Green Infrastructure
Operations & Maintenance
Sightline Stormwater Learning Cohort
Peg Staeheli, PLA, LEED AP

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Green Infrastructure LID

Planning & Design
- Involve, Collaborate

Policy
- Land Use, Zoning
- Implementation Codes

Operations & Maintenance
- Public Crews
- Private
- Volunteers or Stewards

Finance
- Local / State / Federal
- Incentives
- Private

Construction
- New approaches
- PW Industry

Public/private
- Certainty

Focus
GSI Operations & Maintenance Overview

- Public perception - huge variance
- Maintenance Staff Perception
- Operations and Maintenance Points
  - Commissioning
  - Establishment and Closeout
  - Operations
  - Staffing
  - Documentation
  - Reporting
Bioretention Maintenance
What we are hearing from the public:

- What is the problem
- Why us?
- It is our frontage
- We hear these are toxic
- Ponding! Safety … West Nile Virus
- You are impacting our property values
- Needs for Parking and access
- Who do we call or email
Bioretention Maintenance
What we are hearing from the field:

- Involve the operations and maintenance staff in the planning and design.
- Involve the maintenance staff in the hand off from construction or transfer at the end of establishment.
- Plan for overlap between end of construction and maintenance.
- Provide the design intent. Show staff images of what the maintained system should look like.
- Provide them with a maintenance guide for them (reference vs action).
- Let them know what they can change - adaptive management.
- Maintenance is YEAR ROUND - don’t let it get out of control.
Bioretention Maintenance
What agencies should do:

- Treat public GSI as infrastructure facilities-
  - if we are paying for it out of infrastructure funding it is time to be clear.
- Campaign to inform on who owns the right of way
- Design for maintenance
- Define the maintenance concerns:
  - Drainage function
  - Safety
  - Aesthetics
Bioretention Maintenance
What agencies should do:

- **Manage expectations**
  - Agencies need to be clear in the beginning who is maintaining and what they are maintaining.
  - Explain the function and what can be expected during the seasons.
  - Define maintenance (SPU’s level of service as example)

- **Give them a contact**
Bioretention Maintenance
What agencies should do:

- **Training for Maintenance:**
  - Train for the intended yet variable functions
  - Be clear on what is important


- **Decide on Level of Service**
  - Manage the public expectations of maintenance. Inform the public with images and words

- **Understand volunteers versus stewards**
  - Be clear to the people what the differences are
GSI Maintenance Staffing - it varies but....

- It is not in-house versus contract maintenance. Suggest you plan for both as it helps manage scale.
- Operations best if internal especially if the GSI facility is regulated.
- Crew size- 3 to 5 (plan for absences)
  - A Crew of five is maintaining 15,000 lf of swales, a 5 acre pond site and 3 neighborhood parks
- Use parks crews OR at least share advice
- Train your industry (King County WA landscape maintenance contractor outreach)
Plant Zones - Inform Crews Why

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>ZONE</th>
<th>PLANT TYPE</th>
<th>LOCATION</th>
<th>FUNCTION</th>
<th>PLANT HT.</th>
<th>DECIDUOUS / EVERGREEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Emergents, Perennials &amp; Low Shrubs</td>
<td>Swale Bottom / Lower Slope</td>
<td>Water Quality Treatment</td>
<td>36&quot; max.</td>
<td>Mix</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Steppables / Groundcovers</td>
<td>Crossing / Overflow / Curb Strip / Upper Slope</td>
<td>Steppable</td>
<td>6&quot; +/-</td>
<td>Evergreen</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Groundcovers / Low Shrubs</td>
<td>Driveway / Intersection</td>
<td>Sight Clearance / Durable</td>
<td>24&quot; max.</td>
<td>Evergreen</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Groundcovers / Shrubs</td>
<td>Sidewalk / Upper Slope</td>
<td>Accent / Border / Anchor</td>
<td>6&quot; - 36&quot;</td>
<td>Mix</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Tall Accent Shrubs</td>
<td>Sidewalk / I near Street</td>
<td>Accent</td>
<td>4' - 6' +/-</td>
<td>Mix</td>
<td></td>
</tr>
<tr>
<td>2 + 4</td>
<td>Tree</td>
<td>Crossing / Sidewalk / Upper Slope</td>
<td>Shade / Water Quality</td>
<td>20' - 50' - varies based on power line location</td>
<td>Mix</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Smalls Trees / Large Shrubs</td>
<td>Sidewalk / Upper Slope</td>
<td>Shade / Water Quality</td>
<td>25' max.</td>
<td>Mix</td>
<td></td>
</tr>
</tbody>
</table>
This or That
This or That
Examples - why show your crews the bad?

Rain garden - not graded correctly
Washing out cement truck into rain garden?
Sediment at rain garden overflow

Because it happens
Examples: Poor functioning bioretention swales

- Slope Erosion
- Sediment Accumulation
- Litter
- Ponding and Mosquito Control
Example: Swale Protection during adjacent construction - requires development codes

- Why protect?
  - Indicates to public that these are infrastructure

- What you need: specifications into your development code
  - Bridging across swale for foot traffic. No vehicular traffic.
  - Maintaining continuous protective cover (plastic & filter fabric) over adjacent pervious concrete walk or vehicular surfaces.
  - Use low temporary fencing to control access
Pervious Pavement - The GSI Infiltrator

- Maintenance perception?
  - Drainage function
  - Pavement structure
  - Safety
  - Aesthetics
Moss Growth and Staining

Options for Maintenance:
- Pressure washing (concrete)
- Weed burner
- Sweeping (during dry periods)
- Spot treatment with vinegar

Above: Pervious Concrete City Sidewalk with moss

Right: Non-Pervious Concrete urban sidewalk with moss

Staining from compost spilling onto concrete.
Monitoring System for Drainage

- Annually check infiltration vs. clean when no longer infiltrating
- Annually check overflow subsurface drains to make sure functioning and not blocked
- Check water level in observation ports (24 hours after rain event)
- Have an annual inspection checklist in the maintenance manual.
- Take a video/photos during rain event to document where water is not draining and then identify locations that need maintenance
Ponds - *The GSI Holder*

**Maintenance:**
- Obstructions
- Trash
- Sediment
- Algae
- Invasive Plants
- Recirculation
- Mosquitoes
Ponds - Maintenance

- Review the original plans if you have them on file

- Volunteer Trees- maintain multiple sightlines into the pond area and be careful of tree density. This may mean that alders/maples get thinned out every 3-5 years.

- Shrubs- keep some sight lines open into the pond area that are no higher than 36 inches

- Invasives- pull out regularly
Trees - *The GSI Durables*

- Trees are slowly being understood as public infrastructure
- We are starting to quantify the benefits
- Generally liked or at least accepted
- Increasing performance over the long term
- Best performance if maintained
- Note - we are talking functional trees
Proper pruning takes training.

*Plan to prune about 3 times in the first 7 years of tree planting to provide framework for urban street trees.* Roy Francis, Manager, Seattle Department of Transportation Urban Forestry
Other tools in the GSI Toolbox

- Green Roof Maintenance
- Cisterns - in the public realm
- Green walls
- Proprietary systems
- Plan for long term replacement
Operations + Maintenance

- Operations
- Maintenance
  - Staff In house and Contract
  - Volunteers and Stewards
- Management and Documentation
- Costs
- Field observations and restoration
Documentation

- Document location in records for future utility cuts (no white or black topping).

- Document what materials are required for repair (engineered soils, plants etc.)

- Inspection of systems needs to occur during rain events but maintenance more effective during dry periods.

- Inform public of its location. Notify adjacent neighbors when cleaning is done? Include in a newsletter or list on website?
<table>
<thead>
<tr>
<th>Preventative Maintenance Manager</th>
<th>Maintenance Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekly</td>
<td>Monthly</td>
</tr>
<tr>
<td>Landscaping (pruning, mowing)</td>
<td>Check sprinkler heads</td>
</tr>
<tr>
<td>Fence repair</td>
<td>Check drains</td>
</tr>
<tr>
<td>Lawn care</td>
<td>Check septic system</td>
</tr>
<tr>
<td>Watering</td>
<td>Check foundation</td>
</tr>
<tr>
<td>Pest control</td>
<td>Inspect foundation</td>
</tr>
<tr>
<td>Mulching</td>
<td>Check for leaks</td>
</tr>
<tr>
<td>Pruning</td>
<td>Inspect roof</td>
</tr>
<tr>
<td>Weed control</td>
<td>Inspect grading</td>
</tr>
<tr>
<td>Weed control</td>
<td>Inspect gutters</td>
</tr>
<tr>
<td>Pruning</td>
<td>Inspect deck</td>
</tr>
<tr>
<td>Mulching</td>
<td>Clean gutters</td>
</tr>
<tr>
<td>Pest control</td>
<td>Paint exterior</td>
</tr>
<tr>
<td>Watering</td>
<td>Check foundation</td>
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<tr>
<td>Landscaping</td>
<td>Check for leaks</td>
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</tbody>
</table>

*Note: Regular maintenance tasks are marked with a checkmark (✓). Critical tasks are marked with an asterisk (*) for additional attention.*
Maintaining GSI for the future

- Document as-built conditions
- Determine level of service
- Document GSI location in books/records/GIS for future utility cuts (no white or black topping)
- Document what materials are required for repair
- Develop agency maintenance inspection checklist
- Annually check infiltration vs. waiting to clean when no longer infiltrating
- Check overflow subsurface drains to make sure functioning and not blocked
- Develop protection guidelines for future work in area
FAQ: What to look for in a storm event?

- Go to the low points – check for clogging
- Look at the high end inlets – for free flow- not blocked by debris
- If clogged – be careful to test depth of swale
- Check for debris blocking drains
- Don’t be afraid to remove plant material if blocking

After a storm - rain has stopped

- Look for ponding after 24 hours- if so investigate sub surface conditions
- Check the curb inlets for blocking or sediment build up
- Document issues for preventative maintenance
FAQ: What happens with turnover of GSI systems to public works maintenance?

- **Project Acceptance:** GSI maintenance needs to start immediately at project acceptance if there is no establishment period. Paperwork can often delay formal acceptance yet no maintenance is occurring. It is recommended that the notification to Operations and Maintenance Personnel happen at the time of “punch list” so scheduling occurs.

- **Warranty period:** specs can vary due to project budgets etc. so it is important to review project specific warranties. Suggest a maintenance staff person participate in final walk through and warranty inspection.

- **Establishment period contracts:** if a project includes establishment, the suggestion is that the maintenance staff review conditions 3 months prior to turnover date to allow time for either corrective action and/or scheduling or equipment issues. The turnover should include photos of conditions and written information on “problem spots or issues”
Learning Objectives Revisited

- What maintenance issues should you anticipate?
  - Community expectations / LOS
  - Faster growth of plant material
  - Maintain clear zones
  - Staffing

- Options for identifying resource needs and training
  - Involve maintenance in planning and design
  - In house and/or contract

- Guidelines for key tasks
  - Operations = observe and inspect
  - Maintenance = routine tasks for system performance
Don’t Stress - Questions?
Additional Resources 1/2

- King County Department of Natural Resources - This agency provides information on a variety of natural lawn and garden care topics. Detailed information on pest and weed-identification and control are available. [http://dnr.metrokc.gov/topics/yard-and-garden/](http://dnr.metrokc.gov/topics/yard-and-garden/)
- Seattle Public Utilities - This agency provides information on natural systems drainage, lawn care, plant selections, water use and other topics. - [http://www.seattle.gov/util/services/](http://www.seattle.gov/util/services/)
- [www.seattle.gov/dpd/greenfactor](http://www.seattle.gov/dpd/greenfactor) search for Preparing landscape management plans
- [https://www.seattle.gov/environment/TierTablesFriendlyFormat.xls](https://www.seattle.gov/environment/TierTablesFriendlyFormat.xls)
- Wisconsin Department of Natural Resources Web site includes several resources on raingardens: [http://www.dnr.state.wi.us/org/water/wm/dsfm/shore/raingarden.htm](http://www.dnr.state.wi.us/org/water/wm/dsfm/shore/raingarden.htm)
- [http://michiganbiochar.com/2012/03/what-weeds-tell-us-about-the-soilEco](http://michiganbiochar.com/2012/03/what-weeds-tell-us-about-the-soilEco)

Updated: 2012
Resources 2/2

- City of Olympia
  www.olympiawa.gov/cityutilities/stormwater/scienceandinnovations/porouspavement.htm
- City of Portland 2008 Stormwater Management Manual,
  http://www.portlandonline.com/bes/index.cfm?c=47952&
- “NC State University Permeable Pavement Research: Water Quality, Water Quantity, and Clogging,” Eban Z. Bean, EL, PhD Candidate and William F. Hunt, PhD, PE, NWQEP Notes, North Carolina State University, Number 119, November 2005.
- Pervious pavement in cold climates:
  http://www.perviouspavement.org/asphalt%20vs.concrete.htm
- La Center Parking Lot, http://www.uni-groupusa.org/PDF/La%20Center.pdf
- City of Bellevue Natural Drainage Practices Maintenance Guidelines & Checklists
  http://www.bellevuewa.gov/preventing_water_pollution.htm

- SvR Design Company- we share details etc on our web site  www.svrdesign.com