

Green Infrastructure Maintenance from the Ground Up: Key Strategies and Case Studies



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Green Infrastructure Maintenance Framework

- Why is GI Maintenance Important?
- Barriers to Success
- 3 Elements of a Successful Maintenance Program:
 - Commitment / Funding
 - Planning / Design Strategies
 - Procedures and Training



Why is Maintenance Important?

- Ensure long term performance of ***Green Stormwater Infrastructure***
- Protect capital investments
- Meet regulatory requirements, public and private GI
- Public health issues
- Public/community perceptions



Barriers to Effective GI Maintenance

- Lack of funding for operations and maintenance
 - Specialized equipment
 - Maintenance staffing requirements
- No training in specialized needs of green infrastructure
- Need for consistent inspection & maintenance procedures and enforcement policies
- Poor public awareness



Commitment to GI Maintenance

- Need institutional commitment for long-term success
 - Regulatory requirements
 - Adopt policies and enforcement (or education) procedures
- Establish responsible agency (staff) and provide adequate funding
- SW fees and credits can provide incentives and reinforce maintenance requirements
 - Offer financing or rebate for installation and maintenance of GI on residential or commercial property





Typical GI O&M Cost Considerations

- Establish a business case - consider the incremental costs of maintaining GI compared to conventional infrastructure or landscape maintenance
- Economies of Scale – the ability to keep maintenance crews busy full time are more efficient
- Size, design complexity, location, public visibility, system age, etc. – **maintenance costs can vary dramatically!**
- **Very little reliable cost data available!**

Paying for GI Maintenance

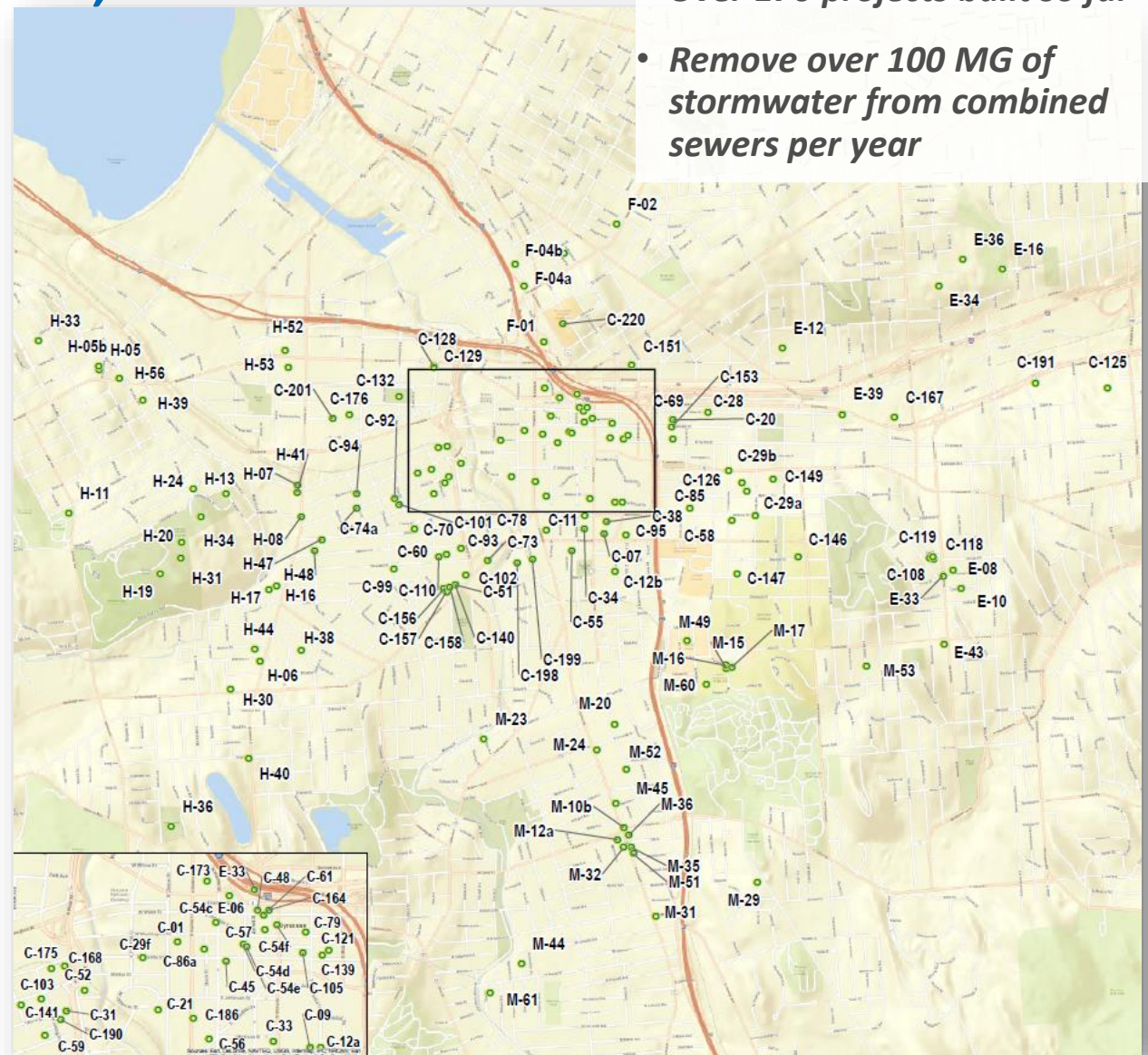
- Stormwater Utilities to Fund O&M
 - Provide a stable revenue source
 - Equitable approach that bases fees on impact
 - Incentivize private investment through credit programs that reduce fees
- Alternative Financing Strategies
 - Public-private partnerships
 - In Lancaster, PA, private recipients of (partial) funding for GI projects must agree to 40 years of O&M



Funding Maintenance for a Large-Scale GI Program: Onondaga County, Syracuse, NY

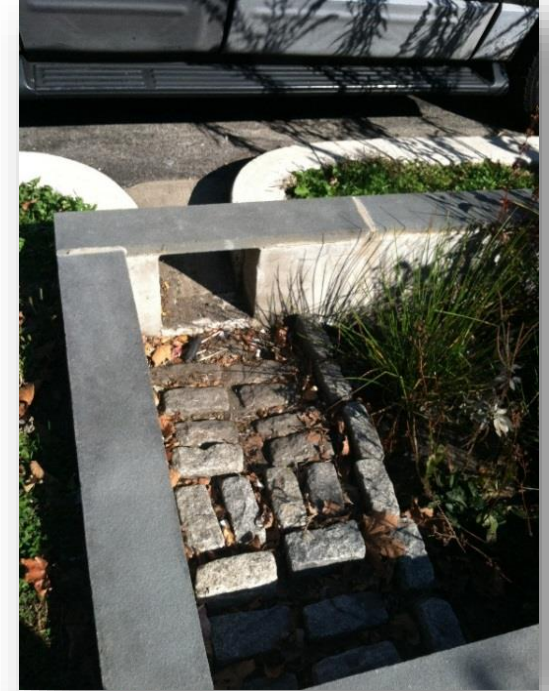
- O&M funding through combination of strategies
- Integration of GI O&M into existing infrastructure maintenance regime and CMMS tracking system
- Utilization of large-scale O&M contracts (permeable pavements, landscaping, etc.)
- Community partnerships to provide low-cost O&M and provide entry-level jobs and training
- Establishment of incentive program to offset costs through private implementation (10-year maintenance agreement)

- *Over 170 projects built so far*
- *Remove over 100 MG of stormwater from combined sewers per year*



Effective Maintenance Starts with Design

- **Consider maintenance requirements** when selecting types *and locations* of GI technologies for project
- Be aware of **site constraints** that make maintenance difficult and avoid locating GI in these areas (e.g. steep slopes)
- Design adequate **pre-treatment** that ensures long-term functionality
- Design GI techniques for **ease of inspection** and maintenance; include cleanouts and observation ports, as appropriate (ensure structures are accessible)
- Select the **appropriate plants** for the application (e.g. salt tolerant, drought tolerant, suited to the hydrologic zone of the system, etc.)
- **Design for minimal maintenance** where limited resources are available or when located on private property



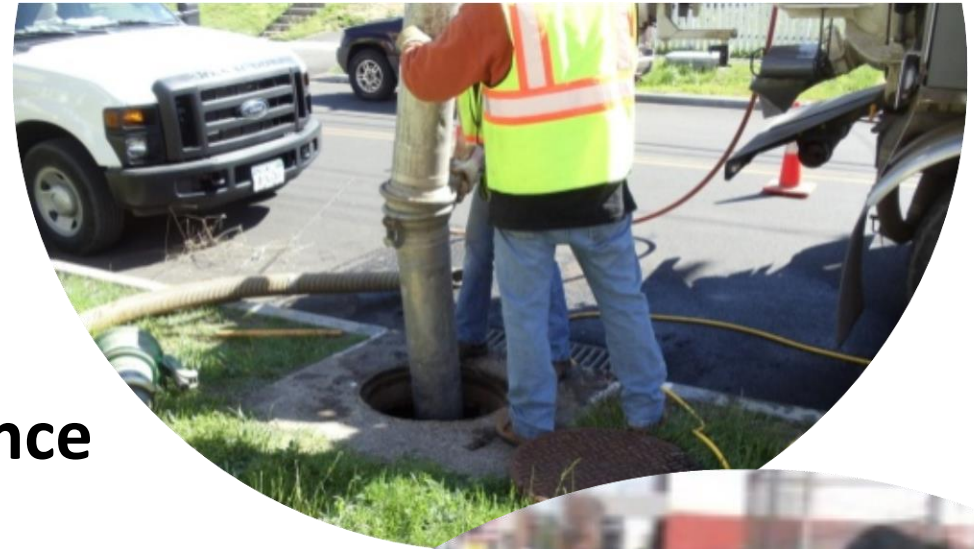
Effective Maintenance Starts with Design

- Establish design process: when will new BMPs or new materials be confirmed?



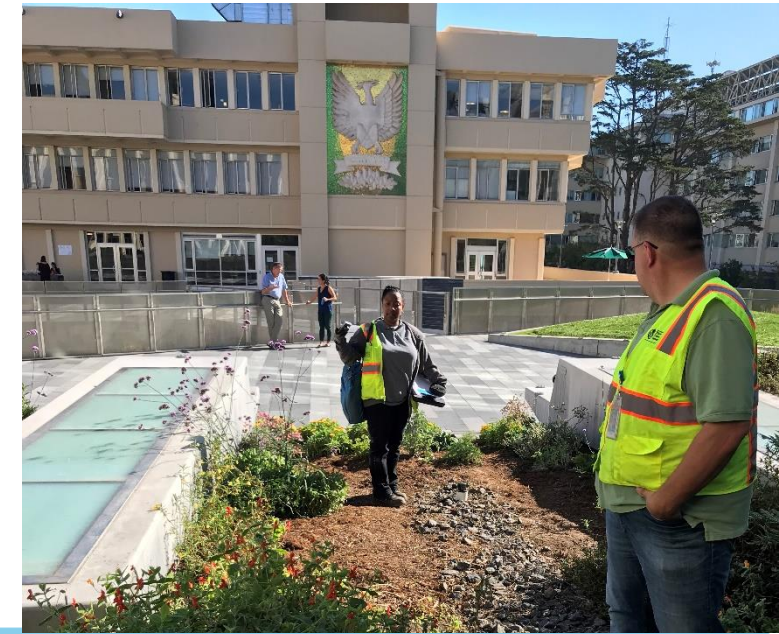
Standard Maintenance Procedures

- **Some overlap with existing maintenance activities**
- Vary based on primary system function, visibility, size, drainage area size, land cover/use, season, etc.
- Highly visible systems and structures require more
- Inspections required to meet regulatory requirements (e.g. MS4)
- **GI Systems are dynamic... *consider adaptive management***



Enforcement and Inspection Procedures

- Establish **Inspection Procedures and Schedules**
- Develop or Require **Inspection Certification and Training Programs**
- Evaluate Opportunities for **Volunteer Inspection Programs**
- **Adapt Enforcement Procedures** for Green Infrastructure Practices
- **SW Fees and Credits** can provide Incentive and Reinforcement of Maintenance Requirements



SITE CONDITIONS-RH: Building Cistern

Satisfactory (S) - In compliance

Marginal (M) - In compliance, needs maintenance

Unsatisfactory (U) - Needs immediate attention or repair to achieve compliance

Not Applicable (N/A) - Not present or can't be observed

SITE CONDITION	STATUS	POSSIBLE MAINTENANCE SOLUTION(S)
Unpleasant Odors	Satisfactory - No unpleasant odors originate from any part of the system	
Lids, Access Hatches, Ladders, etc. Damaged / Inoperative / Inaccessible / Missing	Satisfactory - Access equipment in working order	
Catchment Surface Condition	Marginal - Small amount of dirt/sediment present. Surface materials have slight wear.	Clear any debris and sediment accumulation on catchment surface
Conveyance System Condition	Marginal - Minor debris/algae present in gutters or around downspouts. Materials have slight wear but not affecting system functionality	Remove accumulated debris and clogs.
Pretreatment Device / First Flush Diverter Clear of Debris	Satisfactory - Moderate amount of debris present (less than 30% of capacity) in sediment catchment or on filter surface	
Pretreatment Device / First Flush Diverter Clear of Debris		

City of Lancaster GI Program : Measuring Success through O&M

- Full-time staff to support implementation (design & construction), monitoring & maintenance
- O&M Manual
- Integrate Asset Management with CMMS
- Trained parks staff to serve as dedicated bioretention maintenance crew
- Field inspection & performance testing informs future design & construction
 - During construction and post-construction



Honolulu Inspection Program/LA Training

Green Stormwater Infrastructure (GSI) Academy

Joint Partnership between the City of Los Angeles – LASANITATION and LA Trade Tech College

Balancing compliance, integration, and innovation with opportunity



Bioretention Swale

TC-34

Description

Similar to vegetated swales, bioretention swales are vegetated shallow depressions that temporarily hold storm water and filter the water through plants and soil before infiltration or release to the downstream storm drain. Bioretention swales may include a thick layer of amended native soil or engineered soil mix intended to provide contaminant removal, storm water retention, and support plant health. Vegetation may consist of grasses, or native wetland plants, shrubs, and trees. Bioretention swales may be distributed throughout a site or roadway and are preferably integrated into the landscape.



Function

Bioretention swales provide both pollutant removal and runoff control and may provide runoff volume reduction through evapotranspiration or infiltration if native subsoils allow infiltration.

Key Performance Indicator

Key Performance Indicator	Standard	Maintenance Trigger	Required Action	Maintenance Frequency	Recommended Maintenance
Litter	Minimal litter	Visible litter	Remove litter	Biannually; particularly after heavy runoff at the end of the wet season	Must remove litter, particularly prior to mowing (if applicable)
Sediment	Minimal sediment	Sediment accumulating near culverts and in channels should be removed when it builds up to 75 millimeters (3 inches) at any spot, or covers vegetation	Remove sediment	Biannually; particularly after heavy runoff at the end of the wet season	Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. The application of fertilizers and pesticides should be minimal
Debris	Minimal debris	Visible debris	Remove debris	Biannually; particularly after heavy runoff at the end of the wet season	Remove debris, particularly prior to mowing (if applicable)
Grass or Wetland Planter Cover	Areas permanently stabilized with vegetation have at least 80% coverage	Areas permanently stabilized with vegetation have less than 80% coverage	Add plants or seeds to achieve at least 80% vegetative coverage	Biannually; particularly after heavy runoff at the end of the wet season	Periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in


Training in Green Infrastructure O&M

- Provide practical training on maintenance standards and guidelines
- Established maintenance training programs
 - National Green Infrastructure Certification Program (NGICP)
 - Chesapeake Bay Stormwater Training Partnership Program
 - Montgomery County, MD – Contractor Training
 - Other state and university training programs
 - NC State
 - Washington State University
 - Denver, CO



Linking Green Infrastructure O&M to Green Jobs

- Requires workforce with new skills
- Potential to create long term permanent jobs
- Specially trained professionals for inspections
- Opportunity to create entry level positions to disadvantaged youth (e.g. Onondaga Earth Corps)



NEWS

Summer 2012

This summer, OEC expanded its youth development and employment program to include a young adult crew that is responsible for leadership of the summer youth program as well as for management and leadership of OEC's growing fee-for-service program. This summer the crew was responsible for education and outreach to thousands of neighborhood residents and children, maintenance of City and County-owned green infrastructure parking lots and a number of other exciting projects, including the installation of rain gardens and food gardens.

www.onondagearthcorps.org



Special thanks to the Allyn Foundation for supporting our capacity building efforts which enabled us to purchase our first pickup truck. Thank you!



OEC summer activities were made possible by funding from Onondaga County's Save the Rain campaign. Thank you Onondaga County!

The Onondaga Earth Corps summer activities were made possible in part by funding from Onondaga County's Save the Rain campaign, Onondaga Lake Partnership, NYS DEC, and CNY Works Summer Youth Employment Program.

Summer Program Orientation

The Onondaga Earth Corps kicked-off the 2012 summer program orienting the crew to the Onondaga Lake Watershed. Our 15 person crew observed the Tully Valley mudboils and learned about the existing land surface subsidence. They learned historical information about the Onondaga Creek and Onondaga Lake as they hiked along the boardwalk on the Onondaga Nation and participated in a board game at Willow Bay.

The rest of the Orientation was spent camping at Oneida Shores. The crew participated in team building activities, learned the structure of the



BJ Adigun from CH2M Hill discusses the Save the Rain program with crew members during orientation at Oneida Shores.

Additional Resources

Staying Green: Strategies to Improve Operations and Maintenance of Green Infrastructure in the Chesapeake Bay Watershed, American Rivers (2013):

<http://americanrivers.org/wp-content/uploads/2016/05/staying-green-strategies-improve-operations-and-maintenance.pdf>

National Green Infrastructure Certification Program (NGICP):

<http://ngicp.org/>

The Importance of Operation and Maintenance for the Long-Term Success of Green Infrastructure, US EPA (2013):

http://water.epa.gov/grants_funding/cwsrf/upload/Green-Infrastructure-OM-Report.pdf

Stormwater BMP Maintenance, Chesapeake Stormwater Network:

<http://chesapeakestormwater.net/training-library/design-adaptations/stormwater-bmp-maintenance/>

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