Stormwater Runoff & Water Quality: Some Considerations

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Stormwater workshop
3/12/14
Stormwater Quality

• Concerns:
  – Protecting water quality
  – Protecting water supplies
  – Land use/impervious cover
  – Need for controls
  – Challenges

• Questions
  – What are the contaminant loads entering surface waters?
  – What are the controls and how effective are they?
  – What are the impacts?
Stormwater Quality - Constituents

- **Nutrients**
  - Phosphorus ($H_2PO_4^-$, $HPO_4^{2-}$, $PO_4^{3-}$)
  - Nitrogen ($NH_4^+$, $NO_2^-$, $NO_3^-$)

- **Trace elements**
  - Cd, Cr, Cu, Fe, Pb, Ni, etc.

- **Inorganics**
  - Ca, Mg, K, Na, $SO_4^{2-}$, Cl, etc.

- **Pathogens/bacteria**
  - Total coliform
  - Fecal coliform
  - Total Step
  - E-Coli

- **Solids**
  - Suspended, volatile, bottom

- **Organics**
  - Petroleum hydrocarbons
    - PAHs
    - BTEX Compounds
  - Additives
    - MTBE
  - Deicing agents
    - CMA
## Stormwater Quality – Some values

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Overall</td>
<td>Coliform</td>
<td>E-Coli</td>
<td>NH$_3$</td>
<td>NO$_2$/NO$_3$</td>
<td>TKN</td>
<td>Diss P</td>
<td>Tot P</td>
<td>Tot As</td>
</tr>
<tr>
<td>5091</td>
<td>1750</td>
<td>0.44</td>
<td>0.6</td>
<td>1.4</td>
<td>0.13</td>
<td>0.27</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>Mixed Res</td>
<td>11000</td>
<td>1050</td>
<td>0.39</td>
<td>0.6</td>
<td>1.35</td>
<td>0.12</td>
<td>0.27</td>
<td>3</td>
</tr>
<tr>
<td>Mixed Comm</td>
<td>4980</td>
<td>0.6</td>
<td>0.58</td>
<td>1.39</td>
<td>0.12</td>
<td>0.26</td>
<td>15</td>
<td>2.0</td>
</tr>
<tr>
<td>Industrial</td>
<td>2500</td>
<td>0.5</td>
<td>0.73</td>
<td>1.4</td>
<td>0.11</td>
<td>0.26</td>
<td>3.7</td>
<td>3.0</td>
</tr>
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</table>

http://rpitt.eng.ua.edu/Research/ms44/Paper/Mainms4paper.html
Wachusett Watersheds

Maps from MassGIS
West Boylston Brook

Smith-Horn, Stanton, Warfel MQP
P. Mathisen, S. LePage
Collaboration with DCR
West Boylston Brook – Proposed Retrofits

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Lbs. per year or billions of colonies per year</th>
<th>Percent removed from subbasin</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS</td>
<td>10,678</td>
<td>10%</td>
</tr>
<tr>
<td>TP</td>
<td>45</td>
<td>11%</td>
</tr>
<tr>
<td>TN</td>
<td>487</td>
<td>24%</td>
</tr>
<tr>
<td>Fecal Coliform</td>
<td>13,387</td>
<td>23%</td>
</tr>
</tbody>
</table>
Integrated View of water budget

Rainfall/runoff

Retrofits

Septic Systems

ITHINK Modeling
Best Management Practices

Retention Ponds

Surface water supply

Retention Ponds

Surface water body

Edge of region affected by retention pond

a. Plan view

Edge of region affected by retention pond

b. Profile view (Section A-A)
Stormwater basins
BMP Assessment

WPI/DCR Project (ongoing)
Inverse modeling schematic

Flow Direction

Upstream Well

Precip. & dissolution reactions

Oxidation Reduction Reactions

Surface Exchange Reactions

Downstream Well

Downstream sample location

Upstream sample location
Analysis/Inverse Modeling

Upstream sample location

In-pond sample location

Surface Exchange Reactions

Oxidation Reduction Reactions

Precip. & Dissolution Reactions

Downstream sample location

WPI/DCR Project (ongoing)
Key Processes

• Some of the key processes
  – Aqueous complexation reactions
  – Surface exchange reactions (e.g. sodium/others) & sortion/desorption processes (e.g. phosphorus)
  – Rate-limited processes
    • Aerobic respiration ($\text{CH}_2\text{O} \rightarrow \text{CO}_2$)
    • Nitrification ($\text{NH}_4^+ \rightarrow \text{NO}_3^-$)

• Impacts
  – Eutrophication; algae growth
  – Oxygen demand
  – High conductivity/ionic strength
  – Metals toxicity
  – Organics toxicity
Urban Areas - Worcester

Cherenzia and Zuccaro MQP; Houyou and Medaglio MQP
Urban Areas....
Mgt. of Combined Sewer Systems in an Uncertain Climate

- Difficulties in managing urban stormwater
- Expected increases in extreme storm events under climate change.

- Stormwater management challenges in urban areas:
  - Increased population
  - Impervious land
  - Increased stormwater runoff
  - Flooding
  - Decrease in water quality
  - Pressure from regulatory agencies to better manage stormwater

- Thomas Renaud MS Thesis (May 2012)
Project Approach

- Model calibration
- Climate change model predictions and design storms
- Identification of performance metrics and stormwater management BMP options
- Assessment of options
- Cost and benefit analysis

Worcester CSO System

- Thomas Renaud MS Thesis (May 2012)
Some Project Results/Observations (Comparisons between Worcester and Somerville)

<table>
<thead>
<tr>
<th>Worcester</th>
<th>Somerville</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best strategy – Storage</td>
<td>Best Strategy – Sewer Separation</td>
</tr>
<tr>
<td>Large CSO area (4 square miles)</td>
<td>Small CSO area (1 square mile)</td>
</tr>
<tr>
<td>Moderate-high percentage of impervious land</td>
<td>High percentage of impervious land</td>
</tr>
<tr>
<td>Sewer separation for select areas only</td>
<td>Sewer separation for entire CSO area</td>
</tr>
<tr>
<td>Located near hills</td>
<td>Located near coast</td>
</tr>
</tbody>
</table>

Worcester, MA

Somerville, MA

- Thomas Renaud MS Thesis (May 2012)
Concluding notes

• Transport and transformations can be important to consider
• Processes are site specific and variable, although the results do provide insight to other locations
• Some needs
  – Quantifying the water budget and loads
  – Defining the role of the sediments
  – Designing effective BMPs
  – Defining the role of seasonal variability
  – Designing for an uncertain climate
Thanks to:

**MA Dept of Conservation and Resources**
(Pat Austin, Larry Pistrang, Steve Sulprisio and Vincent Vignaly, and others)

**WPI Faculty/staff**
(Suzanne LePage; D. Pellegrino, Others)

**WPI Students**

**City of Worcester**
(J. Buckley, D. Harris, M. Hollis, and others)