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Making LID Inspection and Maintenance Easier and Cheaper By Design

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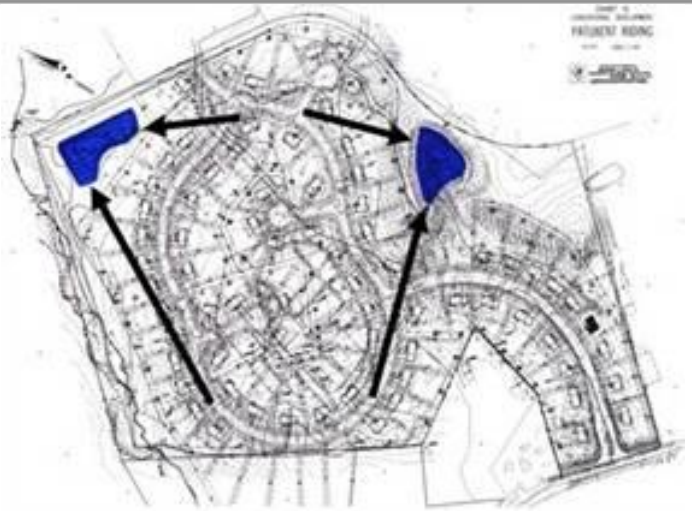
Toronto and Region Conservation Authority
Sustainable Technologies Evaluation Program

TRIECA 2015 conference
March 26, 2015

Low Impact Development (LID) is a stormwater management approach that seeks to manage urban runoff and pollutants using distributed, small-scale controls.

The goal is to mimic a site's pre-development hydrology through:

- site designs that minimize impervious cover and preserve natural drainage features and patterns; and
- best practices that filter, harvest, evapotranspire, detain and infiltrate stormwater as close to its source as possible.



Conventional "end-of-pipe" approach

Low Impact Development approach

The need for rigorous BMP inspections

Early experiences have shown failures are often due to:

- Practices not constructed as designed or not with specified materials;
- Lack of attention to erosion sediment control during construction;
- Lack of rigorous inspection during construction and prior to project acceptance (i.e. assumption by owner).

Municipal SWM Inspection and Maintenance – Common Challenges

- Lack of sustainable funding mechanisms;
- Lack of compliance and enforcement authority/access;
- Lack of dedicated program/ staff;
- Uncertainty of BMP locations;
- Inability to track responsible parties;
- Designs not conducive to easy maintenance/access;
- Owners unaware of maintenance responsibility.

LID BMP Inspection and Maintenance – New Challenges

- Distributed, decentralized, small-scale practices = more effort to track;
- Little or no experience with LID BMPs;
- Legal arrangements to ensure inspection/maintenance on private property;
- Lack of detailed guidance and tools/templates for program design and implementation.

LID Stormwater Inspection and Maintenance Guide

1. Provide guidance to municipalities and ICI property managers on planning and implement. of LID BMP I&M programs.

2. Establish standard protocols for inspection, testing and maintenance of LID BMPs in Ontario.

- Bioretention/Dry swales;
- Grass swales;
- Vegetated filter strips/Soil amendments;
- Permeable pavements;
- Underground infiltration systems;
- Green roofs;
- Rainwater cisterns.

LID Stormwater Inspection and Maintenance Guide - Outline

Part 1: Designing an Effective LID I&M Program

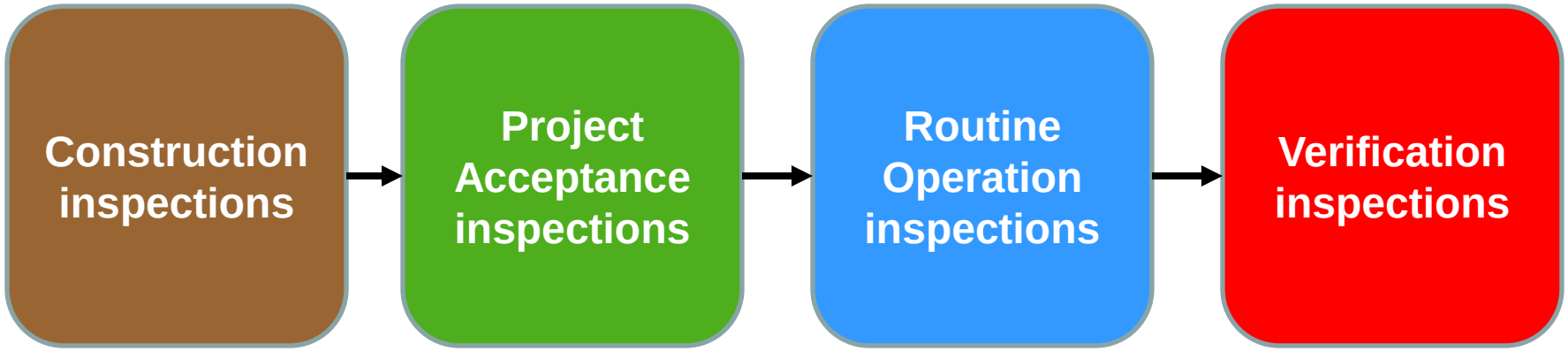
1. Setting the program scope
2. Approaches to assigning responsibilities
3. Steps in program development
4. Key considerations during BMP design and plan review
5. Opportunities for public involvement

Part 2: Inspection and Maintenance of LID BMPs

1. Inspection and testing framework
2. BMP-specific inspection/testing, maintenance & lifecycle I&M costs
3. Inspection and testing protocols

Inspection and testing framework

Four types of inspections over a BMP life cycle



Weekly, at critical/hand-off points & after storms ≥ 15 mm in depth

Immediately post-construct. & near end of vegetation warranty period

Annually at a minimum, more frequently for high maint. locations

Compliance – every 5 yrs. Performance – every 10 yrs.

Inspection and testing framework

Indicator	Inspection Type			
	Construction	Project Acceptance	Routine Operation	Compliance/ Performance Verfication
Visual (29 indicators)	X	X	X	X
Soil characterization testing	X	X		X
Sediment accumulation testing	X	X	X	X
Surface infiltration rate testing		X		X
Natural or simulated storm event testing		X		X
Continuous monitoring		X		X

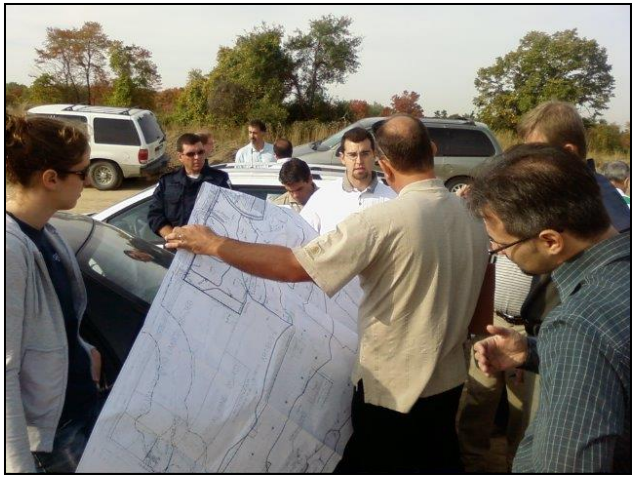
Most frequent (1 or 2 times annually) but least rigorous

I & M Program Design

Rigorous inspection and testing during and immediately post-construction is critical to ensure stormwater BMPs are:

- Built according to approved plans and specifications;
- Installed at appropriate time and with adequate erosion and sediment controls;
- Fully operational prior to assumption by owner (i.e. project acceptance)

Avoids assuming BMPs already in need of repair or maintenance



I & M Program Design

Routine Operation inspections will also:

- Proactively identify maintenance issues before they affect BMP function;
- Help optimize stormwater infrastructure management programs by providing feedback needed to determine when structural repairs are needed and optimize frequencies of I&M tasks.

Extends BMP lifespan and avoids more costly structural repairs/rehabilitation (e.g. unclogging pipes or permeable pavements, replacing filter media)

Inspection and testing framework

Relies on simple visual indicators for Routine Operation inspections (most frequent type):

- Can be completed rapidly by road/sewer and landscaping maintenance field crews;
- Uses quantitative “triggers” for follow-up tasks/corrective action.

Limits the need for highly trained engineers/technicians to Construction, Project Acceptance and Verification inspections (~12 to 15 over a 30 yr. BMP lifespan).

Visual inspection protocols

9.1.3 INLET OBSTRUCTION

Construction Inspection | Project Acceptance ✓ | Routine Maintenance and Inspection ✓ | Compliance Verification ✓ | INLET

Check inlets to ensure nothing is obstructing flow of stormwater into the BMP. An obstruction can be due to damaged or displaced structures (e.g. heaved or sunken curb or pavement) or accumulated sediment, trash, debris or vegetation in the inlet, pretreatment device or on the filter bed. Measure sediment depth.

Rain Gardens/Bioretention Cells/Dry Swales

PASS: There are no obstructions at the inlet and stormwater can freely flow into the BMP.

FAIL: Accumulated sediment and vegetation is preventing stormwater from entering the BMP. Sediment on the pavement surface in front of the inlet indicates ponding is occurring.

MAINTENANCE TRIGGER: Sediment, trash, debris is ≥ 5 cm deep. Sediment, trash, debris or vegetation is blocking inflow over one third (33%) of the inlet width or area.

FOLLOW-UP TASKS: Remove or repair the obstruction. Re-grade at the inlet to provide a 5 cm drop in elevation between pavement edge and pretreatment device or filter bed surface.

Enhanced Swales

PASS: There are no obstructions at the inlet and stormwater can freely flow into the BMP.

FAIL: Accumulated sediment and vegetation is preventing stormwater from entering the BMP. Sediment on the pavement surface in front of the inlet indicates ponding is occurring.

MAINTENANCE TRIGGER: Sediment, trash, debris is ≥ 5 cm deep. Sediment, trash, debris or vegetation is blocking inflow over one third (33%) of the inlet width or area.

FOLLOW-UP TASKS: Remove or repair the obstruction. Regrade at the inlet to provide a 5 cm drop in elevation between pavement edge and pretreatment device or BMP surface.

Vegetated Filter Strips/Soil Amendments

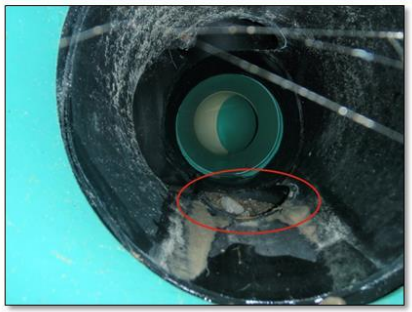
PASS: There are no obstructions at the inlet and stormwater can freely flow into the BMP as sheet flow from the pavement and gravel diaphragm. (Source: CSN).

FAIL: Concrete barriers are preventing stormwater from entering the BMP as sheet flow from the pavement. Sediment has accumulated at the inlet edge of the BMP.

MAINTENANCE TRIGGER: Sediment, trash, debris is ≥ 5 cm deep. Sediment, trash, debris or vegetation is blocking inflow over one third (33%) of the width edge.

FOLLOW-UP TASKS: Remove or repair the obstruction. Re-grade the width edge to provide a 5 cm drop in elevation between pavement edge and top of the flow spreader or BMP surface.

Underground Infiltration Systems



PASS: There are no obstructions at the inlet and stormwater can freely flow into the BMP.

FAIL: Sediment has accumulated in the inlet pipe to the infiltration trench and is fully obstructing flow of stormwater into the BMP.

MAINTENANCE TRIGGER: Sediment, trash, debris is ≥ 5 cm deep. Sediment, trash, debris or vegetation is blocking inflow over one third (33%) of the inlet width or area.

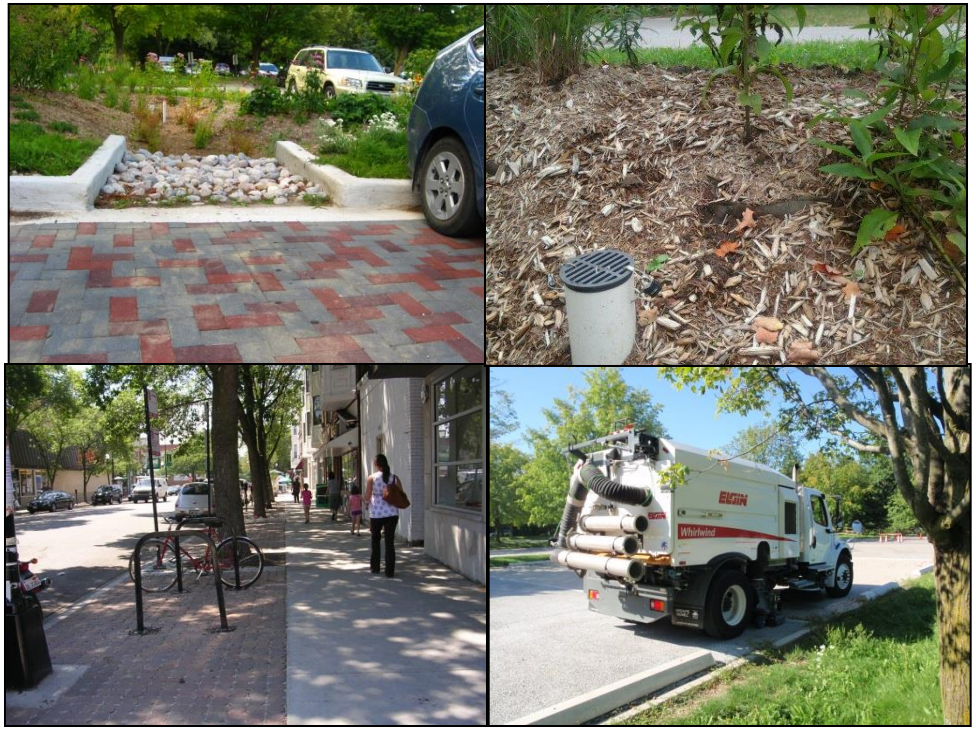
FOLLOW-UP TASKS: Remove or repair the obstruction. A vacuum truck service will be needed to clear obstructed inlet pipes.

Inspection and testing framework

INSPECTION AND TESTING FRAMEWORK		BMP						
Section	Indicator	Bioretention/ Rain Gardens/ Dry Swales	Enhanced Swales	Vegetated Filter Strips/Soil Amendments	Permeable Pavements	Underground Infiltration Systems	Green Roofs	Rainwater Cisterns
Visual inspection								
8.1.1	Contributing drainage area condition	x	x	x	x	x		x
8.1.2	Inlet//Flow spreader structural integrity	x	x	x		x		x
8.1.3	Inlet/Flow spreader obstruction	x	x	x		x		x
8.1.4	Pretreatment sediment accumulation	x	x			x		x
8.1.5	Inlet erosion	x	x					
8.1.6	BMP dimensions	x	x	x	x	x	x	x
8.1.7	Side slope erosion	x	x					
8.1.8	Surface ponding area	x	x					
8.1.9	Standing water	x	x	x	x		x	
8.1.10	Trash	x	x	x	x		x	
8.1.11	Filter bed erosion	x	x	x			x	
8.1.12	Mulch depth	x	x	x				
8.1.13	Filter bed sediment accumulation	x	x			x		
8.1.14	Surface ponding depth	x						
8.1.15	Filter bed surface sinking	x	x	x				
8.1.16	Check dams	x	x					
8.1.17	Vegetation cover	x	x	x	x		x	
8.1.18	Vegetation condition	x	x	x	x		x	
8.1.19	Vegetation composition	x	x	x	x		x	
8.1.20	Monitoring well condition	x			x	x		
8.1.21	Sub-drain/Perforated pipe obstruction	x			x	x		
8.1.22	Overflow outlet obstruction	x	x		x	x	x	x
8.1.23	Pavement surface condition				x			
8.1.24	Pavement surface sediment accumulation				x			
8.1.25	Control structure condition				x	x		x
8.1.26	Control structure sediment accumulation				x	x		
8.1.27	Green roof structural integrity						x	
8.1.28	Cistern structural integrity							x
8.1.29	Cistern sediment accumulation							x
Testing								
8.2	Soil characterization testing	x	x	x			x	
8.3	Sediment accumulation testing	x	x	x		x		x
8.4	Surface infiltration rate testing	x	x	x	x			
8.5	Natural or simulated storm event testing	x	x		x	x		
8.6	Continuous monitoring	x			x	x		
8.7	Green roof irrigation system test						x	
8.8	Green roof leak detection system test						x	
8.9	Cistern pump test							x

Consider I&M needs during BMP design and plan review

1. Provide pretreatment;
2. Include inspection and maintenance features (e.g. lockable standpipes/wells, valves for draining, traffic barriers, measuring tapes);
3. Specify plants tolerant to wet & dry conditions and de-icing salt laden runoff;
4. Plan for sediment removal (access, equip., disposal);
5. Design “easy-to-maintain” conveyances & inlets.



Inlet design

- Design for ease of sediment removal (e.g . forebays, gravel diaphragms);
- Wider is better;
- Provide 5 cm (2”) drop from imperv. surface to forebay/filter bed surface;
- Use level spreaders/check dams, diaphragms to slow & promote sheet flow;

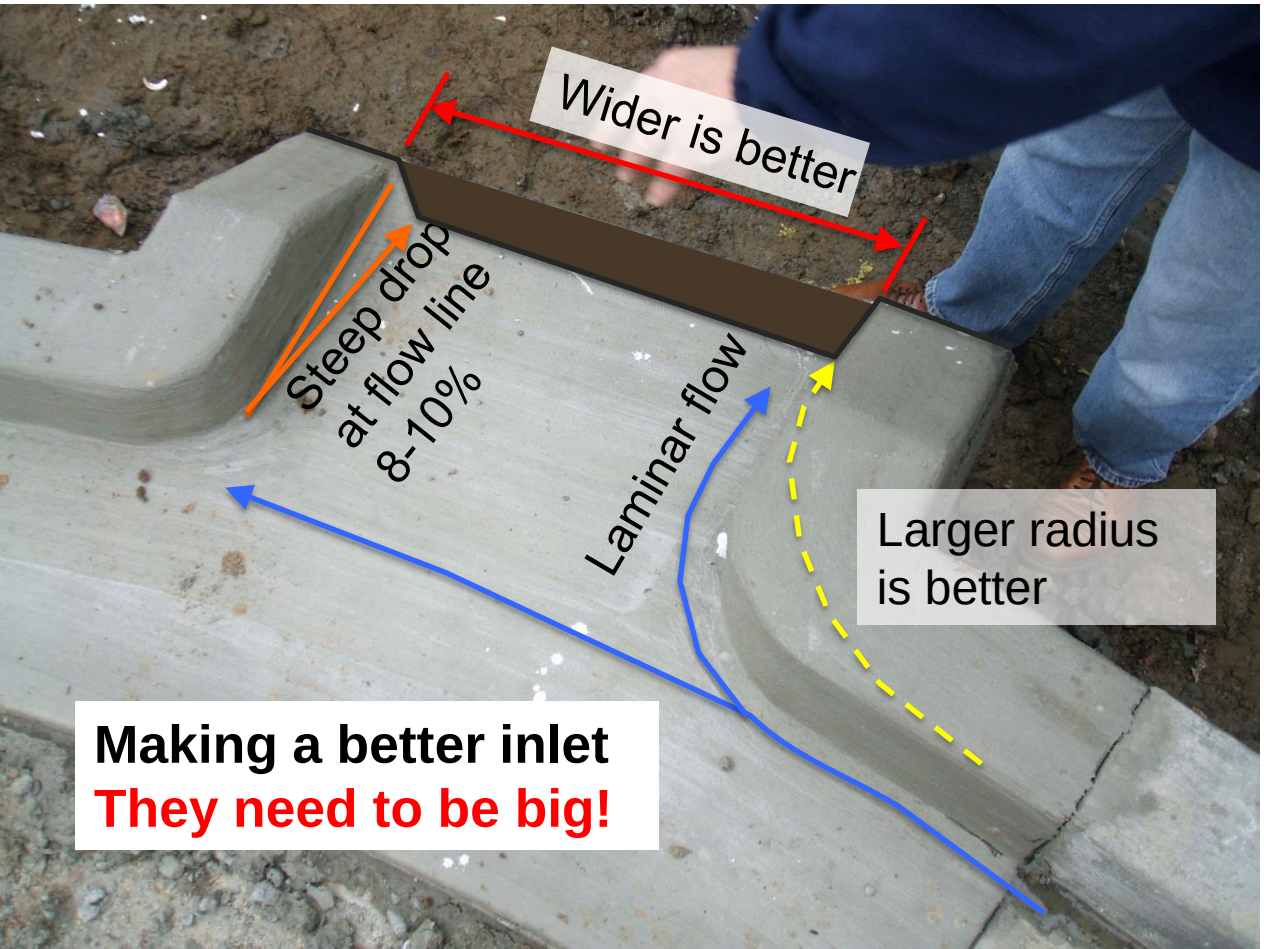
Source: James Urban, 2013

Lower maintenance inlet design:

Turning the water into the BMP

Water does not want to turn 90°

Use gravity and / or laminar flow to get it around the corner



Making a better inlet
They need to be big!

Cheater curbs

Too low and narrow

Too narrow

Snow storage

- Plan for where snow will be stored/piled during site drainage and BMP design;
- Avoid storing snow on permeable pavements (risk of clogging);
- Store on/upstream of pervious areas or vegetated BMPs;
- Keep woody vegetation outside of snow storage areas;
- Design for sediment accumulation in easily accessed areas (e.g. forebays, impermeable pavements).

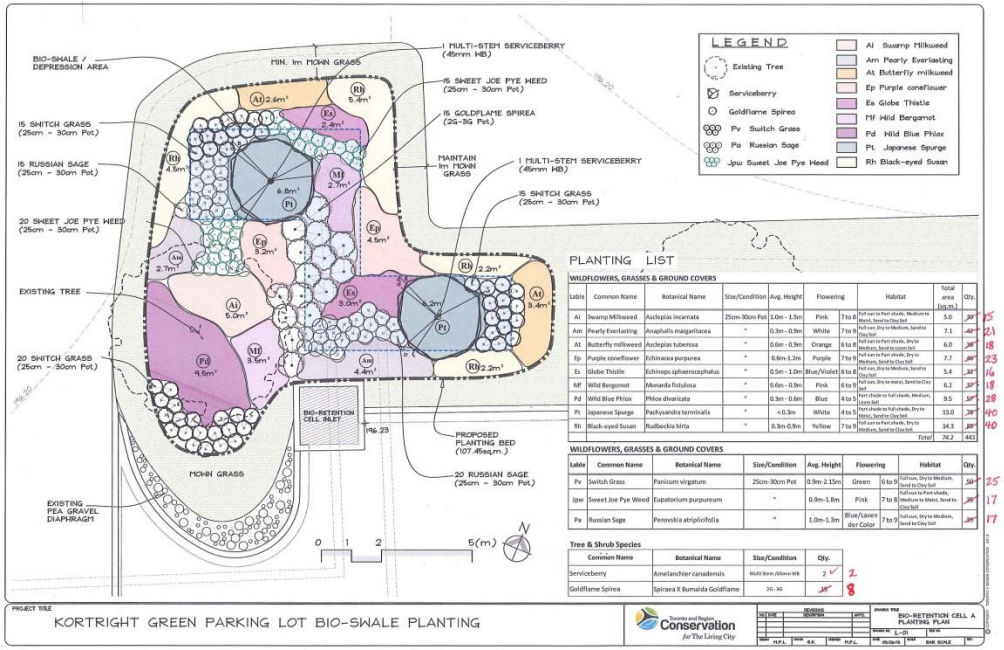
Secure easements for I&M access through plan review

Maintenance easements:

- Legal document granting municipality right-of-entry to a private property for BMP I&M purposes;
- Secured during plan review;
- Must cover:
  - Footprint of the BMP;
  - Margin of land around all BMP components sufficient for access by maintenance/repair machinery
  - Access paths;
  - Conveyances and pretreatment devices associated with the BMP.

Require as-built drawings from construction contractors

- Must describe any change orders or other deviations from final design drawings;
- Must include planting plan so inspectors and maintainers of vegetation can distinguish plantings from weeds;
- Used to populate the BMP inventory/I&M tracking database and compare to results from Project Acceptance inspections.



Encourage community participation

- Coordinate a volunteer, “Adopt-a-BMP” program that recruits community members/groups to help with some routine maintenance tasks (e.g. trash removal and weeding);
- Works best for highly visible BMPs that have safe and easy access;
- Provide certificates of accomplishment, prizes, publicity or other incentives to make participation a rewarding experience.

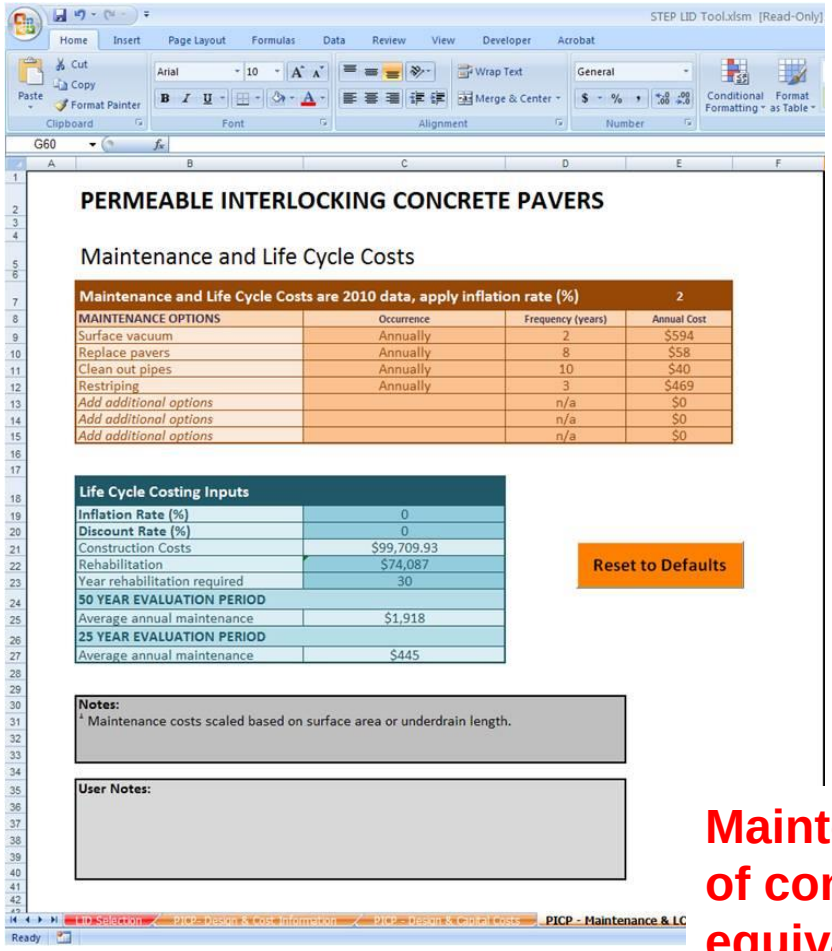
Could reduce maintenance costs for municipalities

Life Cycle Costs of LID BMP I&M

- Collaborative project with University of Toronto, completed 2013
  - Mariko Uda and Chris Kennedy - Civil Engineering Department
- Evaluates **capital** and **life cycle I&M** costs over 50 years based on:
  - Ontario input costs from RS Means and industry surveys
  - LID designs from local guides
- **Life Cycle Costing Tool** for planning stage estimates
  - Spreadsheet decision support tool

Available to download at www.sustainabletechnologies.ca

Life Cycle Costs of LID BMP I&M



PERMEABLE INTERLOCKING CONCRETE PAVERS

Maintenance and Life Cycle Costs

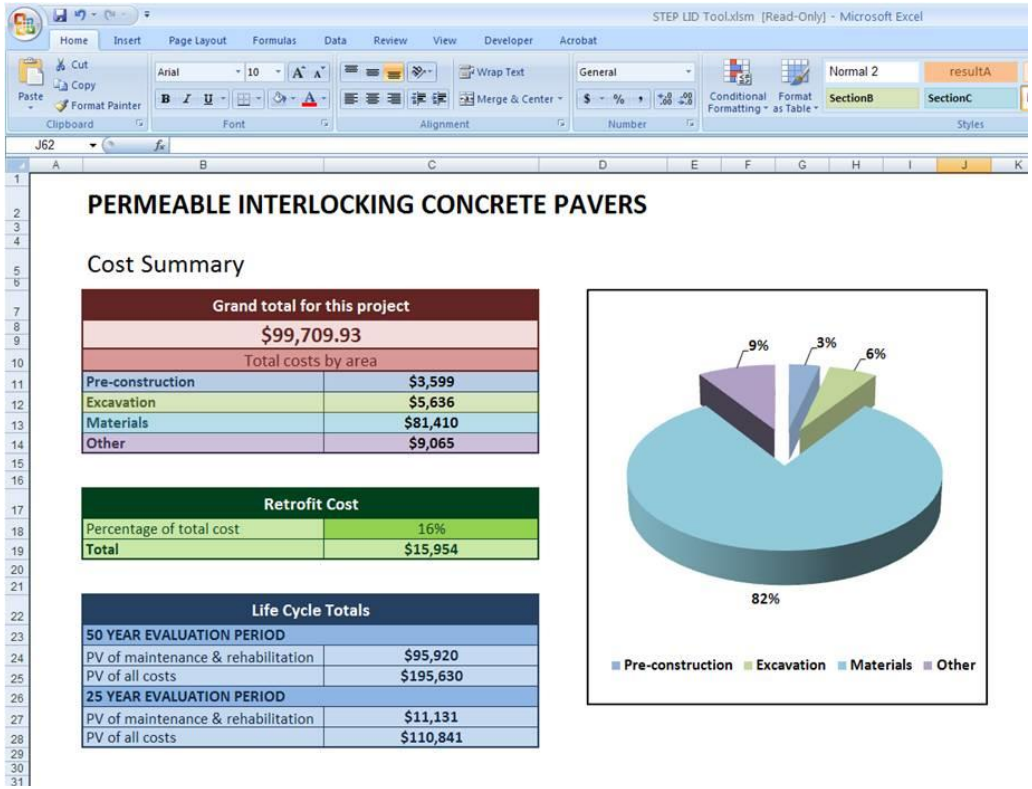
Maintenance and Life Cycle Costs are 2010 data, apply inflation rate (%)			2
MAINTENANCE OPTIONS	Occurrence	Frequency (years)	Annual Cost
Surface vacuum	Annually	2	$594
Replace pavers	Annually	8	$58
Clean out pipes	Annually	10	$40
Restriping	Annually	3	$469
Add additional options		n/a	$0
Add additional options		n/a	$0
Add additional options		n/a	$0

Life Cycle Costing Inputs	
Inflation Rate (%)	0
Discount Rate (%)	0
Construction Costs	$99,709.93
Rehabilitation	$74,087
Year rehabilitation required	30
50 YEAR EVALUATION PERIOD	
Average annual maintenance	$1,918
25 YEAR EVALUATION PERIOD	
Average annual maintenance	$445

Reset to Defaults

Notes:
[4] Maintenance costs scaled based on surface area or underdrain length.

User Notes:



PERMEABLE INTERLOCKING CONCRETE PAVERS

Cost Summary

Grand total for this project	
$99,709.93	
Total costs by area	
Pre-construction	$3,599
Excavation	$5,636
Materials	$81,410
Other	$9,065

Retrofit Cost	
Percentage of total cost	16%
Total	$15,954

Life Cycle Totals	
50 YEAR EVALUATION PERIOD	
PV of maintenance & rehabilitation	$95,920
PV of all costs	$195,630
25 YEAR EVALUATION PERIOD	
PV of maintenance & rehabilitation	$11,131
PV of all costs	$110,841

Maintenance and rehabilitation costs are ~10-15% of construction costs over 1st 25 yrs. and roughly equivalent to construction costs over 50 yrs.

Summary of key points

- Rigorous inspection and testing prior to acceptance/assumption of the BMP and as part of routine operation/ maintenance will help avoid more costly repair work;
- Focus on simple visual indicators so most inspection work can be done rapidly by maintenance field crews;
- Consider I&M needs during BMP design and plan review;
  - Include pretreatment devices and features needed to perform I&M tasks
  - Secure easements for access
  - Design conveyances for ease of maint.

Next steps…

- Consultation on first draft with Project Advisory Committee in April/May;
- Publication of final guide (Sept. 2015);
- LID inspector training course (Sept. 2015);
- Updates to LID Planning and Design Guide (2016).

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Thank you

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