Case Study

Green Glade Sr. Public School Rain Garden Retrofit

Location: Mississauga
Constructed: 2011

Public Lands

Project Objectives, Design & Performance

- Rain garden installed to treat 320 m^2 drainage area comprising roof and parking lot runoff.
- Garden retrofit is dual-purpose: treats stormwater and reduces nuisance ponding in parking lot, decreasing slippery ice conditions in winter.
- Surface draw down time is well within a 24 hour period, avoiding any potential mosquito risk.
- A multi-contributor approach was used so that the school incured no direct costs for the design and cosntruction of the rain garden.

Overcoming Barriers & Lessons Learned

- Attaining 'buy-in' from stakeholders, identifing and empower champions to facilitate communication and build consensus during all project phases were key to the success of this project.
- Bioretention media supplied did not meet specifications leading to poor drainage. Project partners worked with the soil supplier to replace media, restoring proper drainage.
- A support network has been developed to ensure that all maitenance is being done properly.

Practices Implemented

Bioretention

Barriers & Issues Encountered

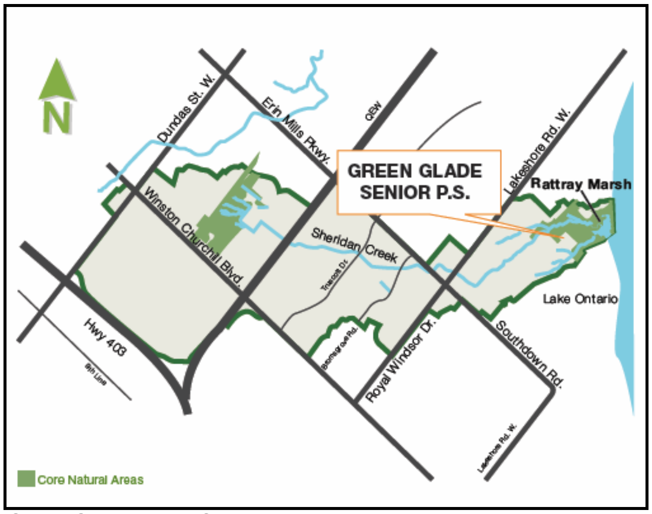
Construction & Comissioning

Economic (Capitol & O&M Costs)

Operation & Maintenance

Overview

Green Glade Sr. Public School is a senior elementary school located in south Mississauga, adjacent to Rattray Marsh, a provincially significant wetland.



Green Glade Public School is located near the Rattray Marsh Conservation Area

In 2011, Green Glade and Peel District School Board (PDSB) staff worked with Credit Valley Conservation (CVC) to retrofit the school property to incorporate a rain garden low impact development (LID) feature. The rain garden accepts runoff from a portion of the school's roof as well as runoff from a section of the parking lot.

Goals & Drivers

The retrofit project was initiated through conversations held between Green Glade and CVC, which was involved with the delivery of environmental education programs at the school. The goals and drivers for the project included:

- Demonstrating the school's and PDSB's commitment to greening their buildings and property
- Enhancing stormwater management practices at a site adjacent to a provincially significant wetland (as recommended by the Sheridan Creek sub-watershed study conducted by CVC)
- Addressing nuisance ponding within the parking lot (near a pedestrian walkway) that took place following rain events

Successes

The successes achieved with this project include:

Multi-stakeholder collaboration – The project involved a variety of stakeholders, including the parent council, teachers, students, and school board, who all provided input and support towards the implementation of the project.

Opportunities for students – The rain garden has been incorporated within the school's curriculum through the creation of art pieces that were installed within the rain garden, as well as lectures on the function of the garden given in science classes.

Addressed nuisance ponding – The rain garden has reduced the nuisance ponding issues in pedestrian walkway area, reducing winter salting requirements and reducing site safety and accessibility issues.

Multiple Financial Contributors – the school had a very limited budget to contribute to the rain garden project. Over $ 17,000 was provided by both public and private organizations allowing the rain garden project to proceed from planning to design and construction

Overcoming Barriers & Lessons Learned

The barriers and issues encountered with this project included:

- Securing the necessary funding to implement the project
- Attaining 'buy-in' from the necessary persons to move the project forward was an initial concern
- Improper bioretention soil media was installed, leading to poor drainage of the rain garden
- School staff required a greater degree of support to facilitate taking on the management of the rain garden than originally anticipated
- Description of warranty within tender should note that the contractor is responsible for any associated costs with replacement of construction materials that don't meet spec

The following approaches were used to address these barriers and issues:

- Funding was sought and received from multiple contributors, including RBC Blue Water Program and local horticultural/landscaping organizations
- A sub-committee was formed with the project stakeholders to facilitate communication and build consensus

- A champion was identified within each of the stakeholder groups and was empowered to move the project forward
- The soil supplier removed the improper soil media and installed a modified bioretention soil mix that drained properly
- Maintenance support was provided to PDSB by member's of Green Glade's parent council and Credit Valley Conservation's Youth Corps

Lessons learned:

- Bioretention soil media must be tested prior to installation to ensure that it drains adequately (meets design specifications)
- Greater support must be provided to stakeholders (property owners/managers, maintenance staff, etc.) to ensure that the necessary maintenance takes place

Planning & Regulations

One of the first challenges associated with implementing an environmentally-focused retrofit project is securing funding – often schools do not have the additional funds within their budget. To help facilitate the implementation of this project CVC applied for (and received) grant funding through the RBC Blue Water Program and sought in-kind contributions from Fern Ridge Landscaping, Oakville Horticultural Society, Clover Leaf Garden Club of Mississauga, Bronte Horticultural Society, and Milton and District Horticultural Society. By utilizing this multi-contributor approach, no direct costs were incurred by the school for the design and construction of the rain garden project, allowing it to proceed from the planning stages.

Another consideration during the planning stages was the long term commitment required for the rain garden. In the case of this project, there were multiple approvals required from school administration, parent council, school board, and maintenance staff as consensus was needed on design, location, funding, construction and maintenance. To achieve consensus, not only were regular meetings required, but it was important to identify someone who could lead or champion the project from within. In addition, further consensus was built with the inception of the environmental project sub-committee.

The subcommittee that was formed was comprised of parents, teachers, administration, maintenance personnel and CVC staff. The subcommittee met bi-monthly at the school during the planning and design phases of the project and provided oversight and input. All designs and drawings were put forward to the subcommittee who would then provide input and/or approval to the designs. Once CVC received approval from the subcommittee, designs were then presented to the full parent council and members of the Peel District School Board for final approval. This process ensured that all parties were kept informed regarding the project, and that no significant barriers or concerns were raised that could delay or derail the project.

Design

Prior to implementation of the rain garden, issues with ponding were taking place in the school's parking lot. Ponding was centralized in a pedestrian walkway area, near the front entrance to the school. An example of this ponding is shown below.

Nuisance ponding in pedestrian walkway

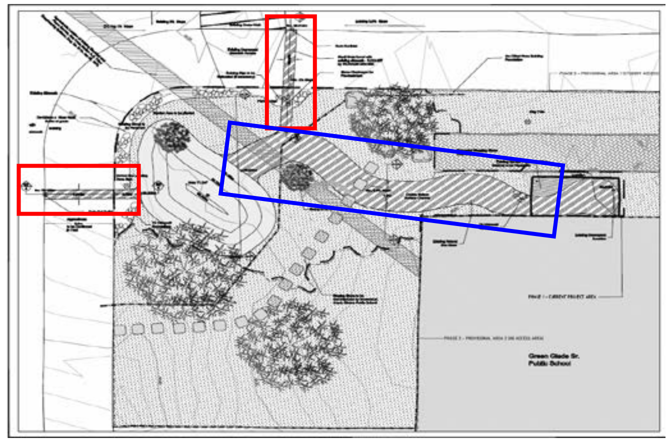
Design of the rain garden was led by CVC in concert with an engineering firm and a rain garden sub-committee comprised of parents and school staff. Addressing the nuisance ponding issue was one of the main goals of the project. To accomplish this goal, an area adjacent to the ponding site was selected as the ideal location for the garden. This proposed site encompassed an existing garden and grassed area. A site survey was completed and the drainage area of the proposed rain garden was delineated.

Surveying of the proposed rain garden site

Surveying established that the total contributing drainage area to be treated by the rain garden was 320 m^2, based upon the portions of the parking lot and roof draining to the garden. Infiltration testing found that the native sandy soils had an infiltration rate of 75 mm/hr, making them ideal for an infiltrating bioretention practice. An aerial photograph of the site, indicating the drainage areas is shown below.

Contributing drainage area of rain garden

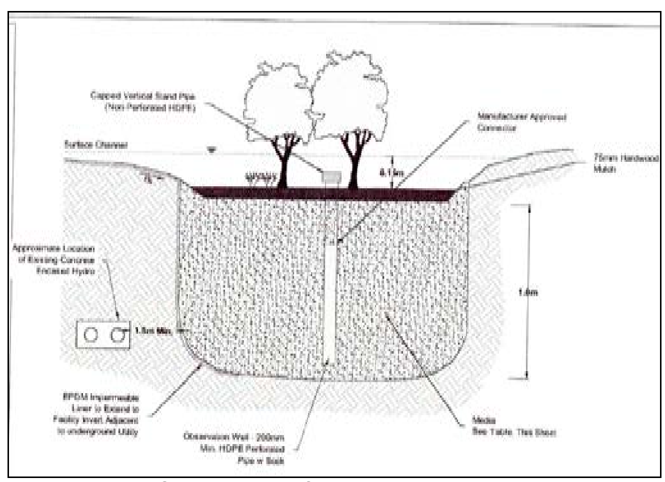
To address the ponding issue along the front walkway the curb and walkway was cut in two locations to provide an inlet and an outlet (outlined in red in the figure below). The design of the inlet cannot address the ponding issue completely. However, when the school's parking lot is resurfaced, the grade of the lot can be modified to direct more of the water into the rain garden inlet to further reduce any ponding. In addition, the rain garden design accounted for the roof top drainage which was directed to a dry river bed which then flowed into the depression (outlined in blue in the figure below).



Rain garden site plan

In order to avoid unsightly metal grates running across the school's front walkway, a decorative leaf pattern grate was selected for both the inlet and outlet walk way cut-ins.

The dimensions of the rain garden are approximately 3.5 m long by 1.5 m wide by 1.4 metres deep. The rain garden has a maximum ponded depth of 150 mm and can provide water quality treatment for 7.95 m^3 (7,950 L). An observation well was included in the design plans for the garden. The observation well can be used by school staff to monitor how well water is draining within the garden. Monitoring equipment (depth probes) can also be installed within this well to automatically monitor water levels within the bioretention area. This arrangement is detailed in the following cross section.



Cross section of the rain garden

The bioretention soil media specified for use within the rain garden was based upon the recommendations from *The Low Impact Development Stormwater Management Planning and Design Guide*. The specifications provided by the engineer are as follows:

Media	Size	% by Weight
1 – Sand	2 to 0.05 mm	85 – 88%
2 – Fines	< 0.05 mm	8 – 12%
3 – Leaf compost (Organic Matter)	–	3 – 5%

One issue that was encountered with this project was that the soil that was initially supplied and installed at the site did not meet these specifications. This led to issues with poor drainage, which had to be corrected at a later stage in the project. For more information, refer to the *Construction and Commissioning* section.

Landscape Design – Plant Selection

The landscape design and plant selection took into account recommendations from the *Landscape Design Guide for Low Impact Development.* Plants selected for the rain garden were based upon the native plant list provided in this guide.

Plant species selected were salt tolerant and would be characteristic of a wet meadow environment subject to both dry and wet conditions. A list of the plants is provided in the landscape plan, located below. Overall, the intention of the design was to minimize the amount of maintenance required by planting in thick densities to minimize weed growth.

Key Facts

Issues

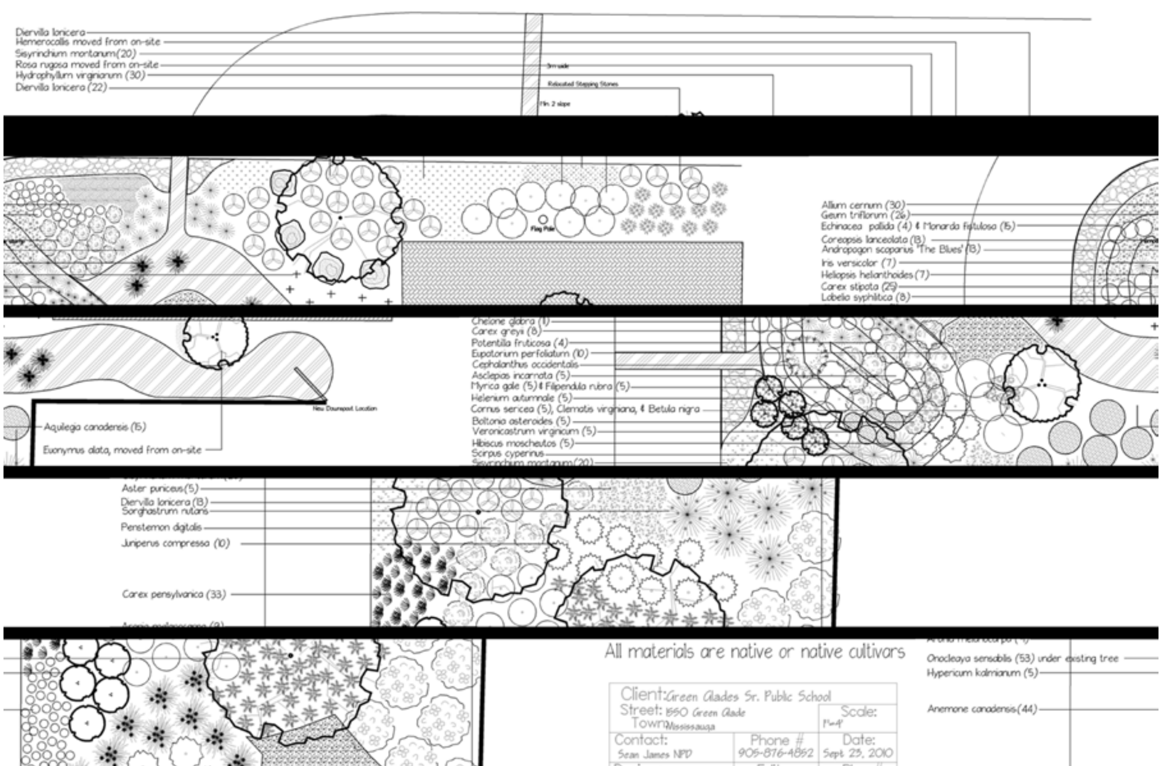
- Multiple approvals were required from the school administration, parent council, school board and maintenance staff on rain garden location, funding, design, construction and maintenance.

Solutions & Lessons Learned

- To build consensus, it is important to meet with all of the stakeholders, gather their feedback and incorporate it into the project.
- To improve the success of LID projects, identify one or more champions among the stakeholders – these individuals or organizations can often reduce the barriers and accelerate the process of implementing an LID project.
- The soil media mix specified within the *Low Impact Development Stormwater Management Planning and Design Guide* should be used when designing bioretention practices.

Construction & Commissioning

Construction of the rain garden bioretention facility took approximately five days. Initial construction consisted of clearing existing shrubbery and re-planting where possible. After the vegetation was removed, the outline of the dry river bed was marked out and excavation of bioretention area began. An effort was made by the contractor to preserve the roots of the exiting tree adjacent to the rain garden.



Landscaping plan (indicating plant selection)

Once the dry river bed had been dug out the bottom of the bed was covered with an impermeable geotextile liner. The bioretention area was further excavated and the observation well was installed. Additional impermeable geotextile was installed on the side of excavated space nearest to the school to minimize water accumulating near the building foundation.

Excavation Work Being Conducted at Rain Garden

[Foreground]-observation well, [Background]-pond liner covering dry river bed and rear wall of the bioretention area

Once this work was completed the bioretention area was filled with the bioretention media and the dry riverbed lined with river stone. The rain garden was then planted and mulched according to the landscape plan.

An issue that was identified shortly after construction was that the rain garden was not infiltrating runoff at an appropriate rate, resulting in a drawdown rate far greater than 24 hours. Although the first batch of soils delivered to the site did meet specifications (as determined through soil testing), further batches delivered to the site were not tested. A review of soil test results from a composite from the as-built garden found that overall the bioretention soil media did not meet specifications, and thus the soil was the source of the problem. An example of the poor drainage conditions in the rain garden are provided in the following image.

Water not properly draining into through the soil media

The only means of addressing this issue was through the removal of the improper bioretention soil media and replacing it with the proper mix of sand, fines and organics. The costs associated with this remediation work were incurred by the soil supplier and CVC. Excavation of the faulty bioretention mix required use of a mini-excavator, dump truck to haul the mix away, and a slinger truck to add the new bioretention mix.

Removal of the soil media with mini-excavator

The soil supplier indicated that the bioretention did not meet specification due to an improper mixing process. The supplier had used topsoil to meet the bioretention mix's organic and fines requirements. However, the composition of the topsoil was highly variable and was added to the mix without being properly measured. Thus, test results showed that the amount of fines in the mix had reached 30 – 40% although specifications for fines by weight should only be 8 – 12%. The high amount of fines led to the failure of the rain garden to properly infiltrate runoff.

To address this issue with the manufacturing process, topsoil was removed as a component material and only sand and organic mulch were used to create the mix. However, before the mix was installed, the manufacturer needed to ensure that the bioretention mix met specification. Three soil samples were provided for testing and verification prior to installation.

One lesson learned from this project was the need to strengthen the terms of the tender to address this type of situation should it arise with a LID project. Green Glade's construction tender did not make it the responsibility of the contractor or material supplier to cover all associated financial costs when materials are not made and/or installed to specification.

Below is the direct text taken from the construction tender:

9.0 QUALITY ASSURANCE/QUALITY CONTROL

The contractor shall determine exact quantities of excavation, media, stone, and piping using the drawings and specifications. The contractor shall be responsible for layout, elevation, quantity and quality of each work item required and shall request engineer/inspector's approval before proceeding with construction. The engineer/inspector will monitor the contractor's construction activities and materials used for bioretention facility.

The engineer/inspector on site shall perform and document the following:

- Certification and test for compliance with specification for all materials received on site and control of non compliance materials.
- Line and grade as per design drawings.
- Vendor/manufacturer's certificates and test results of the supplied material.
- Filling out daily progress report forms.

No wording with regards to coverage of costs associated with the replacement of materials not manufactured to spec.

As a result, CVC had to cover the costs ($1,500) for plant removal and replanting by the landscaper and for construction supervision by an engineer.

It is recommended that tender documents for projects that include LID features be modified to specify the supplier's and/or contractor's responsibilities to prevent this issue from arising with future LID projects.

Key Facts

Issues

- The soil media installed in the rain garden did not meet specifications, leading to issues with improper drainage.
- The construction tender did not include contingencies for the installation of improper soil media, which led to additional costs incurred by CVC to complete the project.

Solutions & Lessons Learned

- To address the improperly draining garden all of the improper bioretention soil media was removed and replaced with the proper mix of sand, fines and organics.
- To prevent issues with bioretention soils, soil media composites must be tested prior to delivery and installation at the site. The soil supplier must also be consistent with the materials used and their ratios throughout multiple loads/deliveries.
- Tender documents for LID projects must clearly specify all of the supplier's and/or contractor's responsibilities, including cases where soil media must be replaced.
- It is recommended that designers and contractors refer to the *Construction Guide for Low Impact Development* for further guidance on constructing LID practices.

Economics (Capital & O&M Costs)

The approximate costs for the project are provided in the following table.

Design	Implementation	Operation & Maintenance
$11,000	$13,200	TBD*

**Plants and construction work are currently covered under a one year warranty.*

One of the means by which the costs for this project were reduced was a $10,000 grant awarded as part of the RBC Blue Water Project. Additional donations were provided by the landscape contractor, Fern Ridge Landscaping and by Oakville Horticultural Society, Cloverleaf Garden Club of Mississauga, Bronte Horticultural Society, and Milton and District Horticultural society which totaled $8,000.

Forming these partnerships and seeking external sources of funding were key factors to the successful implementation of this project. Taking this type of approach is highly recommended for other schools or IC (industrial, commercial) sites that are interested in implementing LID or other types of green practices. A first step in this process could be contacting a local conservation authority, municipality or environmental NGO (non-governmental organization) to see what type(s) of financial support are available.

Operations & Maintenance

Since construction was completed recently, the operation and maintenance requirements and costs have not yet been determined. The major O&M challenge encountered to date was the poor drainage of the rain garden, however, this was due to inappropriate materials installation and not poor maintenance.

During the school year, maintenance of the garden was incorporated into the maintenance of the property by school facilities staff. Maintenance included irrigating the plants during establishment and weeding. During the summer months when facilities staffs are away, maintenance tasks are supported by members of Green Glade's parent council and by Credit Valley Conservation Youth Corps (CYC). Other cost such as the replacement of dead plants and mulch has been subsidized by funding provided by the David Suzuki Foundation and mulch donations.

One of the ways in which the rain garden has been integrated within the day-to-day operations of the school is its incorporation within the school curriculum.

Incorporation of Art

At Green Glade P.S., art classes were involved so that artwork could be incorporated prominently into the landscape design. Artwork completed by students represented the local environment which included plants, birds and animals found in Rattray Marsh. A picture highlighting some of the art pieces are shown below.

Decorative turtles created by Green Glade's art classes

Ensuring Maintenance of Rain Garden

A major component of this project was obtaining buy-in from the various parties involved to support not only the design and construction of the rain garden, but also its maintenance. Green infrastructure (LID features, renewable energy, etc.) often has a large impact on the workloads of the operations and maintenance staff at a school and school board level. An important lesson learned from this project was that getting the support of these staff is critical to permitting the successful implementation of a LID project. Equally important is to ensure that maintenance staff is supported by the broader school community. Having teachers, support staff, and students participate in the maintenance of LID practices can reduce the burden they place on maintenance staff, while also providing hands-on education opportunities for these groups.

Another way in which broader support for the rain garden was built was through public outreach. Signage was designed by CVC and installed on the school property. The signage highlighted all project partners which included donations from four botanical societies.

Signage installed at Green Glade P.S.

Long-Term Performance

The rain garden at Green Glade has been operational for two years. The site is one of seven bioretention practices currently being studied in an effort to develop 'certification protocols' for LID practices. These certification protocols are a process that municipalities and property managers can use to ensure that LID practices function as intended. This process utilizes a variety of techniques, including inspections, testing and monitoring of the practices. It is recommended that these certification protocols be implemented during the warranty period – typically two years before the practice is assumed from the contractor by the owner. The protocols can identify design or construction deficiencies that might have otherwise been missed.

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

Table 1 Level of Certification and Associated Protocols

Protocols	Level 1: Visual Inspection	Level 2: Capacity Testing	Level 3: Water Level Monitoring	Level 4: High Intensity Monitoring
Checklist Inspection	✓	✓	✓	✓
Vegetation Surveys	✓	✓	✓	✓
Soil Testing	✓(optional)	✓	✓	✓
As-Constructed Survey		✓	✓	✓
Infiltration Testing or Synthetic Runoff Test		✓	✓ (optional)	✓ (optional)
Water Level Monitoring			✓	✓ (optional)
Water Flow & Quality Monitoring				✓

protocol reduces the risk to the owner that they are assuming a facility that is functioning properly and will not require costly near or long term repairs. These certification protocols are particularly important for stormwater management facilities. A 2007 survey of southern Ontario municipalities found that certification and monitoring protocols for stormwater ponds to be weak or non-existenti. This has resulted in many instances of ponds that have been assumed by the municipality that do not meet design requirements. A study of 98 ponds in the Lake Simcoe Conservation Area found that nearly half the ponds failed to meet their design level of service.ii Both studies recommended more rigorous certification protocols before assumption, including at a minimum an as-constructed survey.

Given that LID is a relatively new SWM practice for municipalities and property owners. CVC is working with a number of partners to develop certification protocols for LID practices. These certification protocols will provide municipalities and property owners with assurance that the LID practices they are taking ownership of following the warranty period was design and constructed properly.

Property owners and municipalities have varying capacities for performing certification protocols. Also, there are LID practices that require varying levels of monitoring scrutiny from a simple inspection for a residential rain garden to more intensive monitoring for the engineered bioretention cell treating runoff from a large parking lot. Table 1 summarizes multiple levels of certification and the recommended tests associated with each.

Green Glades Public School is one of seven bioretention sites where the protocols were piloted. At Green Glades, all of the tests in the Levels 3 certification were performed on the bioswale. The protocol results are presented in the sections below which outline whether the facility passed or failed the various protocols and recommendations to address identified deficiencies.

Visual Inspection Findings

The most recent visual inspection was made on October 29th, 2013. During the visual inspection, the key assessment areas are inspected including the drainage area, bioretention area, inlets, underdrain (if applicable), vegetation and overflows. Overall the practice ***passes*** the visual inspection. However, additional changes need to be made to ensure the practice is working properly such as adding a layer of mulch to ensure atleast 50 mm is present. Additional survey investigation is required because the drainage area plays a key role in sizing the LID system. Visual inspection indicates that there is no positive grade towards the bioretention area.

Vegetation Survey Findings

The vegetation protocol is a tool that evaluates the overall condition of the vegetation in a practice. When carrying out the vegetation protocol, 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. The site must pass each of those assessment items in order for the property owner to shift to a post establishment maintenance program. Once plant health and species makeup are recorded, the property owner then determines if the aesthetic goals of the original site design are being met, which can include but are not limited to colour, year round interest, clean formal appearance and planter visibility. The property owner can then determine which site management changes can be made and which plant species need to be replaced.

Landscaping assessments were conducted in September 2013 as presentedc in the table below. Some of the vegetation has only had one growing season to establish. Sparse planting hinders aesthetic of site.

Assessment Item	Metric / Passing Threshold	Result	Pass / Fail
1. What percentage of the ground is covered?	80%	60%	Fail
2. What percentage of plants is invasive/ undesirable?	5%	2%	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%	85%	Pass
5. Does the site meet aesthetic goals? Ex. colour, year round interest, clean formal appearance and planter visibility	Yes	No	Fail

Overall, the site ***passes*** the vegetation survey however, bare areas need to be replanted and unattractive plants need to be replaced to meet the aesthetic goal.

As-constructed Survey Findings

The as-constructed survey results are summarized in the table below which outline that:

- The as-built drainage area is relatively smaller than specified in the design plans. The bioretention area is not receiving any appreciable runoff due to the general grading of the parking lot. The eastern and south-western portions are sloped away from the bioretention area and the catch basin configuration causing runoff to bypass the system. Runoff is designed to be directed past the sidewalk through two grates and into the rip-rap on the bioretention area perimeter. The survey data suggests that insufficient grading exists to direct water to either grate, and that the southern grate may be entirely ineffective as an inlet.
- The as-built total storage capacity matches the design plans.

Assessment Item	Metric / Passing Threshold	Result	Pass / Fail
Contributing drainage area:	317.9 m^2	42 m^2	Fail
Bioretention area	11 m^2	9 m^2	Pass
Surface storage volume	-	0.8 m^3	Pass
Total storage capacity (water quality storage volume)	13.2 m^3	11.5 m^3	Pass

Overall, the Green Glades facility ***fails*** the as-constructed survey protocol because the contributing drainage area is seriously affected by the inadequate grades for positive flow.

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 objectives should be within the range provided in table below along with the soil test results for the site.

Texture	%	Test Result	Pass/Fail
Coarse to fine sands >0.075 mm dia.	88 - 92 % by weight	77 % by weight	Fail
Silt and Clay (< 0.075mm dia. or sieve 270)	8- 12 % by weight	23% by weight	Fail
Organic Content:	3- 5% by dry weight (supplied by leaf and yard compost or composted pine mulch)	1.9% by weight	Fail
Cationic exchange capacity (CEC):	>10 meq/100 g	19.5 meq/100 g	Pass
Soil Acidity:	5.5 - 7.5 pH	7.1 pH	Pass

The site ***fails*** the soil test protocol as the texture and organic content did not meet the desired objectives range. This site was one of the first bioretention practices in the GTA and suppliers had not yet refined a mixing strategy that met the specification. A failed soil test could trigger replacement if under warranty or further observation and testing. In this case, infiltration testing and water level monitoring shows that the site is functioning within the design parameters.

Infiltration Test Findings

The Guelph Permeameter method was used at the site on October 23rd and 29th, 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.

Assessment Item	Metric / Passing Threshold	Result	Pass / Fail
Infiltration Rate	> 25 mm/hr	Ranges from 79 mm/hr to 101 mm/hr with an average infiltration rate of 90 mm/hr	Pass

The test was performed in three spots spanning the length of the bioretention facility and the results were averaged as presented above. Overall, the facility ***passes*** the infiltration testing protocol as it is greater than the infiltration capacity threshold of 25 mm/hr. The results provided above are the in-situ saturated hydraulic conductivity measurements which equal the infiltration rate. The sorptivity is influenced by the initial and final moisture contents. As the moisture content approaches saturation, sorptivity tends to zero and the infiltration rate equals to the field saturated hydraulic conductivity[iii].

Continuous Water Level Monitoring

Infiltration testing will not provide the same level of accuracy as the real world monitoring that occurs in level 3 and 4. The collection of water level data over time within the practice can provide an accurate picture of infiltration rates over a variety of antecedent conditions and storm types. This type of monitoring is cost effective and interpreting the results is straightforward. To collect water level data, observation wells and inexpensive water level loggers need to be installed.

Assessment Item	Metric / Passing Threshold	Result	Pass / Fail
1 – Surface Drawdown Time (hrs)	24 hrs	-	-
2. Subsurface Drawdown Time (hrs)	48 hrs	Ranges from 0.5 hrs to 2 hr with an average of 1.1 hrs	Pass

The as-constructed bioretention facility ***passes*** the water level monitoring test as the subsurface drawdown time is less than 48 hours. The water level analysis was performed on rain events greater than 10 mm and the assessment of surface ponding drawdown rates and times was neglected due to inadequate data. Only above and below drain drawdown rates and times were calculated based on this data. As a lesson learned, additional information is needed to perform a complete analysis including surface ponding capacity and duration as recommended below.

Summary

All certification protocol tests were completed by November 2013. The Green Glade bioretention facility passed most of the protocol tests however some improvements need to be made to ensure proper function.

The Final Certification Protocols will be released on CVC's website in February 2014. Please stayed tuned at www.bealeader.ca

Acknowledgements

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- Green Glade Public School Administration, Facility Staff, Teachers, Students, and Parent Council
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- Region of Peel
- Ontario Ministry of the Environment and Climate Change

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[i] Drake J., Y. Guo. 2008. Maintenance of Wet Stormwater Ponds in Ontario. Canadian Water Resources Journal, 33(4): 351-368.

[ii] Lake Simcoe Region Conservation Authority (LSRCA). 2011. Stormwater Pond Maintenance and Anoxic Conditions Investigation. Final Report

[iii] Diamond J., Shanley T 2003. Infiltration Rate Assessment of Some Major Soils. Irish Geography, 36(1): 32-46.