CREDIT VALLEY CONSERVATION

Mississauga Road

Low Impact Development Infrastructure
Performance and Risk Assessment
May 2016

Monitoring Plan

Road Right-of-Way Retrofit

MISSISSAUGA ROAD, CITY OF MISSISSAUGA

LOW IMPACT DEVELOPMENT MONITORING PLAN

MAY 2016

DRAFT

NOTICE

CVC CREDIT VALLEY CONSERVATION

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1 INTRODUCTION

In February 2015, the Ministry of Environment and Climate Change (MOECC) released an Interpretation Bulletin regarding stormwater management expectations. The bulletin clarifies that the *'Ministry's existing policies and guidance emphasize an approach to stormwater management that mimics a site's natural hydrology as the landscape is developed. The main tenet of this approach is to control precipitation as close as possible to where it falls by employing lot level and conveyance controls, otherwise known as Low Impact Development (LID), often as part of a treatment train approach'.* In the future, LIDs and other source control practices that mimic the hydrologic cycle and provide a range of benefits on a watershed scale will be reflected in the Ministry's Environmental Compliance Approval (ECA) process. This interpretation is in line with what is outlined in other acts, regulations, policies and guidelines such as the Water Opportunities Act, Ontario Environmental Protection Act, Great Lakes Protection Act; the Ministry of Economic Development, Employment and Infrastructure's (MEDEI's) Building Together: Municipal Infrastructure Strategy; and the Ministry of Municipal Affairs and Housing's Go Green: Ontario's Action Plan on Climate Change.

The current focus of stormwater management (SWM) is on end-of-pipe treatment facilities. However, it has become painfully clear that a strong reliance on end-of-pipe controls is grossly inadequate. Recent work has shown that 57% of stormwater ponds in the Lake Simcoe watershed operate at treatment levels below what they were they were designed for, and that many ponds required cleanout 6 – 10 years after assumption (LSRCA, 2011). End-of-pipe approaches also fail to mimic the natural hydrologic cycle in the same way that LID does, and these findings have been echoed by published research (e.g. Drake and Guo, 2008). It is this growing recognizance that is shaping many of the policy changes we are beginning to see.

Incorporation of LID technology within the Mississauga Road reconstruction will help to mitigate the adverse thermal impacts associated with urban stormwater runoff, which will help sensitive aquatic species like Redside Dace. LID helps to slow down and infiltrate stormwater, which in addition to cooling it also removes many common stormwater pollutants like heavy metals, thereby restoring much of its former quality. The delayed release of stormwater from LID facilities mimics the natural water cycle and replenishes groundwater supplies. The water absorbed by LID practices also nourishes the plants bedded within them, thereby reducing or eliminating the need for irrigation with potable water resources. Characterizing the various improvements in stormwater runoff quantity and quality due to the installation of LID approaches hinges on effective monitoring; a robust field monitoring program will also yield valuable insight into the operation and maintenance requirements needed to maintain LID infrastructure at a high level of service. This last point is critical as this stretch of Mississauga Road serves as a gateway to the City of Brampton, and maintaining the aesthetic appeal of LID in this area is critical.

The Region of Peel's Climate Change Strategy Background Report (June 2011) also calls for the redesign and retrofit of water collection and conveyance infrastructure and systems to reduce vulnerabilities due to climate change. Augmenting existing infrastructure with LID practices can extend their service life and mitigate climate-related stresses, both of which are important given the Province's $60 billion municipal infrastructure deficit. Using LID to reduce the impact of extreme weather events is critical in light of the severe storms which occurred in Mississauga and elsewhere on July 8, 2013, resulting in over $1 billion in property damage within the GTA in a single day (IBC, 2014). In light of the Interpretation Bulletin, the Peel Climate Change Strategy, and other Provincial and Federal acts and regulations, the Region incorporated a variety of LID features into the Mississauga Road reconstruction. These features will be evaluated through a robust monitoring program developed between the Region of Peel (ROP) and Credit Valley Conservation (CVC), and CVC will be responsible for monitoring over a span of 5 years.

1. The main purposes of the comprehensive monitoring program for the Mississauga Road pilot project (Phase 1 and Phase 2) are to:
2. Assess the water quality and quantity performance of LID technologies;
3. Evaluate how a site with multiple LID practices treats stormwater runoff and manages stormwater quantity as a whole;
4. Evaluate long-term maintenance needs and maintenance programs, and the impact of maintenance on performance;
5. Determine the life cycle costs for the LID practices;
6. Evaluate whether LID stormwater management systems are providing flood control, erosion control, water quality, recharge, and natural heritage protection per the design standard;
7. Demonstrate the degree to which LID mitigates urban thermal impacts on receiving waters;
8. Assess the potential for soil contamination; and
9. Assess the overall performance of LID technologies under winter conditions

The individual components noted above are all nested within the list of 19 core LID monitoring objectives identified previously by CVC and its partners, and parts 2 through 5 were previously identified as being high priority (Section 2.0).

CVC has a proven track record in LID performance monitoring and reporting in partnership with various ROP stakeholders. As part of the Showcasing Water Innovation (SWI) project, CVC initiated the implementation of several smaller scale LID sites within the ROP, such as road right-of-way retrofits in the Lakeview residential neighbourhood and at Elm Drive. Monitoring results from these sites show promising results. For example, at Elm Drive during the large July 8th 2013 storm event, bioretention cells provided peak flow reductions of ~60%. The positive results from these smaller-scale pilot sites suggest that a larger-scale project can have sufficient impact to positively influence watershed health. Given that streets are the largest urban pollutant contributor and are municipally owned land, they provide the greatest opportunity to control runoff through the implementation of innovative LID features. These LID demonstration projects on regional roads will assist in achieving ROP's Climate Change Strategy Action Item # 3.4 which is to *"Redesign and retrofit water collection and conveyance infrastructure and systems to reduce vulnerabilities due to climate change"*.

The Mississauga Road pilot project will better position ROP to meet the Provincial Policy Statement (PPS, 2014) and Water Opportunities Act, which recommends that municipalities evaluate water infrastructure risks in light of climate change and optimize their management of infrastructure assets. Specifically, the Water Opportunities Act provides the Province with the authority to make regulations requiring municipalities to prepare Municipal Water Sustainability Plans. This may require the development of asset management plans and an assessment of risks that may interfere with the future delivery of municipal services, including climate change. The Provincial Policy Statement (PPS, 2014) states 'Planning authorities shall consider the potential impacts of climate change that may increase the risk associated with natural hazards.' LID projects such as Mississauga Road can provide ROP with new tools to help meet these objectives and remain within legislative bounds. Finally, the data collected by monitoring LID projects such as Mississauga Road can facilitate and promote the incorporation of LID practices into municipal requirements, and potentially help streamline the permitting processes going forward.

2 LID PROGRAM MONITORING OBJECTIVES

As noted in Section 1 CVC, in conjunction with its project partners and stakeholders, has defined 19 objectives for CVC's LID monitoring program. Several meetings were held to collect input regarding monitoring plan objectives by surveying various stakeholders including municipal decision makers, state and federal environmental agencies, engineering and planning professionals, conservation authorities, academia, and watershed advocacy groups. Of the 19 monitoring objectives, the top five priority objectives as selected by the multi-stakeholder group are highlighted in bold.

1. **Evaluate how a site with multiple LID practices treats stormwater runoff and manages stormwater quantity as a whole.**
2. **Evaluate long-term maintenance needs and maintenance programs, and the impact of maintenance on performance.**
3. **Determine the life-cycle costs for LID practices.**
4. **Assess the water quality and quantity performance of LID designs in clay or low infiltration soils.**
5. **Evaluate whether LID stormwater management systems are providing flood control, erosion control, water quality, recharge, and natural heritage protection per the design standard.**
6. Assess the potential for groundwater contamination in the short and long term.
7. Assess the performance of LID designs in reducing pollutants that are dissolved or not associated with suspended solids (i.e. nutrients, oils/grease, and bacteria).
8. Demonstrate the degree to which LID mitigates urban thermal impacts on receiving waters.
9. Assess the water quality and quantity performance of LID technologies.
10. Evaluate how stormwater management ponds perform with LID upstream. Can the wet pond component be reduced or eliminated by meeting the erosion and water quality objectives with LID?
11. Assess the potential for soil contamination for practices that infiltrate.
12. Evaluate effectiveness of soil amendments and increased topsoil depth for water balance and long-term reliability.
13. Evaluate and refine construction methods and practices for LID projects.
14. Develop and calibrate event mean concentrations (EMCs) for various land uses and pollutants.
15. Assess performance of measures to determine potential rebates on development charges, credits on municipal stormwater rates and/or reductions in flood insurance premiums (i.e. can LID reduce infrastructure demand?).
16. Assess the ancillary benefits, or non-stormwater management benefits.
17. Assess the potential for groundwater mounding in localized areas.
18. Improve and refine the designs for individual LID practices.
19. Assess the overall performance of LID technologies under winter conditions.

3 STUDY AREAS

The main study area is located in the central Credit Valley Watershed on Mississauga Rd in Brampton, Ontario (**Figure 3-1**).

The section of Mississauga Road undergoing construction and low impact development installation stretches from the Credit River and Mississauga Road crossing north to Bovaird Drive (**Figure 3-2**).

During phase 1, ROP and CVC retained consulting engineering services for two LID design projects:

- **LID Retrofit** - Project 1: Mississauga Road (Credit River to Williams Parkway)
    - The LID retrofit (Project 1) will incorporate LID into an existing median along Mississauga Rd.
- **LID Design -** Project 2: Mississauga Road (Williams Parkway to Bovaird)
    - The LID design project (Project 2) aims to incorporate LID into a section of Mississauga road that has yet to undergo expansion construction (**Figure 3-2**).

The introduction of LID into the design of the Mississauga Road retrofit and re-construction project will result in one of the largest LID road right-of way features in the Region of Peel.

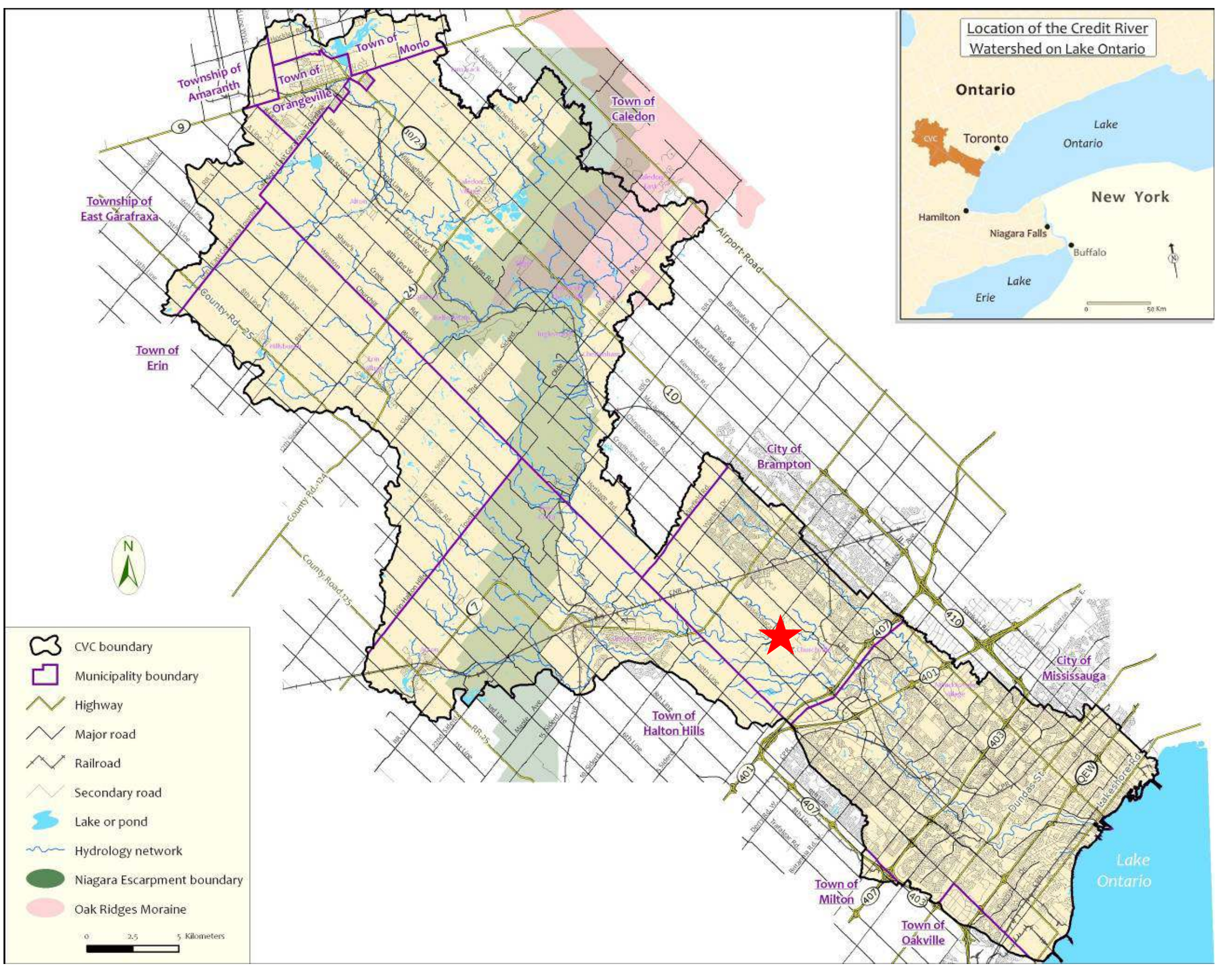

Figure 3-1 Study area located in the Credit River Watershed

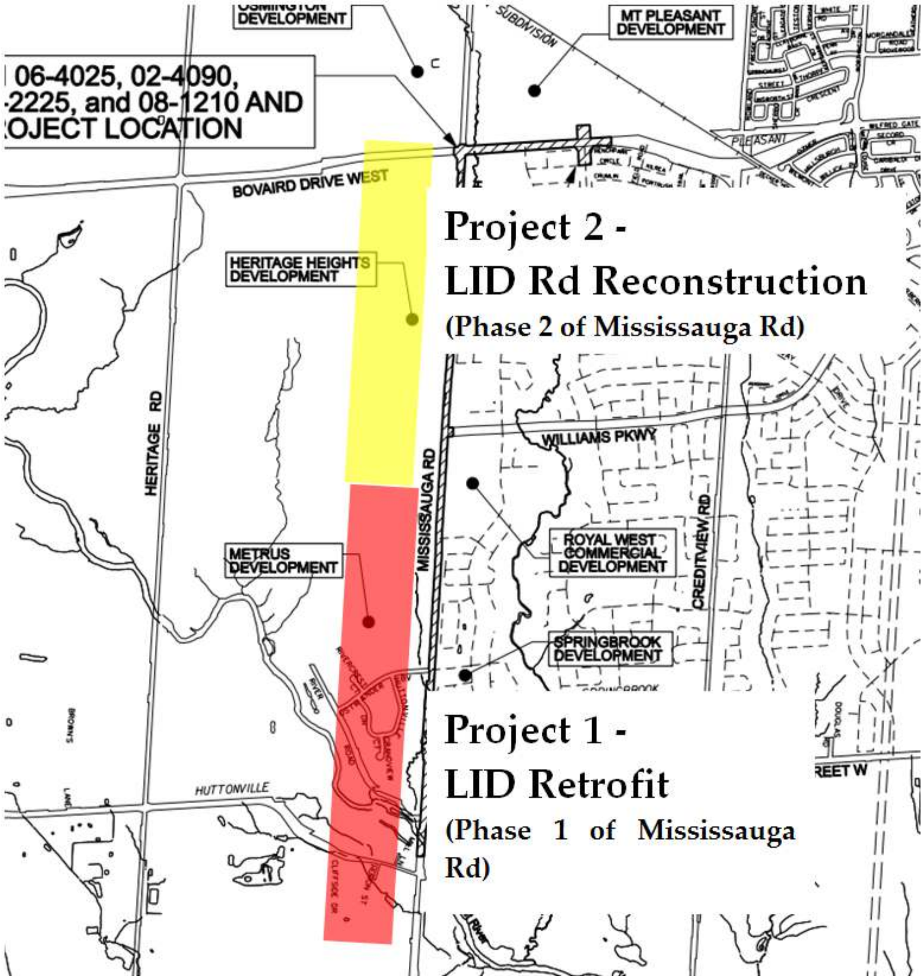

Figure 3-2 Phase and project segments identified

4 OVERVIEW OF MONITORING PROJECT SITES

4.1 Project 1

Mississauga Rd is being expanded to a 4 lane arterial road in a phased process through west Brampton. Phase 1 of the project, Credit River to Williams Parkway has been constructed. It has broad landscaped medians ranging from 2 to 6 m wide. This section of road is intended to be a gateway to the new West Brampton Community, yet the current landscape fails to meet that high aesthetic standard. The median contains only trees and mulch. The trees are dying from lack of water, poor soils, and being buried too deep in mulch. Furthermore, an oil grit separator is the only stormwater management for much of the road. The Region is seeking a retrofit solution that cost effectively provides for a beautiful, low maintenance, water efficient median landscape that stores and treats road runoff where feasible.

The LID features proposed for this project aim to provide compliance of enhanced water quality treatment (MOE Level 1 treatment - long-term removal of 80% TSS) through the control of the 25mm event.

Monitoring this retrofit project will provide detailed information on the functionality of the LID features in order to inform similar implementations for other projects. Project 1 will determine the performance of the Mississauga Road LID facility in terms of water quantity, quality and thermal loading. Refer to Figures 4a and 4b for monitoring locations and a detailed design drawing. The monitoring objectives, schedule and work plan for project 1 are as follows:

4.1.1 Project 1 Monitoring Objectives

The project's ***monitoring objectives*** were selected in consultation with the Region of Peel and were selected from the core 19 LID monitoring program objectives identified by program stakeholders. The selected monitoring objectives for Project 1 are as follows:

1. Assess the water quality and quantity performance of LID technologies.
2. **Evaluate how a site with multiple LID practices treats stormwater runoff and manages stormwater quantity as a whole.**
3. **Evaluate long-term maintenance needs and maintenance programs, and the impact of maintenance on performance.**
4. **Determine the life cycle costs for the LID practices.**
5. **Evaluate whether LID stormwater management systems are providing flood control, erosion control, water quality, recharge, and natural heritage protection per the design standard.**
6. Demonstrate the degree to which LID mitigates urban thermal impacts on receiving waters.
7. Assess the potential for soil contamination.
8. Assess the overall performance of LID technologies under winter conditions (provided flow valves remain open during winter).

4.1.2 Project 1 Design Details

The design for Project 1: Mississauga Road (Credit River to Williams Parkway) is intended to improve the overall streetscape and aesthetic and provide an opportunity for street "greening".

The proposed LID stormwater techniques and design features proposed that will be monitored for this project include:

- Flow Splitter;
- Stormwater Conveyance System (Minor System);
- Oil and Grit Separator (OGS);
- Enhanced Swales;
- Bioswale; and,
- Planting Beds

The process of developing the preliminary designs included the use of the 25mm event peak flow (320L/s) and volume (586m3) determined by the PCSWMM existing conditions and modelling results completed by CHI.

To convey the required 25mm water quality control volume to the enhanced swales and bioswale systems, a flow splitter was design to separate storm sewer flows at existing Manhole 662.

The detailed designs for this project can be found in Appendix D of the LID Implementation Process for Regional Road Right-of-ways (2015).

Flow Splitter and Orifice

The flow splitting system consists of two main components:

- 700mm x 700mm plate with 400mm diameter orifice designed to convey flows up to and including the 25mm event to the enhanced swales and bioswale systems; and,
- 150mm wide concrete weir which extends 0.75m height above the orifice invert and conveys flow which exceeds the 25mm event to the existing stormwater pond at Adamsville Road as originally designed.

Oil and Grit Separator (OGS)

As a method of pre-treatment, and Oil and Grit Separator (OGS) device was integrated into the design upstream of the enhanced swale and bioswale systems. The OGS is sized to treat stormwater runoff by removing pollutants through gravity separation and floatation. Significant levels of pollutants such as heavy metals, free oils and nutrients are prevented from entering natural water resources and the re-suspension of previously captured sediment (scour) does not occur. The Stormceptor selected for this project is intended to achieve 80% TSS removals and 93% runoff volume.

Enhanced Swales

Approximately 200m downstream of the flow splitter the storm sewer network daylights to a series of six (6) enhanced swales. The proposed enhanced swales act as media filter systems that temporarily store and then filter stormwater runoff. The swales rely on the engineered media bed comprised of a mixture of washed clear stone and typical biomedia (sand and organic) mix to provide runoff reductions and improvement in water quality. The incorporation of washed clear stone in the media composition was threefold:

- increase the connected porosity to increase infiltration rate such that saturation conditions are achieve prior to overflow;
- increase thermal mitigation potential; and,
- increase particle size to limit potential scour and media displacement

Contrary to most LID practices designed within tight soils, an underdrain was not incorporated into the enhanced swale design. The use of rainwater as a resource to sustain the landscape elements was a major project goal and to achieve this, saturation of the enhanced swale media and surface drainage was encouraged. To fully retain inflow volumes, surface flows from each enhanced swale are controlled by a series of concrete weirs situated at the downstream end of each swale. Weep holes within the weirs control the drawdown times and prolong water availability without drowning plant material.

The first six of the enhanced swales in series accepts discharge directly from the day lighted storm sewer. Due to the concentrated pipe flow conditions and expected velocities the design of the first enhanced swale is more indicative of a plunge pool where the entire surface of the swale including the side slopes and thalwag is covered by roundstone varying in diameter from 200-300mm. Staggered armour stone placed downstream of the outfall will prevent scour and undermining of the headwall structure. The stones will also dissipate energy and flow velocities by spreading out concentrated flows from the storm sewer.

Concrete weir structures situated between each enhanced swale ensure full flow control was provided from one enhanced swale to the next. With a road and centre median profile grade of 3.5%, the use of weir structures were necessary to minimize the slope and flow velocity through the enhanced swales.

The weirs also ensured that the enhanced swale profile would fill completed as a method of providing irrigation.

Two (2) weep holes (25mm in diameter) casted into the weir structure approximately 0.6m below the weir invert allowed accumulated stormwater to drain from one swale to the next. The weep holes intended to retain stormwater for irrigation purposes but allow the swale to drain to prevent prolong periods of saturation, conditions which would not be favourable for selected plant material. The 0.4m of storage below the weep holes is intended to be infiltrated.

Bioswales

The proposed bioswale facility designed for Project 1 provides the bulk of the water quality and quantity control benefits for the system (Figure 3). The bioswale is located downstream of the enhanced swale sections and receives the majority of flow volume conveyed by the swales. At the bioswale section, road grades reduce dramatically from 3.5% to 1.0-0.5% which influences the surface grades of the bioswales. The flatter bioswale section allows inflows to spread which further reduces flow velocities and promotes uniform filtration of stormwater by the media layers.

The bioswale soil media specified within the design is consistent with the specifications outlined within the TRCA/CVC Low Impact Development Stormwater Management Planning & Design Guide, Version 1.0, 2010. Stormwater filters through the media to the gravel storage reservoir below. A portion of the filtrated runoff is stored below the underdrain embedded with the gravel layers and allowed to infiltrate back into the native subsoils over a 24-96 hour period. Excess stormwater is conveyed by a 200mm underdrain which discharges to the existing stormsewer network and ultimately, Adamsville SWM Pond as before. The bioswales allow for 0.3m of surface ponding before excess volume overflows into a standard catch basin which also discharges to the existing stormsewer network and ultimately, Adamsville SWM Pond.

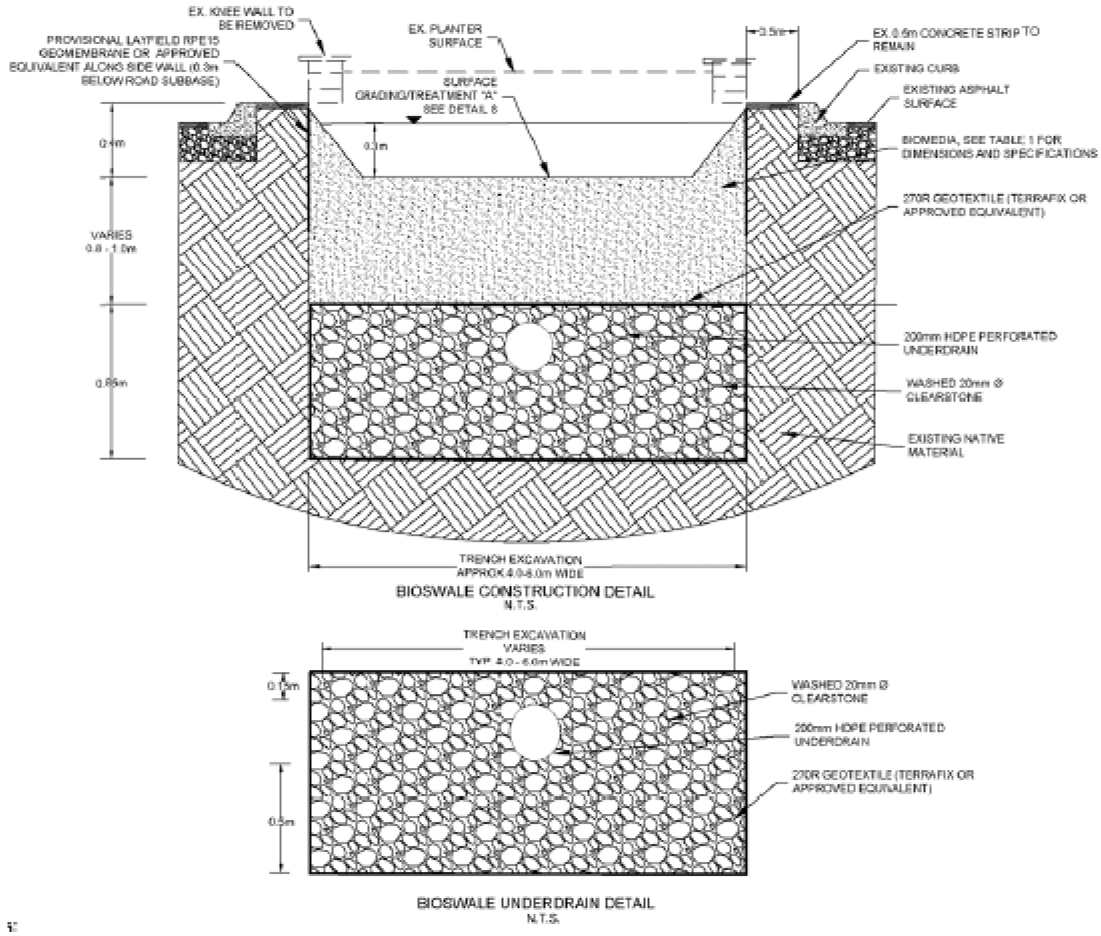

Figure 4-1 Project 1 Bioswale details

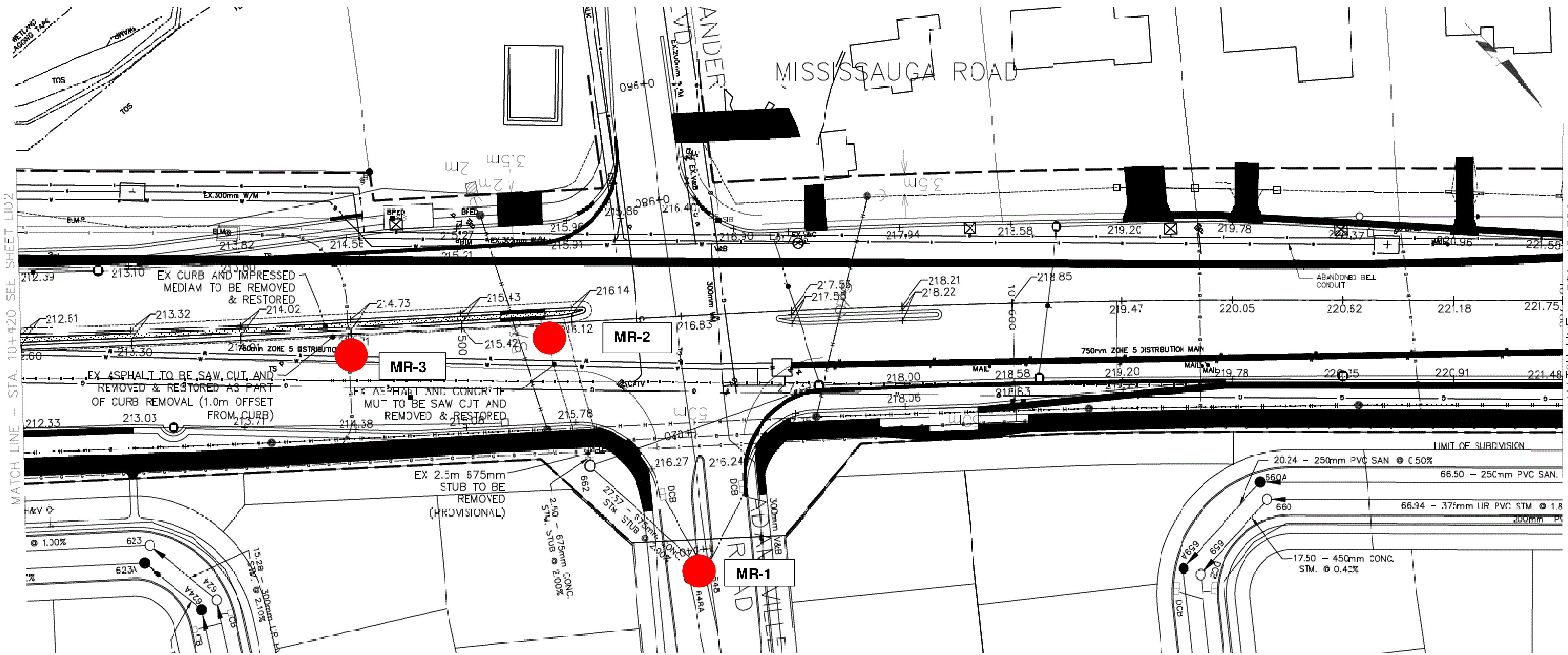

Figure 4-2 Mississauga Road Design Drawing and Monitoring Locations

MR-1: After flow split (overflow); quantity only
MR-2: After Flow split to LID: inlet station; quality and quantity
MR-3: After OGS and valve: quality and quantity

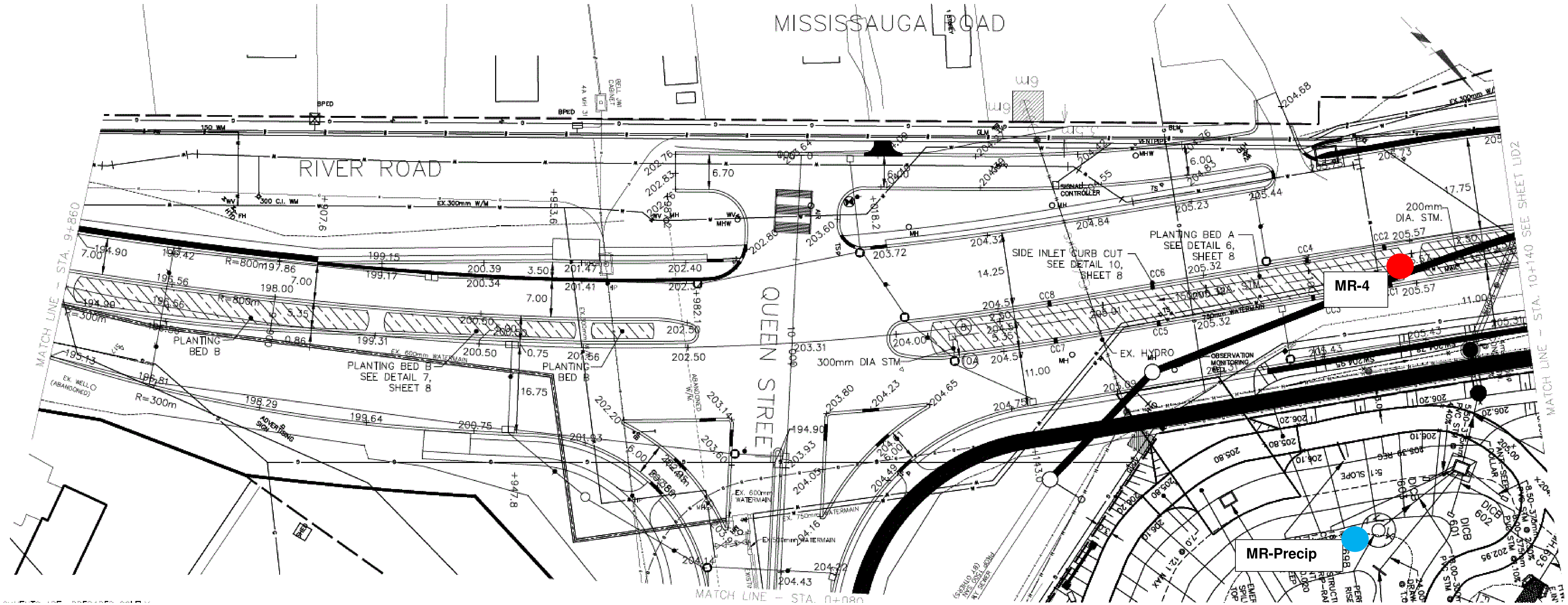

Figure 4-3 Mississauga Road Design Drawing and Monitoring Locations

MR-4: Outlet station (downstream): quality and quantity
MR-Precip: Meteorological station with precipitation and air temperature data collection

4.1.3 Environmental Compliance Approval (ECA) Monitoring Objectives

Based on the Design Brief and associated calculations, a suite of objectives to be monitored as part of the ECA process were identified. These objectives are summarized in the following table (Table 2):

Table 4-1 ECA Monitoring Objectives

Stormwater Management Design Criteria	Mississauga Road Project 1 Design Estimations
Flood control (peak flows)	Peak flow reduction from MH662 to Adamsville SWM Pond compared to pre-retrofit conditions: 25mm event* (25mm) – 91.0% 2 year event (30.3mm) – 82.8% 5 year event (41.5mm) – 54.4% 100 year event (72.4mm) - 32.3%
Erosion control (runoff volume)	Net runoff volume reduction from MH662 compared to pre-retrofit conditions: 25mm event (25mm) – 52.7% 2 year event (30.3mm) – 39.9% 5 year event (41.5mm) – 25.6% 100 year event (72.4mm) – 12.6%
Water Quality	Enhanced level of treatment (80% TSS removal)

*No direct outflow from MH662 to Adamsville SWM Pond, so LID outflow used instead

4.1.4 Project 1 Monitoring Work Plan

Table 4-2 Project 1 Monitoring Work Plan

Location(s)	Objective(s)	What will be monitored	Frequency	Equipment (How)
MR-1: Overflow to pond **MR-2:** Inlet to LID median feature **MR-3:** Post-OGS treatment **MR-4**: Outlet from median LID feature	#1 Assess the water quantity performance of LID technologies #2 Evaluate how a site with multiple LID practices treats stormwater runoff and manages stormwater quantity as a whole. #5 Evaluate whether LID stormwater management systems are providing flood control, erosion control, water quality, recharge, and natural heritage protection per the design standard.	**Level and Flow** (Flow reduction/control, peak flow reduction, water conservation, etc.).	• Continuous logging at **5** minute intervals • Site visits weekly for calibration	• ISCO pressure transducers in conjunction with compound or v-notch weirs (depending on expected flows) • Level meter to calibrate levels
2 locations along bioswale TBD near overflows if possible	Assess the water quantity performance of LID technologies	**Continuous soil infiltration and ponding** **Photo and Video Inventory**	• Continuous logging at **5** minute intervals (spring-fall)Data downloaded once per month (spring-fall) • Continuous photo record (photos taken once every 30-60min to visually record ponding) and video observations during precip. events	• Hobo level loggers installed in shallow and deep wells at two locations along the bioswale (2 deep and 2 shallow wells) • One barometric pressure logger for compensation • Trail camera
MR-2: Inlet to LID median feature **MR-3:** Post-OGS treatment **MR-4**: Outlet from median LID feature	#1 Assess the water quality performance of LID technologies #5 Evaluate whether LID stormwater management systems are providing flood control, erosion control, water quality, recharge, and natural heritage protection per the design standard. Assess the water quantity performance of LID technologies	**Stormwater Quality** ▪ Chloride ▪ Conductivity ▪ pH ▪ Total Suspended Solids (TSS) ▪ Nutrients: o Total Phosphorus o Total Ammonia o Nitrate & Nitrite ▪ Metals ▪ PAH (only in the first year of sampling)	• **15** flow-weighted samples per year for each station starting in year 2 of monitoring	• ISCO 6712 autosamplers and associated parts and equipment (batteries, tubing etc.) • Samples to be submitted to an accredited lab for analysis(Maxxam Analytics) • Lab sample containers and associated equipment
MR-Precip. (near local stormwater pond)	#1 Assess the water quality and quantity performance of LID technologies #2 Evaluate how a site with multiple LID practices treats stormwater runoff and manages stormwater quantity as a whole.	Meteorological station for background environmental data • Precipitation • Air temperature	• Continuous precipitation and air temperature data recorded at 5 min interval	• Heated rain gauge (TBD) • Power source to be city hydro if possible • Back-up battery and solar panel in case of power failure?
Throughout median (various locations and depths for a total of 6 composite samples submitted)	#7 Assess the potential for soil contamination.	Soil Quality	Once per year in the fall	• Lab sample containers

MR-2: Inlet to LID median feature **MR-4**: Outlet from median LID feature	#8 Assess the overall performance of LID technologies under winter conditions.	*Conductivity and chloride sampling (provided winter monitoring is conducted)	• Continuous logging at **5** minute intervals • Data downloaded once per month with grab samples of chloride and conductivity collected for calibration	• Hobo conductivity loggers (high range) (1 per location) • Lab sample containers
All inlets, outlets and overflow structures throughout the drainage area and bioswale		Conduct winter visual inspections to include inspections of inlets, outlets and presence of salt	Winter inspections to be conducted once every week over winter months	• Inspection checklists • Camera
2-3 Locations throughout the bioswale		*Winter infiltration testing (provided winter monitoring is conducted)	Twice in winter months	Double ring infiltrometer and associated equipment for infiltration testing
1. 2 inlet catch basins along Mississauga Rd 2. **MR-2:** Inlet to LID median feature 3. **MR-4**: Outlet from median LID feature	#6 Demonstrate the degree to which LID mitigates urban thermal impacts on receiving waters. #1 Assess the water quality performance of LID technologies #2 Evaluate how a site with multiple LID practices treats stormwater runoff and manages stormwater quantity as a whole.	Stormwater temperature	Continuous temperature loggers recording at 5 minute intervals	Hobo pendant temperature loggers Spare batteries
Drainage area, inlets, outlets, facility	#3 Evaluate long-term maintenance needs and maintenance programs, and the impact of maintenance on performance.	Site conditions and maintenance needs	Each site visit Fill out inspection checklist monthly	Inspection checklists and legend Camera
Drainage area, inlets, outlets, facility		Inspection and maintenance tasks and costs	Each site visit or when maintenance is completed Annual interviews with property managers	Inspection checklists and legend Camera
6 Double ring infiltrometer tests, approximately 1 test between each weir		Soil infiltration	Annually	Double ring infiltrometer, stop watch, source of water, buckets, graduated cylinder
Overall project	#4 Determine the life cycle costs for the LID practices.	Track costs throughout lifecycle: 1. Design 2. Pre-construction 3. Construction 4. Maintenance 5. Rehabilitation 6. Disposal	As needed during the duration of monitoring. Expected costs outside of the monitoring timeframe will be estimated using the TRCA life cycle assessment tool.	Staff time

*Winter monitoring activities will only be conducted if the LID features remain online during the winter. Inspections and some infiltration testing may take place (TBD) if the LID features remain online.

4.1.5 Project 1 Gantt Chart

Table 4-3 Project 1 Gantt chart

Activity	Year One				Year Two				Year Three				Year Four				Year Five				Year Six			
	Sp.	Sum.	F	W	Sp.	Sum.	F	W	Sp.	Sum.	F	W	Sp.	Sum.	F	W	Sp.	Sum.	F	W	Sp.	Sum.	F	W
Detailed Monitoring Plan Design and Review																								
Soil Sampling and Contamination Assessment																								
Weekly Flow Structure Checklist Inspections																								
Install Rain Gauge and Begin Data Collection																								
Event-Based Flow-Weighted Sample Collection																								
Initiation of Monitoring & First Fact Sheet																								
Soil Sampling and Contamination Assessment																								
Weekly Flow Structure Checklist Inspections																								
Year 2 Monitoring and Second Fact sheet																								
Soil Sampling and Contamination Assessment																								
Weekly Flow Structure Checklist Inspections																								
Year 3 Monitoring and Third Fact sheet																								
Soil Sampling and Contamination Assessment																								
Weekly Flow Structure Checklist Inspections																								
Year 4 Monitoring and Fourth Fact sheet																								
Soil Sampling and Contamination Assessment																								
Weekly Flow Structure Checklist Inspections																								
Year 5 Monitoring																								
Final Reporting																								

Note: The above Gantt chart is not intended to be comprehensive

4.1.6 Project 1 Monitoring Schedule and Gantt Chart

1. Detailed monitoring infrastructure plan and design review – Spring 2015
2. Finalise monitoring plans and equipment purchase – Winter/Spring 2015
3. Initiation of monitoring, year 1 (flow only) & bulletin/fact sheet
4. Monitoring year 2 (water quality sampling begins)& bulletin/fact sheet
5. Monitoring year 3 & bulletin/fact sheet
6. Monitoring year 4 & bulletin/fact sheet
7. Monitoring year 5
8. Final reporting

4.1.7 Project 1 Reporting and Communication

Results will be analysed and reported on at the end of the project period with fact-sheets/bulletins produced annually. Annual fact-sheets/bulletins will include interesting monitoring information/observations with more detailed analyses conducted for the final report. Fact sheets and case studies will provide more regular information to stakeholders and interested parties. Results will also be reported on during conferences and workshops.

The final report will include analysis methodology, results, discussion and recommendations.

Content of Discussion will be focused on giving context to the results including:

- The extent of volume and load reductions including the percent of storms not producing runoff and the implications on load reduction.
- Results related to project specific monitoring objectives.
- Water quality result comparison to International BMP DB, NSQD and other jurisdictions
- Comparison to a site serviced by traditional SWM pond (i.e., no LID).
- How results translate to alleviating pressure on local stormwater infrastructure.
- How results/performance benefit local environment (thermal benefits, water quality improvements etc.).
- Causes of elevated water quality results.
- Rainfall/event volume and or intensity related to performance.
- Seasonal comparisons.
- Water quality discussion focused on load reductions (inlet and outlet comparisons) rather than EMC.
- Winter performance
- Overall LID performance compared to design standards

4.2 Project 2

Stormwater runoff from the Mississauga Road LID site drains into Huttonville Creek, a Redside Dace habitat. Redside Dace is an endangered species therefore its habitat needs to be protected from external stress such as erosion, pollution, and water temperature increases, all of which are consequences of conventional stormwater management practices. The majority of Canada's Redside Dace population is found in the Golden Horseshoe Region of Ontario, which is undergoing rapid development/urbanization. The Mississauga Rd LID site uses a TerraSlope®Web retaining wall and infiltration technology to mitigate **thermal loading** which will be evaluated through thermal monitoring.

The monitoring objectives, schedule and work plan are as follows:

4.2.1 Project 2 Monitoring Objectives

The project's ***monitoring objectives*** are as follows:

1. Demonstrate the degree to which LID mitigates urban thermal impacts on receiving waters
2. **Evaluate long-term maintenance needs and maintenance programs, and the impact of maintenance on performance**
3. **Determine the life cycle costs for the LID practices**

4.2.1 Project 2 Design Details

The design for the **Project 2: Mississauga Road (Williams Parkway to Bovaird)**, utilizes an innovative state of the art approach to managing stormwater by first and foremost treating runoff at its source, as a resource to be managed and protected rather than a waste.

The proposed infiltration system was designed to accept inflow from the individual catch basin/manhole inlets included as part of the original roadway design.

The detailed designs for this project can be found in Appendix E of the LID Implementation Process for Regional Road Right-of-ways (2015).

The individual LID practices and design features were designed to satisfy the goals and objectives set out by the TOR. From a water quality and quantity perspective the design criteria included:

- **Enhanced Water quality** by providing treatment equivalent or exceeding MOE Level 1 treatment (long-term removal of 80% TSS) through the control of the 25mm event. Design event recommendation is to capture up to and including the 25 mm because approximately 90% of annual rainfall events capture in the Greater Toronto Area is 25 mm or less. Thermal mitigation of effluent stormwater was also required by MNR as compensation due to Species at Risk concerns (Redside Dace).
- **Provision for Water Balance (infiltration) and Erosion control** through the retention and infiltration of a minimum of 5mm per event
- **Improved Flood Control** by provision for peak flow mitigation and volume reductions.

In the context of Project 2: Mississauga Road (Williams Parkway to Bovaird Drive), the proposed LID stormwater techniques and design features proposed as part of the overall detailed design include:

- Flow Splitter;
- TerraslopeWeb Retaining Wall/Infiltration System;
- Enhanced Swales; and,
- Bioswales

The following sections provide additional detail with respect to the function and design of the individual LID practices and design features proposed as part of the **Project 2** design.

Flow Splitter

To convey the required 25mm water quality control volume to the infiltration system, flow splitters were designed to separate storm sewer flows from the proposed stormsewer network at individual inlet locations. The flow splitters function by capturing runoff entering the proposed catch basins/ manhole inlets prior to proceeding to the minor system. Flows less than the 25mm peak flow are diverted to the infiltration system by orifice. Flows which exceed the 25mm peak flow overflow to the proposed storm sewer network as originally designed.

Storm Conveyance System (Minor System)

The proposed storm sewer leads from the catch basin/manhole inlets to the infiltration system were designed to convey the 25mm peak flow. Lead slopes were adjusted such that connection from the catch basin/manhole inlets to the infiltration system was possible. Two factors dictated the lead position and required slope:

- Location of 300mm perforate pipe within **TerraSlope®Web**
- Obvert of existing minor system pipes connected to catch basin/ manhole inlets – flow splitter sumps were required to be positioned above the obverts of storm sewer pipe connected to the manhole such that through flows were not obstructed. This dictated the minimum sump invert elevation to be maintained. Leads, orifices and weirs were positioned accordingly.

TerraSlope®Web Retaining Wall/Infiltration System

The use of the **TerraSlope®Web** Retaining Wall system (Figure 4) provides an economic and natural solution for the steep slope application adjacent to Huttonville Creek while also providing a wall structure compatible with the proposed infiltration system. The use of Granular "O" as backfill material ensures free draining properties are maintained behind the wall and the integration of the infiltration system within the wall cross-section, possible.

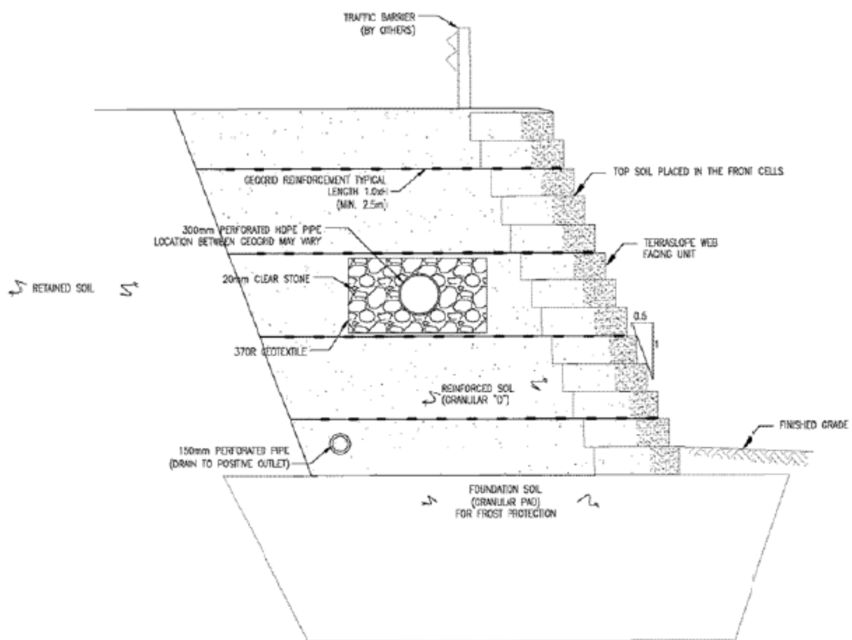

Figure 4-4 TerraSlope®Web Retaining Wall/Infiltration System

To ensure that the exfiltrated stormwater behind the **TerraSlope®Web** will not accumulate causing build ups of hydrostatic pressure, the wall is drained by a 150mm cloth-wrapped perforated underdrain situated at the wall bottom and interface between backfill and native material. The underdrain system outlets to Huttonville Creek at sixteen (16) locations (downstream of #123 inlet) and spaced approximately every 25m along the length of the **TerraSlope®Web**. The outlets discharge to roundstone spillways which dissipate outflow velocities and encourage sheet flow conditions to Huttonville Creek

Enhanced Swales

To provide added water quality benefit, enhanced swales were designed for the west side of the Mississauga Road ROW where a rural cross-section is to be maintained as part of the interim four (4) lane road configuration. The design of the enhanced swale is basic and involves the removal of the top 0.3m of topsoil from the existing roadside ditch and replacement with engineered media bed material; extending approximately 1.0m on either side of the ditch centerline.

The proposed enhanced swales act as media filter systems that temporarily store and then filter stormwater runoff. The swales rely on the engineered media bed (typically sand and organic matter mix) to provide runoff reductions and improvement in water quality.

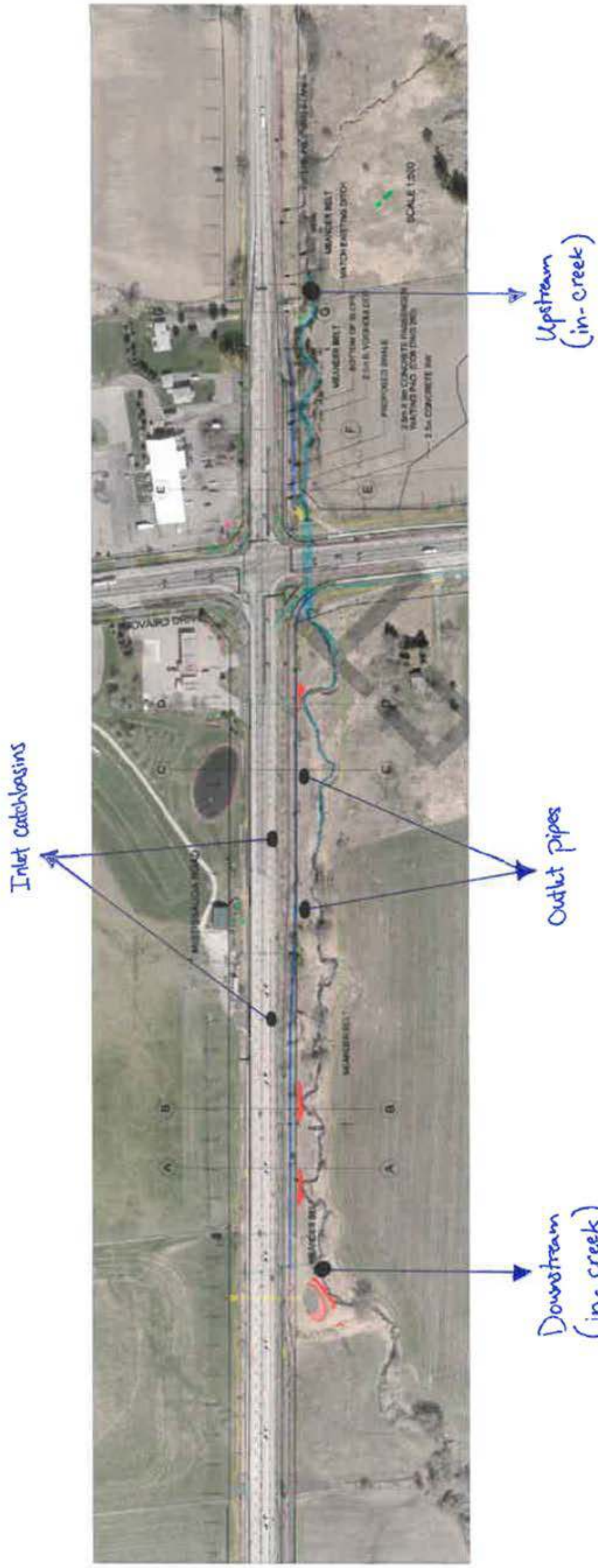

Figure 4-5 Approximate thermal monitoring locations for Project 2

4.2.2 Project 2 Monitoring Work Plan

Table 4-4 Project 2 Monitoring Work Plan

Location(s)	Objective	What will be monitored	Frequency	Equipment (How)
• 2 inlet catch basins along Mississauga Rd • 2 Infiltration wall outfall locations • 2 in-stream locations (upstream and downstream of where effluent from the LID site enters Huttonville Creek)	Demonstrate the degree to which LID mitigates urban thermal impacts on receiving waters	Storm water temperature	• Continuous logging every 10 minutes	• Hobo Pendant temperature loggers
• Various locations along roadway • Inlets • Outlets		Surface temperatures of the roadway, inlets and outlets using a thermal imaging camera	• Once per sampling year	• Thermal imaging camera (type to be determined)
MR-Precip. (near local stormwater pond)	Demonstrate the degree to which LID mitigates urban thermal impacts on receiving waters	Meteorological station for background environmental data • Precipitation • Air temperature	• Continuous precipitation and air temperature data recorded at 5 min interval	• Heated rain gauge (TBD) • Power source to be city hydro if possible • Back-up battery and solar panel in case of power failure?
Drainage area, inlets, outlets, facility	Evaluate long-term maintenance needs and maintenance programs, and the impact of maintenance on performance.	Site conditions and maintenance needs	Each site visit Fill out inspection checklist monthly	Inspection checklists and legend Camera
Drainage area, inlets, outlets, facility	Evaluate long-term maintenance needs and maintenance programs, and the impact of maintenance on performance.	Inspection and maintenance tasks and costs	Each site visit or when maintenance is completed	Inspection checklists and legend Camera
Overall project	Determine the life cycle costs for the LID practices.	Track costs throughout lifecycle: 1. Design 2. Pre-construction 3. Construction 4. Maintenance 5. Rehabilitation 6. Disposal	As needed during the duration of monitoring. Expected costs outside of the monitoring timeframe will be estimated using the TRCA life cycle assessment tool.	Staff time

4.2.3 Project 2 Gantt chart

Table 4-5 Project 2 Gantt chart

Activity	Year One				Year Two				Year Three				Year Four				Year Five				Year Six			
	Sp.	Sum.	F	W	Sp.	Sum.	F	W	Sp.	Sum.	F	W	Sp.	Sum.	F	W	Sp.	Sum.	F	W	Sp.	Sum.	F	W
Stormwater Outflow Temperature Monitoring																								
Install Rain Gauge and Begin Data Collection																								
On-Site Conditions and Maintenance Reqs.																								
Cost Tracking																								
Final Reporting																								

Note: The above Gantt chart is not intended to be comprehensive

4.2.4 Project 2 Monitoring Schedule

1. Detailed monitoring infrastructure plan and design review – Spring 2015
2. Initiation of monitoring, year 1 & bulletin/fact sheet
3. Monitoring year 2 & bulletin/fact sheet
4. Monitoring year 3 & bulletin/fact sheet
5. Monitoring year 4 & bulletin/fact sheet
6. Monitoring year 5
7. Final reporting

4.2.5 Project 2 Reporting and Communication

Results will be analysed and reported on at the end of the project period with fact-sheets/bulletins produced annually. Annual fact-sheets/bulletins will include interesting monitoring information/observations with more detailed analyses conducted for the final report. Fact sheets and case studies will provide more regular information to stakeholders and interested parties. Results will also be reported on during conferences and workshops.

The final report will include analysis methodology, results, discussion and recommendations.

Content of Discussion will be focused on giving context to the results including:

- The extent of thermal mitigation including thermal load reductions
- Results related to project specific monitoring objectives.
- How results/performance benefit local environment (thermal benefits, etc.).
- Rainfall/event volume and or intensity related to performance.
- Seasonal comparisons
- Overall LID performance compared to design standards

5 DATA MANAGEMENT AND ANALYSIS

Data from all locations and loggers will be downloaded **at minimum** once every two weeks and more frequently during rainy periods. Any issues encountered will be dealt with in a timely manner in order to avoid any loss of data records. Initial reviews of the data will be conducted using logger software in the field, while more detailed reviews and QA/QC will be conducted in the office at a minimum of once per month.

Calibrations will be conducted once per week for level/flow stations, with all remaining calibrations conducted once every two weeks.

Microsoft Excel (MS Excel) is the primary tool used for data analysis for this project. Due to the large dataset being generated, data is split into a number of different spreadsheet files to perform the statistical analysis and calculations. A Master spreadsheet is used to compile data and ensure that data is not lost when transferring it between users and spreadsheets.

Detailed data analysis tasks will be conducted by external consultants to be selected by the project team. Specifics regarding the type of analyses to be conducted will be discussed and agreed upon by the project team. All data analyses and records will be provided back to CVC for detailed review and long term storage.

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APPENDIX - OVERVIEW OF MONITORING COMPONENTS

Hydrology

Compound or v-notch weirs (depending on expected flows) are installed in the monitoring manhole structures to ensure accurate level and flow measurements. An area velocity level and flow meter is installed and set to record water level and flow at 5-minute intervals. A rain gauge installed nearby will supply precipitation data.
Level meters will be calibrated weekly using measured datum points and water level tapes to measure water level behind the weir. A lab-generated rating curve will be used to calculate flows from collected level data.
For Project 1, calculated estimates of flow based on precipitation amounts in conjunction with measured flows before and after the flow split will be utilised to evaluate data and determine the water balance of the site, as well as evaluate the overall retention capability of the LID feature.

Water Quality

A minimum of five 15 precipitation events will be sampled per year from the water quality monitoring stations with the ISCO Auto sampler. A wet event will be defined as any rainfall event greater than 2 mm or snowfall event greater than 5 cm.

Samples will be analysed for:

- Chloride
- Conductivity
- pH
- Total Suspended Solids (TSS)
- Nutrients:
    - Total Phosphorus
    - Total Ammonia
    - Nitrate & Nitrite
- Metals
- PAH (only in the first year of sampling)

The sampler holds twenty-four (24) one (1) litre bottles. Event sampling will be conducted as follows:

- One (1) sample will be submitted per monitoring station per event.
- The 24 bottles will be filled 500 mL every 20 minutes. Therefore, one bottle will be filled every 40 minutes and the program will last for 16 hours. The 24 bottles will then be mixed into one flow weighted composite sample and submitted for analysis.
- Samples will be brought to an accredited Canadian Laboratory like the MOE Laboratory Services Branch in Etobicoke for laboratory analysis.

Figure 1: Example of the monitoring equipment used at water quality monitoring locations

Meteorological Monitoring

A meteorological station including a heated tipping bucket gauge and an air temperature gauge will be installed at a nearby (TBD) location. Data will be recorded continuously every five minutes. A nearby Region of Peel rain gauge will be used as a back-up. Data from each gauge will be compared for QA/QC purposes, and any significant differences will be evaluated using measure flow data and information from the Toronto-Pearson Environment Canada meteorological station.

Water Temperature Monitoring

Water temperature information will be collected using Hobo pendant temperature loggers, tied to strings and deployed in various catch basins, monitoring locations and wells. Loggers will record continuously, but data will be post-processed to consider water temperature during precipitation events. Water temperature monitoring will be focused on spring-fall seasons in order to capture temperatures during the warmest times of the year.

Information regarding contributing surface temperatures will be collected through occasional use of a thermal imaging camera.

Continuous Soil Infiltration and Ponding

In order to measure infiltration rates in bioretention media, piezometers and pressure transducers will be used to monitor depth of water within the bioretention practice as well as on the surface.

The depth of water and infiltration rate through the bioretention practice will be measured using deeper wells that are perforated throughout and installed to the bottom of the bioretention cells.

Ponding depth will be monitored with the installation of shallow wells that are perforated above the surface, but solid below the surface. This allows for the quantification of surface water ponding as well as the duration of ponding. The image below shows a cross section of a bioretention cell with a deep well on the left and a shallow well on the right.

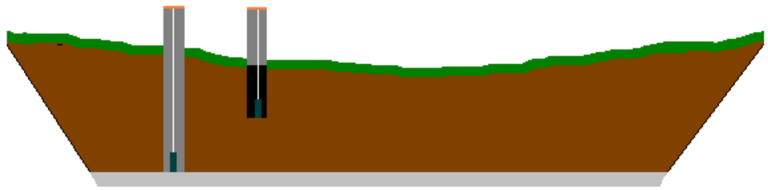

Figure 2. Bioretention cell cross section with monitoring wells

Hobo pressure transducers will be deployed in the wells to record continuous levels at 5 minute intervals.

Soil Sampling

Soil sampling is conducted for two main purposes:

1. Verification of bioretention soil media
2. Analysis of soil quality for contaminant tracking

Verification of Soil Media

Soil sampling of the bioretention filter media will be conducted soon after monitoring initiation to ensure the soil meets the design specifications. The soil will be analyzed for texture, organic content, cationic exchange capacity and soil acidity. The soil sampling methodology practiced in agriculture and recommended by OMAFRA (Ontario Ministry of Agriculture and Rural Affairs) will be used for sample collection.

Contaminant Tracking

Sampling will be conducted annually in the fall after summer precipitation events but prior to the ground freezing. Soil (filter media) sampling will be conducted at two depths.

Two composite soil samples will be collected from three bioretention cells (six samples total). The shallow and deep samples will be collected at approximately 10 cm and 30 cm below the filter media surface. In the sampled cells, three subsamples from each depth will be combined to produce one composite sample. Samples will be submitted to an accredited lab for analysis of metals, nutrients and PAHs.

Comparison between two sampling depths provides information regarding the depth at which pollutant removal occurs for different parameters. In addition, sampling at two depths helps determine whether or not pollutants are migrating through the soil column over time. Collecting samples from multiple bioretention cells will provide insight on pollutant removal for different plant combinations and how parameter concentrations vary depending bioretention cell location (i.e. different water volume inputs and sources depending on the cell).

Winter Conductivity and Chloride

In order to collect continuous data records during the winter months of chloride and conductivity impacts on Project 1's LID system, continuous Hobo conductivity loggers will be installed at the inlet and outlet of the LID median. Loggers will be calibrated using collected grab samples which will be analysed by an accredited lab. A relationship curve will be generated by collecting a grab sample during a rain or snowmelt event from each bottle of the 24 bottle carousel of the autosampler. These individual samples will then be submitted to an accredited lab for analysis.

The relationship between conductivity and chloride concentrations generated from these samples will be used to calculate continuous chloride concentrations using the continuous record from the Hobo conductivity logger.

Maintenance Inspections and Records

Long-term infrastructure assessment is needed (both quality and quantity performance) to capture when a decline in performance occurs and how performance is restored once maintenance work has been completed. Therefore maintenance documentation in concert with long term performance assessment is required in order to link maintenance activities to changes in performance. Some maintenance requirements may only be detectable through long-term performance (i.e. filter media reaching saturation). This information in addition to cost tracking will benefit asset management information.

A checklist inspection format will be used to record site conditions and maintenance needs throughout the monitoring program. The same information will be collected each time in the same format, ensuring proper documentation so that it is easier to track changes over time.

In order to document maintenance and the associated costs, CVC staff will evaluate and note maintenance needs during site visits and coordinate with those responsible for performing maintenance. CVC staff will then follow up with those responsible to gather associated records and costs. Once a year CVC staff will interview property managers to collect maintenance records, costs and information on recurring maintenance issues.

The table below outlines the type of information that will be collected and the frequency.

Table 2: Maintenance activities and frequency

Take photos from reference locations at the site.	When an inspection checklist is completed (biweekly in the spring, summer, and fall, monthly in winter) and before and after maintenance.
Keep logs of site visits, inspections and maintenance dates, activities performed, observations and associated costs.	Each visit or when maintenance is performed.
Look for common issues and maintenance tasks associated with LID such as trash accumulation, sediment deposition, erosion, and vegetation health to watch for changes over time.	Each visit
Inspect different areas of the LID feature such as the drainage area, inlets, outlets, and vegetation, to ensure nothing is overlooked and that the site can perform optimally.	When an inspection list is completed.
Outline any maintenance issues that need to be addressed and whether they are urgent or routine so that the appropriate actions can take place.	When an inspection list is completed.

Infiltration Testing

The infiltration rate of the bioswale soil media will be measured using a double ring infiltrometer outlined under the ASTM standard designation D3385-09. The double-ring infiltrometer method consists of driving two open cylinders, one inside the other, into the ground, partially filling the rings with water or other liquid, and then maintaining the liquid at a constant level. The test is used to find the maximum steady state or average infiltration rate.

Tests will be conducted once per year during growing season months to monitor infiltration in dry conditions and twice during winter months to evaluate infiltration rates during the winter.

Figure 3: Double ring infiltrometer used to measure infiltration rate in a bioswale

Qualitative Observations

Qualitative observations will include the installation of trail cameras at 2 locations along the LID median. Cameras will be installed to gather information on presence and duration of ponding, plant survival and growth through the seasons, and other interesting qualitative records. Cameras will be set to record images approximately every half hour.

In addition, CVC staff will visit the site throughout the monitoring program during a variety of precipitation events in order to record videos of flows into and out of the LID median.

All camera installation procedures and images will be managed in accordance with CVC's Photographic and Video Monitoring and Surveillance Policy established according to the Municipal Freedom of Information and Protection of Privacy Act R.S.O. 1990, c. M.56 as amended.

This type of information will provide insight into the functioning of the system during various sizes of rain events.

Figure 4: Photos from a bioretention cell trail camera