Stormwater and Urban Issues - Outline

• What is Stormwater and how does it relate to impaired waters?
• Stormwater source reduction and treatment
• Stormwater & TMDLs
• TMDL compliance for stormwater
• Urban Challenges
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What is Stormwater?

- Stormwater runoff is the water that flows over the ground surface or into conduits as a result of rain storms, snowmelt, or both. (Gulliver et al., 2009)
What is Stormwater?

• Stormwater categories
  – Urban
    • Roads, roofs, sidewalks, parking lots, compacted soils, manicured turf, etc.
  – Agricultural
    • Crop lands, drain tile, pasture, animal management, etc.
  – Rural or undeveloped
What’s **IN** Urban Stormwater?

- Stormwater Constituents
  - Solids (inorganic, organic)
  - Nutrients (nitrogen, phosphorus, etc.)
  - Metals (copper, cadmium, zinc, lead, etc.)
  - Chloride
  - Hardness, alkalinity
  - Others
### What’s **IN** Urban Stormwater?

<table>
<thead>
<tr>
<th></th>
<th>Total Suspended Solids</th>
<th>Total Phosphorus</th>
<th>Nitrate</th>
<th>Nitrite</th>
<th>Chloride</th>
<th>Copper</th>
<th>Zinc</th>
<th>Cadmium</th>
<th>Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean highway runoff</strong></td>
<td>116.3 mg/L</td>
<td>0.43 mg/L</td>
<td>0.77 mg/L (total N)</td>
<td>11.5 mg/L</td>
<td>0.023 mg/L</td>
<td>0.123 mg/L</td>
<td>0.0025 mg/L</td>
<td>0.242 mg/L</td>
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</tr>
<tr>
<td>concentrations (Twin Cities, MN), (Weiss and Hondzo 2004)</td>
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<tr>
<td><strong>Mean highway runoff</strong></td>
<td>157.3 mg/L</td>
<td>0.48 mg/L</td>
<td>0.79 mg/L (total N)</td>
<td>33 mg/L</td>
<td>0.0527 mg/L</td>
<td>0.923 mg/L</td>
<td>0.0063 mg/L</td>
<td>0.254 mg/L</td>
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<td>concentrations (nationwide), (Weiss and Hondzo 2004)</td>
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<tr>
<td><strong>Drinking water</strong></td>
<td>500 mg/L (TDS)</td>
<td>NA</td>
<td>10 mg/L</td>
<td>1 mg/L</td>
<td>250 mg/L</td>
<td>1.300 mg/L</td>
<td>5.00 mg/L</td>
<td>0.005 mg/L</td>
<td>ZERO</td>
</tr>
<tr>
<td><strong>Water quality standards,</strong></td>
<td>10 NTU</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>230 mg/L</td>
<td>CS: 0.009 mg/L$^i$</td>
<td>MS: 0.0149 mg/L$^i$ FAV: 0.030 mg/L$^i$</td>
<td>CS: 0.0907 mg/L$^i$</td>
<td>MS: 0.100 mg/L$^i$ FAV: 0.200 mg/L$^i$</td>
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<tr>
<td><strong>Class 2 Aquatic Life and</strong></td>
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<tr>
<td><strong>Recreation (Minnesota)</strong></td>
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<td>(Minnesota P.C.A. 2003)</td>
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</tbody>
</table>

*Gulliver et al., 2009*
Stormwater and Impaired Waters

Gulliver et al., 2009 (MPCA Draft 2010)

What about Volume and Rate?
Stormwater and Urban Issues - Outline

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Stormwater Source Reduction and Treatment

• Historically, stormwater management...
  – vehicle safety (curb and gutter, subsurface pipes)
  – flood prevention (i.e., runoff rate control by detention ponds, etc.)

• More recently, through regulations...
  – Treatment for pollutant capture
  – Runoff volume reduction
  – Habitat protection (increased rate control)
Stormwater Source Reduction and Treatment

• Source Reduction
  – Lawn and fertilizer management (runoff, nutrients)
  – Water supply corrosion inhibitors (phosphorus)
  – Animal waste management (bacteria, pathogens, nutrients)
  – Sediment and erosion control (solids)
  – Deicing agents (chloride, sediment)
  – Street Sweeping (solids, nutrients, etc.)
  – Disconnected impervious (runoff, solids, nutrients, etc.)
  – Car washing (runoff, nutrients, detergents, hydrocarbons)
  – De-compacted soils (runoff, solids, nutrients)
Stormwater Source Reduction and Treatment

• Treatment
  – Filtration
  – Infiltration
  – Sedimentation
  – Biologically enhanced combinations
Stormwater Source Reduction and Treatment

- Sand, soil, and mechanical (screen, porous media) filters, permeable pavements: (solids)

Photo courtesy: A. Erickson
Stormwater Source Reduction and Treatment

- Infiltration basins, trenches, underground vaults: (volume reduction, pollutants?)

Photo courtesy: MN Stormwater Manual

Bradshaw Celebration of Life Center - underground storage & infiltration Stillwater, MN
Stormwater Source Reduction and Treatment

- Wet (detention) ponds, dry ponds, underground vaults: (solids)

Photo courtesy: A. Erickson
Stormwater Source Reduction and Treatment

- Rain gardens (bioretention), constructed wetlands, filter strips, swales, green roofs; (volume reduction, solids, pollutants?)
Stormwater and Urban Issues - Outline

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Stormwater and TMDLs

- Typically permitted (NPDES Phase I or II), but often non-point (load allocation)
- Most stormwater loads estimated with runoff models and monitoring data
- Required load reductions estimated by subwatershed
- Implementation scenarios modeled
Stormwater and TMDLs

• Modeling stormwater loads
  – Runoff models (e.g., P8, XP-SWMM, SWAT, etc.)
    • Subwatersheds, landuse, soils, precipitation and temperature data
  – Calibrated or verified with monitoring data (Flux, BATHTUB, etc.)
Stormwater and TMDLs

- Example
  - McKusick and Lily Lake, Stillwater, MN

- P8 Model
  - Ponds and HydroCad model
  - Wetlands
  - Land use

- Complex flow patterns
  - Diversion structure

# Stormwater and TMDLs

## 2006 Loading Summary for: Lily Lake

### Water Budgets

#### Inflow from Drainage Areas

<table>
<thead>
<tr>
<th>Name</th>
<th>Drainage Area [acre]</th>
<th>Runoff Depth [in/yr]</th>
<th>Discharge [ac-ft/yr]</th>
<th>Phosphorus Concentration [ug/L]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Lily 02</td>
<td>29.8</td>
<td>12.1</td>
<td>30.1</td>
<td>352.8</td>
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<tr>
<td>2 Lily 03</td>
<td>33.6</td>
<td>13.9</td>
<td>39.0</td>
<td>350.1</td>
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<tr>
<td>3 Lily 04</td>
<td>61.0</td>
<td>7.4</td>
<td>37.6</td>
<td>351.9</td>
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<tr>
<td>4 507</td>
<td>56.4</td>
<td>6.7</td>
<td>31.3</td>
<td>295.4</td>
</tr>
<tr>
<td>5 Lily 09</td>
<td>15.0</td>
<td>11.1</td>
<td>13.8</td>
<td>352.8</td>
</tr>
<tr>
<td>6 Brick Pond Basin B</td>
<td>347.0</td>
<td>12.8</td>
<td>368.7</td>
<td>122.6</td>
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<tr>
<td><strong>Summation</strong></td>
<td><strong>543</strong></td>
<td><strong>11.5</strong></td>
<td><strong>521</strong></td>
<td><strong>304.7</strong></td>
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</tbody>
</table>

#### Inflow from Upstream Lakes

<table>
<thead>
<tr>
<th>Name</th>
<th>Discharge [ac-ft/yr]</th>
<th>Estimated P Concentration [ug/L]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td><strong>Summation</strong></td>
<td><strong>-</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

### Atmosphere

- **Lake Area** [acre]: 36
- **Precipitation** [in/yr]: 27.01
- **Evaporation** [in/yr]: 27.01
- **Net Inflow** [ac-ft/yr]: 0.00
- **Aerial Loading Rate** [lb/ac-yr]: 14.91

- Dry-year total P deposition: 12.18
- Average-year total P deposition: 14.91
- Wet-year total P deposition: 17.68

### Groundwater

<table>
<thead>
<tr>
<th>Lake Area [acre]</th>
<th>Flux [m/yr]</th>
<th>Net Inflow [ac-ft/yr]</th>
<th>Phosphorus Concentration [ug/L]</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>0.0</td>
<td>0.00</td>
<td>0</td>
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</tbody>
</table>

### Internal

<table>
<thead>
<tr>
<th>Lake Area [acre]</th>
<th>Anoxic Factor [days]</th>
<th>Release Rate [mg/m²-day]</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>53.0</td>
<td>1.00</td>
</tr>
</tbody>
</table>

### Notes

1. Loading calibration factor used to account for special circumstances such as wetland systems, fertilizer use, or animal waste, among others, that might apply to specific loading sources.
Stormwater and TMDLs

Lily Lake
WQ Response Modeling

Image courtesy: A. Erickson
Stormwater and TMDLs

Lily Lake
WQ Response Modeling

Chlorophyll a [ug/l] vs. Phosphorus Load Reduction [%]

Image courtesy: A. Erickson
Stormwater and TMDLs

Annual load Reductions
Lily Lake

<table>
<thead>
<tr>
<th>Year</th>
<th>Load @ Standard</th>
<th>Load @ Standard</th>
<th>Load @ Standard</th>
<th>Load @ Standard</th>
<th>Load @ Standard</th>
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<td>2001</td>
<td>70</td>
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<td>2002</td>
<td>100</td>
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<tr>
<td>2003</td>
<td>60</td>
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<td>2004</td>
<td>30</td>
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<td>2005</td>
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<tr>
<td>2006</td>
<td>5</td>
<td>5</td>
<td>5</td>
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</table>

St. Anthony Falls Laboratory
UNIVERSITY OF MINNESOTA

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• **TMDL compliance for stormwater**
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TMDL Compliance

• Assessment and maintenance
  – Source reduction practices
    • Measure or estimate reductions
    • Enforce regulations (e.g., phosphorus free fertilizers)
TMDL Compliance

• Assessment and maintenance
  – Stormwater treatment practices
    • Visual inspections
    • Testing performance
    • Monitoring
    • Maintenance
TMDL Compliance

• Visual Inspection
  – Purpose: Quickly determine if any of the following are required:
    • Changes to routine maintenance
    • Non-routine maintenance
    • Repair or replacement
    • More advanced assessment (e.g., capacity testing to determine effective infiltration rate)
Visual Inspection

Bioretention that may be functional.

Non-functional bioretention.

Photo courtesy: B. Asleson
TMDL Compliance

• Testing Performance
  – Purpose: measure treatment capacity or effectiveness for:
    • Infiltration
    • Sedimentation
    • Pollutant capture
Testing Performance
Testing Performance

Photo courtesy: B. Asleson, J. Gulliver
TMDL Compliance

• Monitoring
  – Purpose: measure watershed runoff characteristics and stormwater BMP effectiveness
Monitoring

Photo courtesy: A. Erickson
TMDL Compliance

• Maintenance
  – Purpose: ensure proper function and extend usable life
TMDL Compliance - Maintenance

Routine Maintenance:
- Visual inspection
- Litter & debris removal
- Vegetation and ground cover management

Non-routine:
- Cleanout trees & sediments
  - Structural repairs
  - Partial rehabilitation

Major:
- Rehabilitation
- Rebuild
Stormwater and Urban Issues - Outline

• What is Stormwater and how does it relate to impaired waters?
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• Stormwater management for waterbody protection
• **Urban Challenges**
Urban Challenges

- Limited surface space
- Public and traffic safety
- Public appeal/aesthetics
- Need new technologies
  - High capacity treatment for multiple pollutants and volume/rate control
Urban Solutions

• Green Infrastructure / Low Impact Development (LID)
  – Permeable pavements/parking, green roofs, roadside swales (instead of curb), curbcut rain gardens

• New Technologies
  – Enhanced filtration
Urban Solutions

• Examples
  – Seattle’s Natural Drainage Systems
  – Chicago’s Green Alley and Green Roof Projects
  – Kansas City’s 10,000 Rain Gardens Initiative

Photo courtesy: Seattle Public Utilities,
Questions?

Thank you for your attention!

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

http://stormwater.safl.umn.edu/

For more information, contact:
Andy Erickson (eric0706@umn.edu)