Case Study

Conestoga College Cambridge Campus

Location: Cambridge
Constructed: 2010

Business and Multi-Residential

Project Objectives, Design and Performance

- Expand campus to facilitate growth while maintaining the College's philosophy of a zero runoff campus.
- Campus design will capture and treat runoff for current and future development phases through an infiltration gallery, four bioretention swales, and a stormwater pond.
- As a condition of site approval, a long-term monitoring program is underway to evaluate the performance of stormwater management features on campus.

Overcoming Barriers and Lessons Learned

- The pea gravel used as edge treatment material washed away within the first few precipitation events and had to be replaced with larger river stones.
- The design of the infiltration gallery had to be upgraded to support heavier traffic loading.
- A bypass was incorporated for low flows to avoid thermal enrichment from small storm events.
- Monitoring technologies continue to grow. Proper guidance from the supplier and installer of the monitoring equipment is critical success.

Practices Implemented

Enhanced Grass Swale

Soakaways and Infiltration Gallery

Pollution Prevention

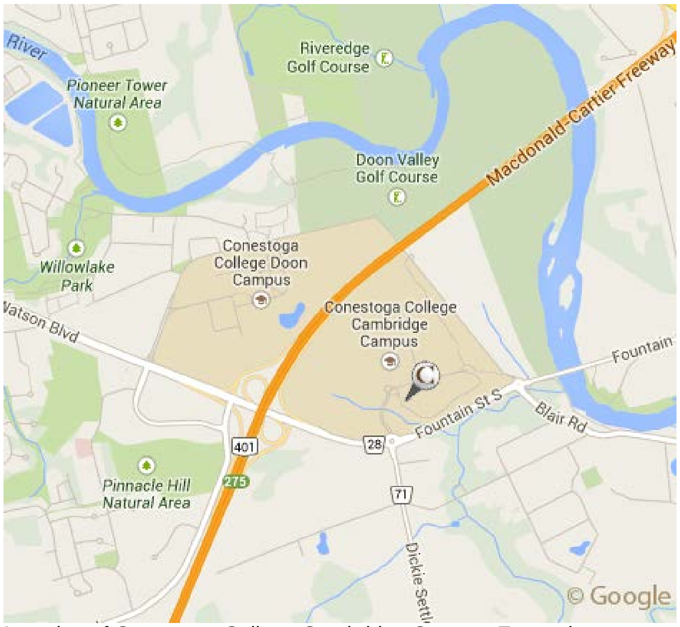
Barriers and Issues Encountered

Design

Construction and Comissioning

Overview

Conestoga College Cambridge Campus is an expansion to the existing Dome Campus located south of Highway 401 at the intersection of Fountain Street and Dickie Settlement Road.



Location of Conestoga College Cambridge Campus Expansion

This newly-constructed campus includes several LID features including:

- An infiltration gallery designed to capture all runoff from rooftops in current and future development phases.
- Four bioretention swales to treat parking lot runoff for storm events up to and including the 25-year event.

Along with these LID features, a stormwater management pond was constructed to provide full redundancy as required by the City of Cambridge, the Grand River Conservation Authority and other approval agencies. The stormwater management pond has three innovative features to address thermal impacts. These features include:

1. A low flow outlet that bypasses the pond, minimizing the potential for thermally enriched standing water to be released into the receiving coldwater creek during small storm events.
2. A pond outlet designed as a percolation gallery, acting as a tertiary polishing measure to mitigate potential thermal impacts.
3. A seepage collection trench placed where the identified seep releases cool groundwater to the thermally enriched surface, draining directly to the pond outlet structure in the forebay.

Goals and Drivers

The goals and drivers for this project were:

- To protect and enhance groundwater quality and quantity, as well as water quality of associated aquatic resources and supplies.
- Minimize the threat to life, as well as destruction of property and natural resources from flooding and erosion while preserving natural floodplain hydrologic functions.
- Improve stormwater management by minimizing required off-site control and maintaining predevelopment hydrologic conditions
- Address the need for thermal mitigation, a primary concern identified in the Blair Creek Subwatershed Plan.
- Install end-of-pipe facilities that incorporate extended detention wet ponds and constructed wetlands for water quality control in accordance with Ministry of Environment (MOE) guidelines.
- Meet sustainable, ecological and economic objectives defined in the Conestoga Campus Master Plan.

Successes

Innovative project – Conestoga College Cambridge Campus has successfully met criteria of the Blair Bechtel Bauman Creeks Subwatershed Study by facilitating development on site with no impact on the receiving system.

Leadership – A great level of detail was required to obtain approval for this sophisticated project. Agencies granting the approval are true champions because they provided direction to develop an innovative design.

Reduction of thermal impacts – The project is aimed at minimizing release of thermally enriched water into the receiving coldwater stream. The site discharges to Blair Creek which is home to one of the last remaining coldwater fisheries in Kitchener. The stormwater management pond incorporates a low flow outlet, a percolation gallery and a seepage collection system, all in an effort to reduce temperature of discharge water to Blair Creek.

Improved Stormwater Management –The infiltration gallery is able to capture and treat all rooftop runoff from current and future development phases. Bioswales capture and treat up to a 25 year event.

Long-Term Monitoring – A long-term monitoring program implemented at the site will provide feedback to facilitate adaptive design in future phases.

Overcoming Barriers and Lessons Learned

Barriers and issues encountered include:

- During construction, a request was made to replace riverstone as the bioswale edge treatment material with pea gravel. The pea gravel washed away within the first few precipitation events.
- The design had to be upgraded in order to accommodate student events on the common green above the infiltration gallery.
- Limited flow was anticipated to drain to the pond so the permanent pool was suspected to be stagnant and warm most of the time. Release of this water would be detrimental to the health of the receiving creek and residing coldwater fisheries.
- As part of the Blair Bechtel Bauman Creek Subwatershed Study, the city and local conservation authority required full redundancy of stormwater management controls, creating additional construction and operations costs.
- The design and installation of the monitoring network doubled in cost due to inexperience and lack of knowledge by the supplier and installer.
- Fill material was seen falling into the gravel bed material during construction inspection visits.

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

- Specific zones of pea gravel were replaced with larger river stone as originally specified in the design.
- The infiltration gallery module design was upgraded to H-20 loading to support high traffic loading ranging from 25,000 – 40,000 lbs. This incurred additional project costs.
- Recognizing that initial flow through a pond is better represented by a plug flow model rather than a fully mixed model, a bypass outlet was incorporated for low flows to avoid thermal enrichment flows from small storm events.
- As this was a condition for approval, full redundancy with a stormwater management pond was accommodated with additional costs paid by the College.
- A number of techniques were used to protect the infiltration areas such as education of the contractor, signage, flagging tape, and fencing.

Lessons learned

- To be successful in monitoring these technologies, both the supplier and installer should have experienced and knowledgeable personnel who can provide appropriate directions.
- In addition to detailed design drawings, sufficient construction supervision and administration is important to the success of LID projects. Individuals competent in LID construction and design not only provide a resource for other contractors but act as a liaison between the contractor, client and other stakeholders to ensure that expectations of all parties are properly coordinated and fulfilled.
- Design drawings should be as detailed as possible, including elements of non-standard components, detailed pipe schedule, and complete sets of dimensions.
- To emphasize the importance of protecting infiltration areas, proper training and education of the contractor is vital.

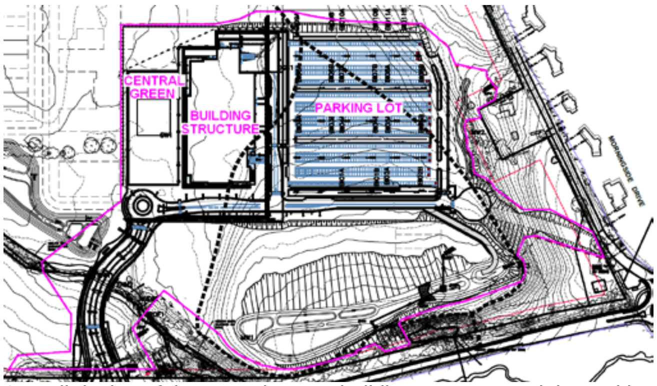
Planning and Regulations

This project had to meet sustainable, ecological and economic objectives defined in the Conestoga Campus Master Plan, including:

- A sense of community fostered through design, decision-making and integration of the natural and built environment.
- Minimize adverse impacts of college activities on environmental life support systems such as air, water, and soil.
- Minimize the ecological footprint of new buildings including energy use through compact built form and sustainable building design.
- Implement a comprehensive stormwater management strategy to mitigate groundwater and surface water impacts to Blair Creek tributaries.
- Target at least a LEED NC Silver accreditation for all buildings on campus.
- Employ sustainable operation, maintenance and construction techniques.
- Encourage revenue sources and cost sharing through innovative sustainable initiatives and partnerships.

Design

The design incorporates three primary features: the main entry road, the buildings and south central common green and the parking lot. The stormwater management system incorporated at-source controls as much as possible. End of pipe treatment measures were also added in the event of bypassing and to provide secondary treatment. The following sections describe primary elements of the site and additional treatment system features proposed as part of the stormwater management plan.



Overall design of the central green, building structure and the parking lot

Main Entry Road

The main entry is a divided roadway featuring a wide median with traditional curb and gutter along its length. Catchbasins are used for drainage on the road. They are routed along the entire length to an oil grit separator and stormwater management pond via the catchbasin-to-storm sewer network.


Main entrance road to the college

Main Building and Central Green

The main building drains to an infiltration gallery located in the south central green. The infiltration gallery has a capture capacity of 700 cubic meters and provides Level 1 treatment based on the MOE best management practices guidelines. The infiltration gallery is designed to capture and infiltrate all runoff from currently proposed and future buildings for 25 mm and 2-year storm events. Overflow from the infiltration gallery drains into the detention pond.


South central green infiltration gallery

Parking Lot

Drainage from the parking lot is provided through sheet flow to four bioswales. The bioswales are distributed evenly across the parking lot. Individual bioswales are approximately 10 m wide they extend the length of the parking lot, in a roughly east-west direction. parallel to the natural grades and water table contours on site. This results in a distributed infiltration strategy that maximizes the infiltration gallery footprint and optimizes a minimum of 1m vertical separation between the base of the infiltration galleries and the water table. Bioretention swales were designed to capture, infiltrate and treat all runoff from the parking lot for storms up to and including a 25-year event.

The design of the bioswales provides a three-stage approach to drainage. The asphalt parking lots are graded toward the bioswales. The bioswales are bounded by a roll-over curb (typical OPSD 600.100). The curb features regularly spaced 3 m wide run-out (i.e. curb cut) locations every 9 m along the length of the bioswale. These run-outs facilitate drainage of surface runoff into the bioswales.

Bioswale plastic infiltration galleries wrapped in filter cloth

Bioswales in early establishment period

A 0.6 m wide ribbon of riverstone disrupts the flow path. This provides a primary settling area for suspended sediment as the flow drains into the bioswale. The bioswales are fully vegetated and provide a natural filtration strip 3-4 m wide as the flow drains into the swale. Along the center of the bioswales, the design incorporates a 1 m wide flat bottomed invert lined with 500 mm of riverstone. Pea gravel is placed on top of structural plastic infiltration galleries wrapped in filter cloth that features a 95 per cent void ratio.

3 meter run-outs

Runoff captured in the bioswales infiltrates until the swale is inundated to a depth of at least 0.2 m. When this inundation depth is reached, water will drain through regularly spaced catchbasins to the site storm sewer collection system and detention pond.

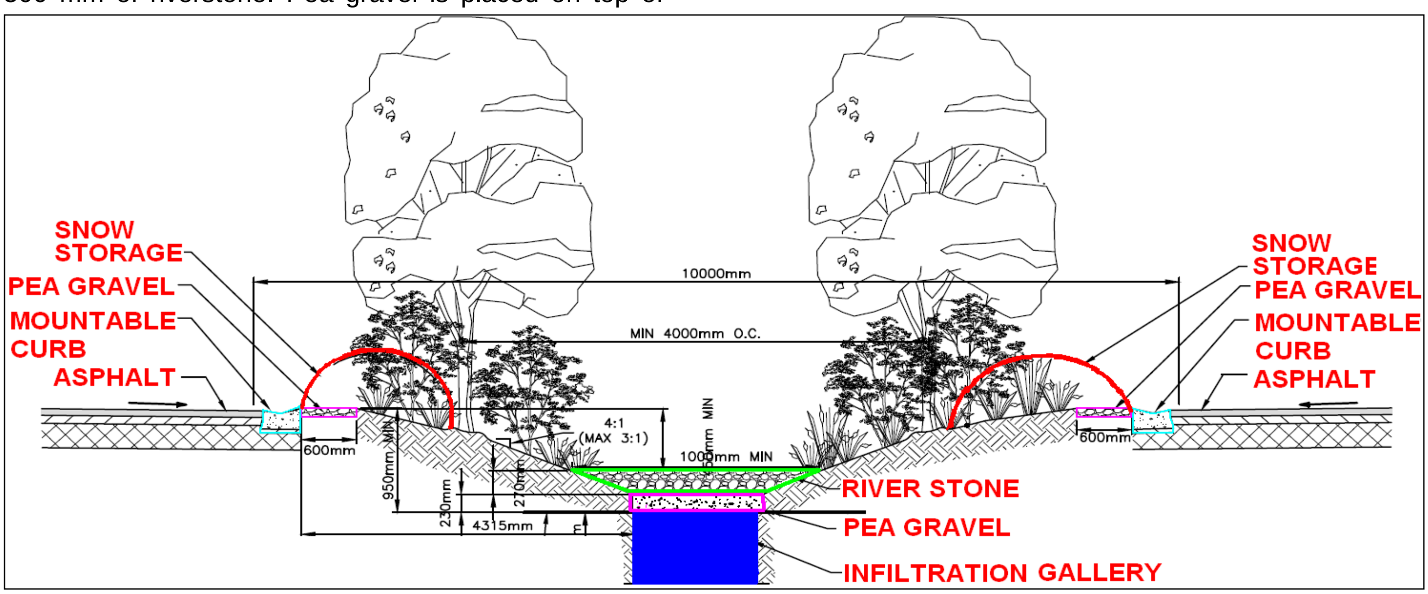


Figure 1: Bioswale details (snow storage, riverstone, pea gravel, infiltration gallery)

Centerline of the bioswale lined with 500 mm riverstone

The bioswale is designed so snow can be plowed into it as part of regular winter maintenance activities. Snow piles typically accumulate on either side of the initial 3 m bioswale, creating a barrier to surface drainage into the swale. During periodic mid-winter melts and precipitation events, runoff from the parking lot drains toward the bioswale. It is intercepted by the roll-over curb with the snow pile backing. The combination of permanent roll-over curb and temporary snow pile routes water along the curb to regularly-located catchbasins which drain directly to the pond. This directs much of the heavily chloride-laden runoff to the pond rather than the infiltration gallery and groundwater. Proper salt application and management during winter will ensure the College can successfully and safely operate while minimizing impacts to groundwater. Groundwater monitoring will be conducted to asses the impact of chlorides. Application rates and methods will be continually reassessed based on these results.

Detention Pond

The detention pond incorporates several levels of treatment as part of the treatment train process. All flow draining to the pond via the storm sewer is initially treated by an oil grit interceptor designed to achieve Level 1 treatment removal for suspended sediment, oil and grease. Flow enters the pond via a forebay that incorporates a permanent pool depth of 1.2 m and a low flow outlet featuring a 75 mm diameter orifice plate that bypasses the remainder of the pond. The flow then discharges directly into Blair Creek via the pond outlet. This design feature is intended to minimize the opportunity for thermal enrichment of captured surface runoff that may potentially degrade the quality of water discharged to the outlet.

The remainder of the pond features numerous micropools and an extended flow length to maximize settling opportunities for flow that surcharges the low flow outlet. A second outlet in the pond is located at an elevated level featuring a 0.2 m wide weir draining to the common outlet structure.

The pond was constructed in native soils. The soils are granular and support infiltration of runoff captured in the micropools. Water quality treatment is provided through the oil/grit separator at the pond inlet after which the runoff is considered clean per MOE guidelines. It is then suitable for infiltration. Micropools were designed to provide opportunistic infiltration at limited grading cost, above and beyond the MOE guidelines.

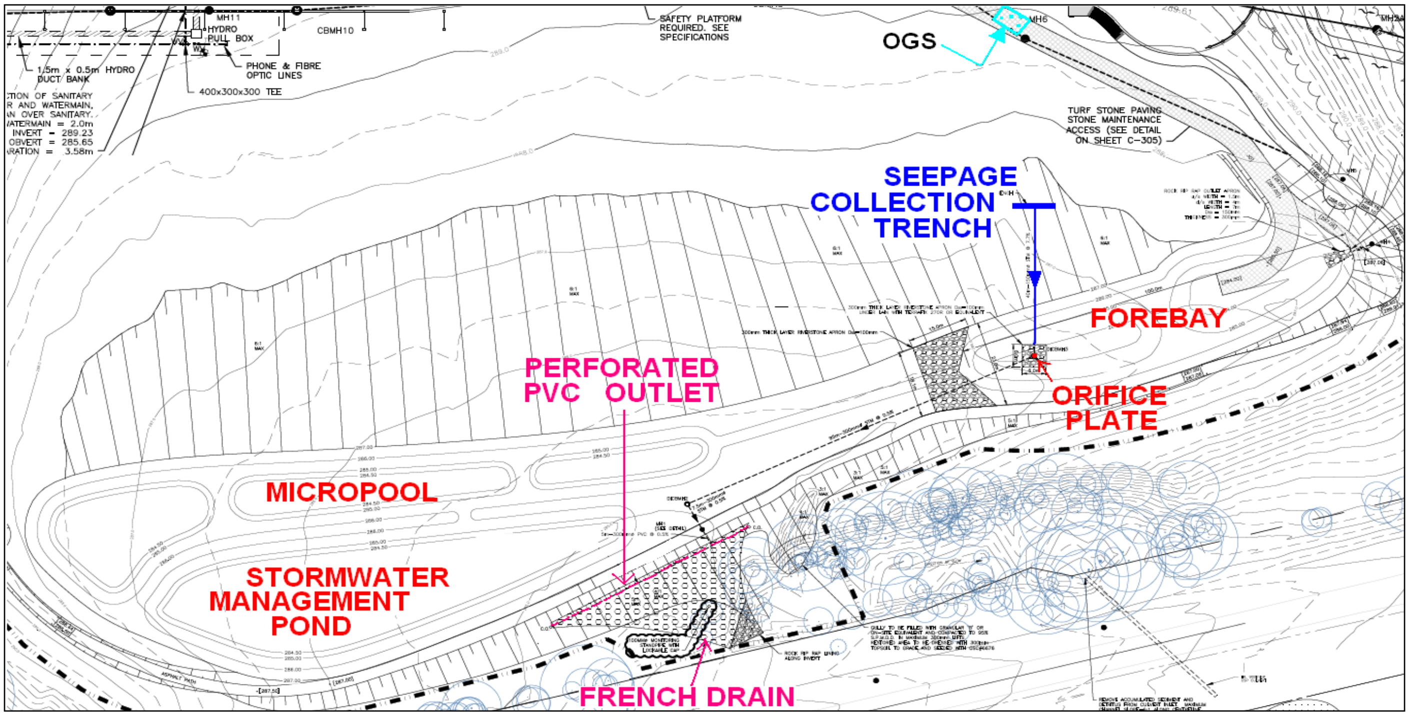


Figure 2: Stormwater management pond details

Stormwater management pond micropools

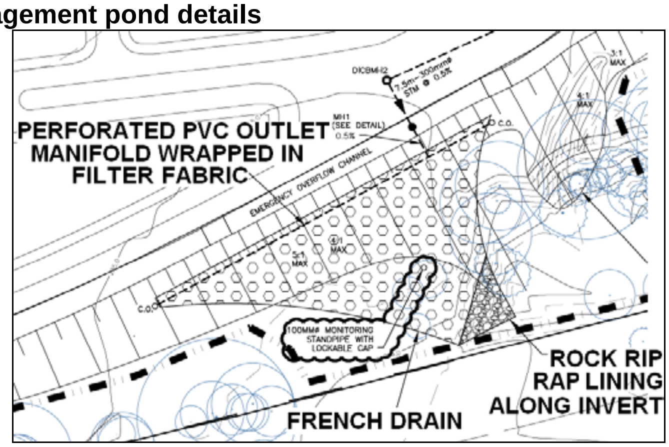


Figure 3: Stormwater management pond details

The pond outlet is designed as a percolation gallery. Site drainage design is intended to mitigate thermal impacts by capturing and infiltrating runoff at the source. Low flows discharged to the pond are routed so that they bypass large open portions of the pond. The outlet provides a tertiary polishing measure to mitigate potential thermal impacts from the site. The outlet releases water below grade via a perforated manifold parallel to the pond embankment. The manifold allows water to seep through a french drain to the existing swale parallel to Fountain Street and the outlet from the site. Contact with the buried stone media comprising the French drain provides final cooling of the water prior to discharge from the site.

Seepage Collection System

A seep was identified in the area of the detention basin during the initial site assessment. This seep released cool groundwater to the surface where the water was thermally enriched and drained to the site outlet. The site design incorporates a seepage collection trench that drains directly to the outlet structure in the pond forebay. During dry periods between precipitation events, this is the only flow in the outlet and it drains seepage water directly to the site outlet without exposure to the surface.

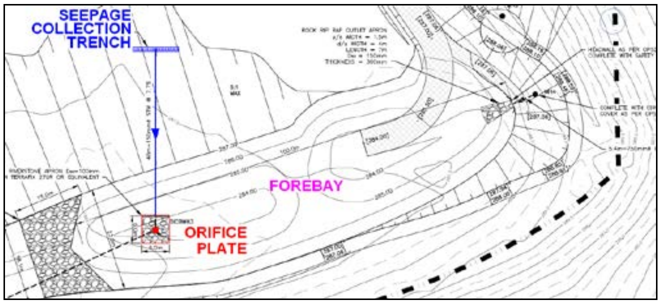


Figure 4: Seepage collection system details

Key Facts

Issues

- The City of Cambridge requested that the edge treatment of the bioswales be modified to utilize pea gravel rather than originally specified riverstone. This request was accommodated, however the pea gravel washed away within the first few precipitation events.
- Conestoga College wanted the flexibility to host student events and functions on the common green.
- The permanent pool was suspected to be stagnant and warm due to anticipated limited flow draining to the pond. Once released to receiving waters, this water can be detrimental to aquatic health.

Solutions and Lessons Learned

- To address the pea gravel washouts, specific zones of the pea gravel were replaced with larger riverstone as recommended in original design.
- The design of the infiltration gallery was upgraded to support heavier traffic loading.
- A low flow bypass was incorporated which allowed low flows to discharge directly to the receiving creek without mixing with thermally enhanced water in the main portion of the pond. This also avoided thermal enrichment from small storm events.

Construction and Commissioning

Construction took place over seven months, during which time the contractor encountered many issues.

Construction Drawings

The contractor overlooked the need for inspection ports and struggled with the concept of draining surface runoff from the parking lot into swales instead of normal overflow catchbasins. Construction drawings illustrated the precise location of the catchbasins but one was aligned along the curb per the design. One catchbasin grate differed in relation to the gutter line in the curb. The contractor recognized this as an “error” because its orientation was different than all other catchbasins on site. The contractors had to relocate some of the structures after installation to correct this issue.


Catchbasin installed by run-out causing short circuiting of the bioswale

Construction Practices

Care was taken during construction to minimize traffic over infiltration areas. This prevented unnecessary compaction of the native soils which would have hindered infiltration potential. Protection of the infiltration areas was emphasized fill material was seen falling in the gravel bed layer of the infiltration gallery during inspection visits. Techniques used to protect the infiltration areas included educating of the contractor, signage, flagging tape and fencing.


Infiltration gallery - fill material falling into gravel bed


Infiltration gallery - fill material in gravel bed

Economic (Capital and O&M Costs)

Approximate costs for construction of the campus and building are provided in the table below:

Capital Costs	
Item	**Cost**
Design/consultant fees (including building work such as mechanical, electrical and structural)	$1,400,000
Construction of south campus	$58,000,000

Full redundancy of the LID practices with traditional stormwater management measures (oil/grit interceptor and detention basin) resulted in additional costs to the College.

Operations and Maintenance

The design and installation of the monitoring network doubled in cost due to inexperience and lack of knowledge by the supplier and installer. The equipment supplier was not knowledgeable about the software limitations and intricacies. Equipment had to be replaced after efforts were made to work through software bugs and firewalls. The equipment was installed below grade in water proof enclosures that in reality were only water resistant. Inundation of the enclosures resulted in loss of equipment.

Annual monitoring reports are reviewed by the College's Physical Resources staff and the design engineer to assess performance of the system. Appropriate operational modifications are recommended to protect the environment receiving runoff to the extent possible while maintaining a level of service and safety necessary for students and staff at the campus. Operational modifications are developed and budgeted for the following year so that appropriate mitigating measures may be implemented in a responsive manner. The Annual Report was released in August 2013.

Long-Term Performance

A full monitoring program was developed and implemented as a requirement and condition of site approval by the region, city and conservation authority. This program includes a suite of continuous monitoring and event observations at numerous locations around the site. Monitoring is to be performed annually between March and December. The equipment used to record the continuous data is sensitive to freezing temperatures and therefore winter monitoring has been excluded. Allowing the equipment to freeze will not only result in short term inaccurate monitoring results, but also subtle long term errors in precision.

The purpose of the monitoring program is to document the performance of measures and controls implemented as part of Phase 1 development. Monitoring observations will be used to optimize the system to reduce measures and controls required for subsequent phases. Alternatively, monitoring data will help retrofit existing controls to ensure infiltration, runoff peak flow and runoff volume. Notes and observations from all inspections will be recorded in a diary or database for trend analysis as sufficient data is collected over time.

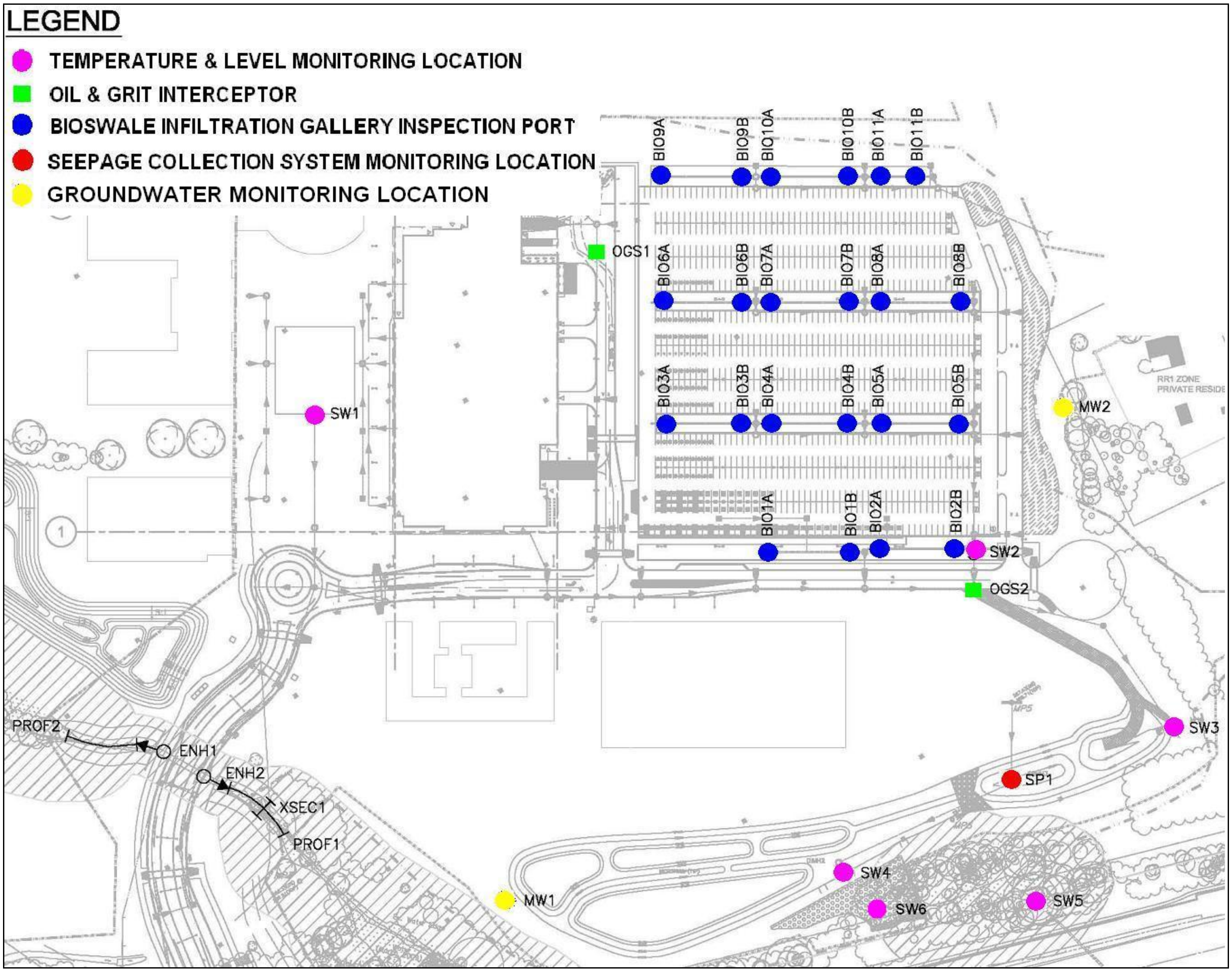


Figure 5: Monitoring Plan and Stations

Bioswale Monitoring Program

Drainage from the parking lot shall be provided via sheet flow to four bioswales. A continuously recording level logger and temperature probe is proposed at the outlet manhole from the parking area shown as location SW2 on Figure 5. Recorded depths shall be converted to flows using a rating curve. The recorded flows shall be reviewed to assess efficiency of the infiltration galleries in the bioswales on an annual year-to-year basis.

Infiltration Gallery Monitoring Program

Drainage from the Phase 1 building rooftop and central green shall be directed to a subsurface infiltration gallery below the central green. A continuous water level logger is proposed to monitor flow from the south central green overflow shown as SW1 on the Figure 5. Since this gallery should not overflow during a storm event less than 12 mm accumulation, evidence of flow from this manhole will indicate whether the infiltration gallery is functioning efficiently.

Oil / Grit Interceptor Monitoring Program

The oil/grit interceptors identified as OGS 1 and OGS 2 on Figure 5 will be monitored according to manufacturer's guidelines. Inspections shall occur at least semi-annually in the late spring and late fall. Accumulated sediments and oily water will be vacuumed from the system. The chambers will be refilled using clean water free from sediment, oils and greases. Vacuumed water from the oil/grit interceptor will be disposed of according to appropriate municipal, provincial and federal regulations. Waste water will not be released into a natural watercourse or the stormwater management system.

Detention Pond Monitoring Program

Continuous water level loggers are proposed to be used to monitor flow through the pond. Level loggers and temperature probes are proposed at the inlet to the stormwater detention basin shown as SW3 and the outlet from the detention basin shown as SW4 on the Figure 5. Stage discharge curves shall be developed that may be used to convert depth of flow to actual flow.

Seepage Collection System Monitoring Program

Discharge from the seep should be visible during baseflow conditions after periods of a minimum of three days of no flow, in the late spring and early summer during normal rainfall conditions. Due to the lack of historic data regarding this seep, three-season monitoring (spring, summer, fall) will be conducted monthly for three years. Monitoring will consist of visual observations for the presence of flow from the seep drain pipe, in the low flow outlet catchbasin manhole, during a period of baseflow conditions. Baseflow conditions exist when no precipitation events have occurred that have exceeded 3 mm accumulation in the preceding three days. A revised monitoring program will be developed following the three-year monitoring period. It will be based on the developed trend identifying critical periods of the year when flow is observed in the seep collection drain. This may be used as an indicator of change in groundwater discharge conditions in future.

Site Outlet Monitoring Program

A level logger and temperature probe is proposed in the culvert under Fountain Street shown as SW5 on Figure 5. Stage discharge curves will be developed for possible use to convert depth of flow to actual flow.

Groundwater Monitoring Program

Groundwater monitoring will include regular spring and late summer/early fall sampling programs to assess water levels and concentration of chlorides in the groundwater. Groundwater monitoring wells are proposed as MW1 and MW2 on Figure 5.

Groundwater monitoring will provide the most pertinent information about the impact of the de-icing program on the receiving groundwater resources. Annual reporting will be used to assess the impact of the de-icing program on groundwater.

Reports are prepared annually based on each monitoring season, from May 1 to April 30. Groundwater salt monitoring is conducted annually in April to identify any immediate impacts of salting operations from the previous winter season and to make recommendations for operational changes for the next winter season.

In addition to monitoring the impact to the receiving environment, the annual report includes a record of de-icing agents applied so that the total amount of de-icing agent applied over the winter months may be tracked from year to year. Performance data over the past year demonstrates that the treatment measures have performed as designed.

Preliminary Monitoring Results

The data shown in the following table represents the continuous temperature data from June to September 18th, 2012. Each reach of the main stormwater management system from the parking lot of the proposed building to Blair Creek achieved a runoff temperature drop. The largest average temperature drop was between SW4 and SW6 in the cooling trench with a total average drop of approximately 4.2°C across the system.

Temperature Monitoring Results from Main Stormwater Management Site Prior to September 18th, 2012

Start Node	End Node	Element	Average Drop (°C)	Maximum Drop (°C)
SW2	SW3	Sewer	0.5	9.4
SW3	SW4	Pond	-1.2	11.3
SW4	SW6	Cooling Trench	4.2	10.2

The average runoff temperature at the inlet of the stormwater management system was 15 °C. The average runoff temperature and temperature drop during the monitoring period, indicates the system adequately conditions the runoff to be discharged into the cold-water creek.

Acknowledgements

Credit Valley Conservation would like to sincerely thank the following companies, organizations and individuals for their support in developing this case study:

- Conestoga College
- Grand River Conservation Authority
- WalterFedy
- City of Waterloo
- Region of Peel
- Ontario Ministry of the Environment
- Carillion Canada

Version 1.0, Released February 2014

This case study was developed through funding support from the Government of Ontario's Showcasing Water Innovation program. Such support does not indicate endorsement by the Government of Ontario of the contents of this material.