Inspection Protocols for Maintaining and Verifying LID Practices
Welcome to the Webcast

- **To Ask a Question**
  - Submit your question in the chat box located to the left of the slides. We will answer as many as possible during Q&A.

- **To Answer a Poll Question**
  - Simply select the preferred option. For those viewing this session alongside several colleagues, respond in a manner that represents your organization as a whole.

- **We ARE Recording this Session**
  - All comments and questions will be recorded and included in the archives. We will notify you as soon as the recording and related resources are loaded on the web.

- **We Appreciate Your Feedback**
  - Fill out our evaluations - our funders need to hear it!
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Laurel Woodworth (Center for Watershed Protection)
Chesapeake Bay
Stormwater Training Partnership

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Tools Coming Soon

• TB 10 Bioretention Illustrated!
• Visual Indicators for other LID Practices
• TB 11 Designing a Local LID Maintenance Program
• Spreadsheet-based tool to develop maintenance punch-list for each site
• LID construction, inspection and maintenance videos on CSN website
  - Spanish translation coming soon
• Field Training in Summer of 2013

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Webcast Agenda

1. The Visual Indicators Framework
2. Some Bioretention Basics
3. Construction Sequence and Project Acceptance
4. Regular Maintenance Inspections and Repair
5. Forensic BMP Investigations
6. Regulatory Inspections
POLL Question 1

Please indicate how much experience you have in assessing LID Practices in the field:

• None
• A Bit
• Some, but still confused
• A lot
• I sleep in them at nite
The Challenge We Face

• A lot more practices to deal with

• More prescriptive MS4 requirements for ongoing maintenance inspection

• New BMP reporting, tracking and reporting requirements for TMDL

• Limited staff resources
Visual Indicator Approach

• Use of simple visual indicators in order to conduct rapid investigations of BMPs
• Employing this approach during routine maintenance, inspections and performance verifications
• Results in a punch list of actions to be taken to maintain functionality of the BMP
• More severe cases trigger a more in depth investigation into the problem
Visual Inspection Framework

- Construction Inspection
- Project Acceptance
- Routine Maintenance
- Routine Inspection
- Performance Verification
- BMP Inventory
- Forensic BMP Investigation (FBI)
- Add legacy BMPs into inventory
**Visual Indicators**

**Goal:** To evaluate the bioretention area in 10 minutes or less

**How:** Follow a prescribed sequence to assess the performance and functionality of bioretention by using numeric triggers to grade each visual indicator from score of Pass, Minor, Moderate or Severe

**Result:** Use of a spreadsheet tool to develop a punch-list of tasks to be completed/to follow-up on in order to bring the BMP up to speed
Bioretention Basics

Warning!
This may be the last pretty bioretention area you see for the next 90 minutes.
Bioretention

Water Quality Swale

Urban Bioretention

Residential Rain Garden
Key Parts of Bioretention

- Ponding area
- Filter media
- Pea gravel
- Overflow
- Vegetation
- **Optional:**
  - Underdrain + stone
  - sump
Bioretention: How it Works

Runoff flows into a bioretention facility and temporarily ponds. Water then slowly filters through the filter bed and either is collected by the underdrain and sent to the storm sewer system or infiltrates into the surrounding area.
Design Variations

• Underdrain
• Infiltration design w/o underdrain
• Infiltration sump with underdrain
Inlets
Outlets

Observation well

Underdrain
Performance Issues Observed in Field

General Performance Problems with Bioretention (n = 40)

- Need Maintenance: 33%
- No Pre-Treatment: 25%
- Inadequate Vegetation: 23%
- Short-Circuiting of Treatment: 18%
- Sediment Deposition: 18%
- Excessive Vegetation: 15%
- Inappropriate Media: 8%
- Clogged Soil Media: 8%

POLL Question 2

What proportion of the BMPs you are seeing recently can be classified as LID practices?

- None
- Less than 10%
- 11 to 25%
- 26% to 50%
- 50% or more
Construction Inspection

PURPOSE
Ensure project built per design and any field changes are acceptable

TOOL
Construction Inspection CHECKLIST

FREQUENCY
2-4 times during construction

SKILL LEVEL
Local Staff

Project Acceptance

Purpose
Ensure project and landscaping are established, functional and acceptable

VISUAL INDICATORS
Once

Engineer/landscape architect

Local Stormwater Management Review Authority
Key Steps

• Typical Construction Sequence for Bioretention
• Critical Inspection Points in the Sequence
• The Establishment Phase
• Final Inspection
Construction Sequence

1. Mark Utilities and Stakeout
2. Stabilize Drainage Area
3. Protect Bioretention Areas During Construction
4. Make Sure the Original Design Still Works*
5. Excavate From the Side
6. Reach and Scarify Bottom Invert
7. Tie into storm drain system
Construction Sequence

7. Optional Filter fabric on SIDES ONLY
8. Install Stone Layers and Underdrain
9. Add Filter Media/Hydraulic Compaction
10. Lay Down Surface Cover
11. Establish Final Elevations and Dig Planting Holes
12. Install Landscaping Materials
Construction Inspection

- Verify the actual contributing drainage area boundaries
- Confirm inlet and outlet elevations
- Confirm inflow actually captures runoff
- Side-slope stabilization
- Full inundation test to inspect underdrain/outflow function (sinking and final grades)

* Subtle changes in grading, paving and drainage can really screw up an otherwise fine design
Other Critical Points for Construction Inspection

- Check quality of filter media
- Make sure stone is washed
- Check underdrain elevations, pipe connections, perforations and caps
- Final ponding depth and side slope grading
Installed but not established
The Landscape Establishment Phase

• Perform final inspection at end of establishment phase

• Usually 12 months after installation for most vegetative LID practices

• Developer or builder responsible for this first year of maintenance
The establishment phase through first growing season

Landscaping contract covers first year after installation
Regular watering first few months
Spot re-seeding, remove/replace dead plants, rake mulch
Remove sediment accumulation at inlets
Repair erosion on side-slopes and drainage area
Final Inspection to Accept Facility

- Use the Full Range of Visual Indicators
- Inspect after a decent storm
- Last chance to reinforce plantings
- Decide what “as built” documentation is needed
- Acquire data needed for future BMP verification
- Release performance bond
As-builts for micro bioretention (CDA less than 5000 sf)

- Digital photo and GPS coordinates
- Vegetative cover and stability
- Confirm ponding depth and volume, flow path and practical overflow
- No survey work
As Built for Larger Bioretention (CDA more than 5000 sf)

- Limited survey work to confirm inlet and outlet elevations, flow paths and ponding depths
- Confirm underdrain daylighting
- Ensure landscaping meets design objectives
- Verify boundaries of stormwater easement
- Check overflow to downstream conveyance system
- Digital photo after establishment phase
Facility Reporting and Tracking

Make sure its working well before releasing performance bond

Log it in to local maintenance tracking system
Questions and Answers
Routine Regulatory Inspection

**PURPOSE**: Ensure BMP is properly maintained and functioning; Develop a punch list of needed maintenance tasks

**AUTHORITY**: MS-4 Permit

**FREQUENCY**: Once every 1-5 years

**SKILL LEVEL**: Trained person

**Tool**: Visual Indicators

**NOTE**: Method should be used to quickly evaluate practice during each routine maintenance visit as well.
Field Investigations

- Take photos, measurements, notes
- Use of a dry erase board and a camera to rapidly document the inspection and note observations on a tablet
- Carry simple tools to inspect facilities from ground surface and perform minor maintenance tasks
## Equipment

<table>
<thead>
<tr>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• White board</td>
</tr>
<tr>
<td>• Manhole pick</td>
</tr>
<tr>
<td>• Digital Camera</td>
</tr>
<tr>
<td>• Dip-sticks (sediment)</td>
</tr>
<tr>
<td>• Various tools for opening observation wells</td>
</tr>
<tr>
<td>(wrenches etc.)</td>
</tr>
<tr>
<td>• Shovel, rake</td>
</tr>
<tr>
<td>• Measuring tape</td>
</tr>
<tr>
<td>• Soil auger</td>
</tr>
<tr>
<td>• Plant ID sheet</td>
</tr>
<tr>
<td>• Authorization letter</td>
</tr>
</tbody>
</table>

Optional items:

- As-builts/site plans
- Safety vests
- Bug spray
- Flashlight
- Six pack of beer
Bioretention from above

INLET ZONE

OUTLET ZONE

BED AND VEGETATION

SIDE SLOPES
## Visual Indicators Sequence

<table>
<thead>
<tr>
<th>No.</th>
<th>Zone</th>
<th>INDICATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inlet</td>
<td>Inlet Obstruction</td>
</tr>
<tr>
<td>2</td>
<td>Inlet</td>
<td>Erosion at Inlet</td>
</tr>
<tr>
<td>3</td>
<td>Inlet</td>
<td>Pretreatment</td>
</tr>
<tr>
<td>4</td>
<td>Inlet</td>
<td>Structural Integrity, Safety Features</td>
</tr>
<tr>
<td>5</td>
<td>Perimeter</td>
<td>Surface Area</td>
</tr>
<tr>
<td>6</td>
<td>Perimeter</td>
<td>Side slope Erosion</td>
</tr>
<tr>
<td>7</td>
<td>Perimeter</td>
<td>Ponding Volume</td>
</tr>
<tr>
<td>8</td>
<td>Bed</td>
<td>Bed Sinking</td>
</tr>
<tr>
<td>9</td>
<td>Bed</td>
<td>Sediment Caking</td>
</tr>
<tr>
<td>10</td>
<td>Bed</td>
<td>Standing Water</td>
</tr>
<tr>
<td>11</td>
<td>Bed</td>
<td>Ponding Depth</td>
</tr>
<tr>
<td>12</td>
<td>Bed</td>
<td>Mulch Depth/Condition</td>
</tr>
<tr>
<td>13</td>
<td>Bed</td>
<td>Trash</td>
</tr>
<tr>
<td>14</td>
<td>Bed</td>
<td>Bed Erosion</td>
</tr>
<tr>
<td>15</td>
<td>Vegetation</td>
<td>Vegetative Cover</td>
</tr>
<tr>
<td>16</td>
<td>Vegetation</td>
<td>Vegetative Condition</td>
</tr>
<tr>
<td>17</td>
<td>Vegetation</td>
<td>Vegetative Maintenance</td>
</tr>
<tr>
<td>18</td>
<td>Outlet</td>
<td>Outlets, Underdrains, Overflows</td>
</tr>
</tbody>
</table>
Visual Indicator Approach for Bioretention
#1

**Inlet Obstruction**

- **Pass**
  - Good condition
  - Removal of sediment, obstruction

- **Minor**
  - Moderate
  - Remove sediment, debris

- **Severe**
  - Sediment staining = entry problem

**INLET ZONE**
#2

**Erosion @ the Inlet**

**Pass**

*Good condition*

**Minor**

**Moderate**

*Disperse flow, investigate cause*

**Severe**

**Stabilize inlet**

*Evaluate inflow protection measure*

**INLET ZONE**

*FBI*
# Pretreatment

## #3

### Free of sediment/debris
- Pass

### Remove accumulated sand/sediment
- Minor

### Moderate
- Remove accumulated sand/sediment

### Severe
- Locate source, mitigate

### INLET ZONE
- FBI

Structural Integrity

Good condition

Reinforcement needed immediately

Design repair
Surface Area

Does the surface area match the design?

### Surface Area

<table>
<thead>
<tr>
<th>Minor</th>
<th>5% different from design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td>10% different from design</td>
</tr>
<tr>
<td>Severe</td>
<td>&gt; 25% different from design</td>
</tr>
</tbody>
</table>

Proceed to Topographic Survey, Check Easement
#6 Side slope erosion

**Pass**
- Good condition

**Minor**
- Spot re-seeding

**Moderate**
- Vegetative stabilization needed

**Severe**
- Evaluate runoff source and conveyance, and stabilize
Water flows through entire facility

Some short circuiting occurring, mound up outlet

Design repair

PERIMETER ZONE

Pass

Minor

#7

FBI

Moderate

Severe

Short circuiting occurring, ineffective facility
Sinking Filter Bed

Even, flat bed

Mulch, media replacement

Moderate

Mulch, media replacement

Severe

Check underdrain or outfalls for evidence of media migration
Sediment Deposition/Caking

Pass

Moderate

Rake the cake

Severe

FBI

Remove sediment, check pretreatment, find and stabilize source in CDA
Standing Water

- None
  - <3" of standing water after 72 hrs

- Moderate
  - Proceed to pump down and test pit

- Saturated soils

- Severe
  - FBI
  - BED ZONE
#11

Topographic survey and adjust grade by removal/addition of mulch/media.
Mulch Depth, Condition

Pass

Good condition

Moderate

Replace mulch/Add ground cover

Severe

Remove mulch to design depth (2”-3”)

Level of mulch — blocking curb inlet
#13

Trash

No trash

Pass

Trash

Severe

Remove trash
Bed Erosion

Pass

Good condition

Moderate

Rake

FBI

Disperse flow, rake, investigate the cause, evaluate pretreatment
Vegetation is Different b/c…

• Vegetation changes over time
• Maintenance depends on landscaping regime

To assess: look at 3 different Visual Indicators:

• Vegetative Cover
• Vegetative Condition
• Vegetative Maintenance
Dynamic Vegetation Management

Original design plan should specify desired plant community through time.
Understand the desired landscaping objective

Perennial Garden

Tree-shrub-mulch

Perennial-Shrub

Turf-tree
Check Vegetation Indicators During Growing Season
Depending on landscaping Regime, these are all in good shape
Vegetative Cover

**Good cover**

Tip: more mulch area exposed = more maintenance cost

**Few bare spots**

Tip: Routinely split and replant Herbaceous material to reduce mulch area

< 75% coverage
Evaluate planting plan and replant
Plants alive and in good condition

Weeding needed

Determine cause of plant mortality

Invasive plants
Vegetative Maintenance

Well maintained

Tree removal needed

Maintenance needed!
Free of obstructions and debris
Sediment in underdrain

Check for broken or missing caps

Look for Bed Sinking
Do a test pit
Q & A
POLL Question 3

When it comes to LID practices in our community, we are experiencing ______ problems

• No
• A few isolated
• A moderate amount of
• Widespread
Forensic BMP Investigation

FBI

Purpose: to diagnose why a BMP is not working and how to fix it

Audience: BMP owner

Frequency: as warranted by field inspection

Skill Level: engineer/project estimator

Indicate what needs to be checked by private BMP owner in a letter on non-compliance
<table>
<thead>
<tr>
<th>No</th>
<th>Indicator</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Severe Inlet Obstruction</td>
<td>Most runoff cannot enter the facility</td>
</tr>
<tr>
<td>4</td>
<td>Structural Integrity</td>
<td>Facility or adjacent infrastructure at risk of failure</td>
</tr>
<tr>
<td>2, 6, 14</td>
<td>Severe Inlet Erosion, Sideslope or Bed</td>
<td>A foot or more of gully erosion</td>
</tr>
<tr>
<td>7</td>
<td>Severe Design Departures</td>
<td>More than 25% departure from design assumptions for surface area, ponding depth and/or contributing drainage area</td>
</tr>
<tr>
<td>8</td>
<td>Severe Bed Sinking</td>
<td>A foot or more of localized bed sinking and/or sediments observed in underdrain</td>
</tr>
<tr>
<td>9</td>
<td>Severe Sediment Caking</td>
<td>More than two inches of deposition in the facility</td>
</tr>
<tr>
<td>10</td>
<td>Severe Standing Water</td>
<td>More than 3 inches of ponding 72 hours after rain</td>
</tr>
<tr>
<td>15</td>
<td>Severe Vegetative Cover</td>
<td>35% of less vegetative cover</td>
</tr>
</tbody>
</table>
Severely Sinking Filter Bed

Proceed to Test Excavation
Potential Causes of a Severely Sinking Filter Bed

- Sink hole
- Damaged pipe or poor connection
- Sediment in Underdrain
- Poor connection at structure
- Sediment in Overflow Structure and Pipe
Test Excavation in the Bioretention area

Investigate Mulch, Soil Media, Filter Cloth
Optional: Underdrain Stone and Pipe

Evaluate for voids, loss of material, filter cloth or layer failures, etc.
What to Look for in the Overflow or Underdrain

Indicator:
Sediment or Soil Media in Underdrain or downstream structures
Secondary Investigation Techniques to Explore Pipes
Determine Sediment Depth and its probable Source in the facility or its contributing drainage areas
Standing Water

Investigate Mulch, Soil Media, Filter Cloth

Optional: Underdrain Stone and Pipe

Evaluate materials, signs of sediment, saturation

FBI Proceed to Pump Down & Test Pit
Landscaping Detective Work

- < 35% coverage
- Dead or Diseased Plants
- Invasive Plants

Evaluate cause of plant failure (soils, species, design)
Do new planting plan (higher density or fast growing species)

Design and implement eradication plan,
Evaluate remaining plants
Design new planting plan with higher density,
Institute O & M Procedures
Urban BMP Verification and the Bay Pollution Diet

- BMP Verification a priority for all sectors in the Chesapeake Bay Program
- Urban Stormwater Workgroup adopted its verification protocol in November 2012 (see CSN website/webcast webpage)
- States will implement them thru their existing MS4 BMP reporting efforts
Performance Verification

Ensure BMP still exists and is providing the pollutant removal it was designed to achieve or if it requires major restoration.

MS-4 Permit/ Bay TMDL

Once every 9-10 years

Trained evaluator

State BMP Reporting for Bay TMDL

Local BMP Inventory
Certification of Hydrologic Performance

Field evaluation of LID practices to ensure they are operating properly and are achieving nutrient reduction

Local BMP Reporting to state for Bay-wide TMDL and MS4 Permits

Bay BMP credits are tied to periodic recertification (5 years)
So how would performance verification apply to a bioretention area?

Hint: we look at a subset of visual indicator to make a site determination
Three Part Test
Pass/Fail

1. Does it still physically exist?
2. Is it still operating to treat and reduce runoff as it was originally designed?
3. Is it’s maintenance condition sufficient to still support its pollutant reduction functions?
Does it still physically exist?

- Can you find it?
- Are the conditions and cover in the contributing drainage area still the same?
Critical Visual Indicators for Verification

**Hydrologic Condition**
- Severe Bed Sinking *(runoff gets thru to fast)*
- Severe Inlet Obstruction *(runoff never gets in)*
- Standing Water *(runoff not fully treated)*
- Loss of Surface Ponding Capacity *(runoff not treated)*
- Severe Erosion at outlet/underdrain *(runoff is bypassing facility)*

**Maintenance Condition**
- Inadequate Vegetative Cover *(no bio)*
- Severe pretreatment failure *(reduced longevity)*
- Severe Inlet or Sideslope Erosion
Permeable Pavement

• 10 key visual indicators, including a flow test
Infiltration

• 12 Key Indicators
Swales and Strips

• 17 Key Indicators
Thanks!

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Or e-mail your comments directly to watershedgal@hotmail.com
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