CREDIT VALLEY CONSERVATION

CVC Head Office

Low Impact Development Infrastructure Performance and Risk Assessment

May 2016

Monitoring Plan

Business and Multi-Residential Retrofit

Credit Valley Conservation Head Office Monitoring Plan Executive Summary: Monitoring of a Low Impact Green Office Building

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1 BACKGROUND

Municipalities across Canada are struggling to address a number of issues surrounding stormwater management; from aging infrastructure to insufficient stormwater management. To prevent the degradation of receiving streams and the Great Lakes, and damage to property and infrastructure from erosion and flooding, innovative stormwater management techniques and technologies will need to be implemented.

The purpose of the study is to evaluate the effectiveness of a rainwater harvesting system, permeable paving, and bioswales, with respect to: reducing stormwater effluent volume, reducing total loadings of parameters of concern, and reducing the use of municipally treated water. This project will help educate urban municipalities on how to balance growth, redevelopment, stormwater infrastructure, and the environment in light of climate change; providing a template that municipalities can employ to cost-effectively address environmental and development issues.

PROJECT OBJECTIVES

1. "Innovative" stormwater management demonstration site:
   This treatment approach is "above and beyond" the standard practices in place pertaining to stormwater management in Ontario, using a rainwater harvesting system, permeable pavement, and bioretention trenches as source control for treatment and management. This project will also add much needed performance data to support design initiatives of such practices.

2. To support initiatives such as source protection and municipal stormwater management in light of climate change.

3. Template for Municipalities Across Ontario:
   Comprehensive effectiveness monitoring of performance data will be conducted to provide municipalities across Ontario with a template for LID implementation and stormwater credit application in Mississauga.

PROJECT SCHEDULE

1. Initiation of Environmental Monitoring – Summer 2013
2. End of Project – Late Fall 2021

2 MONITORING PURPOSE AND OBJECTIVES

The purpose of the study is to evaluate the overall stormwater runoff reductions and pollutant removals for a typical office building and parking lot when multiple Low Impact Development (LID) practices are employed.

The following monitoring objectives are based on the nineteen objectives identified for CVC's overall stormwater management program and are relevant for CVC's Head Office site:

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. Evaluate whether LID SWM systems are providing flood control, erosion control, water quality, recharge, and natural heritage protection per the design standard.
4. Assess the water quality and quantity performance of LID technologies.
5. Evaluate and refine construction methods and practices for LID projects.
6. Develop and calibrate event mean concentrations (EMCs) for various land uses and pollutants.
7. 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?).
8. Assess the ancillary benefits, or non-SWM benefits.
9. Improve and refine the designs for individual LID practices.

This monitoring plan is based on the protocols and practices being used across the CVC infrastructure performance monitoring assessment program.

2.1 Background

Our communities are supported by functions provided by our environment such as abundant, safe drinking water, and clean air. Studies conducted on the Credit River Watershed have found that we need to integrate how we build our communities with how we manage our stormwater to support a sustainable environment. This is known as Low Impact Development (LID). The design of the new CVC head office building includes LID measures such as a rainwater harvesting system and a permeable pavement parking lot with perimeter grass swales, which will help to reduce the buildings environmental impact.

LID attempts to mimic natural processes by reducing surface runoff and increasing infiltration. Therefore, its performance depends on local conditions including, climate, soils, and drainage. Individual LID measures should be examined with respect to basic hydrological cycle components: evapotranspiration, infiltration, and runoff. Stormwater infiltration occurs on natural soils with pervious cover and at special facilities (bioretention and swales) located throughout the catchment area. At the CVC Head Office site, it is expected that infiltration will occur in the permeable parking lot and the grass swale areas. Long-term sustainable infiltration depends on soil cover, soils, hydrology, risk of clogging of infiltration sites, and infiltration facility maintenance. Mimicking a natural water balance also supports the enhancement of runoff quality and ecological integrity in receiving streams (J. Marsalek and Q. Rochfort 2008). CVC will assess if the LID practices put in place provide runoff control, improved water quality, and increased groundwater recharge leading to more natural site hydrology and water quality when compared to conventional stormwater management practices.

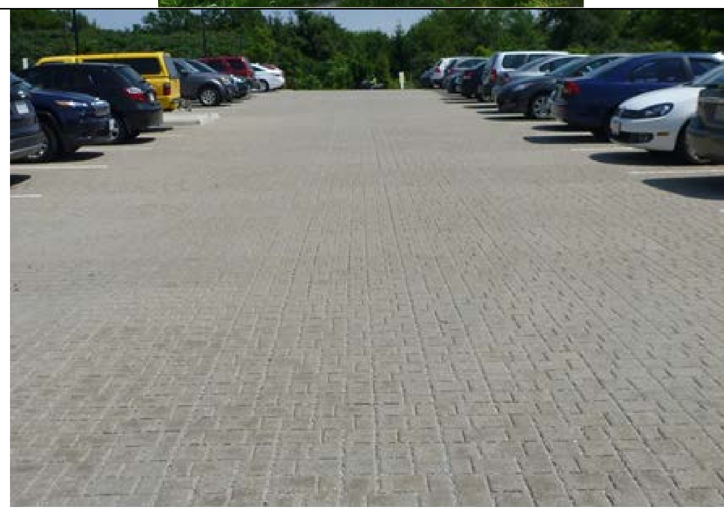
This monitoring project can act as a model to other sites contemplating LID stormwater management ideas and a point of comparison to other locations with similar systems already in place.

3 LID INITIATIVES

The most commonly used method of stormwater conveyance from streets in urban areas is curb and gutter. With this method, storm water is quickly brought to receiving watercourses in underground pipes. A small volume of water soaks into the ground to be naturally filtered before it reaches these watercourses. This can lead to a number of problems in local streams including flash flooding, declining water quality and reduced stream baseflow and groundwater levels.

Through a combination of swale drainage and permeable paving stones, outlined in **Table 3-1**, the hydrology and water quality leaving the CVC Head Office site will be improved over conventional stormwater practices.

Table 3-1 Swale and LID practices located at the CVC head office

LID Practice	Picture
Swale drainage can reduce pollutant and sediment concentrations, and can have significant reduction time of flow to local creeks and storm drain systems. Open drainage also has the ability to reduce mosquito breeding areas through the reduction of areas with standing water.	
Permeable Paving Stones increase stormwater infiltration by allowing water to soak into the joints between the paving stones and into the ground.	
Rainwater Harvesting Systems reduces rooftop runoff as rainwater is collected by roof downspouts and directed to a cistern. At the CVC head office building, water collected in the cistern is used for flushing toilets and landscape watering.	

4 STUDY AREA

The subject site for the study is located in the City of Mississauga, within the Credit River Watershed, and drain directly to the Credit River (**Figure 4-1**). The surrounding area is primarily residential with pockets of agricultural and natural areas. A catchbasin has been installed in a location down gradient of the permeable parking lot and the confluence of the swale underdrains. This is the ideal location for monitoring equipment. Since the monitoring station will drain an area of 4469m^2, 33% of which is impervious, it will be possible to calculate a water balance by installing monitoring equipment to measure flow and take water samples during rainfall events. A rain gauge is located on top of the CVC Office Building to provide precipitation data.

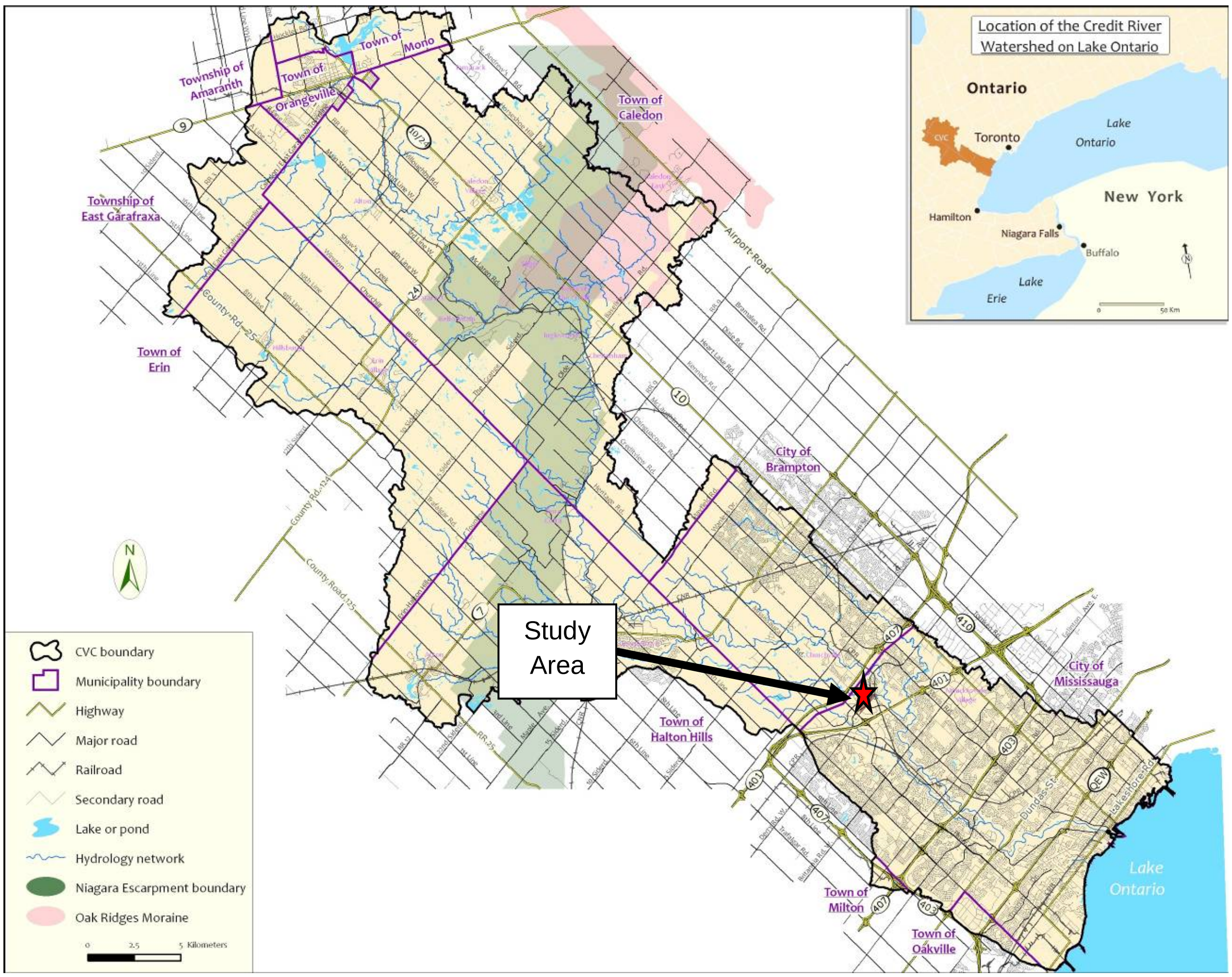
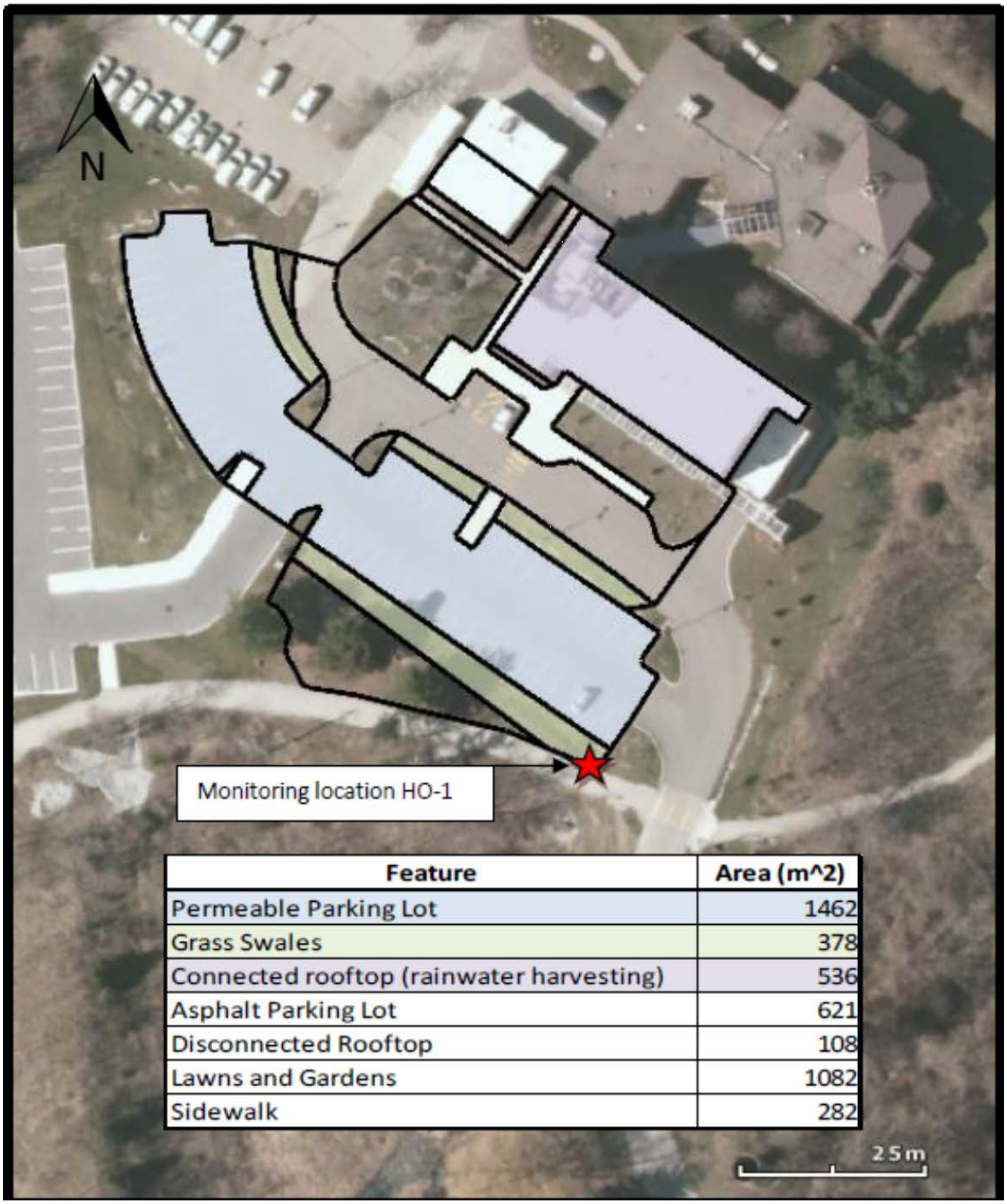


Figure 4-1 Study area located in the Credit River Watershed



Feature	Area (m^2)
Permeable Parking Lot	1462
Grass Swales	378
Connected rooftop (rainwater harvesting)	536
Asphalt Parking Lot	621
Disconnected Rooftop	108
Lawns and Gardens	1082
Sidewalk	282

Figure 4-2 Aerial View of Project Area

Figure 4-3 New CVC Office Building

4.1 Monitoring Site

Existing site plans were reviewed followed by a site walk to gain an understanding of the existing drainage system for the study area. One monitoring station is proposed to monitor stormwater leaving the site, located in the southernmost grass swale (**Figure 4-2**).

5 WORK PLAN

5.1 Instrumentation

A site visit was conducted to review the existing drainage infrastructure and assess suitable types of equipment for the monitoring program.

The equipment located in the catchbasin is as follows:

- Isco 6712 sampler
- Isco 2150 area velocity flow meter
- Hobo UA-002-64K temperature logger
- Hobo U20 level logger located in the perimeter grass swale to determine the presence of overland flow contributing to outflow
- Steel box for secure onsite equipment storage

The equipment located for the rainwater harvesting system is proposed as follows:

- Hobo U20 level logger located in the rainwater storage tank to measure water depth
- Water meter located on the outflow pipe from the tank to calculate water outflow
- OM-CP-PULSE101A pulse loggers located on the water meter to log outflow from and municipal water top-up to the rainwater harvesting system

All equipment, except the OM-CP-PULSE101A pulse loggers, will be set to log every 10 minutes. The pulse loggers will log every hour. Data will be stored in the logger's memory and downloaded in-person biweekly as a minimum using ISCO Flowlink 5, Hoboware, and OMEGA software. The software will automatically summarize and plot the data together graphically, which can then easily be exported to a program like Microsoft Excel.

The site will be visited a minimum of once every two weeks to check battery power, inspect equipment, and make sure everything is operational.

5.2 Hydrology

A compound weir is installed in the monitoring catchbasin 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 10-minute intervals. The rain gauge currently installed on the roof of the CVC office building will supply precipitation data. In addition, a water level meter located in the rainwater storage tank will be used to calculate water inflow, a water meter located on the outflow pipe from the tank will calculate water outflow, and a pressure transducer located in the rainwater storage tank will measure rainwater level. This data will help determine how much roof runoff is diverted from the stormwater infrastructure and repurposed for use in toilets and irrigation.

Figure 5-1 Monitoring station in the catchbasin

5.3 Water Quality

A minimum of five (5) precipitation events will be sampled per year from the monitoring catchbasin 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. In addition, five (5) samples will be collected from the rainwater harvesting system during various conditions throughout the first year of the monitoring program.

Samples will be analysed for:

- Chloride
- Conductivity
- pH
- Total Suspended Solids (TSS)
- Nutrients:
    - Total Phosphorus
    - Orthophosphate
    - 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 then be filled 500 mL every 20 minutes. Therefore, 1 bottle will be filled every 40 minutes and the program will last for 16 hours. The timing may be changed to 500 mL every 10, 30 or 40 minutes based on the forecasted event.
- Using the flow data, water from the ISCO bottles will then be mixed into 1 flow weighted composite sample at the time of collection.

- Samples will be brought to an accredited Canadian Laboratory such as the MOE Laboratory Services Branch in Etobicoke for laboratory analysis.

Figure 5-2 Data logger and autosampler used at HO-1

5.4 Data Management & Analysis

CVC will manage water level, water usage, water flow, and water quality data sets, and provide data analysis for the study. Water quantity and quality data will be organised into hydrological events so that analysis can be performed on an event by event basis. Table 2 summarises the conditions which define the beginning and end of a hydrological event. Parameters which will be calculated for each hydrological event are outlined in **Table 5-1**. Flow weighted composite water quality samples will provide event-mean concentrations (EMC) for parameters of interest and continuously monitored water quality parameters, like temperature, can be processed to calculate event mean temperature (EMT). A hydrologic summary will be prepared for each event and a water quality summary will be prepared for each sampled event.

Table 5-1 Defining hydrological events

Event Type	Beginning	End
Precipitation	Precipitation observed	Outflow from monitoring site returns to baseflow for a period of 6 hours
Thaw	Outflow observed, no precipitation observed	Outflow from monitoring site returns to baseflow for a period of 6 hours
No outflow	Precipitation observed, outflow does not exceed baseflow	No precipitation observed for a period of 6 hours

Table 5-2 Hydrologic and water quality parameters

Precipitation	Outflow	Hydrologic evaluation	Water quality
• Event type • Precipitation depth • Antecedent dry period • Duration • Intensity	• Presence/absence of outflow • Outflow volume • Peak flow rate • Duration	• Volume reduction (using simple method to calculate inflow) • Peak flow reduction • Lag time	*Composite samples:* • EMC • Pollutant loads *Continuously monitored:* • Temperature

Table 5-3 How objectives will be monitored

Objective	How objective will be monitored
1.	• Precipitation data collection and outflow data collection. • The precipitation data will be used to calculate a total volume of water that is entering the site; this is determined by the total precipitation depth and drainage area. • The outflow data will be calculated using continuous water level measurements and a rating curve created for the installed weir. • The total volume of water entering the site will then be compared to the total volume of water leaving the site giving a total volume reduction.
2.	• Performing site inspections on an ongoing basis along with logging the timing and details of maintenance activities will provide data to evaluate long term maintenance needs of LID systems. • Periodic infiltration testing of the paver surface can be used to determine the rate of clogging and to evaluate the effectiveness of maintenance activities. • Performance data, such as discharge quantity and quality, will be compared to maintenance schedules and actions to determine the impact of maintenance on performance.
5.	• The CVC head office is not designed for flood control, however, the total volume of reductions can be used to help evaluate whether the LID SWM system is reducing surface runoff thus providing flood control. • Calculating peak flow reductions will assist in this evaluation as well as be used to evaluate erosion control. • The water quality of the of the LID's discharge will be evaluated by collecting flow weighted water samples using an autosampler providing EMCs of targeted water quality parameters. The water quality results will be compared to typical EMCs from similar land uses to determine if the LID system provides an improvement in water quality. • Load reductions of selected water quality parameters will be calculated
9.	• The water quality and quantity performance will be assessed through collecting water samples from precipitation events and through the collection of discharge data

	respectively. • Water quality and quantity results from the CVC head office site will be compared to EMC data available in literature to assess the performance of the LID technology
10.	• The total volume of water entering the site will then be compared to the total volume of water leaving the site giving a total volume reduction. • The reduction in volume will quantify reduction in demand on stormwater management infrastructure allowing for potential rebates on development charges, credits on municipal stormwater rates and reductions in flood insurance premiums.
13.	• Creating photo logs of construction activities while construction is taking place performing site inspections after the construction is completed will help evaluate and refine construction methods and practices for LID projects.
14.	• Collecting flow weighted composite samples will provide EMCs from precipitation events of different sizes and intensities will help develop and calibrate EMCs of pollutants for commercial and institutional land uses.
16.	• Monitoring the amount of water saved, through the use of a rainwater harvesting system, will help assess the non-SWM benefits of LID • The amount of water that is harvested and used through the use of a rainwater harvesting system is the amount of treated water that is not used reducing the amount of money spent on utilities.
18.	• The completion of site inspections and through observations taken during rain events. • These activities will demonstrate how the LID system works at managing stormwater as well as highlight any deficiencies either in the construction or the design. This will allow for improvements on LID systems to better capture and treat stormwater.
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. 5. Evaluate whether LID SWM systems are providing flood control, erosion control, water quality, recharge, and natural heritage protection per the design standard. 9. Assess the water quality and quantity performance of LID technologies. 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-SWM benefits. 18. Improve and refine the designs for individual LID practices	

6 REPORTING

CVC will develop a draft report, case study and fact sheet. CVC will post a final report detailing the entire study and results. CVC will also develop interpretive signage to be erected at the study site. CVC will develop a public information strategy and identify information to communicate to the public.

6.1 Intentions to Publish

While the study is underway, information collected is confidential and not to be shared with personnel outside the study team. Once the monitoring data has undergone a thorough internal review, the intention is for the information to enter into the public domain.

6.2 Costing

A table outlining monitoring costs for the research project is summarized in Appendix 1.

The cost estimate provides the following breakdown:

- Cost to purchase equipment;
- Cost of equipment installation;
- Cost to trigger samplers and collect samples;
- Cost of monthly data acquisition, equipment maintenance and calibration;
- Cost of laboratory analysis.
- Cost of data analysis and reporting
- Cost of staff time

These costs are based on hiring a consultant to install the equipment. Since some of the equipment will be installed within the catchbasins, personnel certified in confined space entry will be required. In addition, staff may need to trigger and collect samples outside of typical business hours as precipitation events may occur during evenings and weekends.

6.3 Adaptive Program

The program is intended to be adaptive in nature, implying that the program will be continually reviewed and changes may be made to the sampling protocols, methods, and locations as needed. Data will need to be collected for multiple years in order to make accurate conclusions about the site's performance. The program will continue until enough data is collected to make conclusions based on the monitoring objectives.

7 REFERENCES

CVC (Credit Valley Conservation Authority). (2008). Cooksville Creek Watershed Study and Impact Monitoring: Background Report Draft. Not Published.

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J. Marsalek and Q. Rochfort. 2008. Observations on Monitoring the LID Project "Meadows in the Glen". Memo to Credit Valley Conservation & Intercorp.