

A Green Infrastructure Guide for Small Cities, Towns and Rural Communities

Green Infrastructure
ONTARIO COALITION

GREEN BELT
Possibility grows here.



Table of Contents

Introduction 4

Section 1: Overview of Green Infrastructure Types and Their Functions 9

This section introduces the types of green infrastructure included in this Guide and provides high-level information on their primary and secondary functions.

Section 2: Introduction to Planning Zones 15

This section introduces different planning zones that can guide the development of a green infrastructure in small cities, towns and rural settlements. It also summarizes the types of green infrastructure that might be appropriate within the context of each unique zone.

Section 3: Green Infrastructure Opportunities for Each Planning Zone 19

For each planning zone, this section provides a summary of the compatible types of green infrastructure, their specific benefits, a discussion about design and implementation considerations, and a best practice case study. The case studies often feature larger cities but have lessons that are applicable to smaller communities.

Section 4: Green Infrastructure Types in More Detail 35

This section provides more details on the types of green infrastructure presented in this Guide as well as some of the key considerations in the implementation and maintenance of each type.

References 55

The Friends of the Greenbelt Foundation and Green Infrastructure Ontario Coalition would like to thank Anni-Claudine Buelles, Kelsey Carriere, Holly Wacker, and Jennifer Williamson for the original report that made this Guide possible. We also thank Michelle Berquist, Ivana Towhid, Nick Pileggi and the Town of East Gwillimbury for their important contributions.

This Guide was published in June 2017.

Introduction

Background

In 2016, the Friends of the Greenbelt Foundation asked a Masters' planning studio group from the University of Toronto to investigate the benefits of small-scale vegetative or green infrastructure for small cities, towns and rural communities located throughout the Greenbelt. Their research showed that green infrastructure has considerable value for small settlements, as well as the natural heritage and agricultural systems that form the surrounding countryside. The final report included a design guide for the different types of green infrastructure that are appropriate in these settings and a planning process to integrate them into existing communities. The town of Mount Albert was used as an illustrative case study in the report. The Friends of the Greenbelt Foundation and Green Infrastructure Ontario Coalition worked in partnership to adapt this report into the following Guide.

Introduction

The purpose of this Guide is to support small cities, towns and rural settlements with the integration of green infrastructure into their communities. Much of the current green infrastructure research and guidance focuses on densely populated urban centres. Smaller and rural settlements are often overlooked despite the many benefits that green infrastructure can provide in these settings. This Guide aims to fill that gap by providing an overview of the types of green infrastructure that make the most sense for these communities and by outlining a strategic zoning approach for implementation.

How to Read this Guide

This Guide is a communication and information resource. It provides high-level information about types and functions of green infrastructure and how they can be integrated into existing communities. Where maps and renderings are included in the Guide, they have been taken from the community of Mt. Albert, Ontario for illustration purposes. This Guide is intended to be a tool for planners, developers, Councillors, resident and interest groups concerned about their community, their taxes and the environment.

What is Green Infrastructure?

Green infrastructure is defined as natural vegetative systems and green technologies that collectively provide society with a multitude of environmental, social and economic benefits. The green technologies encompassed in this definition include porous pavements, rain barrels and cisterns, which replicate the functions of ecosystems, such as stormwater storage and filtration. Green infrastructure can contribute to the effective implementation of a range of policy areas, including climate action, water, health, agriculture, growth and disaster risk management. One of the key attractions of green infrastructure is its ability to perform several functions and provide several benefits in the same area, in contrast to its 'grey' infrastructure counterparts (e.g. sewers) which tend to be designed to perform only one function (e.g. drainage).

The Benefits of Green Infrastructure

Green infrastructure is often associated with storm water management but it has many applications, such as improving air and water quality, providing habitat for plants and animals, and enhancing human health. Green infrastructure is also multi-functional and provides co-benefits alongside its primary purpose. This makes it very cost efficient use of public finances; a single investment delivers the core service while also providing numerous other public benefits. In many ways, the use of green infrastructure embodies the shift towards a green economy; cost effective infrastructure that deliver better environmental and social outcomes.

PROSPERITY

Green infrastructure can play a role in enhancing community prosperity, be it economic, social or environmental. While each rural community faces its own unique set of challenges, they can experience some common issues, including out-migration, an aging population, lack of services, and aging infrastructure (Strengthening Rural Canada, 2016).

Investing in green infrastructure can enhance prosperity by:

- Generating construction and maintenance jobs
- Creating recreational and educational opportunities
- Revitalizing downtown and streetscapes
- Expanding trail networks and outdoor recreation
- Attracting businesses, services, and new residents
- Postponing or eliminating the need for infrastructure upgrades
- Increasing groundwater supply and quality
- improving local waterway conditions and aquatic species health

RESILIENCY

Green infrastructure is a key component of climate change resiliency planning because it is more adaptable to environmental fluctuations and stressors than traditional grey infrastructure. Green infrastructure can also help natural systems adapt and cope with the impact of climate change.

Investing in green infrastructure can enhance resiliency by:

- Reducing the impact of a heavy rainfalls on a fixed-capacity storm sewer system
- Reducing the impact of extreme heat days on grey infrastructure and human health
- Providing services that are better able to recover following extreme weather events
- Providing essential food and habitat for many birds and pollinators
- Increasing connectivity between larger natural heritage features, such as forests and wetlands

Guiding Principles

While all levels of government need to be engaged for green infrastructure to reach its full potential, municipalities are at the forefront of implementation. To assist municipalities in maximizing the potential for green infrastructure, this document presents a set of principles to help guide municipal decision and policy making:

1. Implement a Green Infrastructure First policy

Adopt a Green Infrastructure First policy, which considers the potential for green infrastructure investments as conventional infrastructure development, maintenance and replacement decisions are made. This approach has been enacted in Maryland and in Washington, where developers are required to demonstrate that they have implemented green infrastructure techniques to the maximum extent possible before permission to use traditional stormwater management approaches is granted.

2. Incorporate the multiple benefits of green infrastructure

Ensure the multiple benefits of green infrastructure are considered in the early design phase of projects to maximize its potential for increasing recreation, urban heat island mitigation, place-making and aesthetic improvement opportunities. It is also useful to consider the potential of how the multiple benefits of green infrastructure can be incorporated in educational programming, economic development, public health, and community building initiatives.

3. Apply best practices in green infrastructure design and maintenance

It is important in the implementation of green infrastructure to incorporate good design and plan for any required maintenance. This ensures that the services of this valuable resource are maximized and are not degraded due to lack of maintenance. Green infrastructure should also be designed with social and cultural expectations in mind, while simultaneously providing an opportunity to introduce nature back into settlement areas.

4. Preserve and protect natural heritage features and existing urban vegetation

Strive to preserve and protect natural heritage features and existing urban vegetation wherever possible and appropriate. This is critical to the success of a green infrastructure plan or strategy. These areas support natural processes necessary for the provision of clean air and water. Furthermore, these areas are responsible for supporting floral and faunal species, the health and diversity which is dependent on the size of the natural area and exposure to human activity.

5. Integrate green infrastructure into asset management

It is important to consider integrating green infrastructure into asset management systems to ensure these assets get the implementation funding, maintenance priority, and data tracking that they deserve. This will also help establish these features as functional parts of a town's infrastructure.

1

Overview of Green Infrastructure Types and Their Functions

The term 'Green Infrastructure' encompasses both natural systems and engineered solutions. This Guide identifies 17 types of green infrastructure that are most suitable for built areas of smaller cities, towns and rural communities.

These green infrastructure types and their primary function are described below. For ease of reference, each type of green infrastructure has a corresponding number that is used throughout the Guide.

See Section 4: "**Green Infrastructure Types in More Detail**" for a more detailed description of each green infrastructure type.



BIOSWALE (WET or DRY)

Vegetated channel that conveys, reduces, and filters runoff. Dry swales include a filter bed.



CONSTRUCTED WETLAND

A wetland designed and engineered to treat wastewater and manage runoff by removing sediments and pollutants.



DRY POND

Grassy depression that holds water following a storm and allows sediments to settle prior to discharge.



ECOSYSTEM PLANNING

An approach to planning for new developments that considers existing natural areas and drainage ways.



FILTER STRIP

Gently sloped planted strip of grass or dense vegetation designed to filter runoff.



GREEN ROOF

Rooftop vegetation that provides ecological value and habitat, reduces runoff, and enhances building performance.



GREEN WALL

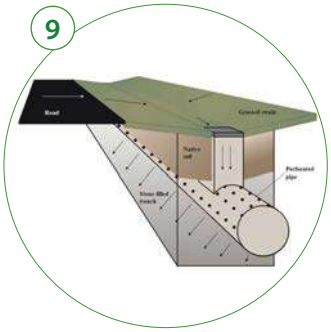
Vertical structure designed to absorb air pollution and act as a sound barrier and beautification feature.



HEDGEROW

Planted strips of shrubs and trees that act as a wind buffer to reduce soil erosion while providing wildlife habitat.

9



PERFORATED PIPE

An underground pipe featuring small holes or slots that allow for the entry and exit of stormwater into the ground or gravel bed.

10



PERMEABLE PAVEMENT

Surface treatments suitable for pedestrian or vehicular traffic which allow water to infiltrate into the ground.

11



RAIN GARDEN AND BIORETENTION

A planted or ornamental rock-filled depression designed to collect, infiltrate, and filter runoff.

12



RAIN HARVESTING

Use of a rain barrel or cistern to collect rainwater and supplement fresh water supply.

13



RIPARIAN BUFFER

Vegetation that slows runoff into streams, as well as reduces erosion, sedimentation, and pollution in a waterway.

14



SOAKAWAYS, INFILTRATION TRENCHES AND CHAMBERS

Underground stormwater storage systems at the individual lot level.

15



TREE CANOPY EXPANSION

Tree planting, protection and maintenance increases the total amount of tree canopy, which helps clean air, filter water and provide shade.

16



WET POND

Large permanent pool that allows sediments to settle. Biofiltration slows and filters water.

17



XERISCAPING

Groupings of vegetation with similar needs, in particular native species, to reduce watering requirements.

Table 1 shows the other primary and secondary functions of each green infrastructure type.

TABLE 1: Green infrastructure Primary and Secondary Functions

		Reduce stormwater runoff	Filter /reduce water pollutants	Store stormwater	Water saving / recycling	Ground water recharge	Energy saving	Mitigate urban heat island effect	Absorb greenhouse gases	Create visual amenity	Provide recreation space	Reduce soil erosion	Biodiversity habitat	Transportation
	● Primary function ○ Secondary function													
Building	Green Roof	●	○	○	○		●	○	○	○	○		○	
	Green Wall						●	○	○	○				
	Rainwater Harvesting			●	●									
Public realm and landscape	Bioswale	●	●	○	○	○		○	○	●		○	○	
	Constructed Wetland	●	●	●		○			○	●	○	○	○	
	Dry Pond	●												
	Filter Strip		●							○		○		
	Hedgerow									○		●	○	
	Perforated Pipe	●				○								
	Permeable Pavement	●	●			○				○				●
	Rain Garden & Bioretention	●	●	●		○		○	○	●	●	○	○	
	Riparian Buffer		●										●	
	Soakaways, Infiltration Trenches & Chambers			●										
	Tree Canopy Expansion	○	○				○	○	○	●	○	○	○	
	Wet Pond	●	●	●				○	○	●	○	○	○	
	Xeriscaping	●	○							●			○	

2

Introduction to Planning Zones

Urban planning is typically structured around defining different zones in a community. Different types and scales of green infrastructure are appropriate for different zones and provide varying benefits depending upon their location.

This Guide considers the following planning zones:

- Private Residential
- Transportation Right-of-ways
- Public Lands and Parks
- Downtowns
- Institutional and Commercial
- Future Developments
- Agricultural Lands

This zoning approach to green infrastructure can guide the development of a green infrastructure strategy. The zoning map below is an illustration of how this approach could be applied using Mt. Albert, Ontario as an example.

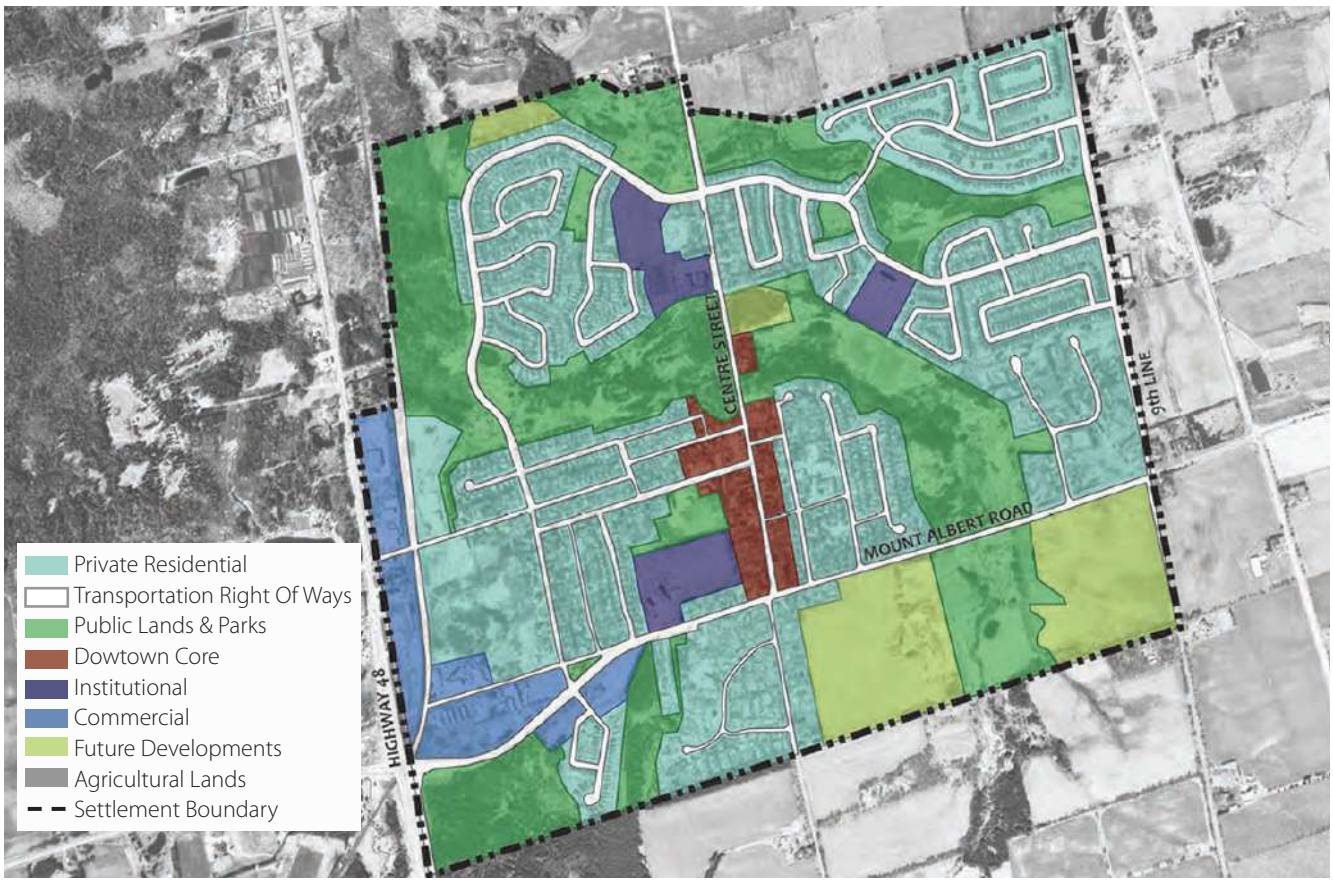


Figure 1: Illustrative Zoning Approach to Green Infrastructure in Mt. Albert, Ontario.

Table 2 identifies the most appropriate green infrastructure types for each of the seven green infrastructure zone. The following section provides a visualization of possible interventions in a before and after image for each zone. It was not possible to include all types of suitable Green Infrastructure in each rendering.

TABLE 2: Green Infrastructure Types by Zones

	Green Infrastructure Zones						
	Private Residential	Transportation Rights-of-ways	Public Lands & Parks	Institutional & Commercial	Downtowns	Future Developments	Agricultural Lands
Bioswale	●	●	●	●		●	●
Constructed Wetland			●			●	
Dry Pond			●	●		●	●
Ecosystem Planning			●	●		●	
Filter Strip		●		●		●	●
Green Roof	●	●	●	●	●	●	
Green Wall	●	●		●	●	●	
Hedgerow	●	●	●	●		●	●
Perforated Pipe System				●	●	●	
Permeable Pavement	●		●	●	●	●	
Rain Garden & Bioretention	●	●	●	●	●	●	
Rain Harvesting	●			●	●	●	
Riparian Zone			●			●	●
Soakaways, Infiltration Trenches & Chambers		●		●	●	●	
Tree Canopy Expansion	●	●	●	●	●	●	●
Wet Pond			●	●		●	●
Xeriscaping	●	●	●	●	●	●	
Natural features	Existing natural areas, such as forests, woodlots, wetlands, riparian zones, meadows and agricultural land are all important components of a green infrastructure system. These areas are vital for the overall health and connectivity of the ecosystem. Conservation and expansion of these areas should be considered when developing a green infrastructure strategy.						

3

Green Infrastructure Opportunities for Each Planning Zone

3.1 PRIVATE RESIDENTIAL

This zone refers to existing yards and buildings on private property in residential neighbourhoods.







BENEFITS

- Additional vegetation and natural features for homes and the public realm have been shown to increase property values, while also improving air quality and creating habitat for wildlife, including pollinators
- Rain gardens and bioswales can help recharge groundwater supply, manage stormwater, and improve local water quality
- Green roofs and green walls can insulate a home, reducing heating costs, and shade from planting trees can lower air temperatures, reducing cooling costs
- Cisterns and rain barrels can be used to harvest rainwater and provide an additional water source for gardening and car washing
- Permeable paving for driveways and sidewalks increases water infiltration into the ground

SITE SPECIFIC DESIGN CONSIDERATIONS

A few simple considerations will help maximize the benefits of green infrastructure on residential properties. It is important to consider the natural topography of a property to see where water naturally pools. Further, the type and quality of soil will also impact the type of green infrastructure that is possible. Areas with heavy clay soils and poor infiltration qualities may not be appropriate for rain gardens or permeable pavement without a gravel foundation or other proper drainage considerations. It is also important to pay attention to sun and shade on any property to ensure appropriate planting takes place, and consider the orientation of any trees with respect to the building to maximize cooling potential by planting along the west side.

Types of Green Infrastructure Suitable for Private Residential



Bioswale (wet or dry)



Green roof



Green wall



Hedgerow



Permeable pavement



Rain garden and bioretention



Rain harvesting



Tree canopy expansion



Xeriscaping

CASE STUDY: SNAP'S NEIGHBOURHOOD SOLUTIONS FOR DRIVING UPTAKE

The sheer number of privately-owned homes and multi-unit residential properties, coupled with homeowner attitudes and competing priorities, pose challenges for municipalities interested in promoting residential adoption of green infrastructure.

Toronto and Region Conservation Authority's (TRCA) Sustainable Neighbourhood Retrofit Action Plan (SNAP) is a proven solution for achieving multiple sustainable urban renewal outcomes that places neighbourhoods at the centre of the implementation framework. By understanding the needs and interests in neighbourhoods, SNAP reframes environmental projects to incorporate greater social and economic outcomes that help municipalities draw strong community support and build trust for long-term engagement in public and private realm initiatives.

Six SNAPs are underway in the Toronto region, each driving uptake of green infrastructure and other sustainability actions. Locally tailored home retrofit programs use behavioural insights to reach hard-to-engage homeowners and increase adoption of actions. Front Yard Makeover demonstrations on private residential lots have been effective at attracting attention, influencing trends and generating interest in programs.

SNAP has demonstrated new partnerships for privately-owned public space renewal. Partnerships with commercial owners and residents of multi-unit residential properties have resulted in revitalization of underutilized open space, including green infrastructure projects that provide community amenities, health benefits, active living and skills training opportunities.

SNAP also promotes integrated green infrastructure renewal in streets, parks and school properties - projects which act as catalysts for engaging residents in actions at home. Successful approaches developed in the pilot neighbourhoods are now being applied in other neighbourhoods with similar demographics.

Visit the TRCA website for more information: www.sustainableneighbourhoods.ca

RESOURCES

Greening Your Grounds: A Homeowners Guide to Stormwater Landscaping Projects by Toronto and Region Conservation Authority.

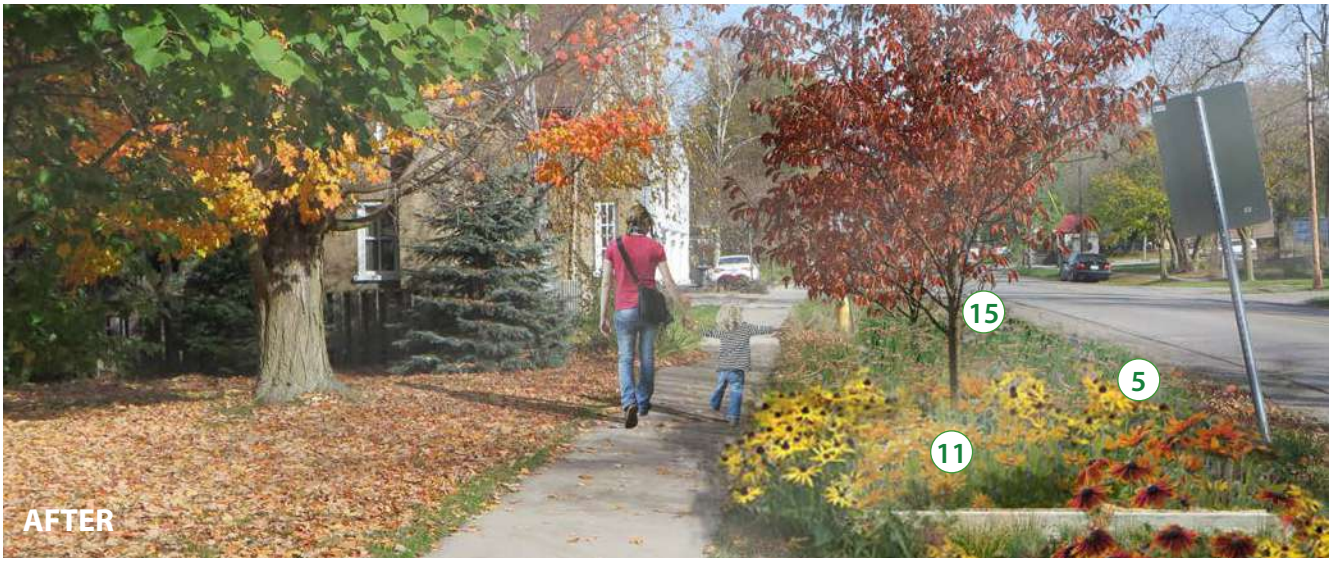
The 1200 Rain Gardens **website** has an extensive resource library including design guides, plant selection lists, studies, and technical reports, about rain gardens. Although the information is Washington-based, it provides a very thorough guide for people interested in the maintenance, benefits or possibilities of rain gardens.

3.2 TRANSPORTATION RIGHT-OF-WAYS

This zone refers to land used for transportation purposes, including the lot easements that run alongside roads and rail lines.







BENEFITS

- Using vegetation and natural features in transportation right-of-ways increases the aesthetic value of streets and roadways. This helps improve human health and increases the rates of active transportation
- It also builds habitat corridors for native and migratory species. In rural settings, it can provide much needed support for pollinators and the vital role they play for farmers
- Rain gardens and bioswales will help filter pollutants in the air and water, improve local stream and river health, manage stormwater quality and quantity, and recharge the groundwater table

SITE SPECIFIC DESIGN CONSIDERATIONS

The design of green infrastructure in transportation right-of-ways can range from manicured flowerbeds to naturalized areas. For example, careful consideration of the colour, scale and bloom patterns of plants can make for beautiful no-mow naturalized or manicured areas in filter strips and bioswales. Green roofs can be installed on bus shelters and local gardening clubs could provide valuable consultation for planting design. Green walls and climbing vegetation can be used as a noise barrier for busy roads near residential zones.

While green infrastructure in transportation right-of-ways requires some changes to public works maintenance schedules, the general skills and equipment are most likely already available to municipal staff. Most right-of-way design elements can be installed without the use of specialized equipment, and the implementation costs can be reduced by 30-60% if these projects are worked into regular maintenance or upgrading schedules. For example, implementing a bioswale in the transportation right-of-way could involve retrofits to existing ditches.

Types of Green Infrastructure Suitable for Transportation Right-of-ways



Bioswale (wet or dry)



Filter strip



Green roof



Green wall



Hedgerow



Rain garden and bioretention



Soakaways, infiltration trenches & chambers



Tree canopy expansion



Xeriscaping

CASE STUDY: TORONTO'S GREEN STREETS PROGRAM

The City of Toronto's Green Streets Technical Guidelines project provides planning and design direction for the integration of green infrastructure solutions that are appropriate for the city's street types and conditions. The Guidelines list 40 potential green infrastructure options that would be suitable for Toronto given its geographical and climatic conditions. Environmental pressures outlined in the Toronto Green Standard are used to categorize the green infrastructure options according to their primary benefit. These benefits include: air quality, climate change mitigation and energy efficiency, water quality and quantity management, ecology, and solid waste management. This approach was applied with the understanding that each green infrastructure option would have several ancillary environmental benefits as well.

Several "Green Streets"demonstration projects have been designed, constructed and monitored since 2008. These include tree planting with soil cells and bioretention areas below pavement (the Queensway Sustainable Sidewalk), bioswales (South Station Street, and Fairford Avenue/Coxwell Avenue), and permeable pavement options for concrete, asphalt and concrete unit pavers.

Visit the Ryerson Urban Water website for more information: http://www.ryerson.ca/water/education/outreach/greeninfrato/

RESOURCES

York Region Streetscape Program by York Region.

Green Infrastructure Opportunities that Arise During Municipal Operations by the United States Environmental Protection Agency.

3.3 PUBLIC LANDS AND PARKS

This zone refers to public lands and parks of all shapes and sizes .







BENEFITS

- Public lands and parks are vital community assets that provide many important services, but additional features can enhance their functionality
- Natural and engineered features in parks, including trees, constructed wetlands and renaturalized areas, increase wildlife habitat and opportunities for outdoor activity and education
- Parks can also increase connectivity between other natural heritage features, improving overall ecosystem health and contributing to climate change mitigation by increasing the tree canopy and natural cover

SITE SPECIFIC DESIGN CONSIDERATIONS

Every park and open space offers unique opportunities in the context of local priorities. The local community can explore and shape potential enhancements. Communities should be encouraged to look beyond the obvious opportunities for natural cover and features, for example, green roofs on shade structures and public facility buildings.

Types of Green Infrastructure Suitable for Public Lands and Parks



Bioswale (wet or dry)



Constructed wetland



Dry pond



Ecosystem planning



Green roof



Hedgerow



Permeable pavement



Rain garden and bioretention



Riparian buffer



Tree canopy expansion



Wet pond



Xeriscaping

CASE STUDY: LAKESIDE PARK, MISSISSAUGA

Lakeside Park is located in a highly industrial area of Mississauga, Ontario. The park was redeveloped in 2012 with the goal of balancing natural features with active recreation. Through the redevelopment process the new park incorporated several types of green infrastructure including bioswales, native vegetation, a reclaimed water irrigation system, pervious concrete in the overflow parking lot, and a green roof located over the public washrooms and maintenance facilities. The parks design was planned in accordance with the City of Mississauga's Waterfront Parks Strategy and incorporates green infrastructure features to reduce its environmental impact while increasing the aesthetic value. The green stormwater infrastructure features were integrated into the design alongside more traditional park features such as a leash free dog area, open spaces, viewing platforms, spray pad, playground, picnic sites, and trails. Many of the park features were designed to connect to one another and provide multiple functions. In particular, the new features help improve water quality and quantity by filtering, infiltrating and reusing stormwater. The park's new intensive green roof has soils deep enough to sustain large plants like shrubs and trees and be accessible recreational space

Visit the Credit Valley Conservation Authority website for more information: http://www.creditvalleyca.ca

RESOURCES

City Parks, Clean Water: Making Great Places Using Green Infrastructure by the Trust for Public Land.

Beautiful Non-Invasive Plants for your Garden, A resource guide for Southern Ontario by the Ontario Invasive Plant Council.

Native Plant Resource Guide Ontario by the Society for Ecological Restoration. This guide provides information on where to source native plant species in Ontario (updated annually).

3.4 DOWNTOWNS

This zone refers to a community's center for local business and social activity.







BENEFITS

- Revitalization and placemaking in the downtown core can attract new businesses and visitors
- Integrated green infrastructure features in a community's downtown can improve public health
- Different types of green infrastructure such as trees provide protection from sun and wind exposure, as well as produce oxygen and store carbon
- Replacing asphalt parking strips with permeable pavers and adding street trees help to define and improve the pedestrian realm

SITE SPECIFIC DESIGN CONSIDERATIONS

Green infrastructure is an integral element of revitalization. Incorporating seating, public spaces and aesthetic themes into downtown green infrastructure installations will enhance their impact. Communities can take advantage of pleasant sunny areas or naturally shady areas in order to create gathering places. Naturalized areas can be designed to be low-maintenance, and defined by neat and orderly edge treatments.

Many types of green infrastructure can be coordinated with maintenance projects, which minimize disturbance and allow for efficient use of equipment and staff. Smaller elements like rain gardens and streets trees could be implemented by working with local businesses.

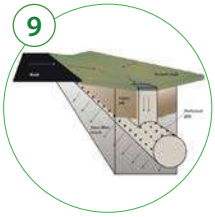
Types of Green Infrastructure Suitable for Downtowns



Green roof



Green wall



Perforated pipe



Permeable pavement



Rain garden and bioretention



Rain harvesting



Soakaways, infiltration trenches & chambers



Tree canopy expansion



Xeriscaping

CASE STUDY: DOWNTOWN PLAN, CITY OF PENTICTON, B.C.

The City of Penticton's Downtown Plan aims to create a more vibrant and resilient downtown. The vision in the Downtown Plan is "dependent on increases in landscaping and green infrastructure, both from the City and through private investment" (2012, pg. 24). The plan includes a green policies section, which encourages the installation of street trees, investment in parks and open space, and enhancement of natural heritage areas. Specific strategies include converting parking lots to parks, linking the downtown core to natural areas and parks, tree planting and landscaping on streets and parkettes. Key actions in the Plan include measuring existing tree canopy and setting a goal of doubling it, enhancing existing and building new pocket parks, and encouraging the incorporation of rooftop gardens and patios on downtown buildings.

Visit the City of Penticton website for more information: www.penticon.ca

RESOURCES

City Green: Innovative Green Infrastructure Solutions for Downtowns and Infill Locations by the United States Environmental Protection Agency. This report contains case studies across the USA of different ways to use green infrastructure for streetscaping and placemaking.

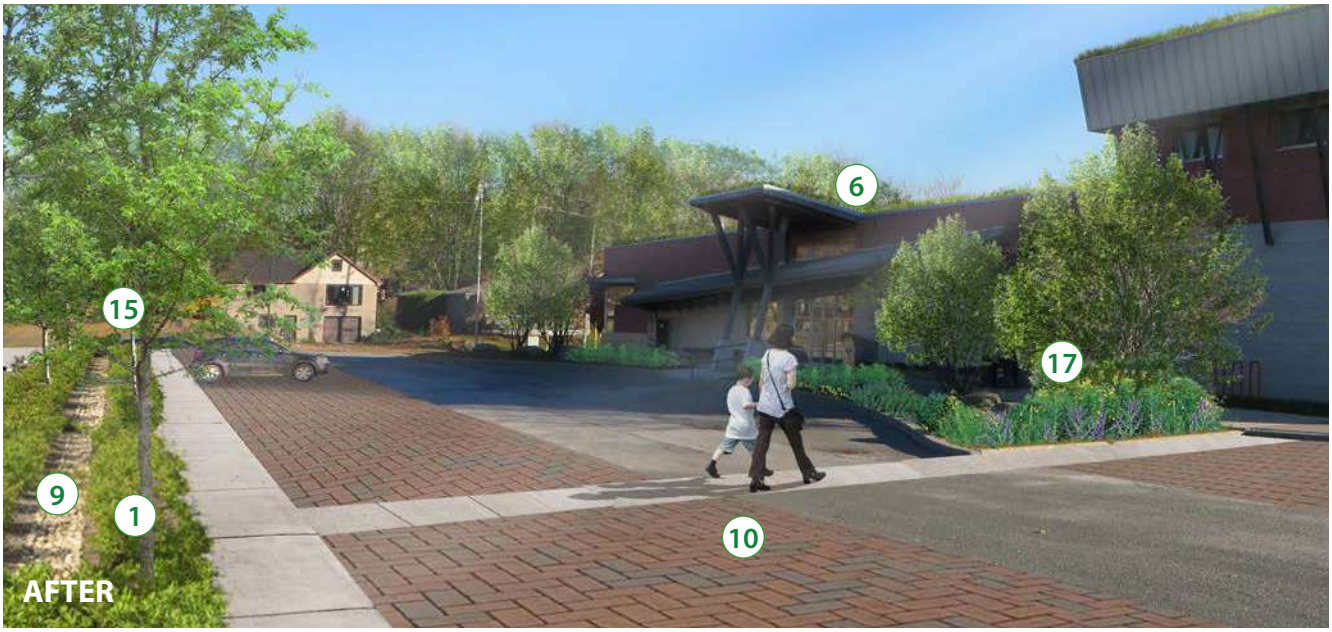
Streetscape Improvement: Capital Project Overview & Guidelines by the City of Toronto.

3.5 INSTITUTIONAL AND COMMERCIAL

This zone refers to sites used for institutional and commercial purposes. These sites are often large in scale with lots of impervious surfaces in the form of rooftops and parking lots.







BENEFITS

- Given the large size of commercial and institutional properties and the buildings on site, this zone provides many opportunities for the inclusion of small, medium, and large-scale green infrastructure
- Green roofs and green walls can reduce heating and cooling costs while creating wildlife habitat, reducing sound pollution, providing clean air, and absorbing stormwater
- Large-scale water harvesting and stormwater systems can help manage water at the source and reduce municipal water bills
- Properly engineered grading, draining, and infiltration of parking lot runoff can decrease municipal water treatment expenses
- Trees not only beautify the urban landscape, they also provide an opportunity to connect with nature and support stormwater management

SITE SPECIFIC DESIGN CONSIDERATIONS

In large parking lots, green infrastructure should be designed to create pedestrian-friendly walkways to main entrances, increase safety, and provide shade.

Building specifications will define the opportunities for green roofs and green walls.

Types of Green Infrastructure Suitable for Institutional and Commercial



Bioswale (wet or dry)



Dry pond



Ecosystem planning



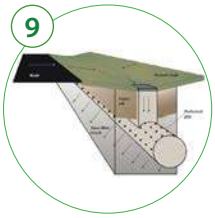
Filter strip



Green roof



Green wall



Perforated pipe



Permeable pavement



Rain garden and bioretention



Rain harvesting



Riparian buffer



Soakaways, infiltration trenches & chambers



Tree canopy expansion



Wet pond



Xeriscaping

CASE STUDY: ALTON PUBLIC SCHOOL RAIN GARDEN, ALTON VILLAGE

The Alton Park Rain Garden is a community resource and educational tool located in Alton Village, Ontario. The local Alton community and Alton Public School assisted with fundraising, design and construction of the project. In June 2014, Credit Valley Conservation and Alton students initiated and participated in a design charrette as a collaborative design approach to developing a design solution for the garden. The plants selected by students were incorporated into the final design and the garden was constructed in September 2014. To continue engaging students in environmental education, CVC worked with the school to create garden art pieces from reclaimed materials. Students and staff each painted logs that were incorporated in to four sculptures that were revealed at a ceremony attended by the entire school including the superintendent and trustee, CVC staff, and members of the community.

Visit the CVC website *for more information: http://www.creditvalleyca.ca*

RESOURCES

Design Guidelines for 'Greening' Surface Parking Lots by the City of Toronto.

Growing Green Guide: A Guide to Green Roofs, Walls and Facades by Green Roots Australia.

3.6 FUTURE DEVELOPMENTS

This zone refers to some communities and towns that have areas designated for infill and greenfield development. Green infrastructure and the preservation of natural features can be prioritized in the design and construction of both, for example by adopting a treatment train approach to manage stormwater runoff.





An example of a new developing design

BENEFITS

- New developments offer limitless opportunities to include green infrastructure in the initial design process
- Entire neighbourhoods can be graded to treat stormwater with swales, rain gardens and ponds, reducing the need for storm sewers
- This approach can also minimize the size of the stormwater management ponds required and therefore potentially increase the number of salable lots
- Water pollution can be treated on site through a properly engineered wetland, reducing the need for expanding wastewater treatment facilities
- At a household scale, alternative building orientation and design can take advantage of solar energy and tree placement to reduce heating and cooling costs
- On a neighbourhood scale, ecosystem planning can ensure the retention of large trees and natural features increasing value of the whole development

SITE SPECIFIC DESIGN CONSIDERATIONS

When integrating green infrastructure, the design of the development should consider the existing topography and natural heritage features on the site, and use grading and infiltration to convey and treat stormwater on site. Each property should take advantage of green infrastructure opportunities for shading, insulation, infiltration, and beautification.

Types of Green Infrastructure Suitable for Future Developments



Bioswale (wet or dry)



Constructed wetland



Dry pond



Ecosystem planning



Filter strip



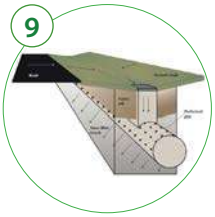
Green roof



Green wall



Hedgerow



Perforated pipe



Permeable pavement



Rain garden and bioretention



Rain harvesting



Riparian buffer



Soakaways, infiltration trenches & chambers



Tree canopy expansion



Wet pond



Xeriscaping

CASE STUDY: VALES OF GLENWAY, NEWMARKET, ONTARIO

Mosaik's Vales of Glenway subdivision is one of the first projects in Ontario to use low impact development (LID) techniques across the entire site. Aside from managing 90% of annual stormwater runoff on site, the LID techniques will also significantly reduce phosphorus loading, help reduce stream erosion, protect downstream infrastructure, and prevent degradation of downstream aquatic habitat. The project includes rain gardens, biofilters, an exfiltration system, and best practices for the management of soils in landscaped areas. Vales of Glenway is also the first development in York Region to participate in Enbridge's Savings by Design, an initiative to improve energy performance and reduce energy costs.

Visit the Sustainable Technologies website for more Information: http://www.sustainabletechnologies.ca

RESOURCES

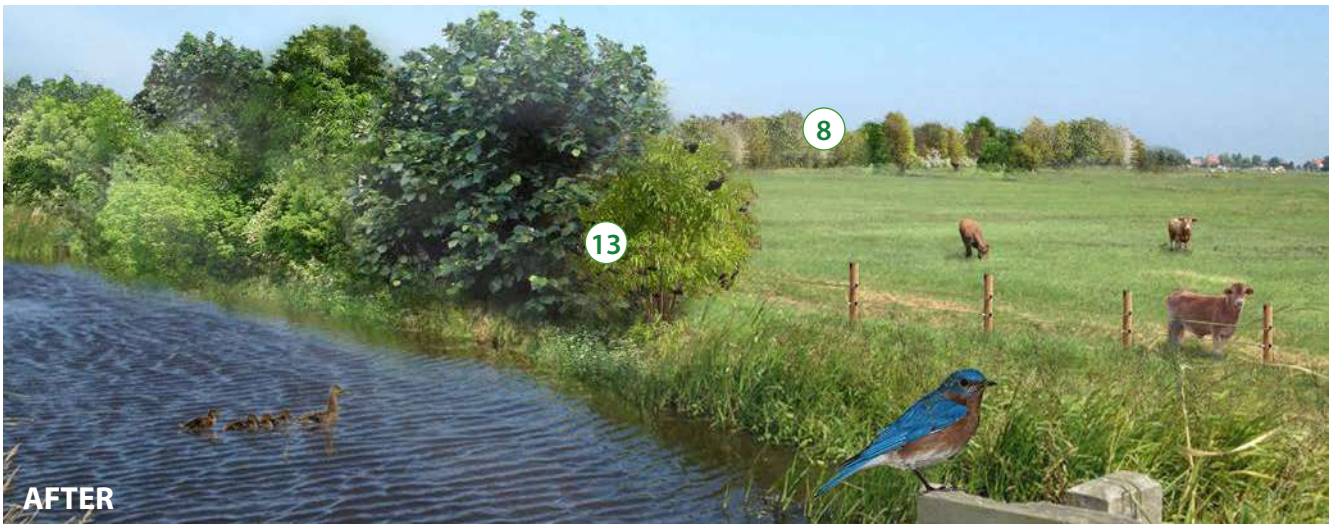
Sustainable Community Design by Urban Strategies Inc.

Innovative Sustainable Development Approvals Project by York Region.

3.7 AGRICULTURAL LANDS

This zone refers to agricultural lands, which are an important industry in rural communities. The agricultural system plays a significant role in maintaining the health of the natural heritage system in Ontario. Engaging farmers in a green infrastructure strategy offers substantial social and environmental benefits.





BENEFITS

- Green infrastructure on agricultural properties can support farming production and provide additional ecological goods and services
- Green infrastructure features can retain stormwater for use during droughts while also filtering runoff, which reduces phosphorus loads and contributes to improving water quality
- Buffers and hedgerows protect agricultural lands from wind erosion, provide connections to the natural heritage system and vital habitat for wildlife, including pollinators. These vegetated strips can also be used to grow fruit trees and mushrooms, or harvest maple syrup, firewood and lumber to add income diversity

SITE SPECIFIC DESIGN CONSIDERATIONS

Many farmers are engaged in stewardship activities and adopt management practices that include green infrastructure features, but more can be done at a local level to support them. In developing a green infrastructure strategy municipalities should take into account their local context to work out how best to engage with the agricultural community. A key success factor in agricultural-related green infrastructure is choosing robust native vegetation that is adapted to our climate and can withstand the nutrient loads associated with runoff. Although the planting of a large riparian buffer zone or hedgerow can seem like a daunting expense for farmers, partnerships can be made with conservation authorities, municipalities and community groups (e.g. services clubs, student groups, scouts) to work together to implement green infrastructure on agricultural lands. This lowers costs for the farmers, and may provide opportunities for public education.

Types of Green Infrastructure Suitable for Agricultural Lands



Bioswale (wet or dry) | Dry pond | Filter strip

Hedgerow | Riparian buffer | Wet pond

CASE STUDY : COOPER'S FARM, ZEPHYR, ONTARIO

Steve and Lisa Cooper have dedicated themselves to the sustainable farming and supply hundreds of families with CSA's (Community Shared Agriculture) shares. "Handling soil is the one of the most important jobs on the farm. Years ago, we decided to stop participating in the conventional style of managing soil - drenching the soil in a bath of nitrogen, phosphorus and potassium fertilizers - and started treating the soil like the living breathing entity that it is. One of the ways we do this is by feeding the soil compost - for instance, properly timed applications of manure and plowed in green crops (green manure). When it is necessary, we will till the soil in order to mix it and aerate it, which prepares it for planting. We also add naturally occurring sources of nutrients to breed a balanced soil that holds all of the nutrients naturally available to plants - not just excessive amounts of the three mentioned above. Through these practices we create healthy soil, which yields healthy food all while maintaining the sustainability of our farm."

Visit the Coopers Farm website for more information: http://www.coopersfarm.ca/from-the-field/

RESOURCES

Landowner Environmental Assistance Program (LEAP) by Lake Simcoe Regional Conservation Authority.

Golden Horseshoe Food and Farming Alliance **website**.

York Natural Planting Partnership for Private Land by York Region.

Grow Agriculturally Productive Buffers Guide by University of Vermont.

4

Green Infrastructure Types in More Detail

Green infrastructure is a cost effective way to contribute to the health of the natural environment while providing a multitude of other functions. Maintenance and cost requirements will differ depending on the scale of the project, the chosen vegetation, and the use of professional services. Key considerations for each type of GI include:

- Maximize benefits while decreasing maintenance-related tasks by choosing types of green infrastructure based on the specific goals, needs, and climate conditions of the settlement area
- Place, design and coordinate types of green infrastructure strategically to maximize efficiency and effectiveness in terms of construction, operations, and maintenance
- Monitor the performance of green infrastructure features to determine their level of success and make changes as necessary, such as replanting or introducing different vegetation

The following backgrounders provide an overview of the types of green infrastructure presented in this Guide as well as some of the key considerations in their implementation and maintenance. It includes cost estimates where they were available from existing research. Visit the Sustainable Technologies Evaluation Program **website** for more information on the STEP Low Impact Development Life Cycle Costing Tool.

1 BIOSWALE (WET OR DRY)

Swales are shallow vegetated open channels designed to convey, reduce and filter runoff. A wet swale includes design features that improve the contaminant removal and runoff reduction functions of a simple roadside ditch. A dry swale, also referred to as a bioswale, is an enhanced wet swale that incorporates an engineered filter media bed and optional perforated pipe underdrain or a bioretention cell.



COMPATIBILITY

- Suitable in narrow areas alongside trails and roadways
- Topographic and soil conditions must be taken into account to ensure plant growth
- Deep rooted plants are most compatible as they withstand the water force and help to slow water flow
- Ensure that the drainage pattern does not encourage water pooling on sidewalks, which contributes to icy conditions and poses a hazard to pedestrians during the winter months

MAINTENANCE

- Pruning, weeding, and mowing carried out as needed, but primarily in the spring and fall
- Watering as needed, although new plants may require additional watering while their roots establish
- Removing built up leaf litter to prevent blockage of water flow
- Removing sediment built up
- Checking for signs of erosion after heavy rainfall will ensure continuous water runoff and prevent clogging
- Channels and rills can be repaired by re-seeding washed out areas

COSTS

- Installation costs are dependent on location and design features, but typically are cheaper than alternative curb and gutter treatments
- Initial costs involve moving of earth to create a swale
- Main cost difference between a dry and wet swale is the highly permeable soil and underdrain system required for a dry swale

RESOURCES

Wet Swale Fact Sheet by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

Dry Swale Fact Sheet by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

Low Impact Development Stormwater Management Planning and Design Guide by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

Reducing Stormwater Costs Through Low Impact Development (LID) Strategies and Practices by United States Environmental Protection Agency.

2 CONSTRUCTED WETLAND

Constructed wetlands use natural processes involving vegetation, soils, and associated microbial assemblages to improve water quality. They are designed and engineered to treat wastewater and manage runoff. Constructed wetlands are tailored to respond to site and community specific needs. The uses of constructed wetlands can contribute to one or all of the following: improved water quality, stormwater management, sewage treatment, public access points, and habitat for wildlife.



COMPATIBILITY

- Primarily constructed on municipally-designated land and positioned outside floodplains and floodways to prevent harm to existing natural wetlands and other hydrologic features
- Site considerations include the substrate and soil chemistry, hydrological and geological features, existing vegetation and habitat for endangered and threatened species
- Standing water in constructed wetlands may contribute to thermal pollution and downstream warming. This may preclude their use in areas where sensitive aquatic species live
- Planning considerations include land-use and zoning approvals, and additional safety precautions to mitigate potential safety and health impacts

MAINTENANCE

- Regular monitoring and inspections in accordance to maintenance plans
- Annual checking of inlet and outlet structures
- Removal of litter and other debris to ensure no blockage of water flow
- Removal of excess sediment buildup to maintain water flow and drainage, as needed
- Maintain general appearance of vegetation, as desired
- Monitor wildlife to ensure animals are healthy and do not negatively impact the wetland

COSTS

- Costs vary depending on context and scale of the proposed constructed wetland
- Installation costs range from $6,000 to $300,000 per hectare, with an average of $100,000
- Average maintenance costs are less than $1,500 per hectare a year and can be more cost effective than alternative treatment options
- Wetlands in the Greenbelt typically provide flood protection services worth over $10,000 per year

(Costs source: Canada Mortgage and Housing Corporation)

RESOURCES

Constructed Wetlands by Sustainable Technologies Evaluation Program.

Resources on Constructed Wetlands by United States Environmental Protection Agency.

3 DRY POND

A dry pond is a grassy depression that holds water for up to a week, removing sediment as water filters out into a stream. Dry ponds control peak runoff flows, help improve water quality and lessen the effects of erosion. Between rain events, a dry pond looks like a large, grassy low area.



COMPATIBILITY

- Works particularly well alongside parking areas and new subdivisions
- Often used in conjunction with perforated pipe systems, permeable pavement and vegetated buffer zones
- May need to take additional safety precautions, such as fencing, if located in close proximity to school yards and community centers

MAINTENANCE

- Mowing of grass and removal of invasive species, as needed
- Inspecting vegetation to ensure there is no drain blockage in the spring and fall
- Checking of inlet and outlet structures, annually
- Removing litter and debris, especially around drainage area, monthly and after heavy rainfall
- Slope stabilization depending on erosion, especially after heavy rainfall
- Monitoring sediment accumulation, semi-annually or after heavy rainfall
- Removing excess sediment built up to prevent clogging of drainage, every five years or based on capacity of the pond

COSTS

- Installation costs range significantly depending on the size of the pond

RESOURCES

Stormwater Management Ponds by Sustainable Technologies Evaluation Program.

Operation and Maintenance Report for Stormwater Management Facilities by the City of Hamilton.

Stormwater Management Fact Sheet - Dry Extended Detention Pond by Stormwater Resource Centre.

4 ECOSYSTEM PLANNING



This is not a type of green infrastructure but an approach to planning that seeks to conserve existing natural features and incorporate design features that enhance the provision of ecosystem services. Ecosystem planning is the use of sustainable land use practices that carefully examine the existing topographic and geological characteristics of the site, and their respective opportunities and constraints. This includes designing the site in a way that protects natural features, such as existing trees and wetlands. Ecosystem planning can also incorporate compatible types of green infrastructure, such as xeriscaping, bioswales, and permeable pavement.

SUITABILITY

- Site considerations include topographic and geological considerations as well as local climatic and seasonal considerations
- Site context within the larger area, such as proximity to the Greenbelt or major provincial infrastructure

COSTS

- This approach can reduce infrastructure costs and development fees, as well as speed up the permitting process, if incorporated into the initial design process of a community. For example, the Vales of Glenway development incorporated a treatment train approach with rain gardens, bioswales and an underground storage tank that reduced the required volume for a stormwater management pond. The developer received financial support through Enbridge's Save By Design program, and was able to incorporate additional extra residential lots

RESOURCES

Innovative Sustainable Development Approvals Project by York Region.

Sustainable Community Design by Urban Strategies Inc.

Green with Incentives - Supporting Sustainable Infrastructure and Development by Carla Stewart in the Canadian Institute of Planners.

5 FILTER STRIP

A filter strip is a gently sloped planted strip of grass or dense vegetation designed to filter runoff. It will slow runoff velocity, filter out suspended sediment and associated pollutants, and provide some infiltration into underlying soils. It also provides a convenient area for snow storage and treatment, and is particularly valuable due to its capacity for snowmelt infiltration. When planted with vegetation, filter strips can include other types of green infrastructure such as trees, shrubs, and other plants.



COMPATIBILITY

- Work particularly well along roadways, swales, trails and parking areas, and often used in conjunction with infiltration trenches
- Most effective on slopes with less than 5% incline and not recommended for slopes greater than 15% incline
- While designed to treat small drainage areas, a key site consideration is the ability to slow water flow
- If used for snow storage, the area should be planted with salt-tolerant, non-woody plant species
- Incompatible with soil that has high clay content due to lack of infiltration

MAINTENANCE

- Mowing grass to maintain appearance on a regular basis
- Checking for signs of erosion, after heavy rainfall
- Repairing channels and rills by reseeding area, especially after heavy rainfall
- Removing excess sediment buildup to maintain water flow and drainage, as needed
- If sediment build-up is more than 15 cm deep, the affected area should be re-cultivated
- May require control of invasive species

COSTS

- Installation costs include topsoil, grading, and sodding, which are estimated at $\$6/m^2$
- Hydroseeding and mulch is estimated at $\$3/m^2$
- Including shrubs or trees on a filter strip is estimated at $\$18/m^2$
- While maintenance costs vary widely, they include mowing, reseeding, replanting, and removing debris and sediment

(Costs source: Canada Mortgage and Housing Corporation - Vegetative Practices)

RESOURCES

Low Impact Development Stormwater Management Planning and Design Guide (Chapter 4.6) by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

Vegetated Filter Strips Fact Sheet by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

6 GREEN ROOF

A green roof is a vegetated surface on a building roof or other architectural element, which provides ecological value, enhances building performance, and reduces stormwater runoff. Green roofs can be intensive (greater depth of planting medium that sustains a larger variety species of plants) or extensive (lower depth of planting that sustains smaller plants such as mosses, sedums, succulents, herbs and certain grasses).



COMPATIBILITY

- Compatibility with new or retrofitted rooftops
- Ideally, the rooftop should be relatively flat, with a 30 degree pitch
- The roof needs to be able to hold an increased load due to the added weight
- Requires a legal access point to the roof

MAINTENANCE

- Watering may be required during initial installation stage and growth of vegetation
- Amount of regular watering required will depend on the type of vegetation and installation techniques used
- Inspecting vegetation-free zones, which are usually at perimeter to protect sensitive points, such as roof drains
- Removing litter, sticks, leaves, and other debris, and controlling of weeds as needed
- Checking of moisture level and irrigation system, especially during dry periods
- May require cutting and pruning in the fall

COSTS

- Installation costs range from $64 to $226 /$m^2$ depending on building materials, complexity of design, and local availability of materials. This does not include the base roof cost
- Annual maintenance is estimated to range from $2.7 to $44/$m^2$
- Site inspections should take place approximately five times a year and a maintenance company would likely charge $250 per site visit
- The lifespan of a green roof ranges from 10 to 30 years, which is similar to a conventional roof design. After this time, significant work may be required

(Costs source: An Economic Analysis of Green Roofs by Toronto and Region Conservation Authority)

RESOURCES

An Economic Analysis of Green Roofs by Toronto and Region Conservation Authority.

Low Impact Development Stormwater Management Planning and Design Guide (Chapter 4.2) by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

Green Roofs Fact Sheet by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

Green Roof Policy Brochure by Green Roofs for Hearlthy Cities.

7 GREEN WALL

A green wall, also referred to as a vertical garden, is a vertical structure partially or fully planted with vegetation, designed to absorb air pollutants, act as a sound barrier, and provide aesthetic value. A green wall can be a living wall or a green facade. A green facade usually features climbing vegetation planted at ground level, whereas a living wall has a growing medium throughout the wall design.



COMPATIBILITY

- Compatible with private and public buildings and other public infrastructure
- Can be introduced during the initial design process or as a retrofit to an existing structure through a trellis system, a cable/rope wire system, or pre-grown panels

MAINTENANCE

- Watering may be required during initial growth of vegetation
- Replacing existing plants as needed
- Inspecting irrigation and drainage system to prevent water overflow
- Should consider installing an automated drip-irrigation system for watering during the dry season
- May require pruning in the fall and spring

COSTS

- Installation costs vary depending on the system type, support structure needed, building location, design complexity, availability of materials and plants used
- A living wall will often cost more than a green façade

RESOURCES

Green Roofs and Walls Presentation by Green Roofs for Healthy Cities.

Introduction to Green Walls Technology, Benefits & Design by Green Roofs for Healthy Cities.

A Guide to Green Roofs, Walls and Facades in Melbourne and Victoria, Australia by the State of Victoria, Australia.

8 HEDGEROW



Hedgerows are rows of trees, shrubs and/or vines along roads, and between fields and residential lots. In the context of agricultural lands, hedgerows are planted strips that reduce soil erosion by providing a wind buffer. Along right-of-ways, in residential areas and on agriculture land they offer a more aesthetically pleasing alternative to standard chain link or wooden fences and provide wildlife habitat and visual screens, while helping define boundaries.

COMPATIBILITY

- Often used in conjunction with agricultural filter strips and infiltration trenches
- Depending on height, may limit sun exposure and impact the growth of certain crops
- Residential developments present opportunities to conserve existing hedgerows or plant new ones with trees and shrubs suitable for the space

MAINTENANCE

- Controlling weeds in close proximity to hedges supports growth and reduces competition for water
- Monitoring wildlife activity in proximity to hedges helps to protect agricultural lands and the hedges from damage
- Requires inspecting for invasive species during seasonal pruning of hedges

COSTS

- Little information exists on the installation and maintenance of hedges in agricultural or residential areas
- Installation costs are largely determined by hedge size
- Maintenance costs include hedge trimming and potential pest control

RESOURCES

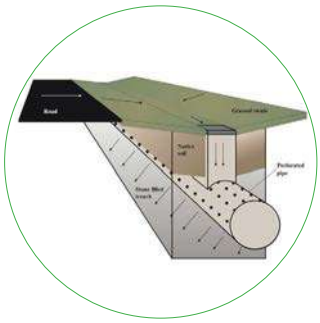
Windbreaks, Hedgerow and Living Fences by Evergreen.

How to Plant And Maintain Hedgerows by The Mersey Forest.

H(edge)rows: Structuring a Suburban Neighbourhood Identity by Ontario Association of Landscape Architects.

9 PERFORATED PIPE

Perforated pipe systems are designed for both the conveyance and infiltration of stormwater runoff. In some situations, a perforated pipe can be used as an alternative to conventional storm sewer pipes. It is installed in gently sloping granular stone beds that allow runoff to infiltrate into the gravel bed and underlying native soil.



COMPATIBILITY

- Typically located on public property (including boulevards, grass swales, and shoulders of roadways) to ensure easy access
- Must be located on natural slopes with an incline of no greater than 15%
- Should be setback from building foundations to prevent basement flooding and damage during the freeze/thaw cycle
- Incompatible with high traffic areas due to amount of de-icing salts and sand used for winter road maintenance
- Incompatible with pollution hot spots, such as gas stations, and outdoor storage areas for equipment and hazardous materials
- Incompatible in close proximity to underground facilities, which pose a hazard to the perforated pipes

MAINTENANCE

- Removing built up leaf litter and sediment should be carried out as required or every 5 to 10 years
- Inspecting drainage flow via manhole to ensure waterflow
- During heavy rainfall, if it takes more than 72 hours for the pipe to fully drain, pumping or flushing of the pipe may be required
- Removing any sand build up resulting from winter road maintenance practices

COSTS

- Little information is available regarding installation and maintenance costs for perforated pipe systems
- The Low Impact Development Stormwater Management Planning and Design Guide by the Credit Valley Conservation Authority states that the design components of a perforated pipe system are similar to infiltration trenches or dry swales, and costs may therefore be similar

RESOURCES

Perforated Pipe Systems Fact Sheet by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

Grey to Green Public Lands Retrofits by Credit Valley Conservation Authority.

Guidelines for the Design and Construction of Stormwater Management Systems by City of New York, USA.

Low Impact Development Stormwater Management Planning and Design Guide (Chapter 4.10) by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

10 PERMEABLE PAVEMENT



Permeable pavement refers to surface treatment that is suitable for pedestrian or vehicular traffic and contains pore spaces or joints that allow stormwater to pass through to a stone base where it is infiltrated into the underlying native soil or temporarily detained and conveyed to a stormwater management pond. Types of permeable pavement include: pervious concrete, porous asphalt, and permeable interlocking concrete pavers.

COMPATIBILITY

- Commonly used in parking lots, internal roadways, and pedestrian pathways
- Permeable pavement options vary depending upon whether the pavement receives light, moderate, or heavy use
- Ensure underlying soil type is permeable to prolong lifespan of infrastructure

MAINTENANCE

- Regular maintenance is critical to the continued effectiveness and durability of permeable pavement materials
- Routine street sweeping to avoid sediment built up
- Weeding and mowing depending on type of permeable pavement
- Removing leaves and debris to avoid clogging, ideally 2 to 4 times a year
- Avoid using sand to treat icy-conditions, especially in parking lot areas, to prevent clogging
- Regular mechanical street sweepers are compatible with most permeable pavements. Alternatively, regenerative air street sweepers and vacuum street sweepers may be used

COSTS

- Design, operation, and maintenance procedures will impact installation and maintenance costs
- Costs vary widely depending whether permeable asphalt, concrete, or interlocking pavers are used
- Maintenance may require special street sweepers, which increases initial maintenance costs if machinery needs to be purchased

RESOURCES

Evaluation of Permeable Pavements in Cold Climates by University of Guelph and Toronto and Region Conservation Authority.

Permeable Pavement Fact Sheet by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

Low Impact Development Stormwater Management Planning and Design Guide (Chapter 4.7) by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

11 RAIN GARDEN AND BIORETENTION



Rain gardens and bioretention facilities use a combination of soil and plant material to capture and treat stormwater. Bioretention facilities are engineered to treat and manage a specific amount of stormwater and have exact design criteria to ensure they function according to the design intent. Rain gardens are typically smaller systems that do not require engineering. They feature a planted or rock-based depression, designed to provide temporary rainwater storage and filter runoff. These are typically cost effective and easy to maintain options for both private and public land.

COMPATIBILITY

- Often used in conjunction with infiltration trenches and swales

MAINTENANCE

- Water should not stand in a rain garden longer than 48 hours and should not interfere with any neighbouring properties
- Pruning, weeding, and mowing should be carried out as needed, but primarily in the spring and fall
- Using native vegetation that thrives in the local conditions will reduce maintenance requirements
- New vegetation may require additional watering while its roots establish
- Removal of built up leaf litter and sediment, annually
- Checking for signs of erosion will ensure runoff and prevent clogging, annually and after heavy rainfall

COSTS

- Installation costs of bio-retention features can vary depending on the size, vegetation, and design of the feature
- Rain gardens can be implemented through affordable do-it-yourself projects
- Cost summaries from various municipal programs (US and Canada) can be retrieved from Green Values

RESOURCES

Rain Gardens - Improve Stormwater Management in Your Yard by Canada Mortgage and Housing Corporation.

Bioretention Fact Sheet by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

Rain Gardens Information Sheet by Toronto and Region Conservation Authority.

Resources for Rain Gardens by 1200 Rain Gardens.

12 RAIN HARVESTING

Rain harvesting involves the collecting of rainwater in a rain barrel or cistern, usually from a roof of a house or building to supplement fresh water supply. A rain barrel or cistern is most effective when the stored water is used regularly as this allows for renewed harvesting of rainwater.



COMPATIBILITY

- Gutter slope should have a 0.5 to 2% incline throughout the gutter length to ensure runoff
- Captured rainwater can be used for non-potable water uses such as gardening, or in a building to flush toilets

MAINTENANCE

- Cleaning of the rain barrel or cistern, as required
- Clearing downspout of leaf and debris to allow runoff, which will increase the amount and quality of the rainwater collected
- Draining rain barrel or cistern and adjusting conveyance drainage pipe to allow for alternative runoff during the winter months to prevent freezing of water buildup

COSTS

- Average cost for a rain barrel is $100 and ranges depending on style and capacity. A 220-litre rain barrel holds the equivalent of approximately 9 minutes of watering with a garden hose
- Costs for a cistern vary widely depending on capacity but can range from $150 to $10,000
- Minimal maintenance cost if rain barrel and cistern are annually cleaned and emptied during the winter months

RESOURCES

Guidelines for Residential Rainwater Harvesting Systems Handbook by Canada Mortgage and Housing Corporation.

Rainwater Harvesting Fact Sheet by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

13 RIPARIAN BUFFER ZONE

A riparian buffer is planted to create a buffer zone between land uses that may negatively impact bodies of water, including floodplains and wetlands. A riparian buffer zone is comprised of thick vegetation that slows stormwater runoff, reduces erosion and sedimentation, and decreases pollution in the waterway. While buffer zones can be as simple as planted strips of coarse grass, the most effective buffer zones include a mix of vegetation, such as grasses, shrubs, and trees.



COMPATIBILITY

- Incompatible with soil that has a high clay content due to lack of infiltration
- Adequate amount of buffer width is required, depending on what is being protected
- Sturdy and tall perennial native grasses work well in trapping sediment

MAINTENANCE

- Mowing of grass and removal of invasive species, as needed
- Removing litter and debris, annually and after heavy rainfall
- Replanting and reseeding may be required, especially during the initial growth spurt
- Checking for signs of erosion, after intense rainfall event
- Repairing channels and rills by reseeding areas
- Mowing the strip to allow sunlight and air circulation if bacteria is detected in runoff

COSTS

- Forest buffers cost more than a grass buffer due to the cost of tree seedlings
- Depending on the severity of the pollutant content in the runoff, the lifespan of a riparian buffer is generally self-renewing
- Volunteer and community involvement can reduce the implementation and maintenance costs

RESOURCES

Ecological Buffer Guideline Review by Credit Valley Conservation Authority.

Natural Heritage Reference Manual by Ontario Ministry of Natural Resources.

Riparian Buffers by Agriculture and Agri-food Canada.

14 SOAKAWAYS, INFILTRATION TRENCHES AND CHAMBERS



Soakaways are rectangular or circular shallow excavations lined with filter fabric and filled with stone to create underground reservoirs for stormwater runoff. The runoff gradually percolates through the sides and bottom of the feature into the surrounding soil. Infiltration trenches are essentially long thin soakaways that are well suited for sites where available space is limited to narrow strips of land between buildings or properties, or along road right-of-ways. Infiltration chambers are also a design variation of soakaways that feature a range of proprietary manufactured modular structures installed underground to create large void spaces for temporary storage and infiltration of stormwater runoff.

COMPATIBILITY

- Soils underlying the site should be permeable
- A pre-treatment green infrastructure element such as a swale or filter strip is recommended upstream of the trench to reduce incoming water speed and coarser sediments
- Should be set back from building foundations

MAINTENANCE

- Requires regular inspection to ensure proper performance
- Maintenance consists of cleaning out leaves, debris and accumulated sediment caught in pretreatment devices, inlets and outlets, annually or as needed
- If installed on private lots, property owners or managers need to be educated on routine maintenance needs, understand the long-term maintenance plan, and be subject to a legally binding maintenance agreement
- As part of routine maintenance, capped vertical non-perforated pipes connected to the inlet and outlet pipes are recommended to provide a means of inspecting and flushing them out

COSTS

- Limited information is available regarding the installation costs of soakaways, infiltration trenches and infiltration chambers

RESOURCES

Low Impact Development Stormwater Management Planning and Design Guide (Chapter 4.4) by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

Soakaways, Infiltration Trenches and Chambers by Sustainable Technologies Evaluation Program.

Soakaways, Infiltration Trenches and Chambers Fact Sheet by Toronto and Region Conservation Authority and Credit Valley Conservation Authority.

15 TREE CANOPY EXPANSION: PLANTING, PROTECTION, AND MAINTENANCE



Tree planting, protection and maintenance contribute to stormwater management, climate change mitigation and adaptation, improved biodiversity, and many other health, environmental and economic benefits. Increasing canopy cover on private and public properties can be achieved by planting trees, and protecting and maintaining trees that are already established to help them grow to maturity. New tree planting can be encouraged through systematic and/or subsidized planting programs.

COMPATIBILITY

- Selecting appropriate species, ensuring adequate space and soil volume, and avoiding potential hazards (e.g. power lines) are important considerations
- Checking provincial, regional, and municipal policy for tree by-laws and tree planting in woodland areas

MAINTENANCE

- Monitoring well-being of seedlings and tree growth
- Protecting tree trunks from severe weather conditions, wildlife, and maintenance equipment
- Maintenance of young trees includes mulching, staking, watering and pruning
- Maintenance of mature trees includes pruning and soil management

COSTS

- Costs vary by location; a forest tree will require minimal maintenance, trees as part of parking lot design will require trimming and proper installation to ensure their longevity
- Tree seedlings range from $50 to $500 per 1000 seedlings
- Purchasing caliper trees is more expensive but they are common along right-of-ways because they have a higher chance of survival

RESOURCES

Urban Forestry by Canada Mortgage and Housing Corporation.

Tree Planting and Maintenance Programs by Forests Ontario.

16 WET STORMWATER POND

A wet stormwater pond is a large vegetated area designed to control runoff by holding a permanent pool of water to allow sediments to settle before discharging to a nearby stream. A wet pond will only reduce the rate, not the volume of stormwater runoff entering watercourses. Therefore, they are most effective when used in conjunction with upstream opportunities for source controls and infiltration.



COMPATIBILITY

- Suitable for new developments or as a stormwater retrofit option for established areas
- Require large pervious area to function properly, therefore highly urbanized areas may be unsuitable
- If installed in a stormwater hotspot with high levels of contaminated runoff (e.g. gas stations), a large buffer zone is required to protect groundwater
- An improperly placed wet stormwater pond can interfere with existing natural wetlands
- Shading by trees and vegetation helps to lower the temperature of runoff and protect existing wildlife

MAINTENANCE

- Inspecting vegetation to ensure no drain blockages, in the spring and fall
- Removing litter, invasive species, algae bloom, scum and other debris, monthly and after heavy rainfall
- Slope stabilization depending on erosion, especially after heavy rainfall
- Monitoring sediment accumulation and removing sediment, as required

COSTS

- Installation costs vary considerably, depending on size and design of pond
- Recurring maintenance and waste disposal costs

RESOURCES

Retention Ponds information Sheet by Canada Mortgage and Housing Corporation.

Stormwater Management Ponds by Sustainable Technologies Evaluation Program.

Stormwater Management Planning and Design Manual by Ontario Ministry of the Environment.

17 XERISCAPING

Xeriscaping is the grouping of vegetation with similar needs to reduce watering requirements. Native species offer many advantages, such as better adaptation and providing food for native pollinators. The practice of xeriscaping uses creative landscaping techniques, such as grouping of drought-resistant vegetation, and creates an aesthetically interesting natural environment, which contributes to a sense of place.



COMPATIBILITY

- Consider the microclimate of the potential site (sunny vs. shady, windy vs. protected)
- Group plants strategically to concentrate water usage
- Choose ground cover that will control erosion
- Avoid steep slopes, but may also use a terrace design as a mitigation technique for erosion
- Consider plants that flower at different times of the year to enhance aesthetic value

MAINTENANCE

- Weeding, and mowing is carried out as needed, but primarily in the spring and fall
- Allow plants to achieve natural growth by not over pruning and fertilizing
- Requires little if any watering, especially in the case of taller grass which help to retain water
- Using native vegetation that thrives in local climate can reduce overall maintenance requirements

COSTS

- Cost of plants will range depending on size and maturity level
- Hardscaped landscape, such as rocks, pavers, and concrete, will be more expensive
- Maintenance costs are generally equal if not less than regular gardening costs due to savings from reducing mowing and watering

RESOURCES

Plant Selection and Design - Xeriscaping by Halton Region.

Xeriscaping - Drought resistant gardening by Teresa Forte of Landscape Ontario.

Healthy Yards Programs by Toronto and Region Conservation Authority.

References

1200 Rain Gardens

An Economic Analysis of Green Roofs by Toronto and Region Conservation Authority

Beautiful Non-Invasive Plants for your Garden by the Ontario Invasive Plant Council

Challenges by Strengthening Rural Canada

Childers, D., Cadenasso, M., Grove, J., Marshall, V., McGrath, B., & Pickett S. (2015). An ecology for cities: A transformational nexus of design and ecology to advance climate change resilience and urban sustainability. ***Sustainability,*** 7(4), 3774-3791. doi:**10.3390/su7043774**

City Green: Innovative Green Infrastructure Solutions for Downtowns and Infill Locations by the United States Environmental Protection Agency

City Parks, Clean Water: Making Great Places Using Green Infrastructure by the Trust for Public Land

Design Guidelines for 'Greening' Surface Parking Lots by the City of Toronto

Evaluation of Low Impact Development Best Practices for Residential Developments - Mosaik Homes, Glenway Subdivision Newmarket by Sustainable Technologies Evaluation Program

Green Infrastructure Case Studies: Municipal Policies for Managing Stormwater with Green Infrastructure by United States Environmental Protection Agency

Green Infrastructure Opportunities that Arise During Municipal Operations by the United States Environmental Protection Agency

Green Roof Maintenance Guideline by Columbia Green Technologies

Green Roof Toolkit by DC Greenworks

Green with Incentives: Supporting Sustainable Infrastructure and Development by Carla Stewart of the Canadian Institute of Planners

Grow Agriculturally Productive Buffers Guide by the University of Vermont

Growing Green Guide: A Guide to Green Roofs, Walls and Facades by Green Roofs Australia

Innovative Sustainable Development Approvals Project by York Region

Lakeside Park Case Study by Credit Valley Conservation Authority

Landowner Environmental Assistance Program (LEAP) by the Lake Simcoe Regional Conservation Authority

Low Impact Development Stormwater Management Planning and Design Guide by Credit Valley Conservation Authority

Native Plant Resource Guide Ontario by the Society for Ecological Restoration

Reducing Stormwater Costs Through Low Impact Development (LID) Strategies and Practices by the United States Environmental Protection Agency

Retention Ponds by the Canada Mortgage and Housing Corporation

Soak it Up: Building a Rain Garden in Alton Village by Credit Valley Conservation Authority

Stormwater Design Handbook For Homes and Small Projects by the City of Salem, Massachusetts

Streetscape Improvement: Capital Project Overview & Guidelines by the City of Toronto

Sustainable Community Design by Urban Strategies Inc.

The Economic Benefits of Green Infrastructure: A case study of Lancaster, PA by United States Environmental Protection Agency

Urban Forestry by Canada Mortgage and Housing Corporation

Vegetative Practices by the Canada Mortgage and Housing Corporation

York Natural Planting Partnership for Private Land by the York Region

York Region Streetscape Program by York Region