Stream and Watershed Restoration
Design and Quantitative Benefits

Kelly Gutshall, RLA and Mike LaSala

Suquehanna Greenway River Towns Workshop
September 30, 2013
Benefit Stacking

Single Function

Multiple Function
Benefit Stacking

Stormwater Management (MS4, TMDL and PA Stormwater BMP Manual - BMP 6.7.4 Floodplain Restoration)

Sediment and Nutrient Reduction

Groundwater Recharge

Wetland Creation

Flood Reduction

Riparian Buffers

Wildlife Habitat Improvement

Invasive Plant Species Removal

Consistent Hydrology

Aesthetic Enhancement

Topsoil Generation

Carbon Storage

Environmental Education

Reduced Maintenance
Design

Quantifiable Results

EXAMPLE PROJECTS

• New Street Park – urban park
• Logan Park – regional park
• Wrightsville Riverfront – rivertown
• Bushkill Watershed – watershed
• Cobbs Creek Golf Course – urban GC
New Street Ecological Park
New Street Ecological Park
Before Restoration
New Street Ecological Park
During Restoration
Flood Flow

4.74” inches of rainfall  Sept. 30, 2010

Immediately Downstream of Restoration Site

Restoration Site

Immediately Downstream of Restoration Site
## Quantitative Results

### New Street Park Santo Domingo Restoration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>3 +/- acres</td>
</tr>
<tr>
<td>Stream Length</td>
<td>750 l.f. before restoration</td>
</tr>
<tr>
<td></td>
<td>950 l.f. after restoration</td>
</tr>
<tr>
<td>Created Wetlands</td>
<td>1 acre</td>
</tr>
<tr>
<td>Design Area</td>
<td>3.7 sq. mi.</td>
</tr>
<tr>
<td>Design Discharge</td>
<td>3.3 cfs</td>
</tr>
<tr>
<td>Design Boundary Stress</td>
<td>0.06 lbs/sq.ft.</td>
</tr>
</tbody>
</table>

### Removed from the watershed:
- over 7,800 tons of sediment
- over 8,930 pounds of phosphorus
- over 26,080 pounds of nitrogen
New Street Ecological Park
Planned Improvements

Credits:
Derck and Edson – park design
LandStudies – restoration design
# Quantitative Results

## New Street Park Santo Domingo Restoration

| INDIRECT BENEFITS                  | EA/YR | $     | $     | $     | Based on clean-up costs per "event"
|------------------------------------|-------|-------|-------|-------|-------------------------------
| Avoided damages in watershed       | 2     | 3,000.00 | 6,000.00 | $74,773.26  | PDA method (Protocol 2 per on ACOE, City of Roanoke study); $597/property
| Flood reduction mitigation          | 26    | 597.00 | 15,522.00 | $193,438.43 | $48 per visitor, assumes visitors spend money in Lititz area (Trust for Public Land, 2009); 120 visitors per year
| Tourism-park visitors (via Healthy Watershed Tour) | 120 | 48.00 | 5,760.00 | $71,782.33 | Assumes annual compliance, uses non-compliance fines in Lancaster County as basis-$72,000/EA (Manor Township) 5-yr permit term
| MS4 Permit compliance              | 4     | 72,000.00 | 288,000.00 | $1,021,233.75 | $19.77/mile annually
| Wildlife Value-Trout               | 0.42  | 29.77 | 12.50 | $155.78 | $19.77/mile annually
| **TOTAL INDIRECT BENEFITS**        |       | $315,294.50 | $1,361,383.55 | |

| THEORETICAL                        |       | $     | $     | $     | $     |
|------------------------------------|-------|-------|-------|-------|-------------------------------
| Nitrogen                           | 432.6 | 3.19  | 1,379.99 | $17,197.78  | $3.19/lb (PADEP)
| Phosphorus                         | 71.8  | 3.37  | 241.97 | $3,015.43 | $3.37/lb (PADEP)
| Sediment                           | 66.1  | 13.85 | 915.49 | $11,408.97 | $13.85/ton (PADEP)
| SW Volume Offset Value             | 20000 | 2.59  | 51,800.00 | $51,800.00 | $2.59/cf
| Healthcare cost savings            | 180   | 250   | 45,000.00 | $560,799.47 | Total visitors; assumes average difference of $250 between active and inactive persons (Trust for Public Land, 2009); assumes weekly repeat of visitors
| **TOTAL THEORETICAL BENEFITS**     |       | $99,337.45 | $644,221.64 | |

**TOTAL COSTS**  
$550,272  
$732,521.42

**TOTAL BENEFITS (DIRECT+INDIRECT+THEORETICAL)**  
$1,020,201  
$2,788,553.97

**BCR (DIRECT+INDIRECT+THEORETICAL)**  
3.8068

**NPV - DIRECT ONLY / ROI**  
$17,328.99  
6.9%

**NPV - ALL COSTS AND BENEFITS / ROI**  
$203,089.24  
280.7%
Logan Park
Rife Run Restoration
Quantitative Results
Logan Park Rife Run Restoration

<table>
<thead>
<tr>
<th>Site</th>
<th>20 +/- acres</th>
</tr>
</thead>
</table>
| Stream Length         | 1,050 l.f. before restoration  
                        | 1,500 l.f. after restoration |
| Created Wetlands      | 1.86 acre    |
| Design Area           | 6.52 sq. mi. |
| Design Discharge      | 21.8 cfs     |
| Design Boundary Stress| 0.180 lbs/sq.ft. |

Projected yearly reductions*:
- over 118 tons of sediment (9,500 cu. yds removed)
- over 293 pounds of phosphorus
- over 757 pounds of nitrogen

*Based on the “Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects”, Chesapeake Bay Program, May 2013
Highwater Line Tropical Storm Lee
Logan Park Rife Run Restoration
Wrightsville Riverfront Park
Totals for Two Basins Only (excludes Orange Street):

Infiltration volume:  > 7,500 cf

Annual N load reduction:  132 lb.

Annual P load reduction:  6.5 lb.

Annual Sediment load reduction:  2.7 tons

Bushkill Watershed

Visual Stream Assessment

- Headwaters
- Stockertown
- Main Stem
- City of Easton

Study Areas
Bushkill Watershed – Prioritized Projects

Main Stem Area

Flow Reduction Project Location

Water Surface Elevation Reduction Project Location
## Quantifiable Results

### Flood Storage Potential
(2 identified restoration projects)

- 36 acres of restoration area
- 4’ average depth of Legacy Sediment removal
- 6,272,640 cu.ft. of flood storage potential

**Could provide a 6% reduction in 100 year flood events for the Bushkill Watershed**

---

### Potential Peak Flow Reduction

<table>
<thead>
<tr>
<th>Restoration Reach</th>
<th>Approximate Drainage Area (sq. mi.)</th>
<th>Reach Length (ft)</th>
<th>Excavation Volume (cu. ft.)</th>
<th>2-Year Storm</th>
<th>10-Year Storm</th>
<th>100-Year Storm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pre Q-peak (cfs)</td>
<td>Post Q-peak (cfs)</td>
<td>% Reduction</td>
</tr>
<tr>
<td>Bushkill Reach 3</td>
<td>30</td>
<td>1700</td>
<td>1,591,200</td>
<td>2647.09</td>
<td>2629.00</td>
<td>0.68%</td>
</tr>
<tr>
<td>Bushkill Reach 16</td>
<td>22.5</td>
<td>2300</td>
<td>8,595,340</td>
<td>1495.81</td>
<td>1421.22</td>
<td>4.99%</td>
</tr>
</tbody>
</table>

---

Existing farm field at Reach 16
Cobb’s Creek Golf Club – Philadelphia, PA
Cobb’s Creek Golf Course - Existing Conditions
Cobb’s Creek Golf Course - Existing Conditions

August 2013 Flood
Projected Improvements:

Restored Stream Channel    ~ 12,000 linear feet
Restored Floodplain Area   ~ 40 acres
Legacy Sediments removed   ~ 275,000 cubic yards
Created Wetlands*          25 – 40 acres

*Cobb’s Creek Golf Course is an appropriate location for mitigation and abatement of impacts as well as wetlands compensatory mitigation.

- Non-contributing area relative to PWD’s CSO/MS4 program
- Highly unlikely it is susceptible to development
Banking on the front-end will allow PWD (and the City and its agencies) more latitude and leverage for planning and development in the watershed.

- CSO/MS4 abatement/mitigation (PWD and EPA) also addresses 303(d) listing
- Aesthetic Enhancement (Parks & Recreation)
- Adjacent infrastructure preservation (SEPTA)
- Reconnection of floodplain and restoration of reach (PWD and Parks & Recreation)
- Watershed Mitigation (Philadelphia’s municipal partners)
- Water quality improvements such as temperature, dissolved oxygen, pollutant loading, etc. (EPA, DEP and PWD)
<table>
<thead>
<tr>
<th>Simplified Calculation</th>
<th>Nitrogen (lbs/ft/yr)</th>
<th>Phosphorus (lbs/ft/yr)</th>
<th>Sediment (lbs/ft/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total N in soil removed from floodplain + Annual Denitrification and Plant Uptake</td>
<td>Streambank Erosion Reduction (Total P) + Plant Uptake</td>
<td>Streambank Erosion Reduction + Sediment Capture</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Black Hole Creek</th>
<th></th>
<th>Landis Homes</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N (lbs)</td>
<td>P (lbs)</td>
<td>Sediment (tons)</td>
<td>N (lbs)</td>
<td>P (lbs)</td>
<td>Sediment (tons)</td>
</tr>
<tr>
<td>Load Reduction</td>
<td>146.8</td>
<td>128.4</td>
<td>42.0</td>
<td>380.7</td>
<td>248.9</td>
<td>146.4</td>
</tr>
<tr>
<td>Leaching Load Reduction</td>
<td>48.0</td>
<td>0.0</td>
<td>0.0</td>
<td>4266.8</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Denitrification/Plant Uptake</td>
<td>18.9</td>
<td>24.8</td>
<td>--</td>
<td>273.0</td>
<td>357.5</td>
<td>--</td>
</tr>
<tr>
<td>Removal Efficiency</td>
<td>0.3</td>
<td>0.1</td>
<td>0.0</td>
<td>10.0</td>
<td>4.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Total Annual Removal</td>
<td>214.1</td>
<td>153.3</td>
<td>42.0</td>
<td>4930.5</td>
<td>610.7</td>
<td>146.7</td>
</tr>
<tr>
<td>Delivery Ratio*</td>
<td>201.4</td>
<td>66.8</td>
<td>18.3</td>
<td>4393.1</td>
<td>266.3</td>
<td>64.0</td>
</tr>
<tr>
<td>Reserve Ratio (10%)</td>
<td>20.1</td>
<td>6.7</td>
<td>1.8</td>
<td>439.3</td>
<td>26.6</td>
<td>6.4</td>
</tr>
<tr>
<td>Total Credits Generated Per Year</td>
<td>181.3</td>
<td>60.1</td>
<td>16.5</td>
<td>3953.8</td>
<td>239.6</td>
<td>57.6</td>
</tr>
</tbody>
</table>

*Delivery Ratio (N) 0.941 (BHC), 0.891 (Landis Homes)
*Delivery Ratio (P and Sed.) 0.436

<table>
<thead>
<tr>
<th></th>
<th>Nitrogen (lbs/ft/yr)</th>
<th>Phosphorus (lbs/ft/yr)</th>
<th>Sediment (lbs/ft/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Hole Creek</td>
<td>0.428</td>
<td>0.307</td>
<td>168</td>
</tr>
<tr>
<td>Landis Homes</td>
<td>3.300</td>
<td>0.409</td>
<td>196</td>
</tr>
<tr>
<td>EPA CBP Interim Values for Stream Restoration</td>
<td>0.200</td>
<td>0.068</td>
<td>310</td>
</tr>
</tbody>
</table>