Public Lands

Low Impact Development Infrastructure Performance and Risk Assessment
May 2016

Monitoring Plan

Public Lands Retrofits

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1 INTRODUCTION

Public lands constitute a significant portion of municipal land use areas and hold much of the green space in our communities. These spaces are ideal for implementing green infrastructure projects like bioretention units or rain gardens. Using the principles of low impact development (LID) to re-establish natural processes, public land sites can help to reverse the impacts of urban development. Small changes made on multiple sites throughout a watershed can add up to significant impacts. These changes ensure water resources remain drinkable, swimmable and fishable for future generations.

Bioretention units are vegetated practices that detain, filter and infiltrate stormwater runoff. The most important component of these practices is the bioretention soil media. Bioretention soil media is made using specific ratios of sand, fine soils and organic material to achieve an optimal balance of subsurface storage, filtration, pollutant removal and plant growth. Bioretention practices can be integrated into a diverse range of landscapes, including parking lot islands, gardens, and lawn areas. They are best located within (or adjacent to) hard surfaces like roadways, parking lots, buildings and pedestrian pathways as these surfaces generate large amounts of runoff that can be intercepted and treated by these features. Bioretention maintenance requirements are similar to those of other landscaped areas and include trash removal, weeding, replacement of dead vegetation, and checking for clogging of inlets and outlets. The amount of effort requirement to maintain this type of practice will vary based upon the type of vegetation and landscape design. The choice of selecting grasses or other plants for a particular bioretention practice should be based on several factors including aesthetics, maintenance requirements, and climate. In general, planted bioretention features requiring a higher degree of maintenance are recommended for higher profile settings where sufficient resources can be dedicated to maintaining a high degree of visual appeal. This can help to build community support and achieve buy-in, so long as regular maintenance is conducted. For more information on LID plantings, please refer to CVC's *Landscape Design Guide for Low Impact Development*.

The Public Lands monitoring program is comprised of eight different LID sites within the Credit Valley watershed that are all located within the City of Mississauga, with the exception of the Terra Cotta Conservation Area, which is located in the Upper Credit Watershed in the Town of Caledon. These sites vary in terms of both design and implementation as some sites were retrofits that had to accommodate existing onsite conditions, while other LID features were incorporated as part of a new site development. In the latter case the LID practices could customized and designed in conjunction with the rest of their respective project sites.

This monitoring program aims to monitor the subsurface water level to track stormwater infiltration and storage in the LID feature (bioretention unit or rain garden). This will help to understand how the feature functions as they are all unique, using different LID designs to facilitate in infiltration. Different soil mixes and design features were used at various locations, and this data will be important in determining whether specific design features enhance performance, and what the relative impact of maintenance activities are over time.

1.1 Low Impact Development Features and Site Designs

Table 1-1 provides an overview of the various Public Lands sites and summarizes the key differences in each LID feature's characteristics. Although some sites incorporated multiple LID features (e.g. permeable pavements in addition to bioretention features or rain gardens), the monitoring of water level is only occurring in the bioretention and rain garden units. Maintenance inspection logs are going to be completed for both the bioretention and permeable paver sections of each site. A limited number of LID features located on some of the Public Lands sites (the green roof at Lakeside Park, for example) is not going to be monitored in any way by CVC. For an in-depth discussion of each site and an overview of its LID features and site design, refer to the individual site case studies that can be found on CVC's LID website: *creditvalleyca.ca/low-impact-development*

Table 1-1 Public Lands LID Site Summary

Site Location	Type of Public Land Site	LID Features on Site	Primary Drainage Area Inlet to LID Features	Soil and drainage materials	Underdrain Present?	Outlet to municipal Storm Sewer?
O'Connor Park	Municipal Park	• Permeable pavers • Bioretention cell • Infiltration trenches	Parking lot	• Bioretention filter media • Clearstone • Pea gravel	Yes	No
Lakeside Park	Municipal Park	• Bioretention cell • Green Roof • Pervious concrete parking lot • Reclaimed water pond and irrigation system	Parking lot	• Bioretention filter media • Clearstone	Yes	No
Green Glade P.S.	Senior Public School	• Rain Garden	Parking lot and roof runoff	• Bioretention filter media	No	No
Lakeview Neighbourhood	Residential road-right-of-way	• Permeable pavers • Bioretention cells	Residential Road and Driveways	• Bioretention filter media • Angular clearstone • Angular chipstone	Yes	Yes
Unitarian Church	Place of Worship	• Rain Garden	Parking lot	• Amended native soil	No	Yes
Elm Drive Adult Education Center	Adult Education School	• Permeable pavers • Bioretention cells	Road	• Angular clearstone • Sand • Bioretention filter media	Yes	Yes
Portico Church	Place of Worship	• Bioretention cell	Parking lot	• Bioretention filter media • Clearstone	Yes	Yes
Terra Cotta Conservation Area	CVC Conservation Area	• Rain Garden	Roof runoff	• Amended native soil	No	No

2 MONITORING PURPOSE AND OBJECTIVES

2.1 Purpose

The purpose of this study is to quantify the rate at which different infiltration practices (i.e. rain gardens and bioretention units) are able to absorb and infiltrate stormwater on-site on a year-round basis. Each LID feature has a unique design, so infiltration rates are expected to vary accordingly. In light of this, it is important to understand how much of an impact – if any – specific design features have on overall performance. The evaluation of functionality will focus on water quantity and maintenance aspects from the spring of 2012 onward, based on available funding.

2.2 Goals and Objectives

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

1. Determine the infiltration rates of the LID features by measuring the subsurface water levels within each practice
2. Evaluate whether the LID features are functioning as designed, or if modifications are required
3. Evaluate long-term maintenance needs and maintenance programs, and the impact that maintenance has on performance
4. Determine the life cycle costs for the LID practices based on the site conditions and maintenance performed

3 PROJECT SCHEDULE

1. Development of Site Inspection Log for Maintenance Tracking – Spring 2012
2. Installation of observation wells and monitoring equipment – Spring 2012
3. Perform soil sampling – Spring 2012
4. Development of individual site Case Studies – Fall 2012
5. Compile and analyse data from first monitoring year – Winter 2013
6. Compile and analyse data from second monitoring year – Winter 2014
7. Compile and analyse data from third monitoring year – Winter 2015
8. Complete cost analysis of maintenance tasks performed and site conditions – Spring 2016
9. Complete analysis and reporting for all sites – Spring 2016
10. Final data analysis– TBD

4 STUDY AREA

4.1 Site Locations

There are eight Public Lands sites throughout the CVC watershed that are being monitored in this program. They are all within the City of Mississauga with the exception of the Terra Cotta site, which is in the Town of Halton Hills.

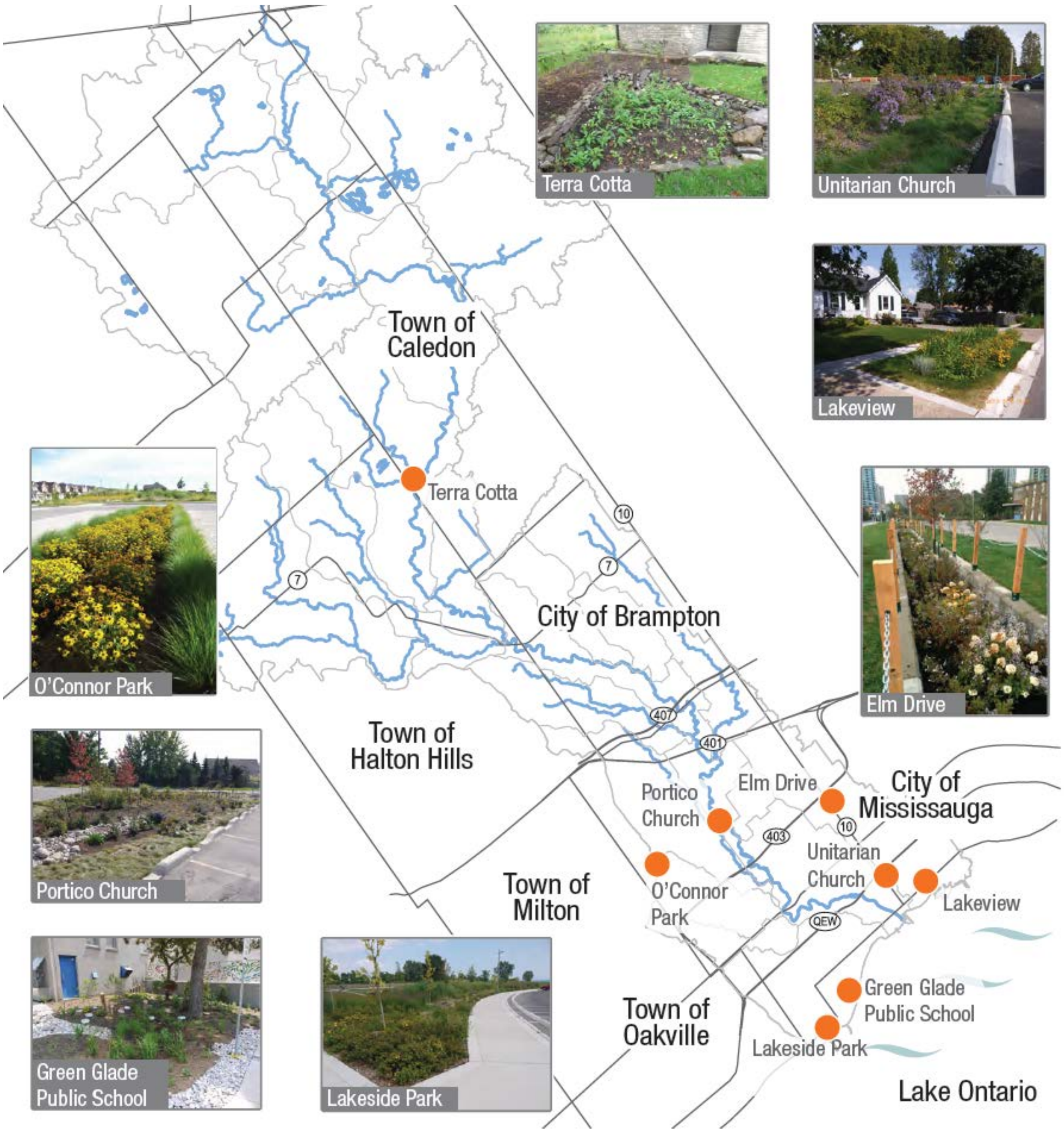

Figure 4-1 Public Lands monitoring locations

4.2 Monitoring Locations – Equipment Selection and Placement

Areas selected for monitoring equipment placement should be the lowest-lying areas within the bioretention or raingarden practice, as it is these locations where water is likely pond and where the soils will be most saturated. Deep wells monitoring infiltration rates can be installed either during facility construction or after construction is complete. It is preferable to install deep wells during construction if at all possible as this approach is less intrusive to the facility and allows for deeper placement. A standard piezometer is used, with a metal well casing on the outside to prevent theft and vandalism. The piezometer is buried, and for the ease of monitoring purposes the well casing should be level with the finished facility grade. This allows for more accurate manual measurements - to both compensate the logger data and confirm the sensor's accuracy.

In addition to level loggers, a barometric pressure transducer is required to compensate the raw data in order to provide an accurate measurement of water level. If multiple sites are being monitored, one barometric pressure transducer can be used for compensation across several locations, so long as the sites themselves are within a few kilometers of each other. Three barometric pressure loggers installed as part of the Public Lands monitoring initiative: one each at Terra Cotta, Elm Drive, and Lakeview. This is considered to provide sufficient coverage of the entire monitoring area, and will help to ensure each water level logger is within a reasonable proximity to one of the barometric pressure loggers.

5 WORK PLAN

This work plan lists the objectives of the program and provides the details on how and where these objectives will be met. The overall length of the program will be based on future funding.

Table 5-1 Project Work Plan

Objective	Location(s)	What will be monitored	Frequency	Equipment (How)
1. Determine the infiltration rates of the LID features by measuring the subsurface water level	Various City of Mississauga rain gauges and two CVC owned rain gauges	Meteorological station for background environmental data • Precipitation • Air temperature	• Continuous precipitation and air temperature data downloaded at **10** min intervals	• Heated rain gauge
	All monitoring sites, Subsurface water level	Level of the ground surface in relation to the well bottom to determine when/if surface ponding is occurring and drawdown rates over time.	• Continuous logging at **10** minute intervals • Site visits monthly for download	• One Hobo water level logger per site • Level tape to calibrate levels
2. Evaluate whether the LID features are functioning as designed and if modifications are required	All monitoring sites, As-built survey and subsurface water level	Level of the ground surface in relation to the well bottom to determine when/if surface ponding is occurring and drawdown rates. Crosscheck monitoring observation with as-built survey to ensure proper functionality.	• Initially review the as-built survey to see if features were constructed as designed, make modifications if needed • Review monitored water level in relation to different features (i.e. inlet and overflow outlet) to see if they are used and the frequency/functionality	• External consultant to complete as-built survey • Water level and meteorological monitoring equipment listed above
3. Evaluate long-term maintenance needs and maintenance programs, and the impact of maintenance on performance.	All monitoring sites, Drainage areas, inlets, outlets, facilities, etc.	• Site conditions • Maintenance needs, tasks and costs	• Each site visit or when maintenance is completed • Fill out inspection log monthly • Annual interviews with property managers	• Inspection log and legend • Camera
4. Determine the life-cycle costs for the LID practices.	Overall project	Track costs throughout life-cycle: • Design • Pre-construction • Construction • Maintenance and materials • Rehabilitation • Disposal	As needed throughout 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 Subsurface Water Level Monitoring and Site Visit Activities

All sites will be visited monthly as the water level loggers to be used in this monitoring program are low-maintenance and do not require frequent downloading. This is an ideal site visitation interval which allows CVC staff to collect data in a timely manner, as well as track site conditions via a regular inspection interval.

In order to download the loggers in the field a laptop and the appropriate software is needed, in addition to all requisite connection cables. Connecting to the loggers and downloading data is a relatively simple process which requires little time to complete, and can be done year-round. A water level tape is also required as manual water level measurements are needed to compensate the water level data. It is also important to have a reference point (datum), so the water level tape is used to ensure that the loggers are taking accurate level measurements. If the loggers are found to be losing their accuracy, the reference datum and water level tape can be used as a calibration aid.

Tasks that occur during a regular field visit include:

- Opening the well and taking a water level measurement
- Removing the logger from the well in order to download the data
- Replacing the logger in the well and securing the well casing to protect against theft or vandalism
- Taking photos and documenting any changes that might have occurred onsite since the last visit
- Taking detailed notes of measurements, downloads, logger information, and site information
- Completing an inspection log for the visit, which includes recording the current site conditions and any maintenance needs

6.2 Meteorological Monitoring

A City of Mississauga rain gauge, located less than one kilometer from O'Connor Park, Lakeside Park, Green Glade P.S., Lakeview, Portico Church and Unitarian Church, will be used for the collection of precipitation data for the aforementioned locations. Field data will be recorded by the loggers and rain gauge at ten minute intervals. Data from the gauge will be compared to other nearby gauges for QA/QC purposes.

Both Elm Drive and Terra Cotta will use precipitation data recorded by a CVC-owned rain gauge. Data will be recorded and analyzed using a ten minute interval format, as above. Data from the gauge will be compared to other nearby gauges for QA/QC purposes.

6.3 Maintenance Inspections and Records

Long-term infrastructure performance assessment is needed to capture when a decline in performance occurs and how performance is restored after maintenance or remedial works have been completed. Maintenance documentation - in concert with long-term performance assessment - is therefore required in order to link maintenance activities to changes in performance when compared to design criteria. Some maintenance requirements may only be detectable through long-term performance (i.e. filter media reaching pollutant saturation). This information, in addition to tracking the associated costs, will support effective asset management.

An inspection log format will be used to record site conditions and maintenance needs throughout the monitoring program. The inspection log records information such as plant health, weed cover, inlet blockage, overflow blockage, litter and debris cover, etc. The same information will be collected during each monthly visit in a consistent format, thus ensuring the proper documentation of condition assessment data. This will allow for streamlined analysis of the inspection data and will make it easier to track changes over time.

In order to document maintenance activities and their associated costs, CVC staff will evaluate and note maintenance needs during site visits and coordinate with those responsible for performing maintenance. CVC staff will follow up with those responsible to gather records related to both the activities and their costs. CVC staff will interview property managers annually to collect maintenance records, costs and other related information on recurring maintenance issues. **Table 6-1** outlines the types of information that will be collected and the frequency.

Table 6-1 Summary of Proposed Inspection Activities and Timing

Activity	When to be Completed
Take photos from reference locations at the site.	When an inspection checklist is completed 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.

6.4 Infiltration Testing

Infiltration testing will be conducted at each site within the bioretention facility once after construction is complete to ensure the facility passes the designed infiltration drawdown volume prior to assumption by the property owner. A Guelph Permeameter will be used for infiltration testing.

6.5 Soil Sampling

Soil sampling will be conducted at each site within the bioretention facility once after construction is complete to ensure the facility passes the design specifications to determine grain size and to ensure that the proper soil mixture was used. Some monitoring sites will be excavated during construction and filled with special engineered filter media mix, which is a blend of sand, organic debris, and fines. LID practices located at other sites will utilize the native soils in these locations, and will amend them with additional sand and compost to increase their porosity, infiltration and pollutant adsorption capacity. Collecting soil samples will be crucial in determining whether the soils meet design specifications and if the sites are constructed as intended.

6.6 Qualitative Observations

Throughout the monitoring program, photos will be taken at consistent locations at regular intervals to track seasonal and long-term variations.

Furthermore, CVC staff will visit the various sites throughout the monitoring program during a variety of precipitation events in order to record videos of flows going both into and out of the LID features.

This type of information will provide insight into the functionality of the system during variously-sized rainfall/runoff events.

7 DATA MANAGEMENT AND ANALYSIS

Data from all loggers at all locations will be downloaded once every month. Any issues encountered will be dealt with in a timely manner in order to avoid any loss of sensor data or other 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.

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

The inspection logs that are filled out in the field will then be entered into a Microsoft Access database in order to be analysed more easily. The database will allow all of the information to be centrally kept, but permits quick manipulation of the data. It will also help with the tracking of site conditions over time.

Results will be used to complete a technical report outlining the performance compared to the project objectives. This will be posted on the CVC website for the public to access. Monitoring results will help to inform the future design and maintenance needs of different LID features.