DuPage County

Stormwater Session:
“Manufactured BMPs”

Summer 2008

Scott Perry; CPSWQ – Imbrium Systems
Agenda

- Definition of a “Manufactured BMP”
- Meeting Objectives
- Applications / Case studies
- Stormwater Quality
- DuPage County Design Requirements / Examples
- Reviewer Check List
- Installation / Maintenance / Inspection
- Life cycle costs – case study
Definition

- Manufactured Best Management Practices (BMPs)
  - Section 3.2.2.5 of the DuPage County BMP Manual Practice Standard

- Many different references?
  - Hydrodynamic Separators
  - Vortex Separators
  - Structural BMPs
  - Wet Vaults
  - Oil Grit Separators
  - Oil Sediment Separators

“These are flow through devices, also known as hydrodynamic separators, which rely on gravity to capture both floating and settleable pollutants.”
“Hydrodynamic Devices”

- Flow-through devices
- Separation/ settling devices; all rely on gravity
- Underground structures

Pollutant Removal:

- Settleable solids and pollutants associated with particulate matter
  - Total Suspended Solids (TSS) - sediment
- Typically remove floatables
  - Oil, debris, grease
Figure 3-14 Typical Oil Grit Separator (Berg 1991)
## Manufactured BMPs – General Performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hydrodynamic Separators</th>
</tr>
</thead>
<tbody>
<tr>
<td>%TSS Removal</td>
<td>50-90%</td>
</tr>
<tr>
<td></td>
<td>Dependent on; technology, PSD used in sizing, prevention of scour, site characteristics</td>
</tr>
<tr>
<td>% Total Phosphorus</td>
<td>10-40% - particulate bound only</td>
</tr>
<tr>
<td>% Total Nitrogen</td>
<td>0-30%</td>
</tr>
<tr>
<td>% Metals (Cu, Zn)</td>
<td>20-50%</td>
</tr>
<tr>
<td>Oil Removal</td>
<td>0-95%</td>
</tr>
<tr>
<td></td>
<td>Dependent on; technology, spill conditions (wet weather, dry weather)</td>
</tr>
</tbody>
</table>

Note: Removal levels dependent on many factors such as loading, site type and technology

References: [www.bmpdatabase.org](http://www.bmpdatabase.org); [www.imbriumsystems.com](http://www.imbriumsystems.com)
# Meeting Objectives

<table>
<thead>
<tr>
<th>Audience</th>
<th>Potential Questions</th>
<th>Items Addressed</th>
</tr>
</thead>
</table>
| Design Community          | How do we design/size? When/where do we utilize these devices? How much do these devices cost? | ▪ Design - Guidelines / Key Considerations / Examples  
                            |                                                                                       | ▪ Performance  
                            |                                                                                       | ▪ Unit Costs |
| Reviewers                 | What should a submittal package look like? How do I know the WQ goals are being met? | ▪ Permit Submittal Check List             |
| Contractors / Property Owners / Planners | How much do these devices cost? How do we install these devices? How do we maintain these devices? Costs? | ▪ Whole Life Costs  
                            |                                                                                       | ▪ General Installation  
                            |                                                                                       | ▪ Maintenance |
| Inspectors                | How/when do we maintain these devices?                                               | ▪ Inspection Considerations              |
Applications for Manufactured BMPs

1. **Stand Alone**
   - Commercial, Industrial Sites and Roadways
   - Where surface BMPs are not feasible

2. **Pre-treatment**
   - Surface and Manufactured BMPs

3. **Retrofit / Re-development / In-fill projects**
   - Small footprint / limited space

4. **Hot Spots --- high loadings**
   - Gas Stations & Fueling Areas, Fast-Food, Industrial sites, Maintenance Yards
Land uses where Manufactured BMPs would not be the first choice:

- Individual residential lots

- Rural land development sites

  However, they may serve as pre-treatment for wet pond applications
Case Studies

- **Roadway Spill Capture (Illegal Discharge Prevention)**
  - Fuel/oil spill from auto crash
  - Several gallons that seeped into storm drains intercepted by a hydrodynamic separator unit
  - Saves critical drinking water reservoir from contamination

- **Pre-treatment to Wet Basin**
  - Reduce long-term maintenance cost
  - Capture unsightly floatables – oils, debris
  - Eliminate Forebay
  - Increase Green Space
Case Studies

- **Power Plant Project on a river bank setting**
  - Hydrodynamic separator designed for a tailwater condition
  - Unit installed to protect stormwater sump feeding a retention pond used for turbine/generator cooling (sedimentation of the pump causes failure)
  - Unit also serves as inlet and outlet bend structure

- **Redevelopment Car Wash Project**
  - Hydrodynamic separator used to treat runoff prior to additional underground storage and water re-use
  - Removes Hot Spot pollutants (oils and debris)
Comparing Quantity to Quality

Quantity

- Extreme Flood Protection → 100 yr Storm
- Over-bank Flood Protection → 10 or 25 yr Storm
- Channel Protection → 2 yr Storm

Quality

- Water Quality → 75% to 90% Ave. Annual Rainfall Runoff Volume

Figure Adapted from Georgia Stormwater Management Manual: Volume 2
Stormwater **Quality** Objectives

- EPA
  
  “remove 80% TSS on an average annual basis”
  
  - TSS is a surrogate for pollutants of concern

- Other Potential Objectives
  
  - TMDL 303d
    
    - Heavy metals, nutrients, bacteria, etc.
  
  - Hydrocarbon capture / illicit discharge
Water Quality Objective

- To protect down stream water resources, a clear water quality goal has to be established

  80% annual average TSS Removal

  Lacks definition

**Leads to:**
- poor Manufactured BMP sizing
- reduced water quality
- design confusion
Water Quality Goal must define a Particle Size Distribution

If you want to remove this... Don’t size for this...
DuPage County – WQ Objective

1. 80% annual removal of TSS
   - OK-110 Particle Size Distribution
     - 50 – 150 µm (fine sand)

2. 80% annual removal of free floatable hydrocarbons

3. Prevent Re-suspension / Scour
   - On-line installation acceptable, if lab verified
   - No lab verification (no data), must install Off-Line
Sizing – WQ Runoff Rates / Volume

- Rational Method
- NRCS / SCS Method
  - HEC-1, TR-20

Northeastern Illinois Design Storm

OR

- US EPA SWMM
  - XPSWMM
  - PCSWMM
  - Mike SWMM

Continuous Simulation Modeling
Key Design/Sizing Parameters

**TR-20**
- Site Acreage
- Composite Curve Number (CN)
- Huff or Type II rainfall distribution
- Time of Concentration ($t_c$)
- Antecedent moisture condition $\geq 2$

**Continuous Simulation**
- Site Acreage
- % Impervious
- TSS loading
- OK-110 PSD
- Historical rainfall data ($> 10$ years)
- Abstractions
TR-20 Sizing Example
TR-20 Modeling Example

Step 1: Calculate the Peak Discharge Flow Rate for the Water Quality Design Storm

- 3.04 inch, 24 hour, water quality storm event
- SCS Type II Rainfall
- Antecedent Moisture Condition = 2

<table>
<thead>
<tr>
<th>Site Area (ac)</th>
<th>Composite Curve Number (CN)</th>
<th>Time of Conc. (hrs.)</th>
<th>Peak Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>90</td>
<td>0.795</td>
<td>1.0</td>
</tr>
<tr>
<td>3.0</td>
<td>90</td>
<td>0.832</td>
<td>1.5</td>
</tr>
</tbody>
</table>
TR-20 Modeling Example

Step 2: Select a technology and appropriate unit size, which provides the following treatment levels at the calculated peak discharge rate:

1. 80% removal of TSS
   (TSS defined by OK-110 Particle Size)

2. 80% removal of free floatable hydrocarbons
TR-20 Modeling Example

**Step 3:** Determine if selected technology has been verified to prevent re-suspension / scour at flow rates above the peak discharge rate:

- If lab verified to prevent scour:
  - ON-LINE installation acceptable
    (internal by-pass)

- If not lab verified (no data):
  - OFF-LINE installation required
    (external by-pass/WQ flow diversion)
Continuous Simulation Modeling Sizing Example
Continuous Simulation Model Example

**Step 1: Input required entries into model**

Required User Entered Parameters

- Water Quality Objective
  - 80% TSS Removal
  - Ok-110 Particle Size Distribution (PSD)
- Local Rainfall Station/Data Set
- Total Site Drainage Area (acres)
- Imperviousness (%)

**Step 2: Run model**
Continuous Simulation Model Example

**Step 3:** Determine if selected technology has been verified to prevent re-suspension / scour at flow rates above the peak discharge rate:

- If lab verified to prevent scour:
  → **ON-LINE** installation acceptable  
    (internal by-pass)

- If not lab verified (no data):
  → **OFF-LINE** installation required  
    (external by-pass/WQ flow diversion)
Welcome to PCSWMM for Stormceptor 2006. Using PCSWMM for Stormceptor 2006 allows you to design the right Stormceptor System to achieve your stormwater quality objectives.

PCSWMM for Stormceptor 2006 was developed in partnership with Computational Hydraulics International (CHI) and Imbrium Systems.

The PCSWMM for Stormceptor 2006 continuous simulation model combines the broadest selection of sediment particle sizes with the most up-to-date rainfall data available to ensure our customers are using the most accurate design tool in the stormwater industry today.

To begin, please select one of the following options:
Step 1 - Project Details

Enter project details and identify the water quality objective by specifying the required average annual total suspended solids (TSS) removal.

**Project information**
- Name
- Project #: Workshop Example
- Location: Chicago, IL
- Date: 4/2/2007

**Regional information**
- Units: US
- Region: United States

**Water quality objective**
- TSS removal (%): 80%

**Designer information**
- Company: ABC Engineering
- Contact:

**Optional objective**
- None

**Design notes**
- Notes:
Step 2 - Site Details

Enter site drainage area and imperviousness.

Site drainage area
- Total area (ac): 2.4
- Imperviousness (%): 85

Site parameters below are defaulted to represent common Stormceptor System applications. For specific parameters, contact a local representative for assistance.

Surface characteristics
- Width (ft): 647
- Slope (%): 2
- Impervious depression storage (in.): 0.02
- Pervious depression storage (in.): 0.2
- Impervious Manning's n: 0.015
- Pervious Manning's n: 0.25

Infiltration parameters
- Max. infiltration rate (in/hr): 2.44
- Min. infiltration rate (in/hr): 0.4
- Decay rate (1/s): 0.00055
- Regeneration rate (1/s): 0.01
- Dry weather flow: 0.0
- Dry weather flow (cfs): 0

Evaporation
- Daily evaporation rate (in./day): 0.1

Maintenance frequency
- Maintenance frequency (months): 12
### Step 4 - Rainfall

Select the rain station closest to the project location.

<table>
<thead>
<tr>
<th>State/Prov.</th>
<th>ID #</th>
<th>Location</th>
<th>Yrs</th>
<th>Elev (ft)</th>
<th>Coordinates</th>
<th>Res</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois</td>
<td>82</td>
<td>ALEXIS 1 SW</td>
<td>58</td>
<td>680</td>
<td>41°35'50&quot;N, 90°33'50&quot;W</td>
<td>60</td>
</tr>
<tr>
<td>Illinois</td>
<td>510</td>
<td>BELLEVILLE SIU RESEARCH</td>
<td>58</td>
<td>450</td>
<td>38°31'12&quot;N, 89°50'48&quot;W</td>
<td>60</td>
</tr>
<tr>
<td>Illinois</td>
<td>1166</td>
<td>CAIRO 3 N</td>
<td>58</td>
<td>310</td>
<td>37°23'3&quot;N, 89°11'8&quot;W</td>
<td>60</td>
</tr>
<tr>
<td>Illinois</td>
<td>1522</td>
<td>CHICAGO CAL TREAT WKS</td>
<td>27</td>
<td>590</td>
<td>41°40'0&quot;N, 87°37'0&quot;W</td>
<td>60</td>
</tr>
<tr>
<td>Illinois</td>
<td>1542</td>
<td>CHICAGO MAYFAIR PUMP ST</td>
<td>33</td>
<td>650</td>
<td>41°58'0&quot;N, 87°45'0&quot;W</td>
<td>60</td>
</tr>
<tr>
<td>Illinois</td>
<td>1549</td>
<td>CHICAGO OHARE AP</td>
<td>44</td>
<td>658</td>
<td>41°59'42&quot;N, 87°56'1&quot;W</td>
<td>60</td>
</tr>
<tr>
<td>Illinois</td>
<td>1552</td>
<td>CHICAGO ROSELAND PUMP</td>
<td>33</td>
<td>659</td>
<td>41°42'0&quot;N, 87°38'0&quot;W</td>
<td>60</td>
</tr>
<tr>
<td>Illinois</td>
<td>1564</td>
<td>CHICAGO S WTR FILT PLAN</td>
<td>33</td>
<td>610</td>
<td>41°45'0&quot;N, 87°33'0&quot;W</td>
<td>60</td>
</tr>
<tr>
<td>Illinois</td>
<td>1567</td>
<td>CHICAGO SPRINGFLD PUMP</td>
<td>33</td>
<td>600</td>
<td>41°55'0&quot;N, 87°43'0&quot;W</td>
<td>60</td>
</tr>
<tr>
<td>Illinois</td>
<td>1572</td>
<td>CHICAGO UNIVERSITY</td>
<td>48</td>
<td>594</td>
<td>41°47'0&quot;N, 87°36'0&quot;W</td>
<td>60</td>
</tr>
<tr>
<td>Illinois</td>
<td>1577</td>
<td>CHICAGO MIDWAY AP 3SW</td>
<td>58</td>
<td>620</td>
<td>41°44'14&quot;N, 87°46'39&quot;W</td>
<td>60</td>
</tr>
<tr>
<td>Illinois</td>
<td>2140</td>
<td>DANVILLE</td>
<td>55</td>
<td>558</td>
<td>40°8'20&quot;N, 87°36'54&quot;W</td>
<td>60</td>
</tr>
</tbody>
</table>

- **Search for stations by State/Prov.**
  - **Illinois**

- **Selected Rainfall Station**
  - **Location**: CHICAGO OHARE AP
  - **State/Prov.**: Illinois

Problems finding a rain gauge? Please enter coordinates into Google Earth.
Step 5 - Particle Size Distribution

Removing fine particles from runoff ensures the majority of pollutants such as heavy metals, free oils, hydrocarbons and nutrients that adhere to fine sediment, are not discharged into natural water resources.

**Stormceptor is the only oil and sediment separator designed to remove fine silts from stormwater runoff.**

PCSWMM for Stormceptor recommends defining total suspended solids (TSS) removal using the Fine Distribution (organics, silts and sands) option. It is critical to define TSS with a particle size distribution to achieve water quality objectives.

Select the particle size distribution specific to your project or local regulations.

- NJDEP (clay, silt, sand)
- Fine (organics, silts and sand)
- OK-110 (sand)
- F-95 (sand)
- Coarse (sand)

<table>
<thead>
<tr>
<th>Particle (μm)</th>
<th>(%)</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>2.65</td>
</tr>
<tr>
<td>53</td>
<td>3</td>
<td>2.65</td>
</tr>
<tr>
<td>75</td>
<td>15</td>
<td>2.65</td>
</tr>
<tr>
<td>88</td>
<td>25</td>
<td>2.65</td>
</tr>
<tr>
<td>106</td>
<td>40.8</td>
<td>2.65</td>
</tr>
<tr>
<td>125</td>
<td>15</td>
<td>2.65</td>
</tr>
<tr>
<td>150</td>
<td>1</td>
<td>2.65</td>
</tr>
</tbody>
</table>
Step 6 - Simulate

Select Run Simulation to recommend the Stormceptor model for your site.

Run simulation

Simulation will recommend the Stormceptor unit that best meets the treatment criteria identified.

Hydrology & TSS Simulation

Calculating Hydrology and TSS Removal

1948 2005

Calculating for year 1958
### Step 7 - Design Summary

Highlighted in the table below, is the recommended Stormceptor System that meets the treatment criteria identified. In addition to the recommended unit, the annual TSS removal of other Stormceptor Models are included for your information.

<table>
<thead>
<tr>
<th>Stormceptor Model</th>
<th>TSS Removal (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STC 450i</td>
<td>66</td>
</tr>
<tr>
<td>STC 900</td>
<td>75</td>
</tr>
<tr>
<td>STC 1200</td>
<td>75</td>
</tr>
<tr>
<td>STC 1800</td>
<td>75</td>
</tr>
<tr>
<td><strong>STC 2400</strong></td>
<td><strong>80</strong></td>
</tr>
<tr>
<td>STC 3600</td>
<td>81</td>
</tr>
<tr>
<td>STC 4800</td>
<td>85</td>
</tr>
<tr>
<td>STC 6000</td>
<td>85</td>
</tr>
<tr>
<td>STC 7200</td>
<td>88</td>
</tr>
<tr>
<td>STC 11000</td>
<td>91</td>
</tr>
<tr>
<td>STC 13000</td>
<td>91</td>
</tr>
<tr>
<td>STC 16000</td>
<td>92</td>
</tr>
</tbody>
</table>
Continuous simulation Model Example

Cumulative Volume of Runoff by Runoff Rate
For area: 2 (ac), imperviousness: 90%, rainfall station: CHICAGO OHARE AP
What do these calculations mean?

- **TR-20** – calculates the water quality storm peak discharge from one simulated storm event.
  - Sizing based on 80% TSS removal at peak flow rate.
  - the water quality storm equates to a representation of runoff from approximately 75-80% of all rain events.

- **Continuous simulation** - analyzes all rainfall events and runoff flow rates.
  - Sizing based on annual 80% TSS removal from analyzing all flow rates.
  - Considers cumulative runoff volume from all rain events.
Key Design/Sizing Parameters

**TR-20**

**Continuous Simulation**
Critical Design Factors: Scour Prevention

- High Flows External Bypass (Diversion Structure)
  - Prevents scouring

- External Diversion By-Pass
  - Prevents scouring

- BMP
  - WQ Flows

Plan View

- High Flows Internal Bypass + WQ Flows

Verified Internal By-Pass
- Prevents scouring

Off-Line

On-Line
SUMMARY:

- Effective treatment defined as;
  - 80% annual TSS removal
    - TSS defined as OK-110 PSD
  - 80% annual removal of free floatable hydrocarbons

- Scour Prevention needed through certified lab or field monitoring data
  - If not verified for scour, device must be placed off-line (regardless of sizing methodology)
Manufactured BMPs - Overview

- Typical Capital Cost
  \( \approx \$10,000 - \$20,000 \) per impervious acre
  - based on DuPage County water quality objectives/requirements

- Typical Annual Maintenance Costs
  \( \approx \$500 - \$2000 \) per year (internal vs contracting out)
Manufactured BMP Check List

- DuPage County Checklist needs to be provided by design engineer to reviewer
  - Contains site specific information and design criteria
  - Qualifies the manufactured BMP structure as acceptable for:
    1. Sized to meeting water quality objectives
    2. Determines On-Line or Off-Line installation
  - Contains operation & maintenance information

### Dupage County Manufactured BMP Submittal Checklist - August 2008
(to be incorporated in to the Countywide Stormwater and Flood Plan Ordinance Checklist - 8/1/2008)

<table>
<thead>
<tr>
<th>Date:</th>
<th>Reviewer:</th>
<th>Stormwater Permit No.</th>
</tr>
</thead>
</table>

#### Manufactured BMP Info
- Manufactured BMP Type: 
- Model Number: 
- Company: 
- Street Address: 

#### Site/Design Details
- Commercial: 
- Industrial: 
- Residential: 
- Roadway: 
- Special Management Area: 
- Total site area (acres): 
- % Impervious: 
- Is there a tail water condition? (see attached Figure1): Yes

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General Installation Process

- Place top slab & embossed cover, using grade rings for adjustment
- Install storage chamber & backfill with approved material
- Place sub-base, set slab section and check level
Installation Details

- New Construction Development Stand-alone
- Manufactured device with 2 inlet pipes

34 LF - 24” RCP @ 0.24%
38 LF - 12” RCP @ 0.50%
101 LF - 27” RCP @ 0.20%
Installation Details
- New commercial development Pretreatment
- Manufactured device placed before Basin
Installation Details

- Redevelopment of Retail Plaza
- Manufactured device (Stand-alone) placed Off-Line
Maintenance Considerations

- Access / Easements
- Post Construction Inspection
- Inspection Frequency
  - Available Sediment capacity
- Ease of Maintenance
  - Confined space entry required?
  - Replacement of Parts or Oil Sponges?
- Disposal of captured pollutants
Ease of Maintenance

- Majority of Manufactured BMPs can be inspected and cleaned from ground level
- 1 or up to 3 structures to be inspected and cleaned
  - BMP
  - WQ Diversion Structure & Manhole
- Ease of oil removal should be considered
  - Some utilize oil absorbency pads to achieve WQ objective
Pre-Treatment & Maintenance Life Cycle Costs - Example

<table>
<thead>
<tr>
<th>BMP</th>
<th>Year 1-5</th>
<th>Year 6-10</th>
<th>Year 11-15</th>
<th>Year 16-20</th>
<th>Year 21-25</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Pond</td>
<td>$0</td>
<td>$0</td>
<td>$80k - $150k</td>
<td>$0</td>
<td>$80k - $150k</td>
<td>$160k - $200k</td>
</tr>
<tr>
<td>Pretreatment Manufactured BMP &amp; Pond</td>
<td>$7,500</td>
<td>$7,500</td>
<td>$7,500</td>
<td>$88k</td>
<td>$7,500</td>
<td>$118k</td>
</tr>
</tbody>
</table>

Example compares maintaining a stand-alone pond every 11 years to pre-treating a pond using a manufactured BMP. Manufactured BMP is cleaned annually and the pond’s maintenance cycle is conservatively extended from year 11 to year 16 (5 years).
Disposal Management

- Captured sediment material can be treated as catch basin material
  - Require disposal at landfill

- Oil / hydrocarbons – must be specially removed & treated

- Follow State and Federal guidelines for pollutant disposal
Thank you!

Questions?

Scott Perry; CPSWQ – Imbrium Systems