Urban Stormwater BMP Performance and Cost-Effectiveness in the Capitol Region Watershed District

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Capitol Region Watershed District, St. Paul, MN
Capitol Region Watershed District

- 41 Square Miles
- Portions of 5 Cities
- Population: 245,000
- 42% Impervious Surfaces
- All Runoff Ultimately Flows to the Mississippi River
Arlington Pascal Stormwater Improvement Project

- Multi-Jurisdictional Project in the Como 7 Subwatershed
- Goals:
  - Reduce Flooding
  - Address Storm Sewer Improvements
  - Improve Water Quality of Como Lake
  - Determine Equitable Distribution of Costs
Arlington Pascal Stormwater Improvement Project

- Original Project Cost: $2.5 Million
  - 60” Storm Sewer Pipe
  - No Water Quality Benefits
- Final Project Cost: $2.0 Million
  - 18 Stormwater BMPs
  *Costs do not include bond interest

- Final Total Project Capital Cost: $2.7 Million
  *Total Capital Cost = Design + Construction + Bond Interest
Stormwater BMPs Constructed

- Underground Stormwater Storage and Infiltration System (Arlington-Hamline Facility)
- Regional Stormwater Pond (Como Park Regional Pond)
- 8 Underground Infiltration Trenches
- 8 Rain Gardens
Stormwater BMPs

- Treatment Train of BMPs
- Total Drainage Area: 190 Acres
- Combined Storage Area: 141,553 ft²
- Combined Storage Volume: 444,390 cf
BMP Stormwater Monitoring

- **2007 & 2008**
  - Arlington-Hamline Facility
  - 2 Infiltration Trenches (Trenches 4 and 5)
  - 8 Rain Gardens
  - Como Park Regional Pond (2008 Only)
P8 Model

- Simulated the Performance of Each BMP over an Entire Year
  - Total Discharge and TP and TSS Loads
- Calibrated Using Actual Precipitation Data and 2008 BMP Monitoring Data
- Annual Results for 2007, 2008, and an Average Precipitation Year (Projected Annual)
Removal Efficiencies

- **Volume**
  - Arlington-Hamline Facility: 100%
  - Como Park Regional Pond: 10%
  - Infiltration Trenches: 90%
  - Rain Gardens: 80%

- **TP**
  - Arlington-Hamline Facility: 90%
  - Como Park Regional Pond: 30%
  - Infiltration Trenches: 20%
  - Rain Gardens: 10%

- **TSS**
  - Arlington-Hamline Facility: 100%
  - Como Park Regional Pond: 80%
  - Infiltration Trenches: 70%
  - Rain Gardens: 60%

Legend:
- □ 2007
- ■ 2008
- □ Projected Annual
### Total Solids Removal Results

<table>
<thead>
<tr>
<th>Subwatershed Area (acres)</th>
<th>Arlington-Hamline Facility</th>
<th>Como Park Regional Pond</th>
<th>Infiltration Trenches</th>
<th>Rain Gardens</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2007</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainfall (in)</td>
<td>29.72</td>
<td>29.72</td>
<td>29.72</td>
<td>29.72</td>
</tr>
<tr>
<td>Total Solids Load Removed (lbs)</td>
<td>70,142</td>
<td>NA</td>
<td>76,991</td>
<td>53,014</td>
</tr>
<tr>
<td>Total TSS Load Removed: BMP</td>
<td>16,420</td>
<td>NA</td>
<td>6,605</td>
<td>3,089</td>
</tr>
<tr>
<td>Settleable Solids Removed: BMP</td>
<td>28,130</td>
<td>NA</td>
<td>NA</td>
<td>49,925</td>
</tr>
<tr>
<td>Settleable Solids Removed: Pretreatment Units</td>
<td>25,592</td>
<td>NA</td>
<td>70,386</td>
<td>NA</td>
</tr>
<tr>
<td><strong>2008</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Solids Load Removed (lbs)</td>
<td>48,159</td>
<td>197,932</td>
<td>39,144</td>
<td>26,122</td>
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<tr>
<td>Total TSS Load Removed: BMP</td>
<td>5,869</td>
<td>30,175</td>
<td>4,158</td>
<td>1,305</td>
</tr>
<tr>
<td>Settleable Solids Removed: BMP</td>
<td>28,130</td>
<td>167,757</td>
<td>NA</td>
<td>24,817</td>
</tr>
<tr>
<td>Settleable Solids Removed: Pretreatment Units</td>
<td>14,160</td>
<td>NA</td>
<td>34,986</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Projected Annual</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainfall (in)</td>
<td>26.02</td>
<td>26.02</td>
<td>26.02</td>
<td>26.02</td>
</tr>
<tr>
<td>Total Solids Load Removed (lbs)</td>
<td>51,110</td>
<td>210,434</td>
<td>39,767</td>
<td>26,597</td>
</tr>
<tr>
<td>Total TSS Load Removed: BMP</td>
<td>8,820</td>
<td>42,677</td>
<td>4,781</td>
<td>1,780</td>
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<tr>
<td>Settleable Solids Removed: BMP</td>
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<td>167,757</td>
<td>NA</td>
<td>24,817</td>
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<tr>
<td>Settleable Solids Removed: Pretreatment Units</td>
<td>14,160</td>
<td>NA</td>
<td>34,986</td>
<td>NA</td>
</tr>
</tbody>
</table>
BMP Operation and Maintenance

2007 & 2008

- Arlington-Hamline Facility
  - Vortech® Unit
- 8 Infiltration Trenches
  - 30 Sumped Catch Basins
  - 16 Sumped Manholes
- 8 Rain Gardens
- Como Park Regional Pond (2008 Only)
Arlington-Hamline Facility

2007, 2008, and Projected Activities

- Pipe Gallery Inspections
- Vortech® Sediment Inspections
- Manhole Sediment Inspections
- Debris Removal From Vortech® Unit

Additional Projected Activities

- Debris Removal From Pipe Gallery
Como Park Regional Pond

2008 and Projected Activities

- Sluice Gate and Gate Valve Maintenance
- Debris Removal From Pond Perimeter and Outlet Structure
  - Completed by City of St. Paul

Additional Projected Activities

- Bathymetric Survey of Pond
- Debris Removal From Pond (Dredging)
Infiltration Trenches

2007, 2008, and
Projected Activities

- Manhole and Catch Basin Sediment Inspections
- Post-Rain Trench Infiltration Inspections
- Debris Removal From Sumped Catch Basins and Manholes

Additional Projected Activities

- Jet Out and Remove Debris Accumulated in Perforated Pipes
Rain Gardens

2007, 2008, and Projected Activities

- Monthly Inspections
- Post-Rain Inspections
- Maintenance
  - Mulching, Weeding, Mowing, Leaf Removal
### Annual O & M: Costs & Hours

- **Annual O & M Cost =**
- **Total Cost of Labor + Equipment and Materials + Contract Services**

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
<th>Projected Annual O &amp; M Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost</td>
<td>Hours</td>
<td>Cost</td>
</tr>
<tr>
<td>Arlington-Hamline Facility</td>
<td>$531</td>
<td>13</td>
<td>$2,025</td>
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<tr>
<td>Como Park Regional Pond</td>
<td>NA</td>
<td>NA</td>
<td>$6,558</td>
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<tr>
<td>Infiltration Trenches</td>
<td>$5,509</td>
<td>138</td>
<td>$12,405</td>
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<tr>
<td>Rain Gardens</td>
<td>$14,851</td>
<td>640</td>
<td>$7,544</td>
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<tr>
<td>APSIP Total:</td>
<td>$20,891</td>
<td>791</td>
<td>$28,532</td>
</tr>
</tbody>
</table>
Cost-Benefit Analysis

- Volume Reduction and Pollutant Removal Costs ($/cf, $/lb)
  - Annual Operating Cost / Volume or Pollutant Reduction

Reference Document:
(Minnesota Public Works Association, 2007)
### Annual Capital Costs

- **Total Capital Cost Amortized Over 35 Years**

<table>
<thead>
<tr>
<th>Project</th>
<th>2007</th>
<th>2008</th>
<th>Projected Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arlington-Hamline Facility</td>
<td>$24,605</td>
<td>$24,605</td>
<td>$24,605</td>
</tr>
<tr>
<td>Como Park Regional Pond</td>
<td>NA</td>
<td>$38,981</td>
<td>$38,981</td>
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<tr>
<td>Infiltration Trenches</td>
<td>$11,430</td>
<td>$11,430</td>
<td>$11,430</td>
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<tr>
<td>Rain Gardens</td>
<td>$4,578</td>
<td>$4,578</td>
<td>$4,578</td>
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<tr>
<td><strong>APSIP Total:</strong></td>
<td><strong>$40,614</strong></td>
<td><strong>$79,595</strong></td>
<td><strong>$79,595</strong></td>
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</table>

*Total Capital Cost = Construction + Design + Bond Interest*
### Annual Operating Costs

#### Sum of Annual O & M Cost and Annual Capital Cost

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
<th>Projected Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arlington-Hamline Facility</td>
<td>$25,136</td>
<td>$26,630</td>
<td>$27,473</td>
</tr>
<tr>
<td>Como Park Regional Pond</td>
<td>NA</td>
<td>$45,539</td>
<td>$43,531</td>
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<tr>
<td>Infiltration Trenches</td>
<td>$16,939</td>
<td>$23,835</td>
<td>$23,769</td>
</tr>
<tr>
<td>Rain Gardens</td>
<td>$19,429</td>
<td>$12,122</td>
<td>$10,381</td>
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<tr>
<td>APSIP Costs:</td>
<td>$61,505</td>
<td>$108,127</td>
<td>$105,154</td>
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</tbody>
</table>
### Volume Reduction and Pollutant Removal Costs

- **Volume Reduction Costs** = \( \frac{\text{Annual Operating Cost} (\text{\$})}{\text{Volume Reduction (cf)}} \)
- **Pollutant Removal Costs** = \( \frac{\text{Annual Operating Cost} (\text{\$})}{\text{TP or Total Solids Load Removed (lbs)}} \)

<table>
<thead>
<tr>
<th></th>
<th>Arlington-Hamline Facility</th>
<th>Como Park Regional Pond</th>
<th>Infiltration Trenches</th>
<th>Rain Gardens</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual Operating Cost</strong></td>
<td>2007 $25,136</td>
<td>NA</td>
<td>$16,939</td>
<td>$19,429</td>
</tr>
<tr>
<td></td>
<td>2008 $26,630</td>
<td>$45,539</td>
<td>$23,835</td>
<td>$12,122</td>
</tr>
<tr>
<td></td>
<td>Projected $27,473</td>
<td>$43,531</td>
<td>$23,769</td>
<td>$10,381</td>
</tr>
<tr>
<td><strong>TP Removal Cost ($/lb)</strong></td>
<td>2007 $1,007</td>
<td>NA</td>
<td>$1,126</td>
<td>$3,494</td>
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<tr>
<td></td>
<td>2008 $2,517</td>
<td>$888</td>
<td>$2,221</td>
<td>$4,329</td>
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<tr>
<td></td>
<td>Projected $1,828</td>
<td>$714</td>
<td>$1,909</td>
<td>$2,791</td>
</tr>
<tr>
<td><strong>Total Solids Removal Cost(^a) ($/lb)</strong></td>
<td>2007 $0.36</td>
<td>NA</td>
<td>$0.22</td>
<td>$0.37</td>
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<td></td>
<td>2008 $0.55</td>
<td>$0.23</td>
<td>$0.61</td>
<td>$0.46</td>
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<td></td>
<td>Projected $0.54</td>
<td>$0.21</td>
<td>$0.60</td>
<td>$0.39</td>
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<tr>
<td><strong>Volume Reduction Cost ($/cf)</strong></td>
<td>2007 $0.03</td>
<td>NA</td>
<td>$0.02</td>
<td>$0.06</td>
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<td></td>
<td>2008 $0.07</td>
<td>$0.02</td>
<td>$0.03</td>
<td>$0.07</td>
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<td></td>
<td>Projected $0.05</td>
<td>NA</td>
<td>$0.03</td>
<td>$0.04</td>
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</table>
Conclusions

- BMP monitoring is important
- BMPs are performing as or better than expected
- Properly designed, constructed, and maintained BMPs are exhibiting high removal efficiencies
- Pond had the lowest removal costs, however, scale is important
- Pretreatment units are very beneficial
- Few studies which have this type of comprehensive analysis
- Continue research
Questions

Stormwater BMP Performance Assessment and Cost-Benefit Analysis

Report is available online at:

www.capitolregionwd.org