Resilient Stormwater Management in Urban Applications

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Advanced Drainage Systems-BaySaver Technologies
CLIMATE CHANGE: agree or disagree?
REALITY: EXTREME WEATHER EVENTS ARE INCREASING IN FREQUENCY
Observed US Trends in Heavy Precipitation

*Extreme event=5 year storm

http://nca2014.globalchange.gov
Extreme weather events lead to erosion, pollution and property damage.
Managing Stormwater Runoff
RATE

VOLUME

QUALITY
Can current designs handle the increase in extreme weather?
Some Green Infrastructure Limitations

- Detailed installation inspection is critical
- Frequent maintenance is critical for performance
- Potential mosquito (Zika Virus) habitat near public
- Sensitive to winter road salt and freeze/thaw conditions
- Limited ability to capture and treat large storm events
- Vegetation may not establish itself
- Areas are attractive to invasive species
- Added annual maintenance expense for City or Owner
- Permeability/hydraulic rate difficult to maintain over time
Municipal Owners: Green Infrastructure

• Education: Is the intent of the BMP and maintenance requirements understood from top to bottom?

• O&M Annual Costs / Equipment / Requirements: Is this understood? Can it withstand the revolving door of City Officials over the years?

• Winter Salt / Snow Considerations: Where can staff place the salt and snow?

• How is service life ensured? Long-Term Reliability? Is a plan in place?
Design Life Considerations

- **Vegetation Maintenance**
  - Effects of salt and winter
  - Introduction of unwanted species
  - Prolonged drought
  - Re-planting / reconstruction
  - Sunlight considerations

- **Permeable Pavement Vacuum Maintenance**

- **Soil / Engineered media / Stone trench**
  - Consolidation over time
  - Grit accumulation
  - Reduced permeability
  - Reduced volume capacity

- **Freeze/Thaw Impacts**
How do we ensure DESIGN SERVICE LIFE?
Bioretention: Design Components Affecting Performance

• Ksat (hydraulic conductivity)
• Soil media depth
• Internal Water Storage Zone
• Root depth
• Bowl storage depth
• Hydraulic Loading Ratio

Permeable Pavement: Design Components Affecting Performance

• Ksat (hydraulic conductivity)
• Aggregate depth
• Internal Water Storage Zone
• Hydraulic Loading Ratio
Reduce the Hydraulic Loading To the BMP
Retrofitting Existing Bioretention
Modifying the Internal Water Storage (IWS) Zone
HOW DO WE ENSURE THE BMP ALWAYS MEETS ITS DESIGN INTENT?

VOLUME CAPACITY
HYDRAULIC CONDUCTIVITY
WATER QUALITY
6.3 — PREFABRICATED BURIED INFILTRATION STRUCTURES

DESCRIPTION: Prefabricated buried infiltration structures can be used to provide void space for water storage. These structures may be installed as stand-alone storage or in combination with bioretention basins, green infrastructure practices. Systems vary greatly by manufacturer, but generally include shapes or rectangular shapes and made of plastic or concrete material. Prefab structures promote infiltration where underlying soils allow. This specification does not cover linear elements such as pipes and box culverts. Buried infiltration structures are generally limited in length of the system, and the depth should be larger than the depth of the bioretention basin.

Used in parking lots, parks or other private property settings with the permission of the owner, permitted for use within the ROW. Use for greater water storage capacity or storage of stormwater is possible. Void space in prefabricated materials can often be greater than 90%. Void space in stone aggregate ranges from 30 to 40%. Can be used under the following situations:

- To transfer water from the stone storage bed to an outlet structure and convey it to a drain or stormwater system.
- To meet the design standards of the AASHTO LRFD Bridge Design Specification, Section 3 and Section 12.

Prefabricated Buried Infiltration Structures [Source: CDM Smith]
PERMEABLE PAVERS
WITH INFILTRATION/STORAGE CHAMBERS

STORMTECH CHAMBER

AASHTO M288 CLASS 2 NON-WOVEN GEOTEXTILE AROUND CLEAN, CRUSHED, ANGULAR STONE

MIN. COVER: SC-310/SC-7 0 = 18" (457 mm)
MC-00 = 24" (610 mm)
MAX. COVER: SC-310/7 = 8' (2438 mm)
MC-00 = 8.5' (1981 mm)

DESIGN ENGINEER IS RESPONSIBLE FOR ENSURING SUITABILITY OF SUBGRADE SOILS

SUBGRADE CROSS SECTION TO BE DESIGNED FOR PERVERIOUS PAVEMENT APPLICATION. BACKFILL MATERIALS SHALL CONFORM TO TABLE OF ACCEPTABLE FILL MATERIALS PER STORMTECH INSTALLATION GUIDELINES.

STONE ABOVE
STONE FOUNDATION
Keeping our Great Lake great.

How hotel drainage works to protect Doan Brook and Lake Erie

The Courtyard by Marriott and its parking lot were designed to protect our local waterways by reducing the amount of water entering the sewer system. How does that work? The Northeast Ohio Regional Sewer District explains it this way.

Pervious Parking Lot

Bricks with spaces between allow runoff to soak through and into the surrounding soils.

Treat + Clean

Combined flow travels to a wastewater treatment plant so it can be cleaned safely.

Infiltration

Roof runoff drains to a storage and infiltration chamber which dispenses runoff into soil below, reducing runoff entering sewers.

Combined Sewer

Collects sewage and stormwater runoff (from rooftops, roads, parking lots).

Combined Sewer Overflow

This is an outfall, which carries excess flow from a combined sewer system to area waterways during heavy rains to prevent sewer backups.

Infiltration reduces the amount of stormwater in the combined sewer, thereby reducing overflows and pollution.

Northeast Ohio Regional Sewer District
BIORETENTION
WITH INFILTRATION/STORAGE CHAMBERS
RAIN GARDEN
WITH INFILTRATION/STORAGE CHAMBERS
BIORETENTION WITH INFILTRATION/STORAGE CHAMBERS

OVERFLOW TO CHAMBERS
Modified Curb: Permeable Pavements with Infiltration/Storage Chambers
BIORETENTION
WITH INFILTRATION/STORAGE CHAMBERS
INTERNAL WATER STORAGE ZONE

- Increases vertical and lateral exfiltration

UPTURNED ELBOW OUTLET
In a study in Durham, New Hampshire, four years of runoff temperature data were examined for a range of stormwater best management practices (BMPs) in relation to established environmental indicators.

The following Stormwater BMPs were studied for thermal impacts:

- Vegetated Swale
- Detention Pond
- Retention Pond
- Hydrodynamic Separator
- Gravel Wetland
- StormTech Isolator Row
- Bioretention
Thermal Benefits

StormTech Isolator Row

Non-Exceedance Probability (%) vs. Temperature (°F)

- College Brook @DMP
- Wednesday Hill Brook
- Detention Pond
- Gravel Wetland
- Vegetated Swale
- StormTech Isolator Row
Rain Water Harvesting
Above Ground Tanks

Most common materials are metal and plastic.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Typically less expensive</td>
<td>• Must be opaque to prevent algae growth</td>
</tr>
<tr>
<td>• Easy to inspect</td>
<td>• Must be protected from UV</td>
</tr>
<tr>
<td>• Easy to detect and repair any crack or leaks</td>
<td>• Subject to freezing</td>
</tr>
<tr>
<td></td>
<td>• Sunlight heats water</td>
</tr>
<tr>
<td></td>
<td>• Visible, takes up space</td>
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</table>
Below Ground Tanks

Most common materials are plastic and fiberglass.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Better protected from freezing</td>
<td>• Typically more expensive than above ground tanks</td>
</tr>
<tr>
<td>• UV is not a concern</td>
<td>• More difficult to inspect</td>
</tr>
<tr>
<td>• Out of sight</td>
<td>• Precautions should be taken to avoid surface</td>
</tr>
<tr>
<td>• Does not take up space</td>
<td>water contamination</td>
</tr>
<tr>
<td>• Keeps water cooler</td>
<td></td>
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</table>
Rainwater Harvesting Tanks
THREE MAIN TYPES OF WATER QUALITY TREATMENT

• Sedimentation/Separation
• Passive Filtration
• Active Filtration

Which type do you need?

We have to identify the target.
Sedimentation

- Slow down the water to allow for pollutants to settle
- Longer residence times required for small particles to settle
- No removal of dissolved particles
- Collected suspended pollutants can become dissolved pollutants over time
Hydrodynamic Separators
What does it remove?

– Mainly TSS, floatable, hydrocarbons

Oils & Grease

Trash & Debris

Sediments
• Maintenance can be performed from the surface
• No parts to remove, no need to enter the structure
• Remove the frame and grate
• Vac hose is lowered into the sediment chamber
Passive Filtration

- Water is forced through a membrane or media
- Membrane or media provides physical barrier to particles
- Sedimentation may also occur
- Removes suspended particles but does not address dissolved particles
## Isolator Row - Water Quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th># of paired samples</th>
<th>Influent (median values)</th>
<th>Effluent (median values)</th>
<th>% Reduction</th>
<th>P-Value</th>
<th>Significant at 0.05</th>
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<tbody>
<tr>
<td>Ammonia Nitrogen</td>
<td>mg/L</td>
<td>14</td>
<td>0.32</td>
<td>0.09</td>
<td>71.5%</td>
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<td>Nitrite + Nitrate</td>
<td>mg/L</td>
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<td>0.28</td>
<td>0.35</td>
<td>0%</td>
<td>0.9713</td>
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<td>TKN</td>
<td>mg/L</td>
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<td>1.10</td>
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<td>Total Nitrogen</td>
<td>mg/L</td>
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<td>1.24</td>
<td>0.78</td>
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<tr>
<td>Total Phosphorus</td>
<td>mg/L</td>
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<td>0.19</td>
<td>0.06</td>
<td>68.1%</td>
<td>0.0001</td>
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<tr>
<td>SSC</td>
<td>mg/L</td>
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<td>98.0</td>
<td>5.90</td>
<td>94%</td>
<td>0.0017</td>
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<tr>
<td>TSS</td>
<td>mg/L</td>
<td>14</td>
<td>54.0</td>
<td>5.60</td>
<td>89.6%</td>
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<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>13</td>
<td>18.0</td>
<td>6.85</td>
<td>61.9%</td>
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<tr>
<td>Chromium</td>
<td>ug/L</td>
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<td>2.11</td>
<td>*</td>
<td>*</td>
<td>*</td>
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<tr>
<td>Copper</td>
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<td>14</td>
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<td>0.6047</td>
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<tr>
<td>Lead</td>
<td>ug/L</td>
<td>14</td>
<td>1.55</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
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<tr>
<td>Zinc</td>
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<td>14</td>
<td>54.50</td>
<td>13.0</td>
<td>76.1%</td>
<td>0.0001</td>
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</tbody>
</table>

* Data set contained too many non-detect values to accurately calculate summary statistics or provide statistical analysis

**Figure 6:** Cherry Gardens Apartments – Storm Tech Chambers - Data Analysis Results
Maintenance = typically once every 5-10 years
Active Filtration

- Works in conjunction with passive filtration
- Membrane or media provides physical barrier to particles while also collecting other pollutants through ion exchange, adsorption, etc.
- Removes dissolved pollutants, eliminates leaching
- Increase pollutant removal
- Highest form of treatment
Cartridge Media/Membrane Filters
Performance

>80% TSS removal (d50 = 23µ)
>60% Total Phosphorus reduction
>50% Turbidity reduction

Sediment Capacity
– Up to 350 pounds of sediment removal per cartridge
Configurations

Manhole BayFilter

Vault BayFilter
• Maintenance is typically driven by the accumulated sediment, but can be impacted by other contaminants of concern (nutrients, hydrocarbons).

• Maintenance procedure includes cartridge replacement and vault cleaning.

• Typical maintenance cycles in the 2-4 year range.
- We have to consider the increased frequency of extreme rain events when planning urban sites.
  - Flow
  - Volume
  - Quality

- Flow and Volume concerns may likely require a balance of “green” and “grey” infrastructure methods. Be creative!

- For Quality, the key is to understand your objective to select the treatment method to match. TSS, nutrients, metals, agency requirements, etc.