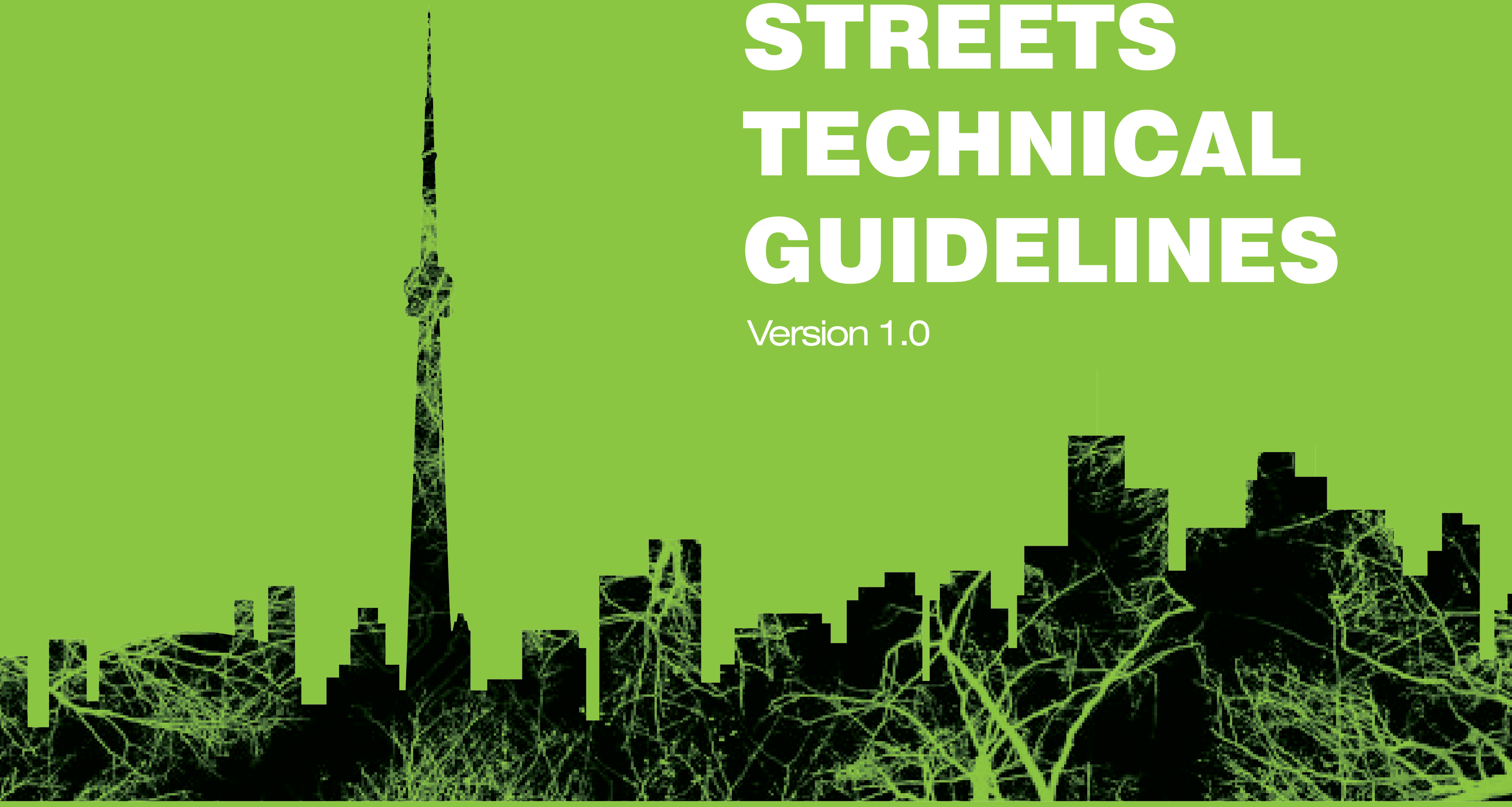
TORONTO

GREEN STREETS TECHNICAL GUIDELINES

Version 1.0



NOVEMBER 2017

Schollen & Company Inc.
Urban Forest Innovations
TMIG
DPM

ACKNOWLEDGEMENTS

In the efforts to create a resilient city with green infrastructure, the City acknowledges the traditional territory of the Mississaugas of the New Credit, the Huron-Wendat, the Haudenosaunee and home to many diverse Indigenous people.

Working in partnership, meaningful places with green infrastructure can be created to respect and celebrate Indigenous ways and beliefs, improving the quality of life for all our relations, for present and future generations.

Photo Credit: Schollen & Company Inc.

ACKNOWLEDGEMENTS

The **Toronto Green Streets Technical Guidelines (GSTG)** were generated as a product of a thorough and intensive consultation process that involved various City departments as well as utility and service providers and the City of Toronto Complete Streets team. The project was co-led by Sheila Boudreau (Urban Design, City Planning) and Patrick Cheung (Water Infrastructure Management, Toronto Water), with support from Kate Nelischer (Public Consultation, Policy, Planning, Finance & Administration) and Shayna Stott (Strategic Initiatives, Policy & Analysis, City Planning).

Since 2015, stakeholders and City representatives were involved in a series of interview and work sessions in order to provide the Green Streets (GS) consulting team with a better understanding of the specific opportunities, benefits and challenges associated with integrating Green Infrastructure (GI) initiatives into Toronto's streets. The GS consulting team would like to acknowledge the contributions of the following groups. Please refer to Appendix A for a complete list of representatives from each respective group.

GSTG Working Group

GSTG Advisory Group

GSTG Technical Advisory Group

City of Toronto

- City Planning
- Economic Development & Culture
- Engineering & Construction Services
- Environment & Energy
- Parks, Forestry & Recreation
- Policy, Planning, Finance & Administration
- Major Capital Infrastructure Coordination Office
- Solid Waste Management Services
- Toronto Building
- Toronto Water
- Transportation Services

Toronto Hydro

Toronto Parking Authority

Ministry of the Environment and Climate Change

Credit Valley Conservation Authority

Toronto and Region Conservation Authority

Region of Peel

City of Mississauga

Town of The Blue Mountains

Photo Credit: Schollen & Company Inc.

TABLE OF CONTENTS

TABLE OF CONTENTS

SECTION 3.0 | TECHNICAL GUIDELINES Continued

TABLE OF CONTENTS

SECTION 4.0 | SELECTION TOOLS

SECTION 5.0 | OPERATIONS AND MAINTENANCE GUIDELINES

SECTION 6.0 | MONITORING RECOMMENDATIONS

APPENDICES

LIST OF FIGURES & MAPS

FIGURES

MAPS

LIST OF TABLES

TABLES

Photo Credit; Schollen & Company Inc.

ACRONYMS AND ABBREVIATIONS

BMP	Best Management Practice
CSG	Toronto Complete Streets Guidelines
CVC	Credit Valley Conservation Authority
ECA	Environmental Compliance Approval
ESA	Environmentally Significant Areas
GHG	Greenhouse Gas
GI	Green Infrastructure
GIS	Geographic Information System
GSTG	Green Streets Technical Guidelines
I&M	Inspection and Maintenance
LED	Light Emitting Diodes
LEED	Leadership in Energy and Environmental Design
LID	Low Impact Development
LRT	Light Rail Transit
MMAH	Ministry of Municipal Affairs and Housing
MOECC	Ontario Ministry of the Environment and Climate Change
NHS	Natural Heritage System
OALA	Ontario Association of Landscape Architects
ODWQS	Ontario Drinking Water Quality Standards
O&M	Operations and Maintenance
OP	Toronto's Official Plan
OPA	Official Plan Amendment
PWQO	Province of Ontario Water Quality Objective
SRI	Solar Reflective Index
STEP	Sustainable Technologies Evaluation Program
SWM	Stormwater Management
TGS	Toronto Green Standard
TRCA	Toronto and Region Conservation Authority
WWFMMP	Wet Weather Flow Management Master Plan

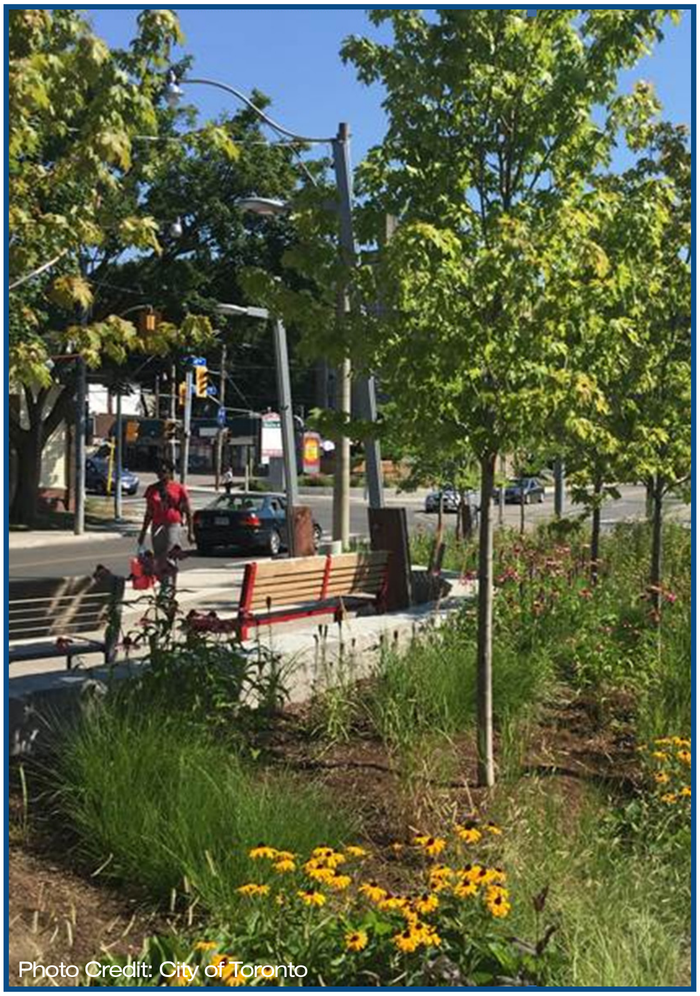
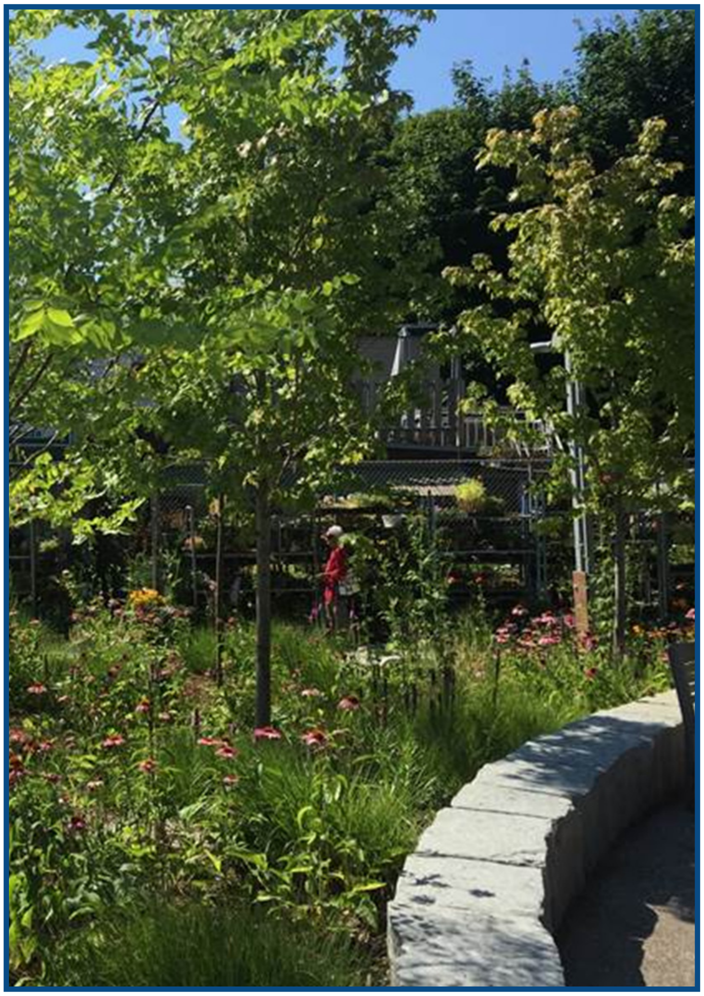


Photo Credit: City of Toronto



EXECUTIVE SUMMARY

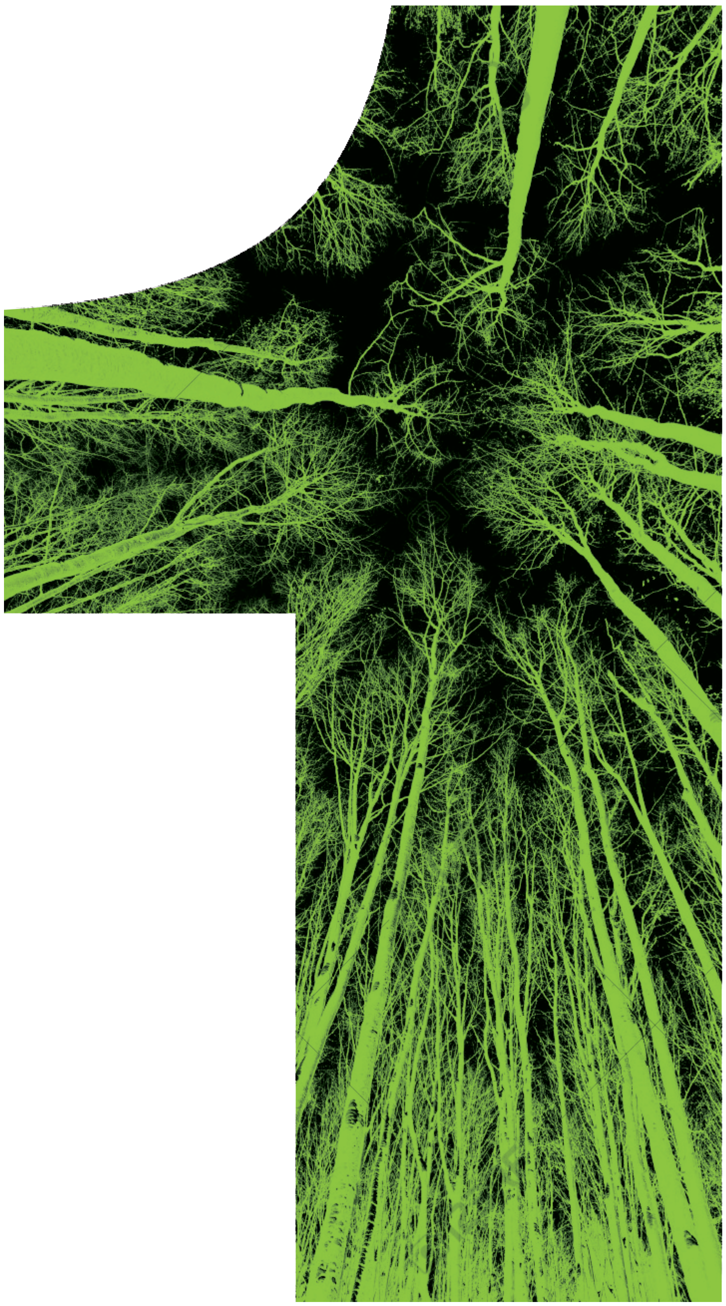
Toronto's Green Streets Technical Guidelines (GSTG) provides direction for the planning, design, integration and maintenance of a range of green infrastructure (GI) options appropriate for Toronto street types and conditions.

The Guidelines were informed by a thorough review of City policy documents, such as the City of Toronto Official Plan, the Toronto Green Standards (TGS), and the Wet Weather Flow Management Master Plan and Guidelines. Research included an analysis of twenty-two precedent manuals and guidelines from municipalities across North America (information provided in Appendix F, Foundational Work). Extensive interviews were conducted with staff from these municipalities, in addition to City of Toronto staff, stakeholders, industry experts and product suppliers, in order to develop a deep understanding of experiences and issues related to green infrastructure in Toronto.

The TGS (a set of performance measures for sustainable site and building design) identifies key environmental pressures which helped categorize the GSTG green infrastructure techniques with direct benefits for: air quality, climate change mitigation and energy efficiency, water quality and quantity management, ecology and solid waste management.

The precedent study produced a 'long list' of forty green infrastructure techniques that are suited to Toronto's geographical and climatic conditions, and thirty-two techniques that are viable for implementation in the City's specific road right-of-way conditions. GI Selection Tools were developed to simplify the process of identifying specific GI options for both new road reconstruction and road rehabilitation projects. Techniques are screened using eleven key parameters, with recommendations provided for scenarios with limited options. A Vegetation Selection Tool was developed to identify appropriate plant species for various GI options (where applicable).

A comprehensive set of technical drawings provide direction on the configuration and layout, construction profile, drainage, conveyance/overflow, monitoring provisions and plant material to assist with design of the GI facilities. Measures required in adopting a life-cycle asset management approach are also provided. Considerations such as operations and maintenance costs, protocols and monitoring recommendations are addressed since these are critical to the long-term effectiveness of every GI practice.



1.0
INTRODUCTION

INFLUENCES

- Boston
- Chicago
- Cleveland
- Edmonton
- Los Angeles
- Milwaukee
- New York
- Omaha
- Philadelphia
- Portland
- San Diego
- Seattle
- US EPA
- Washington
- Toronto Streetscape Manual
- Toronto Ravine Strategy
- Biodiversity in the City of Toronto
- Toronto Climate Change Action Plan
- Toronto Pollinator Protection Strategy
- Tree Planting Solutions in Hard Boulevard Surfaces
- Toronto's Strategic Forest Management Plan 2012-2022
- Toronto Street Trees: Guide to Standard Planting Options
- Wet Weather Flow Management Master Plan
- Best Practices Manual for Green Walls
- TRCA Living Cities Policies
- TRCA LID Inspection and Maintenance Guide
- TRCA Low Impact Development Stormwater Management Planning and Design Guide
- CVC Low Impact Development Stormwater Management Planning and Design Guide
- CVC SWM and LID Monitoring and Preformance Assessment Guide

1.1 PURPOSE OF THE DOCUMENT

In the spring of 2016, the Ministry of Municipal Affairs and Housing (MMAH) approved Official Plan Amendment 262 which modifies Toronto's Official Plan policies and mapping with respect to climate change and energy, the natural environment, green infrastructure and Environmentally Significant Areas (ESAs). Amendment 262 requires: "a healthy natural environment including clean air, soil, energy and water; infrastructure and socioeconomic systems that are resilient to disruptions and climate change; and, a connected system of natural features and ecological functions that support biodiversity and contribute to civic life" (Toronto, Nov. 3, 2015).

The Green Streets Technical Guidelines (GSTG) provide a new standards for development within Toronto's streets. They assist in realizing the City's vision by offering green infrastructure (GI) solutions that can yield significant environmental benefits to relieve urban pressures on ecological systems, improve air quality, achieve energy efficiency and enhance water quality, while ensuring that Toronto's streets remain efficient conduits for vital infrastructure and beautiful, functional corridors for pedestrians, transportation and transit.

The Guideline document was developed on behalf of the City of Toronto to assist City staff, developers and consultants to better understand planning, design, operations & maintenance and monitoring requirements for GI solutions. GI and Vegetation Selection Tools that accompany the document are designed to first identify site specific GI options that are viable for implementation as part of a street retrofit or reconstruction project and then determine plant species that would be context appropriate (where applicable). Guideline drawings provide direction on integration of GI facilities into typical road rights-of-way.

Creation of the GSTG was a complex endeavour that required consideration of the City's foundational documents as identified on the previous page.

The GSTG are aligned with the Toronto and Region Conservation Authority's (TRCA) Living City policies as they advocate for a cleaner, greener and healthier city for future generations. They also support Toronto's Biodiversity, Pollinator Protection and Ravine strategies, as well as the City's efforts to reduce greenhouse gas emissions.

GHG Target - reduction of 80% below 1990 levels by 2050.

The Guidelines were informed by precedents and innovative solutions from around the world. Therefore, as technology evolves so too will the Guidelines.

The GSTG is a companion to the CSG and should be consulted concurrently. Together these documents prescribe a holistic approach to the development and renewal of Toronto's streets.

Although the Guidelines have been developed with a specific focus on city streets, they are intended to be applied to various landscapes throughout public and private realms within the City of Toronto.

1.2 GREEN STREETS

1.2.1 | What are Green Streets?

Green Streets are road rights-of-way that incorporate green infrastructure to complement or replace grey infrastructure.

Green Infrastructure (GI), as defined in Toronto's Official Plan, refers to "*natural and human-made elements that provide ecological and hydrological functions and processes"* (Toronto, 2015). Examples of GI options that can be integrated into Green Streets include: street trees, green walls, alternate energy sources (wind / solar) and high efficiency lighting, Low Impact Development (LID) stormwater infrastructure and more.

In addition to supporting the environmental objectives of the TGS, Green Streets are designed to focus on the at-source treatment of stormwater runoff. Green Streets typically employ a 'treatment train' of GI options that are designed to replicate the function of a natural drainage system by attenuating, filtering and infiltrating stormwater runoff as close as possible to where it is generated. This approach to managing runoff can reduce or even eliminate the requirement for a conventional (grey infrastructure) stormwater conveyance and management system.

Green Streets help to build a city that is resilient to climate change and contributes to an improved quality of life.

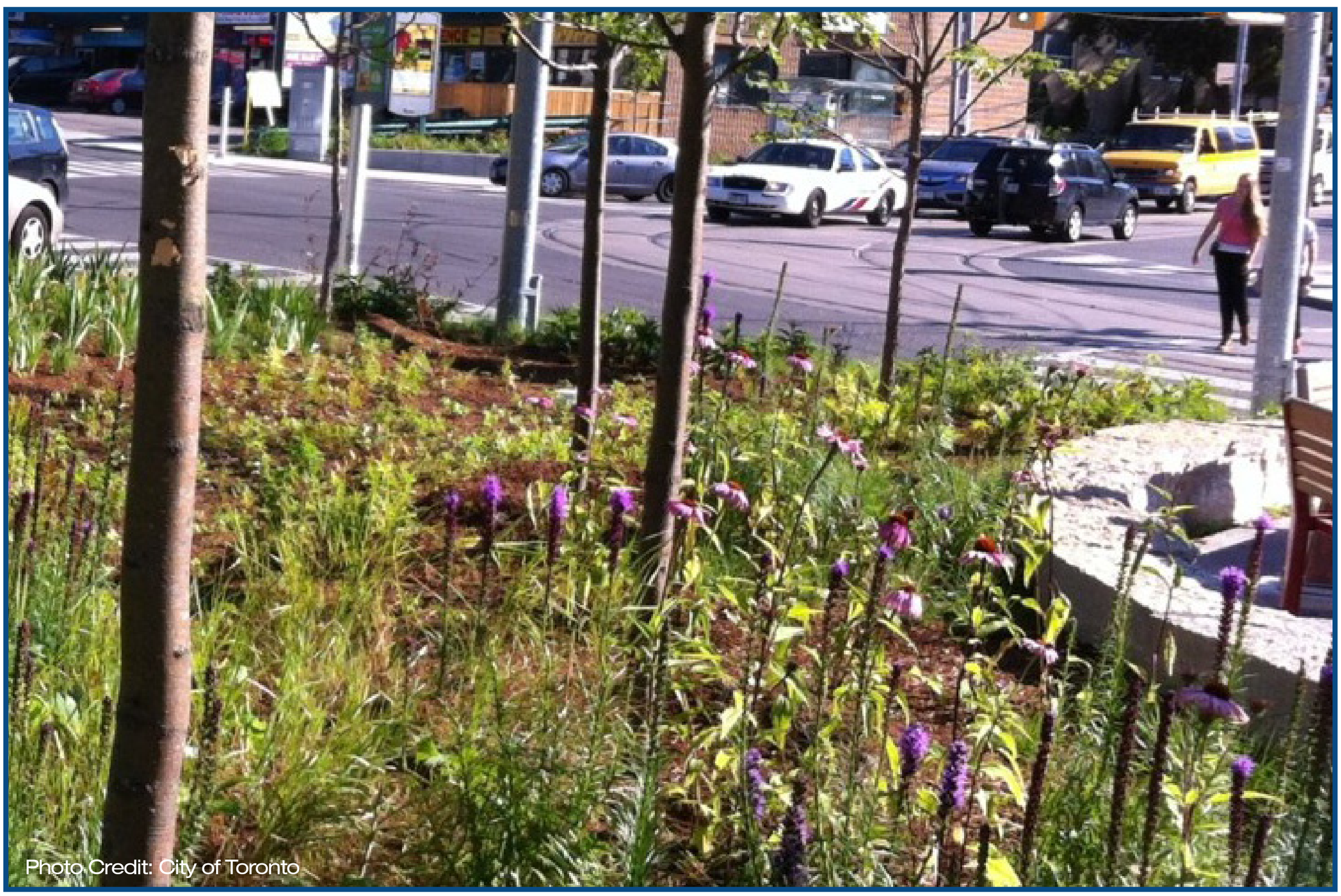


Photo Credit: City of Toronto

1.2.2 | Why do Green Streets Matter?

There are approximately 5,400 ha of roadways in the City of Toronto (Toronto, 2012). With a traditional stormwater pipe conveyance, even a typical rainfall event results in significant concentrations of pollutants entering the City's stream and river systems and ultimately, Lake Ontario. Pollutant concentrations in the stormwater runoff generated by the City's system of roads are estimated to be up to 11,900% greater than the Province of Ontario Water Quality Objective (PWQO) during a typical 25 mm rainfall event.

The following table conveys the total pollutant concentrations that local streams and rivers receive from runoff discharged from Toronto's public roads during one average 25 mm rainfall event.

Contaminants Contribution Through Road Runoff

Fecal Coliform	**500 to 800,000** more counts than recommended for drinking water
	50 to 80,000 more counts than recommended for swimming
Suspended Solids (SS)	**117,400 to 253,700 kg**
Total Phosphorous (TP)	**405 to 945 kg** 0-133% more than the PWQO
Phenolics	**19 to 26 kg** 1,300-1,800% more than the PWQO
Lead (Pb)	**51 to 74 kg** 52-120% more than the PWQO
Silver (Ag)	**3 to 7 kg** 1,900-4,900% more than the PWQO
Copper (Cu)	**61 to 62 kg** 800-820% more than the PWQO
Zinc (Zn)	**189 to 351 kg** 367-767% more than the PWQO
Cadimium (Cd)	**1.5 to 32 kg** 400-11,900% more than the PWQO

Contaminant contributions were extrapolated from concentrations outlined in the Ministry of Ontario Stormwater Management Planning and Design Manual (March 2003, pg. I-9).

1.2.3 | Objectives for Green Streets

Specific objectives that can be achieved through the implementation of the Green Streets initiative include:

- **Enhancing the extent and longevity of the urban forest;**
- **Mitigating urban heat island effect;**
- **Managing stormwater runoff to mitigate flooding and enhance water quality;**
- **Promoting infiltration to sustain shallow groundwater systems and maintain interflow patterns;**
- **Enhancing air quality; and,**
- **Conserving / generating energy.**

1.2.4 | Policy Support & Targets

The GSTG have been developed as a tool to assist in achieving the City of Toronto's environmental goals through sensitive integration of Green Infrastructure into the City's network of streets. Support for this initiative has been building over several years from local and provincial levels of government.

In July 2013, City Council directed that *"City Agencies, Corporations and Divisions apply Tier 1 of the Toronto Green Standard, as amended, as the minimum standard to all capital projects " (PG25.10).* This was followed by an additional request by City Council in October 2013 for Toronto Water, Transportation Services and City Planning departments *"…to work together to develop 'green infrastructure' standards for the public right-of-way for implementation in Transportation Services and Toronto Water capital projects…" (PW25.7)*

In 2014, the Provincial Policy Statement (PPS) stated that "*planning authorities should promote green infrastructure to complement infrastructure" (1.6.2).*

In February 2015, the Ontario Ministry of the Environment and Climate Change (MOECC) released an Interpretation Bulletin along with a covering letter that stated, in part, *"…the MOECC's current guidelines and policies support locally derived site-specific performance criteria based on watershed/ sub-watershed studies and source control measures such as low impact development (LID)."*

In May 2016, the Ministry of Municipal Affairs and Housing (MMAH) approved Official Plan Amendment (OPA) 262 that focuses on climate change, energy conservation, green infrastructure and the natural environment.

The City's vision was amended to include the following:

- *a healthy natural environment including clean air, soil, energy and water;*
- *infrastructure and socioeconomic systems that are resilient to disruptions and climate change; and,*
- *a connected system of natural features and ecological functions that support biodiversity and contribute to civic life.*

Revisions in Chapters 2, 3 & 4 of the Official Plan also reinforce climate change mitigation, energy conservation and support for the implementation of GI initiatives in all areas of future development throughout the City. GI is defined in the PPS 2014 as:

> *"Green infrastructure refers to natural and human-made elements that provide ecological and hydrological functions and processes. Components may include natural heritage features and systems, parklands, stormwater management system, street trees, urban forests, natural channels, permeable surfaces and green roofs."*

CITY OF TORONTO

ENVIRONMENTAL GOALS

GREEN HOUSE GAS EMISSIONS

By 2020 - 30% reduction in greenhouse gas emissions
2020-2050 - 80 % reduction in greenhouse gas emissions
(Toronto Climate Change Action Plan, Current as of June 2007)

URBAN FOREST

Increase tree canopy to 40%
(Toronto's Strategic Forest Management Plan 2012-2022, Current as of 2013)

TORONTO GREEN STANDARD REQUIREMENTS

Stormwater Retention (Water Balance)*

- Maintain pre-development levels for annual average runoff volumes
- Max runoff to 50% of annual rain fall depth
- Minimum stormwater to be retained on-site = initial rainfall up to 5 mm from all rainfall events

Water Quality (Stormwater Run-off)

- Removal of 80% of Total Suspended Solids from runoff leaving a site
- E. coli <1000 / 100 ml (wet periods during June - Sept) and <100 / 100 ml (dry periods)

(Stormwater performance measures in the TGS are found in the WWFMG, current as of November 2006)*

1.3 HOW TO USE THE GUIDELINES

1.3.1| Intended Audience

Integration of GI options into Toronto's streets will require a change in how streets are planned, designed, constructed, operated and maintained. The GSTG have been developed to provide guidance to City staff, developers and consultants who are involved in the design, construction, maintenance and operation of Toronto's inventory of streets.

1.3.2 | Applicability

The Guidelines are designed to address both new street construction and street reconstruction projects, as well as rehabilitation and retrofit work within road rights-of-way. The following descriptors define the typical characteristics of New/Reconstruction and Rehabilitation/Retrofit projects:

New and Reconstruction Projects

- Limited combined sewer systems;
- Limited overhead utilities;
- Moderate flexibility in location of underground utilities; and,
- Limited utility relocations at localized areas possible.

Rehabilitation and Retrofit Projects

- Location of overhead and underground utilities is fixed;
- Combined sewers may exist; and,
- Health, maturity and species composition of existing trees must be considered.

GSTG Concept Sample - Bioswale

BEFORE

AFTER

Photo Credit: Schollen & Company Inc.

1.4 DOCUMENT OUTLINE

The GSTG comprise two main components: the Guideline document and the Selection Tools. The document provides technical guidance regarding GI options, while the Green Infrastructure (GI) and Vegetation Selection Tools provide an initial level of site screening that will help users to identify a palette of GI options (and appropriate plant species where applicable) that would be viable given specific site conditions and circumstances. The following outlines the Guideline document.

Section 2.0 | Green Street Solutions
Green Street solutions consider all Green Infrastructure options that would be viable within a site given its specific characteristics and circumstances. Section 2.0 provides background on the process that was undertaken in order to define a list of GI options that would be viable within Toronto's road rights-of-way. The chapter also addresses climate change adaptation.

Section 3.0 | Technical Guidelines
Section 3.0 describes the integration between the GSTG and CSG and provides a description for each GI option identified in the Selection Tools. Construction considerations and Guideline Drawings are also addressed in this chapter.

Section 4.0 | Selection Tools Outline
As a key element of the GSTG, the GI Selection Tools and associated Vegetation Selection Tool provide efficient means of identifying the most appropriate GI options for a given street condition and context. These Tools are described in Section 4.0.

Section 5.0 | Operations and Maintenance
Proper operations and maintenance is required in order to ensure the longevity and function of GI options. Section 5.0 describes considerations, costs, repairs, replacement and expansion for GI techniques.

Section 6.0 | Monitoring Recommendations
Section 6.0 outlines monitoring objectives, methods, mapping and tracking techniques as well as recommendations to guide integration with other monitoring initiatives/databases.


Photo Credit: City of Toronto

2

2.0
GREEN INFRASTRUCTURE (GI) TECHNIQUES

Photo Credit: Schollen & Company Inc.

2.1 GREEN INFRASTRUCTURE OPTIONS

The GSTG were designed to provide the tools necessary to promote complete street designs that address environmental sustainability as a fundamental tenet for development within the City's street rights-of-way.

At the outset of this project, the Green Streets team spent several weeks reviewing precedents from across North America in order to establish a comprehensive list of potential GI options that would be suitable for Toronto's geographical and climatic conditions.

A long list of potential GI options was derived from this background research and then GI practices were organized according to their most relevant Toronto Green Standard environmental driver. For example, street trees provide air quality benefits and are therefore located in the Air Quality section of the list.

TGS environmental drivers include:

- Air Quality;
- Green House Gas Emissions / Energy Efficiency;
- Water Quality, Quantity and Efficiency;
- Ecology; and,
- Solid Waste

As part of the long list, each GI option was described and ancillary benefits outlined. Their suitability for various applications within each street type was also considered.

Once the list was established, a 'Considerations' column was added to identify a variety of factors that might restrict or preclude a GI option from becoming a viable candidate for inclusion within the Selection Tool. Each potential GI option was evaluated against a suite of criteria and its feasibility for implementation relative to each proposed 'Application' noted. The 'Rationale' for selection or elimination of each GI options was also noted. The resulting short-list of GI options was used to provide a foundation of the GI Selection Tool.

Both the long-list and the short-list of GI options can be found in Appendix B.



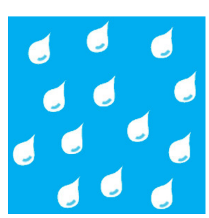


Photo Credit: Schollen & Company Inc.

2.2 CLIMATE CHANGE ADAPTATION

According to Toronto's *"Future Weather & Climate Driver Study: Outcomes Report"* (Senes, 2012), over the coming decades, climate change will produce variable weather patterns throughout the City of Toronto. The study projects shorter, milder winters with less snow and more rain; longer growing seasons; and more extreme weather events.

The report predicts that temperatures in the City of Toronto will rise on average 4.4°C by 2049 with winter and summer temperatures anticipated to increase by 5.7°C and 3.8°C respectively. Temperature extremes are expected to increase by 7.6°C with temperatures feeling even hotter as a result of a significant rise in the humidity index. The report also predicts that although storm frequency will be similar or less than it is today, a small proportion of those storms will be extreme events that will produce high volumes of runoff in a very short duration.

Based on these predictions, the City must take aggressive action immediately to not only reduce GHG emissions, but also to adapt to the changes that are forecasted for the coming decades.

The GSTG will contribute to the development of a resilient City by providing a new vision and methodology for design, implementation and care of GI within Toronto's rights-of-way. The Guidelines are consistent with the TGS and seek to:

- **Enhance ecology and reduce heat Island effect;**
- **Protect air quality;**
- **Manage stormwater quality and quantity; and,**
- **Reduce greenhouse gases and promote energy efficiency.**

Implementation of Green Streets will assist in addressing climate change adaptation challenges by:

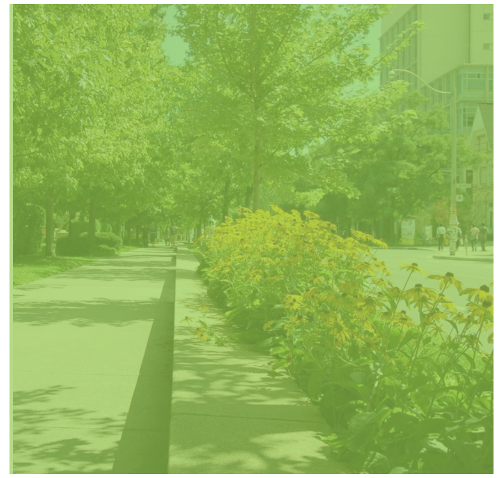
- **Facilitating a reduction in GHG emissions that contribute to climate change; and,**
- **Mitigating the effects of climate change by attenuating and infiltrating stormwater runoff.**

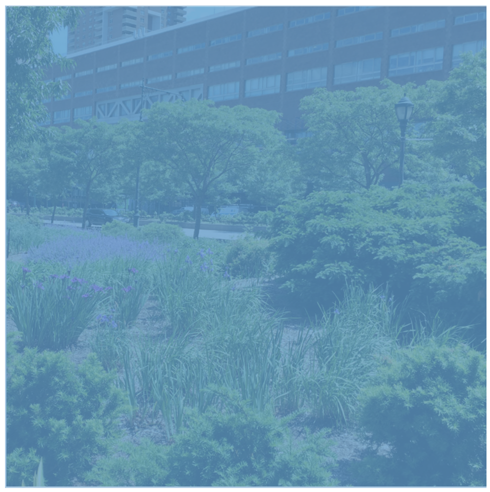
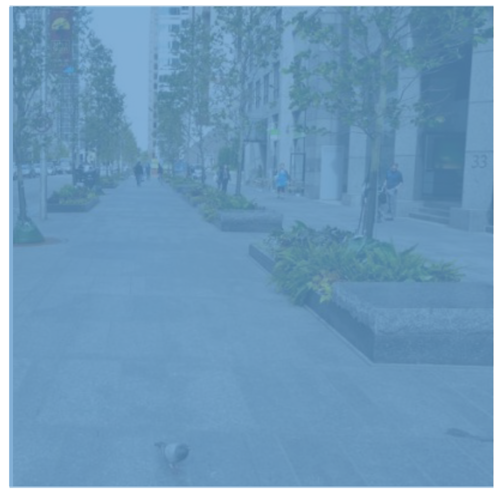
Although stormwater management initiatives proposed in the GSTG may improve the function and resilience of existing stormwater infrastructure by reducing runoff volumes and freeing up capacity within the downstream stormwater drainage system, they will not contribute significantly to mitigating the impacts of extreme precipitation events. Implementation of the GTSG is one of many strategies that must be employed in order for the City to adapt to climate change and to build a more resilient Toronto for the future.

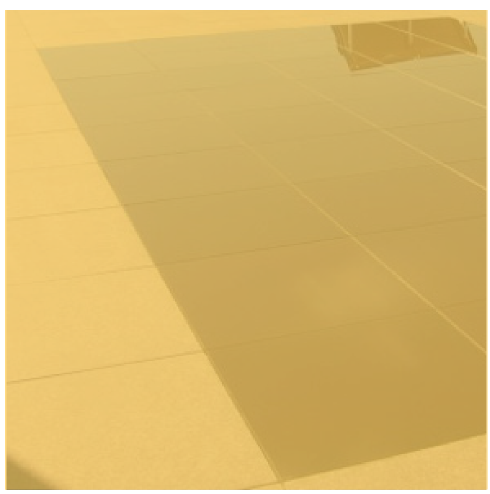
3

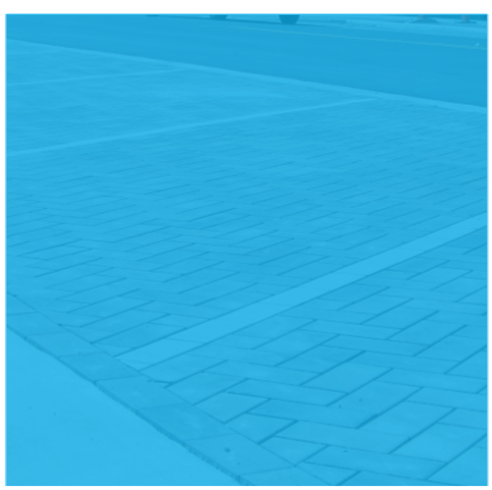
3.0
TECHNICAL GUIDELINES








3.1 INTEGRATION OF GREEN STREETS WITH COMPLETE STREETS

The GSTG and the CSG are compatible and complementary documents that have been developed through an iterative process to ensure that Green Street objectives can be achieved across the City's entire portfolio of street types.

Street types presented in the CSG are a key parameter for preliminary screening in the GI Selection Tool. CSG street types are listed in the sidebar to the right.

Applications outlined in the CSG have also been integrated as a parameter in the GI Selection Tool to identify appropriate locations for each GI option within the overall road right-of-way. CGS applications are listed below.

CSG STREET TYPES

1. Civic Street
2. Downtown & Centres Main Street
3. Avenues & Neighbourhood Main Street
4. Downtown & Centres Residential Street
5. Apartment Neighbourhood Residential Street
6. Neighborhood Residential Street
7. Mixed-Use Connector Street
8. Residential Connector Street
9. Scenic Street
10. Park Street
11. Employment Street
12. Mixed- Use Access Street
13. Mixed-Use Shared Street
14. Residential Shared Street
15. Mixed-Use Lane
16. Residential Lane

CSG APPLICATIONS

1. Frontage and Marketing Zones
2. Pedestrian Clearway Zones
3. Furnishing and Planting Zones
4. Edge Zones
5. Curbside Space
6. Vehicle Lanes
7. Transit Lanes
8. Medians/Raised Islands
9. On-street Parking
10. Parking Lay-bys
11. Cycling Infrastructure
12. Crosswalks
13. Intersections
14. Mid-Block
15. Transit Stops

ADDITIONAL APPLICATIONS

1. Bridges
2. Feature Paving
3. Street Lights
4. Decorative Lights
5. Parking Meters
6. Vehicle Charging Stations

3.2 GREEN STREETS TECHNIQUES AND TECHNICAL GUIDANCE

GI options have been categorized according to their association with environmental drivers as outlined in the TGS. The following section provides a description of GI options. GI options marked by an asterisk (*) are emerging technologies for pilot project use only at this time. These techniques may be considered for broad-scale implementation once they have been tested, proven and adopted by the City's various departments.

The list of GI options have been organized to correspond with TGS objectives. The following GI options will address ecological priorities within Toronto's streets.

3.2.1 |Urban Forest Canopy

The natural (urban) tree canopy is composed of all layers, leaves, branches and stems, that cover the ground. Tree canopy performs critical ecological functions within the urban environment such as managing stormwater; reducing the urban heat island effect and air pollution and providing wildlife habitat. Enhanced tree canopy also has an aesthetic value, improves quality of life and increases property values.

The City of Toronto seeks to increase tree canopy cover to 40% (Toronto, 2013), therefore designers should look for opportunities to integrate trees within the City's rights-of-way. Tree planting is appropriate within all street types with the exception of residential and mixed-use lanes. Large canopy native species are preferred and the most appropriate species are defined for a specific site application using the Vegetation Selection Tool.

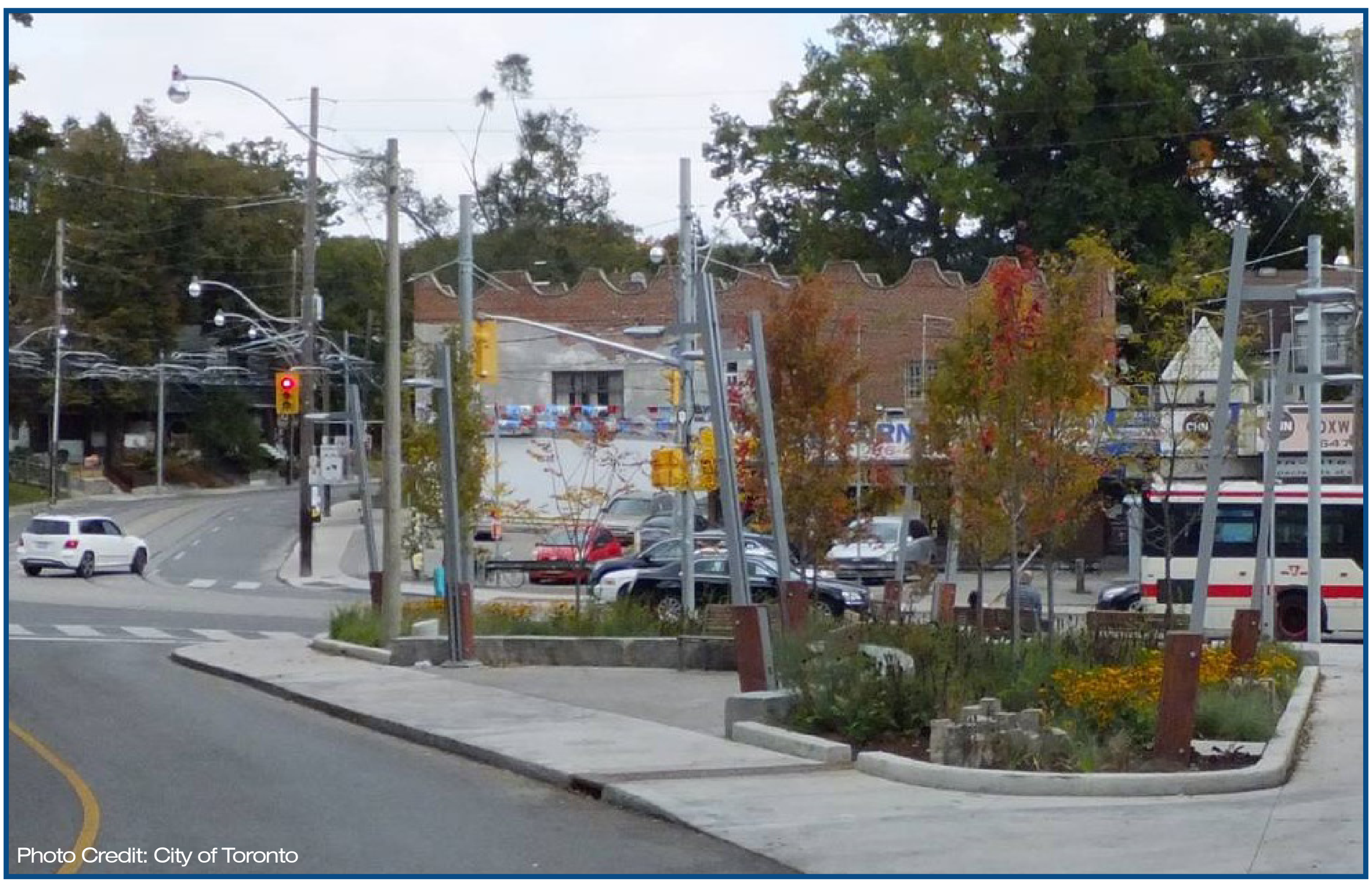


Photo Credit: City of Toronto

3.2.2 | Native Herbaceous Planting

Native herbaceous plants are indigenous to the Toronto region and are characterized by their lack of woody stems above ground level. Herbaceous plant material can be integrated into a variety of GI options to promote pollinator habitat and enhance biodiversity within Toronto's streets. Plant material should not only be selected for its aesthetic quality and habitat value, but also for its tolerance of drought and urban conditions. Refer to the Vegetation Selection Tool for GI and context appropriate plant material.

3.2.3 | Ecopassages

Ecopassages are bridges or tunnels that guide animals and reptiles safely over or under roads and highways. Within the City of Toronto, ecopassages can be particularly valuable on streets that bisect the Natural Heritage System (NHS) by facilitating wildlife migration and aiding in the reduction of road mortality. The Toronto and Region Conservation Authority's (TRCA) *Crossings Guideline for Valley and Stream Corridors* (TRCA, 2015) addresses ecopassage design in detail and should be referenced whenever ecopassages are considered for implementation as part of a Green Streets project.

"Toronto is home to healthy pollinator populations that support resilient ecosystems and contribute to a rich urban biodiversity."
(Toronto Pollinator Protection Strategy)

Green Infrastructure solutions that feature native herbaceous plants, shrubs and trees can be implemented throughout Toronto's streets to provide key linkages that connect existing pollinator habitats throughout the City.

3.2.4 | Light Limitation

Excessive light stray from street lights can impact wildlife and wildlife habitats. Limiting light dispersion at night can assist in maintaining native wildlife populations, habitats and ecological functions. Every effort should be made on all new street and street retrofit projects to limit light dispersion by making appropriate fixture choices and providing targeted luminaire placement. This is particularly critical on streets that bisect the City's NHS.

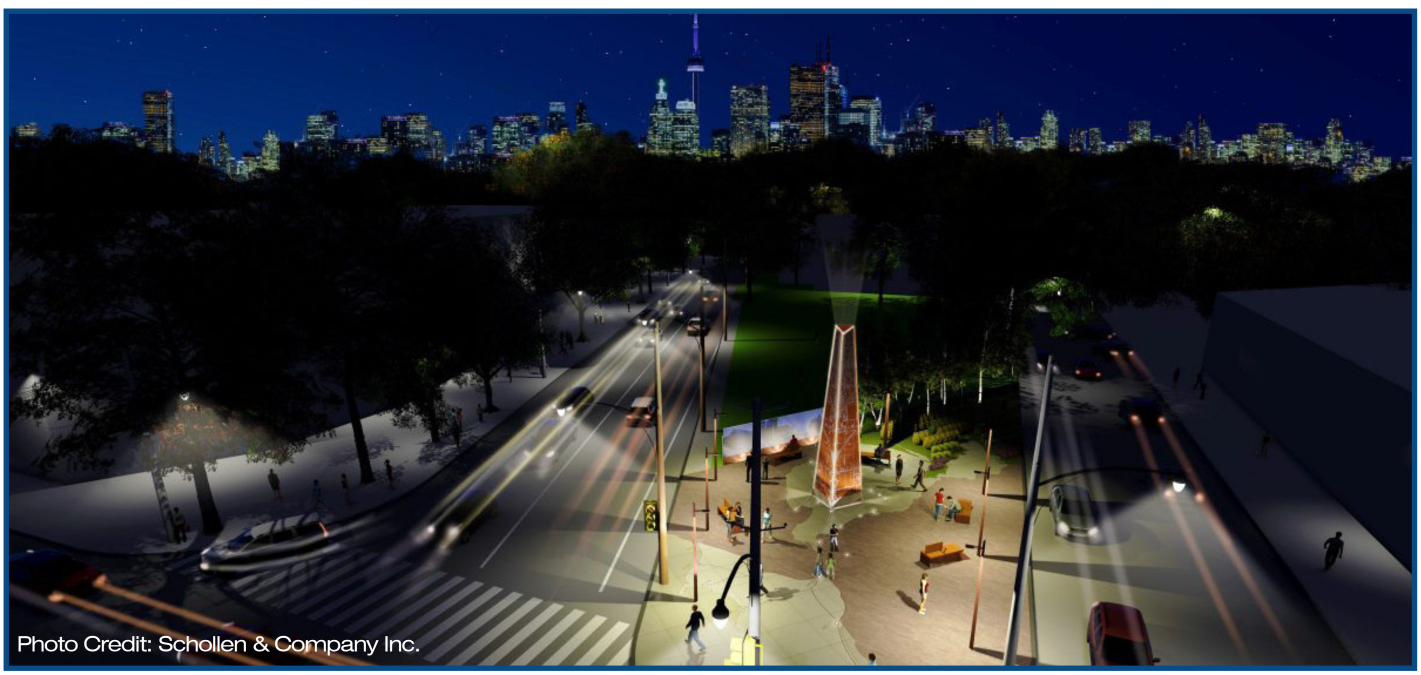


Photo Credit: Schollen & Company Inc.

The following Green Street options will promote Air Quality as a primary benefit.

3.2.5 | Green Walls

Green walls can provide valuable green infrastructure within confined urban spaces. They can feature plants rooted in the ground and trained to grow up a vertical wall, known as a 'green facade' or plants that are rooted in a vertical modular, composite or custom substrate system that is affixed directly to an existing structural wall, known as a 'living wall'. Refer to Toronto's *Best Practices Manual for Green Walls* (Toronto, 2014) for a detailed description of each.

Green walls provide numerous environmental, social and economic benefits including:

Green walls can be applied to bridge abutments within any street type, but will provide the greatest ecological benefits along streets that are adjacent to or that bisect the NHS. Green walls can also be applied to noise barriers along street corridors to assist with noise attenuation.

Selecting the appropriate green wall system and the appropriate plant materials for a particular site is critical to the long-term sustainability of the green wall. Refer to the Vegetation Selection Tool for an appropriate palette of green wall plant material.

- **Promoting biodiversity;**
- **Providing habitat and nesting opportunities;**
- **Encouraging ecological linkages;**
- **Improving air quality; and,**
- **Providing water quantity and quality benefits.**


Photo Credit: City of Toronto

3.2.6| Street Trees

Street trees can be planted in hard or soft landscape conditions within Frontage Zones, Furnishing Zones or Medians of most street types, with the exception of residential lanes and mixed-use lanes.

Street trees help to increase the overall urban forest canopy and can assist in improving air quality, reducing the urban heat island effect and providing wildlife habitat. The City prefers large canopy native species for street tree planting. Suitable species can be identified using the Vegetation Selection Tool.

Planting in grassed areas is easier than in paved conditions, where special construction methods are required. Key areas of concern include the interface between trees and utilities, adequate soil volumes (20 - 30 m^3 /tree) in order to grow trees to maturity and the provision of appropriate structural support in conjunction with non-compacted soils.

The following planting options proposed for the GSTG are adapted from Toronto's *Tree Planting Solutions in Hard Boulevard Surfaces, Best Practices Manual* (Toronto, 2013) and have been designed to meet all criteria noted above.

3.2.6.1| Trees in Soil Cells

Soil cell systems can be used when street trees are desirable in locations where surface areas are limited.

Soil cells are rigid modular systems that increase the soil volume under paved surfaces in ultra-urban areas. They provide the structural integrity required to support vehicular load on paved surfaces while offering up to 92% porous space in order to accommodate underground services and utilities.

Soil cells can be used under conventional concrete or unit pavers as well as under pervious interlocking concrete pavers. In addition, given their structural integrity, soil cells be used under vehicular load bearing sidewalks, parking lay-bys or cycling infrastructure to increase soil volumes.

Paved surfaces should be designed to withstand loads from sidewalk ploughs and midsize service vehicles, therefore, structural soil can be used under paved areas to allow for roots to grow into adjacent soil volumes.

Planting options adopted by the GSTG include:

- **Trees in Soil Cells; and,**
- **Trees in Open Planters.**

Photo Credit: Schollen & Company Inc.

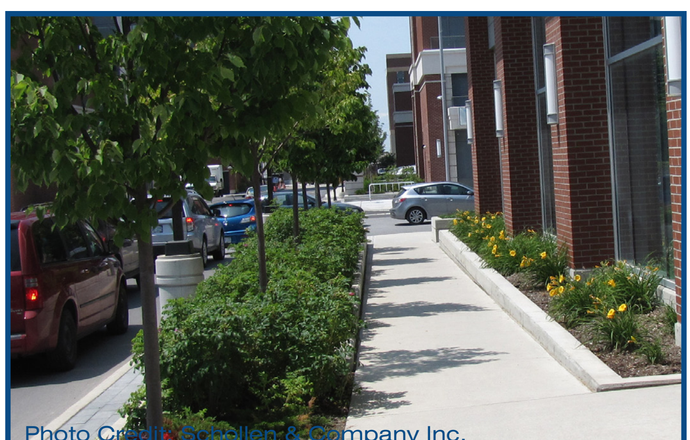


Photo Credit: Schollen & Company Inc.

3.2.6.2 | Trees in Open Planters

Open tree planters can be used in Planting / Furnishing Zones, Frontage Zones and Medians where widths are more generous. They are able to accommodate two or more trees per planter and can be framed by a low curb or higher seat wall. Open tree planters are typically the most cost effective way to plant in a hard landscape if space allows, but are not the preferred solution in areas with high volumes of pedestrian traffic. The soil volume can also be augmented by installing soil cells below the grade of the planter.

3.2.6.3 | Planter Boxes / Movable Planters

Planter boxes are available in a variety of forms and materials and can be used as accents in Frontage or Furnishing Zones or for buffering between competing uses like Cycling Infrastructure and Vehicle Lanes. Planter boxes can enhance biodiversity and improve air quality, but have a limited ability to manage stormwater as they only receive direct rainfall and have a limited capacity for volume retention.

3.2.6.4 | Precast Tree Planters

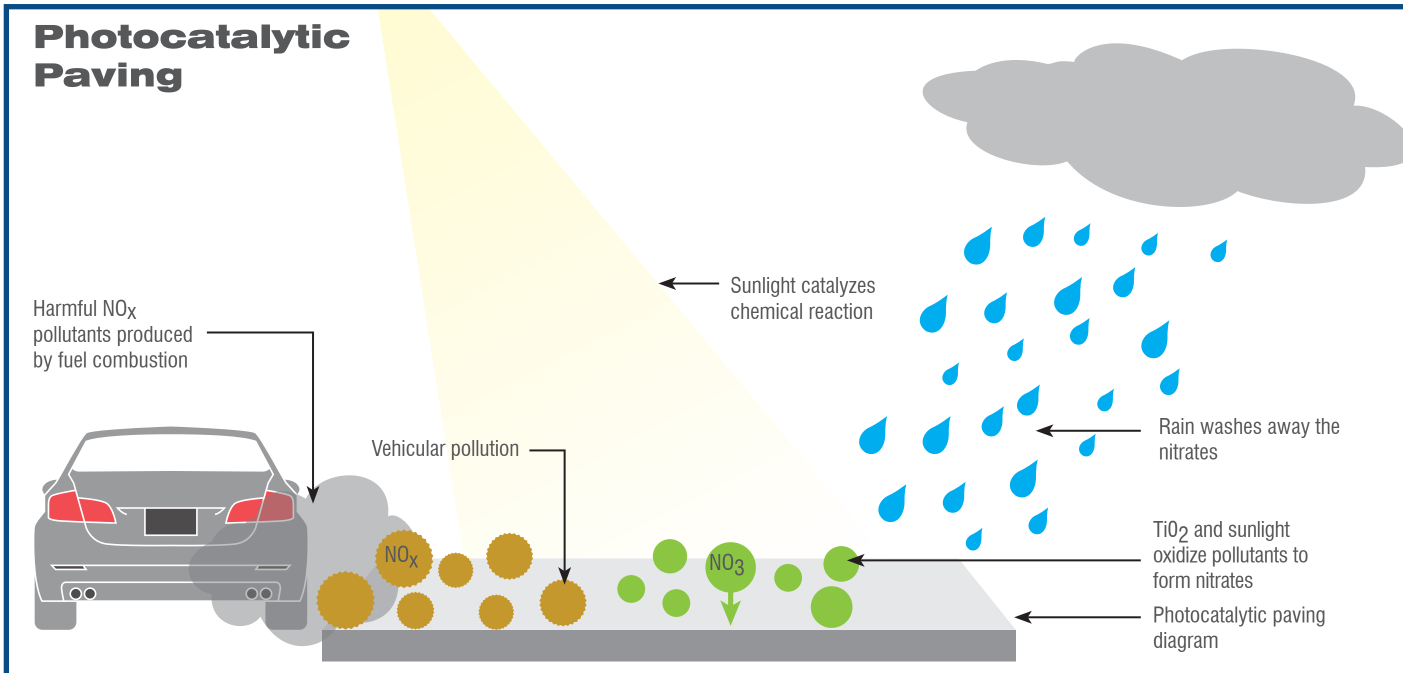
Precast tree planters are prefabricated impervious planters filled with bioretention media and equipped with a perforated pipe outlet for filtration and conveyance of direct rainfall. Precast planters are suitable for use throughout urban street types, however they have a limited capacity for volume retention.

3.2.7| Photocatalytic Paving*

Photocatalytic paving is a surface treatment that has the ability to purify outdoor air by eliminating airborne toxins that result from traffic emissions. When exposed to sunlight, the titanium dioxide embedded within the paving surface generates a chemical reaction that converts nitrogen oxide gasses to non-toxic nitrates that wash away when it rains.

Photocatalytic paving is currently being tested for vehicular and pedestrian applications with promising results. Once this product becomes widely available, it could provide a significant improvement in air quality and therefore should be considered for a variety of paving applications within all street types throughout Toronto.

Photocatalytic Paving



Data Source: Intect Open Science - Open Minds

The following GI options will assist in addressing GHG and Energy Efficiency priorities within Toronto's streets.

3.2.8 | LED Lighting*

LED (light emitting diodes) lights represent the latest in lighting technology. They are long lasting (30,000-60,000 hours) and are extremely energy efficient (up to 90% more efficient then conventional incandescent bulbs). In addition, they generate very little heat and are made of non-toxic materials that can be recycled. LED lights provide superior visibility with more even light dispersion and can reduce light pollution through appropriate fixture choices and targeted placement.

3.2.9 | Solar Photovoltaic Panels*

Photovoltaic panels harness sunlight and convert it to usable energy. Solar units can be used to power streetlights and parking meters, to illuminate transit stops and as decorative paving. They provide considerable benefits over conventional grid-powered systems including energy efficiency, location flexibility and wireless monitoring capability. However, due to the fact that many of Toronto's streetlights, parking meters and transit stops are privately-owned and operated, service agreements will be required in order to facilitate the use of solar panels.


Photo Credit: Scholler & Company Inc.

3.2.10 | Solar Roads*

Solar roads are a new and evolving technology currently in research and development in the United States. They comprise a modular system of photovoltaic panels designed to convert sunlight to usable energy.

Solar roads are engineered to be an all-in-one system that will eliminate requirements for resurfacing, repainting and even winter maintenance. LED lights are embedded within the panels to provide lane markings, turning arrows, HOV, cycling infrastructure or any other type of marking necessary. These markings can be illuminated on the surface of the panels as required.

Solar road panels are made from tempered glass that has the traction of asphalt and can support the weight of a semi-truck. They are also self-heating to prevent snow and ice accumulation thereby reducing winter maintenance costs. The panels are equipped with microprocessors that enable communication with each other, operators and users.

Solar roads are not yet widely available, but have been implemented using grants from the United States government and are currently being tested on driveways and parking lots throughout the USA. This product may be a few years away from broad-scale implementation, however once more widely available and proven, they will be worthy of consideration for application throughout all of the City's street types. Solar roads hold the potential to yield significant financial and environmental benefits.

3.2.11| Solar Paver Lights*

Solar-powered LED paver lights are designed to withstand most vehicle traffic and are durable under harsh winter conditions. Each unit is self-contained and comes equipped with its own solar cells that charge an internal battery. A light sensor is included to activate and deactivate the LED lights at dusk and dawn. These pavers are well-suited for application as accent lights within the Frontage Zones, Furnishings Zones or Medians of ultra-urban street types.

3.2.12| Photoluminescent Road Markings*

Photoluminescent road markings are created from a paint product that has an embedded photoluminescent powder. The paint absorbs sunlight during the day and then emits a green glow at night that lasts up to 10 hours. This type of road marking system can help to reduce street lighting requirements thereby improving energy efficiency.

Photoluminescent road markings can be used within Vehicular Travel Lanes or to define Crosswalks and Cycling Infrastructure in almost all street types.

3.2.13| Wind Energy*

Small-scale wind turbines can be highly versatile and can provide a renewable energy source. Wind turbines are recommended as a sustainable option to power street lights, however given that the majority of Toronto's street lights are owned and operated privately, service agreements would be required to facilitate wide-scale adoption throughout Toronto's streets.

3.2.14| Cool Pavements*

Pavement with higher solar reflectivity reduces local heat island effects and reduces the heat transferred to stormwater thereby improving water quality. Currently, the TGS Tier 2 and LEED support a requirement for SRI of at least 29 for 75% of all hard landscape surfaces.

Photo Credit: Smart Highway by Studio Rossegaarde and Heijmans

The following GI options are designed to promote water quality improvement, quantity control and efficiency within Toronto's streets.

3.2.15 | Bioretention

Bioretention is a Low Impact Development (LID) practice that is designed to provide temporary storage, filtration and infiltration of stormwater runoff. Although the physical design of a bioretention facility can vary, the construction profile generally consists of the following: a gravel storage layer, a choker layer (optional), a bioretention media layer, a mulch layer and a vegetation layers.

A critical component of any bioretention facility is its drainage system. Proper design of the drainage system will depend on the infiltration rate of existing native soils. Sites with highly permeable soils (>15mm/hr) can facilitate bioretention practices that are designed with no underdrain to provide full infiltration. Bioretention facilities designed for sites with less permeable soils (<15mm/hr) will require an underdrain for partial infiltration. In cases where contaminated soils exist or where the water table is high, an impermeable liner and underdrain can be integrated into the bioretention cell to create a facility designed for filtration only. This type of bioretention facility is also known as a biofilter.

When considering an infiltration or partial infiltration bioretention option, practices should be located a minimum of 5 m from the foundation of any building in order to reduce the risk of seepage. Attenuation type biofiltration techniques are suitable within 5 m of a foundation.

Bioretention practices are designed to capture and treat runoff from small storm events. The maximum ponding depth after a storm event should be 150 - 250 mm with larger events handled by an overflow/bypass. Bioretention facilities can also serve as areas for snow storage and snowmelt treatment.

The physical form of bioretention practices can vary to provide a complementary aesthetic within any street type from rural to ultra-urban contexts. Types of bioretention facilities include:

- **Bioretention / Stormwater Planters;**
- **Bioretention Curb Extensions/Bump-outs;**
- **Bioretention Cells; and,**
- **Rain Gardens.**

Photo Credit: Schollen & Company Inc.

3.2.15.1| Bioretention Planters

Bioretention planters are constructed with vertical walls, are often narrow and rectangular in shape and can be installed in close proximity to utilities, driveways, trees, light standards and other street features. Bioretention planters receive roadway runoff through curb inlets and by overland flows from the surrounding sidewalk and paved surfaces.

They are well-suited for ultra-urban street types and can be adapted to fit within Furnishing Zones and Medians. As a result of their context, bioretention planters require hardy, aesthetically-pleasing plant materials that tolerate harsh urban conditions and winter maintenance protocols.

Bioretention planters are often located in higher pedestrian traffic areas, therefore design solutions should consider planting, curb or railing options that will impede pedestrians from inadvertently stepping into a planter bed.

Stormwater planters are similar to bioretention planters in their form and function, however stormwater planters typically located within the Frontage Zone or directly adjacent to a building. They can be designed to receive runoff from downspouts and surrounding sidewalks.

Photo Credit: Schollen & Company Inc.

3.2.15.2 | Bioretention Curb Extension/Bump-Outs

Curb extensions and bump-outs provide another design variation of the bioretention practice. They can be located at intersections, mid-block areas and at transit stops within the Edge and Roadway Zones of various street types. In addition to stormwater management functions, curb extensions / bump-outs can also enhance biodiversity, offer visual appeal and provide traffic calming benefits. Curb extensions / bump-outs are ideal for street retrofit projects as they can usually be installed within the limits of existing street cross-section.

Curb extensions / bump-outs are typically on-line stormwater management practices, meaning that they are in the direct flow path of runoff that is conveyed along the curb. This is an important consideration as it affects the pretreatment design and maintenance protocols for these options.

3.2.15.3| Bioretention Cells

Bioretention cells provide a design variation that is suitable for more suburban street types within Furnishing / Planting Zones or Medians where space is not as constrained. This form of bioretention often receives overland flows from the surrounding landscape and from the roadway through curb cut inlets.

3.2.15.4| Rain Gardens

Rain gardens are sunken planting beds constructed of highly permeable nutrient rich soils. They can include an engineered soil layer and overflow structure to increase their stormwater management performance. Rain gardens should always be designed to drain efficiently after a storm event to avoid creating areas of standing water where mosquitoes can breed. They are well-suited to suburban neighborhood street types and can be installed within Planting Zones, Medians and Islands.

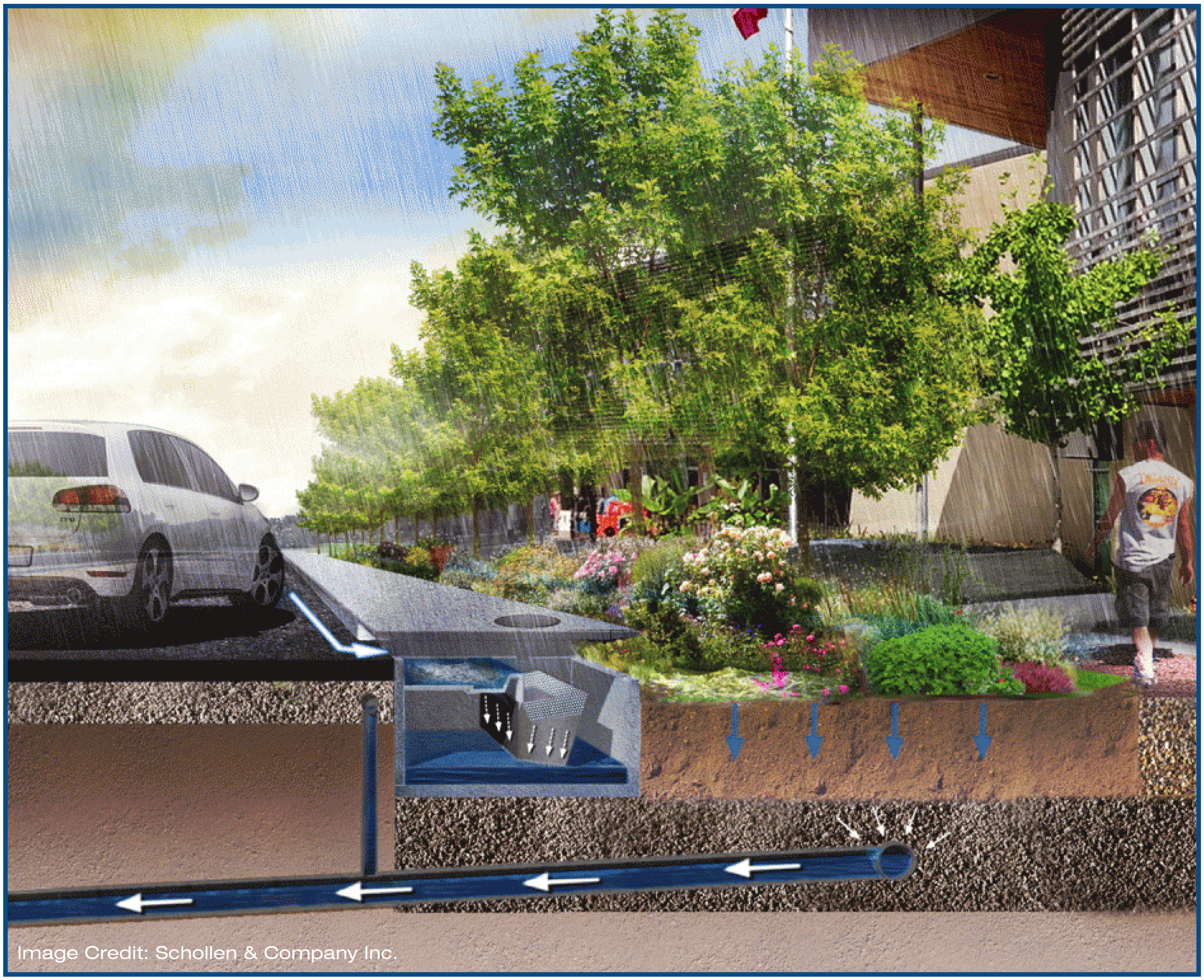


Image Credit: Schollen & Company Inc.

3.2.16| Stormwater Tree Pits

Stormwater tree pits are a variation of the traditional tree pit that receives stormwater runoff from the road through curb inlets. They consist of a tree installed in filter media with an open bottom to promote infiltration into the surrounding native soils.

Stormwater tree pits are well-suited to ultra-urban street types and are typically installed within the Furnishing Zone. Where large mature trees are desired, additional soil volume can be provided using soil cells.

3.2.17| Stormwater Tree Trenches

Stormwater tree trenches consist of a series of stormwater tree planters connected through the underground trench system. The excavated trenches are backfilled with engineered soil. Soil volumes can be further augmented by installing soil cells.

Stormwater tree trenches are well-suited to ultra-urban street types and are typically installed within the Furnishing Zone. Permeable pavement is an optional appropriate surface treatment over a stormwater tree trench as this type of pavement allows for air circulation and water infiltration into the tree trench.

3.2.18| Swales

Swales typically require a large area and are therefore well-suited for installation within Planting Zones and Medians in suburban street cross-sections such as Neighborhood Residential, Connector and Employment streets. They consist of linear vegetated channels that convey, treat and attenuate stormwater runoff. Vegetation and check dams may be integrated into swales to slow the velocity of runoff, allowing for sedimentation, filtration, evapotranspiration and infiltration (depending on soil infiltration rates). Swales also provide a suitable location for snow storage during the winter months.

3.2.18.1| Enhanced Grass Swales

Enhanced grass swales are similar to traditional grass swales, however they feature a slightly altered parabolic form and incorporate amended soils that slow runoff and assist in contaminant removal. Enhanced grass swales can serve as a pretreatment option for infiltration practices, particularly on low traffic volume roadways that do not receive high loads of de-icing compounds in the winter. Check dams can be integrated into the design in order to maximize infiltration benefits.

3.2.18.2| Bioswales

Bioswales are similar to enhanced grass swales in their linear and cross-sectional surface geometry, however their subsurface profile is more reflective of a bioretention cell, with filter media and/or a storage gallery and optional underdrain (depending native soil permeability) below. Bioswales can either be planted with grasses or finished with more elaborate combinations of plant and aggregate materials. These additional components help to slow the velocity of runoff and assist in sedimentation, filtration evapotranspiration and infiltration. As a result of their bioretention profile, bioswales have the potential to be more effective at removing pollutants, reducing runoff and protecting downstream channels from erosion then enhanced grass swales. Bioswales are also referred to as dry swales or infiltration swales.

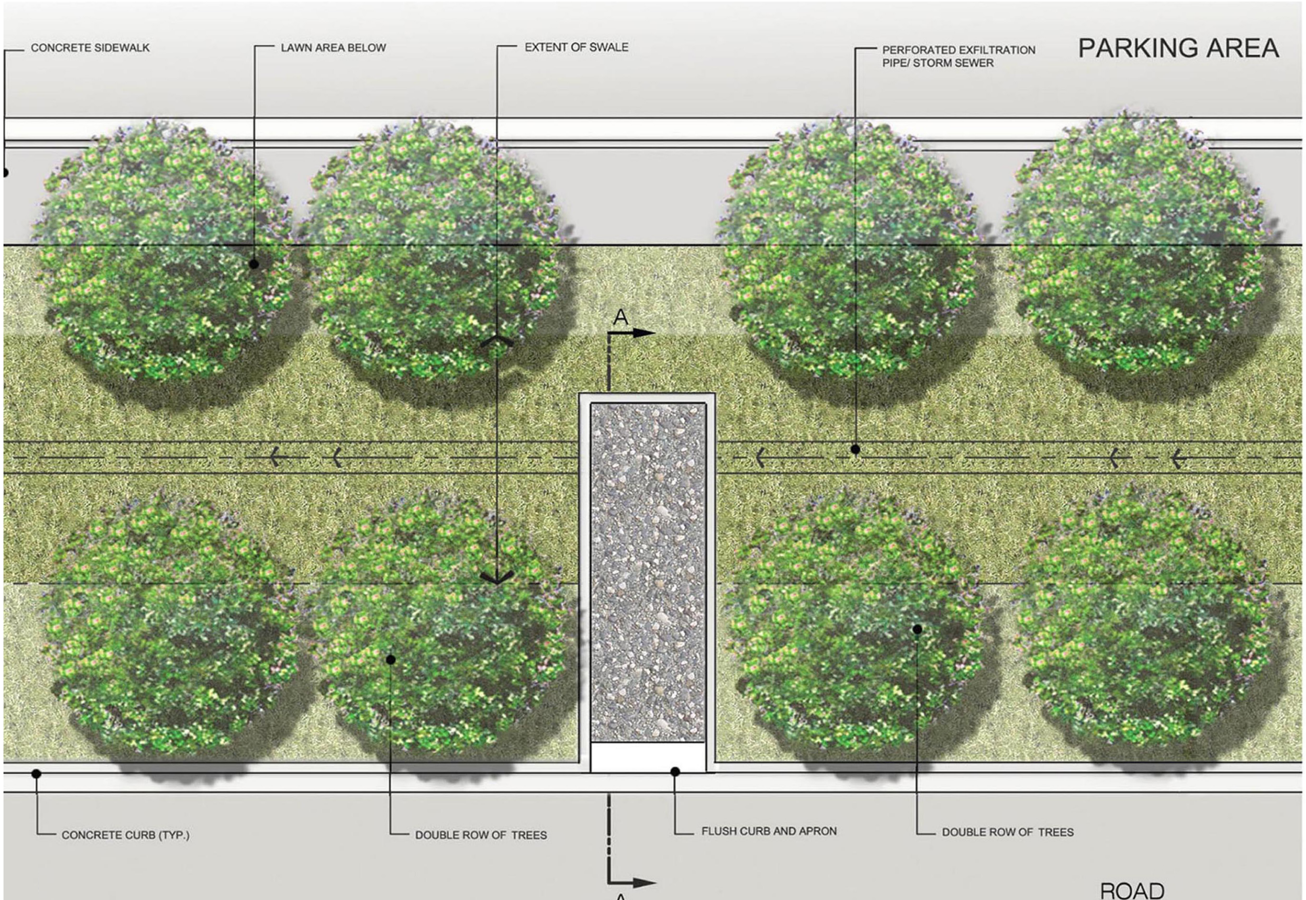


Image Credit: Schollen & Company Inc.

3.2.18.3| Bioswales with Stone Wells

Bioswales with stone wells provide a formal aesthetic that can be integrated into urban street types. They feature the longitudinal surface geometry and sub-surface profile of a bioswale, but also include stone filled wells installed at equidistant spacing along the length of the bioswale to draw stormwater into highly permeable (>15mm/hr) native subsoils more efficiently. This type of bioswale can also be fitted with curb outlets to direct overflows downstream to an existing catch basin. A variation on this design can also include a stormwater inlet at the upstream end that funnels runoff directly to the stone layer of the cell.

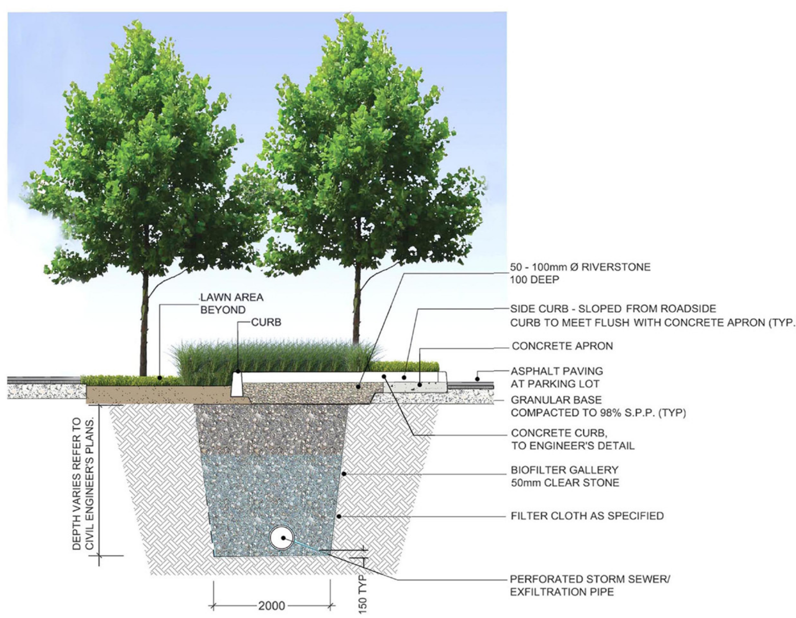


Image Credit: Schollen & Company Inc.

3.2.19| Green Gutters

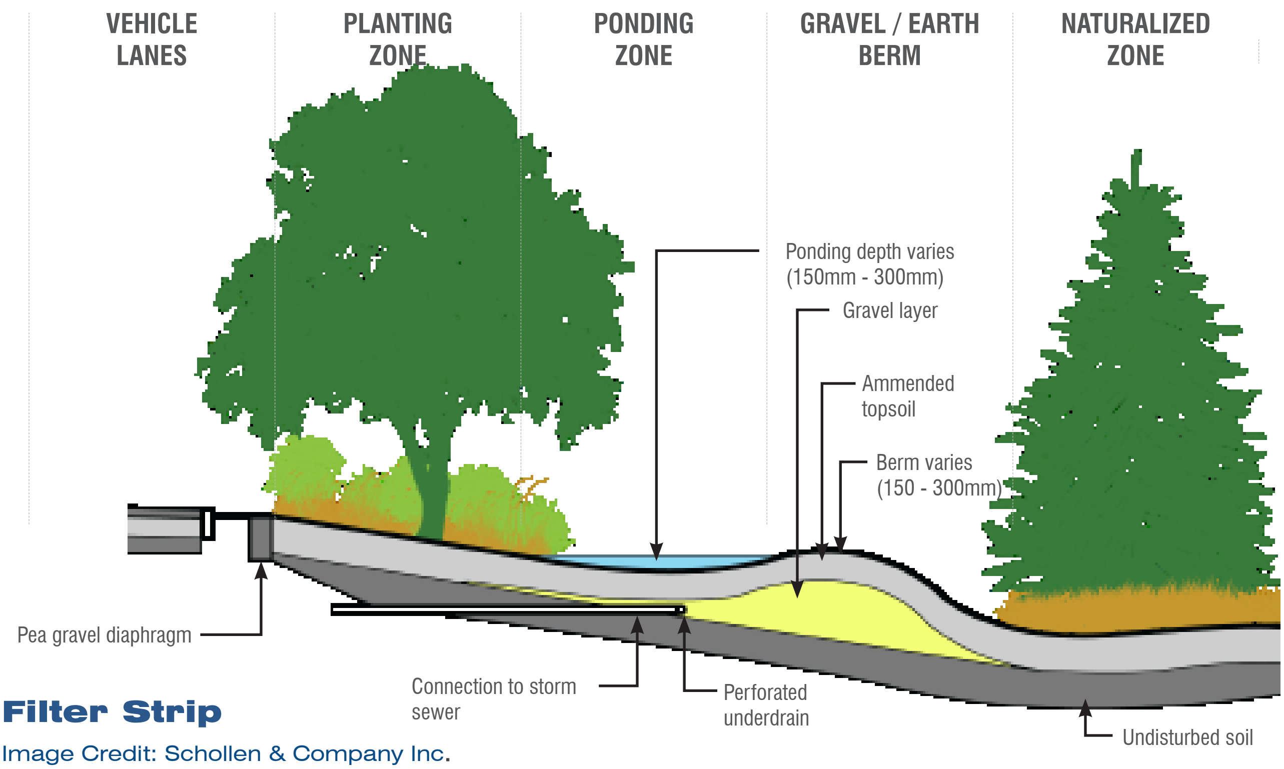
Green gutters are shallow planters that extend the full length of a street section which may incorporate breaks at intervals to accommodate pedestrian movement. Green gutters can be installed as separation between conflicting uses such as between Cycling Infrastructure and Vehicle Lanes within street types where space allows. They can also be installed as GI within dedicated LRT lanes. Green gutters are typically planted with low-growing grasses or sedums and are designed to attenuate, filter and infiltrate stormwater runoff.

Photo Credit: Schollen & Company Inc.

3.2.20| Filter Strips

Filter strips are gently-sloping, heavily-vegetated areas that treat runoff from adjacent impervious surfaces including roadways, sidewalks and driveways. They can be stand-alone stormwater management practices or they can function as pretreatment for other infiltration practices. Filter strips are well-suited to streets with a suburban cross-section or connector streets where no curbs presently exist.

Filter strips should be planted with native material in order to provide maximum ecological and water quality benefits. In the winter months, these areas are well-suited to provide snow storage capacity as they have an excellent capability to filter and infiltrate snow melt in the spring. Filter strips are also referred to as buffer strips.



Filter Strip

Image Credit: Schollen & Company Inc.

3.2.21| Underground Infiltration Systems

Underground infiltration systems have little to no surface footprint and can therefore be integrated within the Planting Zone or Vehicle Lanes of almost any street type. The primary function of these systems is to capture, convey (occasionally) and infiltrate stormwater, therefore these systems should only be used in locations with highly permeable (>15mm/hr) native soils. Due to the fact that infiltration is a primary function of underground infiltration systems, care should be taken to avoid contributing drainage areas that may be contaminated or that may receive high volumes of de-icing compounds in the winter. Pretreatment should also be integrated into all systems that receive roadway runoff that may contain large quantities of sediments.

3.2.21.1| Drainage Wells

Drainage wells are vertical perforated pipes that are installed under the surface of a roadway and gradually allow stormwater to discharge into the surrounding native soils. They are connected to inlets along the street and because they treat roadway runoff, a pretreatment system is required. Due to their relatively small surface footprint, drainage wells can easily be implemented throughout a variety of street types including ultra-urban contexts, in both new construction and retrofit scenarios. Care must be taken throughout the design and construction processes to ensure that there are no conflicts with existing utilities in retrofit scenarios.

3.2.21.2| Perforated Pipe Systems

Perforated pipe systems are connected to catch basins installed within the Edge or Planting Zone. This type of system receives runoff from sidewalks, driveways and roadways. The system itself consists of perforated pipes that are installed horizontally along a gradually sloping subsurface trench that is filled with granular and wrapped in geotextile fabric. They can be used in place of, or as a complement to, conventional pipe systems. Due to their relatively small surface footprint, perforated pipe systems can be implemented in almost any street type. However, because of the many constraints inherent to the retrofit scenario, perforated pipe systems are ideally-suited to new construction projects.

3.2.21.3| Soakaways

Soakaways are rectangular excavations, lined with geotextile and filled with clear stone created under a hard or a soft landscape area. They attenuate and infiltrate runoff from sidewalks and other paved surfaces and are ideally-suited for application within the Planting Zones of residential streets or under low volume vehicle lanes (i.e. multi-use or residential lanes). Soakaways are also referred to as infiltration galleries, dry wells or soakaway pits.

3.2.21.4| Infiltration Trenches

Infiltration trenches are a design variation of a soakaway that consists of a linear trench lined with geotextile fabric and filled with clear granular stone. Infiltration trenches are well-suited for areas where space is limited to a narrow strip including Medians, Planting Zones or low volume Vehicle Lanes. They can be covered with stone, vegetation or paving depending on context. Infiltration trenches are also referred to as linear infiltration galleries or linear soakaways.

Photo Credit: Schollen & Company Inc.

3.2.21.5| Infiltration Chambers

Infiltration chambers are another design variation on soakaways that incorporate prefabricated modular chambers that are installed under Medians, Planting Zones or low volume Vehicle Lanes to store runoff temporarily before infiltrating it into the underlying native soils. The chambers typically have an open bottom and perforated side walls and are usually placed over a stone reservoir. They can be installed individually or in series depending on available space. Infiltration chambers are well-suited to new construction scenarios, but can also be integrated into retrofit projects with careful planning. Infiltration chambers are also be referred to as infiltration tanks.

Photo Credit: Schollen & Company Inc.

3.2.22| Rainwater Cisterns

Rainwater cisterns intercept, convey and store rainfall for future use. Within the right-of-way there are opportunities to capture runoff in prefabricated cisterns below grade and then to reuse rainwater for irrigation and maintenance purposes. This type of system can be effective in reducing demands on the municipal potable water system.

3.2.23| Permeable Pavements

Unlike traditional impervious surfacing materials, permeable pavement allows stormwater to infiltrate through the surface into a subsurface stone reservoir rather than collecting and being conveyed as surface runoff. Stormwater is temporarily detained and, in most cases, infiltrated into the native subsoils. Similar to other infiltration-based practices, the requirement for an underdrain relates directly to the permeability of underlying native soils.

Permeable pavements are suited to several applications within streets including: Decorative Paving, Cycling Infrastructure, Parking Lay-Bys and On-street Parking areas, as well as on the roadway surfaces of low traffic streets such as Lanes and Shared streets. Permeable pavements can be used in both new and retrofit scenarios. The following types of permeable pavements are recommended for use within road rights-of-way.

3.2.23.1| Pervious Concrete

Pervious concrete has fewer fines then conventional concrete, creating void spaces (15%-35%) within the material. This material provides a suitable replacement for conventional concrete throughout all street types for use in Sidewalk applications and is ideally-suited to applications within sites where space is limited.

Photo Credit:Chesapeake Stormwater Network http://chesapeakestormwater.net/wp-content/uploads/2012/01/Porous-Concrete-Driveway.jpg

3.2.23.2| Porous Asphalt

Porous asphalt features air pockets that are created as a result of the inclusion of fewer fines and less sand content than traditional impervious asphalt. These void spaces allow water to filter through to the aggregate layer below. Porous asphalt provides a suitable alternative to conventional asphalt and can be used within road rights-of-way in areas such as Cycling Infrastructure, Parking Lay-Bys, and multi-use recreational trails.

Photo Credit:Ilpelling Co. http://www.llpelling.com/wp-content/uploads/2011/10/Porous-Asphalt.jpg

3.2.23.3| Permeable Interlocking Precast Concrete Pavers

Permeable concrete paver systems have expanded joints that allow for 5%-10% of a paved surface area to be filled with porous aggregate material. These voids allow water to filter through to the aggregate layer below. Permeable concrete pavers can be used in a variety of applications such as for Lane paving, Decorative Paving treatments and Parking Lay-bys within various street types.

Photo Credit: Schollen & Company Inc.

3.3 DESIGN AND CONSTRUCTION CONSIDERATIONS

3.3.1| Design Considerations

GI projects are complex and require the expertise of industry specialists, municipal divisions and government agencies at various stages throughout the process. The project team must comprise knowledgeable professionals with experience in GI design and construction, who understand the project objectives as well as the complexities of the site. Project team members often include: Project Managers, Municipal Planners, Civil/Environmental/Water Resource Engineers, Landscape Architects, Hydrologists, Geotechnical Engineers, Structural Engineers, Ecologist/Biologists, Product Suppliers and Government Agencies.

The first step in the design process for any Green Streets project is to establish environmental objectives based on TGS priorities. These objectives will guide the design and implementation process. Subsequently, a palette of GI options must be defined based on site specific criteria using the GI Selection Tool. Once a palette of GI options is identified, utility locates and site testing should be undertaken immediately in order to confirm the applicability of selected GI options for the given site. Testing and time requirements can vary for each GI option. These requirements are outlined in Figure 1.0 *(GI Project Timeline - Site Specific Investigations)*. The creation of an appropriate design solution will require input from team members representing the various disciplines as well as representatives from the relevant departments within the City and the TRCA prior to implementation.

3.3.2| Construction Considerations

3.3.2.1| Contractor Selection

Contractors selected to undertake work on GI projects should have extensive knowledge and experience in the design and construction of GI options.

3.3.2.2| Site Preparation

Requirements for site preparation will vary based on the types and complexity of GI options proposed and whether the work is part of an extensive reconstruction project or a less intensive retrofit project. For example:

If a proposed bioretention planter is designed to incorporate an infiltration component, then it will be important to ensure that appropriate barrier fences and erosion and sediment control measures are established around the perimeter of the site prior to construction in order to avoid any potential for compaction or contamination of the profile during construction. In addition, any contributing stormwater runoff should be diverted away from the installation until construction is complete. Finally, it will be important to have an erosion and sediment control plan in place in order to mitigate the potential effects of heavy storm events. This plan must be implemented by the contractor in order to reduce the risk of site contamination.

3.3.2.3| Construction Sequence

The following are typical steps for constructing GI practices that are aimed at achieving stormwater management objectives. This process may vary depending on the exact specifications and performance requirements of the design.

1. Verify locations of underground services and utilities;
2. Perform infiltration testing to confirm the permeability of the subsoils;
3. Confirm that the designed capacity of the GI option will accommodate the volume of stormwater anticipated from the contributing drainage area;
4. Establish an Erosion Control plan and install ESC measures;
5. Divert contributing runoff temporarily;
6. Stage construction materials in a clean and secure location in close proximity to the installation site. This will minimize the risk of material compaction or contamination;
7. Implement traffic controls (pedestrian and / or vehicular) where required;
8. Where applicable, isolate pretreatment installations until the main facility is complete;
9. Wherever possible, excavate installation using equipment located outside of the area of disturbance;
10. Scarify the base of the excavation for infiltration-based GI facilities;
11. Install the sub-base profile (if applicable) as per construction drawings;
12. Install premixed filter media (if applicable) in maximum 300 mm lifts. Apply water to pack material without excessive compaction;
13. Apply mulch layer (if applicable) as per construction drawings;
14. Install plant material (if applicable) as per the landscape plan;
15. Install surface material (if applicable) per construction drawings;
16. Confirm that all elevations are in accordance with the detailed design drawings including: inlets/outlets, pretreatment and overflow;
17. Ensure that the GI installation is functional prior to redirecting contributing stormwater runoff into it.

3.3.2.4| Additional Considerations

- Inspect the installation weekly for 3-6 months after construction (as well as after heavy rainfall) to ensure that the facility is functioning as designed.
- Consider options for reducing the carbon footprint of a project during construction by sourcing local products and specifying lower carbon or recycled materials and components.

	Number	Green Infrastructure Project Timeline Site Specific Investigations Name	Geotechnical Testing (Lead Time: 3 weeks-months)	Infiltration Testing (Lead Time: 3 weeks - months)	Utility Locates (Lead Time: 1-2 weeks)	Average Wind Speed Testing (Lead Time: 2-3 weeks)	Sun Angle Analysis (Lead Time: 2 -3 weeks) ✱ refers to Bridge applications
WATER QUANTITY, QUALITY & EFFICIENCY	WQ-1.1	Bioretention Planter w/o Pre-treatment or Underdrain	✓	✓	✓		✱
	WQ-1.1	Bioretention Planter with Pre-treatment w/o Underdrain	✓	✓	✓		✱
	WQ-1.1	Bioretention Planter with Underdrain	✓		✓		✱
	WQ-1.1	Bioretention Planter with Pre-treatment & Underdrain	✓		✓		✱
	WQ-1.1	Biofilter Planter (Filtration Only Bioretention) - Impervious Bottom	✓		✓		✱
	WQ-2.1	Stormwater Planter w/o Pre-treatment or Underdrain	✓	✓	✓		✱
	WQ-2.1	Stormwater Planter with Pre-treatment w/o Underdrain	✓	✓	✓		✱
	WQ-2.1	Stormwater Planter with Underdrain	✓		✓		✱
	WQ-2.1	Stormwater Planter with Pre-treatment & Underdrain	✓		✓		✱
	WQ-2.1	Stormwater Biofilter (Filtration Only Bioretention) - Impervious Bottom	✓		✓		✱
	WQ-3.1	Bioretention Curb Extension/Bump-out w/o Pre-treatment or Underdrain	✓	✓	✓		
	WQ-3.1	Bioretention Curb Extension/Bump-out with Pre-treatment w/o Underdrain	✓	✓	✓		
	WQ-3.1	Bioretention Curb Extension/Bump-out with Underdrain	✓		✓		
	WQ-3.1	Bioretention Curb Extension/Bump-out with Pre-treatment & Underdrain	✓		✓		
	WQ-3.1	Biofilter Curb Extension/Bump-out (Filtration Only Bioretention) - Impervious Bottom	✓		✓		
	WQ-4.1	Bioretention - Cell w/o Pre-treatment or Underdrain	✓	✓	✓		
	WQ-4.1	Bioretention - Cell with Pre-treatment w/o Underdrain	✓	✓	✓		
	WQ-4.1	Bioretention - Cell with Underdrain	✓		✓		
	WQ-4.1	Bioretention - Cell with Pre-treatment & Underdrain	✓		✓		
	WQ-4.1	Biofilter - Cell (Filtration Only Bioretention) - Impervious Bottom	✓		✓		
	WQ-5.1	Rain Gardens	✓	✓	✓		
	WQ-6.1	Enhanced Grass Swale	✓	✓	✓		✱
	WQ-6.1	Enhanced Grass Swale with Check Dam	✓	✓	✓		✱
	WQ-6.1	Enhanced Grass Swale with Check Dam & Underdrain	✓		✓		✱
	WQ-7.1	Dry Swale/Bioswale w/o Pre-treatment or Underdrain	✓	✓	✓		✱
	WQ-7.1	Dry Swale/Bioswale with Pre-treatment w/o underdrain	✓	✓	✓		✱
	WQ-7.1	Dry Swale/Bioswale with Underdrain	✓		✓		✱
	WQ-7.1	Dry Swale/Bioswale with Pre-treatment & Underdrain	✓		✓		✱
	WQ-7.1	Dry Swale/Bioswale with Pre-treatment, Underdrain & Impermeable Liner	✓		✓		✱
	WQ-7.2	Bioswale with Well	✓	✓	✓		✱
	WQ-8.1	Green Gutter	✓	✓	✓		
	WQ-9.1	Filter Strip / Buffer Strip with Underdrain	✓		✓		
	WQ-9.1	Filter Strip / Buffer Strip as Pre-treatment Option	✓	✓	✓		
	WQ-10.1	Drainage Well with Pre-treatment	✓	✓	✓		
	WQ-11.1	Perforated Pipe System - with Pre-treatment	✓	✓	✓		
	WQ-12.1	Soakaway/infiltration Gallery/Dry Well/Soakaway Pit with Pre-treatment	✓	✓	✓		
	WQ-13.1	Infiltration Trench/Linear Infiltration Gallery/Linear Soakaway	✓	✓	✓		✱
	WQ-13.1	Infiltration Trench/Linear Infiltration Gallery/Linear Soakaway with Pre-treatment	✓	✓	✓		✱
	WQ-13.1	Infiltration Trench/Linear Infiltration Gallery/Linear Soakaway w Pre-treatment & Underdrain	✓		✓		✱
	WQ-14.1	Infiltration Chamber/Infiltration Tank	✓	✓	✓		✱
	WQ-14.1	Infiltration Chamber/Infiltration Tank with pre-treatment	✓	✓	✓		✱
	WQ-15.i	Permeable Paving - Pervious Concrete	✓	✓	✓		
	WQ-15.i	Permeable Paving with underdrain - Pervious Concrete	✓		✓		
	WQ-15.i	Permeable Paving with underdrain & Impermeable Liner - Pervious Concrete	✓		✓		
	WQ-15.ii	Permeable Paving - Porous Asphalt	✓	✓	✓		
	WQ-15.ii	Permeable Paving with underdrain - Porous Asphalt	✓		✓		
	WQ-15.ii	Permeable Paving with underdrain & Impermeable Liner - Porous Asphalt	✓		✓		
	WQ-15.iii	Permeable Paving - Interlocking Precast Concrete Pavers	✓	✓	✓		
	WQ-15.iii	Permeable Paving with underdrain - Interlocking Precast Concrete Pavers	✓		✓		
	WQ-15.iii	Permeable Paving with underdrain & Impermeable Liner - Interlocking Precast Concrete Pave	✓		✓		
	WQ-16.1	Stormwater Tree Pits	✓		✓		
	WQ-17.1	Stormwater Tree Trenches	✓		✓		
	WQ-18.1	Rainwater Cistern with Pre-treatment	✓		✓		

Figure 1.0 - Green Infrastructure Project Timeline - Site Specific Investigations

	Number	Green Infrastructure Project Timeline Site Specific Investigations Name	Geotechnical Testing (Lead Time: 3 weeks-months)	Infiltration Testing (Lead Time: 3 weeks - months)	Utility Locates (Lead Time: 1-2 weeks)	Average Wind Speed Testing (Lead Time: 2-3 weeks)	Sun Angle Analysis (Lead Time: 2 -3 weeks) ✱ refers to Bridge applications
ECOLOGY	E-1	Natural Canopy					
	E-2	Native Herbaceous Planting					
	E-3	Ecopassages			✓		
	E-4	Light Limitation					
AIR QUALITY	AQ-1	Green Wall					
	AQ-2	Street Trees			✓		
	AQ-2A	Trees in Soil Cell	✓		✓		
	AQ-2B	Tree in Open Planter	✓		✓		
	AQ-2B	Tree in Open Planter with Soil Cells	✓		✓		
	AQ-2C	Planter Boxes/Movable Planters					
	AQ-2D	Precast Tree Planters					
	AQ-3	Photocatalytic Paving					
GHG & ENERGY EFFICIENCY	GHG-1	LED Lights			✓		
	GHG-2	Solar Photovoltaic Panels			✓		✓
	GHG-3	Solar Roads			✓		✓
	GHG-4	Solar Paver Lights			✓		✓
	GHG-5	Photo-luminescent Road Markings			✓		✓
	GHG-6	Wind Energy			✓	✓	
	GHG-7	Cool Pavements					✓

3.4 GUIDELINE DRAWINGS

Guideline Drawings have been prepared for most of the options listed in the GI Selection Tool. It is important to note that these drawings are NOT City of Toronto Standard Drawings. However, they do contain the information necessary to develop site specific construction details. Figure 2.0 illustrates the layout and content of a typical GSTG Guideline Drawing.

Area #1 provides a drawing reference number. This number correlates with the reference numbers beside each GI option in the GI Selection Tools.

Area #2 provides the name and permutation (if applicable) of the GI option.

Area #3 provides a graphic illustration of the components and assembly of the GI option. A range of depths for materials and dimensions are also provided.

Area #4 outlines design guidance for the GI option. This section describes:

- Materials - Standards and Depth/Sizing Calculations
- Geometry and Site Layout
- Underdrains
- Conveyance / Overflow
- Monitoring Wells
- Plant Material

The Guideline Drawings are organized according to TGS priorities and are located in Appendix C.

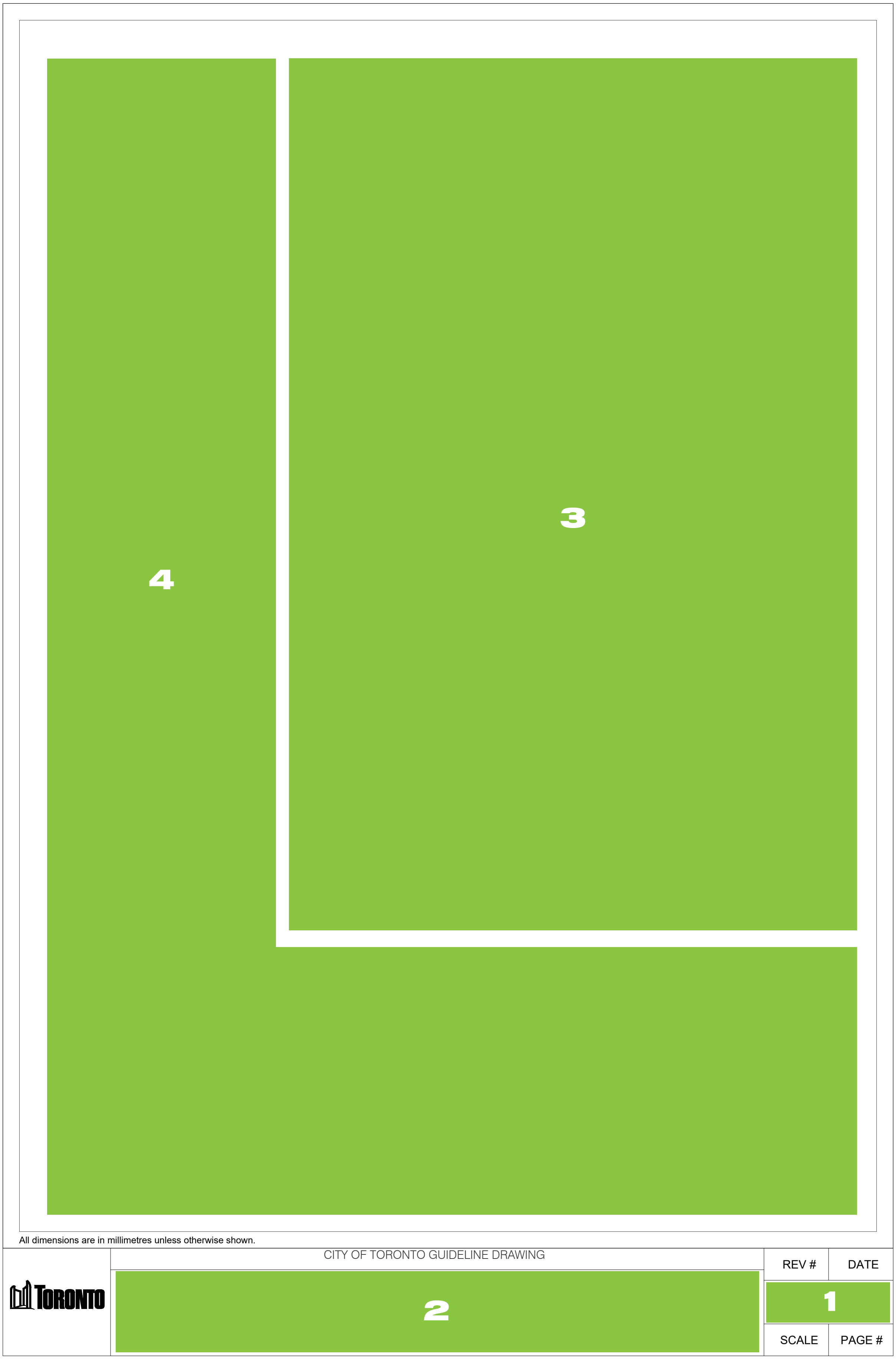


Figure 2.0 - Typical Guideline Drawing Format


Photo Credit: Schollen & Company Inc.

4

4.0 SELECTION TOOLS

Photo Credit: Schollen & Company Inc.

4.1 THE SELECTION TOOL

The GI Selection Tool assists users to identify a palette of GI options for a site given its specific characteristics. A sub-tool called the Vegetation Selection Tool has also been provided as part of this guideline to identify appropriate plant material for vegetated GI options.

The GI Selection Tool is excel-based system that comprises the following four tabs:

Tab1.0 | How to Use the Tool
This is a quick reference that provides a detailed description of the Tools and guidance on their use. Refer to Appendix D of this guideline document for a complete description of methods for utilizing the Selection Tool.

Tab 2.0 | Key Criteria
An additional quick reference that defines each of the screening parameters that are built into the Selection Tool.

Tab 3.0 | New Projects Selection Tool
This tab should be used for initial screening of new or full street reconstruction projects.

Tab 4.0 | Retrofit Projects Selection Tool
This tab should be used for initial screening of rehabilitation or retrofit projects.

New Projects & Retrofit Projects Selection Tools
The New Projects & Retrofit Projects Selection Tools provide comprehensive databases of all possible GI options that could be implemented within Toronto rights-of-way. The data can be filtered based on any single, multiple or all 11 key selection parameters. This screening process allows for a palette of viable GI options to be identified based on specific site criteria. Criteria relevant to a specific GI option (or permutation) are denoted by an 'X' in the appropriate cell. As the database is progressively filtered, a refined list of relevant GI options is provided.

4.1.1 | Green Infrastructure Options

GI options have been selected for their compatibility with the City's climate and context and are listed according to their relationship with TGS drivers. Each potential GI practice is described in detail in Section 3.0. Several of the GI practices listed include various permutations of the same option. For example, in the category of Pervious Concrete the following permutations exist:

1. Pervious concrete without underdrain
2. Pervious concrete with underdrain
3. Pervious concrete with underdrain and impervious liner

Each of these variations exist because they provide a functional solution related to certain specific conditions, therefore each has been listed as a separate line item. In addition, each GI option can be used in various street 'Applications', therefore individual line items have also been created for the various permutations of a GI option within each relevant 'Application'.

4.1.2 | Screening Criteria

Relevant GI options are identified through a screening process using the 'filter' function. Users are to work from left to right through the screening parameters to arrive at a suite of GI options that are suitable to specific site conditions. The balance of this chapter focuses on describing the screening parameters incorporated within the GI Selection Tool.

GREEN STREETS TECHNICAL GUIDELINES - GI SELECTION TOOL PROCESS FLOWCHART

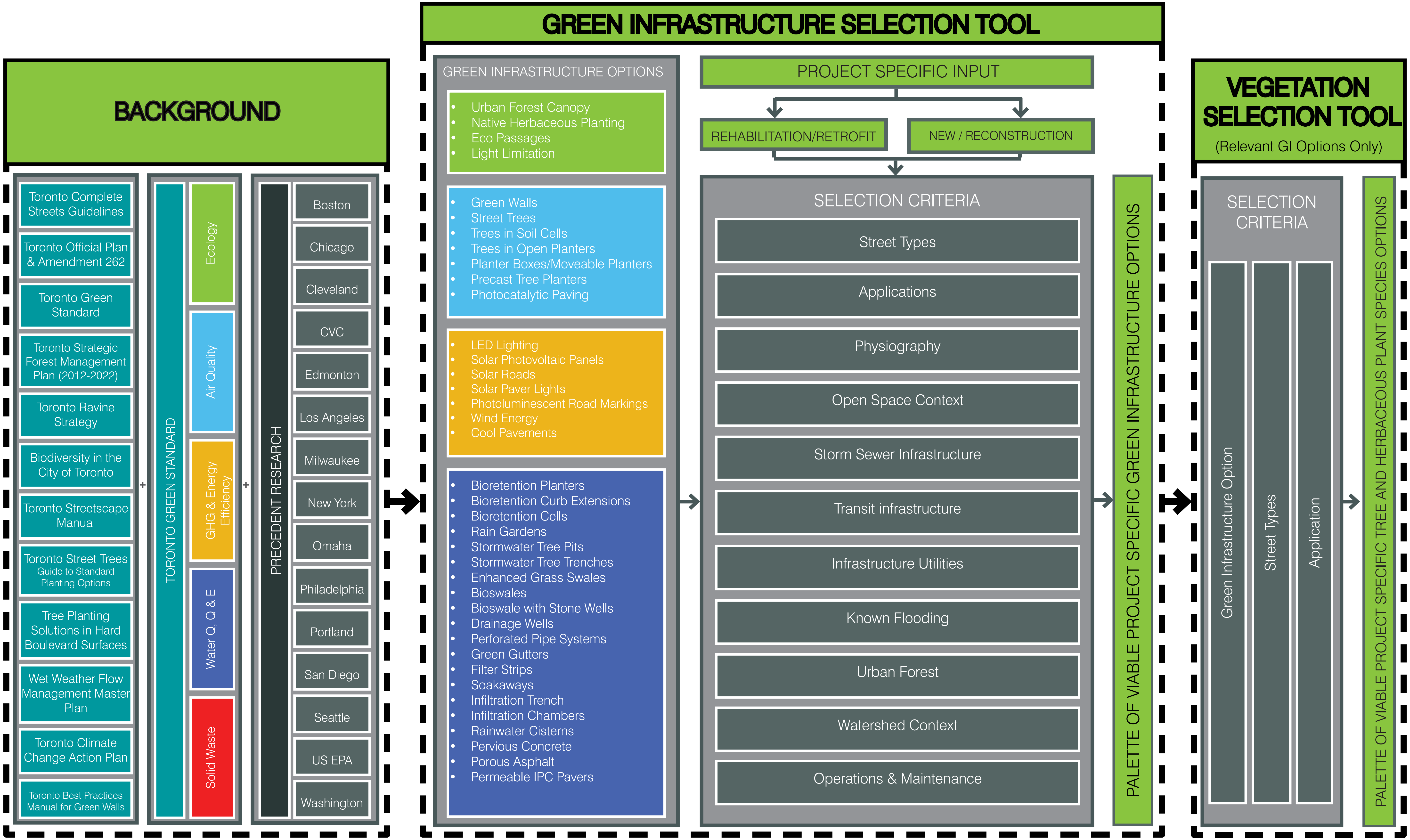


Figure 3.0 - GI Selection Tool Process Flowchart

4.2 SELECTION PARAMETERS

4.2.1 | Type of Work

The first step in using the GI Selection Tool is to identify whether the proposed work is a new / reconstruction or a retrofit / rehabilitation project. Variations on the GI Selection Tool have been developed for each scenario since there are different opportunities and constraints that apply to each. In a reconstruction project, both surface and subterranean facilities are affected. This presents opportunities to relocate utilities and services to accommodate various GI options in the right-of-way. Renovation and retrofit projects tend to be more surficial in nature, therefore GI options must sometimes be modified in order to be implemented.


Photo Credit: Schollen & Company Inc.

4.2.2 | Selection Parameter A - Street Types

Street Types are of critical importance to the selection process as they not only dictate the types of applications within a street, but also the form and aesthetics of viable GI techniques. As such, Street Type is the first parameter addressed in the GI Selection Tools. Street types are adopted from the Toronto Complete Streets manual and include the following categories:

1. **Civic Street**
2. **Downtown & Centres Main Street**
3. **Avenues & Neighbourhood Main Street**
4. **Downtown & Centres Residential Street**
5. **Apartment Neighbourhood Residential Street**
6. **Neighborhood Residential Street**
7. **Mixed-Use Connector Street**
8. **Residential Connector Street**
9. **Scenic Street**
10. **Park Street**
11. **Employment Street**
12. **Mixed-Use Access Street**
13. **Mixed-Use Shared Street**
14. **Residential Shared Street**
15. **Mixed-Use Lane**
16. **Residential Lane**

The key characteristics of each street type include the following:

Civic Streets
Design Objectives: Design quality and workmanship, high quality materials, furnishings and details, wide Furnishing/Planting Zone and Pedestrian Clearway (both sides of the street), high visibility pedestrian crossings, pedestrian-scale lighting, transit priority corridor and enhanced transit stops, separated cycling infrastructure, high density bicycle parking, on-street parking possible, distinctive planting and enhanced tree canopy and integrated SWM facilities.

Downtown & Centres Main Streets
Design Objectives: Design quality and workmanship, wide Frontage/Marketing Zones, wide / flexible Furnishing/Planting Zone and Pedestrian Clearway (both sides of the street), transit priority corridor and enhanced transit stops, separated cycling infrastructure and generous bicycle parking areas, outdoor retail space and cafe seating, parklets possible, enhanced tree canopy and integrated SWM facilities.

Avenues & Neighbourhood Main Streets
Design Objectives: Design quality, workmanship and street furnishing, wide / flexible Furnishing/ Planting Zone and Pedestrian Clearway (both sides of the street), pedestrian level lighting, transit priority corridor and enhanced transit stops, separated cycling infrastructure and generous bicycle parking areas, on-street parking possible on one or both sides, café seating and gathering areas, parklets possible, enhanced tree canopy and integrated SWM facilities.

Downtown & Centres Residential Streets
Design Objectives: Wide Frontage/Marketing Zone and Pedestrian Clearway (both sides of street of the street), transit route, integrated cycling infrastructure and increased bicycle parking, on-street parking possible, street lighting, traffic calming possible, enhanced tree canopy and integrated SWM facilities.

Apartment Neighbourhood Residential Streets
Design Objectives: Frontage Zone - large with buildings set back from street. Can include vehicle drop-off and/or private short-term parking, transit route, integrated cycling infrastructure and increased bicycle parking, wide Pedestrian Clearway and Furnishing/Planting Zone (both sides of the street), on-street parking available (at least one side of the street), traffic calming, street lighting, enhanced tree canopy and integrated SWM facilities.

Neighborhood Residential Streets (Sub-type - Built Circa Pre-1950)
Design Objectives include: Narrower pavement widths, traffic calming, on-street parking available (at least one side of the street), Pedestrian Clearway/Sidewalk beside Edge Zone (both sides of street), landscape between sidewalk and building, on-street parking possible, dedicated bicycle routes possible (one direction), enhanced tree canopy and integrated SWM facilities.

Neighborhood Residential Streets (Sub-type - Built Circa Post 1950)
Design Objectives: Pedestrian Clearway/Sidewalk (at least one sides of the street), landscaped Furnishing/Planting Zone, on-street parking possible, traffic calming, integrated bicycle routes, enhanced tree canopy and integrated SWM facilities.

Mixed-Use Connector Streets
Design Objectives: Separated cycling infrastructure, transit priority route, enhanced transit stops, Pedestrian Clearway/Sidewalk (both sides of the street) scale to volume, wide landscaped Furnishing/ Planting Zone, high visibility pedestrian crossings, HOV lanes, enhanced tree canopy in Frontage/ Marketing Zone and in Furnishing/Planting Zone and integrated SWM facilities. No on-street parking.

Residential Connector Streets

Design Objectives: Separated cycling infrastructure, transit priority route, enhanced transit stops, Pedestrian Clearway/Sidewalk (both sides of the street) scale to volume, landscaped Furnishing/ Planting Zone to buffer Sidewalk, enhanced tree canopy and integrated SWM facilities, No on-street parking.

Scenic Streets

Design Objectives: Separated cycling infrastructure and Pedestrian Clearway/Sidewalk or multiuse trail (at least one side of the street), landscaped median, transit priority route, landscaped boulevard to buffer sidewalk, enhanced tree canopy and integrated SWM facilities.

Park Streets

Design Objectives: Enhancing environmental quality, enhanced tree canopy, integrate SWM facilities, separated cycling infrastructure and Pedestrian Clearway/Sidewalk or multiuse trail (at least one side of the street), traffic calming and street lighting.

Employment Streets

Design Objectives: Vehicle Travel Lanes designed to accommodate larger vehicle types, separated cycling infrastructure, transit priority route and enhanced transit stop design, Pedestrian Clearway/ Sidewalk (both sides of the street) scale to volume, wide boulevards where possible, enhanced tree canopy and integrated SWM facilities. No on-street parking.

Mixed-Use Access Streets

Design Objectives: Pedestrian Clearway (both sides of the street), limited Furnishing Zone on both sides, design quality and workmanship to compliment adjacent Main & Civic Streets, secondary pedestrian route, integrated cycling infrastructure, street lighting, durable materials, on-street parking possible, enhanced tree canopy and integrated SWM facilities. Transit is rare on mixed-use streets.

Mixed-Use Shared Streets

Design Objectives: Design quality, workmanship and street furnishing, pedestrian only zone adjacent buildings, pedestrian only streets possible, universal accessibility, uniform grade for flexible use, low vehicle volumes at low travel speeds, on-street parking possible, safe accommodation for cyclists and pedestrians and higher density bicycle parking.

Residential Shared Streets

Design Objectives: Design quality, workmanship and street furnishing, pedestrian only zone adjacent buildings, uniform grade for universal accessibility, low vehicle volumes at low travel speeds, on-street parking possible, safe accommodation for cyclists and pedestrians, higher density bicycle parking, enhanced tree canopy and landscape Furnishing/Planting Zone.

Mixed-Use Lanes

Design Objectives: Access for delivery, garbage removal and residents, durable paving materials, safe accommodation for cyclists and pedestrians, minimal Furnishing Zone and appropriate lighting.

Residential Lanes

Design Objectives: Access for residents, low vehicle volumes at low travel speeds, durable paving materials, safe accommodation for cyclists and pedestrians and appropriate lighting.

For a detailed description of Street Types, please refer to Toronto Complete Streets Guideline (2017).

4.2.3| Selection Parameter B - Applications

Applications refer to the various component areas within a typical right-of-way where GI practices may be suitable. These areas include:

1. **Frontage and Marketing Zones**
2. **Pedestrian Clearway Zone**
3. **Furnishing and Planting Zones**
4. **Edge Zones**
5. **Curbside Space**
6. **Vehicle Lanes**
7. **Transit Lanes**
8. **Medians/Raised Islands**
9. **On-street Parking**
10. **Parking Lay-bys**
11. **Cycling Infrastructure**
12. **Crosswalks**
13. **Intersections**
14. **Mid-Block**
15. **Transit Stops**
16. **Bridges**
17. **Feature Paving**
18. **Street Lights**
19. **Decorative Lights**
20. **Parking Meters**
21. **Vehicle Charging Stations**

If the objective of a particular screening exercise is to identify a palette of GI options that would be suitable within a given Street Type, then the 'Applications' parameter will be omitted as a filter because it would limit the search results. This parameter should only be used to isolate a specific Application as a primary search criterion, or to withdraw an Application as a potential result candidate.

Key characteristics of the various applications include the following:

Frontage/Marketing Zone
Part of the Sidewalk Zone that is directly adjacent to private property within an urban street type. This area can accommodate cafe seating, window shopping etc.; minimum width varies depending on Street Type.

Pedestrian Clearway Zone
Part of the Sidewalk Zone that facilitates a clear unobstructed path of travel; minimum width varies depending on Street Type.

Furnishing/Planting Zone
Part of the Sidewalk Zone between the Pedestrian Clearway and the Edge Zone that can include planting, SWM facilities, street furniture and utilities.

Edge Zone
The Edge Zone separates the Sidewalk Zone from the Roadway Zone; and comprise a standard curb or a decorative curb edge depending on the street type; the Edge Zone can accommodate traffic/parking regulation signage poles, transit stop poles, etc.

Curbside Space
The Curbside Space is the area adjacent the curb within the Roadway Zone that can be used for bicycle parking, on-street parking, parking lay-bys, cycling infrastructure etc.

Vehicle Lane
Main travel lanes of the Roadway Zone. The number of lanes and lane width can vary based on Street Type.

Transit Lane
These are dedicated transit lanes within the Roadway Zone. The width of the Transit Lane can vary based on Street Type.

Median / Raised Island
These are the formalized areas between two opposing directions of travel or at the centre of a directional change.

On-Street Parking
Part of the Curbside Space that is identified by street signage. On-Street Parking areas are not applicable within all CSG street types.

Parking Lay-By
Part of the Curbside Space that is formalized by the curb alignment. Parking Lay-By areas are not applicable within all CSG street types.

Cycling Infrastructure - Separated/Integrated
Part of the Curbside Space that is identified by road markings / colour and are sometimes formalized with barriers. Cycling infrastructure is not applicable within all CSG street types.

Crosswalk
Formalized pedestrian crossings identified by pavement markings and in some instances by alternative materials.

Intersection
Within the Curbside Space, where Vehicle Lanes intersect one another.

Mid-Block
Within the Curbside Space, between intersections.

Transit Stop
Within the Curbside Space, at a transit stop.

Bridge
At bridge walls or abutments.

Feature Paving
Paved areas that do not comprise standard concrete and can be located in Edge Zone, Parking Lay-By, or Civic spaces.

Street Light
The GSTG addresses the potential for efficiency, but not the aesthetic or material characteristics.

Decorative Lighting
The GSTG addresses the potential for efficiency, but not the aesthetic or materials characteristics.

Parking Meter
The GSTG addresses the potential for efficiency, but not the aesthetic or materials characteristics.

Vehicle Charging Station
The GSTG addresses the potential for efficiency, but not the aesthetic or materials characteristics.

4.2.4| Selection Parameter C - Physiography

An understanding of the landscape character of a site provides direction critical to the development of functional GI options that complement the neighbourhood and fulfill the City's environmental objectives.

The physiographic, biophysical and hydrologic conditions of a site will not only determine the types of GI options that are possible, but also the permutation of the option that will produce a functional solution. For example, on sites with highly permeable soils, infiltration-based GI options will provide the optimal solution. However, on a site with impervious soils, a practical permutations to the option would include an underdrain (and impervious barrier when required) to provide a solution that relies on a combination of attenuation, conveyance and filtration practices.

4.2.4.1| Characterization Parameters

The physiographic, topographic and hydrogeological characteristics determine the palette of potential GI options (or permutations thereof) that would be viable within a given site.

Physiographic factors such as soil permeability and depth to bedrock determine whether infiltration-based GI options would be viable on a particular site. If certain tolerances are not met then alternative permutations (underdrains) are considered.

Topography refers to the change in gradient over a site and can affect factors such as discharge rates, runoff velocities and flow patterns. Certain GI options are not well-suited to steep slopes and therefore can be excluded from consideration based on this parameter.

Hydrogeological factors, including depth to water table and bedrock, can also impact the design and function of various GI options.

4.2.4.2| Reference Maps

In order to expedite the screening process, reference maps have been developed for each of the following parameters:

- **Topography**
- **Depth to Water Table**
- **Depth to Bedrock**
- **Soil Permeability**
- **Contamination**

These maps were developed based on City GIS data and are included in Appendix E.0 to allow for quick referencing throughout the process. Reference maps should only be used for preliminary screening purposes. Site specific investigations will be required in order to produce optimized site specific design solutions.

A. Topography

Topography is another key factor in determining whether infiltration-based GI options are appropriate for a given site. Topographical gradients are divided into the following range classes:

- **Area TG-1 = Slope 0-5%**
- **Area TG-2 = Slope 5-10%**
- **Area TG-3 = Slope >10%**

The topographic gradient ranges throughout the City are illustrated on Map 1.0 in Appendix E.0.

B. Depth to Water Table

Shallow water table conditions (<1m) can present challenges for the location, design and function of infiltration-based GI options. The potential for discharge of contaminated runoff into ground water resources is the primary concern, however this does not eliminate the opportunity to implement GI options. Infiltration-based GI options will require design adjustments that will allow the facility to perform attenuation, filtration and conveyance functions, rather than infiltration. Depth to Water Table has been subdivided into the following three categories in the GI Selection Tool:

- **Area WT-1 = <1m**
- **Area WT-2 = 1-2m**
- **Area WT-3 = >2m**

Water table depths throughout the City are illustrated on Map 2.0 in Appendix E.0.

C. Depth to Bedrock

Depth to Bedrock influences the ability to implement infiltration-based options and options that require deeper excavation. Depth to Bedrock has been subdivided into the following three categories in the Selection Tool:

- **Area BE-1 = <1m**
- **Area BE-2 = 1-2m**
- **Area BE-3 = >2m**

Bedrock depths throughout the City are illustrated on Map 3.0 in Appendix E.0.

D. Soil Permeability

Soil Permeability is a key factor in determining whether infiltration-based GI options are suitable for a given site. Where native soil infiltration rates are >15mm/hr, GI options can be designed without an underdrain, however, where infiltration rates are <15mm/hr, an underdrain will be required. Soil Permeability throughout the City is illustrated on Map 4.0 in Appendix E.0.

E. Contamination

Contamination refers to areas of existing soil contamination within the City. Contamination could be on private property, within the road right-of-way or on sites associated with former landfills. The screening options for this category are simply 'Yes' or 'No'. Contaminated sites generally provide limited Water Quantity, Quality and Efficiency GI options, but can provide benefits related to Ecology, Air Quality and Energy Efficiency GI options.

Site contamination mapping for the City of Toronto is represented on Map 6.0 in Appendix E.0.

4.2.5| Selection Parameter D - Open Space Context

Ecological benefits from a Natural Heritage System (NHS) can extend well beyond its physical boundaries into adjacent streets and communities through integration of appropriate GI practices within adjacent rights-of-way. These GI options can also serve to protect and enhance existing wildlife habitat within open spaces and the NHS. It is therefore important to consider the relationship between the road right-of-way and natural heritage / open space systems as a component of the selection process. The following natural heritage and open space parameters are addressed with the GI Selection Tool:

i. Natural (Map #, Appendix E)
- **Adjacent to a Ravine or Natural Area**
- **Traversing a Ravine or Natural Area**

ii. Open Space
- **Adjacent to a Park**
- **Adjacent to a Hydro / Utility Corridor**

Map 5.0 illustrates the NHS within the City. Major hydro and utility corridors are illustrated on Map 8.0 in Appendix E.0.


Photo Credit: Schollen & Company Inc.

4.2.6| Selection Parameter G - Transit Infrastructure

Transit Infrastructure refers to all fixed transit routes above and below grade throughout the City including Subways and LRT lines (Dedicated or Integrated). The existence of this infrastructure within or under a proposed site can preclude the implementation of certain GI options and can provide opportunities for others.

For example: infiltration is prohibited above subway tunnels, therefore, GI options that are compatible with this context include bioretention, dry swales and permeable paving, all designed with an impervious barrier. This will allow for runoff to be filtered and attenuated but not infiltrated. Other suitable options fulfill ecological priorities in the form of planter boxes and planting beds using structural soils or soil cells.

The presence of dedicated LRT infrastructure provides opportunities for implementation of green gutters and permeable paving since the surface of the LRT right-of-way does not require the same load-bearing capacity as a regular city street. These options will require support by Metrolinx.

Map 7.0 illustrates existing subway, streetcar and LRT lines in the City.

4.2.7| Selection Parameter H - Utilities

Utility infrastructure forms a large and complex part of the composition of a road right-of-way and provides one of the greatest barriers to the implementation of GI options. New and reconstruction projects offer flexibility in locating utilities and services and priority should be placed on locating GI practices first in order to maximize ecological and hydrological benefits. In addition, overhead wires are rare on new streets, therefore the establishment of a robust tree canopy is a priority.

In rehabilitation and retrofit situations, ingenuity will be required in order to modify GI options to suit existing site conditions. This parameter considers whether or not a specific GI option can exist over, under or in proximity to the following utility installations, and if so what modifications might be necessary for installation within retrofit or rehabilitation projects.

i. Natural Gas
- **Type/Size**

ii. Hydro / Electrical
- **Underground**
- **Overhead**
- **Transformer / Switchgear**

iii. Bell Canada
- **Overhead**
- **Underground**

iv. Rogers
- **Overhead**
- **Underground**

v. Enwave
vi. Oil
vii. Water
viii. Sanitary Sewer
ix. Street Lights
x. Service Laterals

Map 8.0 illustrates the location and alignment of major hydro, natural gas, diesel fuel, aviation fuel and heating fuel pipelines within the City. Regardless of whether or not a given site is located above or in close proximity to one of these major utilities, it is essential to have the site surveyed to confirm the location and type of underground utilities that exist prior to initiating both the detailed design and construction processes.

Photo Credit: Schollen & Company Inc.

4.2.8 | Selection Parameter E - Storm Sewer Infrastructure

Traditional stormwater drainage systems were designed to collect runoff from impervious surfaces and convey it as quickly as possible through a system of underground pipes or surface ditches to outlet in the nearest river, stream or water body. The two common types of conveyance infrastructure include combined sewer systems and separated sewer systems. Combined systems collect and transport sewage water and runoff within the same pipe, whereas separated systems convey sewage independently from stormwater runoff. Combined systems are of particular concern since flows that exceed the capacity of the system in large storm events discharge untreated effluent into the receiving watercourse or water body.

GI can help to relieve pressure on conventional conveyance infrastructure through the implementation of options that control and treat stormwater runoff as close to the source as possible. In areas where combined sewers exist, stormwater management priorities include attenuation and infiltration in order to reduce runoff volumes, therefore GI options identified through application of the GI Selection Tool are focused on quantity control.

Rural systems comprise open swales or ditches that are well-suited to retrofitting to include bioretention, infiltration or storage. Urban streets generally employ piped systems and therefore different GI options are more appropriate due to the presence of curbs and catch basins (CBs).

Areas services by combined and separated sewers are illustrated on Map 9.0. in Appendix E.0.

4.2.9| Selection Parameter I - Known Flooding

The risk of flooding and property damage is critical in determining the most appropriate selection of GI options. This parameter is subdivided into three categories in the GI Selection Tool:

i. Proximity to Basement Flooding
- **Within Flood Prone Area**
- **Outside Flood Prone Areas**
- **Contributing to Flood Prone Area**

In areas where chronic basement flooding risk exists, the priority will be to select GI options that will attenuate runoff and optimize quantity control. In areas directly adjacent, quantity control is important but not a specific priority. In areas outside of chronic flood risk zones, quantity control is not a specific priority.

Reported basement flooding areas are illustrated on Map 10.0. Flood risk areas are illustrated on Map 12.0 in Appendix E.0.

4.2.10| Selection Parameter H - Urban Forest

An enhanced urban forest canopy is a key priority since it will improve air quality and help to reduce urban heat island effect. Within the GI Selection Tool, Urban Forest canopy is considered in terms of its general health and abundance in an area. In areas where the quality and extent of the Urban Forest canopy is low, GI options that incorporate extensive tree planting are a priority. Where Urban Forest canopy quality is high, priorities may shift to focus on other higher priority GI options.

4.2.11| Selection Parameter K - Stream Restoration

Watershed context is a parameter that is used to identify GI options that will help to mitigate erosion in a receiving watercourse. Map 11.0 (Appendix E.0) illustrates areas of erosion vulnerability within the City.

Where erosion vulnerability is high, the priority is to be placed on quantity control and focus will be on implementation of GI options that provide attenuation and infiltration. In areas that have medium to low vulnerability, quantity control may not be as important as quality control or other environmental priorities.

4.2.12| Selection Parameter L - Operations and Maintenance

Siting for GI options must consider existing operations and maintenance regimes in order to be practical. Therefore the following maintenance and operations criteria have been incorporated into the GI Selection Tool.

i. Garbage /Solid Waste
- **Curbside Waste Removal – GI options cannot obstruct access for garbage removal**
- **Other – No limitations**

ii. Winter Maintenance Protocol
- **Salt Application**
- **Sand Application**

Photo Credit: Schollen & Company Inc.

4.3 GI SELECTION TOOL NIL RESPONSE

The GI Selection Tool is designed to provide no 'nil' response. In other words, there should be at least one GI option available for every site. If the tool provides a 'nil' response, then adjustments to the following selection parameters should be considered:

1. Soil amendments
2. Alterations to site grading
3. Use of impervious liners
4. Relocation of utilities

4.4 SELECTION PRIORITIES

Objectives related to TGS priorities should be established prior to application of the Selection Tool on any GI project. Once City staff or the project designers have arrived at a site-appropriate palette of GI options using the GI Selection Tool, options should be assessed to determine the relative priority based on their ability to satisfy the TGS related project objectives. The selection of a preferred option should not simply default to the least expensive solution, but rather should optimize benefits while achieving cost efficiency.

4.5 IMPLEMENTATION

The process of generating the GSTG included a review of the various implementation programs that have been adopted by several municipalities within Canada and the United States. The review identified a number of commonly adopted initiatives, including the following:

a) Dedicated Green Infrastructure (GI) Team
- Every city studied had assembled a GI team that is dedicated to implementing GI projects.

b) Interdepartmental Communication and Coordination
- Interdisciplinary coordination was identified as a key objective to address multi-departmental implementation and operations/maintenance issues.

c) Consistent Funding
- All of the municipalities that were researched had allocated consistent and appropriate funding to complete the design, implementation and monitoring of GI installations.

d) Policy Support
- All of the municipalities that were researched had implemented policies to support the implementation of GI works.

e) Partnerships
- The establishment of partnerships with BIAs, stakeholder groups and community groups was identified as a necessary step to catalyze the implementation, maintenance and monitoring of GI.

f) Cost/Benefit
- Many of the municipalities had identified a need to confirm the cost and benefit of each GI option.

g) Training
- The need to implement a comprehensive education and training program was identified as essential to ensure that City/municipality staff that are involved in the design, construction and maintenance of GI are fully aware of the objectives, functions and unique attributes and requirements associated with GI.

In addition to these general findings the following specific implementation initiatives have been identified for consideration to support the implementation of GI.

1| Coordination

- Develop a dedicated Green Streets team to administer the GSTG;
- Confirm infrastructure ownership/responsibility;
- Update design and construction standards to include GI specifications;
- Refine the approvals process to accommodate GI applications;
- Coordinate GSTG implementation with utility and infrastructure life-cycle estimates to ensure that new GI installations are not damaged or destroyed due to scheduled maintenance or replacement;
- Review and update the GSTG and Selection Tools as required;
- Create and maintain a concise inventory database of GI projects throughout the City.

2| Education and Training

- Undertake outreach to engage consultants and contractors;
- Investigate the potential to require mandatory professional training and certification for consultants and contractors involved in GSTG projects;
- Investigate the potential to develop professional training and certification programs in cooperation with CVC and the TRCA;
- Develop demonstration projects to showcase different GI options.

3| Public Consultation

- Enable community engagement and education to enhance public awareness of the number and locations of GI options implemented throughout Toronto as well as and environmental benefits of each;
- Promote participation in conferences and workshops that heighten public awareness and youth engagement;
- Explore expanded partnerships with community and resident groups for management of GI installation.

4| Design Process

- Identify project objectives (based on TGS priorities) from the outset;
- Integrate GI projects with the CSG as well as the GSTG;
- Investigate the merits of ensuring that all GI landscape plans are stamped and signed by an OALA member certified in GI practices. As this certification does not currently exist, acceptable certification criteria would need to be established.

5| Operations and Maintenance

- Develop of an appropriate operations and maintenance plan for each GI option;
- Explore the merits of alternative methods that could assist with maintenance of GI practices such as citizen reporting (via an app), maintenance agreements with neighborhood residents or community groups.

6| Monitoring and Tracking

- Explore the potential to implement post construction monitoring and evaluation programs for each GI solution;
- Pursue integrating monitoring practices with TRCA's Sustainable Technologies Evaluation Program (STEP) to ensure universality of data and reports;
- Monument each GI installation (refer to detail G-1) and record the location of GI installations in the database.

5

5.0 OPERATIONS AND MAINTENANCE GUIDELINES

5.1 OPERATIONS & MAINTENANCE

5.1.1 | Operations and Maintenance Considerations

It is critical that the requirements for the operations and maintenance (O&M) of GI options be considered from inception of the conceptual design through the extent of their life-cycle. Designers must understand the capabilities of O&M staff and the available inventory of equipment and should design GI facilities in accordance with these considerations. At the same time, GI will soon become the ‘new normal’ within Toronto’s road rights-of-way, therefore, adjustments will be required to O&M policies and procedures, budgets, staffing and equipment in order to accommodate these evolving technologies moving forward.

Key areas of focus will include:

- The creation of a comprehensive and up-to-date inventory of Green Streets installations throughout Toronto. This inventory will enable the implementation of enhanced maintenance, monitoring and engagement programs throughout the City;
- Education and training for staff so that they are equipped to address GI related maintenance requirements such as proper operation, maintenance, monitoring and inspection;
- Updating of the City’s O&M strategies, policies and procedures (including winter maintenance);
- Development of inspection, monitoring and maintenance plan templates for each GI option. Design professionals should refer to the TRCA’s LID Inspection and Maintenance Guide (I&M) and the CVC’s LID Monitoring and Performance Assessment Guide for direction on producing site / GI specific plans. A maintenance and monitoring strategy must be confirmed for each GI project prior to implementation/installation; and,
- Updating of the City’s inventory of equipment.

A level-of-service model should also be developed in order to identify maintenance requirements throughout Toronto’s Green Streets. Appendix F provides a general outline of O&M requirements for each GI option listed within the Selection Tool. The database identifies tasks, timing/frequency, equipment, personnel and training that will be required. Inspection & monitoring; repair & replacement, access to utilities infrastructure and life-cycle requirements are also addressed.

5.1.2 | O&M Costs

O&M costs are a significant consideration for the City. The Sustainable Technologies Evaluation Program (STEP) LID Life Cycle Costing Tool provides an effective mechanism to assist City staff in generating planning-level estimates of life-cycle costs including construction, inspection, maintenance and rehabilitation. Additional budget considerations should include:

- Any increase in costs to maintain GI options over and above what would have been required in a “business-as-usual” case;
- Opportunities to synthesize GI and routine maintenance regimes;
- Additional equipment and staffing requirements; and,
- Education and training for all O&M staff.

Opportunities exist for cost savings through creative partnerships with neighborhood residents and volunteer community groups, where resident groups might care for the plant material, while the City would be responsible for inspections, flushing, vacuuming, etc. In order to capitalize on these partnership opportunities, an initial investment would be required to address outreach and education, however with established maintenance expectations identified and partnership agreements in place, this initial effort and investment can prove beneficial to reduce maintenance efforts.

5.2 GI REPAIRS, REPLACEMENT, EXPANSION

5.2.1 | Repairs

Repairs are inevitable throughout the life-cycle of most GI options. Repairs are typically required less frequently than routine maintenance and are often discovered during annual visual or performance inspection of the GI installation as a result of a resident complaint. In rare cases, repairs can be required due to impacts from outside forces including:

- Extreme weather events;
- Contamination of the contributing runoff area;
- Failure of erosion and sediment control systems associated with an adjacent exposed site;
- Failure of drainage, inlet or pretreatment devices; and,
- Requirements to access utilities that are in need of repair, replacement and augmentation.

5.2.2 | Replacement

Replacement refers complete reinstatement of the GI option at the end of it's life-cycle, however full or partial replacement may also be required in rare cases partway through the life-cycle due to a failure of a key component. During replacement some structural elements can be salvaged and reused however materials such as soils, geotextiles, pavements, aggregates, plant materials & pipe generally cannot.

Other elements such as plant material and mulch may be required to be replaced throughout the normal course of an GI life-cycle without disrupting the function of the GI feature.

Appendix F outlines routine repair and replacement items that can be anticipated throughout the life-cycle of each GI option.

5.2.3 | Expansion

Unlike conventional stormwater management systems, some GI options have the potential to be expanded to provide additional storage capacity. This will be of critical importance for ensuring that Toronto remains a resilient City in spite of potential future changes in precipitation volumes and weather patterns that may occur as a result of climate change.

6.0
MONITORING RECOMMENDATIONS


Photo Credit: Schollen & Company Inc.

6.1 MONITORING

6.1.1 | Objectives

The implementation of effective monitoring programs is critical to ensuring that Green Streets objectives are met. Data garnered through the monitoring process should:

- Provide a baseline for performance tracking and evaluation of design standards and construction specifications;
- Evaluate the performance of GI options against indicators outlined in the TRCA's LID I&M Guide;
- Ensure that GI facilities are installed according to design details and specifications, are adequately maintained through establishment/warranty periods and are functioning properly prior to assumption. This can also inform refinement of design and construction specifications;
- Provide testing/monitoring work as part of assumption and performance verification inspections, to be compliant with ECA conditions for drainage performance;
- Demonstrate the effectiveness of the management strategy, plan and practices to reduce risk and liability in association with GI options in the future;
- Assist in developing the basis for appropriate and cost effective asset management by City staff through an understanding of how to extend operating life spans and make prudent decisions regarding repair and replacement;
- Illustrate success and provide a business case to promotes broad-scale acceptance and to inform future policies; and,
- Create a standardized database of performance information, maintenance and life-cycle.

The monitoring program for GI options should be designed to address the following parameters:

1. Regulatory compliance related to policy targets and objectives (TGS, WWFMMP, ODWQS, PWQO & MOECC ECA);
2. The performance and effectiveness of techniques that are interrelated with various GI options;
3. Effectiveness in mitigating urban heat island effect;
4. Effectiveness in achieving pollutant reduction;
5. Rates of infiltration in facilities that employ infiltration as a tool;
6. Energy efficiency and reduction in GHG emissions;
7. Effectiveness in flood mitigation; and,
8. Water quality enhancement performance.

6.1.2 | Monitoring Approach

Depending on the type of GI, monitoring may be undertaken as part of inspection work prior to assumption and periodically throughout the operating phase to comply with ECA conditions, support the City's (stormwater) infrastructure asset management program and inform revisions to improve design standards/specifications.

The TRCA LID I&M Guide (TRCA, 2016) is the definitive resource document on the topic of LID operation, inspection and maintenance in Ontario. The guide provides detailed guidance on indicators to inspect / test / monitor, standard sampling procedures and testing methods, acceptance criteria / triggers for follow-up action and repair / rehabilitation work required for each type of LID BMP through construction and operating phases of their life cycles.

The Guide recommends continuous performance monitoring for stormwater infiltration practices as part of assumption inspections during the establishment / warranty period and performance verification inspections every 15 years post-construction at a minimum. The recommended framework is designed to rely on visual indicators that can be assessed by all levels of staff and includes inspection types, frequencies and testing indicators.

6.1.3 | Inspection and Monitoring Plan

An inspection and monitoring plan should be developed from the inception of a street reconstruction or retrofit project. The LID I&M Guide is a valuable resource that provides advice on designing monitoring programs for assumption and performance verification inspection and includes checklists / field data forms for performing inspection, testing and monitoring work, broken down by BMP type.

6.1.4 | Monitoring Costs

Since monitoring is an integral part of a GI system, the cost of developing and implementing a comprehensive monitoring plan should be should be incorporated into the overall project budget. Monitoring costs throughout the life of the project are proportional to the scale and lifespan of the system and include:

1. Staff Resources - Salaries and training;
2. Equipment - Purchase, installation, maintenance and replacement;
3. Laboratory Testing and Data Analysis;
4. Maintenance of the Information Database and GIS Mapping;
5. Supplies; and,
6. Reporting and Communication Costs - (Reports, fact sheets case studies and bulletins).

The STEP LID Life Cycle Costing Tool provides a valuable resources for generating planning level estimates related to construction, inspection, maintenance and rehabilitation costs for LID practices.

INDEX

Photo Credit: Schollen & Company Inc.

INDEX

Photo Credit: Schollen & Company Inc.

GLOSSARY OF TERMS

Photo Credit: City of Toronto

Aggregate | a broad range of materials used in construction and available in various sizes. These materials include: sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates.

Berm | a compacted mound of earth that diverts or creates shallow ponding areas for runoff. In some cases, runoff can pond behind a berm and will gradually infiltrate or flow through it.

Check Dam | a structure used in dry or enhanced grass swales to slow the velocity of runoff, allowing for sedimentation, filtration, evapotranspiration and infiltration. Check dams can be constructed from aggregate, wood, gabions, riprap or concrete,

Cistern | a tank or vessel that is used to store rainwater.

Detention | temporary storage of stormwater runoff to reduce flooding and remove pollutants.

Evapotranspiration | the process of water being lost from land and plant surfaces to the atmosphere through evaporation and transpiration.

Filter Media | engineered soil with limited fines, that is used to filter runoff.

Filtration | the process of removing fine particles and pollutants from runoff. In the context of GI this can occur as stormwater runoff infiltrates through the rootzone of plant material.

Fines | are fine-grained soils with a particle size of less than 0.050 mm diameter.

First Flush | the initial flow of stormwater runoff into a system. First flush runoff typically contains greater pollutant concentrations than runoff generated throughout the rest of a storm as these surface flows pick up pollutants accumulated during dry periods between storms.

Geotextile | a permeable fabric used to separate materials (fine-textured soils from course gravel), filter runoff and reinforce LID components.

Granular | gravel or crushed stone used in the construction of bedding and stone storage reservoirs in certain LID installations. This material is available in various particle sizes to suit specific infiltration, filtration and conveyance requirements.

Gravel Diaphragm | a pretreatment and level spreading device that is installed perpendicular to surface runoff to dissipate the velocity of flows; distribute runoff evenly throughout an LID practice; and intercept suspended sediments.

Green Infrastructure (GI) | as defined in the PPS (2014) includes: *"natural and human-made elements that provide ecological and hydrological functions and processes. Components may include natural heritage features and systems, parklands, stormwater management system, street trees, urban forests, natural channels, permeable surfaces and green roofs".*

In the context of the Green Street Technical Guidelines, GI includes various ecological solutions, LID techniques and other technologies that support the environmental initiatives and priorities outlined in the TGS including: ecology, air quality, green house gas (GHG) reduction and energy efficiency as well as water quality and quantity.

Groundwater Recharge | the infiltration of surface water to an aquifer.

Hydrologic Soil Groups | a classification system that categorizes soil types based on their infiltration, filtration and conveyance capabilities. Hydrologic soil groups are categorized as:

Type A | well-drained sands and gravel, high infiltration capacity, high leaching potential and low runoff potential;

Type B | moderately-drained fine to coarse grained soils, moderate infiltration capacity, moderate leaching potential and moderate runoff potential;

Type C | fine grained soils with a low infiltration capacity, low leaching potential and high runoff potential; and,

Type D | clay soils with a very low infiltration capacity, very low leaching potential and very high runoff potential.

Impervious | a material or surface that is resistant to water penetration into native soils.

Infiltration | the flow of surface water into the surrounding native soils.

Landscape-Based Approach| the philosophy of design that promotes biophysics, hydrology and ecology.
.

Low Impact Development (LID) | is a design approach that focuses on restoring and preserving water quality and maintain pre-development hydrologic processes by implementing LID techniques to manage stormwater as close to its source as possible. LID techniques can reduce or even eliminate pollutants in stormwater runoff from impervious surfaces; can regulate surface flow patterns and recharge rates; and, can be connected to form a 'treatment train' that can replicate a natural system.

Mulch | shredded woody material or leaf compost applied over soil to provide nutrients, remove pollutants and retain moisture.

Native Soil | a combination of minerals, organic matter and organisms that exist on a site or within a geographic region.

Off-Line | an LID practice that is not in the direct route of stormwater surface flows. Off-line LIDs are designed for a specific capacity, therefore flows are diverted into the systems through a flow splitter or bypass channel to control the volume of water entering the facility.

On-Line | an LID practice that is in the direct route to receive surface flows. In large storm events flows would be conveyed through an overflow outlet.

Physiography | the physical geography of a site including: topography, soil permeability, soil contamination and depth to bedrock or water table.

Pollution Hot Spot | areas where land uses have the potential to generate highly contaminated runoff (e.g. gas stations, demolition, hazardous materials storage and heavy industry).

Pollutant Load | the measurement of an individual pollutant entering a stormwater system in a given rainfall event.

Pretreatment | a device used to remove sediments, debris and contaminants from runoff prior to it reaching an LID facility.

Runoff | is excess water that flows over pervious or impervious surfaces.

Sedimentation | the settling of particles in liquid.

Soil Amendment | organic matter (mulch or compost) added to soils to improve fertility, alleviate compaction and restore hydrological functions.

Standing Water | water that has stopped flowing and cannot infiltrate through the ground surface.

Stone Reservoir | a layer of aggregate material that can temporarily store water before it infiltrates into the native soil or is conveyed through an underdrain.

Stormwater Management (SWM) | refers to quantity and quality controls for storm water.

Treatment Train Approach | a combination of LID, conveyance, and end-of-pipe stormwater management practices.

Underdrain | perforated pipe used to convey excess water from soils.

Water Balance | annual inflows vs outflows within a site. Water balance considers runoff, infiltration and evapotranspiration and can impact erosion vulnerability, ground water recharge and downstream habitat protection of a site.

Water Budget | the measurement of water balance.

Water Quality | the level of contaminants present in stormwater runoff. Controlling levels of Total Suspended Solids (TSS)and E. coli are the primary concern within the City of Toronto.

Water Quality Volume | the amount of stormwater runoff required to be attenuated by LID practices in order to reduce pollutant loads.

Water Quantity | the amount of runoff entering a downstream system. The management of water quantity focuses on minimizing impacts on downstream flooding, stream bank erosion and impacts on infrastructure.

Water Table | the level at which water pressure from below is equal to atmospheric pressure from above. Below this level the ground becomes saturated.

Watershed | A geographic area, that is defined by topography and drains into a lake or river system.

REFERENCE DOCUMENTS

HYPRERLINKS

Click the text below to link to the reference documents:

Best Practices Manual for Green Walls

Biodiversity in the City of Toronto

Complete Streets Guidelines for Toronto

Toronto Climate Change Action Plan

Toronto Green Standard

Toronto Official Plan

Tree Planting Solutions in Hard Boulevard Surfaces

Toronto Pollinator Protection Strategy

Toronto Ravine Strategy

Toronto's Strategic Forest Management Plan 2012-2022

Toronto Streetscape Manual

Toronto Street Trees: Guide to Standard Planting Options

Wet Weather Flow Management Master Plan

TRCA Living Cities Policies

TRCA's LID Inspection and Maintenance Guide (I&M)

CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide

CVC SWM and LID Monitoring and Performance Assessment Guide

Sustainable Technologies Evaluation Program (STEP) LID Life Cycle Costing Tool

SCHOLLEN & Company Inc.

30 Wertheim Court, Unit 15
Richmond Hill, Ontario L4B 1B9
Tel: 289-695-0009
Fax: 289-695-0010
Email: design@schollenandcompany.com

TMIG
The Municipal Infrastructure Group Ltd.

URBAN FOREST INNOVATIONS INC

DPM

Toronto Green Streets