

Costs of Maintaining Stormwater Control Measures



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SCM Maintenance

- North Carolina Department of Environmental Quality (NC DEQ) requires signed and notarized maintenance plan for all stormwater control measures (SCMs)
- SCMs also required to be inspected on annual basis by a Professional Engineer or Registered Landscape Architect
- For more information contact regional NC DEQ office (<https://deq.nc.gov/contact/regional-offices>)
 - Visit <https://deq.nc.gov/sw-bmp-manual>
 - Operation and Maintenance chapter
 - Stormwater Rules and Regulations

Impacts of Maintenance on SCMs

- Maintenance affects SCM performance
 - Johnson and Hunt (2019) discovered bioretention cell performance in NC improved 17 years later
 - Willard et al. (2017) found bioretention cell performance in VA improved 7 years later
 - Bean et al. (2007) determined permeable pavement infiltration improved from 2 in/hr to 3.5 in/hr after maintenance



The 'Mow, Blow, and Go' Method will NOT Work for SCMs



Nor Will the ‘Spray and Pray Method’



SCM Maintenance vs. Landscaping

- Landscapers observe plant material and use soil and tissue analyses to fertilize for good plant nutrition
- SCMs built to *remove* nutrients (TN and TP); plant growth is secondary concern
- Adding fertilizer to SCMs causes nutrient export



SCM Maintenance vs. Landscaping

- Using SCM maintenance companies ensures:
 - Issues are identified and corrected before annual inspection
 - SCMs meet permit requirements while aesthetically pleasing
 - More cost effective to routinely maintain SCMs



Bioretention Cell/Rain Garden Maintenance

- Typical maintenance includes:
 - Trash removal
 - Inspecting components (inlet(s), outlet, cleanouts)
 - Pruning and replacing woody vegetation
 - Mowing
 - Removing sediment from surface



Sources of Sediment

- Sources include traffic and outparcels



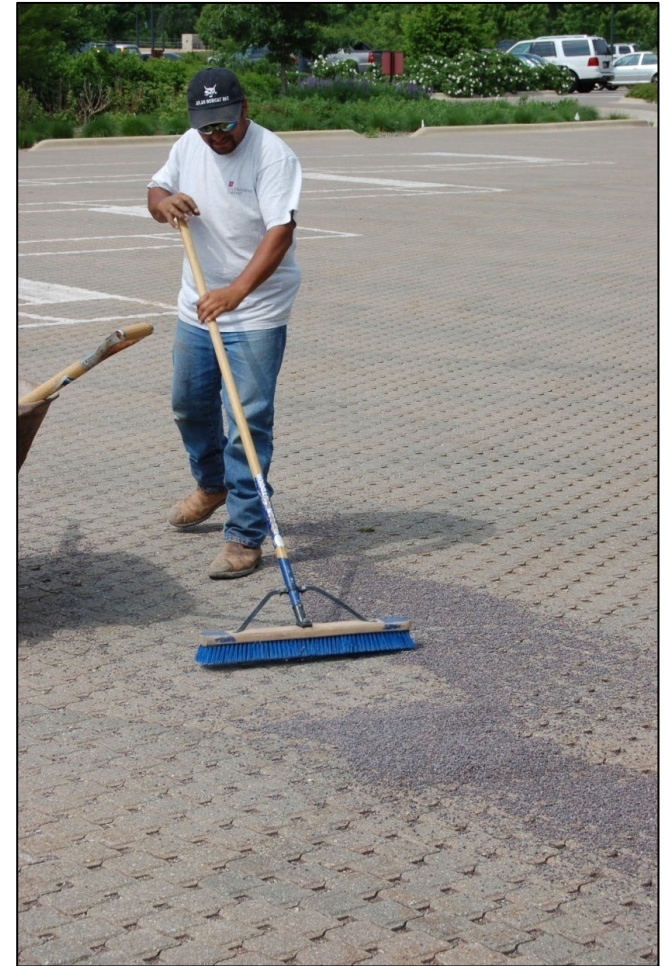
Cistern/Rain Barrel Maintenance

- Typical maintenance includes:
 - Inspecting and repairing all leaks
 - Cleaning gutters
 - Unclogging screens and filters
 - Inspecting distribution system (e.g. pump)
 - Flushing out tank



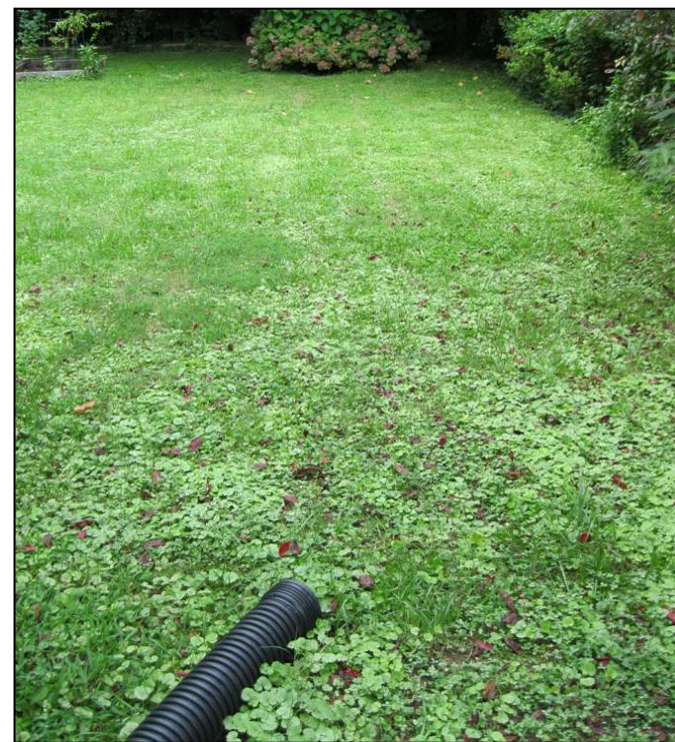
Permeable Pavement Maintenance

- Typical maintenance includes:
 - Stabilizing surrounding area
 - Vacuuming or sweeping surface
 - Inspecting observation well(s)
 - Annual infiltration testing



Downspout Disconnection/Swales

- Typical maintenance includes:
 - Unclogging gutters
 - Remove any trees or shrubs in designated vegetated area
 - Removing excess sediment or debris from drainage area
 - Maintaining non-clumping vegetation at height of 3 to 4 inches
 - Swale vegetation should be between 4 to 6 inches



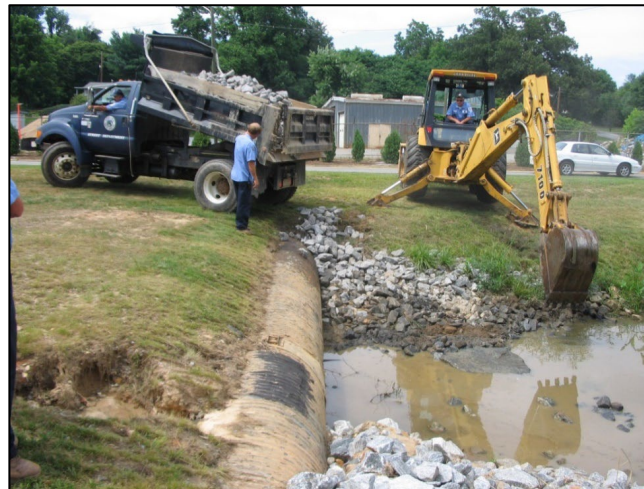
A Little More About Mowing

- Don't mow after rain/
soggy conditions
 - More water than
nature intended
- Be careful with lowering
mower – scarring



Wet Pond/Wetland Maintenance

- Typical maintenance includes:
 - Trash and invasive vegetation removal
 - Mowing adjacent landscape and banks
 - Revegetation as needed
 - Inspecting components (inlets, outlet, forebay)
 - Removing vermin (beavers, muskrats) as needed



Maintenance Costs

- NCSU received grant from UNC WRRI to quantify maintenance costs for NC DEQ approved SCMs
- Identified costs for routine/proactive and restorative maintenance
- Compiling information into Excel based tool
 - Estimating lifespan of SCMs
 - Providing contingency factors
 - Accounting for inflation

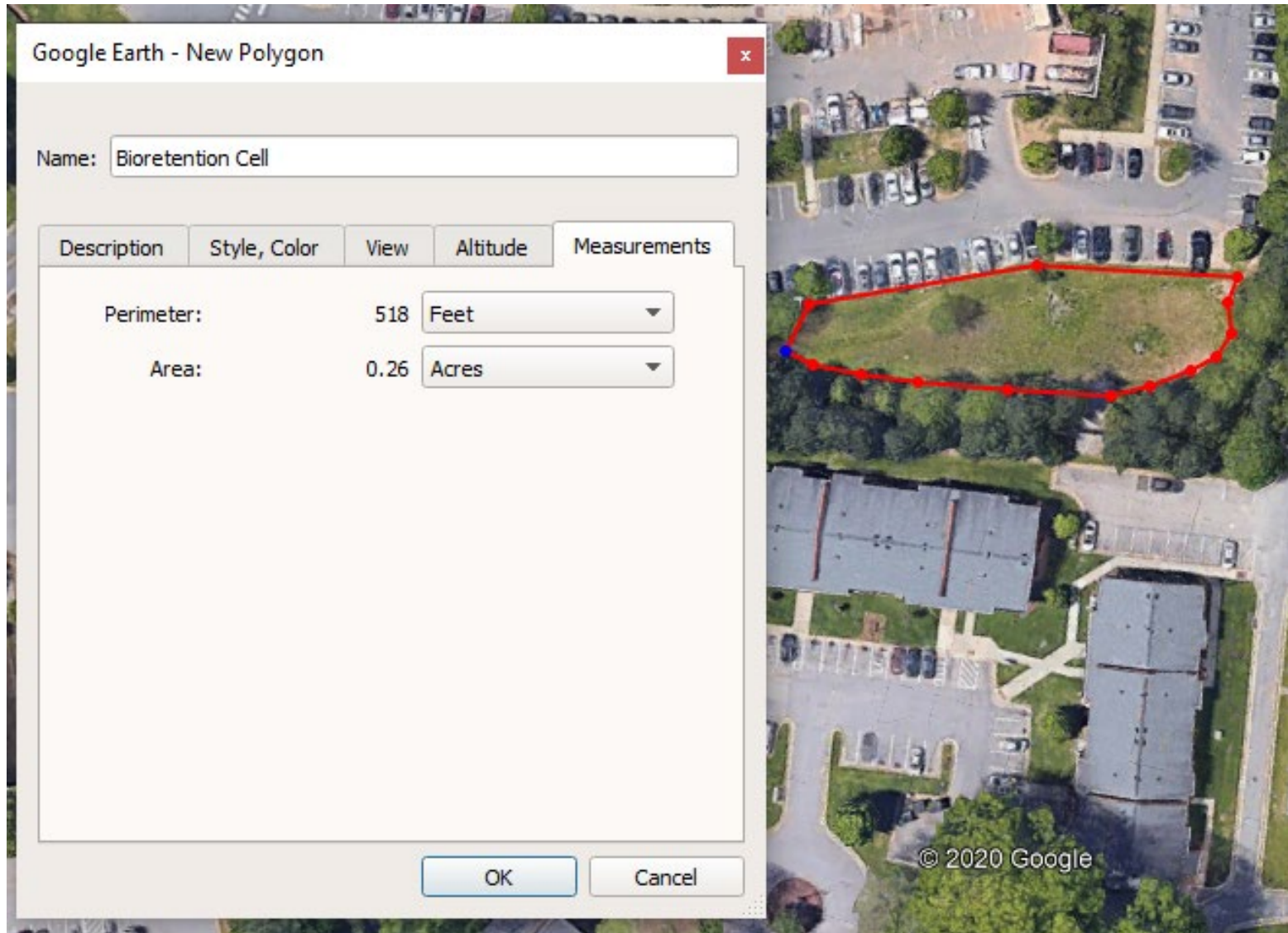
Permeable Pavement			Type	PICP		Surface Area	1 Acre		Annual Cost
Category	Task	Resource	Frequency Per Year	Duration Hours per Visit	Cost \$ Per Hour	Total Cost \$			
Routine Maintenance	Inspection and Reporting	Manpower	4	0.5	20	40			305
		Equipment / Material / Transportation				0			
	Litter and Debris Removal	Manpower	2	4	20	160			
		Equipment / Material / Transportation				0			
	Surface Cleaning (Mechanical/Regenerative)	Manpower	2	0.5	20	20			
		Equipment / Material / Transportation	2	0.5	85	85			
Non-Routine Maintenance	Restore Permeability	Manpower	0.2			0			140
		Equipment / Material / Transportation	0.2	1	700	140			

So when is restorative maintenance needed...?

- It depends
- To restore function after years of neglect
- After major weather events
 - Such as...



How to Use the Tool



Routine Bioretention Cell Costs

Parameter	Average	Median	Range
Age (yr)	14	15	10 to 15
Typical footprint (ac ¹)	0.17	0.13	0.05 to 0.25
Maintenance frequency	Monthly	-	8 to 21 times per yr
Time spent on tasks-mulched (hr)	1	1	0.25 to 3
Number of employees maintaining SCM- mulched	3	2	1 to 9
Routine costs without mowing- mulched (\$/ac ¹)	11,867	12,000	9,200 to 14,400
Routine costs with mowing- mulched (\$/ac ¹)	12,400	12,000	12,000 to 14,400
¹ ac refers to bioretention cell surface area			

Routine Bioretention Cell Costs

Parameter	Average	Median	Range
Time spent on tasks-grassed (hr)	1	1	1 to 1.5
Number of employees maintaining SCM-grassed	3	2	1 to 9
Routine costs without mowing-grassed (\$/ac ¹)	13,467	12,000	9,200 to 19,200
Routine costs with mowing-grassed (\$/ac ¹)	15,600	12,000	10,800 to 24,000
¹ ac refers to bioretention cell surface area			

Task	Average	Median	Range
< 1 gal plant replacement (\$/plant)	3	4	2.75 to 4
1 gal plant replacement (\$/plant)	17	15	12 to 25
3 gal to 5 gal plant replacement (\$/plant)	43	35	30 to 70
Tree replacement (\$/tree)	325	300	100 to 600
Mulch replacement (\$/cy ¹)	80	75	40 to 150
Media testing (\$/test)	183	200	150 to 200
¹ cy refers to mulch replaced			



Restorative Bioretention Cell Costs

Task	Average	Median	Range
Replace media (\$/ton ¹)	77	80	25 to 125
Replace media (\$/hr ²)	300	-	-
Complete restoration (\$/ac ³)	455,213	480,000	300,000 to 585,640
Camera underdrains (\$/hr ²)	250	-	-
Flush out underdrains (\$/lf ⁴)	20	-	-
Replace underdrains (\$/lf ⁴)	7,000	-	-
¹ ton refers to media replaced			
² hr refers to work completed			
³ ac refers to bioretention cell surface area			
⁴ lf refers to underdrain length			

Calculating Maintenance Costs



Calculating Maintenance Costs

- Annual **routine** costs for mulched bioretention cell with mowing: \$12,400 per ac
- **Restorative** costs for mulched bioretention cell: \$455,213 per ac
- Estimated costs:
 - Typical bioretention cell surface area = 0.20 ac
 - Routine:

$$\text{Annual Cost} = \frac{\$12,400}{\text{ac}} * 0.20 \text{ ac} = \$2,480$$

- Restorative:

$$\text{Cost} = \frac{\$455,213}{\text{ac}} * 0.20 \text{ ac} = \$91,043$$

Routine Wet Pond Costs

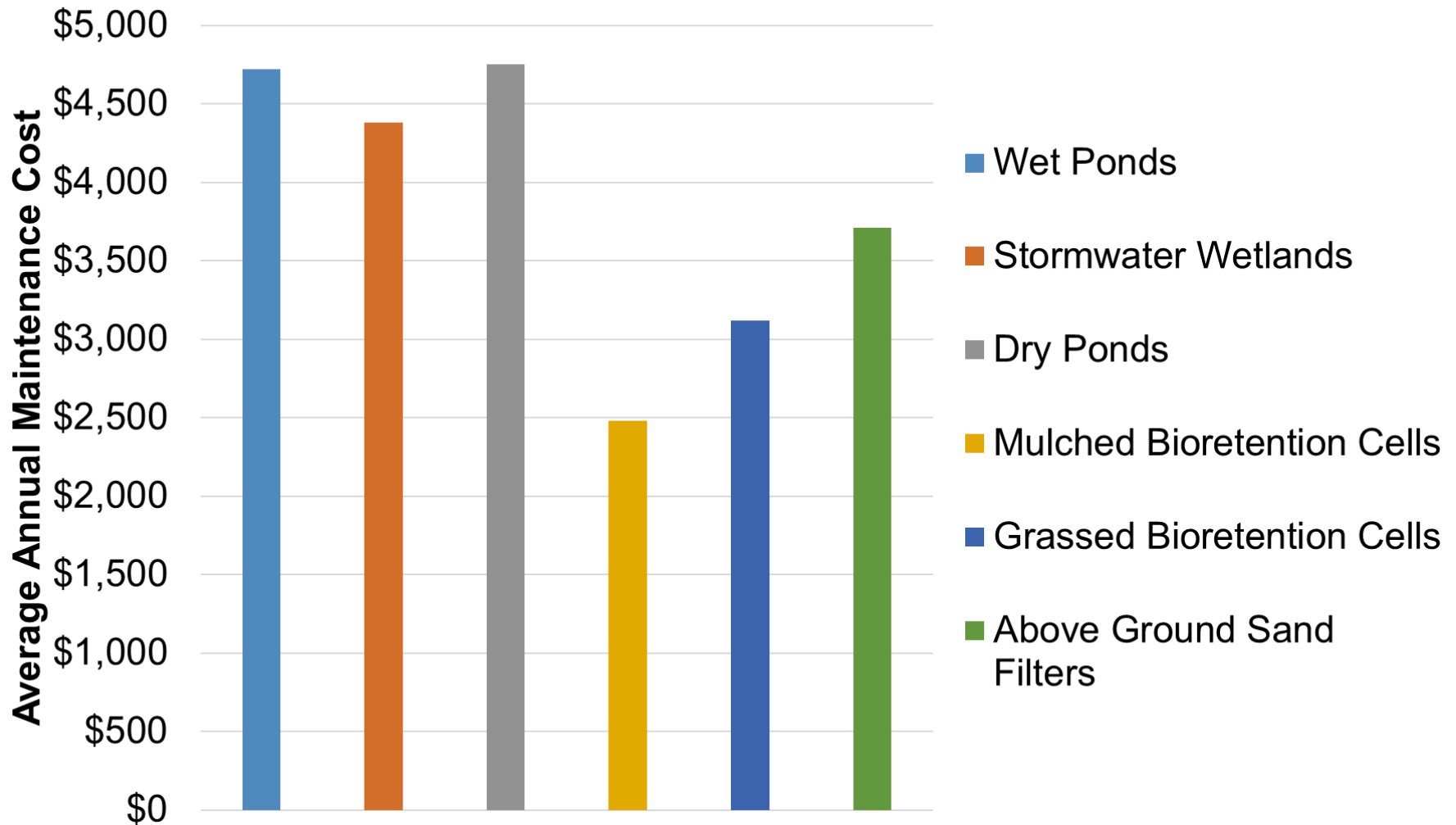
Parameter	Average	Median	Range
Age (yr)	16	16	10 to 28
Typical footprint (ac)	0.50	0.50	0.25 to 0.75
Maintenance frequency	Monthly	-	8 to 21 times per yr
Time spent on tasks (hr)	2	1	0.25 to 6
Number of employees maintaining SCM	3	2	1 to 9
Routine costs w/o mowing (\$/ac)	6,360	4,600	4,000 to 9,600
Routine costs with mowing (\$/ac)	9,440	8,800	5,400 to 15,200
¹ ac refers to wet pond surface area			

Routine Dry Pond Costs

Parameter	Average	Median	Range
Age (yr)	14	15	10 to 18
Typical footprint (ac ¹)	0.42	0.50	0.25 to 0.50
Maintenance frequency	Monthly	-	4 to 21 times per yr
Time spent on tasks (hr)	1	1	0.17 to 2
Number of employees maintaining SCM	3	4	1 to 9
Routine costs without mowing (\$/ac ¹)	6,920	6,000	5,400 to 9,600
Routine costs with mowing (\$/ac ¹)	11,320	10,400	6,600 to 18,000
¹ ac refers to dry pond surface area			

Cost Comparisons Between SCMs

Average Annual Routine Maintenance Costs



Questions?



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<https://www.bae.ncsu.edu/workshops-conferences/>