Assessing the Cost of Stormwater Infrastructure

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- Acknowledgements
  - Center for Watershed Protection
  - Georgia DNR Environmental Protection Division, Coastal Nonpoint Source Management Program
  - Chatham Co.-Savannah (GA) Metropolitan Planning Commission
  - University of Georgia Marine Extension Service
  - Lake Co. Stormwater Management Commission
  - Numerous Colleagues

- National trend:
  - Significant increased interest in the use of green infrastructure to manage wet weather
  - To the point where green stormwater infrastructure is preferred or required
    - State: MD (Environmental Site Design), VA (Runoff Reduction Method), NC (LID Guidebook), Coastal GA (Green Infrastructure Approach)
    - Municipal: Portland, OR (Sustainable Stormwater Program), Philadelphia, PA (Green City-Clean Waters Program), Lenexa, KS (Rain to Recreation Program), Chicago, IL (Green Streets/Roof/Alley Programs)
    - County: Lake County, IL (Proposed Runoff Volume Reduction Criteria)

Shift away from “pipe and manage”…

Development Project w/ Storm Sewers

Stormwater
Management Practices

Receiving Waters

Traditional/“Gray” Infrastructure

…toward distributed source control and runoff reduction

Better Site Planning

Development Project

Better Site Design

Low Impact Development Practices

Green Infrastructure

Stormwater Management Practices

Receiving Waters


QUIET
TREES AT WORK
“He who sweats stormwater…manages stormwater runoff by sitting in the shade with a cold beverage.”
- Aquadiates (310 - 272 BC) Stormwater Philosopher

- With the shift, questions abound:
  - Does this stuff really work?
  - How do you incorporate it into local ordinances?
  - How do you use it on a development or redevelopment site?
  - Where can I find design guidance?
  - What about maintenance?
  - HOW MUCH DOES IT COST?

- "Cost"
  - Typically, number of dollars (i.e., price) paid by an individual in the short-term to achieve or obtain an object
  - Merriam-Webster Dictionary
    - 1a: the amount or equivalent paid or charged for something; price
    - 1b: the outlay or expenditure (as of effort or sacrifice) made to achieve an object
    - 2: loss or penalty incurred especially in gaining something
  - So, "cost" can be more than just dollars…

Let's look at an example…

- Stormwater Management
- Objectives:
  - Flood Control
    - 2-year, 24-hour event, 0.04 cfs/acre max
    - 100-year, 24-hour event, 0.15 cfs/acre max
  - Water Quality
    - Water Quality Volume
      - 0.01 in. runoff/1% imperviousness, 0.2 in. min.

What stormwater management infrastructure can be used to meet our objectives?

THESE!


AND THIS!

AND THESE!

AND THIS!

Objectives Achieved

CAN:

- <u>Flood Control</u>
- <u>Water Quality (?)</u>
- Centralized Maintenance

CAN'T:

- Channel Protection
- Groundwater Recharge
- Runoff Reduction
- Wildlife Habitat

(Maybe an urban goose farm…)

DOES THIS WORK?

WHAT ABOUT THESE?

Source: http://www.greenroofs.com


HOW ABOUT THIS?
Objectives Achieved
CAN:
• Flood Control (w/ others)
• Water Quality
• Channel Protection
• Groundwater Recharge
• Runoff Reduction
• Wildlife Habitat
CAN'T:
• Centralized Maintenance

- Some services/potential objectives are "lost" simply by the choices we make
- These losses could also be considered in our evaluation of the cost of infrastructure
- But never calculated; very difficult to valuate the ecosystem services provided by stormwater infrastructure

Environmental and social services provided by green stormwater infrastructure (US EPA green infrastructure website):

How Does Green Infrastructure Benefit the Environment?

Green Infrastructure is associated with a variety of environmental, economic, and human health benefits, many of which go hand-in-hand with one another. The benefits of green infrastructure are particularly accentuated in urban and suburban areas where green space is limited and environmental damage is more extensive. Green infrastructure benefits include:

Reduced and Delayed Stormwater Runoff Volumes - Green infrastructure reduces stormwater runoff volumes and reduces peak flows by utilizing the natural retention and absorption capabilities of vegetation and soils. By increasing the amount of pervious ground cover, green infrastructure techniques increase stormwater infiltration rates, thereby reducing the volume of runoff entering our combined or separate sewer systems, and ultimately our lakes, rivers, and streams.

Enhanced Groundwater Recharge - The natural infiltration capabilities of green infrastructure technologies can improve the rate at which groundwater aquifers are 'recharged' or replenished. This is significant because groundwater provides about 40% of the water needed to maintain normal base flow rates in our rivers and streams. Enhanced groundwater recharge can also boost the supply of drinking water for private and public uses.

Stormwater Pollutant Reductions - Green Infrastructure techniques infiltrate runoff close to its source and help prevent pollutants from being transported to nearby surface waters. Once runoff is infiltrated into soils, plants and microbes can naturally filter and break down many common pollutants found in stormwater.

Reduced Sewer Overflow Events - Utilizing the natural retention and infiltration capabilities of plants and soils, green infrastructure limits the frequency of sewer overflow events by reducing runoff volumes and by delaying stormwater discharges.

Increased Carbon Sequestration - The plants and soils that are part of the green infrastructure approach serve as sources of carbon sequestration, where carbon dioxide is captured and removed from the atmosphere via photosynthesis and other natural processes.

Urban Heat Island Mitigation and Reduced Energy Demands - Urban heat islands form as cities replace natural land cover with dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat. The displacement of trees and vegetation minimizes their natural cooling effects. Additionally, tall buildings and narrow streets trap and concentrate waste heat from vehicles, factories, and air conditioners. By providing increased amounts of urban green space and vegetation, green infrastructure can help mitigate the effects of urban heat islands and reduce energy demands. Trees, green roofs and other green infrastructure can also lower the demand for air conditioning energy, thereby decreasing emissions from power plants.

What is the value of these services?

Improved Air Quality - Green infrastructure facilitates the incorporation of trees and vegetation in urban landscapes, which can contribute to improved air quality. Trees and vegetation absorb certain pollutants from the air through leaf uptake and contact removal. If widely planted throughout a community, trees and plants can even cool the air and slow the temperature-dependent reaction that forms ground-level ozone pollution (smog).

Additional Wildlife Habitat and Recreational Space - Greenways, parks, urban forests, wetlands, and vegetated swales are all forms of green infrastructure that provide increased access to recreational space and wildlife habitat.

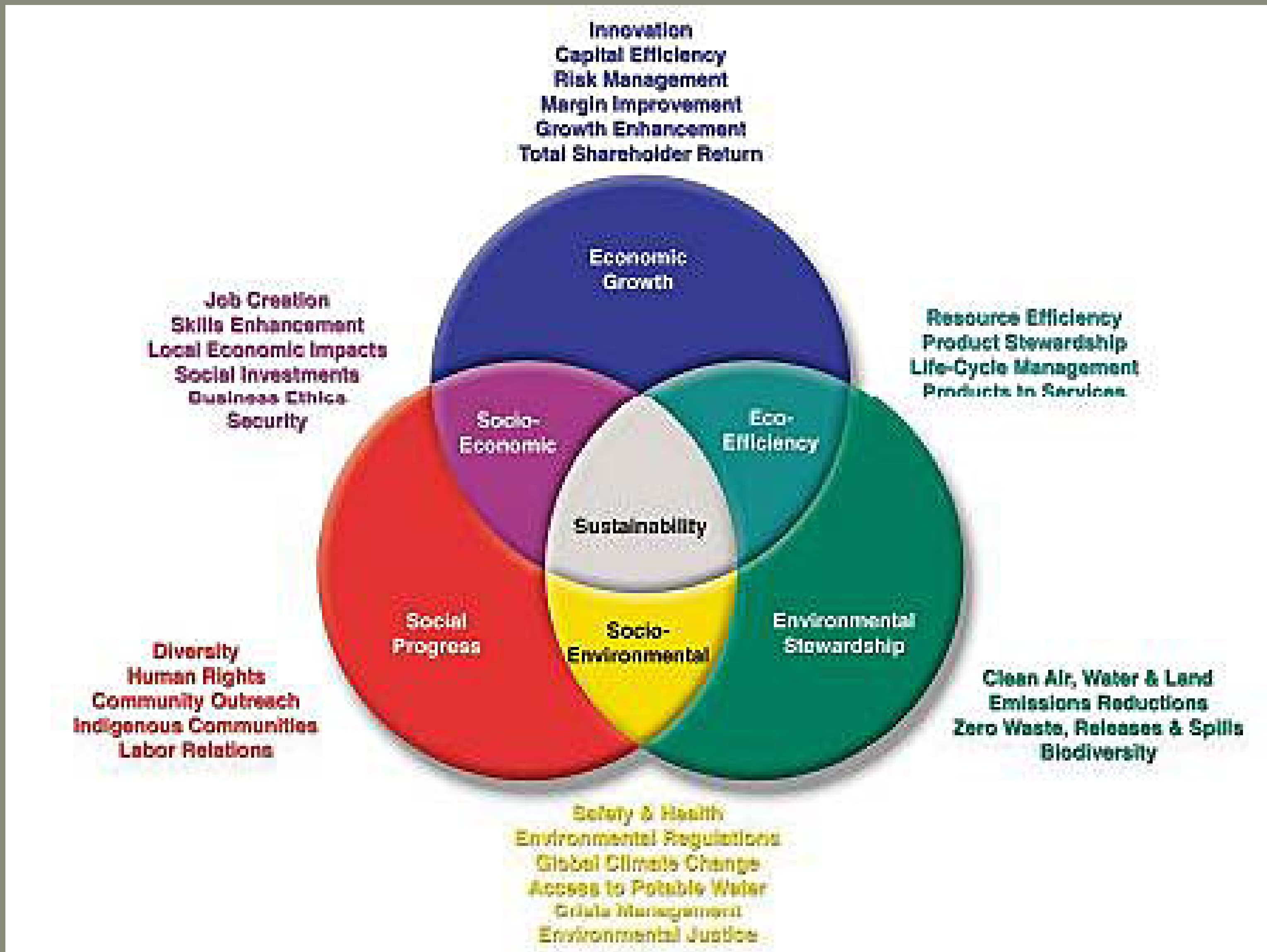
Improved Human Health - An increasing number of studies suggest that vegetation and green space - two key components of green infrastructure - can have a positive impact on human health. Recent research has linked the presence of trees, plants, and green space to reduced levels of inner-city crime and violence, a stronger sense of community, improved academic performance, and even reductions in the symptoms associated with attention deficit and hyperactivity disorders. One such study (PDF) (7 pp, 102K) discusses the association between neighborhood greenness and the body mass of children. For more information on other studies, visit: http://www.lhhl.uiuc.edu/all.scientific.articles.htm . EXIT Disclaimer

Increased Land Values - A number of case studies suggest that green infrastructure can increase surrounding property values. In Philadelphia, a green retrofit program that converted unsightly abandoned lots into "clean & green" landscapes resulted in economic impacts that exceeded expectations. Vacant land improvements led to an increase in surrounding housing values by as much as 30%. This translated to a $4 million gain in property values through tree plantings and a $12 million gain through lot improvements.

- *Braden, J.B. and A.W. Ando, 2011*
  - Hypothetical national policy that would require new construction to maintain/restore pre-development hydrology:
    - Water quality improvement alone could yield benefits of at least $624 million each year
    - Flood reduction benefits and reduced infrastructure costs would add another $34 million annually
- *US EPA, 2010*
  - Portland, OR:
    - Considers its $9 million investment in green infrastructure to have saved ratepayers $224 million in CSO costs, such as in infrastructure maintenance and repair costs
    - Sees a number of additional benefits, whether for Coho salmon and Steelhead trout, or for residents in neighborhoods with green streets and green infrastructure retrofit projects

- *Harrison et al., 2001; Bin and Polasky, 2004*
  - Effects of flooding on housing prices
    - Houses located in flood prone areas have a 4-12% lower market value than equivalent homes located outside of areas prone to flooding
    - Preservation of pre-development site hydrology prevents additional flooding and maintains or increases home values
- *Pennsylvania Horticultural Society website*
  - Philadelphia, PA:
    - Conversion of over 5,500 blighted vacant lots to "clean & green" lots resulted in an increase in surrounding housing values by as much as 30%; this translates into a $12 million investment in lot improvements and a $4 million gain in property values as a result

- Analysis of the "cost" of infrastructure depends on perspective and the objectives/services that our infrastructure must/should/could provide
  - Role: developer, elected official, regulator, stormwater manager, municipal staff, resident, preservationist
  - Scale: site, block, neighborhood, city, watershed
  - Time Frame: now, short-term, mid-term, long-term
- Difficult to capture all of these perspectives with "dollars only" analysis of cost



http://www.gcbl.org/system/files/sustainability-venn-sm.jpg

- That triple bottom line and big picture stuff makes for great presentations, but I’ve really only got one bottom line
  - What is it going to cost – in terms of dollars – to provide those additional benefits?
- Does green stormwater infrastructure cost more than traditional stormwater infrastructure at the site scale?

- US EPA, 2007
  - 17 Case Studies
  - Total construction cost savings ranged from 15 to 80% when green infrastructure was used, with a few exceptions
  - Significant savings were attributed to reduced costs for site grading and preparation, stormwater infrastructure, site paving, and landscaping

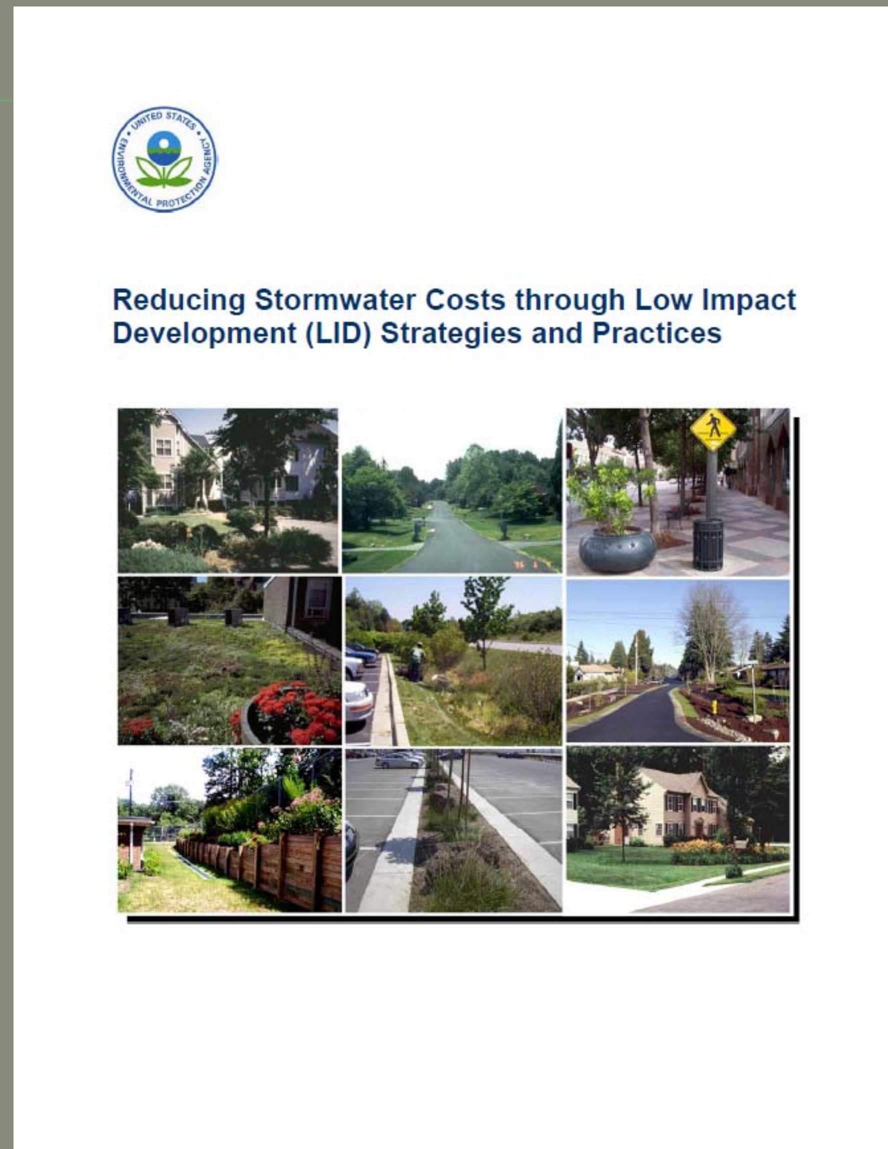


Table 2. Summary of Cost Comparisons Between Conventional and LID Approaches[a]

Project	Conventional Development Cost	LID Cost	Cost Difference[b]	Percent Difference[b]
2nd Avenue SEA Street	$868,803	$651,548	$217,255	25%
Auburn Hills	$2,360,385	$1,598,989	$761,396	32%
Bellingham City Hall	$27,600	$5,600	$22,000	80%
Bellingham Bloedel Donovan Park	$52,800	$12,800	$40,000	76%
Gap Creek	$4,620,600	$3,942,100	$678,500	15%
Garden Valley	$324,400	$260,700	$63,700	20%
Kensington Estates	$765,700	$1,502,900	–$737,200	-96%
Laurel Springs	$1,654,021	$1,149,552	$504,469	30%
Mill Creek[c]	$12,510	$9,099	$3,411	27%
Prairie Glen	$1,004,848	$599,536	$405,312	40%
Somerset	$2,456,843	$1,671,461	$785,382	32%
Tellabs Corporate Campus	$3,162,160	$2,700,650	$461,510	15%

[a] The Central Park Commercial Redesigns, Crown Street, Poplar Street Apartments, Prairie Crossing, Portland Downspout Disconnection, and Toronto Green Roofs study results do not lend themselves to display in the format of this table.
[b] Negative values denote increased cost for the LID design over conventional development costs.
[c] Mill Creek costs are reported on a per-lot basis.

US EPA, 2007

- Winer-Skonovd et al., 2006
  - 10 Case Studies
  - Estimates of construction cost savings ranged from 12 to 50 % with the application of green infrastructure over traditional stormwater infrastructure
  - Significant savings were attributed to reduced costs for site preparation, stormwater infrastructure, and landscaping

Memorandum

CENTER FOR WATERSHED PROTECTION
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www.stormwatercenter.net

Date: December 29, 2006

To: Jonathan Doherty, NPS
Amy Handen, NPS

From: Rebecca Winer-Skonovd, Dave Hirschman, Hye Yeong Kwon and Chris Swann
Center for Watershed Protection

Re: Synthesis of Existing Cost Information for LID vs. Conventional Practices

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This memorandum quantifies some of the economic cost information for low impact (LID) development through the examination of case studies from around the United States. The case studies selected compare the costs and benefits of LID practices against the costs of conventional stormwater treatment and control practices. When possible, actual development costs are provided for comparison, although cost comparisons may be based on modeling efforts. In other case studies, the benefit information presented is focused on LID or conservation designs that have resulted in significant environmental benefits. These environmental benefits can come in many forms, including natural areas (forest or wetland) preservation, reduced stormwater runoff, protection of aquatic habitat, and reduction in pollutant loads in runoff. The third type of case study provides economic data on the benefits of LID projects, but offers no cost comparison with conventional development.

The case studies presented are only a sampling of the many LID projects that have been or are currently being implemented nationwide. The examples selected concentrate on projects that have been implemented in the Chesapeake Bay region that include economic data comparisons or quantifiable impacts. Other case studies from around the country are included where economic cost comparison information is available.

For each case study presented below, a brief description of the project is provided followed by monetary benefits, other benefits and source of information. The studies are summarized in the conclusion and the additional resources section will point the reader to additional case studies not included in this technical memorandum.

Table 8. Summary of Cost Benefits of LID vs. Conventional from Case Studies

Case Study	Clearing and Grading	Infrastructure	House Value	Overall Project Savings
Laurel Springs	👍	👍	👍	👍
SEA Streets	👎	👍	--	👍
Rivergate	--	👍	--	👍
South Kingstown	--	--	👍	👍
WSSI	👎	👎	--	--
Pembrook Woods	👍	👍	👍	👍
Somerset	👍	👍	👍	👍
Jordan Cove	--	👎	--	--
Forest Ridge	--	--	👍	--
Forest Brooke	👎	👎	👍	👍

👍 - Indicates that LID techniques cost less

👎 - Indicates that the use of conventional development techniques cost less

--: study did not examine this benefit

Winer-Skonovd et al., 2006

- Gunderson et al., 2011
  (Stormwater, Mar.-Apr. 2011)
  - 2 Projects: Boulder Hills (Residential), Greenland Meadows (Commercial)
  - Construction cost savings of $49,000 for Boulder Hills and $930,000 for Greenland Meadows


Gunderson et al., 2011


Gunderson et al., 2011

Table 1. Comparison of Material Unit Costs for Boulder Hills			
Item	**Conventional Option**	**Low-Impact Development Option**	**Cost Difference**
Site Preparation	$23,200.00	$18,000.00	($5,200.00)
Temporary Erosion Control	$5,846.50	$3,811.50	($2,035.00)
Drainage	$92,398.00	$20,125.00	($72,273.00)
Roadway	$82,054.00	$127,972.00	$45,918.00
Driveways	$19,722.00	$30,108.00	$10,386.00
Curbing	$6,464.00	$0.00	($6,464.00)
Permanent Erosion Control	$70,070.00	$50,610.00	($19,460.00)
Additional Items	$489,700.00	$489,700.00	$0.00
Buildings	$3,600,000.00	$3,600,000.00	$0.00
Project Total	$4,389,454.50	$4,340,326.50	($49,128.00)

Gunderson et al., 2011

Table 2. Comparison of Material Unit Costs for Greenland Meadows			
Item	**Conventional Option**	**Low-Impact Development Option**	**Cost Difference**
Mobilization / Demolition	$555,500	$555,500	$0
Site Preparation	$167,000	$167,000	$0
Sediment / Erosion Control	$378,000	$378,000	$0
Earthwork	$2,174,500	$2,103,500	($71,000)
Paving	$1,843,500	$2,727,500	$884,000
Stormwater Management	$2,751,800	$1,008,800	($1,743,000)
Additional Work-Related Activity (utilities, lighting, water & sanitary sewer service, fencing, landscaping, etc.)	$2,720,000	$2,720,000	$0
Project Total	$10,590,300	$9,660,300	($930,000)

Gunderson et al., 2011

- What about maintenance?
  - The fact that green stormwater infrastructure can result in lower construction costs is good for the developer, but what about the long-term bottom line for the HOA, property owner, or municipality?
  - Important to consider life-cycle costs in evaluating the true cost of infrastructure

- <u>All</u> stormwater management practices require maintenance
- With traditional stormwater infrastructure true maintenance typically occurs only when there is failure because the infrastructure is “outta sight, outta mind”

“You don’t see me now
You don’t want to anyhow”
- J. Tweedy, Wilco

- Water Environment Research Foundation (WERF), 2005
  - *"Probably 80% of the total man hours spent in the field in many jurisdictions are associated with grass mowing, rather than the issues one might expects such as sediment, debris and trash removal, or structural repair."*
  - *"Of this 80%, most of the effort has little effect on BMP performance, but results from the level of service expectations of residents living near these facilities."*

- Almost all green stormwater infrastructure is visible and considered an aesthetic amenity; harder to ignore maintenance
- Vegetation upkeep plays a more significant role in performance
- Since green infrastructure systems aren't dependent upon one practice (e.g., wet pond), small problems rarely lead to complete system failures
  - Particularly when larger scales (e.g., neighborhood, municipality, watershed) are considered

SMP	Summary of Typical AOM Costs (% of Construction Cost) (USEPA, 1999A)	Collected Cost Data: Estimated Annual O&M Costs (% of Construction Costs)
Retention Basins and Constructed Wetlands	3%-6%	--
Detention Basins	<1%	1.8%-2.7%
Constructed Wetlands	2%	4%-14.1%
Infiltration Trench	5%-20%	5.1%-126%
Infiltration Basin	1%-3% 5%-10%	2.8%-4.9%
Sand Filters	11%-13%	0.9%-9.5%
Swales	5%-7%	4.0%-178%
Bioretention	5%-7%	0.7%-10.9%
Filter Strips	$320/Acre (maintained)	--
Wet Basins	Not Reported	1.9%-10.2%

Weiss et al., 2005

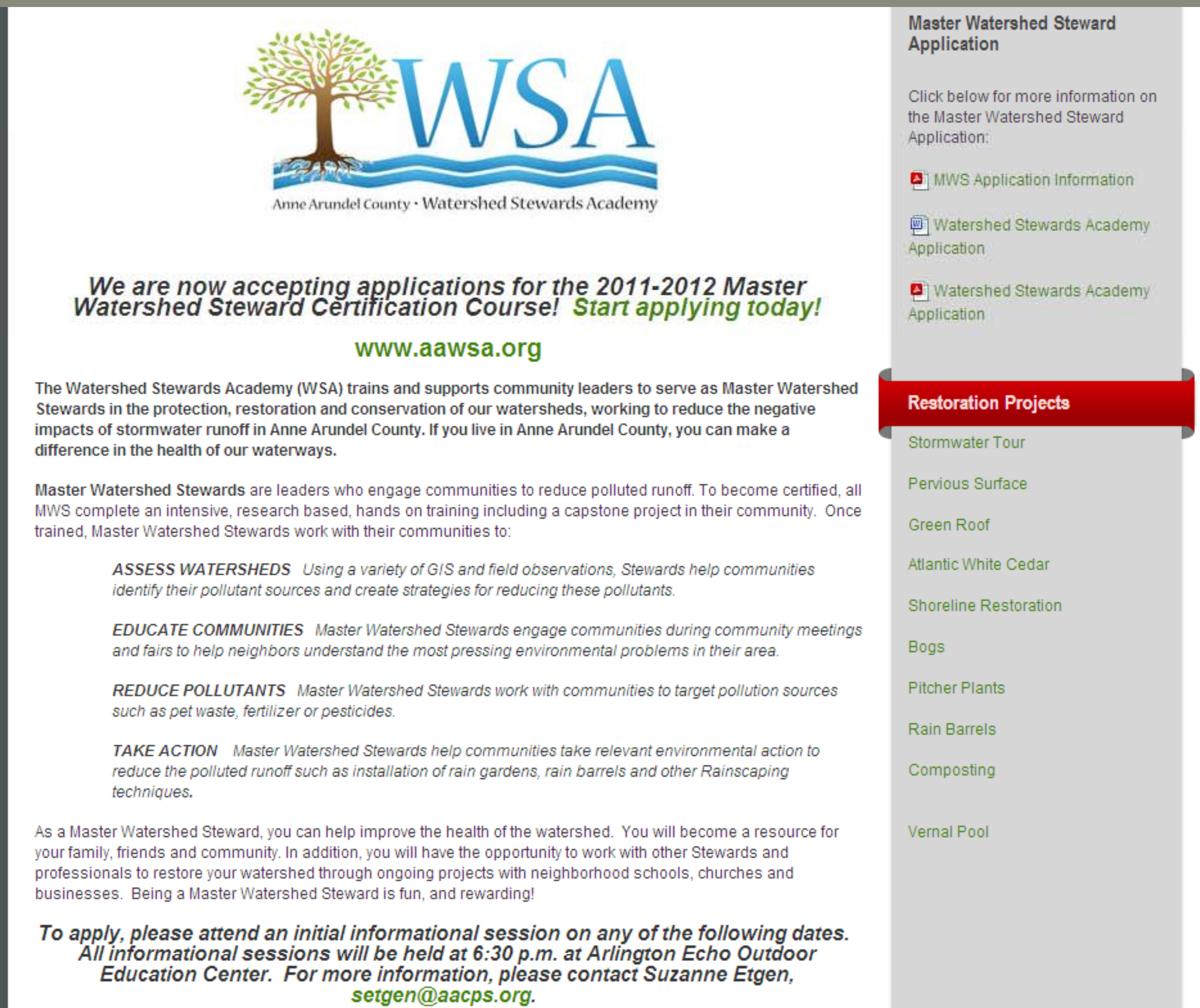
Bioretention

Maintenance Tasks

Task	Frequency	Maintenance Notes
Pruning	1 - 2 times / year	Nutrients in runoff often cause vegetation to flourish
Mowing	2 - 12 times / year	Frequency depends upon location and desired aesthetic appeal
Mulching	1 - 2 times / year	Use shreaded hardwood mulch
Mulch removal	1 time / 2 - 3 years	Mulch accumulation reduces available water storage volume. Removal of mulch also increases surface infiltration rate of fill soil.
Watering	1 time / 2 - 3 days for first 1 - 2 months. Sporadically after establishment	If droughty, watering after the initial year may be required.
Fertilization	1 time initially	One time spot fertilization for "first year" vegetation
Remove and replace dead plants	1 time / year	Within the first year, 10 percent of plants may die. Survival rates increase with time.
Miscellaneous upkeep	12 times / year	Tasks include trash collection, spot weeding, and removing mulch from overflow device.

North Carolina State Univ. Stormwater Engineering Group Bioretention Website

- Many tasks can be performed by knowledgeable volunteers/watershed stewards
  - Decreased maintenance costs
  - Increased public education and involvement



Anne Arundel County · Watershed Stewards Academy

We are now accepting applications for the 2011-2012 Master Watershed Steward Certification Course! Start applying today!

www.aawsa.org

The Watershed Stewards Academy (WSA) trains and supports community leaders to serve as Master Watershed Stewards in the protection, restoration and conservation of our watersheds, working to reduce the negative impacts of stormwater runoff in Anne Arundel County. If you live in Anne Arundel County, you can make a difference in the health of our waterways.

Master Watershed Stewards are leaders who engage communities to reduce polluted runoff. To become certified, all MWS complete an intensive, research based, hands on training including a capstone project in their community. Once trained, Master Watershed Stewards work with their communities to:

__ASSESS WATERSHEDS__ Using a variety of GIS and field observations, Stewards help communities identify their pollutant sources and create strategies for reducing these pollutants.

__EDUCATE COMMUNITIES__ Master Watershed Stewards engage communities during community meetings and fairs to help neighbors understand the most pressing environmental problems in their area.

__REDUCE POLLUTANTS__ Master Watershed Stewards work with communities to target pollution sources such as pet waste, fertilizer or pesticides.

__TAKE ACTION__ Master Watershed Stewards help communities take relevant environmental action to reduce the polluted runoff such as installation of rain gardens, rain barrels and other Rainscaping techniques.

As a Master Watershed Steward, you can help improve the health of the watershed. You will become a resource for your family, friends and community. In addition, you will have the opportunity to work with other Stewards and professionals to restore your watershed through ongoing projects with neighborhood schools, churches and businesses. Being a Master Watershed Steward is fun, and rewarding!

To apply, please attend an initial informational session on any of the following dates. All informational sessions will be held at 6:30 p.m. at Arlington Echo Outdoor Education Center. For more information, please contact Suzanne Etgen, setgen@aacps.org.

Master Watershed Steward Application

Click below for more information on the Master Watershed Steward Application:

- MWS Application Information
- Watershed Stewards Academy Application
- Watershed Stewards Academy Application

Restoration Projects

- Stormwater Tour
- Pervious Surface
- Green Roof
- Atlantic White Cedar
- Shoreline Restoration
- Bogs
- Pitcher Plants
- Rain Barrels
- Composting
- Vernal Pool

Anne Arundel County (MD) Watershed Stewards Academy Website

- In summary, analysis of the "cost" of infrastructure depends on perspective and the objectives/services that our infrastructure must/should/could provide
- Difficult to capture all of these perspectives with "dollars only" analysis of cost
- In any evaluation, consider ALL of the objectives/ services that are important to you and your community and/or customers

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