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Implementing Green Infrastructure in the Public ROW

Lake Shore Boulevard East Public Realm Pilot Project

Sonja Vangjeli, Waterfront Toronto, Planning & Design
Kristina Hausmanis, City of Toronto, Transportation Services

March 20, 2019

LEARNING OBJECTIVES

1. See an interesting example of incorporating green infrastructure in a highly constrained and challenging transportation corridor.

2. Understand the challenges to approvals and implementation process of green infrastructure in public streets in Toronto.

3. See examples of design strategies to address challenges and pursue opportunities for low-maintenance green infrastructure in the public realm.

POLICY CONTEXT: Green Streets Technical Guidelines

Council Directive to develop "*green infrastructure standards for the public right-of-way for implementation in Transportation Services and Toronto Water capital projects...*"

October 2013, (PW25.7)

POLICY CONTEXT: Multiple Drivers for Implementation of Green Streets

Managing stormwater runoff to enhance water quality, to reduce erosion in receiving water bodies, and to enhance urban resilience.

Provide opportunities to enhance biodiversity

Mitigating urban heat island effect

Enhancing the extent and longevity of the urban forest

Enhancing air quality

Promoting infiltration

Conserving / generating energy

Beauty

POLICY CONTEXT: Green Streets Evolution

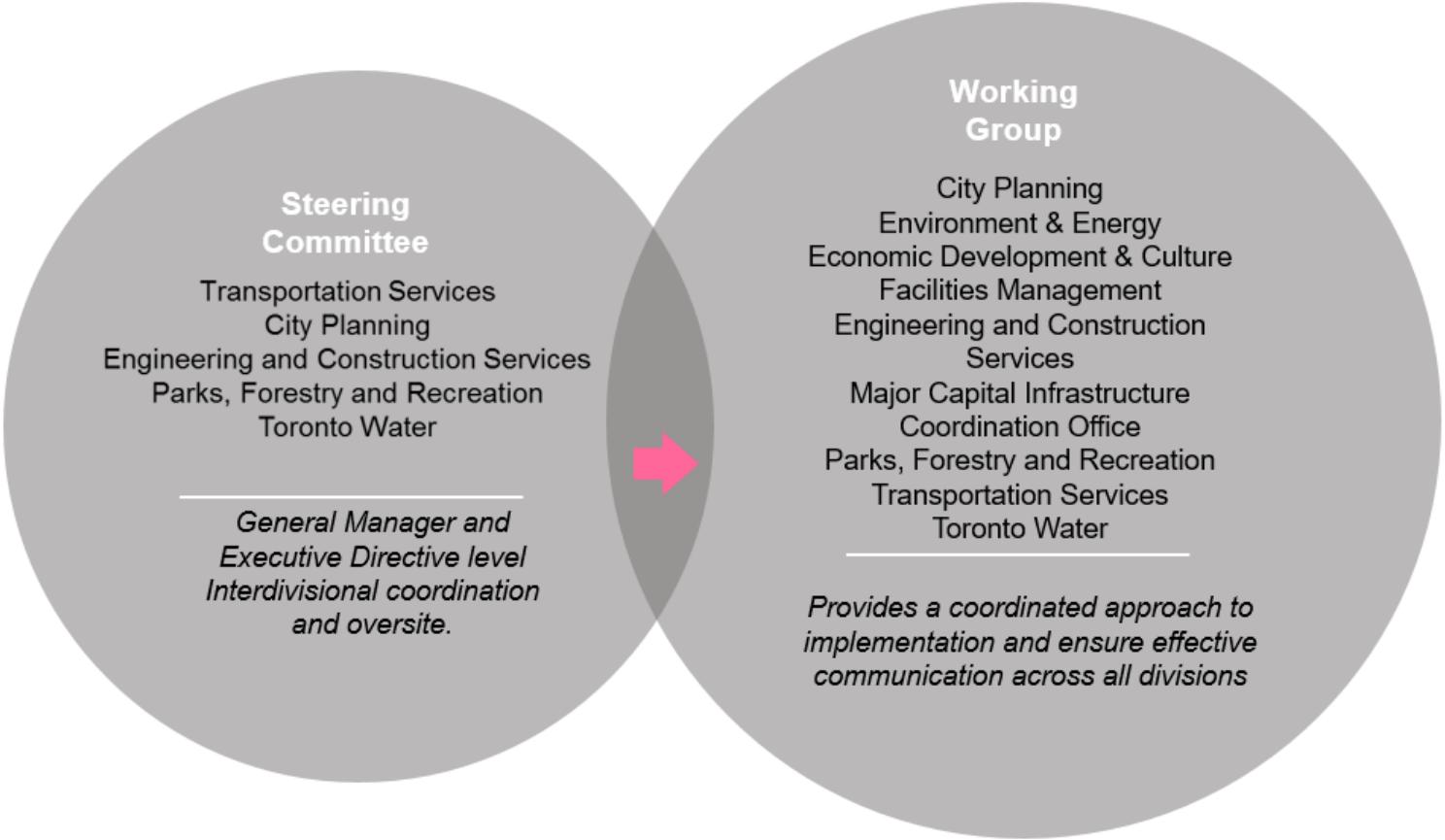
PHASE 1

(2008-2017)
Early Projects and Development of Green Streets Technical Guidelines.

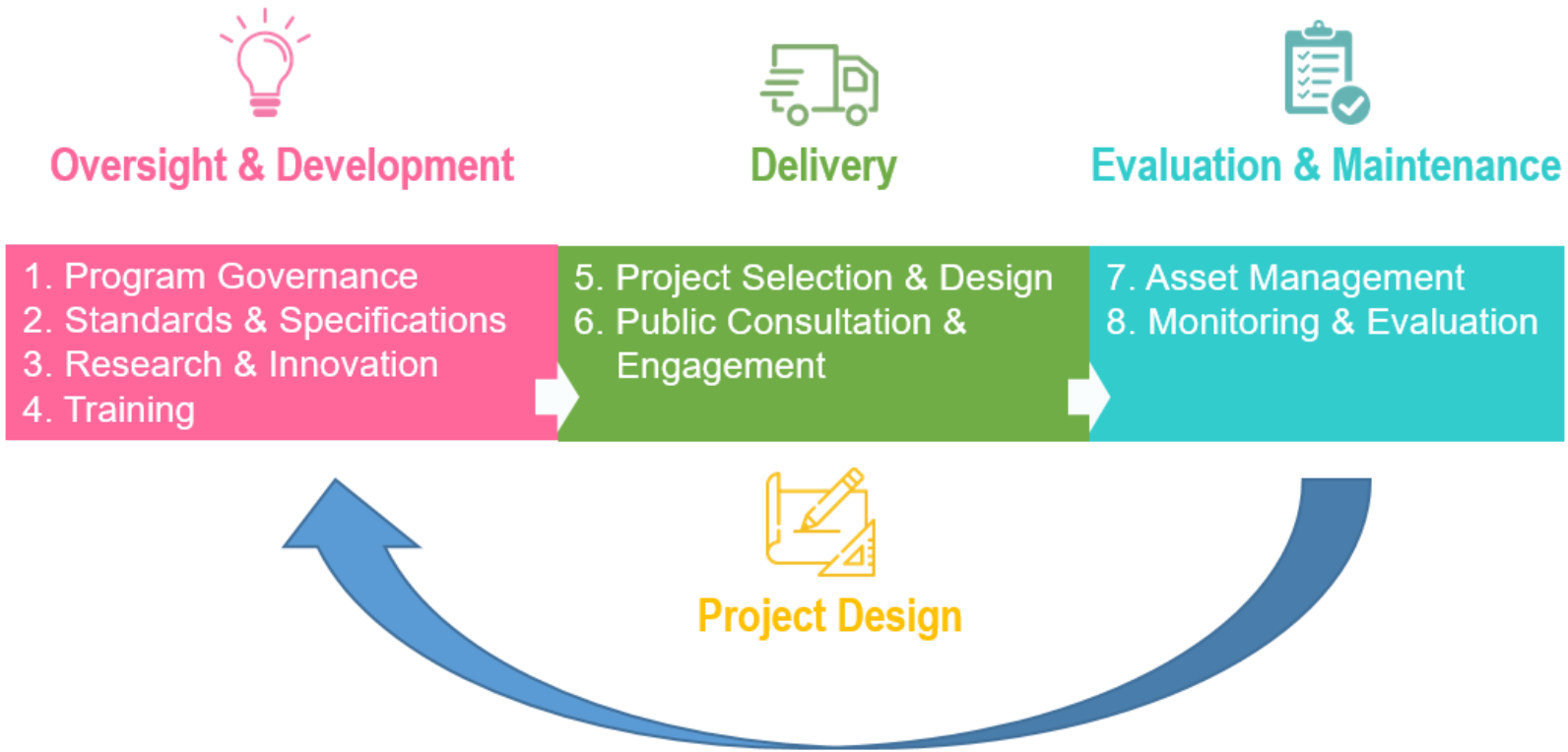
PHASE 2

(2017- Present)
Integration of Green Streets across all City departments in order to work towards collaborative and functional implementation.

POLICY CONTEXT: Implementation Across Divisions



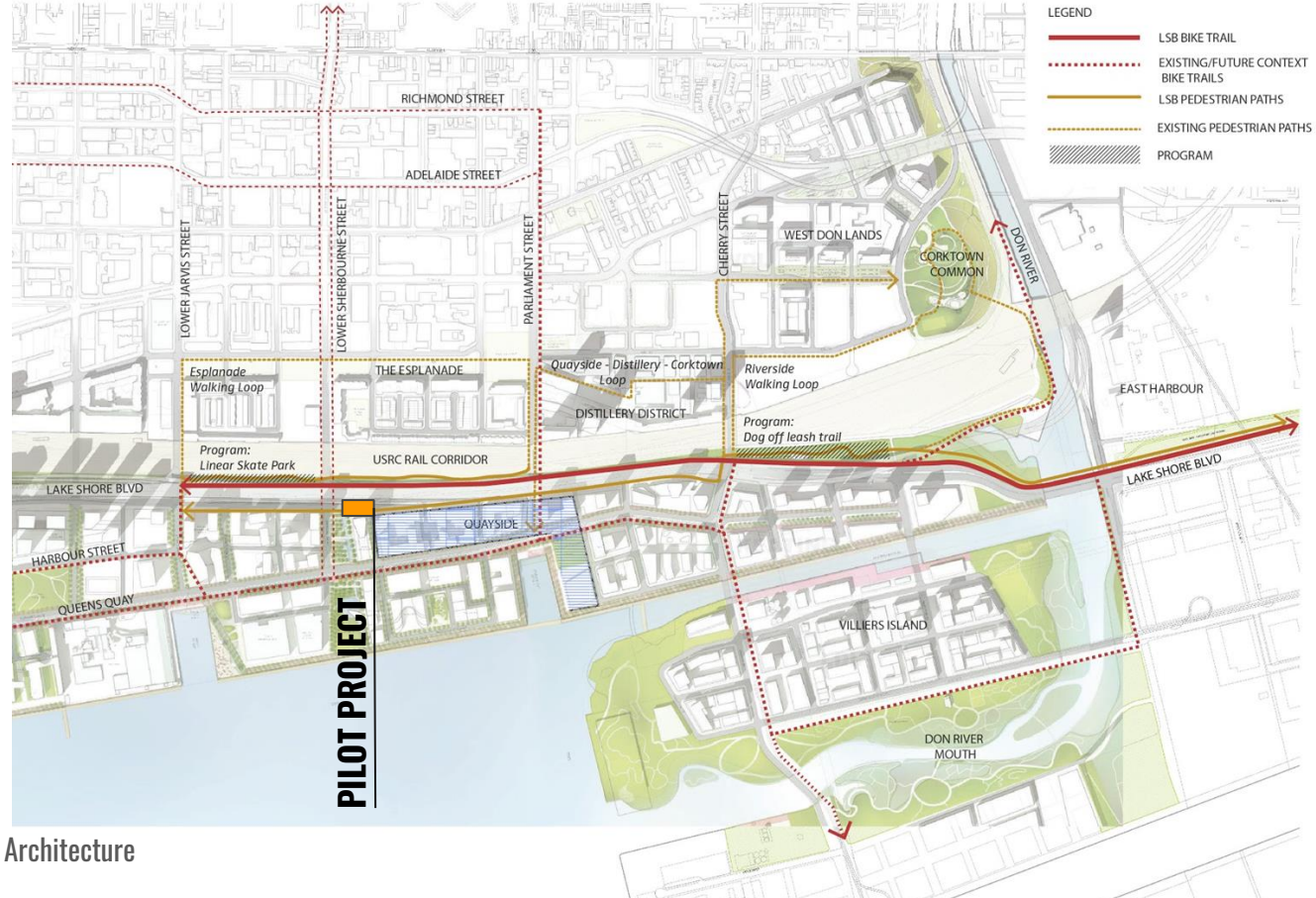
POLICY CONTEXT: Green Streets Implementation Strategy



PROJECT CONTEXT: Gardiner Public Realm

The Gardiner East EA was approved in Nov. 2017 including provisions for public realm improvements at grade along Lake Shore Blvd. East from Jarvis St. to Logan Ave. to support new development along the eastern waterfront:

1. **Improved Pedestrian & Cycling Infrastructure**
2. **Enhanced Stormwater Management**
3. **Public Realm Implementation Plan**



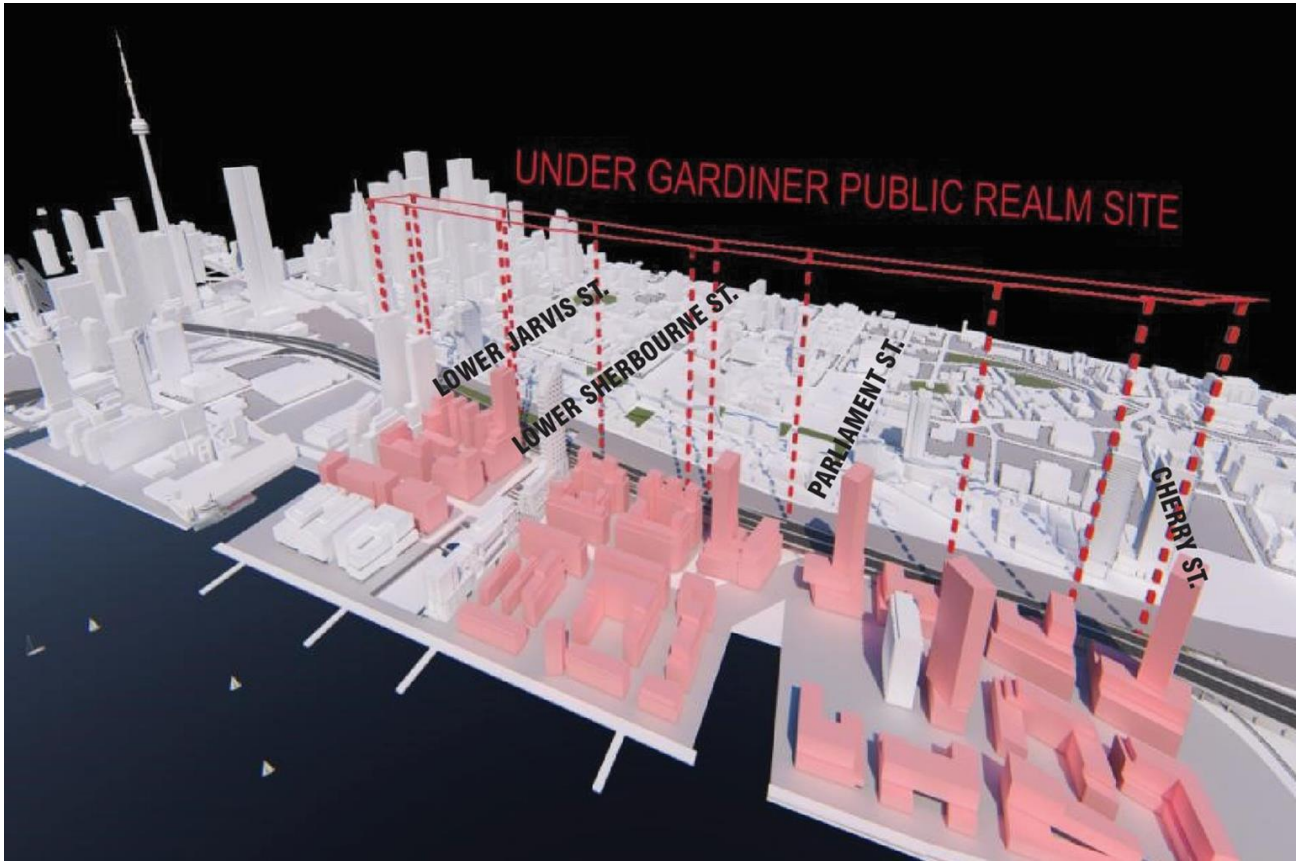
Design by Dillon Consulting + West 8 Landscape Architecture

PROJECT CONTEXT: Gardiner Public Realm

Existing Conditions: South Side

Existing Conditions: North Side

PROJECT CONTEXT: Gardiner Public Realm



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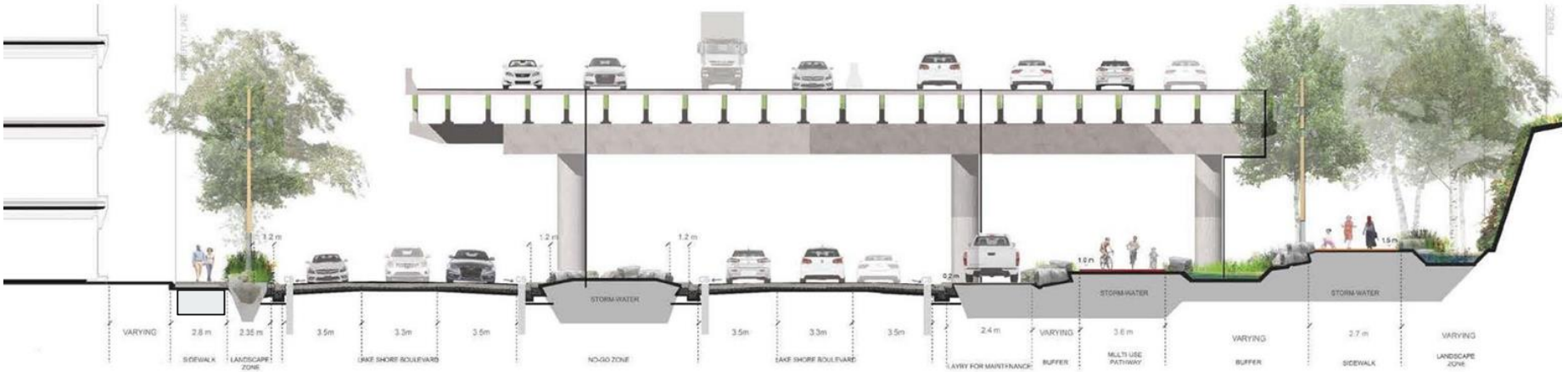
PROJECT CONTEXT: Gardiner Public Realm

South Side Public Realm

North Side Linear Park

Design by Dillon Consulting + West 8 Landscape Architecture

PROJECT CONTEXT: Gardiner Public Realm



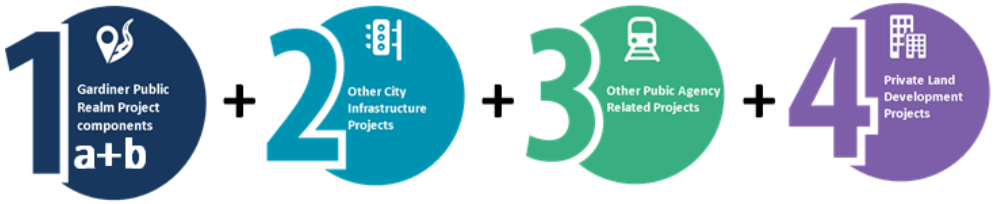
South Side Public Realm

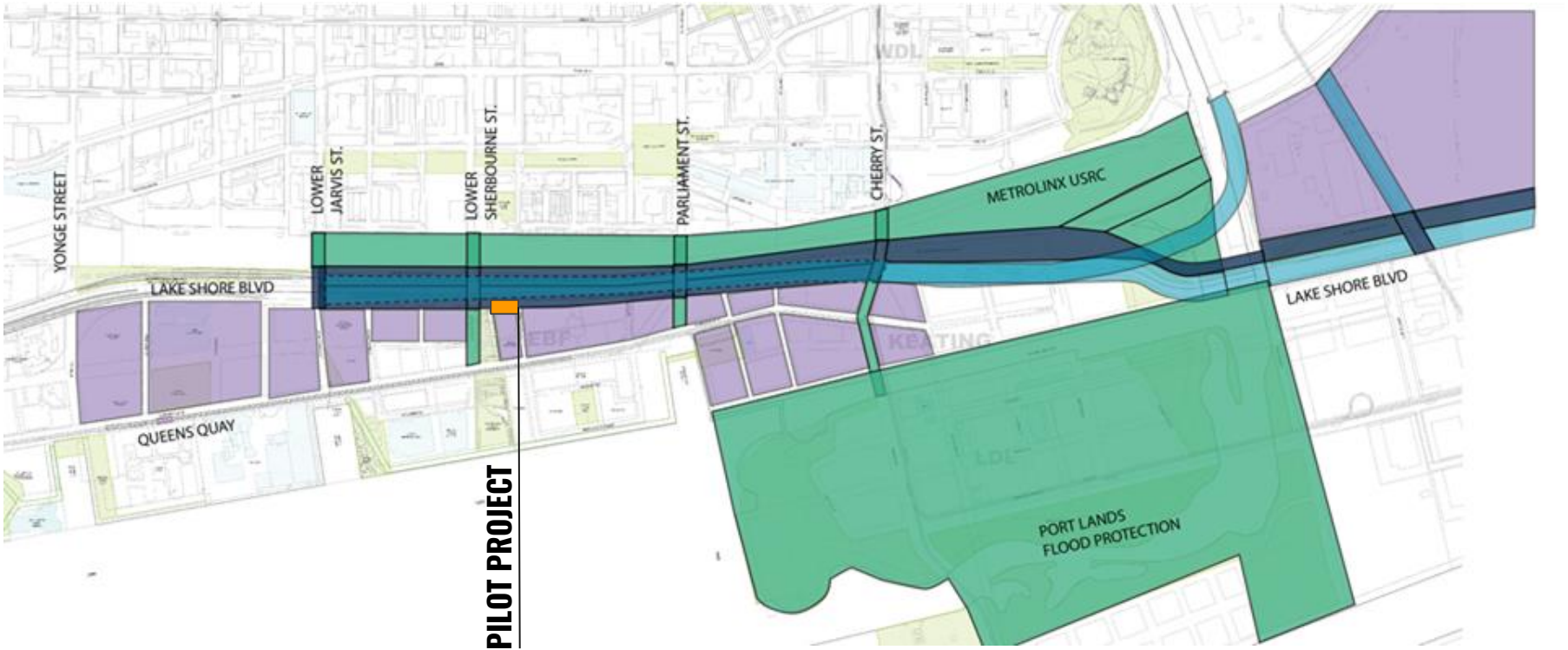
North Side Public Realm

Design by Dillon Consulting + West 8 Landscape Architecture

PROJECT CONTEXT

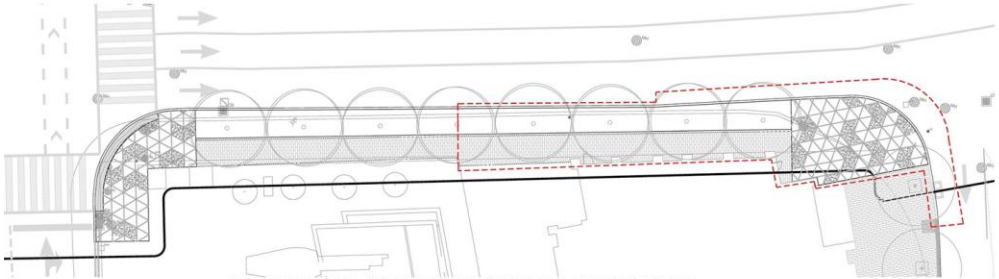
Gardiner Public Realm Implementation Plan





PILOT OPPORTUNITY

CONTEXT PLAN
1:250



FUTURE VISION - LOWER SHERBOURNE TO BONNYCASTLE
N.T.S.

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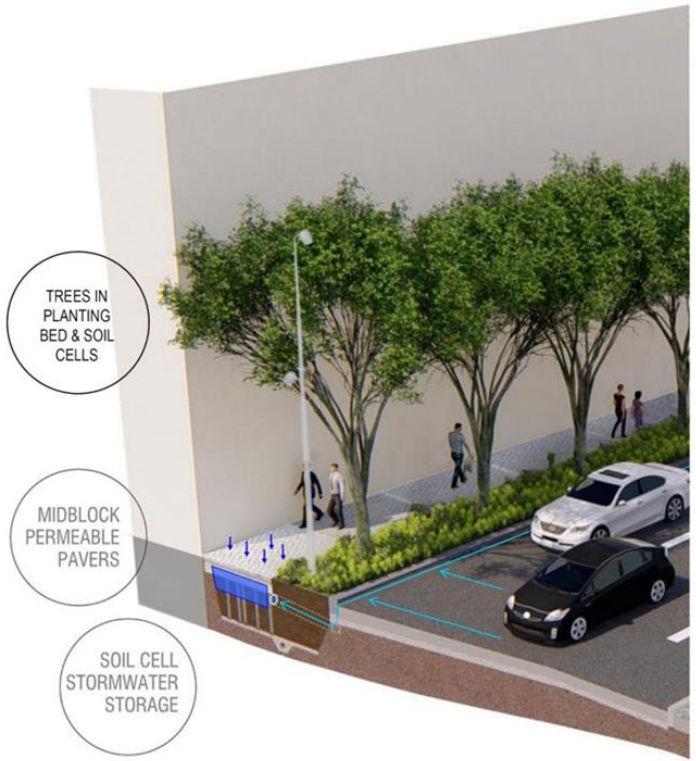
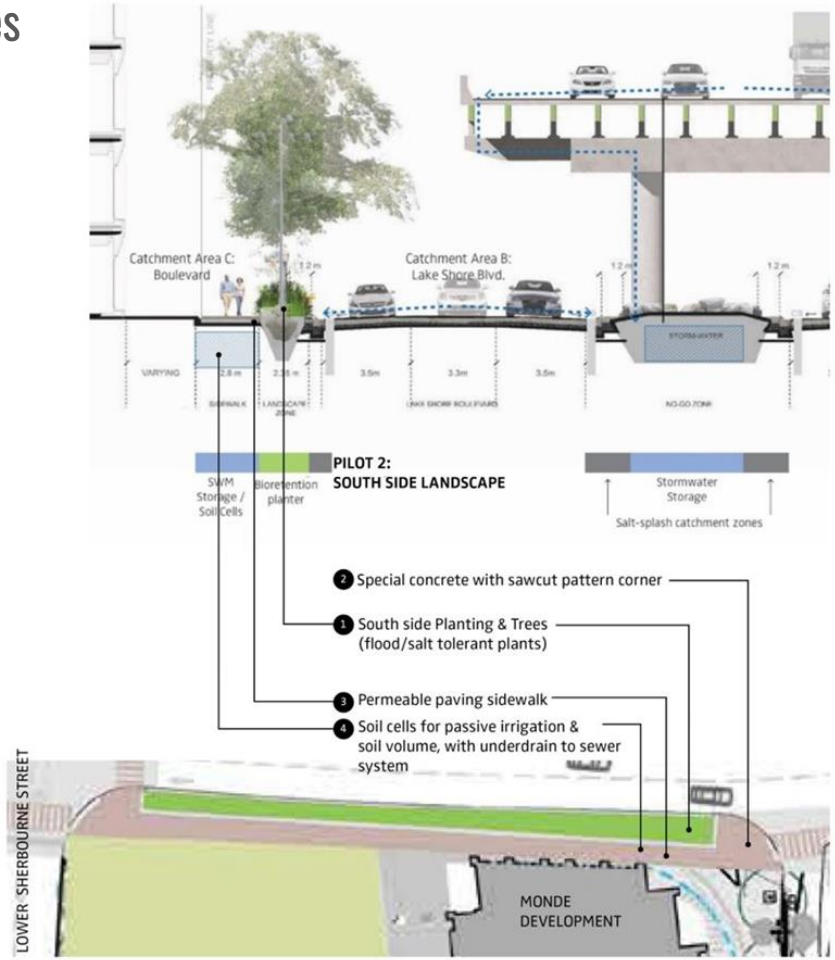
PILOT PROJECT: South Boulevard Design Strategies





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SITE CONSTRAINTS

1. Narrow boulevard area
2. Shaded by tall tower
3. Adjacent to high traffic road
4. Heavily salted in winter
5. Existing underground utilities

CHALLENGES TO GREEN INFRASTRUCTURE IMPLEMENTATION:

1. Utility Coordination

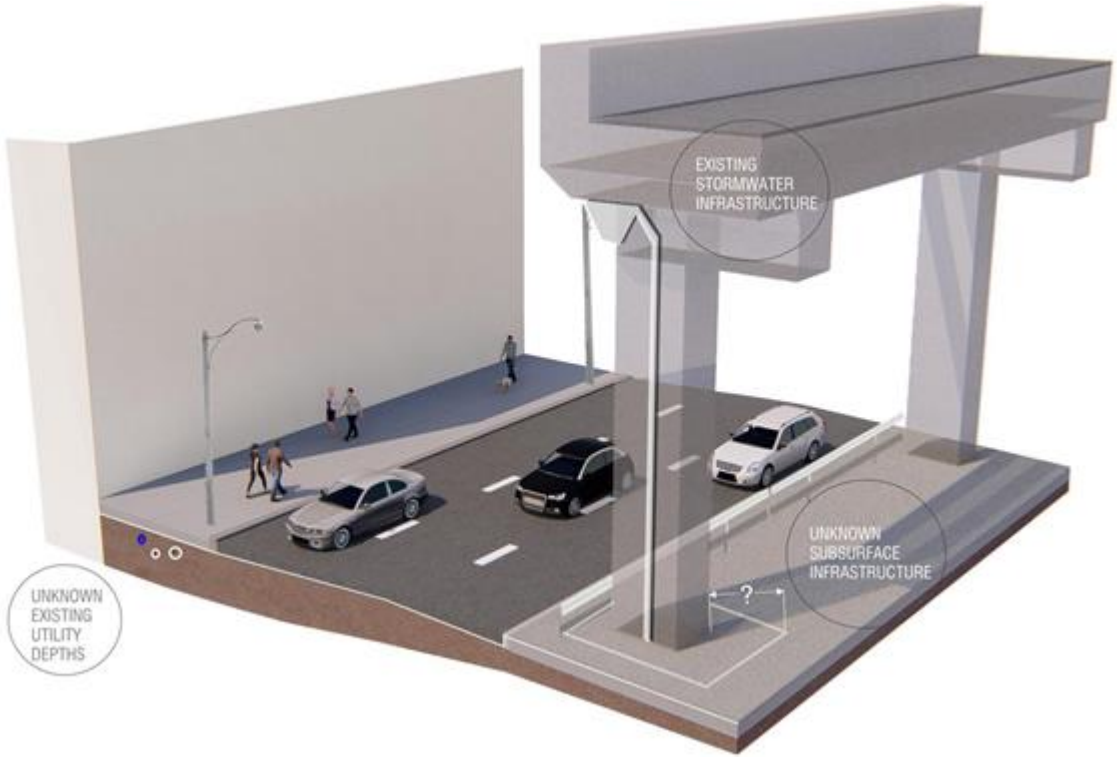
2. Environmental Approvals

3. Permeable Paving

4. Operations & Maintenance

OPPORTUNITIES:

5. Monitoring



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CHALLENGES TO GREEN INFRASTRUCTURE IMPLEMENTATION:

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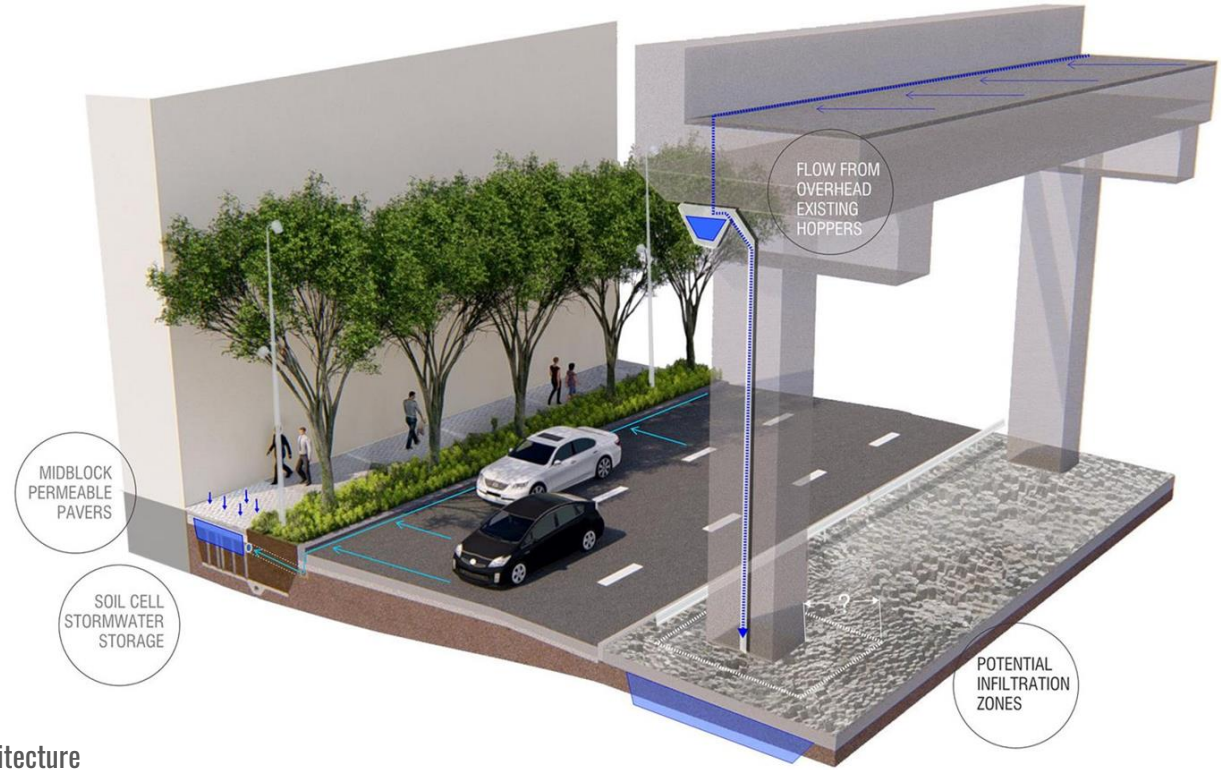

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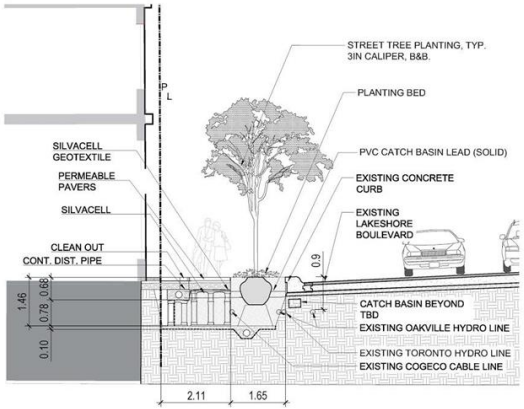
ORIGINAL DESIGN



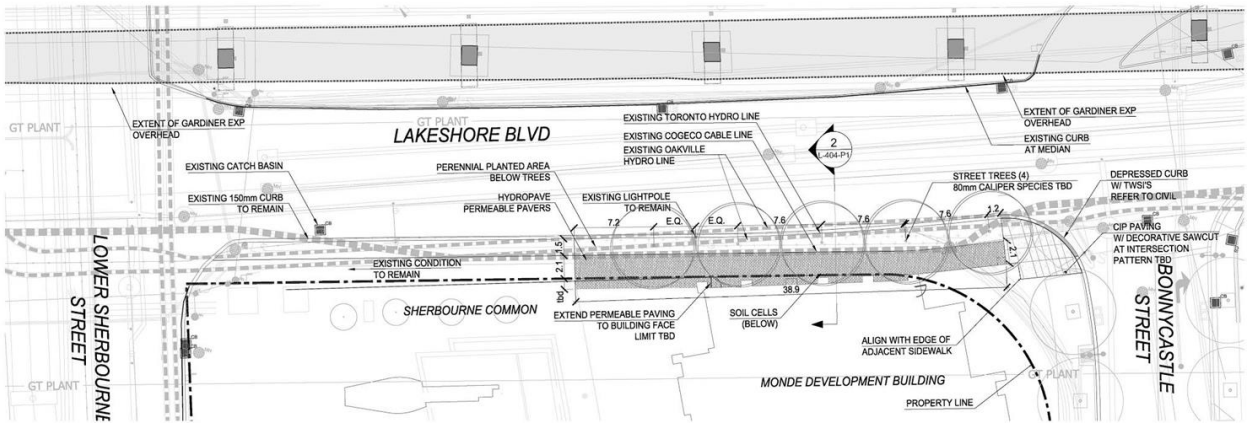
2 SOUTH SIDE PILOT - TYPICAL SECTION
1:50

NOTES

1. DRAWING ASSUMES 25' (7.62M) SETBACK BETWEEN EXISTING LIGHT POLE AND NEW TREES.
2. SOIL VOLUME = 36.6m3 PER TREE. CALCULATION ASSUMES A CONTINUOUS SOIL TRENCH, AND EXCLUDES ROOT BALL VOLUMES.
3. DESIGN ASSUMES MAINTAINING THE EXISTING CURBS AND ROAD ALIGNMENTS FOR LAKESHORE BOULEVARD.
4. TREE SPECIES TBD.
5. TORONTO HYDRO UTILITY ALIGNMENT SOURCED FROM PROVIDED SUBTERRANEAN UTILITY ENGINEERING DRAWING. DEPTH TO BE VERIFIED IN FIELD. CURRENT DEPTH ASSUMED AS 0.9m FROM SURFACE.
6. UTILITY INFORMATION SOURCED FROM CITY OF TORONTO DIGITAL MAP OWNERS GROUP MAP DATABASE. DEPTHS AND ALIGNMENTS TO BE VERIFIED IN FIELD.

LEGEND

PROPERTY LINE
LIMIT OF WORK
SUBSURFACE ELEMENTS
EXTENT OF SOIL CELLS IN CONTINUOUS TREE TRENCH – INSTALL SOIL CELLS AROUND UTILITY CHAMBERS, TO BE VERIFIED IN FIELD
UTILITY LINE
PLANTING AND PAVING
PROPOSED TREE
PERMEABLE PAVERS
UTILITIES
TRAFFIC SIGNAL POLE (EXISTING)
TRAFFIC CONTROL PANEL (EXISTING)
FIRE HYDRANT (EXISTING)
MAN HOLE (EXISTING)
HYDRO POLE (EXISTING)
UTILITY BOX (EXISTING)
LIGHT POLE (EXISTING)
PROPOSED RELOCATION OF CATCH BASIN
CATCH BASIN (EXISTING)
GARDINER DECK DRAIN (EXISTING)
STREET SIGN (EXISTING)
TRAFFIC CONTROL BOX (EXISTING)



1 LOWER SHERBOURNE STREET INTERSECTION - PLAN
1:150

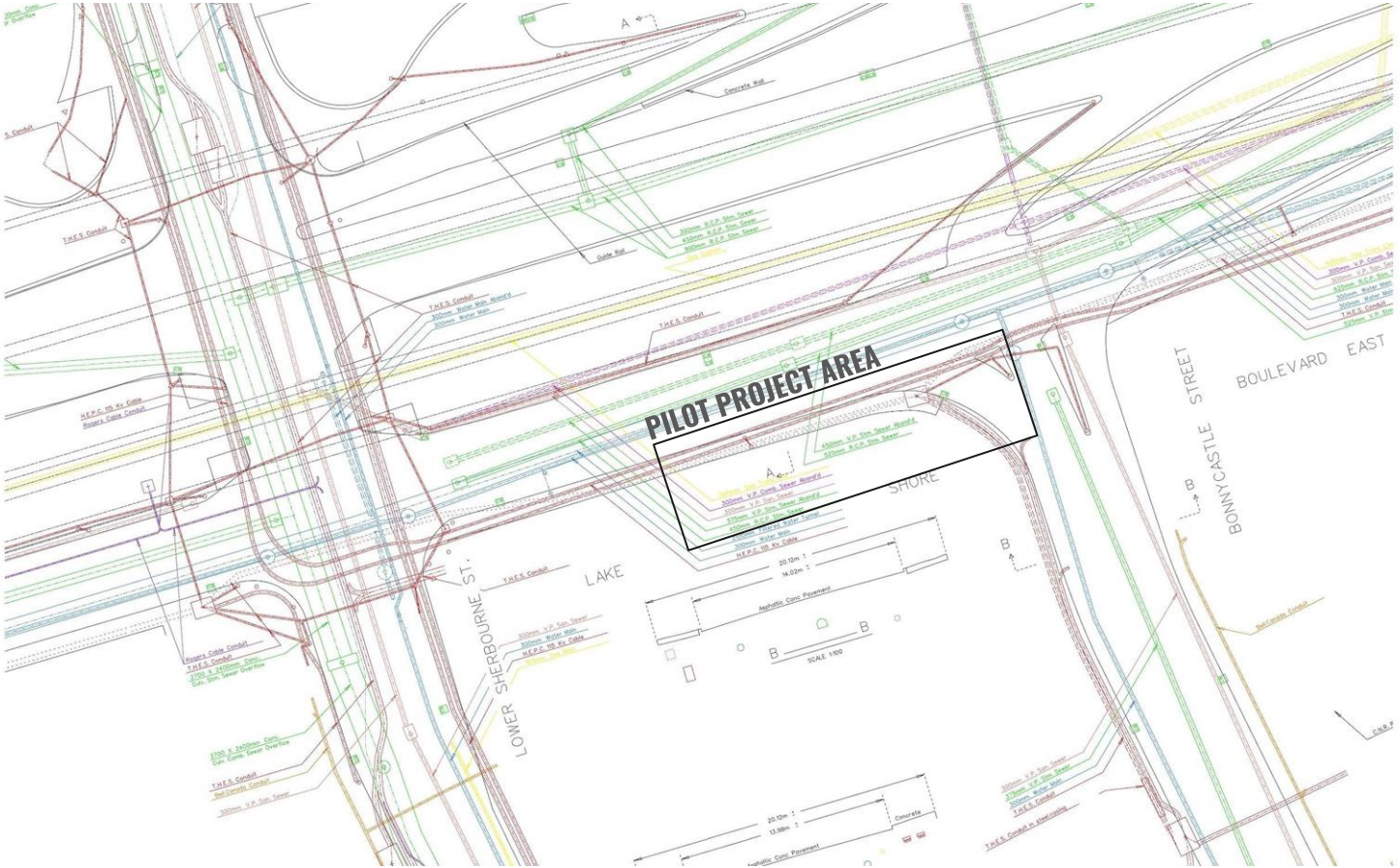
Design by Dillon Consulting + West 8 Landscape Architecture

UTILITY COORDINATION

Challenges:

- Existing infrastructure in urban streets constrain space available for LIDs with clearances that make it difficult to plant trees and integrate stormwater infrastructure;
- Utility horizontal clearance requirements make it difficult to fit trees in urban contexts;
- Precise utility location information is not commonly available and requires daylighting utilities;
- Protection of utilities and planting best practices are often in conflict .

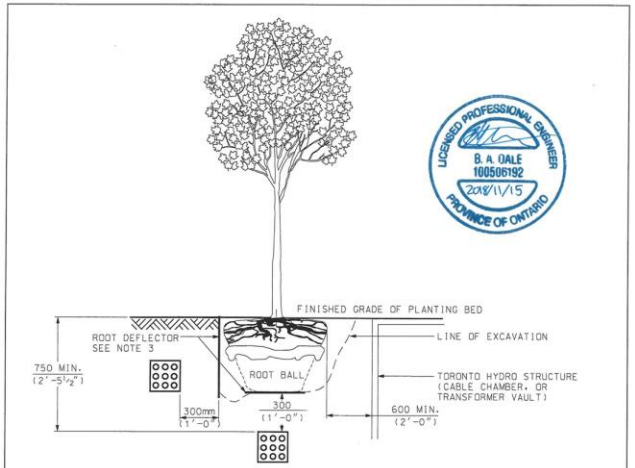
UTILITY COORDINATION: Existing Utilities



DMOG Utility Data

UTILITY COORDINATION: Required Clearances

Toronto Hydro Tree Planting Clearance Requirements 2019 Update

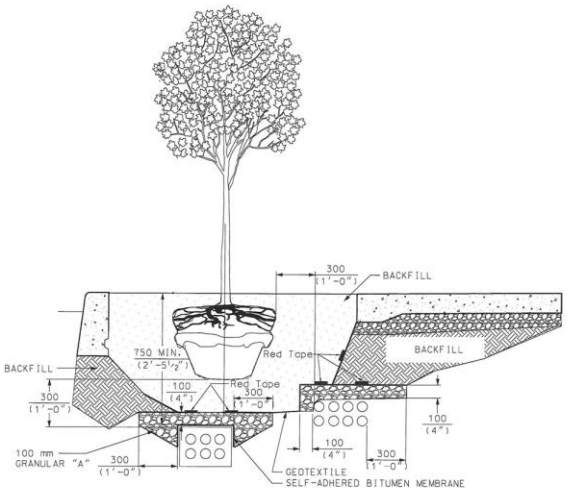


TYPICAL TREE INSTALLATION ⚠

NOTES: ⚠

1) FINAL LOCATION OF THE TREES MUST BE CONFIRMED AND APPROVED BY TORONTO HYDRO ELECTRIC SYSTEM TO AVOID INTERFERENCE WITH THE EXISTING TORONTO HYDRO STRUCTURE.
2) IN CASES WHERE 600 mm (2'-0") CLEARANCE CANNOT BE MAINTAINED, A MINIMUM CLEARANCE OF 300 mm (1'-0") CAN BE PERMITTED, PROVIDED A ROOT DEFLECTOR IS INSTALLED ON THE SIDES OF THE ROOT BALL ADJACENT TO THE TORONTO HYDRO STRUCTURE.
3) A ROOT DEFLECTOR SHALL BE PLACED BETWEEN TREE ROOTS AND TORONTO HYDRO STRUCTURE TO PREVENT DAMAGE TO THE STRUCTURE. A ROOT DEFLECTOR SHALL BE 6.4 mm (¼") RIGID PLASTIC, FIBERGLASS, A NON-DEGRADABLE MATERIAL OR EQUIVALENT.
4) IF TREES ARE PLANTED VIA LONG TRENCHING, PARALELLED TO THESL STRUCTURE, ROOT DEFLECTORS MUST BE INSTALLED ON THE SIDE OF THE TREE FACING THE THESL STRUCTURE, AND MUST EXTEND 1200 mm (4'-0") FROM THE CENTER OF THE TREE TRUNK, PARALLEL TO THE THESL STRUCTURE. IN BOTH DIRECTIONS; OR THE DEFLECTOR MUST CIRCLE THE TREE.
5) ROOT DEFLECTORS SHALL HAVE A COLLAR TO KEEP THE TOP OF THE DEFLECTOR AT FINISHED GRADE LEVEL, AND SHALL EXTEND TO THE BOTTOM OF THESL STRUCTURE, OR TO THE BOTTOM OF THE ROOT BALL FOR SHALLOW STRUCTURES.
6) SIDEWALK AND CURB SPECIFICATIONS AS PER CITY STANDARD.
7) SOIL AND TREE PLANTING SPECIFICATIONS AS PER URBAN FORESTRY STANDARDS.
8) IF DEPTH OF COVER TO TOP OF STRUCTURE IS LESS THAN 750 MM (2'-5½"), CONTACT TORONTO HYDRO FOR APPROVAL.

DISTRIBUTION CONSTRUCTION STANDARD Civil Construction	UNDERGROUND CLEARANCES TREE CLEARANCE REQUIREMENT IN THE VICINITY OF TORONTO HYDRO STRUCTURE							
TORONTO HYDRO	Approved By: 2018/11/15	Drafted By: U.K.	Designed By: B.D.	Original Issue: J.D. 2010-10-21	Scale: N.T.S.	Rev: 2	31-0400	1/2



TREE INSTALLATION IN OPEN PLANTING SIDEWALK/BOULEVARDS ⚠

NOTES: ⚠

9) TREE INSTALLATION PROCEDURE:
- EXCAVATE (HAND DIG OR HYDRO VAC TO EXPOSE EXISTING DUCTS).
- REFER TO ESA "GUIDELINE FOR EXCAVATING IN THE VICINITY OF UTILITY LINES" FOR INFORMATION.
- CALL HYDRO INSPECTIONS FOR APPROVAL TO INSTALL DUCT PROTECTION

FOR DIRECT BURIED DUCTS:
- COVER DUCTS WITH MIN. OF 100 mm GRANULAR "A".
- OVERLAY GEOTEXTILE AND RED TAPE

FOR CONCRETE ENCASED DUCTS:
- PROTECT CONCRETE DUCT WITH A SELF-ADHERED BITUMEN MEMBRANE
- COVER DUCTS WITH 100mm GRANULAR "A" AS SHOWN.
- OVERLAY GEOTEXTILE AND RED TAPE

10) ALL SELF-ADHERED BITUMEN MEMBRANE, GEOTEXTILE AND WARNING TAPE TO EXTEND 1.2 m IN EITHER DIRECTION ALONG DUCT (2.4m MIN. CENTERED ON TREE). INSTALL RED "ELECTRICAL DANGER" TAPE ON TOP OF ROOT DEFLECTOR MEMBRANE

DISTRIBUTION CONSTRUCTION STANDARD Civil Construction	UNDERGROUND CLEARANCES TREE CLEARANCE REQUIREMENT IN THE VICINITY OF TORONTO HYDRO STRUCTURE							
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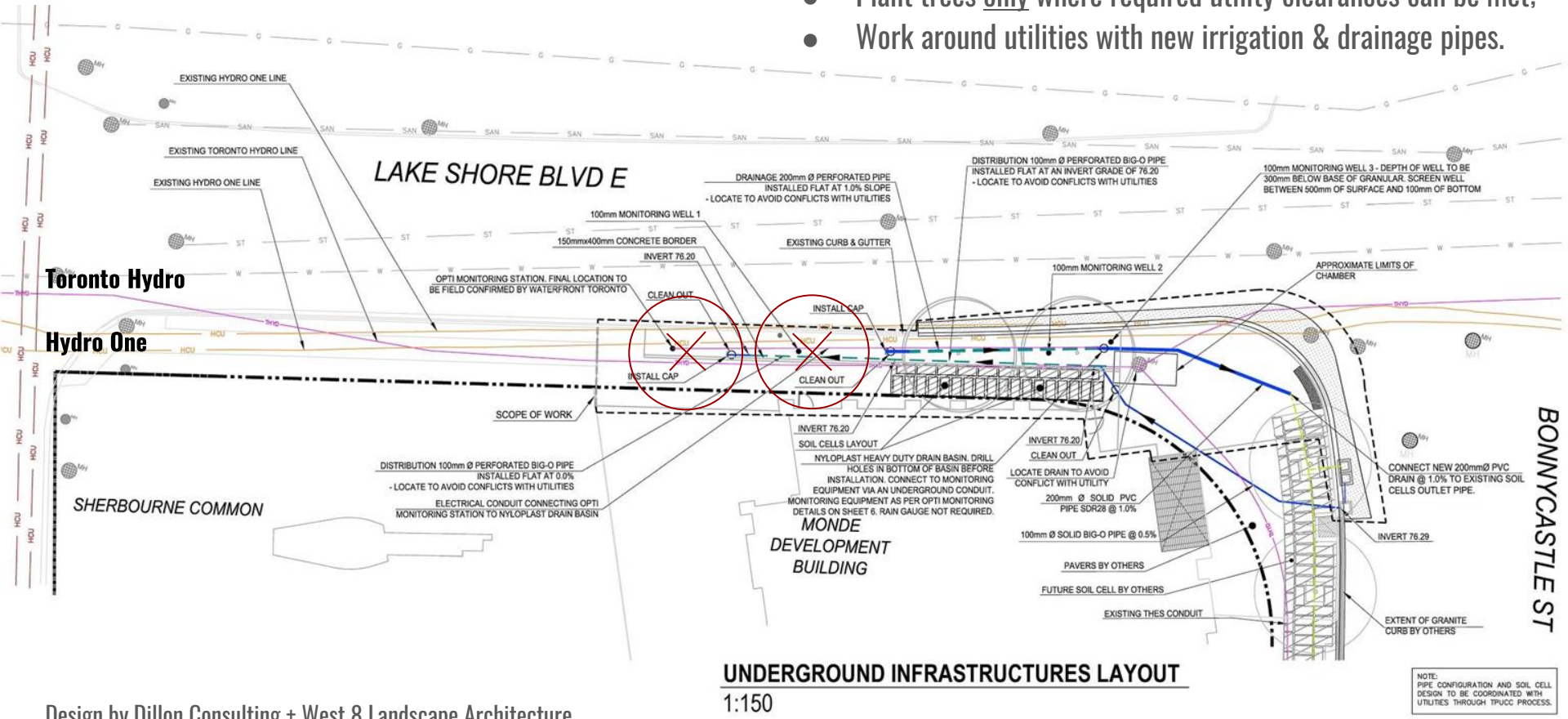
UTILITY COORDINATION

Pilot Strategy:

- Plant trees only where required utility clearances can be met;
- Work around utilities with new irrigation & drainage pipes.



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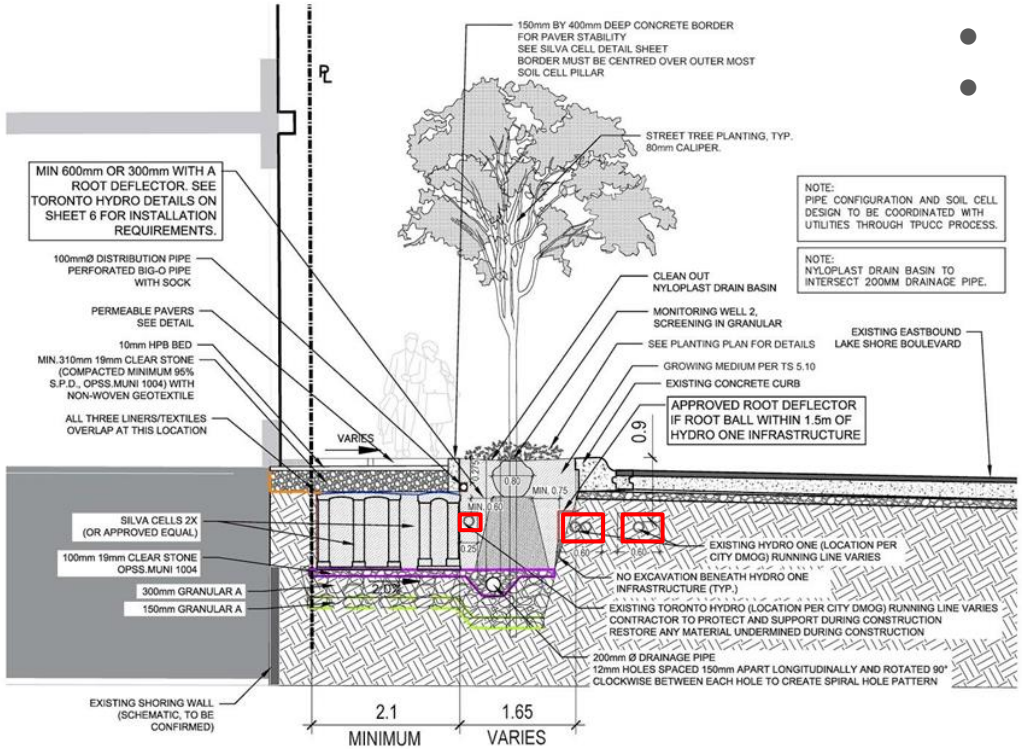
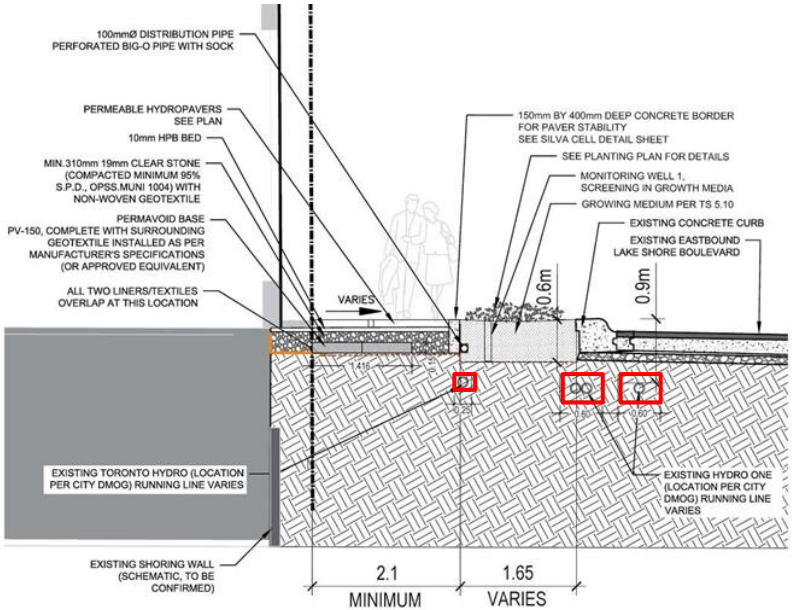
UTILITY COORDINATION

Pilot Strategy:

- Daylight utilities to determine precise locations
- Plant trees only where required utility clearances can be met;
- Work around utilities with new irrigation & drainage pipes.



1/4 TYPICAL CROSS SECTION WITH SOIL CELLS - SECTION A
1:40



2/4 TYPICAL CROSS SECTION WITHOUT SOIL CELLS - SECTION B
1:40

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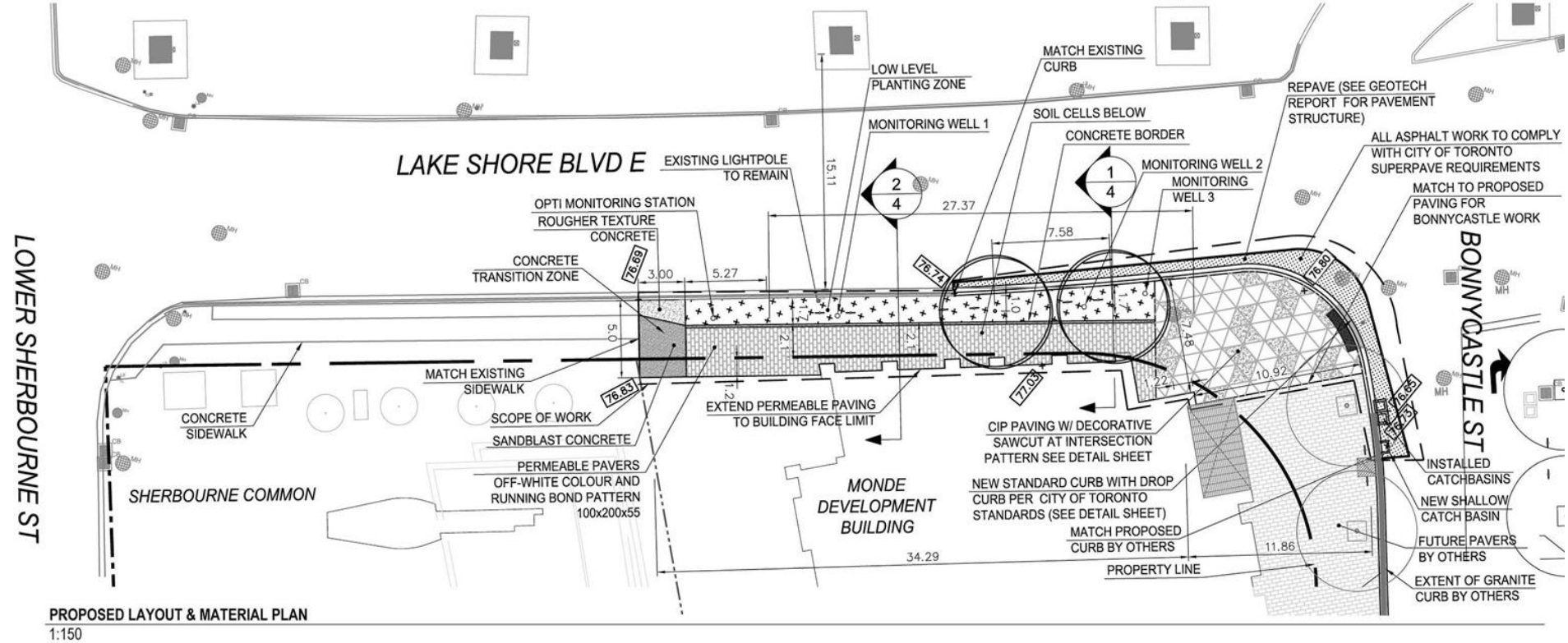
EXISTING UTILITIES

UTILITY COORDINATION

Pilot Strategy:

- Adjust surface conditions to accommodate existing utilities



PROPOSED LAYOUT & MATERIAL PLAN
1:150

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ENVIRONMENTAL APPROVALS

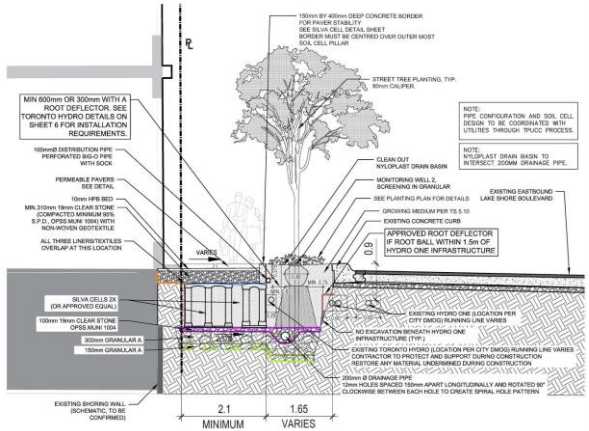
Challenges:

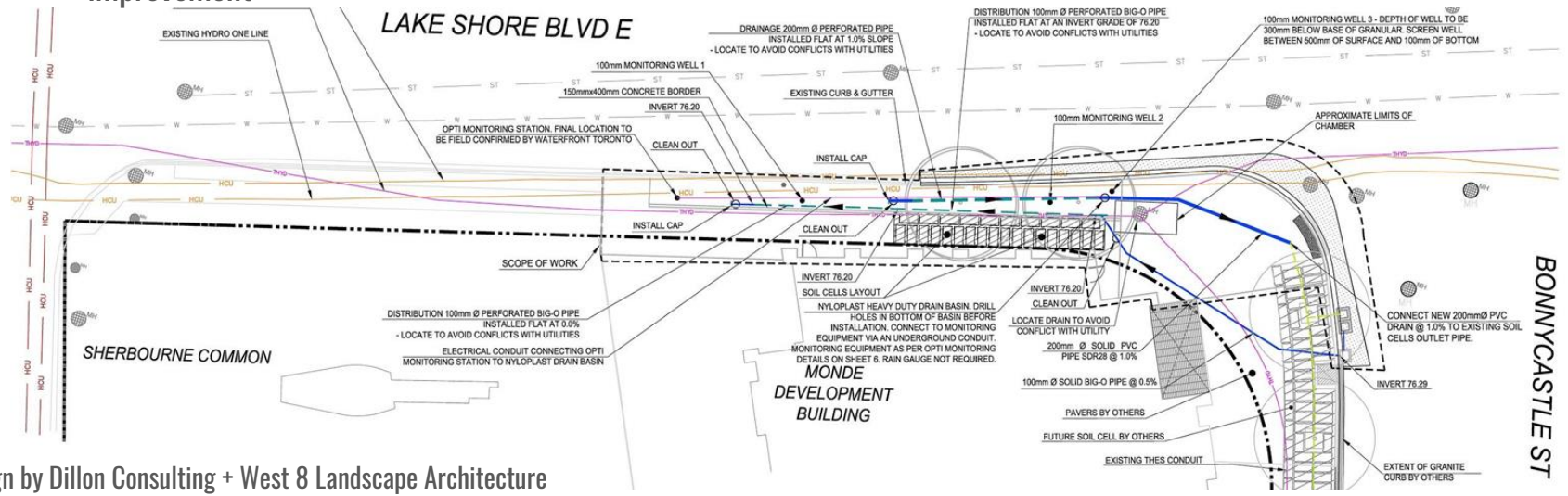
1. Difficult to quantify benefits: volumes infiltrated / retained and water quality improvements;
2. LID stormwater management only trusted as redundancy on top of hard SWM infrastructure;
3. Environmental Compliance Assessment (ECA) required when using LIDs for stormwater management.

ENVIRONMENTAL APPROVALS

Pilot Strategy:

- Capture stormwater from catch basin in roadway and permeable paving on sidewalk, and use it for passive irrigation of plantings ;
- Use LID system of permeable pavers, soil cells, and trees as redundant stormwater bioretention strategy;
- Monitor co-benefits of LID for stormwater detention and water quality improvement





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PERMEABLE PAVING

Challenges:

- Lack of confidence and familiarity with permeable pavers;
- AODA compliance (Paver Policy specifies 2-3mm maximum gap for pedestrian clearway);
- No standard maintenance protocols and perception of higher maintenance requirements and costs;
- Maintenance equipment needs (for both road and sidewalk application);
- Cold climate considerations (salt/sand/freeze-thaw);
- Lack of City standard specifications for permeable pavers;
- TS3.80 requires base concrete course.

PERMEABLE PAVING: NOT included in Paver Policy

TORONTO

FACT SHEET

The City's Paver Policy & Fees for Projects in City Right-of-Way

As of January 1st 2017, all streetscape capital projects must sign a maintenance agreement and pay a maintenance fee when installing pavers in public right-of-way in accordance with By-law 1247-2016. This will improve accessibility, legibility and the City's ability to maintain streets & sidewalks. The fee will be paid when an application is made for a streetscape permit. These fees will be placed in a Paver Maintenance Reserve Fund and are limited to each individual projects' scope of work in the maintenance agreement. Funds from one account cannot be used for any other project.

Concrete Sidewalks: Typical Design

- All designers are encouraged to follow the City's typical sidewalk design: concrete sidewalks with an *optional* standard paver banding.
- The City will assume full maintenance responsibility for these treatments and no fee is required.
- This banding is typically 2 rows as shown on the right, but in some historic areas, 6 is acceptable.
- A paver band is not required for sidewalk design, and should not be implemented at the expense of an adequate concrete pedestrian clearway (as it is not included in the clearway measurement).

Paver Sidewalks: Standard Use

If a designer wishes to use City Standard pavers instead of concrete across the sidewalk, they must adhere to the new specification (see TS3.80 for full details):

Type 1 – Interlocking Precast Concrete Paver	
Sizes	100 mm x 200 mm x 80 mm
	200 mm x 200 mm x 80 mm
	200 mm x 300 mm x 80 mm
Colours	Medium Grey
	Light Grey
	Dark Grey
	Dark Red
	Light Red
Joint Width and Top Radius/Chamfer	2 – 3 mm joint width with spacer
	2 mm top radius/chamfer width

ddition to the above specifications, the following conditions must also be met:

The furniture zone or banding can be dark grey, a mix of light and dark red, or medium/light grey.
Three unit sizes are available but cannot be mixed.
If City Standard pavers are used in complex or unique patterns, an extra fee is required as well as approval from the Paver Working Group. The Paver Working Group is made up of representatives from Transportation Services, City Planning, Engineering & Construction Services, and Economic Development. This group will advise the GM, Transportation Services whether the proposals are acceptable in the public right-of-way and if extra fees are required. Pavers used in the pedestrian clearway must be medium or light grey, or a random mix of the two. If some darker colours are desired, no more than 30% of the total random mix can comprise darker coloured pavers, see table:

Paver colour	Use in pedestrian clearway	Use in Furniture zone or banding
Medium Grey	Yes	Yes
Light Grey	Yes	Yes
Dark Grey	Not more than 30% in random mix	Yes
Dark Red	Not more than 30% in random mix	Yes
Light Red	Not more than 30% in random mix	Yes

ıdway Pavers

City will accept pavers in the roadway provided they are City standard pavers in approved ıurs. The same standard fee applies for these pavers (see TS3.80 for full details).

ewalks with Pavers: Non Standard Use

posals that do not meet the above criteria will be considered a unique proposal and are subject urther review.

- The project will need to be reviewed by the Paver Working Group.
- Ultimately the GM, Transportation Services has delegated authority and must approve non-standard proposals

Note: These specifications have been updated since the original 2016 Report to Council. The fee and process remains the same, however the paver details in this briefing note and in TS3.80 supersede those in the 2016 Report appendix.

Paver Fees

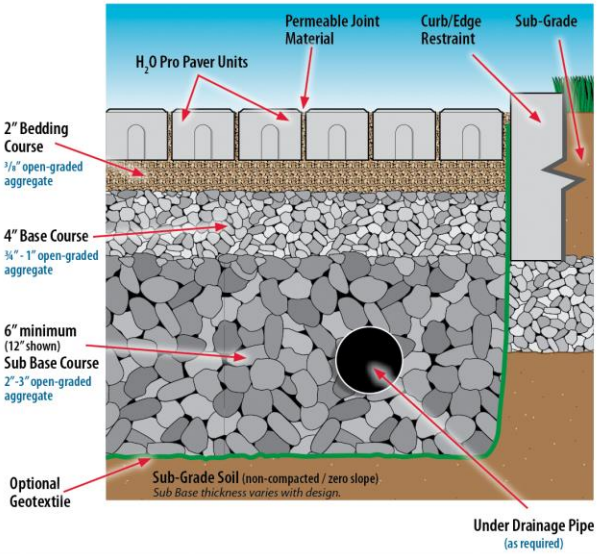
Third parties who install pavers in the right of way will be required to pay a fee, and to sign a maintenance agreement prior to receiving a streetscape permit. The following table outlines the different types of pavers (as explained above) and how the approval, fee, and maintenance is calculated.

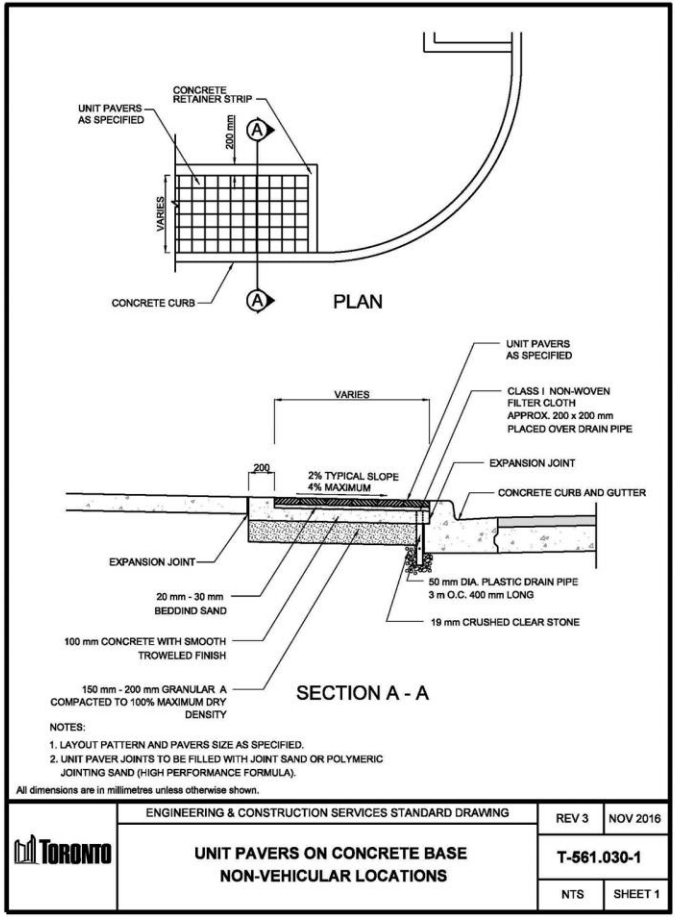
Scenarios	Maintenance Agreement Required	Maintenance Fee (2018)	City Provides Maintenance (labour)	Unique materials provided by third party when repairs are needed	Paver Working Group approval required
City standard pavers	Yes	$56.47/Sq. M. of pavers installed	Yes	No	No
City standard pavers with a unique pattern	Yes	$56.47/Sq. M. of pavers installed + Pattern 15 %	Yes	No	Yes
Non-standard pavers (City to maintain)	Yes	$56.47/Sq. M. of pavers installed	Yes	Yes	Yes
Non-standard pavers with a unique pattern (City to maintain)	Yes	$56.47/Sq. M. of pavers installed + Pattern 15 %	Yes	Yes	Yes
Non-standard use of pavers (Third party to maintain: only appropriate for areas outside the pedestrian clearway)	Yes	none	No	Yes	Yes

PERMEABLE PAVING

Challenges:

- Sidewalk paving assembly must meet the same structural standard as vehicular roads;
- Standard City details for unit pavers require concrete slab below, which is not compatible with permeable pavers.

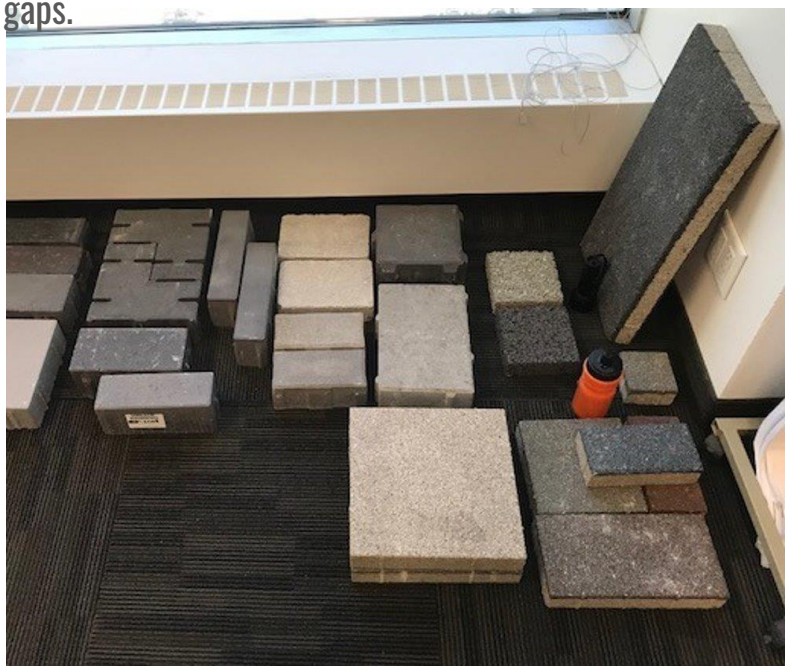




PERMEABLE PAVING

Pilot Strategy:

- Use permeable pavers that meet AODA and paving policy criteria, and are permeable throughout so don't require big gaps.



hydro PAVERS®

STORM WATER MANAGEMENT SOLUTIONS

TECHNICAL DATA

TEST CERTIFICATES

Compressive Strength
mean: 9,690 psi // 66.8 MPa
Complies with and satisfies both: CSA A231.2-14 and ASTM C936

H20-The American Association of State Highway Transportation Officials (AASHTO)
Based on these tested results, the hydroPAVERS® satisfy and exceed the requirements of H20 Standards for heavy vehicles.

Dimensional Checks
In accordance with Section 7.4 of CSA 231.2-14, mean: 55.1mm x 299.7mm x 299.2mm

Density and Absorption
In accordance with CSA A23.2-11C, mean: Absorption % 6.9, SSD Density (kg/m3) 2,034

Infiltration Rate
In accordance to ASTM C1781, average: 2,240 mm/hr (88.2 inches /hr) or (1.47 inches/min)

Freeze/Thaw and De-icing Durability
In accordance with Section 7.3 of CSA A231.2-14. The material loss from the specimens after 49 freeze/thaw cycles was negligible and meets the requirements. Visually, there was no change in the condition of the specimens and the test specimens are in very good condition.

ADA—Americans with Disabilities Act
After reviewing the ADA Standards for ground surfaces, the hydroPAVERS® meet the ADA requirements.

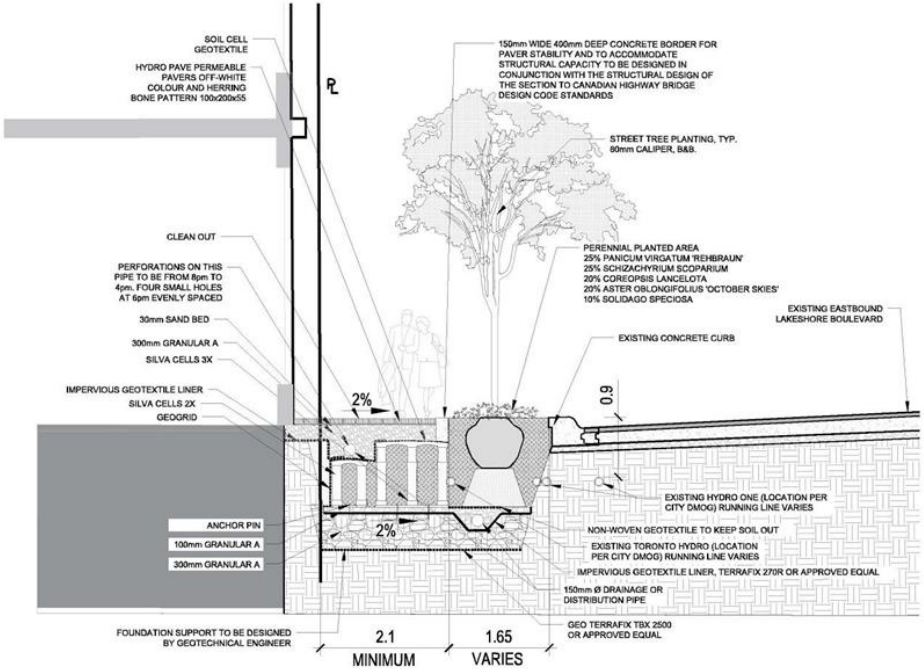
Water Retention
6L/m2 or 0.15 US Gallons /square foot. The hydroPAVERS® will absorb a 1/4" rain event.

DAVROC TESTING LABORATORIES FILE: L16-0591MT

PERMEABLE PAVING

Pilot Strategy:

- Use permeable pavers and soil cells that can sustain vehicular loading as per City requirements
- Get paving assembly certified by two structural engineers



The limits of responsibility for the Generation 2 Silva Cell shop drawing assembly, and the Professional Engineer sealing of the shop drawings is:

1. from the bottom up: aggregate sub-base, Silva Cells and cell anchors, planting soil, geotextile on top of the cell decks, and aggregate base on top of geotextile.
2. at tree side: the backfill covered with geotextile in the excavation directly adjacent to the Silva Cell assembly edge.
3. at tree side opening: the Silva Cell assembly edge abutting the soil and/or fill materials in the tree opening.
4. at non-tree side: the backfill and the geotextile extended on to the excavation directly adjacent to the geogrid curtain along the Silva Cell assembly edge.

The following pavement system is anticipated:

A. 100mm pre-cast concrete unit pavers, 30mm sand setting bed, 300mm granular 'A' aggregate base course. Loading will be CSA-S6 87.5kN

B. 100mm pre-cast concrete unit pavers, 30mm sand setting bed, 600mm granular 'A' aggregate base course. Loading will be CSA-S6 87.5kN

ajw engineering

LICENSED PROFESSIONAL ENGINEER A. J. WALKER PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER A. FOROUTAN PROVINCE OF ONTARIO

For structural review of Silva Cells and full sidewalk assembly as shown in this drawing.

Design by Dillon Consulting + West 8 Landscape Architecture

OPERATIONS & MAINTENANCE

Challenges:

Asset Management:

- No clear divisional ownership of LID facilities (shared assets);
- “New” assets that do not exist in divisional asset repositories;
- Multi-functional assets pose challenges to asset classification.

Maintenance:

- Maintenance requirements cross traditional divisional maintenance responsibilities;
- Maintenance protocols and levels of services need to be defined for LID assets;
- Training and special equipment can be required for maintenance;
- Chapter 743 of the Municipal Code (use of Streets and Sidewalks) outlines City/Property Owner responsibilities for Boulevard and Sidewalk maintenance.

OPERATIONS & MAINTENANCE

Opportunities:

- Trees and plantings are healthier and require less maintenance if receiving stormwater as passive irrigation;
- Permeable paving reduces puddles and slush buildup on sidewalks;
- Potential for reduction in winter salt usage;
- Leverage monitoring system to inform maintenance frequency.

OPERATIONS & MAINTENANCE

Pilot Strategy: Monitoring Plan

Monitoring Objectives :

- Verify performance of LID for SWM retention and water quality improvements;
- Evaluate impact of stormwater and salt on plant and tree health;
- Evaluate a new permeable paver technology with respect to sustained permeability and durability;
- Understand **maintenance requirements** including costs and potential savings.

Research Question :

Can a sidewalk bioretention system of permeable paving, soil cells, and salt & shade-tolerant street trees reduce peak flows and improve stormwater quality, while supporting healthy plantings without increasing the maintenance burden on the City?

MONITORING

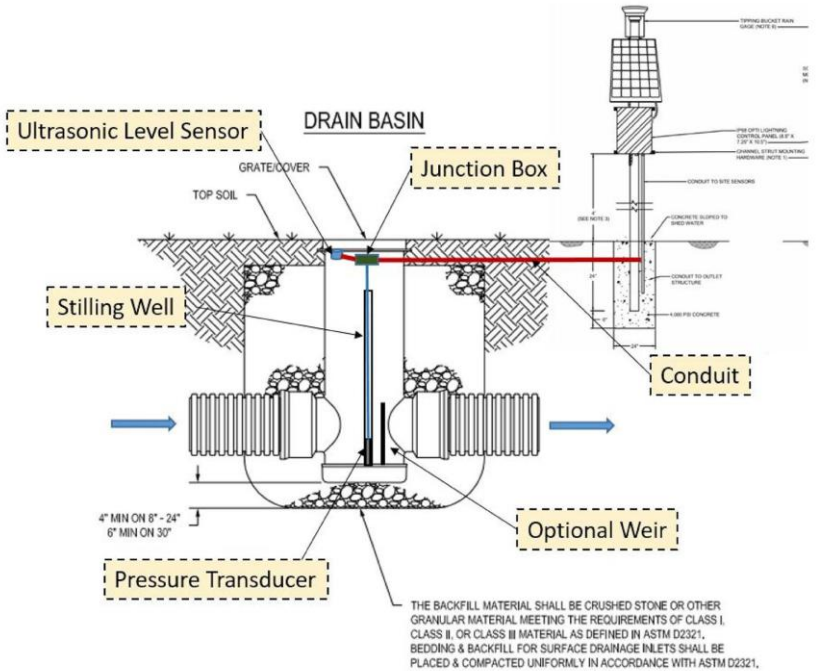
The monitoring plan was defined in collaboration with the TRCA **Sustainable Technologies Evaluation Program (STEP)** who will be performing the monitoring work for this Pilot.

Testing :

- Hydropavers - permeability, stability in freeze /thaw, structural performance, durability
- Effect of winter salt on tree & plant health
- Effect of stormwater irrigation on tree & plant health

Monitoring :

- Water Quality Improvement
- Stormwater Attenuation - reduced peak flows
- Tree & Plant Health in response to stormwater & salt
- Paver permeability over time, pre- & post-maintenance
- Maintenance demands



Triple Bottom Line Cost Benefit Analysis by Autocase (forthcoming...)

- Evaluate Financial, Social, and Environmental costs vs. benefits of design case vs. base case in the short and long term to inform decision-making

LESSONS LEARNED

- Find champions across divisions and networks;
- Learn from precedents;
- LID requires knowledge from a multitude of disciplines to address multiple objectives;
- Green Infrastructure is a platform for collaboration across divisions and can help break down silos;
- Compromise: going from YES or NO to YES, *BUT*....
- There is value in the process!

NEXT STEPS: Green Streets Technical Guideline Implementation Pilot Projects & Standards

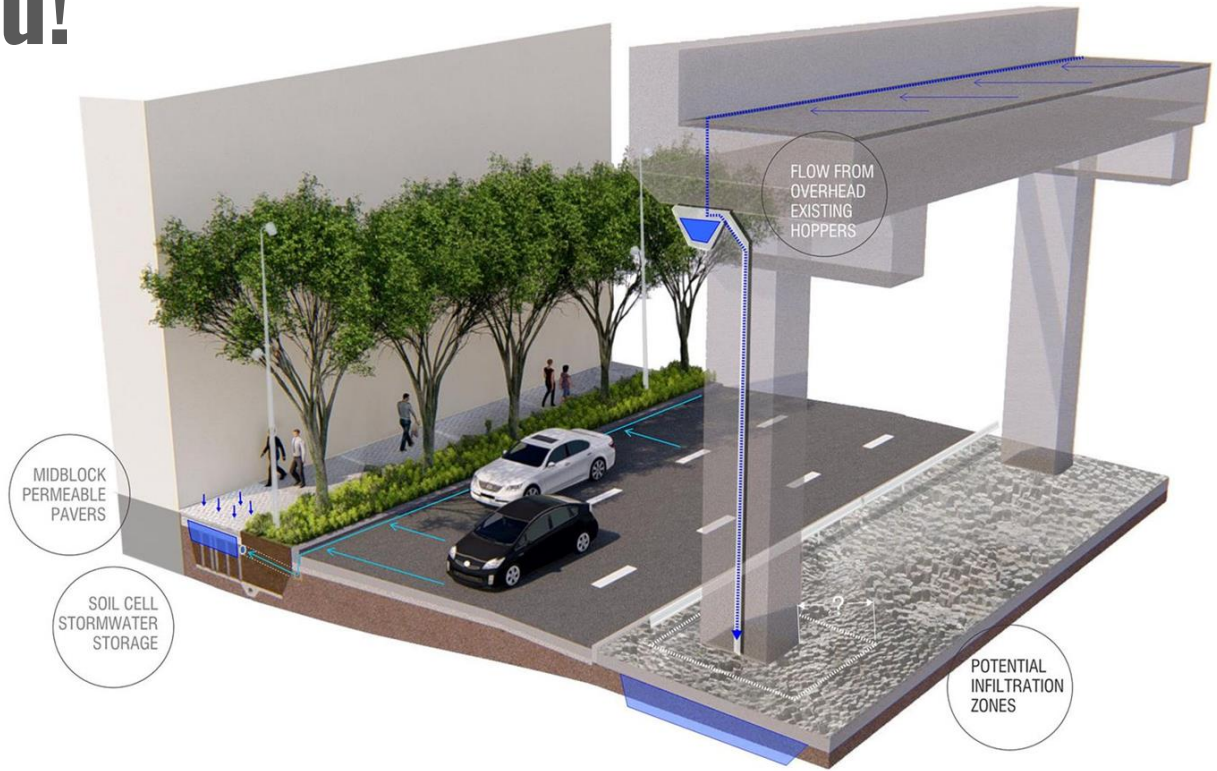
- Screen State of Good Repair projects using GIS Co-Benefit Screening Tool to identify opportunities for Green Streets projects that:
  - maximize co-benefits of implementation;
  - provide opportunities to evaluate designs towards the development of standards.

- Continue to implement Green Streets pilot projects within the Capital Works Program, Development and Growth related Opportunities;

- Monitor and evaluate projects from both a functional and an operational perspective to contribute to development of standard specifications and standard maintenance and operating procedures;

- Build capacity through training, tours, outreach and partnerships with subject matter experts.

Thank You!



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Design by Dillon Consulting + West 8 Landscape Architecture

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