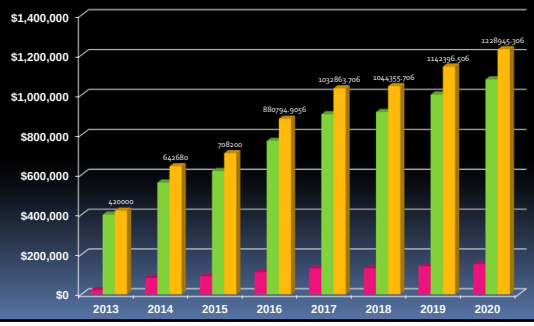
Operations and Maintenance

- O&M Maintenance Took Kit
  1. Landscape Maintenance Manual
  2. GSI/LID Maintenance Manual for ROW
  3. Identifiable and detailed levels of service
  4. Porous Pavement
  5. O&M Facility Checklists
  6. Key Performance Indicators
  7. O&M Estimating Database Tool
- Life Cycle Costs
- Maintenance Costs
- Additional Tools
- Risks/Lessons Learned

Current and Forecasted Bioretention

- Current (2000-13)
- 180K sq ft
- 20K sq ft installed 2013
- 2014-2020
- SPU: 42 acres
- SDOT: +100K sq ft
- County: 442 acres
- Code Required: ~12 blks per year

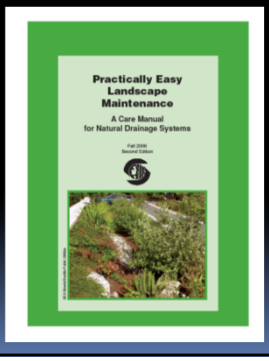
Strategic Business Plan - O&M Baseline Budget



SPU Tools

Homeowners Landscape Manual

- Landscape Maintenance Manual
- Maintenance personnel
- Homeowners living adjacent to systems



Restoration and Repair Manual

~ 10 Swales retrofitted
~ 4 possible failures 3-11
~ 2 possible infiltration failure 3-13

Maintenance Management

- Two crews
  - Hardscape: city crew
  - Landscape: contractor through 2020
- Scheduled by LOS –*not frequency!*
- Semi annual inspections
  - pre fall
  - pre spring

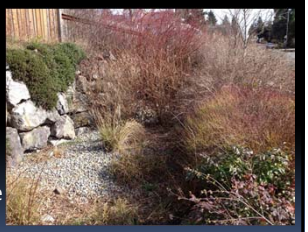
GSI Manual Sections

Inspection/Checklist and Maintenance Activities

1. Vegetation and Landscaping
2. System Functionality
3. Hardscape and Infra-Structure
4. Infiltration Failure – Swale Ponding
5. Recommended Maintenance for Other Elements
6. Safety, Mobility, and Accessibility

Maintenance Manual

- Summary
  - Routine maintenance activities
  - Non-routine maintenance activities
  - Inspection/checklist
  - Scheduling and performing maintenance activities in the ROW
  - Images and descriptions



Program is designed by

- Levels of Service
- LOS A
  - Excellent effort
- LOS B
  - Good effort
- LOS C
  - Moderate effort
- LOS D
  - Poor effort

Determining your LOS

- Project Goals
- Size
- Location
- Public Safety
- Age of facility
  - Plant establishment
- Functionality
- Economics or funding

Layout and How To

- Select the desired Service Level for maintenance

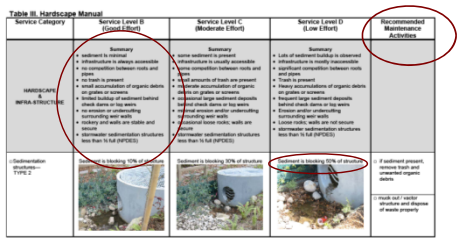


Table III. Hardscape Manual

Service Category	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Low Effort)	Recommended Maintenance Activities
HARDSCAPE & INFRASTRUCTURE	Summary • sediment is minimal • infrastructure is always accessible • no competition between roots and pipes • no trash is present • Minimal accumulations of organic debris on grates or screens • limited buildup of sediment behind check dams or log weirs • no erosion or undercutting surrounding weir walls • rockery and walls are stable and secure • stormwater sedimentation structures less than ½ full (NPDES)	Summary • some sediment is present • infrastructure is usually accessible • some competition between roots and pipes • small amounts of trash are present • Moderate accumulations of organic debris on grates or screens • occasional large sediment deposits behind check dams or log weirs • minimal erosion and/or undercutting surrounding weir walls • occasional loose rocks; walls are secure • stormwater sedimentation structures less than ½ full (NPDES)	Summary • Lots of sediment buildup is observed • infrastructure is mostly inaccessible • significant competition between roots and pipes • Trash is present • Significant accumulations of organic debris on grates or screens • frequent large sediment deposits behind check dams or log weirs • Erosion and/or undercutting surrounding weir walls • Loose rocks; walls are not secure • stormwater sedimentation structures less than ½ full (NPDES)	
○Sedimentation structures— TYPE 2	Sediment is blocking 10% of structure	Sediment is blocking 30% of structure	Sediment is blocking 50% of structure	○ If sediment present, remove trash and unwanted organic debris ○ muck out / vactor structure and dispose of waste properly

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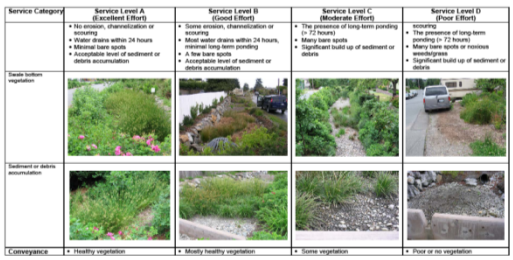
Ease of Use



Service Category	Service Level A (Excellent Effort)	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Poor Effort)
	• No erosion, channelization or scouring • Water drains within 24 hours • Minimal bare spots • Acceptable level of sediment or debris accumulation	• Some erosion, channelization or scouring • Most water drains within 24 hours, minimal long-term ponding • A few bare spots • Acceptable level of sediment or debris accumulation	• The presence of long-term ponding (> 72 hours) • Many bare spots • Significant build up of sediment or debris	• scouring • The presence of long-term ponding (> 72 hours) • Many bare spots or noxious weeds/grass • Significant build up of sediment or debris
Swale bottom vegetation				
Sediment or debris accumulation				
Conveyance	• Healthy vegetation	• Mostly healthy vegetation	• Some vegetation	• Poor or no vegetation

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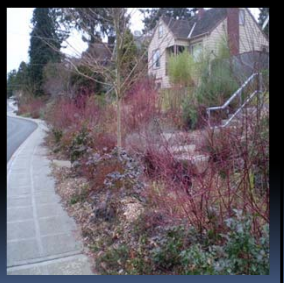
1-Vegetation and Landscape Maintenance

- **Inspection/checklist**
- Vegetation is mostly healthy
- Good appearance
- Small quantities of weeds
- Edges are loosely defined
- Grass encroaching on the swale (or vice versa)

Levels of Service B - Good

Levels of Service B - Good

- **Inspection/checklist**
- Plants growing onto the street or sidewalk
- Mulch is present with occasional bare spots
- Erosion is likely unless maintenance is improved
- Some shoulder compaction adjacent to the swale
- Plant palette is mostly working for the facility



Noxious and Nuisance Weeds

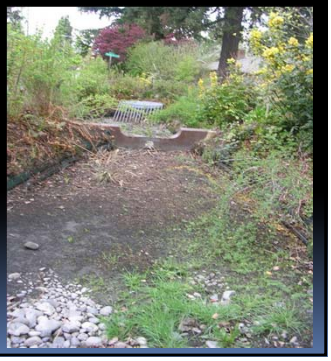
- Special considerations need to be identified
- Provide link to jurisdiction's web site
- Photos
- Identification key
- Reporting requirements – *if applicable*

Spotted Knapweed

2-System Functionality

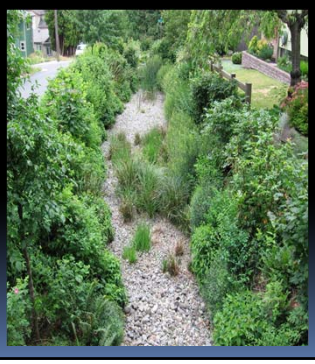
- Bioretention
- Biofiltration
- Bioretention and biofiltration
- Vegetation, soils, and substrate

Level of Service D



Inspection/checklist LOS C

- Bioretention and or biofiltration
  - for vegetation, soils and substrate
- 40% to 60% bottom covered
- Healthy vegetation
- Uniformed fine-stemmed at least 18 to 24 inches high



Continued….

- Soil is compacted
- Evidence of vehicle compaction
- Ponded water takes at least 72 hours to drain
- Many bare spots
- Significant level of sediment and debris accumulation

3-Hardscape and Infra-Structure

- Debris and sediment removal
- Clearing and cleaning

Hardscape and Infra-Structure – Long Term Maintenance

- Every fifteen years
- Remove and replace top two inches of sediment
- Prevent swale clogging
- Maintains infiltration rates

All Levels of Service-Meet permit requirements

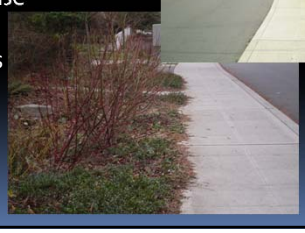
- Stormwater sedimentation structures are less than ½ full or in accordance with NPDES requirements

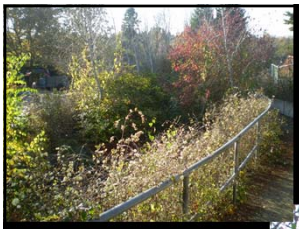
4-Infiltration Failure

- Evidence of a cell holding water for more than 24 hours needs to be reported
- Operations and Maintenance Asset Manager
- Monitor swale for ponding water
- Retrofit swale

5-Recommended Maintenance for Other Elements

- Pest control
- Spill prevention and response
- Permeable pavements
- Irrigation systems





Section 6: Safety

Accessibility

ADA

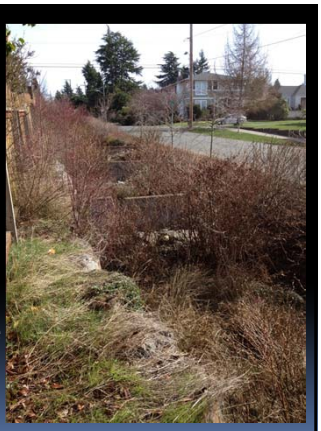
Right plant for right place

Simplified plant pallet

Maintenance access

Checklists

- Condensed version of manual
- Developed for each section of the manual
- Reduce maintenance activities to a summary
- Eliminate photos
- Identify key performance indicators
  - monitoring and reporting



Key Performance Indicators (KPI's)

- Data includes
  - Project location
  - Drainage area
  - Maintenance target
  - Reporting of maintenance LOS achieved
- Provides
  - Accountability
  - Reporting method
- Excellent asset management tool for management

NDS KPI Reporting Form
URM Urban Watersheds

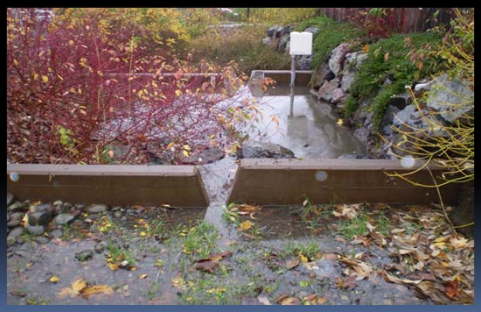
O&M Estimating Database Tool- Vegetation

- Inputs:
  - Level of Service
  - sq footage
  - discount rate
  - establishment time
  - Life of project
  - replacement frequency
- Outputs
  - Mowing for grass lined swales
  - Plant maintenance inspection including litter and minor weed removal
  - Watering
  - Mulching *above ordinary high water mark*
  - Replacement cost (15yr)

Vegetation Estimated O&M Costs

LOS B – 47,290 SQ FT	Total Present Value	Annual Value
Initial 3 year Landscape Establishment		
assuming 0% community participation	$177,614	$65,221
Established (starting year 4)		
0% community participation	$562,228	$28,615
25% community participation	$421,671	$21,461
50% community participation	$281,114	$14,308
75% community participation	$140,557	$7,154
90% community participation	$56,223	$2,862
Soil Replacement (every 15yrs)	$466,952	$23,527

Life Cycle Costs



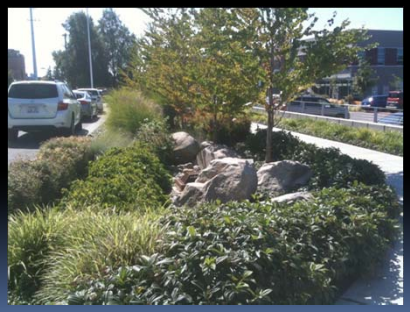
Life Cycle Costs - Pinehurst

- Present value of O&M + construction costs
- LCC for Pinehurst (47,290 ft²)
  - $1.2M+ $5.2M = $6.4M
- Initial estimates
  - $4.8 million construction cost
- Comparable project to retrofit $8.9 million
- Total project cost 453K for 660 ft blk
  - Includes all design, project management, const. cost
- Present value of O&M costs compared to traditional systems is significantly less

Construction Costs

- $280,000 for 660' block
- 42% Stormwater elements (including soil)
- 45% Street improvements (road, curb, sidewalk)
- 13% Landscaping

Maintenance Costs



Total Maintenance Cost

- Total $$ = Vegetation + Hardscape
- Initial Vegetation – 3 years
  - SPU cost: $2.21
  - Watering method and frequency increase cost up to 4X
- Established Vegetation – 4 plus
  - SPU cost: $1.66
  - 25% reduction
- Replacement costs - $0.50 per sq. ft.
- Hardscape - $0.31 per sq. ft.

SPU – Field Operations and Maintenance Estimated Costs

	HC	SW	LA	Other	Cost per SF
Complex - A	36	12	23	1	$3.54
Simple - A	15	3	12	0	$2.86
Complex - B	29	12	17	1	$2.87
Simple - B	15	2	12	0	$2.90
Complex - C	30	12	17	1	$2.94
Simple - C	15	2	13	0	$2.94
*197 sites					

Additional tools and resources

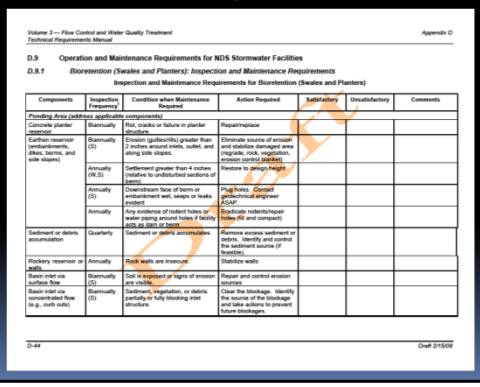
Porous Pavement

- SPU porous pavement spec
- Inspector and installer checklists
- BMP's
- Levels of services
- Frequency schedule & method
- Standardized infiltration testing
- Recommended maintenance activities
- Technical Report -available

Client Assistance Memo's

- Mostly for Private Facilities
- Post Construction Soil Management
- Bioretention Cells (Rain Gardens)
- Permeable Pavement Surfaces and Facilities
- Tree Planting
- Green Roofs
- Bioretention Planters

Private Property O&M



Volume 3 — Flow Control and Water Quality Treatment
Technical Requirements Manual

Appendix D

D.9 Operation and Maintenance Requirements for NDS Stormwater Facilities

D.9.1 *Bioretention (Swales and Planters): Inspection and Maintenance Requirements*

Inspection and Maintenance Requirements for Bioretention (Swales and Planters)

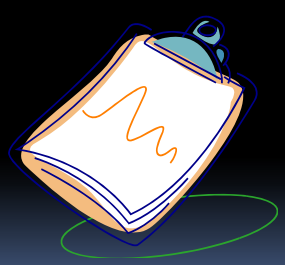
Components	Inspection Frequency	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Ponding Area (address applicable components)						
Concrete planter reservoir	Biannually	Rot, cracks or failure in planter structure.	Repair/replace			
Earthen reservoir (embankments, dikes, berms, and side slopes)	Biannually (S)	Erosion (gullies>6in) greater than 2 inches around inlets, outlet, and along side slopes.	Eliminate source of erosion and stabilize damaged area (regrade, rock, vegetation, erosion control blanket)			
	Annually (W,S)	Settlement greater than 4 inches (relative to undisturbed sections of berm)	Restore to design height			
	Annually (S)	Downstream face of berm or embankment wet, seeps or leaks evident	Plug holes. Contact geotechnical engineer ASAP			
	Annually	Any evidence of rodent holes or water piping around holes if facility acts as dam or berm	Eradicate rodents/repair holes (fill and compact)			
Sediment or debris accumulation	Quarterly	Sediment or debris accumulates.	Remove excess sediment or debris. Identify and control the sediment source (if feasible)			
Rockery reservoir or walls	Annually	Rock walls are insecure	Stabilize walls			
Basin inlet via surface flow	Biannually (S)	Soil is exposed or signs of erosion are visible	Repair and control erosion sources.			
Basin inlet via concentrated flow (e.g., curb cuts)	Biannually (S)	Sediment, vegetation, or debris partially or fully blocking inlet structure.	Clear the blockage. Identify the source of the blockage and take actions to prevent future blockages.			

D-44

Draft 2/15/08

ROW Facilities - documentation

- Construction and installation checklist
- Plan review checklist for bioretention
- Plan review checklist for permeable pavements
- GSI Restoration and Repair Manual



SPU Specifications:

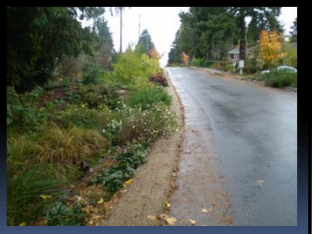
- Bioretention infiltration testing
- Porous pavement infiltration testing
- Bioretention soil
- Permeable/porous pavement
- Weir installation

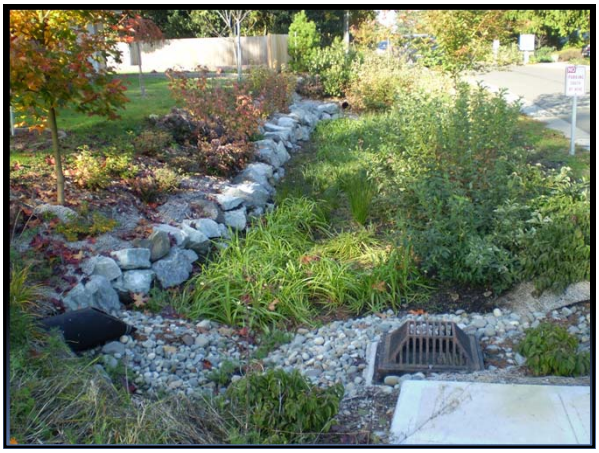
Inspection Processes and Protocols

Successful liner installation

Evolving Systems

- Work, work, work with field or contracting crews
- Update photos to continue refining doc.
- Document learned
- Include BMP's

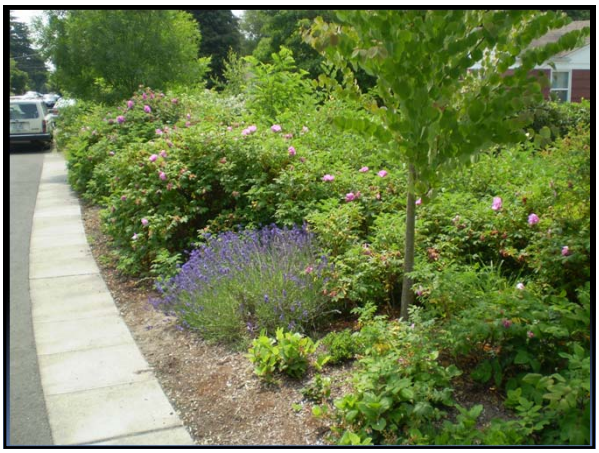





Minimal maintenance – Functioning system
•Erosion control during plant establishment (3yr)
•Tree canopy (leaf litter)
•Plant pallet (bushes shade swale bottom)


•Planting season
•Plants available
•Interim?


Maintenance can be overwhelming

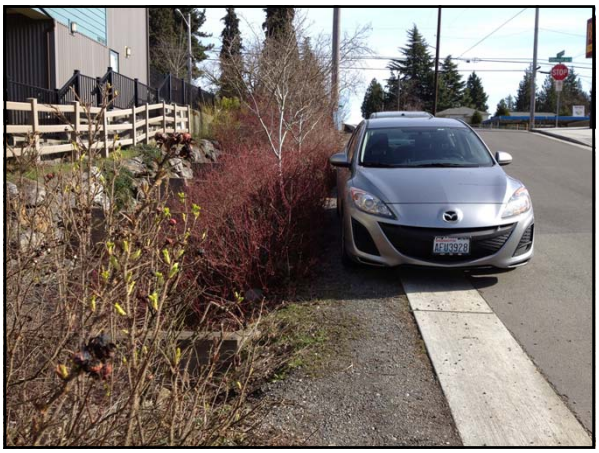



Acceptable? Still functions


•Invasives
•Aesthetically unpleasing
•Neighborhood nuisance
•Still functions


Street edge parking?
Erosion
Compaction


•Street Edge
•Parking
•Access to vehicle
•Erosion control
•Vegetation/bushes
•Rock?
•Vegetation/ground cover?
•sheet flow
•Mulch?




www.seattle.gov/util/naturalsystems