Cost Efficiency and Other Factors in Urban Stormwater BMP Selection

WIP Local Technical Meeting Series
November 2013

Greg Busch
Maryland Department of the Environment
gbusch@mde.state.md.us
Which BMPs to choose?

• Cost efficient BMPs
  – Ones that remove the greatest quantity of nitrogen, phosphorus or sediment for the least cost

• BMPs that provide benefits beyond nutrient & sediment removal
  – Removal of other pollutants
  – Public health
  – Neighborhood beautification
  – Heat island reduction
Measuring the cost effectiveness of a BMP

• How much nitrogen does an acre of forest buffer remove in a given year?

1 acre of forest buffer removes about 6 pounds of nitrogen from the Bay each year

6 lbs

• How much does an acre of forest buffer cost per year?

1 acre of forest buffer costs about $530 per year

$530
Among urban stormwater BMPs, we have generally chosen a lifespan of 20 years. Although many of the BMPs – including forest buffers – would be expected to last much longer than this, 20 years provides a good horizon for stormwater planning.
Cost of nutrient removal

Cost of BMP

$530

$530 per acre per year

Effectiveness of BMP

6 lbs

6 pounds of nitrogen removed per acre per year

Cost of nutrient removal

$88 /lb

$88 per pound of nitrogen

Note that over the life of this BMP (say, 20 years) the cost of this BMP to remove 1 pound of nitrogen each year will be: \(20 \text{ years} \times \$88 \text{ per pound} = \$1,760\)

Another way to look at this is in terms of cost efficiency. How many pounds of a nutrient can be removed for $1,000? In this example, an investment of $1,000 will result in a 11.4 pound reduction of nitrogen.
Comparing urban stormwater BMPs by cost effectiveness

$ per pound of delivered nitrogen removed by BMP

TN Cost Range
- high
- low

More Cost Effective
Less Cost Effective

Urban Forest Buffers
Bioswales
Urban Infiltration*
Urban Nutrient Management
Vegetated open Channels
Bioretention & Rain gardens
Urban Infiltration
Wet Ponds & Wetlands
Erosion and Sediment Control
Dry Extended Detention Ponds
Urban Tree Planting
Urban Filtering Practices
Impervious Surface Reduction
MS4 Stormwater Retrofit
Permeable Pavement***
Dry Detention Ponds
Erosion and Sediment Control****
Urban Stream Restoration
Street Sweeping

* with sand & vegetation, no underdrain
** with sand & vegetation, no underdrain
*** on A or B soils, with underdrain
**** on extractive land use
Comparing septic & wastewater BMPs based on cost efficiency

Critical area

Within 1,000' of stream

Outside 1,000' of stream

TN Cost Range

High

Low

$ per pound of delivered nitrogen removed

Septic connection

Septic upgrade

Septic pumping

Septic connection

Septic upgrade

Septic pumping

Septic connection

Septic upgrade

Septic pumping
<table>
<thead>
<tr>
<th>BMP Name</th>
<th>Land Use</th>
<th>Unit</th>
<th>Acres of BMP Applied in 2025 WIP</th>
<th>Pollutant Removal Effectiveness</th>
<th>Cost of BMP</th>
<th>Cost per pound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioretention &amp; raingardens</td>
<td>all urban</td>
<td>acre treated</td>
<td>5,626.8</td>
<td>TN delivered [lbs removed per acre per year]</td>
<td>$9,469</td>
<td>$254</td>
</tr>
<tr>
<td>Bioretention &amp; raingardens</td>
<td>impervious urban</td>
<td>acre treated</td>
<td>736.1</td>
<td>TP delivered [lbs removed per acre per year]</td>
<td>$3,000</td>
<td>$2,980</td>
</tr>
<tr>
<td>Bioretention &amp; raingardens</td>
<td>pervious urban</td>
<td>acre treated</td>
<td>4,890.7</td>
<td>TSS delivered [lbs removed per acre per year]</td>
<td>$383</td>
<td>$383</td>
</tr>
<tr>
<td>Impervious Urban Surface Reduction</td>
<td>impervious urban</td>
<td>acre</td>
<td>0.0</td>
<td>Design and Construction Costs [$/unit]</td>
<td>$96,250</td>
<td>$972</td>
</tr>
<tr>
<td>Permeable Pavement with Sand and Veg</td>
<td>pervious urban</td>
<td>acre</td>
<td>0.0</td>
<td>Land Acquisition Cost [$/unit]</td>
<td>$50,000</td>
<td>$7,700</td>
</tr>
<tr>
<td>Street Sweeping</td>
<td>impervious urban</td>
<td>acre</td>
<td>0.0</td>
<td>O&amp;M Costs [$/unit]</td>
<td>$885</td>
<td>$8,198</td>
</tr>
<tr>
<td>Urban Filtering Practices</td>
<td>all urban</td>
<td>acre treated</td>
<td>122.2</td>
<td>Project Life [$/unit]</td>
<td>20</td>
<td>$4,958</td>
</tr>
<tr>
<td>Urban Filtering Practices</td>
<td>impervious urban</td>
<td>acre treated</td>
<td>28.2</td>
<td>Annual Cost [$/unit]</td>
<td>20</td>
<td>$4,737</td>
</tr>
<tr>
<td>Urban Filtering Practices</td>
<td>pervious urban</td>
<td>acre treated</td>
<td>94.0</td>
<td>Cost of delivered TN removal [$/pound removed]</td>
<td>$447</td>
<td>$3,136</td>
</tr>
<tr>
<td>Urban Forest Buffers</td>
<td>pervious urban</td>
<td>acre</td>
<td>2.5</td>
<td>Cost of delivered TP removal [$/pound removed]</td>
<td>$106</td>
<td>$759</td>
</tr>
<tr>
<td>Urban Nutrient Management</td>
<td>pervious urban</td>
<td>acre</td>
<td>6,078.4</td>
<td>Cost of delivered TSS removal [$/pound removed]</td>
<td>$47</td>
<td>$982</td>
</tr>
<tr>
<td>Urban Tree Planting</td>
<td>pervious urban</td>
<td>acre</td>
<td>22.0</td>
<td>Wet Ponds and Wetlands all urban acre treated</td>
<td>$6,506</td>
<td>$2,330</td>
</tr>
<tr>
<td>Wet Ponds and Wetlands</td>
<td>all urban</td>
<td>acre treated</td>
<td>4,404.4</td>
<td>Wet Ponds and Wetlands impervious urban acre treated</td>
<td>$28,409</td>
<td>$6</td>
</tr>
<tr>
<td>Wet Ponds and Wetlands</td>
<td>impervious urban</td>
<td>acre treated</td>
<td>736.2</td>
<td>Wet Ponds and Wetlands pervious urban acre treated</td>
<td>293.6</td>
<td>$6</td>
</tr>
<tr>
<td>Wet Ponds and Wetlands</td>
<td>pervious urban</td>
<td>acre treated</td>
<td>3,668.2</td>
<td>Wet Ponds and Wetlands all urban acre treated</td>
<td>38.5</td>
<td>$6</td>
</tr>
</tbody>
</table>
How loading rate affects BMP performance

BMPs installed on segments with higher loading rates will remove more pollution.

Example:

- A Bioswale is expected to reduce an urban nitrogen load by 70%

- If it is placed on an impervious acre with a loading rate of 10 lbs per year, it will remove 7 lbs of nitrogen per year.

- But if it is placed on an acre of urban impervious land with a loading rate of 15 lbs per year, it will remove 10.5 lbs of nitrogen per year.
Geographic Factors

How much geographic variation is there between delivered urban loading rates within a county?

9 counties show variation:
• Allegany County
• Baltimore City
• Baltimore County
• Carroll County
• Frederick County
• Garrett County
• Harford County
• Howard County
• Montgomery County
Example

Treating one acre of impervious urban land with a rain garden can reduce the delivered nitrogen loads to the Bay by:

<table>
<thead>
<tr>
<th>Loading Rate</th>
<th>Reduction</th>
<th>Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.44 lbs/acre/year</td>
<td>70%</td>
<td>3.11 lbs/acre/year</td>
</tr>
<tr>
<td>7.32 lbs/acre/year</td>
<td>70%</td>
<td>5.12 lbs/acre/year</td>
</tr>
<tr>
<td>11.56 lbs/acre/year</td>
<td>70%</td>
<td>8.09 lbs/acre/year</td>
</tr>
</tbody>
</table>
Benefits Beyond Nutrient Removal

- Other benefits of Urban Stormwater BMPs
  - public health benefits
    - air quality
    - bacteria reduction
  - local water quality
    - other TMDLs
  - quality of life benefits
    - neighborhood beautification
    - recreation
    - wildlife habitat
  - urban heat island
    - ozone formation
    - stream temperature
  - carbon sequestration
  - flood control
The Value of Street Trees to the City of Fond du Lac, WI

http://www.itreetools.org/resources/reports/WDNR_Fond_du_Lac_reports.pdf
## Gray vs. Green Practices

<table>
<thead>
<tr>
<th></th>
<th>Public Health</th>
<th>Recreation</th>
<th>Neighborhood Beautification</th>
<th>Urban Heat Island</th>
<th>Wildlife Habitat</th>
<th>Carbon Sequestration</th>
<th>Flood Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gray Options</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry Detention Ponds</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Hydrodynamic Structures</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Permeable Pavement</td>
<td>Mid</td>
<td>Low</td>
<td>Mid</td>
<td>Mid</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Street Sweeping</td>
<td>Mid</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Green Options</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bioretention</td>
<td>Mid</td>
<td>Low</td>
<td>High</td>
<td>Mid</td>
<td>Mid</td>
<td>Low</td>
<td>Mid</td>
</tr>
<tr>
<td>Forest Buffers</td>
<td>Mid</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Urban Impervious Surface Reduction</td>
<td>Low</td>
<td>Mid</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Tree Planting</td>
<td>Mid</td>
<td>Mid</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

source: Center for Watershed Protection, Cost-Effectiveness Study of Urban Stormwater BMPs in the James River Basin, Ellicott City, MD 2013
Comparing BMPs Across Sectors by Cost Effectiveness

$ per pound of delivered nitrogen removed

More Cost Effective

AFO, CAFO & nursery

Cropland & Pasture

Forest

Septic & Wastewater

Urban Stormwater

Less Cost Effective

TN Cost Efficiency Range

high

low

Alternative Crops

Irrigation Water Reuse

Enhanced Nutrient Mgmt.

Agr Forest Buffers

Cover Crops

Wetland Restoration

Wastewater Upgrades

Nutrient Management

Conservation Tillage

Barnyard Runoff Control

Septic Connection

Urban Forest Buffers

Soil Conservation Plans

Septic Nutrient Mgmt.

Urban Infiltration Practices

Urban Infiltration Practices

Urban Filtering Practices

Urban Filtering Practices
Future Steps

• County-Level Data to be Provided
• MAST is being upgraded in 2014 to include cost estimates
  – The updated version will incorporate a user-defined BMP cost option