Statewide LID Training Program

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.wastormwatercenter.org/statewide-lid-training-program-plan
• 2014: Training program built from state LID Training Plan.

PROJECT LEAD

OVERVIEW OF PROGRAM

CORE TEAM

ADDITIONAL TRAINING SUPPORT
• Implement first phase of trainings (September 2014 through May 2015)
• 64 trainings offered in first phase
• Three levels: Introductory, Intermediate, and Advanced
• Train the Trainer program for service providers and LID topic experts
• Anticipate two more years of funding.
INTRODUCTION TO LID
INSPECTION & MAINTENANCE STAFF

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

AGENDA

1. introduction
2. LID O&M overview
3. BMP specifics
4. administrative tools
5. wrap up
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.

LOGISTICS

SCHEDULE
• 3-hour classroom training with one break
• 1-hour for site visit/field exercise

OTHER LOGISTICS
• Restroom location
• Food
• Turn off cell phones
• Sign in and sign out
INTRODUCTION

TOPICS

Intro to LID
NPDES Permit

INTRODUCTION

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

INTRODUCTION

LID Principles: Pre-developed Forest
LID Principles: Developed Condition

INTRODUCTION

LID Principles: Site Design And Planning

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

Traditional
LID

LID BMPs: Small-Scale Engineering Controls

- Infiltration
- Filtration
- Storage
- Evaporation
- Transpiration

Conserv[e or regain pre-developed hydrologic functions

Synonym for LID BMPs: Green Stormwater Infrastructure (GSI), Integrated Management Practices (IMPs), and On-Site Stormwater Management BMPs
INTRODUCTION:

NPDES PERMIT REQUIREMENTS

National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permits

<table>
<thead>
<tr>
<th>Municipal Stormwater Permittees in Washington State</th>
<th>Phase I Permittees</th>
<th>Western Washington Phase II Permittees</th>
<th>Eastern Washington Phase II Permittees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seattle, Tacoma, Clark County, King County, Pierce County, Snohomish County</td>
<td>82 Cities</td>
<td>5 Counties</td>
<td>18 Cities</td>
</tr>
<tr>
<td>Secondary Permittees: Approximately 45; such as ports and universities</td>
<td></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](http://www.ecy.wa.gov/programs/wq/stormwater/municipal/MuniStrmWtrPermList.html)

INTRODUCTION:

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.9.a of the Phase I Permit</td>
<td>Per Section S5.C.9.a of the Phase II Permit</td>
</tr>
<tr>
<td>Most Permittees</td>
<td>Lewis Co. and Cowlitz Co.</td>
</tr>
<tr>
<td>June 30, 2014</td>
<td>June 30, 2015</td>
</tr>
<tr>
<td>June 30, 2016</td>
<td>June 30, 2017</td>
</tr>
<tr>
<td>June 30, 2018</td>
<td>Dec. 31, 2018</td>
</tr>
<tr>
<td>Lewis Co.</td>
<td>Aberdeen City</td>
</tr>
</tbody>
</table>

9/8/2014
INTRODUCTION

NPDES PERMIT REQUIREMENTS:
Requirements Vary By BMP Classification

- On-site Stormwater Management BMPs
- Stormwater Treatment and Flow Control BMPs/Facilities

INTRODUCTION

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

INTRODUCTION

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

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

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)
- Downspout Full Infiltration (BMP T5.10A)
- Downspout Dispersion (BMP T5.10B)
- Concentrated Flow Dispersion (BMP T5.11)
- Sheet Flow Dispersion (BMP T5.12)
- Compost-amended soils (BMP T5.13)
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>X</td>
<td></td>
</tr>
<tr>
<td>Implement practices, policies, &amp; procedures to reduce SW impacts associated with runoff</td>
<td>X</td>
<td></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>

### 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
### 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>X</td>
<td></td>
</tr>
</tbody>
</table>

#### 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>

#### 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></td>
<td>X</td>
</tr>
<tr>
<td>Map connections between BMPs and tributary conveyances*</td>
<td></td>
<td>X</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
  - Downspout infiltration systems
  - Rain gardens
  - Downspout, sheet flow, and concentrated dispersion systems
  - Permeable pavement
  - Compost-amended soils
  - Vegetated roofs
- 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

LID O&M GUIDANCE: Overview

- Maintenance standards and procedures
LID O&M GUIDANCE: Overview

- Equipment and material list

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shovel</td>
<td>For digging and moving soil</td>
</tr>
<tr>
<td>Rake</td>
<td>For leveling and smoothing</td>
</tr>
<tr>
<td>Sprayer</td>
<td>For applying liquid treatments</td>
</tr>
<tr>
<td>Pruner</td>
<td>For trimming overgrown vegetation</td>
</tr>
</tbody>
</table>

- 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)
- Entomology knowledge
- General drainage system maintenance skills (e.g., rain garden, underdrain cleaning experience)

BMP specifics
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
**COMPONENTS: Downspout Dispersion**

- Splash block
- 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

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

1. Dispersion Trench
2. Infiltration
3. Compost-Amended Soils
4. Bioretention
5. Trees
6. Permeable Pavement
7. Vegetated Roofs
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
MAINTENANCE PROCEDURES: Infiltration

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

DEFINITION

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

www.buildingsoil.org
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 weeder, or hot water weeder)
• Remove and dispose of noxious weeds properly

Q&A
www.agricapsemills.com
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
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
- Underdrain collects water in gravel layer and routes to overflow
BIORETENTION VS RAIN GARDENS

- Structures/Underdrains
  - Bioretention: Yes
  - Rain Garden: No

- Soil mixes
  - Rain Garden: Designed
  - Bioretention: Soil mixes

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
INLETS: Types

Curb cut with grate

BMP SPECIFICS - BIORETENTION

Curb cut

BMP SPECIFICS - BIORETENTION

INLETS: Types

Trench drain from upslope BMP

Trench drain from roadway

BMP SPECIFICS - BIORETENTION

INLETS: Types

Piped inlet from roadway/parking lot

Piped inlet from upslope BMP
• Stormwater must freely enter facility (no obstructions)
• Water entering facility should not cause erosion

INLETS: Maintenance Considerations

12th Avenue, Portland

INLETS: Maintenance

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

Curb cut Piped flow Trench drain

INLETS: Maintenance

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

Curb cut Catch basin inlets
PONDING AREA: Types

- Earthen depression
- Rockery walls

PONDING AREA: Types

- 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

**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

**Excessive Ponded Water**
- Overflows 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**
- Portland (2012 LID Manual)
- Meadow on the Hylebos
- 110th Street Cascade, Seattle, WA

**Earthen**
- SPU Puget Sound LID Manual

**Gravel**
- Log/Wooden

**Earthen**
- High Point, Seattle, WA
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

- 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)
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>Shrub</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

**MULCH: Maintenance Considerations**

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

MULCH:
- No mulch and undefined edge
- Hand apply mulch to avoid covering base of trees and shrubs

DISPERSION
- Infiltration
- Compost
- Amended Soils

BIORETENTION
- Trees
- Vegetated Roofs

Western WA LID Manual

HOW THEY WORK

- Trees
- Aeration Zone
- Planting Soil
- Structural Soil
- Drainage (Sand Base)
- 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.

Refer to Seattle Street Tree Manual or ISA website for more information.

MAINTENANCE PROCEDURES: Watering

3- to 5-year Establishment Period

<table>
<thead>
<tr>
<th>Year</th>
<th>Irrigation Frequency</th>
<th>Trees</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>
</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>
</tr>
</tbody>
</table>

Trees may take up to 5 years to become fully established.

MAINTENANCE PROCEDURES: Mulch

Hand apply mulch to avoid covering base of tree.
TOPICS

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

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

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
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

INSPECTION & MAINTENANCE STAFF

INTRODUCTION TO LID
ROUTINE AND CORRECTIVE MAINTENANCE BY COMPONENT

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

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)
  - 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: Asphalt & Concrete**

- Corrective maintenance (clogged wearing course)
  - 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)

- 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

- 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
BMP SPECIFICS - PERMEABLE PAVEMENT

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

BMP SPECIFICS - PERMEABLE PAVEMENT

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)

BMP SPECIFICS - PERMEABLE PAVEMENT

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
BMP SPECIFICS - PERMEABLE PAVEMENT

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
PAVEMENT SURFACE: Gravel 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

- 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

- **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
**PAVEMENT SURFACE: Grass Grid**

**Structural integrity**

- **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

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**ROUTINE AND CORRECTIVE MAINTENANCE**

**BY COMPONENT**

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

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**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
**BMP SPECIFICS - PERMEABLE PAVEMENT**

**ADJACENT LANDSCAPED AREAS**

- 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

**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

**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
DRAIN 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

Q&A

1. DISPERSION
2. INFILTRATION
3. COMPOST- AMENDED SOILS
4. BIORETENTION
5. TREES
6. PERMEABLE PAVEMENT
7. VEGETATED ROOFS
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)

BMP SPECIFICS – VEGETATED ROOFS

HOW THE FACILITY WORKS

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

MAINTENANCE CONSIDERATIONS
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

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
MMAH SPECIFICS – VEGETATED ROOFS

MAINTENANCE PROCEDURES:
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

Stressed vegetation
Vegetation growing over path

BMP SPECIFICS – VEGETATED ROOFS

MAINTENANCE PROCEDURES:
Weeds

- Remove weeds manually, with pincer-type weeding tools, flame weeder, or hot water weeder 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-builts" or "record drawings" (individual lots and public ROW)
- Legal agreements (covenants, easements)

LOCATION INFORMATION

- 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

**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 to 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)

**Q&A**

1. Wrap up
http://www.wastormwatercenter.org/lidwtrainingprogram/

**Statewide LID Training Program**

**Course Catalog**

**Introduction to LID for Eastern Washington**

**Intermediate**

- Introduction to LID for Inspection & Maintenance Staff
- Introduction to LID for Developers & Money for Green

**Advanced**

- Intermediate LID Design: Rainwater Collection Systems & Vegetated Roofs
- Intermediate LID Design: Permeable Pavement
- Intermediate LID Design: Hydrologic Modeling

**Train the Trainers**

- Interim LID Design: Site Assessment, Planning & Layout
- LID Topic Experts

**Online Evaluation**

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

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:
training@cascadiaconsulting.com
(206) 449-1163
LOGISTICS

SCHEDULE

• Site Visit and Field Exercise (11:30-12:30)
  • LID BMP inspection worksheets
  • Best practices and lessons learned
• You will need to sign out at the end of the training to receive credit for the Long-term LID Operations certificate