Terra Cotta Conservation Area Rain Garden

Location: Town of Caledon

Constructed: 2011

Case Study

Public Lands

Project Objectives, Design & Performance

- Create a low impact development (LID) education tool through the consturction of a rain garden on Credit Valley Conservation property.
- The rain garden was planned, designed, constructed and maintained in house by CVC staff.
- CVC staff are currently monitoring water levels, landscape health and maintenance needs of the rain garden in order to understand the life cycle performance of LID practices.

Overcoming Barriers and Lessons Learned

- In order to accept runoff from the roof of the Visitors Welcome Centre, the downspout had to be disconnected and burried under a sidewalk.
- The location of the rain garden was more shaded than originally thought. Shade tolerant plants were added to the rain garden.
- It is important to do a thorough site evaluation prior to choosing a location for a rain garden. This includes determining soil types, completing an infiltration test, locating potential obstacles, determinig slope, and completing a sun/shade assessment.

Practices Implemented

Bioretention

Barriers & Issues Encountered

Construction & Comissioning

Operation & Maintenance

Overview

Terra Cotta Conservation Area (TCCA) is a 250 hectare naturalized area in the village of Terra Cotta. Located in the Niagara Escarpment, it is home to several different species of plants, birds, and wildlife. TCCA is a 4 season conservation area providing many recreation and environmental education opportunities. It is owned and operated by Credit Valley Conservation (CVC).

Location of Terra Cotta Conservation Area

In early 2010, the Water Resources department at CVC teamed up with the Lands and Natural Heritage department. Their goal was to develop a low impact development (LID) demonstration site on CVC owned property. Terra Cotta CA was chosen as an ideal demonstration site because it receives many visitors and some areas were in need of landscaping.

In the summer of 2011, a rain garden was constructed next to the Visitors Welcome Centre at TCCA. This rain garden was similar to what would typically be constructed on a residential property.

Goals and Drivers

Several factors motivated the construction of the rain garden at Terra Cotta CA including:

- Establishing a demonstration residential rain garden that could be easily monitored by CVC staff.
- Adding colour and interest around the Visitors Welcome Centre at TCCA through landscaping.
- Demonstrating the ease and low cost of constructing a residential rain garden.
- Create an education tool that will promote homeowner LID techniques to the general public.

Successes

Demonstration Site: The garden is a publically accessible demonstration site showcasing a residential rain garden.

Departmental Integration: CVC's Water Resources and Lands & Natural Heritage departments have worked together to plan, design, construct and maintain the rain garden at TCCA.

Residential LID Education Tool: Interpretive signage and park educational activities help to teach park visitors about the benefits of residential rain gardens.

Overcoming Barriers & Lessons Learned

The following barriers were encountered when constructing the Terra Cotta rain garden:

- Rain garden area was more shaded than originally thought, affecting the health of some plants.
- The downspout directed runoff onto a sidewalk. The sidewalk also blocked the drainage path toward the rain garden.

These barriers were addressed by:

- Adding additional shady plant species to the rain garden.
- Installing a downspout extension beneath the sidewalk. This eliminated winter ice hazards on the sidewalk and brought roof runoff into the rain garden.

Lessons learned through this project include:

- It is important to note the level of shade and sun the area will receive when completing a pre-design evaluation of a potential rain garden site. This will help you choose appropriate plants for the rain garden.
- Creative solutions such as dry river bed channels and buried downspout extensions can safely carry runoff away from foundations and sidewalks to your rain garden.

Planning & Regulations

Terra Cotta Conservation Area was selected as a potential location for an LID demonstration site because it is one of the most active recreational parks in CVC's conservation areas system. An LID demonstration

feature at this location would receive lots of public visitors. TCCA also offered several educational programs and special events that an LID demonstration project could be incorporated into.

The project was designed and constructed by CVC staff. The core project team included a water resource engineer, landscape architect, and the park superintendent. The Terra Cotta rain garden had to go through an internal approval process because it was a project on CVC owned property. This process included preparing a proposal of the project that was approved by senior management in both the Water Resources department and the Lands & Natural Heritage department. The plants chosen had to be native, match the ecology of the park and be approved by CVC ecology planners.

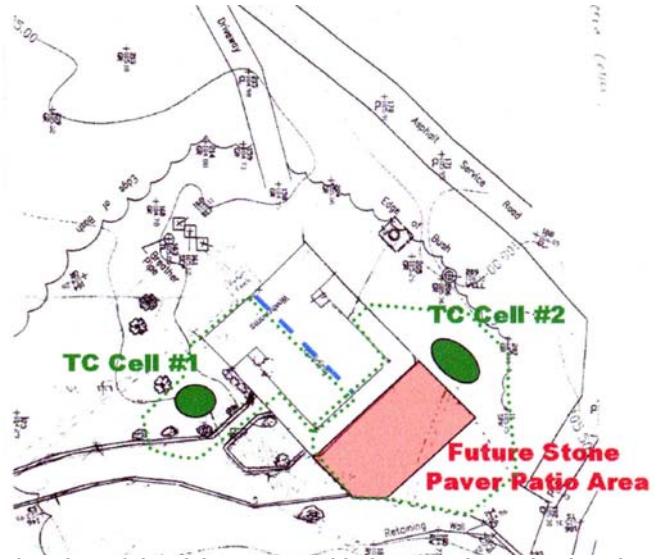
In the spring of 2010, CVC water resources staff met with the park superintendant and CVC's landscape architect at TCCA. They discussed potential locations and project ideas for an LID demonstration site. The Visitors Welcome Centre was chosen as an ideal location for the project. As a focal point for the park it would likely receive the most foot traffic. The interior and exterior of the building had recently been renovated. However no landscaping around the building had been completed. A rain garden in this area would bring more colour and visual interest to the buildings exterior while helping to screen the buildings mechanical support systems.

Outside of the Visitors Welcome Centre prior to rain garden installation.

Prior to starting a rain garden project, it is important to evaluate site conditions. This will ensure that the selected location is viable. Site evaluations should include:

- Determining soil type.
- Completing an infiltration test.
- Locating any potential obstacles such as utility lines, tree roots, or septic systems.
- Determining slope of selected location.
- Reviewing overall landscape, including a sun/shade assessment.
- Determining a safe overland flow route for extreme rainfall events.
- Consideration for future expansions and improvements.

For this project a total station survey was performed and a site plan was developed.



Plan view of the visitor center with the two rain garden locations identified and a planned patio addition.

Two potential locations for rain gardens were identified, labeled Cell #1 & Cell #2 in the above picture. Cell #1 was the first choice of location due to visibility and proximity to the roof downspout. Cell #2 is a potential future location once improvements such as the outdoor patio are completed.

A closer evaluation of the preferred rain garden location was completed by the project team. They found shallow bedrock within 1-2 meters. The soil was found to be sandy clay loam/ clay loam. Sandy soils are ideal for well draining rain gardens while clay soils require significant amendments and must be sized larger. The soils at Terra Cotta are in between and would need some amendments of compost to function well. A double ring infiltration test was performed to determine an accurate infiltration rate (14 mm/hr) of the native soils.


CVC staff completes a double ring infiltrometer test

Utilities ran through the north of the Visitors Welcome Centre and were not expected to interfere with the rain garden site.

Design

The Terra Cotta rain garden was designed in-house by a member of the water resources team. Information gathered during the site evaluation helped to guide design decisions. The goal was to design a rain garden that would be easy to replicate by a typical homeowner on a small budget.

Sizing

CVC wanted the rain garden to be sized to accept 25 mm of rainfall before overflowing. The first step in determining size is to determine the drainage area. A larger drainage area requires a larger rain garden. Rain gardens are typically sized at a conservative ratio of 1:5 (rain garden to drainage area). Drainage size along with other factors outlined in the table below, were used to calculate an appropriate size for the Terra Cotta rain garden.

Impervious Drainage Area	106 m^2
Pervious Drainage Area	18 m^2
% Impervious Drainage Area	85%
Water Quality Volume	6.2 m^3
Maximum Ponding Depth	0.1 m
Infiltration Rate	0.013 m/hrs
Ponding Time	24 hrs
Minimum Area	14.8 m^2
1:5 Conservative Sizing	25 m^2

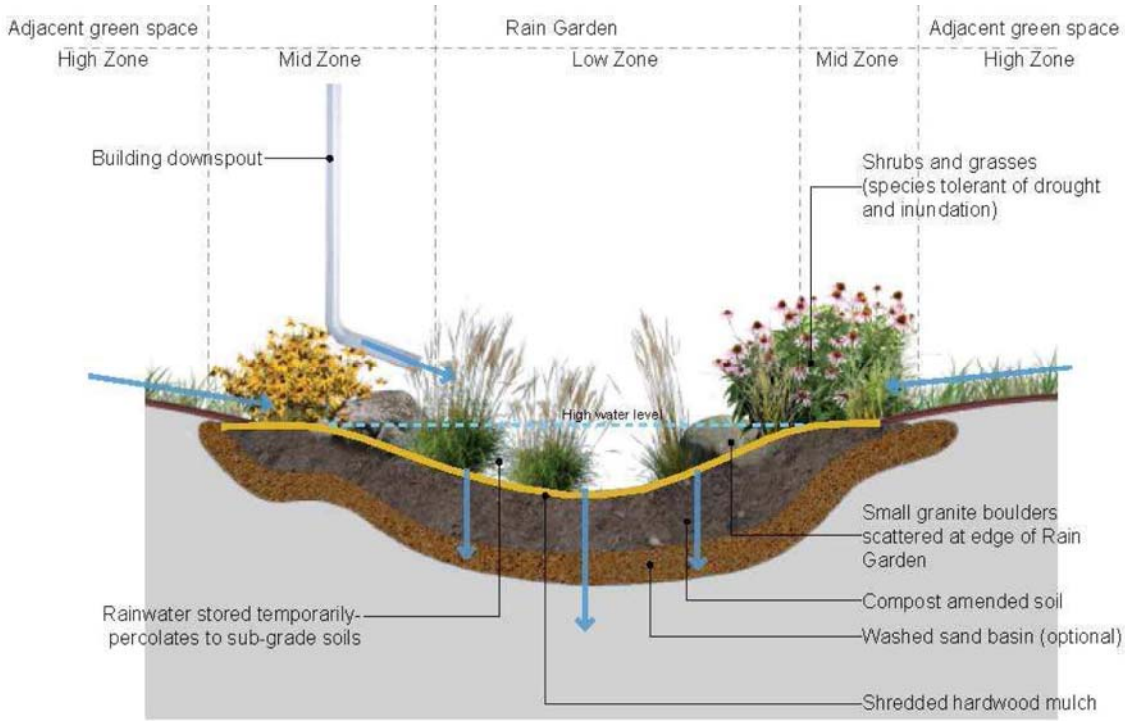
Design Detail

When completing detailed design for the Terra Cotta rain garden, the designer had to keep in mind that this model had to be easy for a homeowner to recreate. This meant choosing materials which could be easily found at local nurseries and hardware stores.

Many bioretention practices (i.e. rain gardens) use specific engineered soil media. However as this was to be a demonstration residential rain garden, the designer chose to use compost and mulch supplies that were readily accessible at local nurseries. The designer also ensured that heavy equipment was not required to replace soils. The design called for the garden bed area to have 100 mm of well-aged (1 year) leaf compost mixed into the native soil to a depth of 300 to 450 mm. The rain garden soil would then have a mix ratio of 1 part leaf compost to 3 parts clay loam native soil. This soil mix would be about 400 mm deep.

The soil would then be covered by 50-75 mm of shredded hardwood mulch. Shredded mulch needs to be used (individual pieces smaller than 100 mm in length) because it interlocks and will be less likely to float around like chip mulch will.

The design also specified a surface ponding depth of 150 to 200 mm. The ponding depth allows runoff to be stored temporarily and gives it time to soak into the soils below. Based on this ponding depth and the infiltration rate, all ponded water should drain out within 15 hours after a rain storm. Designers generally keep ponding time to less than 24 hours to avoid causing a nuisance, damaging vegetation, or becoming mosquito breeding areas. Mosquitoes can hatch from standing water anywhere between 5-14 days, but a properly designed rain garden will have drained well before that time.



Typical landscape design cross section.

Redirecting roof runoff into the rain garden was a challenge because there was a sidewalk between the building downspout and the proposed rain garden location. To avoid water falling onto this impervious surface, the design called for the downspout to be buried underneath the sidewalk. Fortunately the path consisted of large paver blocks that could be lifted and did not require cutting and patching pavement.

Landscaping Plan

Several criteria had to be met when developing the TCCA rain garden landscaping plan. It had to be appealing to homeowners so they would want to replicate it in their own homes. The landscape needed to add colour and interest to the site, while still fitting into the ecology of the park. It needed to be easy to maintain while providing hydrological functions. Those hydrologic functions include having a deep fibrous root system that helps maintain the infiltration capacity of the soil and its ability to absorb runoff. The root zone of the plants also provides stormwater treatment before runoff infiltrates deeper into the soil.

The landscape plan included native, drought tolerant plants. These plants were also widely available at local nurseries. A mix of colourful and varying height vegetation was chosen to create visual interest to the area. Plants chosen for the rain garden included:

- Red Osier Dogwood
- New England Aster
- Tall Meadow Rue
- Black Eyed Susans
- Canada Anemone

As part of the Niagara Escarpment, this site contained large stones and gravel. These were incorporated into the project to define a border and reduce erosion on the slopes. The bench sized boulders were incorporated around the garden to provide interest, places to sit and visual queues to avoid the slumped garden.

Design drawing of the Terra Cotta rain garden

Construction & Commissioning

Construction of the Terra Cotta rain garden was completed in the summer of 2011 by CVC Water and Lands staff. No outside contractors were brought in. This demonstrated that building a residential rain garden can be done by a homeowner. Earthwork construction (digging out the garden and replacing soils) took place in one day and planting was completed one week later.

Earthwork Construction

Earthwork construction of the rain garden was completed by the CVC Lands department and supervised by the Water Resources department.

First, the rain garden area was defined using twine to outline the perimeter. Following this, the area was excavated to a depth of 350 mm. Stakes with twine and a bubble level tool were used to ensure that excavation was level. Stakes were placed every five feet along the length of the rain garden. Twine was tied to the first uphill stake, and then leveled and tied off to the downhill stake. Digging began on the uphill side of the string, which was used to measure for depth accuracy.

Excess soil from excavation was used to make a berm on the downhill side of the garden. The berm was hard packed and blended in to the topography.

Next, about 5 cubic meters of compost was added into the excavation area. It was mixed with native soils to a depth between 300-450 mm. The soil was thoroughly soaked to encourage settling.

The downspout on the roof of the Visitors Welcome Centre was then redirected to the garden using downspout pipe extensions. This is a product available at any local hardware supply store. The downspout was buried under the pedestrian walkway and routed into the rain garden. The downspout was left unconnected until the garden was planted and mulched.

Downspout was buried under the pathway and directed towards the rain garden

Following this, a splash pad comprised of 2”-6” diameter stone were installed at the inlet. A splash pad will slow the water coming out of the downspout and help to spread the flow in different directions into the garden. This will reduce erosion and plant damage from concentrated fast moving water entering the garden. A second area of large stone was used to create an overflow channel. Stones for the riprap were provided by another conservation area.

With the entire infrastructure in place, all of the exposed soil, including the berm, was covered with coconut fiber netting. This would stop unwanted dirt and debris from entering the site until planting the following week.

Planting the Rain Garden

The rain garden was planted by 13 members of the Water Resources staff as part of a team building activity. It was completed within a couple hours. In total, 125 plants were placed in the rain garden. Plants were laid out in a grid pattern approximately a foot apart. Holes were dug twice as wide as the plant plug and deep enough to keep the crown of the young plant level at the existing grade. Once planted, soil was compacted into the hole, taking care to firmly tamp around roots to avoid air pockets. The volunteers took efforts to plant from outside the garden when possible to avoid compacting the soils.

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Planting of the Terra Cotta rain garden was completed by water resources staff as a team activity.

Once everything was planted, shredded hardwood mulch was spread over the garden. The mulch conserves moisture in the garden, reduces weed growth, improves health of the soil, and adds to the visual appeal of the rain garden.

Completed Terra Cotta rain garden pictured with landscaping team.

Economic (Capital & O&M Costs)

As one of the key drivers of this project was to demonstrate that a rain garden can be built by any home owner, it was important that the cost of implementation be reasonable. Costs of constructing the Terra Cotta rain garden are outlined in the following table.

Material	Qty	Unit Cost	Cost
Excavation (m^3 of material to be moved or tilled)*	10	in-house*	$0.00
Compost Amendment (m^3)	2	$39.00/ m^3	$78.00
Mulch (m^3)	1.5	$47.00/ m^3	$70.50
Stone (m^3 river run or crushed gravel)	2	$88.00/ m^3	$176.00
Herbaceous Plants (i.e. Asters, Black Eyed Susans)	100	$2.00/ ea	$200.00
Shrubs (Red Osier Dogwood)	10	$9.00/ ea	$90.00
Total cost			**$614.50**

*All soil was kept onsite. There were no costs for disposing of soil offsite. CVC staff and tools were used to move soil and plant.

CVC received 3 tones of free compost from the Region of Peel's composting program. A homeowner could find similar savings by using compost made at their home.

Additional savings came from using staff for the design, construction and planting of the rain garden. In a residential rain garden, it can cost 2 to 3 times more to hire a landscaper than to complete work yourself. Eliminating labour costs by not using a landscaper will save money on a rain garden project. Assess the complexity of the work to determine whether professional advice is needed.

Another way for homeowners to save money on their residential rain garden is by growing their own plants or getting plants from neighbours. This will substantially reduce the amount of money needed for the project.

Operations and Maintenance

Maintenance is important, particularly during the initial establishment phase. It will increase the performance, aesthetics, and longevity of the LID practice. In the long run, maintenance will prevent small problems from becoming large ones and improve the overall public acceptance of the practice. Maintenance typically includes removing accumulated trash, leaves, debris and sediments, weeding, mulching and watering.

When the rain garden is establishing, it requires more intensive maintenance. As of Fall 2013 only establishment maintenance has been completed. If rain gardens establish properly, long term maintenance will require minimal effort. Typically, rain gardens require

two years for plant life to establish. During this period, it is important that plants receive water weekly. If they do not receive water from a rainfall, they will have to be watered. Once established, plants should be able to thrive without watering, except in periods of extreme drought. The rain garden was able to take in rainwater roof runoff soon after planting because plugs and mature stock were used. A rain garden that is planted with seeds may not be able to receive runoff until the plants have established.

Weeding is also required in the first few years. Once the native plants in the garden begin to mature they should be able to out-compete the weeds, minimizing the amount of weeding needed.

Maintenance is routinely completed by conservation area staff. The rain garden does not require any maintenance above and beyond what is required of a regular garden, watering and weeding.

Conservation areas staff waters the rain garden at Terra Cotta

The rain garden at Terra Cotta is operating as expected. For the most part, plants are establishing well. The rain garden has experienced some die back, caused by shady site conditions. A large tree next to the rain garden affected growth more than was expected. In the summer of 2013, additional native shade-tolerant plants were added to the garden, including common elderberry, sensitive fern and heart-leaved aster. They were planted by CVC's Conservation Youth Corps, a volunteer environmental education program for high school students.

Supplemental shade-tolerant plantings completed in July 2013

Since June 2012, CVC monitoring staff has been inspecting conditions of the rain garden at Terra Cotta on a biweekly basis. Preliminary data shows that leaf debris accumulation is a recurring maintenance issue. The area is heavily forested and the depressed landscape traps the leaves. Erosion and weeds were also seen in moderate to high amounts during early establishment but has lessened overtime.

Leaves accumulating in the rain garden, October 2013.

Erosion of the berm outside the rain garden. The overflow channel is in the foreground.

As a rain garden does not look that different from a regular garden, interpretive signage was installed. The sign describes what a rain garden is and how it helps to keep streams and drinking water healthy. The sign helps to raise awareness of stormwater issues and highlight actions the general public can take to improve their drinking water.

Interpretive signage in front of the rain garden. The language used was kept plain and simple to speak to wide audience.

Performance Monitoring

One motivation for constructing a residential rain garden on CVC property was to ensure it could be effectively monitored, without requiring landowner permissions. Landscaping, maintenance and water levels are being monitored at the Terra Cotta rain garden.

By collecting water level data and recording maintenance requirements, CVC staff has been able to determine how well the rain garden functions. While monitoring is ongoing, water level data collected in 2012 and 2013 indicates that the rain garden is successful at treating stormwater runoff from the roof of the Visitors Center.

Monitoring results from 2012 and 2013 showed that there have been few instances of the rain garden overflowing. Nearly all runoff from the roof was either infiltrated through the rain garden or lost through evapotranspiration. When ponding occurs during larger events the water is infiltrated within 24 hours of the event. This meets design standards. Ongoing collection of water level data and the completion of inspection checklists will determine long-term performance trends and examine the relationship between maintenance and infiltration rates. This information will be used to determine the life-cycle cost of the rain garden. It will also help to establish whether design has an influence on maintenance and performance.

2013 Certification Protocols Summary

Municipalities and businesses (property owners and managers) have protocols in place to thoroughly inspect work done on their property to ensure that the work was carried out in accordance with the design and was properly constructed. A thorough certification protocol reduces the risk to the owner that they are assuming a facility that is functioning properly and will not require costly short or long term repairs.

LID is a new stormwater management practice for Ontario municipalities. To assist municipalities, CVC has developed certification protocols for infiltration and filtration practices. Terra Cotta is one of the seven sites where the protocols were piloted. A simple rain garden like this one may only warrant a visual inspection, but additional measures were performed to test the protocols. These included:

- Visual inspection
- Vegetation survey
- As-constructed survey
- Soil testing
- Infiltration testing
- Water level monitoring

The protocol results are presented in the sections below which outline whether the facility passes or failed the various protocols and recommendations to address identified deficiencies. For the full description of the protocols and procedures used and the checklists see bealeader.ca.

Visual Inspection Findings

A standard visual inspection of the drainage area, inlets, outlets, and bioretention bed was perfromed on November 4th, 2013. Overall, the facility passes the visual inspection protocol. However, the bioretention bed was entirely covered with leaf debris (~ 30 mm),

which needs to be cleared and additional mulch needs to be added to top up to a depth of 50-100 mm.

Vegetation Survey Findings

The vegetation protocol is a tool that evaluates the overall condition of plant life in a practice. The property owner records the percentage of covered ground and invasive, dead, struggling or unattractive plants. The symptoms of the dead and struggling plants and the reason for their decline is also recorded. The site must pass each of those assessment items in order for the property owner to shift to a post establishment maintenance program. The property owner must also determine if the aesthetic goals of the original site design are being met. At Terra Cotta, the goals were to provide colour, year round interest, clean, formal appearance, and planter visibility. The property owner can then determine any site management changes and which plant species need to be replaced.

Assessment Item	Metric / Passing Threshold	Result	Pass / Fail
1. What percentage of the ground is covered?	80%	80%	Pass
2. What percentage of plants is invasive/ undesirable?	5%	**5%**	Pass
3. What percentage of planted species has died?	5%	**0%**	Pass
4. What percentage of the species is thriving? Ex. ranked 3 or higher	80%	84%	Pass
5. Does the site meet aesthetic goals?	Yes	Yes	Pass

The landscaping assessments were conducted in September 2013 and overall, the site passes the vegetation survey. The plants are thriving and are meeting the aesthetic goals.

As-constructed Survey Findings

The as-constructed survey was compared with the design plans for consistency. Specifically, the drainage area and the practice areas were confirmed. The drainage patterns were evaluated to ensure no bypass is occurring. Results are summarized in the table below:

Assessment Item	Design	As-built	Pass / Fail
1. Contributing drainage area:	120 m^2	120 m^2	Pass
2. Bioretention area	15 m^2	15 m^2	Pass
3. Surface storage volume	3 m^3	3 m^3	Pass
4. Total storage capacity (water quality storage volume)	8.3 m^3	8.3 m^3	Pass

The bioretention facility and draiange area sizes match the design, and there is no bypass.

Soil Test Findings

Bioretention soil is a critical component that needs to be tested by the contractor before it is even delivered to the site. This testing protocol verifies that the soil placed by the contractor meets the specification. The soil composition target and the soil test results are in the table below:

Assessment Item	Metric / Passing Threshold	Result	Pass / Fail
1. Texture:	The soil is compost amended silt till mix.	53 % by weight 47 % by weight	Pass
2. Organic content:	3- 5% by dry weight	0.72 %	Fail
3. Cationic exchange capacity (CEC):	>10 meq/100 g	11 meq/100 g	Pass
4. Soil Acidity:	5.5 - 7.5 pH	7.1 pH	Pass

Since this practice is a simple rain garden design as opposed to a larger scale bioretention faclity, the soils used are different. The soil composition was mainly compost amended with silt till mix.

Infiltration Test Findings

The Guelph Permeameter method was used at the site on November 4th, 2013. The Guelph Permeameter is one of several methods to measure the saturated hydraulic conductivity of soils which can then be translated into an infiltration rate. The tests were performed within a 24 hour dry period to ensure accurate infiltration results. A total of three tests for field saturated hydraulic conductivity were conducted and converted to an infiltration rate. The average infiltration rate of the three wells was 10 mm/hr which is expected

given that the soils are an amended mix as opposed to a bioretention soil mix.

Continuous Water Level Monitoring

Continuous collection of water level data over time will provide the most accuracy of all the tests performed. It gives an accurate picture of infiltration rates over a variety of conditions and storm types. This type of monitoring is cost effective and interpreting the results is straightforward. Observation wells and inexpensive water level loggers were installed to measure surface and subsurface water level data.

Assessment Item	Metric / Passing Threshold	Result	Pass / Fail
1 – Surface Drawdown Time (hrs)	24 hrs	no extended ponding	Pass
2. Subsurface Drawdown Time (hrs)	48 hrs	Ranges from 1.2 hrs to 3.3 hr with an average of 2.4 hrs	Pass

The rain garden ***passes*** the water level monitoring test. The rain garden soils drained in less than 48 hours. The water level analysis was performed on rain events greater than 10 mm. The observed ponding times on the surface have not exceeded 24 hours

Summary

All certification protocol tests were completed by November 2013. The Terra Cotta rain garden passed all protocol tests. A few recommendations were made to correct minor deficiencies.

The final Certification Protocols are available on CVC's website. For more information visit www.bealeader.ca

Maintenance and Life-Cycle Cost Monitoring

The second study is the long-term collection of lifecycle maintenance and costs. As part of this study, CVC monitoring staff developed an inspection checklist to document maintenance needs during routine site visits. Along with these inspections, CVC staff meet with facility managers at least once a year to gather information on the rain garden's maintenance tasks and related costs. The data collection began in 2012 and will continue through the life of the practice. As the practice moves from the establishment period to routine maintenance, the inspections may only occur quarterly or semi-annually. The project goals are:

1. Determine establishment and routine maintenance schedule for the practice.

2. Identify improvements for future designs that will reduce maintenance and address operational issues.

3. Provide regionally based life cycle activity and cost information to better inform designers and property owners on stormwater management choices.

LID Inspection Checklist

CVC monitoring staff has developed an inspection checklist with a corresponding legend to document site conditions and maintenance needs as accurately and consistently as possible. The checklist and legend were developed to make inspections straightforward for anyone to complete. The legend helps inspectors rate the severity of maintenance issues such as erosion and litter coverage. The same information is collected each visit in the same format, ensuring proper documentation and making it easier to track changes over time. The checklist and legend can be downloaded from bealeader.ca.

Early Results as of Fall 2013

Two years of maintenance data has been collected, enough to determine the required maintenance for establishment and identify design issues that could be improved upon. Additional years of monitoring will be needed before a meaningful interpretation about long term performance, routine maintenance, and future rehabilitation can be made.

Establishment Maintenance Schedule

The level of maintenance is mostly dictated by the time since the initial planting and subsequent plantings. Once plants are established, less maintenance is needed. See table below for planting dates and details as these dates have a direct impact on the amount of maintenance occurring on the site.

Planting Date	Planting Details
July 2011	Initial planting: 125 plants
June 2012	Supplemental planting: 3 shrubs
August 2013	Supplemental planting: 50 plants and transplanted a few shrubs and grasses

The maintenance schedule below summarizes the establishment maintenance. The table shows the number of times each task was completed since the initial planting date of July 2011 to December 2013.

Maintenance Task Performed	Initial Planting Year (2011)	1st Year (2012)	2nd Year (2013)
Planting	1	1	2
Watering	1	6	3
Weeding	2(8)	6	2(8)
Mulching	1	1	0(1)
Other plant tasks*	1	1(2)	1(2)
Removing trash	26	52	52
Removing sediment**	-	-	-
Removing leaves	6	7	7
Clearing roof leaders and eavestrough	1	1	1
Repairing erosion	-	-	0(1)
Inspecting	0(12)	9(12)	16

*Other plant tasks include trimming, deadheading, cutting back and pruning
**Sediment removal was not carried out since buildup was not observed to be a problem.
(#) Recommended number of times tasks should have occurred

The number of times each task was completed was estimated from an interview with CVC's conservation areas superintendent. He was asked whether each task was done weekly, monthly, or annually. Maintenance done by CVC's water resources staff was also recorded. From this information, the number of times was estimated for each year. In addition to observed maintenance, the recommended schedule is shown in brackets. The recommended establishment schedule is based on additional maintenance that could have been done to address recurring issues observed during inspections.

Recommended Design Improvements and Design Successes

Based on observations during the establishment period, design recommendations are provided in the table below.

Design	Observations	Recommendations
Building a berm along one side of the rain garden	In 2012, the inspections noted that most of the red osier dogwoods on the berm were dying. The inspections also noted that the berm is hard packed, dry and eroding.	Stabilize the soil with a seed mix that is shade and drought tolerant
Locating rain garden under large shade tree	From 2011 to 2013, each fall inspection noted that a thick layer of leaves covered the rain garden.	If possible do not place rain garden under a large shade tree. If no other location is possible then plan for more frequent maintenance
Burying a downspout extension beneath the sidewalk	During inspections, no ice was noted on the sidewalk and that water was able to enter the rain garden.	Use in future designs where applicable
Draining roof rain water into rain garden	During inspections from 2012-2013, no sedimentation was observed in the rain garden or near inlets or outlets.	Use in future designs where applicable
Installing a splash pad comprised of 2"-6" diameter stone at the inlet	During inspections, no erosion was noted within the rain garden. The splash pad slowed and spread incoming flow efficiently.	Use in future designs where applicable

This LID Checklist Inspection photos is included in the photo log. It helps to track site progress and maintenance needs over time.

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