BMP Performance and Cost-Benefit Analysis

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Capitol Region Watershed District, St. Paul, MN

Outline
- Background
- Model Results
- Operation and Maintenance (O & M) Results
- Cost-Benefit Analysis Results
- Conclusions

Background
- Capitol Region Watershed District (CRWD)
- BMP Project Area
- BMPs
- BMP Stormwater Monitoring
- P8 Model
- BMP Operation and Maintenance

Capitol Region Watershed District
- 41 Square Miles
- Portions of 5 Cities
- Population: 245,000
- 42% Impervious Surfaces
- 4 Lakes (Como, Crosby, Loeb, McCarrons)
- All Runoff Ultimately Flows to the Mississippi River

Arlington Pascal Stormwater Improvement Project
- Multi-Jurisdictional Project in the Como 7 Subwatershed
- Goals:
  - Reduce Flooding in the Como 7 and Adjacent Subwatersheds
  - Address Needed Storm Sewer Improvements
  - Improve Water Quality by Reducing the Amount of Phosphorous Discharging to 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
  - Stormwater Volume and Pollutant Reduction Benefits
  
  *Costs do not include bond interest

- Final Total Project Capital Cost: $2.7 Million
  
  *Total Capital Cost = Construction + Design + 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
Underground Stormwater Storage and Infiltration System
(Arlington-Hamline Facility)
- Total Capital Cost: $799,000
- Storage Volume: 85,813 cf
- Drainage Area: 50 Acres
- 849 Feet of 10-Foot Diameter, Corrugated, Perforated Metal Pipes
- Vortech® Serves as a Pretreatment Unit
- Began Operation: Fall 2006

Como Park Regional Pond
- Total Capital Cost: $1,364,000
- Storage Volume: 301,871 cf
- 128 Acres Direct Drainage Area
- Also Receives Discharges From Gottfried’s Pit in Roseville (540 Acres)
- Began Operation: December 2007

Underground Infiltration Trenches
- Total Capital Cost: $400,000
- Combined Storage Volume: 37,352 cf
- Combined Drainage Area: 23 Acres
- Comprised of an Aggregate Backfill with 2, 10-Inch Perforated Pipes
- 30 Sumped Catch Basins and 16 Sumped Manholes Serve as Pretreatment Units
- Began Operation: June 2007

Rain Gardens
- Total Capital Cost: $160,000
- Combined Storage Volume: 19,354 cf
- Combined Drainage Area: 16 Acres
- All Rain Gardens Were Operational in 2007

BMP Stormwater Monitoring
- 2007 & 2008
  - Arlington-Hamline Facility
  - 2 Infiltration Trenches (Trenches 4 and 5)
  - 8 Rain Gardens
  - Como Park Regional Pond (2008 Only)

BMP Monitoring Methods
- Inlet and Outlet Monitored (except Rain Gardens)
- Continuous Water Level and Flow Recorded Every 10 Minutes
- Water Quality Samples Collected During Storm Events
- For Each Storm Event and Monitoring Season:
  - Determined Total Flow and Calculated Total Phosphorous (TP) and Total Suspended Solids (TSS) Loads
  - Also Determined Total Solids Loads Removed
## Rain Garden Monitoring

- **Manual Crest Gauges**
  - Installed at the Lowest Point in Each Garden
  - Measured Peak Water Level Reached During a Storm Event

## Total Solids Load

- **Sum of:**
  - Total TSS Load Removed by BMP
  - Settleable Solids Captured by BMP
  - Settleable Solids Captured by Pretreatment Units

  Settleable Solids are Particles Larger than Suspended Size (Debris such as Floatables, Organic Matter, and Sediment).

- **Settleable Solids were Measured in Pretreatment Units for Arlington-Hamline Facility and Infiltration Trenches**

- **Settleable Solids Captured by Rain Gardens and Como Park Regional Pond Were Estimated**

## 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)**

## BMP Operation and Maintenance

- **Developed a Manual of Inspection and Maintenance Protocols**

- **Documented Activities Using Electronic Field Forms**
  - BMP, Activity, Staff Time

- **Staff Labor Rates Determined and Used to Calculate Labor Costs of Each Activity**

- **Determined Annual Operation and Maintenance Costs**
  - 2007, 2008, Projected Annual Year

## BMPs Maintained

**2007 & 2008**

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

## Model Results

- **Volume Reduction and Pollutant (TP & TSS) Removal Efficiencies**
- **Total Solids Removal Results**
Removal Efficiencies

<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>Volume</td>
<td>100%</td>
<td>na</td>
<td>88%</td>
<td>98%</td>
</tr>
<tr>
<td>TP</td>
<td>100%</td>
<td>na</td>
<td>90%</td>
<td>98%</td>
</tr>
<tr>
<td>TSS</td>
<td>100%</td>
<td>na</td>
<td>94%</td>
<td>98%</td>
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<tr>
<td>Volume</td>
<td>100%</td>
<td>27%</td>
<td>96%</td>
<td>100%</td>
</tr>
<tr>
<td>TP</td>
<td>100%</td>
<td>45%</td>
<td>97%</td>
<td>100%</td>
</tr>
<tr>
<td>TSS</td>
<td>100%</td>
<td>83%</td>
<td>98%</td>
<td>100%</td>
</tr>
<tr>
<td>Volume</td>
<td>100%</td>
<td>0%</td>
<td>93%</td>
<td>100%</td>
</tr>
<tr>
<td>TP</td>
<td>100%</td>
<td>30%</td>
<td>94%</td>
<td>100%</td>
</tr>
<tr>
<td>TSS</td>
<td>100%</td>
<td>78%</td>
<td>96%</td>
<td>100%</td>
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</table>

NA: Not Applicable

Total Solids Removal Results

<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>Subwatershed Area (acres)</td>
<td>50</td>
<td>128</td>
<td>23</td>
<td>16</td>
</tr>
<tr>
<td>Rainfall (in)</td>
<td>29.72</td>
<td>29.72</td>
<td>29.72</td>
<td>29.72</td>
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<tr>
<td>Total Solids Load Removed (lbs)</td>
<td>70,142</td>
<td>70,142</td>
<td>70,142</td>
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<tr>
<td>Total TSS Load Removed</td>
<td>16,420</td>
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<tr>
<td>Settleable Solids Removed</td>
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<td>na</td>
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<tr>
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<td>25,592</td>
<td>na</td>
<td>70,386</td>
<td>na</td>
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<tr>
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<td>48,159</td>
<td>197,932</td>
<td>197,932</td>
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<tr>
<td>Total TSS Load Removed</td>
<td>5,869</td>
<td>30,175</td>
<td>4,158</td>
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<td>28,130</td>
<td>167,757</td>
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<tr>
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<td>14,160</td>
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<td>34,986</td>
<td>na</td>
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<tr>
<td>Rainfall (in)</td>
<td>26.02</td>
<td>26.02</td>
<td>26.02</td>
<td>26.02</td>
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<tr>
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<td>51,110</td>
<td>51,110</td>
<td>210,434</td>
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<td>42,677</td>
<td>4,781</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</td>
<td>14,160</td>
<td>na</td>
<td>34,986</td>
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</tr>
</tbody>
</table>

Operation and Maintenance Results

- Inspection and Maintenance Activities
- O & M Costs
  - 2007, 2008, Projected Annual
  - O & M Hours

Arlington-Hamline Facility

2007, 2008, and Projected Activities:
- Pipe Gallery Inspections
- Vortech® Sediment Inspections
- Manhole Sediment Inspections
- Debris Removal From Vortech® Unit

Projected Activities:
- Debris Removal From Pipe Gallery

Como Park Regional Pond

2008 and Projected Activities:
- Shale Gate and Gate Valve Maintenance
- Debris Removal From Pond Perimeter and Outlet Structure
- Completed by City of St. Paul

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
- Catch Basin Hood Inspections and Gasket Replacement

**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 O &amp; M Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>U &amp; M Cost</strong></td>
<td>$2,045</td>
<td>$2,045</td>
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<tr>
<td><strong>Hours</strong></td>
<td>14</td>
<td>14</td>
<td>14</td>
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### Cost-Benefit Analysis

- **Annual Capital Costs**
- **Annual Operating Costs**
- **Volume Reduction Costs**
- **TP Removal Costs**
- **Total Solids Removal Costs**

### Annual Capital Costs

**Total Capital Cost Amortized Over 35 Years**

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
<th>Projected Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arlington-Hamine Facility</td>
<td>$24,605</td>
<td>$24,605</td>
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<td>Como Park Regional Pond</td>
<td>$38,981</td>
<td>$38,981</td>
<td>$38,981</td>
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<td>Infiltration Trenches</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>$79,595</td>
<td>$79,595</td>
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</table>

*Total Capital Cost = Construction + Design + Bond Interest

### Annual O & M: Costs & Hours

**Reference Document:**
### Annual Operating Costs

- **Sum of Annual O & M Cost and Annual Capital Cost**

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<tr>
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<th>2008</th>
<th>Projected Annual</th>
</tr>
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<tbody>
<tr>
<td>Arlington-Hamline Facility</td>
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<td>$26,630</td>
<td>$27,473</td>
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<tr>
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<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>
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<td>Rain Gardens</td>
<td>$19,429</td>
<td>$12,122</td>
<td>$10,381</td>
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<tr>
<td><strong>APSIP Costs:</strong></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** = Annual Operating Cost ($) / Volume Reduction (cf)

- **Pollutant Removal Costs** = Annual Operating Cost ($) / TP or Total Solids Load Removed (lbs)

<table>
<thead>
<tr>
<th></th>
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<th>2008</th>
<th>Projected</th>
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<td>$10,381</td>
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<tr>
<td><strong>APSIP Costs:</strong></td>
<td>$61,505</td>
<td>$108,127</td>
<td>$105,154</td>
</tr>
<tr>
<td><strong>TP Removal Cost (lbs):</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
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<tr>
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<td>$574</td>
<td>$1,909</td>
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<tr>
<td><strong>Total Solids Removal Cost ($/lb):</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
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<tr>
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<td>$0.61</td>
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<tr>
<td><strong>Volume Reduction Cost ($/cf):</strong></td>
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<tr>
<td>2007</td>
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<tr>
<td>Projected</td>
<td>$0.05</td>
<td>NA</td>
<td>$0.03</td>
</tr>
</tbody>
</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
- Volume reduction and pollutant removal costs are largely affected by volume and pollutant load reductions
- Pond had the lowest removal costs
- Few studies which have this type of comprehensive analysis
- Continue research
- Pretreatment units are very beneficial

### Questions

**Stormwater BMP Performance Assessment and Cost-Benefit Analysis**

Report is available online at:

[www.capitolregionwd.org](http://www.capitolregionwd.org)