

INSPECTION & MAINTENANCE OF BMPs: PROGRAM COMPONENTS & ASSET MANAGEMENT

Noelle Slater and Maura Carroll, PE



Outline

Stormwater Best Management Practices (BMPs)

- Types of BMPs and how they work
- An asset management approach to maintenance

Inspection and Maintenance of BMPs

- Why do BMPs need to be maintained
- Elements of a maintenance program
- Routine and non-routine maintenance needs

Types of stormwater BMPs

Stormwater Asset Category	Example Types of Assets	
Basins	<ul style="list-style-type: none"> • Dry basins • Cisterns and rain barrels • Wetlands 	<ul style="list-style-type: none"> • Wet basins • Vaults and swirl concentrators • Forebays
Swales and Strips	<ul style="list-style-type: none"> • Swales • Level spreaders 	<ul style="list-style-type: none"> • Vegetated strips
Filters	<ul style="list-style-type: none"> • Surface and subsurface sand filters • Landscaped / vegetated roofs • Manufactured filters (boxes) 	<ul style="list-style-type: none"> • Bioretention • Drain inlet inserts • Subsurface gravel wetlands
Infiltrators	<ul style="list-style-type: none"> • Infiltration basins • Dry wells 	<ul style="list-style-type: none"> • Infiltration trenches and vaults • Permeable pavement
Gross Pollutant Traps and Mechanical Operations	<ul style="list-style-type: none"> • Screens • Baskets • Hoods 	<ul style="list-style-type: none"> • Nets • Racks

How BMPs work: pollutant removal mechanisms

- Storage
- Settling
- Filtering
- Biological and chemical processes
- Evapotranspiration
- Soil infiltration



How BMPs work: factors in BMP design

- Volume (runoff inflow and outflow)
- Velocity
- Resuspension (consideration of by-pass flows)
- Pollutant concentration
- Dissolved or suspended pollutants
- Pre-treatment areas/devices

BMP design and maintenance criteria need to be improved

- Routine maintenance is not being performed consistently and proactively in many cases
- Some BMPs are failing
- Performance feedback is needed to address design and maintenance needs





Asset Management Approach to Maintenance

Asset Management definition – adapted from USEPA

Asset Management is a *body of management practices* that

- Is applied to the *entire portfolio of infrastructure assets* at all levels of the organization
- Seeks to *minimize total costs* of acquiring, operating, maintaining, and renewing assets
- Works within an environment of *limited resources*
- Delivers *service levels* customers desire and regulators require
- Targets *acceptable level of risk* to the organization

There is more to Asset Management than Data Collection





A well-defined AM structure is critical

<p>ASSET GROUP</p>	 <p>Outfalls/ Pipes</p>	 <p>Junctions/ Chambers</p>	 <p>Pumps</p>
<p>ASSET TYPE</p>	<ul style="list-style-type: none"> • Pipe • Pipe Inlet • Pipe Outlet 	<ul style="list-style-type: none"> • Manhole • Catch basin • Junction box • Drop inlet 	<ul style="list-style-type: none"> • Pump • Gate • Valve
<p>ASSET COMPONENT</p>	<ul style="list-style-type: none"> • Manhole • Catch basin • Headwall • Flume 	<ul style="list-style-type: none"> • Walls • Chimney • Lid 	<ul style="list-style-type: none"> • Motor (if <100 HP pump)

Good AM Protocols for Traditional Assets

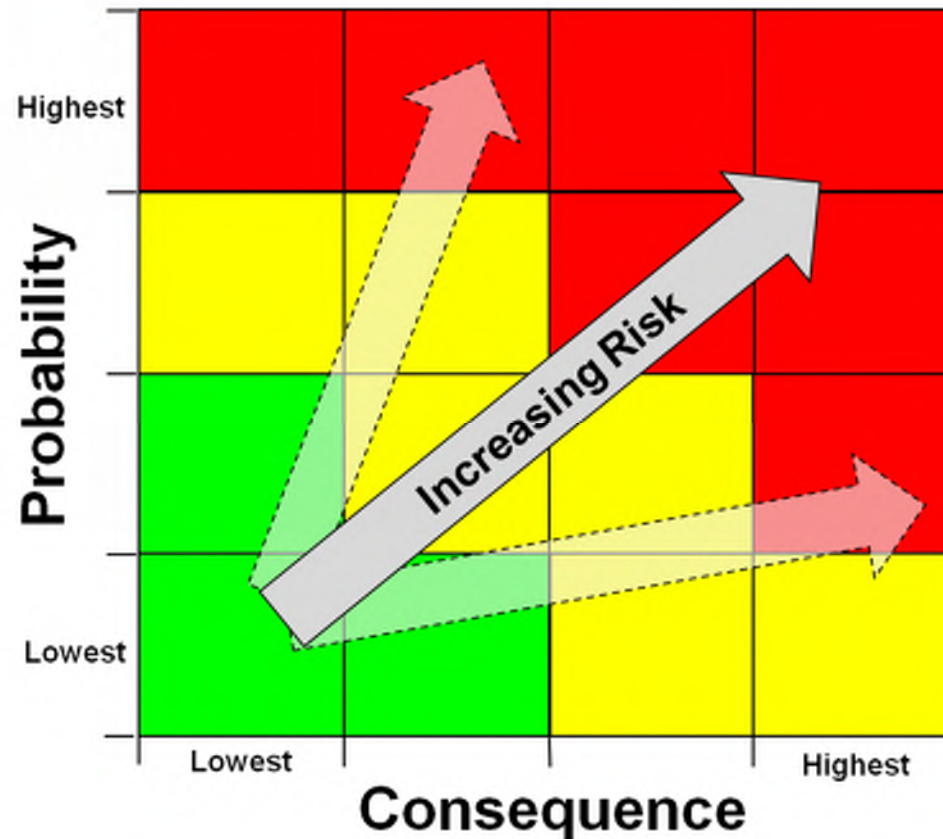
A well-defined AM structure is critical

<p>ASSET GROUP</p>	 <p>Open Linear Systems</p>		 <p>BMPs/GI</p>	
<p>ASSET TYPE</p>	<ul style="list-style-type: none"> • Ditch • Channel • Swale 	<ul style="list-style-type: none"> • Rain gardens • Bioswales • Wet ponds • Dry ponds • Constructed wetlands • Manufactured devices 		
<p>ASSET COMPONENT</p>	<ul style="list-style-type: none"> • Check dams • Vegetation 	<ul style="list-style-type: none"> • Forebay • Overflow / riser • Channel • Vegetation • Structure protection 		

Need Better AM Protocols for Stormwater Assets

A key focus of the Asset Management process is Risk-Based Evaluations

*Risk Is a Simple Equation: Probability * Consequence*



Condition assessment helps determine probability of failure

Condition Type	Failure Mode	Description	Assessment Method
Performance	Capacity	Does not meet demand (flow, loading, storage volume, etc.)	Test or Desktop
	Level of Service	Does not meet functional needs (regulatory permits, customer commitments)	Desktop
Physical	Efficiency	Not lowest cost alternative (labor, maintenance, obsolescence)	Desktop
	Mortality	Current state of repair and operation as influenced by age, historical maintenance and operating environment	Test, Visual, Desktop, Modeling

Physical condition examples

Condition Score 1



Condition Score 5



Multiple stormwater assets example

Stormwater Assets:

- Detention basins – 6
- Retention basins – 4
- Storm filters – 3
- Underground pipe – 1
- Filterra – 23
- Streams/Channels – 2



Condition ratings for all stormwater asset types

Object ID	Location ID	Asset ID	Technology/ Type	Structure Number	Condition Assessment Rating				
					Structural Problem	Erosion/ Sedimentation	Vegetation	Clogging Trash	Pretreatment Device
1	278	1363	Detention	-	3	2	4	4	
2	3278	1598	Detention	WCVE	5	2	3	2	
3	3298	1614	Retention	Home Depot		2	4	4	3
4	8162	1469	Detention	-		1	4		
5	8555	1221	Extended Detention	# 1	2	3	4	2	1
6	8559	1222	Extended Detention	# 2	2	4	5	2	1
7	8561	899	Filtrera	F1	2	2	3	2	1
8	8566	1070	Storm Filter	17	2	1	1	4	1
9	8568	1466	Detention	-	4	5	5	5	1
10	8580	1173	Retention	#1	2	2	2	2	
11	8580	1630	Retention	#2	2	2	3	3	

Which assets to repair/retrofit?

Total Score	No. of Assets	Percent	Repair Priority
1-6	39	74%	None
7-9	12	23%	Low
10-12	2	4%	Medium
13-15	0	0	High
Total	53	100%	

Benefits of Asset Management

- ✓ Informed asset investment decisions
- ✓ Managed risk
- ✓ Demonstrated compliance
- ✓ Improved organizational sustainability
- ✓ Improved efficiency and effectiveness
- ✓ Improved services and outputs
- ✓ Demonstrated social responsibility

= Real organizational savings (reduced borrowing costs, right-timed asset replacement, reduced asset failures)



Why BMPs Need Maintenance

Maintenance of BMPs?

- No BMP is maintenance free
- A properly cared for stormwater management facility can work effectively for years without major maintenance costs
- Neglected, a stormwater BMP can potentially be a continual financial drain



Maintenance requirements will change as BMPs age



Maintenance requirements will change as BMPs age



Maintenance requirements will change as BMPs age



Outflow impacts on maintenance requirements



Downstream impacts on maintenance requirements



Ponds – specs and debris management



Retrofitted pond to facilitate maintenance





Establish a Maintenance Program

Identify BMP characteristics and maintenance needs



Dry Pond



Wet Pond



Infiltration Trench



Bioretention Facility



Vegetated Swale



Permeable Paving



Vegetated Rooftop



Underground Detention



Manufactured Device

Define maintenance tasks and costs

- Regular Inspections
- Vegetation Management
- Embankment and Outlet Stabilization
- Debris and Litter Control
- Mechanical Components Maintenance
- Insect Control
- Access Maintenance
- Overall Pond Maintenance
- Sediment/Pollutant Removal
- Components Replacement



Perform routine inspections

- Detect issues early
- First line of defense to ensure optimal operation
- Helps avoid long term problems

Sample Self Inspection Checklist	
<p>STRUCTURAL INTEGRITY</p> <p>Yes No N/A Does the facility show signs of settling, cracking, bulging, misalignment, or other structural deterioration?</p> <p>Yes No N/A Do embankments, emergency spillways, side slopes, or inlet/outlet structures show signs of excessive erosion or slumping?</p> <p>Yes No N/A Is the outlet pipe damaged or otherwise not functioning properly?</p> <p>Yes No N/A Do impoundment and inlet areas show erosion, low spots, or lack of stabilization?</p> <p>Yes No N/A Are trees or saplings present on the embankment?</p> <p>Yes No N/A Are animal burrows present?</p> <p>Yes No N/A Are contributing areas unstabilized with evidence of erosion?</p> <p>Yes No N/A Do grassed areas require mowing and/or are clippings building up?</p> <p>WORKING CONDITIONS</p> <p>Yes No N/A Does the depth of sediment or other factors suggest a loss of storage volume?</p> <p>Yes No N/A Is there standing water in inappropriate areas, such as on filters or cartridges after a dry period?</p> <p>Yes No N/A Is there an accumulation of floating debris and/or trash?</p>	<p>OTHER INSPECTION ITEMS</p> <p>Yes No N/A Is there evidence of encroachments or improper use of impounded areas?</p> <p>Yes No N/A Are there signs of vandalism?</p> <p>Yes No N/A Do the fence, gate, lock, or other safety devices need repair?</p> <p>Yes No N/A Is there excessive algae growth, or has one type of vegetation taken over the facility?</p> <p>Yes No N/A Is there evidence of oil, grease, or other automotive fluids entering and clogging the facility?</p> <p>Yes No N/A In rain gardens, is there evidence of soil erosion, does mulch cover the entire area, are specified number and types of plants still in place, or is there evidence of disease or plant stress from inadequate or too much watering?</p> <p>OTHER OBSERVATIONS</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>A yes answer to any of these items should result in corrective action or a call to a professional inspector.</p>

Source: Northern Virginia
Regional Commission

Regular inspections reduce maintenance costs

Inspection Checklist

- ✓ Remove obstructions of the inlet or outlet devices by trash and debris
- ✓ Look for excessive erosion, scouring, or sedimentation in the pond perimeter, inlets, outlets, and energy dissipaters
- ✓ Look for cracking or settling in the embankment, dam, inlet and outlet structures
- ✓ Look for animal burrows, nests, or lodges
- ✓ Look for permanently ponded areas in the bottom of an extended-detention dry pond or bioretention facility
- ✓ Look for sluggishly draining infiltration devices
- ✓ Look for algae growth, stagnant pools, or noxious odors
- ✓ Look for poor or distressed stands of grass

Regular inspections reduce maintenance costs

Inspection Checklist (continued)

- ✓ Look for distressed aquatic vegetation
- ✓ Look for deterioration of pipes and conduits
- ✓ Look for piping along the outlet barrel
- ✓ Look for deterioration in the emergency spillway (grass should not be cut to less than 8 inches in height)
- ✓ Look for washouts, bulges or slumps, and woody growth in the embankment
- ✓ Identify seepage at the toe of wet ponds or constructed treatment wetlands
- ✓ Identify unstable side slopes and embankments
- ✓ Document deterioration of downstream channels
- ✓ Document signs of vandalism

Provide proper/consistent training

- Provide guidance on proper maintenance techniques for different BMPs
- Keep staff up-to-date on changes in BMP technology
- Provide instruction on use of maintenance equipment



Source: King County, WA



Source: NYCDEP

Keep records of maintenance

- Identifying persistent problems by asset type
- “Calibrate” your crews
- Identify chronic maintenance problems by location
- Aid in future budget preparation

Project Basic: Project Name: Crest Commerce Center, Project Type: Commercial, Project ID: 000, Facility ID: 128.

Facility Information: SWM Plan Acceptance Date: 6/23/2006, Type of Facility: South Sand Filter.

Inspection Date	Performed By	Inspection Status	Action Status	Show Form	Show Report
3/4/2006	Jan Fawcett	Annual	None	off	off
4/6/2006	Greg Harper	Annual	Minor Needed	off	off

Streamwater Pond Semi-Annual Inspection Checklist*

Inspector: _____ Date: _____ Pond Number: _____

Inspection Items:	Checked?	Maintenance Needed?	Comments
	VN/NA	VN	
Vegetation (§ 4.6)			
1. Are the boundaries of the buffer being observed? (Are mowers to the edge, grass $\geq 6"$ tall?)			
2. Is your shoreline vegetation dominated by one or a few species?			
3. Is your surface water vegetation dominated by one or a few species?			
4. Is your underwater vegetation dominated by one or a few species?			
5. Is there an excessive amount of algae? (Less than 20% surface coverage is ideal)			
Wildlife (§ 8.8)			
1. Are there signs of nuisance wildlife? (Gone droppings, beaver dams, burrows, other signs)			
2. Are there areas of stagnant water that provide a breeding ground for mosquitoes?			
Water Quality (§ 7.8)			
1. Is there trash/debris in nearby storm drains?			
2. Is there trash/debris in the pond or on the shore?			
3. Does your shoreline show signs of erosion? (undercutting, crumbling, or slumping)			
4. Are there signs of sedimentation in the pond? (sediment accumulation in pond, decreased available pond volume)			
Pond Structures (§ 1.8)			
1. Are there obstructions at inlets and outlets? (trash, plant debris, construction materials)			
2. Do inlet or outlet structures show signs of wear? (cracked, corroded, or broken pipes)			
Fountains and Aeration (§ 11.8)			
1. Is the aeration system functioning properly? (water is circulating, diffuser is bubbling)			
2. Have any fish kills been reported? (cyanobacteria)			
Access and Safety			
1. Is maintenance access to the pond and aeration system free of obstructions? (tree limbs, or inaccessibly placed or gates)			
2. Are fences, gates, and locks in need of repair? (broken or unlocked locks, gates, or fences)			
3. Are there signs of vandalism/graffiti on or around pond structures?			

*Note: This checklist is presented to provide an example. Streamwater pond inspections may need to be performed more frequently and include other inspection items based on the unique conditions present at your pond. It is also good practice to inspect your pond after major storm events.

Source: Clemson University

Don't forget to involve the public!

- Educating and involving the community is a cost-effective way to prolong the life of the stormwater BMPs
- Activities can range from organized clean-up days to a community-wide education program
- Supplies, resources, and technical support should be provided to businesses and communities



Provide routine maintenance

- Costs are relatively consistent and can usually be predicted for an annual budget
- Typical range is 1 to 10% of original capital construction costs per year depending on BMP type and size



Considerations for routine maintenance

- Visibility of the Facility/
Aesthetics
- Landscaping
- Upstream Conditions
- Safety
- Need for Professional
Judgement
- Financing



Plan for non-routine maintenance

- Non-routine maintenance is highly specific and varies depending on different factors
- Costs can be substantial over the long run, especially when considering the possibility of eventual BMP replacement
- Having a dedicated BMP maintenance fund account to cover these costs is highly recommended



Non-routine maintenance items

- Major sediment removal
- Inflow and outflow pipes
- Trash racks and anti-vortex devices
- Valves, orifices, and aerators
- Concrete structures (riser structures in ponds, etc.)
- Pumps and switches
- Manhole covers and access hatches
- Earthworks such as embankments and side slopes
- Mulch and vegetation



Summary

Old Problems

- Reactive response to BMP maintenance
- Limited funding

New Solutions

- Proactive response to BMP maintenance
- Take an asset management approach
- Establish a maintenance program
- Provide routine and non-routine maintenance

Improving quality of life.

Thank you!



Contacts



Noelle Slater

- Senior Environmental Engineer
- 757-419-3974
- noelle.slater@arcadis.com



Maura Carroll, PE

- Staff Engineer
- 256-929-7595
- maura.carroll@arcadis.com