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Costs and Maintenance of Green Infrastructure Practices

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Green Infrastructure

COSTS



Costing Green Infrastructure Projects

- Community Partnership Projects typically less than \$10,000
- Small Contractor Projects typically less than \$40,000
- Publicly Bid & Prevailing Wage Projects



Community Partnership Projects

- Grant funded and less than \$10,000
 - Designed with grant partner
- Volunteer driven
- Municipal support
- Constructed on public property
- Active community support
- Not appropriate for some green infrastructure practices
- Costs for materials drives budget
- In-kind labor



Small Contract Projects (<\$40,000)

- Owner has ability to solicit cost proposals from multiple contractors
- Provides owner ability to identify appropriate experience contractors
- Provides flexibility to use more green infrastructure strategies
- Professional design plans and approvals needed
- Higher quality finished product
- Project guarantees



Publicly Bid/Prevailing Wage Projects

- Need to aggregate projects to make cost effective
- Look to include green infrastructure into scheduled/planned capital improvements
- Requires experienced designers and construction managers
- Coordinating with project partners can be challenging



Managing Expectations

- Begin planning process with an understanding of the preferred implementation strategy
- It always takes longer than you expect
- Planting is limited to the Spring & Fall
- Talk with property owner and partners early and often



Costs for Rain Gardens / Bioretention Systems

Type	Low Cost	High Cost	Project Range
Small systems (up to 200 sq. ft.)	\$5.00	\$10.00	\$1,000 - \$2,000
Large systems (up to 1,000 sq. ft.)	\$10.00	\$35.00	\$2,000 - \$35,000

Construction work to include:

- Excavation
- Disposal of excess soil
- Soil amendments
- Mulch
- Plants
- Stone
- Piping



Costs for Roadway Bioretention Systems

Type	Low Cost	High Cost	Project Range
Roadway bioretention systems (up to 500 sq. ft.)	\$85.00	\$105.00	\$42,500 - \$52,500

Construction work for curb rain gardens, stormwater planters, and bump outs:

- Demolition of existing paving and curbing
- Excavation
- Disposal of excess soil
- Soil amendments
- Mulch
- Plants
- Stone
- Piping
- Curbing
- BEWARE: Costs for Traffic Control!!!



Costs for Enhanced Tree Pits

Type	Low Cost	High Cost	Project Range
Tree Pit (each pit at 4'x8' or 4'x6' with tree)	\$2,500.00	\$3,000.00	\$2,500 - \$3,000

Construction work for enhanced tree pits:

- Demolition of existing paving and curbing
- Excavation
- Disposal of excess soil
- Soil amendments
- Stone
- Tree
- Tree grate



Costs for Rain Barrels & Cisterns

Type	Low Cost	High Cost	Project Range
Residential rain barrel (50-75 gallons)	\$50.00	\$300.00	\$50 - \$300
Small Cistern (up to 100-600 gallons)	\$300.00	\$2,000.00	\$300 - \$2,000
Large Cistern (up to 5,000 gallons)	\$6,500	\$12,000	\$6,500 - \$12,000

Construction work to include:

- Purchase and delivery of tank
- Placement of tank on stable foundation
- Connection of piping to roof drain (external)
- Installation of first-flush diverter
- Installation of overflow
- Providing supplemental electric pump
(\$1,500 - \$2,000)



Costs for Downspout Planter Boxes

Type	Low Cost	High Cost	Project Range
Residential planter box (each box up to 6 sq. ft.)	\$250.00	\$500.00	\$250 - \$500
Institutional planter boxes (larger systems over 6 sq. ft.)	\$500.00	\$8,000.00	\$500 - \$8,000

Construction work to include:

- Constructing free standing box
- Providing stable foundation
- Installing underdrain pipe
- Placement of stone and soil layers
- Piping connections to roof drains and overflow
- Plantings



Costs for Permeable Pavements

Type	Low Cost	High Cost	Project Range (1,000 sq. ft.)
Porous asphalt (per sq. ft.)	\$12.00	\$22.00	\$12,000 - \$22,000
Pervious concrete (per sq. ft.)	\$18.00	\$28.00	\$18,000 - \$28,000
Permeable pavers (per sq. ft.)	\$22.00	\$34.00	\$22,000 - \$34,000
Grass pavers (per sq. ft.)	\$16.00	\$18.00	\$16,000 - \$18,000

Construction work to include:

- Demolition of existing pavement
- Excavation and disposal of existing soil
- Placement of stone reservoir layers
- Installation of under drain piping and cleanouts
- Paving materials



Portland, OR: Costs per gallons managed (\$0.89-\$4.08)

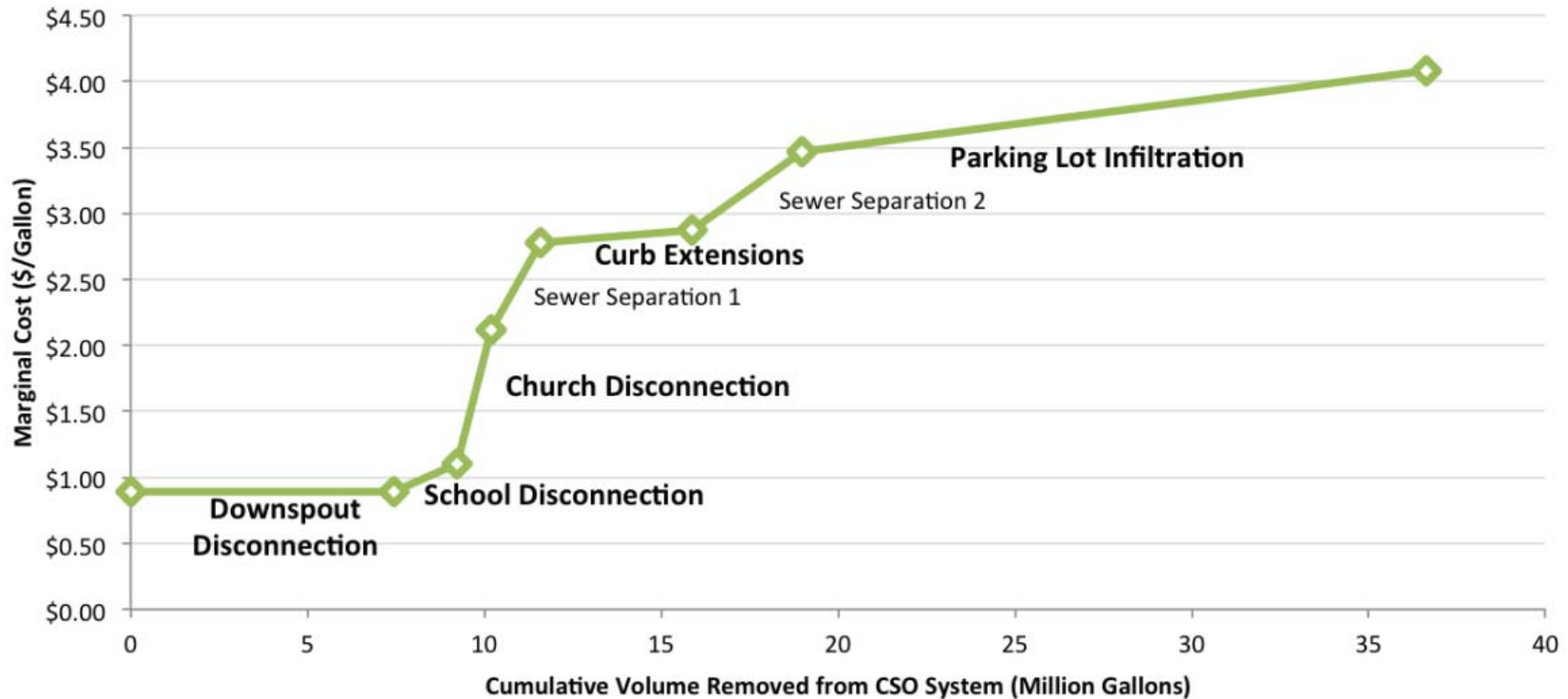


Figure 2. Cost and Cumulative Volume of Stormwater Removed from the CSO System through various grey and green strategies (Green in Bold). Source: ECONorthwest, with data from City of Portland 2005.

SOURCE: "Banking on Green," ASLA & American Rivers



Washington D.C.: Typical Construction Estimates

D.C. Water Green Infrastructure Cost Evaluation		
Green Infrastructure Practice	Cost	Unit
Bioretention: Residential	\$5.00 - \$12.00	SF
Bioretention: Commercial	\$15.00 - \$60.00	SF
Pervious Pavement	\$2.00 - \$15.00	SF
Soil System Detention: Suburban/Rural	\$0.10 - \$0.75	SF
Soil System Detention: Urban	\$1.00 - \$5.00	SF
Vegetated Swales	\$20,000 - \$30,000	Drainage Area (ac)
Green Roofs: Extensive	\$8.00 - \$20.00	SF
Green Roofs: Intensive	\$15.00 - \$50.00	SF
Rainwater Harvesting: Rain Barrels	\$2.00 - \$4.00	Gal
Rainwater Harvesting: Cistern	\$0.50 - \$4.00	Gal
Rainwater Harvesting: Gray Water Systems	\$20.00 - \$30.00	Gal
Blue Roof	\$5.00 - \$8.00	SF
Filter Systems: Multichamber	\$70,000.00 - \$136,000.00	Drainage Area (ac)
Filter Systems: Surface	\$25,000.00 - \$35,000.00	Drainage Area (ac)
Filter Systems: Subsurface	\$20,000.00 - \$40,000.00	Drainage Area (ac)
Filter Systems: Proprietary	\$24,000.00	Drainage Area (ac)



Resources and References: Costs

Source	Title	Link	Notes
NRDC	Rooftops to Rivers II	http://www.nrdc.org/water/pollution/rooftopsii/files/rooftopstoriversII.pdf	Onondaga County, NY
NYC EP	NYC Green Infrastructure Plan	http://www.nyc.gov/html/dep/pdf/green_infrastructure/NYCGreenInfrastructurePlan_ExecutiveSummary.pdf	Contains NYC GI Costs
American Rivers, ASLA	Banking on Green	https://www.asla.org/uploadedFiles/CMS/Government_Affairs/Federal_Government_Affairs/Banking%20on%20Green%20HighRes.pdf	Contains Portland GI Costs
CNT	The Value of Green Infrastructure	http://www.cnt.org/sites/default/files/publications/CNT_Value-of-Green-Infrastructure.pdf	Overview of GI BMP's. Case studies: Aurora Illinois, Chicago, Milwalki NYC, Philadelphia, Portland, Seattle
EPA	Green Infrastructure Implementation Strategy for the Town of Franklin, Massachusetts	http://www.epa.gov/sites/production/files/2015-10/documents/franklin_report.pdf	Franklin, Massachusetts
NOAA	Green Infrastructure Options to Reduce Flooding	https://coast.noaa.gov/data/docs/digitalcoast/gi-econ.pdf	Storage Potential and Costs
EPA	The Economic Benefits of Green Infrastructure A Case Study of Lancaster, PA	http://www.floods.org/ace-files/NAI/July2015_IL/IL_NAI_Workshop_CNT_EPA_LancasterGICaseStudy.pdf	Lancaster, PA
UMD	The 'Impact' and 'Benefits' of Green Infrastructure in Stormwater Financing Programs	http://efc.umd.edu/assets/stormwater_financing_manual/10.2efc_stormwater_financing_manual_appendix_a.pdf	Lancaster, PA
D.C. Water	Long Term Control P January 2014 Modification for Green Infrastructure	https://www.dwater.com/education/gi_challenge_images/gi_public_comment_draft.pdf	DC
Seattle, WA	Green Stormwater Infrastructure in Seattle	http://www.seattle.gov/Documents/Departments/OSE/GSI_Spreads_v2_July_2015_WEB.pdf	Seattle, WA
	Economics and LID Practices	http://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/docs/FTL_Chapter3%20LR.pdf	



Green Infrastructure

MAINTENANCE



Rain Garden/Bioretention System Maintenance

- Remove liter, weed, water, mulch, and trim
- Inspect for sediment build up, the health of the vegetation and erosion
- Clean out and inspect outlets, inlets, overflow risers, etc.
- Keep inlets free and clear so water does not bypass the system



Vegetative System



Landscape Features Maintenance

- Trees
 - Watering
 - pruning
- Vegetation
 - Weeding
 - Mulching
 - Watering
 - pruning/cutback
 - landscape replacement



Vegetative System



Landscape Features Maintenance

- Maintenance of Vegetation
 - Frequency:
 - Checking vegetation for damage caused by a lawnmower, string trimmers, edger, or other power equipment
 - **Weeding: early and often- 3x spring, 1x fall and summer**
 - Pull weeds from there roots use tool if it is difficult
 - Avoid compacting the soil and other plants
 - Remove invasive plants
 - Tools and supplies:
 - Trash bags, gloves, shovels, trowels, weed id guide



Vegetative System



Landscape Features Maintenance

- Mulching
 - Frequency:
 - **Apply 2-3 inches of mulch in the spring**
 - Keep mulch away from the stem of the plants
 - May need to remove or mix up old mulch that is already there
 - Tools and supplies:
 - Trash bags, gloves, shovels, Hardwood mulch



Landscape Features Maintenance

- **Watering**
 - Frequency:
 - 1 inch the first week installed
 - ½ inch the first 4-6 weeks of the growing season for years 2 and 3 and for drought in years 2 and 3
 - Water the roots not the leaves
 - Soil should be moist 2 -3 inches below grade
 - Properly used hoses are more efficient than sprinklers
 - Tools and supplies:
 - Hose and water source
 - Gator bags



Vegetative System



Cistern / Rain Barrel Maintenance

- Release the water in there before the next rain event
- Rain barrels, cisterns and downspouts should be inspected and cleaned regularly
- Seals on the infrastructure need to be inspected to prevent mosquito infestation
- Winterize



Harvesting System



Cistern/ Rain Barrel Maintenance

- Cistern/Rain Barrel (provides supplemental water supply for irrigation and other nonpotable water use)
 - Frequency:
 - Annually release all the water before the winter
 - Tools and supplies:
 - Trash bags, gloves, wrench
 - Procedure:
 - Refer to guidance document in handout



Planter Box Maintenance

- Apply mulch / stone
- Install plantings
- Remove weeds
- Check/maintain inflow
- Keep overflow clear of debris
- Ensure proper drainage
- Winterize



Permeable Pavement Maintenance

- Porous Pavement Vacuuming
- Porous Pavement Power Washing
- Porous Paver Maintenance (Restoring Aggregate)
- Winter Maintenance for Porous Pavement



Storage System



Permeable Pavement Maintenance

- Porous Pavement Power Washing (should be done if pavement is clogged; NEVER power wash porous pavers)
 - Frequency:
 - Once every three years
 - Power wash after thorough vacuuming
 - Perform task in the spring
 - Tools and supplies:
 - Power washer
 - Water source
 - Trash bags, gloves, safety cones, street broom



Storage System



Permeable Pavement Maintenance

Winter Maintenance for Porous Pavements Procedures

- 1) Inspect:
 - If location is no visible look at site plan to identify where its located
 - Locate where obstacles are located like speed bumps, bushes, trees so the snowplow can be raised
 - Record observations in maintenance report log
- 2) Plow Site:
 - Use a rubber plow blade
 - Plow 1" above the pavement to prevent hitting the plow on a edge or a paver and ripping it up
- 3) Storage of snow piles:
 - Don't store snow piles on top of porous pavement surfaces; move the snow piles on lawn or non porous pavement
- 4) Salting
 - Use in moderation
- 5) Record observations in maintenance report log and clean up



Storage System



COMMON PROBLEMS



Issues and Concerns: Pedestrian Safety

- Obstructions to sidewalks
- Line of sight obstruction
- Tripping hazards
- Standing water (over 72 hours)
- Icing



Issues and Concerns: Vehicle Safety

- Branches/debris in roadway or parking area
- Lines of sight at intersections or parking areas
- Water overflow and icing in the roadway



Issues and Concerns: Sediment & Debris

- Trash accumulation
- Sediment accumulation
- Erosion
- Dumping
- Road salt and sand
- Bare soils



Issues and Concerns: Clogging

- Leaves and plant material
- Sediment
- Debris
- Ponding
- Filter screen or fabric
- Stone



Issues and Concerns: Ponding

- Standing water for more than 72 hours
- Saturated soils
- Plant loss
- Poor soil infiltration
- High groundwater
- Insufficient drain piping
- Too much water



Issues and Concerns: Winterizing

- Drain all piping, first flush diverters, fixtures, and storage tank
- Clean all filters and screens
- Divert flow from storage tanks



Resources and References: Maintenance

Caitlin Feehan: A Survey of Green Infrastructure Maintenance Programs in the United States

Available at: http://hixon.yale.edu/sites/default/files/files/fellows/paper/feehan_hixonpaper20131.pdf

Onondaga County, NY: Save the Rain Program Green Infrastructure Maintenance Training

Available at:

<http://savetherain.us/wp-content/uploads/2012/03/MaintenanceTrainingBinder.pdf>

Philadelphia, PA: Green City, Clean Waters Green Infrastructure Maintenance Manual

Available at:

<http://phillywatersheds.org/ltcpu/Green%20Infrastructure%20Maintenance%20Manual%20Development%20Process%20Plan.pdf>

Chesapeake Bay: Strategies to Improve Operations and Maintenance of Green Infrastructure

Available at:

<https://www.americanrivers.org/assets/pdfs/reports-and-publications/staying-green-strategies-improve-operations-and-maintenance.pdf>



Questions?



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