Maintenance of Stormwater Best Management Practices

By John S. Gulliver, Joohyun Kang and Peter T. Weiss

University of Minnesota

Stormwater Management Practice Assessment Project

This portion of the project was supported by the MPCA.
## Acknowledgements

<table>
<thead>
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<th>City of Albert Lea</th>
<th>City of Little Canada</th>
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<td>City of Andover</td>
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<td>City of Moorhead</td>
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<td>City of White Bear Lake</td>
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<td>City of Lauderdale</td>
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</table>
Statewide Survey

- Objectives
  - Investigate current status on BMPs and their maintenance in Minnesota
  - Identify maintenance components and corresponding costs
  - Obtain information to establish guidance for scheduling and budgeting maintenance of BMPs

- Sent to 106 cities in Minnesota
- 27 of them have responded
Spatial Distribution of the 27 Cities Surveyed
Components of BMP Maintenance

**Routine**
- Visual Inspection
- Remove debris and litter
- Mowing
- Vegetation management, etc.

**Non-routine**
- Remove accumulated sediment
- Structure maintenance
- Stabilize eroded bank
- Check dam replacement
- Repair mechanical components, etc.
Questionnaire

- Q1. Number of BMPs
- Q2. Frequency of regular inspection and maintenance
- Q3. Staff-hours for regular inspection and maintenance
- Q4. Complexity of maintenance
- Q5. Factors affecting performance of BMPs
- Q6. Costs of non-routine maintenance activities
Q1. Number of BMPs

Pond type BMPs

- Wet Ponds
- Dry Ponds
- Wetlands

Filtration/infiltration BMPs

- Surface Sand/Soil Filter
- Infiltration Basins/Trenches
- Raingardens
- Porous pavements
- Filter strips/swales

Underground devices

- Underground Sed. devices
- Underground Filt. Devices
Q2. Frequency of regular inspection and maintenance

Pond type BMPs

Filtration/infiltration BMPs

Underground devices
Q3. Staff-hours for regular inspection and maintenance

<table>
<thead>
<tr>
<th>Wet ponds</th>
<th>Dry ponds</th>
<th>Wetlands</th>
<th>Surface sand/soil filter</th>
<th>Infiltration Basins/trenches</th>
<th>Rain gardens</th>
<th>Porous pavements</th>
<th>Filter strips/swales</th>
<th>Underground sed. devices</th>
<th>Underground fill. devices</th>
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<tbody>
<tr>
<td>N = 24</td>
<td>N = 19</td>
<td>N = 14</td>
<td>N = 7</td>
<td>N = 17</td>
<td>N = 13</td>
<td>N = 9</td>
<td>N = 11</td>
<td>N = 14</td>
<td>N = 7</td>
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Median and 25th and 75th percentiles.
Q4. Maintenance complexity

<table>
<thead>
<tr>
<th>Category</th>
<th>Minimal</th>
<th>Simple</th>
<th>Moderate</th>
<th>Complicated</th>
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</thead>
<tbody>
<tr>
<td>Wet Ponds</td>
<td>32%</td>
<td>5%</td>
<td>13%</td>
<td>40%</td>
</tr>
<tr>
<td>Surface Sand/Soil Filters</td>
<td>25%</td>
<td>13%</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>Porous Pavements</td>
<td>42%</td>
<td>8%</td>
<td>42%</td>
<td>8%</td>
</tr>
<tr>
<td>Underground Sed. Devices</td>
<td>33%</td>
<td>7%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Dry Ponds</td>
<td>30%</td>
<td>5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filtration Basins/Trenchs</td>
<td>40%</td>
<td>13%</td>
<td>13%</td>
<td>34%</td>
</tr>
<tr>
<td>Filter Strips/Swales</td>
<td>31%</td>
<td>8%</td>
<td>61%</td>
<td>8%</td>
</tr>
<tr>
<td>Underground Filt. Devices</td>
<td>20%</td>
<td>10%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>Wetlands</td>
<td>13%</td>
<td>40%</td>
<td>12%</td>
<td>19%</td>
</tr>
<tr>
<td>Rain Gardens</td>
<td>31%</td>
<td>12%</td>
<td>19%</td>
<td>38%</td>
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</tbody>
</table>

- Minimal: (SW professional is seldom needed)
- Simple: (SW professional is occasionally needed)
- Moderate: (SW professional is needed half the time)
- Complicated: (SW professional is always needed)
Q5. Factors affecting performance of BMPs (Multiple-answers allowed)

- **Wet Ponds**
  - Groundwater level
  - Bank erosion
  - Mechanical problems
  - Invasive vegetation
  - Structural problems
  - Pipe Clogging
  - Oil spill
  - Litter & Debris
  - Sediment buildup

- **Dry Ponds**
  - Groundwater level
  - Bank erosion
  - Mechanical problems
  - Invasive vegetation
  - Structural problems
  - Pipe Clogging
  - Oil spill
  - Litter & Debris
  - Sediment buildup

- **Wetlands**
  - Groundwater level
  - Bank erosion
  - Mechanical problems
  - Invasive vegetation
  - Structural problems
  - Pipe Clogging
  - Oil spill
  - Litter & Debris
  - Sediment buildup
Q5. Factors affecting performance of BMPs, Cont'd

<table>
<thead>
<tr>
<th>Groundwater level</th>
<th>Pipeline Clogging</th>
<th>Oil spill</th>
<th>Litter &amp; Debris</th>
<th>Sediment buildup</th>
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<tbody>
<tr>
<td>3</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>4</td>
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<tr>
<td></td>
<td>2</td>
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<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>1</td>
<td>1</td>
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<td>1</td>
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<tr>
<td></td>
<td></td>
<td>9</td>
<td>1</td>
<td>1</td>
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</tbody>
</table>

**Surface sand/soil filters**

- **Infiltration basins/trenches**
  - Groundwater level: 5
  - Bank erosion: 3
  - Pipeline Clogging: 2
  - Oil spill: 1
  - Litter & Debris: 1
  - Sediment buildup: 1

**Rain gardens**

- **Porous pavements**
  - Groundwater level: 4
  - Bank erosion: 3
  - Pipeline Clogging: 2
  - Oil spill: 1
  - Litter & Debris: 1
  - Sediment buildup: 1

**Filter strips/swales**

- Groundwater level: 3
- Bank erosion: 2
- Pipeline Clogging: 1
- Oil spill: 1
- Litter & Debris: 1
- Sediment buildup: 1

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**Sediment buildup**

- Litter & Debris
- Oil spill
- Pipeline Clogging
- Structural problems
- Pipe Clogging
- Oil spill
- Litter & Debris
- Sediment buildup

**Groundwater level**

- Bank erosion
- Pipeline Clogging
- Oil spill
- Litter & Debris
- Sediment buildup

**Mechanical problems**

- Invasive vegetation
- Structural problems
- Pipe Clogging
- Oil spill
- Litter & Debris
- Sediment buildup

**Mechanical problems**

- Invasive vegetation
- Structural problems
- Pipe Clogging
- Oil spill
- Litter & Debris
- Sediment buildup

**Structural problems**

- Pipe Clogging
- Oil spill
- Litter & Debris
- Sediment buildup

**Invasive vegetation**

- Structural problems
- Pipe Clogging
- Oil spill
- Litter & Debris
- Sediment buildup

**Mechanical problems**

- Bank erosion
- Pipeline Clogging
- Oil spill
- Litter & Debris
- Sediment buildup

**Bank erosion**

- Pipeline Clogging
- Oil spill
- Litter & Debris
- Sediment buildup

**Invasive vegetation**

- Structural problems
- Pipe Clogging
- Oil spill
- Litter & Debris
- Sediment buildup

**Structural problems**

- Pipe Clogging
- Oil spill
- Litter & Debris
- Sediment buildup

**Pipe Clogging**

- Oil spill
- Litter & Debris
- Sediment buildup

**Oil spill**

- Litter & Debris
- Sediment buildup

**Litter & Debris**

- Sediment buildup

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**Surface sand/soil filters**

**Infiltration basins/trenches**

**Rain gardens**

**Porous pavements**

**Filter strips/swales**
Q5. Factors affecting performance of BMPs, Cont’d

Underground Sedimentation Devices

- Groundwater level
- Bank erosion
- Mechanical problems
- Invasive vegetation
- Structural problems
- Pipe Clogging
- Oil spill
- Litter & Debris
- Sediment buildup

Count

Underground Filtration Devices

- Groundwater level
- Bank erosion
- Mechanical problems
- Invasive vegetation
- Structural problems
- Pipe Clogging
- Oil spill
- Litter & Debris
- Sediment buildup

Count
Q6. Costs for non-routine maintenance activities

**Wet Ponds**

**Sediment Removal**

**Inlet/Outlet Structure Maintenance**
Q6. Costs for non-routine maintenance activities, *Cont’d*

**Dry Ponds**

**Sediment Removal**

<table>
<thead>
<tr>
<th>Maintenance Interval (year)</th>
<th>Cost ($)</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>5000</td>
</tr>
<tr>
<td>10</td>
<td>10000</td>
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<tr>
<td>15</td>
<td>15000</td>
</tr>
<tr>
<td>20</td>
<td>20000</td>
</tr>
<tr>
<td>25</td>
<td>25000</td>
</tr>
<tr>
<td>30</td>
<td>30000</td>
</tr>
</tbody>
</table>

**Inlet/Outlet Structure Maintenance**

<table>
<thead>
<tr>
<th>Maintenance Interval (year)</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>1000</td>
</tr>
<tr>
<td>10</td>
<td>2000</td>
</tr>
<tr>
<td>15</td>
<td>3000</td>
</tr>
<tr>
<td>20</td>
<td>4000</td>
</tr>
<tr>
<td>25</td>
<td>5000</td>
</tr>
</tbody>
</table>

[Graphs showing data for Sediment Removal and Inlet/Outlet Structure Maintenance]
Polycyclic Aromatic Hydrocarbons and Pond Sediments

- Pond sediments are anaerobic
  - PAHs do not bio-degrade
- Minnesota changed their dredged sediment testing
  - Test for PAHs
  - Found PAHs > 10X hazardous waste limits
- Dredging of pond sediments has stopped in Minnesota
- Is this also a concern for:
  - Wetlands?
  - Soil and sand filters?
  - Rain gardens?
## Concentration of PAHs in White Bear Lake

### 7 of 24 Benzo(a)pyrene (BaP) Equivalents

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Relative Potency Factor</th>
<th>Site Concentration (mg/kg)</th>
<th>BaP Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benz[a]anthracene</td>
<td>0.1</td>
<td>8.300</td>
<td>0.830</td>
</tr>
<tr>
<td>Benzo[b]fluoranthene</td>
<td>0.1</td>
<td>9.600</td>
<td>0.960</td>
</tr>
<tr>
<td>Benzo[k]fluoranthene</td>
<td>0.1</td>
<td>8.800</td>
<td>0.880</td>
</tr>
<tr>
<td>Benzo[a]pyrene (1)</td>
<td>1</td>
<td>9.500</td>
<td>9.500</td>
</tr>
<tr>
<td>Chrysene</td>
<td>0.01</td>
<td>11.000</td>
<td>0.110</td>
</tr>
<tr>
<td>Indeno[1,2,3,-c,d]pyrene</td>
<td>0.1</td>
<td>2.000</td>
<td>0.200</td>
</tr>
<tr>
<td>5-Methylchrysene</td>
<td>1</td>
<td>11.000</td>
<td>11.000</td>
</tr>
</tbody>
</table>

Total BaP equivalents = 23.48

- Residential usage BaP < 2
- Industrial Use BaP < 3
- Hazardous Waste BaP > 3
Our Approach to a Solution
=> Composting

- Add bulking agent
- Seed with bacteria and fungus
- Maintain aerobic conditions
- Maintain temperatures below 45° C

www.turnandscreen.com
Annual O&M Costs for Stormwater Ponds (Weiss et al., 2005)

Dry Ponds

Wet Ponds

Wetlands
Annual O&M Costs for Stormwater Ponds (Weiss et al., 2005)

### Bio-retention Practices

![Graph showing O&M costs as a percentage of total construction cost for bio-retention practices.]

### Sand Filters

![Graph showing O&M costs as a percentage of total construction cost for sand filters.]

### Swales

![Graph showing O&M costs as a percentage of total construction cost for swales.]

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[Image of the University of Minnesota Water Resources Center logo.]
## Median O & M Costs
(Weiss, et al., 2005)

<table>
<thead>
<tr>
<th>Practice</th>
<th>Median Annual O&amp;M Costs / Total Construction Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Ponds</td>
<td>2%</td>
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<tr>
<td>Wet Ponds</td>
<td>3.5%</td>
</tr>
<tr>
<td>Wetlands</td>
<td>6%</td>
</tr>
<tr>
<td>Bio-retention</td>
<td>5%</td>
</tr>
<tr>
<td>Sand Filters</td>
<td>4%</td>
</tr>
<tr>
<td>Swales</td>
<td>20%</td>
</tr>
</tbody>
</table>
Summary

- Wetlands, surface filters and porous pavements are most difficult to maintain.
- Staff-hours range from 1-4 except for wetlands and rain gardens.
- Most of the BMPs are inspected once/year or less.
- Sediment buildup, litter & debris accumulation, pipe clogging, and invasive vegetation are the major factors reducing the effectiveness of BMPs.
- Generally sediment removal and repair of inlet/outlet structure are major activities accounting for a large portion of total maintenance costs.
- Accurate estimation the sediment accumulation rate in a BMP is very important to establish the schedule and budget for maintenance.
- Annual O&M Cost / Total Construction Cost:
  - Dry ponds < Wet Ponds < Sand filters < Bio-retention < Wetlands < Swales.
Questions?

Thank you for your attention!

MN/DOT pond near Hwy. 13 (J. Weiss)