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Appendix A – Stormwater Management Report

Lake Shore Boulevard East Public Realm Vision, Phasing and Implementation Plan

February 2020

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1.0 Introduction

This report provides further details regarding work completed to development stormwater management measure recommendations to support the Lake Shore Boulevard East Public Realm Vision, Phasing and Implementation Plan (January 2020). As per the November 2017 Ministry of Environment, Conservation and Parks (MECP), formerly Ministry of Environment and Climate Change (MOECC) approval conditions of the Gardiner East Environmental Assessment, the City of Toronto is to “consider the overall resiliency of the stormwater management system for the Undertaking and implement stormwater management measures for the project right-of-way to achieve enhanced level of sediment removal where possible”.

To meet this approval condition, a storm water management (SWM) plan has been developed to complement the public realm and streetscape improvements proposed for the LSB corridor that extends from Jarvis St to Logan Ave. The roadway boulevard area where the public realm improvements are proposed are currently impacted by roadway flows from the elevated Gardiner Expressway during storm events. This SWM plan is proposed to manage flows that are currently being generated by existing roadways (e.g. Gardiner Expressway). The proposed public realm project will not in itself generate additional storm flows in the corridor. This report is primarily focused on the Jarvis Street to Cherry Street Section to support the up to 60% public realm design completed for this section. East of Cherry St., the public realm plan is visionary in nature and modelling work was not undertaken for this section. Only flows generated within the corridor by the existing roadways and boulevard area were considered in the study.

This Appendix describes the baseline conditions that influence the specific SWM measures that are considered viable for the corridor and describes the stormwater modelling that was undertaken to determine flow volumes that were considered in the design of the SWM plan.

The proposed public realm improvements vary throughout the corridor. Along the south side of the LSB corridor from Jarvis St. to Cherry St., the public realm improvements are to consist of relocation of the roadway curb to widen the boulevard, the enhancement of pedestrian walkways/sidewalks using permeable pavers, the installation of soil cells under the sidewalk (to provide passive irrigation and expanded root zone for trees), and the creation of a planted zone between the sidewalk and the roadway lanes (see Figure 1.1).

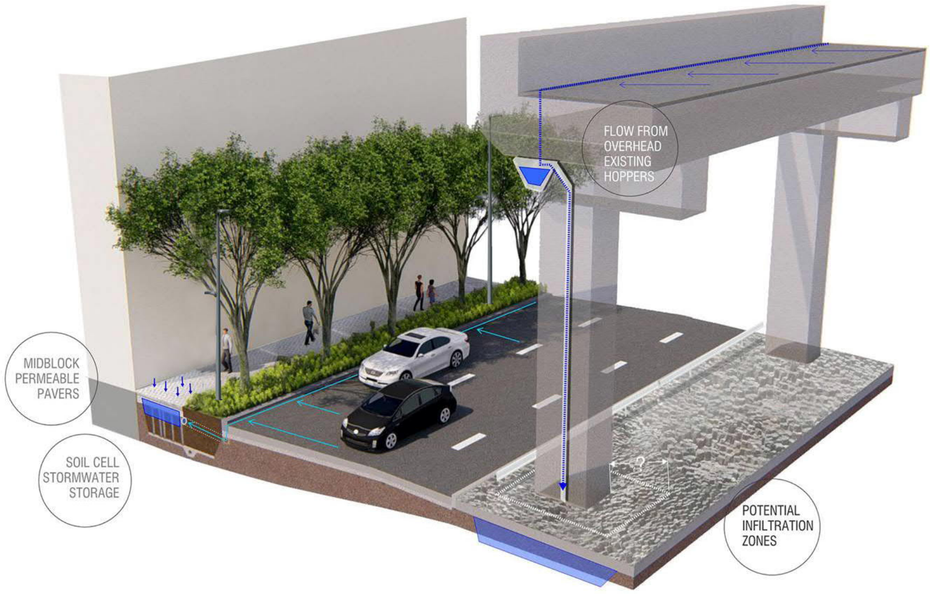

Figure 1.1: Lake Shore Blvd South Side Improvements

The north side of the LSB corridor from Jarvis St. to Cherry St. is to include the proposed grade rise to support a planned pedestrian and cycle path (to improve pedestrian/cyclist safety and provide adequate clean soil for planting trees). The improvements along the north side would also integrate improvements to the south edge of the Metrolinx USRC corridor retaining wall. The grade rise would also support future SWM measures, which is discussed in further detail in this report in Section 5.0.

There are also planned improvements to the intersections to better facilitate the safe crossing of LSB and north-south streets by pedestrians and cyclists.

East of Cherry St. a vision scale public realm and SWM strategy has been proposed which includes an improved pedestrian and cycling pathway and generous boulevard plantings.

A key challenge for this project, particularly from Jarvis St. to Cherry St. where the exiting overhead Gardiner is to remain in place, is managing the substantial run-off coming from the Expressway. While the planed urban design improvements along LSB will not contribute to increased run-off, there is a need to better manage the run-off from the Gardiner along the Jarvis St. to Cherry St section that is to remain. In this section, Gardiner downspouts are not directed connect to storm sewers, rather run-off is directed to splash pads which can cause surface ponding during high flow events. The volumes are substantial as described in this report. The planned urban design improvements would be compromised through the Jarvis St. to Cherry St. sections if the Gardiner run-off is not better managed. For the planned realigned section east of Cherry St., it is assumed that an adequate SWM system, including sewers, will be developed in parallel with the implementation of the new Expressway.

2.0 Site Considerations and Assumptions

A number of site characteristics impact and limit the feasibility of SWM measures within the study area. These considerations include:

- Lack of available space: The project limits are the northern and southern boulevards (not the road itself) of LSB, which limits available space for SWM measures. The availability of space within the corridor varies between Jarvis St. and Cherry St. and depends on whether the location being assessed is the north boulevard, south boulevard or roadway median (median). Within the north boulevard, most of the available space is between Jarvis St. and Bonnycastle St., whereas most of the available space within the south boulevard is between Parliament St. and Cherry St. The majority of available space within the medians is between Jarvis St. and Bonnycastle St., however there are other considerations that affect the feasibility of SWM measures, as discussed below.

- Location of Gardiner columns/bents: The Gardiner columns (bents) are intermittently located throughout the LSB corridor and fall within the north and south boulevard and the medians. The location of these bents are important since they are the discharge points for stormwater runoff from the Gardiner deck and typically contribute a significant portion of runoff in the area. Runoff from the Gardiner deck is typically very high in sediment and salt content, and results in substantial local ponding, especially during large storms. Inspection and maintenance access requirements associated with the Gardiner columns/bents, include a buffer zone or lay-by area around the bents and a minimum distance to be kept from the bent foundations. This limits the amount of space available for features, particularly within the medians.

- Location of utilities within the ROW (median and boulevard): There are extensive utilities located within the ROW including, gas and water mains, Bell, Rogers and Telus lines, Toronto Hydro lines, communication and lighting lines, as well as fibre optic cables. SUE investigations were undertaken along the south side of LSB from Jarvis St. to Cherry St. The utilities may place limitations on the possibility of subsurface SWM measures due to clearance and loading requirements. Figures 2-1 and 2-2 (Attachment A) show the extent of utilities within the ROW, as well as the location of the Gardiner columns/bents.

- Condition and capacity of storm sewers: There are storm sewers within the LSB roadway that have existed since the 1970's, and the condition of most of these storm sewers is limited to unknown. It is unclear if there are blockages, high levels of sediment or deteriorated sections of the sewer. The storm sewer capacity is potentially limited by these obstructions and/or groundwater intrusion and backwater effects from high lake levels.

- High ground water table and lake level: Due to proximity to the lake and average water levels of 74.2 m (but ranging between 75.2 and 75.7 m for the normal and high lake levels, respectively), high groundwater levels are observed in the area. Groundwater levels vary between 0.5 to 3.0 m below the surface. This high groundwater level limits the potential for sub-surface measures, due to considerations of buoyancy. It also removes the option for infiltration based measures as the required 1 m minimum distance between the bottom of any infiltration feature and the annual high water table cannot be maintained.

- Contaminated Soils (mostly Compact Fill, some Coal Tar contamination): based on review of available reports and knowledge of historical industrial land uses, there are contaminated soils located throughout the corridor. The presence of contaminated soils limits SWM features due to considerations of leaching contaminants to SWM features and migration of contaminants to surface and ground water.

Assumptions

Due to the numerous constraints in the study area, a number of assumptions were made to allow for the feasibility of the proposed solution. These include:

- Relocation of the Enbridge gas main running between through the Jarvis to Cherry section along the North Boulevard and median.
- Storm sewers within the roadways are in suitable condition (or will be improved in the future) and have the capacity to support/receive controlled discharge from the proposed stormwater management system/overhead Gardiner in the Jarvis to Cherry corridor section.
- Properties adjacent to the road ROW on the south side will redevelop and control their stormwater runoff to the rates required by the WWFMG instead of discharging uncontrolled to the boulevard. The private properties are expected to be redeveloped, therefore it is assumed that they will meet the City of Toronto WWFMG criteria for water quantity control, and will no longer discharge runoff to the boulevard under future conditions.

3.0 Design Considerations

A review of the following design guidelines was completed to support and inform the proposed SWM system:

- Toronto Green Street Technical Guideline (2017);
- Toronto Complete Streets Guideline (2017);
- TRCA & CVC Low Impact Development Stormwater Management Manual (2010); and
- City of Toronto Wet Weather Flow Management Guidelines (WWFMG, 2006).

While it is understood that it would be ideal to meet the design criteria outlined in the above documents, site constraints generally limit the amount of runoff reduction, water quality treatment and water balance volumes that can be achieved. It is expected that at a minimum, the proposed public realm improvements will be an improvement from existing conditions for all storms. Best Management Practices will be employed throughout the design process to maximize the performance of the proposed measures. The Green Streets Guideline in particular were referred to in the selection and design of appropriate low-impact development (LID) measures to be installed within the road ROW.

As outlined in the City's WWFMG, three main criteria are used to assess the performance of stormwater management systems: water quantity control, water quality and water balance. These criteria are discussed further below and how it is envisioned that the proposed measures can contribute to meeting this criteria, however possible.

3.1 Water Quantity

Due to the limited opportunities for infiltration, no significant reductions in water quantity are expected. However the use of soil cells in the south boulevard is expected to contribute to a modest reduction in runoff volumes due to absorption from plant roots. It is expected that proposed measures will predominantly attenuate stormwater runoff and release at a more controlled rate to the storm sewers than under existing conditions. This approach will allow for a more controlled, slower discharge to the storm sewers. Furthermore, there may be some additional (but minor) water quantity reductions due to the shifting of the road curb on the south boulevard and the introduction of more green space and pervious land.

3.2 Water Quality

Improvements in water quality are expected due to filtration of runoff through soil media and granular material (soil cells and dry swale). It is expected that improvements in water quality will be mostly due to sediment removal/reduction. Sediment removal efficiencies for LIDs can range from 40-90% total suspended solids (TSS) removal, and it is expected that something within this range will be achieved. No additional water quality treatment measures are expected to be installed within the study area.

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3.3 Water Balance

The increase in green space/planted areas will result in some natural water balance/water retention, specifically through initial abstraction of grasses and trees. There will be no water balance retention achieved through infiltration, due to the site limitations/constraints discussed earlier. While it is difficult to quantify the exact level of initial abstraction achieved, and noting that it will not be evenly spread throughout the corridor but rather concentrated in green/planted spaces, it is generally anticipated that the first 5 mm of rainfall will be abstracted and used through evapotranspiration (ET) and natural irrigation.

4.0 Existing Conditions

As discussed in **Section 2.0**, the linear nature of the study area means there is limited space for SWM measures to be implemented within the LSB corridor. The dense network of utilities also limits the space available and placement of potential SWM measures.

A site visit was completed on February 13, 2018 to undertake a visual assessment of the drainage conditions in the area, particularly the south boulevard. During the site visit, significant ponding was observed on the boulevard between Parliament and Cherry Streets, where the Gardiner bents discharge directly to the surface. It was also observed that there was contributing flow from the properties adjacent to the boulevard. **See photo.**

The predominant surface cover in the median and boulevards is bare earth with intermittent grassed areas and rocky/granular material. There are broken splash pads and weeds adjacent to the bent/downspout outlets in the median; however some smaller sections of the median are fully paved. Sections of the Lower Don Trail and Martin Goodman Trail fall within the north and south boulevard respectively. There are no designated land uses within the boulevards or medians.

The subsoils in the area are typically comprised of contaminated compacted fill. Several borehole locations were installed between Bonnycastle and Cherry Street across the length of Lakeshore. The groundwater levels in these borehole investigations ranged from 0.5 to 3.0 m.

Storm sewers within the study area range in size from 450 mm to 1050mm in diameter. Within the eastbound lanes of LSB, there are two short segments of sewer between Lower Jarvis and Sherbourne; and between Small St. and Sherbourne. The segment between Lower Jarvis and Sherbourne discharges to a north-south trunk sewer along Sherbourne, whereas the segment between Sherbourne and Small discharge to a north-south trunk sewer along Small St, both of which eventually discharge to Lake Ontario. Between Small Street and Cherry Street, there are no sewers on within the eastbound lanes; however there are two large trunks sewers within the westbound lanes.

Topographic information provided by the City was reviewed to further understand the drainage patterns in the area. Overall, there are multiple sources of runoff within the study area. On the south side, runoff is generated from the roadway and pavements, the Gardiner deck, and in some cases, external catchments areas that are comprised of the commercial properties to the south of the boulevard

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(external areas). Runoff from these external areas on the south side tend to flows overland towards the boulevard, if they are not managed on-site.

On the north side, runoff is generally generated from the Gardiner deck and boulevard, as the roadway is fully covered by the overhead Gardiner deck. Runoff from the Gardiner deck discharges to the ground via downspouts, and runoff from the roadway and pavement generally flows overland to nearby catch basins and into the storm sewers beneath LSB.

The contribution of runoff from the Gardiner deck varies through the corridor, between the north and south boulevards, and median. For ease of discussion, the corridor has been divided into five segments as described below.

4.1 Segment 1: Lower Jarvis St. to Bonnycastle St.

In this segment, the eastbound lanes of LSB and the south boulevard are exposed to precipitation (i.e. not underneath the Gardiner deck) and the bents are within the road median and on the north boulevard. The westbound lanes are fully covered by the Gardiner deck, however a portion of the north boulevard is exposed to precipitation. Figure 4-1 (Attachment A) shows the key features in this segment.

Runoff from the Gardiner deck is discharging to the north boulevard and the road median between the eastbound and westbound lanes. This runoff eventually reaches the nearest catchbasins and ultimately drains to the storm sewers within the LSB. Based on a review of the topography, there is limited runoff from the external areas to the south boulevard and runoff from the Gardiner does not reach the south boulevard. Runoff from the Gardiner deck does however reach the north side boulevard, and will be accounted for in the assessment of potential LIDs.

4.2 Segment 2: Bonnycastle St. to Parliament St.

In this segment, the eastbound and westbound lanes are both covered by the Gardiner deck. The bents are located within the north and south boulevards and the median. On the south side, there is limited space between the roadway and adjacent properties, therefore runoff from the bents is falling directly onto the south boulevard. The topography shows that under existing conditions, there is a medium amount runoff to the south boulevard from the adjacent properties. Figure 4-2 (Attachment A) shows the key features in this segment.

Runoff from the median is not anticipated to reach the boulevards, but rather will flow overland towards the nearest catch basins on the east and westbound lanes.

4.3 Segment 3: Parliament St. to Cherry St.

In this segment, both the east and west-bound lanes are beneath the Gardiner deck. The bents are located within the north and south boulevards and the median. On the north side, there is limited space between the roadway and the CN rail retaining wall so runoff from the Gardiner deck is discharging directly onto the north boulevard. This flow eventually makes its way onto the roadway to be directed to the catch-basins and sewer. On the south side, the bents are located directly within the boulevard, and there is a medium runoff contribution from the properties adjacent to the boulevard under existing conditions. Figure 4-3 (Attachment A) shows the key features in this segment.

4.4 Segment 4: Cherry St to Don River

Through this section the Gardiner Expressway and LSB are to be realigned through the Keating Channel Precinct as per the Gardiner East EA. The new alignment is located to the north of the existing alignment and will connect with the DVP as it does today. This section is less constrained than the section of west of Cherry Street but is still expected to have challenges associated with high groundwater, contaminated soils and buried utilities. Included as part of the design for the realigned Gardiner and LSB, as part of a separate assignment, is a plan to manage stormwater from both roadways. Waterfront Toronto has advised that the new stormwater management facility just east of Cherry St. (480 Lakeshore East) has been sized to managed flows from these roadways. A vision scale stormwater management plan has been developed for this section to provide guidance to future design work that is presented in the Public Realm Plan.

4.5 Segment 5: Don River to Logan Ave.

Through this section the overhead Gardiner is to be removed and a new 6-lane roadway is to be developed. As for Segment 4, a design for this section of LSB is to be developed, under a separate assignment, for which a plan to manage stormwater is to be part of it. With the removal of the overhead Gardiner ramps, this section will become less constrained but is still expected to have challenges associated with high groundwater, contaminated soils and buried utilities A vision scale stormwater management plan has been developed for this section to provide guidance to future design work.

5.0 Proposed SWM Solutions

As noted in Section 1.0, public realm improvements include relocation of the roadway curb on the south side of LSB and raised grades in the north boulevard to support planned pedestrian and cycling path. The addition of more grassed/treed and pervious areas is expected to provide a general, overall improvement to stormwater management within the study area by providing natural water quality improvements and modest water quantity reduction and runoff attenuation. Additional SWM measures are proposed within the study areas to supplement this natural approach, and in keeping with the Waterfront Toronto and City of Toronto mandates, the proposed SWM measures incorporate low impact development measures (LIDs).

5.1 North Side

A decision matrix was used to assess a range of available LIDs against the constraints faced within the north boulevard. LID options were selected from the Best Management Practices suggested using the Green Streets Guide. While the Green Streets Selection Tool could have been used exclusively to inform the decision for the stormwater management ideas, the tool itself considered the street in its entirety rather than simply the public realm. As a result, a number of options would have been made unavailable based on the Selection Tool. Instead, a weighted scoring system was then used to rank the suitability and feasibility of SWM measures and the top three measures were selected as the preferred and most viable options to be implemented within the boulevard and medians (see **Table 5-1)**. The top LIDs options were:

- Enhanced grass swale/dry swale;
- Granular/Pervious surface treatment; and,
- Above and below-ground storage.

These options were further developed in collaboration with the landscape architect team and a high-level hydraulic model was developed to assess their functionality.

5.2 South Side

A high level analysis was completed to determine the runoff reduction and potential runoff retention from the increased pervious area (compared to existing conditions) within the south boulevard. Table 5-2 shows a decision matrix completed for the south side boulevard, similar to that which was completed for the north side. In addition to naturalized landscaping within green spaces in the boulevard, the top LID options for the south side were:

- Soil Cells beneath the landscaping areas; and,
- Permeable pavements for sidewalks within the boulevard.

Figures 5-1 to 5-3 (Attachment A) show the proposed public realm and roadway improvements, including the proposed SWM measures.

Table 5-1: LID Feasibility Matrix (North Side Jarvis to Cherry St)

Potential LIDs	Space Requirement/ Availability (North Blvd.)	Space Requirement/ Availability (Median)	Accommodates Gardiner Inspection	Volume of Runoff Managed	Accommodates Underground Utilities	Manages Salt/Sediments in Runoff	Reduces Storm Sewer Reliance	Accommodates High Groundwater Table	Contaminated Soils Mgt. Requirements	RANK
Enhanced Grassed Swales (with or without underdrain)	☑	X	X sloped ground	☑	☑	☑	☑	☑	X	1
Infiltration Trenches (subsurface gravel)	☑	☑	X gravel/uneven surface	☑	X	☑	☑	X	X	3
Surface Treatment (gravel/soft scaping)	☑	☑	X - uneven surface	X	☑	X	X	X	X	4
Below Ground Storage tank	☑	☑	X - needs to be structurally sound to allow Lift Genie load	☑	X	X	X	X	X	4
Above ground/vertical storage - public art sculptures	☑	☑	☑	X	☑	X	☑	☑	☑	2
Above ground/vertical storage - median curbs	X	☑	☑	☑	☑	X	☑	☑	☑	2
Permeable Concrete/Asphalt	☑	☑	☑	X	☑	X	X	☑	☑	5
Sand Filters	☑	☑	X	X	☑	X	X	X	X	4

Table 5-2: LID Feasibility Matrix (South Side Jarvis St. to Cherry St.)

Potential LIDs	Space Requirement/ Availability (South Blvd.)	Space Requirement/ Availability (Median)	Accommodates Gardiner Inspection	Volume of Runoff Managed	Accommodates Underground Utilities	Manages Salt/Sediments in Runoff	Reduces Storm Sewer Reliance	Accommodates High Groundwater Table	Contaminated Soils Mgt. Requirements	RANK
Enhanced Grassed Swales (with or without underdrain)	X	X	X sloped ground	☑	☑	☑	☑	☑	X	2
Soil Cells	☑	☑	☑	X	☑	X	☑	☑	☑	1
Infiltration Trenches (subsurface gravel)	☑	☑	X gravel/uneven surface	☑	X	☑	☑	X	X	4
Surface Treatment (gravel/soft scaping)	☑	☑	X - uneven surface	X	☑	X	X	X	X	5
Below Ground Storage tank	☑	X	X - needs to be structurally sound to allow Lift Genie load	☑	X	X	X	X	X	4
Above ground/vertical storage - public art sculptures	☑	☑	☑	X	☑	X	☑	☑	☑	3
Above ground/vertical storage - median curbs	X	☑	☑	☑	☑	X	☑	☑	☑	3
Permeable Concrete/Asphalt	☑	X	☑	X	☑	X	X	☑	☑	6
Sand Filters	☑	☑	X	X	☑	X	X	X	X	7

6.0 Hydrologic and Hydraulic Modelling

PCSWMM (PC Storm Water Management Model) Professional v. 2.0 was used to undertake hydrologic and hydraulic modelling of the project.

Time-Intensity pairs for the 1:2 to 1:100-year return period storms were calculated from the City of Toronto IDF parameters (shown in Table 6-1) and IDF equation (see below). The rainfall hyetograph was generated in PCSWMM using the City of Toronto time-intensity pairs and a Chicago storm distribution. Both 4-hour and 24-hour duration storm were ran to test the system sensitivity; however the longer duration storm was used as the basis for system performance. The 1:2-year and 1:100-year Chicago storms were selected to assess the system under major and minor storms.

Equation: $I = A.T^{C}$
Where:
I = Rainfall Intensity (mm/hr)
T = Time of Concentration (hour)*
**use 10 minute inlet time (or initial time of concentration)*

Table 6-1: City of Toronto IDF Curve Parameters

Return Period (Year)	A	C
2	21.8	-0.78
5	32.0	-0.79
10	38.7	-0.80
25	45.2	-0.80
50	53.5	-0.80
100	59.7	-0.80

Drainage sub-catchments were delineated utilizing the DEM data provided by the City of Toronto. Sub-catchment parameters such as percent imperviousness, sub catchment width and area were estimated using a combination of GIS/CAD and visual estimation from aerial photography. Initial abstraction values of 1mm and 5mm were used for impervious and pervious areas, and a Curve Number (CN) of 80 was assumed based on available soils information.

Existing storm sewers were included in the model to provide outlets for the runoff coming from the various sub-catchments, particularly the roadways. The public realm improvements were designed to avoid spills onto the existing roadways to avoid exacerbating existing major system conditions. Therefore, overland flows over the roadway were not incorporated. The minor system capacity to accept water was considered in the design. It is not anticipated that any storm sewers will be replaced under future conditions; however the sewers are expected to be the final outlet for runoff from the

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LIDs. An overland flow system is not included in this model however, a ponded area of 1.14 m^2 is specified in the model to allow ponded water to sit on the surface above the junctions before being released back into the sewer system as capacity becomes available.

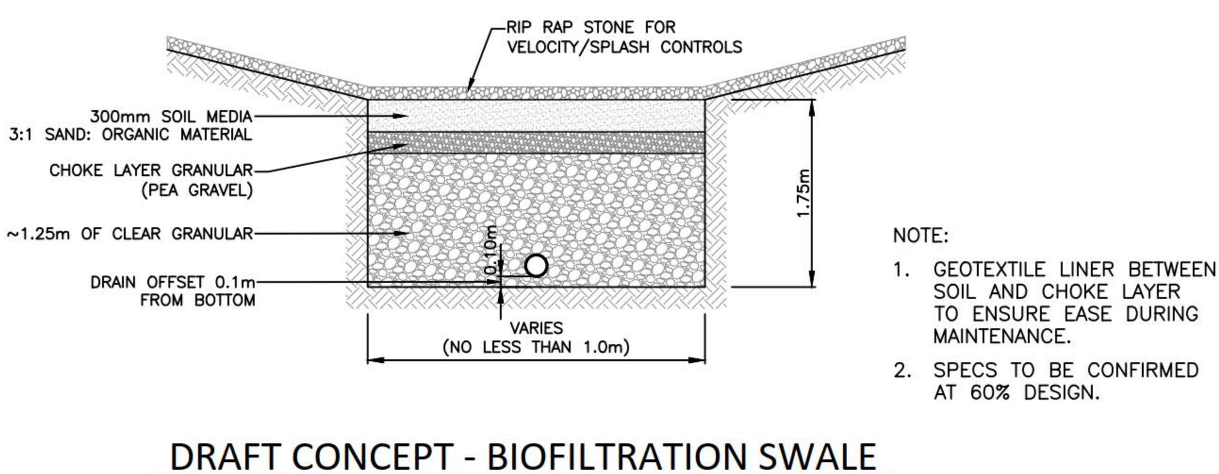
6.1 North Side

The proposed dry swale was modelled using the LIDs Control feature in PCSWMM. An allowable release rate to the storm sewer was calculated using the Rational Method, based on a maximum pre-development runoff coefficient of 0.5 as required in the City's WWFMG. The allowable release rate was based on the area of the roadway between Jarvis and Sherbourne. The dry swale was modelled as a bio-retention unit in PCSWMM with an underdrain and liner. A void space of 0.4 was assumed to account for storage space in the system.

The feature is proposed in the north boulevard between Jarvis and Sherbourne. The total surface area of the swale was estimated from the architect/landscape renderings. A rectangle with the equivalent surface area was then input into PCSWMM as a representation of the proposed feature. The depth of the feature, and size of the underdrain determined through an iterative process that allowed the feature to meet the allowable release rate to the storm sewer. A high-level constructability check was completed to determine if the proposed lead from the system could connect into the MH with a slope of 0.3%.

A conceptual schematic of the feature is shown in Figure 6-1.

Figure 6-1 – Biofiltration Swale Concept



6.1.1 Model Results

6.1.1.1 Jarvis to Sherboune

Feature dimensions are summarized below. Table 6-2 and Table 6-3 summarize the results for the LID feature between Jarvis and Sherbourne. The total area of the Gardiner deck in this segment is 1.07 ha, and the total area of the boulevard is estimated at 0.30 ha.

Dry Swale dimensions

- Allowable release rate: 0.051 m^3/s
- Swale Area (footprint): 890 m^2
- Depth: 1.75m
- Underdrain pipe size: 300 mm
- Void ratio (granular material): 0.4
- Max volume (temporarily) stored: 623m^3

Table 6-2: Summary Output Flow from Dry Swale

Return Period	Max Drain outflow (mm/hr)	Max Q (m^3/s)	Max Storage Depth (m)	Max Volume Stored (m^3)	Surface Level (m)	Surface Runoff (mm/hr)	Total Runoff (m^3)	LID Storage as % Total Runoff
2	30.6	0.035	0.86	306	0	0	570	54%
5	38.1	0.044	1.33	472	0	0	820	58%
10	42.0	0.048	1.61	574	0	0	980	59%
25	43.8	0.050	1.75	623	0.3	127	1130	55%
50	43.8	0.050	1.75	623	0.3	5712	1350	46%
100	43.8	0.050	1.75	623	0.3	2487	1500	42%

Table 6-3: LID Area 1 storage as % of Gardiner runoff

Return Period	Max Volume Stored in LID (m^3)	Runoff Volume from Blvd to LID (m^3)	Runoff Volume from Gardiner Deck to LID (m^3)	Total Runoff Volume from Gardiner Deck (m^3)	% Total Gardiner Runoff Vol managed by LID
2	306	110	196	460	43%
5	472	160	312	660	47%
10	574	200	374	780	48%
25	623	230	393	900	44%
50	623	280	343	1070	32%
100	623	310	313	1190	26%

As per the above tables, the LID feature can handle an average of 40% of the runoff from the Gardiner deck and 100% of runoff from the boulevard in this area. The feature can hold up to the 1:10-year storm runoff volumes before water begins to pond on the surface. Surface overflow from the system begins at the 1:25-year up to the 1:100-year storm, with a maximum depth of 0.3 m. Overall the dry swale is able to manage up to 60% of the runoff in the area.

6.1.1.2 Sherbourne to Cherry

Due to space restrictions/limitations in the north boulevard, there is no dry swale proposed within this area. Runoff from the boulevard is proposed to be handled by the Permavoid system, and runoff from the Gardiner deck is to be directed to the storm sewers as per existing conditions. **Table 6-4** below summarizes the anticipated flows in the area, divided into runoff from the Gardiner deck and runoff from the boulevard. As shown in the table, the majority of flows in the area (85% on average) are from the Gardiner deck. The total estimated area of the deck is 2.45 ha, with the estimated area of the boulevard at 0.46 ha.

The Permavoid system is a sub-surface stormwater management system designed to system designed to manage stormwater at the source by providing storage and controlled conveyance for stormwater runoff.

Table 6-4: Total Volume between Sherbourne and Cherry (potentially directed to BFF*)

Return Period	Gardiner Deck Volume (m^3)	Boulevard Volume (m^3)	Total (m^3)	%Total Volume from the Gardiner	% Total Volume from the Boulevard
2	1040	170	1210	86.0%	14.0%
5	1500	230	1730	86.7%	13.3%
10	1800	300	2100	85.7%	14.3%
25	2090	360	2450	85.3%	14.7%
50	2440	430	2870	85.0%	15.0%
100	2720	490	3210	84.7%	15.3%

*Note: BFF refers to the Ballasted Flocculation Facility at 480 Lakeshore Blvd.

A preliminary sizing of the Permavoid system was completed to determine the required system dimensions to handle the proposed boulevard flows. The system dimensions were based on the volumes for the 1:100-year storm since the total volume of flow is relatively small compared to the total volume from the Gardiner deck. Sizing of the Permavoid system was based on an assumed single-layer depth of 150mm (0.15m) and a 0.9 void ratio. It was assumed that the Permavoid system would be installed beneath the pedestrian paths, with widths ranging from 3.6 to 6.5 m. The length of the Permavoid segments between Sherbourne and Parliament, and Parliament to Cherry were estimated at 220 m and 405 m respectively. An estimate of two to three layers of Permavoid system was determined as necessary to handle the above flows however this is yet to be verified with the manufacturers/providers.

It should be noted that since the Permavoid is a shallow system, connection of discharge pipes to the storm sewer (on average 3m below ground) may prove challenging in this location. The system can be utilized throughout most seasons in the year, however, since the system is above the frost line, runoff will freeze on days when the temperature is below freezing. Depending on the length of freeze-thaw cycles, additional runoff to the area while the system is frozen will need to be handled by the storm sewers, particularly during the spring melt. It is recommended that the functionality of the Permavoid system be further assessed during detailed design.

6.2 South Side

A high-level assessment was completed in PCSWMM for the south side to assess the volumes of runoff generated from the boulevard and the Gardiner Deck. A different approach was taken for the south side based on the proposed land use changes and use of naturalized surface cover as compared to the north side. Runoff from the south boulevard is generally handled/managed by the landscaping changes within the boulevard itself.

In order to assess the impacts of a change in land use/cover, a comparison of runoff volumes from an existing conditions model and two future conditions models was undertaken. The future conditions models reflected the reduced roadway width and increased boulevard area due to the relocation of the south curb. The model also re-directs runoff from the adjacent properties (south of the boulevard) to the storm sewer based on the assumption that redevelopment of these properties is likely to occur and when it does, they will comply with the requirements of the City's WWFMG to control the 1:100-year post-development peak flows to the 1:2-year predevelopment peak flows prior to discharging to the municipal system.

Due to the high level nature of the modelling exercise; the soil cells and permeable pavements were not modelled as separate entities. The proposed features were reflected by a reduction in the percent impervious value of the boulevard sub-catchments. This approach represents the additional runoff retention anticipated from soil cells and permeable pavements, as well as the change in the predominantly paved surface cover.

Three modelling scenarios were run to represent the above conditions:

1. **Existing Conditions:** Percent Impervious for boulevards east of Parliament at 90%; for boulevards west of Parliament at 50%
2. **Future Conditions**: Percent Impervious for boulevards at 40% (representing change in surface cover due to naturalized landscaping)

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3. **Future Conditions:** Percent Impervious for boulevard @ 20% (representing additional surface infiltration/runoff retention from permeable pavements and soil cells)

Modelling results are summarized in the sections below.

6.2.1 Model Results

6.2.1.1 Segment 1: Lower Jarvis St to Bonnycastle St.

As expected, model results in this segment show a decrease in runoff between existing and future conditions (**Table 6-5**). As previously mentioned, runoff from the Gardiner deck discharges to the median north of the roadway and does not reach the south boulevard. **Figure 7-1** (Attachment A) shows the location of the boulevard subcatchments in PCSWMM.

Table 6-5: Comparison of Boulevard Runoff Volumes

Return Period (Year)	Runoff Volume(m^3) Existing	Runoff Volume(m^3) Future	Runoff Volume(m^3) Future with Pervious Pavement
2	80	60	40
5	120	90	80
10	140	120	100
25	160	140	120
50	190	160	160
100	220	190	180

An estimate of the available retention capacity of the soil cells was also completed using an MS Excel spreadsheet and is summarized in **Table 6-6** below. The available volumes were calculated based on a 600mm soil media layer, a 300mm gravel layer (with a void ratio of 0.4) and a surface area extracted from the landscape architectural drawings. It was assumed that an engineered soil mix/media layer would be used in the soil cells, and that the bottom of the soil cells would be lined to prevent groundwater intrusion. This was used get a high-level estimate of the potential effectiveness of the system.

Table 6-6: Comparison of South Boulevard Runoff Volumes and Soil Cell Retention Capacity

Soil Cell ID	Footprint/ Area (m^2)	Soil Cell Retention Capacity (m^3)	Total Available Retention Capacity (m^3)	1:2-yr Runoff Volume from Boulevard **(m^3)**
S_Blvd_Jarv-Sherb1	160	19	74	80
S_Blvd_Jarv-Sherb2	295	35		
S_Blvd_Sherb-Bonny	160	19		

Based on the above results, the soil cells are generally able to retain runoff from the boulevard for a 1:2-year storm. There is also some extra capacity to handle a portion of runoff from the roadway. It should be noted that this is the maximum/total volumetric retention expected for all storms, up to and including the 1:100-year storm.

6.2.1.2 *Segment 2: Bonnycastle St. to Parliament St.*

Model results (Table 6-7) in this segment also show a reduction in runoff volume from existing conditions. It is expected that there will be runoff from the Gardiner deck onto the boulevard, however the runoff is anticipated to flow overland to the storm sewers in the roadway once the soil cells are saturated. Figure 7-2 (Attachment A) shows the location of the boulevard subcatchments in PCSWMM.

Table 6-7: Comparison of South Boulevard Runoff Volumes and Soil Cell Retention Capacity

Return Period (Year)	**Runoff Volume(m^3) Existing**	**Runoff Volume(m^3) Future**	**Runoff Volume(m^3) Future with Pervious Pavement**
2	60	60	40
5	100	70	60
10	120	100	90
25	130	120	110
50	170	130	130
100	180	170	150

Estimates of retention capacity of the soil cells are summarized in **Table 6-8** below. Similar to the results presented for Segment 1: Lower Jarvis Street to Bonnycastle Street above, the estimated retention capacity of the soil cells can manage of the 1:2-year storm runoff from the boulevard.

Table 6-8: Comparison of South Boulevard Runoff Volumes and Soil Cell Retention Capacity

Soil Cell ID	Footprint/ Area (m^2)	Soil Cell Retention Capacity (m^3)	Total Available Retention Capacity (m^3)	1:2-yr Runoff Volume from Boulevard **(m^3)**
S_Blvd_Bonny-Parl1	115	14	65	60
S_Blvd_Bonny-Parl2	105	13		
S_Blvd_Bonny-Parl3	320	38		

6.2.1.3 *Segment 3: Parliament St. to Cherry St.*

Similar to the previous road segments, model results (**Table 6-9)** indicates a reduction in runoff volumes from the boulevard in this segment. There is less of a reduction between existing and future conditions in this segment because the surface cover under existing conditions is bare earth which allows for some infiltration into the ground, compared with the paved areas of Segments 1 and 2. **Figure 7-3** (Attachment A) shows the location of the boulevard subcatchments in PCSWMM.

Table 6-9: Comparison of Boulevard Runoff Volumes

Return Period (Year)	**Runoff Volume(m^3) Existing**	**Runoff Volume(m^3) Future**	**Runoff Volume(m^3) Future with Pervious Pavement**
2	120	80	70
5	180	120	110
10	230	150	140
25	270	180	180
50	320	210	210
100	370	250	240

Estimates of retention capacity of the soil cells are summarized in **Table 6-10** below.

Table 6-10: Comparison of South Boulevard Runoff Volumes and Soil Cell Retention Capacity

Soil Cell ID	Footprint/ Area (m^2)	Volume per section of Soil Cell (m^3)	Total Available Volume (m^3) per Segment	1:2-yr Runoff Volume from Boulevard (m^3)
S_Blvd_Parl-Cherry1	115	14	60	120
S_Blvd_Parl-Cherry2	200	24		
S_Blvd_Parl-Cherry3	180	22		

Based on the above results, the soil cells are generally able to retain 50% of the runoff from the boulevard for the 1:2-year storm. Due to the larger boulevard space within this segment, the runoff volumes from the boulevard exceed the estimated storage capacity of the soil cells. Consequently, while some runoff reduction is expected; there may still be instances of localized ponding in this area. It is anticipated that the depth of surface ponding in this area will be below the allowable 0.3 m.

7.0 Recommended Design

As noted in this report the focus of this study was to recommend stormwater management measures (LIDs) to be implemented in parallel with the proposed public realm design improvements. These proposed SWM measures are intended to manage flows that are currently being generated by existing roadways (e.g. Gardiner Expressway) and which drain onto the boulevard space intended for public realm improvement. The proposed public realm project will not in itself generate additional storm flows in the corridor.

The existing and future site conditions on both the north and south side boulevards and the assessment of how runoff volumes generated in the area can be managed using low-impact development measures (LIDs) was considered in developing the design for the management of stormwater in the LSB corridor.

There are a number of constraints that limit the suitability and feasibility of a range of stormwater management works including a lack of available space, the location of Gardiner columns/bents, the location of utilities within the ROW (median and boulevard), the condition and capacity of storm sewers and a high ground water table and lake level.

A number of design considerations were assessed to determine the applicability of City design guidelines and criteria in this area. Site constraints generally limit the amount of runoff reduction, water quality treatment, and water balance volumes that can be achieved, however it is expected that at a minimum, the proposed public realm improvements will be an improvement from existing conditions.

A high-level hydrologic and hydraulic model was developed using PCSWMM 2D Professional for the Jarvis St. to Cherry St. section. The model was used to determine runoff volumes generated by the boulevard and the Gardiner deck and assess how much the proposed LID features could accommodate.

On the north side of LSB (north boulevard), a rock/dry swale feature is proposed between Jarvis St. and Sherbourne St. to manage the runoff from the boulevard, as well as a portion of runoff from the Gardiner deck. Model results show that the dry swale feature can handle an average of 40% of the runoff from the Gardiner deck and 100% of runoff from the boulevard in this area. The feature can hold up to the 1:10-year storm runoff volumes before water begins to pond on the surface. Surface overflow from the system begins at the 1:25-year up to the 1:100-year storm, with a maximum depth of 0.3 m. Overall the dry swale is able to manage up to 60% of the runoff in the area.

Runoff from the north boulevard form Sherbourne St. to Cherry St. is proposed to be handled by a Permavoid system, a sub-surface stormwater system designed to manage stormwater at the source by providing storage and controlled conveyance for stormwater runoff. Preliminary sizing of the Permavoid system was completed using an Excel spreadsheet, which determined that up to the 1:100-year runoff

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from the boulevard can be temporarily stored/attenuated before discharge to the sewer. Runoff from the Gardiner deck in this area is expected to be managed as per existing conditions in the short-term, with the potential to direct flows to improved or new storm sewers that would be implemented as part of future LSB resurfacing/reconstruction.

On the south side of LSB, runoff is generally managed by the landscaping changes within the boulevard itself. These include naturalized landscaping within green spaces in the boulevard; permeable pavements for sidewalks within the boulevard; and, soil cells beneath the landscaping areas. In order to assess the impacts of a change in land use/cover, a comparison of runoff volumes from an existing conditions model and two future conditions models was undertaken.

Model results show a reduction in runoff volume from existing conditions. For the area between Jarvis St. and Bonnycastle St., runoff from the Gardiner deck discharges to the median north of the roadway and does not reach the south boulevard. For the segment between Bonnycastle St. and Cherry St., runoff from the Gardiner deck onto the boulevard is anticipated; however, the runoff is anticipated to flow overland to the storm sewers in the roadway once the soil cells are saturated.

An estimate of the available retention capacity of the soil cells was also completed using an MS Excel spreadsheet. In general, the soil cells are generally able to retain runoff from the boulevard for a 1:2-year storm between Jarvis and Parliament; however soil cells are able to retain 75% of the runoff from the boulevard between Parliament and Cherry for the 1:2-year storm. Due to the larger boulevard space within this segment, the runoff volumes from the boulevard exceed the estimated storage capacity of the soil cells. Consequently, while some runoff reduction is expected; there may still be instances of localized ponding in this area. It is anticipated that the depth of surface ponding in this area will be below the allowable 0.3 m.

Overall, it is expected that the use of LIDs within the north and south boulevards as proposed in this report will result in runoff attenuation and improved quality of stormwater.

8.0 Next Steps

The designs presented for enhanced SWM management in the Gardiner/LSB corridor will need to be advanced as part of future detailed design work required for the advancement of the public realm from Jarvis St to Cherry St. For the section east of Cherry St., the vision scale SWM plan will need to be advanced as part of the Gardiner/LSB 30% Design work that the City of Toronto is advancing.

Attachement A

Figures

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FILENAME: C:\PROJECTWISE\WORKING DIRECTORY\ACTIVE\20GCC\D0624792\SMM UTILITIES FIGURES.DWG PLOTTED BY: CHONG, GARY
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LEGEND

- Storm sewer
- Sanitary sewer
- Rescu Traffic Camera System
- Gas
- Toronto Hydro
- Hydro Electric Power Corporation
- Watermain
- Bell
- Rogers
- AT&T
- Cogeco
- Telus

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EXISTING UTILITIES

PROJECT NO. 18-7161

Fig. 2-1

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LEGEND

- Storm sewer
- Sanitary sewer
- Combined sewer
- Rescu Traffic Camera System
- Gas
- Toronto Hydro
- Hydro Electric Power Corporation
- Watermain
- Bell
- Rogers
- AT&T
- Cogeco
- Telus

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GCC	YDA
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28 MAY 2019	
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EXISTING UTILITIES

PROJECT NO. 18-7161

Fig. 2-2

Lake Shore Blvd. E.

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LEGEND

- Storm sewer
- Existing curb
- Existing contours
- Overland flow arrow

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EXISTING CONDITIONS

PROJECT NO. 09-1405

SHEET NO. 4-1

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LEGEND

- Storm sewer
- Existing curb
- Existing contours
- Overland flow arrow

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EXISTING CONDITIONS

PROJECT NO. 09-1405

SHEET NO. 4-2

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LEGEND

- Storm sewer
- Combined sewer
- Existing curb
- Existing contours
- Overland flow arrow

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LEGEND

- Storm sewer
- Existing curb
- Existing contours
- Overland flow arrow

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DATE 28 MAY 2019	
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PROPOSED CONDITIONS

PROJECT NO. 09-1405

SHEET NO. **5-1**

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LEGEND

- Storm sewer
- Existing curb
- Existing contours
- Overland flow arrow

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PROJECT NO. 09-1405

SHEET NO. 5-2

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Lake Shore Blvd. E.

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LEGEND

- Storm sewer
- Combined sewer
- Existing curb
- Existing contours
- Overland flow arrow

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PROPOSED CONDITIONS

PROJECT NO. 09-1405

SHEET NO. 5-3

Figure 7-1: Segment 1 (Lower Jarvis St to Bonnycastle Av) - PCSWMM Subcatchments

Figure 7-2: Segment 2 (Bonnycastle Ave to Parliament St) - PCSWMM Subcatchments

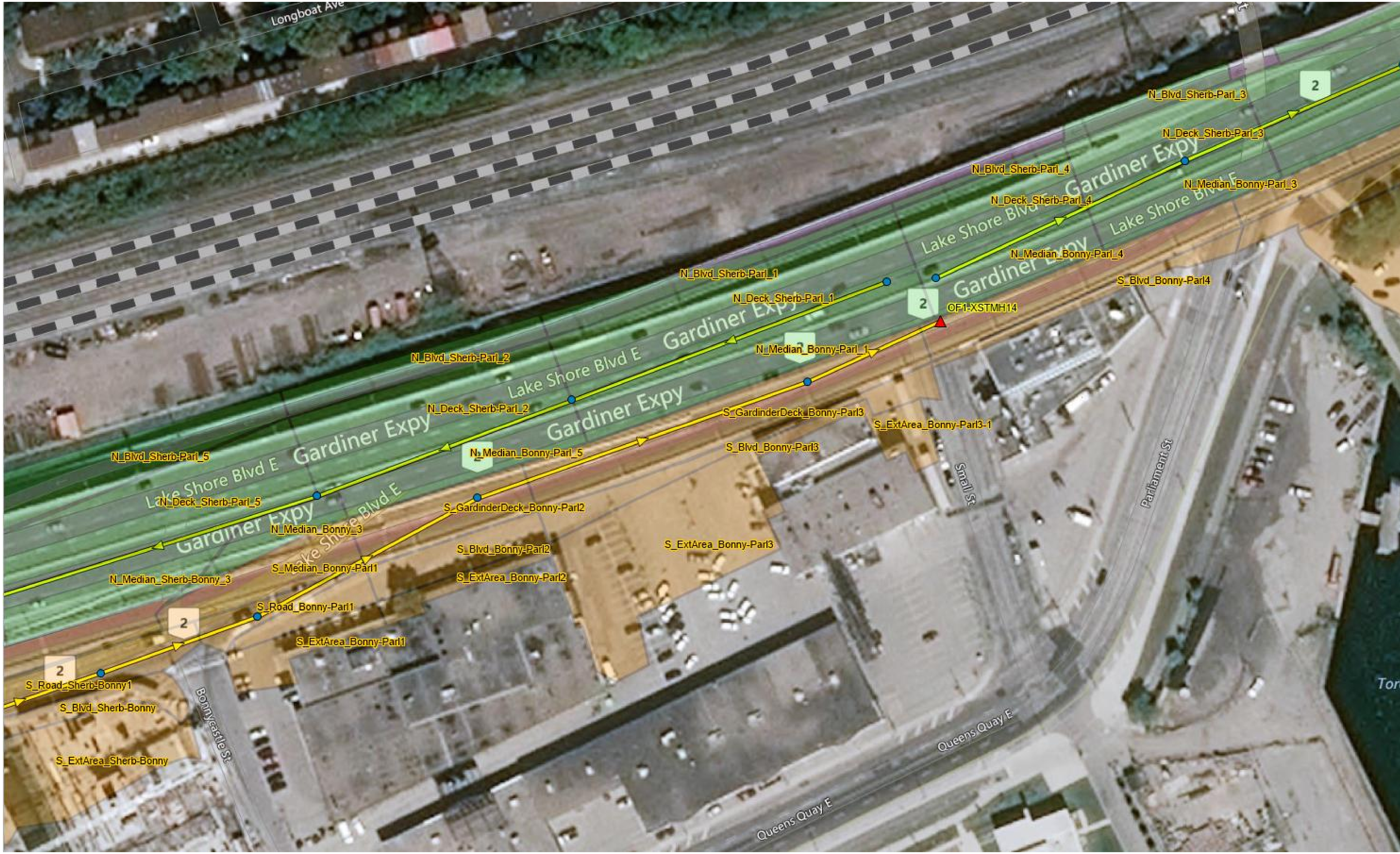

Figure 7-3: Segment 3 (Parliament St to Cherry Ave) - PCSWMM Subcatchments