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Toronto and Region Conservation for The Living City

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WATER CANADA THE COMPLETE WATER MAGAZINE

DESIGN OF INFILTRATION PRACTICES

Chris Denich, M.Sc., P.Eng
Aquafor Beech Ltd

TRIECA - March 25-26th, 2015

Aquafor Beech Limited

HIGHLIGHTS OF:

Infiltration Options

Policies & Design Criteria

Site Evaluation and Reconnaissance

Pre-Design

Detailed Design

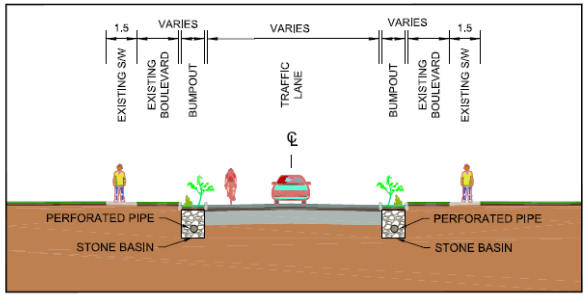
Importance of Construction Supervision

*Overview

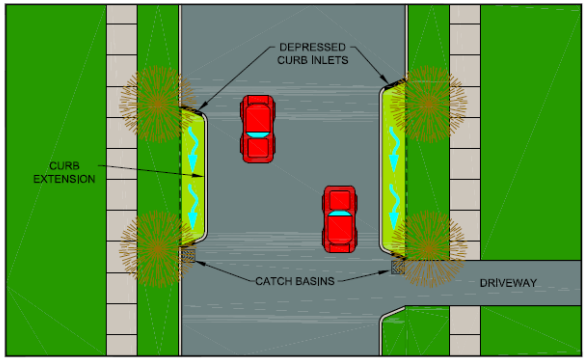
Infiltration Practices Options

Green Glades Public School, Mississauga, ON
(by Aquafor Beech)

*Bioretention



SECTION



PLAN

Sunnyside Avenue, Ottawa, ON
(by Aquafor Beech)

*Bioretention Bump Out

King Street, Kitchener, ON

Portland, Oregan

Elm Drive, Mississauga, ON
(by TMIG and Schollen & Company)

*Bioretention Planter

IMAX Headquarters, Mississauga, ON
(by Aquafor Beech)

*Bioswales

Private Residence, Etobicoke, ON
(by Aquafor Beech)

*Soakaways & Chambers

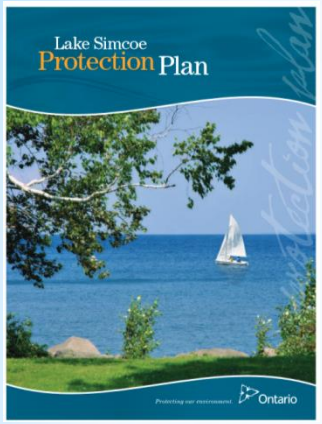
Cheltenham, ON
(by Aquafor Beech)

*Soakaways & Chambers

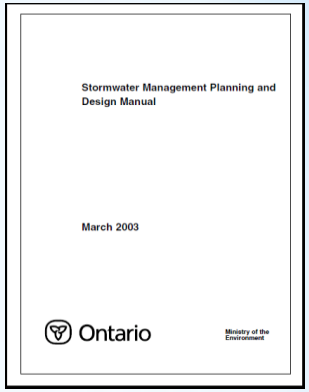
IMAX Headquarters, Mississauga, ON
(by Aquafor Beech)

*Permeable Pavements

*Policies, Regulations, Criteria



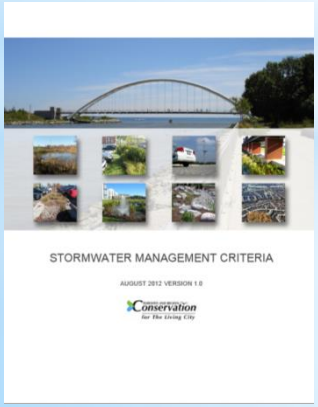
Species at Risk Legislation



SWS, EIS, MDP, Wetland Policies

LID IMPLEMENTATION

Climate Change Mitigation Strategies



Local Requirements i.e. City of Toronto

Source Water Protection

*Site Evaluation & Reconnaissance

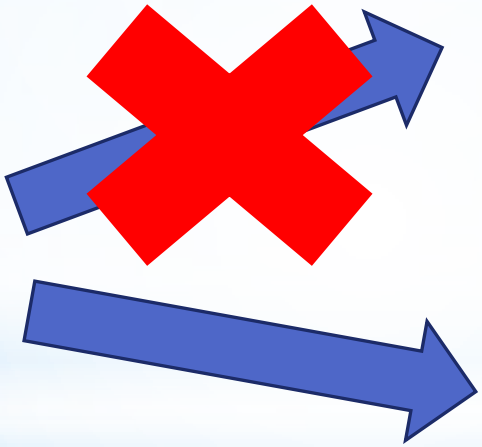
Do you have/know ?

1. Existing soils mapping or geotechnical reports
2. Size of catchment area
3. Land-use
4. Types of scheduled uses i.e. sports field
5. Winter Maintenance Requirements - Snow storage
6. Winter de-icing protocol – salt / sand
7. Pedestrian/ accessibility requirements
8. Soil permeability
9. Depth to water table/Bedrock
10. Topography
11. Existing SWM Reports/ flood reports

*Screening the Options

* Select LID that have the potential to satisfy your established site criteria

Infiltration target = 10mm



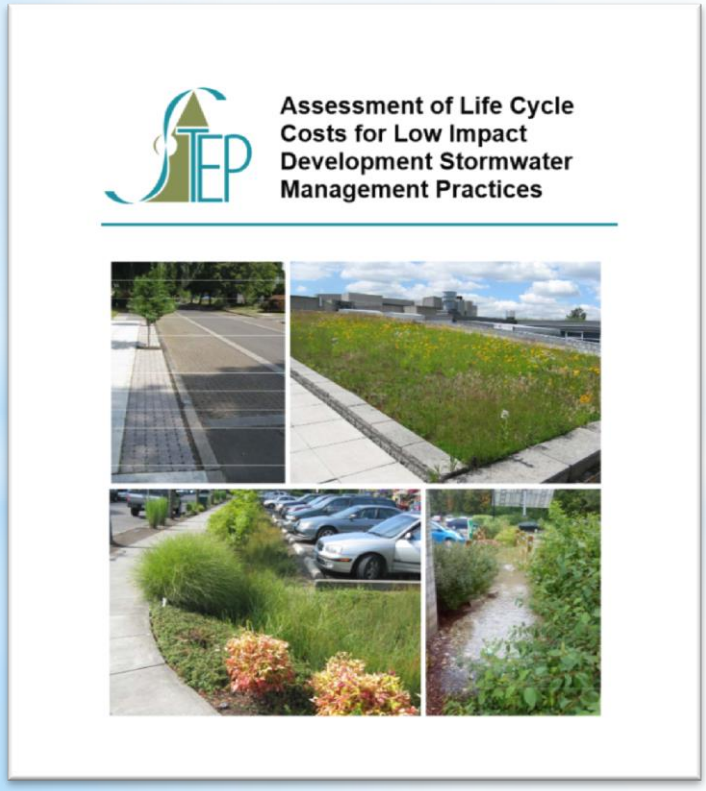
Screening the Options

- Define your priorities beyond SWM - aesthetics, parking, open spaces etc.

VS.

*Screening the Options

* Cost - Use delineated drainage areas of potential control to estimate the costs based on the established site criteria



LID Technique	Installation Cost (avg)
Rainwater Harvesting	$250- $1,000 / m^3 ($620)
Green Roofs	$120 - $300 / m^2
Downspout Disconnection	New Development = no cost Retrofit = $100/ disconnection
Soakaway Pits	$430 - $550 $500 / m^3
Bioretention	$32,000 – $105,000/ ha treated ($52,000 / ha treated)
Special Bioretention	Stormwater Planter $750 – $1,500 ($1,100)/m^3 Small Retrofits $1,000 - $1,600 ($1,200)/m^3 Stormwater Tree Pits $2,400 - $3,400 ($2,900)/m^3
Soil Amendments	Unknown
Tree Clusters	$105/40mm diameter tree[iv]
Filter Strips	Seed $3.50 / m^2 Sod $ 9.00/ m^2
Permeable Pavement	Asphalt • 10% -20% increase compared to traditional asphalt Porous Concrete • $140 - $175/ m^2
Grass Channels	$32,000 – $105,000/ ha treated ($52,000 / ha treated)
Dry Swales	$30,000 – $105,000/ ha treated ($52,000 / ha treated) $300 - $900 / m^3 ($500 / m^3)

All figures in 2008 Canadian Dollars (Source: TRCA, 2008)

i MacMullan, E., Reich, S., Puttman, T., Rodgers, D. and Evans, E (2008) Cost- Benefit Evaluation of Ecoroofs. ASCE- Low Impact Development.

ii Wise. S. (2008) Water Quality in a Changing World: Envisioning Green Infrastructure in the Great Lakes and Beyond. CVC LID Symposium, Brampton, ON.

iii EPA (2007) Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Proactices. EPA 841-F-07-006

ivThe Stormwater Manager's Resource Center (SMRC) (2009). Maintenance Frequencies: Unit Costs for Stromwater Treatment Practice Maintenance- Draft. www.stormwatercenter.net. Accessed: Feb 4, 2009.

Site Information Requirements

- Geotechnical Assessments
  - Number of boreholes TBD based on background review and proposed facility location
  - Includes soil texture(s), particle size distribution, and moisture content
  - Extend min. of 1.5m below the proposed invert of the LID facility
  - Consider chemical analysis for soil disposal options (per Class EA)
  - **Infiltration rates derived from borehole analysis <u>is not suitable for LID design</u>**

Site Information Requirements

Geotechnical Assessment

- Boreholes (2-100)
  - Minimum 1.5m below the proposed invert of the facility
- particle size distribution (ASTM D422 and D2217),
- Stratigraphy,
- Piezometer(s)
- natural moisture content (ASTM D2216),
- plasticity characteristics (ASTM D4318),
- strength assessment (CBR and Soaked CBR)

www.allservicedrilling.com/web/equipment_soilmax.php

Site Information Requirements

- Geotechnical Assessments: Seasonally High Groundwater Elevation
  - Standpipes – O.Reg 389/09
  - March – April or Late fall before snowfall

*Site Information Requirements

In-Situ Infiltration Testing

1. Guelph Permeameter
2. Double Ring Infiltrometers (constant head)
3. Single ring (constant head pressure)
4. Borehole Permeameter (estimates only)
5. Philip-Dunne (MPD) Infiltrometer

* Want to know:
  * Field Saturated Hydraulic Conductivity (Kfs) –Calculate design infiltration rate

* **Needed to:**
  * **Design and Size the Facility**
  * **Determine if underdrains are required**

*Site Information Requirements

Others

*Topographic Survey

*Utility Locates

*Tree Inventory

In-situ Infiltration Rate

Appendix C – LID 2010

Above 15mm/hr

No Underdrain Required
(Full infiltration)

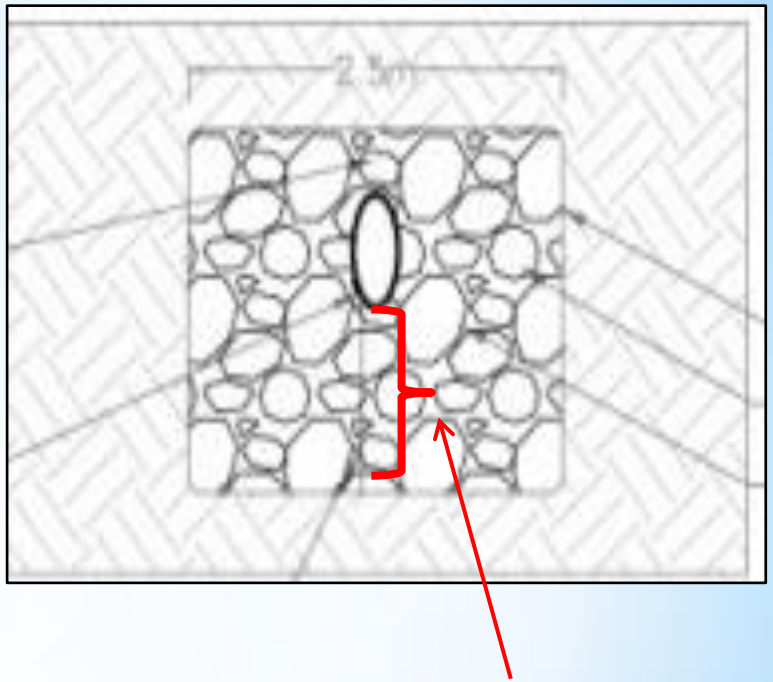
Below 15mm/hr

Underdrain Required
(**Partial Infiltration**)

*How to use the In-situ Infiltration Rate

If your native soils are below 15mm/hr

* Apply the Kfs to calculate infiltration rate (apply SF i.e. 2.5 or greater) to determine the height of the pipe above the invert of the facility



Volume of water that the soils can infiltrate in 24-48 hrs

dr max = i * ts / Vr

Where:
dr max = Maximum stone reservoir depth (mm)
i = Infiltration rate for native soils (mm/hr)
Vr = Void space ratio for aggregate used (typically 0.4 for 50 mm clear stone)
ts = Time to drain (design for 48 hour time to drain is recommended)

* Partial Infiltration

Hydrology and Hydraulics

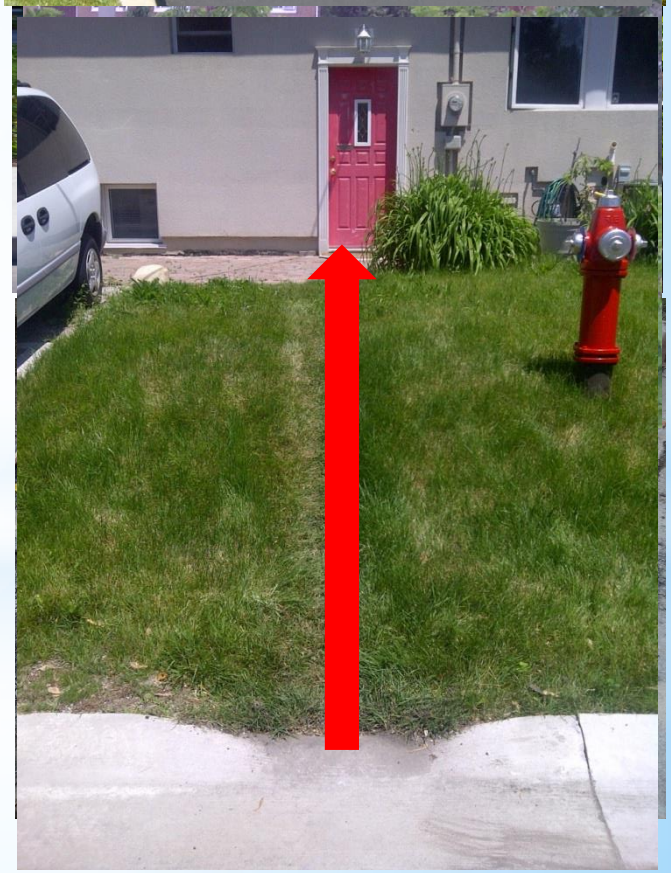
- The hydrologic assessment of the proposed drainage areas should be conducted before hydraulic assessments.
- Can use:
  - Simple spreadsheet for small sites
  - Continuous and event based models (SWMM, HSPF, GAWSER etc.)
  - Some models have integrated LID routines (typically surface storage with infiltration) i.e. EPA SWMM etc.
  - HEC-RAS and other such models can b used for conveyance

In almost all cases a combination of approaches is needed.

*Design Optimization

Consider:

* Street/parking lot profile and grades
* Inlets/ Curbs/Curb Cuts
* Emergency Overflows
* Utilities
* Storage options
* RWH integration
* Aesthetics
* How the site will ultimately be used



Lakeview, Mississauga, ON
(by Aquafor Beech)

*Design and Utilities

*Design Drawings Requirements

* Vendor/contractor must undertake and pay for testing
* No installation without approval from field engineer
* Installation without approvals = removal at the contractor's expense
* Media not conforming to approved mechanically mixed sample shall be removed and replaced at the contractor's expense
* Media testing can be expected approximately 7-10 days after submission
* Contractor responsible for any delays resulting from testing, NO COMPENSATION PROVIDED FOR DELAYS DUE TO TESTING
* On-site mixing is not acceptable

MEDIA FOR BIOSWALE FACILITY

MEDIA	SIZE	% BY WEIGHT
1 - SAND	2 to 0.05mm	85 - 88%
2 - FINES	< 0.050mm	8 - 12%
3 - LEAF COMPOST (Organic Matter)	-	3 - 5%

Notes:

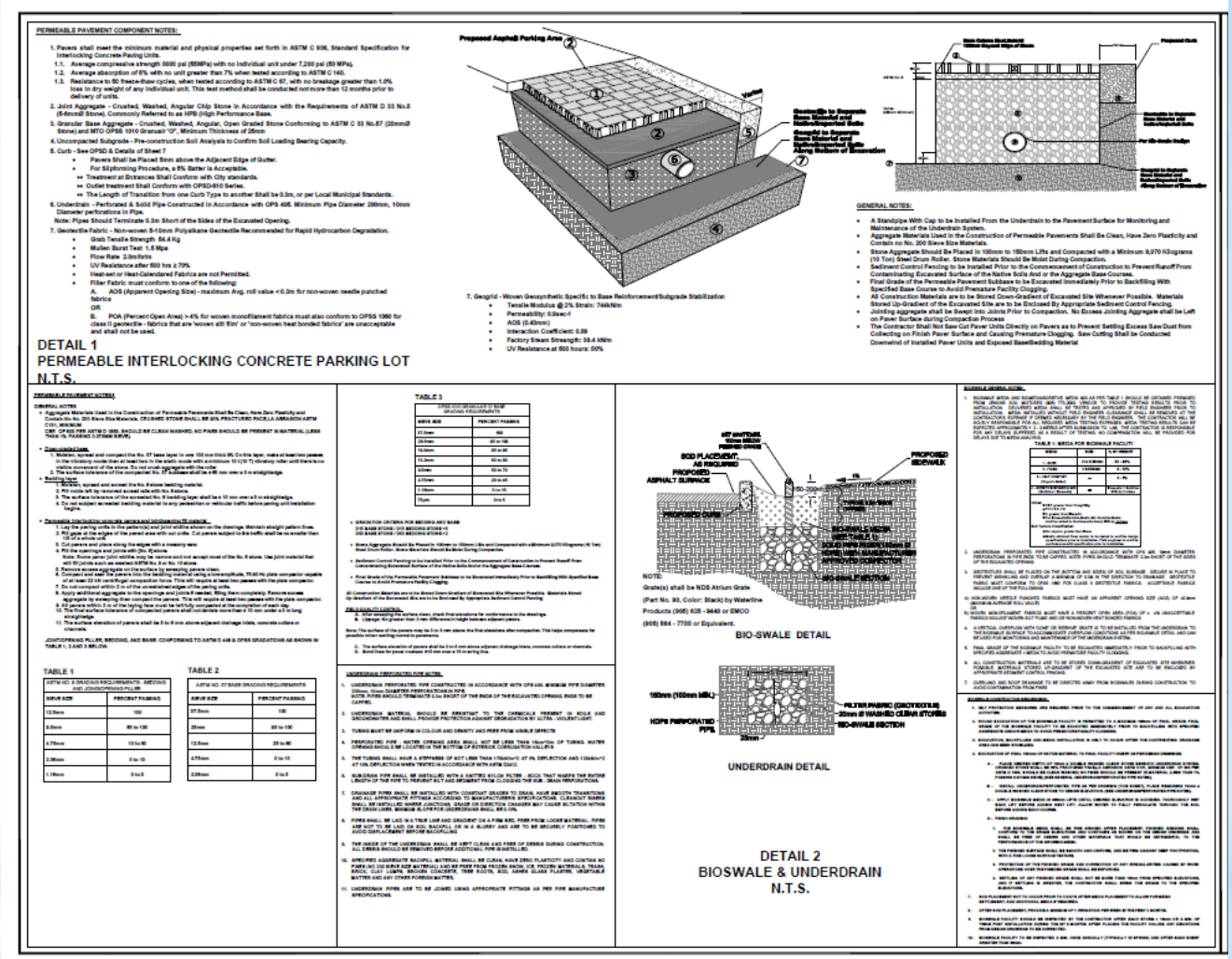
- CEC greater than 10 mg/100g
- PH = 5.5 - 7.5
- K greater than 25mm/hr

Soil Texture Classification:

- No objects greater than 50mm
- Media obtained from vendor to be tested to confirm design specifications prior to installation. Field engineer to confirm conformance with specification prior to installation.

*ON THE DRAWINGS, IN THE TENDER!

*NOTES !!!!



PERMEABLE PAVEMENT COMPONENT NOTES:

1. Pavers shall meet the minimum material and physical properties set forth in ASTM C 936, Standard Specification for Interlocking Concrete Paving Units.
   1.1. Average compressive strength 8000 psi (55MPa) with no individual unit under 7,200 psi (50 MPa).
   1.2. Average absorption of 6% with no unit greater than 7% when tested according to ASTM C 140.
   1.3. Resistance to 50 freeze-thaw cycles, when tested according to ASTM C 67, with no breakage greater than 1.0% loss in dry weight of any individual unit. This test method shall be conducted not more than 12 months prior to delivery of units.
2. Joint Aggregate - Crushed, Washed, Angular Chip Stone in Accordance with the Requirements of ASTM D 33 No.8 (5-4mm)Stone, Commonly Referred to as HPB (High Performance Base.
3. Granular Base Aggregate - Crushed, Washed, Angular, Open Graded Stone Conforming to ASTM C 33 No.57 (20mm)Stone) and MTO OPSS 1010 Granular "O", Minimum Thickness of 25mm
4. Uncompacted Subgrade - Pre-construction Soil Analysis to Confirm Soil Loading Bearing Capacity.
5. Curb - See OPSD & Details of Sheet 7
   - Pavers Shall be Placed 5mm above the Adjacent Edge of Gutter.
   - For Slipforming Procedure, a 8% Batter is Acceptable.
   - ↔ Treatment at Entrances Shall Conform with City standards.
   - ↔ Outlet treatment Shall Conform with OPSD-810 Series.
   - ↔ The Length of Transition from one Curb Type to another Shall be 0.3m, or per Local Municipal Standards.
6. Underdrain - Perforated & Solid Pipe Constructed In Accordance with OPS 405. Minimum Pipe Diameter 200mm, 10mm Diameter perforations in Pipe.
   Note: Pipes Should Terminate 0.3m Short of the Sides of the Excavated Opening.
7. Geotextile Fabric - Non-woven 5-10mm Polyalkene Geotextile Recommended for Rapid Hydrocarbon Degradation.
   - Grab Tensile Strength 64.4 Kg
   - Mullen Burst Test 1.8 Mpa
   - Flow Rate 2.0m/hr/m
   - UV Resistance after 500 hrs ± 70%
   - Heat-set or Heat-Calendared Fabrics are not Permitted.
   - Fiber Fabric must conform to one of the following:
     A. AOS (Apparent Opening Size) - maximum Avg. roll value < 0.3m for non-woven needle punched fabrics
     OR
     B. POA (Percent Open Area) > 4% for woven monofilament fabrics must also conform to OPSS 1060 for class II geotextile - fabrics that are 'woven slit film' or 'non-woven heat bonded fabrics' are unacceptable and shall not be used.

Proposed Asphalt Parking Area

7. Geogrid - Woven Geosynthetic Specific to Base Reinforcement/Subgrade Stabilization
   - Tensile Modulus @ 2% Strain: 744kN/m
   - Permeability: 0.9m/s-1
   - AOS (0.42mm)
   - Interaction Coefficient: 0.89
   - Factory Steam Strength: 39.4 kN/m
   - UV Resistance at 500 hours: 80%

GENERAL NOTES:

- A Standpipe With Cap to be Installed From the Underdrain to the Pavement Surface for Monitoring and Maintenance of the Underdrain System.
- Aggregate Materials Used in the Construction of Permeable Pavements Shall Be Clean, Have Zero Plasticity and Contain no No. 200 Sieve Size Materials.
- Stone Aggregate Should Be Placed in 150mm to 180mm Lifts and Compacted with a Minimum 9,070 Kilograms (10 Ton) Steel Drum Roller. Stone Materials Should Be Moist During Compaction.
- Sediment Control Fencing to be Installed Prior to the Commencement of Construction to Prevent Runoff From Contaminating Excavated Surface of the Native Soils And or the Aggregate Base Courses.
- Final Grade of the Permeable Pavement Subbase to be Excavated Immediately Prior to Backfilling With Specified Base Course to Avoid Premature Facility Clogging.
- All Construction Materials are to be Stored Down-Gradient of Excavated Site Whenever Possible. Materials Stored Up-Gradient of the Excavated Site are to be Enclosed By Appropriate Sediment Control Fencing.
- Jointing aggregate shall be Swept into Joints Prior to Compaction. No Excess Jointing Aggregate shall be Left on Paver Surface during Compaction Process
- The Contractor Shall Not Saw Cut Paver Units Directly on Pavers so to Prevent Settling Excess Saw Dust from Collecting on Finish Paver Surface and Causing Premature Clogging. Saw Cutting Shall be Conducted Downwind of Installed Paver Units and Exposed Base/Bedding Material

DETAIL 1
PERMEABLE INTERLOCKING CONCRETE PARKING LOT
N.T.S.

TABLE 1

ASTM NO. 8 GRADING REQUIREMENTS - BEDDING AND JOINT/CRACK FILLER	
SIEVE SIZE	PERCENT PASSING
13.2mm	100
9.5mm	85 to 100
4.75mm	10 to 30
2.36mm	0 to 10
1.18mm	0 to 5

TABLE 2

ASTM NO. 57 BASE GRADING REQUIREMENTS	
SIEVE SIZE	PERCENT PASSING
37.5mm	100
26mm	95 to 100
13.5mm	25 to 60
4.75mm	0 to 10
2.36mm	0 to 5

TABLE 3

SIEVE SIZE	PERCENT PASSING
37.5mm	100
26.5mm	95 to 100
19.0mm	60 to 95
13.2mm	50 to 85
9.5mm	30 to 75
4.75mm	20 to 65
1.18mm	0 to 15
75µm	0 to 5

PROPOSED ASPHALT SURFACE
SOD PLACEMENT, AS REQUIRED
PROPOSED SIDEWALK
BIO-SWALE SECTION
NOTE:
Grate(s) shall be NDS Atrium Grate (Part No. 90, Color: Black) by Waterline Products (906) 625 - 9440 or EMCO (905) 564 - 7700 or Equivalent.

BIO-SWALE DETAIL

150mm (100mm MIN.)
HDPE PERFORATED PIPE
FILTER FABRIC (GROTEX T27UL)
20mm Ø WASHED CLEAR STONES
BIO-SWALE SECTION

UNDERDRAIN DETAIL

DETAIL 2
BIOSWALE & UNDERDRAIN
N.T.S.

*Design Drawings Requirements

*Key Message

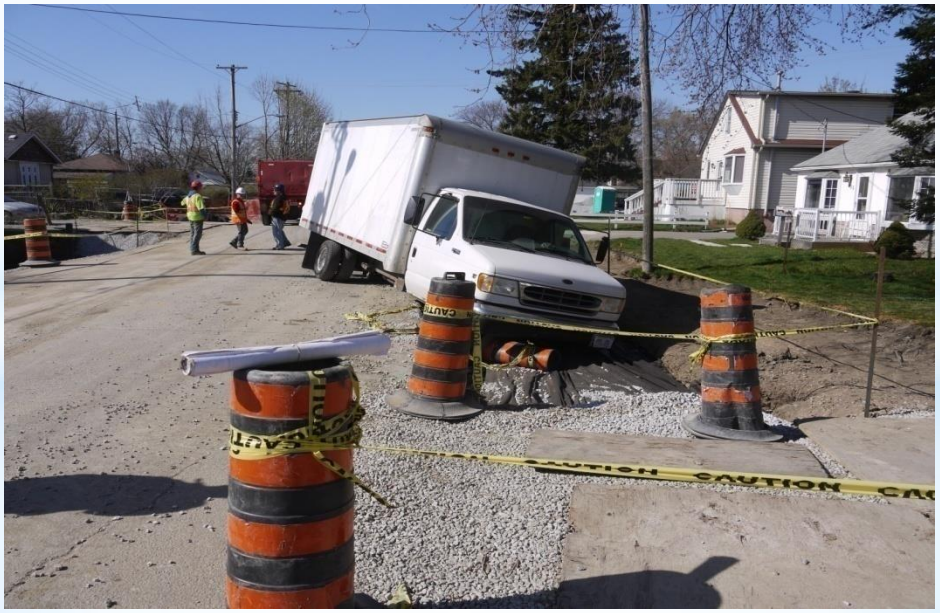
* A general rule of thumb to consider during construction supervision is,

* "if it doesn't look like the design drawings it is probably constructed wrong"

*Key Message

*LID is new to contractors, surveyor, suppliers, truck drivers, machine operators and inspection staff

*Education is needed



*Key Message

*Pilot projects have to work, if they don't there likely won't be another

*Key Message

* Mistakes happen, LIDs will introduce new installation methods for the contractor

*FINAL KEY MESSAGE

Having Full-time construction supervision should not be considered optional for LID projects…..it is money well spent

Want to learn more…?

https://www.thelivingcitycampus.com/workshops/online-learning

* Instructor: C. Denich
* $99.00
* 2-3 hours
* Contact: adelaney@trca.on.ca

*E- Learning

*Questions

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