20.7		39.2	55.3	38.1
	Avg. Travel Time (min:sec)						
	Total	*5,925*	*0:22:45*		*0:30:40*	*0:53:34*	*0:38:19*
	Southbound Through	1,655	0:02:33		0:02:51	0:06:55	0:02:43
	Northbound Through	1,225	0:03:39		0:03:34	0:03:37	0:04:13
	Eastbound Left	795	0:02:15		0:02:23	0:02:24	0:02:21
	Eastbound Through	725	0:01:35		0:01:55	0:01:52	0:01:41
	Southbound Right	725	0:03:02		0:04:51	0:23:11	0:04:18
	Westbound Through	450	0:01:57		0:01:56	0:01:53	0:01:56
	Eastbound Right	210	0:02:43		0:02:37	0:02:52	0:02:43
	Westbound Right	70	0:02:21		0:02:44	0:02:47	0:02:19
	Northbound Right	70	0:02:40		0:07:50	0:08:04	0:16:05
Pedestrians	**Safety**						
	Permitted Dual RT	-	-		Yes	No	Yes
	Avg. Travel Time (min:sec)		Able	Wheelchair			
	Total	*1,400*	*0:16:09*	*0:34:30*	*0:14:41*	*0:14:43*	*0:16:27*
	West Side	300	0:03:58	0:09:04	0:04:00	0:04:03	0:04:06
	East Side	300	0:04:45	0:08:01	0:03:46	0:03:49	0:03:52
	North Side [3]	400	0:03:51	0:09:08	0:03:56	0:03:54	0:05:24
	South Side	400	0:03:35	0:08:17	0:02:59	0:02:58	0:03:05
Transit	**Overall Model Performance**						
	Average Travel Speed (km/h)	-	9.6		8.1	5.9	8.1
	Person Hours of Delay [2]	-	643		903	1,210	810
	Avg. Travel Time (min:sec)						
	Total	*272*	*1:11:02*		*1:15:25*	*1:48:30*	*1:19:14*
	From Graham to North	44	0:10:42		0:13:12	0:13:30	0:16:41
	From Graham to South	35	0:07:38		0:07:34	0:07:07	0:07:56
	From North to Graham	31	0:09:09		0:10:26	0:27:54	0:10:18
	From South to Graham	24	0:06:14		0:05:32	0:04:50	0:05:52
	Eastbound Right	61	0:08:51		0:08:11	0:07:27	0:08:08
	Eastbound Left	26	0:07:16		0:08:26	0:25:19	0:08:18
	Northbound Left (via St. Mary)	18	0:06:32		0:07:08	0:07:09	0:07:30
	Westbound Through	14	0:04:48		0:05:08	0:04:50	0:04:42
	Southbound Right	10	0:03:48		0:03:46	0:04:11	0:03:48
	Eastbound Through	9	0:06:03		0:06:02	0:06:13	0:06:01

[1] Volume for automobiles is from balanced intersection counts; volume for buses is from model observations with combined routes and schedules
[2] Person Hours of Delay based on occupancies of: 1.24 per auto and 20 per bus
[3] North side trip in Alt 3 involves three crossings, as northern crosswalk is closed

Table 8 – Phase 1 Alternative Evaluation Summary – 2016 PM Peak Hour

		Volume[1]	Existing		Alt 1	Alt 2	Alt 3
Automobiles	**Overall Model Performance**						
	Average Travel Speed (km/h)	-	20.4		15.0	10.4	12.1
	Unmet Demand	-	1		364	2,096	1,182
	Person Hours of Delay [2]		375		588	814	713
	Portage / Main Performance						
	Intersection Level of Service	-	B		E	F	E
	Intersection Avg Vehicle Delay (sec)	-	19.6		61.9	82.6	59.9
	Avg. Travel Time (min:sec)						
	Total	*6,240*	*0:25:44*		*0:50:31*	*1:11:20*	*0:59:48*
	Southbound Through	1,750	0:04:35		0:04:05	0:04:54	0:03:48
	Northbound Through	1,440	0:02:47		0:03:30	0:03:05	0:04:24
	Eastbound Left	860	0:02:23		0:03:33	0:05:40	0:04:49
	Eastbound Through	610	0:01:57		0:03:56	0:10:13	0:07:18
	Southbound Right	605	0:02:48		0:03:20	0:13:19	0:03:13
	Westbound Through	520	0:01:50		0:03:58	0:03:46	0:02:07
	Eastbound Right	280	0:04:44		0:06:00	0:11:04	0:09:10
	Westbound Right	130	0:02:41		0:10:23	0:10:29	0:04:41
	Northbound Right	45	0:01:59		0:11:45	0:08:50	0:20:19
Pedestrians	**Safety**						
	Permitted Dual RT	-	-		Yes	No	Yes
	Avg. Travel Time (min:sec)		Able	Wheelchair			
	Total	*2,000*	*0:16:09*	*0:34:30*	*0:15:03*	*0:15:00*	*0:16:41*
	West Side	500	0:03:58	0:09:04	0:04:02	0:04:03	0:04:07
	East Side	500	0:04:45	0:08:01	0:03:53	0:03:54	0:03:57
	North Side [3]	500	0:03:51	0:09:08	0:04:07	0:04:04	0:05:31
	South Side	500	0:03:35	0:08:17	0:03:01	0:03:00	0:03:06
Transit	**Overall Model Performance**						
	Average Travel Speed (km/h)	-	10.3		8.0	4.4	5.6
	Person Hours of Delay [2]	-	550		757	1,229	1,098
	Avg. Travel Time (min:sec)						
	Total	*251*	*1:05:11*		*1:24:02*	*1:49:28*	*1:40:04*
	From Graham to North	44	0:09:19		0:15:30	0:11:48	0:22:33
	From Graham to South	39	0:07:03		0:06:14	0:06:39	0:08:09
	From North to Graham	31	0:08:47		0:09:27	0:17:15	0:10:33
	From South to Graham	16	0:04:30		0:04:43	0:07:33	0:06:57
	Eastbound Right	40	0:07:33		0:08:56	0:11:50	0:12:24
	Eastbound Left	25	0:06:32		0:07:47	0:11:30	0:10:49
	Northbound Left (via St. Mary)	24	0:06:18		0:06:37	0:07:57	0:07:25
	Westbound Through	11	0:04:30		0:12:34	0:12:25	0:06:04
	Southbound Right	11	0:06:17		0:06:53	0:13:34	0:07:00
	Eastbound Through	10	0:04:23		0:05:22	0:08:56	0:08:10

[1] *Volume for automobiles is from balanced intersection counts; volume for buses is from model observations with combined routes and schedules*

[2] *Person Hours of Delay based on occupancies of: 1.24 per auto and 20 per bus*

[3] *North side trip in Alt 3 involves three crossings, as northern crosswalk is closed*

The most important point to note from a pedestrian perspective is the significant decrease in travel time in all tested alternatives for residents in wheelchairs or with other mobility impairments. Under existing conditions, residents that require the use of a wheelchair must navigate the underground concourse via a series of elevators and lifts, which introduces an extra four to five minutes of delay for every crossing. The results show that allowing wheelchair users to cross the intersection at grade will result in a 50% to 60% reduction in their travel time per crossing.

There are no significant differences in pedestrian crossing times between the alternatives, with the exception of Alternative 3. The northern crosswalk is closed in Alternative 3, which forces pedestrians moving between the northern corners of the intersection to make two or three crossings (dependent on destination) instead of one. Interestingly, the time to make the three crossings does not result in a tripling of travel time. This is due to the fact that the length of the pedestrian phases has been set relatively close to walking speed, which results in a relatively efficient crossing for a pedestrian wishing to make all three crossings sequentially with little delay in waiting for a phase. The distance covered in that time to make the crossing, however, triples, as the pedestrian must divert through all three of the open crosswalks.

Transit service in general does see some increases in travel time in all three alternatives. Increases in person hours of delay range from 25% in Alternative 3 to 90% in Alternative 2. These come despite seemingly minor increases in transit travel time for Alternatives 1 and 3, which illustrate the effects of even small delays to transit vehicles on delays to a greater number of occupants. Note that based on the assumptions in the tables above relative to vehicle occupancy, transit riders make up 40-43% of all people travelling through the study area during the peak hour (5,000-5,500 of a total 12,800). This reinforces the need to maintain the quality and primacy of transit service in a dense urban environment over largely single occupant vehicles. Small savings or increases in travel time per transit vehicle have an outsized impact on travellers – not only in delay on their journey, but also via an increase in wait times for delayed buses in potentially inclement weather.

Alternative 2 clearly performs the worst of the three alternatives with respect to transit vehicles, with approximately 90% more person-hours of delay and a 50% increase in total travel time along the observed routes. This is particularly evident for buses travelling from the north to Graham Avenue, as they travel southbound in the diamond lane, which becomes the second southbound right turning lane for cars at Portage/Main. With the removal of permitted right turns at this location, the buses get caught in the increased delay to this movement even though they are travelling southbound through the intersection.

Of the three alternatives, the overall best performance was shown to be via Alternative 1. For automobiles, its performance is essentially on par with Alternative 3, with an advantage to Alternative 1 for overall travel time for the observed routes. Alternative 1 also has a significant advantage for pedestrians over Alternative 3 as all four crossings are open. Transit performance from the perspective of person-hours of delay is better for Alternative 3 in the AM peak, and worse in the PM peak, but not significantly so. Alternative 2, while providing safety benefits for pedestrians, is clearly much worse for operations of both automobiles and Transit.

Discussions of the results for the Phase 1 alternatives in a meeting with the TSC resulted in a recommendation of the use of Alternative 1 as the base for construction of the Phase 2 alternatives. The committee found that Alternative 1 provided the best balance of overall performance and freedom for pedestrians.

5.3 Phase 2 Alternatives

As described in **Section 5.2.1** above, the TSC recommended that Alternative 1 from the Phase 1 analysis be applied as the base in construction of the Phase 2 alternatives. This provided the best balance of performance across the three travel modes and provided a template for further refinement by Dillon in two additional alternatives. Dillon examined available data for the intersections, the results of the Phase 1 analysis, and local knowledge of travel patterns and behaviour in the area to pursue opportunities for improvement of operations for all three travel modes.

Table 9 shows the turning movement volumes for the two peak hours at Portage/Main sorted by their magnitude.

Table 9 – Portage Avenue and Main Street Turning Volume

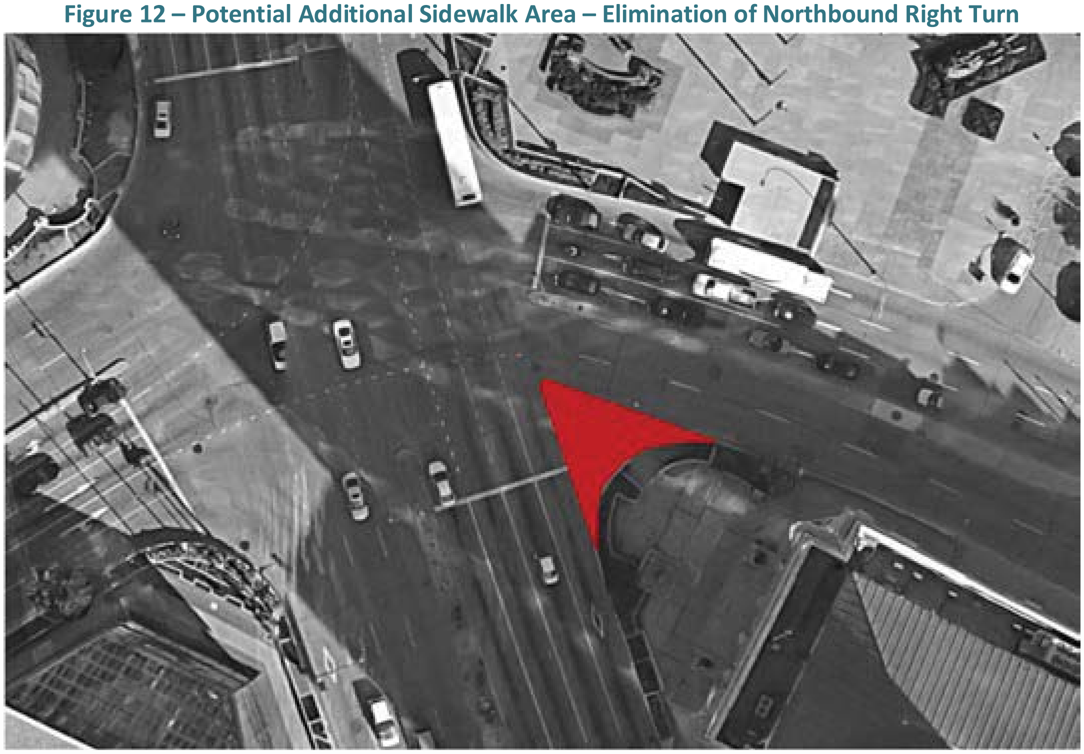
Movement	Peak Hour	
	AM	PM
SBT	1655	1750
NBT	1225	1440
EBL	795	860
EBT	725	610
SBR	725	605
WBT	450	520
EBR	210	280
WBR	70	130
NBR	70	45

It can be seen in the table that the movement with by far the fewest vehicles is the northbound right turn. Elimination of this movement from the intersection was seen as a minor change in convenience for a small subsection of drivers, but would have significant improvements for pedestrians and will also provide operational benefits to the Portage/Main intersection. Examination of the likely destinations for northbound right turning vehicles showed that they were most likely destined to the significant parking facilities to the east of the intersection or the Fairmont Hotel. All of these destinations can be accessed by making the same northbound right turn to the south of the intersection at William Stephenson Way or proceeding slightly further north to perform a northbound right turn at Lombard Avenue, as illustrated on **Figure 11**. It can be reasonably assumed that the current northbound right turning vehicles would be split 50/50 between the two alternate routes.

Figure 11 – Northbound Right Turn Alternative Routes

Figure 12 shows the space that could be recovered through elimination of the northbound right turn movement.

Figure 12 – Potential Additional Sidewalk Area – Elimination of Northbound Right Turn



Removal of the northbound right turn for cars from the intersection would have benefits for all three travel modes:

- For automobiles passing northbound through the Portage/Main intersection, there will be a slight reduction in weaving movements directly at the intersection. The occurrence of queuing of northbound right turn will also be eliminated, which can affect northbound through vehicles. Both of these elements will result in more efficient flow for vehicles headed northbound through the intersection – the second highest volume at the intersection.
- For transit vehicles, elimination of the northbound right turn for cars will remove interference in the curb diamond lane. Under existing conditions, vehicles making the northbound right turn are allowed to enter the diamond lane at the intersection. As above, potential queuing caused by vehicles waiting for pedestrians to cross will be removed, which will allow northbound transit vehicles to move more efficiently through the intersection.
- For pedestrians, the elimination of the northbound right turn allows for a significant increase of available sidewalk area at the intersection, as illustrated on **Figure 12**. In fact, unless the staircase to the concourse is removed or relocated, the enlarged sidewalk area is a necessity to provide space for the curb ramps and crosswalks. Given the acute angle of this corner, this also provides a significant reduction in the crossing distance for pedestrians using the eastern crossing. As an overall very large intersection, any reduction in the crossing distance for pedestrians will result in significant improvement in their safety and comfort. Shorter crossing distances for pedestrians are also of benefit to vehicles, as they allow for shorter minimum pedestrian phases.

Removal of the northbound right turn at the Portage/Main intersection is of clear benefit to all travel modes and was considered in both Phase 2 alternatives.

Further examination of the automobile volumes using the intersection showed additional opportunities on the eastern leg of the intersection. **Table 10** shows the total automobile volume approaching and departing the intersection by the individual legs of the intersection.

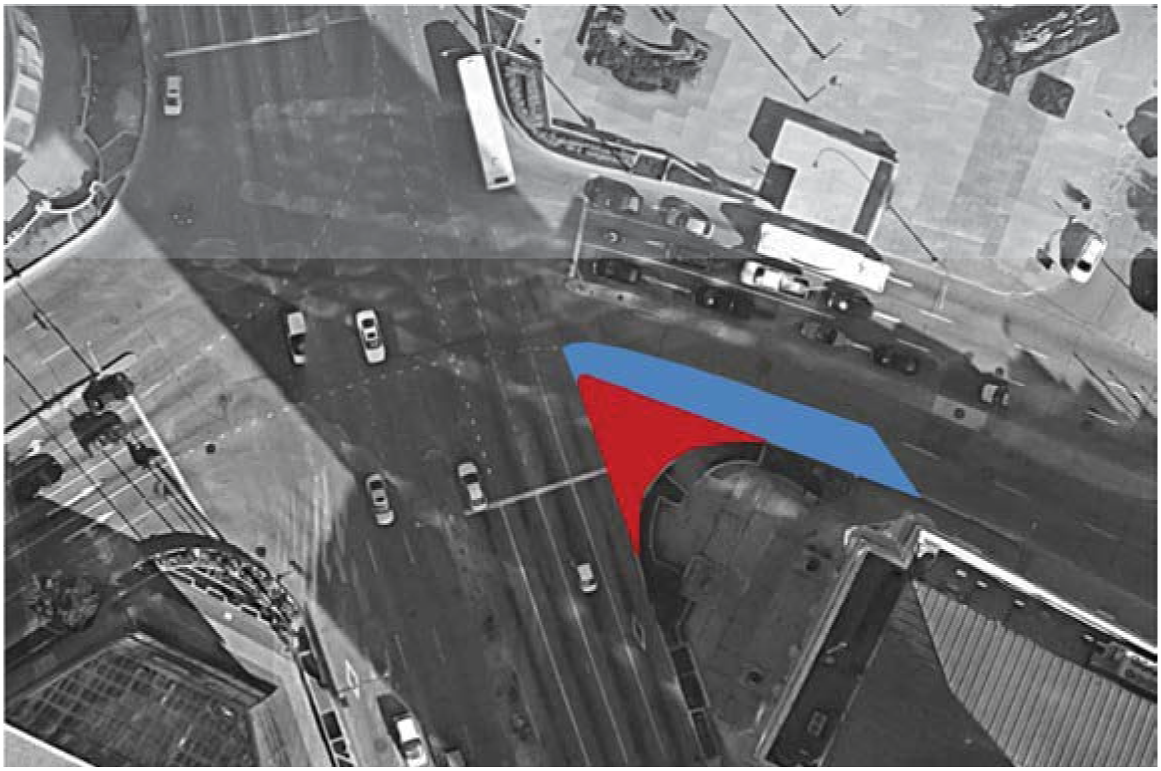
Table 10 – Portage Avenue and Main Street Intersection – Approaching and Departing Volume

Leg	AM Peak Hour		PM Peak Hour	
	Approach	Depart	Approach	Depart
North	2380	2090	2355	2430
South	1295	1865	1485	2030
West	1730	1175	1750	1125
East	520	725	650	610

It can be seen in the table that the east leg of the intersection carries the least volume in the intersection. In particular, the departing volume on the eastern leg was shown to be 725 and 610 vehicles in the AM and PM peak hours, respectively. (Note that the values on the eastern leg shown in the table assume that the northbound right turning movement has been closed.) The volume here in both periods is significantly less than the capacity of a single lane, whereas two receiving lanes are currently provided. It was therefore logical to propose that one of the two receiving lanes on the eastern leg of the intersection could be eliminated. The two lanes provided slight differences in their advantages and disadvantages.

Elimination of the curb lane on the eastern leg would provide a further extension to the pedestrian space on the southern side of the intersection, which would create more contiguous space for use by pedestrians and further reduce the crossing distance along the eastern edge of the intersection, as shown in the blue area on **Figure 13**.

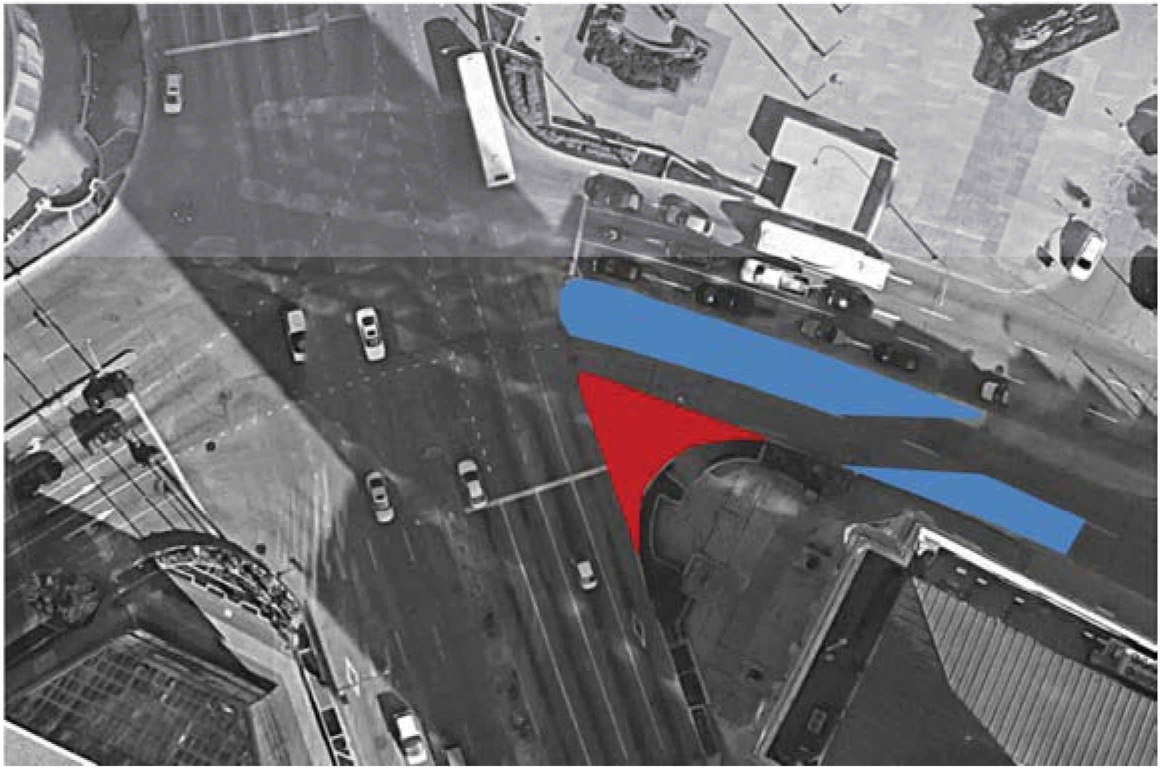
Figure 13 – Potential Additional Sidewalk Area – Elimination of Eastern Curb Lane



The figure shows the reclamation of a short portion of the eastern leg of the intersection to reduce the number of receiving lanes, but also maintains the parking further east on Portage Avenue. This approach also has the advantage of providing space to the north of the existing staircase to the underground concourse. As this staircase is currently built directly adjacent to the eastbound lanes of the roadway, this allows pedestrians the ability to walk to the north around the staircase and simplifies any required physical changes to accommodate the existing staircase.

Alternately, the median receiving lane on the eastern leg could be eliminated, as shown on **Figure 14**.

Figure 14 – Potential Additional Pedestrian Area – Elimination of Eastern Median Lane



This alternative provides the opportunity for a pedestrian refuge island in the middle of the eastern crossing, which can provide some extra comfort and safety for pedestrians making the eastern crossing. It, however, does not provide any advantages concerning the space surrounding the existing concourse staircase.

Both of these alternatives for elimination of a lane on the eastern leg of the intersection provide different opportunities with respect to the turning movements on the western leg.

If the curb lane on the eastern leg of the intersection is eliminated, the allocation of turning lanes on the western approach could be adjusted as follows:

- Double eastbound left turning lanes
- Eastbound through lane (Buses may make an eastbound left turn)
- Double eastbound right turn

This is a minor modification of the existing condition, where the second right turn lane is currently a shared through and right turn lane. This will result in a more efficient movement for the eastbound right turn and provides the potential to treat the eastbound through and eastbound right turn via separate signal phases, if necessary or advantageous. There is the potential for increased queuing in the centre lane as it is now the sole lane allowing an eastbound through movement. This could potentially impact the movement of transit vehicles making the eastbound left turn from the centre lane, or conversely automobiles waiting behind a Transit vehicle.

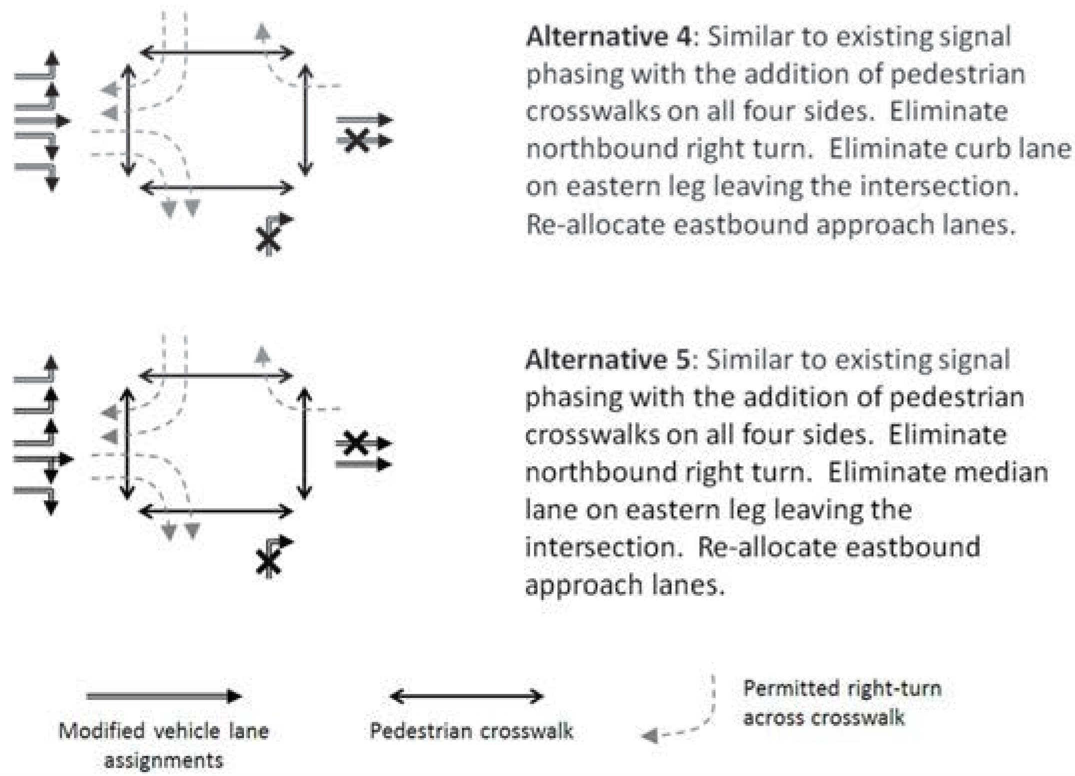
If the median lane on the eastern leg is eliminated, the allocation of turn lanes could be adjusted as follows:

- Triple eastbound left turn (buses make eastbound left turn from the third lane)
- Shared eastbound through and right turn lane
- Single eastbound right turn lane

This is again a minor modification to the existing condition, as it converts the center lane from an eastbound through lane to an eastbound left turn lane. This provides an opportunity at the intersection to move more eastbound left turning vehicles (a significant movement at the intersection) in a potentially shorter amount of time, which could return some signal time to other movements. There is the potential for increased queuing in the shared through/right lane due to an increased number of vehicles in that lane travelling eastbound through the intersection. This could impact the efficiency of the eastbound right turn movement and upstream queuing.

The above discussion on options for modification of the intersection into two additional alternatives resulted in Alternatives 4 and 5, as illustrated on **Figure 15** below.

Figure 15 – Phase 2 Alternative Schematics



As shown in the figure, both alternatives assumed that the northbound right turn will be eliminated at the intersection. Alternative 4 additionally assumed that the curb lane on the eastern receiving leg will be removed, with the associated changes to pedestrian space and eastbound turning movements as described above and shown in the figure. Alternative 5 assumed that the median lane on the eastbound receiving lane will be removed and the turning movements and pedestrian space will be modified as shown in the figure and discussed above.

5.3.1 Analysis

Table 11 and **Table 12** present the results for all tested alternatives (Phase 1 and Phase 2) to provide a complete review of all alternatives tested as part of the project.

Table 11 – Phase 1 and 2 Alternative Evaluation Summary – AM Peak Hour

Automobiles

	Volume[1]	Existing	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Overall Model Performance							
Average Travel Speed (km/h)	-	21.3	17.2	14.4	17.0	20.5	20.2
Unmet Demand	-	0	1,116	1,886	607	27	25
Person Hours of Delay [2]		340	518	502	469	370	381
Portage / Main Performance							
Intersection Level of Service	-	C	D	E	D	C	C
Intersection Avg Vehicle Delay (sec)	-	20.7	39.2	55.3	38.1	30.6	30.9
Avg. Travel Time (min:sec)							
Total	*5,925*	*0:22:45*	*0:30:40*	*0:53:34*	*0:38:19*	*0:22:40*	*0:24:00*
Southbound Through	1,655	0:02:33	0:02:51	0:06:55	0:02:43	0:02:48	0:02:48
Northbound Through	1,225	0:03:39	0:03:34	0:03:37	0:04:13	0:03:21	0:03:17
Eastbound Left	795	0:02:15	0:02:23	0:02:24	0:02:21	0:02:34	0:02:43
Eastbound Through	725	0:01:35	0:01:55	0:01:52	0:01:41	0:02:05	0:02:55
Southbound Right	725	0:03:02	0:04:51	0:23:11	0:04:18	0:04:38	0:04:35
Westbound Through	450	0:01:57	0:01:56	0:01:53	0:01:56	0:01:52	0:01:51
Eastbound Right	210	0:02:43	0:02:37	0:02:52	0:02:43	0:02:54	0:03:25
Westbound Right	70	0:02:21	0:02:44	0:02:47	0:02:19	0:02:28	0:02:26
Northbound Right [3]	70	0:02:40	0:07:50	0:08:04	0:16:05	-	-

Pedestrians

	Volume[1]	Existing		Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Safety								
Permitted Dual RT	-	-		Yes	No	Yes	Yes	Yes
Avg. Travel Time (min:sec)		Able	Wheelchair					
Total	*1,400*	*0:16:09*	*0:34:30*	*0:14:41*	*0:14:43*	*0:16:27*	*0:14:29*	*0:14:38*
West Side	300	0:03:58	0:09:04	0:04:00	0:04:03	0:04:06	0:04:00	0:04:00
East Side	300	0:04:45	0:08:01	0:03:46	0:03:49	0:03:52	0:03:36	0:03:45
North Side [4]	400	0:03:51	0:09:08	0:03:56	0:03:54	0:05:24	0:03:55	0:03:55
South Side	400	0:03:35	0:08:17	0:02:59	0:02:58	0:03:05	0:02:59	0:02:59

Transit

	Volume[1]	Existing	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Overall Model Performance							
Average Travel Speed (km/h)	-	9.6	8.1	5.9	8.1	9.4	9.3
Person Hours of Delay [2]	-	643	903	1,210	810	663	677
Avg. Travel Time (min:sec)							
Total	*272*	*1:11:02*	*1:15:25*	*1:48:30*	*1:19:14*	*1:12:36*	*1:14:10*
From Graham to North	44	0:10:42	0:13:12	0:13:30	0:16:41	0:09:52	0:09:53
From Graham to South	35	0:07:38	0:07:34	0:07:07	0:07:56	0:07:29	0:07:31
From North to Graham	31	0:09:09	0:10:26	0:27:54	0:10:18	0:10:29	0:10:27
From South to Graham	24	0:06:14	0:05:32	0:04:50	0:05:52	0:05:58	0:06:02
Eastbound Right	61	0:08:51	0:08:11	0:07:27	0:08:08	0:08:19	0:08:20
Eastbound Left	26	0:07:16	0:08:26	0:25:19	0:08:18	0:08:32	0:08:35
Northbound Left (via St. Mary)	18	0:06:32	0:07:08	0:07:09	0:07:30	0:07:08	0:07:24
Westbound Through	14	0:04:48	0:05:08	0:04:50	0:04:42	0:04:43	0:04:40
Southbound Right	10	0:03:48	0:03:46	0:04:11	0:03:48	0:04:00	0:04:44
Eastbound Through	9	0:06:03	0:06:02	0:06:13	0:06:01	0:06:04	0:06:33

[1] Volume for automobiles is taken from balanced intersection counts; volume for buses is taken from model observations with combined routes and schedules

[2] Person Hours of Delay based on occupancies of: 1.24 per auto and 20 per bus

[3] Northbound Right is blocked in Alternatives 4 and 5. Use caution when comparing total auto travel time to other alternatives.

[4] North side trip in Alt 3 involves three crossings, as northern crosswalk is closed

Table 12 – Phase 1 and 2 Alternative Evaluation Summary – PM Peak Hour

		Volume[1]	Existing		Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Automobiles	**Overall Model Performance**								
	Average Travel Speed (km/h)	-	20.4		15.0	10.4	12.1	15.5	15.5
	Unmet Demand	-	1		364	2,096	1,182	413	331
	Person Hours of Delay [2]		375		588	814	713	559	559
	Portage / Main Performance								
	Intersection Level of Service	-	B		E	F	E	D	D
	Intersection Avg Vehicle Delay (sec)	-	19.6		61.9	82.6	59.9	52.6	53.4
	Avg. Travel Time (min:sec)								
	Total	*6,240*	*0:25:44*		*0:50:31*	*1:11:20*	*0:59:48*	*0:38:18*	*0:38:57*
	Southbound Through	1,750	0:04:35		0:04:05	0:04:54	0:03:48	0:04:18	0:04:22
	Northbound Through	1,440	0:02:47		0:03:30	0:03:05	0:04:24	0:02:45	0:02:46
	Eastbound Left	860	0:02:23		0:03:33	0:05:40	0:04:49	0:04:22	0:04:31
	Eastbound Through	610	0:01:57		0:03:56	0:10:13	0:07:18	0:05:37	0:05:41
	Southbound Right	605	0:02:48		0:03:20	0:13:19	0:03:13	0:03:16	0:03:15
	Westbound Through	520	0:01:50		0:03:58	0:03:46	0:02:07	0:02:47	0:03:12
	Eastbound Right	280	0:04:44		0:06:00	0:11:04	0:09:10	0:07:26	0:06:55
	Westbound Right	130	0:02:41		0:10:23	0:10:29	0:04:41	0:07:47	0:08:15
	Northbound Right [3]	45	0:01:59		0:11:45	0:08:50	0:20:19	-	-
Pedestrians	**Safety**								
	Permitted Dual RT	-	-		Yes	No	Yes	Yes	Yes
	Avg. Travel Time (min:sec)		Able	Wheelchair					
	Total	*2,000*	*0:16:09*	*0:34:30*	*0:15:03*	*0:15:00*	*0:16:41*	*0:14:48*	*0:15:04*
	West Side	500	0:03:58	0:09:04	0:04:02	0:04:03	0:04:07	0:04:03	0:04:02
	East Side	500	0:04:45	0:08:01	0:03:53	0:03:54	0:03:57	0:03:43	0:03:58
	North Side [4]	500	0:03:51	0:09:08	0:04:07	0:04:04	0:05:31	0:04:02	0:04:03
	South Side	500	0:03:35	0:08:17	0:03:01	0:03:00	0:03:06	0:03:01	0:03:01
Transit	**Overall Model Performance**								
	Average Travel Speed (km/h)	-	10.3		8.0	4.4	5.6	8.2	8.6
	Person Hours of Delay [2]	-	550		757	1,229	1,098	710	671
	Avg. Travel Time (min:sec)								
	Total	*251*	*1:05:11*		*1:24:02*	*1:49:28*	*1:40:04*	*1:17:38*	*1:15:59*
	From Graham to North	44	0:09:19		0:15:30	0:11:48	0:22:33	0:09:31	0:09:21
	From Graham to South	39	0:07:03		0:06:14	0:06:39	0:08:09	0:06:16	0:06:04
	From North to Graham	31	0:08:47		0:09:27	0:17:15	0:10:33	0:09:51	0:09:49
	From South to Graham	16	0:04:30		0:04:43	0:07:33	0:06:57	0:05:03	0:04:52
	Eastbound Right	40	0:07:33		0:08:56	0:11:50	0:12:24	0:09:19	0:09:01
	Eastbound Left	25	0:06:32		0:07:47	0:11:30	0:10:49	0:08:31	0:08:01
	Northbound Left (via St. Mary)	24	0:06:18		0:06:37	0:07:57	0:07:25	0:06:53	0:06:53
	Westbound Through	11	0:04:30		0:12:34	0:12:25	0:06:04	0:09:09	0:09:28
	Southbound Right	11	0:06:17		0:06:53	0:13:34	0:07:00	0:06:54	0:06:53
	Eastbound Through	10	0:04:23		0:05:22	0:08:56	0:08:10	0:06:11	0:05:38

[1] *Volume for automobiles is taken from balanced intersection counts; volume for buses is taken from model observations with combined routes and schedules*

[2] *Person Hours of Delay based on occupancies of: 1.24 per auto and 20 per bus*

[3] *Northbound Right is blocked in Alternatives 4 and 5. Use caution when comparing total auto travel time to other alternatives.*

[4] *North side trip in Alt 3 involves three crossings, as northern crosswalk is closed*

It can be seen in the tables that both Alternative 4 and Alternative 5 operate the same or better in all respects than the previously tested alternatives.

For automobiles, delay and LOS are significantly improved in both Alternative 4 and 5 compared to the Phase 1 alternatives with the LOS improving by a letter-grade in both periods. Person-hours of delay are reduced in both periods compared to the Phase 1 alternatives. The AM peak hour shows that person-hours of delay for autos will be marginally higher than the existing condition. Person-hours of delay are still increased during the PM peak hour when compared to existing, but are slightly reduced compared to Alternative 1, which served as the basis for Alternatives 4 and 5.

Comparison of Alternative 4 and 5 shows no significant advantage to eastbound automobile travel time for Alternative 5 with its triple left turn and modified signal timing. Eastbound travel time is generally unchanged.

Travel time for pedestrians is unchanged in the Phase 2 alternatives compared to Phase 1. The pedestrian experience, relative to travel time, is unchanged, as they must still wait for the appropriate phase at the Portage/Main intersection. This delay has not changed significantly in the new alternatives. These figures do not illustrate the advantages to pedestrians with respect to their comfort and safety provided by both Phase 2 alternatives with the additional space and reduced crossing distances on the eastern leg of the intersection.

Pedestrian safety at the intersection does still present a challenge in the Phase 2 alternatives due to the presence of dual right turn lanes on the southbound and eastbound approaches. Vehicles travelling in the interior lane of a dual right turn will naturally have reduced sight lines to the crosswalk due to vehicles also turning in the curb lane. The geometry of the intersection also presents an element of risk for the southbound approach in particular. The obtuse angle where the western and northern legs of the intersection meet provide a larger turning radius for vehicles making a southbound right turn in the inside lane, thus allowing for higher travel speeds.

Transit performance is improved in both Alternative 4 and 5 compared to the Phase 1 alternatives. Person-hours of delay are improved in both alternatives when compared to Alternatives 1 to 3. In the case of the AM peak hour, there is no significant difference between the Phase 2 alternatives and the existing condition for both person hours of travel and overall travel via the observed routes. The PM peak hour does show some impacts as to person-hours of delay and overall route travel times when compared to existing, but these are both still significantly improved over the Phase 1 alternatives. Performance from the Graham Avenue transit mall to the north and south is improved in both Alternative 4 and Alternative 5. There are, however, some impacts for transit vehicles destined to the Graham transit mall.

On the whole, there is not a significant operational difference between Alternative 4 and Alternative 5 for any mode. Transit service does show minor differences with Alternative 4 performing marginally better in the AM peak hour, and Alternative 5 performing marginally better during the PM peak hour, which is overall a wash.

Discussion of the alternative results with the TSC resulted in a recommendation of Alternative 4 as the preferred alternative from all of those tested. Alternative 4 presents an equivalent operational condition to Alternative 5, but has significant advantages in the distribution of pedestrian space on the eastern leg of the intersection. Provision of more contiguous space to the south of the intersection creates and more comfortable environment for pedestrians. This also provides separation between the staircase barrier walls and eastbound traffic, improving automobile safety. Without the additional space provided by the removal of the curb lane, the pedestrian environment in the southeast corner would be significantly impacted to accommodate the existing staircase. This also provides advantages when considering the structural elements of the underground concourse beneath the intersection, as more space is available to accommodate any physical modifications of the space.

Comparing Alternative 4 to the existing condition results does show some differences. As can logically be expected, re-introducing pedestrians to the intersection at at-grade crossings will have some minor to moderate effects on automobile and transit travel through the study area.

The AM peak hour shows that operations for all modes in the study area will not be significantly affected. There are some minor impacts to motorised travel via cars and buses. This is indicated via some increases to person delay (+10%) and a slight decrease in average travel speed (-4%). Transit service is largely unaffected during the AM peak hour. Note, however, that despite the small increases in delay to vehicles, the intersection of Portage and Main was still shown to operate at a level of service of C, which indicates that the overall experience for drivers will not be significantly different at the intersection.

The PM peak hour does see some more significant impacts to travel through the intersection in Alternative 4, when compared to existing conditions. The level of service for Portage and Main was shown to decrease from B to D with the increases to delay for automobiles. This increased delay is felt mainly by the right turning movements at the intersections, which must now yield to pedestrians. Note that the travel time for the two most significant movements – northbound and southbound through – are unaffected by the change and show similar or even slightly improved travel times for cars in the model versus the existing condition. Note, however, that level of service D for an urban signalised intersection still meets the standards applied by many North American cities. Transit service does see some significant increases in delay in the study area due to the change. Most significantly affected are eastbound buses, which see increases in delay for all eastbound movements at the Portage and Main intersection. As described in previous sections, the experience for pedestrians in both peak hours when comparing existing conditions to Alternative 4 is largely improved – for wheelchair and mobility-challenged users the travel time savings is significant; for able-bodied users the travel time is similar, but the distance required to cross the street is greatly reduced.

Following the selection of the preferred alternative by the TSC, the model was further enhanced to provide additional safety for pedestrians at Portage and Main and restrict automobile traffic in the model to the posted speed limit of 50 km/h.

Pedestrian safety at the intersection was enhanced through the implementation of Leading Pedestrian Interval (LPI) phases to each crossing, as applicable. An LPI provides a short head start to pedestrians over turning vehicles at the beginning of the phase. This allows pedestrians to take ownership of the crossing prior to the entrance of vehicles into the intersection, which makes them more visible and forces vehicles to yield. Note, however, that this does not eliminate the conflict between pedestrians and vehicles at right turns and that an LPI does not provide any benefit to a late-arriving pedestrian at the intersection. An LPI of five seconds was added to assist the north, west, and south crosswalks (the east crosswalk does not have any conflicting turning movements during the north-south signal phase).

The recommended signal phasing and timing for Portage/Main is illustrated on **Figure 16** below. Note that vehicle phases are denoted ØX, where X is the phase number. Pedestrian phases are denoted as Ø1XX, where XX corresponds to the phase number for the concurrent vehicle phase. The overall cycle length of 120 seconds has been maintained for the intersection in the preferred alternative.

As can be seen in the figure, a five second LPI has been added to all approaches where right turning vehicles will be in conflict with pedestrians (EB, WB, SB). The time to accommodate the LPI was taken from the NB/SB phases to reduce delays for the EB movements due to the restriction. Initial testing showed that EB movements saw the most delay due to the implementation of pedestrians, whereas NB/SB travel was largely unaffected. As shown in the analysis above, NB and SB travel were shown to perform largely the same as existing conditions with the proposed phasing and timing. City of Winnipeg has indicated that existing equipment is adequate to accommodate the use of LPI.

It is important to note the difference in walk time available to the pedestrian crossings on the east (Ø102) and west (Ø101) sides of the intersection. The shorter crossing distance on the east side of the intersection due to the removal of the NBR movement and the departing curb lane on the eastern leg allows for much more walk time before the Flashing Don't Walk phase when compared to the west side. This provides for a more comfortable and convenient crossing for pedestrians on the east side as they can arrive much later at a walk phase and still be able to cross the road safely.

Note also that it was necessary to maintain an exclusive eastbound phase of the signal which allows for the heavy EBL movement to move unencumbered through the intersection. Without this allowance, delays for eastbound movements would be quite significant, as pedestrians crossing the northern leg greatly reduce the capacity for the EBL movement.

Figure 16 – Portage and Main - Final Signal Timing

6.0 Sensitivity Analysis

As the pedestrian volume crossing the Portage/Main intersection applied during the analysis portion of the project was synthetically forecasted relative to adjacent intersections, the City of Winnipeg requested that sensitivity analysis on the preferred model's operations be performed that varies the amount of pedestrian volume. The test involved modifying the pedestrian crossing volume from the base condition (Alternative 4 with LPI) to the following scenarios: - 10%, +10%, +25%, +50%. No other inputs or settings in the model were modified, to allow for the sensitivity of the network to changes in pedestrian volume to be assessed.

Table 13 shows the pedestrian crossing volumes applied in each scenario. The underlying pedestrian origin/destination table was simply factored up or down for the specific percentage in each case.

Table 13 – Portage Avenue and Main Street – Pedestrian Crossing Volumes – Sensitivity Analysis

Crosswalk	-10%		Base		+10%		+25%		+50%	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
North	360	450	400	500	440	550	500	625	600	750
South	360	450	400	500	440	550	500	625	600	750
East	270	450	300	500	330	550	375	625	450	750
West	270	450	300	500	330	550	375	625	450	750

Model runs were performed using the Alternative 4 network for the AM and PM peak hour. Each scenario was run using 10 different random seeds and the results were averaged to create a true average condition. **Table 14** and **Table 15** present the results for the sensitivity tests. **Figure 17** and **Figure 18** show the trend in travel times for each travel mode for the AM and PM peak hours.

Table 14 – Pedestrian Sensitivity Analysis Results – AM Peak Hour

		Volume[1]	Existing		-10%	Base	+ 10%	+ 25%	+ 50%
Automobiles	**Overall Model Performance**								
	Average Travel Speed (km/h)	-	20.0		15.8	15.6	15.6	15.4	14.6
	Unmet Demand	-	0		94	94	77	107	152
	Person Hours of Delay [2]		349		515	521	522	529	564
	Portage / Main Performance								
	Intersection Level of Service	-	C		D	D	D	D	E
	Intersection Avg Vehicle Delay (sec)	-	22.7		47.4	49.8	50.4	52.2	55.4
	Avg. Travel Time (min:sec)								
	Total	*5,925*	*0:26:02*		*0:34:25*	*0:35:38*	*0:35:12*	*0:35:30*	*0:37:32*
	Southbound Through	1,655	0:03:16		0:04:29	0:04:33	0:04:37	0:04:44	0:04:53
	Northbound Through	1,225	0:04:03		0:04:12	0:03:58	0:04:02	0:03:53	0:04:05
	Eastbound Left	795	0:02:28		0:04:41	0:04:57	0:04:40	0:04:41	0:04:57
	Eastbound Through	725	0:01:45		0:05:18	0:05:35	0:05:13	0:04:47	0:05:06
	Southbound Right	725	0:03:28		0:04:33	0:04:59	0:05:13	0:05:58	0:06:43
	Westbound Through	450	0:02:06		0:02:29	0:02:32	0:02:34	0:02:34	0:02:33
	Eastbound Right	210	0:03:04		0:05:59	0:06:09	0:05:55	0:05:38	0:05:50
	Westbound Right	70	0:02:30		0:02:43	0:02:55	0:02:58	0:03:14	0:03:24
	Northbound Right [3]	70	0:03:23		-	-	-	-	-
Pedestrians	**Safety**								
	Permitted Dual RT	-	-		Yes	Yes	Yes	Yes	Yes
	Avg. Travel Time (min:sec)		Able	Wheelchair					
	Total	*1,400*	*0:16:09*	*0:34:30*	*0:14:40*	*0:14:47*	*0:14:45*	*0:14:51*	*0:14:46*
	West Side	300	0:03:58	0:09:04	0:04:04	0:04:08	0:04:09	0:04:10	0:04:08
	East Side	300	0:04:45	0:08:01	0:03:43	0:03:47	0:03:43	0:03:48	0:03:45
	North Side	400	0:03:51	0:09:08	0:03:50	0:03:51	0:03:52	0:03:50	0:03:51
	South Side	400	0:03:35	0:08:17	0:03:03	0:03:02	0:03:01	0:03:02	0:03:02
Transit	**Overall Model Performance**								
	Average Travel Speed (km/h)	-	9.7		8.9	8.9	8.9	8.8	8.6
	Person Hours of Delay [2]	-	637		729	729	731	730	760
	Avg. Travel Time (min:sec)								
	Total	*272*	*1:10:39*		*1:18:54*	*1:18:50*	*1:18:47*	*1:18:37*	*1:20:06*
	From Graham to North	44	0:10:44		0:10:40	0:10:30	0:10:29	0:10:28	0:10:28
	From Graham to South	35	0:07:43		0:07:33	0:07:27	0:07:27	0:07:28	0:07:27
	From North to Graham	31	0:08:57		0:10:30	0:10:42	0:10:44	0:10:58	0:11:23
	From South to Graham	24	0:06:07		0:06:09	0:05:57	0:05:58	0:05:39	0:05:58
	Eastbound Right	61	0:08:43		0:08:39	0:08:25	0:08:29	0:08:19	0:08:25
	Eastbound Left	26	0:07:19		0:08:23	0:08:35	0:08:39	0:08:51	0:09:15
	Northbound Left (via St. Mary)	18	0:06:40		0:08:09	0:08:11	0:08:06	0:08:01	0:08:06
	Westbound Through	14	0:04:39		0:05:33	0:05:41	0:05:38	0:05:54	0:05:57
	Southbound Right	10	0:03:46		0:05:41	0:05:41	0:05:44	0:05:30	0:05:33
	Eastbound Through	9	0:06:01		0:07:38	0:07:42	0:07:32	0:07:28	0:07:34

1 Volume for automobiles is taken from balanced intersection counts; volume for buses is taken from model observations with combined routes and schedules

2 Person Hours of Delay based on occupancies of: 1.24 per auto and 20 per bus

3 Northbound Right is blocked in Preferred.

Table 15 – Pedestrian Sensitivity Analysis Results – PM Peak Hour

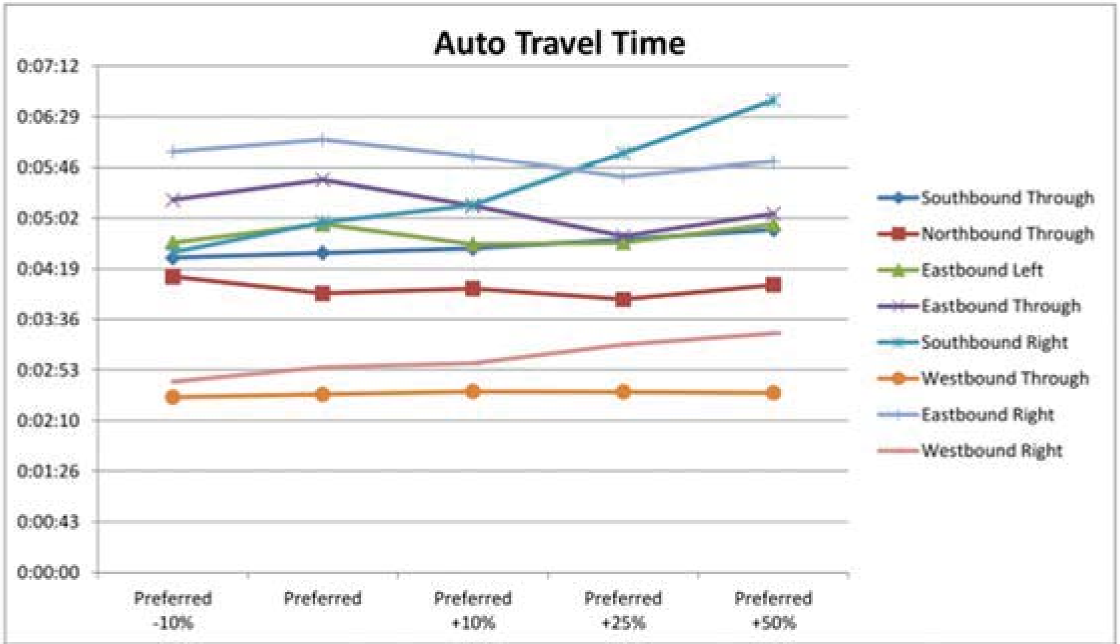
		Volume[1]	Existing		-10%	Base	+ 10%	+ 25%	+ 50%
Automobiles	**Overall Model Performance**								
	Average Travel Speed (km/h)	-	19.0		12.1	12.1	11.9	11.9	11.8
	Unmet Demand	-	0		1,012	953	1,073	1,037	1,077
	Person Hours of Delay [2]		386		719	722	727	730	734
	Portage / Main Performance								
	Intersection Level of Service	-	C		E	E	E	E	E
	Intersection Avg Vehicle Delay (sec)	-	22.1		62.8	63.6	64.8	66.3	67.3
	Avg. Travel Time (min:sec)								
	Total	*6,240*	*0:28:30*		*0:47:41*	*0:47:27*	*0:48:38*	*0:50:14*	*0:50:47*
	Southbound Through	1,750	0:05:03		0:05:45	0:05:43	0:05:43	0:05:43	0:05:47
	Northbound Through	1,440	0:03:14		0:03:25	0:03:28	0:03:25	0:03:25	0:03:26
	Eastbound Left	860	0:02:43		0:05:54	0:05:51	0:05:53	0:05:57	0:05:52
	Eastbound Through	610	0:02:17		0:08:10	0:07:42	0:08:02	0:08:17	0:07:59
	Southbound Right	605	0:03:07		0:04:07	0:04:13	0:04:11	0:04:22	0:04:32
	Westbound Through	520	0:01:56		0:03:19	0:03:26	0:03:30	0:03:53	0:04:02
	Eastbound Right	280	0:05:15		0:09:17	0:08:58	0:09:19	0:09:30	0:09:14
	Westbound Right	130	0:02:45		0:07:43	0:08:05	0:08:37	0:09:07	0:09:55
	Northbound Right [3]	45	0:02:11		-	-	-	-	-
Pedestrians	**Safety**								
	Permitted Dual RT	-	-		Yes	Yes	Yes	Yes	Yes
	Avg. Travel Time (min:sec)		Able	Wheelchair					
	Total	*2,000*	*0:16:09*	*0:34:30*	*0:15:01*	*0:14:54*	*0:14:54*	*0:14:58*	*0:15:09*
	West Side	500	0:03:58	0:09:04	0:04:15	0:04:11	0:04:12	0:04:15	0:04:16
	East Side	500	0:04:45	0:08:01	0:03:48	0:03:49	0:03:53	0:03:49	0:03:54
	North Side	500	0:03:51	0:09:08	0:03:53	0:03:51	0:03:48	0:03:51	0:03:55
	South Side	500	0:03:35	0:08:17	0:03:04	0:03:02	0:03:02	0:03:03	0:03:03
Transit	**Overall Model Performance**								
	Average Travel Speed (km/h)	-	10.2		8.1	8.2	7.7	8.0	7.7
	Person Hours of Delay [2]	-	559		767	748	805	771	810
	Avg. Travel Time (min:sec)								
	Total	*253*	*1:05:45*		*1:23:18*	*1:22:57*	*1:24:07*	*1:24:38*	*1:28:58*
	From Graham to North	45	0:09:09		0:09:26	0:09:23	0:09:49	0:09:18	0:09:41
	From Graham to South	40	0:07:05		0:06:22	0:06:27	0:06:36	0:06:16	0:06:37
	From North to Graham	31	0:08:52		0:10:24	0:10:29	0:10:13	0:10:53	0:11:25
	From South to Graham	16	0:04:33		0:05:53	0:05:43	0:05:19	0:06:09	0:06:34
	Eastbound Right	40	0:06:25		0:07:59	0:07:56	0:07:47	0:07:48	0:08:19
	Eastbound Left	25	0:06:20		0:06:57	0:07:03	0:07:02	0:07:00	0:07:14
	Northbound Left (via St. Mary)	24	0:07:45		0:10:18	0:09:57	0:10:13	0:10:01	0:10:37
	Westbound Through	11	0:04:26		0:09:24	0:09:51	0:10:31	0:10:58	0:11:37
	Southbound Right	11	0:04:31		0:07:01	0:07:00	0:07:02	0:06:53	0:07:12
	Eastbound Through	10	0:06:39		0:09:33	0:09:07	0:09:34	0:09:22	0:09:42

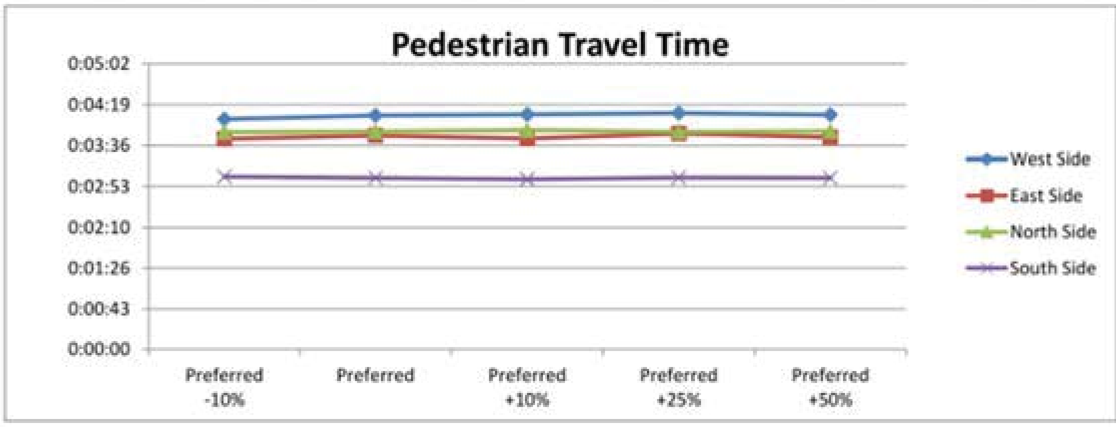
1 Volume for automobiles is taken from balanced intersection counts; volume for buses is taken from model observations with combined routes and schedules

2 Person Hours of Delay based on occupancies of: 1.24 per auto and 20 per bus

3 Northbound Right is blocked in Preferred.

Figure 17 – Pedestrian Sensitivity Analysis Results – Change in Travel Time – AM Peak Hour





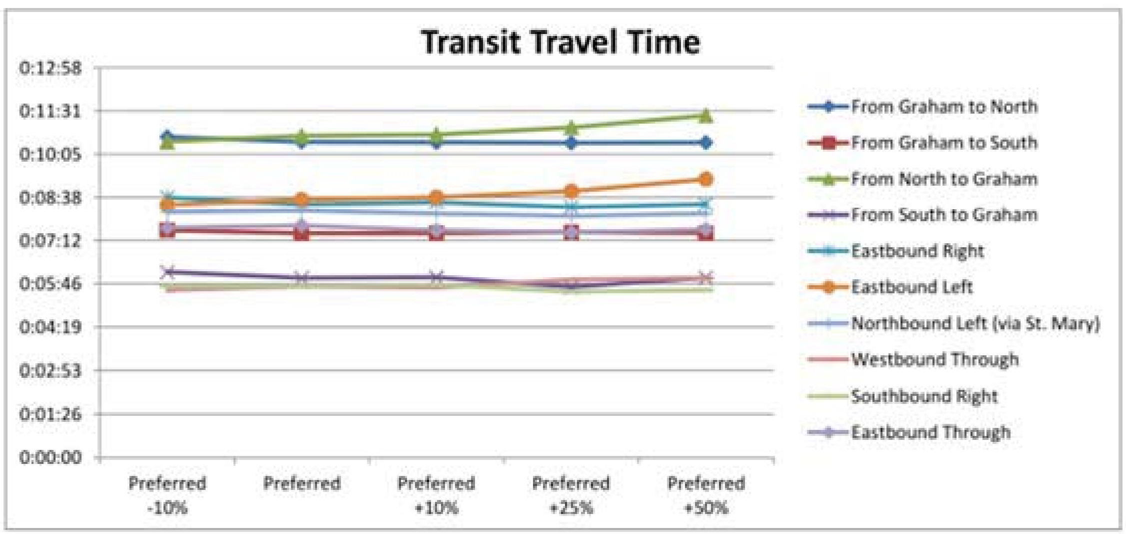
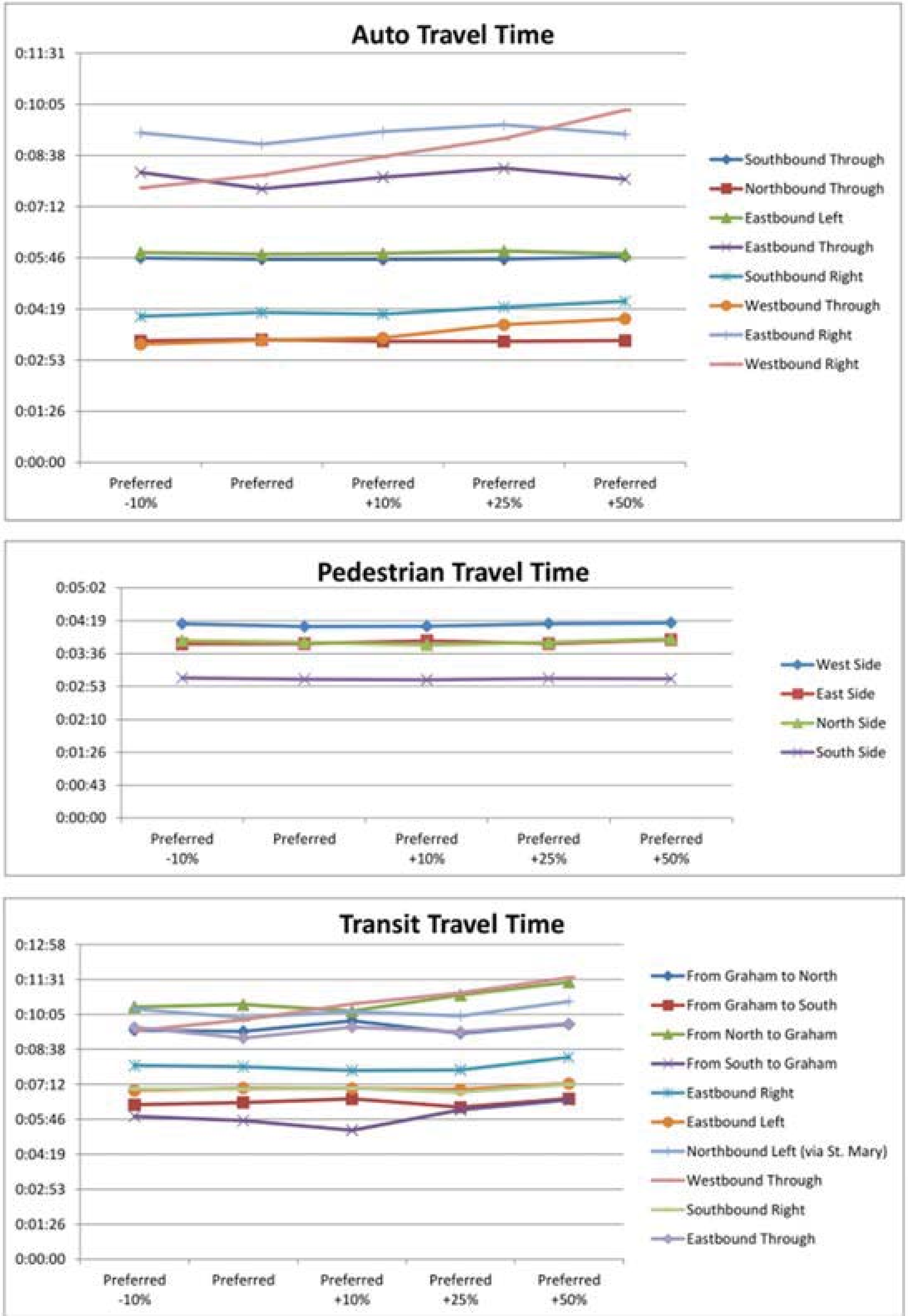


Figure 18 – Pedestrian Sensitivity Analysis Results – Change in Travel Time – PM Peak Hour



For automobiles, the average travel speed, unmet demand, and person hours of delay show little change across the alternatives. The one exception is the +50% case in the AM, which sees a deviation in all three elements (-1km/hr. or 8% reduction in average speed, +50% unmet demand, +10% person delay). This level of change is certainly noticeable in the numbers, but may not be significant in practice.

LOS and intersection delay at Portage and Main does show some logical increases in both AM and PM - there is a clear relationship between pedestrian volume and overall intersection delay. However, the change from the -10% scenario to +50% is only an additional 5 to 8 seconds per vehicle. This may not be perceptible in practice. In essence, things have not completely failed in any of the test scenarios.

The travel times in the graphs show that there is a clear and logical relationship between increasing the number of pedestrians and delay for the westbound right turn and southbound right turn movements; for example, the southbound right turn moves up sharply in the AM in particular (+2:10). Interestingly, the eastbound right turn travel time stays fairly flat. The delays and queuing for the westbound right turn in the PM peak hour are enough that it starts to affect the westbound through movements in the +25% and +50% scenarios.

As has been observed in all of the previous model runs, the travel time for pedestrians does not change when the pedestrian volume is increased or decreased. This indicates that, even at the highest level of pedestrian volume in the sensitivity analyses, the crosswalks and available sidewalk space at the crossings still have not reached capacity and signal timing is the determinant factor in travel time for pedestrians.

Travel times for transit vehicles in the AM peak hour are relatively flat across the range of pedestrian volume, except for From the North to Graham and the eastbound left turn. North to Graham suffers due to the increased delay to the southbound right turning autos with the increase in pedestrians, as they share a lane (an approximate 40 second increase). The eastbound left turn sees an increase of approximately 40 seconds in the +50% scenario, which is likely due to extra friction in getting over to the left turn lane due to the some additional friction from the eastbound right vehicles.

The PM peak hour shows a heightened sensitivity to pedestrian volume for transit vehicles for four movements. As with the AM peak hour, the buses travelling from the north to Graham Avenue show increasing travel time due to the shared lane with autos making a southbound right turn. Similarly, the westbound through buses experience increasing travel times with increases to the pedestrian crossing volumes due to increased congestion for the westbound right turning autos. Buses making the eastbound right turn show an increase in the +50% scenario that is larger than the impacts seen for cars (40 seconds versus 20 seconds). This is likely due to the need for a larger gap for buses to accelerate via a single lane, whereas cars are more agile and can move between the curb and second lane.

7.0 Safety and Risk Analysis

This section summarizes the safety and risk concerns of implementing the preferred alternative.

The technical requirements for the traffic signals at Portage and Main are not substantially different from other signalized intersections in Winnipeg. There will not be more than eight signal phases, so a standard controller will be used. The only new or untested portion of the proposed signal timing is that a leading pedestrian walk interval is proposed on multiple phases in combination with the southbound right-turn and eastbound left-turn movement overlap. This has already been used on a single phase at Main Street and Broadway to allow pedestrians time to establish themselves in the intersection in advance of the turning vehicles. This change has had a positive effect but it has not been in place long enough to judge long-term safety benefits. The Traffic Signals Branch has bench tested the timings on a controller using current hardware and software. There were no operational issues with having the leading pedestrian walk interval in combination with the southbound right-turn and eastbound left-turn movement overlap.

The safety risks resulting from pedestrian-vehicle interaction will undoubtedly be higher than with the existing configuration as opening the intersection to pedestrians creates conflict points. This is of particular concern with the dual unprotected right turn vehicle movements for the eastbound right turn and southbound right turn. The southbound right-turn movement has a large volume of traffic travelling at higher speeds around the obtuse angle of that corner. While the risks of a collision with pedestrians will undoubtedly increase from zero, they will not be any greater than the risks of pedestrian-vehicle interactions that currently exist at other major intersections in Winnipeg. The risk will be mitigated by using leading pedestrian walk intervals that have been shown to enhance pedestrian safety at Main and Broadway and are being considered for other intersections in downtown Winnipeg.

There are risks in creating an unusual intersection that does not meet driver expectations by being inconsistent with other intersections in Winnipeg. This scenario would be created if only some of the pedestrian crosswalks were opened, or if the pedestrian crosswalks were located at unusual locations. The preferred alternative largely avoids this potential problem by proposing that all four pedestrian crosswalks be opened and located as close to the intersection box and stop lines as possible. This will make Portage and Main consistent with other large intersections by ensuring that pedestrians are directed to cross the street where drivers naturally expect them to and know to look for them. The current configuration is particularly unsafe when pedestrians jaywalk across Portage or Main, either midblock where the barriers end or sometimes even by jumping over the barriers. Drivers are not expecting to encounter any pedestrians at this intersection currently and so may not see them until it is too late to avoid a collision.

Despite proposing to extend the sidewalk in the southeast corner further into the intersection to tighten up the overall footprint of the intersection box, Portage and Main will remain a particularly large intersection. This presents risks to slower pedestrians navigating the long crossing distances and potentially being stranded on the median or left in the middle of the intersection while traffic receives a green light. This can be mitigated by providing countdown signals to give pedestrians a clear indication of how much crossing time they have, and by designing adequate space for pedestrian refuge in the medians.

Under the current configuration, many pedestrians have reported feeling unsafe walking through the underground concourse on evenings and weekends outside of business hours when the concourse is largely empty. The mazelike nature of the tunnels, especially to those who are unfamiliar with them, prevents people from having a full view of their surroundings. Perceived safety will be improved by allowing people to cross at street level where there are longer sightlines and more “eyes on the street”, both from other pedestrians and travellers in vehicles. Regardless of the infrastructure alternative selected, wayfinding signage both at ground level and in the concourse should be reviewed and improved to provide pedestrians with clear directions and inform them of the route choices available to them to cross the intersection.

Pedestrians who use wheelchairs or other mobility aids that cannot navigate on stairs or escalators currently experience significantly longer travel times to cross Portage and Main than able-bodied pedestrians do, as shown in **Section 2.4**. Some of the elevators these pedestrians require are located in private buildings that are not open 24 hours a day, preventing people from crossing the intersection at all hours if they cannot navigate stairs or escalators. When there are mechanical issues with the escalators and elevators in the underground concourse, pedestrians who rely on this infrastructure are unable to cross the intersection. Universally designed pedestrian infrastructure at ground level will be accessible to all pedestrians at all times.

Opening Portage and Main to pedestrians will both increase travel times and decrease the reliability for the vehicular movement of goods or people through downtown Winnipeg. The intersection will operate closer to maximum capacity at peak periods and small disruptions may cause larger ripple effects to the traffic network downtown. While this is undoubtedly a risk for those who travel exclusively by vehicle, reconfiguring Portage and Main will improve the movement of people by multiple modes. Infrastructure that is more conducive to walking may encourage a modal shift from vehicular trips and make the area more attractive for urban living. On weekdays, there are an estimated 15,000 people within 100 metres of Portage and Main, making it the densest area of the city. Any improvements to peoples’ access to transit, walking, and biking around Portage and Main have the potential to result in a significant impact on the number of single-occupant vehicles driven to the area.

8.0 Conceptual Design

8.1 Methodology

In preparation for a conceptual design of a recommended alternative, Dillon procured background data from the City of Winnipeg. This included:

- LBIS – CAD files for location of right-of-way, selected City underground utilities such as watermain/sewermain.
- Underground Structures Branch procured record drawings – mainly digitized hard copies of projects constructed in the public right-of-way. This also included a few CAD based drawings of various levels of detail. Note that these drawings generally had no information on the underground concourse or barrier wall construction.
- Municipal Accommodations Branch procured drawings – digitized hardcopies of what appears to be the circa 1976 construction plans for the concourse, as well as 360 Main Street (Winnipeg Square). They do not appear to be record drawings from after construction, so some changes may have been made during construction. Some CAD files were also present, including floor plan and sub-floor plans of the adjacent buildings (some plans are confidential and the information was not utilized). These drawings were invaluable in determining the structure and foundation of the barrier walls, and the walking paths used in the pedestrian analysis.

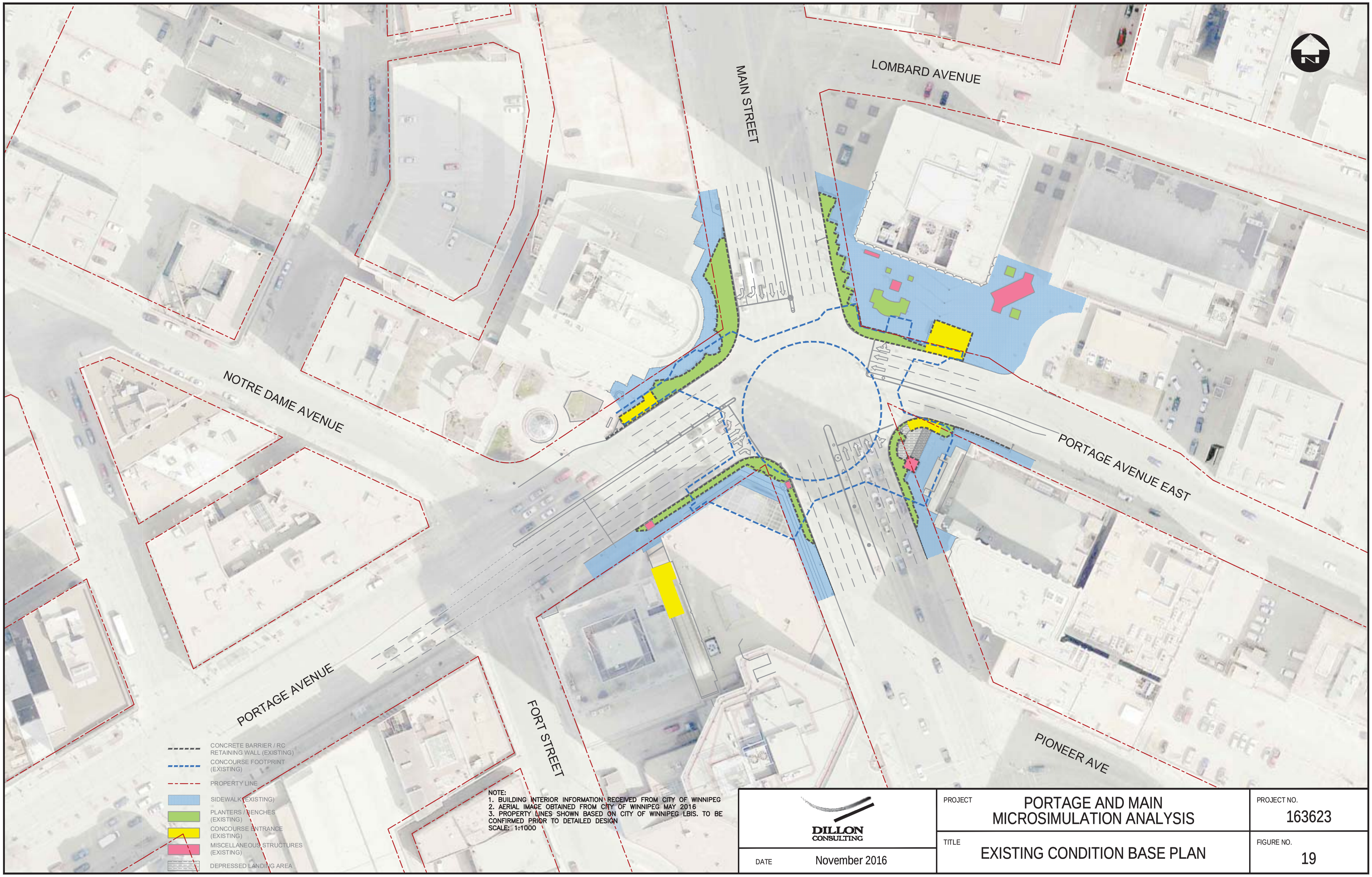
As the focus of the study is on transportation planning analysis, and the design was to only be at a level for a Class 4 estimate, the data sources above were deemed sufficient. Site visits supplemented the drawings to ground truth design items and the subsequent cost estimate.

The various City-provided CAD drawings were used to develop a base plan of the existing conditions. This is shown on **Figure 19**. Existing lane widths, medians, and sidewalk locations were determined from the CAD drawings, ortho-rectified photos, and digitized hard copy plans.

The main guidelines used for subsequent conceptual design included:

- Transportation Association of Canada's Geometric Design Guide for Canadian Roads (TAC)
- City of Winnipeg – Transportation Standards Manual (2012 Draft) (TSM)
- AASHTO Roadside Design Guide (RSDG)

In a complex and busy urban environment, TAC is not always an appropriate guide; hence the TSM would take precedence as required. An example of this is that Table 5.3 of the TSM is used for clear zone from the edge of the travelled vehicle lane to a fixed object. Both Portage and Main in the study area are posted at 50 km/hr., hence a minimum clear zone of 2.5 m and a desirable of 3.5 m is the goal. In all cases, design engineering best practices were employed at the conceptual level.



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	PROJECT: PORTAGE AND MAIN MICROSIMULATION ANALYSIS	PROJECT NO. 163623
DATE: November 2016	TITLE: EXISTING CONDITION BASE PLAN	FIGURE NO. 19

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The conceptual design is focused mainly on horizontal geometry. Basic features to make the intersection functional for both vehicles and pedestrians are considered. This would include sidewalks, curb ramps, roadway lanes, medians, and traffic signal pole locations. Features such as public art, aesthetic treatments for sidewalks, benches or other street furniture, or other place making elements are not part of the conceptual design. The conceptual design to this stage was focused on provision of quick, least cost solutions.

Note that all corners excluding the NW have marginal sidewalk width in the public right-of-way. This is especially evident in the property corners of the SE and SW corners. However, the sidewalk area spans onto private property, implying there are agreements in place unknown to Dillon Consulting Limited that the public can use the private plazas to traverse the area. The functional designs do not address this issue.

8.2 Alternatives 1-3

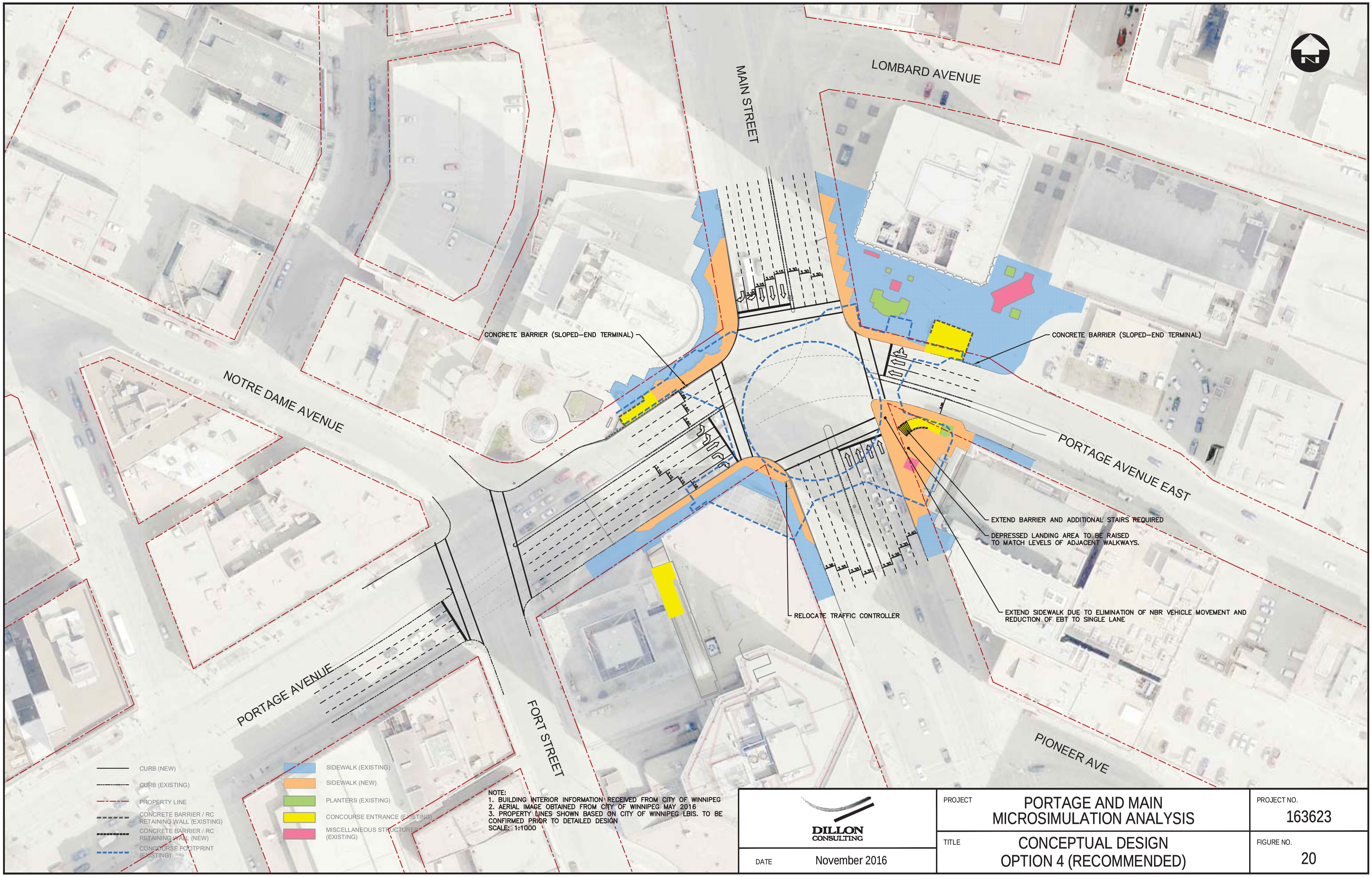
Alternatives 1 through 3 as defined by the City did not include any geometric changes to the intersection (barring the removal of barriers and addition of crosswalks). Therefore, no specific design drawing was produced. Curb ramp (and thus crosswalk) locations for the NE, SW, and NW corners would be similar to that shown in Alternative 4 or 5. However, the SE corner is problematic. The staircase and associated barrier is at back of curb, preventing access to the optimal location for the east side crosswalk. The depressed patio area also blocks access to curb ramp locations for both the west and south crosswalks. If the SE corner geometry was left as is, it would force pedestrians to walk on a narrow sidewalk in the former planter area immediately adjacent to northbound traffic on Main Street. There is also no escape route for pedestrians as the planter wall adjacent to the depressed patio would have to remain to protect pedestrians from the drop off.

As noted previously, barrier walls would have to remain to protect pedestrians from falling into the depressed patio, and into the staircase. These same barriers then remain within the clear zone, but would require new end treatments or crash attenuation as they would no longer be continuous as in their current situation.

The SE corner is not functional in its current geometry and layout to open the intersection to pedestrians. This was a major impetus to create Alternatives 4 and 5.

8.3 Alternative 4

Alternative 4 (ultimately the recommended option) is shown on **Figure 20**. The key component to this alternative is the elimination of the NBR movement, which allows the SE corner sidewalk to be built out away from the staircase. Partnered with this is the raising of the depressed patio to create pedestrian space. The details of this design are described below by intersection quadrant.



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DILLON CONSULTING	PROJECT: PORTAGE AND MAIN MICROSIMULATION ANALYSIS	PROJECT NO. 163623
DATE: November 2016	TITLE: CONCEPTUAL DESIGN OPTION 4 (RECOMMENDED)	FIGURE NO. 20

FileName:c:\projectwise\working directory\active\40gg\d0309129\163623-02-sk-003-prop road layout(option 4).dwg

8.3.1 Northeast Corner

- Virtually full removal of the barriers and associated planters is possible.
- No changes to EB traffic lanes.
- The staircase structure adjacent to WB Portage Avenue is immediately adjacent to back of curb. This presents a fixed, immoveable object within the clear zone (See **Figure 21**). It does not currently have any protection for motorists. It is recommended that a new concrete barrier wall with sloped end treatment be constructed. This would match the aesthetics of the existing staircase structure (and any other remaining wall sections) and provides a quick and low cost solution. This is similar to that employed as end treatments for F-Shape concrete barriers on the Osborne Bridge or the Provencher Bridge.
- The north and east crosswalk curb ramps can be sufficiently separated from each other to provide separate pedestrian wait areas. The plaza in front of the Richardson building provides an open environment with little pedestrian congestion expected.

8.3.2 Southeast Corner

- Elimination of the NBR movement allows the sidewalk to be pushed out into the former roadway area. The acute angle for the existing NBR required a very large amount of area to accommodate vehicles. Without this movement, the sidewalk space can be greatly enlarged. This shortens the pedestrian crossing distance, which assists in reducing signal time needed for pedestrian crossings. This also provides the necessary space for traffic signal poles.
- Elimination of the NBR converts all NB lanes into through lanes, increasing capacity of the NBT movement.
- The depressed patio area must be eliminated. (See **Figure 22** and **Figure 23**). This allows for continuous walking paths from the sidewalks along the east leg of Portage and south leg of Main Street to reach the curb ramps and crosswalks. Eliminating the patio allows for all the barrier walls along Main Street to be demolished and removed.
- Eliminating the patio requires the staircase to be extended upward to sidewalk level. This is likely an additional six to seven stairs, which then requires the barrier walls on either side to be extended in parallel. These walls are required for attachment of handrails, and so that pedestrians do not fall into the staircase area from the sidewalk.
- The World War I memorial and base can remain in its existing location. The nearest edge is approximately 2.9 m from the travelled lane, which is out of the clear zone.
- As the staircase requires barrier walls to remain, these walls would be within the clear zone of EB Portage Avenue traffic. In addition, the staircase blocks pedestrians from accessing the sidewalk along EB Portage. Therefore, Alternative 4 includes a sidewalk extension to the north, reducing the EB through lanes from two to one. This provides approximately 2.1 m of space between the remaining EB through lane and the nearest edge of the staircase barrier. This is less than the minimum specified

clear zone, thus protection is warranted. However, the curvilinear arrangement of the staircase gets the blunt end of the wall well outside the clear zone. It is doubtful that the curve replicates any recommended flare rate from the RSDG, but in this urban environment, a design exception may be warranted so end protection is not recommended. In detailed design, the barrier curve may be able to be modified to a more acceptable flare; however this would negatively impact the pedestrian space.

- The sidewalk extension to the north creates a protected curb lane that could be used for permanent parking (or loading/food truck/special event vehicles) immediately to the east of the intersection adjacent to the BMO building. The length of this potential permanent parking should be reviewed by the Traffic Management Branch in terms of downstream effect on storage for the EB movement approaching the Westbrook Street intersection.
- With these changes, the south and east crosswalk curb ramps can be sufficiently separated from each other to provide separate pedestrian wait areas. Sidewalk space is still somewhat constrained by the proximity of the staircase, but is better than in Alternative 5.

Figure 21 – Staircase Structure Adjacent to WB Portage Avenue on NE corner

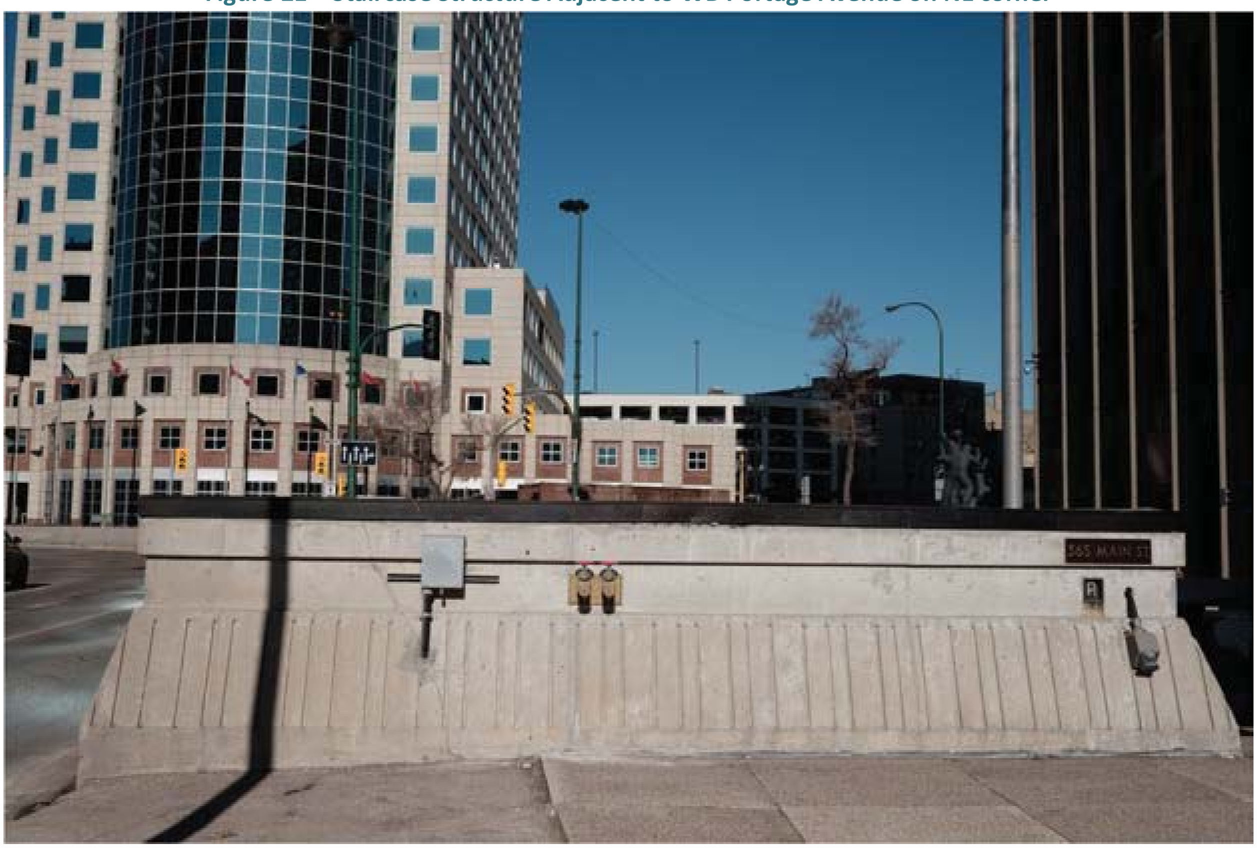


Figure 22 – Depressed Patio Area on SE corner

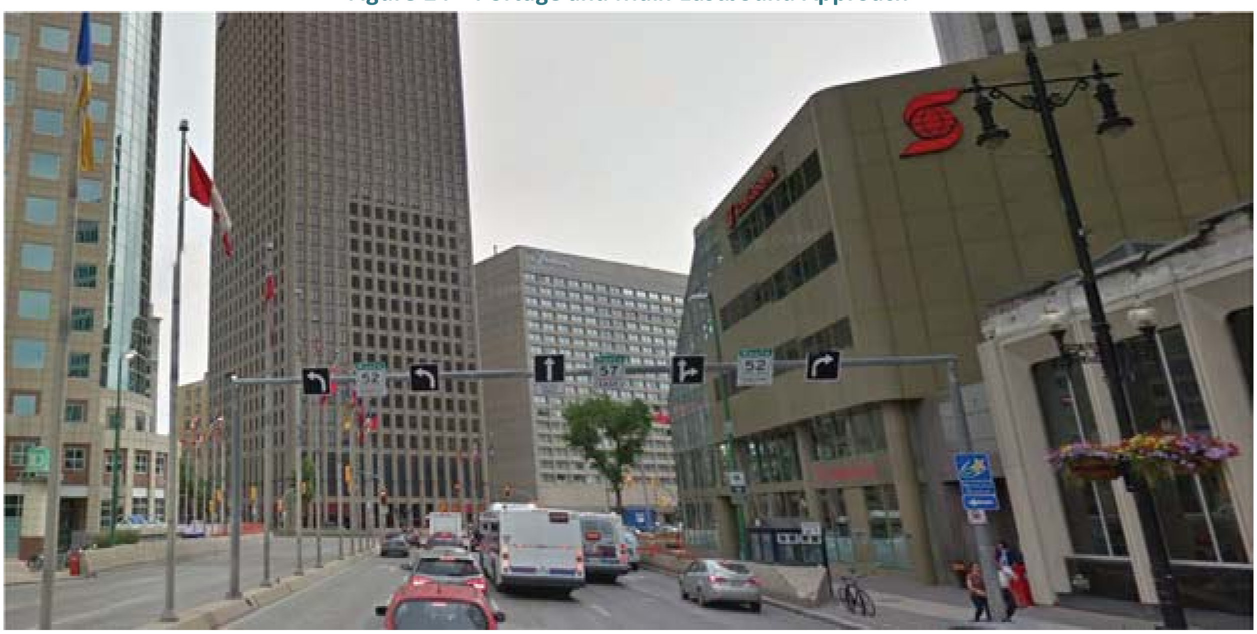
Source: Google Maps Streetview

Figure 23 – Depressed Patio Area - Existing Staircase on SE corner

8.3.3 Southwest Corner

- No geometric changes are proposed to the sidewalk. Complete removal of barriers/planters is included.
- EB traffic lanes reconfigured to accommodate reduction of far side EB through lanes from two to one. Would include two right turn lanes, a single through lane (with buses exempted so they can turn left) and two left turn lanes. Lane addition from four EB lanes to five EB lanes between Fort and Portage remains unchanged (See **Figure 24**).
- The traffic signal controller is in this quadrant and would need to be relocated adjacent to the property line to prevent errant SB vehicles from colliding with it (it was previously protected by the barrier).
- The existing EBR radius allows for good separation between the curb ramps for the south and west crosswalks. Sidewalk area is still limited compared to the other three corners due to 360 Main Street having a zero setback from the property line.

Figure 24 – Portage and Main Eastbound Approach



Source: Google Maps Streetview

8.3.4 Northwest Corner

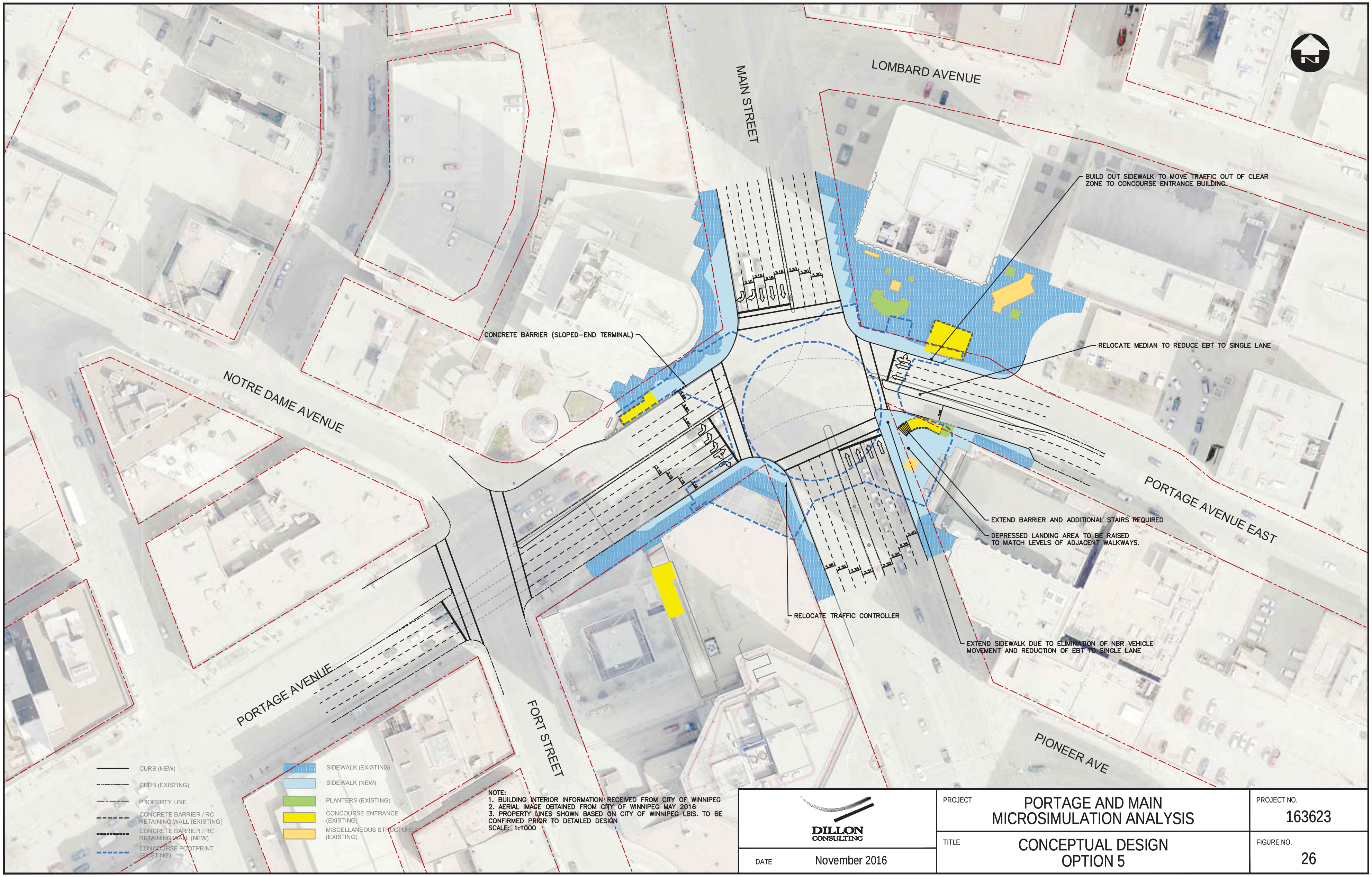
- No geometric changes are proposed to the sidewalk. Most of the barriers/planters can be removed.
- No changes to SB traffic lanes.

- Similar to the NE corner, the staircase structure adjacent to WB Portage Avenue is immediately adjacent to back of curb. This presents a fixed, immoveable object within the clear zone (See **Figure** 25). It is recommended that a portion of the existing concrete barrier wall remain and a sloped end treatment be constructed. This would match the aesthetics of the existing barrier adjacent to the staircase structure and provide a quick and low cost solution. The end treatment would be of a distance not to block the west crosswalk.
- The north and west crosswalk curb ramps can be sufficiently separated from each other to provide separate pedestrian wait areas. The plaza in front of 201 Portage Avenue provides adequate room for pedestrians and street furniture. The building also has an open air arcade where pedestrians can travel through (note that this is solely within private property).

Figure 25 – Fixed Staircase Structure on NW corner

8.4 Alternative 5

Alternative 5 is shown on **Figure 26** and is very similar to Alternative 4. Like Alternative 4, it eliminates the NBR movement, and raises the depressed patio to create pedestrian space. However, instead of eliminating the EB curb lane at the far side of the intersection, it eliminates the EB median lane, resulting in a different EB lane arrangement between Fort and Portage. The details of this design are described below by intersection quadrant.



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DATE: November 2016

PROJECT: PORTAGE AND MAIN MICROSIMULATION ANALYSIS

TITLE: CONCEPTUAL DESIGN OPTION 5

PROJECT NO. 163623

FIGURE NO. 26

FileName:c:\projectwise\working directory\active\40gg\d0309129\163623-02-sk-004-prop road layout(option 5).dwg

8.4.1 Northeast Corner

- Virtually full removal of the barriers and associated planters is possible.
- No changes to EB traffic lanes.
- With the elimination of one of two EB through lanes in the SE corner of the intersection, the WB lanes could be shifted south. The staircase structure adjacent to WB Portage Avenue would then be offset from back of curb, but still within the clear zone. Thus, a new concrete barrier wall similar to Alternative 4 would still be required.
- Crosswalk alignments and locations are similar to Alternative 4.

8.4.2 Southeast Corner

- As with Alternative 4, elimination of the NBR movement allows the sidewalk to be pushed out into the former roadway area, enlarging the sidewalk space.
- Elimination of the NBR converts all NB lanes into through lanes, increasing capacity of the NBT movement.
- As with Alternative 4, the depressed patio area must be eliminated and the staircase extended upwards. The World War I memorial and base can remain in its existing location.
- In Alternative 5, the EB far side median lane is eliminated and the far side median widened. The geometry is adjusted, which results in the staircase barrier still immediately adjacent to the remaining EB lane. Thus, the staircase wall barrier is within the clear zone of EB Portage Avenue traffic. In addition, the staircase blocks pedestrians from accessing the sidewalk along EB Portage compared with Alternative 4.
- The curvilinear arrangement of the staircase gets the blunt end of the wall approximately 4.8 m from the travel lane, which is outside the clear zone. As with Alternative 4, it is doubtful that the curve replicates any recommended flare rate from the RSDG, but in this urban environment, a design exception may be warranted so end protection is not recommended. In detailed design, the barrier curve may be able to be modified to a more acceptable flare. This would not further affect the pedestrian space as the staircase already blocks the sidewalk along EB Portage.
- The geometry is shown to create a protected curb lane east of the intersection similar to that in Alternative 4.
- With these changes, the south and east crosswalk curb ramps can be separate, but are in close proximity. The staircase is immediately adjacent and when congested, may be difficult or even dangerous to navigate for persons with visual impairments.

8.4.3 Southwest Corner

- EB traffic lanes reconfigured to accommodate reduction of far side EB through lanes from two to one. This would include a right turn lane, a shared thru and right lane, and a triple left turn lane. Lane addition from four EB lanes to five EB lanes between Fort and Portage would be modified so that the median lane becomes the option lane, which is more typical when a left turn lane is added to the near side of an intersection. Note that this alternative eliminates the benefit to Transit of using the third lane for left turning buses. Buses must now share the lane with the heavy left turn volume of vehicles.
- There are some minor concerns with driver unfamiliarity with a triple left turn, however this is not expected to function any less effectively than the current configuration. A triple left turn configuration exists at a few other high-volume locations in Winnipeg, notably WB Bishop Grandin Boulevard at Pembina Highway, NB Kenaston Boulevard at Sterling Lyon Parkway, and EB Sterling Lyon Parkway at Kenaston Boulevard.
- Other features are identical to Alternative 4.

8.4.4 Northwest Corner

- Identical to Alternative 4.

8.5 Conceptual Structural Design

A desktop structural review was undertaken of the planter walls and supporting structure to be able to produce a Class 4 cost estimate. Sources of information include the 1976 construction drawings, a site visit on July 28, 2016 while concourse roof water leak repairs were taking place in the north-west corner, and site photos. Following is a summary of the observed conditions and likely modifications to remove the planters and construct sidewalk described for each quadrant of the intersection. Excerpts from the 1976 construction drawings are utilized as figures in this section of the report.

Note that for all quadrants, new street lights and traffic signals must be founded on piers connecting on top of the existing concourse roof, preferably on concourse walls. If outside the concourse area, standard piles can be used.

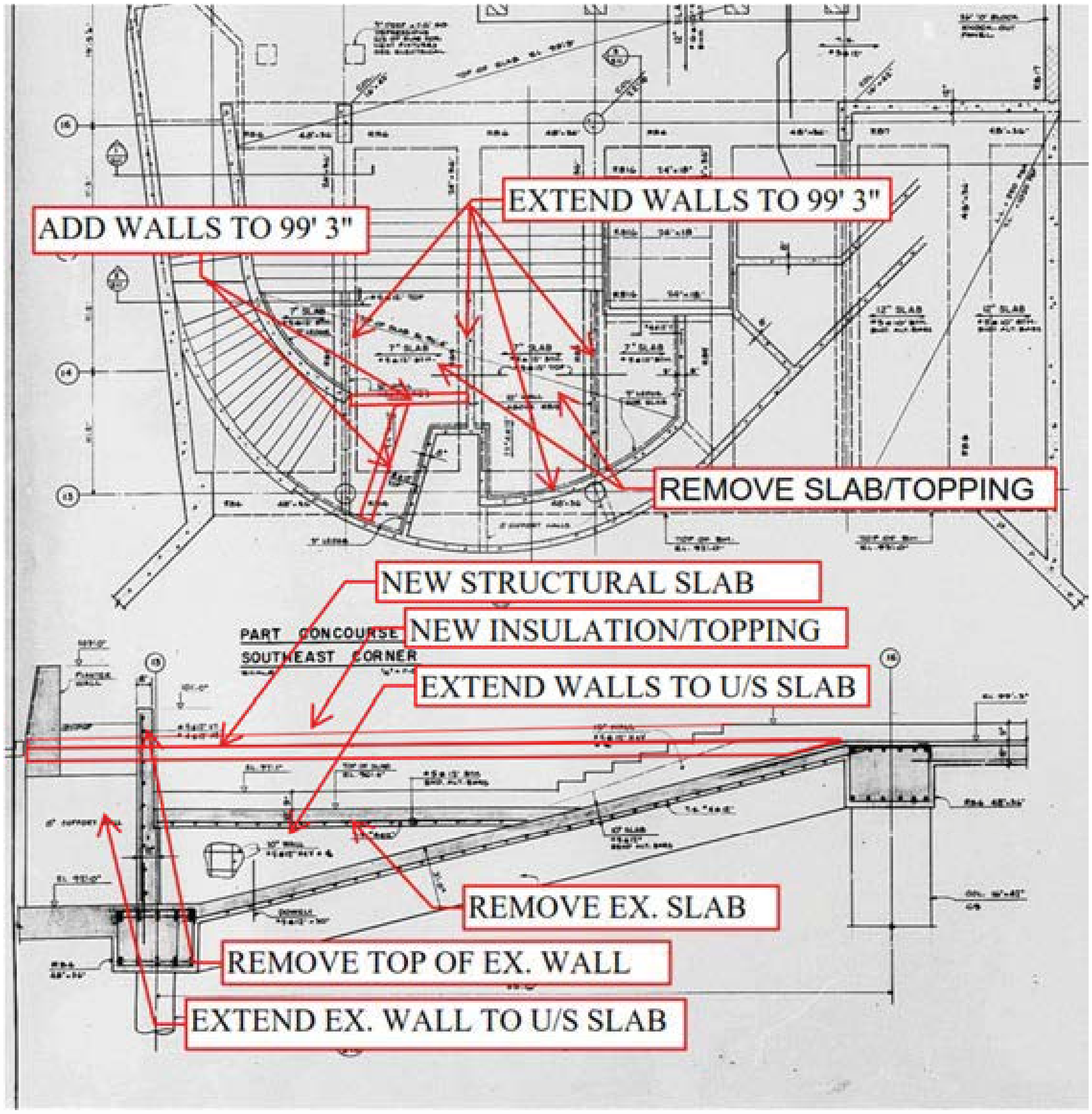
8.5.1 Northeast Corner

The northeast corner structure appears to be the same as shown in the 1976 drawings. Planter walls are either founded on piers that extend to the concourse roof or on piles. The removal of the planter walls can be done as outlined in the south-west corner discussion.

8.5.2 Southeast Corner

The depressed "patio" area in front of the BMO building leading to the staircase to the underground concourse is the main structural issue of the entire project (see **Figure 27**). As it is lower than the street grade, a new structural slab must be constructed at sidewalk elevation. There are two existing structural slabs, with a 10” thick slope slab spanning between 3’ 0” deep slope beams and 10” thick horizontal slab spanning between 10” walls on 3’ 0” deep slope beams with a 7” thick topping on top of a 3” thick insulation. The slope slab would be retained. The slab @ elevation 96’ 4” including topping and the insulation are to be removed. The walls on slope beams are to be extended to support a new slab @ elevation 99’ 3”. New walls would be added for stair extension framing. Since the new loading is approximately the same as the existing loading, the existing structure should be able to carry the new loading without additional reinforcement. However, it is recommended that the existing structures be assessed due to updated building code requirements.

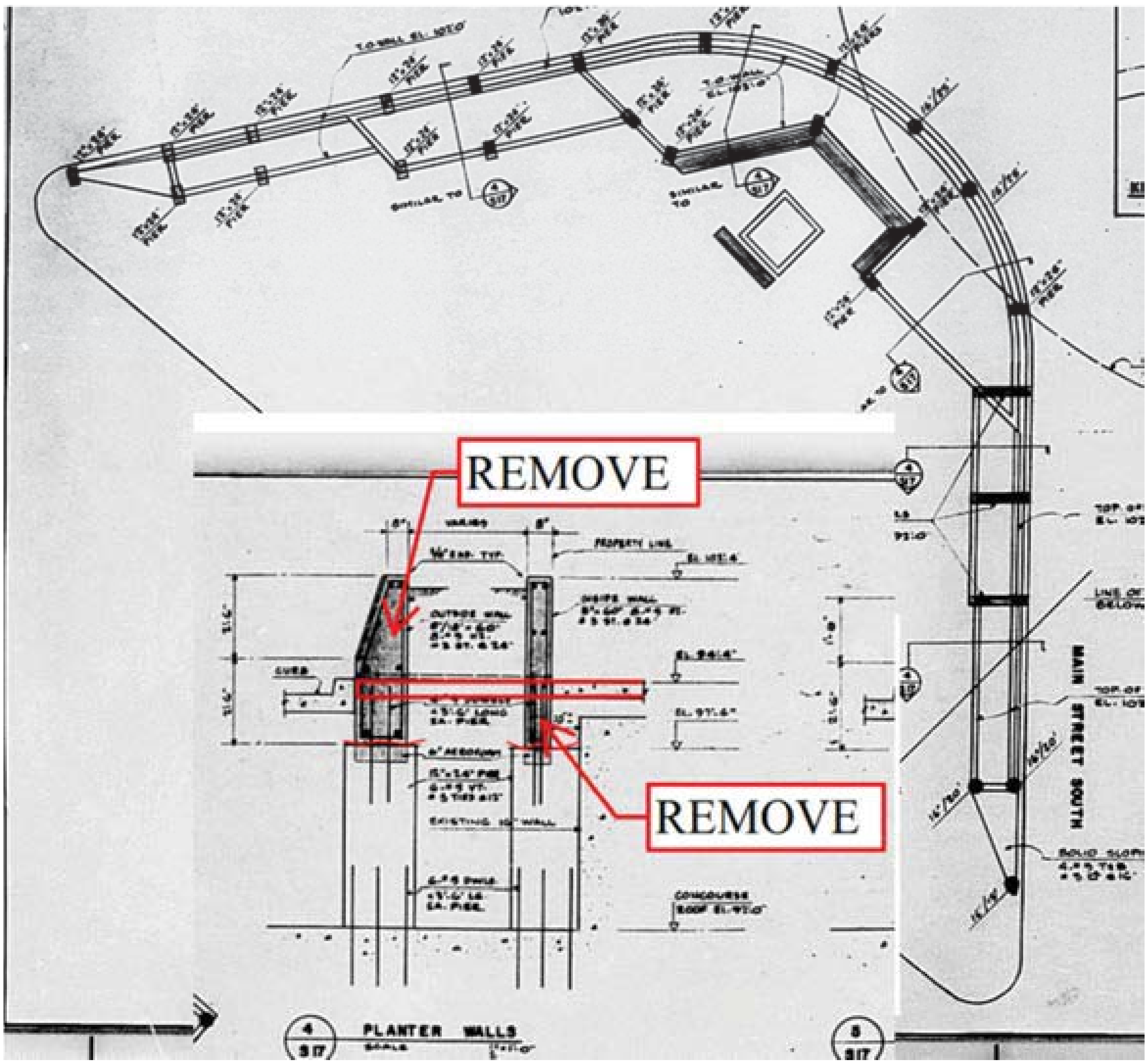
Figure 27 – Southeast Corner



8.5.3 Southwest Corner

The underground layout leading to Winnipeg Square has been modified from its 1976 design based on a review of those drawings as compared to a site visit of the Square. The planter walls, however, are the same as shown on the original drawings. The majority of the planter walls are founded on 1’ x 2’ piers dowelled into the roof structure, while the rest are founded on 16” piles. Removal of these planter walls can be done by cutting them off at the base of the walls. Proper repair and modification is required to prevent rusting of the remaining wall reinforcement (see **Figure 28**).

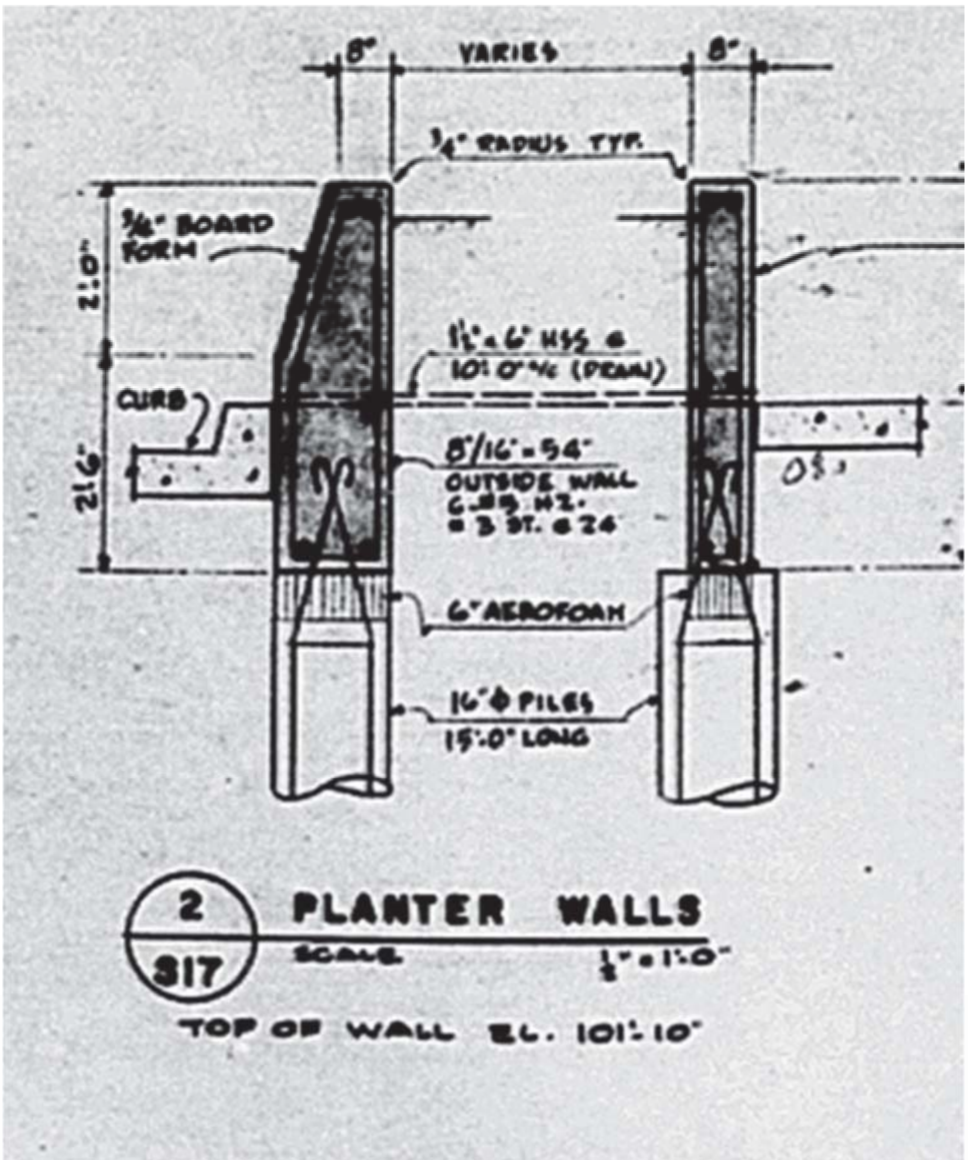
Figure 28 – Southwest Corner



8.5.4 Northwest Corner

The area along the northwest corner appears to have been modified from its original design when compared to the 1976 construction drawings. This likely occurred during the construction of 201 Portage Avenue. The majority of the above ground exterior planter walls appear similar to the original drawings. This exterior planter wall, based on the original drawings (see **Figure 29**), is the extension of the wall below. Removal of this wall can be done by cutting off the top of the wall below grade. Exact existing condition requires further investigation prior to detailed design to ensure that the wall has horizontal restraint since it is not believed to be designed as a cantilevered wall. Additional structural reinforcement may be needed. The northern portion of the exterior planter walls are on piles (**Figure 29** below). The structure of the interior planter wall is unknown. During the site visit on July 28, there was repair work being carried out. Based on an interview with construction personnel, the depth of the soil in the planter is approximately 4’ 0” with 1’ 0” of rock on top of what appears to be a concrete slab. Back calculation of the elevation indicates that this slab is approximately at 97’ 6”. Therefore, it is believed that the interior planter walls are connected directly onto top of the underground roof. Removal of the wall can be performed by cutting off the wall at its base.

Figure 29 – Typical Planter Walls on Piles



9.0 Cost Estimation

A Class 4 cost estimate (-30% to +60% intended accuracy to final cost) was prepared for the preferred alternative as described in **Section 8.0**. As this is a high level conceptual design and there are many unknowns regarding the configuration of the existing underground infrastructure, this cost estimate contains substantial contingencies on all costs. The total construction cost for the project is estimated at **$6,130,000.00**. With more detailed engineering design in the future, the projected costs will be known with increased certainty. However, due to the age of the structure, it is possible that any deterioration may not be discovered until excavation and demolition of the barriers begins.

The cost estimate for the different components of the project is summarized in **Table 16** and a more detailed breakdown is included in **Appendix C**. The costs of the roadworks, land drainage system, watermains, electrical, and telecommunications were all estimated based on comparisons to historical costs in recent infrastructure projects in Winnipeg undertaken by Dillon Consulting. Due to the complex and unique nature of the structural work, costs were estimated based on representative projects from outside the province of Manitoba. The estimates for traffic signals were provided by the City of Winnipeg Traffic Signals Branch and the estimates for Hydro infrastructure were derived from informal conversations with Manitoba Hydro.

Table 16 – Class 4 Construction Estimate

PORTAGE AVENUE AND MAIN STREET TRANSPORTATION STUDY

CLASS 4 CONSTRUCTION COST ESTIMATE - 2016 DOLLARS

Item	Total Cost
Construction (by Major Components)	
Roadworks	$620,000.00
Structural	$1,350,000.00
Land Drainage System	$100,000.00
Watermains	$85,000.00
Electrical	$100,000.00
Subtotal	**$2,255,000.00**
Utility Costs	
Traffic Services & Traffic Signals	$310,000.00
Hydro - Power Distribution	$150,000.00
Hydro - Street Lighting	$90,000.00
Hydro - Gas	$50,000.00
MTS	$100,000.00
Shaw	$50,000.00
Subtotal	**$750,000.00**
Engineering	

Item		Total Cost
Detailed Design	8%	$241,000.00
Contract Administration	8%	$241,000.00
Subtotal		**$482,000.00**
Land Acquisition		**$0.00**
Project Subtotal Before Contingencies		**$3,487,000.00**
Contingencies		
Construction	60%	$1,353,000.00
Utilities	60%	$450,000.00
Engineering	60%	$290,000.00
Land Acquisition	0%	$0.00
Other	5%	$175,000.00
Contingency Subtotal		**$2,268,000.00**
Project Subtotal After Contingencies		**$5,755,000.00**
City Overhead and Administration	6.5%	$375,000.00
Total Project Construction Cost		**$6,130,000.00**
Transit Capital Cost*		**$5,500,000.00**
Total Project Cost		**$11,630,000.00**

*Provided by the City of Winnipeg

This cost estimate is comprehensive of the basic work that is anticipated to be required to construct the preferred alternative. However, it should be noted that there are a number of potentially desirable items that are not included in the cost estimate:

- Overhead sign structures (the existing structures are far enough back from the intersection to remain unaffected);
- Heating and hoarding costs for winter construction work;
- Waterproofing or repairs to the existing concourse that may be discovered during construction;
- Additional cost to Winnipeg Transit to purchase and maintain additional buses to maintain existing service levels. Winnipeg Transit has estimated their annual operating requirements to maintain current bus service and minimize impact on passengers is estimated to be 12.5 additional Full Time Equivalent positions and $1,866,000 annually in operating costs; and,
- Costs for land acquisition (if needed) are not included.

The cost estimate assumes the construction of a fully functional but standard level of infrastructure at Portage and Main. This would be comparable to recent roadworks on St. Matthews Avenue near Empress Street as shown on **Figure 30**.

Figure 30 – Recent Roadworks – St. Matthews Avenue and Empress Street

Given the prominence of Portage and Main as both the symbolic and practical centre of downtown and Winnipeg as a whole, consideration should be given to incorporating decorative and signature elements into the reconfiguration of the intersection. Heritage light fixtures, street furniture, and public art could be considered in order to transform Portage and Main into a signature focal point. This could include an aesthetic continuation of the heritage themed streetscaping on Portage Avenue and Main Street west and north of the intersection, or a different theme akin to the Sports, Hospitality, and Entertainment District (SHED) around the MTS Centre. Some of these features are illustrated on **Figure 31**. In either case, the cost estimates do not account for aesthetic treatments or features such as these. The focus of the current assignment was on provision of quick and least cost solutions to enable the project to proceed on an accelerated timeline.

Figure 31 – Potential Streetscape Elements

10.0 Schedule

A high level aggressive schedule for detailed design and construction of the preferred alternative is shown on **Figure 32**. The schedule assumes a start date of November 1, 2016 and utilizes a traditional Design-Bid-Build approach, which is typical of most City of Winnipeg projects. The timeframes of the component tasks were determined based on the past experience of the project team working on similar infrastructure projects for the City of Winnipeg. The entire project is anticipated to take 12.5 months from commencement until completion. The north and west crosswalks would be able to open a month earlier than the south and east crosswalks due to the more extensive structural work required on the southeast corner.

Note the following regarding the schedule:

- The design and construction timeframe for third-party utilities such as Manitoba Hydro or MTS is unknown. There is schedule risk as these timeframes (and costs) are outside the City's control. The short lead time illustrated adds risk as the utilities may not have the resources to meet the schedule.
- It is assumed that the curb lanes and all sidewalks can be closed simultaneously on all four quadrants of Portage & Main. Pedestrians would be able to access the concourse excluding the SE (BMO) external staircase for most of the construction timeframe.
- The schedule does not account for additional time needed to obtain construction permits, negotiation or staging to accommodate adjacent businesses and private property
- There is schedule risk in that repairs or waterproofing may be required for the concourse roof after excavation begins and it can be inspected.
- As with the cost estimate, the schedule assumes the construction of a fully functional but standard level of infrastructure at Portage and Main. Heritage elements, street furniture, and public art, if included, would add time to the overall project schedule in order to design, source and order/construct custom fixtures and appurtenances.

Winnipeg Transit provided the following additional information on the schedule:

- In order for Winnipeg Transit to implement changes to schedules of routes travelling through Portage and Main, lead time of a minimum of five months is required.
- In order for Winnipeg Transit to order and purchase additional buses, lead time of a minimum of six months is required. Transit also does not currently have garage space to store additional buses.

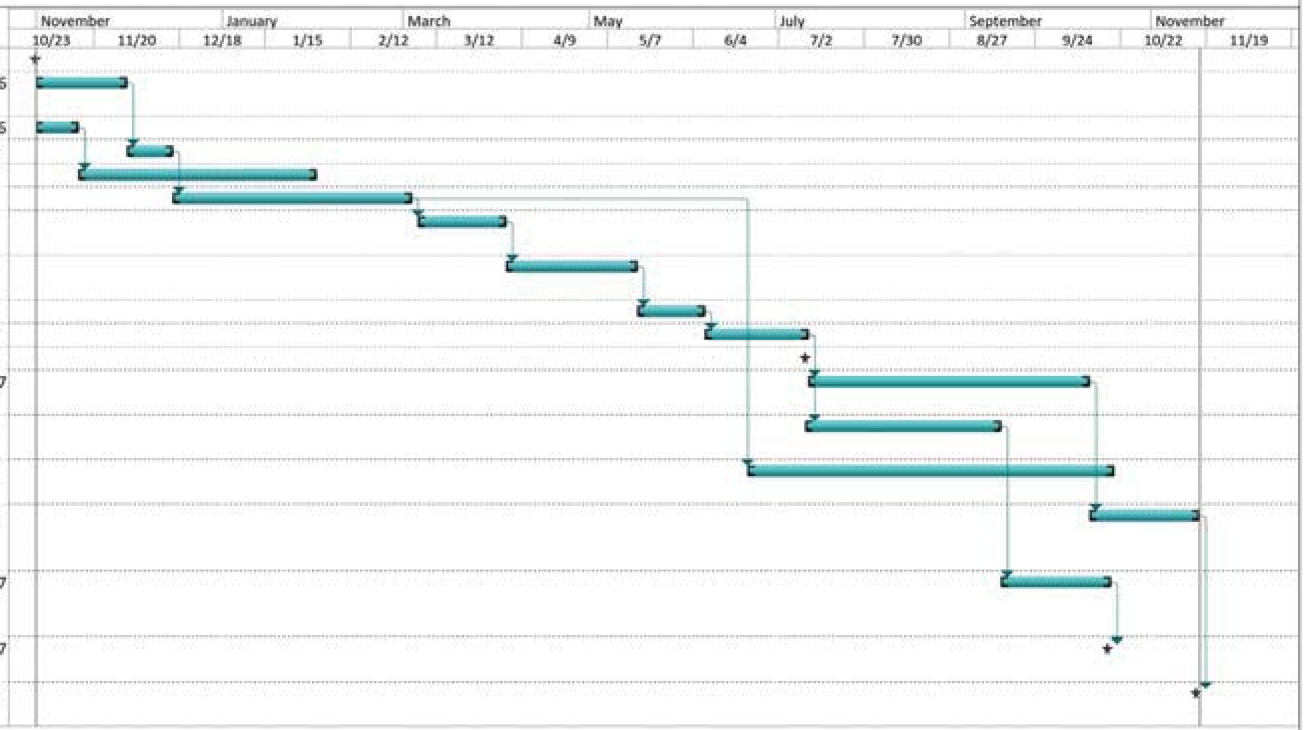
There is potential to shorten the timeframe required to complete the project. Strategies to speed the completion could include:

- Strike a steering committee comprised of all adjacent building owners, City Departments, and third party utilities. Members must be empowered to make decisions and direct staff to focus on project and "fast track" all aspects.
- Use an alternative delivery model such as a "cost plus" assignment to a consultant and same to a contractor. This would allow for demolition to begin while the structural/road design is still underway.
- Authorize the City manager to fast track all processes and reviews. Allow the Manager or Department Director to direct assign work (versus competitive bid) and approve additional expenditures as necessary.

Figure 32 – Design and Construction Schedule

Portage & Main Design and Construction Schedule

ID	Task Name	Duration	Start	Finish
1	Project Start	1 day	Tue 11/1/16	Tue 11/1/16
2	Gather Underground Structures Information	22 days	Tue 11/1/16	Wed 11/30/16
3	Topographic Survey	10 days	Tue 11/1/16	Mon 11/14/16
4	Structural Investigation	11 days	Thu 12/1/16	Thu 12/15/16
5	Roadworks Design	56 days	Tue 11/15/16	Tue 1/31/17
6	Structural Design	56 days	Fri 12/16/16	Fri 3/3/17
7	TSC Review and final Report	21 days	Mon 3/6/17	Mon 4/3/17
8	Underground Structures Circulation	31 days	Tue 4/4/17	Tue 5/16/17
9	Tender Period	16 days	Wed 5/17/17	Wed 6/7/17
10	Award Period	24 days	Thu 6/8/17	Tue 7/11/17
11	Start Construction	1 day	Tue 7/11/17	Tue 7/11/17
12	Structural Construction - BMO Corner	66 days	Wed 7/12/17	Wed 10/11/17
13	Structural Construction - Other Corners	46 days	Tue 7/11/17	Tue 9/12/17
14	Traffic Signals, Hydro Street Lights, MTS	86 days	Thu 6/22/17	Thu 10/19/17
15	Road/Sidewalk Construction - BMO Corner	26 days	Thu 10/12/17	Thu 11/16/17
16	Road/Sidewalk Construction - Other Corners	26 days	Wed 9/13/17	Wed 10/18/17
17	Open North and West Crosswalks	1 day	Wed 10/18/17	Wed 10/18/17
18	Open South and East Crosswalks	1 day	Thu 11/16/17	Thu 11/16/17



11.0 Conclusions

Under the existing condition at Portage and Main pedestrians are currently prohibited to cross the intersection at ground level via signage and physical barriers. They must instead make their way through an underground concourse via a series of circuitous paths to return to grade on the other side. This is an inconvenient situation for both able-bodied and mobility-challenged residents alike. Those with mobility issues are especially disadvantaged due to the need to use several elevators and lifts (or negotiate several staircases). These facilities are located inside of the underground concourse, which is not always open or the devices sometimes suffer mechanical breakdowns, rendering it impossible for those with mobility issues to cross the street.

To analyse the effects of restoring the pedestrian crossings on the auto, truck, bus, and pedestrian travel modes in the area, Dillon created a detailed and accurate transportation microsimulation model. Dillon worked with the City of Winnipeg's assembled TSC to determine a set of comprehensive, but not overly complex set of measures of effectiveness with which to analyse the effects of the changes across multiple alternatives.

Analysis of alternatives for the intersection was performed in two phases. Phase 1 examined three City-proposed alternatives that presented alternatives for the crossings and signal controls at the intersection. The TSC selected a preferred alternative from this first set of three alternatives, which included full opening of all pedestrian crossings and allowed for permitted right turns by vehicles.

The Phase 2 alternatives built upon the Phase 1 preferred alternative and examined physical changes to the intersection and reallocation of turning movement lanes. Two alternative treatments were created by Dillon for analysis. The TSC examined the results of the model runs and selected a preferred alternative. The preferred alternative eliminates the northbound right turn at Portage and Main and also removes the curb lane from the departing direction of the eastern leg of the intersection. The allocation of the turning movements for eastbound vehicles was also slightly adjusted.

Sensitivity analysis for the preferred alternative was performed with respect to changes in the forecasted pedestrian volume crossing at Portage and Main. The sensitivity tests reduced and increased the pedestrian crossing volume to create five separate scenarios (-10%, +10%, +25%, and +50%) for comparison. As can be expected, increases in pedestrian volume will generally increase the travel time for vehicles making left or right turn movements at the intersection. Overall roadway operations are relatively unaffected with increases generally contained to the individual turning movements.

A qualitative review of safety at the intersection was undertaken and produced a number of points worthy of consideration by the City:

- Leading Pedestrian Intervals will be a benefit to the safety and comfort of pedestrians traversing the intersection. These have been implemented elsewhere in the City. As of the time of this writing, the City is conducting tests on the signal controller equipment at Portage and Main to judge its suitability for use of LPIs.
- The interaction of pedestrians in the crosswalks and turning vehicles is potential safety risk. The City should take care to protect pedestrians and lengthen sight lines for vehicles wherever possible.
- Consistency with driver expectations is important to maintain. Having all crosswalks open at Portage and Main (as opposed to none or some) will serve to make the intersection consistent with all other intersections in the city and reduce unexpected elements for drivers.
- Even with some reductions in the number of lanes on the eastern leg of the intersection, Portage and Main is still a very large intersection. The City should keep pedestrians with mobility issues in mind when designing the intersection and implementing signal phasing/timing in the field.
- The underground concourse presents some concern for late night use in crossing Portage and Main currently. The paths through the underground facilities are circuitous and may not always be open or functional, which presents inconvenience and risk for late night pedestrians or those with mobility issues. Restoration of the at-grade crosswalks will reduce these risks and inconveniences.
- There will be an increase in travel time through the area after the crosswalks are restored, primarily to the turning movements at the Portage and Main intersection as they must yield to pedestrians. This poses a risk to cross-city travel as congestion and variability will increase on average. This, however, should be balanced with the improvements to mobility for non-auto users and progress towards the City's goals of a multi-modal and sustainable transportation system. Note also, that the two major automobile movements - northbound and southbound through, representing 50% of automobiles – are unaffected by the changes with no difference in travel time through the study area after the change.
- Transit service will be impacted during the PM peak hour with clear increases in travel time for buses moving through the area, particularly those that make turning movements at Portage and Main. As pedestrian volumes increase in the future at Portage and Main, the sensitivity testing showed that the buses proceeding southbound through at the intersection would also see an increase in travel time due to delays to southbound right turning automobiles in a shared lane.

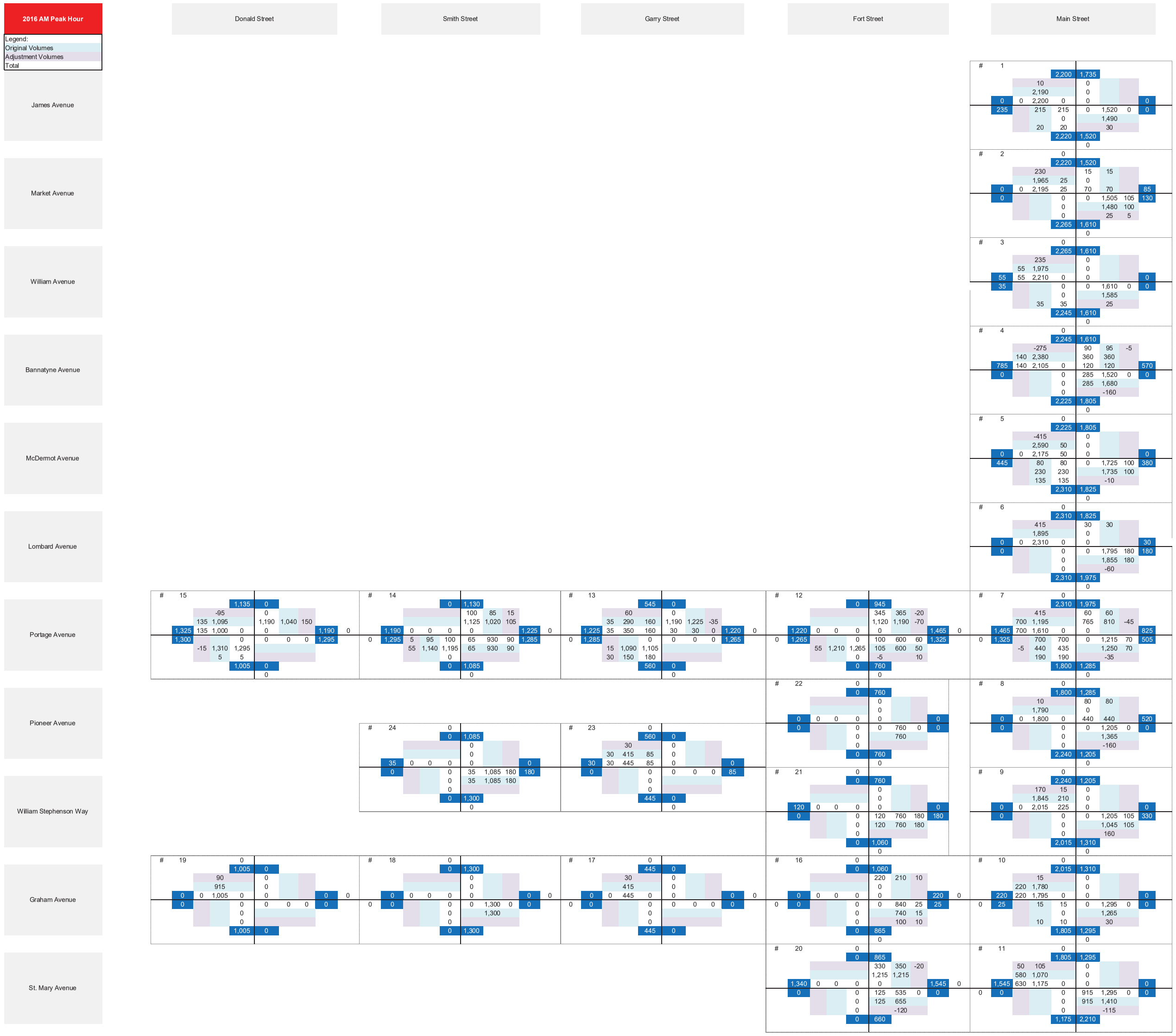
A base plan of existing conditions was created through the application of background data received from the City (e.g., rights-of-way, utilities, underground structures) for use in the creation of conceptual design alternatives for the intersection. A total of five conceptual design alternatives were created; Alternative 4 was selected as the preferred. An examination of the structural challenges in the area was also undertaken using the 1976 construction drawings and verified with a field visit. It was determined that the depressed patio area in front of the BMO building is critical to the reconstruction of the intersection.

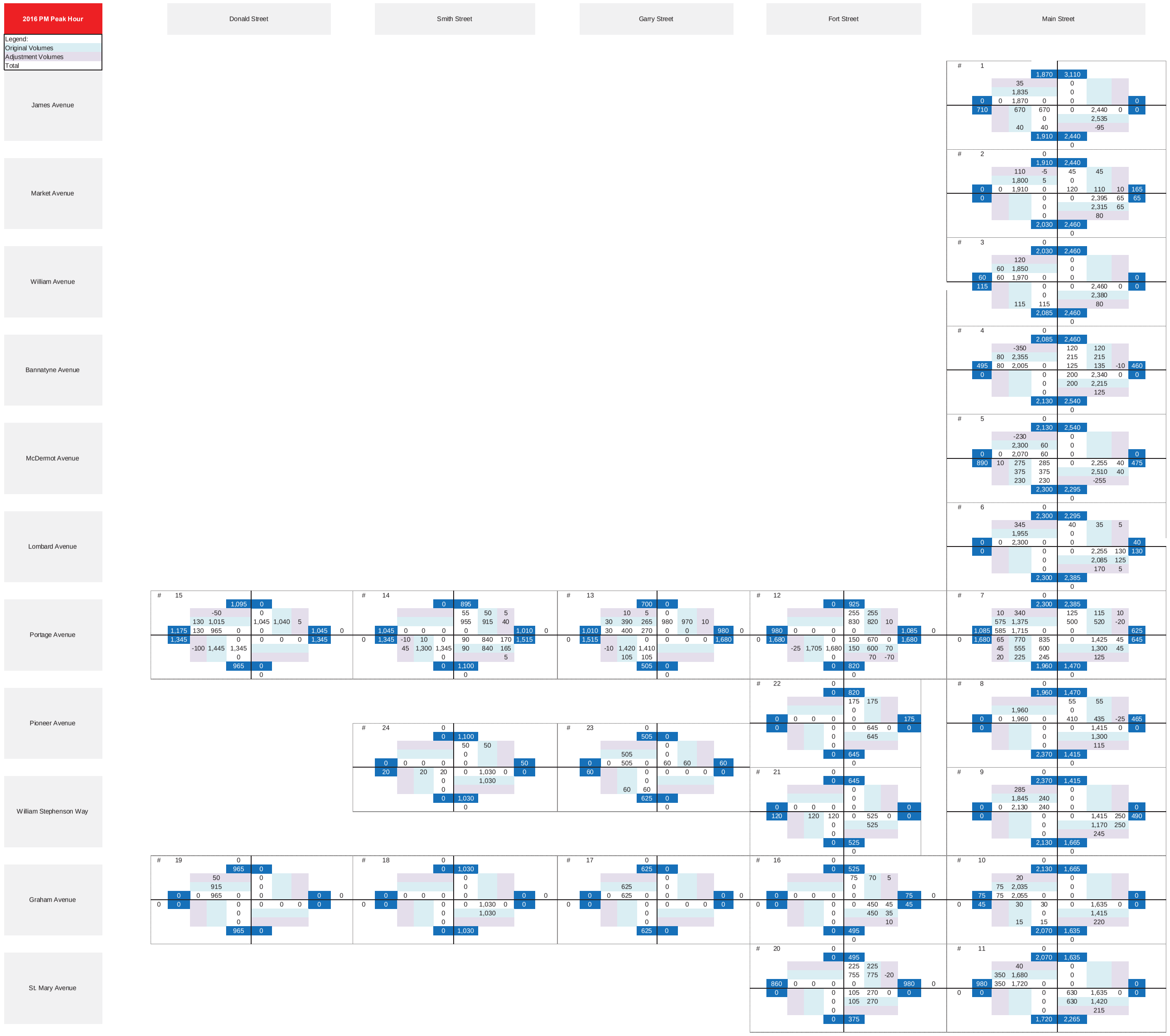
Class 4 cost estimates were created for the preferred conceptual design. Class 4 estimates vary from -30% to +60% of the final construction cost as there are still a number of elements needed for confirmation to further solidify the actual cost of construction. The Class 4 cost estimate was determined to be $6,130,000 for the construction costs and $5,500,000 for the Transit capital costs, for a total project cost of $11,630,000. This considers functional but basic infrastructure and urban design elements. As an important focal point for the city, consideration should be given to decorative and signature design elements for Portage and Main.

Given the understanding of the design and structural elements involved in reconstructing the intersection to include pedestrians, a time for construction of 12.5 months was estimated, with a start date of November 1, 2016. This estimate assumed a traditional Design-Bid-Build approach to construction and was based on the understanding of the area and the experience of the project team on similar projects. City of Winnipeg can potentially shorten the construction timeframe with the creation of a steering committee of adjacent land owners, City departments, and third party utilities; considering alternate delivery methods for the project; and/or authorising the City Manager to fast track all processes and reviews, recognizing all legal processes must be followed.

Appendix A

Volume Balancing


2016 AM Peak Hour
Legend:
Original Volumes
Adjustment Volumes
Total
Donald Street
Smith Street
Garry Street
Fort Street
Main Street
James Avenue
Market Avenue
William Avenue
Bannatyne Avenue
McDermot Avenue
Lombard Avenue
Portage Avenue
Pioneer Avenue
William Stephenson Way
Graham Avenue
St. Mary Avenue



2016 PM Peak Hour
Legend:
Original Volumes
Adjustment Volumes
Total
Donald Street
Smith Street
Garry Street
Fort Street
Main Street
James Avenue
Market Avenue
William Avenue
Bannatyne Avenue
McDermot Avenue
Lombard Avenue
Portage Avenue
Pioneer Avenue
William Stephenson Way
Graham Avenue
St. Mary Avenue

Appendix B

Model Calibration Results

2016 AM Peak Hour

TURNING VOLUME		LINKS		VOLUME		STATISTICS		
Location	Movement	From	To	COUNT	MODEL	DIFF	% DIFF	GEH
1	NBT	18	17	1570	1514	-56	-3.6	1.4
1	SBT	16	13	2250	2253	3	0.1	0.1
1	EBL	15	17	220	220	0	0.0	0.0
1	EBR	15	13	25	25	0	0.0	0.0
2	NBT	102	18	1550	1492	-58	-3.7	1.5
2	NBR	102	96	105	102	-3	-2.9	0.3
2	SBL	12	96	25	25	0	0.0	0.0
2	SBT	12	109	2250	2254	4	0.2	0.1
2	WBL	99	109	90	90	0	0.0	0.0
2	WBR	99	18	20	20	0	0.0	0.0
3	SBT	109	110	2255	2282	27	1.2	0.6
3	SBR	109	50	120	66	-54	-45.0	5.6
3	EBR	49	110	45	30	-15	-33.3	2.4
4	NBL	20	10	290	271	-19	-6.6	1.1
4	NBT	20	103	1560	1500	-60	-3.8	1.5
4	SBT	262	8	2165	2165	0	0.0	0.0
4	SBR	262	10	145	145	0	0.0	0.0
4	WBL	94	8	120	126	6	5.0	0.5
4	WBT	94	10	365	363	-2	-0.5	0.1
4	WBR	94	103	95	95	0	0.0	0.0
5	NBT	104	21	1765	1726	-39	-2.2	0.9
5	NBR	104	92	100	97	-3	-3.0	0.3
5	SBL	7	92	50	52	2	4.0	0.3
5	SBT	7	24	2235	2240	5	0.2	0.1
5	EBL	55	21	85	85	0	0.0	0.0
5	EBT	55	92	235	234	-1	-0.4	0.1
5	EBR	55	24	145	145	0	0.0	0.0
6	NBT	105	104	1830	1790	-40	-2.2	0.9
6	NBR	105	90	190	185	-5	-2.6	0.4
6	WBR	91	104	35	35	0	0.0	0.0
7	NBT	264	105	1225	1181	-44	-3.6	1.3
7	NBR	264	25	70	80	10	14.3	1.2
7	SBT	24	27	1655	1663	8	0.5	0.2
7	SBR	24	107	725	721	-4	-0.6	0.1
7	EBL	42	105	725	727	2	0.3	0.1
7	EBT	42	25	450	436	-14	-3.1	0.7
7	EBR	42	27	210	211	1	0.5	0.1
7	WBT	52	107	795	790	-5	-0.6	0.2
7	WBR	52	105	70	71	1	1.4	0.1
8	NBT	32	26	1210	1175	-35	-2.9	1.0
8	SBT	30	31	1865	1874	9	0.5	0.2
8	WBL	122	31	450	450	0	0.0	0.0
8	WBR	259	26	85	86	1	1.2	0.1
9	NBT	34	32	1210	1174	-36	-3.0	1.0
9	NBR	34	117	110	101	-9	-8.2	0.9
9	SBL	31	117	245	244	-1	-0.4	0.1
9	SBT	31	33	2070	2081	11	0.5	0.2
10	NBL	36	70	0	0	0	0.0	0.0
10	NBT	36	34	1305	1267	-38	-2.9	1.1
10	SBT	33	106	1850	1849	-1	-0.1	0.0
10	SBR	33	70	220	235	15	6.8	1.0
10	EBL	71	34	15	27	12	80.0	2.6
10	EBR	71	106	10	10	0	0.0	0.0
11	NBL	6	63	940	898	-42	-4.5	1.4
11	NBT	6	38	1305	1267	-38	-2.9	1.1
11	SBT	263	4	1220	1224	4	0.3	0.1
11	SBR	263	63	640	631	-9	-1.4	0.4
12	NBL	62	53	115	110	-5	-4.3	0.5
12	NBT	62	5	615	601	-14	-2.3	0.6
12	NBR	62	42	70	59	-11	-15.7	1.4
12	EBT	43	42	1315	1314	-1	-0.1	0.0
12	WBT	108	53	1155	1140	-15	-1.3	0.4
12	WBR	108	5	365	371	6	1.6	0.3
13	SBL	88	43	165	167	2	1.2	0.2
13	SBT	88	133	355	314	-41	-11.5	2.2

2016 AM Peak Hour

TURNING VOLUME		LINKS		VOLUME		STATISTICS		
Location	Movement	From	To	COUNT	MODEL	DIFF	% DIFF	GEH
13	SBR	88	57	35	35	0	0.0	0.0
13	EBT	266	43	1150	1149	-1	-0.1	0.0
13	EBR	266	133	185	195	10	5.4	0.7
13	WBL	56	133	30	35	5	16.7	0.9
13	WBT	56	57	1240	1216	-24	-1.9	0.7
14	NBL	268	45	65	61	-4	-6.2	0.5
14	NBT	268	74	935	934	-1	-0.1	0.0
14	NBR	268	59	90	94	4	4.4	0.4
14	EBL	47	74	100	100	0	0.0	0.0
14	EBT	47	59	1245	1246	1	0.1	0.0
14	WBT	265	45	1175	1141	-34	-2.9	1.0
14	WBR	265	74	100	109	9	9.0	0.9
15	SBT	112	80	1020	1017	-3	-0.3	0.1
15	SBR	112	48	135	126	-9	-6.7	0.8
15	EBT	273	46	1345	1343	-2	-0.1	0.1
15	EBR	273	80	5	9	4	**80.0**	1.5
15	WBT	45	48	1240	1202	-38	-3.1	1.1
16	NBT	69	135	755	708	-47	-6.2	1.7
16	NBR	69	71	25	37	12	48.0	2.2
16	WBR	70	135	165	175	10	6.1	0.8
16	NBT	69	29	125	117	-8	-6.4	0.7
16	WBR	70	29	55	59	4	7.3	0.5
17	SBT	134	85	455	440	-15	-3.3	0.7
18	NBT	73	123	1305	1295	-10	-0.8	0.3
19	SBT	80	113	1025	1026	1	0.1	0.0
20	NBL	66	67	125	126	1	0.8	0.1
20	NBT	66	68	550	556	6	1.1	0.3
20	WBT	63	67	1225	1177	-48	-3.9	1.4
20	WBR	63	68	355	310	-45	-12.7	2.5
21	NBL	135	141	120	117	-3	-2.5	0.3
21	NBT	135	138	800	767	-33	-4.1	1.2
21	NBR	29	136	180	176	-4	-2.2	0.3
21	EBL	142	138	0	0	0	0.0	0.0
22	NBT	135	138	800	767	-33	-4.1	1.2
22	WBR	137	140	0	0	0	0.0	0.0
23	SBL	65	131	85	78	-7	-8.2	0.8
23	SBT	65	134	455	440	-15	-3.3	0.7
23	SBR	22	129	30	28	-2	-6.7	0.4
23	EBR	130	65	0	0	0	0.0	0.0
23	WBL	132	134	0	0	0	0.0	0.0
24	NBL	123	126	35	35	0	0.0	0.0
24	NBT	123	124	1090	1084	-6	-0.6	0.2
24	NBR	123	127	180	179	-1	-0.6	0.1
24	EBL	125	124	0	0	0	0.0	0.0
24	WBR	128	124	0	0	0	0.0	0.0

2016 PM Peak Hour

TURNING VOLUME		LINKS		VOLUME		STATISTICS		
Location	Movement	From	To	COUNT	MODEL	DIFF	% DIFF	GEH
1	NBT	18	17	2490	2477	-13	-0.5	0.3
1	SBT	16	13	1885	1829	-56	-3.0	1.3
1	EBL	15	17	675	694	19	2.8	0.7
1	EBR	15	13	45	50	5	11.1	0.7
2	NBT	102	18	2440	2428	-12	-0.5	0.2
2	NBR	102	96	65	63	-2	-3.1	0.3
2	SBL	12	96	0	0	0	0.0	0.0
2	SBT	12	109	1930	1879	-51	-2.6	1.2
2	WBL	99	109	145	150	5	3.4	0.4
2	WBR	99	18	50	51	1	2.0	0.1
3	SBT	109	110	2010	1965	-45	-2.2	1.0
3	SBR	109	50	65	65	0	0.0	0.0
3	EBR	49	110	120	120	0	0.0	0.0
4	NBL	20	10	200	193	-7	-3.5	0.5
4	NBT	20	103	2385	2362	-23	-1.0	0.5
4	SBT	262	8	2045	2012	-33	-1.6	0.7
4	SBR	262	10	80	74	-6	-7.5	0.7
4	WBL	94	8	130	151	21	16.2	1.8
4	WBT	94	10	220	215	-5	-2.3	0.3
4	WBR	94	103	120	127	7	5.8	0.6
5	NBT	104	21	2295	2255	-40	-1.7	0.8
5	NBR	104	92	45	44	-1	-2.2	0.1
5	SBL	7	92	60	54	-6	-10.0	0.8
5	SBT	7	24	2115	2109	-6	-0.3	0.1
5	EBL	23	21	290	301	11	3.8	0.6
5	EBT	23	92	380	374	-6	-1.6	0.3
5	EBR	23	24	240	285	45	18.8	2.8
6	NBT	105	104	2300	2255	-45	-2.0	0.9
6	NBR	105	90	130	129	-1	-0.8	0.1
6	WBR	91	104	40	42	2	5.0	0.3
7	NBT	264	105	1440	1402	-38	-2.6	1.0
7	NBR	264	25	45	48	3	6.7	0.4
7	SBT	24	27	1750	1837	87	5.0	2.1
7	SBR	24	107	605	561	-44	-7.3	1.8
7	EBL	42	105	860	837	-23	-2.7	0.8
7	EBT	42	25	610	602	-8	-1.3	0.3
7	EBR	42	27	280	333	53	18.9	3.0
7	WBT	52	107	520	538	18	3.5	0.8
7	WBR	52	105	130	142	12	9.2	1.0
8	NBT	32	26	1430	1386	-44	-3.1	1.2
8	SBT	30	31	2030	2169	**139**	6.8	3.0
8	WBL	122	31	420	417	-3	-0.7	0.1
8	WBR	259	26	55	65	10	18.2	1.3
9	NBT	34	32	1430	1385	-45	-3.1	1.2
9	NBR	34	117	255	216	-39	-15.3	2.5
9	SBL	31	117	265	194	-71	-26.8	4.7
9	SBT	31	33	2185	2391	**206**	9.4	4.3
10	NBL	36	70	0	0	0	0.0	0.0
10	NBT	36	34	1655	1601	-54	-3.3	1.3
10	SBT	33	106	2105	2305	**200**	9.5	4.3
10	SBR	33	70	80	79	-1	-1.3	0.1
10	EBL	71	34	0	0	0	0.0	0.0
10	EBR	71	106	0	0	0	0.0	0.0
11	NBL	6	63	655	595	-60	-9.2	2.4
11	NBT	6	38	1655	1605	-50	-3.0	1.2
11	SBT	263	4	1755	1928	**173**	9.9	4.0
11	SBR	263	63	365	353	-12	-3.3	0.6
12	NBL	62	53	170	177	7	4.1	0.5
12	NBT	62	5	695	675	-20	-2.9	0.8
12	NBR	62	42	5	5	0	0.0	0.0
12	EBT	43	42	1745	1769	24	1.4	0.6
12	WBT	108	53	850	849	-1	-0.1	0.0
12	WBR	108	5	275	250	-25	-9.1	1.5
13	SBL	88	43	275	317	42	15.3	2.4
13	SBT	88	133	410	398	-12	-2.9	0.6

2016 PM Peak Hour

TURNING VOLUME		LINKS		VOLUME		STATISTICS		
Location	Movement	From	To	COUNT	MODEL	DIFF	% DIFF	GEH
13	SBR	88	57	35	36	1	2.9	0.2
13	EBT	266	43	1470	1453	-17	-1.2	0.4
13	EBR	266	133	105	94	-11	-10.5	1.1
13	WBL	56	133	0	0	0	0.0	0.0
13	WBT	56	57	1020	1025	5	0.5	0.2
14	NBL	268	45	95	96	1	1.1	0.1
14	NBT	268	74	855	833	-22	-2.6	0.8
14	NBR	268	59	170	205	35	20.6	2.6
14	EBL	47	74	0	0	0	0.0	0.0
14	EBT	47	59	1405	1344	-61	-4.3	1.6
14	WBT	265	45	1000	996	-4	-0.4	0.1
14	WBR	265	74	55	63	8	14.5	1.0
15	SBT	112	80	980	973	-7	-0.7	0.2
15	SBR	112	48	130	141	11	8.5	0.9
15	EBT	55	46	1405	1343	-62	-4.4	1.7
15	EBR	55	80	0	9	9	**100.0**	4.2
15	WBT	45	48	1095	1090	-5	-0.5	0.2
16	NBT	69	135	495	472	-23	-4.6	1.0
16	NBR	69	71	0	0	0	0.0	0.0
16	WBR	70	135	80	79	-1	-1.3	0.1
16	NBT	69	29	0	0	0	0.0	0.0
16	WBR	70	29	0	0	0	0.0	0.0
17	SBT	134	85	635	611	-24	-3.8	1.0
18	NBT	73	123	1050	1066	16	1.5	0.5
19	SBT	80	113	980	982	2	0.2	0.1
20	NBL	66	67	110	107	-3	-2.7	0.3
20	NBT	66	68	290	255	-35	-12.1	2.1
20	WBT	63	67	770	731	-39	-5.1	1.4
20	WBR	63	68	250	216	-34	-13.6	2.2
21	NBL	135	141	0	0	0	0.0	0.0
21	NBT	135	138	575	550	-25	-4.3	1.1
21	NBR	29	136	0	0	0	0.0	0.0
21	EBL	142	138	120	126	6	5.0	0.5
22	NBT	135	138	695	550	**-145**	-20.9	5.8
22	WBR	137	140	175	180	5	2.9	0.4
23	SBL	65	131	0	0	0	0.0	0.0
23	SBT	65	134	515	551	36	7.0	1.6
23	SBR	22	129	0	0	0	0.0	0.0
23	EBR	130	65	60	60	0	0.0	0.0
23	WBL	132	134	60	60	0	0.0	0.0
24	NBL	123	126	0	0	0	0.0	0.0
24	NBT	123	124	1050	1067	17	1.6	0.5
24	NBR	123	127	0	0	0	0.0	0.0
24	EBL	125	124	20	20	0	0.0	0.0
24	WBR	128	124	50	51	1	2.0	0.1

2016 AM Peak Hour

LINK VOLUMES		Approach	VOLUME		STATISTICS		
Location	Approach	Link	COUNT	MODEL	DIFF	% DIFF	GEH
1	NB	18	1570	1514	-56	-3.6	1.4
1	SB	16	2250	2253	3	0.1	0.1
1	EB	15	245	245	0	0.0	0.0
2	NB	102	1655	1594	-61	-3.7	1.5
2	SB	12	2275	2279	4	0.2	0.1
2	WB	99	110	110	0	0.0	0.0
3	SB	109	2375	2348	-27	-1.1	0.6
3	EB	49	45	30	-15	-33.3	2.4
4	NB	20	1850	1771	-79	-4.3	1.9
4	SB	262	2310	2310	0	0.0	0.0
4	WB	94	580	584	4	0.7	0.2
5	NB	104	1865	1823	-42	-2.3	1.0
5	SB	7	2285	2292	7	0.3	0.1
5	EB	55	465	464	-1	-0.2	0.0
6	NB	105	2020	1975	-45	-2.2	1.0
6	WB	91	35	35	0	0.0	0.0
7	NB	264	1295	1261	-34	-2.6	1.0
7	SB	24	2380	2384	4	0.2	0.1
7	EB	42	1385	1374	-11	-0.8	0.3
7	WB	52	865	861	-4	-0.5	0.1
8	NB	32	1210	1175	-35	-2.9	1.0
8	SB	30	1865	1874	9	0.5	0.2
8	WB	122	535	536	1	0.2	0.0
9	NB	34	1320	1275	-45	-3.4	1.2
9	SB	31	2315	2325	10	0.4	0.2
10	NB	36	1305	1267	-38	-2.9	1.1
10	SB	33	2070	2084	14	0.7	0.3
10	EB	71	25	37	12	48.0	2.2
11	NB	6	2245	2165	-80	-3.6	1.7
11	SB	263	1860	1855	-5	-0.3	0.1
12	NB	62	800	770	-30	-3.8	1.1
12	EB	43	1315	1314	-1	-0.1	0.0
12	WB	108	1520	1511	-9	-0.6	0.2
13	SB	88	555	516	-39	-7.0	1.7
13	EB	266	1335	1344	9	0.7	0.2
13	WB	56	1270	1251	-19	-1.5	0.5
14	NB	268	1090	1089	-1	-0.1	0.0
14	EB	47	1345	1346	1	0.1	0.0
14	WB	265	1275	1250	-25	-2.0	0.7
15	SB	112	1155	1143	-12	-1.0	0.4
15	EB	273	1350	1352	2	0.1	0.1
15	WB	45	1240	1202	-38	-3.1	1.1
16	NB	69	905	862	-43	-4.8	1.4
16	WB	70	220	234	14	6.4	0.9
17	SB	134	455	440	-15	-3.3	0.7
18	NB	73	1305	1295	-10	-0.8	0.3
19	SB	80	1025	1026	1	0.1	0.0

2016 AM Peak Hour

LINK VOLUMES		Approach	VOLUME		STATISTICS		
Location	Approach	Link	COUNT	MODEL	DIFF	% DIFF	GEH
20	NB	66	675	682	7	1.0	0.3
20	WB	63	1580	1487	-93	-5.9	2.4
21	NB	135	1100	1060	-40	-3.6	1.2
21	EB	142	0	0	0	0.0	0.0
22	NB	135	800	767	-33	-4.1	1.2
22	WB	137	0	0	0	0.0	0.0
23	SB	65	570	546	-24	-4.2	1.0
23	EB	130	0	0	0	0.0	0.0
23	WB	132	0	0	0	0.0	0.0
24	NB	123	1305	1298	-7	-0.5	0.2
24	EB	125	0	0	0	0.0	0.0
24	WB	128	0	0	0	0.0	0.0

2016 PM Peak Hour

LINK VOLUMES		Approach	VOLUME		STATISTICS		
Location	Approach	Link	COUNT	MODEL	DIFF	% DIFF	GEH
1	NB	18	2490	2477	-13	-0.5	0.3
1	SB	16	1885	1829	-56	-3.0	1.3
1	EB	15	720	744	24	3.3	0.9
2	NB	102	2505	2491	-14	-0.6	0.3
2	SB	12	1930	1879	-51	-2.6	1.2
2	WB	99	195	201	6	3.1	0.4
3	SB	109	2075	2030	-45	-2.2	1.0
3	EB	49	120	120	0	0.0	0.0
4	NB	20	2585	2555	-30	-1.2	0.6
4	SB	262	2125	2086	-39	-1.8	0.8
4	WB	94	470	493	23	4.9	1.0
5	NB	104	2340	2299	-41	-1.8	0.9
5	SB	7	2175	2163	-12	-0.6	0.3
5	EB	23	910	960	50	5.5	1.6
6	NB	105	2430	2384	-46	-1.9	0.9
6	WB	91	40	42	2	5.0	0.3
7	NB	264	1485	1450	-35	-2.4	0.9
7	SB	24	2355	2398	43	1.8	0.9
7	EB	42	1750	1772	22	1.3	0.5
7	WB	52	650	680	30	4.6	1.2
8	NB	32	1430	1386	-44	-3.1	1.2
8	SB	30	2030	2169	139	6.8	3.0
8	WB	122	475	482	7	1.5	0.3
9	NB	34	1685	1601	-84	-5.0	2.1
9	SB	31	2450	2585	135	5.5	2.7
10	NB	36	1655	1601	-54	-3.3	1.3
10	SB	33	2185	2384	199	9.1	4.2
10	EB	71	0	0	0	0.0	0.0
11	NB	6	2310	2200	-110	-4.8	2.3
11	SB	263	2120	2281	161	7.6	3.4
12	NB	62	870	857	-13	-1.5	0.4
12	EB	43	1745	1769	24	1.4	0.6
12	WB	108	1125	1099	-26	-2.3	0.8
13	SB	88	720	751	31	4.3	1.1
13	EB	266	1575	1547	-28	-1.8	0.7
13	WB	56	1020	1025	5	0.5	0.2
14	NB	268	1120	1134	14	1.3	0.4
14	EB	47	1405	1344	-61	-4.3	1.6
14	WB	265	1055	1059	4	0.4	0.1
15	SB	112	1110	1114	4	0.4	0.1
15	EB	55	1405	1352	-53	-3.8	1.4
15	WB	45	1095	1090	-5	-0.5	0.2
16	NB	69	495	472	-23	-4.6	1.0
16	WB	70	80	79	-1	-1.3	0.1
17	SB	134	635	611	-24	-3.8	1.0
18	NB	73	1050	1066	16	1.5	0.5
19	SB	80	980	982	2	0.2	0.1

2016 PM Peak Hour

LINK VOLUMES		Approach	VOLUME		STATISTICS		
Location	Approach	Link	COUNT	MODEL	DIFF	% DIFF	GEH
20	NB	66	400	362	-38	-9.5	1.9
20	WB	63	1020	947	-73	-7.2	2.3
21	NB	135	575	550	-25	-4.3	1.1
21	EB	142	120	126	6	5.0	0.5
22	NB	135	695	550	-145	-20.9	5.8
22	WB	137	175	180	5	2.9	0.4
23	SB	65	515	551	36	7.0	1.6
23	EB	130	60	60	0	0.0	0.0
23	WB	132	60	60	0	0.0	0.0
24	NB	123	1050	1067	17	1.6	0.5
24	EB	125	20	20	0	0.0	0.0
24	WB	128	50	51	1	2.0	0.1

Appendix C

Detailed Cost Estimate

PORTAGE AVENUE AND MAIN STREET
TRANSPORTATION STUDY
CLASS 4 CONSTRUCTION COST ESTIMATE - 2016 DOLLARS

ITEM NO.	DESCRIPTION OF WORK	UNIT	UNIT COST	EST. QTY.	AMOUNT
A	STRUCTURAL WORKS				
1.	Cutting off barrier bases	per location	$500	50	$25,000
2.	Removal of planter walls - Concrete breaker	hour	$121	150	$18,200
3.	Removal of planter walls - Concrete loader	hour	$171	150	$25,600
4.	Removal of planter walls - Tandem	hour	$108	449	$48,500
5.	Removal of soil	cubic ft	$0.60	32,600	$19,600
6.	Slab/topping cutting	sq ft	$12	9,500	$114,000
7.	Slab/topping removal	sq ft	$12	9,500	$114,000
8.	Slab waterproofing	sq ft	$7.50	9,500	$71,300
9.	Rigid insulation	sq ft	$3.00	9,500	$28,500
10.	Form work for new slab/wall	sq ft	$10.00	7,000	$70,000
11.	Concrete and reinforcement	cubic ft	$28	12,000	$336,000
12.	Dispose of concrete	cubic ft	$3.75	10,000	$37,500
13.	6" Concrete Topping	sq ft	$20	0	$0
14.	2' Concrete piers for poles/signs (8' deep)	unit	$1,100	31	$34,100
15.	Temporary shoring	sq ft	$200	2,000	$400,000
STRUCTURAL WORKS SUBTOTAL				$1,350,000	

ITEM NO.	DESCRIPTION OF WORK	UNIT	UNIT COST	EST. QTY.	AMOUNT
B	ROADWORKS				
1.	Sidewalk Reconstruction				

2.	NE corner	sq m	$130	480	$62,400
3.	SE corner	sq m	$130	859	$111,700
4.	SW corner	sq m	$130	442	$57,500
5.	NW corner	sq m	$130	772	$100,400
6.	Median renewal S Main St	sq m	$130	141	$18,400
7.	Rehabilitate Curb Lanes				
8.	NE corner	sq m	$160	413	$66,100
9.	SE corner	sq m	$160	480	$76,800
10.	SW corner	sq m	$160	263	$42,000
11.	NW corner	sq m	$160	501	$80,100
ROADWORKS SUBTOTAL				$620,000	

ITEM NO.	DESCRIPTION OF WORK	UNIT	UNIT COST	EST. QTY.	AMOUNT
C	LAND DRAINAGE SYSTEM				
1.	Catchbasins	unit	$5,000	8	$40,000
2.	Catchbasin lead pipe	m	$300.00	40	$12,000
3.	Lowering NW corner manhole & misc.	lump	$48,000.00	1	$48,000
LAND DRAINAGE SYSTEM SUBTOTAL				$100,000	

ITEM NO.	DESCRIPTION OF WORK	UNIT	UNIT COST	EST. QTY.	AMOUNT
D	WATERMAINS				
1.	Fire hydrant replacement	unit	$10,000	4	$40,000
2.	Fire protection standpipe relocation on SW corner	unit	$15,000	1	$15,000
3.	Miscellaneous	lump	$30,000	1	$30,000
WATERMAINS SUBTOTAL				$85,000	

ITEM NO.	DESCRIPTION OF WORK	UNIT	UNIT COST	EST. QTY.	AMOUNT
E	ELECTRICAL				

1.	Disconnect existing electrical fixtures	lump	$100,000	1	$100,000
2.	Subtotal Electrical (Construction)				$100,000
3.	_				
F	UTILITIES				
4.	Traffic Services	lump	$30,000	1	$30,000
5.	Traffic Signals	lump	$280,000	1	$280,000
6.	Subtotal Traffic Services & Traffic Signals				$310,000
7.					
8.	Underground power distribution	lump	$100,000	1	$100,000
9.	Lower Hydro chamber in NW corner	lump	$50,000	1	$50,000
10.	Subtotal Hydro - Power Distribution				$150,000
11.					
12.	Galvanized standard streetlights	unit	$5,500	16	$88,000
13.	Subtotal Hydro - Street Lighting				$90,000
14.					
15.	Underground natural gas distribution	lump	$50,000	1	$50,000
16.	Subtotal Hydro - Gas				$50,000
17.					
18.	Underground telecom distribution	lump	$100,000	1	$100,000
19.	Subtotal MTS				$100,000
20.					
21.	Underground cable distribution	lump	$50,000	1	$50,000
22.	Subtotal Shaw				$50,000
UTILITIES SUBTOTAL					$750,000