Case Study

Ontario Ministry of Transportation Carpool Parking Lot (Beamsville)

Location: Beamsville

Constructed: 2010

Public Lands

Project Objectives, Design and Performance

- Construct a green carpool parking lot in accordance with the Ministry of Transportation's (MTO) *Strategic Direction* to have the "greenest highways in North America"
- Green features on-site include rubber modified asphalt and low impact development bioretention practices for stormwater management
- Parking lot designed to meet the Ministry of the Environment's Enhanced water quality treatment requirements and control the peak flow for two to 100 year storm events to pre-development peak flows

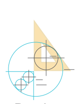
Overcoming Barriers and Lessons Learned

- Following construction, bioretention media started washing out through the underdrain (causing surface depressions) due to a lack of a transition material between soil media and the sub-drain bedding material. Pea gravel 'choking course' or geotextile fabric is highly recommended with infiltrating practices to prevent loss of media through the underdrain.
- Vegetation died during the dry summer of 2012. Plants did not establish and needed to be replaced. Frequent inspection and irrigation is required during the establishment period to ensure plant health.

Practices Implemented

Bioretention

Barriers and Issues Encountered

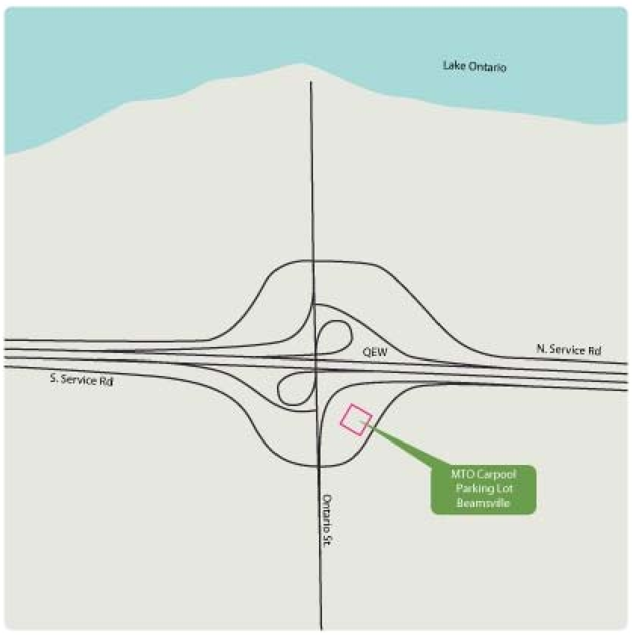


Design

Operation & Maintenance

Overview

An Ontario Ministry of Transportation (MTO) carpool parking lot was constructed in 2010 in the community of Beamsville, adjacent to the intersection of the Queen Elizabeth Way Highway and Ontario Street.



Location of MTO Carpool Parking Lot, Beamsville, ON

The 0.7 hectare site provides 100 parking spaces and features four bioretention cells to manage stormwater runoff. The site also incorporates a test strip of special asphalt containing recycled material, referred to as "rubber modified asphalt". The bioretention cells were installed to add aesthetic value while offering an enhanced level of stormwater management compared to a conventional parking lot.

To better understand the performance of the LID features at this demonstration site the MTO has partnered with the University of Guelph to monitor the bioretention cells. The monitoring program is currently underway, assessing the cells over a three-year period, following which a report will be developed to summarize performance and recommendations for improvements on future MTO LID projects.

Goals and Drivers

The Beamsville carpool parking lot was constructed to meet several MTO goals and drivers. These include:

- Encouraging carpooling in the Greater Hamilton area
- Implementing MTO's *Strategic Direction* to have the "greenest highways in North America"
- Utilizing new construction materials and methods to create a green site
- Serving as a demonstration project to learn from and improve future green parking lot designs
- Designing the practices to meet the Ministry of the Environment's *Enhanced* water quality treatment requirements and control the 100-year storm event to pre-development peak flows.

Successes

Successes achieved with the project include:

Award winning project **–** The project received the *2011 Recognition Award from the Environmental Commissioner of Ontario*.

Waste diversion **–** Old tires were recycled and used within the rubber modified asphalt mix. It is estimated that 624 tires were diverted from landfill.

Pollution control **–** 4000 m^3 of runoff is expected to be treated annually.

Use of monitoring to improve future designs **–** This was the first LID bioretention-based project for the MTO and was designed entirely in-house. A monitoring partnership was formed with the University of Guelph to learn from the demonstration project and improve design specifications.

Overcoming Barriers and Lessons Learned

Some of the barriers and issues encountered with this project include:

- As a demonstration project, confidence regarding the long-term performance of LID practices needed to be built internally
- Standard in-house design specifications and drawings did not yet exist and needed to be created
- The contractor had no previous experience constructing bioretention practices

- Following commissioning, large depressions were observed on the surface of the bioretention cell. It was determined that the sandy bioretention soil media was migrating through the coarse bedding material and being drained through the underdrain
- The vegetation did not survive the particularly dry summer of 2012. Vegetation on the sides of the cells faired better than the bottom

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

- Over-sizing and a conservative design approach were utilized to build confidence
- Drawings were developed and modified in-house based on lessons learned by the MTO
- Additional site supervision was provided during construction to ensure cells were constructed to specifications
- Vegetation that had died during the 2012 dry season was assessed and replanted with different plants

Lessons learned:

- A transition material is required to separate the bioretention soil medium from the granular clear stone below. Using 100 mm of pea gravel or geotextile filter fabric is recommended in accordance with CVC's LID Design Guide
- Future MTO bioretention projects will benefit from having greater in-house experience with implementing LID projects

Planning and Regulations

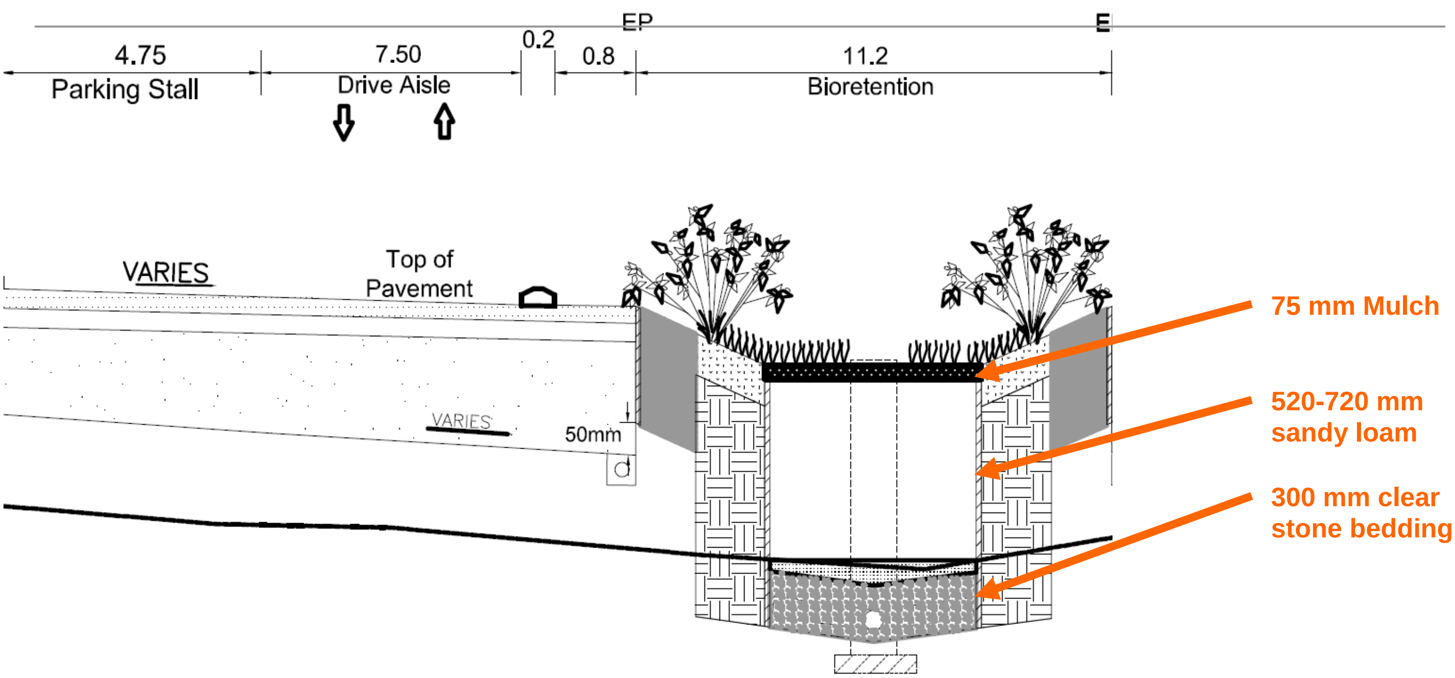
As an MTO project, approvals were not required from the municipality or the conservation authority. However, an Environmental Compliance Approval (ECA) was required from the MOE.

This project was driven by *MTO's Strategic Direction* to have "the greenest highways in North America." It meets several objectives of the strategy, including:

1. Incorporating environmental enhancements in planning, design, operations, maintenance, construction and procurement
2. Creating internal/external culture of enhancing the environment
3. Promoting and supporting green research and development for roads
4. Greening MTO's everyday processes

Design

Three bioretention cells are used to capture all parking lot runoff. A forth cell captures runoff from a bus loop within the lot. The cells are depressed areas and are comprised of 75 mm of mulch, 520-720 mm sandy loam engineered soil, followed by 100 mm sand, and 300 mm clear stone bedding surrounding an underdrain. Catch basins are used as an overflow bypass and allow for 100 mm of ponding on cell surfaces. A cross-section of the bioretention cell and the pavement is shown in the following figure.



Cross section of one of the bioretention cells within the MTO carpool parking lot

The bioretention cells were designed in-house by MTO engineers. Cells were sized following Table 3.2 and Eqn. 4.12 of the MOE *Stormwater Management Planning and Design Manual* to meet *Enhanced* Level One water quality control. As this was a demonstration project, to ensure success conservative sizing was used. The cells cover 11.6% of the 0.7 ha parking surface.

The post development peak flow for a 100-year event is expected to be 0.06 m^3/s; matching predevelopment conditions. As the native soil is clay and considered to have a poor permeability, exfiltration was not accounted for when estimating discharge rates from the site. Eqn. 4.20 of the *MOE SWM Manual* was used to estimate the maximum flow rate through the filter media and size the cells to control a 100 year storm event to pre-development peak flows. An orifice plate was used to control and model expected peak flow for design storms.

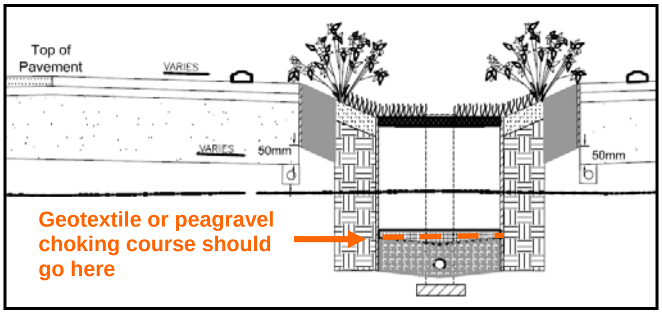
One issue identified following construction was development of large depressions within the bioretention soil media at the surface of the practice. One of these depressions is shown in the following photograph.

Image of a surface depression that formed within the bioretention cell shortly after construction

Performance monitoring at the site observed large amounts of fines exiting the practice through the underdrain. A field investigation and review of design drawings were undertaken to identify the source of this issue.

This investigation found that the fine filter media was seeping into the underdrain. Observation ports used for monitoring confirmed that visible clogging was present. The fine filter media was travelling through the clear stone bedding surrounding the underdrain and into the drain pipe.

To address this issue it is recommended that infiltrating LID practices include a transition layer to prevent fines from mobilizing. This transition layer can be a pea gravel 'coking course' or geotextile fabric.



Cross section of bioretention cell, showing location where transition material should have been placed to prevent soil media from eroding through the sub-drain

More information regarding transition layer can be found in the CVC *Low Impact Development Stormwater Management Planning and Design Guide* found at **www.bealeader.ca**. Section 4.5 discusses design considerations for bioretention facilities with underdrain design discussed on pg 4-85.

Key Facts

Issues

- Bioretention soil media eroded through the sub-drain due to lack of a transition material separating the bioretention soil media from the underdrain coarse bedding.

Solutions and Lessons Learned

- A transition material such as pea gravel or geotextile filter fabric is necessary to prevent the fine sandy/loam bioretention as per recommendations in CVC'sLID Design Guide.

Construction & Commissioning

The Beamsville carpool parking lot presented a new opportunity for Rankin Construction who had never constructed bioretention cells before. While typical parking lots are generally graded to direct runoff to the perimeter, this lot is graded to direct runoff to the cells in the center. Clear design drawings and an understanding of how the lot was to function enabled the contractor to construct the parking lot to the design requirements without major issues.

Unique rubber modified asphalt was used on a portion of this site. This material was made of ground scrap rubber tires and conventional hot mix asphalt. Using such material on a wide scale may potentially divert large quantities of used tires from stockpiles. It is estimated that 624 tires were diverted from landfill with this project. A photograph showing installation of this material is shown below.

Installation of rubber modified asphalt test strip

The engineered soil specified in the design was sourced locally. The sandy loam soil was mixed onsite and the cells were constructed during project grading. Landscaping was completed after the asphalt was laid. A photograph of the large central bioretention cell located within the bus loop showing the initial landscaping follows.

A large bioretention cell is located within the bus loop. This photograph shows the cell shortly after construction

With all LID projects, sediment and erosion controls are reccomended to protect the cells during construction from fine materials that can clog the engineered filter and impact cell performance. Consult CVC's LID Construction Guide for further details regarding erosion and sediment control best practices.

Economics (Capital and O&M Costs)

Costs of constructing the carpool lot and directly associated with the bioretention cell are provided in the following table:

Capital Costs	
Item	**Cost**
Construction of bioretention cells (includes stormwater infrastructure, bioretention soil media and mulch)[1]	$49,000
Landscaping warranty (2 years)	$6,000
Total parking lot construciton costs (includes bioretention cells, asphalt surfacing, and all landscaping)	**$732,000**

[1] *excludes landscaping.*

The cost of post construction monitoring at this site (along with one other demonstration project) is $116,400. Further details on the monitoring program are provided in the *Long Term Performance* section below.

Operations and Maintenance

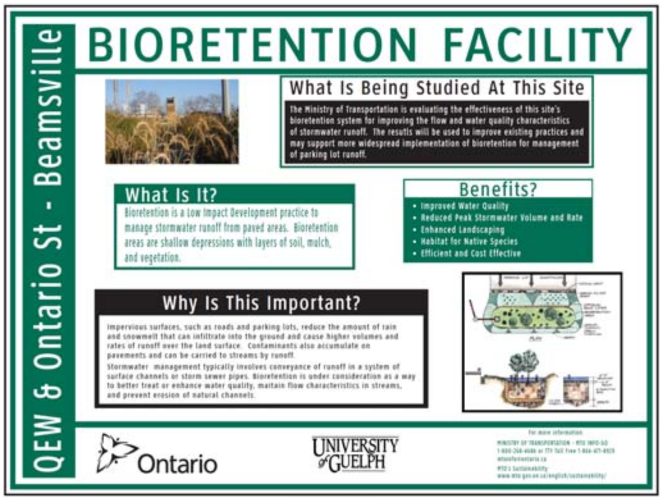
As a demonstration project, the MTO is interested in maintenance requirements for the bioretention cells. Vegetation replacement, garbage removal, and soil replacement requirements are being recorded at this site to provide information for future projects.

Due to very dry summer conditions in 2012, the majority of vegetation failed within the first year of planting. Warranties for all LID projects with landscape features are recommended to include provision(s) that dead vegetation be replaced on an ongoing basis throughout the warranty period – not just before the end of the contract. This ensures the aesthetics and functions of the landscaped practice are maintained during the warranty period and that plants are well established by the end of the warranty period.

Such provisions were in place for this project, but plant replacement was put on hold due to the issues with surface depressions described above. The bioretention cell underdrains had to be fixed first so the landscaping contractor has extended the warranty beyond the initial two years. Reconditioning the cells with new soil material and replanting will take place after the surface depressions are fixed.

To improve vegetation establishment, the existing mulch will be replaced with a mulch and compost mixture. Diligent attention to irrigation will be practiced until the vegetation is established. Vegetative plugs did not establish well previously. A seed mix will be tried to take advantage of the resilient germination stage of plant development. It is hoped that the seed mix will be more resilient than the plugs. In future projects, irrigating the vegetation while it establishes will be important to enhance chances of survival.

Educational signage was installed at the site to inform users of the unique bioretention features and ongoing performance monitoring. Signage is recommended for demonstration projects as a low cost and effective way to connect with local residents and/or users of the site. An example of educational signage content is provided below.



Educational signage installed at the Beamsville carpool lot to highlight the unique bioretention features at the site and the ongoing monitoring taking place by the University of Guelph

Long-Term Performance

As a recently constructed project, long-term performance data is not yet available. The expected water quality control performance is noted in the following table and compared to the conventional asphalt lot alternative.

Contaminant	Typical Urban Stormwater Runoff (mg/L)	Typical Pollutant Removal Rate for Bioretention (mg/L)	Water Quality Output (mg/L)	MOE Provincial Water Quality Objective (mg/L)	Meets Objective With Traditional System	Meets Objectives With Biorentention System
Total Suspended Solids (TSS)	100	77%	23	25	NO	YES
Biochemical Oxygen Demand (BOD)	11	90%	1.1	15	YES	YES
Chemical Oxygen Demand (COD)	58	90%	5.8	-	YES	YES
Total Phosphorus (P)	0.34	64%	0.12	0.03	NO	NO
Total Kjeldahl Nitroge (TKN)	1.9	59%	0.78	-	YES	YES
Nitrate (NO3)	0.63	15%	0.532	10	YES	YES
Copper (Cu)	0.03	84%	0.005	0.005	NO	YES
Lead (Pb)	0.09	89%	0.01	0.005	NO	NO
Zinc (Zn)	0.19	87%	0.024	0.03	NO	YES
Bacteria	400	77%	92	100	NO	YES
Hydrocarbons	varies	95%	Negligible	-	NO	YES
Chloride	varies	0%	Significant	-	NO	NO

Indicators of Environmental Performance table (Source: MTO)

Monitoring will completed by the University of Guelph and the final report will be posted to the MTO's Research Library. The current monitoring program examines;

- Water quality improvements
- Winter performance
- Performance changes as the parking lot ages
- Design changes to improve future projects

Flow discharged from the site is being continuously monitored. Overflow conditions are being noted as both the underdrain and overflow share the same outlet. Water quality samples are collected by hand during storm events. Soil and temperature probes are positioned at various depths and used to describe antecedent conditions. Equipment is housed in a temporary wooden structure as shown in the photo below.


University of Guelph students collecting data from the monitoring station

Key Facts

Issues

- A majority of vegetation within the bioretention cells died as a result of dry summer conditions in 2012

Solutions and Lessons Learned

- A landscaping/vegetation warranty with strict provisions on regular inspection and watering during the sensitive establishment period is highly recommended
- To try and improve plant health at the site, the MTO is using a mulch with additional organics, and a drought-tolerant seed mix.

As part of the monitoring program a surveillance camera was installed to observe occasions where water ponding took place. This information was used to help determine when overflows through the surface catch basins occurred

A unique component of the monitoring program is highlighted in the above series of photographs. A surveillance camera was installed to monitor occurrences of surface ponding and overflows through the surface catch basins. Using low cost cameras is recommended as a potential tool for municipalities and/or landowners to observe performance of infiltrating LID practices during rainfall events. This method allows for easy detection of any issues with extended drainage periods, blocked (or poorly graded) flow route(s) into the practices, and monitoring plant health over time.

Acknowledgements

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