Getting More Green for your Stormwater Infrastructure

Tuesday, May 5th, 2015
1:00 – 2:30pm EDT

Speakers:

Chris Kloss, U.S. EPA
Dan Christian, Tetra Tech
Andrew Potts, CH2M HILL

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Webcast Agenda

– Speaker introduction
– Chris Kloss, U.S. EPA
  • EPA cost analysis of post construction stormwater BMPs
– Dan Christian, Tetra Tech
  • Quantifying benefits of green infrastructure – tools and resources
– Andrew Potts, CH2M HILL
  • Case studies on cost savings from green infrastructure
– Q&A session

*slides will be made available at www.epa.gov/greeninfrastructure
Interpreting the Costs of Green Infrastructure & Stormwater Control

May 2015
2015 Green Infrastructure Webcast Series

Chris Kloss
US EPA Office of Water
# EPA GI Cost-Effectiveness Study

## Table 2. Summary of Cost Comparisons Between Conventional and LID Approaches

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

<sup>a</sup> 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.

<sup>b</sup> Negative values denote increased cost for the LID design over conventional development costs.

<sup>c</sup> Mill Creek costs are reported on a per-lot basis.

Other Sources of Information for the Costs of Green Infrastructure

• ASLA case studies (www.asla.org/stormwater)
• 479 case studies identified.
• Half of the case studies were retrofits of existing properties, 31% were new developments and 19% were redevelopment projects.
• 44% of case studies found a decrease in costs by using green infrastructure; 31% found green infrastructure did not influence costs while 25% found increased costs.

Green Roof at ASLA Building, Washington, DC.
Analysis of Costs and Performance of Different Stormwater Practices

Analysis Components

- Site-Level Cost Analysis
- Estimates of Land Development Activity
- Site-Level Pollutant and Runoff Analysis
- National estimates of costs, pollutant reductions and changes in runoff characteristics
- Regional and national economic impacts and environmental benefits estimates
Site-Level Analysis Goals

• Determine costs and performance of stormwater management strategies at new and re-development projects reflecting existing state/local requirements
• Determine costs and performance of various different stormwater management strategies (e.g., retention)
• Evaluate changes (increases, decreases) in costs, pollutant discharges and hydrologic performance at various scales (MS4s, states, national) due to nationwide application of different strategies
BMP Types: Retention/Treatment

- Retention Only:
  - Greenroof
  - Pervious Area Dispersion
  - Dry Well
  - Cisterns
  - Infiltration Trench
  - Infiltration Vault/Gallery
  - Infiltration Basin

- Treatment Only:
  - Flow-through Planters
  - Treatment Vault
  - Sand Filter
  - Wet Detention Basin/Wet Pond

- Retention and/or Treatment:
  - Bioretention
  - Permeable Pavement
Summaries of Predicted Construction Spending & Predicted Projects for years 2020 - 2040

<table>
<thead>
<tr>
<th>Projects</th>
<th>Development Acres</th>
<th>Impervious Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
</tr>
<tr>
<td>New Development Inside Reg MS4s</td>
<td>536,030</td>
<td>36%</td>
</tr>
<tr>
<td>Redevelopment Inside Reg MS4s</td>
<td>497,003</td>
<td>33%</td>
</tr>
<tr>
<td>New Development Outside Reg MS4s</td>
<td>282,595</td>
<td>19%</td>
</tr>
<tr>
<td>Redevelopment Outside Reg MS4s</td>
<td>176,729</td>
<td>12%</td>
</tr>
<tr>
<td>Total Development</td>
<td>1,492,357</td>
<td></td>
</tr>
</tbody>
</table>
Some Example Results

- All costs are in 2012 dollars, and presented as costs/acre
- All data are specific to Illinois
Retention Estimates

- Assumed a retention standard of 90\textsuperscript{th} percentile rainfall event for new development, and 85\textsuperscript{th} percentile for redevelopment
- Retention standard is applied statewide (inside and outside of MS4s)
- EPA also assessed impact of reducing impervious surfaces which includes:
  - Modest reductions to street widths and parking stall sizes
  - EPA did not change parking ratios, address shared parking or other changes that can more significantly reduce impervious surfaces
Commercial project type

- EPA projected 24,000 commercial projects in IL from 2020-2040 (most are redevelopment in MS4 areas).
- Median project size 3 acres.
- Average 45% impervious surface.
- Most common BMPs are soil amendments and soil/vegetation conservation (99%), downspout disconnection (69%), bioretention (65%), and infiltration basins (44%).
Single Family Residential project type

• EPA projected 12,400 SFR projects in IL from 2020-2040 (most are new developments outside MS4 areas).

• Median project size 6 acres (15 acres average).

• Average 20% impervious surface.

• Most common BMPs are soil amendments and soil/vegetation conservation (100%), downspout disconnection (93%), permeable pavement (48%), and infiltration basins (25%).
Stormwater retention’s estimated impacts on commercial developments

<table>
<thead>
<tr>
<th></th>
<th>Current Regs</th>
<th>New Retention Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current Cost</td>
<td>With imp. surface reduction</td>
</tr>
<tr>
<td>New Development in MS4</td>
<td>$12,700/ac</td>
<td>- $1,500/ac</td>
</tr>
<tr>
<td>Redevelopment in MS4</td>
<td>$16,400/ac</td>
<td>+ $3,500/ac</td>
</tr>
</tbody>
</table>

• Most cost savings are from impervious surface reduction. Additional savings from O&M and reduced size of detention pond needed for flood control.
Retaining stormwater saves money for single family home developments

<table>
<thead>
<tr>
<th></th>
<th>Current Regs</th>
<th>New Retention Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current Cost</td>
<td>With imp. surface reduction</td>
</tr>
<tr>
<td>New Development in MS4</td>
<td>$9,000/ac</td>
<td>- $3,100/ac</td>
</tr>
<tr>
<td>Redevelopment in MS4</td>
<td>$14,300/ac</td>
<td>- $3,000/ac</td>
</tr>
</tbody>
</table>

• Most cost savings are from impervious surface reduction and reduced O&M costs.
Changes to Site Design and Performance Can Save Money

• Environmental Site Design
  – Reducing impervious surfaces (parking lot areas and narrowing street widths) lessens the runoff volume that needs to be controlled
  – EPA is actively encouraging states and metro areas to conduct reviews of codes and ordinances that may limit the use of environmental site design and green infrastructure

• Reduced need for Flood Storage
  – Retaining stormwater can reduce or eliminate the need for other water infrastructure that is currently required
  – Most projects need to meet local flood storage requirements - typically through detention ponds (wet/dry) or detention vaults
  – Retention practices offset the volume that needs to be captured for flood storage
How Green Infrastructure Can Save Money – Boulder Hills, NH (UNH Stormwater Center)

• 24-unit active adult condominium community built in 2009
• Makes use of porous asphalt for road, driveways, and sidewalks
• The use of green infrastructure practices resulted in project costs 6% lower than conventional approaches
Boulder Hills, NH (UNH Stormwater Center)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>CONVENTIONAL</th>
<th>LOW IMPACT</th>
<th>DIFFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Preparation</td>
<td>$23,200.00</td>
<td>$18,000.00</td>
<td>−$5,200.00</td>
</tr>
<tr>
<td>Temp. Erosion Control</td>
<td>$5,800.00</td>
<td>$3,800.00</td>
<td>−$2,000.00</td>
</tr>
<tr>
<td>Drainage</td>
<td>$92,400.00</td>
<td>$20,100.00</td>
<td>−$72,300.00</td>
</tr>
<tr>
<td>Roadway</td>
<td>$82,000.00</td>
<td>$128,000.00</td>
<td>$46,000.00</td>
</tr>
<tr>
<td>Driveways</td>
<td>$19,700.00</td>
<td>$30,100.00</td>
<td>$10,400.00</td>
</tr>
<tr>
<td>Curbing</td>
<td>$6,500.00</td>
<td>$0.00</td>
<td>−$6,500.00</td>
</tr>
<tr>
<td>Perm. Erosion Control</td>
<td>$70,000.00</td>
<td>$50,600.00</td>
<td>−$19,400.00</td>
</tr>
<tr>
<td>Additional Items</td>
<td>$489,700.00</td>
<td>$489,700.00</td>
<td>$0.00</td>
</tr>
<tr>
<td>Buildings</td>
<td>$3,600,000.00</td>
<td>$3,600,000.00</td>
<td>$0.00</td>
</tr>
<tr>
<td>PROJECT TOTAL</td>
<td>$4,389,300.00</td>
<td>$4,340,300.00</td>
<td>−$49,000.00</td>
</tr>
</tbody>
</table>
How Green Infrastructure Can Save Money – Greenland Meadows, NH (UNH Stormwater Center)

• Three, 1-story retail units on 56 acres (25 acres of impervious surface) built in 2008
• 4.5 acres of porous asphalt and gravel wetland used for stormwater management
• The use of green infrastructure practices were estimated to save 9% in overall project development costs
### TABLE 1: Comparison of Unit Costs for Materials for Greenland Meadows Commercial Development

<table>
<thead>
<tr>
<th>ITEM</th>
<th>CONVENTIONAL OPTION</th>
<th>LID OPTION</th>
<th>COST DIFFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobilization / Demolition</td>
<td>$555,500</td>
<td>$555,500</td>
<td>$0</td>
</tr>
<tr>
<td>Site Preparation</td>
<td>$167,000</td>
<td>$167,000</td>
<td>$0</td>
</tr>
<tr>
<td>Sediment / Erosion Control</td>
<td>$378,000</td>
<td>$378,000</td>
<td>$0</td>
</tr>
<tr>
<td>Earthwork</td>
<td>$2,174,500</td>
<td>$2,103,500</td>
<td>$71,000</td>
</tr>
<tr>
<td>Paving</td>
<td>$1,843,500</td>
<td>$2,727,500</td>
<td>$884,000</td>
</tr>
<tr>
<td>Stormwater Management</td>
<td>$2,751,800</td>
<td>$1,008,800</td>
<td>$1,743,000</td>
</tr>
<tr>
<td>Addtl Work-Related Activity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Utilities, Lighting, Water &amp; Sanitary Sewer Service, Fencing, Landscaping, etc.)</td>
<td>$2,720,000</td>
<td>$2,720,000</td>
<td>$0</td>
</tr>
<tr>
<td><strong>Project Total</strong></td>
<td><strong>$10,590,300</strong></td>
<td><strong>$9,660,300</strong></td>
<td><strong>$930,000</strong></td>
</tr>
</tbody>
</table>

*Costs are engineering estimates and do not represent actual contractor bids.

### TABLE 2: Conventional Option Piping

<table>
<thead>
<tr>
<th>TYPE</th>
<th>QUANTITY</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution</td>
<td>6 to 30-inch piping</td>
<td>9,680 linear feet</td>
</tr>
<tr>
<td>Detention</td>
<td>36 and 48-inch piping</td>
<td>20,800 linear feet</td>
</tr>
</tbody>
</table>

### TABLE 3: LID Option Piping

<table>
<thead>
<tr>
<th>TYPE</th>
<th>QUANTITY</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution</td>
<td>4 to 36-inch piping</td>
<td>19,970 linear feet</td>
</tr>
<tr>
<td>Detention*</td>
<td>—</td>
<td>$0</td>
</tr>
</tbody>
</table>

*Costs associated with detention in the LID option were accounted for under “earthwork” in Table 1.
In 2014, nearly 10” of rain fell over a 4-day period causing flooding in other parts of the Twin Cities-metro area. Minimal runoff reached the regional infiltration basins and no stormwater left the City.

The 134 acre retail & residential development used a rain-treatment approach, that included:

- 35 raingardens,
- 274 permeable asphalt parking stalls,
- 2 permeable paver intersections,
- 2 infiltration basins
- and a biofiltration swale
Regulated MS4 Program Universe

- **Individual Permits**
  - 250 Individual MS4 permits cover 855 Phase I MS4s
  - 100 Individual MS4 permits cover ~106 Phase II MS4s

- **General Permits**
  - 54 General MS4 permits cover 6,589 Phase II MS4s

- **3 watershed MS4 permits**
  - cover ~3 Phase I and 40 Phase II MS4s
Opportunities

Bioretention Cell in El Monte, CA. Photo courtesy of Bill DePoto.
Lancaster, PA Alley 148 Greened for 10% Added Cost + 200,000 gallons captured per year

Before (July 2011) ~$20.30/SF

After (February 2012) ~$22.40/SF

Conventional reconstruction (8-inch reinforced concrete)

Green alley retrofit (permeable pavers with infiltration)
US EPA Green Infrastructure Program

Thank you
BENEFITS OF GREEN INFRASTRUCTURE

Getting More Green For Your Stormwater Infrastructure

Tuesday, May 5, 2015
EPA Webcast
Benefits of Green Infrastructure

Environmental

Economic

Social

Sustainable

Equitable

Bearable

Viable
Plant a tree

- Reduced runoff
- Reduced water pollution
- Reduced air pollution
- Improved stream stability
- Improved ecology health
- Lower temperatures
- Increased shade
- People walk more
- Increased property value
- Shop more
- Spend more $$$
- Improved social health
- Improved economics
- More time outdoors
- Happier
- Reduced energy consumption
Green Infrastructure Benefits and Practices

This section, while not providing a comprehensive list of green infrastructure practices, describes the five GI practices that are the focus of this guide and examines the breadth of benefits this type of infrastructure can offer. The following matrix is an illustrative summary of how these practices can produce different combinations of benefits. Please note that these benefits accrue at varying scales according to local factors such as climate and population.

| Benefit          | Reduces Stormwater Runoff | Improves Water Quality | Reduces Grey Infrastructure Needs | Reduces Flooding | Increases Available Water Supply | Increases Groundwater Recharge | Reduces Soft Use | Improves Energy Use | Reduces Air Quality | Reduces Atmospheric CO₂ | Reduces Urban Heat Island | Improves Community Livability | Improves Aesthetics | Increases Recreational Opportunity | Reduces Noise Pollution | Improves Community Cohesion | Urban Agriculture | Improves Habitat | Cultivates Public Education Opportunities |
|------------------|---------------------------|------------------------|-----------------------------------|------------------|---------------------------------|-----------------------------|-----------------|---------------------|------------------|------------------------|---------------------------|---------------------------|------------------|--------------------------------|----------------|----------------|--------------------------|
| Practice         |                           |                        |                                   |                  |                                 |                             |                 |                     |                  |                        |                           |                           |                  |                               |                  |                |                          |
| Green Roofs      | ![Green Roofs Icon]        | ![Green Roofs Icon]    | ![Green Roofs Icon]               | ![Green Roofs Icon] | ![Green Roofs Icon]             | ![Green Roofs Icon]         | ![Green Roofs Icon] | ![Green Roofs Icon] | ![Green Roofs Icon] | ![Green Roofs Icon]   | ![Green Roofs Icon]          | ![Green Roofs Icon]       |                  |                        |                  |                |                          |
| Tree Planting    | ![Tree Planting Icon]      | ![Tree Planting Icon]   | ![Tree Planting Icon]             | ![Tree Planting Icon] | ![Tree Planting Icon]         | ![Tree Planting Icon]       | ![Tree Planting Icon] | ![Tree Planting Icon] | ![Tree Planting Icon] | ![Tree Planting Icon]   | ![Tree Planting Icon]          | ![Tree Planting Icon]       |                  |                        |                  |                |                          |
| Bioretention & Infiltration | ![Bioretention & Infiltration Icon] | ![Bioretention & Infiltration Icon] | ![Bioretention & Infiltration Icon] | ![Bioretention & Infiltration Icon] | ![Bioretention & Infiltration Icon] | ![Bioretention & Infiltration Icon] | ![Bioretention & Infiltration Icon] | ![Bioretention & Infiltration Icon] | ![Bioretention & Infiltration Icon] | ![Bioretention & Infiltration Icon] | ![Bioretention & Infiltration Icon] | ![Bioretention & Infiltration Icon] |                  |                        |                  |                |                          |

- **Yes**
- **Maybe**
- **No**
**Hydrology**

- Increased interception
- Increased onsite storage
- Increased infiltration
- Increased plant-water uptake
- Increased time of concentration
- Decreased runoff volume
- Decreased runoff rate

**Leads to**

- Reduced infrastructure needs
- Reduced flooding
- Increased water supply
EPA Nonpoint Source Pollution

Benefits of Green Infrastructure

May 5, 2015

Water: Polluted Runoff

Managing Urban Runoff

Urbanization increases the variety of polluted waters. In urban and suburban areas, buildings, pavement and compacted surfaces do not allow rain and snowmelt to be absorbed, increasing the volume and velocity of runoff and allowing sediments, pollutants and nutrients to enter streams and other bodies of water. This maintains a consistent flow in the waterways, and when the storms are over, the water flows away until the next storm occurs. These pollutants can harm fish and drinking water, and make recreation in the water bodies unpleasant.

Fact Sheets

- Protecting Water Quality from Septic Systems
- This is an EPA fact sheet about the Clean Water Act and 2001. EPA A41-F-03-0003.

Water Infrastructure

Green Infrastructure

Sustainable Systems

Water Security

Wastewater

WaterSense

What You Can Do

Databases and Summary Reports

- Databases and Summary Reports
- Green Roofs
- Permeable Pavements
- Rainwater Harvesting
- Rain Gardens and Planter Boxes
- Bioswales
- Urban Tree Canopy
- Constructed Wetlands
- Watershed Scale

A wealth of research has examined the performance of green infrastructure in reducing the discharge of pollutants to receiving waters, removing air pollutants, and even reducing energy use. Here we provide links to EPA’s research on green infrastructure performance, as well as to a sample of recent publications from the scientific literature.

EPA’s Office of Research and Development provides technical and engineering expertise to evaluate water infrastructure for their effectiveness, and to develop new tools for decision making.

This page provides links to non-EPA web sites that provide additional information. You will lose the EPA.gov domain and enter another page with more information. EPA cannot attest to the accuracy of information on non-EPA pages. Providing links to a non-EPA Web site is not an endorsement of the other site or the information it contains by EPA or any of its employees. Also, be aware that the privacy protection provided on the EPA.gov domain (see Privacy and Security Notice) may not be available on the external link. Text © Disclaimer.
International Stormwater BMP Database (bmpdatabase.org)


News
- 2013 Advanced Analysis
- National Stormwater Quality Database Has
  A
- 21
- 21

Urban Stormwater Research Reports
- 2012 BMP Performance Summaries
- 2012 Statistical Appendices
- 2012 Manufactured Device Performance Analysis Summary
- 2012 Volume Reduction in Bioretention
- 2012 Database Overview
- 2012 Chesapeake Bay BMP Performance Summary

Retrieve Urban Stormwater
- BMP Study Retrieval Tool
- BMP Map Tool
- BMP Category Reports
- Online Statistical Analysis Tool
- Download Access Database

Figure 2. Box Plots of Influent/Effluent TSS Concentrations
Air Pollution Reduction

- Urban trees and shrubs offer the ability to remove significant amounts of air pollutants.
- Urban tree canopy cover could be a viable strategy to improve air quality and help meet clean air standards.
- Green roofs can be used to supplement the use of urban trees in air pollution control.


<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Low (lbs/ac)</th>
<th>High (lbs/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozone ($O_3$)</td>
<td>26</td>
<td>40</td>
</tr>
<tr>
<td>Particulate (PM$_{10}$)</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Nitrogen Dioxide (NO$_2$)</td>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td>Sulfur Dioxide (SO$_2$)</td>
<td>10</td>
<td>18</td>
</tr>
</tbody>
</table>

Air Pollutant Removal by Green Roof
Urban Heat Island Effect

- Temperatures in urban areas are higher than in surrounding rural areas
- Results from the generation and retention of heat by urban buildings and paved surfaces
- Results in higher energy demand during the summer
- Ambient temperatures may be reduced by increasing
  - Albedo (solar reflectivity)
  - Vegetation density
- Example practices
  - Green roofs
  - Trees

**Greenhouse Gas Emissions**

- Greenhouse Gas Emissions contribute to climate change
- **Target**
  - Reduced emissions from reduced energy consumption
  - Increased sequestration of carbon dioxide by vegetation
- Energy consumption linked to urban heat island effect
- **Carbon Sequestration, impacted by:**
  - Age of vegetation
  - Type of vegetation
  - Density of vegetation

<table>
<thead>
<tr>
<th>Vegetation Type</th>
<th>Mean Plant Biomass (grams of Carbon/sf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperate Forest</td>
<td>743.5</td>
</tr>
<tr>
<td>Temperate Steppe</td>
<td>278.8</td>
</tr>
<tr>
<td>Wetland</td>
<td>250.9</td>
</tr>
<tr>
<td>Cultivated Land</td>
<td>130.1</td>
</tr>
</tbody>
</table>

Greenness and General Physical Health Benefits

- People perceive streets with trees and gardens as more attractive for walking.
- Access to a garden or short distances to green areas from the dwelling are associated with less stress and a lower likelihood of obesity.
- The amount of green areas in the vicinity of the participant's residence and the short distance to green areas suitable for recreational use increased the number of close-to-home outings among residents.
- Higher greenness was significantly associated with lower BMI regardless of residential density characteristics.
- Greener environments can reduce mortality rates for populations that would normally have higher mortality rates due to socioeconomic factors such as income and available health services.

Mental and Emotional Health Effects

- Significant relationships have been found between the use of urban open spaces and experiences of stress.
- Other research has shown that time in natural settings can help mental fatigue recovery and improve one’s capacity to concentrate.
- Results indicate that children function better than usual after activities in green settings.
- The “greener” a child’s play area, the less severe his or her attention deficit symptoms.
- Desk workers surveyed about their rate of illness and level of job satisfaction claimed 23% fewer incidents of illness in the prior six months if they had a view of nature from their desks.

Crime Reduction

• Within the same housing development, building with high levels of vegetation had 48% fewer property crimes and 56% fewer violent crimes than building with low levels of vegetation.

• Medium levels of vegetation were associated with 40% fewer property crimes and 44% fewer violent crimes than low levels of vegetation.

Kuo, F. (2001)
Community Cohesion

In a series of studies involving over 1,300 person–space observations, 400 interviews, housing authority records, and 2 years of police crime reports, tree and grass cover were systematically linked to a wide range of social ecosystem indicators.

These indicators included stronger ties among neighbors, greater sense of safety and adjustment, more supervision of children in outdoor spaces, healthier patterns of children’s play, more use of neighborhood common spaces, fewer incivilities, fewer property crimes, and fewer violent crimes.

In residential areas, barren, treeless spaces often become “no man’s lands,” which discourage resident interaction and invite crime.

The presence of trees and well-maintained grass can transform these no man’s lands into pleasant, welcoming, well-used spaces.

Vital, well-used neighborhood common spaces serve to both strengthen ties among residents and deter crime, thereby creating healthier, safer neighborhoods.

Kuo, F. (1998); Kuo, F. 2003.
Property Value

- Trees add $7,020 to the price of a house, a 2.4% of the mean sale price.
- Open spaces have a statistically significant effect on a home’s sale price.
- Introduction of LID increased property values by 3.5 – 5 percent.
- These results suggest people are willing to pay for the combination of neighborhood amenities and environmental services provided by LID stormwater controls.

Distance Variables Evaluated at the Mean Open Space for each Open Space Type (1990 Dollars)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Urban Park</th>
<th>Natural Area Park</th>
<th>Golf Course</th>
<th>Speciality Park/Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance ≤ 200</td>
<td>$1,926***</td>
<td>$11,210*</td>
<td>$13,916*</td>
<td>$7,396***</td>
</tr>
<tr>
<td>Distance 201–400</td>
<td>2,061*</td>
<td>10,216*</td>
<td>7,851*</td>
<td>5,744**</td>
</tr>
<tr>
<td>Distance 401–600</td>
<td>1,193***</td>
<td>12,621*</td>
<td>2,814*</td>
<td>10,283*</td>
</tr>
<tr>
<td>Distance 601–800</td>
<td>817</td>
<td>11,269*</td>
<td>8,842*</td>
<td>5,661*</td>
</tr>
<tr>
<td>Distance 801–1,000</td>
<td>943</td>
<td>8,981*</td>
<td>8,898*</td>
<td>4,972*</td>
</tr>
<tr>
<td>Distance 1,001–1,200</td>
<td>1,691*</td>
<td>8,126*</td>
<td>4,391***</td>
<td>4,561*</td>
</tr>
<tr>
<td>Distance 1,201–1,500</td>
<td>342</td>
<td>9,980*</td>
<td>4,366**</td>
<td>t3,839*</td>
</tr>
</tbody>
</table>

Number of observations 16,747; λ = 0.0995; adjusted $R^2 = 0.656$

* ** *** denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Porous Pavements

- Melting water seeps through the pavement instead of refreezing
- Lack of refreezing melt water eliminates the need for additional deicing applications
- Observational data supported by laboratory biomechanical investigations
- Pavement noise is generated through tire pavement interaction and block compression of tire tread against the pavement surface
- 5 to 6 dB reduction in noise level
- Decreased hydroplaning
- Decreased glare

Kevern J. (2012), Neithalath N. (2005),
Quantifying Benefits

- Reduced Runoff
  - Computational Methods – Curve Number, Rational, Small Storm Hydrology, SWMM Runoff
  - Models: By hand, TR-20, TR-55, SWMM, National Stormwater Calculator, etc.

- Trees – iTree (https://www.itreetools.org/)

- Green Values National Stormwater Management Calculator (http://greenvalues.cnt.org/)

- CNT and American Rivers (2010)
  - Benefit quantification
  - Valuation

<table>
<thead>
<tr>
<th>Target</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soc 4.2-2: Increase the wellness of City employees and their families</td>
<td>• Identify projects with vegetation as assisting with this target</td>
</tr>
<tr>
<td></td>
<td>• Correlate project areas with crime locations</td>
</tr>
<tr>
<td>Soc 5.1: Reduce the occurrence of crime</td>
<td></td>
</tr>
<tr>
<td>Soc 5.4-2: Increase by at least 5% the neighborhood conditions (safety and/or appearance)</td>
<td></td>
</tr>
<tr>
<td>Env 1-3: Reduce total direct/indirect CO2 emissions by 10,000 metric tons</td>
<td>Quantify carbon sequestered from vegetation and avoided CO2 emissions from energy savings</td>
</tr>
<tr>
<td>Env 2.1-4: Increase reuse of captured water and/or gray water</td>
<td>Quantify water harvesting use</td>
</tr>
<tr>
<td>Env 2.2-4: Reduce wastewater flow by at least 5% by 2014</td>
<td>Quantify runoff reduction in combined sewer areas</td>
</tr>
<tr>
<td>Env 2.2-6: Increase the number and square footage of green roofs</td>
<td>Quantify green roof area</td>
</tr>
<tr>
<td>Env 2.2-7: Reduce stormwater discharge by at least 50,000 gallons per rain event</td>
<td>Quantify runoff reduction in separate storm sewer areas</td>
</tr>
<tr>
<td>Env 2.2-9: At least 5% of reconstructed streets, alleys and City parking lots to be constructed of pervious pavement</td>
<td>Quantify pervious pavement installed</td>
</tr>
<tr>
<td>Env 2.3-1: Increase the percentage of tree canopy in the city to at least 37.5%</td>
<td>Count trees installed and estimate canopy area</td>
</tr>
<tr>
<td>Env 2.3-2: Increase the percentage of low-maintenance grasses and native plants used in landscaping by at least 25%</td>
<td>Quantify the vegetation area installed</td>
</tr>
<tr>
<td>Env 3.2-7: Increase the number of acres of City owned park property using LID</td>
<td>Quantify green infrastructure practices installed in parks</td>
</tr>
</tbody>
</table>
## Sustainability Plan Targets

- LID in city parks
- Water harvesting
- Green roof
- Porous pavement
- Tree canopy
- Low maintenance grasses and native plants
- Vegetation for social wellness
- CO2
- Runoff volume reduction

## Example Walsh St

North side of Walsh St. between Martin Ave and Eastern Ave

<table>
<thead>
<tr>
<th>LAND COVER</th>
<th>HYDROLOGY RUNOFF (CF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Area (ft²)</td>
</tr>
<tr>
<td>Breeds &amp; Roads (Paved, curbs and storm sewers excl. ROW)</td>
<td>6,241</td>
</tr>
<tr>
<td>Urban</td>
<td>1,531</td>
</tr>
<tr>
<td>Urban</td>
<td>1,531</td>
</tr>
<tr>
<td>Urban</td>
<td>1,531</td>
</tr>
<tr>
<td>Urban</td>
<td>1,531</td>
</tr>
<tr>
<td>Urban</td>
<td>1,531</td>
</tr>
<tr>
<td>Total</td>
<td>20,844</td>
</tr>
</tbody>
</table>

### PROPOSED IMPROVEMENTS

#### Green Infrastructure

<table>
<thead>
<tr>
<th>Practice Selection</th>
<th>Surface Area</th>
<th>Volume Retain</th>
<th>Volume Total</th>
<th>Unit Cost</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioretention - Curb Extension, at intersection</td>
<td>660</td>
<td>660</td>
<td>59</td>
<td>$31</td>
<td>$20,160</td>
</tr>
<tr>
<td>Bioretention - Curb Extension, mid-block</td>
<td>560</td>
<td>560</td>
<td>47</td>
<td>$31</td>
<td>$17,850</td>
</tr>
<tr>
<td>Pervious Pavement - Paving</td>
<td>2,000</td>
<td>2,000</td>
<td>0</td>
<td>$23</td>
<td>$46,000</td>
</tr>
<tr>
<td>Subtotal</td>
<td>3,220</td>
<td>2,242</td>
<td>826</td>
<td>$83,200</td>
<td></td>
</tr>
</tbody>
</table>

#### Linear Conveyance

<table>
<thead>
<tr>
<th>Practice Selection</th>
<th>Length (ft)</th>
<th>Unit Cost</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot; PVC, Shallow</td>
<td>400</td>
<td>$34</td>
<td>$30,000</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$13,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### OPINION OF PROBABLE COST

- Capital Cost: $76,000
- Average Annual O&M: $4,800
- 50-yr Net Present Value: $494,000

### BENEFITS

#### Targeted Practices and Locations

- Drainage area (DA) | Area green infrastructure (GI) | Ratio DA: GI | Ratio imp: GI |
- 0.66 acres | 0.07 acres | 9.1 | 2.5:1 |
- Green roof (Env. 2.2 #6) | Pervious pave (Env. 2.2 #6) |
- 2,000 sf | 1200 sf |
- New trees planted (Env. 2.3 #1) | Quantity (10yr Canopy) | 50yr Canopy |
- 600 sf | 2 each |
- Area of low maintenance grasses and native plants used (Env. 2.3 #6) |
- Social Benefits |
  - Increased wellness (Soc. 4.2) and reduced crime (Soc. 5.1) with vegetation |
  | Yes | ADA Ramp(s) | Yes | Soc. 1.3, Target 6 |

### Environmental Benefits

- Total direct and indirect CO₂ emissions reduction (Env. 1.46) |
- Water quality treatment volume (95%) managed and retained |
- Average annual runoff volume retained off-site | 0.15 Mgal | 91% percent of total runoff retained |
THANK YOU

Daniel P. Christian, PE, D.WRE
Senior Project Manager, Water Resources
Dan.Christian@TetraTech.com
517.316.3939
References

References

Cost Saving Approaches for Implementing Green Stormwater Infrastructure

Andrew Potts, P.E., LEED AP, CPESC

EPA Webinar
May 5, 2015

andrew.potts@ch2m.com
215.640.9033
Outline

- City of Lancaster (PA) Green Infrastructure Program Overview
- Integrated Infrastructure Programs – achieving multiple benefits to stretch our public investments
  - Parks
  - Roads/Sidewalks
  - Other utilities
- Public-Private Partnership Program
- Additional Information
- Questions
55% separate sewers / 45% combined

Conestoga River → Chesapeake Bay (TMDL)

7.34 square miles with 60,000 residents in the 2010 census, significant poverty levels

Incorporated in 1742 as a borough and in 1818 as a City

Historic building stock (median home age of 100 years)
2011 Green Infrastructure Plan
Envisions Widespread GI

- Roads & Alleys
- Parking
- Rooftops
Green Infrastructure Program Status

City of Lancaster
Green Infrastructure Program

Green Infrastructure Projects and Status
November 2014

Legend
GI Project Status (11/14)
- Complete
- Under Construction
- Design
- Concept
- Idea
- On Hold

Combined Sewer System Basins
Municipal Boundary

0 800 1,600 Feet
1 inch = 1,600 feet
## Green Infrastructure Program Status

<table>
<thead>
<tr>
<th>Status</th>
<th>Number of Projects</th>
<th>Impervious Area Managed (sq. ft.)</th>
<th>Impervious Area Managed (acres)</th>
<th>Annual Runoff Capture (Gal/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constructed / Under Construction</td>
<td>52</td>
<td>1,009,587</td>
<td>23</td>
<td>20,172,000</td>
</tr>
<tr>
<td>In Design for Construction</td>
<td>14</td>
<td>943,000</td>
<td>22</td>
<td>17,984,000</td>
</tr>
<tr>
<td>Conceptual Designs (non-PV/GGP)</td>
<td>24</td>
<td>640,000</td>
<td>15</td>
<td>12,262,000</td>
</tr>
<tr>
<td>PENNVEST Concepts</td>
<td>19</td>
<td>367,000</td>
<td>8</td>
<td>7,033,000</td>
</tr>
<tr>
<td>Growing Greener Plus Concepts</td>
<td>1</td>
<td>46,000</td>
<td>1.1</td>
<td>881,000</td>
</tr>
<tr>
<td>In Project Planning</td>
<td>52</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>162</strong></td>
<td><strong>3,005,587</strong></td>
<td><strong>69</strong></td>
<td><strong>58,332,000</strong></td>
</tr>
</tbody>
</table>
Building off existing plans: Parks

- Lancaster’s Urban Park, Recreation and Open Space Plan (2009) called for renovations of a number of City parks
- Green Infrastructure Plan recommended GI be integrated with park improvements
- Significant GI successfully included in the 4 renovation projects completed to date
Integrated Infrastructure: Green Parks
Expanding the Benefit of the Park – 6th Ward Park (2010)
 Sixth Ward Park

- Porous basketball court with storage infiltration bed
- Funding from DCNR, DEP and Chesapeake Bay Stewardship Fund (NFWF)

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runoff Reduction</td>
<td>713,000</td>
<td>gallons / year</td>
</tr>
<tr>
<td>Bid Cost (Total Project Cost)</td>
<td>$116,300</td>
<td></td>
</tr>
<tr>
<td>Cost of Basketball Court Only</td>
<td>$49,650</td>
<td></td>
</tr>
<tr>
<td>Incremental Cost of GI</td>
<td>$66,650</td>
<td></td>
</tr>
<tr>
<td>Total Cost</td>
<td>$0.16</td>
<td>/gallon / year</td>
</tr>
<tr>
<td>Incremental Cost of GI</td>
<td>$0.09</td>
<td>/gal/yr ($87k per acre)</td>
</tr>
</tbody>
</table>

[over 40% savings from full project cost]
GREEN PARKS
BRANDON PARK

4 Million Gallons / year reduction in runoff volume
$0.15 / gal
PHS Gardening and Greening Contest
The Pennsylvania Horticultural Society

Grand D. Brandon Park

The Pennsylvania Horticultural Society encourages the use of native plants to help improve our environment and create a sense of community through beautification in the category of Storm Water Management.

Garden of Distinction

[Signature]
Integrated Infrastructure: Green Streets & Alleys
Composite Prioritization Criteria Yielded Most Cost-effective Green Streets Opportunities

- Pavement Condition
- ADA Priority
- Basin Priority (CSO vs MS4)
- Street Slope & Other Factors
- Road Type
  - Width
  - Traffic ("Functional Class")
  - Ownership (City, State, private alleys)
- Tree Canopy
- Flooding locations
- Overhead Wires
- Sidewalk Condition
- Inlet Condition

Lowest Overall Green Street Cost
Alley 148 Greened for 10% Additional Cost, Captures 200,000 Gallons per Year

**Before (July 2011)**

**After (February 2012)**

<table>
<thead>
<tr>
<th>Component</th>
<th>Conventional Unit Cost ($/square foot)</th>
<th>Green Unit Costs ($/SF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement Removal/Excavation</td>
<td>$1.08</td>
<td>$1.08</td>
</tr>
<tr>
<td>Crushed Stone w/ geotextile</td>
<td>$0.35</td>
<td>$1.39</td>
</tr>
<tr>
<td>Pipes/Cleanouts/etc.</td>
<td>---</td>
<td>$0.82</td>
</tr>
<tr>
<td>8-inch reinforced concrete</td>
<td>$18.89</td>
<td>$18.89</td>
</tr>
<tr>
<td>Permeable Pavers</td>
<td>---</td>
<td>$19.44</td>
</tr>
<tr>
<td><strong>Total Weighted Average</strong></td>
<td><strong>$20.32</strong></td>
<td><strong>$22.37</strong></td>
</tr>
<tr>
<td>Additional Green Cost ($/SF)</td>
<td>---</td>
<td><strong>$2.05</strong></td>
</tr>
<tr>
<td>Additional Green Cost (%)</td>
<td>---</td>
<td><strong>10%</strong></td>
</tr>
</tbody>
</table>

**Conventional reconstruction (8-inch reinforced concrete) ~$20.30/SF**

**Green alley retrofit (permeable pavers with infiltration trench) ~$22.40/SF**
Broad St. & New Dauphin St. Green Street
<table>
<thead>
<tr>
<th><strong>Project Reference ID</strong></th>
<th>P-121</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Name</strong></td>
<td>Pavement Removal at New Dauphin and N. Broad St.</td>
</tr>
<tr>
<td><strong>GI Prototype Project Type</strong></td>
<td>Alley/Street</td>
</tr>
<tr>
<td><strong>Construction Year (Actual)</strong></td>
<td>2012</td>
</tr>
<tr>
<td><strong>Impervious Area Contributing (ft²)</strong></td>
<td>31,000</td>
</tr>
<tr>
<td><strong>GI Area (ft²)</strong></td>
<td>3,000</td>
</tr>
<tr>
<td><strong>Calculated Estimated Capture Volume (gal/yr)</strong></td>
<td>554,000</td>
</tr>
<tr>
<td><strong>Estimated Constructed Cost (Class 3)</strong></td>
<td>$86,000</td>
</tr>
<tr>
<td><strong>Bid GI Construction Cost</strong></td>
<td>$80,000</td>
</tr>
<tr>
<td><strong>Cost / Stormwater Volume ($/gal)</strong></td>
<td>$0.14</td>
</tr>
</tbody>
</table>

**550,000 Gallons / year reduction in runoff volume**
Using Traffic Safety & Transportation Funding To Reduce Accidents and Runoff while Enhancing Local Business

5 MPH reduction in average traffic speed
Integrating Traffic Improvements Improves Safety, Local Business, and Brings New Funding Sources

- Built with Transportation and GI Grant funds
- Helps local business
- 2014 Best Urban BMP in the Bay Award
- Pennsylvania Governor’s Award for Environmental Excellence
- $0.24/gal/year
New Outdoor Seating with Permeable Pavers
<table>
<thead>
<tr>
<th>Impervious Area Contributing (ft²)</th>
<th>GI Area (ft²)</th>
<th>Calculated Storage Volume (ft³)</th>
<th>Calculated Capture Depth (in)</th>
<th>Calculated Estimated Capture Volume (gal/yr)</th>
<th>Actual Construction Cost (Bid)</th>
<th>Construction Cost / Stormwater Volume ($/gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1.01</td>
<td>250,000</td>
<td>$21,000</td>
<td>$0.08</td>
</tr>
</tbody>
</table>

Integrating with water and sewer upgrades – Greening Spruce Street
Spruce Street Greening Project (2013)

250,000 Gallons / year reduction in runoff volume
$7M SRF PENNVEST Loan to fund implementation of GI on public & private property

- 45 initial GI sites with an additional ~25% to be determined (TBD)
  - Divided into 5 bundles for bidding

- City pays up to 90% of GI Costs

- Property owner pays remainder and signs on to long-term maintenance.
Overall PENNVEST Processes

Private Owner Endorsement

Bid Package Development

Refine Designs & Quantities

Close Loan

Field Work / Final Design

Construction

Quantities from Current Project List and Concepts + Projected Quantities for TBD Projects = Total Quantities for Bid
Cost Estimating Tool Based on Unit Prices in Bids

P-XXX BID COST FORM

Bid Bundle No: 2

Enter Project Runoff Capture Volume (CF): 1,671

Capture Volume (Inches): 1.22

Enter Project Capture Area (SF): 16,423

Estimated Annual Runoff Capture (%): 89.8%

Estimated Annual Runoff Capture (gal): 386,441

Cost Efficiency of GI Improvements ($/gal): $ 0.01

Unless covered by a separate Pay Item, Unit Prices shall include all materials, labor, equipment, etc. required for their applicable Pay Items (e.g., procurement, delivery, installation, compaction, parts, fittings, incidental work required, etc.) in accordance with the contract documents, drawings, details, specifications and industry standard construction practices.

**NOTE: USER INPUTS VALUES IN GREEN BOXES AND ITEM QUANTITIES ONLY**

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Name</th>
<th>Unit</th>
<th>Estimated Quantity</th>
<th>Unit Price ($ or %)</th>
<th>Total GI Cost ($) (Quantity x Unit Price)</th>
<th>Estimated Non-GI (NGI) Quantity</th>
<th>Non-GI Cost ($) (NGI Cost x Unit Price)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Site Clearing and Disposal (removal of grass, shrubs, small trees, debris, etc.)</td>
<td>SY</td>
<td>10</td>
<td>$ 43.80</td>
<td>$ 438.00</td>
<td>0</td>
<td>$ -</td>
</tr>
<tr>
<td>2</td>
<td>Structure and Pavement Demolition (includes sawcutting, demo and disposal)</td>
<td>CY</td>
<td>10</td>
<td>$ 25.90</td>
<td>$ 259.00</td>
<td>0</td>
<td>$ -</td>
</tr>
<tr>
<td>3</td>
<td>Asphalt Milling - up to 2&quot; Depth (includes disposal)</td>
<td>SY</td>
<td>5</td>
<td>$ 6.00</td>
<td>$ 30.00</td>
<td>0</td>
<td>$ -</td>
</tr>
<tr>
<td>4</td>
<td>Common Excavation, Grading, and Backfill (includes disposal)</td>
<td>CY</td>
<td>20</td>
<td>$ 23.90</td>
<td>$ 478.00</td>
<td>0</td>
<td>$ -</td>
</tr>
<tr>
<td>5</td>
<td>Rock Excavation and Disposal</td>
<td>CY</td>
<td>0</td>
<td>$ 75.00</td>
<td>$ -</td>
<td>0</td>
<td>$ -</td>
</tr>
<tr>
<td>6</td>
<td>Reset Brick Pavers (Roadway or Sidewalk)</td>
<td>SY</td>
<td>0</td>
<td>$ 71.50</td>
<td>$ -</td>
<td>5</td>
<td>$ 357.50</td>
</tr>
<tr>
<td>7</td>
<td>Establish Turf</td>
<td>SY</td>
<td>5</td>
<td>$ 13.90</td>
<td>$ 69.50</td>
<td>5</td>
<td>$ 69.50</td>
</tr>
</tbody>
</table>

Granular Materials

SECTION 2 - ALLOWANCES (ENTER UNIT COST FROM BID BUNDLE)

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Name</th>
<th>Unit</th>
<th>%</th>
<th>Estimated Unit Price ($)</th>
<th>Total LNC Cost ($) (Total GI Cost x 90%)</th>
<th>Partner GI Cost Share ($) (Total GI Cost x 10%)</th>
<th>Total Partner Cost ($) (Cost Share + Alternate Cost)</th>
</tr>
</thead>
<tbody>
<tr>
<td>97</td>
<td>Performance Bond/Insurance</td>
<td>-</td>
<td>-</td>
<td>$ 0.01</td>
<td>$ 13.51</td>
<td>$ 0.0106</td>
<td>$ 4.53</td>
</tr>
<tr>
<td>98</td>
<td>Mobilization and Demobilization (per notice to proceed on one or more projects)</td>
<td>EA</td>
<td>1</td>
<td>$ 3,500.00</td>
<td>$ 3,500.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>100</td>
<td>Temporary Maintenance and Control of Traffic</td>
<td>%</td>
<td>-</td>
<td>$ 0.01</td>
<td>$ 9.81</td>
<td>0.0077</td>
<td>0.0329</td>
</tr>
<tr>
<td>101</td>
<td>Coordination with Other Contractors (assume 1 coordination meeting and follow-up notifications)</td>
<td>EA</td>
<td>1</td>
<td>$ 300.00</td>
<td>$ 300.00</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

TOTAL OF ALL ITEMS

$ 5,097.82 $ 434.81 $ 5,735.09 $ 637.23 $ 6,169.91
<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impervious Area Contributing (ft²)</td>
<td>17,000</td>
</tr>
<tr>
<td>GI Area (ft²)</td>
<td>4,000</td>
</tr>
<tr>
<td>Calculated Estimated Capture Volume (gal/yr)</td>
<td>295,000</td>
</tr>
<tr>
<td>Estimated Constructed Cost (Class 3)</td>
<td>$93,000</td>
</tr>
<tr>
<td>Estimated Construction Cost (Class 4)</td>
<td>$93,000</td>
</tr>
<tr>
<td>Cost / Stormwater Volume ($/gal)</td>
<td>$0.32</td>
</tr>
<tr>
<td>Primary Funding</td>
<td>PENNVEST</td>
</tr>
</tbody>
</table>
317 N. Mulberry

- PENNVEST project coordinated with redevelopment
- Challenging coordination/sequencing
- Developer expanded decorative pavers to full driveway
- Captures large neighboring building
- Hosted EPA Press Conference on Green Infrastructure in April 2014

| Impervious Area Contributing (ft²) | 20,000 |
| GI Area (ft²)                     | 2,000  |
| Calculated Estimated Capture Volume (gal/yr) | 399,000 |
| Estimated Constructed Cost (Class 3) | $75,000 |
| Estimated Construction Cost (Class 4) | $75,000 |
| Bid GI Construction Cost          | $75,000 |
| Cost / Stormwater Volume ($/gal)   | $0.19  |
| Primary Funding                   | PENNVEST |
2014 EPA report estimates the following benefits of implementing the GI Plan:

- $4.2 million/year in energy, air quality, and climate-related benefits
- $660,000 annually in reduced wastewater pumping and treatment costs (at current costs)
- $120 million in avoided gray infrastructure (e.g., tanks, tunnels)

For an GI investment of $80 - $140 million over 25 years (depending on level of integration)
QUESTIONS?

Cost Saving Approaches for Implementing Green Stormwater Infrastructure

Andrew Potts, P.E., LEED AP, CPESC

EPA Webinar
May 5, 2015

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Next Webcast – July 7, 2015

Paying for Stormwater – The Benefits of a Utility

– Robert D. Chandler, Assistant Public Works Director, City of Salem, OR
– Shelia Dormody, Director of Policy, City of Providence, RI
– Andrew Reese, Vice President, AMEC Foster Wheeler

Registration in late June

Information and registration will be posted at http://water.epa.gov/infrastructure/greeninfrastructure/gi_training.cfm