Green Infrastructure and Practical Pollutant Load Accounting

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Matthew P. Jones, PE, PhD
mjones@hazenandsawyer.com
Estimating BMP Impacts

\[
\text{Tributary Watershed Load} \times \text{BMP Effectiveness} = \text{Load Reduction}
\]
## Pollutant Removal Efficiencies

<table>
<thead>
<tr>
<th>Control</th>
<th>Total Suspended Solids</th>
<th>Total Phosphorus</th>
<th>Total Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stormwater Ponds</td>
<td>80%</td>
<td>50%</td>
<td>30%</td>
</tr>
<tr>
<td>Stormwater Wetlands</td>
<td>80%</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td>Bioretention Areas</td>
<td>80%</td>
<td>60%</td>
<td>50%</td>
</tr>
<tr>
<td>Sand Filters</td>
<td>80%</td>
<td>50%</td>
<td>25%</td>
</tr>
<tr>
<td>Infiltration Trench</td>
<td>80%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>Enhanced Dry Swale</td>
<td>80%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Enhanced Wet Swale</td>
<td>80%</td>
<td>25%</td>
<td>40%</td>
</tr>
</tbody>
</table>
BMP Efficiency and Planning

![Graph showing TP Removal vs. BMP Construction Costs]

- **High Cost**
- **Med Cost**
- **Low Cost**
- **Target**

$30M vs. $80M
Bioretention Nutrient Monitoring

Total Nitrogen

Median Conc. Reduction = 23%

Total Phosphorus

Median Conc. Reduction = 2%

http://www.bmpdatabase.org
Pollutant Reduction Example

- 20,000 ft² impervious area
- 45 inches annual runoff
- 75,000 ft³ annual runoff volume
- Inflow Concentration
  - 1.2 mg/L TN
  - 0.15 mg/L TP
Ex: Concentration Reduction Only

<table>
<thead>
<tr>
<th>Total Nitrogen</th>
<th>Total Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inflow</strong></td>
<td><strong>Inflow</strong></td>
</tr>
<tr>
<td>- 1.2 mg/L</td>
<td>- 0.15 mg/L</td>
</tr>
<tr>
<td>- 5.6 lbs</td>
<td>- 0.7 lbs</td>
</tr>
<tr>
<td><strong>Reduction</strong></td>
<td><strong>Reduction</strong></td>
</tr>
<tr>
<td>- 23%</td>
<td>- 1.6%</td>
</tr>
<tr>
<td><strong>Outflow</strong></td>
<td><strong>Outflow</strong></td>
</tr>
<tr>
<td>- 0.92 mg/L</td>
<td>- 0.148 mg/L</td>
</tr>
<tr>
<td>- 4.3 lbs</td>
<td>- 0.69 lbs</td>
</tr>
<tr>
<td><strong>1.3 lbs removed</strong></td>
<td><strong>0.01 lbs removed</strong></td>
</tr>
</tbody>
</table>
Bioretention Volume Reduction

http://www.bmpdatabase.org
Ex: Volume Reduction Only

**Total Nitrogen**
- **Inflow**
  - 1.2 mg/L
  - 5.6 lbs
- **Reduction**
  - 66% Vol.
- **Outflow**
  - 1.2 mg/L
  - 1.9 lbs
- **3.7 lbs removed**

**Total Phosphorus**
- **Inflow**
  - 0.15 mg/L
  - 0.7 lbs
- **Reduction**
  - 66% Vol.
- **Outflow**
  - 0.15 mg/L
  - 0.24 lbs
- **0.46 lbs removed**
Ex: Vol. and Conc. Reduction

**Total Nitrogen**
- **Inflow**
  - 1.2 mg/L
  - 5.6 lbs
- **Reduction**
  - 23% Conc. 66% Vol.
- **Outflow**
  - 0.92 mg/L
  - 1.5 lbs
- 4.1 lbs removed

**Total Phosphorus**
- **Inflow**
  - 0.15 mg/L
  - 0.7 lbs
- **Reduction**
  - 1.6% Conc. 66% Vol.
- **Outflow**
  - 0.148 mg/L
  - 0.23 lbs
- 0.47 lbs removed
Load Reduction Drivers

- TN Load Reduction (lbs)
  - Conc. Only: 1.5
  - Vol. Only: 4.0
  - Combined: 4.5

- TP Load Reduction (lbs)
  - Conc. Only: 0.1
  - Vol. Only: 0.5
  - Combined: 0.5
NYC Stormwater Pilot Study

Develop Stormwater Pilot Designs
• Find locations suitable for GI retrofits
• Develop designs feasible as retrofits within the dense urban environment

Construct and Maintain Pilots
• Evaluate the logistics of GI implementation within NYC
• Characterize the type and frequency of maintenance needs

Evaluate Pilot Performance
• Qualitative performance
• Quantitative performance
Overall Monitoring Strategy

- Robust remote monitoring equipment
- Standardized equipment setups
- Regular site visits
- Standardized forms and procedures
Protecting and Concealing Monitoring Equipment
Routine Monitoring Maintenance
Storm Data Collection and Analysis
Hydrant Testing

- In-field calibration of monitoring equipment
- Rating curve differences observed for all equipment
- Testing provided insight into general system functionality

![Graph showing flow vs depth for Lab Calibration and Control Hydrant Test](image)
Distributed Green Infrastructure Controls at Public Housing
Bioretention Monitoring
Retention Performance

Bioretention Performance

Monitoring Equipment:
• 11 water level loggers
• 1 rain gauge

Performance:
• 95% annual retention
• 44,000 ft³/yr retained
• 3.3 lb/yr TN removed
• 0.4 lb/yr TP removed

With 95% annual retention, concentrations could increase by 700% and still meet stated 60% reduction
Roadway Median Bioretention
Roadway Median Bioretention
Enhancing Volume Reduction
Performance Variability

**Stormwater Chambers**

- **Rainfall Depth (in)**: 0.0625, 0.25, 1, 4
- **Volume Retained (%)**: 0%, 20%, 40%, 60%, 80%, 100%

**Perforated Pipes**

- **Rainfall Depth (in)**: 0.0625, 0.25, 1, 4
- **Volume Retained (%)**: 0%, 20%, 40%, 60%, 80%, 100%
Bioswale Monitoring
Bioswale Monitoring

Water Level Loggers

Soil Moisture Sensors
Water Quality Analysis

- Compare pollutant concentrations to those observed elsewhere
- Inform potential maintenance needs
Utilizing Monitoring Findings
BMP Efficiency and Planning

The graph illustrates the relationship between TP Removal (lb/yr) and BMP Construction Costs. The costs are categorized into High Cost, Med Cost, Low Cost, and Target. The graph shows that as the cost increases, the TP Removal also increases. A comparison is made between $30M and $80M, indicating the efficiency and planning considerations for different budget allocations.
Summary

• Retention responsible for much of GI water quality benefits

• Simple retention monitoring possible within an urban environment

• Retention monitoring results can be translated into accountable load reductions
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