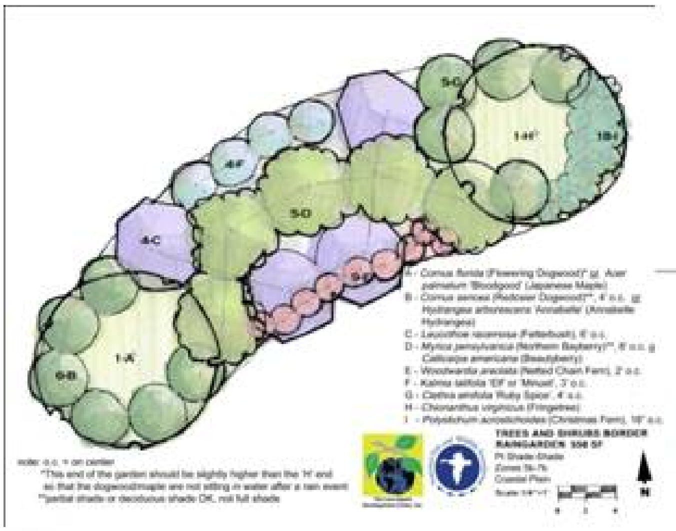
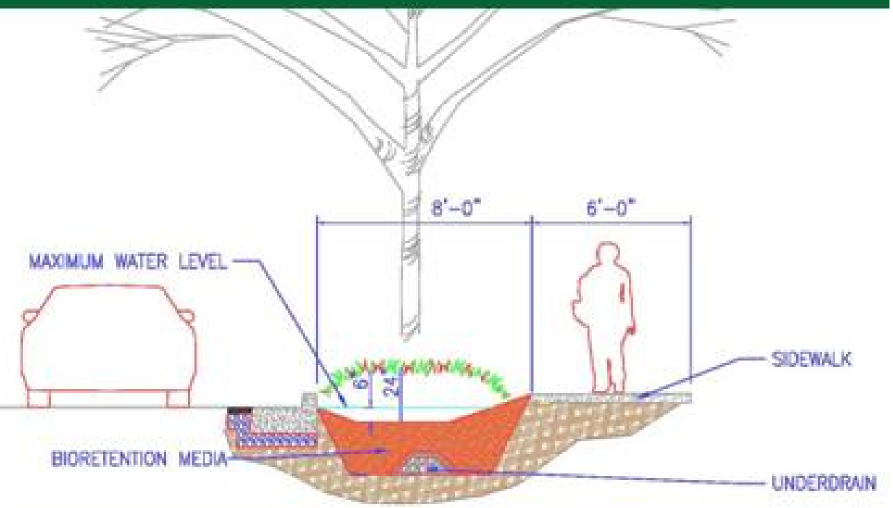
EDMONSTON: A GREAT GREEN TOWN

INTEGRATING MAIN STREETS WITH GREEN STREETS

JULY 2010





FROM THE MAYOR'S DESK
The Bridge
A history of Edmonston

In the early 1900s, a neighborhood of closely-knit working families lived together among a collection of modest farmhouses and bungalows along the lowlands of the Anacostia River between Bladensburg and Hyattsville. In the year 1924, with an ambition to establish an improved quality of life, the people of this community decided to form an incorporated municipality to address a variety of community needs. Chief among these were streetlights, streetpaving, and most importantly, the building of a new Decatur Street bridge across the Anacostia River. It was named Edmonston, after a prominent Prince George's family in the region. Shortly afterward, a simple structure of steel and concrete replaced rickety wood to become the Decatur Street Bridge.

...

We are building our bridge to a prosperous and inclusive future for the next generation of Edmonston residents.

Mayor Adam Ortiz
Edmonston News
October 2007

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Source: Town of Edmonston, MD (Edmonston, MD Logo, *From the Mayor's Desk* text, and photograph of NE Branch of the Anacostia River)
Source: Low Impact Development Center, Inc. (Rain garden template, Bioretention cross-section)

Message from the Executive Director of the Low Impact Development Center, Inc.

America's 21st century infrastructure needs and urbanization patterns are radically different than previous generations. We are faced with aging infrastructure and increased demands for revitalization of older cities in the face of severe fiscal challenges. In order to meet these demands, we must grow smarter through innovation, leveraging of resources, and collaboration. Green Highways, Green Streets, and Green Infrastructure provide a foundation and stimulus to meet this challenge. The Town of Edmonston, Maryland is taking a leadership role in the revitalization of the Anacostia by using a Green Highways Partnership (GHP) grant that is funded by the Chesapeake Bay Trust. The products of this effort, guided by the Low Impact Development (LID) Center, Inc., are planned as a platform to launch a comprehensive sustainability and revitalization effort that will transform the town into one of the most progressive and innovative communities in the country. This GHP project uses the theme of addressing stormwater management retrofits that use LID practices as a springboard to create interest and help launch alternative energy, housing revitalization, recycling, alternative transportation, green community master plans, and green jobs programs for the community. The project brings together the resources of key federal programs for energy, environment, economic, and community development that are leveraged with state transportation and local public and private resources. The result is an integrated and powerful program that is a business based non-regulatory solution to improved environmental protection as well as additional social and economic benefits.

Neil Weinstein, P.E., R.L.A., AICP, MASCE
Executive Director

Executive Summary

Edmonston, Maryland is a community, like many throughout the United States, challenged by environmental and infrastructure needs with limited resources. Urban areas are typified by degraded infrastructure and polluted waters. Two-thirds of urban streams have excessive nutrient pollution, and fecal coliform bacteria in these streams commonly exceed standards for water recreation.[1] Water quality pollution not only impacts the beneficial uses of our receiving waters (e.g. aquatic life, recreation), but also represents a significant cost to cities as they strive to meet increasingly stringent state and federal water quality regulations. Small towns such as Edmonston are faced with rapid population growth, a limited tax base, and continuous budget constraints. Edmonston will meet the challenge of balancing growth and environmental protection by incorporating LID, or Green Infrastructure, into both new and redevelopment efforts. Investing in Green Infrastructure offers the opportunity to enhance the existing infrastructure and protect the environment while simultaneously creating new green jobs, creating demand for green technologies, and revitalizing local neighborhoods.

Edmonston (population - 1,400; total area - 0.9 square miles) straddles the Northeast Branch of the Anacostia River, 2.5 miles from Washington, D.C. The Anacostia is one of the nation's most polluted rivers, and stormwater is a large source of pollution. To improve stormwater management and spur green development, the town is pursuing Green Infrastructure alternatives. With a $25,000 grant from the Chesapeake Bay Trust (CBT), the Town of Edmonston and the Low Impact Development (LID) Center, Inc. developed a Green Street design for Decatur Street, the town's main street. Funding from additional sources identified by the town amplified the effectiveness of the CBT grant allowing the project to be taken from conceptual to structural solutions. The planning efforts contributed by the LID Center include an evaluation of the remainder of the town for subsequent projects that would green their infrastructure over time. Those concepts are presented in this report. Community input was obtained through monthly workshops and meetings. The information gathered from these outreach efforts was integral in assisting the LID Center to align technical information with community vision, resulting in recommendations that are truly tailored to the issues and desires of Edmonston. This project will serve as a national model for implementing a Green Infrastructure strategy that can be easily replicated in communities across the country.

This document provides Edmonston with the initial framework of a Green Master Plan to assist in devising strategies to improve stormwater management and encourage green development by pursuing Green Infrastructure alternatives. While this document is intended for a general audience, it also provides technical details to assist the community in their decision making process. The document includes the following elements:

1. An overview of LID opportunities and constraints for both public and private property is provided, followed by identification of those LID technologies and opportunities that have the highest potential for meeting Edmonston's sustainability vision. The LID technologies addressed include permeable pavement; bioretention; bioswales; compost

[1] U.S. Geological Survey (2008). Water Quality and Nonpoint Sources in Urban Watersheds: Key Findings from the First Decade of NAWQA Studies. National Water-Quality Assessment (NAWQA) Program.

amended soils, vegetation, and trees; and rain barrels and cisterns. Each LID technique includes a description of the benefits and potential implementation recommendations.

2. A description of the Green Highways and Green Street design for Decatur Street[2] is provided along with plan sheets identifying the locations of the recommended design options. The Decatur Street model demonstrates a multi-benefit infrastructure approach that was derived from discussions with the community and project engineers. The design integrates green practices directly into the right-of-way to treat rain where it falls and reduce the flow of stormwater pollution to the Anacostia.

3. Additional resources, links to case studies, and a glossary are provided in Appendix A, which may promote further discussion and additional insight for planning efforts. Plants recommended for the streetscape are included to further assist the community in making informed decisions in pursuit of Green Infrastructure alternatives (see Appendix B).

[2] A separate report entitled, "Greening of Decatur Street" provides more detail on the Decatur Street design opportunities and constraints, specifics on recommended design components of curbside bioretention, and an analysis of the three design options.

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1.0 Why is Edmonston going green?

Urban areas are home to some of the nation's most degraded infrastructure and polluted waters. Water quality pollution not only impacts the beneficial uses of our receiving waters (e.g. aquatic life, recreation), but also represents a significant cost to cities as they strive to meet increasingly stringent state and federal water quality regulations. Small towns such as Edmonston, Maryland (population - 1,400; total area - 0.9 square miles) are faced with rapid population growth, a limited tax base, and continuous budget constraints. The people of Edmonston recognize the value of going green and are committed to a future for their town that includes social, environmental, and economic sustainability. By investing in LID, or Green Infrastructure, the town will have the opportunity to enhance the existing infrastructure and protect the environment while simultaneously generating new green jobs, creating demand for green technologies, and revitalizing local neighborhoods.

Figure 1. Enhance the existing infrastructure and protect the environment while simultaneously generating new green jobs, creating demand for green technologies, and revitalizing local neighborhoods.
Source: Low Impact Development Center, Inc.

Edmonston straddles the Northeast Branch of the Anacostia River, 2.5 miles from Washington, D.C. The Anacostia is one of the nation's most polluted rivers, and stormwater is a large source of pollution. To improve stormwater management and spur green development, the town is pursuing Green Infrastructure alternatives. This report contains suggestions for implementing LID features on Decatur Street, on other public property areas throughout town, and on private property.

Figure 2. Map of Anacostia Watershed showing location of the Town of Edmonston.
Source: Chesapeake Quarterly, adapted from the Anacostia Watershed Restoration Committee.

2.0 What is stormwater?

Stormwater runoff is that portion of rainfall that does not soak into the ground. The region encompassing the Town of Edmonston was originally a forest landscape and rainwater was absorbed by the soil and helped recharge groundwater aquifers[3] rather than running off as surface flow (see Figure 3). Urbanization causes an increase in stormwater runoff volume and flow rates because rainwater cannot infiltrate through impervious surfaces such as streets, rooftops, driveways, and parking lots. The increase in stormwater runoff can cause flooding and represents a threat to public safety and property. In addition, the higher velocity flows and volumes of stormwater runoff can damage our streams and lakes by causing erosion, increased turbidity, and the delivery of urban pollutants such as fertilizers, metals, and bacteria. Additionally, summer base flows, important to stream health, may be decreased when rainwater is lost quickly as surface runoff rather than being metered out slowly throughout the year from rainwater held in the soil.

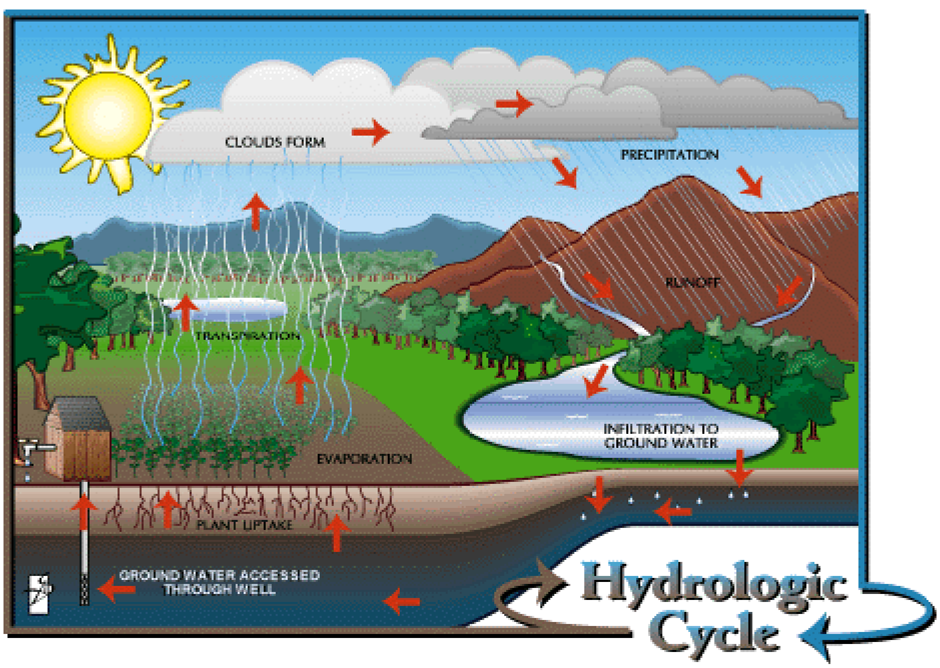

Figure 3. Typical Hydrologic Cycle.
Source: U.S. EPA

[3] Aquifer: An underground bed or layer of earth, gravel, or porous stone that is saturated and sufficiently permeable to yield water to wells or springs. Typically used or could be used as a source of water, for drinking or other purposes.

2.1 Who is responsible for stormwater pollution?

You are. If you live, work, or play in Edmonston then you are responsible for stormwater pollution. The things that we value in our lakes, rivers, and streams such as recreation, clean drinking water, and aquatic life are influenced by our individual and collective behaviors. Nationally, stormwater runoff is identified as the primary cause of aquatic degradation.[4] Stormwater is both an urban and rural, public and private problem. To make a difference everyone needs to take responsibility for stormwater management to protect public safety, health, and our environment.

In general, the local government is responsible for managing stormwater within the public areas (e.g. streets). In practical terms, this includes the planning, design, and construction of infrastructure that controls and/or conveys storm runoff to receiving waters. Private property owners are responsible for managing stormwater that falls on their land, either by managing that water on the parcel, or directing it to an approved publicly owned area (e.g. street, detention areas). Improvements to how we manage stormwater will ensure that we, and future generations, will have a healthy aquatic ecosystem.

Figure 4. Anacostia River looking towards Colmar Manor: Trash and debris floating in the water.
Source: Jim Connolly, Anacostia Watershed Society

[4] U.S. Geological Survey (2008). Water Quality and Nonpoint Sources in Urban Watersheds: Key Findings from the First Decade of NAWQA Studies. National Water-Quality Assessment (NAWQA) Program.

2.2 How is stormwater currently managed in Edmonston?

Stormwater management presents a wide array of complex ecosystem and human health protection challenges, some of which are not addressed by conventional stormwater technology or approaches. Communities struggle with the economic reality of funding aging and ever-expanding stormwater infrastructure. The current stormwater conveyance system in Edmonston is a combination of underground storm sewer pipes and aboveground conveyance channels. Stormwater is discharged to the Northeast Branch of the Anacostia River, which runs through the middle of the community. Edmonston's mostly flat topography and seasonally high groundwater elevations[5] make conventional stormwater management with stormwater ponds difficult.

The pressure on the current drainage system can be relieved through the implementation of LID practices that infiltrate or capture stormwater nearest to where it falls. This reduces the volume of stormwater that needs to be conveyed. In contrast to conventional stormwater techniques, LID practices can be used on both private and public properties. This provides increased design flexibility for the town to enhance its stormwater management and increases the number of LID practices available for use.

Figure 5. NE Branch Anacostia River, Edmonston, MD
Source: Town of Edmonston, MD

[5] Generally referring to the water level, or upper surface of the groundwater. Level fluctuates seasonally and year to year as climatic conditions change.

3.0 What is Low Impact Development (LID)/Green Infrastructure?

As development introduces more impervious surfaces and changes land cover, rain that once infiltrated into the ground now runs off directly to receiving streams. The traditional method of managing this runoff has focused on moving water as quickly as possible through surface channels and concrete pipes. This stormwater management approach does not remove pollutants introduced by urban activities, prevent downstream flooding, or recharge groundwater supplies.

Stormwater is increasingly being managed through the strategies and principles of Low Impact Development (LID), which is defined as an ecosystem-based approach to design a built environment that remains a functioning part of an ecosystem rather than exist apart from it. It is an innovative approach to urban stormwater management that does not rely on the conventional end-of-pipe structural methods rather it strategically integrates stormwater controls throughout the urban landscape. Targeted watershed goals and objectives are addressed through the use of structural and non-structural techniques such as permeable pavement, bioretention/rain gardens, rain barrels, and public outreach.

Green Infrastructure is the aspect of **Low Impact Development** that relates to how streets, sidewalks, parking lots, and buildings are designed to be more stormwater and environmentally friendly.

Green infrastructure is the term used to address the structural aspects of LID enhancing overall environmental quality and providing utility services. Green infrastructure provides *social*, *economic*, and *environmental* benefits. The goal of LID and Green Infrastructure is to mimic the natural hydrologic condition by allowing rain to do what it did before development; infiltrate into the ground and evapotranspirate[6] into the air.

Social Benefits:
- Reduction in urban heat island effect
- Provides "Green Job" opportunities
- Educational through street kiosks
- Crime reduction benefit
- Health benefit

Economic Benefits:
- Energy cost reduction and water conservation
- "Green Enterprise" business opportunities

Environmental Benefits:
- Carbon sequestration
- Improved water quality through 90% capture of stormwater
- Carbon footprint reduction
- Recycling and beneficial reuse

[6] Evapotranspiration is the term used to describe the combination of evaporation from soil and plants and the transpiration of water vapor from plants into the atmosphere.

Figure 6. Residential Rain Garden.
Source: City of Maplewood, MN

Figure 7. U.S. EPA Headquarters: Example of combination of permeable pavement, bioretention, and cistern (not pictured).
Source: The Low Impact Development Center, Inc.

Figure 8. U.S. EPA Headquarters: Educational Sign *Managing Stormwater with Rain Gardens*.
Source: The Low Impact Development Center, Inc.

3.1 What is Permeable Pavement?

Permeable pavement allows for the infiltration of stormwater rather than creating runoff. There are several different types of permeable pavements including open-grid and interlocking pavers, and porous asphalt and concrete. Conventional pavement causes rainwater to run off, increasing costs for municipal stormwater systems due to excessive water quality problems, flooding, and damage to the streams and aquatic life. Permeable pavements provide stormwater management benefits while also creating good surfaces for walking, biking and driving.

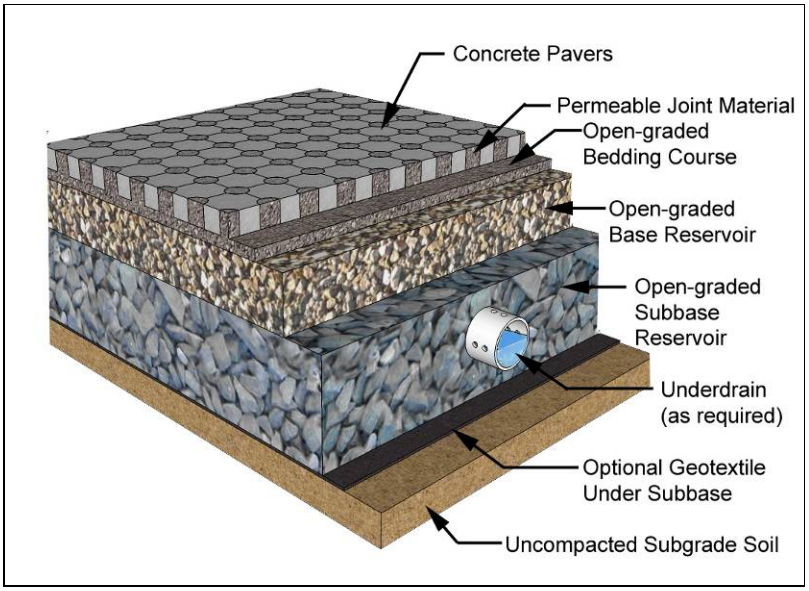

Figure 9. System Components of Permeable Interlocking Concrete Pavement (PICP): The base layers of a permeable pavement system are similar for permeable pavers, porous asphalt, and pervious concrete. Each system has some variations which are important for structural integrity.
Source: Interlocking Concrete Pavement Institute (ICPI)

Figure 10. Permeable Pavement on Residential Street.
Source: Interlocking Concrete Pavement Institute (ICPI)

3.2 What is Bioretention?

Bioretention is a versatile and valuable Green Streets tool. Bioretention cells are small, landscaped basins that reduce stormwater runoff through storage, infiltration, and evapotranspiration. They contain a special soil mix, or media, and underdrains, if necessary. Stormwater is treated through physical, chemical, and biological processes. They can be adapted to many settings, from a high-density urban street to a quiet, low-density residential street. Bioretention is one of the most effective tools for retaining and treating stormwater. Table 1 lists pollutant removals from a University of Maryland College Park study of bioretention in the lab and in parking lots. Beyond its use for stormwater control, the bioretention cells provide an aesthetically pleasing landscape, reduce urban heat island effect, and promote sustainable design practices while encouraging environmental stewardship and community pride.

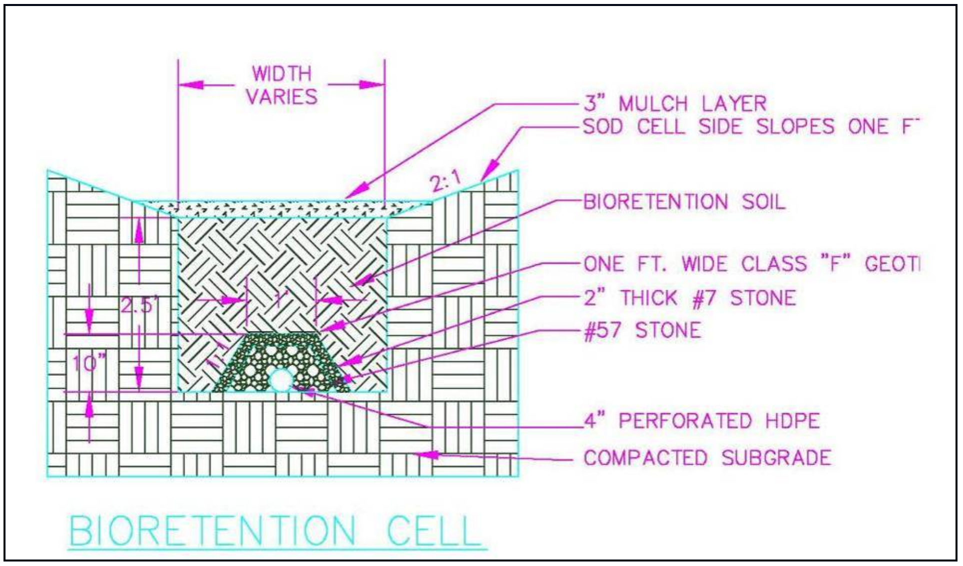

Figure 11. Components of a bioretention cell.
Source: The Low Impact Development Center, Inc.

Table 1. Pollutant Removal by Bioretention[7]

Parameter	% Pollutant Removal
Copper	43 – 97%
Lead	70 – 95%
Zinc	64 – 95%
Phosphorus	65 – 87%
Total Kjeldahl Nitrogen (TKN)	52 – 67%
Ammonium (NH4+)	92%
Nitrate (NO3-)	15 – 16%

[7] Source: Allen P. Davis, et al., Water Quality Improvement Through Bioretention: Lead, Copper, and Zinc Removal, Water Environment Research, 75, 73-82, January/February 2003

Figure 12. Bioretention cell.
Source: The Low Impact Development Center, Inc.

Figure 13. Bioretention cell, Washington Navy Yard, District of Columbia.
Source: The Low Impact Development Center, Inc.

3.3 What are Infiltration Planters?

An infiltration planter is a partially aboveground, partially buried vegetation planter, usually open on both top and bottom. The planter may act as a step, or a set of steps, on a slope that transports water down the slope. An infiltration planter may also be situated along a building to capture roof runoff. The planter is filled with bioretention media (special soil mix, or media, typically consisting of 50 percent sand, 30 percent organic material, and 20 percent topsoil by volume) and plants which are capable of growing well in extreme conditions of moisture and drought. Water enters the planter from the top of the slope and infiltrates through the media. An underdrain or set of weep holes[8], holes in the side of the planter wall, allow filtered water to drain out of the planter at its base. If the planter is underdrained, it is typically linked into the storm drain system. Infiltration planters filter runoff through the media and vegetation, and provide the opportunity for infiltration into the subsoil. Planters which are used to step water down a slope prevent erosion caused by high velocity flows that scour earthen slopes by slowing the water at each step and passing it through the soil media. Infiltration planters not only provide strormwater treatment, they provide the opportunity to create attractive landscape areas which enhance local property values and provide a natural habitat for birds and butterflies.

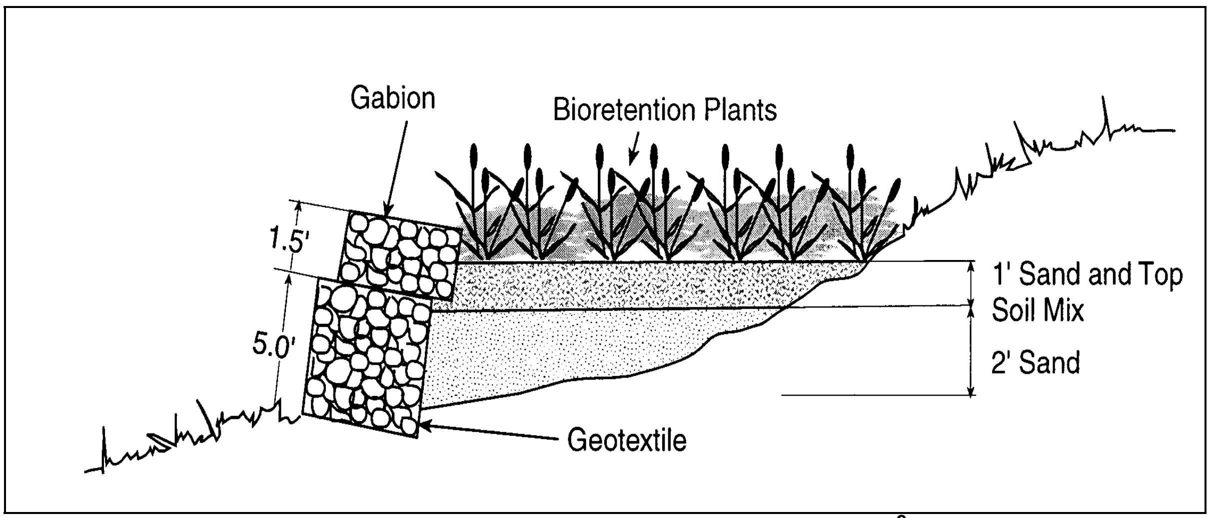

Figure 14. Diagram of an Infiltration Planter[9].
Source: Prince George's County, MD Department of Environmental Resources

[8] Weep Holes: Small holes that allow water drainage and prevent pressure build-up in the retaining wall.
[9] Gabion: Wire baskets filled with stone which can be stacked to form gravity type retaining walls. Gabions are typically used to hold soils on steep slopes in place and prevent erosion.

Figure 15a. and b. Example of an Infiltration Planter (a.). Provides aesthetically pleasing landscaping and a natural habitat for birds and butterflies (b.).
Source: Prince George's County, MD Department of Environmental Resources

3.4 What are Bioswales?

A swale is an open, aboveground drainage channel designed to detain or infiltrate stormwater runoff. Bioswales are modified vegetated swales that use bioretention media beneath the swale to improve water quality, reduce the runoff volume, and reduce the peak runoff rate. They act as conveyance systems, using the bioretention soils and vegetation to slow, filter, infiltrate, and evapotranspirate stormwater, as well to transport the stormwater through the watershed. Because of the conveyance functionality of bioswales, they are typically linked to conventional stormwater systems, specifically traditional grassed swales. The advantage of the bioswale, however, is that the use of bioretention media enhances infiltration, water retention, and nutrient and pollutant removal. Like bioretention cells and basins, bioswales encourage infiltration in order to retain runoff volume, and a variety of physical, chemical, and biological processes are used to reduce runoff pollutant loadings. Infiltration may be enhanced by adding gravel or other permeable material below the channel bottom.

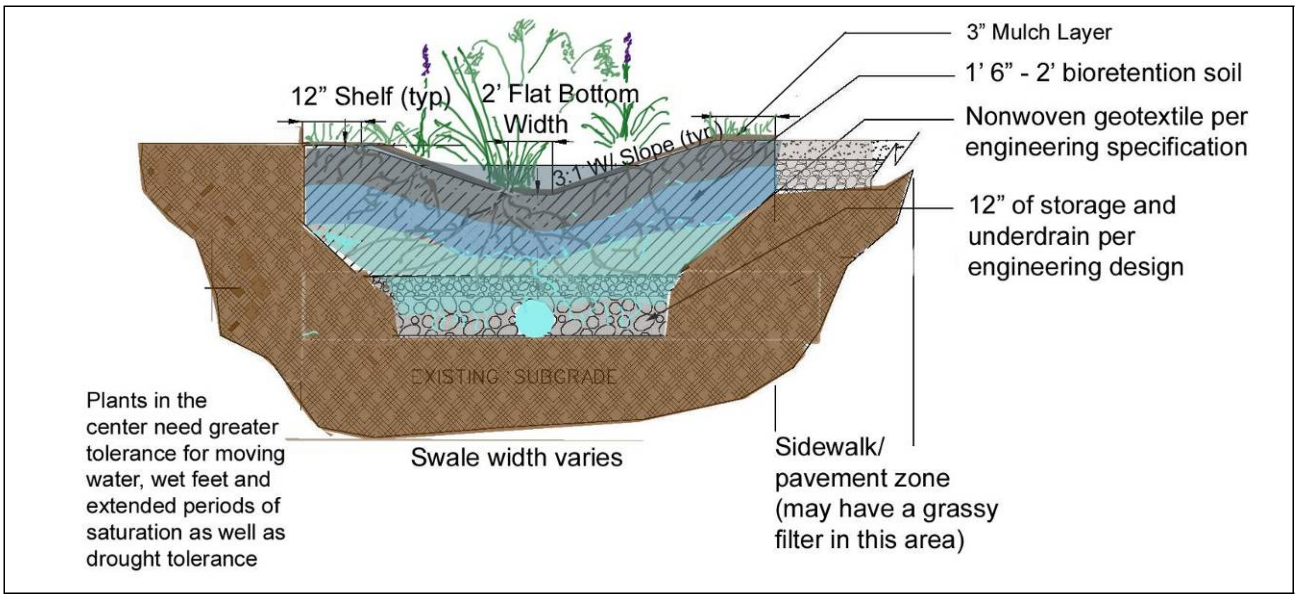

Figure 16. Bioswale Cross-section: Vegetation for bioswales is selected based on the adaptability to conditions that span from extreme moisture to extreme drought.
Source: The Low Impact Development Center, Inc.

Figure 17. Vegetated Bioswale.
Source: BelleWood Gardens

Figure18. Bioswale.
Source: Franklin County, Ohio Engineer's Office

3.5 What are Compost Amended Soils, Vegetation, and Street Trees?

Soil amendments, or additives, can be used to minimize urban development impacts on native soils by restoring their infiltration capacity and chemical characteristics. After soils have been amended, their improved physical, biological, and hydrological characteristics will make them more effective agents of stormwater management. Soil amendments can include not only compost and mulch, but also top soil, lime, and gypsum. These additional components help offset any nutritional deficiencies and control acidity.

By compost amending native soils and adding vegetation, the soil becomes better able to hold water (like a sponge), more prone to infiltration, and more nutrient rich for sustaining healthy plants. Vegetation and trees take up water and stabilize soil with their root structures. Roots also keep the soil structure porous, aiding infiltration.

Street trees provide many community benefits such as intercepting rainfall before it becomes polluted runoff, reducing the urban heat island effect, and making walking space more comfortable. While street trees are not a new Green Street concept, planting requirements of a healthy large canopy tree are often overlooked. Many urban trees have been planted too close together or in a soil area that is too small to allow the tree to reach a mature size and provide the desired community benefits. Tree roots require an uncompacted soil area that allows water and air to get through. Casey Trees, a nonprofit organization whose mission is to restore, protect, and enhance Washington, D.C.'s tree canopy, published the *Tree Space Design Guide* in 2008. The guide emphasizes soil volume as the main factor in determining a tree's size and health.

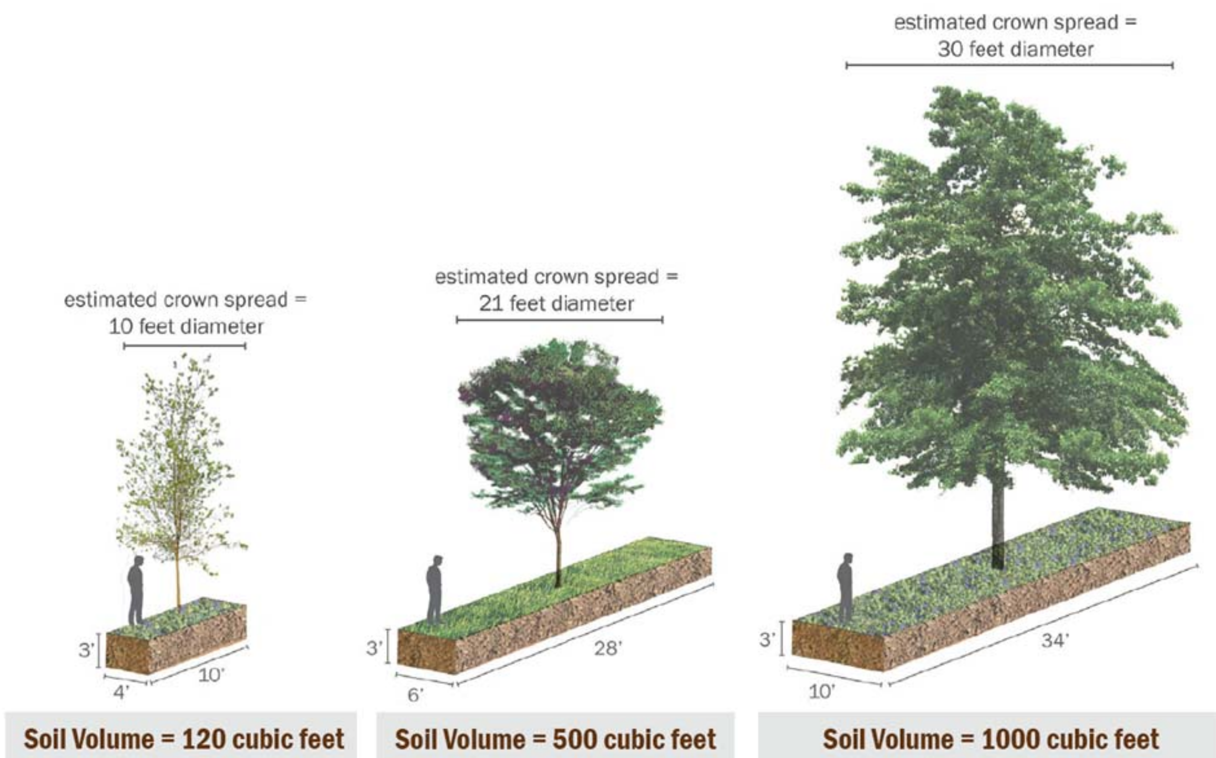

Figure 19. Tree canopy size increasing with increased soil volume.
Source: Tree Space Design Guide, Casey Trees

3.6 What are Rain Barrels and Cisterns?

Rain barrels are cost-effective and easily maintainable retention and detention devices that are applicable to residential, commercial, and industrial sites for managing rooftop runoff. Rain barrels serve as water conservation tools that can be used to reduce runoff volume and, for smaller storm events, delay and reduce the peak runoff flow rates (i.e. maximum instantaneous flow rate during a storm event). By storing and diverting runoff from impervious areas such as roofs, these devices reduce the undesirable impacts of runoff that would otherwise flow swiftly into receiving waters and contribute to excessive water quality problems, flooding, erosion, and damage to the streams and aquatic life.

Rainwater collected in rain barrels is primarily used for residential landscape irrigation. Landscape irrigation can account for as much as 40 percent of domestic water consumption. An advantage of roof water recycling is that roof water is relatively clean, compared to surface runoff, and can provide a source of chemically untreated “soft water,” free of most sediment and dissolved salts.

Figure 20. Residential rain barrel.
Source: District of Columbia Water & Sewer Authority

Figure 21. Residential rain barrel.
Source: J. McCausland, Sunset Magazine

Stormwater runoff cisterns are roof water management devices that provide retention storage volume in above or underground storage tanks. They are typically used for water supply. Cisterns are generally larger than rain barrels, with some underground cisterns having the capacity of 10,000 gallons.

Cisterns can serve as a secondary source of water for applications that do not require potable water, potentially lowering a building's potable water demand (and costs) and reducing the volume of stormwater that leaves the site as runoff. Many municipalities are promoting the use of cisterns for potable water use as well as for commercial and industrial applications. Both rain barrels and cisterns can provide a source of chemically untreated 'soft water' for gardens and compost, free of most sediment and dissolved salts.

Figure 22. Cisterns used for irrigation.
Source: R. D. Brodman, J. McCausland, Sunset Magazine

Figure 23a. and b. U.S. EPA Headquarters: Example of combination of permeable pavement, bioretention, and cistern.
Source: The Low Impact Development Center, Inc. (left); 'RiverSmart' DVD, Produced by the District Department of the Environment, Directed by Virginia Village Productions (right)

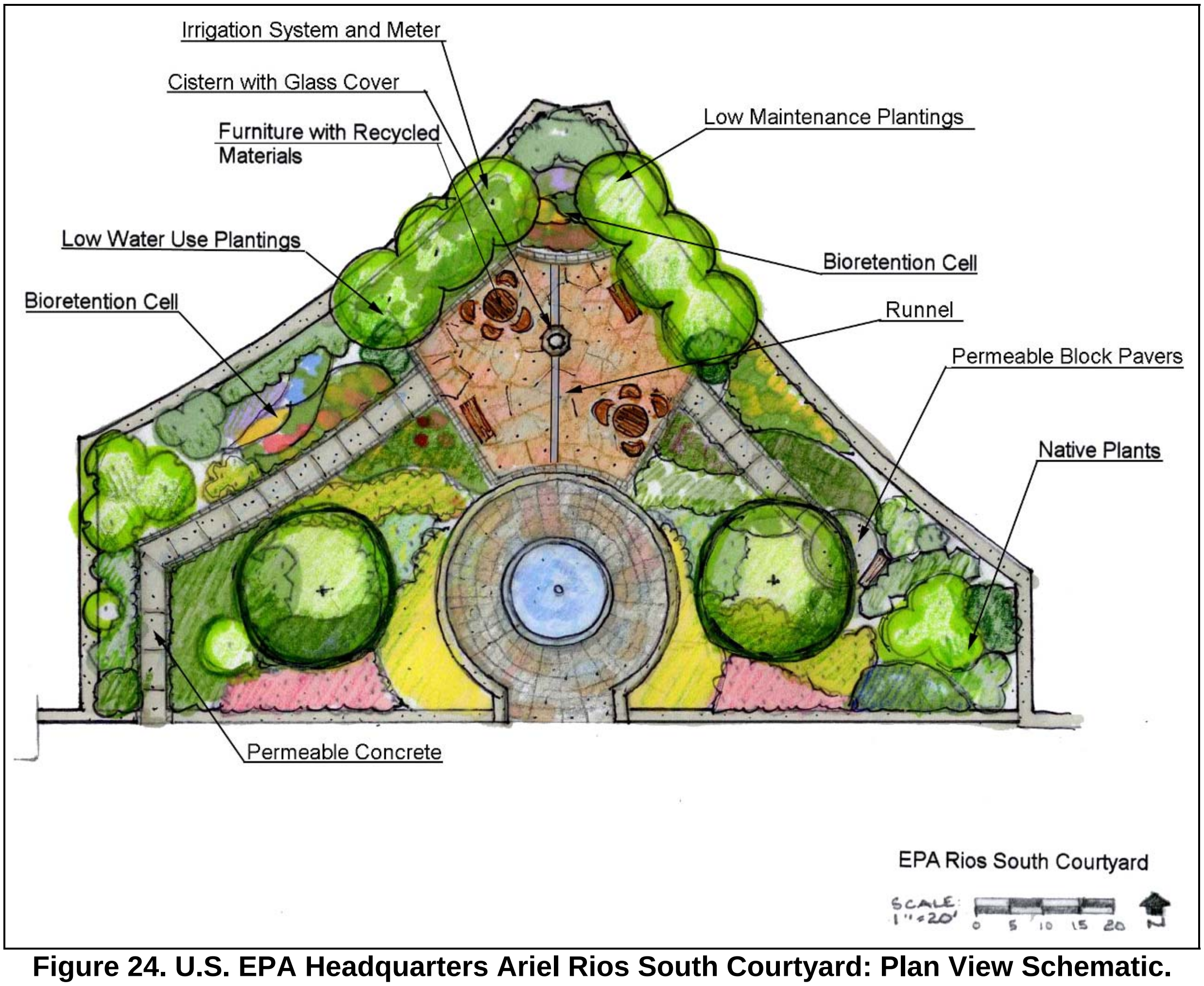

Figure 24. U.S. EPA Headquarters Ariel Rios South Courtyard: Plan View Schematic.
Source: The Low Impact Development Center, Inc.

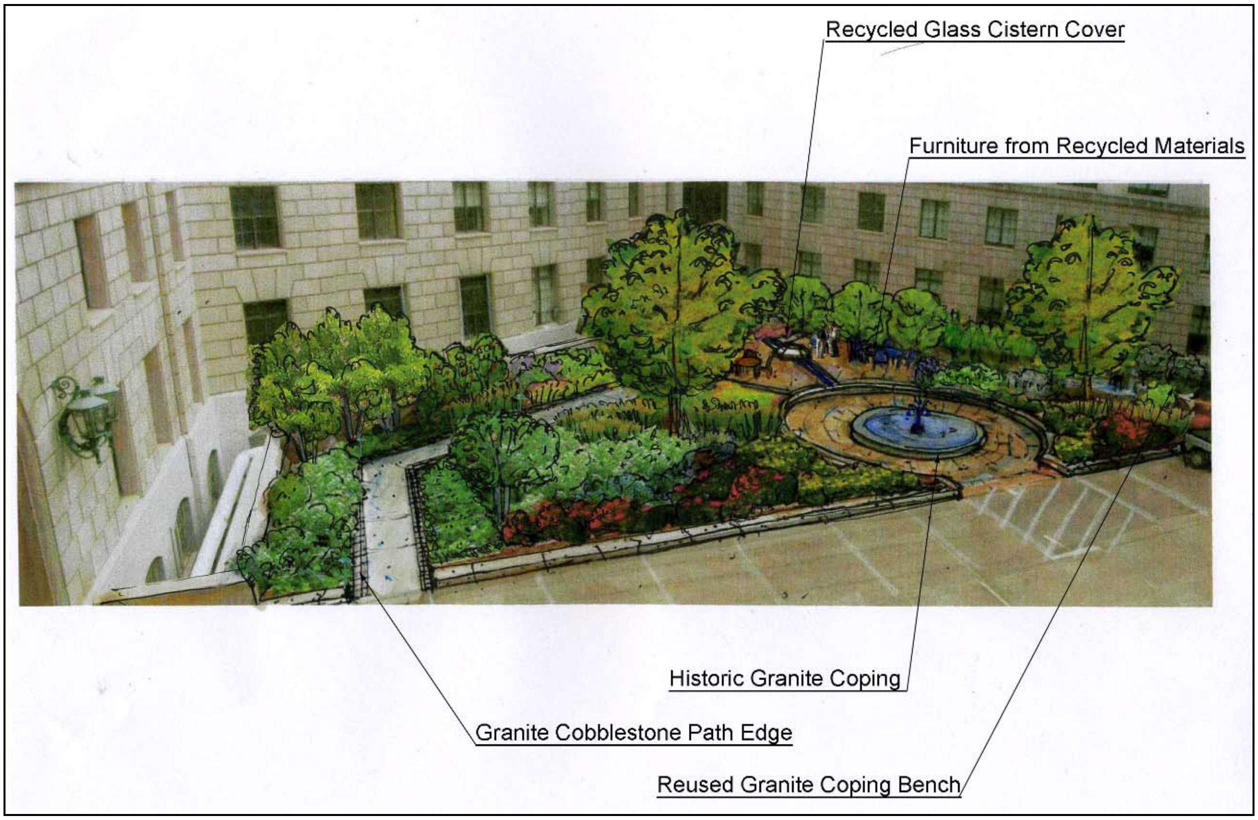

Figure 25. U.S. EPA Headquarters Ariel Rios South Courtyard: Pre-Construction Artist Rendering.
Source: The Low Impact Development Center, Inc.

3.7 What are Green Roofs[10]?

Green roofs, also known as vegetated roofs or eco-roofs, help mitigate the effects of urbanization on water quality by detaining or retaining rainfall volume. Green roofs can be placed on any residential, commercial, industrial roof surface that is not reserved for patio or utility access, or roofs with greater than 40% slope.

There are two basic types of green roofs: *extensive* and *intensive*. Extensive roofs form a thin vegetated sheath of self-sufficient mosses, sedums, and small shrubs of 2-6 inches. Their low profile allows them to be added to existing buildings, including those with sloping roofs usually without structural enhancement or modification. By contrast, intensive roofs permit the use of trees and walkways. A greater depth of media (6 inches or greater) and a greater roof structural capacity may be required to accommodate larger vegetation and surface features.

Figure 26. Housing Initiative Partnership (HIP) House, Mt. Rainier, MD Green Roof.
Source: The Low Impact Development Center, Inc.

Figure 27. Housing Initiative Partnership (HIP) House, Mt. Rainier, MD Green Roof.
Source: The Low Impact Development Center, Inc.

[10] The description of green roofs has been included for the purpose of completeness in listing the various Low Impact Development techniques. Green roofs are not specifically included in this report as a recommendation for the Town of Edmonston.

4.0 What can the Town of Edmonston do to 'Go Green'? (LID on Public Property)

Conventional stormwater management (i.e., underground vaults and ponds) cannot adequately mimic the natural hydrology of a watershed and therefore have limited use in achieving flood control and environmental protection objectives. Additionally, these conventional approaches are often land intensive and more expensive than LID. Stormwater ponding in the town can be reduced by using LID practices that facilitate infiltration, such as bioretention or permeable pavements. Implementation of these LID practices will increase the amount of rainwater that is absorbed into the soil and reduce the burden on the storm sewer system.

There are numerous locations throughout the town where the use of LID practices can be integrated as part of the existing private (e.g., residential and commercial parcels) and public (e.g. streets and sidewalks) infrastructure. These practices would reduce runoff through retention and detention, and reduce pollutants by encouraging stormwater contact with vegetation and soils.

The following sections outline specific public and private opportunities for LID in Edmonston with an emphasis on Green Streets. LID in other parts of the country are provided as examples to illustrate design and integration into the community infrastructure.

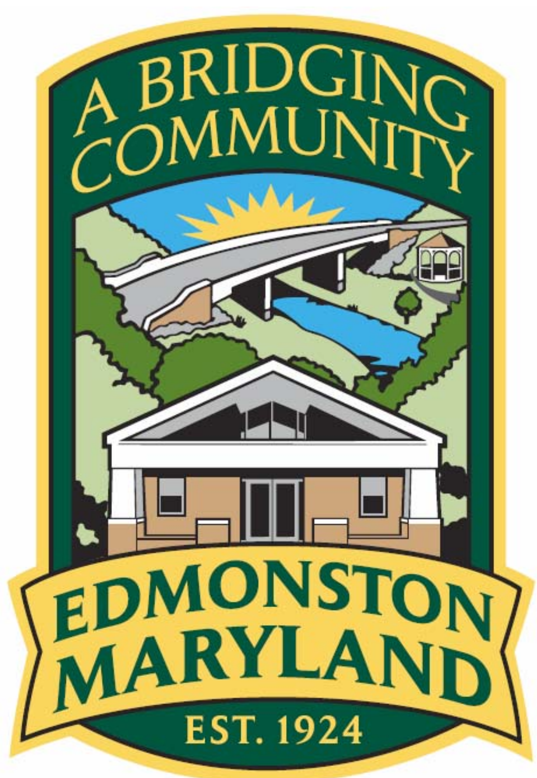

Figure 28. Town of Edmonston, MD Logo.
Source: Town of Edmonston, MD

4.1 LID Opportunities in the Public Right-of-Way: Green Streets

The most effective Green Street strategy maximizes benefits of stormwater treatment, reduces urban heat island effect, and improves aesthetics while meeting the community needs of safety and comfort. After a series of community meetings and input from project engineers (G & C Consulting, Inc.) and the LID Center, the town decided to select Decatur Street as a pilot retrofit project for learning more about the design, construction, and maintenance of LID features. As the community's main street, Decatur Street provides a perfect opportunity to implement a model that demonstrates a multi-benefit infrastructure approach.

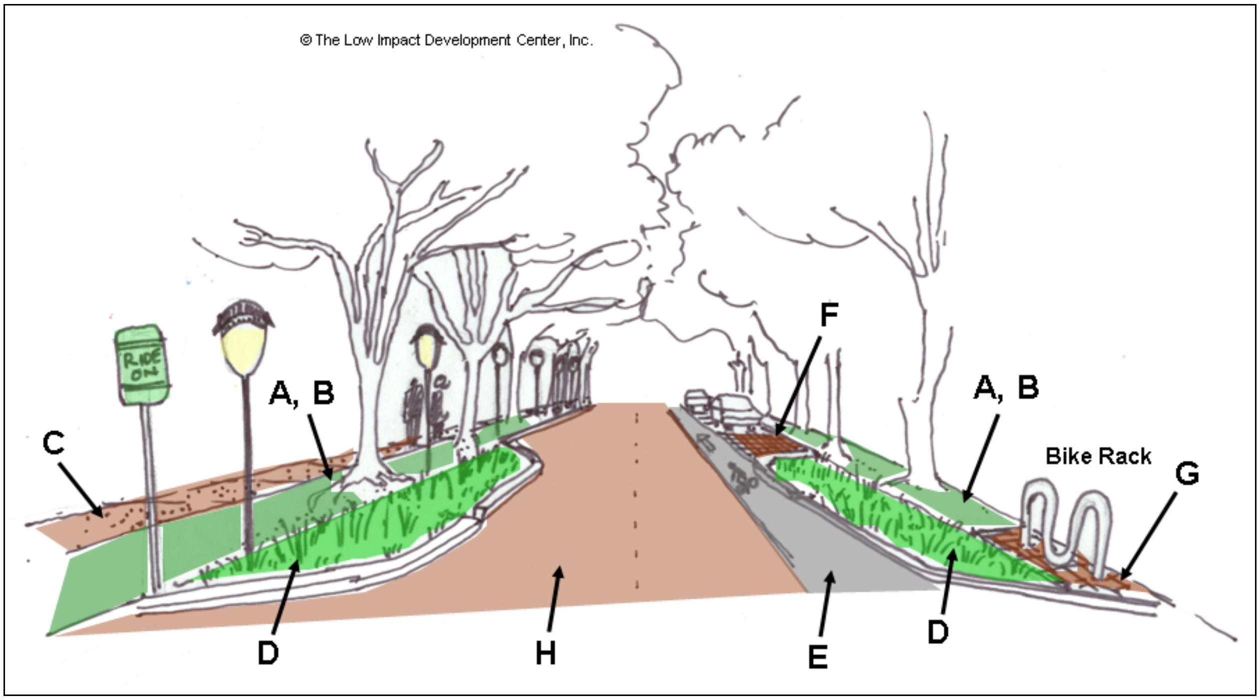

Figure 29. A graphic depiction of some of the LID features that can be used in the public right-of-way. What makes this a "Green Street"? A top (tree canopy) to bottom (water quality) plan; Native tree canopy; Street lighting with clean energy; Walking, running, and biking; Recycled materials; Stormwater bioretention and filtration; Open process and public engagement; Education and replication.
Source: The Low Impact Development Center, Inc.

Image Legend:
A. Street Tree Space (Soil Volume = 1,000 cf)
B. Compost Amended Soils
C. Permeable Sidewalks
D. Bioretention
E. Permeable Bike Lane
F. Permeable Pavement in Parking Lane
G. Permeable Pavement under Bike Rack
H. Permeable Pavement in Transitway

Figure 30a. and b. Seattle Street Edge Alternative (SEA) Street. Before (left) and after retrofit (right).
Source: Seattle Public Utilities

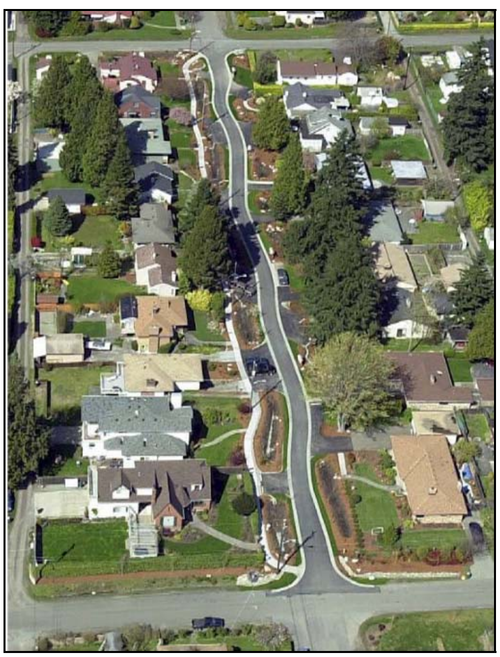

Figure 31a. and b. SEA Street aerial view (left) and street view of sidewalk on one side of the street (right).
Source: Seattle Public Utilities

4.2 Additional Public Right-of-Way Opportunities in Edmonston

There are several LID techniques that could be utilized outside of Decatur Street. These include permeable pavement, bioretention, amended soils, and the addition of trees and vegetation. Figure 29 depicts some of the features that may be appropriate to implement in Edmonston's public right-of-way.

Good candidates for additional public right-of-way opportunities were identified on some of the side streets off of Decatur Street where sidewalks are the low point of the right-of-way. Permeable pavement sidewalks or bioretention cells in the planting strips would infiltrate stormwater and reduce localized flooding. Examples of implementation of these LID features and opportunities within Edmonston are described in more detail in the following sections.

Permeable pavement sidewalks would be appropriate where the sidewalks are the low point for the street, for example 48th Avenue. Permeable pavement can also be used in the vehicle lanes on streets with low traffic volume. On streets with higher traffic volumes, where streets may be wider, permeable pavement can be installed in parking lanes or in bike lanes to treat the runoff from roadway. Bioretention curb bump-outs, or extensions, can be implemented to treat road runoff on any street that has a parking lane. Areas of public property where there is adequate soil volume for tree roots are ideal for using compost amended soils and planting trees and vegetation.

Figure 32a. and b. 48th Avenue, Edmonston, MD.
Source: The Low Impact Development Center, Inc.

Kenilworth Avenue is an example where stormwater runs off over a slope to the end of Crittenden Street. This slope could be improved with an infiltration planter or some reforestation to capture or slow the release of stormwater. Due to low traffic volumes, this segment of Crittenden Street is a good location for permeable pavement in the roadway to reduce surface runoff. At the opposite end of Crittenden Street, at the Neighborhood Mini Park, infiltration might be improved by using compost amended soils and native plants. Finally, adding plantings to the drainage swales in this area would filter and slow the reduced quantity of runoff that has not been captured in other LID features throughout the neighborhood.

Figure 33. End of Crittenden Street near Kenilworth Avenue, Edmonston, MD.
Source: The Low Impact Development Center, Inc.

Figure 34. Crittenden Street Neighborhood Mini Park, Edmonston, MD.
Source: The Low Impact Development Center, Inc.

4.2.1 Permeable Pavement on Public Property

The sidewalks on 48th Avenue (see Figure 32) take runoff from the roadway and adjacent properties. Consequently, they provide a cost-effective opportunity to use permeable pavement for the sidewalk. Permeable pavement allows rainwater to infiltrate through the paved surface to a base system that captures, filters, and stores stormwater before infiltrating it into the native soils below or metering the flow out to the storm sewer through an underdrain system. This results in removal of pollutants and reduced surface runoff volumes. In addition, there are benefits to pedestrians when permeable pavement sidewalks are used near street trees. Permeable pavement allows enough air and water to reach the roots and still provides a paved surface for pedestrians to use.

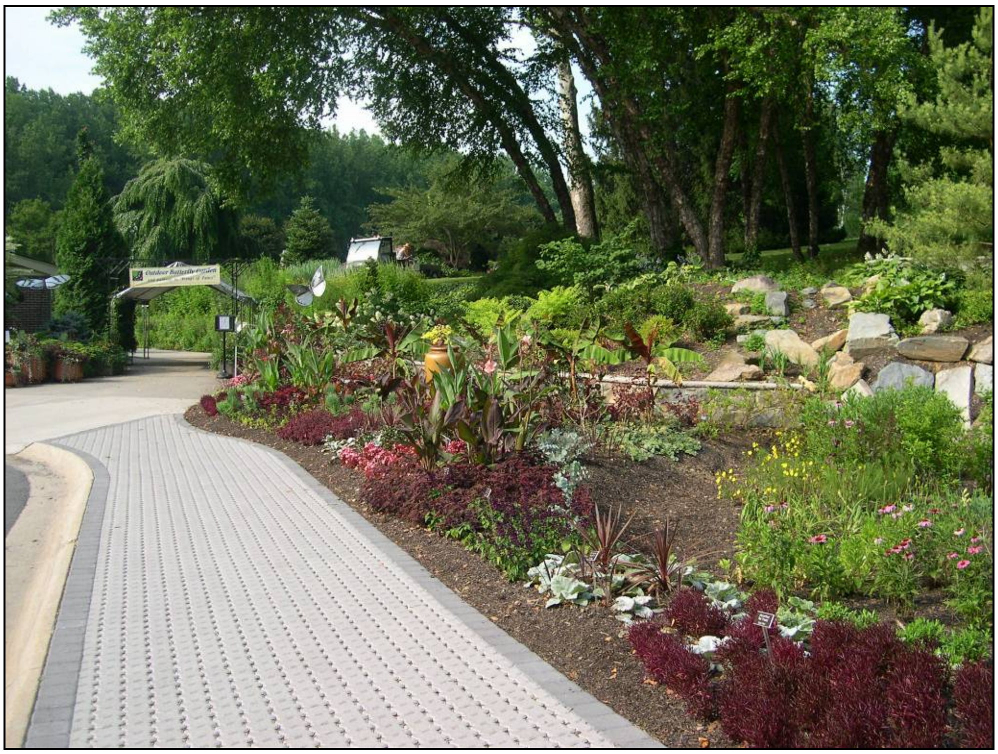

Figure 35. Brookside Gardens, Montgomery County, MD:
Rain Garden and Permeable Pavement Walkway
Source: Low Impact Development Center, Inc.

Figure 36. Residential permeable pavement, Highpoint Neighborhood, Seattle, WA.
Source: Interlocking Concrete Pavement Institute (ICPI)

Streets that have a low traffic volume, such as Crittenden Street, are perfect candidates for permeable pavement[11]. Permeable pavement in the roadway will reduce localized flooding by capturing and filtering runoff and infiltrating it or metering the discharge to the storm sewer system through an underdrain.

Figure 37. Crittenden Street as it appears today, Edmonston, MD.
Source: The Low Impact Development Center, Inc.

Figure 38. Crittenden Street as it might appear with a permeable paver roadway, Edmonston, MD.
Source: The Low Impact Development Center, Inc.

Figure 39. Permeable pavers in the roadway at Westmoreland in Portland, OR.
Source: Interlocking Concrete Pavement Institute (ICPI)

[11] The industry-recommended design profile for roads which are suited to be paved with permeable pavement.

4.2.2 Bioretention on Public Property

Figure 40. Capitol Hill (District of Columbia) Police Station Retrofit: Urban Residential Rain Garden (recently planted) and Downspout Disconnection
Source: Low Impact Development Center, Inc.

4.2.2.1 Curb Bump-outs/Extensions

Streets that have on-street parking provide an opportunity to install curb bump-outs and use bioretention in the right-of-way. By creating a new curb, and saw cutting and removing the road surface behind the new curb, bioretention can be placed right in the flow path of stormwater (the gutter area) without sacrificing more than one or two parking spaces. Curb openings allow water in and out, and an underdrain system prevents the practice from holding standing water. Another benefit of curb bump-out is that they also provide the benefit of traffic calming as a result of the narrowed road.

Curb bump-out bioretention could be used on any street in Edmonston with on-street parking and a nearby storm sewer connection, to filter and infiltrate stormwater and reduce localized flooding. Specifically, curb bump-out bioretention could be used on 48th Avenue (see Figure 32) where water already collects at a low point between the sidewalk and planting strip. There is an existing storm sewer system nearby to connect an underdrain, which would handle any excess volumes during large storm events.

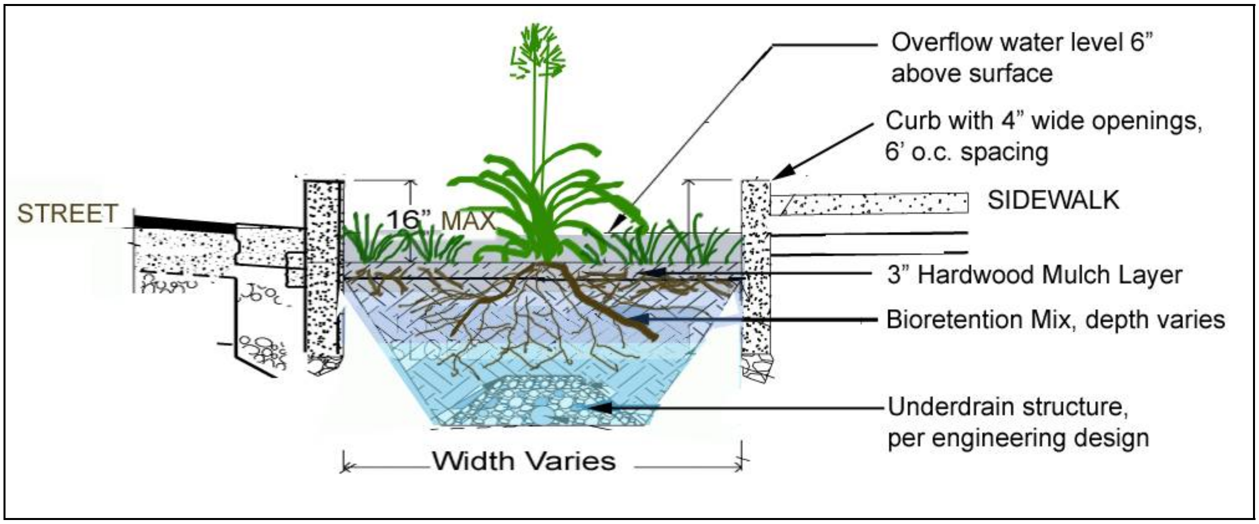

Figure 41. Curb Bump-out Cross-section: Vegetation in bump-outs is typically 3' tall or less, or is a street tree with no branches below 6' so that visibility is not obstructed.
Source: The Low Impact Development Center, Inc.

Figure 42. Curb bump-out bioretention on Siskiyou Green Street in Portland, OR.
Source: Portland Bureau of Environmental Services (BES)

4.2.2.2 Infiltration Planter

An option for managing stormwater runoff where there is an elevation change is to use an infiltration planter, which is a wall that is backfilled with bioretention media and topsoil that supports vegetation. Stormwater enters from the top of the slope and is released slowly to the bottom. Stormwater volume and velocity are reduced by the infiltration planter and the stormwater is filtered by the soil and vegetation.

At the end of Crittenden Street (see Figure 33), where Kenilworth Avenue passes above it, the slope shows signs of stormwater runoff erosion and the need for repair. The use of an infiltration planter in this location would capture runoff and infiltrate it into the soil behind the wall. Excess stormwater could exit the system through an underdrain or weep holes[12] at the base of the wall.

Figure 43. Infiltration Planter.
Source: The Low Impact Development Center, Inc.

[12] Weep Holes: Small holes that allow water drainage and prevent pressure build-up in the retaining wall.

4.2.3 Bioswales on Public Property

Bioswales are conveyance systems that use bioretention soils and vegetation to slow, filter, infiltrate, and evapotranspirate stormwater as well as convey it through the watershed (see Figure 16, Bioswale Cross-section). Edmonston has existing aboveground stormwater conveyance channels that present opportunities for bioswale retrofits. For example, the Edmonston Neighborhood Mini Park has a swale along the fence near the tennis court. A cut in the curb already allows excess flow to leave the system. By checking the soil infiltration rates, and amending the soil with a bioretention mix if necessary, then adding plants suitable to bioswale conditions, infiltration could be increased and stormwater volumes reduced. Bioswales improve water quality by removing pollutants through uptake by vegetation and soil filtration. Bioswales also reduce localized flooding by providing the opportunity for infiltration and evapotranspiration.

Figure 44. Edmonston Neighborhood Mini Park.
Current view of swale (left). Proposed view with a bioswale (right).
Source: The Low Impact Development Center, Inc.

4.2.4 Compost Amended Soils, Vegetation, and Trees on Public Property

The slope at the end of Crittenden Street could be stabilized by adding a curb or infiltration planter at the top of the slope to prevent stormwater from flowing down the slope (see Figure 33). The rock could be removed and compost could be added to the native soil. Native plants and shrubs could be planted on the slope to increase infiltration. Native plants and shrubs require less maintenance than turf grass or other water intensive plants. Because they are already acclimated to the climate, they usually don't require irrigation after the plant establishment phase.

Another option for reducing stormwater runoff volume is the addition of trees and vegetation. Vegetation and trees can also provide other benefits such as shade, noise breaks, wind breaks, air pollution reduction, oxygen production, and carbon sequestration. When planting trees, it is important to consider the root space that the tree will need once it is fully grown. In order for trees to grow to maturity, the roots need air and water. Paving over the root space with impermeable pavement can jeopardize the health of the tree. According to Casey Trees[13] overall street tree health is improved when soil volume requirements increase as the size of the tree canopy increases (see Figure 19).

Figure 45. An example of a vegetated slope in Georgia
Source: A. English

[13] Casey Trees. 2008. *Tree Space Design Guide*. Washington, D.C.

5.0 I am a community member. What can I do to help with the greening of Edmonston? (LID on Private Property)

There are many LID features that are appropriate for new construction and retrofit applications on private property. Figure 46 depicts some of the features that may be appropriate in Edmonston.

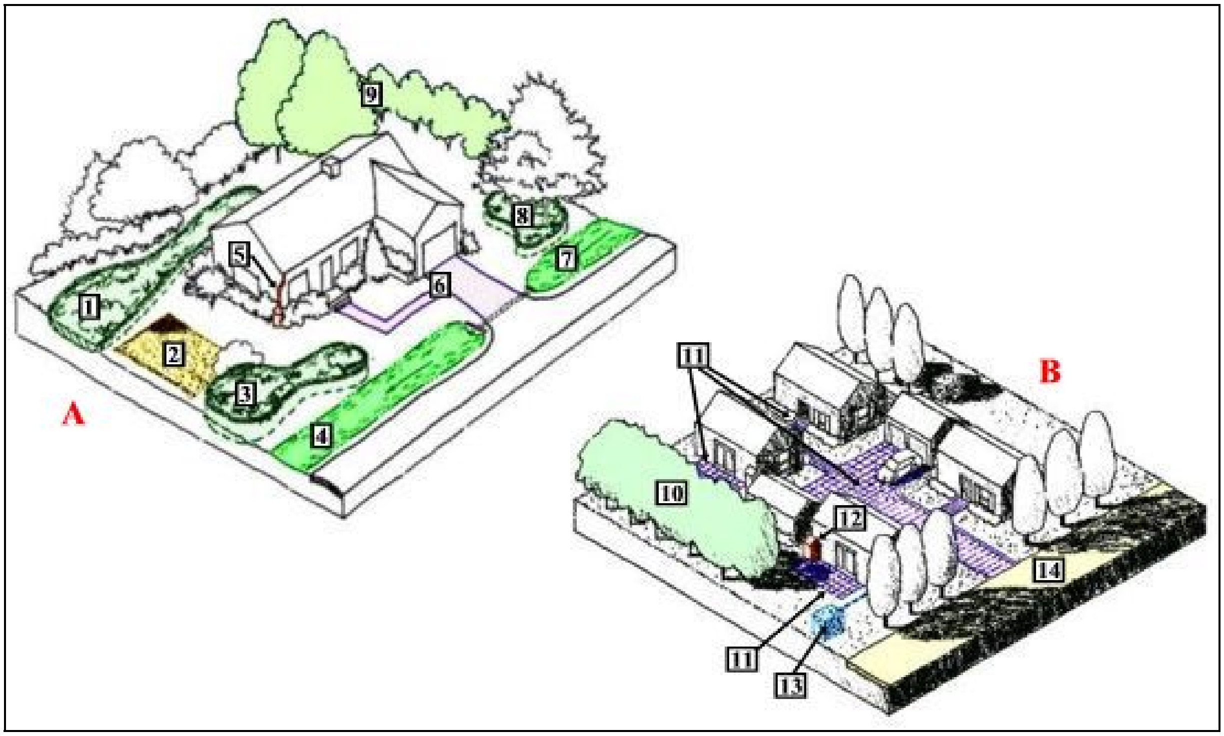

Figure 46. A graphic depiction of some of the LID features that can be used on urban residential property.
Source: Sketch A was adapted from Prince George's County, MD "LID IMP Guidance Document", 2002. Sketch B was modified from the [San Francisco] Bay Area Stormwater Management Agencies Association's "Start at the Source: Design Guidance Manual for Stormwater Quality Protection, 1999.

Image Legend:

A: Low Density Residential

1. Bioretention / Rain Garden
2. Soil Amendments
3. Bioretention / Rain Garden
4. Grassed Swale
5. Disconnectivity (Rain Barrel)
6. Permeable Pavers
7. Grassed Swale
8. Bioretention / Rain Garden
9. Conservation

B: High Density Residential

10. Conservation
11. Permeable Pavers
12. Disconnectivity (Rain Barrel)
13. Disconnectivity (Dry Well)
14. Minimizing Imperviousness (Reduced street width)

Conventional impervious surfaces such as patios, walkways, and driveways cause rainwater to run off, creating flooding and excessive water quality problems. Permeable pavement controls stormwater runoff volume, filters pollutants, and may be used to recharge groundwater by allowing rainwater to pass through the pavement and into the ground. A simple, yet effective method to control stormwater on private property is through the use of rain gardens, also known as bioretention cells. Rain gardens can be used to treat stormwater coming off of roofs or paved surfaces. Another example for consideration on private property is the use of compost amended soil and vegetation to increase rainwater infiltration into the soil.

Street trees provide many community benefits such as intercepting rainfall before it becomes polluted runoff, reducing the urban heat island effect, and making walking space more comfortable. While street trees are not a new Green Street concept, the planting requirements for a healthy, large canopy tree are often overlooked. Trees improve air quality and provide shade for homes, which can reduce air conditioning demands and save money.

Rain barrels and cisterns reduce the undesirable impacts of runoff that would otherwise flow swiftly into receiving waters and contribute to flooding and erosion problems by diverting and storing runoff from impervious areas such as roofs. Rain barrels are an inexpensive water conservation device that can be used to capture stormwater from roofs and reduce runoff volume and flow rates. They can be used to capture roof runoff that can be recycled as landscape irrigation. Cisterns capture roof runoff to be used for cleaning, toilet flushing, or clothes washing.

Figure 47. Residential Rain Barrel
Source: The Low Impact Development Center, Inc.

5.1 LID Opportunities on Private Property

Each LID practice that is used on private property reduces the volume of runoff that is discharged to the municipal storm sewer system. This not only reduces the burden on the storm sewer system, reducing the potential for flooding, it also delays the need for pipe sizing upgrades to the storm sewer system. While LID practices on private property benefit the community, the town does not currently (as of April 2009) have an ordinance requiring these practices on private property. Some communities choose to adopt ordinances requiring LID and/or provide incentive programs or grants that result in an increase in the number of LID practices installed on private property. Additional benefits and uses of these practices are described in the following sections.

5.1.1 Permeable Pavement on Private Property

Using permeable pavement on private property reduces the amount of impermeable surface on a given property that contributes runoff to the municipal storm sewer system. Permeable pavement can be used in residential driveways, walkways, and patios. The stone base of permeable pavement provides storage volume so that the captured water slowly infiltrates into the ground (see Figure 9, System Components of Permeable Interlocking Concrete Pavement). If soils do not drain well, an underdrain can be used to slowly drain water out of the pavement base system into the storm sewer system. Permeable pavement systems filter pollutants so the water discharged to the storm sewer system is cleaner than if it had traveled across impermeable paved surfaces, potentially picking up pollutants as it goes.

Figure 48. Permeable pavement patio and walkway
Source: Two Brothers Brick Paving

Figure 49. Permeable pavement driveway
Source: Interlocking Concrete Pavement Association (ICPI)

Figure 50. Residential permeable pavement driveway and path at Highpoint in Seattle, WA.
Source: Interlocking Concrete Pavement Institute (ICPI)

5.1.2 Bioretention/Rain Garden on Private Property

Bioretention cells, when constructed to look like a rural garden as opposed to an urban planter, are usually referred to as *rain gardens*. However, all bioretention features, no matter what they are called, have the same components; bioretention soil mix, plants suitable for bioretention conditions, and an underdrain system, if necessary. There are two basic types of rain gardens: underdrained and self-contained. Both are used to improve stormwater quality, reduce runoff volumes and generally facilitate infiltration of cleaned water. Important design factors include consideration of the volume of water to be treated, existing soil conditions, available space, and project budget. Figure 51 depicts a rain garden cross-section.

Rain gardens can be placed near downspouts to capture and treat roof runoff, or they can be placed where stormwater from paved surfaces can be captured. Not only do rain gardens serve as stormwater management practices, reducing the volume of water that reaches the storm sewer system, but they are also attractive. They can be designed as formal gardens or more natural looking gardens. They can be constructed in shady areas or in sunny areas, to be deer resistant, or fragrant.

Residents in the Town of Edmonston have a great resource available to them to aid in the creation of a rain garden that meets their preferences: the LID Center Rain Garden Design Website (www.lowimpactdevelopment.org/raingarden_design/). This website provides rain garden templates and plant recommendations, as well as construction, maintenance, and cost information.

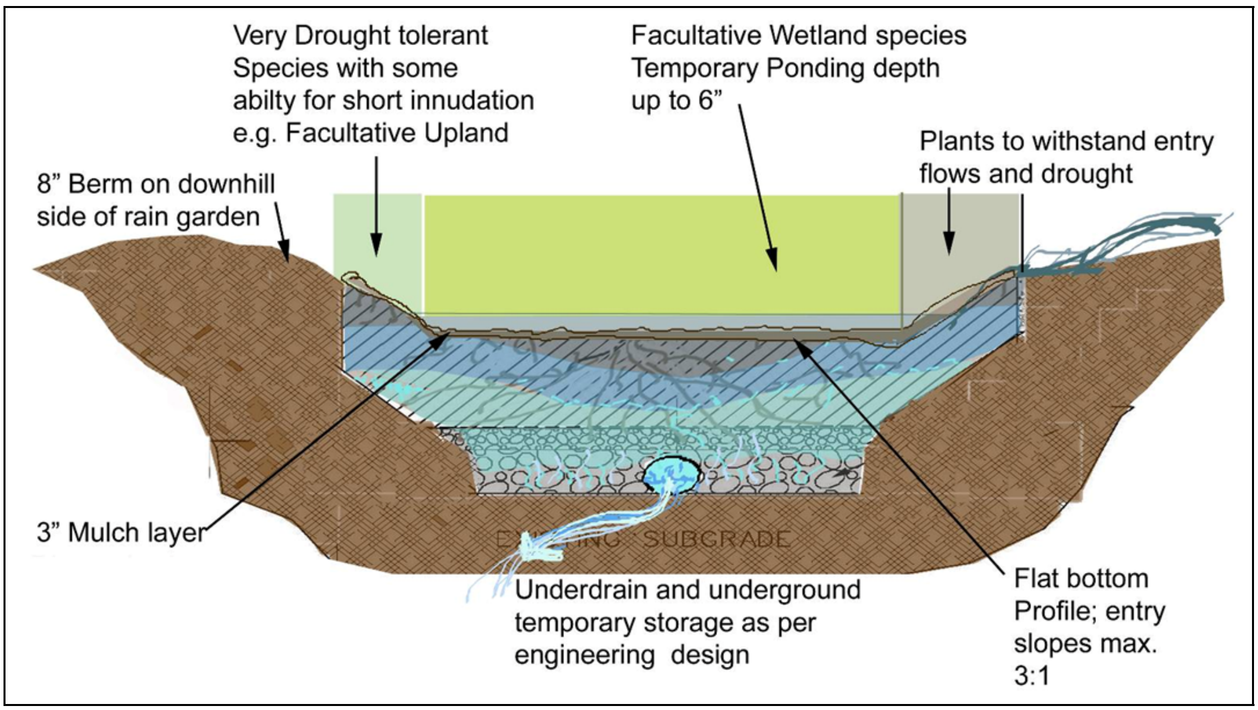

Figure 51. Rain Garden Cross-Section: Rain gardens are small controls with the greatest range of moisture regimes within them. (Clay soils that do not percolate at a rate of .5”/ hr. should be underdrained.)
Source: The Low Impact Development Center, Inc.

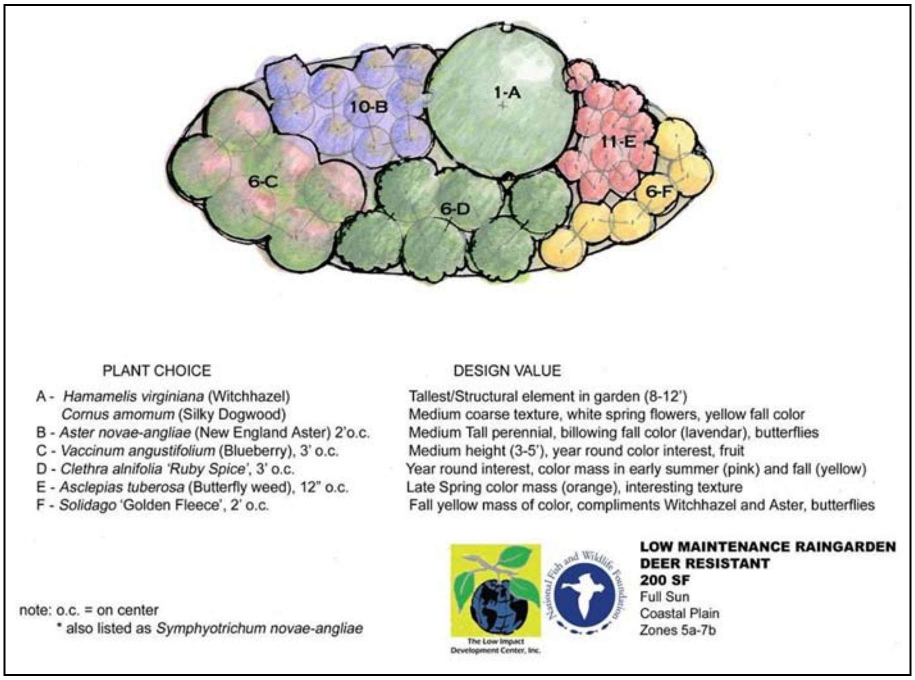

Figure 52. Rain garden template from the LID Center Rain Garden Design Website. www.lowimpactdevelopment.org/raingarden_design
Source: The Low Impact Development Center, Inc.

Figure 53. Residential Rain Garden.
Source: City of Maplewood, MN

5.1.3 Bioswales on Private Property

A conventional swale is designed to convey stormwater off site. A bioswale also conveys stormwater but contains soil and plants that encourage infiltration and evapotranspiration, while providing an aesthetic benefit (see Figure 16, Bioswale Cross-section). Edmonston has many aboveground conveyance systems such as swales that are easier to maintain than underground pipe systems that can become clogged. Swales reduce localized flooding by infiltrating the rain from small storm events rather than sending it through pipes to the river.

By selecting the right plants for the conditions, a simple backyard swale can become a beautiful, functional part of the landscape that reduces the quantity of stormwater transported to the storm sewer system.

Figure 54. Vegetated Bioswale.
Source: BelleWood Gardens

5.1.4 Compost Amended Soils, Vegetation, and Trees on Private Property

The simple addition of compost amended soil, vegetation, and trees has a beneficial impact on stormwater management. The practice of mixing compost into the existing soils loosens up compacted soil and increases infiltration of stormwater, reducing runoff and recharging groundwater. It also creates a more nutrient-rich soil condition that aids plant health, which in turn increases evapotranspiration.

The addition of vegetation and trees has the benefit of stabilizing soil which prevents erosion and sediment transport to the river. In addition, vegetation and trees can shade homes, which can reduce indoor air conditioning costs in the summer. Trees and vegetation can also act as noise breaks and wind breaks, and can reduce air pollution, produce oxygen, and sequester carbon.

Planting trees near the street on private property can add to the street's tree canopy, provide shade for pedestrians, and leave room in the right-of-way for other things such as bike lanes or bioretention cells that treat road runoff. Private property may offer a healthier environment for trees since they can be planted without the obstacles of underground utilities, overhead utilities, and pavement.

Figure 55. A tree lined street.
Source: Portland Bureau of Environmental Services (BES)

Figure 56: Trees and vegetation on private property.
Source: Woking Borough Council

5.1.5 Rain Barrels & Cisterns on Private Property

5.1.5.1 Rain Barrels

Roof runoff can be captured in rain barrels and used for landscape irrigation. Rain barrels come in standard sizes and can be placed near a house or building so that the down spout can be directed into it. A spigot allows for a hose to be attached so that the collected rain water can be used for watering plants throughout the yard.

5.1.5.2 Cisterns

Cisterns also capture rainwater from roof down spouts, but unlike rain barrels, cisterns can be sized to ensure that enough water is available throughout the year for a specific desired use. Cisterns can be above or below ground. They can be used for outdoor uses such as irrigation or indoor uses such as toilet flushing and clothes washing. The size of the cistern used is based on the amount of water needed for the intended use.

5.1.5.3 Benefits of Rain Barrels and Cisterns

Not only do rain barrels and cisterns store rain water, reducing the amount of runoff that flows out to the storm sewer system, but they also reduce the amount of potable water used for non-potable uses which lowers water bills and saves potable water for other uses.

Figure 57. Residential rain barrel.
Source: Indiana Association of Soil and Water Conservation Districts

Figure 58. Residential cistern.
Source: Technicians for Sustainability, LLC

6.0 Recommendations

The best strategy for stormwater management involves implementing practices as close to the place where the runoff is generated as possible. This reduces the size or need for conveyance systems and minimizes water quality impacts since the longer the distance stormwater has to travel, the higher the likelihood of coming in contact with pollutants. Stormwater also picks up velocity in channelized conveyance, which can be damaging to downstream habitat and structures.

The point of runoff origination is often on private property, such as roofs and driveways, but roads account for a large percentage of connected impervious area[14] and a large contribution of stormwater pollutants. Addressing road runoff through retrofit applications of bioretention and permeable pavement will give the town the greatest benefit for cost. Implementation of LID on private property should include a public education strategy for informing property owners of the impacts of unmanaged stormwater runoff and the simple things they can do that will make a difference.

The following sections include a brief summary of the recommendations for LID strategies on both public and private property, followed by a description of the Green Highways and Green Street design for Decatur Street[15] with plan sheets identifying the locations of the recommended design options.

6.1 Recommended Strategy for Public Property

Beginning LID implementation on public property not only gives the town experience with construction and maintenance, but also serves as an example of how community members can benefit if they choose to implement LID practices on their property. The use of signs with details explaining the LID practices will educate the community on what they are seeing, how it works, and why it is important. The signs can be used to explain to the reader how to implement something similar on their property, where to find more information, or where to purchase the materials themselves. Double-sided kiosks can be used in public spaces to describe the LID feature on one side and to post community information on the other. While large-scale implementation of something new can be intimidating, the key is to start small and repeat successes.

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[14] Connected impervious area refers to impervious areas that discharge to storm sewer systems without first passing over pervious surface.

[15] A separate report entitled, “Greening of Decatur Street” provides more detail on the Decatur Street design opportunities and constraints, specifics on recommended design components of curbside bioretention, and an analysis of the three design options.

Figure 59. Solar powered two-sided kiosk
Source: Artcraft Signs

Figure 60. Educational sign explaining LID features
Source: Chuck Taylor, Advanced Pavement Technology

6.2 Recommended Strategy for Private Property

If the Town of Edmonston can offer incentive programs or grants that raise awareness of stormwater management issues and LID practices, more property owners are likely to participate in LID implementation than if left to research and install LID practices on their own. For example, if the town purchases rain barrels in bulk, sells them to residents at a discounted rate, and includes instructions for installation or a number to call for help, there is a much greater chance that property owners will install rain barrels successfully.

The advantage of private property LID features to the community includes reduced localized flooding and reduced volumes of, and pollutant load in, stormwater runoff discharged to the storm sewer system. When it comes to implementing or retrofitting LID practices, private property provides some easy places to start. Installing rain barrels or rain gardens, turning swales into bioswales, compost amending soils, and adding vegetation and trees are all relatively simple additions that can make a big difference collectively.

Other communities have implemented grant and incentive programs to aid in the implementation of LID features on private property. Many of the strategies are captured in U.S. EPA's *Managing Wet Weather with Green Infrastructure Municipal Handbook, Green Infrastructure Retrofit Policies*. This document is available on the U.S. EPA's website at cfpub.epa.gov/npdes/greeninfrastructure/munichandbook.cfm. In addition to *Retrofit Policies*, the *Green Infrastructure Municipal Handbook* series includes chapters discussing *Funding Options*, *Green Streets*, and *Rainwater Harvesting Policies*.

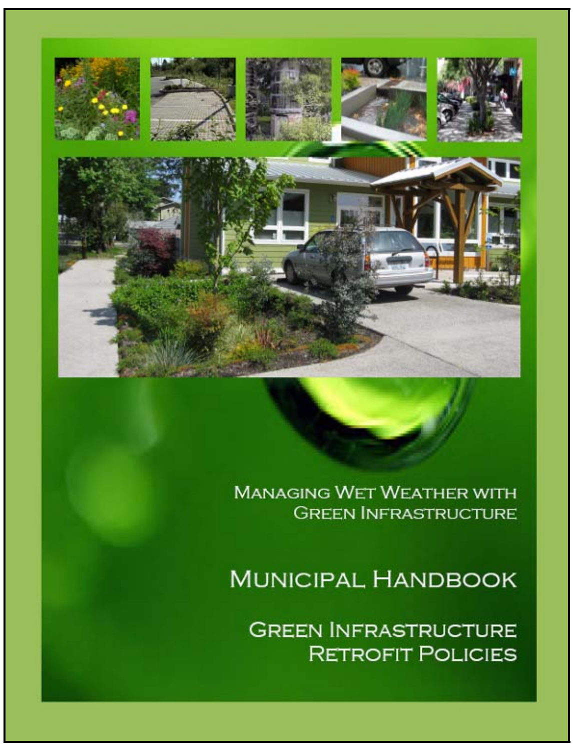

Figure 61. Cover of *Managing Wet Weather with Green Infrastructure Municipal Handbook, Green Infrastructure Retrofit Policies*, EPA-833-F-08-008.
Source: U.S. Environmental Protection Agency

7.0 LID on Decatur Street: A National Model

7.1 Recommended Strategy for Decatur Street

Decatur Street provides a great opportunity for the Town of Edmonston to make a statement about its commitment to "Go Green" and implement many types of environmentally responsible practices, including LID. By implementing bioretention cells and healthy street tree applications, the town will have the opportunity to gain experience with the design, construction, and maintenance of these features in a local context.

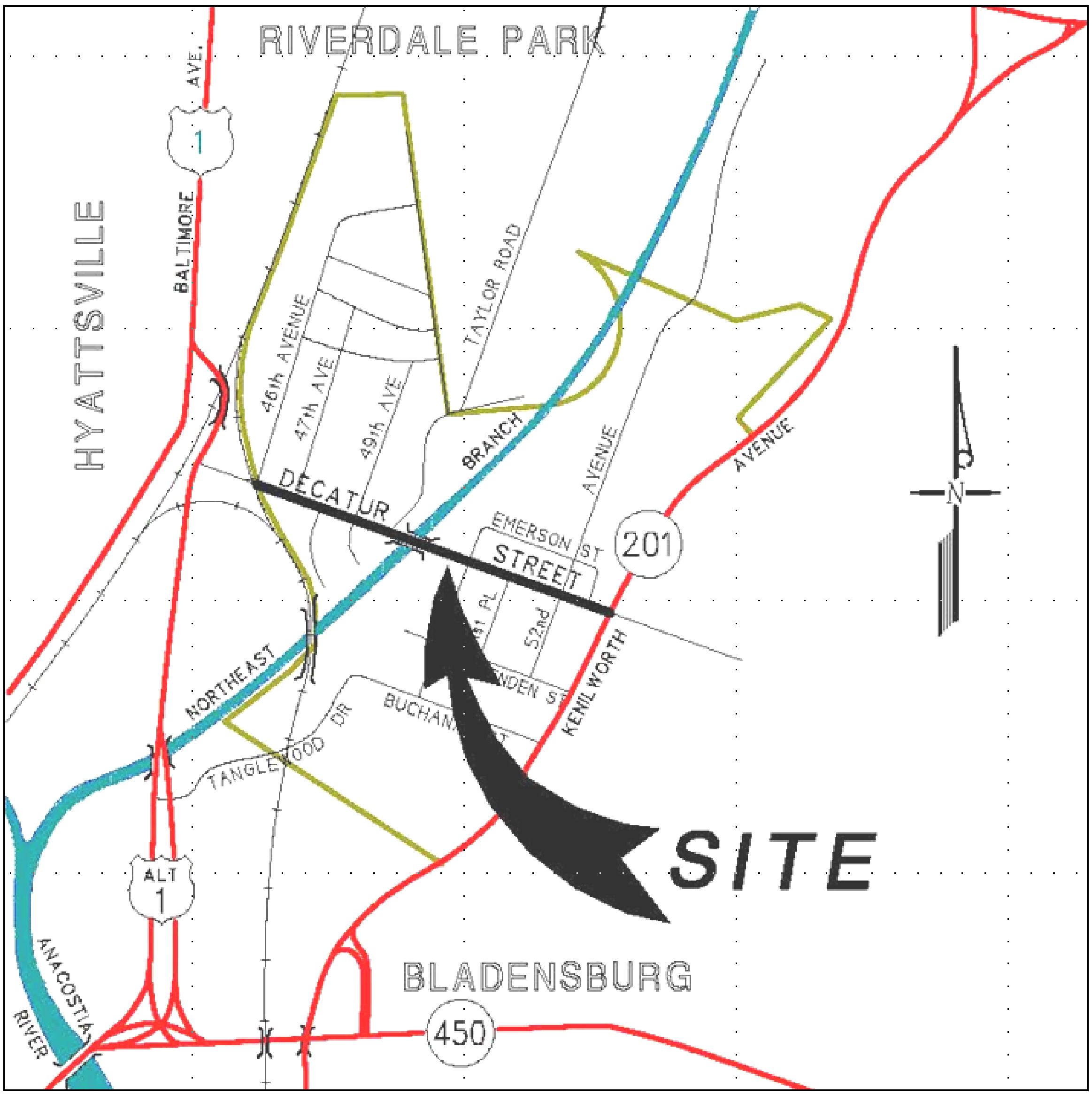

Figure 62. Vicinity map displaying the Town of Edmonston boundary and location of Decatur Street.
Source: G&C Consultants, Inc.

7.2 Why was Decatur Street chosen and what are the project goals?

The Town of Edmonston chose Decatur Street to be the focus of their LID efforts because it is the main street of the town. The street draws much attention and traffic, and the community has a number of improvement goals that they want to accomplish with the project. In addition to making the street more sustainable, they want to encourage green businesses, improve pedestrian and bicyclist safety, bring mass transit to the street, and add art to the street that will define the community.

The Town of Edmonston requested that Decatur Street, which has no on-street parking, be narrowed in order to slow traffic, shorten pedestrian crossing distance, and reduce imperviousness. The project goals, derived from discussions with the community and project engineers, are as follows:

- Capture stormwater pollution before it enters the Anacostia River
- Reduce flooding along Decatur Street
- Encourage green economic development in Edmonston
- Incorporate large canopy street trees
- Slow traffic along Decatur Street
- Create a safe and pleasant environment for pedestrians and bicyclists

7.3 What are the Opportunities and Constraints?

There are many LID or green practices that can be incorporated onto a street, including permeable pavement, bioretention, swales, and trees. The goals of these practices are to reduce runoff through retention, detention, and infiltration, and to reduce pollutants by encouraging stormwater contact with the vegetation and soils. Based on the design goals and site constraints, bioretention and improved tree planting areas are the key green strategies for Decatur Street.

Reducing impervious area in itself will make the street more sustainable by reducing runoff and providing more open soil area for rainfall to infiltrate. G & C Consultants, Inc. produced two street layout options with a reduced street width. The alternative chosen by the town creates a meander in the street by increasing the planting strip on one side by 4–6 feet for one block and then increasing the planting strip on the opposite side of the street on the next block. The total width of widened planting strip available for LID practices is 8–9 feet. The expanded planting strip areas allow enough space for bioretention and healthy street tree plantings.

The project constraints include:

- Narrow, 50 foot, right-of-way
- Flat topography
- Truck use of the street
- High groundwater
- Underground and overhead utilities
- Driveway access

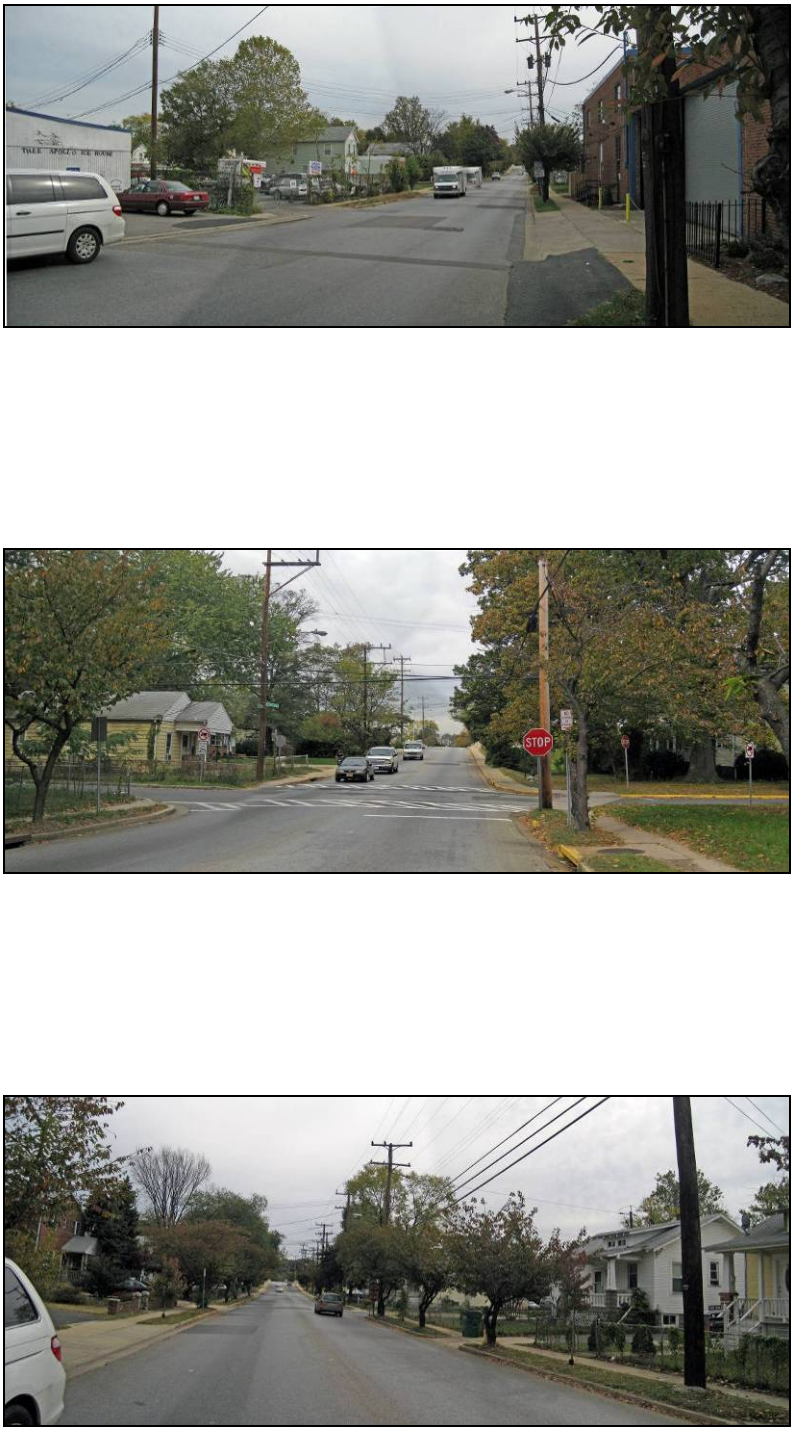

Figure 63a., b. and c. The Town of Edmonston's Main Street, Decatur Street
Source: The Low Impact Development Center, Inc.

7.4 Design Options for Decatur Street

The best Green Street strategy for Decatur Street would be to maximize the benefits of stormwater treatment, urban heat island reduction, and aesthetics while meeting the user needs of safety and comfort. Three arrangements of bioretention and street trees were analyzed for Decatur Street, and are summarized below. Options 1 and 2 best accomplish the Green Street goals for Decatur Street. A separate report entitled *Greening of Decatur Street*[16] provides more detail on the Decatur Street design opportunities and constraints, specifics on recommended design components of curbside bioretention, and an analysis of the three design options.

Option 1 includes four bioretention cells along Decatur Street. The locations were selected for adequate space in the planting strip, a large drainage area, and nearby access to the storm sewer system. This option will treat runoff coming from 29 percent of the street area.

Option 2 increases the street area treated to 62 percent and includes nine bioretention cells, each placed wherever there is adequate space and drainage area. However, there are no nearby storm sewers for connecting the underdrains from five of the bioretention cells. Choosing option 2 will require additional engineering investigation and will likely have higher construction costs to connect underdrains over a longer distance to reach the existing storm sewer system.

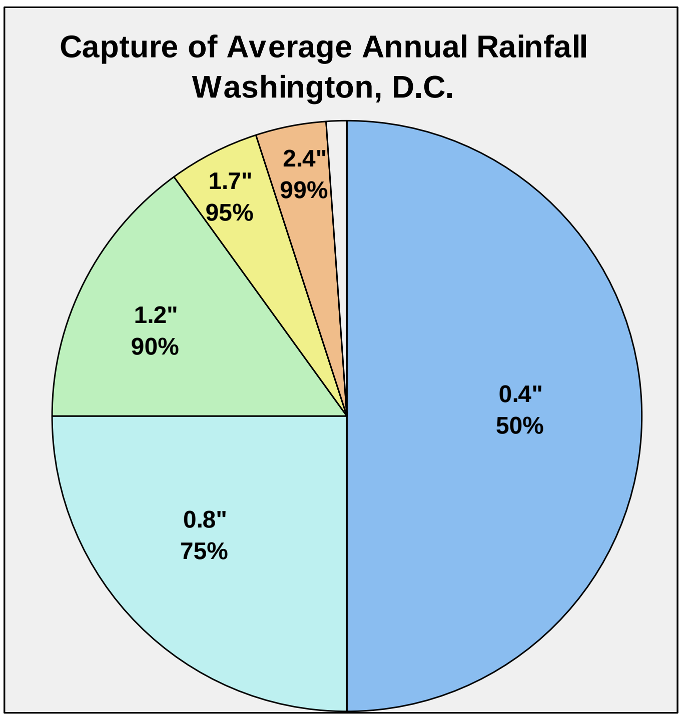

Figure 64. Analysis of Annual Rainfall Volumes and Capture Rates for Washington, D.C.
Source: Hirschman and Kosco, 2008, Managing Stormwater in Your Community: A Guide for Building an Effective Post-Construction Program, Center for Watershed Protection

[16] After the presentation of the bioretention and street tree design options to the Town of Edmonston, an opportunity arose to include a shared bike lane and permeable pavement in the street design. An addendum to the *Greening of Decatur Street* report provides information on a permeable pavement option and suggested locations for permeable pavement bike lanes.

7.4.1 Bioretention on Decatur Street

The bioretention cells proposed for Decatur Street will be located between the sidewalk and curb. The design includes a 2 foot depth of bioretention soil and allows a maximum of 6 inches of surface ponding. Openings in the curb will allow street runoff to enter the cells. Once the cells are full, the street runoff will continue along the gutter to the storm sewer inlet. An underdrain will draw stormwater out of the cell within 48 hours and prevent groundwater from rising into the cell.

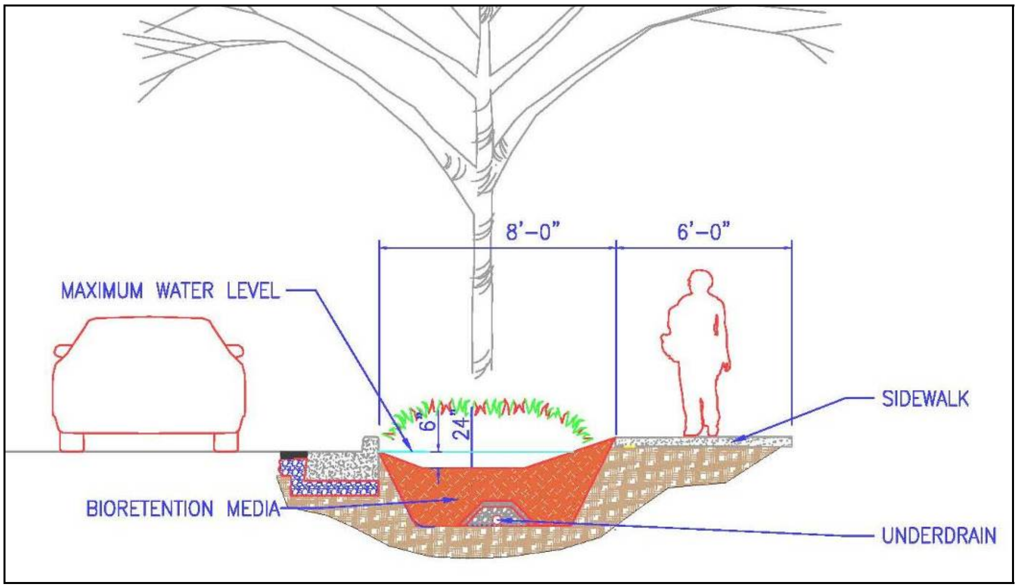

Figure 65. Proposed cross-section for Decatur Street curb-side bioretention cells.
Source: The Low Impact Development Center, Inc.

7.4.2 Street Trees on Decatur Street

The redesign of Decatur Street will widen the planting strip between the curb and the sidewalk, providing more space for each tree. The soil volume goal for each new street tree along Decatur Street is 1,000 cubic feet. In addition, the soils will be enhanced with compost amendments which will provide the tree with nutrients and allow for more water and air to reach the roots.

Table 2. Bioretention and Street Tree Options for Decatur Street

Option	# of Bioretention Cells	Total Bioretention Area (sf)	% Street Area Treated	Average Water Quality Volume (in)	# of New Trees
1	4	870	29	1.27	43
2	9	1,928	62	1.33	38
3	14	3,533	62	2.45	25

7.4.3 LID on East Decatur Street

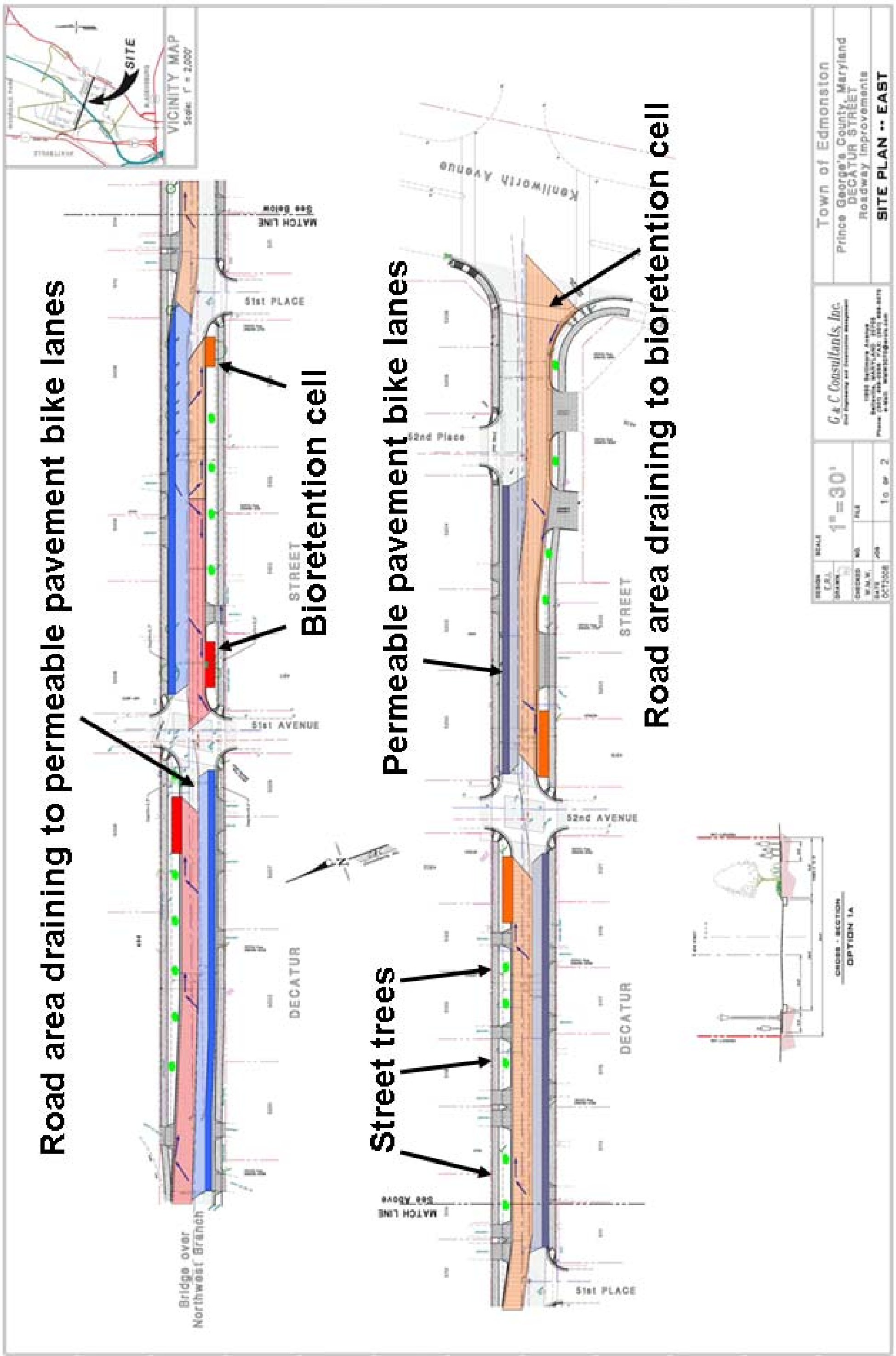

Figure 66. LID on East Decatur Street: Plan view of proposed road layout with proposed LID feature locations and drainage areas shown.

Source: Plan sheet: Road layout, G&C Consultants, Inc.; LID locations and drainage areas: The Low Impact Development Center, Inc.

7.4.4 LID on West Decatur Street

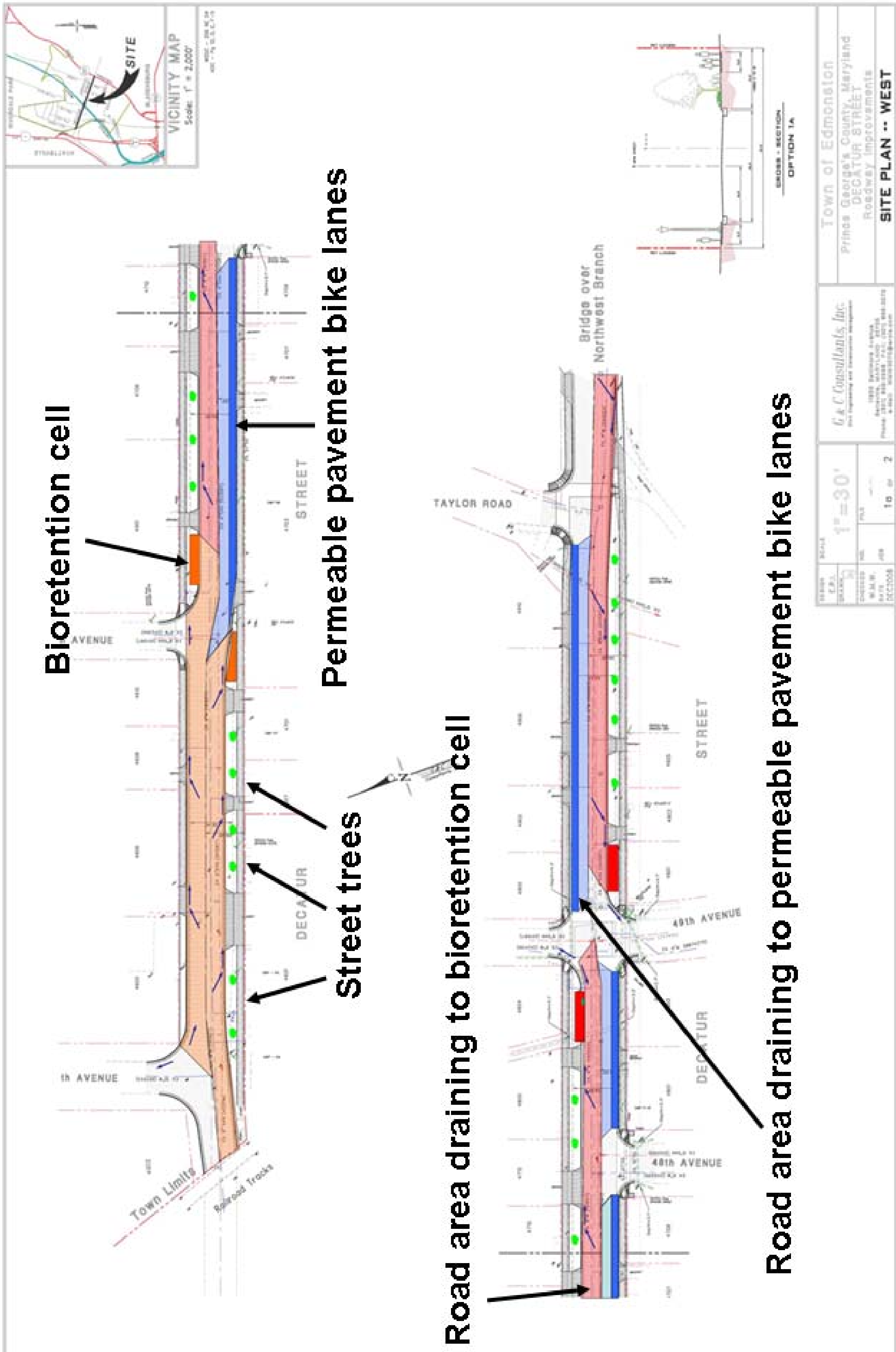

Figure 67. LID on West Decatur Street: Plan view of proposed road layout with proposed LID feature locations and drainage areas shown.

Source: Plan sheet: Road layout, G&C Consultants, Inc.; LID locations and drainage areas: The Low Impact Development Center, Inc.

8.0 Conclusion

The goal of the LID approach to stormwater management is to mimic the natural hydrologic condition, meaning the stormwater does what it did before impervious surfaces covered the landscape: infiltrate into the ground and evapotranspirate into the air. In addition to the information provided in this report, there are other resources that can assist the Town of Edmonston with the implementation of LID features. These resources are listed in Appendix A.

Using the right vegetation and trees for the vegetated LID features is an important part of ensuring success. Appendix B contains a list of plants that are suitable for LID features in Edmonston.

By implementing LID practices throughout the Town of Edmonston, there is potential to not only improve water and air quality, reduce flooding, reduce the urban heat island effect, and conserve water and energy, but also lead by demonstrating environmental, social, and economic responsibility.

Figure 68. Streets constructed of pervious concrete pavement or other permeable surfaces.
Source: City of Bellingham, WA

Figure 69. Rain gardens across the street from pedestrian-friendly permeable concrete walks.
Source: LID Center

9.0 Appendix A: LID Resources

9.1 General LID Resources

LID Center:
www.lowimpactdevelopment.org

- Rain Garden Design Templates
- LID BMP Fact Sheets
- LID Design Manuals

U.S. EPA Menu of BMPs:
cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=5

- BMP Fact Sheets (Includes design and maintenance information, pollutant removal rates, and cost information)
- Links to other internet resources

Rain Garden Plant Database:
rainkc.com/index.cfm/fuseaction/plants.search/index.htm

9.2 Porous Pavement Resources

Interlocking Concrete Pavement Institute:
www.icpi.org

- Technical Specifications
- List of Certified Installers

Pervious Concrete:
www.perviouspavement.org

- Performance
- Engineering Properties
- Design & Construction

National Asphalt Pavement Association:
www.hotmix.org

- How it works
- Pavement life time and effectiveness

9.3 Case Studies/Policy

Chicago Green Alley Handbook:
egov.cityofchicago.org/webportal/COCWebPortal/COC_EDITORIAL/GreenAlleyHandbook.pdf

- Award Winning Graphics
- Stormwater Management
- Material Recycling

U.S. Environmental Protection Agency (EPA):
cfpub.epa.gov/npdes/home.cfm?program_id=298

- Green Infrastructure Municipal Handbook (Series includes chapters discussing Funding Options, Retrofit Policies, Green Streets, and Rainwater Harvesting Policies)
- Case Studies
- Green Jobs Training

Street Edge Alternatives (SEA) Streets:
www.ci.seattle.wa.us/util/About_SPU/Drainage_&_Sewer_System/Natural_Drainage_Systems/Street_Edge_Alternatives/SPU_001805.asp

- Hydrologic Monitoring Report
- Contract Plans
- Community Cost and Benefits

Portland Bureau of Environmental Services:
www.portlandonline.com/BES/index.cfm?c=34598

- Green Streets
- Ecoroofs
- Case Studies
- Monitoring

Water Environment Research Foundation (WERF):
Using Rainwater to Grow Livable Communities: Sustainable Stormwater Best Management Practices (BMPs)
www.werf.org/livablecommunities/studies_list.htm

- Case Studies

9.4 Glossary

- A -

Aquifer: An underground bed or layer of earth, gravel, or porous stone that is saturated and sufficiently permeable to yield water to wells or springs. Typically used or could be used as a source of water, for drinking or other purposes.

- B -

Bioretention: Also known as a rain garden. On-lot retention of stormwater through the use of vegetated depressions engineered to collect, store, and infiltrate runoff.

BMP: Best Management Practice; a practice or combination of practices that are the most effective and practicable (including technological, economic, and institutional considerations) means of controlling point or nonpoint source pollutants at levels compatible with environmental quality goals.

Buffer: A vegetated zone adjacent to a stream, wetland, or shoreline where development is restricted or controlled to minimize the effects of development.

- C -

Curbs: Concrete barriers on the edges of streets used to direct stormwater runoff to an inlet or storm drain and to protect lawns and sidewalks from vehicles.

- D -

- E -

EPA: Environmental Protection Agency.

Erosion: The process of soil detachment and movement by the forces of water.

Evapotranspiration: The term used to describe the combination of evaporation from soil and plants and the transpiration of water vapor from plants into the atmosphere.

- F -

Fecal Coliform: Bacteria found only in the intestinal tracts of humans and animals. The major sources are animal waste, waste treatment plants, and failing septic systems. The presence of this bacteria typically indicates pollution that may pose a health risk.

Filter Strips: Bands of closely-growing vegetation, usually grass, planted between pollution sources and downstream receiving waterbodies.

- G -

Gabion: Wire basket filled with stone that can be stacked to form gravity type retaining walls. Typically used to hold soils on steep slopes in place and prevent erosion.

Green Infrastructure: See low impact development. *An adaptable term used to describe an array of products, technologies, and practices that use natural systems – or engineered systems that mimic natural processes – to enhance overall environmental quality and provide utility services. As a general principal, Green Infrastructure techniques use soils and vegetation to infiltrate, evapotranspirate, and/or recycle stormwater runoff. When used as* *components of a stormwater management system, Green Infrastructure practices such as green roofs, porous pavement, rain gardens, and vegetated swales can produce a variety of environmental benefits. In addition to effectively retaining and infiltrating rainfall, these technologies can simultaneously help filter air pollutants, reduce energy demands, mitigate urban heat islands, and sequester carbon while also providing communities with aesthetic and natural resource benefits.*(U.S. EPA Green Infrastructure Website, Glossary of Commonly Used Terms, Accessed: April 12, 2009)

Groundwater: Water stored underground in the pore spaces between soil particles or rock fractures.

- H -

Habitat: An area that supports plant or animal life.

Hydrology: The science dealing with the waters of the earth, their distribution on the surface and underground, and the cycle involving evaporation, precipitation, flow to the seas, etc.

- I -

Impervious Area: A hard surface area (e.g., parking lot or rooftop) that prevents or retards the entry of water into the soil, thus causing water to run off the surface in greater quantities and at an increased rate of flow.

- J -

- K -

- L -

Leadership in Energy and Environmental Design (LEED): The current industry-accepted benchmark for the design, construction, and operation of high performance green buildings and neighborhood developments. Certification and rating system are administered by the U.S. Green Building Council (USGBC).

Low Impact Development (LID): See green infrastructure. The integration of site ecological and environmental goals and requirements into all phases of urban planning and design from the individual residential lot level to the entire watershed. Examples of LID techniques are permeable pavement, rain gardens/bioretention, rain barrels and cisterns, and green roofs.

- M -

- N -

Nonpoint Source Pollution: Water pollution caused by rainfall or snowmelt moving both over and through the ground and carrying with it a variety of pollutants associated with human land uses. A nonpoint source is any source of water pollution that does not meet the legal definition of point source in section 502(14) of the Federal Clean Water Act.

NPDES: National Pollutant Discharge Elimination System; a regulatory program in the Federal Clean Water Act that prohibits the discharge of pollutants into surface waters of the United States without a permit.

- O -

o.c.: on center; plant spacing center to center

- P -

Permeable: Soil or other material that allows the infiltration or passage of water or other liquids.

- Q -

- R -

Rain Barrels: Barrels designed to collect and store rooftop runoff.

Recharge Area: A land area in which surface water infiltrates the soil and reaches the zone of saturation or groundwater table.

Rain Garden: See bioretention. Synonymous with bioretention, this term is typically used for general audience discussions when referring to small garden sited close to the source of runoff.

Runoff: Water from rain, melted snow, or irrigation that flows over the land surface.

- S -

Stormwater: Precipitation such as rain or snowmelt that flows across a surface rather than evaporating or seeping into the ground.

Swale: An open drainage channel designed to detain or infiltrate stormwater runoff.

- T -

Tetraploid: Four sets of chromosomes in each cell of the plant. For daylilies, 44 chromosomes altogether.

- U -

Underdrain: A perforated pipe, typically 4-6” in diameter, placed longitudinally at the invert of a bioretention facility for the purposes of achieving a desired discharge rate.

- V -

- W -

Watershed: The topographic boundary within which water drains into a particular river, stream, wetland, or body of water.

Weep Holes: Small holes that allow water drainage and prevent pressure build-up in the retaining wall.

- X -

- Y -

- Z -

10.0 Appendix B: Plant List for LID Streetscape in Edmonston, MD

10.1 Tree List

Figure Number	Scientific/Botanic Name	Cultivar	Common Name	Mature Size (H x W)	Spacing	Characteristics
T1	*Acer rubrum*	'October Glory'	Red Maple	40' x 30'	20' o.c.	Red fall color, canopy tree, native to flood plains
T2	*Amelanchier x grandiflora*	'Autumn Brilliance'	Serviceberry	20' x 15'	15' o.c.	Red fall color, fruit for birds, attractive white flower in spring, gray winter bark, upright vase shaped
T3	*Betula nigra*	'Heritage'	River Birch	30' x 20'	15' - 25' o.c.	This could be used for afforestation near the levee. Attractive exfoliating bark, upright vase-shaped habit with branches that arch. May be multi-stemmed
T4	*Carpinus caroliniana*	'Palisade'	Hornbeam, American Hornbeam, Musclewood	20-23' x 15-25'	10-15' o.c. depending on desired effect	Muscular looking bark, dark green leaves, interesting catkins
T5	*Cercis canadensis*		Redbud	20' x 15'	N/A	Four season interest; attractive leaves and branching structure, purple spring flowers. *Cercis canadensis* var. *texensis* 'Texas White' (Texas Redbud) or *Cercis reniformis* 'Oklahoma' (Oklahoman Redbud), are glossy leaved, more drought tolerant forms of this tree that can be used
T6	*Cercis canadensis*	'Forest Pansy'	Red Bud	20' x 15'	N/A	Four season interest; attractive leaves and branching structure, purple leaf form
T7	*Chionanthus virginicus*		Fringe Tree	10' x 8'	N/A	Four season interest, white spring flowers, yellow fall leaves,

						slow growing; needs horizontal space to spread
T8	*Magnolia virginiana*		Sweetbay magnolia	20’ x 10’	10’ o.c.	Multi-stemmed large shrub/small tree, gray bark, white flower in summer
T9	*Quercus alba*		White Oak	50’ x 50’	35’ o.c.	Widespread native range; well adapted to poorly drained flats, canopy tree
T10	*Quercus bicolor*	‘Long’ (Regal Prince®*)*	Swamp White Oak	60’ x 25’	20’ o.c.	Vigorous grower, results from cross with *Quercus robur* ‘Fastigiata’; tolerant of wet and dry conditions; the straight species is also nice for swampy conditions yet very drought tolerant

o.c.: on center; plant spacing center to center

Figure T1. *Acer rubrum* 'October Glory' (Red Maple).
Source: The Samuel Roberts Noble Foundation, Ardmore, Oklahoma

This tree has a red fall color, is a canopy tree, and is native to flood plains.

Figure T2. *Amelanchier x grandiflora* 'Autumn Brillance' (Serviceberry).
Source: Estabrook's

This small tree has a brilliant red fall color, white spring flowers, gray bark in winter, and an upright oval shape.

Figure T3. Betula nigra 'Heritage' (River Birch).
Source: American Beauties Native Plants

This tree could be used for afforestation near the levee. It has attractive exfoliating bark and an upright vase-shaped habit with branches that arch. It also may be multi-stemmed.

Figure T4. *Carpinus caroliniana* 'Palisade' (Hornbeam, American Hornbeam, Musclewood).
Note: This image is the straight species; 'Palisade' has a 2:1 H:W ratio with ascending branches
Source: The Samuel Roberts Noble Foundation, Ardmore, Oklahoma

This tree has muscular looking bark, dark green leaves, and interesting catkins.

Figure T5. *Cercis canadensis* (Redbud).
Source: The Samuel Roberts Noble Foundation, Ardmore, Oklahoma

This tree has attractive leaves and branching structure. It has year-round interest and produces purple flowers in the spring. Another option for the Town of Edmonston would be the *Cercis canadensis* var. *texensis* 'Texas White' (Texas Redbud) or *Cercis reniformis* 'Oklahoma' (Oklahoman Redbud), which are glossy leaved and are even more drought tolerant forms of this small tree.

Figure T6. *Cercis canadensis* 'Forest Pansy' (Redbud).
Source: The Samuel Roberts Noble Foundation, Ardmore, Oklahoma

This tree has attractive leaves and branching structure and is a purple leaf form of the species.

Figure T7. *Chionanthus virginicus* (Fringe Tree).
Source: The Samuel Roberts Noble Foundation, Ardmore, Oklahoma

This tree has white spring flowers, yellow fall leaves. It is slow growing and needs ample horizontal space to spread.

Figure T8. *Magnolia virginiana* (Sweetbay magnolia).
Source: Mark Brand, UConn Plant Database (Bottom)
Source: American Beauties (Top)

This multi-stemmed large shrub/small tree has gray bark and grows white flowers in the summer.

Figure T9. *Quercus alba* (White Oak).
Source: M.C. Starrett, University of Vermont

This canopy has widespread native range and is well adapted to poorly drained flats.

Figure T10. *Quercus bicolor* 'Long' Regal Prince® (Swamp White Oak*)*.
Note: This image is of the species, not the cultivar of *Quercus bicolor*.
Source: The Samuel Roberts Noble Foundation, Ardmore, Oklahoma

This vigorous upright and oval grower is the result of a cross with *Quercus robur* 'Fastigiata'. It is tolerant of wet and dry conditions. The straight species is also nice for swampy conditions, yet very drought tolerant.

10.2 Shrub List

Figure Number	Scientific/Botanic Name	Cultivar	Common Name	Mature Size (H x W)	Spacing	Characteristics
S1	*Aronia arbutifolia*		Red Chokeberry	6' x 3'	4' o.c.	White flower & red fruit, which are the Cedar Waxwing bird's favorite food
S2	*Clethera alnifolia*	'Ruby Spice'; 'Sixteen Candles'	Summersweet	3' x 4'	3' o.c.	Pink summer flower 'Ruby Spice', white summer flower 'Sixteen Candles', yellow fall color, spreads and makes a colony
S3	*Cornus stolonifera; Cornus sericea*	'Arctic Fire'; 'Kelseyi'	Red Twig Dogwood	1-2' x 2-3'	2' o.c.	Dwarf forms of red twig dogwood, upright branches, flame red in winter
S4	*Ilex vomitoria*	'Schilling's Dwarf'; 'Stoke's Dwarf	Dwarf yaupon holly	2' x 3'	3' o.c.	Very regular growth form, evergreen, tolerates drought and flooded soils
S5	*Itea virginica*	'Merlot'	Virginia Sweetspire	3' x 3'	3' o.c.	Dwarf form of Virginia Sweetspire, red winter twig, white spring flower, burgundy fall color
S6	*Rosa*	'Radrazz' Knock-out®	Rose	3' x 3'	3.5' o.c.	Disease resistant, long blooming, landscape rose, dark raspberry, pink

o.c.: on center; plant spacing center to center

Figure S1. *Aronia arbutifolia* (Red Chokeberry).
Source: The Low Impact Development Center, Inc.

This shrub has a white flower and red fruit.

Figure S2. Bottom: *Clethra alnifolia.* Straight species pictured; 'Sixteen Candles' (Summersweet) more upright in flower and shorter.
Top: *Clethra alnifolia* 'Ruby Spice' (Summersweet, Sweet Pepperbush).
Source: The Samuel Roberts Noble Foundation, Ardmore, Oklahoma

This colony-forming shrub attracts butterflies, bees, and some hummingbirds. 'Ruby Spice' has pink, upright summer flowers and yellow fall color. 'Sixteen Candles' has white, upright summer flowers and yellow fall color.

Figure S3. *Cornus sericea* 'Kelseyi' (Red Twig Dogwood).
Source: The Samuel Roberts Noble Foundation, Ardmore, Oklahoma

Cornus sericea 'Kelsyi' is a dwarf form of red twig dogwood. If not available, *Cornus stolonifera* 'Artic Fire' may be substituted. Both forms have upright branches and are flame red in winter.

Figure S4. *Ilex vomitoria* 'Schilling's Dwarf', 'Stoke's Dwarf' (Dwarf Yaupon Holly).
Source: The Samuel Roberts Noble Foundation, Ardmore, Oklahoma

This evergreen shrub has a very regular form and tolerates drought and flooded soils.

***Figure S5. Itea virginica* 'Henry's Garnet' (Virginia Sweetspire).**
Note: Image shown is 'Henry's Garnet'; 'Merlot' is a dwarf form that is 3' tall, with burgundy leaves in fall. Both can be grown in Edmonston, but 'Merlot' is the preferred choice due to its smaller size.
Source: The Samuel Roberts Noble Foundation, Ardmore, Oklahoma

'Merlot' is a dwarf form of Virginia Sweetspire that is about 3 feet tall. It has a white spring flower, a burgundy fall color, and a red winter twig.

Figure S6. *Rosa Knock-out*® 'Radrazz' (Rose).
Source: Bloomin Designs Nursery

This dark raspberry or pink shrub is disease resistant and long blooming.

10.3 Grass List

Figure Number	Scientific/Botanic Name	Cultivar	Common Name	Mature Size (H x W)	Spacing	Characteristics
G1	*Chasmanthium latifolium*		Upland Sea Oats; Spangle Grass	2-3' x 2'	2' o.c.	Also known as (Spangle Grass) for its decorative seed heads
G2	*Deschampsia cespitosa*		Tufted Hair Grass	2-3' x 1-3'	2' o.c.	Fine textured clumping grass, several cultivars available
G3	*Muehlenbergia capillaris*		Pink Muhly Grass	2' x 2 .5'	2 .5' o.c.	Pink fall flowers, fine texture; plant in spring only
G4	*Panicum virgatum*	'Heavy Metal'	Heavy Metal Switchgrass	4' x 6'	4' o.c.	Year round interest, especially summer and fall
G5	*Stipa tenuissima*		Mexican Feather Grass	2' x 2.5'	2' o.c.	Very fine texture, 2' tall with 3' flower stalks

o.c.: on center; plant spacing center to center

Figure G1. *Chasmanthium latifolium* (Upland Sea Oats, Spangle Grass).
Source: Allan M. Armitage; The Educated Gardener, Volume 1: Interactive Guide to Herbaceous Perennial Plants

This type of grass is commonly referred to as Spangle Grass because of its decorative seed heads.

Figure G2. *Deschampsia cespitosa* (Tufted Hair Grass).
Source: Greg Stack, University of Illinois Extension

This is a fine, hair-like textured clumping grass.

Figure G3. *Muehlenbergia capillaries* (Pink Muhly Grass).
Source: North Creek Nurseries, Inc.

A fine textured grass that should be planted in the spring. It produces pink flowers in the fall.

Figure G4. *Panicum virgatum* 'Heavy Metal' (Switchgrass).
Source: Allan M. Armitage; The Educated Gardener, Volume 1: Interactive Guide to Herbaceous Perennial Plants

This grass has year-round interest, especially in the summer and fall.

G5. *Stipa tenuissima* (Mexican Feather Grass).
Source: Bluestem Nursery

This grass has a very fine texture and grows to a height of 2 feet with 3 foot flower stalks

10.4 Perennial List

Figure Number	Scientific/Botanic Name	Cultivar	Common Name	Mature Size (H x W)	Spacing	Characteristics
P1	*Aesclepias tuberosa*		Butterfly Weed	24” x 24”	18” o.c.	Bright orange flowers, monarch butterfly plant, summer bloom
P2	*Amsonia hubrechtii*		Arkansas Bluestar	36” x 24”	24” o.c.	Blue late spring flowers, yellow foliage in fall
P3	*Aquilegia canadensis*		Columbine	12” x 12”	12” o.c.	Orange-yellow drooping flowers, reseeds freely, lives two years but reestablishes through reseeding
P4	*Aster novae-angliae*	‘Purple Dome’	New England Aster	varies; 24-36” x 24-36’	24” o.c.	Dwarf form, fall purple flowers, appearing mid-late Oct
P5	*Boltonia asteroides*		Boltonia	36” x 36”	24” o.c.	White spring flowers
P6	*Echinacea purpurea*	‘Magnus’	Bright Star Purple Coneflower	30” x 18”	18” o.c.	Pink summer daisy-like flowers, butterfly attractor - other cultivars available
P7	*Hemerocallis* Hybrids		Daylily	varies; 12-36” x 12-30”	varies by plant selection	Tetraploid[17] types of daylilies provide extended bloom, low maintenance, and are not invasive
P8	*Iris hexagona*		Dixie Iris	14” x 12”	12”	Violet flowers early summer, linear foliage; attractive even when not in bloom; not visible in winter
P9	*Iris* LA Hybrid		Louisiana Iris	2.5’ x 18”	15” o.c.	Linear foliage, clean, late spring/early summer flowers; variety of colors available

[17] Tetraploid: Four sets of chromosomes in each cell of the plant. For daylilies, 44 chromosomes altogether.

P10	*Liatrus spicata*		Blazing Star	2' x 1-2'	15" o.c.	Linear foliage, upright spike purple flower, very drought tolerant, reliable performer, needs good drainage
P11	*Phlox subulata*	'Emerald Cushion Blue' 'Emerald Cushion Pink'	Thrift	6" x 12"	8" o.c.	'Emerald Cushion Blue' and 'Emerald Cushion Pink' are typical cultivars; best for bioswales or rain gardens with soft edges; very drought tolerant
P12	*Rudbeckia fulgida*	'Goldsturm'; 'Golden'	Black-eyed Susan	24" x 36"	34" o.c.	Yellow summer daisy-like flowers, evergreen foliage
P13	*Solidago sphacelata*	'Golden Fleece'	Goldenrod	2' x 18"	12" o.c.	Very showy native, blooms in late summer; introduced by Mt. Cuba, Delaware

o.c.: on center; plant spacing center to center

Figure P1. *Aesclepias tuberosa* (Butterfly Weed).
Source: North Creek Nurseries, Inc.

This perennial has bright orange flowers that bloom in the summer, attracting monarch butterflies.

Figure P2. *Amsonia hubrechtii* (Arkansas Bluestar).
Source: North Creek Nurseries, Inc.

The *Amsonia hubrechtii* has blue flowers in late spring and yellow foliage in fall.

Figure P3. *Aquilegia Canadensis* (Columbine).
Source: North Creek Nurseries, Inc.

These orange-yellow drooping flowers live for two years, reestablishing through reseeding freely.

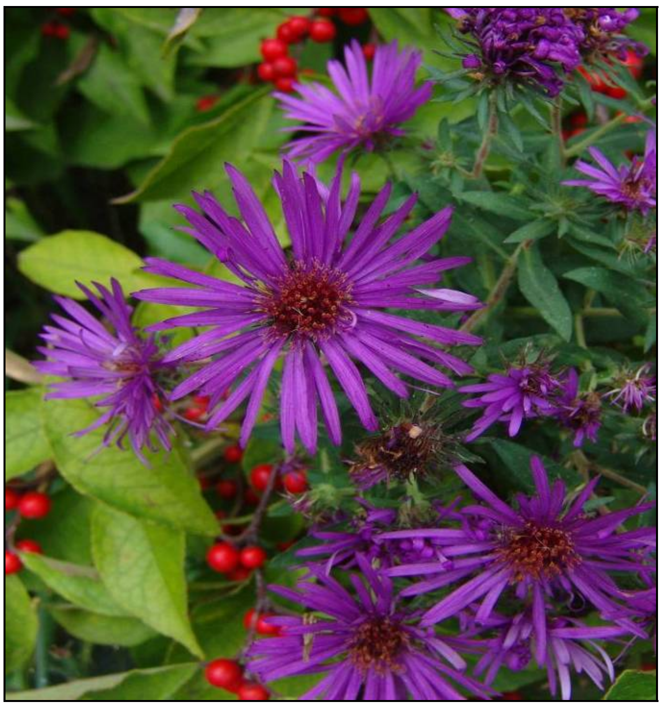

Figure P4. *Aster novae-angliae* 'Purple Dome' (New England Aster).
Source: North Creek Nurseries, Inc.

This perennial is a dwarf form and has purple flowers that bloom in mid-late October.

Figure P5. *Boltonia asteroides* (Boltonia)
Source: Bluestone Perennials

This perennial has white flowers that bloom in the spring.

Figure P6. Echinacea purpurea **'Magnus' (Bright Star, Purple Coneflower)**
Source: Allan M. Armitage; The Educated Gardener, Volume 1: Interactive Guide to Herbaceous Perennial Plants (top)
Source: North Creek Nurseries, Inc. (bottom)

This perennial has pink daisy-like flowers that bloom in summer and attract butterflies. Other cultivars are available.

Figure P7. *Hemerocallis* hybrid (Daylily)
Source: North Coast Perennials, Inc.

This is a non-invasive, low maintenance daylily that provides an extended bloom.

Figure P8. *Iris hexagona* (Dixie Iris).
Source: Allan M. Armitage; The Educated Gardener, Volume 1: Interactive Guide to Herbaceous Perennial Plants

This perennial with linear foliage produces violet flowers in early summer. It is attractive even when not in bloom, but it is not visible in winter.

Figure P9. ***Iris*** **LA Hybrid (Louisiana Iris)**
Source: Louisiana Iris Farms, LLC

This perennial has clean, linear foliage. It produces flowers in late spring/early summer. A variety of colors are available.

Figure P10. *Liatrus spicata* (Blazing Star)
Source: North Creek Nurseries, Inc.

This perennial is a reliable performer and has an upright spike purple flower. It is very drought tolerant, but needs good drainage.

Figure P11. *Phlox subulata* (Thrift)
Source: Allan M. Armitage; The Educated Gardener, Volume 1: Interactive Guide to Herbaceous Perennial Plants

'Emerald Cushion Blue' and 'Emerald Cushion Pink' are typical cultivars of this perennial. They are recommended for bioswales or rain gardens with soft edges that are very drought tolerant.

Figure P12. *Rudbeckia fulgida* 'Goldsturm', 'Golden' (Black-eyed Susan)
Source: North Creek Nurseries, Inc.

These yellow daisy-like flowers bloom in summer and have evergreen foliage.

Figure P13. *Solidago sphacelata* 'Golden Fleece' (Goldenrod)
Source: North Creek Nurseries, Inc.

This perennial is a very showy native that blooms in late summer.