Central Parkway

Low Impact Development Infrastructure
Performance and Risk Assessment
May 2016

Monitoring Plan

Road Right-of-Way Retrofit

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1 INTRODUCTION

1.1 Low Impact Development Features and Site Design

The project proposes to retrofit an existing street with a tree-lined landscape and low impact development (LID) feature within the existing median on Central Parkway East, south of Burnhamthorpe Road, in the City of Mississauga, ON.

The tree-lined landscape feature will serve dual functions as bioretention/filtration of stormwater and beautification/aesthetic improvement. The bioretention system created within the median will utilize the DeepRoot Silva Cell system, a modular suspended-pavement soil cell system which will provide filtration of stormwater runoff for the contributing 1,046 m^2 drainage area. The trees, shrubs, and bioretention soils within this system will filter out nutrients and pollutants as the water moves through the soil profile beneath paved surfaces.

The project proposes to utilize infrastructure improvements to the extent possible such that removal/replacement is minimized, and disruption to traffic on the road is minimized. The existing street pavement, curb/gutter, and storm sewer system are to remain in place.

The majority of the project involves removal of the concrete median pavement and replacement of it with Silva Cells and bioretention material. Stormwater from select areas will be collected into existing storm sewer catchbasins with a portion of the stormwater routed to the biofiltration/filtration system that will ultimately discharge to existing storm sewer facilities.

The project is designed to achieve the maximum stormwater treatment benefit by taking full advantage of the available void space volume provided by the Silva Cells and bioretention soil media. The Silva Cells and planter area for the project provide a soil media volume of 105 m^3. An industry standard conservative value of 20% void space is assumed to be provided within the soil media macropores. The resulting void space volume for the project is then 21 m^3. This volume is then utilized for water storage/filter capacity.

The existing infrastructure (pavements and curb/gutter) direct stormwater from defined contributing drainage areas to existing catchbasins adjacent to the street median. Stormwater will initially be captured and pre-treated in the existing catchbasins that are retrofit with internal pipe extensions to create a sump area and provide surface water screening. The sump area and surface water screening result in pre-treatment of larger sediments as well as floatable debris prior to conveyance to the LID feature. Distribution pipes installed within the LID facility will route water to the bioretention/filtration system. The water will then be distributed through perforated pipes into bioretention soil media where it will percolate through the soil column, providing water to the trees and filtering out excess nutrients. Once percolated through the soil column, water will ultimately discharge at the base of the system through an underdrain installed with connection to an existing manhole connected to the City's storm sewer system.

The underdrain at the base of the Silva Cells ensures the trees are not inundated for extended periods. Any excess soil moisture in the bioretention system will be removed and transported to the storm sewer system via this underdrain. This design feature and its components also dictate that there is not permanent water storage within the soil volume, but rather the soil volume will act as a temporary "filter" through which water flows.

The system is designed as "offline" of the City's standard storm sewer system. Stormwater treatment and benefits are provided for smaller rainfall events as the capacity of the system allows, and larger rain events that exceed the capacity of the Silva Cells bypass the system.

Water exceeding the capacity of the system will overflow within the retrofit existing catchbasins through the internal pipe extensions and will discharge through existing storm sewer pipes.

2 MONITORING PURPOSE AND OBJECTIVES

2.1 Purpose

The purpose of this study is to evaluate the functionality of the Silva Cell and low impact development bioretention feature at Central Parkway East. The evaluation of functionality will focus on water quality, water quantity and maintenance aspects during the spring-fall seasons from 2015-2018. The monitoring program aims to address the outstanding knowledge gaps and stakeholder objectives identified in CVC's Stormwater Management Monitoring Strategy (2012).

2.2 Goals and Objectives

The ***monitoring objectives*** are as follows:

1. Assess the water quality and quantity performance of LID technologies
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. Demonstrate the degree to which LID mitigates urban thermal impacts on receiving waters

3 PROJECT SCHEDULE

1. Construction of the LID feature and infrastructure – Fall 2014
2. Installation of monitoring infrastructure – Winter 2015
3. Installation of monitoring equipment – Spring 2015
4. Initiation of water quantity monitoring – Spring 2015
5. Initiation of water quality sampling – Spring 2016
6. Final data analysis and reporting – Spring 2019

4 STUDY AREA

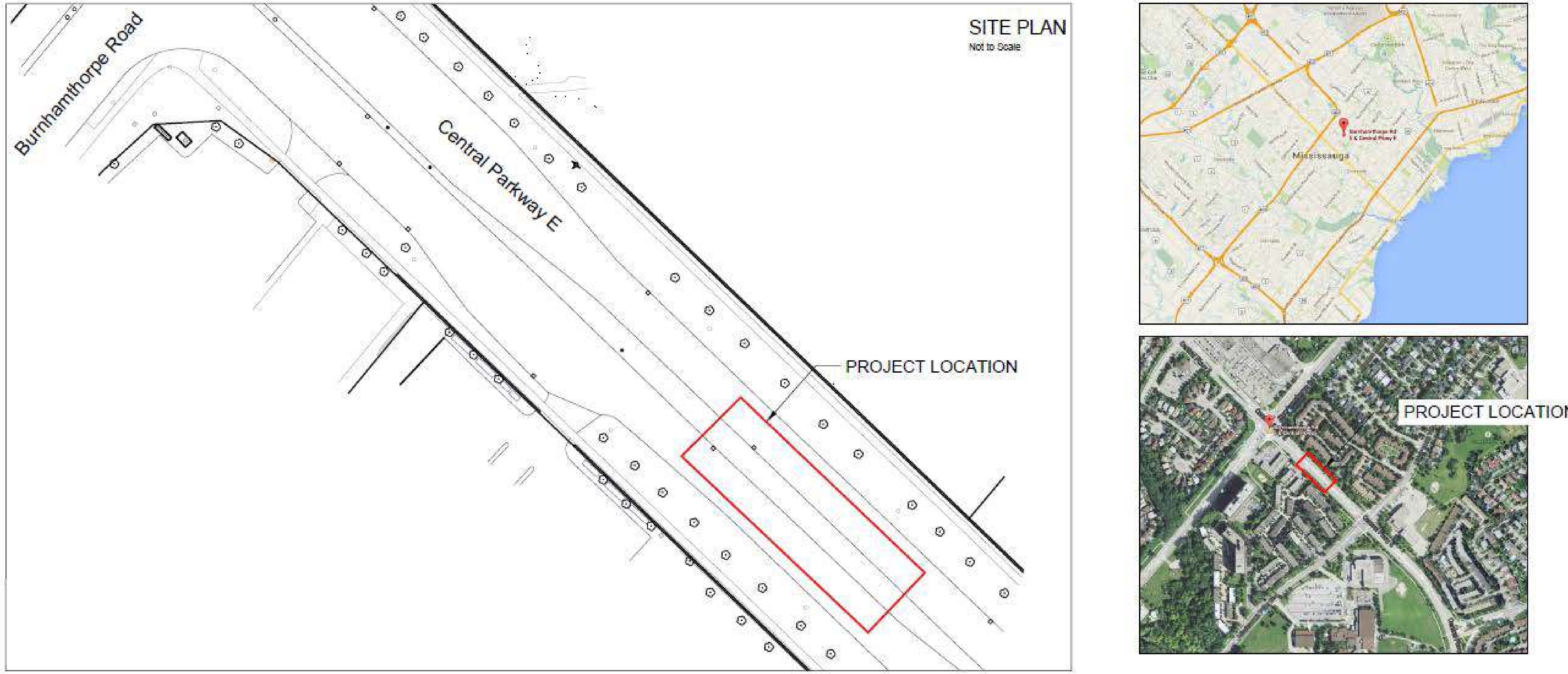

Figure 4-1 Site Location

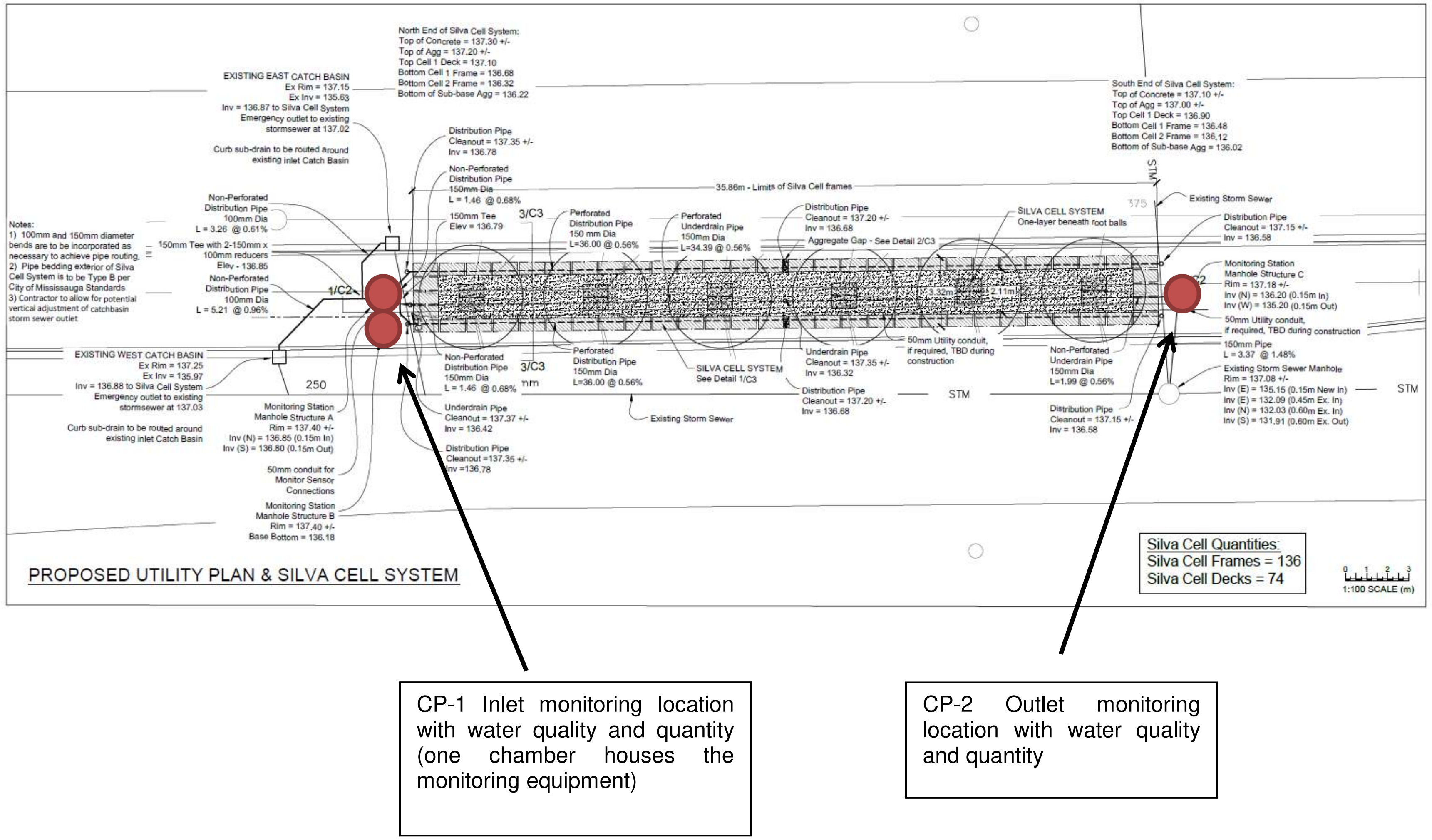

Figure 4-2 Monitoring Locations

5 WORK PLAN

Location(s)	Objective(s)	What will be monitored	Frequency	Equipment (How)
Stormwater Quantity Monitoring 1. CP-1 Inlet 2. CP-2 Outlet	#1	• Flow and level ○ Flow reduction/control ○ Peak flow reduction	• Continuous logging at 5 minute intervals • Site visits bi-weekly for calibration	• ISCO 2150 Area/Velocity logger and pressure transducer in conjunction with v-notch weirs • Water meter to calibrate levels
Monitoring Wells 1. Within bioswale	#1	Continuous soil infiltration and ponding	• Continuous logging at 5 minute intervals (spring-fall) • Data downloaded once per month (spring-fall)	• Hobo level loggers installed in shallow and deep wells at two locations along the bioswale (1 deep and 1 shallow well) • One barometric pressure logger for compensation
Catch Basin Level Monitoring 1. East catch basin 2. West catch basin	#1	• Water level in catch basins relative to: ○ LID inlet pipes ○ Municipal overflow pipes	• Continuous logging at 5 minute intervals (spring-fall) • Data downloaded once per month (spring-fall)	• Hobo level loggers
Stormwater Quality Monitoring 1. CP-1 Inlet 2. CP-2 Outlet	#1	• Chloride • Conductivity • pH • Total Suspended Solids (TSS) • Nutrients: ○ Total Phosphorus ○ Total Ammonia ○ Nitrate and 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 • Sampled events will be = or > 5mm	• ISCO 6712 autosamplers and associated parts and equipment (batteries, tubing etc.) • Samples to be submitted to an accredited lab for analysis • Lab sample containers and associated equipment
Meteorological Monitoring 1. Mississauga Valley (STN 06) rain gauge from the City of Mississauga Precipitation Network 2. CVC's Elm Drive meteorological station (located at 100 Elm Drive)	#1	• Precipitation (Mississauga Valley gauge) • Air temperature (Elm Drive meteorological station)	Continuous precipitation and air temperature data recorded at 5 min interval	Heated rain gauge with 12v battery charged by a solar panel
Soil Quality Sampling 1. Composite samples (2) within bioswale	#2	Pollutant removal quantities	Once every other year in the fall	Lab sample containers
Thermal Reduction Monitoring 1. CP-1 Inlet 2. CP-2 Outlet	#4	Stormwater temperature	Continuous temperature loggers recording at 5 minute intervals	• Hobo pendant temperature loggers • Spare batteries

Location(s)	Objective(s)	What will be monitored	Frequency	Equipment (How)
Maintenance Inspection **1.** Drainage area, inlets, outlets, facility	#2	• Site conditions • Maintenance needs, tasks and costs	• Each site visit or when maintenance is completed • Fill out inspection checklist monthly • Annual reviews with municipal staff	Inspection checklists and legend, camera
2. Double ring infiltrometer tests (2 in bioswale)		Soil infiltration	Annually	• Double ring infiltrometer • Stop watch • Source of water • Buckets • Graduated cylinder
Overall Project	#3	Track costs throughout lifecycle: • Design • Pre-construction • Construction • Maintenance • Rehabilitation • 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

6 OVERVIEW OF MONITORING COMPONENTS

6.1 Hydrology

V-notch weirs will be installed in the monitoring manhole structures to ensure accurate (+/- 3mm) level and flow measurements. An area velocity level and flow meter will be installed and set to record water level and flow at 5-minute intervals. A rain gauge installed nearby will supply precipitation data.

Level probes 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.

The Simple Method in conjunction with measured flows at the inlet location 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.

6.2 Qualitative Observations

Throughout the monitoring program, photos will be taken at consistent locations at regular intervals to track seasonal and long-term variations. 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. This type of information will provide insight into the functioning of the system during various sizes of rain events.

6.3 Water Quality

A minimum of 15 precipitation events will be sampled per year from the monitoring manhole structures with the Isco autosampler. A wet event will be defined as any rainfall event greater than 2 mm or snowfall event greater than 5 cm. Events greater than 5 mm will be considered for sample collection.

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 autosampler 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 10 minutes. Therefore, 1 bottle will be filled every 20 minutes and the program will last for 8 hours. The 24 bottles will then be mixed into 1 flow weighted composite sample and submitted for analysis.
- Samples will be brought to an accredited Canadian Laboratory such as the MOECC Laboratory Services Branch in Etobicoke or Maxxam Analytics in Mississauga for laboratory analysis.

Figure 6-1 Example of the monitoring equipment that is used in the catchbasin

6.4 Meteorological Monitoring

A City of Mississauga rain gauge, located approximately 200 m from the site, will be used for precipitation data. Data will be recorded downloaded in 5 minute intervals. Data from this gauge will be compared to other nearby gauges for QA/QC purposes, and any significant differences will be evaluated using measured flow data and information from the Toronto-Pearson Environment Canada meteorological station. An air temperature logger at the Elm Drive demonstration site, approximately 1.5 km from the site will be used for air temperature data.

6.5 Water Temperature Monitoring

Water temperature information will be collected using Hobo pendant temperature loggers, tied to strings and deployed in the inlet and outlet monitoring locations. Loggers will record continuously, but data will be post-processed to focus on water temperature during precipitation events. Water temperature monitoring will be isolated to the 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.

6.6 Continuous Soil Infiltration and Ponding

In order to measure infiltration/detention 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. Hobo pressure transducers will be deployed in the wells to record continuous levels at 5 minute intervals.

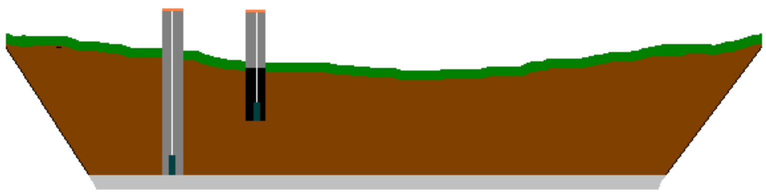

Figure 6-2 Bioretention cell cross section with monitoring wells

6.7 Maintenance Inspections and Records

Long-term infrastructure performance assessment is needed (both water 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 over time. 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 support effective asset management.

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 municipal staff 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:

Activity	When to be Completed
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.

6.8 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. These tests will be conducted right after construction to set a baseline 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 6-3 Double ring infiltrometer used to measure infiltration rate in a bioswale

6.9 Soil Sampling

Soil sampling will be conducted for the analysis of soil quality for contaminant tracking. Sampling will be conducted every other year 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 the planter, at shallow and deep depths. The shallow and deep samples will be collected at approximately 10 cm and 30 cm below the filter media surface. In the planter, 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.

7 DATA MANAGEMENT AND ANALYSIS

Data from all locations and loggers will be downloaded at minimum once every 2 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. A discussion outlining CVC's QA/QC process can be found in "Lessons Learned: CVC Stormwater Management and Low Impact Development Monitoring and Performance Assessment Guide" at **bealeader.ca**.

Calibrations will be conducted once per week for level/flow stations, with all remaining calibrations conducted once every 2 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.

8 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.
- Water quality discussion focused on load reductions (inlet and outlet comparisons) rather than EMC.
- Overall LID performance compared to design standards