American University – McLean Gardens Stormwater Management Project

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University Honors in Environmental Studies
Spring 2011
Advised By: Dr. Kiho Kim

Deliverables

1. Phase I Final Report
2. Presentation given to community on 1/30/2011
3. Phase II draft sections (living document)

Meetings attended

October 13, 2010: Property assessment with Ty Voles, Project Manager of DC Greenworks

- Assessed the property for the viability of green roofs and rain gardens.

January 30, 2011: Community meeting to present Phase I student findings

- Represented American University student groups and presented the Phase I inventory and ground truthing results and initial student recommendations to McLean Gardens, DDOE, DCWASA and community representatives.

February 16, 2011: McLean Gardens Sustainability Committee general meeting

- Updated the committee members on the findings of Phase I and expectations for Phase II.

March 2, 2011: Planning meeting with MG Sustainability Committee president

- Outlined necessary information for completion of Phase II and identified individuals and organizations critical to meet with.

March 11, 2011: Meeting with MG Community Manager Pervaiz Ahmed

- Inquired about ongoing and upcoming projects on the MG property that would impact stormwater including construction, maintenance, paving, digging and other disruptive projects.

March 30, 2011: Casey Trees

- Toured the Casey Trees facility which mitigates 100 percent of the stormwater that lands on the property and additional stormwater from the street. Property has three types of green roofs, bioretention facilities, a rain cistern, and advanced street scaping. Also discussed the possibilities for collaborating on grant work and developing a comprehensive sustainability plan for McLean Gardens.

March 30, 2011: American University Sustainability

- Updated the AU Sustainability department on the status of Phase II and requested resources on investment decision making tools and LEED guidance.

April 8, 2011: Property assessment with American University Landscape Architect Michael Mastrota

- Performed a physical walk-through of the McLean Gardens complex in order to identify areas with potential for mitigation projects and to assist in the visualization of conditions necessary for each project. Also discussed the possibility of a parking lot redesign project designed by Mike Mastrota.

April 12, 2011: Meeting with District Department of the Environment

- Discussed upcoming grant program for Condominiums in line with RiverSmart Homes and the unofficial likelihood of certain mitigation efforts to be listed as “acceptable” under the future incentive program.

April 20, 2011: Planning meeting two with MG Sustainability Committee president

- Determined the broad final decisions of phase II and the information necessary to for a report to the board of directors.

...American University...McLean Gardens...

a collaboration to reduce future costs related to stormwater

A Stormwater Management Framework for McLean Gardens

Phase I Report

Assessment of Existing Site Conditions

With

Potential Solutions for Future Strategies

March 2011

ACKNOWLEDGEMENTS

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Casey Trees

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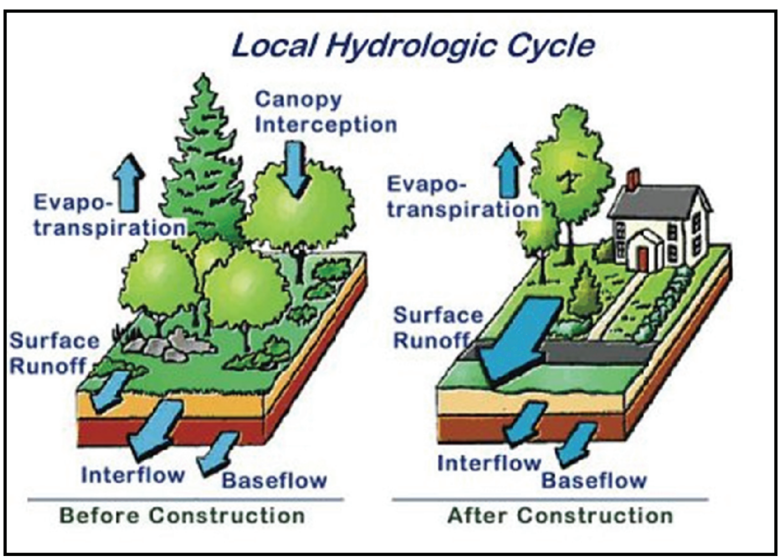
1. EXECUTIVE SUMMARY

Stormwater runoff is generated when water from rain and snowmelt events flows over land or impervious surfaces and does not percolate into the ground.

Sample DC Water Impervious Area Map

The DC government has imposed two new fees on water bills which directly affect McLean Gardens. The cost of the new fees on McLean Gardens Condominium Association is projected to rise from $10,000 to $123,000 by 2018. This report outlines the findings of the first part of a three phase collaborative project between American University and McLean Gardens to reduce future costs related to stormwater.

The city has lowered the rate for sewer services but is charging a monthly Stormwater Fee and Impervious Area Charge (IAC) for surfaces that water cannot penetrate called impervious surfaces. Impervious surfaces include roofs, pools, recreation areas, driveways, sidewalks, parking lots and similar surfaces.



Rain water and snow melt flow over these surfaces creating stormwater runoff which accumulates debris, chemicals, sediment, and other pollutants. Untreated, stormwater runoff can have serious adverse environmental, health, and social effects. In natural ecosystems, rainwater flows slowly as it is intercepted by tree canopies and absorbed by plants allowing water to percolate into the ground. Development practices remove these natural barriers and cause larger amounts of rain to flow as surface runoff rather than being recharged into the ground water.

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The overall goal of the project is to provide the Board of Directors and residents with data and information that describe how McLean Gardens currently manages stormwater, information about future regulatory actions by the city to address stormwater runoff, and options and investment analysis to make informed decisions about managing stormwater in the future.

Sample Inventory Property Features

A summary of Phase I follows:

Objectives

- Conduct an inventory of property features that capture and move runoff.
- Ground-truth DC impervious area measurements.
- Perform an historical and physical analysis of hydrology, vegetation and soil conditions.
- Observe impacts of stormwater runoff on the property.
- Make general recommendations of potential solutions to be investigated further for viability.

Impervious Surface	
DC Water (Square Feet)	388,770.8
Independent Evaluation (Square Feet)	391,818.3
Difference (Percent)	1%

Findings

- MG has significant impervious area; AU-MG data verifies accuracy of DC Water data.
- Overall state of the soil and prevalence of shallow rooted vegetative cover, coupled with medium to steep slopes, results in low retention of water during storm events.
- Property features contribute to the negative effects of runoff to the property (i.e. erosion) and / or collect and convey rainwater into the City's separate stormwater sewer system.

Potential solutions

- **Green Roofs on HVAC plants**: vegetated roof systems that replace typical shingle, tar, gravel, or asphalt roofs.

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A green roof reduces runoff flow rates and can retain 50 -95% of rain water. They also insulate buildings thereby reducing cooling and heating costs, extend the life of a roof by up to 50 years, and greatly improve aesthetic qualities of a building.

- **Rain Gardens/Bioretention Cell**: professionally installed rain gardens absorb, filter, and slow the rate of runoff before it reaches the sewer system. Rain gardens are depressed areas with porous backfill under a vegetated surface, they often have underdrains. Carefully designed systems reduce erosion, avoid pooling (no possible mosquitoes), increase absorption (reduce flooding events), filter debris (reduce drainage maintenance and back flooding), and lower sewer stresses.
- **Restore Soil Permeability** by incorporating specifications into requests for proposals and contracts. Soil permeability and organic content of the soil can be improved where future construction and restorative landscaping is planned. Improving soil conditions will result in healthier and longer living plants at a lower annual cost, especially in areas where turf is desired. It will also reduce (and potentially eliminate) the amount of chemical inputs (and associated costs) which plant materials cannot effectively use given the current soil conditions.
- **Natural Landscaping**: lawns are surprisingly impervious. Replacing grass with more natural plantings improves absorption rates considerably and deeper rooted plants increase percolation while stabilizing hillsides.
- **Increased Tree Canopy**: tree canopies reduce the rate of percolation to rooftops.
- **Vegetated Filters**: densely planted vegetation can act as a buffer layer between sources of polluted runoff and sewage grates or other ecosystems. Filter strips are well suited for treating runoff from roads and .

highways, roof downspouts, very small parking lots, and impervious surfaces. Unlike rain gardens, filters are not engineered to store quantities of water.

- **Infiltration Trenches**: shallow ditches with permeable soils and stone create an underground reservoir which allows the water to percolate into the ground water. These trenches are often integrated beautifully into landscape architecture adding to the property's appeal.
- **Permeable Pavement**: allows water to percolate through gaps between stonework or directly through the paving material. Underneath the pavement is a stone reservoir that temporarily stores surface runoff before infiltrating it into the subsoil. A combination of decorative pavers and porous concrete and asphalt can provide a handicap friendly, low maintenance, eye pleasing change that is also environmentally preferable
- **Rain Barrels**: redirecting downspouts into rain barrels not only reduces the risk of flooding and erosion on your property, but also allows you to re-harvest the water.
- **Community Education and Involvement:** Creates understanding and support among residents.

Research in Phase I indicates there are a range of solutions available to mitigate stormwater runoff. It also indicated that further work was necessary to develop data and information that would allow the Association to determine its options and make thoughtful, practical, and cost-effective decisions.

For example the above list of potential solutions includes some options which may not be addressed in the DC government incentive system. However, they still need to be considered as potential options in developing Phase II recommendations since the City's incentive program is only one of several factors in determining the feasibility, cost, and value of an option.

In Phase II, the Sustainability Committee will use the information provided in the City's incentive program along with

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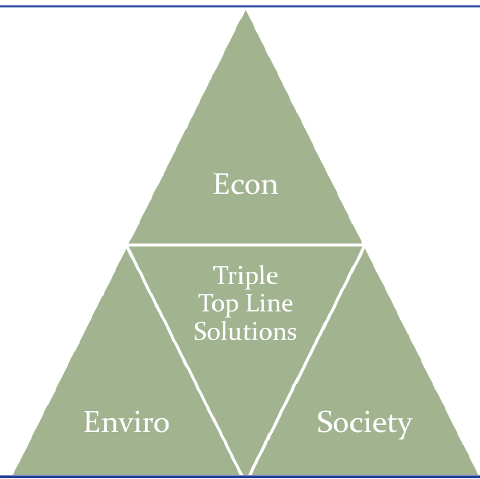
other factors to develop an overall approach for the short and long-term that :

- Matches site characteristics to mitigation approach requirements (e.g., rain gardens require full sun).
- Evaluates workable mitigation approaches in the context of pre-defined set of quantitative and qualitative indicators/measures.

The Committee expects its Phase II work to result in a framework for managing stormwater runoff in the short and long-term that reflects stormwater management projects suitable for each building and surrounding land.

The Committee will use the Triple Topline Approach as its decision framework. This approach goes beyond looking at economic performance and considering environmental and social performances either as an afterthought, or not at all.



Triple Top Line Decision Approach

In this approach, decision-makers work towards a triple-top line of generating financial, environmental, and social benefits. Rather than an afterthought or a way of making a project "less bad," triple-top line maximizes all three considerations, *including* cost in making investment decisions.

For McLean Gardens this means *considering and communicating the qualitative and quantitative value* of the recreation spaces, aesthetic appeal of the grounds, unit marketability, habitat and food for song birds, a sense of pride in community, etc. in conjunction with the monetary investment in onsite stormwater

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2. BACKGROUND

Stormwater runoff is generated when water from rain and snowmelt events flows over land or impervious surfaces and does not percolate into the ground. As the runoff flows over the land or impervious surfaces (paved streets, parking lots, and building rooftops), it accumulates debris, chemicals, sediment, or other pollutants that adversely affects water quality when the runoff is discharged untreated, as it is from McLean Gardens.

Precipitation Facts*

Average Rain Fall – **42.1 inches per year**

2010 Actual – **39.4 inches**

Major Rain Event – **1.0 inches in 24 hours**

Annual Average – **9.5 per year**

2010 Actual – **6.0**

Rain Events 0.5 inches or Greater

Annual Average **– 27.5**

2010 Actual **– 26.0**

* NOAA Data for National Airport

In May 2009, the City imposed two new fees on water bills to collect money for improvements to the systems that collect and distribute stormwater. The initial impact of new fees on McLean Gardens Condominium Association[2-1] was modest (about $10,000 in 2010). However, these fees increased between 2010 and 2011 and are scheduled to increase each year. The projected cost as of November 2010 was $123,000 per year by 2018. The Board of Directors asked the Sustainability Committee to research reasons for the new fees, how other organizations are planning to address the rising costs, and information about the City's incentive program to discount fees by mitigating stormwater runoff.

In May 2010, McLean Gardens (MG) entered into an agreement with American University (AU) to collaborate on development of *A Stormwater Management Framework* for MG. This Framework would include an assessment to identify stormwater runoff sources and any pollution sources on the property; provide baseline data about the sources of runoff; develop a comprehensive set of potential solutions (with costs and schedules); and develop appropriate measures to assess

2-1. The McLean Gardens Unit Owners Association is the legal name of the entity described in this report; referred to with the acronym (MG). The term McLean Gardens refers to the land and dwellings owned by the residents and entity, individually or in common.

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progress resulting from mitigation of stormwater runoff from rain and snow melt events. Together AU and MG developed a grant proposal to the National Fish and Wildlife Foundation requesting $30,000 to:

- Determine the accuracy of DC Water's calculations of impermeable surfaces.
- Define, document, and estimate source contributions to runoff during rain events at Mclean Gardens.
- Estimate sources and contributions of runoff from Mclean Gardens site to Glover Archbold Park. Assess soil and existing use of vegetation (including tree canopy, shrubs, grass, and other vegetation).
- Determine current and potential future on-site management of stormwater.
- Recommend what, if any, steps MG could take to mitigate stormwater runoff and any attendant projected costs.

Although the proposal was not funded, MG and AU agreed to proceed with a collaborative effort to assess existing conditions on the MG property since this did not depend on grant funding. In June 2010, AU and MG formed a project team to design and conduct an assessment that could be accomplished by AU students and MG volunteers. This effort was designed to:

- Measure impermeable surfaces — the basis for the new fees (stormwater and impervious area) included on monthly water bills from DC Water to MG starting in May 2009.
- Create an inventory of existing features on the MG property that capture and move or store runoff during rain or snowmelt events.
- Create an inventory of features and conditions that move runoff into the City's stormwater sewer system and/or into Glover Archbold Park.
- Determine the role of existing soil and vegetation in stormwater management and runoff.
- Identify potential solutions to identified problems.

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This report describes the overall goals for the entire project (to be done in Phases I, II, and III) and the work conducted in Phase I by AU students and MG volunteers.

PROJECT GOAL

The overall goal of the project is to provide the Board of Directors and residents with data and information that describe how McLean Gardens currently manages stormwater, information about future regulatory actions by the city to address stormwater runoff, and options and investment analysis to make informed decisions about managing stormwater in the future.

- Phase I Objective – Identify existing site conditions (natural and manmade) on the McLean Gardens property that contribute to stormwater runoff, understand and describe how stormwater is currently managed, and understand the relationship of these factors to current and future stormwater and impervious area charges paid in monthly water bills.
- Phase II and III Objectives
    - Research and recommend to the Board and residents options for action or non-action based on the City's approach to incentives and other factors.
    - Develop recommendations about opportunities for adopting integrated strategies that consider management of stormwater as part of other projects and activities, and can guide future uses and improvements to the property (e.g., purchase and installation of new plant materials, annual maintenance and refurbishment of soils, replacement of sidewalks and parking lots).
    - Develop cost estimates that describe return on investment for recommended actions where appropriate.

PHASE I PROJECT

<u>Scope</u> – Phase I includes identifying, describing, and assessing:

- Existing site specific conditions and features (both natural and manmade) that contribute to stormwater runoff and stormwater management.

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- Existing soils, hydrology, and vegetation patterns.
- Existing and potential pollution sources (both point and nonpoint sources) on the site.
- Other factors that may influence stormwater management decisions.

It also includes preliminary information about potential future strategies. Specific recommendations on future strategies will be explored in phase II.

Methodology – The investigators adapted the pre-design and site assessment guidelines published in the Sustainable Sites Initiative: Guidelines and Performance Benchmarks 2009[2-2] to ensure they conducted a comprehensive assessment of site conditions and features (natural and manmade) that have potential to impact the management of stormwater on the McLean Gardens property. This methodology inventoried and evaluated:

- General site conditions and features (e.g., slope of the land, downspout and drain locations, current stormwater management systems, impervious surfaces).
- Hydrology (water movement and distribution).
- Soils (historical and current).
- Vegetation (historical and current).

The investigators employed a variety of methods including literature and internet research, observations, measurements, sampling, and tools (geographic information systems, Google earth, and photographs) to conduct the assessment in Fall 2010. (Appendix 2.1 describes the methodology design.)

2-2. The Sustainable Sites Initiative is a partnership of the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center, and the United States Botanic Garden in conjunction with a diverse group of stakeholder organizations to establish and encourage sustainable practices in landscape design, construction, operations, and maintenance.

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The remainder of this report is organized as follows :

Section 3: The McLean Gardens Property – *Wilderness to Estate to Community*: A review of the natural conditions of the land surface, soil, and vegetation on the McLean Gardens property between 1100 BCE and 2010.

Section 4: Stormwater Management at McLean Gardens – The Details: A description of the collaborative research project conducted by seven AU-MG study teams to provide some of the basic information necessary to develop a *Stormwater Management Framework for McLean Gardens.*

Section 5: Implications for the Future – *Findings, Conclusions, and Next Steps:* A summary of overall findings, with conclusions and next steps.

Section 6: Appendices

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3. THE MC LEAN GARDENS PROPERTY:
Wilderness to Estate to Community

This section reviews the conditions of the land surface, soil, and vegetation on the McLean Gardens property between 1100 BCE and 1898 and alterations made by several owners between 1713 and 1941. It provides pictorial examples of how the creation of the McLean Gardens complex in 1941-42 reshaped the land, altered the soil, and changed the vegetation. Additional changes to the soil have resulted from construction activities during and since condominium conversion in 1979-82. Finally, it describes the land conditions as of Fall 2010.

A Brief History

ca. 1,100 to 700 BCE – "...the topography and watercourses of the Potomac broadly resembled those of today… A diverse array of deciduous trees thrive on the inner coastal plain's varied topography and soils."[3-1]

1700 to 1790 – Evidence of tobacco and corn farming on Friendship Tract. [3-2]

1790 to 1847 – Unnamed 63 acre farm complete with brick mansion with several owners.[3-1 and 3-2]

1847 to 1898 – Georgetown College creates the Villa as retreat for priests and scholars.[3-3]

1898 to 1941 – McLean expands estate boundaries, enlarges mansion, and adds amenities. [3-3]

1941 to 1948 – Government builds McLean Gardens, a garden-style apartments and dormitories for WW II workers.

1949 to 1982 – Property converts to rental units.

1982 to present – Converted to and maintained as 720 condominium apartments with 1,000+ residents.

1100 BCE to 1898
Land Surface, Soil, and Vegetation

<u>Land Surface</u> – Descriptions of the property in colonial times indicate that ridges and valleys were found throughout the property. These descriptions also indicate that the current high and low points found on the property are reasonably close to the original.[3-1] The highest point on the property is about 400 feet above sea level, near Wisconsin Avenue and Rodman Street, and the lowest point is about 338 feet above sea level on 39th Street at the far corner of Building 31 and in Parking Lot B.

<u>Soil</u> – The original soil on the McLean Gardens site was derived from marine formations since the property is located where the Piedmont meets the Coastal Plain. The geologic formation underlying most of the area is of relatively recent marine origin (formed about 2 to 5 million years ago, during the Pliocene Epoch). Most of the original soil is derived from the Pliocene deposits.

3-1. James D. Rice. 2009. *Nature and History in the Potomac Valley: From Hunter-Gatherers to the Age of Jefferson*. Baltimore: Johns Hopkins University Press.

3-2. Judith Beck Helm. 1981. *Tenleytown, Country Village into City Neighborhood*. Rockville, MD. Tennally Press.

3-3. Conrad Wilson. 1906. "Ohio at Washington: 'Friendship', the Country Seat of Hon. John R. McLean." *The Ohio Magazine. September 1906*.

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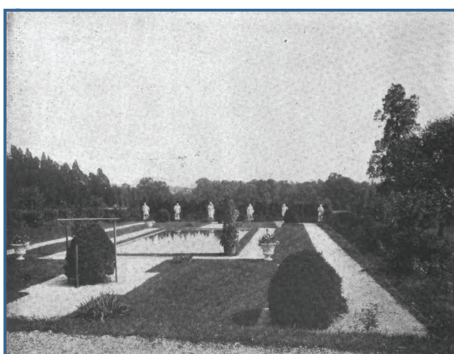
Vegetation – Records indicate that the land on which McLean Gardens is located was a deciduous forest with a diversity of trees from about 1100 BCE to 1700. In 1713, Charles Calvert granted to James A. Stoddert and Colonel Thomas Addison land named Friendship to honor their relationship. Colonel Addison took the southern portion (about 1,600 acres), which extended from Fessenden Street to as far south as today's Van Ness Street and Sidwell Friends School. It is likely that both Stoddert's and Addison's land was heavily wooded and free from major human activity. It is unlikely that Thomas Addison lived on his "Friendship" property.[3-4]

Farming on a relatively modest scale began early in the 18th Century and continued until John Roll McLean purchased the land in 1898. Most of the land seems to have been left forested, but some was probably used to grow tobacco (mainly 1760-1840), corn, orchards, and gardens. There is also evidence for pasture land for cows and pigs. The land was sparsely populated, with an original English brick home built in ca. 1800 and supplemented in later years with outbuildings for housing farm workers (surely some slaves) and animals. This house was added on to and renovated several times before Georgetown College purchased the estate in 1847 and converted the house into an ecclesiastical retreat known as the Villa. The Villa building later became the core of the new McLean Friendship mansion. [3-4]

1898 * 1941-42 * 1979-82
Reshaping of Land Surfaces, Soil, and Vegetation
In Three Phases


THE ITALIAN GARDEN AT FRIENDSHIP.

Google Digital Books (7)

The McLean Estate — Significant alteration of the vegetation occurred after John R. McLean purchased the Villa property that included a mansion and 60 acres of woodland and 40 additional acres of nearby property to create his "Friendship" Estate in 1898. During his ownership, McLean probably removed trees and moved soil to expand the mansion to add other buildings, tennis courts, gardens,

3-4. Judith Beck Helm. 1981. *Tenleytown, Country Village into City Neighborhood.* Rockville, MD. Tennally Press.

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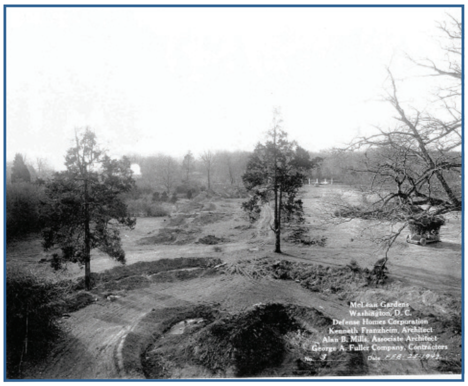

a nine hole golf course, and to construct roads on the estate. There is no historical evidence that new soils were introduced.[3-5]

War Housing Construction — Significant changes were introduced when the property was first developed as the McLean Gardens apartment complex in 1941-42. The photographs at the left document how the building of apartments, roads, and other features in that period moved soil and altered vegetation to reshape the contours of the land. It is likely that fill of unknown origin was added and mixed with the existing soil. The use of heavy equipment on the site would have resulted in compacted soils throughout the property.

Condominium Conversion — In 1979-82, the apartment complex was converted to condominiums. Post-conversion engineering drawings from 1983 indicate that disturbances to the land during conversion included digging trenches to install connections for downspouts to the city's stormwater system, creation of dry wells (excavated pits designed to receive stormwater), and installation of the original water supply pipes for the HVAC systems.[3-6] The swimming pool, which was constructed as part of the conversion, altered the land between it and Building 13.

Since 1982 and continuing through today, the soils have been further disturbed and compacted due to various projects such as installing water proofing materials on some buildings, replacement of HVAC water supply pipes, and sewer lines. Utility and cable companies have also disturbed and compacted the soil.

3-5. Conrad Wilson. 1906. "Ohio at Washington: 'Friendship', the Country Seat of Hon. John R. McLean." *The Ohio Magazine. September 1906*.
3-6. 1983 Engineering drawings of the McLean Gardens site are available in the condominium office.

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McLean Gardens Today

Land Surfaces — While today's elevations are close to those found in colonial times, the current hills, slopes, and flat surfaces were created during the construction of buildings, parking lots, sidewalks, and roads in 1941-42. More than 75% of the property has moderate to steep slopes which are key factors in determining where and how fast water flows during rain events.

Slope Behind Building 21

Hydrology and Soil Conditions – Investigators conducted an evaluation of current hydrology and soil conditions between September and November 2010 to:

- Gain a better understanding of the current movement of stormwater on the property as a whole.
- Determine whether current soil conditions facilitate or impede stormwater infiltration into the soil.[3-7]

Evaluation Results

- Hydrology: Water Movement and Distribution – There are no natural water courses on the McLean Gardens property. The nearest stream is Foundry Creek, in Glover Archbold Park, which drains into the Potomac River. The behavior of water that precipitates onto the property is regulated by the impervious structures, the artificial water drainage and storage structures, the existing vegetation, and the soils.

3-7. NRCS Urban Soil Primer, page 22-23 -- "The movement of water into a soil depends heavily on soil texture, soil structure, slope, bulk density, compaction, surface loading, and vegetation…more water moves into the soil on natural landscapes than on disturbed landscapes such as those in urban areas disturbed landscapes …More water runs off urban areas because of the impervious nature of pavement, compacted soil layers, and urban buildings. "

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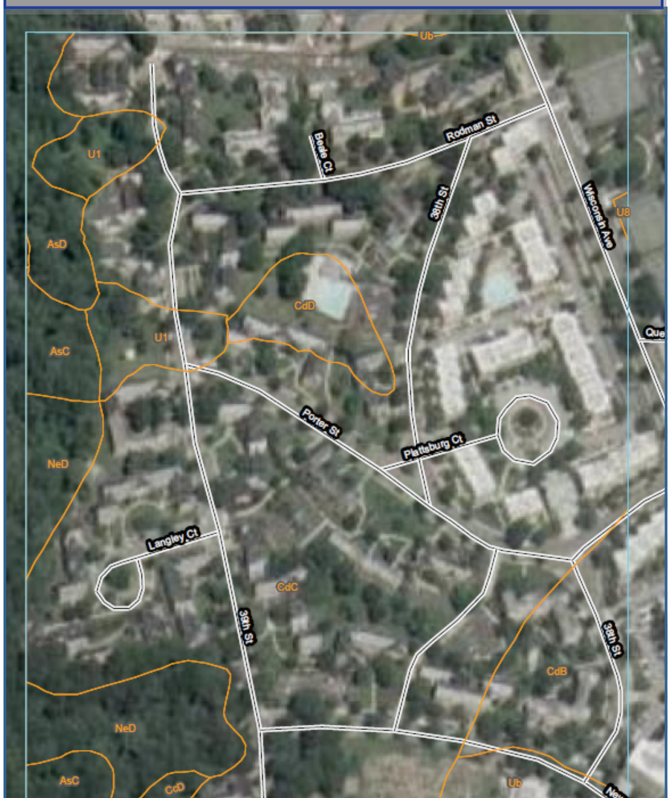
Soils – The soils found on the property today are derived from a mix of the original marine formations and human activity.

NRCS Soil Map of McLean Gardens*



Soil Identifier and Description

AsC Ashe loam, 8 to 15 percent slopes
AsD Ashe loam, 15 to 40 percent slopes
CcD Chillum silt loam, 15 to 40 percent slopes
CdB Chillum-Urban land complex,0 to 8 percent slopes
CdC Chillum-Urban land , 15 to 40 percent slopes
NeD Neshaminy silt loam,15 to 40 percent slopes
U1 Udorthents
U8 Udorthents, sandy, smoothed
Ub Urban land

* The above photo and chart are to illustrate the type of information that the NRCS Soil Report contains.. See Appendix 3.2 for the full report.

Over 85 percent of the soil on McLean Gardens' property is a known as Chillum-Urban land complex (Cd). Cd soil consists of 40% Chillum and similar soil, 40% urban land (Ub), and 20% minor components. Some of the minor components are closely associated with Chillum soils.

- **Cd soils** are silty, derived from wind borne particles, developed under mixed hardwood forests (mostly oaks), well drained, and underlain by marine sediments. Clay is present at 12 to 24 inches below the surface.
- **Ub soils** are ones that have been modified by disturbance of the natural layers with additions of fill material to accommodate large housing installations and related works, such as pipe replacements and demolitions. Urban soils have been disturbed and paved or built upon.[3-8] See Appendix 3.1 for a comprehensive description of McLean Gardens' land characteristics, including soil.

3-8. National Resources Conservation Services (NRCS) Custom Soil Survey, December 2009. NRCS is part of the United States Department of Agriculture and the tool for developing the customized survey for McLean Gardens and Contiguous Areas was created at http://websoilsurvey.nrcs.usda.gov/app/Websoilsurve.aspx.

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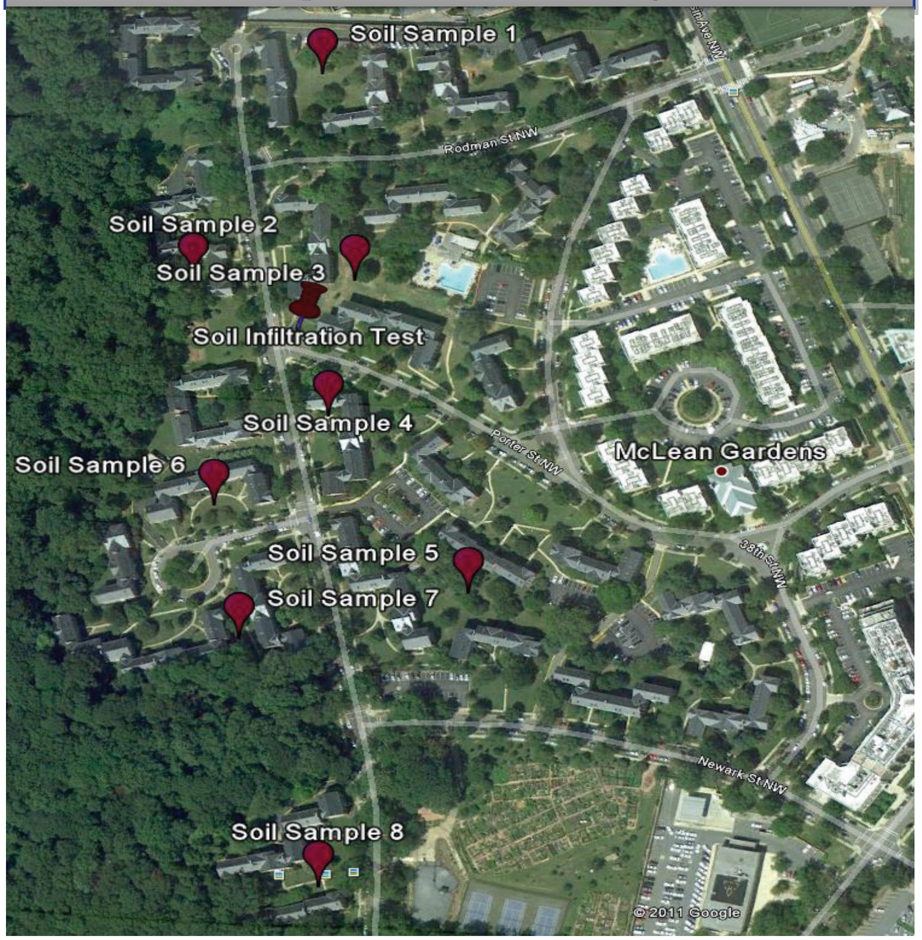
Soil Conditions: Sponges or Concrete –Today's soils, as described on the previous two pages, have the potential to act either like sponges, soaking up stormwater and limiting runoff or like concrete, repelling stormwater and increasing runoff.[3-8] Investigators conducted soil analysis at eight sites to determine potential for absorbing stormwater.[3-9] They conducted an infiltration test to determine the capacity of the soil to absorb or repel stormwater. Summary Results are found on the next page.

Soil Sample and Infiltration Testing Sites



3-8. NRCS Urban Soil Primer, page 20 and USDA NRCS "Urban Hydrology for Small Watersheds."

3-9. The eight sites correspond to the eight groupings of buildings used to organize and collect data for the baseline assessment of sources.

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Summary Soil and Infiltration Test Results

- **Potential to Absorb Stormwater —** A and L Eastern Laboratory analyzed the samples to determine acidity (measured by pH) as well as mineral composition and organic matter content. While the laboratory returned a complete soil analysis for each site, only one of the analyses, the Cation Exchange Capacity (CEC)[3-11], provides information that aids in understanding whether or not the tested soils have the potential to store water during a significant rainfall.[3-12] The results of the tests indicate that ***if the soils at McLean Gardens were not compacted, they have potential to hold and drain water***. Detailed information about sampling protocols and laboratory results are in Appendix 3.3.

Soil Sample

- **Water Infiltration Rate** – Investigators selected a single worst case site to determine the speed at which water enters the soil.[3-13] This site is severely compacted as a result of HVAC construction between fall 2009 and spring 2010 and is located at the bottom of a steep valley which channels water during rain events. The investigators expected a low infiltration rate given the site conditions, and indeed, found that very little if any water infiltrates the soil at this location. Details may be found in Appendix 3.4

Infiltration Test Result

These tests confirmed what the observations of other characteristics at this site had indicated – ***stormwater moves through this area and is not absorbed by the soil.***

3-11. http://extension.unh.edu/resources/representation/Resource000496_Rep518.pdf
3-12. DDOE Rebecca Stack Lecture September 8, 2010, 1.2 inches over 24 hours where no rain has occurred during prior three days.
3-13. NRCS Soil Quality Information Sheet, "Soil Quality Indicators: Infiltration." January 1998.

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Soil Restoration Potential

Based on the information from the soil infiltration testing, the investigators conducted preliminary research to determine if there were any techniques or specifications for restoring compacted soil. This research revealed the following sources of information to assist in developing approaches for restoring compacted soil to a more permeable state:

- "Up By the Roots — Healthy Soils and Trees in the Built Environment" (2008).[3-14]
- "Pennsylvania Stormwater Best Management Practices Manual 6.7.3 Soil Amendment and Restoration" (December 30, 2006).[3-15]
- "Virginia DCR Stormwater Design Specifications No. 4 Soil Compost Amendment Version 1.7" (2010).[3-16]

All three sources indicated that by using subsoiling, ripping (a form of deep plowing to breakup soil and reduce runoff), and scarification (removing surface soil with machinery such as a backhoe to prepare a site for planting) techniques, and amending the existing soil with organic material such as compost, compacted soils can be restored. See Appendix 3.5 for draft specifications that could be applied to soil management for construction projects at McLean Gardens.

3-14. James Urban. 2008. "Up By the Roots — Healthy Soils and Trees in the Built Environment." International Society of Arboriculture. Champagne, Illinois.

3-15. Pennsylvania Stormwater Best Management Practices Manual *6.7.3 Soil Amendment and Restoration* (http://www.stormwaterpa.org/assets/media/BMP_manual/07_Chapter_6.pdf).

3-16. Virginia DCR Stormwater Design Specification No. 4 *Soil Compost Amendment* Version 1.7; 2010 **(http://www.chesapeakestormwater.net/all-things-stormwater/soil-compost-amendments.html).**

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Vegetation – Investigators determined the characteristics that allow vegetation (trees, shrubs, grasses, annuals, perennials, and turf grass) to reduce runoff. However, rather than conduct an in-depth evaluation of the vegetative cover on the property, they relied on the results of the 2009 assessment of vegetation conducted in conjunction with Casey Trees, and on field observations to provide the assessment described below.

- *Role of Vegetation in Reducing Runoff* – Vegetation has the capacity to reduce runoff by attenuating the effects of rainfall and redistributing the flow of precipitation as it reaches the ground.[3-17] Vegetation does this by:
  - Intercepting rainfall.
  - Making soil that absorbs water.
  - Creating channels in the ground that allow water to penetrate the soil.

  These three actions allow water to percolate slowly into groundwater without running on the surface. In addition, during the growing season, vegetation slowly uses the water that is retained in the soil, releasing it into the atmosphere, and making room in the soil to retain new precipitation. The release of the moisture into the air by vegetation tends to cool the surrounding air. Vegetation also provides for a water absorptive layer on the ground that results from the accumulation of fallen leaves, twigs, seeds, branches, and trunks. These organic materials improve the quality and depth of soils. Over time, a thick water absorbing layer of organic material can form on the ground.

Mixed Vegetation

The tree canopy attenuates the effects of the rainfall. As rainfall reaches the ground, the leaves and branches

3-17. While all plants have capacity, their ability to reduce runoff depends on such factors as the depth and extent of their root system, the size and structure of their leaves, and their seasonality.

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of plants intercept the water and keep the water from impacting the soil directly and dislodging soil particles. The leaves retain a large amount of water and can completely keep it from reaching the ground. For example, during summer showers the area directly under a tree may not get wet at all; this is because the tree's leaves retain the rainfall. Additional rainfall can result in water reaching the ground, but this will be with much less force than if it were to fall directly onto the soil. In addition to the canopy of leaves and branches, the tree's roots spread as the tree grows, loosening the soil for water to penetrate.

Two Trees

Other vegetation has similar effects. Leaves on shrubs, ornamental grasses, annuals, perennials, and turf grass catch rainfall but smaller volumes of it. In addition, perennial plant roots channel into the ground, loosening it and, as old roots die and new ones are formed, leave space for water to penetrate the soil. The deeper the roots reach and the longer they have been penetrating the soil, the more water retention capacity will be created in the soil. Some shrubs and grasses (mostly natives) have deep root systems that have a greater effect on soil water retention than the short roots of other plants, such as non-native turf grasses like fescue.

<u>2009 Vegetation Inventory and Assessment Summary</u>

In May 2009, McLean Gardens, working with Casey Trees, inventoried and evaluated the trees, shrubs, and hedges planted on the property. The inventory also collected data on the location and extent of garden areas throughout the property.[3-18]

3-18. http://www.caseytrees.org/geographic/tree-inventory/map/js/McLean.php

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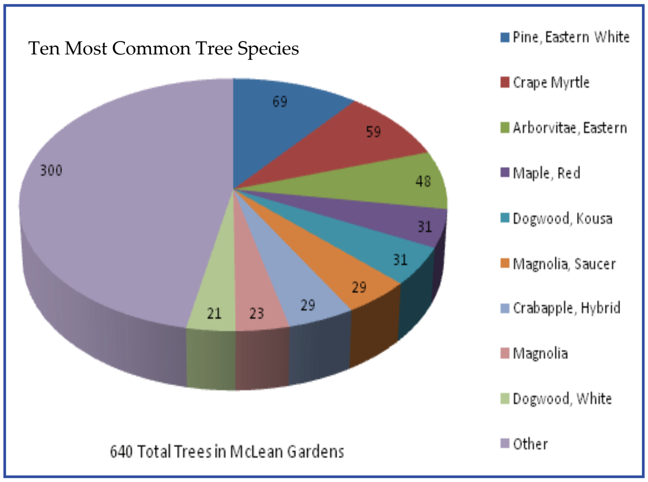
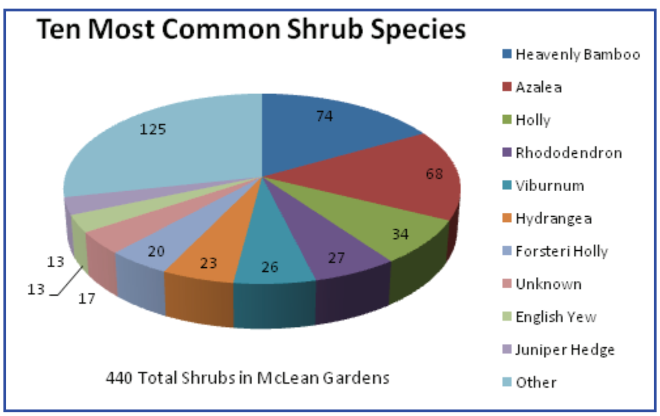
✼ Trees – The inventory identified 640 trees, which equates to a tree canopy of 35 percent, the same as the city-wide canopy. This is considered reasonably good for cities east of the Mississippi. The inventory identified 90 tree species among the 640 trees, with more than 55 percent of the trees concentrated in 10 species. The tree population has a healthy distribution of new and old trees and almost 90 percent of the trees are in good condition. Eastern White Pine is the predominant species for those in poor condition.



✼ Shrubs and Hedges – The inventory identified over 400 shrubs and 270 hedges through-out the property. Most shrubs and hedges are not native to the to the United States. Heavenly Bamboo along with non-native holly, juniper, and yews are the predominant plants used as shrubs and hedges. These non-native species do not provide the insect food source that would attract Eastern song birds. Liriope, a non-native, is the primary ground cover under trees. English Ivy and Winged Euonymus, alien invasive species, are found throughout the property.



✼ Garden Areas – Ornamental grasses, annuals, and perennials are found in garden areas throughout the property. There was no evaluation of the specific materials planted in each garden area since they are a low percentage of all plantings.

✼ Lawn Area Conditions in 2010 – Turf type plant materials cover between 10 and 13 acres of the property.[3-19] The photos on the following pages illustrate turf conditions as they relate to stormwater.

3-19. Estimate provided by Association Manager.

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Turf is not growing well under trees due to competition for moisture and the absence of full sun.

Erosion is present on slopes. Turf roots are not deep enough to hold the soil.

Seed and soil are washing down the slopes of newly planted areas since the soil is compacted and the grade is too steep.

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Many areas are quite compacted either from heavy equipment used during construction or people walking on them.

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4. STORMWATER MANAGEMENT AT MC LEAN GARDENS: THE DETAILS

This section describes the collaborative research and data gathering activities conducted by seven AU-MG study teams. The purpose of the teams' work was to identify, collect, and analyze some of the basic information and data necessary to develop a *Stormwater Management Framework for McLean Gardens.* Their activities included:

Down Spout Drains on Vegetation

- Field work (180 hours) conducted between mid-September and late-November to:
  - Determine the number and location of current features (e.g., downspouts, storm drains) on the McLean Gardens property that may facilitate or prevent retention of stormwater on site.
  - Observe impacts of stormwater runoff on the property (e.g., soil erosion) and identify some sources of the observable impacts.
  - Measure impervious surfaces (e.g., buildings, walkways, parking lots) to collect the raw data necessary to verify the accuracy of DC-Water's assessment of impervious surface.
  - Verify and update the Casey Tree Inventory.
- Lectures on:
  - The stormwater problem and management solutions facing the District of Columbia.
  - Green roof technology.
  - Remote sensing and geo-spatial tools and geo-referencing tools and techniques.
- Literature searches to identify best practices for managing stormwater onsite and reducing the impacts of stormwater.

The remainder of this section includes:

- A description of the methodology and approach for the research.
- A summary of observations and findings that apply across McLean Gardens.
- Detailed observations, findings, and potential solutions for each of the seven study areas.

4.

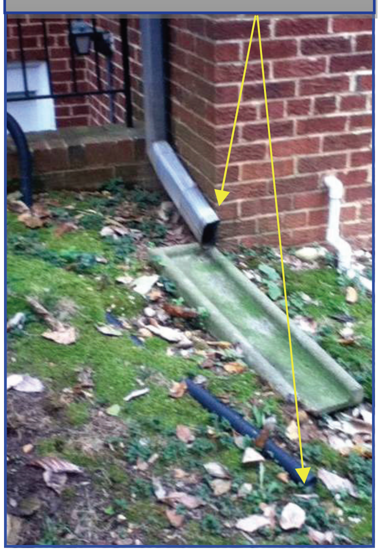
Methodology or Approach

Study Areas – The property was divided into seven study areas with three to six buildings in each area. Appendix 4.1 provides a list of study areas and locations. Investigators working in teams of two to three members made several visits to the property to:

Study Team Areas

- Measure each building's footprint, sidewalks, parking lots, and the pool area.
- Locate individual downspouts for each building and determine their latitude and longitude.
- Locate and determine the latitude and longitude for other features in some of the study area.
- Locate and determine the latitude and longitude for trees.
- Look for impacts of stormwater, such as erosion.
- Observe general characteristic of the land surface with potential to influence how stormwater is managed on the property.

Water From Pump and Downspout Drains to Driveway



Tools – The investigators employed a variety of tools in their work, including:

- 100-meter tape measure to determine building dimensions.
- Rolling distance measuring wheel to determine sidewalk and parking lot dimensions.
- Post conversion engineering drawings of all MG buildings with details of significant features, including the pipes to convey rain water and snow melt from the downspouts to the city stormwater system, dry wells (excavated pits designed to receive stormwater).

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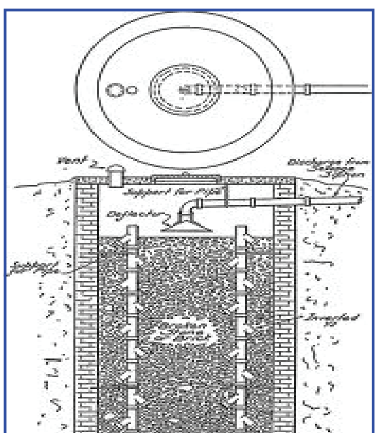
designed to capture water, and pipes from parking lots that convey water into the city stormwater system.

- Global positioning system (GPS) unit to determine the location of all downspouts, storm drains, and trees.
- Google Earth to present data on the location of downspouts.
- Maps with satellite images of buildings and other physical features (e.g., sidewalks) and digital symbols denoting tree locations and names provided by the Casey Trees Foundation (from the May 2009 inventory).

Investigator in the Field

Summary of Results

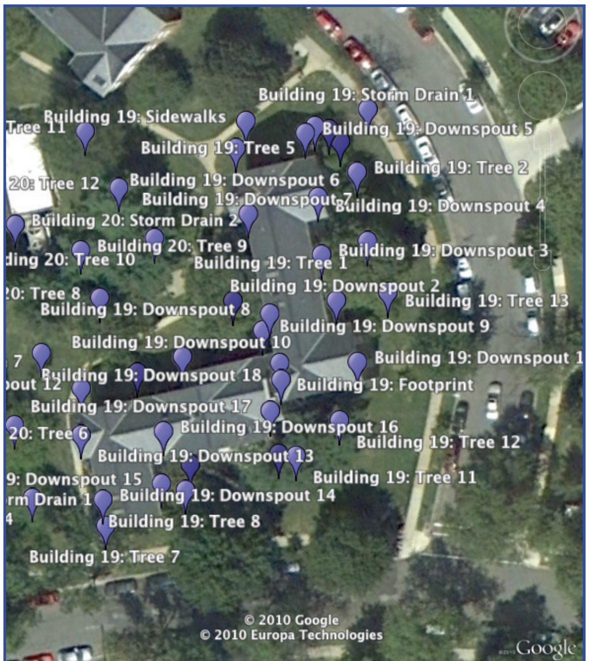
- Key Features Inventory — The stormwater (rain water and snow melt) collection systems at McLean Gardens consists mainly of the gutters and downspouts on each building and dry wells (excavated pits designed to receive stormwater) located throughout the property. This collection system (according to the post conversion engineering drawings) transports the water through pipes to the City's stormwater system. Drains in parking lots also capture and transport stormwater directly into the City's stormwater system. The City's drains on the street capture stormwater that runs off the McLean Gardens property and move it to the City's stormwater system (a series of underground pipes) that runs through Glover Archbold Park and empties untreated into the Potomac River north of Georgetown. The investigators were asked to locate and document key features of the stormwater collection system. They were also asked to locate and document manhole covers and electrical boxes. The investigative teams visited the site an average of four times per study area and spent 102 hours (or almost



Dry Well Diagram
historycooperative.org

three work weeks) collecting and geo-referencing (determining latitude and longitude) the location of downspouts and other features. Investigators used their maps on site to mark the location of downspouts and then determined the latitude and longitude with GPS devices or Google Earth.

While investigators did not locate and document all the requested data, they located and geo-referenced downspouts. As a result, they developed a data set with 517 geo-referenced downspouts that enables mapping of these features on geospatial maps in Google Earth and other geographic information systems. The investigative teams also geo-referenced the location of dry wells, manhole covers, and electrical boxes for buildings 1 -22. The Google Earth image to the left is a sample display of geo-referenced downspouts and other features for a single building.



Geo-referenced Data

Investigators tested a variety of GPS devices in their collection of features data. They evaluated the accuracy of their GPS tool against measured distances on the buildings. The results showed that some of the GPS tools were spot-on accurate and others were not. Most teams calibrated their field results with Google Earth. The resulting geo-referenced data sets from this study do not always show the precise location of each downspout. However, the data are valuable as a starting point for future work.

✼ Impervious Surface Area Assessment — Impervious surfaces as defined by DC-Water for the McLean Gardens property include building roofs, sidewalks, parking lots, and the swimming pool. Using satellite imagery, DC-Water measured the square footage of the surfaces. DC-Water estimates that MG has 388,500 square feet of impervious surface. The resulting measures are used to assess two monthly fees – an impervious area charge and stormwater charge. The fees collected from the impervious area charge go to DC-Water to pay

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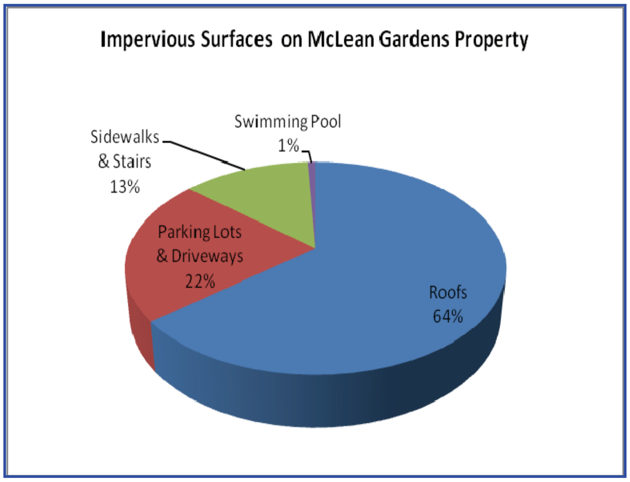
for upgrades to the City's stormwater systems. The fees from the stormwater charge go to the District Department of the Environment to provide incentives for property owners to reduce the amount of water that runs off their property. The combined fees associated with stormwater currently cost MG an estimated $28,000 per year and are estimated to cost over $123,000 per year by 2018. [4-1]



The investigators were asked to determine if DC-Water's assessment of impervious areas on the McLean Gardens property is accurate. The investigators used several methods and tools to measure buildings, parking lots, sidewalks, and the pool area. Creating measurements of these areas was tedious and time consuming no matter which tool or combination of tools investigators used. For building measurements, for example, the rolling measuring tool was difficult to use through the shrubs and plantings that are found next to buildings. In addition, many of the buildings are not rectangles but a series of connected rectangles. This meant measuring each rectangle, calculating its square footage and then summing up the results for each to reach the total square footage for the building. The most accurate measurements were found by measuring the building perimeters on the post-construction engineering drawings (since there are no measurements on them) and Google Earth images. The sidewalks posed other challenges given the irregular shapes and the great number and considerable length of the sidewalks. The most accurate tool was the rolling measure. However, no matter how accurate the measure, the irregularity of the shapes made calculating the square footage difficult. The most accurate method for calculating square footage of sidewalks is to assume a constant width and measure the length. The

4-1. Current estimate is based on November 2010 Water Bill. The 2018 estimate is based on data in DC-Water's May 2010 Rate Presentation materials.

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resulting calculations were supported by DC-Water's data as well as calculations of area by Google Earth

The results as presented in Chart 1 show that the investigators' independent measurements are one percent higher than DC-Water's, which was likely caused by measurement error. The chart also shows that the current assessment is based on 388,500 square feet, which is lower than the total of each assessment area.

Chart 1: Impervious Surface	
DC-Water (Square Feet)	388,770.8
Independent Evaluation (Square Feet)	391,818.3
Difference (Percent)	1%

- Tree Inventory Verification —In 2009, Casey Trees in collaboration with McLean Gardens conducted an inventory of trees, shrubs, hedges, and gardens. Casey Trees created a data base with geospatial references that allows for digital display of each tree and shrub on maps based on satellite photographs. They also created geospatial references to display digitally the location of hedges and gardens. Given the limited time to conduct all the field work and investigators' lack of experience in identifying plant materials, the investigators were only asked to verify the original inventory of trees and document any changes.

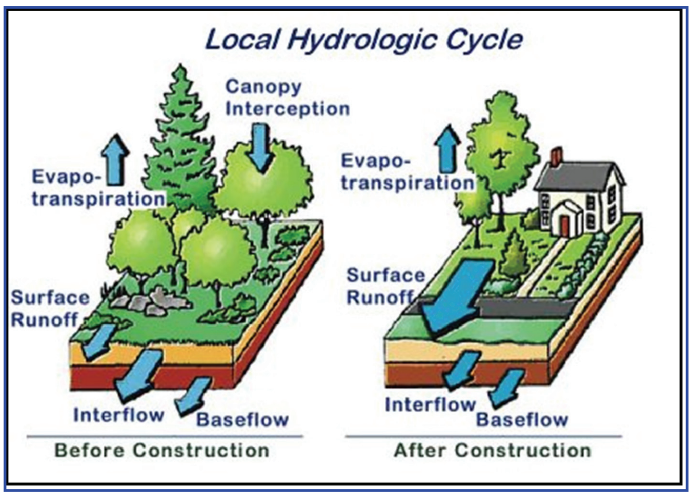
Investigators examined each tree on the property. They used tree guides to determine the species of each tree and verified its diameter, and then determined its latitude and longitude. Most teams encountered no major challenges, were able to determine where trees had been removed or added and found that most trees, their location, and species were already documented on the maps provided by Casey Trees. Study Team 3 encountered problems in identifying trees between buildings 10 and 11 and asked the McLean Gardens project leader to visit the trees. This led to the correction of location and species data for about 10 trees.

4.

Observations, Findings, and Potential Solutions: In Summary

This section summarizes some common observations and findings that appear in most if not all study area reports. It also describes common potential solutions found in the individual study area reports.

- ✼ Common Observations and Findings — The Investigators identified and documented:
  - Slopes that move runoff into the streets or into Glover Archbold Park.
  - Compacted and eroded soil.
  - Buildings surrounded by grass with shrubs planted next to them.
  - Parking lots that promote runoff by collecting and concentrating its movement towards a City storm drain, a hill, or Glover Archbold Park.
  - Trees sometimes dense and sometimes sparse.
- ✼ Potential Solutions for Consideration — Federal and state governments have devised and tested a range of best management practices or approaches for addressing stormwater runoff that can be applied in neighborhood settings like McLean Gardens.[4-2] The design and intent of these approaches is to mimic natural hydrologic functions by creating conditions for onsite capture and percolation of stormwater into the soil (infiltration) or evaporation into the air. The approaches described in this summary for control of stormwater runoff do not provide open water surfaces for mosquitoes to breed. They are also designed to ensure water does not remain on the surface over a long period of time.[4-3]



(4-2) Green Infrastructure -- http://cfpub.epa.gov/npdes/greeninfrastructure/technology.cfm

(4-3) Mosquitoes need liquid surface water to develop. The American Mosquito Control Association, Mosquito Biology at http://www.mosquito.org/mosquito-information/biology.aspx

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The practices described in this summary will be further evaluated in the next phase with respect to their suitability for installation at McLean Gardens.

- Infiltration approaches to capture and temporarily store runoff, percolate it through the soil over several days, and reduce the total volume of runoff. Such approaches include:
  - Infiltration basins – Impoundments created by berms or small dams. They are typically flat-bottomed with no outlet and are designed to temporarily store runoff generated from adjacent drainage areas. Runoff gradually infiltrates through the bed and sides of the basin.
  - Infiltration trenches – Shallow (2- to 10-feet deep) excavated ditches with relatively permeable soils that have been backfilled with stone to form an underground reservoir. The trench surface can be covered with a grating or can consist of stone, sand, or a grass covered area with a surface inlet. Runoff diverted into the trench gradually infiltrates into the subsoil and, eventually, into the ground water.
- Pervious or porous pavements – Similar to traditional pavement but allow rainfall and runoff to percolate through it. There are two types of pervious pavement, porous asphalt and pervious concrete.
- Vegetated open channel practices or vegetated swales to capture and treat runoff through infiltration, filtration, or temporary storage. They serve as alternatives to curb and gutter systems that use grasses or other vegetation to reduce runoff velocity and allow filtration. Filtering practices to capture and temporarily store runoff and pass it through a filter bed of sand, organic matter, soil, or other media. Filtered runoff may be collected and returned to the City stormwater system, or allowed to percolate into the soil. Such practices include:
  - Filter strips are landscape features within parking lots or other areas that collect flows from

large impervious surfaces. They may direct water into vegetated quantity detention areas or special sand filters that capture pollutants and gradually discharge water over a period of time.

- Bio-retention cells or rain gardens -- typically consist of grass buffers, sand beds, a ponding area for excess runoff storage, organic layers, planting soil and vegetation. Their purpose is to provide a storage area, away from buildings and roadways, where stormwater collects and filters into the soil. Rain gardens, properly engineered and constructed, absorb the water and do not provide free water surfaces. Water that is not absorbed within a few hours runs off. (Rain gardens are not recommended for flat surfaces; there must be some slope to allow excess water to drain.)
- Retention practices to capture runoff, which is subsequently withdrawn or evaporated. Such practices include rain barrels, green roofs, and cisterns. Rain barrels can provide free water surfaces, but a properly installed and maintained rain barrel will not allow mosquito access to deposit the eggs in the first place. Rain barrels are sealed and covered so that mosquitoes cannot enter or exit.

- Soil rehabilitation, increased native vegetation, and tree planting contribute to the reduction of runoff. Vegetation intercepts rainfall, decreases runoff velocity by increasing surface roughness, and promotes infiltration. Establishing vegetated areas in strategic locations that currently receive runoff from impervious areas requires minimal effort, especially when native plant species are used. Repeat compaction of these areas by heavy equipment should be avoided in the future.

- Plant trees to attenuate rain fall, increase absorption of water, and maintain existing canopy.

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Observations, Findings, and Potential Solutions By Study Area

Each study team took a slightly different approach to communicating their observations and findings. Some provided written descriptions, others provided photographs, and some provided both. The study teams also proposed short and long term solutions for reducing stormwater runoff. Short-term solutions are those that can be implemented immediately, with little cost and planning. Long-term solutions come with greater cost and planning; therefore the variety of solutions that can be implemented is more diverse than in the short-term. (Appendix 4.2: A compact disk containing Team Reports, Presentations, and Data Collections for each Study area.)

Study Team 1 (Buildings 1-4: 3801 to 3895 Rodman and 3801 to 3821 39th)

- Observations and Findings
  - Characteristics of Land – Grounds surrounding the buildings slope downward toward the street at a steep angle. Each building is surrounded by a significant area of grass landscaping with a relatively small number of trees. The buildings are closely bordered by trees and shrubs.
  - Overall – Each building has areas of significant erosion located downhill from down spouts. The eroded areas often lacked grass and the ground was very hard and dry. The buildings, which are uphill from the street allow runoff to flow directly into the street and down a storm drain. The parking lot (located at the top of the slope lot behind buildings 2-3 and allows stormwater to flow downhill towards the buildings and street. Numerous walkways connecting the buildings to the parking lot, the street sidewalk, and other buildings are impervious and facilitate stormwater towards the street.

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Image 1-1
Parking Lot E

- Potential Solutions to Reduce Stormwater Runoff
  - Short-term (building specific)
    - *Building 1*- Install rain barrels to reduce the amount of runoff that is flowing downhill directly from the down spouts to the street below. Install vegetated filter strips along the back of the building, at the base of the gentle slope, to increase absorption of runoff flowing down the hill towards the building.
    - *Building 2*- Install rain barrels to reduce the amount of runoff from the building's significant slope and number of down spouts. Install vegetated filter strips around the downhill facing side of the Parking Lot E to capture runoff from this large impervious surface and prevent water accumulation at the base of the slope.
    - *Building 3*- Install rain barrels to reduce the amount of runoff from the building's significant slope and number of down spouts. Use of vegetated filter strip along parking lot edge to increase runoff absorption.
  - *Building 4*- Install rain barrels to reduce the amount of runoff from the building's significant slope and number of down spouts. Long-term – The potential mitigation options for all four buildings are similar.
    - Transition landscaping from traditional grass cover to native landscaping, specifically along the sloped areas, in order to enable greater absorption of runoff by both the groundcover and plant species.
    - Locate rain gardens at the base of the slopes, along the edge of the sidewalk to allow water flowing downhill to be trapped and percolate back into the natural environment rather than flow directly onto the street and down a storm drain.
    - Replace current impervious walkways with pervious pavement.

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– Install a green roof on the small utility building located behind building 3. This building is located at the top of a steep slope, and installing a small green roof would be economically feasible and decrease the amount of runoff flowing downhill and towards the street.

Study Team 2 (Buildings 5-9: 3700 to 3850 39th and 3701 to 3741 39th)

✼ Observations and Findings

Image 2-1
Gravel covers a heavily eroded runoff channel in front of Building 6

- Characteristics of Land – Grounds surrounding the buildings have steep slopes, and heavily impacted soil and turf. Each building is surrounded by some turf grass landscaping with a relatively small number of trees. The buildings are closely bordered by trees and shrubs.
- Buildings 5 and 6 are built at the bottom of a heavily downward slope with large trees and shrubs in a courtyard type setting. Buildings 7 and 8 are built on a downward slope much less severe than that of 5 and 6 with shrubs planted in the front.
- Building 9 is built on a plateau carved into the hillside. The building front is uphill from 39th Street on a very steep slope with shrubs and trees planted immediately in front of the building and turf grass planted on the slope in the front and back.
- Buildings 5 and 6 – The land slopes from the street towards the buildings. A roadway from the street gradually leads to a parking lot. Large patches of turf grass have been eroded away on the downward grade, and runoff patterns are obvious. Some mitigation efforts, such as covering affected areas with gravel, have already been undertaken, and this can be seen in Image 1-1 to the left.

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- Parking Lot – All stormwater drained into the parking lot adjacent to Building 5 (either from direct rainfall or from the pitched roof of Building 5 diverted through downspouts) runs off to a single curb cut. This curb cut is enhanced with a concrete downspout that is estimated at 10 feet in length (direct measurement was not possible). The curb cut leads to forested land owned by the National Park Service. However, the downspout is completely covered with brush and debris, and appears to be ineffective at allowing all water to drain from the parking lot. Furthermore, the area beneath the downspout appears to be heavily compacted clay with little ability for water infiltration. This can be seen in Image 2-2 to the left.

Image 2-2
Poorly maintained curb cut on the parking lot adjacent to Building 5

- Buildings 7and 8 suffer from much less erosion. Minor erosion of the turf occurs in some areas. The parking lot adjacent to Building 7, however, lacked a curb cut or any other form of drainage, posing a significant problem for a relatively large impermeable area.
- Building 9 -- A four-foot vertical retaining wall separates the grass turf from the sidewalk that borders the site. It appears that grass at the margin of the retaining wall is often replanted due to either constant runoff or water pooling that drowns the plants.

❇ Potential Solutions to Reduce Stormwater Runoff

- Short-term – Install rain barrels to supplement downspouts. Rain barrels operate from gravity flow alone and therefore can be implemented at a low cost with an immediate impact. For small precipitation events, peak runoff flow rates will be delayed and potentially reduced. They will be especially useful beneath downspouts that empty onto asphalt, such as the parking lots on Buildings 5 and 7,

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or on compacted clay such as on the west side of the buildings facing National Park Service land. The rain-water collected in these barrels can be used for non-potable applications such as lawn and garden watering by attaching a hose..

- Long-term
  - Install permeable pavement – This porous alternative to asphalt and concrete allows stormwater to drain through it and collect in a stone reservoir underneath the pavement. This allows the runoff to slowly infiltrate into the subsoil. The appearance and function of paved areas will not change, but this will re-classify them as permeable surfaces and will no longer be subject to the Impervious Area Charge.
  - Eliminate Curbs and install a vegetated swale around the parking lots. This will be particularly beneficial to the parking lot adjacent to Building 7. Parking lots without curbs allow rain water to form a sheet flow directed into a vegetated swale or vegetated filter strip. The bioretention that these alternatives provide will help to prevent erosion surrounding the parking lot, such as has occurred around the single curb cut on Building 5.
  - Install vegetated filter strips – Dense vegetation should be at the bottom of the westward slopes on Buildings 5-8. They will help to eliminate the erosion that is occurring at the bottom of the slopes.
  - Install bioretention cell/rain garden on the more extreme slopes where runoff is too channelized and concentrated for the vegetated filter strips to be effective. These will also be more effective where the soil is primarily impacted clay, due to the presence of an underground drain that encourages filtration and infiltration. While they may cost more than the vegetated filter strips, they will also be more effective.

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– Install infiltration trenches around the gravel-filled areas surrounding Buildings 5 and 6 (see Image 2-2). These rock filled ditches will help to collect runoff during precipitation events and slowly release it into surrounding soil.

Study Team 3 (Buildings 10-13: 3850 to 3870 Rodman, 3600 to 3690 38th, and 3851 to 3891 Porter)

- Observations and Findings
  - Characteristics of Land – The dominant features of this area are the intense slopes, eroded green space, unused green space, and large seasonal impervious surface areas. Steep slopes were found in every grid assessed. Behind Building 10, there is a drastic slope between the south wall of the pool and the north side of Building 13. The slope behind Building 13 is divided by rock berms installed post HVAC construction to reduce the flow of water down the hill. In front of Building 11, a hill to the east dips downward and creates a ditch adjacent to the intersection of Rodman and 38th Street. Buildings 12 and 13 contain slopes adjacent to the front sides of their respective buildings – the hills decline towards Porter Street, creating potential for significant amounts of runoff. The grass itself showed signs of chronic erosion.
  - General – The areas around Buildings 10-13 have large amounts of eroded and unused green space. Each slope on the property is virtually unused by the residents for recreation or aesthetic value. These slopes are also seriously eroded, with significant amounts of dirt and rock visible. This area contains two impervious surfaces that are typically only used during the summer months — the community swimming pool and picnic area

Image 3-1

Erosion on Slope Behind Building 13

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behind Buildings 10 and 11. It also contains a large parking lot adjacent to the pool. These two areas are the only two major impervious surfaces that were not residential buildings.

- Potential Solutions to Reduce Stormwater Runoff
  - Short-term
    - – Install vegetation filter strips. There are steep and moderated slopes throughout this area. Such an installation would improve the use of the existing green space much of which is not suitable for lawn or recreation. They would also reduce the intense erosion. The existing berms behind Building 13 are a good initial attempt to reduce water flow. However, replacing the berms with vegetation filter strips or rain gardens that could significantly slow runoff and at the same time add an aesthetic appeal to the area.
    - – Install rain barrels to some, if not all, of the downspouts on each of the buildings. Rain barrels would work well in this area. Many of the downspouts are already hidden behind vegetation which would serve to also hide the rain barrel from the public. The rain barrels collect water for reuse in gardens which would lower water bills and usage of city water. They also decrease runoff after a storm.

Image 3-2
Rain Barrel Installation on Existing Down Spouts
(Image from aquabarrel.com)

  - Long-term -- Implement green parking technologies for the pool parking lot by installing a swale or bio-retention area on the edge of Parking Lot C that lines the pool. The current border of the parking lot only assists in tunneling the stormwater runoff from the parking lot into the drain at the very bottom of the slope. A swale or bioretention area consists of vegetation used to decelerate the progression of water. Vegetation already exists in this area and if the curb was broken down to release

4.

Image 3-3 and 3-4
Current Drainage in Parking Lot C

- runoff into this vegetated area, there would be less runoff draining into the sewage system.

Study Team 4 (Buildings 14-18: 3601 to 3641 39th, 3830 to 3890 Porter, and 3440 to 3450 38th)

✼ Observations and Findings

- Characteristics of Land

– Building 14 – The land is fairly flat with steep sloping sides and includes undeveloped landscaped areas. Construction activity is present on the site.

– Building 15 – The land slopes along building sides and erosion is noted around curbs.

– Building 16 – The land has a steep slope behind building with noticeable erosion. Construction activity is present on the site. A small parking lot is present behind the building.

– Building 17 – The land slopes around sides of the building and has a large open field.

– Building 18 – The land slopes around sides of building and contains a garden area with stepping stones. There is major construction activity behind the building.

✼ Potential Solutions to Reduce Stormwater Runoff

- Short-term – Increase the permeable surfaces on the property through such practices as infiltration trenches, stormwater planters, small rain gardens and better developments in landscaping around the buildings.
    - Infiltration trenches are rock filled ditches with no outlets, collecting stormwater runoff and releasing it into the surrounding soil by infiltration, or penetration into soil. These trenches can easily be put into place where there is a significant slope or can be engineered in

4.

Image 4-1

Potential Rain Garden Site

any land area by adding a rock filled ditch, ultimately attracting stormwater, which can also be put into place in areas where slopes connect to a central low point, as in Buildings 16 and 17. Stormwater planters are small landscaped planters placed above or below ground, designed for infiltration practices. Soil infiltration and biogeochemical processes decrease stormwater runoff quantity and improve water quality, similar to rain gardens and green roofs but on a smaller scale.

- Long-term approaches require more construction and engineering but could yield sustainable long-term success. Alterations such as installing green pavements, bio-retention areas, and green roofs are some examples of techniques that will produce long-term benefits.

– Eliminating curbs can increase sheet flow and reduce the amount of fast flowing stormwater into drains. Maintaining sheet flow by eliminating curbs and gutters and directing runoff into vegetated swales, grassy areas, or bio-retention basins help to prevent erosion. This can be put into places in areas with parking lots such as those found behind Buildings 17 and 18, driveways, and curbed sidewalks.

– Greening the parking lot using one of several techniques that reduce the total impervious surface area. Also, using alternative pavements such as those that allow for drainage, and adding bio-retention area or rain gardens on medians or edges such as Parking Lot D will help reduce the amount of stormwater runoff and possibly decrease the impervious area.

– Using alternative pavements, or pavement that is permeable and allows for some drainage. Alternatives to concrete and

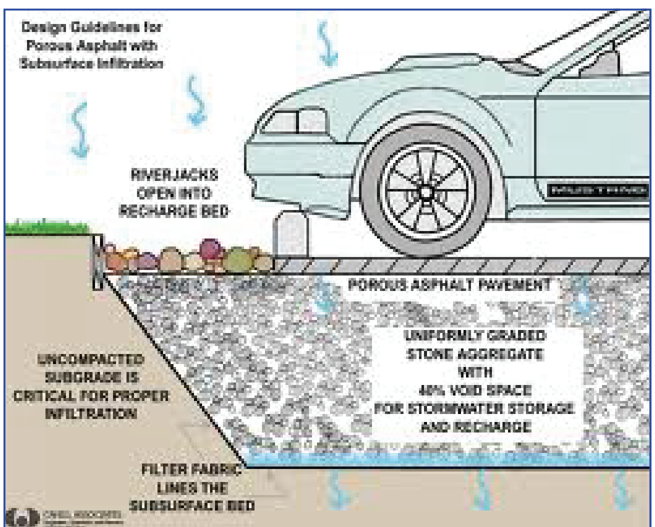

Image 4-2

Permeable Pavement

horsleywitten.com

4.

asphalt such permeable pavements allow stormwater to drain through porous surface to a stone reservoir underneath, temporarily storing surface runoff before infiltrating it into the soil below. These practices would be best for large parking lots and cemented areas. Plot 16 hosts a large parking lot that along with other management practices could be turned into a green, eco-friendly parking lot.

Study Team 5 (Buildings 19-22: 3410 to 3420 38th, 3801 to 3891 Newark, and 3501 to 3551 39th)

Image 5-1
Construction Activity

✼ Observations

- Overall – The land has a gentle downward slope from building 19 toward building 22
- Buildings 22 and 21 sit at the bottom of steeper hills.
- Building 19 – The land is flat with some visible erosion. Construction activity is present on the site.
- Building 20– The land is flat and sits lower than building 19 with some visible erosion. Construction activity is present on the site.
- Building 21– The land has slight incline away from building with minimal erosion. Construction activity is present on the site.
- Building 22– building built into a rolling hill and is the lowest sitting of the buildings in this area. It also has minimal erosion. Construction activity is present on the site.

✼ Potential Solutions to Reduce Stormwater Runoff

- Begin replacing asphalt parking lots and sidewalks with permeable pavement. Permeable pavement allows water to pass through and reach the soil, unlike traditional solid asphalt.
- Create rain gardens at low points
- Use rain barrels
- Install green roofs on the A and B power plants.

4.

Study Team 6 (Buildings 23-25: 3600 to 3650 39th and 3901 to 3941 Langley)

- Observations

Image 6-1
Down Spouts Drain to Grass

  - The land on which these three buildings sit is fairly flat, which helps prevent erosion, although there is a steep section next to the HVAC building leading up to the driveway.
  - There are few signs of erosion; the grass appears healthy.
  - The retention wall between Building 24 and 25 creates a channel that encourages stormwater to flow down between the wall and Building 24. That being said, the amount of erosion is both minimal as well as very manageable, and could easily be solved with an increase in flora near the edge of the retention wall and top of the incline.
  - Buildings 23 and 24 are adjacent to Glover Archbold Park.
  - A paved driveway leads to the HVAC building and recycling center between building 25 and building 26.
- Potential Solutions to Reduce Stormwater Runoff
  - Short-term
    - Create rain gardens by modifying existing garden areas. Rain gardens increase retention and filtration of stormwater.
    - Create infiltration trenches (an area that is dug out and filled with rocks) at the top of the incline behind building 24 adjacent to the stone retention wall, to form a seamless and eye-pleasing rock garden, which would halt the bulk of the water from flowing down the hill.
    - Install rain barrels at the mouth of downspouts to collect stormwater and prevent the heavy concentration of water flow onto the ground.

4.

- Long-term
  - Install permeable sidewalks and driveway.
  - Remove the curb and gutters of the driveway area. Curbs and gutters allow for the collection of stormwater and create stronger runoff. By removing them, it allows for the easy dispersal of the stormwater on to the grassy area.
  - Install a green roof on the HVAC building. Plant species in direct sunlight and heat would need to be hardy and drought tolerant. Green roofs last longer than traditional roofs with minimal maintenance.

Image 6-1
HVAC Building Roof is Flat and Small

Study Team 7 (Buildings 26-31: 3940 to 3990 and 3951 to 3971 Langley, 3430 to 3470 & 3500 to 3540 39th)

- Observations – The buildings are surrounded by grass with an average of 18 trees per building and plentiful garden spaces. These buildings border Glover Archbold Park on at least two sides. Only a small fraction of buildings 27-28 and 31 are close to the street and a road on at least one other side. The area is largely free of erosion except in high traffic areas near picnic tables or in select areas on the edge of slopes leading into Glover Archbold Park. There is a steep slope surrounding power plant E and parking lot H next to Building 30. The slope of the land was shallow and no areas of concern for flooding were observed.

4.

✼ Potential Solutions to Reduce Stormwater Runoff

- Decrease eroding land through soil amendments and organic materials. Soil amendments will increase the soil's infiltration capacity and help reduce runoff from each residential site. Over time this strategy will also help change the physical, chemical and biological characteristics of the soil to better water quality and growing capabilities. Most areas of erosion on or near buildings 30 and 31 occurred where there was increased foot traffic, for example around the community picnic tables. In order to decrease the issue of erosion in the short-term, permeable substitutes could be applied to high-use land such as gravel or mulch.
- Use permeable substitutes as a replacement for concrete sidewalks and asphalt roads located throughout McLean Gardens. Permeable pavement allows stormwater to drain through porous surfaces to a stone reservoir underneath, which holds the water until it can percolate into the subsoil. Permeable pavers would have the same effect, but could also promote groundwater recharge through the use of plastic turf reinforcing grids that add support to topsoil, while maintaining permeability.
- Install rain gardens on existing semi-permeable land to increase permeability and water retention. Rain gardens are aesthetically pleasing and efficient in capturing excess stormwater runoff. There were several downspouts on building 30 that release directly onto concrete pavers or grass, flowing directly into shallow storm drains that were often crowded with leaves. Installing rain gardens near the building could act as a barrier to downspouts that release directly onto each residential plot, reducing the dependency on the few storm drains that exist throughout the property.

4.

Property-Wide Approaches with Potential to Reduce Stormwater – Investigators from Study Teams 1 and 7 suggested that McLean Gardens:

- Create and implement a community education program. As a condominium complex, many of the potential alterations to the walkways and landscapes could be difficult to implement based on the desires of the community's residents. However, education within the community about the benefits of these various methods of reducing stormwater runoff, as well as involvement of the community in the planning of these various changes can create understanding and support.
- Organize tree plantings throughout the development in order to provide a natural bioretention system for stormwater in the short-run, while also creating a barrier that will slow the percolation of mass rain events from building roofs as trees grow over time.

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IMPLICATIONS FOR THE FUTURE:

FINDINGS, CONCLUSIONS, AND NEXT STEPS

This section summarizes the overall findings and conclusions that can be drawn from the information provided in the previous two sections of the report. It also briefly describes the next steps in developing *A Stormwater Management Framework for McLean Gardens*.

Findings

When it rains at McLean Gardens, some water is absorbed by the land and plants and some evaporates into the air. However, most of the rain water is collected and conveyed by several methods into the City's separate stormwater sewer system, which in turn transports the water and discharges it untreated into the Potomac River.[5-1] These methods include:

- Gutters on the roofs of 31 residences, the pool house, and one HVAC plant (F) collect rain water and convey it (through downspouts and underground pipes) into the City's separate stormwater sewer system.
- Flat roofs on 4 HVAC plants (A, B, C, and D) collect rain water and convey it (through down spouts and a system of underground pipes) into the City's separate stormwater sewer system. (The E plant is underground and does not have a separate roof.)
- Parking lots are sloped to channel rain water across the paved impervious surface from a high point to a storm drain at the low point in the lot or out to a city street (e.g., parking lot E). This storm drain connects to the City's separate stormwater sewer system.
- Sidewalks and grassy areas move rain water downhill into storm drains along the street. These storm drains connect to the City's separate stormwater sewer system. The dry wells on the property, which collect water from the surface, are also connected to the City's

5-1. The amount of water that is collected and conveyed is determined primarily by inches per hour, the number of hours it rains each day, and temperature.

separate stormwater sewer system.

The study also found that:

- Most of the soil on the property has been changed by human activity.
- Construction activity in 1941-42 is when the most significant changes in soil composition occurred. The addition of fill-altered soil from naturally occurring chillum complex (which is sandy and loamy and drains well) to one that includes significant component of urban soil of unknown origin and quality. Other construction projects since then have also introduced unknown soils.
- The soil, while capable of absorbing stormwater, does not since it is heavily compacted.
- The soil's ability to retain water is also affected by the extensive areas of turf grass-like plants which have shallow root systems that do not move water through the soil. [5-2]
- The overall state of the soil and prevalence of shallow rooted vegetative cover, coupled with topography of medium to steep slopes, ***results in low retention of the water during storm events***. Precipitation that is not captured by collection structures is highly likely to mostly runoff the property and into the street.

Conclusions

Given federal and city environmental policy, McLean Gardens is and will continue to pay increasing fees related to stormwater control for the foreseeable future. The observations, findings, and potential solutions presented in this report are consistent with information published about similar studies and provide a foundation for further research to better understand the choices facing the McLean Gardens community. However, they do not in and of themselves provide all of the information necessary to recommend specific stormwater proposals for discussion and decision. Calculating the feasibility,

5-2. http://www.marc.org/environment/water/know_your_roots.htm, Native plant root systems can grow up to fifteen or twenty feet deep; turf grows only 3" deep. http://www.agrecol.com/cms/natives_page2.aspx .

5.

effectiveness, and cost of each proposed solution is essential for presenting information upon which decisions can be made. Such calculations require information such as:

1. How the City's incentive program will work to encourage owners of commercial, professional, and multi-unit residential properties to reduce the runoff into the city stormwater sewer system .
2. The amount of soil disturbed in creating the proposed solution. Most of the proposed solutions disturb soil. Projects with less than 5,000 square feet[5-3] of disturbance could potentially be implemented without permits. Projects disturbing a larger area require engineering and permits.
3. Interaction with the city stormwater system. If the proposed solution does not interact with the stormwater system, then no permit is required.
4. Engineering and design of a proposed solution to determine type and amount of materials, estimated labor and materials costs, and expected reduced runoff. Some of the proposed solutions would require expertise in engineering, hydrology, and other disciplines to design solutions for specific sites.

<u>Next Steps</u>

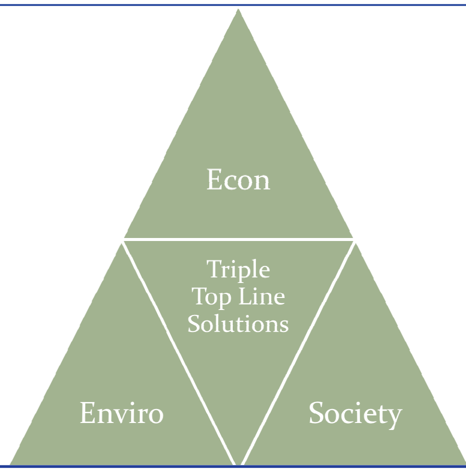
Research in Phase I indicates there are a range of solutions available to mitigate stormwater runoff. It also indicated that further work was necessary to develop data and information that would allow the Association to determine its options and make thoughtful, practical, and cost-effective decisions.

The Committee will use the Triple Topline Approach as its decision framework. This approach goes beyond looking at economic performance and considering environmental and social performances either as an afterthought, or not at all.

In this approach, decision-makers work towards a triple-top line of generating financial, environmental, and social benefits. Rather than an afterthought or a way of making a project "less

5-3. A bit more than the area of a basketball court 94′ x 50′

bad," triple-top line maximizes all three considerations, *including* cost in making investment decisions.



Triple Top Line Decision Approach

For McLean Gardens this means *considering and communicating the qualitative and quantitative value* of the recreation spaces, aesthetic appeal of the grounds, unit marketability, habitat and food for song birds, a sense of pride in community, etc. in conjunction with the monetary investment in onsite stormwater.

In Phase II, the Sustainability Committee will use the information provided in the City's incentive program and other factors to develop an overall approach for the short and long-term that:

- Matches site characteristics to mitigation approach requirements (e.g., rain gardens require full sun).
- Evaluates workable mitigation approaches in the context of pre-defined set of quantitative and qualitative indicators/measures that include:
  - Quantity of rainwater recovered.
  - Size and complexity:
    - Projects less than 5,000 square feet of soil disturbance could potentially be implemented without permits.
    - Projects disturbing larger surfaces require engineering and permits.
    - Projects interacting with the City Stormwater System require engineering and permits.
  - Opportunities to adapt existing planned projects and horticultural practices.
  - Cost of approach (monetary, environmental, social, aesthetic, etc.).
  - Benefits of approach (monetary, environmental, social, aesthetic, etc.).
  - Investment costs and returns in the context of the City's incentive system.

5.

The Committee expects its Phase II work to result in:

- A framework for managing stormwater runoff in the short and long-term that reflects stormwater management projects suitable for each building and surrounding land based on:
  - The Phase I recommendations.
  - Modification of existing projects and activities planned by the Association (e.g., adopting different horticultural practices or changing a construction specification).
  - An approach and data requirements for assessing costs, benefits, and investment return in the context of the City's incentive program.
  - A phased approach for increasing the retention of stormwater over a 10 to 15 year period.
- One to three projects that could proceed in 2012-14 within planned budgets, qualify for the City's incentive program, and demonstrate a commitment to mitigating stormwater impacts.

The Sustainability Committee expects to complete Phase II by July 2011.

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6. APPENDICIES

Appendix 2.1 — Methodology Design

Appendix 3.1 — **C**omprehensive description of McLean Gardens' Soil

Appendix 3.2 — NRCS Custom Soil Resource Report for District of Columbia

Appendix 3.3 — Soil Sampling and Analysis: Determining the Mineral and Organic Content of Soils

Appendix 3.4 — Infiltration Testing: Determining How Fast Rain Soaks into Soil

Appendix 3.5 — Draft Specifications: Soil Management for Construction Projects at McLean Gardens

Appendix 4.1 — List of Study Areas and Locations

Appendix 4.2: Compact Disk with Copies of Team Reports, Presentations, and Data Collections for each Study Area (You may request a copy of the compact disk from the Condominium Office during normal business hours.)

Appendix 2.1

AU-MG Stormwater Assessment of the McLean Gardens Site
Site Assessment Methodology Design[1]

Project Objectives

- *Define, Document and Estimate Source Contributions to Runoff during Storm Events at McLean Gardens Site*
- *Estimate Sources and Contributions of runoff from McLean Gardens Site to Glover Archbold Park*
- *Assess Existing Use of Land Cover's (including Tree Canopy, Shrubs, Grass, and other plantings) determine impact on current and future on-site management of storm water*
- *Recommend next steps*

Project Approach

WORKSHEET: SITE ASSESSMENT AND LOCAL CONTEXT Adapted from Sustainable Sites 2009 Guidelines and Benchmarks				
Mapping and Assessment of Existing Site Conditions				
A. Weather and General Site Conditions				
Identify and map the following information:	Information collected can help develop a comprehensive assessment of existing conditions and uses or information to develop recommendations:	Provide title of map(s) where information is identified and include any additional notes OR provide reasons for not addressing topics. **Primary Collection Method**	**Tools**	**Documentation**
Site-specific Baseline Existing site specific conditions and features are both natural and manmade Natural conditions such as weather patterns may contribute to stormwater runoff and stormwater management decisions. Some natural features include, but are not limited to, excessive slope, micro-topography, other microclimate conditions, and any other unique factors that influence specific areas of the site. Existing manmade features of this developed site (e.g., the buildings, parking lots,	*Observations* 1. Wind, water, and sun impacts on the land and buildings. 2. Siting of residential buildings (e.g. at top of steep incline and faces west) 3. Use of vegetation (e.g., trees and other plantings) that help or hinder management of stormwater on site. 4. Use of land areas for outdoor physical activity or other uses such as social interaction and mental restoration.	*Observations and Measurements* 1. Wind, water, and sun impacts on the land and buildings. 2. Siting of residential buildings (e.g. at top of steep incline and faces west) 3. Use of vegetation (e.g., trees and other plantings) that help or hinder management of stormwater on site 4. Obvious significant soil erosion 5. MGCA reports of flooding during major rain events. 6. Proximity or relationship to Archbold Glover Park. 7. Foot print measures of buildings, sidewalk, parking lot and other impervious structure 8. Pitch of the roof 9. Location of downspouts 10. Location of storm drains and	1. Tape measure 2. Camera 3. Casey Maps 4. Engineering Drawings	Qualitative -- 2 to 3 Bullets describing what the data is and means as well as the implications for management of stormwater and/or photograph(s) and illustrations Measurements – Document on map or in representational drawing

[1] Blue Highlight are key sections for field work

Appendix 2.1

sidewalks, plantings, etc.) also affect conditions that either create or assist in managing stormwater on the site		collection wells on the property 11. Location of building connection to city stormwater system 12. Location of water & sewer meters 13. Location of other relevant features		

Appendix 2.1

	Hydrology The science that encompasses the occurrence, distribution, movement and properties of the waters of the earth and their relationship with the environment within each phase of the hydrologic cycle. USGS http://ga.water.usgs.gov/edu/hydrology.html			
Identify and map the following information:	Information collected can help develop a comprehensive assessment of existing conditions and uses or information to develop recommendations:	Provide title of map(s) where information is identified and include any additional notes OR provide reasons for not addressing topics. **Primary Collection Method**	**Tools**	**Documentation**
100-year floodplain, as determined by FEMA (or using calculations specific to the site if no 100-year floodplain elevations have been calculated for the site).	*Observations and Research* 1. Do any of these conditions apply to this assessment? 2. If so, How? 3. Why might this information be important to have?			
Full extent of the delineated wetland(s), including isolated wetlands and their buffer.				
Existing buffer for shorelines and streams with an identifiable channel				
Streams, wetlands, or shorelines that have been artificially modified (e.g., buried, piped, drained, channelized, bulk-headed, or armored). Determine existing conditions and dimensions, and the historic extent of the stream, wetland, or shoreline (e.g., aerial photographs or maps of the historic location).				
Site Topography Topography and direction of overland		*Observations and Measures* Describe slopes (grades) of land either using qualitative data (e.g., slopes away from or towards	1. Engineering Drawings 2. Topographic Maps 3. Slope Measurement	3 to 5 Bullets Points describing what the slope(s) of the land is to the building, how steep it is and how it impacts stormwater management considerations

Appendix 2.1

water flow on site and its effects on the watershed as a whole.		building) or through measurements Describe direction of overland water flow on site and its relationship to existing buildings the Park, Storm sewer catchments, etc.	methods: (http://www.ehow.com/how_2089604_measure-slope-land.html; http://geology.isu.edu/geostac/Field_Exercise/topomaps/slope_calc.htm; http://en.wikipedia.org/wiki/Grade_(slope)	
Pollution Sources Existing and potential pollution sources (both point and nonpoint sources) and health hazards, including on-site sources and off-site sources in adjacent areas that may impact the site.		*Observations and/or Photographs* Identify existing and potential pollution sources (both point and nonpoint sources).		
	Soils			
Identify and map the following information:	Information collected can help develop a comprehensive assessment of existing conditions and uses or information to develop recommendations:	Provide title of map(s) where information is identified and include any additional notes OR provide reasons for not addressing topics. **Primary Collection Method**	**Tools**	**Documentation**
Soils defined by the NRCS as prime farmland, unique farmland, or farmland of statewide importance.	1. Is this relevant to this assessment? 2. Why might it be important to know?			
Soil Characterization Healthy soils found on site.	1. How do you determine this? 2. Why is this important to know?	*Observations and Sample Collection* 1. Describe soil based on color and feel of soil sample soil collections 2. Collect samples as described on A&E Lab Form 3. Describe test results	Healthy Soil definition -- http://pubs.ext.vt.edu/426/426-711/426-711.html VT Publication List http://pubs.ext.vt.edu/category/gardening-the-environment.html Soil sampling instructions and sample test results -- http://al-labs-eastern.com/lawn_garden.html	Qualitative -- 3 to 5 Bullets describing soil sample characteristics in relation to "Healthy Soils" reference conditions and the implications for management of stormwater Quantitative – 3 to 5 Bullets summarizing test results and implications for stormwater management Measurements – Document on map or in representational drawing or table
Soils disturbed by previous	1. How do you determine this?	Research and Perc Test in One or Two Locations Research historical land use	NRCS DC Soil Report 2009 (Reference)	Qualitative -- 3 to 5 Bullets describing method and results and implications for management of stormwater

Appendix 2.1

development. Identify degree of disturbance (minimal, moderate, or severe). Identify the following characteristics: organic matter content and depth, texture and bulk densities, infiltration rates, soil biological function, and soil chemical characteristics.	2. Why is this important to know?	Use information in NRCS Report to describe basic soil conditions Follow method __________ and record results		Measurements – Document on map or in representational drawing
		Vegetation		
Identify and map the following information:	Information collected can help develop a comprehensive assessment of existing conditions and uses or information to develop recommendations:	Provide title of map(s) where information is identified and include any additional notes OR provide reasons for not addressing topics. **Primary Collection Method**	**Tools**	**Documentation**
Potential threatened or endangered species habitat. Include plant and animal species identified on federal or state threatened or endangered lists or on the International Union for Conservation of Nature Red List of Threatened Species as critically endangered or endangered.	1. Is this relevant to this assessment? 2. Why might it be important to know?			
Land Cover Zones of land cover or vegetation types. Note whether each zone contains the following: • invasive plants as listed by federal, state, and regional entities	1. How would you describe or define existing land cover based on observations? 2. How does DC government define and use land cover information? 3. What data does	*Observations and Calculations* 1. Verification and updating of Casey Tree Inventory 2. Calculate current and potential land cover 3. Update Casey's Assessment of Plantings	1. Casey Tree Inventory Maps 2. MGCA –Map In Acres 3. Casey Tree Canopy Goals 4. University of Vermont UTC Report 5. Tree Canopy Assessment 2-16-10D.1	1. Tree Inventory – Document on Maps 2. Calculations – Document results on map or in representational drawing (e.g. pie chart) 3. Updated report from Casey Trees

• native plants • native plant communities • special status plants For trees, it may be helpful to note their diameter at breast height (DBH). Diameter = Circumference/Pi (3.142)	the DC Atlas contain? 4. Are there other sources of land cover data? 5. Where are the lists of invasive and native plants? 6. How does this information inform stormwater management?			

Identifying Additional Information about the Site, Local resources, and Regional Context				
Reference Conditions for Soil and Vegetation				
Identify and map the following information:	Information collected can help develop a comprehensive assessment of existing conditions and uses or information to develop recommendations:	Provide title of map(s) where information is identified and include any additional notes OR provide reasons for not addressing topics.	**Tools**	**Documentation**
Identify the site's reference soil. Determine the following characteristics of the reference soil: organic matter content and depth, texture and bulk densities, infiltration rates, soil biological function, and soil chemical characteristics.				
EPA Level III ecoregion AND Major native plant community types of the region.				

Appendix 2.1

Weather Conditions				
Identify and map the following information:	Information collected can help develop a comprehensive assessment of existing conditions and uses or information to develop recommendations:	Provide title of map(s) where information is identified and include any additional notes OR provide reasons for not addressing topics. **Primary Collection Method**	**Tools**	**Documentation**
Average annual and average monthly precipitation patterns and temperature conditions for the site.		Existing NOAA Data 1. Document precipitation patterns 2. Document temperature patterns	http://www.weather.gov/climate/index.php?wfo=lwx http://www.weather.com/outlook/travel/vacationplanner/wxclimatology/monthly/graph/USDC0001?from=search http://www.weather.com/weather/climatology/monthly/USDC0001	1. Chart or Diagram for Final Report 2. Charts & Diagrams for Final Report
Precipitation design for DC		Design Event '1.2" rain fall over 24 hours with prior three days being dry		
Hydrology				
Identify and map the following information:	Information collected can help develop a comprehensive assessment of existing conditions and uses or information to develop recommendations:	Provide title of map(s) where information is identified and include any additional notes OR provide reasons for not addressing topics. **Primary Collection Method**	**Tools**	**Documentation**
Watershed conditions, including common stormwater pollutants and specific pollutants of concern that have been identified. Existing local, regional, or state watershed plans for the site's watershed.			Provide narrative describing how information gathered could influence management of stormwater	
Initial water storage capacity of the site, using TR-55 curve number or other continuous				

Appendix 2.1

simulation models.				
Existing and potential pollution sources (both point and nonpoint sources) and health hazards, including sources both on-site and adjacent to the site.				
Seasonal groundwater elevations or problems with over-infiltration that may affect BMP selection.				
Potable and non-potable water sources for the site, and opportunities to capture, treat, and reuse rainwater and gray water.				
Additional Considerations				
Use this section to list any other unique opportunities, characteristics, and constraints of the site.	Site features that impact creation of stormwater run-off. Site features currently used to manage stormwater on site. Site features that may be used to manage stormwater on site. What other context information should the audiences for the assessment know?			

Appendix 3.1

The Land and Its Characteristics

The Hydrology

There are no natural water courses on the McLean Gardens grounds. The nearest stream is Foundry Creek, in Glover-Archbold Park, which drains into the Potomac River. The behavior of water that precipitates onto the property is regulated by the impervious structures, the artificial water drainage and storage structures, the existing vegetation, and the soils.

The soils cannot be expected to absorb and hold much of the precipitation. Although the naturally occurring soil over most of the area is sandy and loamy, and could be expected to drain well, there are few, if any, areas where the soil has not been affected by human activity. Much of the unbuilt or unpaved area is Urban land soil or equivalent (such as Udorthents), greatly compacted, and the remaining soil areas are mostly heavily compacted, resisting water penetration. The soil's ability to retain water is also affected by the extensive areas of lawns, which in many cases do not cover the soil. The overall state of the soils and vegetative cover, coupled with the topography, results in low retention of the precipitation that falls on the soil areas. Precipitation that is not captured by artificial structures is highly likely to mostly run off eventually into the streets.

The Topography

McLean Gardens is hilly. The highest point is about 122 meters (400 feet) above sea level, near Wisconsin Avenue and Rodman Street, and the lowest point is about 102 meters (334 feet) above sea level, or a difference of 20 meters (65 feet), with these points separated by about 592 meters (0.37 miles). The overall slope of the property is about 3.4%. However, there are ridges and valleys that run through the property as well as buildings and other structures (such as parking areas and sidewalks) that sit on flat areas created by man. Man has significantly modified various slopes. More than 75% of the property has slopes between 8% and 15%

The Soils

McLean Gardens is located where the Piedmont meets the Coastal Plain. The geologic formation underlying most of the area is of relatively recent marine origin (formed about 2 to 5 million years ago, during the Pliocene Epoch). The other geologic formations are much older metamorphic and plutonic rocks (formed over a billion years ago, during the Pre-Cambrian Eon). Most of the soil is derived from the Pliocene deposits. The soil survey for McLean Gardens Condominium and Contiguous Areas[1] shows that the predominant the soils are Chillum-Urban land complex, Neshaminy silt loam, Ashe loam, and Udorthents.

- Chillum-Urban land complex (Cd) soil makes up over 85% of McLean Gardens' soils. A complex consists of two or more soils or miscellaneous areas so mixed or in such small areas that they cannot be shown separately on the maps. Cd soil consists of 40% Chillum and similar soil, 40% Urban land, and 20% minor components. Some of the minor components are closely associated with Chillum soils.

[1] Soil surveys are used to make decisions about land use or land treatment. The information helps engineers, city officials, planners, and home-owners identify and reduce the effects of soil limitations on various land uses.

- Cd soils are silty, derived from wind borne particles, developed under mixed hardwood forests (mostly oaks), well drained, and underlain by marine sediments. Rock fragments (generally quartz pebbles) may constitute up to 60% of the volume of the first eight inches of soil and up to 80% of the volume of the lower layers of the soil. Clay is present at 12 to 24 inches below the surface. Chillum soils are found in New Jersey, Maryland, and DC.
- Urban land is soil that has been modified by disturbance of the natural layers with additions of fill material to accommodate large housing installations and related works, such as pipe replacements and demolitions. Urban soils have been disturbed and paved or built upon. They no longer are capable of supporting woodlands and subsurface layers are no longer important.
- Where Porter Street intersects 39th Street, there are Udorthents soils (about 5% of the total). Udorthents are soils that have been disturbed by human activity, commonly development. These soils are characterized by cut or borrow areas, filled areas or some combination of both.[2]
- Other soils are Neshaminy (NeD) silt loam and Ashe loam (As), both on the land that slopes toward Glover-Archbold Park. NeD soils developed in materials weathered from diabase and other dark colored basic rocks (generally of plutonic origin) and As soils developed from felsic or mafic igneous and high-grade metamorphic rocks such as granite, hornblende gneiss, granodiorite, biotite gneiss, and high-grade metagraywacke.

The geological formation underlying the Chillum soils is related to Coastal Plain geology and explains the marine nature of the sediments from which the main soil is derived. Most of McLean Gardens is underlain by the Upland Deposits (Western Shore) geological formation (symbol QTu), which is characterized as gravel and sand, with some limonite cementation, with lower layers of gravel. The formation has a thickness that does not exceed 50 feet. The QTu formation was deposited during the Pliocene Epoch (about 5 to 2 million years ago), and is associated with deposition at a sea shore, probably by the ancient Potomac. (The Pliocene is characterized by wide fluctuations in sea level, with some estimates of sea levels as high as 175 feet above current levels. The physiographic map of the mid-Atlantic Coastal Plan shows a belt of Upland Sands and Gravels from South Carolina to New Jersey.[3] The map identifies one distinct area in DC of these sands and gravels in the area that includes McLean Gardens. Likewise, the Geologic Maps of Maryland: Montgomery County Detail shows the QTu formation in the areas around Wisconsin, Nebraska, and Massachusetts Avenues, including McLean Gardens (except for the areas that adjoin Glover-Archbold Park, where soils are derived from the plutonic Georgetown Mafic Complex, which was formed more than a billion years ago).[4] The only other instance of the QTu formation in DC is to the east of the Anacostia River. The QTu formation is extensive in Prince Georges County

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[2] Definitions for Urban soils and Udorthents from *Natural Resources Inventory for the Town of Branford*, Richard A. Orson, Ph.D., Orson Environmental Consulting, Branford, Connecticut 06405. January 2003

[3] Ator, Scott W., et al. Physiography of the Mid-Atlantic Coastal Plain. U.S. Geological Survey, Professional Paper 1680, Plate 1. 2005.

[4] The geologic map of Maryland includes DC. It was published in 1968 and is no longer available. The map was scanned and is available the web site of the Maryland Geological Survey, at http://www.mgs.md.gov/esic/geo/index.html.

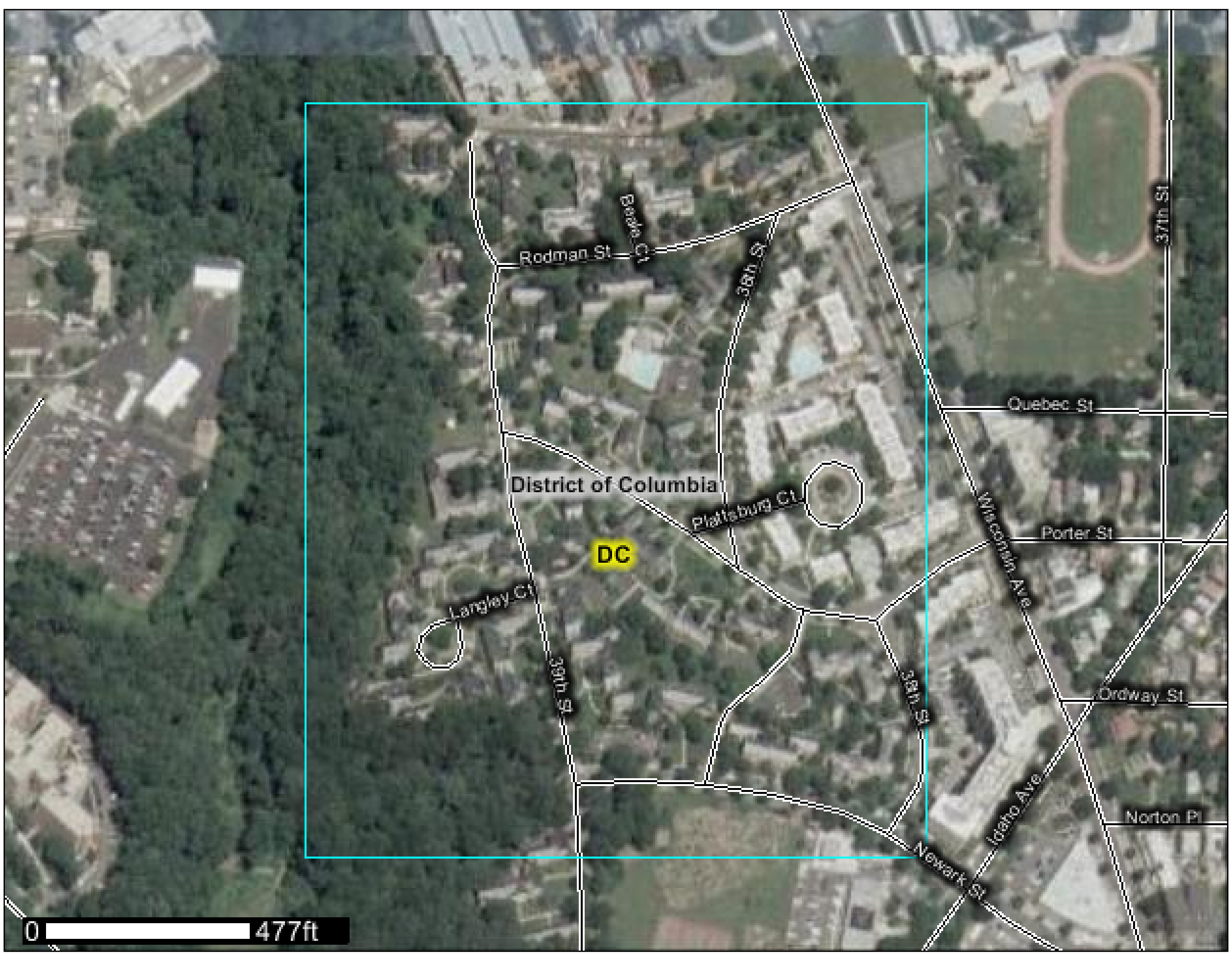
United States Department of Agriculture

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

District of Columbia



December 1, 2009

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://soils.usda.gov/sqi/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://soils.usda.gov/contact/state_offices/).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Soil Data Mart Web site or the NRCS Web Soil Survey. The Soil Data Mart is the data storage site for the official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features

- Gully
- Short Steep Slope
- Other

Political Features

- Cities

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:3,530 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 18N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: District of Columbia
Survey Area Data: Version 5, Sep 14, 2006

Date(s) aerial images were photographed: 6/25/2003; 6/21/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

District of Columbia (DC001)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
AsC	Ashe loam, 8 to 15 percent slopes	2.6	4.6%
AsD	Ashe loam, 15 to 40 percent slopes	1.8	3.2%
CcD	Chillum silt loam, 15 to 40 percent slopes	0.2	0.3%
CdB	Chillum-Urban land complex, 0 to 8 percent slopes	2.8	4.9%
CdC	Chillum-Urban land complex, 8 to 15 percent slopes	39.9	70.2%
CdD	Chillum-Urban land complex, 15 to 40 percent slopes	1.4	2.4%
NeD	Neshaminy silt loam, 15 to 40 percent slopes	5.2	9.2%
U1	Udorthents	1.9	3.3%
U8	Udorthents, sandy, smoothed	0.0	0.0%
Ub	Urban land	1.0	1.8%
Totals for Area of Interest		**56.9**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

District of Columbia

AsC—Ashe loam, 8 to 15 percent slopes

Map Unit Setting

Elevation: 1,400 to 5,000 feet
Mean annual precipitation: 45 to 70 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 90 to 160 days

Map Unit Composition

Ashe and similar soils: 100 percent

Description of Ashe

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.7 inches)

Interpretive groups

Land capability (nonirrigated): 4e

Typical profile

0 to 6 inches: Loam
6 to 23 inches: Sandy loam
23 to 60 inches: Sandy loam
60 to 64 inches: Unweathered bedrock

AsD—Ashe loam, 15 to 40 percent slopes

Map Unit Setting

Elevation: 1,400 to 5,000 feet
Mean annual precipitation: 45 to 70 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 90 to 160 days

Map Unit Composition

Ashe and similar soils: 100 percent

Description of Ashe

Properties and qualities

Slope: 15 to 40 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.7 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 6 inches: Loam
6 to 23 inches: Sandy loam
23 to 60 inches: Sandy loam
60 to 64 inches: Unweathered bedrock

CcD—Chillum silt loam, 15 to 40 percent slopes

Map Unit Setting

Elevation: 20 to 370 feet
Mean annual precipitation: 30 to 46 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 160 to 220 days

Map Unit Composition

Chillum and similar soils: 100 percent

Description of Chillum

Properties and qualities

Slope: 15 to 40 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Moderate (about 6.1 inches)

Interpretive groups

Land capability (nonirrigated): 6e

Typical profile

0 to 2 inches: Silt loam
2 to 9 inches: Gravelly loam
9 to 12 inches: Gravelly loam
12 to 24 inches: Clay loam
24 to 34 inches: Loamy sand
34 to 72 inches: Gravelly silty clay loam

CdB—Chillum-Urban land complex, 0 to 8 percent slopes

Map Unit Setting

Elevation: 20 to 650 feet
Mean annual precipitation: 30 to 55 inches
Mean annual air temperature: 45 to 61 degrees F
Frost-free period: 160 to 250 days

Map Unit Composition

Chillum and similar soils: 40 percent
Urban land: 40 percent
Minor components: 20 percent

Description of Urban Land

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 10 inches to

Interpretive groups

Land capability (nonirrigated): 8s

Description of Chillum

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Moderate (about 6.1 inches)

Interpretive groups

Land capability (nonirrigated): 2e

Typical profile

0 to 2 inches: Silt loam
2 to 9 inches: Gravelly loam
9 to 12 inches: Gravelly loam
12 to 24 inches: Clay loam
24 to 34 inches: Loamy sand
34 to 72 inches: Gravelly silty clay loam

Minor Components

Beltsville

Percent of map unit: 5 percent

Bourne

Percent of map unit: 5 percent

Croom

Percent of map unit: 5 percent

Sassafras

Percent of map unit: 5 percent

CdC—Chillum-Urban land complex, 8 to 15 percent slopes

Map Unit Setting

Elevation: 20 to 370 feet
Mean annual precipitation: 30 to 55 inches
Mean annual air temperature: 45 to 61 degrees F
Frost-free period: 160 to 250 days

Map Unit Composition

Chillum and similar soils: 40 percent
Urban land: 40 percent
Minor components: 20 percent

Description of Urban Land

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 10 inches to

Interpretive groups

Land capability (nonirrigated): 8s

Description of Chillum

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Moderate (about 6.1 inches)

Interpretive groups

Land capability (nonirrigated): 3e

Typical profile

0 to 2 inches: Silt loam
2 to 9 inches: Gravelly loam
9 to 12 inches: Gravelly loam
12 to 24 inches: Clay loam
24 to 34 inches: Loamy sand

34 to 72 inches: Gravelly silty clay loam

Minor Components

Bourne
Percent of map unit: 5 percent

Croom
Percent of map unit: 5 percent

Sassafras
Percent of map unit: 5 percent

Unnamed soils
Percent of map unit: 5 percent

CdD—Chillum-Urban land complex, 15 to 40 percent slopes

Map Unit Setting
Elevation: 20 to 600 feet
Mean annual precipitation: 30 to 55 inches
Mean annual air temperature: 45 to 64 degrees F
Frost-free period: 160 to 250 days

Map Unit Composition
Chillum and similar soils: 40 percent
Urban land: 40 percent
Minor components: 20 percent

Description of Urban Land

Properties and qualities
Slope: 15 to 40 percent
Depth to restrictive feature: 10 inches to

Interpretive groups
Land capability (nonirrigated): 8s

Description of Chillum

Properties and qualities
Slope: 15 to 40 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Moderate (about 6.1 inches)

Interpretive groups

Land capability (nonirrigated): 6e

Typical profile

0 to 2 inches: Silt loam
2 to 9 inches: Gravelly loam
9 to 12 inches: Gravelly loam
12 to 24 inches: Clay loam
24 to 34 inches: Loamy sand
34 to 72 inches: Gravelly silty clay loam

Minor Components

Unnamed soils

Percent of map unit: 10 percent

Croom

Percent of map unit: 5 percent

Sassafras

Percent of map unit: 5 percent

NeD—Neshaminy silt loam, 15 to 40 percent slopes

Map Unit Setting

Mean annual precipitation: 38 to 44 inches
Mean annual air temperature: 48 to 57 degrees F
Frost-free period: 150 to 220 days

Map Unit Composition

Neshaminy and similar soils: 100 percent

Description of Neshaminy

Properties and qualities

Slope: 15 to 40 percent
Depth to restrictive feature: 48 to 99 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 5.9 inches)

Interpretive groups

Land capability (nonirrigated): 6e

Typical profile

0 to 18 inches: Silt loam
18 to 40 inches: Very gravelly clay loam

40 to 60 inches: Bedrock

U1—Udorthents

Map Unit Composition

Udorthents and similar soils: 100 percent

Description of Udorthents

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: 10 inches to
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Interpretive groups

Land capability (nonirrigated): 8s

U8—Udorthents, sandy, smoothed

Map Unit Setting

Mean annual precipitation: 38 to 44 inches
Mean annual air temperature: 48 to 57 degrees F
Frost-free period: 150 to 220 days

Map Unit Composition

Udorthents and similar soils: 100 percent

Description of Udorthents

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 10 inches to
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.38 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 0.7 inches)

Interpretive groups

Land capability (nonirrigated): 8s

Typical profile

0 to 9 inches: Sand
9 to 72 inches: Sand

Ub—Urban land

Map Unit Setting

Frost-free period: 175 to 220 days

Map Unit Composition

Urban land: 100 percent

Description of Urban Land

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 10 inches to

Interpretive groups

Land capability (nonirrigated): 8s

References

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Soil Sampling and Analysis: Determining the Mineral and Organic Content of Soils

Selecting the Sites to Collect Soil Samples

The purpose of the assessment is to characterize the soil in areas that are likely to facilitate movement of water during rain events.[1] The characteristics of such areas include slopes with compacted soils, areas with sunlight for six or more hours each day (full sun) which harden the soil, and areas currently planted in grass which does not absorb large amounts of rain.[2]

The study team looked for worst case conditions in selecting eight sites for evaluation. Investigators used the following methodology to select the sites:

- The satellite image map in the NRCS soil survey to identify open areas for site visits.
- Several visits to each potential site to determine its suitability based the amount of sunlight per day, the type and amount of plant materials on the surface, and the slope of the land. [3]

Each selected site has Chillum-Urban Complex soils, experiences six or more hours of sunlight per day (further hardening already compacted soil), and is covered primarily in turf grass type materials which have shallow roots that do not facilitate movement of rain through the soil. All sites slope towards the street or stormwater collector.

Sample Collection Protocol – followed the testing protocol provided by A & L Eastern Laboratories, Inc. http://al-labs-eastern.com/taking_soil_sample.html This protocol is used by the Cooperative Extension Service of the District of Columbia to collect soil samples for testing. Two investigators collected the samples on two consecutive days. There was no rain fall on testing days or for the preceding three days.

Preparing for Collecting Samples

1. Marked eight one-pint Ziploc bags to correspond to each collection site
2. Assembled tools and supplies – soil probe, plastic bucket, digging tools, tape measure, markers, map of sampling sites, and camera.
3. Reviewed instructions for collecting samples with a soil probe.

Collecting the Samples

General Information

1. Two investigators collected the samples on a two consecutive days, October 23, 2010 between 10:30 AM and 12:30 PM and October 24, 2010 between 1:00 and 3:00 PM.[4]

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[1] NRCS Urban Soil Primer, page 22-23 – "More water runs off urban areas because of the impervious nature of pavement and compacted soil layers and urban buildings."

[2] NRCS Urban Soil Primer, Pages 26-27

[3] NRCS Urban Soil Primer, Pages 26-27

[4] http://www.weather.gov/climate/index.php?wfo=lwx Precipitation Data at National Airport for October 1 to 25, 2010

2. There was no rain fall on the testing day or for the preceding three days. The last rain event occurred on October 20th and the National Weather Service recorded 0.02 inches at National Airport.

Observations—Physical Characteristics

Sample Number	Building Numbers	Location Description	Site Slope	Sample Depth	Physical Characteristics (Horizontal layers, color, texture, and structure)	Field Notes
1	1-4	Upper grass slope between Buildings3, 4 and Plant F	19%	3″ to 5″	No layering, silty, brownish & crumbly	
2	5-9	Grassy area behind Building 8	11%	2″ to 3″	No layering, silty, brownish & crumbly	
3	10-13	Grass slope and bowl area below pool & behind Building 13	11%	3″ to 5″	No layering, silty, brownish & crumbly	Originally planned to sample the center of the area behind building 13 – this area is compacted and could not get probe into the soil
4	14-18	Grass slope between building 14 & 15 on Porter	17%	6″ to 12″	1″-3″: dark & silty 3″- 8″: brown to red, silty 8″-12″: reddish, small pebbles	
5	19-22	Grass slope between Buildings 16 & 21	24%	3″ to 15″	1″-3″: dark & silty 3″- 8″: brown to red, silty 8″-12″: reddish, small pebbles 12″-15″: orange clay	
6	23-25	Grass semi-circle in front of Building 25 on Langley	11%	3″ to 5″	No layering, silty, brownish & crumbly	
7	26-29	Grass slope between Buildings 27 & 29	16%	5″ to 8″	1″-3″: dark & silty 3″- 8″: brown to red, silty	
8	30-31	Grass slope in front of Building 31 between 3400 & 3410 39th	6%	1″ to 3″	No layering, silty, brownish & crumbly	

Observations—Chemical Characteristics

					LABORATORY ANALYSIS															
														Calculated Cation Saturation						
Team	Building Number	Location Description	Site Slope	Sample Depth	pH	Buffer pH	Phos-phorous (P) (ppm)	Potas-sium (K) (ppm)	Calcium (Ca) (ppm)	Mag-nesium (Mg) (ppm)	Sul-pher (S) (ppm)	Organic Matter	ENR	CEC	%K	% Ca	% Mg	% H	Hmeq	K:mg Ratio
1	1-4	Upper grass slope between Buildings3, 4 and Plant F	19%	3” to 5”	6.30	6.82	49	154	1402	276	7	3.6%	106	10.9	3.6	64.3	21.1	10.5	1.1	0.17
2	5-9	Grassy area behind Building 8	11%	2” to 3”	6.50	6.83	177	134	1976	235	6	4.9%	129	13.2	2.6	74.8	14.8	7.4	1.0	0.18
3	10-13	Grass slope and bowl area below pool & behind Building 13	11%	3” to 5”	6.80	6.90	140	260	1739	227	8	4.6%	125	11.8	5.7	75	16.3	2.9	0.3	0.35
4	14-18	Grass slope between building 14 & 15 on Porter	17%	6” to 12”	6.40	6.84	29	85	1402	257	8	3.3%	101	10.3	2.1	68.1	20.8	8.9	0.9	0.10
5	19-22	Grass slope between Buildings 16 & 21	24%	3” to 15”	5.70	6.70	28	182	1252	213	8	3.1%	97	10.8	4.3	58	16.4	21	2.3	0.26
6	23-25	Grass semi-circle in front of Building 25 on Langley	11%	3” to 5”	5.70	6.70	78	212	1258	231	8	4.3%	120	11.1	4.9	56.7	17.3	21.1	2.3	0.28
7	26-29	Grass slope between Buildings 27 & 29	16%	5” to 8”	6.60	6.86	41	138	1564	282	7	3.1%	96	11.2	3.2	69.8	21	5.9	0.7	0.15
7	30-31	Grass slope in front of Building 31 between 3400 & 3410 39th	6%	1” to 3”	5.90	6.70	37	120	1719	289	12	4.0%	110	13.7	2.2	62.7	17.6	17.1	2.3	0.13

Appendix 3.3

Understanding Soil Characteristics (http://extension.unh.edu/resources/representation/Resource000496_Rep518.pdf)

Soil Constituent	Definition			(A)
pH	Indicates whether the soil is acid or alkaline/basic.	7.0 is a neutral level; A level; less than 7.0 is acidic and greater than 7.0 is alkaline.	Most plants prefer a pH 6.0 – 6.5 in the range. Exceptions are acid-loving plants such as azaleas, rhododendrons, and holly, which prefer pH 4.5 – 5.5.	Lime is added to raise the soil pH and sulfur is added to lower the pH
Texture	Refers to the class of soil.	Clay soils (clay, silty clay) tend to be poorly drained and are subject to compaction.	Sandy soils (sand, loamy sand) have lower water and nutrient holding abilities.	Loam soils (loam, sandy loam, clay loam) are best suited to plant growth.
Organic Matter	That portion of the soil comprised of dead and decayed plant and animal parts.	Organic matter provides nutrients for plant growth while improving the physical condition or tilth of the soil.	Generally, levels higher than 5% are desirable.	
Chemical Element	Function in Plant	Low	Optimum	High
Magnesium	Part of the chlorophyll molecule necessary for photosynthesis	0-60	60-120	120-160+
Calcium	Important in cell elongation and cell division	0-800	800-1200	1200-2200+
Potassium	Important in cell elongation and cell division	0-170	170-280	280-430+
Phosphorus	Essential for energy transfer and fruit & seed formation	0-30	30-50	50-75+

Range for C.E.C. that can be expected with different soil textures
http://www.spectrumanalytic.com/support/library/ff/Interpreting_Lawn_and_Garden_Soil_Results.htm

Soil Textures	Common C.E.C. Ranges	CEC Range in Percent Saturation	
Coarse (sands)	5 to 15	Calcium (Ca^{++})	40%-80%
Medium (silts)	8 to 30	Magnesium (Mg^{++})	10%-40%
Fine (clays)	25-50 plus	Potassium (K^{+})	1%-9%

The interpretation provided by a soil testing lab should not be considered the absolute interpretation but rather as a starting point for interpreting the soil test in the context of the other factors. Because of the large amount of variation in response, the interpretation provided by a soil testing lab is based on the average probability of expected response to the nutrient over a wide range of conditions. This simple interpretation provided by the lab is usually expanded on by producers or their agronomic advisors to come up with the best final interpretation and recommendation for the specific site and situation. (http://ag.udel.edu/extension/agnr/pdf/soiltesting%202009/CHAP14-2009-kg.pdf)

Infiltration Testing: Determining How Fast Rain Soaks into the Soil

Testing Protocol – followed and adapted the water infiltration protocol developed for the Global Learning and Observations to Benefit the Environment (GLOBE) worldwide network of students, teachers and scientists working together to study and understand the global environment. http://web.hwr.arizona.edu/globe/globe3/SMInfil.html. (Protocol recommended by DDOE Staff Person.) .

Selecting the Test Area

1. The site is a worst case site based on significant compaction of soil during HVAC replacement which occurred from fall 2009 to spring 2010, is located at the end of a steep sloped "V-shaped" valley with a stormwater catch basin. It also had good potential for a series of engineered rain gardens that could move rain water from the parking lots, pool, and several buildings.
2. Investigators identified three locations within the testing area to run the infiltration protocol -- two near the top of the hill and one near the bottom of the hill.

Preparing for Testing

1. Measured and marked 2.0 cm and 5.0 cm on the bottoms of large and small cans at bottom (two sets).
2. Measured and marked 20.0 mm reference on the top of the smaller can.
3. Assembled tools and supplies – hammer, piece of board, digging tools, tape measure, markers, water containers, data recording sheets, camera,

Conducting the Tests

General Information

1. Three investigators collected the samples on a single day, October 25, 2010 between 8:30 and 10:30 AM.
2. There was no rain fall on the testing day or for the preceding three days. The last rain event occurred on October 20th and the National Weather Service recorded 0.02 inches at National Airport.

Observations

Overall Site Conditions – Multiple dry, hilly with steep slopes (13 to 15%), clay, pebbles, excavated September 2009 to January 2010; original soil restored in January, ½" top soil added in spring 2010and replanted with grass. Grass is spotty.

Site 1 – Upper – Found the soil impenetrable – no testing

Site 2 – Lower

1. First investigator:
   a. Removed all loose organic cover for an 18 cm diameter.
   b. Hammered smaller can 2 cm into the soil.

c. Hammered larger can 2 cm into the soil.
d. Poured water into the outer ring, and maintained a level approximately equal to the level in the inner ring.
e. Poured water into the inner ring, to just above the reference mark.

2. Second investigator:
   a. Started stopwatch.
   b. Observed that the outer water ring leaked slightly but then stopped.
   c. Observed the water level in the inner can reaches the upper reference mark at 10 minutes elapsed.
   d. Observed the water level in the inner can never fell below reference mark at anytime.

Site 3 – Upper

1. First investigator:
   a. Removed all loose organic cover for an 18 cm diameter.
   b. Hammered smaller can 5 cm into the soil.
   c. Hammered larger can 5 cm into the soil.
   d. Poured water into the outer ring, and maintained a level approximately equal to the level in the inner ring.
   e. Poured water into the inner ring, to just above the reference mark.
2. Second investigator:
   a. Started stopwatch.
   b. Observed that no water ring leaked.
   c. Observed the water level in the inner can reaches the upper reference mark at 2 minutes elapsed.
   d. Observed the water level in the inner can fell 1.5 cm below reference mark at 45 minutes.

Findings and Conclusion – The rate of water infiltration at this site is almost imperceptible. Water from significant rain events is not likely to enter the soil and will enter the storm drain.

Appendix 3.4

Soil Management for Construction Projects at McLean Gardens[1]

DRAFT 2-13-11

Introduction

Soil quality is directly related to stormwater retention capacity and the ability to maintain a desirable landscape. Therefore, McLean Gardens endeavors to maintain and restore the quality of its soils and to protect plants that may be disturbed as a result of construction activities. McLean Gardens requires a minimal disturbance of established plantings and the restoration of soils that may be disturbed by construction.

Requirements

McLean Gardens requires any and all contractors that engage in construction or other activities that will result in soil disturbance to:

1. Protect tree and shrub roots by fencing off at the drip line of trees and shrubs and keep all equipment, materials, and work out of this area. (The drip line is the area directly located under the outer circumference of the tree or shrub branches.)

2. Restore soil that was disturbed to the drip line of trees and shrubs. Restoration includes relieving compaction, addition of four (4) inches of compost, and reestablishing the original topsoil grade.

3. Only in cases that work must be carried out within the drip line of trees and shrubs may the soil within the drip line be disturbed and conditions #1 and #2, above, violated.

4. Soil restoration must be performed according to the guidelines below.

Guidelines for Soil Restoration

SUB-SOILING TO RELIEVE COMPACTION

1. When excavation is completed, the subsoil shall be in a loose, friable condition to a depth of 20 inches below final topsoil grade and there shall be no erosion rills or washouts in the subsoil surface exceeding 3 inches in depth.

2. To achieve this condition, subsoiling, ripping, or scarification of the subsoil will be required, wherever the subsoil has been compacted by equipment operation or has become dried out and crusted, and where necessary to obliterate erosion rills. Sub-soiling shall be required to reduce soil compaction in all areas where plant establishment is planned. Sub-soiling shall be performed by the prime or excavating contractor and shall occur before compost placement.

---

[1] Draws from information found in **Pennsylvania Stormwater Best Management Practices Manual** *6.7.3* ***Soil Amendment and Restoration*** (http://www.stormwaterpa.org/assets/media/BMP_manual/07_Chapter_6.pdf) and **VIRGINIA DCR STORMWATER DESIGN SPECIFICATION No. 4** ***SOIL COMPOST AMENDMENT*** VERSION 1.7; 2010 **(http://www.chesapeakestormwater.net/all-things-stormwater/soil-compost-amendments.html)**

3. Subsoiled areas shall be loosened to less than 1400 kPa (200 psi) to a depth of 20 inches below final topsoil grade. When directed by the owner's representative, the Contractor shall verify that the sub-soiling work conforms to the specified depth.

4. Sub-soiling shall form a two-directional grid. Channels shall be created by a commercially available, multi-shanked, parallelogram implement (solid-shank ripper). The equipment shall be capable of exerting a penetration force necessary for the site. 1\10 disc-cultivators, chisel plows, or spring-loaded equipment will be allowed. The grid channels shall be spaced a minimum of 12 inches to a maximum of 36 inches apart, depending on equipment and site conditions. The channel depth shall be a minimum of 20 inches. If soils are saturated, the Contractor shall delay operations until the soil will not hold a ball when squeezed. Only one pass shall be performed on erodible slopes greater than 1 vertical to 3 horizontal. When only one pass is used, work should be at right angles to the direction of surface drainage, whenever practical.

5. Exceptions to sub-soiling include areas within the drip line of any existing trees, over utility installations within 30 inches of the surface, where trenching/drainage lines are installed, where compaction is by design (abutments, footings, or in slopes), and on inaccessible slopes, as approved by the owner's representative.

COMPOST APPLICATION

After the top and subsoil are mixed as a result of sub-soiling operations to remove compaction, remove rocks, distribute compost / amendment over the area and rototill into the top and subsoil mixture. Add seed or other plant material.

COMPOST SOIL AMENDMENT QUALITY

Only compost products that meet all applicable state and federal regulations pertaining to its production and distribution may be used in this application. Approved compost products must meet **the District of Columbia** specifications at http://www.chesapeakestormwater.net/all-things-stormwater/soil-compost-amendments.html.

Appendix 4.1
Study Areas with Building Numbers and Addresses

Study Area 1 1 – 3800 to 3831 Rodman 2 – 3839 to 3863 Rodman 3 – 3871 to 3895 Rodman 4 – 3801 to 3821 39th	**Study Area 4** 14 – 3601 to 3641 39th 15 – 3880 to 3896 Porter 16 – 3856 to 3872Porter 17 – 3832 to 3848Porter 18 – 3816 & 3824Porter 18 – 3440 & 3450 38th	**Study Area 7** 26 – 3951 to 3971 Langley 27 – 3960 to 3990 Langley 28 – 3930 to 3950 Langley 29 – 3500 to 3540 39th 30 – 3430 to 3470 39th 31 – 3400 to 3420 39th
Study Area 2 5 – 3830 to 3850 39th 6 – 3800 to 3820 39th 7 – 3740 to 3770 39th 8 – 3700 to 3730 39th 9 – 3701 to 3741 39th	**Study Area 5** 19 – 3410 & 3420 38th 19 – 3801 & 3811Newark 20 – 3821 to 3851Newark 21 – 3861 to 3881Newark 22 – 33891Newark 22 – 3511 to 3551 39th	
Study Area 3 10 – 3850 to 3880 Rodman 11 – 3660 to 3690 38th 12 – 3600 to 3620 38th 13 – 3851 to 3881 Porter	**Study Area 6** 23 – 3630 to 3650 39th 24 – 3600 to 3620 39th 25 – 3901 to 3941 Langley	

American University – McLean Gardens

A collaboration to reduce future costs related to storm water

Justin Van Der Horn
BA Environmental Studies 2011
BA International Studies 2011

Objectives

- Conduct inventory and ground-truth impervious areas
- Make recommendations to reduce future costs related to storm water

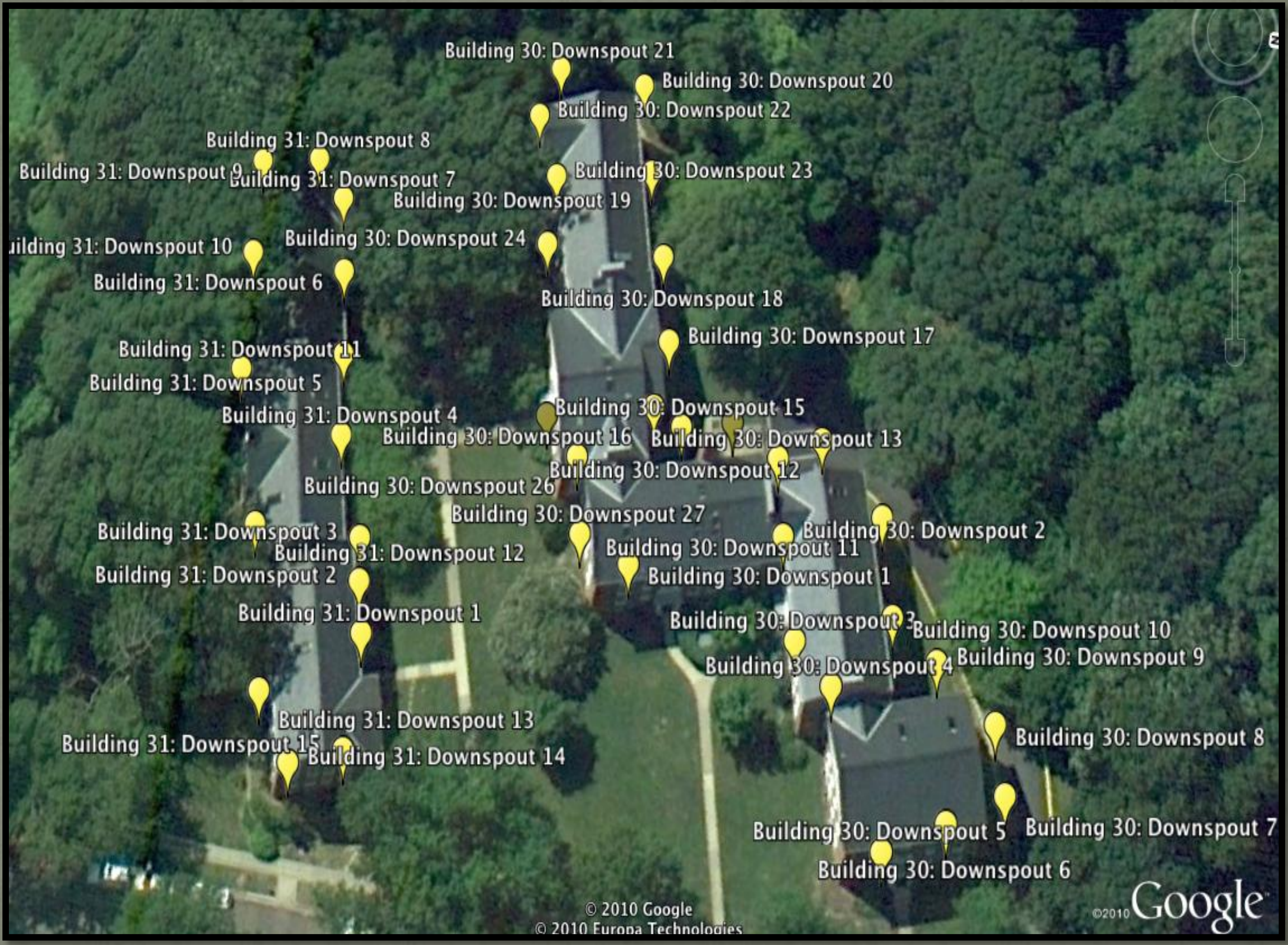
Inventory

<u>Property Features</u>

- Trees
- Downspouts
- Storm drains
- Manholes

<u>Impervious Surfaces</u>

- Building
  -Perimeter/area
- Sidewalks
- Roads
- Pool



Building 30: Downspout 21
Building 30: Downspout 20
Building 30: Downspout 22
Building 31: Downspout 8
Building 31: Downspout 9
Building 31: Downspout 7
Building 30: Downspout 23
Building 30: Downspout 19
uilding 31: Downspout 10
Building 30: Downspout 24
Building 31: Downspout 6
Building 30: Downspout 18
Building 30: Downspout 17
Building 31: Downspout 11
Building 31: Downspout 5
Building 30: Downspout 15
Building 31: Downspout 4
Building 30: Downspout 16
Building 30: Downspout 13
Building 30: Downspout 12
Building 30: Downspout 26
Building 30: Downspout 27
Building 31: Downspout 3
Building 30: Downspout 2
Building 31: Downspout 12
Building 30: Downspout 11
Building 31: Downspout 2
Building 30: Downspout 1
Building 31: Downspout 1
Building 30: Downspout 3
Building 30: Downspout 10
Building 30: Downspout 9
Building 30: Downspout 4
Building 31: Downspout 13
Building 30: Downspout 8
Building 31: Downspout 15
Building 31: Downspout 14
Building 30: Downspout 5
Building 30: Downspout 7
Building 30: Downspout 6
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Findings

- Large amount of property is **impervious** or turf
- **Downspouts** direct water into sewer or add to erosion
- Existing **drainage** methods poorly maintained
- Casey Trees data accurate
- **Soil** does not absorb run off
- **Topography** increases impact of run off

Findings

Impervious Surfaces	
DC Water	388,770.8 sq ft
Student Evaluation	391,818.3 sq ft
Difference	1%

- Data missing due to construction and time constraints


39th St NW

Drainage Features

Poor Drainage

Downspouts

Topography

Steep Slopes

Erosion

Soils

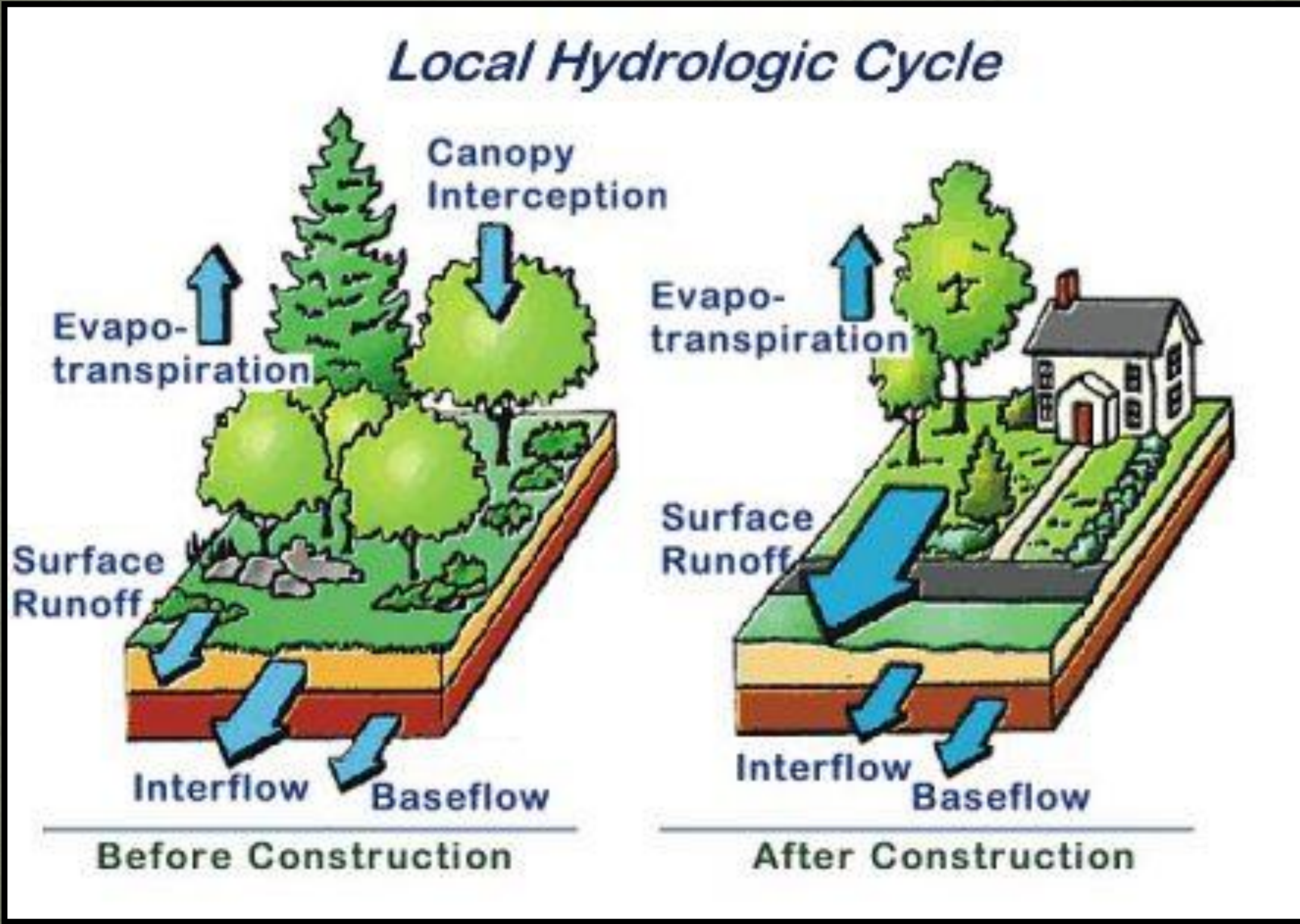
Compacted

Percolation

Vegetation

Trees

Shrubs / Grass

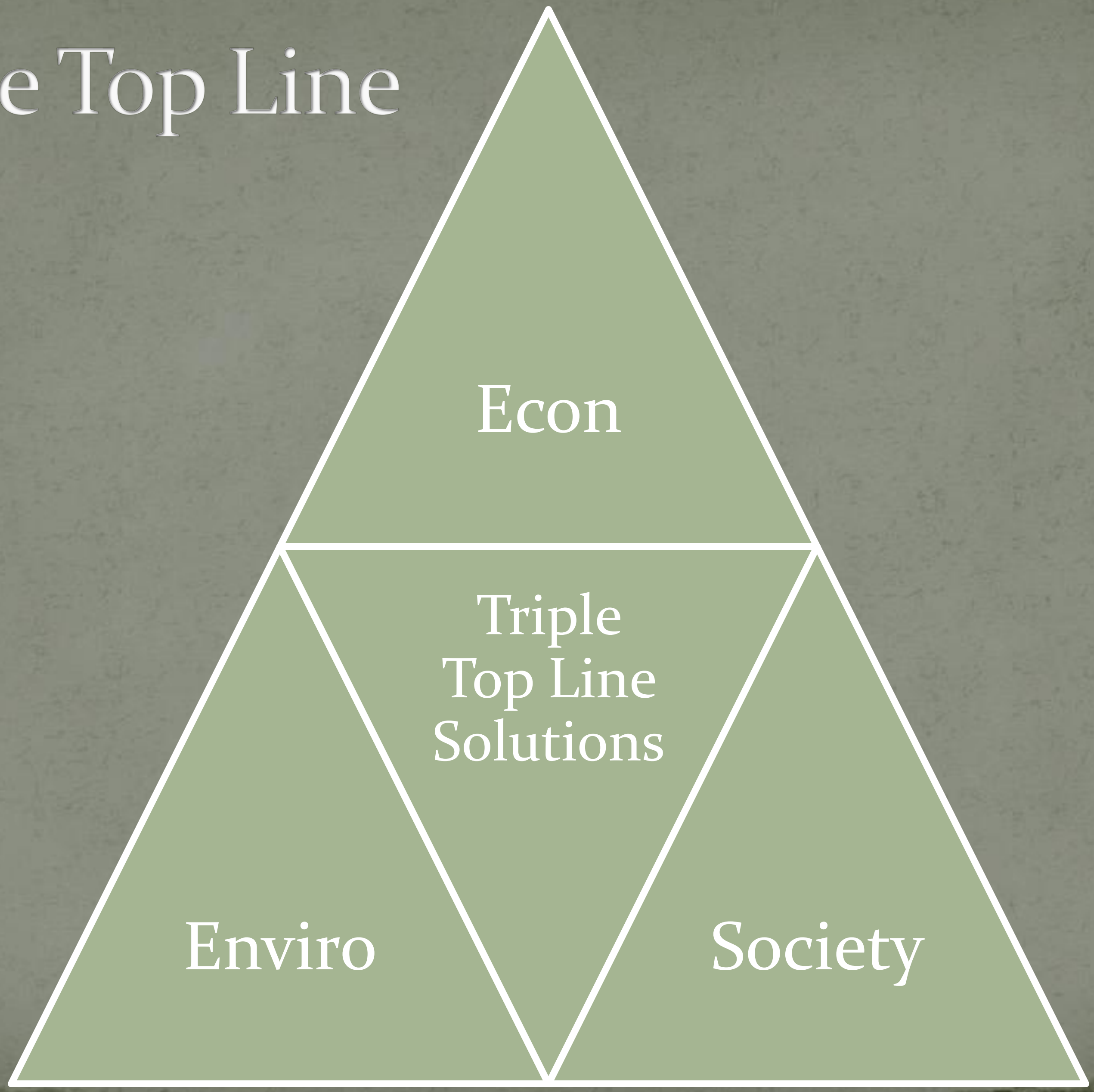


http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/SedimentandStormwaterHome/Pages/Programs/WaterPrograms/sedimentandstormwater/home/index.aspx

Recommendations

- Green roofs
- Rain gardens / Vegetated filters
- Retention and Storage
- Natural ground cover (not grass)
- Tree canopy
- Permeable paving
- Community education and involvement

Triple Top Line



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American University – McLean Gardens

a collaboration to reduce future costs related to stormwater

A Stormwater Management Framework for McLean Gardens

Phase II Report

–DRAFT-

Short- and Long-Term Recommendations
with Management Decision Tools

May 2011

Justin Van Der Horn

Table of Contents

3. CREATING REALISTIC CHOICES: "RIGHT APPROACH – RIGHT SITE"

Choosing the right stormwater mitigation option in the context of a greater sustainability initiative requires considering which options are best for specific sites. The range of options available can be generally categorized as (a) water retention facilities, (b) permeability improvements, and (c) conservation landscaping. Each category, and their specific approaches, has unique requirements and considerations which influence their viability site by site.

Water retention facilities are both natural and synthetic; but for the purposes of this study, all require engineering and professional design. Rain gardens, which we define as synonymous with bioretention cells, are gardens engineered to absorb, filter, and slow the rate of runoff before it reaches the sewer system. Right approach – right site principles for rain gardens indicate that they are most beneficial (and cost effective) where extreme erosion exists, near areas prone to flooding, in social and visible locations, and near existing dry wells. For example, finding a natural community space and giving people a reason to go in addition to having a rain garden that is well marked, can serve as an educational site with social and environmental value with economic benefits (Mastrota, 2011). (See Appendix 1.1 for performance criteria for bioretention design.) Comparatively, rain barrels or cisterns (which are synthetic water retention methods) should be placed near buildings and in hidden or disguised locations. Additionally, right approach principles apply to the size and scale of these projects. For instance, if rain barrels were used to mitigate 100% of the water that hits the roofs of McLean gardens during a 1.0 inch rain event, it is estimated that 4,800 fifty-gallon barrels would be required. Instead, the size of the barrels should be maximized to the greatest extent possible while keeping in mind the negative aesthetic effects, so that a minimum number of barrels need to be installed. Furthermore, barrel location should also be determined by disposal methods available such as near areas to wash cars, water private gardens, and nurture new plantings like Casey Trees so that the water does not sit stagnant in the barrel.

Permeability improvements include replacing impervious walkways with permeable pavers or concrete and repaving parking lots and driveways with permeable asphalt. Amending soil to improve percolation rates may also be considered a permeability improvement. Right approach – right site considerations for walkways include considering which surfaces contribute the most detrimental volumes of stormwater directly into storm drains and which surfaces are most in need of replacement. To be cost effective, replacing unsafe walkways or parking lots scheduled to be ripped up with permeable surfaces would minimize costs while maximizing social and ecological benefits. Additionally, the aesthetic value of pavers encourages their initial placement in visible locations installed in continuous segments rather than hidden walkways or fragmented across space.

Conservation landscaping and ecosystem improvements include large canopy tree plantings, vegetated filter strips, native planting gardens (bayscaping), and other understory improvements. For these approaches, the topography of the land and the sun conditions (full sun, partial shade, etc) are paramount. Consider, for instance, the money spent on grass plantings on steep, shaded slopes where few seeds are likely to sprout and rain events quickly wash away the latent seeds or young grasses. Native grasses and plantings with deeper roots or trees which also help to slow the flow of water downhill are more appropriate approaches for these areas.

In general, the development of a master sustainability plan with projects designed and engineered by landscape architects and urban developers will properly consider right approach –right site. Casey Tree's draft proposal for completion of a Sustainability Plan is available in Appendix 2.

4. DECISION MAKING TOOLS

Incentives of investment include keeping costs from rising, reducing the property's contribution to stormwater runoff, improving aesthetic qualities of the property, educating the local community, and using the landscape to encourage and improve the feeling of community. These are complex factors. The following section provides basic data on rainfall, impervious surfaces, and the costs and benefits of particular mitigation approaches. This information is provided to facilitate the management decision-making process and is intended to serve as guidance rather than steadfast rules. Factors vary depending on site, size, scope, scale, and schedule, including the way McLean Gardens integrates these new values and projects into ongoing or future operations.

Additionally important to the decision making process is a general understanding of the likely incentive structure put forth by various DC agencies. The likely incentive structure will be a combination of grants and installation-cost assistance as well as purchase rebates and retroactive fee rebates. The District Department of the Environment currently has a program for grants and installation assistance for reducing stormwater pollution called RiverSmart. The program already has specific applications for homes and schools, and a condominium program is currently under review. A summary of the incentives RiverSmart Homes provides is listed in Appendix 3.

As per a meeting with DDOE representatives, it is likely that the retroactive rebates will be given at a rate of 50 percent of the DDOE stormwater fee and 30 percent of the DC Water fee, but those estimates are subject to change (Lemoine, 2011). Other cities incentivize a combination of impervious area reductions and stormwater management techniques which they value and measure differently. Additionally, some cities have opted to quantify reductions based on either area covered or water mitigated which will be an important factor when the city of DC releases its incentive structure. A comparative review of fee programs and their corresponding incentive structures in Philadelphia, Chicago, Portland, and Seattle is available in Appendix 4. DC cost estimates of stormwater management techniques are available in Appendix 5.

Table 4.1 - Student Recommendations and McLean Gardens Existing Projects (Rank Order)

Recommendations	Fall 2010 Teams								
Short-term	1	2	3	4	5	6	7	TOTAL	MG Wide
Install Rain Barrels	✓	✓	✓	✓	✓	✓		6	
Install Vegetated Filter Strips, swales, or rain gardens along parking lot	✓	✓	✓					3	
Storm water planters				✓				1	
Mitigate soil									✓
Plant Trees									✓
Long-term									
Install rain gardens at the base of the slopes, along the edge of the sidewalk, or near collective downspout releases	✓	✓	✓	✓	✓	✓	✓	7	
Replace current impervious walkways with pervious pavement	✓	✓		✓	✓	✓	✓	6	
Replace asphalt with pervious pavement		✓		✓	✓	✓	✓	5	
Install a green roof on the small utility building	✓			✓	✓	✓	N/A	4	
Remove curbs		✓	✓	✓		✓		4	
Install infiltration trenches		✓		✓		✓		3	
Develop a landscaping plan for perimeter of buildings and/or a focused tree planting plan	✓			✓			✓	3	
Education programs	✓						✓	2	✓
Install dense Vegetated Filter Strips at the base of slopes		✓	✓					2	
Soil amendments							✓	1	✓
Transition from traditional grass cover to native landscaping on slopes	✓							1	✓

Table 4.2 – Mitigation Approaches and Relative Economic, Environmental, and Social Values

Mitigation Approach	**Cost**[1]				
	1 (high)	2	3	4	5 (low)
Rain Barrel (small)					x
Rain Barrel (large)				x	
Rain Garden (small)		x			
Rain Garden (large)	x				
Permeable Pavers		x			
Green Roof	x				
Trees				x	
Conservation Landscaping			x		
	Likelihood / Impact of Retroactive Fee Rebate[2]				
	1 (low)	2	3	4	5 (high)
Rain Barrel (small)		x			
Rain Barrel (large)			x		
Rain Garden (small)				x	
Rain Garden (large)					x
Permeable Pavers				x	
Green Roof					x
Trees		x			
Conservation Landscaping	x				
	Retention / Percolation Capacity[3]				
	1 (low)	2	3	4	5 (high)
Rain Barrel (small)		x			
Rain Barrel (large)			x		
Rain Garden (small)			x		
Rain Garden (large)				x	
Permeable Pavers				x	
Green Roof				x	
Trees		x			
Conservation Landscaping		x			
	Aesthetic and Social Value[4]				
	1 (low)	2	3	4	5 (high)
Rain Barrel (small)		x			
Rain Barrel (large)	X				
Rain Garden (small)				x	
Rain Garden (large)					x
Permeable Pavers			x		
Green Roof				x	
Trees				x	
Conservation Landscaping				x	

1. See Appendix 5 for various cost estimates for stormwater management techniques
2. RiverSmart Homes (DDOE, 2011), Draft MS4 review of other U.S. city incentive structures(Leistra, Weiss, & Helman, 2010), and estimates on potential for McLean to reduce impervious area or capture runoff using each technique
3. Estimates. True retention values depend on site, size, scope, and scale of approach and calculations should be completed by an engineer on a project by project basis
4. Subjective

Table 4.3 - Rainwater Calculations for DC

Average Rain Fall	42.1 inches per year
2010 Actual	39.4 inches
Annual Average of Major Rain Events (1.0 inches in 24 hours)	9.5 events per year
2010 Actual	6.0 events
Annual Average of Rain events 0.5 inches or Greater	27.5 events per year
2010 Actual	26.0 events

NOAA Data for the National Airport (Blakeslee et al., 2011)

Table 4.4 – Impervious Surfaces on McLean Gardens Property

Total Impervious Surface Area *DC Water*	388,770.8 sq ft	Total
Roof Area	248,813.3 sq ft	64% of total
Approximate average per building	8,000 sq ft	
Parking Lots and Driveways Area	85,529.6 sq ft	22% of total
Sidewalks and Stairs Area	50,540.2 sq ft	13% of total
Swimming Pool Area	3,887.7 sq ft	1% of total

(Blakeslee, et al., 2011)

Table 4.5 – Rain Fall Calculations for McLean Gardens

Total average volume of water collected on rooftops **per year**[1]	5,028,019.2 gallons
Per building per year	162,194.2 gallons
Total Average volume of water collected on rooftops **per month**	419,001.6 gallons
Per building per month	13,516.2 gallons
Total average volume of water on rooftops **per major rain event** (1.0 inches in 24 hours)	119,430.3 gallons
Per building per major rain event	3,852.6 gallons

1. 0.6 x (Building area in sq ft) x 0.8 (*efficiency factor*) x (inches of rainfall per year) = gallons of rain per year (Demesne, 2010)

PHASE II REFERENCES

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6. APPENDICES

Appendix 1.1 – Performance Criteria for Bioretention Design
Appendix 2.1 – Casey Trees Proposal to Generate a Sustainability Plan
Appendix 3.1 – RiverSmart Homes Incentive Structure
Appendix 3.2 – RiverSmart Homes Site Evaluation Form
Appendix 4.1 – Cost Analysis of Proposed District of Columbia Stormwater Regulations: Comparative City Fee Structures
Appendix 5.1 – IEC exhibit 3-2: Unit Cost Estimates for Stormwater Management Techniques
Appendix 5.2 – American University Green Roof Installation Costs

Appendix 1.1 – Performance Criteria for Bioretention Design (Environmental_Services_Division, 2007)

Table 4.1. MDE performance criteria for bioretention design*

Criteria	Filtration design	Infiltration design	CPV storage design
General feasibility			
Location	All locations okay with underdrain	*In situ* soils to be certified suitable	*In situ* soils to be certified suitable[1]
Drainage area	2 acres maximum, 1 acre maximum impervious	1 acres maximum, ½ acre maximum impervious	1 acres maximum, ½ acre maximum impervious
Soils infiltration rate	See soil mixture specifications	*In situ* soils 1" /hour infiltration rate[2]	*In situ* soils 1" /hour infiltration rate[2]
Clay content	< 5%	< 5%	< 5%
Hotspots	Yes w/liner	No without proper treatment	No
Water table	> 2 vert. feet from facility invert	> 4 vert. feet from facility invert	
Water supply well	Maintain > 100" distance		
Building structures	Setback > 10^{-3} Downgradient	Setback > 25^{-3} Downgradient	Setback > 10^{-3} Downgradient
Septic system	Maintain > 50' distance		
Sloped areas	Okay with weep garden design	Not recommended greater than 20%	Not recommended
Property line setback	2' minimum		
Conveyance			
Entrance flow	Surface sheetflow	Surface sheetflow	Surface sheetflow
Entrance treatment	Riprap gabion mattress.surge stone	Riprap gabion mattress.surge stone	Riprap gabion mattress.surge stone
Surface pool dewater	3–4 hours	3–4 hours	3–4 hours
System dewater	< 48 hours		< 48 hours
Overflow outlet	Safe overflow path or appropriate Outlet	Safe overflow path	Safe overflow path or appropriate Outlet
Flow path	Off-line is preferred; where not feasible, in-line is permissible		
Flow regulator	Divert WQv		
Media filter	Non-woven filter fabric or pea gravel diaphragm	None	Non-woven filter Fabric and liner around facility
Underdrain	4" diameter minimum	N/A	4" diameter minimum
Pretreatment			
Pretreatment BMP	Surface	Required	Required
Grass filter strip	Use where space permits. Not always feasible		
Surface treatment	Allowable where impervious area > 75%		
Pretreatment volume	25% of WQv	N/A	25% of WQv
Treatment			
Volume	Entire WQv filtered – pretreatment volume	Entire WQv infiltra. – pretreatment volume	Entire WQv filtered – pretreatment volume
Porosity	n = .25 for soil mix; .40 for stone	n = .25 for soil mix	n = .25 for soil mix; 40 for stone
Landscaping	See Landscaping Chapter		
Maintenance			

* Source: MDE 2000

WQv = Water Quality Volume

Appendix 2.1 - *Casey Trees Proposal to Generate a Sustainability Plan*
(Brown & Maisie, 2011b)

To:

Mary Blakeslee
McLean Gardens Community
blakbock@verizon.net

Dear Ms. Blakeslee,

We are pleased to present this proposal to you to perform services in generating a sustainable plan for your community. Our understanding of the project is that McLean Gardens would like assistance to create a master plan for the community and identify projects and other actions in the neighborhood that would create more environmental sustainability in the community.

Casey Trees mission is to restore, enhance, and protect the tree canopy of the Nation's Capital. Our primary focus is trees; however, we also feel a holistic approach to environmental sustainability directly and indirectly impacts the health and preservation of the tree canopy. Smart growth practices in development and planning ensure that land will be used efficiently and create development patterns that limit the need for removing trees. Additionally, sustainable planning practices ensure a healthy environment that promotes air and water quality that help trees thrive and grow to a fuller maturity; which in turn also helps promote further improvements to air and water quality (a virtuous cycle).

For these reasons, we see tremendous value in assisting McLean Gardens in achieving a 'greener' future, and would like to offer our services and expertise in arboriculture, landscape architecture, planning and design in creating a sustainably-based master plan for the neighborhood.

This document outlines our proposed Scope of Services, Schedule, Products/Deliverables, Staffing and Fee for the project. We are open to any changes you would like to make to this proposal to ensure that we are providing the services that will best fit the needs of McLean Gardens.

Feel free to call or email us anytime to discuss this potential project. We are excited about the opportunity to work with you.

Sincerely,

Scott Brown
Planning Associate
sbrown@caseytrees.org
202.349.1892

Maisie Hughes
Director, Planning & Design
sbrown@caseytrees.org
202.349.1892

SCOPE OF SERVICES

The plan will provide a general assessment and analysis of the existing conditions as outlined, and an overall vision plan with sustainable strategies will be generated for the entire community. Through the community visioning and input process, we would like to select 2 to 3 priority areas for a more detailed plan and landscape design. These priority areas would be chosen by the community through the public visioning process.

TASK 1: EXISTING CONDITIONS ANALYSIS

The Existing Conditions Analysis will be generated through field observations, photo documentation, GIS analysis, research and discussions with local stakeholders with the purpose of generating a document inventorying the existing features, amenities, assets and deficiencies under the categories below. A key part of this will be building on existing plans for the area, and particularly the recent student research done by American University. This will provide the baseline for determining community needs and measuring progress towards future goals.

1. Natural Resources & Environment
    a. Tree Canopy
    b. Hydrology
    c. Soils & Slopes
    d. Existing Green Infrastructure
2. Land Uses & Development
    a. Existing Land Uses
    b. Development Footprints
    c. Zoning and Other Applicable Regulations
3. Community Facilities & Amenities
    a. Neighborhood Facilities
    b. Public Facilities
    c. Local Businesses and Services
    d. Parks & Recreation Facilities
4. Mobility & Connectivity
    a. Parking
    b. Access to Public Transportation
    c. Sidewalks, Trails and Bicycle Amenities
5. Cultural Amenities
    a. Urban Design
    b. Historic Preservation
    c. Viewsheds

TASK 2: PUBLIC INPUT PROCESS/VISIONING

Task 2 involves working with the neighborhood to generate ideas, concerns and aspirations of community residents and gauge citizen interest in pursuing new local strategies and initiatives. At our public meetings, we will aim to both educate the public on the benefits of sustainable planning and design practices, and generate citizen-based ideas or concerns for the future of the neighborhood. We hope to engage the community in a number of ways: open house sessions, public presentations, focus group exercises, table charrette exercises, and online opinion surveys. The following are the proposed public engagement activities, with more details provided on each in the following 'Meetings' section:

1. Public Kickoff Session
2. Public Visioning Charrette
3. Online Surveys (2)- one between kickoff & charrette, one after charrette
4. Presentation of the Vision Plan

TASK 3: VISION & IMPLEMENTATION

The final document will synthesize our findings with community input to provide a guiding blueprint for a more sustainable McLean Gardens. Under each of the first four sections below will be a number of sustainable strategies and goals that may be appropriate and attainable for the neighborhood to pursue. Discussions of priority, costs, and potential impacts will also be included in the text. The last section will provide an implementation plan, charting short, mid, and long-term goals and strategies and benchmarking measures to monitor progress towards those activities.

1. Land Use, Smart Growth & Development
2. Sustainability & Green Infrastructure
3. Community Facilities & Amenities
4. Mobility & Neighborhood Connectivity
5. Action/Policy Implementation Chart

MEETINGS

1. Client Startup Meeting:
    - Finalize scope & schedule,
    - Discuss a steering committee
    - Determine sites/dates for public meetings, etc.
2. Steering Committee Meeting 1:
    - Discuss initial findings and discuss upcoming public meetings
3. Public Kickoff Meeting:
    - Intro to Casey Trees
    - Project description & purpose
    - Presentation of initial findings
    - Casey Trees presentation on State of DC Tree Canopy & Benefits of Sustainable Design
    - Open House
4. Steering Committee:
    - Update on project progress
    - Review of public meeting discussion and feedback
5. Public Visioning Charrette
    - Casey Trees presentation: Intro to Stormwater Best Management Practices, Low Impact Design (LID) and Designing Better Tree Spaces
    - Focus group discussions
    - Design Charrette
6. Steering Committee:
    - Review of charettee and progress report
7. Public Presentation of Vision Plan
8. Final Steering Committee Meeting:
    - Discuss public feedback
    - Discuss final revisions

Steering Committee Composition: The Steering Committee should be made up of key community stakeholders, such as neighborhood association president and chairs of existing neighborhood committees. In addition we may want to have city representation, such as the Ward 3 planner and/or a representative from DDOE. Ultimately, we will lean on McLean Gardens to decide the make-up of the committee, but we are happy to provide some guidance. We suggest a committee of approximately 6 to 10 members (a manageable, but diverse number of viewpoints).

Advertising, Facilities for Public Meetings: We also will leave it up to the neighborhood to determine the best means of advertising public meetings, with any requested guidance or assistance from Casey Trees. We can provide digital flyers, and can do mass email alerts; however, we have not included any flyer printing costs and would prefer to use digital communication rather than printed materials. The fee schedule does not include the rental of facilities for meetings.

SCHEDULE:

The following is the proposed schedule for completing the McLean Gardens plan. This is only an estimated schedule for planning purposes, subject to change based on the start date, any adjustments to the scope of services, or other client needs.

TASK	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
Project Startup								
Client Startup Meeting	S							
Existing Conditions Analysis								
Steering Committee Meeting			S					
Public Kickoff/Open House			P					
Steering Committee Meeting				S				
Public Charrettes				P				
Steering Committee Meeting					S			
Existing Conditions & Public Visioning Report					D			
Draft Visioning & Implementation Plan								
Public Presentation								
Final Steering Committee Meeting							S	
Final Draft of McLean Gardens Plan								D

P = Public Meetings
S = Steering Committee Meetings
D = Deliverables

PRODUCTS/DELIVERABLES:

Existing Conditions Report: The first major deliverable of the project will be an Existing Conditions Report. This will contain observations, maps, photo-documentation and analysis of all existing conditions that fall within the above outlined features. This will help generate the baseline conditions, help to identify local assets and areas of improvement, and provide a reference point for future goals and achievements.

In addition to field observations and analyses, the Existing Conditions Report will contain documentation and summary of the community observations and feedback received during the public input process, as well as any survey results. This will provide a supplement to the existing conditions gained in the field to round out a true snapshot of McLean Gardens at the present time, by identifying the views and aspirations of the area's residents and stakeholders.

Deliverables:

- Three hardcopy documents, plus digital copies on CD or via emailed pdf document

Final Plan Document: The final product is the Sustainable Strategies Plan for McLean Gardens, outlining a community-originated vision for the neighborhood for future development, mobility and especially sustainability. This will include an illustrative plan summarizing the future 'green' vision for McLean Gardens in a map format.

The final plan will feature a strategic implementation schedule, prioritizing short-term, mid-term and long-term projects, actions, goals, and policy changes. This will give the community a blueprint for its transition to a more sustainable future. The plan will also suggest resources for achieving the outlined goals, and provide targets for benchmarking progress towards those goals.

Deliverables

- Three hardcopy documents, plus digital copies on CD or via emailed pdf document
- 1 large-format Illustrative Plan Map (33"x44" or similar poster size)

Meetings: We will provide the following number of meetings throughout the schedule:

- One (1) project startup meeting
- Three (3) public meetings (kickoff meeting, public charette, public presentation)
- Four (4) steering committee meetings

Monthly Progress Reports (option): Optionally, Casey Trees can provide a monthly progress report upon request if it is felt that Steering Committee meetings will not be frequent enough to provide up-to-date project status.

STAFFING & FEE SCHEDULE:

Casey Trees is an established non-profit organization with an excellent track record of provided great products in the areas of tree research, geographic resources, landscape design, and environmental planning. We look forward to adding the additional role of community planning, and we have staff that is very qualified and capable of performing these services. Our intention in this project is strictly non-profit, with an interest in advancing sustainable planning in the District of Columbia that also forwards our mission of restoring, protecting and enhancing the urban tree canopy in DC.

Primary Project Staff:

- *Scott Brown, Planning Associate, (Project Manager):* Scott is a professional urban planner, certified by the American Institute of Certified Planners (AICP), and has over 5 years of quality community planning experience with projects ranging from small neighborhoods to multi-county regions.
- *Maisie Hughes, Director of Planning & Design:* Maisie is a landscape architect and ISA Certified Arborist with vast experience in the District of Columbia and Maryland. Maisie has worked on various community and sustainable design projects that focus on enhancing tree canopy while managing stormwater. She holds expertise in low impact design and innovative tree space design, and has extensive experience working with DC communities in creating sustainable landscapes for their areas.

Additional Staffing:

- *Casey Trees' Sustainability Group:* With a wide-range of analytical, technical and geographic skills, the Sustainability Group is available to assist primary project staff in providing compelling and meaningful maps and tree-related analysis for the project and public participation.
- *Interns & Fellows:* Casey Trees employs several graduate and undergraduate students with a wide range of knowledge and skills in research, writing, landscape architecture, planning, public relations and graphic design. We plan to utilize these members of the Casey Trees team where applicable to help keep project costs more affordable and to incorporate a youthful, exuberant point of view.

The following fee schedule provides the expected costs associated with producing the scope of services outlined previously. Changes in the scope of services will impact the costs proposed.

TASK	*Associates*	*Directors*	*Interns/Fellows*
Client Startup Meeting	2	2	2
Existing Conditions Analysis	60	12	30
Steering Committee Meeting	4	2	
Public Kickoff Meeting	16	4	10
Steering Committee Meeting	2	2	
Public Charrettes	16	6	12
Steering Committee Meeting	4	2	
Existing Conditions & Public Visioning Report	32	8	24
Draft Visioning & Implementation Plan	48	8	28
Public Presentation	8	2	2
Final Steering Committee Meeting	3	3	
Revise and Complete Final Draft of McLean Gardens Plan	16	4	10
Total Estimated Hours	**211**	**55**	**118**
x Billing Rate	**$7,385.00**	**$3,300.00**	**$1,770.00**
Total Labor Costs			**$12,455.00**
Other Costs (Printing, Travel, Visual Eqt.)			**$500**
TOTAL FEE			**$12,955**
ADJUSTED TOTAL *(Discounted 50%)*			**$6,227.50**

We understand that your budget is on the calendar year, and will have a new budget cycle at the year break. With our organization on a fiscal year schedule (July '11 through June '12), we can be flexible with you on the payment schedule, if for example you need to backload most of the fee payment to 2012.

Appendix 3.1 - *RiverSmart Homes Incentive Structure*
(DDOE, 2011)

1. Shade Trees = $50 each. The cost of the shade tree installation is estimated to be $300.
2. Rain Barrels = $30 each. The cost of the rain barrel installation is estimated to be $300. Homeowners can purchase one of seven approved barrels and receive $50-100.
3. BayScaping (native plants) = $100. The cost of the BayScaping varies depending on the size of the area landscaped. It can be up to $1,200.
4. Rain Gardens = $75. The cost of a rain garden varies depending on the size of the area landscaped. It can be up to $1,200.
5. Pervious Pavers = DDOE will pay the difference (up to $1,200) between conventional pavement (concrete) and pervious pavers.

Appendix 3.2 – *RiverSmart Homes Site Audit Form*
(DDOE, 2011)

RiverSmart Homes
Clean Water Starts in Your Yard

DISTRICT DEPARTMENT OF THE ENVIRONMENT

Stormwater Site Audit

Date of Audit: Click here to enter text.
Name of Auditor: Click here to enter text.
Audit #: Click here to enter text.

Property Owner Information:

Property Owner: Click here to enter text.

Telephone: Click here to enter text.

Owner Address:

Telephone Other: Click here to enter text.

Email: Click here to enter text.

Property Square: Click here to enter text.
Ward: Choose an item.
Sewer System: Choose an item.

Property Lot: Click here to enter text.
Watershed: Choose an item.

Recommended Site Improvement Types

☐ **BayScaping** ☐ **Tree Planting** ☐ **Reduction of Impervious Surface**

☐ **Rain Garden** ☐ **Rain Barrel** ☐ **Roof downspout disconnection**

Recommendation Notes for the Homeowner

Trees: Click here to enter text.

Permeable Pavement: Click here to enter text.

Above Ground Cisterns (Rain Barrels): Click here to enter text.

BayScaping: Click here to enter text.

RiverSmart Homes
Clean Water Starts in Your Yard

DISTRICT DEPARTMENT OF THE ENVIRONMENT

Rain Garden: Click here to enter text.

If you have any questions or if you would like to see photos of the areas on your property reference in my recommendations, please let me know.

Other Audit Notes:

Site Information

Building:

Type of Building: Choose an item.
Total number of downspouts: Choose an item. **Color of downspouts:** Choose an item.
Number of downspouts on house: Choose an item. **Shape of downspouts:** Choose an item.
Number of downspouts on other structures: Choose an item. **Size of downspouts:** Choose an item.

Existing Water Management Practices:

Total number of additional drain inlet(s): Choose an item.
Type(s) of additional drain inlet(s): Choose an item.
Click here to enter text.

Are the gutters, downspouts, and stormwater inlets in good repair: Choose an item.
If no, give details: Click here to enter text.

Total number and type of stormwater inlets connected to the sewer: Choose an item.
Details: Click here to enter text.

Does the site have a sump pump or other discharges? Choose an item.
If yes, give details: Click here to enter text.

Are there Low Impact Development practices utilized on site: Choose an item.
If yes, give details (type of stormwater management devices(s), age, location inlets served: Click here to enter text.

Land Characteristics:

Does the site have any considerable slope? Choose an item.
If yes, give details (length, steep, gradual, direction, i.e., toward street or neighboring property or stormwater inlet): Click here to enter text.

Does the site have any retaining wall(s)? Choose an item.
If yes, give details: Click here to enter text.

Amount of Pervious and Impervious Surfaces:

Approximate area of the roof and additional structures: Click here to enter text.

Approximate number of gallons of runoff of roof and additional structures: Click here to enter text.

Approximate area of driveway and other impervious areas for consideration: Click here to enter text.
Approximate number of gallons of runoff of driveway and other impervious surfaces: Click here to enter text.

Approximate area of yard: Choose an item.

Driveway/Paved area surface type: Choose an item.

RiverSmart Homes

Clean Water Starts in Your Yard

DISTRICT DEPARTMENT OF THE ENVIRONMENT

Site Drawing:

NORTH

Government of the District of Columbia
Adrian M. Fenty, Mayor

Appendix 4.1 – *Cost Analysis of Proposed District of Columbia Stormwater Regulations: Comparative City Fee Structures, Pages 11-17*

(Leistra, Weiss, & Helman, 2010)

PHILADELPHIA, PA

Philadelphia's stormwater regulations took effect January 1, 2006. The regulations were developed as part of watershed-based planning efforts ongoing with several municipalities bordering Philadelphia, but also in response to the 1976 Pennsylvania Stormwater Act, which requires municipalities to update stormwater plans as needed to incorporate changes in the regulatory environment. In recent years, the state established TMDLs in the Philadelphia watershed, and federal policy has tightened restrictions on CSO systems. As such, Philadelphia's stormwater regulations had to respond to these changes.

Major features of the new stormwater regulations included requiring retention of one inch of water volume; setting a lower threshold for regulation at between 5,000 – 15,000 sq ft (depending on building type and location); and a series of erosion and flood control measures. Philadelphia eliminated the issuance of waivers for projects that fall within the purview of the stormwater regulations, but coupled promulgation of the regulations with the roll out of transparent, online permit submission, review, and approval processes, as well as financial incentives to promote the use of LID techniques. Over the past three years of implementation, Philadelphia also gradually established policies for stormwater banking and trading to accommodate developers and institutional landholders (including the Philadelphia airport and universities in the City) who prefer to build larger green infrastructure projects that connect multiple sites (as opposed to site-specific stormwater management plans). Based on their own experience, the City recommends establishing the parameters of banking and trading programs upon promulgation of new stormwater rules, instead of taking a gradual approach.

Impact Of The Regulations On Development Activity

Philadelphia sees no impacts of the stormwater regulation on the location of development activity. Although some developers threatened to pull projects from Philadelphia when the stormwater regulation went into effect, this never happened. The Philadelphia official interviewed, Mr. Crockett of the Department of Water, indicated that projects locating within Philadelphia city limits typically need access to the City's infrastructure, including airports and roads, and business clusters. In Philadelphia, factors that commonly drive decisions about locating marginal projects in the City versus the suburbs include prevailing union wage rules for construction, school quality, and taxes. Finally, the State of Pennsylvania and other nearby jurisdictions have similar stormwater requirements for major developments, but without the expedited approval process, incentives, and customer service offered by Philadelphia (discussed below). As such, there is little incentive for developers to move a project to a neighboring jurisdiction based on the stormwater regulation.

Techniques Used To Achieve Compliance

Philadelphia does not mandate use of LID techniques to achieve compliance with the stormwater regulations. However, the City provides incentives for using LID techniques, including an expedited review process for projects that use LID techniques to manage 90 percent of stormwater; and parcel-based billing for impervious surfaces, which facilitates providing credits for LID on sewer bills. As a result, Philadelphia now regularly receives applications for "ultra-green" stormwater plans. In urban areas, ultra-green plans typically include green roofs (40 green roofs have been installed in the last three years), porous pavers, canopy-providing trees, and stormwater reuse. In more suburban areas, ultra-green plans often incorporate bioretention areas and rain gardens. Developers that do not use the ultra-green approach typically use storage tanks in basements or under parking surfaces to manage stormwater.

Reaction From The Development Community

Philadelphia worked with the development community for a year before the new stormwater regulations were put out for comment. The draft regulations were out for comments for three months but no one submitted comments; Mr. Crockett speculates that the development community did not believe that the City was serious about implementing the proposed rules. Once implemented, reaction from the development industry appears to have been largely positive. Philadelphia instituted a transparent and efficient online system for processing stormwater applications when the new regulations came online; the process drastically cut down wait times for approvals, eliminated the City's previous "spiderweb" of zoning and building permit procedures, and provided responsive customer service to the development community. As a result, developers receive their approvals faster and trust that the system is fair and consistent. The City invested heavily in information technology, management systems, and staff to effectively implement the new application and permit process, and Mr. Crockett emphasized that this investment was critical to the stormwater program's acceptance and success. In addition, the City created the fast track approval process and implemented financial incentives for green stormwater plans, which also pleased the development community. Finally, savvy developers are taking the "ultra-green" stormwater management route as part of broader green building projects, and earning rent premiums by marketing the green credentials of their buildings.

On the other hand, Philadelphia adopted a no-waiver policy, which took a long time for developers to accept as the new reality. The City's water department withstood significant political pressure during the first year of implementation regarding their stance on waivers. Under the regulations, the City will provide off-site stormwater mitigation if the applicant proves the infeasibility of on-site management. More commonly, however, the City has worked with developers and landowners to conduct stormwater banking or trading, particularly within a campus or between multiple projects held by the same developers. Communication issues with the development community still persist. Developers were accustomed to ground rules where preserving the status quo of impervious surface was allowed, which was typically 80 percent impervious to 20 percent pervious; now, that ratio is inverted. In addition, although the City responds to permit requests rapidly, it often takes a few iterations before a stormwater permit is issued, as project engineers often gloss over the submission package and submit designs that have major errors and/or are not constructable. The City will not issue an approval without a constructable drawing.

Other Information

Philadelphia currently conducts inspections of stormwater management construction when they conduct inspections for erosion control, but the City is developing a dedicated group for stormwater inspections. The City uses the enforcement tool of withholding occupancy permits in cases where a developer has not demonstrated compliance with stormwater regulations. The City also requires an operations and maintenance agreement for stormwater management systems, and that agreement is attached to the property's deed. Thus, in case of stormwater system failure, Philadelphia has the ability to fix the problem and put a lien on the property to recoup the cost.

CHICAGO, IL[1]

Chicago's current stormwater regulations were developed over the course of several years and became effective on January 1, 2008. The regulatory revisions were entirely driven by the Mayor's office as part of an effort to make stormwater management "greener." The regulations, which moved the City from a prescriptive to a performance-based set of requirements, focus on four areas: site-specific release rates (codifying existing policy that they had been applying for 10 years); volume control; best management practices for operations and maintenance; and pre- and post-construction erosion control. During the rulemaking process, the City Council considered, but ultimately rejected, a proposal to attach a property's stormwater permit to its deed. Instead, the regulations require an affidavit that simply informs future buyers of a property that stormwater-related restrictions may apply (a 'buyer beware' approach). In addition, the development community proposed a payment-based alternative compliance option that was ultimately rejected due to concerns about how the City would manage the collected funds. The regulations do include a (deliberately) burdensome variance process that has not yet resulted in any applications. The rulemaking also included significant debate about stormwater treatment, but failed to reach a resolution; as a result, the water quality issue was tabled with the expectation that it would be revisited separately at a later date.

Impact Of The Regulations On Development Activity

The stormwater regulations do not appear to have had any impact on development activity or patterns. Incremental costs are reportedly being absorbed without much complaint. There is some indication that property values are increasing in areas where open space is being maintained as part of the stormwater management regime.

Techniques Used To Achieve Compliance

Green roofs have been the most popular means for achieving compliance with the stormwater regulations, in part due to a separate Department of Planning green roof requirement established a few years ago for any project that received financial assistance from the City. Many of the buildings that are subject to the stormwater regulations (i.e., those greater than 15,000 sq ft in size) have benefited from some form of city assistance

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[1] Chicago does not have a single stormwater utility. Separate agencies are responsible for stormwater collection and treatment through a system that is nearly entirely (> 99 percent) combined sewers.

and are thus subject to both sets of requirements. High opportunity costs associated with open space have also served to push developers toward green roofs. The Planning Department's initial green roof requirement has subsequently become more flexible (allowing solar panels and other measures as a way to achieve broader sustainability objectives), but for the most part developers appear to be comfortable continuing to use what they now know best. They are also benefiting from declining costs resulting from strong vendor response to the increased demand for green roofs.

Over the past year, there has been an apparent shift in the preferred compliance option for the volume control requirement. Of the two options – a prescriptive 15 percent reduction in impervious surface relative to baseline and a performance-based 0.5 inch reduction in runoff – the runoff option has become more prevalent as developers gain confidence in their ability to meet this performance standard.

Reaction From The Development Community

The City worked closely with the regulated community during the rulemaking process and received substantial public input in response to its requests for comment. As a result, with the exception of the deed proposal (noted above), there was relatively little pushback from developers. Some developers questioned the basis of the numerical targets set, but this did not become a serious point of contention.

Other Information

City officials have reportedly been pleasantly surprised that implementation has occurred largely without any significant problems, though this may be due in part to a significant decline in development activity resulting from unfavorable economic conditions. Furthermore, rather than place an additional burden on City employees, Chicago has hired outside consultants to oversee certain aspects of the permit application approval process; this could contribute to the relative ease of the implementation process thus far. Going forward, the City will most likely move to strengthen some of the requirements. For example, developers using the impervious area performance option for volume control routinely achieve greater reductions than are required (closer to 25 percent), so the City can be expected to shift the standard accordingly.

PORTLAND, OR

Portland was a pioneer in the U.S. in regulating stormwater, and promulgated its first Stormwater Management Manual in 1999. At the time, it was among the first jurisdictions to shift responsibility for stormwater management from centralized treatment systems onto individual sites. Portland increased its emphasis on vegetated techniques in its third revision to the Manual in 2004, and went further in the latest revision, which took effect on August 1, 2008. The current regulations reference a "water quality storm" (slightly lower than the two-year design storm for the City) and a "flow control storm" (equivalent to the 10-year design storm). They require management through vegetated techniques to the maximum extent feasible, first through infiltration and then through detention, with exceptions for contaminated sites, steep slopes, and certain other site conditions. Of particular note is the City's applicability threshold; any project with 500 sq ft or greater of impervious surface is subject to the regulations.

Impact Of The Regulations On Development Activity

As with the other cities considered, Portland has seen little if any impact on major development projects from its stormwater regulations. The City experienced strong, continued growth from the promulgation of the first stormwater regulations in 1999 until the start of the current recession in 2008. Although the regulations were seen as burdensome by the developers, particularly in the early years before there was much experience locally or nationally in complying with such requirements, the effects of the regulations were more than outweighed by other real estate market factors.

One possible difference between Portland and the other cities, however, pertains to smaller development projects. Stormwater management costs can be proportionally higher for the smallest projects that fall under the regulations, given the City's extremely low threshold for exemptions (500 sq ft). While there are no hard data available, Ms. Uchiyama expressed a concern that in the current economic context, Portland's regulations may be discouraging developers from building smaller projects. Portland did not undertake an economic analysis of the likely effects of their regulations before promulgating them in 1999.

Anecdotally, Ms. Uchiyama has heard of developers who have chosen not to build in Portland. However, the City is well-known for its progressive mentality and strict laws and regulations on a wide range of environmental issues. Thus, reluctance to build in Portland may be a response to the City's whole suite of environmental regulations, and not a reaction to the stormwater regulations alone.

Techniques Used To Achieve Compliance

In the previous iteration of the Stormwater Management Manual (2004), Portland identified a large number of vegetated techniques that developers could use to satisfy the regulations, without providing any kind of differentiation or expressing a preference for any particular approach. In the latest revision, the City refined the list to emphasize basins and planters, which represent the "workhorses" among vegetated techniques.

Green roofs and permeable pavement occupy a privileged position in Portland's regulatory scheme. Rather than being considered stormwater management techniques, they are classified as "impervious area reduction techniques" that reduce the regulated amount of impervious surface in a 1-to-1 ratio. Thus, a developer could erect a lot line-to-lot line building with a green roof and have zero impervious area for the purposes of the regulations, effectively exempting the project from any further requirements. However, these techniques cannot be used to manage stormwater runoff from adjacent areas. Despite this regulatory approach, and further support by way of generous incentive programs for green roofs, these techniques have not been widely used in Portland. This is probably due to some high-profile failures of early green roofs. Hopefully, as developers in other cities continue to gain experience and confidence, these technologies will be more widely utilized in Portland as well.

Reaction From The Development Community

The development community voiced significant opposition to Portland's initial promulgation of stormwater regulations in 1999. The regulations entailed a major shift, moving the burden of treatment from large downstream facilities to individual sites and thus placing an unprecedented level of new responsibility on those properties. Much of the opposition was driven by the uncertainty involved, since the sizing requirements for vegetated areas and the attendant costs of the regulations were not yet clear.

Subsequent revisions to the regulations, including the most recent revision in 2008, have gone much more smoothly and engendered little controversy. The most recent revisions focused on process changes and clarifying the requirements without changing the actual engineering standards involved; the development community strongly advocated for these changes.

Other Information

Ms. Uchiyama noted that for several years, Portland's emphasis was on the City's Green Streets Initiative, which focused on rights-of-way in public streets rather than private property. This ended up being a major undertaking that required substantial cooperation with other city and regional departments, as well as utility companies. Only recently has the City shifted its focus to management of private property.

Ms. Uchiyama also noted that the stormwater regulations imposed significant staffing and organizational demands on the City, especially given the regulations' low applicability threshold.

SEATTLE, WA

Seattle Public Utilities' revision of the stormwater regulations was motivated by the City's need to come into compliance with its NPDES permit requirements, as set forth by Washington Department of Ecology. The new regulations took effect on December 1, 2009. A major change from the previous regulations is a significantly (approximately three times) higher standard for flow control when discharge is to a creek watershed (as it is for approximately one-third of the City area). In addition, the determination of post-development peak flow rates and flow durations now requires the use of continuous modeling, rather than the single-event modeling allowed under the prior regulations. Of particular interest, however, is the mandate to use "green stormwater infrastructure" to the "maximum extent feasible." Green stormwater infrastructure is a term that is only generally defined; as a result, the City recognizes the need for, and expects to issue, specific guidance on approaches that would satisfy this requirement.

Impact Of The Regulations On Development Activity

Since the regulations have only recently taken effect, it is too early to judge their impact, if any, on development activity. However, Seattle is essentially built out, so any changes would occur in the context of redevelopment projects, which in turn are generally driven by zoning decisions (e.g., increasing allowable density). As such, Seattle does not expect changes to development patterns to result from the stormwater regulations.

Techniques Used To Achieve Compliance

Developers in Seattle do have a choice of LID techniques, but as part of the permitting process the City requests an evaluation of the different possibilities in a prescribed "pecking order." In general, infiltration techniques are ranked above those that simply delay stormwater flow. The amount of leeway that developers are allowed in their choice of proposed management approaches depends on site characteristics including the site's natural capacity to manage stormwater and the vulnerability of the surrounding area.

Another city law (Seattle Green Factor), which has been in effect for about one year, sets out green space requirements for commercial space. Similar to the stormwater regulations, the law encourages bioretention areas, permeable pavement, and green roofs as preferred options. With open space at a premium, the Green Factor law has resulted in a larger percentage of green roofs as the preferred compliance mechanism.

Reaction From The Development Community

The sense in Seattle was reportedly that the City had little choice but to move toward the new regulations. In addition to the NPDES compliance requirement, a lawsuit in which a non-profit prevailed in its argument that the State Department of Ecology's standards were not strict enough created an atmosphere in which regulatory revisions were inevitable. As a result, there was no strong opposition from the development community. The strategy of mandating LID "to the maximum extent feasible" while deferring the specification of what this means also likely contributed to the relative ease with which the standards have been put into place.

Other Information

Some questions remain among city officials regarding the utility of a performance standard with a focus on infiltration practices when land is generally unavailable to achieve this goal. The challenge of verifying and enforcing a standard based on a "maximum extent feasible" basis (i.e., one that is not readily quantifiable or otherwise measured) has also been noted.

Appendix 5.1 - IEC exhibit 3-2: Unit Cost Estimates for Stormwater Management Techniques
(Leistra, et al., 2010)

EXHIBIT 3-2. UNIT COST ESTIMATES FOR STORMWATER MANAGEMENT TECHNIQUES

TECHNIQUE	IMPLEMENTATION COST	SOURCE	SUPPLEMENTARY SOURCES	NOTES
Green roof	$10 per sq ft	DC Greenworks	• Chicago Guide to Stormwater Best Management Practices • Massachusetts Low Impact Development Toolkit • Portland EcoRoof Handbook • Paladino & Company Green Roof Feasibility Review	• Average value from range of $5 – $15 per sq ft • Reflects price of commercial extensive green roof
Conventional roof	$6 per sq ft	Paladino & Company Green Roof Feasibility Review	• IB Roof Systems • InspectAPedia	• Average value from range of $3 - $9 per sq ft • Supplementary sources indicate price is consistent with estimates for flat commercial roofs • Cost used to determine incremental cost of green roof
Rainwater storage tank	$2500 for 2,000 gallon, in-ground tank	Massachusetts Low Impact Development Toolkit	• Texas Manual on Rainwater Harvesting • Low Impact Development Center, “Rain Barrels and Cisterns”	Galvanized steel storage tank
Bioretention area (large)	Cost = $9.48 * SWRv^{0.991}$	Brown and Schueler; referenced and adapted in numerous other sources.	• Prince George’s County Bioretention Manual • Fairfax County LID BMP Fact Sheet • MA Office of Energy and Environmental Affairs, LID Matrix • Low Impact Development Center, “Bioretention” • City of Chicago	• SWRv = volume of water to be treated, in cubic feet • Supplementary sources generally provide estimates of total costs or costs per sq ft; however, these are consistent with formula cited • Cost is for unlined bioretention area
Bioretention area (small)	$8,300	Prince George’s County Bioretention Manual	• Brown and Schueler • Fairfax County LID BMP Fact Sheet • MA Office of Energy and Environmental Affairs, LID Matrix • Low Impact Development Center • City of Chicago	• Based on cost for single residential lot • Unit costs are higher due to small scale of project requiring same level of engineering (see Prince George’s County Bioretention Manual, p. B-6 – B-7)
Impermeable liner	$0.80 per sq ft	Idaho Association of Soil Conservation Districts	Water Reuse Foundation	• Average value from range of $0.40 - $1.20 per sq ft • Added to cost of unlined bioretention area to determine cost of lined bioretention area

TECHNIQUE	IMPLEMENTATION COST	SOURCE	SUPPLEMENTARY SOURCES	NOTES
Conventional landscaping	$3,622 per acre	Chicago Guide to Stormwater Best Management Practices		• Average value from range of $2,000 - $4,000 per acre (2003 dollars) • Cost used to determine incremental cost of bioretention area
Permeable pavers (for parking lot)	$3.87 per sq ft	New York State Stormwater Design Manual		• Average value of range from $1.50 - $5.75 per sq ft (2007 dollars) • Cost is for grass/gravel pavers
Surface sand filter	$12,130	EPA Storm Water Technology Fact Sheet: Sand Filters	Schueler 1994, cited by Federal Highway Administration	• Cost is for filter with 1 acre drainage area. Assumes there is no cost reduction for smaller systems • Average value from range of $6,600 - $11,000 (1997 dollars)
Underground sand filter	$19,300 per impervious acre	Stormwater Manager's Resource Center		• Cost is for pre-cast filter with 1 acre drainage area. Assumes no cost reduction for smaller systems

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TECHNIQUE	IMPLEMENTATION COST	SOURCE	SUPPLEMENTARY SOURCES	NOTES

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Appendix 5.2 - American University Green Roof Installation Costs
(Curley, 2011)

	Sq ft	Total Cost	Grant	25 Yr Impervious Area Savings	Energy Savings	Maint. Savings	25 Yr Cost
Mary Graydon	10,000	$132,820	$70,000	$50,292	$3,019	$9,000	$509
Ward Circle	11,215	$155,750	$78,505	$56,402	$3,071	$10,500	$7,272
				25 yr cost for both projects			$7,781
				1st year cost for both projects			$140,065