INSTRUCTORS

REBECCA DUGOPOLSKI, PE
Senior Engineer
Key project experience: Stormwater monitoring, design, and NPDES Permit compliance

KATE FORESTER
Environmental Designer
Key project experience: Stormwater design, maintenance, and manual development

PROGRAM OVERVIEW

• 2012: Public and private partners engage state legislature to fund program
• June 2012: LID Training Steering Committee convened
• 2012-2013: Washington State LID Training Plan developed: www.wastormwaterscenter.org/statewide-lid-training-program-plan
• 2014: Training program built from state LID Training Plan.
**Statewide LID Training Program**

**PROGRAM OVERVIEW**

- Implement first phase of trainings (September 2014 through May 2015)
- 49 trainings offered in western and eastern WA first year
- 45 trainings scheduled for western and eastern WA in current phase (through June 2016)
- Three levels: Introductory, Intermediate, and Advanced
- Statewide LID Certificate now available

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**OVERVIEW OF PROGRAM**

<table>
<thead>
<tr>
<th>PROJECT LEAD</th>
<th>CORE TEAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>HERRERA</td>
<td>CASCAPIA</td>
</tr>
</tbody>
</table>

**ADDITIONAL TRAINING SUPPORT**

- CH2M HILL
- SEE/SOR CENTERS
- Kindred Hydro
- MITHUN

---

**OVERVIEW OF PROGRAM**

<table>
<thead>
<tr>
<th>INTRODUCTORY</th>
<th>INTERMEDIATE</th>
<th>ADVANCED</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>3.1</td>
<td>5.6</td>
</tr>
<tr>
<td>2.1</td>
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<td>5.7</td>
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<td>2.2</td>
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<td>5.9</td>
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<tr>
<td>2.2</td>
<td>3.5</td>
<td>5.10</td>
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<tr>
<td>2.2</td>
<td>3.6</td>
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</tbody>
</table>

- Advanced Topics for Long-term LID Operations: Bioretention
- Advanced Topics in LID Design: Permeable Pavement
- Advanced Topics in LID Design: Hydrologic Modeling
- Advanced Topics in LID Design: Site Assessment, Planning & Layout
- Advanced Topics in LID Design: Media and Compost, Amended Soils
LEARNING OBJECTIVES

1. Participants will gain a basic understanding of inspection and maintenance activities associated with LID BMPs.
2. Identify priority elements when conducting inspections for LID facilities
3. Identify and understand the most common problems and associated solutions related to maintaining LID BMPs

INTRODUCTION

TOPICS

Intro to LID
NPDES Permit
LOW IMPACT DEVELOPMENT (LID): Stormwater Management Strategy

- Site design & planning techniques emphasizing conservation
- Use of small-scale engineered and non-engineered controls to closely mimic pre-development hydrologic processes

LID Principles: Pre-developed Forest

LID Principles: Developed Condition
**LID Principles: Site Design And Planning**

- Minimize disturbance
- Reduce impervious surface
- Protect and restore native soils and vegetation
- Manage stormwater close to the source

**LID BMPs: Small-Scale Engineering Controls**

- Infiltration
- Filtration
- Storage
- Evaporation
- Transpiration

Conserves or regains pre-developed hydrologic functions

**TOPICS**

- Intro to LID
- NPOES Permit
NPDES PERMIT REQUIREMENTS

National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permits

<table>
<thead>
<tr>
<th>Municipal Stormwater Permittees in Washington State</th>
<th>Western Washington Phase II Permittees</th>
<th>Eastern Washington Phase II Permittees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I Permittees</td>
<td>82 Cities</td>
<td>18 Cities</td>
</tr>
<tr>
<td>Seattle</td>
<td>5 Counties</td>
<td>5 Counties</td>
</tr>
<tr>
<td>Tacoma</td>
<td></td>
<td></td>
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<tr>
<td>Clark County</td>
<td></td>
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</tr>
<tr>
<td>King County</td>
<td></td>
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<tr>
<td>Pierce County</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snohomish County</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary Permittees: Approximately 45; such as ports and universities</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To see a listing of permittees visit http://www.ecy.wa.gov/programs/wq/stormwater/municipal/MuniStrmWtrPermList.html

NPDES PERMIT REQUIREMENTS:
Requirements Vary By Permittee

- Phase II requirements are somewhat less extensive
- Secondary permittee requirements vary

Timeline for updating maintenance standards

<table>
<thead>
<tr>
<th>Phase I</th>
<th>Phase II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Section S5.C.5.a of the Phase I Permit</td>
<td>Per Section S5.C.5.a of the Phase II Permit</td>
</tr>
<tr>
<td>June 2014</td>
<td>June 30, 2015</td>
</tr>
<tr>
<td>June 30, 2017</td>
<td>June 30, 2018</td>
</tr>
</tbody>
</table>

NPDES PERMIT REQUIREMENTS:
Requirements Vary By BMP Classification

- On-site Stormwater Management BMPs
- Stormwater Treatment and Flow Control BMPs/Facilities
NPDES PERMIT REQUIREMENTS: Minimum Requirements (MRs)

1. Preparation of Stormwater Site Plans
2. Construction SWPPP
3. Source Control
4. Preserve natural Drainage
5. On-Site Stormwater management
6. Run-off Treatment
7. Flow Control
8. Wetlands Protection
9. O&M

NPDES PERMIT LID O&M REQUIREMENTS: Minimum Requirements (MRs)

- MR #2 – Construction Stormwater Pollution Prevention Plan (SWPPP)
  - Protect LID BMPs from sediment and compaction
- MR #5 – On-site Stormwater Management
  - Infiltrate, disperse, and retain runoff on-site to the extent feasible

NPDES PERMIT REQUIREMENTS: Minimum Requirements (MRs)

- MR #6 – Runoff Treatment
  - Water quality treatment for pollution-generating areas
- MR #7 – Flow Control
  - Control of flow peaks and flow durations
INTRODUCTION
NPDES PERMIT REQUIREMENTS: On-site Stormwater Management BMPs

• Used to help meet MR #5

• May be used to help meet MR #6 and/or MR #7

• "On-site Stormwater Management BMPs"= LID BMPs

INTRODUCTION
NPDES PERMIT REQUIREMENTS: On-site Stormwater Management BMPs

Includes the following LID BMPs:

• Rain Gardens (BMP T5.14A)
• Bioretention (BMP T5.14B)
• Permeable Pavement (BMP T5.15)
• Vegetated Roofs (BMP T5.17)
• Full Dispersion (BMP T5.30)

INTRODUCTION
NPDES PERMIT REQUIREMENTS: Treatment and Flow Control BMPs/Facilities

• Subset of On-site Stormwater Management BMPs

• Used to meet MR #6 or MR #7

• May also be used to meet MR #5

• Includes the following BMPs:

  • Bioretention (BMP T5.14B)
  • Permeable Pavement (BMP T5.15)
  • Vegetated Roofs (BMP T5.17)

  • Detention facilities
  • Standard Infiltration facilities
  • Treatment BMPs/facilities
LID O&M overview

NPDES PERMIT LID O&M REQUIREMENTS:
O&M Standards

<table>
<thead>
<tr>
<th>Requirement</th>
<th>On-site SW Management BMPs</th>
<th>SW Treatment &amp; Flow Control BMPs/Facilities (MR #6 and/or MR #7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implement maintenance standards</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Adopt or update ordinance or other enforceable documents</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Implement practices, policies, &amp; procedures to reduce SW impacts associated with runoff</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

NPDES PERMIT LID O&M REQUIREMENTS:
Plan Review

<table>
<thead>
<tr>
<th>Requirement</th>
<th>On-site SW Management BMPs</th>
<th>SW Treatment &amp; Flow Control BMPs/Facilities (MR #6 and/or MR #7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verify maintenance plan completed &amp; O&amp;M responsibility assigned</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Verify submission of maintenance instructions</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Verify that O&amp;M manual is complete</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Review and approve declaration of covenant (including design details, figures and maintenance instructions) and grant of easement</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
NPDES PERMIT LID O&M REQUIREMENTS: Inspection

<table>
<thead>
<tr>
<th>Requirement</th>
<th>On-site SW Management BMPs</th>
<th>SW Treatment &amp; Flow Control BMPs/Facilities (MR #6 and/or MR #7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legal authority to inspect private stormwater facilities and enforce maintenance standards</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Conduct post-construction inspections to ensure proper installation</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Statewide LID Training Program  
INSPECTION & MAINTENANCE STAFF  
INTRODUCTION TO LID #

NPDES PERMIT LID O&M REQUIREMENTS: Inspection (continued)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>On-site SW Management BMPs</th>
<th>SW Treatment &amp; Flow Control BMPs/Facilities (MR #6 and/or MR #7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct inspections during construction in new residential developments*</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Conduct ongoing annual inspections</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Perform spot checks for potentially damaged BMPs owned/operated by Permittee after major storm events</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

*Every 6 months until 90% of the lots are constructed or when construction is stopped and the site is fully stabilized

Statewide LID Training Program  
INSPECTION & MAINTENANCE STAFF  
INTRODUCTION TO LID #

NPDES PERMIT LID O&M REQUIREMENTS: Enforcement

<table>
<thead>
<tr>
<th>Requirement</th>
<th>On-site SW Management BMPs</th>
<th>SW Treatment &amp; Flow Control BMPs/Facilities (MR #6 and/or MR #7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enforce compliance with maintenance standards, as needed, based on inspection</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Statewide LID Training Program  
INSPECTION & MAINTENANCE STAFF  
INTRODUCTION TO LID #
**NPDES PERMIT LID O&M REQUIREMENTS: Training**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>On-site SW Management BMPs</th>
<th>SW Treatment &amp; Flow Control BMPs/Facilities (MR #6 and/or MR #7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train staff involved in plan review, permitting, construction site inspections, &amp; enforcement</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Implement an ongoing training program for employees who have primary O&amp;M job functions that may impact SW quality</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**NPDES PERMIT LID O&M REQUIREMENTS: Record Keeping**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>On-site SW Management BMPs</th>
<th>SW Treatment &amp; Flow Control BMPs/Facilities (MR #6 and/or MR #7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keep records of inspections and enforcement actions (e.g., inspection reports, notices of violations)</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**NPDES PERMIT LID O&M REQUIREMENTS: Mapping**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>On-site SW Management BMPs</th>
<th>SW Treatment &amp; Flow Control BMPs/Facilities (MR #6 and/or MR #7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale drawing of the lot(s) and public ROW that show BMP locations</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Map BMPs owned/operated by Permittee</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Map connections between BMPs and tributary conveyances*</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

*Phase I Only
LID O&M GUIDANCE DOCUMENT: Objective

• Support permittees in implementing LID maintenance programs

• Provide specific O&M guidance so permittees can create maintenance standards that preserve facility function

• Note: Jurisdictions may want to tailor the tables in the O&M guidance document to address varying levels-of-service

LID O&M GUIDANCE DOCUMENT: Development

• Two advisory committees
  - LID Maintenance Advisory Committee
  - LID Maintenance Administrative Issues Advisory Committee

• Best available information
  - Advisory committee input
  - Literature review
  - Targeted surveys sent to jurisdictions, contractors/landscapers, and vendors

• Guidance will evolve over time

LID O&M GUIDANCE DOCUMENT: Overview

• Summary of NPDES Permit Requirements

• Maintaining LID BMPs
  - Bioretention facilities
  - Rain gardens
  - Permeable pavement
  - Vegetated roofs
  - Downspout infiltration systems
  - Downspout, sheet flow, and concentrated dispersion systems
  - Compost-amended soils

• Programmatic & Administrative Guidance
LID O&M GUIDANCE DOCUMENT: Overview

- BMP description
  - How water moves through facility
- Key maintenance considerations to ensure facility function
  - Function by BMP component
  - Key maintenance by BMP component
- Key operations to preserve facility function

Photo courtesy of Seattle Public Utilities

LID O&M GUIDANCE: Overview

- Maintenance standards and procedures

LID O&M GUIDANCE: Overview

- Equipment and material list

Table 4. Miscellaneous Equipment and Materials List:

- Landscaping equipment
  - Shovel
  - Rake
  - Sprayer
- Tools
  - Wrench
  - Drill
- Filters
  - Water
- Maintenance
  - Brushes
- Miscellaneous
  - Hose
- Insects
  - Pest control
LID O&M GUIDANCE: Overview

- Skills and Staffing
  - List of general skills required
  - List of additional specialized skills
  - Staffing survey estimates (e.g., crew hours per facility, per linear foot, or per square foot)

Skills Needed for Maintenance of Bioretention Facilities

- Landscaping skills (e.g., general plant care)
- Plant identification skills (weeds vs. planted species, invasive vs. common weeds)
- How to dispose of invasive weeds, timing of weed seed dispersal
- Erosion control knowledge
- General drainage system maintenance skills (e.g., weirs/pipe/underdrain cleaning experience)

Statewide LID Training Program | INSPECTION & MAINTENANCE STAFF
INTRODUCTION TO LID

1. Introduction
2. LID O&M Overview
3. BMP Specifics
4. Administrative Tools
5. Wrap Up

1. Dispersion
2. Infiltration
3. Compost-Amended Soils
4. Bioretention
5. Trees
6. Permeable Paving
7. Vegetated Roofs
BMP SPECIFICS – DISPERSION

DEFINITION AND TYPES

- Vegetated areas that collect runoff from impervious surfaces
- Restores the natural drainage patterns of sheet flow and infiltration

Types:
- Downspout dispersion
- Concentrated flow dispersion
- Sheet flow dispersion

BMP SPECIFICS – DISPERSION

COMPONENTS: Downspout Dispersion

- Splash block
- Dispersal area
COMPONENTS: Downspout Dispersion

- Dispersion trench
- Dispersal area

COMPONENTS: Sheet Flow and Concentrated Flow Dispersion

Sheet Flow Dispersion
- Transition zone
- Dispersal area

Concentrated Flow Dispersion
- Rock pad at discharge point
- Dispersal area

MAINTENANCE PROCEDURES: Dispersion

Splash Block
- Reconfigure/repair blocks to direct water away from building structure
- Reconfigure/repair blocks to prevent water from disrupting soil media

Dispersal Area
- Investigate cause of erosion (gullies/rills) greater than 2 inches deep
- Remove accumulated sediment or debris blocking or channelizing flow path
- Investigate cause of standing water (e.g., grade depressions, compacted soil) that persists for more than 3 days after the end of a storm event
MAINTENANCE PROCEDURES: Dispersion

Dispersion Trench
- Remove/dispose of accumulated trash, debris, or sediment on drain rock
- Remove/dispose of vegetation/moss present on drain rock
- Repair/seal/replace cracked, collapsed, broken, or misaligned drain pipes
- Remove/dispose of sediment in the sump
- Repair/replace stuck, buried, or missing access lid cover

Rock Pad
- Add additional rock if only one layer of rock exists, exposed soil is present, or soil erosion is occurring

DEFINITION AND TYPES

- Trench or drywell designs intended only for use in infiltrating runoff from roof downspout drains
- Types:
  - Downspout full infiltration (infiltration trenches or drywells)
COMPONENTS: Downspout Full Infiltration

- Rock trench/well
- Inlet
- Storage sump

MAINTENANCE PROCEDURES: Infiltration

Rock Trench/Well
- Remove/dispose of accumulated trash, debris, or sediment on drain rock
- Remove/dispose of vegetation/moss present on drain rock

Inlet/Outlet Pipe(s)
- Remove/dispose of accumulated trash, debris, or sediment
- Clear accumulated sediment from inlet/outlet pipe and screen
- Repair/seal/replace cracked, collapsed, broken, or misaligned drain pipes

Roof Downspout
- Repair/replace missing or damaged splash pad
- Remove/dispose of leaves or debris plugging downspout

Storage Sump
- Remove/dispose of sediment in the sump
- Repair/replace stuck, buried, or missing access lid cover
**BMP SPECIFICS – COMPOST-AMENDED SOILS**

**DEFINITION**

- Soil/landscape system with adequate depth, permeability, and organic matter
- Retains native soil functionality in a post-development landscape

**MAINTENANCE PROCEDURES**

Soil Media (maintain high organic soil content)
- Maintain 2 to 3 inches of mulch over bare areas
- Return leaf fall and shredded woody materials when possible
- "Grasscycle" (mulch mow or leave clippings) to build turf health

Soil Media (maintain infiltration)
- Aerate soil
- Aerate compacted areas and top-dress with ¼ to ½ inch of compost (turf)
MAINTENANCE PROCEDURES

Erosion/Scouring
- Identify and address cause of erosion and stabilize damaged area

Grass/Vegetation
- Remove/replace unhealthy plants

Weeds
- Remove weeds manually (pincer-type weeding tools, flame weeders, or hot water weeders)
- Remove and dispose of noxious weeds properly

OVERVIEW: Definition and Types
- Shallow landscaped depressions that receive stormwater from small contributing areas
- Small scale, dispersed facilities
- Types:
  - Bioretention cells
  - Bioretention swales
  - Infiltration planters
  - Flow-through planters
COMPONENTS

- Flow Entrance
- Pre-Settling
- Ponding Area
- Bioretention Soil
- Mulch/Compost
- Vegetation
- Filter Fabric (?)
- Liner (optional)
- Underdrain (optional)
- Overflow

HOW THE FACILITY WORKS

Bioretention cell
- Water enters facility
- Ponds
- Infiltrates through bioretention soil/gravel bed
- Infiltrates into underlying soil
- Ponded water exceeding max. depth overflows

Bioretention Planter
- Water enters facility
- Ponds
- Infiltrates through bioretention soil/gravel bed
- Infiltrates into underlying soil
- Ponded water exceeding max. depth overflows
**HOW THE FACILITY WORKS**

**Bioretention Planter**
- Water enters facility
- Ponds
- Infiltrates through bioretention soil/gravel bed
- Infiltrates into underlying soil
- Ponded water exceeding max. depth overflows
- Underdrain collects water in gravel layer and routes to overflow

---

**BIORETENTION VS RAIN GARDENS**

<table>
<thead>
<tr>
<th>Structures/Underdrains</th>
<th>Rain Garden</th>
<th>Bioretention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Designed</td>
<td>Designed</td>
</tr>
<tr>
<td>No</td>
<td>Soil mixes</td>
<td>Soil mixes</td>
</tr>
<tr>
<td>Less restrictive</td>
<td></td>
<td>Less restrictive</td>
</tr>
</tbody>
</table>

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**MAINTENANCE STANDARDS & PROCEDURES BY COMPONENT**

- Inlets
- Ponding area
- Check dams/weirs
- Bioretention soil
- Outlets
- Underdrains
- Mulch

---
INLETS: Types

- Sheet flow from sidewalk and roadway
- Sheet flow from parking lot

- Curb cut
- Curb cut with grate

- Trench drain from roadway
- Trench drain from upslope BMP
INLETS: Types

- Piped inlet from roadway/parking lot
- Piped inlet from upslope BMP

INLETS: Maintenance Considerations

- Stormwater must freely enter facility (no obstructions)
- Water entering facility should not cause erosion

INLETS: Maintenance

- Maintain erosion control at concentrated flow inlets (e.g., rock pad)
- Ensure pipe is not damaged or clogged
INLETS: Maintenance

- Remove accumulated sediment, debris, leaves
- Clear/move vegetation inhibiting flow into facility

PONDING AREA: Types

- Earthen depression
- Rockery walls
- In ground concrete planter
- Aboveground metal planter
PONDING AREA: Maintenance Considerations

- Ponding area provides temporary surface storage before infiltration
- Must infiltrate within 48 hour “drawdown” time after the end of a storm
  - Restores hydraulic capacity of system
  - Prevent mosquito breeding conditions

PONDING AREA: Maintenance

Integrity
- Concrete or metal planter: ensure integrity (e.g., cracks, leaks)
- Rockery: ensure rockery sidewalls are secure
- Earthen side slopes/berms:
  - Erosion: stabilize and address cause of erosion, if feasible
  - Settlement: restore to design height
  - Leaks/seeps on face of berm: repair/compact

PONDING AREA: Maintenance

Material Accumulation
- Remove trash and debris
- Remove leaves if impacting facility function
- Accumulated sediment to extent that infiltration rate is reduced (see “excessive ponded water”) or storage capacity reduced
  - Remove excess sediment
  - Replace any vegetation damaged or destroyed by sediment accumulation and removal
  - Identify and control the sediment source, if feasible
PONDING AREA: Maintenance

Excessive Ponded Water

- Overflow during small storms or
- Does not fully infiltrate within 48 hours of end of storm
  - Determine cause:
    - Leaves/debris in bottom impeding infiltration?
    - Underdrain, if present, is clogged?
    - Water inputs (e.g., groundwater, illicit connections)
    - Verify sized for contributing area (and area has not increased)
  - If Steps 1-4 do not solve problem: bioretention soil is likely clogged
    - Consult with an engineer or facility designer (May need to remove/replace bioretention soil)

CHECK DAMS/WEIRS: Purpose

- Provides ponding on sloped facilities
- Provides detention/some water quality (settling)

CHECK DAMS/WEIRS: Types

Concrete

**CHECK DAMS/WEIRS: Types**

- Log/wooden
- Gravel
- Earthen

**CHECK DAMS/WEIRS: Maintenance**

- Remove accumulated sediment, debris, leaves blocking/or with potential to block flow
- Repair any erosion/undercutting and take preventative measures

**BIORETENTION SOIL: Maintenance**

- Infiltration through soil mix provides water quality treatment
- Stormwater must infiltrate freely into bioretention soil
- Infiltration rate may be reduced by compaction or clogging with fine sediment
**BIORETENTION SOIL: Maintenance**

- Remove and replace if clogged (see "excessive ponded water")
- Minimize loading in cell to protect bioretention soil from compaction during maintenance
  - Never drive equipment or apply heavy loads in facility footprint
  - Minimize any loading to cell during wet conditions
  - Consider measures to distribute loading if heavy foot traffic is required or equipment must be placed in facility (e.g., boards to distribute loads)

**OUTLETS: Types and Maintenance Considerations**

- Stormwater must freely exit facility once capacity exceeded (above maximum ponding depth)
- Overflows must be conveyed to safe discharge point (e.g., storm drain system)

**OUTLETS: Maintenance**

- Remove accumulated sediment, debris, leaves at outlet/grate/trash rack
- Clear/move vegetation within 1 foot of outlet to maintain access
- Clear pipes of accumulated material
UNDERDRAINS: Types
- Perforated or slotted pipe wrapped in an aggregate blanket (or filter fabric)
- May have flow restrictor (e.g., orifice) to detain flow
- Can be included to collect treated water under the bioretention soil (e.g., where infiltration to native soil is not feasible)

UNDERDRAINS: Maintenance
- Prolonged surface ponding
  - Jet clean or rotary cut debris/roots from underdrain
  - If equipped with flow restrictor (orifice), clean regularly

VEGETATION: Maintenance Considerations
- Grasses, shrubs and trees:
  - Intercepts rain before it hits the soil and facilitates evaporation
  - Uptakes water from the soil and transpires it to the atmosphere
  - Improve soil structure and increases infiltration capacity
  - Promotes water quality treatment
VEGETATION: General Maintenance

- Determine cause of poor vegetation growth and establishment and replant as necessary to obtain 75% or greater survival rate.
- Identify issues and if necessary, remove and dispose of diseased plants or plant parts.
- Replace dead vegetation within 30 days of reported dead and dying plants (as practical depending on weather and planting season).

Bare ground

VEGETATION: Emergent Vegetation & Grasses

Hand rake with small rake or fingers to remove dead foliage in spring or earlier only if foliage is blocking water flow.

- Emergent vegetation: Sedges and rushes do not like continuous pruning.
- Perennial ornamental grasses: Leave dry foliage for winter interest (e.g. switchgrass (Panicum) and Karl Forester grass (Calamagrostis acutiflora 'Karl Forester'))
- Evergreen ornamental grasses: Clean, rake, and comb grasses when they become too tall. Cut back to the ground or thin every 2 to 3 years.

VEGETATION: Weeds

- Follow IPM protocols for weed management.
- Remove weeds manually, with pincer-type weeding tools, flame weeders, or by other non-chemical means, as appropriate.
- By law, State listed Class A noxious weeds must be removed, bagged and disposed as garbage immediately.
- Requirements for removal of State listed Class B and C weeds varies by County.
VEGETATION: Excessive Vegetation

- Edge or trim groundcovers that grow beyond the facility edge onto sidewalks, paths, or street edges when they create pedestrian safety hazards or clog adjacent permeable pavement surfaces.

- Prune, trim, or if necessary, replace plants when vegetation density inhibits stormwater flow beyond design ponding or becomes a hazard for pedestrian and vehicular circulation and safety.

VEGETATION: Watering

3 Year Establishment Period

<table>
<thead>
<tr>
<th>Year</th>
<th>Irrigation Frequency</th>
<th>Trees</th>
<th>Shrubs</th>
<th>Groundcovers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer – Year 1</td>
<td>Once every 1-2 weeks or as needed during dry periods</td>
<td>10-15 gal</td>
<td>3-5 gal</td>
<td>2 gal/sf</td>
</tr>
<tr>
<td>Summer – Year 2 &amp; 3</td>
<td>Once every 2-4 weeks or as needed during dry periods</td>
<td>10-15 gal</td>
<td>3-5 gal</td>
<td>2 gal/sf</td>
</tr>
</tbody>
</table>

BMP SPECIFICS - BIORETENTION

- Irrigation after 3 year establishment period:
  - Trees may take up to 5 years to become fully established
  - Identify trigger mechanisms for drought stress of different species and water immediately after initial signs of stress appear
    - e.g., leaf wilt, flower and leaf drop, plants falling or leaning, sun scald, etc.
  - Water during drought conditions
Layer of mulch covers bioretention soil to:
- Reduce weed establishment
- Regulate soil temperatures and moisture
- Add organic matter to the soil

MULCH: Maintenance Considerations

- Supplement mulch with hand tools to a depth of 2 to 3 inches
- Replenish mulch per O&M guidance: Often coarse compost used in facility bottom and arborist wood chips on side slopes above typical water levels

No mulch and undefined edge
Hand apply mulch to avoid covering base of trees and shrubs
**HOW THEY WORK**

- Trees
- Planting Soil
- Structural Soil
- Drainage (Sand Base)
- Aeration Zone
- Sidewalk/Street
- Planter
- Compacted Subgrade

**MAINTENANCE PROCEDURES:** Pruning

- Prune trees at the right time of year
  - Deciduous trees: November – February
  - Hazardous trees should be pruned any time of the year to avoid risk or injury
  - Do not prune trees with thin bark in the summer to reduce sun scald injury (e.g., birch (Betula spp.), cherry (Prunus spp.), and crabapple (Malus spp.))
  - Pine (Pinus spp.) or Elm (Ulmus spp.): Do not prune May – October to reduce possible exposure to bark beetle (pine) or Dutch Elm Disease (elm)
  - Avoid pruning during spring growth flush

**MAINTENANCE PROCEDURES:** Watering

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Trees may take up to 5 years to become fully established
BMP SPECIFICS - TREES

MAINTENANCE PROCEDURES: Mulch

Hand apply mulch to avoid covering base of tree

DISPERSION

INfiltration

COMPOST - AMENDED SOILS

BIORETENTION

TREES

PERMEABLE PAVEMENT

VEGETATED ROOFS

TOPICS

• Types
• How the system works
• Maintenance considerations for facility function
• Routine maintenance activities
• Corrective maintenance activities

Sport Court in Seattle
**TYPES: Porous Asphalt**

- Flexible
- Similar to conventional asphalt, but fines < No. 30 sieve reduced
- Typically used for parking and light traffic loads; however, has been used for medium and heavy applications
- ~16% voids typical (2-3% for conventional)

**TYPES: Pervious Concrete**

- Rigid
- 1/4 to 5/8 round or crushed aggregate typical, portland cement, and admixtures (optional) to increase workability and strength
- 15 to 20% voids typical

**TYPES: Pavers**

- Flexible
- Capable of high vehicle loads. Used for lower speeds
- High-density concrete that interlock and transfer vertical loads to surrounding pavers
- 12% voids typical
**BMP SPECIFICS - PERMEABLE PAVEMENT**

**TYPES:** Plastic Grids

- Flexible
- Plastic grid filled with gravel or soil and planted with grass
- Capable of high vehicle loads. Used for lower speeds
- Highest percent voids

**HOW THE FACILITY WORKS**

- Inlets
- Outlets
- Slopes
MAINTENANCE CONSIDERATIONS FOR FACILITY FUNCTION

- Protect subgrade, aggregate base and wearing course from construction sediment
- Stabilize adjacent landscape areas
- Protect surface from material stockpiles

MAINTENANCE CONSIDERATIONS FOR FACILITY FUNCTION

- Modify snow management procedures
  - Skids and rollers
  - Sand minimally and remove ASAP
  - If possible, avoid sanding adjacent streets since tires will track it onto the permeable pavement
  - Avoid stockpiling snow on permeable pavement

ROUTINE AND CORRECTIVE MAINTENANCE BY COMPONENT

- Pavement surface
  - Asphalt and concrete
  - PICP and pavers
  - Gravel grid
  - Grass grid
- Adjacent landscaped areas
- Drains
**BMP SPECIFICS - PERMEABLE PAVEMENT**

**PAVEMENT SURFACE: Asphalt & Concrete**

- Routine maintenance (cleaning surface debris)
  - **Large areas**: vacuum sweep (regenerative air or high efficiency vacuum)
  - **Small areas**: walk behind vacuums, shop vacs, hand held pressure washer or power washer with rotating brushes
  - **Frequency**: 1-2 times annually or as determined by site conditions
  - Consult with equipment manufacturer/rep for optimum operation

- Corrective maintenance (clogged wearing course)
  - **Before**
  - **During**
  - **After**
  - Test the surface infiltration rate using ASTM C1701 (perform 1 test/installation but not < 1 test/2,500 sf)
  - ASTM C1701 results indicate an infiltration rate of 10 inches per hour or less
  - Corrective maintenance options include:
    - Pressure wash and vacuum system
    - Hand held pressure wash or power wash with rotating brushes
    - Pure vacuum sweeper (calibrated to not dislodge wearing course aggregate)
**BMP SPECIFICS - PERMEABLE PAVEMENT**

**PAVEMENT SURFACE: Asphalt & Concrete**

- **Moss (inhibits infiltration or presents slip safety hazard)**
  - Sidewalks: broom to remove moss in the summer when it is dry
  - Parking lots and roadways:
    - Pressure wash (hand held pressure washer or power washer with rotating brushes)
    - Vacuum sweep with brush
    - Combination of pressure washing and vacuum sweeping

**PAVEMENT SURFACE: Picp & Pavers**

- **Routine maintenance (cleaning surface debris)**
  - Large areas: vacuum sweep (regenerative air or high efficiency vacuum)
  - Small areas: walk behind vacuums, shop vacs
  - Frequency: 1-2 times annually or as determined by site conditions
  - Consult with equipment manufacturer/rep for optimum operation
  - Vacuum settings may have to be adjusted to prevent excess uptake of aggregate from paver openings or joints
  - Vacuum surface openings in dry weather to remove dry, encrusted sediment

**PAVEMENT SURFACE: Pervious Concrete**

- Major cracks or trip hazards and concrete spalling and raveling
  - Fill potholes or small cracks with patching mixes
  - Replace in-kind where feasible
  - Large cracks and settlement may require cutting and replacing the pavement section
  - Replacing porous asphalt with conventional asphalt is acceptable if it is a small percentage of the total facility area and does not impact the overall facility function
PAVEMENT SURFACE: PICP & Pavers

- Corrective maintenance (clogged wearing course)
  - Review overall performance of the facility
  - If water ponds or flows off pavement surface during rain event, corrective maintenance or testing is needed
  - Test the surface infiltration rate using ASTM C1701 (perform 1 test/installation but not < 1 test/2,500 sf)

PAVEMENT SURFACE: PICP & Pavers

- Corrective maintenance (clogged wearing course)
  - ASTM C1701 results indicate an infiltration rate of 10 inches per hour or less
  - Corrective maintenance options include:
    - Pure vacuum sweeper
    - Pressure wash and vacuum system calibrated to remove all visible sediment in the joints or infiltration cells
    - Replace aggregate in joints or infiltration cells per manufacturer specifications

PAVEMENT SURFACE: PICP & Pavers

- Structural integrity
  - Loss of aggregate material between paver blocks: Refill per manufacturer’s recommendations
  - Paver block missing or damaged: Remove individual damaged paver blocks by hand and replace or repair per manufacturer’s recommendations
  - Surface settling: May require resetting
**PAVEMENT SURFACE: PICP & Pavers**

- Moss
  - Sidewalks: broom to remove moss in the summer when it is dry
  - Parking lots and roadways:
    - Vacuum sweep
    - Stiff broom/power brush

**PAVEMENT SURFACE: Gravel Grid**

- Routine maintenance (cleaning surface debris)
  - Large areas: vacuum sweep (regenerative air or high efficiency vacuum)
  - Small areas: walk behind vacuums, shop vacs, rake, leaf blower
  - Frequency: 1-2 times annually or as determined by site conditions
  - Consult with equipment manufacturer/rep for optimum operation
  - Vacuum settings may have to be adjusted to prevent excess uptake of aggregate from paver openings or joints
  - Vacuum surface openings in dry weather to remove dry, encrusted sediment
  - Maintain aggregate 0.25 inches above grid structure

- Corrective maintenance (clogged wearing course)
  - Observe the pavement system after a rain event (testing infiltration rate using ASTM C1701 likely not applicable)
  - Corrective action needed, if ponding on surface or water flows off aggregate surface during rain event
PAVEMENT SURFACE: Gravel Grid

- Corrective maintenance (clogged wearing course)
  - Use vacuum system calibrated to remove all visible sediment (likely 2-3 cm of aggregate)
  - Replace aggregate per manufacturer specifications (usually 0.25 inches above grid structure)

- Structural integrity
  - Grid damaged:
    - Remove pins (if present), pry up grid segments, and replace grid, pins and gravel
    - Replace grid segments where three or more adjacent rings are broken or damaged
  - Loss of aggregate material: Refill per manufacturer's recommendations (usually 0.25 inches above grid structure)

PAVEMENT SURFACE: Grass Grid

- Routine maintenance (cleaning surface debris)
  - Large and small areas: rakes, leaf blowers
  - Consult manufacturer guidelines
  - Frequency: 1-2 times annually or as determined by site conditions
  - Maintain soil/sand slightly below grid structure
PAVEMENT SURFACE: Grass Grid

- Corrective maintenance (clogged wearing course)
  - Observe the pavement system after a rain event (testing infiltration rate using ASTM C1701 likely not applicable)
  - Corrective action needed if ponding on surface or water flows off aggregate surface during rain event
  - Follow manufacturer’s guidelines for repairing surface

- Structural integrity
  - Grid damaged:
    - Remove pins (if present), pry up grid segments, and replace grid, pins and grass.
    - Replace grid segments where 3 or more adjacent rings are broken or damaged
  - Grass growth:
    - Mulch mower
    - Top dress with 0.5 inches of compost if nutrient deficient (do not use fertilizer)
  - Surface settling: May require resetting

- Poor grass coverage:
  - Restore growing medium, reseed or plant and/or amend vegetated area as needed
  - Traffic loading may be inhibiting grass growth; reconsider traffic loading if feasible
  - Growing media elevation should be maintained slightly below grid structure
  - Consult manufacturer/sales representative
ROUTINE AND CORRECTIVE MAINTENANCE
BY COMPONENT

- Pavement surface
  - Asphalt and concrete
  - PICP and pavers
  - Gravel grid
  - Grass grid
- Adjacent landscaped areas
- Drains

ADJACENT LANDSCAPED AREAS

- Runoff depositing sediment, mulch, or other material
  - Check the following:
    - Surface elevation of planted area is too high
    - Planted area slopes towards pavement
- Runoff depositing sediment, mulch, or other material
  - Address the source if possible:
    - Re-grading
    - Mulching/planting exposed soils
  - Prior to re-grading, protect porous pavement by covering with temporary plastic and secure covering in place
  - Clean

ADJACENT LANDSCAPED AREAS

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  - Clean
PERMEABLE PAVEMENT O&M

ADJACENT LANDSCAPED AREAS

- Groundcover migration
  - Protect if seeding adjacent areas
  - Modify planting plan and remove invasive plants
  - Maintain adjacent landscaping
  - Weed burners

Groundcover migration happens even with conventional pavement

BMP SPECIFICS - PERMEABLE PAVEMENT

DRAINS: Under- And Elevated- Drains

- Drain clogged:
  - Jet clean or rotary cut debris/roots from under-drain
  - Clean flow restrictor/orifice
  - Identify the source of the blockage and take actions to prevent future blockages

- Soil exposed or erosion damage at discharge point:
  - Identify source of problem
  - Repair erosion and stabilize surface

BMP SPECIFICS - PERMEABLE PAVEMENT

DRAINS: Under- And Elevated- Drains

- Water remains in storage aggregate longer than anticipated:
  - Determine if problem
  - Inspect drains
  - If structural problems possible schedule investigation of subsurface materials or other potential causes of extended ponding
DEFINITION AND TYPES

- Thin layers of engineered soil and vegetation constructed on top of conventional flat or sloped roofs
- Other names
  - Green roofs
  - Living roofs
  - Eco-roofs
  - Roof gardens
- Types:
  - Intensive (> 6” of growth medium)
  - Semi-intensive
  - Extensive (< 6” growth medium)

HOW THE FACILITY WORKS

- Present (edge of building):
  - Roofing
  - Multi-layer
  - Growing medium (5-6”)
  - Flee fabric
  - Drainage layer (1.5-3”)
- Vegetation:
  - Shrubs:
  - Grasses:
  - Woody:

Clean Water Services LID Handbook
MAINTENANCE CONSIDERATIONS

- Stormwater must infiltrate freely through soil
- Stormwater must freely exit facility
- Vegetation should be healthy and cover majority of soil surface

MAINTENANCE STANDARDS & PROCEDURES

BY COMPONENT

- Growth Medium
- Roof Drain
- Flashing, Gravel Stops, or Other System Components
- Vegetation
- Weeds
- Watering

MAINTENANCE PROCEDURES:

Growth Medium

- Scarify if crusted or spot replace medium if failing to infiltrate
- Supplement growth medium to design thickness
- For visible erosion or scour, prevent further damage and repair media
- Repair or replace damaged erosion control material until 90% vegetation cover
MAINTENANCE PROCEDURES:

Roof Drain
- Clear blockage and debris to prevent or repair clogging
- Repair/replace damaged inlet pipes

Flashing, Gravel Stops, or Other System Components
- Repair (e.g., recoat) or replace deteriorating elements to eliminate potential pollutant source

Vegetation
- Plant areas below 90% cover and install erosion control measures, if necessary, until 90% cover is achieved
- Mulch mow sedums to encourage establishment
- Recycle or remove dead vegetation and replace, if necessary

Weeds
- Remove weeds manually, with pincer-type weeding tools, flame weeder, or hot water weeders as appropriate
- Follow IPM protocols for weed management

Watering
- Once every 1-2 weeks as needed during prolonged dry periods during establishment periods
- As needed during prolonged dry periods after establishment
ADMINISTRATIVE TOOLS

RECORD KEEPING & TRACKING

• Parcel information
• City/County permit (ROW and/or building permit)
• Relevant sections of the Stormwater Site Plan
• “As-built” or “record drawings” (individual lots and public ROW)
• Legal agreements (covenants, easements)

ADMINISTRATIVE TOOLS

RECORD KEEPING & TRACKING

• Location information (GPS data, digital maps)
• Project O&M manual (where applicable)
• Maintenance logs (typically included in a Project O&M Manual)
• Inspection forms
• Enforcement documents
ADMINISTRATIVE TOOLS

INSPECTION PROGRAMS

• Immediately post-construction for all LID BMPs - installed per plan and functioning properly

• Every 6 months (until 90% of lots are constructed) for permanent Stormwater Treatment and Flow Control BMPs/Facilities in new residential developments - identify maintenance needs and enforce maintenance standards

• Ongoing annual inspections for all Stormwater Treatment and Flow Control BMPs/Facilities (MR #6 and/or MR #7)

ADMINISTRATIVE TOOLS

RESOURCE LIST

• Western WA LID O&M Guidance Document

• Northwest Plant Disease Management Handbook: http://pnwhandbooks.org/plantdisease

• Pacific Northwest Weed Management Handbook: http://pnwhandbooks.org/weed

wrap up
Statewide LID Training Program

COURSE CATALOG

http://www.wastormwatercenter.org/lidswtrainingprogram/

OVERVIEW OF PROGRAM

INTRODUCTORY

2.1 Introduction to LID for Inspection & Maintenance Staff

INTERMEDIATE

3.1 Intermediate LID Topics: NPDES Phase I & II Requirements

3.2 Intermediate LID Design: Bioretention

3.3 Intermediate LID Design: Permeable Pavement

3.4 Intermediate LID Design: Monitors & Mapping

3.5 Intermediate LID Design: Rainwater Collection Systems & Vegetated Roofs

3.6 Intermediate LID Design: Hydrologic Modeling

ADVANCED

5.0 Advanced Topics in LID Design: Vegetation Maintenance

5.1 Advanced Topics in LID Design: Vegetation Maintenance

5.2 Advanced Topics in LID Design: Permeable Pavement

5.3 Advanced Topics in LID Design: Permeable Pavement

5.4 Advanced Topics in LID Design: Site Planning & Layout

5.5 Advanced Topics in LID Design: Site Planning & Layout

5.6 Advanced Topics in LID Design: Site Planning & Layout

ONLINE EVALUATION

• An on-line evaluation will be sent to you within 5 days following this training
Two certificates:
- LID Design certificate
- Long-term LID Operations certificate

Sign out!

For information on training and other resources, visit the Washington Stormwater Center website:
http://www.wastormwatercenter.org

Stay connected through Social Media
- Come “Like” our Page
- Sign up to follow and get Tweets

Further questions? Contact:
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