Statewide LID Training Program
• 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](http://www.wastormwatercenter.org/statewide-lid-training-program-plan)

• 2014: Training program built from state LID Training Plan
# Statewide LID Training Program

## Overview of Program

<table>
<thead>
<tr>
<th>Project Lead</th>
<th>Core Team</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="#">Herrera</a></td>
<td><a href="#">Cascadia</a> <a href="#">Veda</a></td>
</tr>
</tbody>
</table>

## Additional Training Support

- [CH2M HILL](#)
- [Aspect Consulting](#)
- [Leaping Frog Films](#)
- [SvR Design Company](#)
- [Washington Stormwater](#)
- [StormwaterONE](#)
• 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
# Statewide LID Training Program

## Overview of Program

<table>
<thead>
<tr>
<th><strong>Introduction</strong></th>
<th><strong>Intermediate</strong></th>
<th><strong>Advanced</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>3.1</td>
<td>5.1</td>
</tr>
<tr>
<td>Introduction to LID for Eastern Washington</td>
<td>Intermediate LID Topics: NPDES Phase I &amp; II Requirements</td>
<td>Advanced Topics in LID Design: Bioretention</td>
</tr>
<tr>
<td>2.1</td>
<td>3.2</td>
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</tr>
<tr>
<td>Introduction to LID for Inspection &amp; Maintenance Staff</td>
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<tr>
<td>2.2</td>
<td>3.3</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td>3.4</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td>Intermediate LID Design: Site Assessment, Planning &amp; Layout</td>
<td>Advanced Topics for Long-term LID Operations: Permeable Pavement</td>
</tr>
<tr>
<td>4.1</td>
<td></td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Intermediate LID Design: Rainwater Collection Systems &amp; Vegetated Roofs</td>
<td></td>
</tr>
<tr>
<td>4.2</td>
<td></td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>Intermediate LID Design: Hydrologic Modelling</td>
<td></td>
</tr>
</tbody>
</table>

## Train the Trainers

<table>
<thead>
<tr>
<th><strong>Intermediate</strong></th>
<th><strong>Advanced</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>9.1</td>
<td>9.2</td>
</tr>
<tr>
<td>Service Providers</td>
<td>LID Topic Experts</td>
</tr>
</tbody>
</table>
# Statewide LID Training Program

## TODAY’S TRAINING

<table>
<thead>
<tr>
<th>INTRODUCTORY</th>
<th>INTERMEDIATE</th>
<th>ADVANCED</th>
</tr>
</thead>
<tbody>
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<td>5.3</td>
</tr>
<tr>
<td>3.4</td>
<td></td>
<td>5.4</td>
</tr>
<tr>
<td>4.1</td>
<td></td>
<td>8.1</td>
</tr>
<tr>
<td>4.2</td>
<td></td>
<td>8.2</td>
</tr>
<tr>
<td>Intermediate LID Design: Hydrologic Modelling</td>
<td></td>
<td>Advanced Topics in LID Design: Bioretention Media</td>
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<td></td>
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<td>8.1</td>
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<td>Intermediate LID Design: Permeable Pavement</td>
<td>Advanced Topics in LID Design: Rainwater Collection Systems &amp; Vegetated Roofs</td>
<td></td>
</tr>
<tr>
<td>5.4</td>
<td>8.2</td>
<td></td>
</tr>
<tr>
<td>Advanced Topics for Long-term LID Operations: Permeable Pavement</td>
<td>Advanced Topics in LID Design: Bioretention Media</td>
<td></td>
</tr>
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</table>

## TRAIN THE TRAINERS

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<tr>
<td>Service Providers</td>
<td>LID Topic Experts</td>
</tr>
</tbody>
</table>
ADVANCED TOPICS FOR LONG-TERM LID OPERATIONS: PERMEABLE PAVEMENT
REBECCA DUGOPOLSKI, PE
Senior Engineer
Key project experience: Stormwater monitoring, design, and NPDES Permit compliance

KATHY GWILYM, PE
Principal Civil Engineer
Key project experience: Complete street design, LID and permeable pavements for public works and private projects
LOGISTICS

SCHEDULE

• Classroom training (8:30-11:45)
• 1-hour lunch break (11:45-12:45)
• Classroom training (12:45-1:30)
• Field exercises (1:30-3:30)

OTHER LOGISTICS

• Restroom location
• Food
• Turn off cell phones
• Sign in and sign out
LEARNING OBJECTIVES

1. Understand the structure and function of permeable pavement components.
2. Gain an in-depth understanding of the primary inspection activities and tools to maintain permeable pavement function over time.
3. Know the primary maintenance requirements for permeable pavement.
4. Identify maintenance problems and associated solutions necessary for long-term function of permeable pavement areas.
AGENDA

1. Introduction
2. Permeable pavement O&M
3. O&M costs
4. Tools for success
5. Wrap up & field exercises
introduction

permeable pavement O&M

O&M costs

tools for success

wrap up & field exercises
INTRODUCTION

TOPICS

Intro to LID

NPDES Permit

LID O&M Guidance Document

Statewide LID Training Program

5.4 PERMEABLE PAVEMENT

ADVANCED TOPICS FOR LONG-TERM LID OPERATIONS
INTRODUCTION

LOW IMPACT DEVELOPMENT (LID): Introduction to Principles

- Site design & planning techniques emphasizing conservation
- Use of small-scale engineered controls to closely mimic pre-development hydrologic processes
- Careful assessment of site soils and strategic site planning to best use those soils for stormwater management
INTRODUCTION

LID: Introduction to Principles: Pre-developed Forest Hydrology

Yakima Regional LID Stormwater Design Manual (April 2011)
LID: Introduction to Principles: Developed Condition Hydrology

Yakima Regional LID Stormwater Design Manual (April 2011)
LID: Site Design and Planning Techniques

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

Traditional

LID
LID: Small-Scale Engineering Controls

- Infiltration
- Filtration
- Storage
- Evaporation
- Transpiration

Synonyms for LID BMPs:

Green Stormwater Infrastructure (GSI), Integrated Management Practices (IMPs), and On-Site Stormwater Management BMPs
LID: Permeable Pavement

- Infiltration
- Filtration
- Storage
- Evaporation
- Transpiration
STATEWIDE LID TRAINING PROGRAM

5.4 PERMEABLE PAVEMENT

ADVANCED TOPICS FOR LONG-TERM LID OPERATIONS

INTRODUCTION

TOPICS

Intro to LID

NPDES Permit

LID O&M Guidance Document

Eastern Washington Phase II Municipal Stormwater Permit

Issued Date: August 1, 2012
Effective Date: August 1, 2014
Expiration Date: July 31, 2019

In compliance with the provisions of
The State of Washington Water Pollution Control Act
Chapter 90-68 Revised Code of Washington
and
The Federal Water Pollution Control Act
Title 33 United States Code, Section 1225 et seq.

Until this permit expires, is modified, or revoked, Permits that have properly obtained
coverage under this permit are authorized to discharge to waters of the state in accordance with
the special and general conditions which follow.

[Signature]
Department of Ecology

PREPARED FOR

Washington State Department of Ecology
Water Quality Program

5.4 PERMEABLE PAVEMENT

ADVANCED TOPICS FOR LONG-TERM LID OPERATIONS

STATEWIDE LID TRAINING PROGRAM

DEPARTMENT OF ECOLOGY
State of Washington
NPDES PERMIT REQUIREMENTS

• Phase I*
  • Populations ≥ 100,000

• Phase II
  • Generally populations > 10,000

• Issuance date: August 1, 2012
• Effective date: August 1, 2014
• Permit term: 5 years (through July 31, 2019)

*No Phase I jurisdictions in Eastern WA
## Phase II Cities

<table>
<thead>
<tr>
<th>Asotin</th>
<th>Clarkston</th>
<th>East Wenatchee</th>
<th>Ellensburg</th>
<th>Kennewick</th>
<th>Moses Lake</th>
<th>Pasco</th>
<th>Pullman</th>
<th>Richland</th>
</tr>
</thead>
</table>

## Phase II Counties

<table>
<thead>
<tr>
<th>Selah</th>
<th>Spokane</th>
<th>Spokane Valley</th>
<th>Sunnyside</th>
<th>Union Gap</th>
<th>Walla Walla</th>
<th>Wenatchee</th>
<th>West Richland</th>
<th>Yakima</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Asotin</th>
<th>Chelan</th>
<th>Douglas</th>
<th>Spokane</th>
<th>Walla Walla</th>
<th>Yakima</th>
</tr>
</thead>
</table>

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**Statewide LID Training Program**

**5.4 PERMEABLE PAVEMENT**

ADVANCED TOPICS FOR LONG-TERM LID OPERATIONS
NPDES PERMIT REQUIREMENTS:

Core Elements

1. Preparation of Stormwater Site Plans
2. Construction Stormwater Pollution Prevention
3. Source Control of Pollution
4. Preservation of Natural Drainage Systems
5. Runoff Treatment
6. Flow Control
7. Operation and Maintenance
8. Local Requirements
NPDES PERMIT REQUIREMENTS: Core Elements (CE)

- CE #5 – Runoff Treatment
  - Water quality treatment for pollution-generating areas

- CE #6 – Flow Control
  - Control of flow peaks and flow durations
## NPDES PERMIT LID O&M REQUIREMENTS: O&M Standards

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Permit Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adopt or update ordinance or other enforceable documents that includes O&amp;M standards</td>
<td>Post-construction Stormwater Management for New Development and Redevelopment (S5.B.5.a.ii)</td>
</tr>
<tr>
<td>Include in municipal O&amp;M Plan (stormwater collection and conveyance system component):</td>
<td></td>
</tr>
<tr>
<td>• Catch basin cleaning</td>
<td>Municipal Operations and Maintenance (S5.B.6.a.i.(a))</td>
</tr>
<tr>
<td>• Stormwater system maintenance</td>
<td></td>
</tr>
<tr>
<td>• Scheduled structural BMP inspections and maintenance</td>
<td></td>
</tr>
<tr>
<td>• Pollution prevention and good housekeeping practices</td>
<td></td>
</tr>
</tbody>
</table>
NPDES PERMIT LID O&M REQUIREMENTS: Plan Review

| Requirement                                                                 | Permit Reference                          |
|                                                                           | Appendix 1 – Core Element #7              |
| Verify that O&M plan is completed and includes the following:              |                                               |
| • Addresses all proposed stormwater facilities and BMPs                   |                                               |
| • Identifies the party (or parties) responsible for maintenance and operation |                                               |
| • Addresses the long-term funding mechanism to support O&M                |                                               |
### Inspection

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Permit Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinance providing legal authority to inspect private stormwater facilities</td>
<td>Post-construction Stormwater Management (S5.B.5.a.iii)</td>
</tr>
<tr>
<td>Inspect structural BMPs at least once during installation</td>
<td>Post-construction Stormwater Management (S5.B.5.c.ii)</td>
</tr>
<tr>
<td>Inspect structural BMPs at least once every 5 years after installation (or more frequently)</td>
<td>Post-construction Stormwater Management (S5.B.5.c.iii)</td>
</tr>
<tr>
<td>Perform spot checks for potentially damaged BMPs owned/operated by Permittee after major storm events</td>
<td>Municipal O&amp;M (S5.B.6.a.ii.(c))</td>
</tr>
</tbody>
</table>
### NPDES PERMIT LID O&M REQUIREMENTS: Enforcement

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Permit Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enforce compliance with maintenance standards as needed based on inspection</td>
<td>Post-construction Stormwater Management (S5.B.5.a.iv-v)</td>
</tr>
</tbody>
</table>
NPDES PERMIT LID O&M REQUIREMENTS: Training

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Permit Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train staff involved in permitting, planning, plan review, field inspection, &amp; enforcement</td>
<td>Construction Site Stormwater Runoff (S5.B.4.b.ii and S5.B.4.c.ii) and Post-construction Stormwater Management (S5.B.5.d)</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>Post-construction Stormwater Management (S5.B.6.b)</td>
</tr>
</tbody>
</table>
NPDES PERMIT LID O&M REQUIREMENTS: Record Keeping

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Permit Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keep records of inspections and enforcement actions (e.g., inspection reports, warning letters, notices of violations)</td>
<td>Post-construction Stormwater Management (S5.B.5.c.i)</td>
</tr>
<tr>
<td>Private facilities – retain a copy of the O&amp;M Plan on site or within reasonable access to the site</td>
<td>Appendix 1 – Core Element #7</td>
</tr>
<tr>
<td>Public facilities – retain a copy of the O&amp;M Plan within the appropriate department</td>
<td>Appendix 1 – Core Element #7</td>
</tr>
</tbody>
</table>
NPDES PERMIT LID O&M REQUIREMENTS: Mapping

<table>
<thead>
<tr>
<th>Requirement</th>
<th>SWMMEW Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footprint of proposed drainage features (ponds, vegetated or other infiltration facilities, pipe routes, ditches)</td>
<td>SWMMEW, Appendix 3B</td>
</tr>
</tbody>
</table>
INTRODUCTION

TOPICS

Intro to LID  NPDES Permit  LID O&M Guidance Document

Statewide LID Training Program

5.4 PERMEABLE PAVEMENT

ADVANCED TOPICS FOR LONG-TERM LID OPERATIONS
LID O&M GUIDANCE DOCUMENT: Objective

• Developed for Western WA, but is also applicable to Eastern WA

• 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
INTRODUCTION

LID O&M GUIDANCE DOCUMENT: Content

• Summary of NPDES Permit Requirements

• Maintaining LID BMPs
  • Bioretention facilities
  • Rain gardens
  • Permeable pavement
  • Vegetated roofs

• Programmatic & Administrative Guidance
  • Downspout infiltration systems
  • Downspout, sheet flow, and conc. dispersion systems
  • Compost amended soils
LID O&M GUIDANCE DOCUMENT: Content

- 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 DOCUMENT: Maintenance Standard and Procedures

#### INTRODUCTION

Table B (continued). Maintenance Standards and Procedures for Permeable Pavement.

<table>
<thead>
<tr>
<th>Component</th>
<th>Recommended Frequency*</th>
<th>Condition when Maintenance is Needed (Standards)</th>
<th>Action Needed (Procedures)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlets/Ouotlets/Pipes (cont'd)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overflow</td>
<td>B</td>
<td>Native soil is exposed or other signs of erosion damage are present at discharge port</td>
<td>Repair erosion and stabilize surface</td>
</tr>
<tr>
<td>Aggregate Storage Reservoir</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observation port</td>
<td>A, S</td>
<td>Water remains in the storage aggregate larger than anticipated by design after the end of a storm.</td>
<td></td>
</tr>
<tr>
<td>Vegetation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjoint large shrubs or trees</td>
<td>As needed</td>
<td>Vegetation-related fallout drags or will potentially clog voids</td>
<td>Sweep leaf litter and sediment to prevent surface clogging and ponding. Prevent large root systems from damaging subsurface structural components.</td>
</tr>
<tr>
<td></td>
<td>once in May and once in September</td>
<td>Vegetation growing beyond facility edge onto sidewalks, paths, and street edge</td>
<td>Edging and trimming of planted areas to control groundcovers and shrubs from overreaching the sidewalks, paths, and street edge improves appearance and reduces clogging of permeable pavements by leaf litter, mulch, and soil.</td>
</tr>
<tr>
<td>Leaves, needles, and organic debris</td>
<td>in fall (October to December) after leaf drop (1-3 times, depending on canopy cover)</td>
<td>Accumulation of organic debris and leaf litter</td>
<td>Use leaf blower or vacuum to blow or remove leaves, evergreen needles, and debris (i.e., flowers, blossoms) off of and away from permeable pavement.</td>
</tr>
</tbody>
</table>

* Frequency: A = Annually; B = Biannually (twice per year); S = Perform Inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval). 
* Inspection should occur during storm event.
**LID O&M GUIDANCE DOCUMENT:**

**Equipment and Materials List**

**Table 9. Permeable Pavement Equipment and Materials List.**

<table>
<thead>
<tr>
<th>Equipment to address clogging of wearing course, such as:</th>
<th>Weed / vegetation removal equipment, such as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Hand held pressure washer or power washer with rotating brushes (not recommended for open-celled aggregate-filled systems)</td>
<td>□ Weeding tools</td>
</tr>
<tr>
<td>□ Walk-behind vacuum (sidewalks)</td>
<td>□ Weed burner</td>
</tr>
<tr>
<td>□ Pure vacuum sweeper</td>
<td>□ Edging and trimming equipment to control groundcover and other vegetation from extending onto pavement surface</td>
</tr>
<tr>
<td>□ ShopVac (small areas)</td>
<td></td>
</tr>
<tr>
<td>□ Combined higher pressure wash and vacuum system</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment to remove sediment, debris, and leaf litter, such as:</th>
<th>Additional equipment for grass-filled open-celled grid systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ High efficiency regenerative air or vacuum sweeper (roadways, parking lots)</td>
<td>□ Mower or mulch mower</td>
</tr>
<tr>
<td>□ Push broom (can also be used to spread and clean aggregate in gravel-filled open-celled grid and permeable paver systems)</td>
<td>□ Topdress grass seed</td>
</tr>
<tr>
<td>□ Brush broom (course bristled broom) to remove moss</td>
<td>□ Compost</td>
</tr>
<tr>
<td>□ Leaf blower</td>
<td>□ Replacement grid segments</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Erosion control equipment (to stabilize adjacent landscaped areas and protect pavement from sediment inputs)*</th>
<th>Additional equipment for gravel-filled open-celled grid systems</th>
</tr>
</thead>
</table>

*Note: Choose at least one option from each column.*
LID O&M GUIDANCE DOCUMENT: 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 Permeable Pavement

- Sweeper and equipment operation
- Commercial driver’s license (CDL)
- Landscaping skills (e.g., general plant care) for grass-filled open-celled grid systems
- Engineer and/or landscape architect for major maintenance
introduction

permeable pavement O&M

O&M costs

tools for success

wrap up & field exercises
PERMEABLE PAVEMENT O&M TOPICS

1. Types & terms
2. How the facility works
3. Maintenance considerations for facility function
4. General maintenance for all types
5. Routine maintenance activities specific to each type
6. Corrective maintenance activities
7. Equipment and material recommendations
8. Skills
1. TYPES & TERMS

Pervious Concrete

Porous Asphalt

Permeable Interlocking Concrete Pavers

Open Celled Systems (Flexible & Rigid)
1. TYPES: Porous Asphalt

- Flexible, non-proprietary
- Placement is similar to conventional asphalt but need large quantity
- Typically used for parking and light traffic loads; however, has been used for medium and heavy applications
- Initial Infiltration rate: 200+ inches/hour

Porous asphalt wearing course
Choker course (e.g. 1.5 in. to US sieve No. 8 crushed, washed stone)
Coarse aggregate base (e.g. AASHTO No. 3)
Subgrade (minimal compaction)
1. TYPES: Pervious Concrete

- Rigid, non-proprietary
- Placement differs from conventional. Small batches feasible.
- 3/8” typical (round or crushed) aggregate w/o to minimal fines. Admixtures (optional) to increase workability and strength.
- Initial Infiltration rate 200+ inches/hour
PERMEABLE PAVEMENT O&M

1. TYPES: Permeable Interlocking Pavers

- Flexible, proprietary
- Capable of high vehicle loads. Used for lower speeds
- High-density concrete that interlock and transfer vertical loads to surrounding pavers
- Clean aggregate (w/o fines) filled within the openings/gaps
- Initial infiltration rates can vary depending upon paver type
PERMEABLE PAVEMENT O&M

1. TYPES: Plastic Grids

- Flexible, proprietary
- Plastic grid filled with clean gravel (w/o fines) or soil and planted with grass
- Trails, paths, maintenance access in a park, parking
- Highest percent voids
2. HOW THE FACILITY WORKS

The aggregate median provides a connection and overflow protection from the pavement surface to the aggregate base. Source: Adopted from Cahill

AGGREGATE OPEN INTO RECHARGE BED

UNIFORMLY GRADED WASHED AGGREGATE WITH 30 TO 40% VOID SPACE FOR STORMWATER STORAGE AND RECHARGE

UNCOMPACTED SUBGRADE IS CRITICAL FOR PROPER INFILTRATION

FILTER FABRIC RECOMMENDED ON SIDE WALLS AND OPTIONAL FOR BOTTOM OF SUBGRADE

2012 LID Technical Guidance Manual for Puget Sound
2. HOW THE FACILITY WORKS

- Sections vary – check as-built
  - Top Wearing Course
  - Leveling Course?
  - Sub-base (storage)
  - Water quality treatment layer?
  - Geotextile?
  - Native soil
- Storage within Sub-base
  - Slope conditions – check dams
- Overflow (pipe or structure)
Break
3. MAINTENANCE CONSIDERATIONS

• “The maintenance of LID facilities is essential to ensure that design stormwater management and other benefits continue over the full lifecycle of the installation.”

• What to look for?
  • Drainage Function
  • Safety
  • Aesthetics

• Is it different?

• Long term infiltration capacity can remain high however.............
3. O&M TRANSITION

- O&M starts at the Planning phase

- Transitioning from Construction to O&M
  - Purpose?
  - What are the regulatory reporting requirements?
  - Record/As-built?
  - Training new staff
  - Mapping
4. GENERAL: Protection of Surface

Inform crews about protecting permeable pavements

Use tarps/cover under stockpiles
4. GENERAL: Adjacent Stabilization

Maintain stabilization of adjacent areas to protect from sediment transport

• Proactive vs. reactive
• Address the source
4. GENERAL: Vegetation Migration & Rooting

• Ground Cover Migration

• Cover if Hydroseeding

• Options for Maintenance
  • Modify planting plan and remove invasive plants
  • Maintain adjacent landscaping

Ground cover migration happens even with conventional pavement
4. GENERAL: Moss Growth

- Be careful with expectations
- Moss is present regardless of pavement type in PNW
- More prevalent in shady areas and under trees
- Remove if its observed to affect drainage
- Some is okay
- Perception

Pervious concrete sidewalk with moss
PERMEABLE PAVEMENT O&M

4. GENERAL: Moss Growth

• If severe, options for removal:
  • Pressure washing (concrete)
  • Weed burner
  • Sweeping (during dry periods)
  • Vacuuming (effectiveness varies)

• During planning & design, consider impacts of shade to maintenance frequency

Non-Pervious Concrete urban sidewalk with moss
PERMEABLE PAVEMENT O&M

4. GENERAL: Moss Growth

Installed ~10 years ago
12516 NE 90th Street

Photo taken w/n 1 year of installation
4. GENERAL: Moss Growth

Installed in 2010 – no routine maintenance, Photo July 2014

4. GENERAL: Protection From Staining

- Applies to pavers, asphalt, cement concrete. Same as conventional pavements
- During construction, keeping pervious concrete covered for curing & protection can lead to some discoloration but fades with time
- Avoid placement of organic/compost material on pavement

Staining from compost spilling onto pervious concrete
4. GENERAL: Snow Removal

- Modify snow management procedures

- Avoid sanding since it will clog the system, except in cases of emergencies/safety issues (vacuum sediment as soon as possible after melt)

- Avoid sanding adjacent streets since tires will track it onto the porous pavement

- Avoid stockpiling snow on porous pavement
4. GENERAL: Snow Removal

- Adjust snow plow height to avoid scratching when feasible
- UNH reported up to 75% decrease in salt use but it will depend on site conditions (shade, location etc)
- Permeable sub-base provides drainage
- Voids in wearing course provides space for freeze thaw
- Installed in cold climates such as Iowa, Pennsylvania, Colorado, Ohio, Lake Tahoe
4. GENERAL: Snow Removal

Parking Lot, Denver, CO – Next AM Following 12” Snow

Pervious Concrete

Conventional Asphalt

Photos courtesy of National Ready Mixed Concrete Association and slide courtesy of Center for Portland Cement Concrete Pavement Technology, 2005 via John Kevern at National Concrete Pavement Technology, Iowa State University
4. GENERAL: Drainage Function Inspection

- Inspect drainage function in the rain and identify areas for maintenance
  - Is there runoff from the surface?
  - Is water still ponding on the surface 1 hour after rain has stopped?
  - Is there ponding water in the observation port 24 hours after the rain has stopped?
- If ponding, then corrective action required for cleaning surface.
PERMEABLE PAVEMENT O&M

4. GENERAL: Drainage Function Inspection

• Video/photos of overall area during rain event
• If no ponding on the surface then it's flowing through top wearing course
PERMEABLE PAVEMENT O&M

4. VIDEO IN THE RAIN
PERMEABLE PAVEMENT O&M

4. GENERAL: Drainage Function Inspection

- Inspect drainage function in dry weather
  - Cylinder test: ASTM C1701 results indicate an infiltration rate of 10 inches per hour or less then corrective action required.
  - Test the surface infiltration rate using ASTM C1701 (perform 1 test/installation but not < 1 test/2,500 sf)
  - Run cylinder tests over multiple areas
  - Turn on sprinklers/garden hose to test larger area?
  - Does water pool or drain out?
If not draining through top wearing course then corrective maintenance options include:

- Pressure wash and/or vacuum system
- Hand held pressure wash or power wash with rotating brushes
- Pure vacuum sweeper (calibrated to not dislodge wearing course aggregate)
- Gravel grid and pavers – removing and replacing aggregate
4. GENERAL: Under- and Elevated-Drains

- Under-drain/Elevated drain is 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

- If pipe daylights, check for erosion damage at discharge point:
  - Identify source of problem
  - Repair erosion and stabilize surface
PERMEABLE PAVEMENT O&M

4. GENERAL: Under- and Elevated- Drains

- Water remains in storage aggregate longer than anticipated:
  - Inspect standpipes for under-drain
  - Inspect drains
  - If structural problems possible schedule investigation of subsurface materials or other potential causes of extended ponding
PERMEABLE PAVEMENT O&M

4. GENERAL: Inspect Overflow/Backup System

• Check overflow drainage path
  • What is the flow path if water does not infiltrate?
  • If has under-drain pipes, verify they are draining
  • Verify that the overflow structure is not plugged.
4. GENERAL NON-ROUTINE: Utility Cuts

• Temporary Patch

• Protect adjacent porous to remain

• Permanent Panel replacement

• Permanent Restoration: Use same material as original, except use conventional asphalt for porous asphalt
PERMEABLE PAVEMENT O&M

5. ROUTINE AND CORRECTIVE MAINTENANCE BY COMPONENT

• Pavement surface
  • Porous Asphalt and Pervious Concrete
  • Permeable Interlocking Concrete Pavers
  • Open Celled Gravel grid
  • Open Celled Grass grid
5. ROUTINE: Porous Asphalt & Pervious Concrete

- 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
5. ROUTINE: Porous Asphalt & Pervious Concrete

- No Overlay
- No black topping/sealing
- May need to re stripe parking lot more frequently
PERMEABLE PAVEMENT O&M

5. NON-ROUTINE: Pervious Concrete Structural

• Major cracks or trip hazards and concrete spalling and raveling
• Determine cause
• Replace panel with porous material if feasible
• Modify operations?
PERMEABLE PAVEMENT O&M

5. NON-ROUTINE: Raveling at Construction Joints

- Consult with industry, engineer
- Patch?
- Cut out and replace with new panel (pervious concrete)
- Replace with conventional asphalt?
5. NON-ROUTINE: Drainage Function Rehabilitation

- Consult with industry, engineer
- Significant decline in infiltration when system is not routinely maintained
5. ROUTINE: 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
5. ROUTINE: PICP & Pavers

- Routine maintenance (vegetation)
  - Remove weeds if they start to affect drainage performance
  - Aesthetics
  - Do not use herbicides (this is a stormwater facility)
  - Weed burner
  - Vinegar? (small applications)
  - Larger gaps between pavers easier for removal of weeds (shovel)
6. CORRECTIVE: PICP & Pavers

• 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
  • Dry Weather: Test the surface infiltration rate using ASTM C1781 (perform 1 test/installation but not < 1 test/2,500 sf)
PERMEABLE PAVEMENT O&M

6. CORRECTIVE: PICP & Pavers

• Clogged wearing course
  • Corrective maintenance options include:
    • Pure vacuum sweeper
    • Pressure wash and vacuum system calibrated to remove all visible sediment (likely 2-3 cm of aggregate) in the joints or infiltration cells
  • Replace aggregate in joints or infiltration cells per manufacturer specifications
5. NON-ROUTINE: PICP & Pavers

- Utility work
  - Pavers can be removed individually and replaced after work is complete
  - Clean sub-base material (no to minimal fines)
PERMEABLE PAVEMENT O&M

5. NON-ROUTINE: 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
5. NON-ROUTINE: PICP & Pavers

• Structural integrity and snow
  • The structure of the top edge of the paver blocks reduces chipping from snowplows
  • Skids on the corner of plow blades are recommended
5. ROUTINE: Gravel Grid

- **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
6. CORRECTIVE: Gravel Grid

- 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
6. CORRECTIVE: Gravel Grid

• 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)
PERMEABLE PAVEMENT O&M

5. NON-ROUTINE: Gravel Grid

• 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)
PERMEABLE PAVEMENT O&M

5. ROUTINE: Grass Grid

• 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
6. CORRECTIVE: Grass Grid

• Clogged wearing course
  • Observe the grass 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 grass surface during rain event
  • Follow manufacturer’s guidelines for repairing surface
5. NON-ROUTINE: Grass Grid

- **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
5. NON-ROUTINE: 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
    - May need occasional reseeding
5. NON-ROUTINE: Grid Systems

- Structural integrity and snow
  - Snow plows should use skids to elevate the blades to prevent loss of aggregate and damage to the grid

Fire lane/Maintenance road for housing site. Geoweb® Cellular Confinement system adjacent to walk
# 7. EQUIPMENT & MATERIALS

## Table 9. Permeable Pavement Equipment and Materials List.

<table>
<thead>
<tr>
<th>Equipment to address clogging of wearing course, such as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Hand held pressure washer or power washer with rotating brushes (not recommended for open-celled aggregate-filled systems)</td>
</tr>
<tr>
<td>- Walk-behind vacuum (sidewalks)</td>
</tr>
<tr>
<td>- Pure vacuum sweeper</td>
</tr>
<tr>
<td>- ShopVac (small areas)</td>
</tr>
<tr>
<td>- Combined higher pressure wash and vacuum system</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weed / vegetation removal equipment, such as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Weeding tools</td>
</tr>
<tr>
<td>- Weed burner</td>
</tr>
<tr>
<td>- Edging and trimming equipment to control groundcover and other vegetation from extending onto pavement surface</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment to remove sediment, debris, and leaf litter, such as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- High efficiency regenerative air or vacuum sweeper (roadways, parking lots)</td>
</tr>
<tr>
<td>- Push broom (can also be used to spread and clean aggregate in gravel-filled open-celled grid and permeable paver systems)</td>
</tr>
<tr>
<td>- Brush broom (course bristled broom) to remove moss</td>
</tr>
<tr>
<td>- Leaf blower</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Additional equipment for grass-filled open-celled grid systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Mower or mulch mower</td>
</tr>
<tr>
<td>- Topdress grass seed</td>
</tr>
<tr>
<td>- Compost</td>
</tr>
<tr>
<td>- Replacement grid segments</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Erosion control equipment (to stabilize adjacent landscaped areas and protect pavement from sediment inputs)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Erosion control matting</td>
</tr>
<tr>
<td>- Rocks</td>
</tr>
<tr>
<td>- Mulch</td>
</tr>
<tr>
<td>- Plants</td>
</tr>
<tr>
<td>- Landscaping tools</td>
</tr>
<tr>
<td>- Tarps (to protect pavement in area of landscaping from clogging, e.g., mulch stockpiles)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Additional equipment for gravel-filled open-celled grid systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Rakes and shovels</td>
</tr>
<tr>
<td>- Aggregate to replace material after vacuuming or to replenish material in high use areas</td>
</tr>
<tr>
<td>- Replacement grid segments</td>
</tr>
<tr>
<td>- Wheelbarrow (for transporting replacement aggregate)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pipe/structure inspection and maintenance equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Hand tools</td>
</tr>
<tr>
<td>- Wrench or manhole opener (for opening manhole lids, grates, etc.)</td>
</tr>
<tr>
<td>- Flashlight</td>
</tr>
<tr>
<td>- Mirror (for viewing pipes without entering structure)</td>
</tr>
<tr>
<td>- Garden hose</td>
</tr>
<tr>
<td>- Plumbing snake</td>
</tr>
<tr>
<td>- Measuring tape or ruler</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Additional equipment for permeable paver systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Rakes and shovels</td>
</tr>
<tr>
<td>- Extra pavers and bedding material</td>
</tr>
<tr>
<td>- Aggregate to replace materials between pavers after vacuuming</td>
</tr>
<tr>
<td>- Wheelbarrow (for transporting replacement aggregate)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Snow removal equipment, such as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Plow with skids to prevent damage to permeable pavement</td>
</tr>
<tr>
<td>- Snow blower</td>
</tr>
</tbody>
</table>
PERMEABLE PAVEMENT O&M

7. EQUIPMENT & MATERIALS: Routine Maintenance

Equipment to address clogging of wearing course, such as:

• Hand held pressure washer or power washer with rotating brushes
• Walk-behind vacuum
• Pure vacuum sweeper
• Brush broom
• Combined higher pressure wash and vacuum system
7. EQUIPMENT & MATERIALS: Routine Maintenance

Equipment to remove sediment, debris, and leaf litter, such as:

- High efficiency regenerative air or vacuum sweeper
- Push broom
- Brush broom
- Leaf blower
PERMEABLE PAVEMENT O&M

7. EQUIPMENT & MATERIALS: Routine Maintenance

Weed/vegetation removal equipment, such as:

• Weeding tools

• Weed burner

• Edging and trimming equipment control (groundcover and other vegetation)
7. EQUIPMENT & MATERIALS: Routine Maintenance

Additional equipment for grass-filled open-celled grid systems, such as:

- Mower or mulch mower
- Topdress grass seed
- Compost
- Replacement grid segments
7. EQUIPMENT & MATERIALS: Routine Maintenance

Additional equipment for gravel-filled open-celled grid systems, such as:

- Rakes and shovels
- Replacement grid segments
- Replacement aggregate
- Wheelbarrow (for transporting replacement aggregate)
7. EQUIPMENT & MATERIALS: Routine Maintenance

Additional equipment for permeable paver systems, such as:

- Rakes and shovels
- Extra pavers and bedding material
- Replacement aggregate
- Wheelbarrow (for transporting replacement aggregate)
7. EQUIPMENT & MATERIALS: Routine Maintenance

Snow removal equipment, such as:

- Plow with skids to prevent damage to permeable pavement
- Snow blower
Pipe/structure inspection and maintenance equipment:

- Hand tools
- Wrench or manhole opener
- Flashlight
- Mirror
- Garden hose
- Plumbing snake
- Measuring tape or ruler
7. EQUIPMENT & MATERIALS: Corrective Maintenance

- Elgin’s Whirlwind (pure vacuum sweeper)
- Bunyan B.I.R.D. vacuum attached to vactor truck (10 gpm): $7,800 + power if not on vactor
- Paragon Industries
- Stay tuned ... supply and demand affect technology
7. EQUIPMENT & MATERIALS: Corrective Maintenance
7. EQUIPMENT & MATERIALS:
PERMEABLE PAVEMENT O&M

7. EQUIPMENT & MATERIALS: Corrective Maintenance
7. EQUIPMENT & MATERIALS: Corrective Maintenance

Erosion control equipment:

- Erosion control matting
- Rocks
- Mulch
- Plants
- Landscaping tools
- Tarps (to protect pavement)
2006 Study Findings:

- Leaf/Litter vacuums are more effective than sweepers with dust control vacuum systems
- Vacuum machines had difficulty removing leaf piles when they were more than 2 to 3 inches thick
PERMEABLE PAVEMENT O&M

7. EQUIPMENT & MATERIALS: City of Portland

N Gay Avenue & Westmoreland Projects:

- Pavers, porous asphalt and pervious concrete public streets
- 1X to 2X/year - Vacuum sweepers used to collect fines:
  - Tymco’s 500x, Schwarze’s A7000, Elgin’s Crosswind J-Plus
- Infiltration testing with flusher truck
- “Vegetation growth in pavers did not appear to hinder infiltration on Rex St.” (~63 in/hr)
8. SKILLS

• Sweeper and equipment operation

• Commercial driver’s license (CDL)

• Landscaping skills (e.g., general plant care) for grass-filled open-celled grid systems

• Engineer and/or landscape architect for major maintenance
# CONVENTIONAL VS LID O&M ACTIVITIES

<table>
<thead>
<tr>
<th>Conventional</th>
<th>LID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweeping</td>
<td>Sweeping/ clean surface debris</td>
</tr>
<tr>
<td>Repair structural damage</td>
<td>Unclog wearing course</td>
</tr>
<tr>
<td>Typically Streets Department maintains roadways</td>
<td>Unclog drain and inspect for damage</td>
</tr>
<tr>
<td></td>
<td>Run-on from adjacent landscaping</td>
</tr>
</tbody>
</table>
**PERMEABLE PAVEMENT**

WERF LID Cost Calculator (Last updated 5/9/2009)

<table>
<thead>
<tr>
<th>Item</th>
<th>Maintenance Frequency</th>
<th>Annual O&amp;M Cost for 5,000 SF (Medium)</th>
<th>Cost/SF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Inspection, reporting, and data management</td>
<td>Every 3 years</td>
<td>Every 3 years</td>
<td>1/year</td>
</tr>
<tr>
<td>Litter &amp; minor debris removal</td>
<td>Every 3 years</td>
<td>1/year</td>
<td>12/year</td>
</tr>
<tr>
<td>Sweeping</td>
<td>Every 3 years</td>
<td>1/year</td>
<td>12/year</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**O&M COSTS**

**PERMEABLE PAVEMENT**

Puget Sound Stormwater BMP Cost Database Technical Memorandum (Herrera 2013)

<table>
<thead>
<tr>
<th>O&amp;M Activities</th>
<th>Unit</th>
<th>n</th>
<th>Low</th>
<th>Average</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine sweeping (2X per year)</td>
<td>SF</td>
<td>1</td>
<td>$0.02</td>
<td>$0.02</td>
<td>$0.02</td>
</tr>
</tbody>
</table>

- Restorative maintenance (power washing followed by vactoring to unclog the upper layer and restore porosity) is estimated at $1/SF
## O&M COST PER BMP

<table>
<thead>
<tr>
<th>BMP</th>
<th>30-year Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permeable Sidewalk</td>
<td>$15.30 / SF</td>
</tr>
<tr>
<td>Permeable Pavement</td>
<td>$1.16 / SF</td>
</tr>
<tr>
<td>Conventional Pavement</td>
<td>$1.16 / SF</td>
</tr>
</tbody>
</table>

Source: Herrera - Cost Analysis for Western Washington LID Requirements and Best Management Practices
Lunch
introduction

permeable pavement O&M

O&M costs

tools for success

wrap up & field exercises
TOOLS FOR SUCCESS

TOPICS

• Inspection checklist
• Record keeping and tracking
• Interpreting plans and as-builts
• Inspection programs
# Inspection and Maintenance Checklist

**Porous Pavement**
(e.g., turf block, modular blocks, granular pavement, porous asphalt, pervious concrete)

<table>
<thead>
<tr>
<th>Defect</th>
<th>Conditions When Maintenance Is Needed</th>
<th>Maintenance Needed? (Y/N)</th>
<th>Comments (Describe maintenance completed, and if any needed maintenance was not conducted, note what is needed and when it will be done)</th>
<th>Results Expected When Maintenance Is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debris, Organic Matter, and Sediment</td>
<td>Porous pavement clogging due to debris, organic matter and sediment.</td>
<td></td>
<td>Vacuum sweep porous asphalt or concrete systems (with proper disposal of removed materials), followed by high pressure hosing to free pores on the surface and result in no clogging.</td>
<td></td>
</tr>
<tr>
<td>Contaminants and Pollution</td>
<td>Any evidence of oil, gasoline, contaminants or other pollutants</td>
<td></td>
<td>No contaminants or pollutants present. Spills must be vacuumed immediately and followed by jet washing.</td>
<td></td>
</tr>
<tr>
<td>Erosion</td>
<td>Soil from adjacent areas washed onto pavement.</td>
<td></td>
<td>Landscaped areas that are well maintained should prevent soil from eroding onto pavement.</td>
<td></td>
</tr>
<tr>
<td>Overflow Devices (Pipes)</td>
<td>Trash and debris accumulated on overflow devices.</td>
<td></td>
<td>Trash and debris removed from overflow devices.</td>
<td></td>
</tr>
<tr>
<td>Vegetation</td>
<td>When the planted vegetation becomes excessively tall; when nuisance weeds and other vegetation start to take over.</td>
<td></td>
<td>Vegetation mowed per specifications or maintenance plan, or nuisance vegetation removed so that flow is not impeded. Clippings removed from the porous pavement and disposed of appropriately.</td>
<td></td>
</tr>
<tr>
<td>Structural Components</td>
<td>Cracked or moving edge restraints, Cracked or settled pavement</td>
<td></td>
<td>Repair or replace cracked or shifted components per manufacturer specifications. Prevent large root systems from damaging structural components.</td>
<td></td>
</tr>
<tr>
<td>Filter Medium</td>
<td>Aggregate loss in pavers from settling or power washing.</td>
<td></td>
<td>Replace paver pore space with aggregate from original design.</td>
<td></td>
</tr>
</tbody>
</table>

Central Oregon Manual

Statewide LID Training Program

5.4 PERMEABLE PAVEMENT

ADVANCED TOPICS FOR LONG-TERM LID OPERATIONS
INSPECTION CHECKLIST

Name(s) of Inspectors: ________________________________
Date of Inspection: ________________________________
Location of the permeable pavement facility: ________________
Surface/wearing course type: ________________________________
Address or Intersection: ________________________________
Age of permeable pavement facility: _________________________
Permeable pavement facility area (ft. × ft.): ________________
Time since last rainfall (hr): ________________________________
Quantity of last rainfall (in): ________________________________

Site Sketch (include curbs, islands, trees, north arrow, etc.)
Based on visual assessment of the site, answer the following questions and take photographs of the site:

**Surface/Wearing Course**

1. Are there indications of any of the following on the surface of the permeable pavement facility? (If yes, mark on site sketch)
   - Excessive sediment
   - Moss growth
   - Cracks, trip hazards, or concrete spalling
   - Trash and debris
   - Leaf accumulation
   - Settlement of surface
   - Other: ________________________________
   - None

2. Is there ponding on the surface of the permeable pavement? □ Yes □ No

   If yes, describe the potential reasons for ponded water below (leaf or debris build-up, non-functional underdrain, groundwater input, illicit connection, inadequate capacity in facility, etc.)

Notes
Inlets/Outlets/Pipes

3. How many inlet pipes are present? □ 0 □ 1 □ 2 □ 3 □ 4 □ 5 □ > 5

4. Are any of the inlet pipes clogged? (If yes, mark the location on your site sketch and fill in the boxes below with the cause of the clogging (e.g., debris, sediment, vegetation, etc.)) □ No □ Partially □ Completely □ NA

5. Are any of the inlet pipes altered from the original design or otherwise in need of maintenance? (If yes, write in reason: frost heave, vandalism, unknown, etc.)

<table>
<thead>
<tr>
<th>Inlet #:</th>
<th>Inlet #:</th>
<th>Inlet #:</th>
<th>Inlet #:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partially clogged</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completely clogged</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reason for maintenance</td>
<td></td>
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</tbody>
</table>

Statewide LID Training Program

5.4 PERMEABLE PAVEMENT

ADVANCED TOPICS FOR LONG-TERM LID OPERATIONS
6. Are any overflow, underdrains, raised subsurface overflow pipes, or outlet structures clogged?
   □ No □ Partially □ Completely □ NA
   a. If yes, mark the location on your site sketch and fill in the boxes below with the cause of the clogging (e.g., debris, sediment, vegetation, moss, etc.)
   b. Are any of the overflow structures altered from the original design or otherwise in need of maintenance? (If yes, write in reason: frost heave, vandalism, unknown)

<table>
<thead>
<tr>
<th>Outlet #:</th>
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<th>Outlet #:</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
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<tr>
<td>Reason for maintenance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Observation Port (if present)
7. Is water remaining in the storage aggregate longer than anticipated by design after the end of a storm?
   □ Yes □ No □ Unknown
   a. If yes, identify potential cause of extended ponding and mark the location of observed extended ponding on your site sketch.
Summary

8. Inspector's Recommendations. When is maintenance needed?
   - [ ] Immediately
   - [ ] Within a month or two
   - [X] Within a year
   - [ ] No sign that any maintenance is required

9. Summarize the results of this inspection and write any other observations in the box below.

Summary and other observations
TOOLS FOR SUCCESS

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)
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
INTERPRETING PLANS & AS-BUILTS

• How to interpret construction plans, installation photos, and as-builts
TOOLS FOR SUCCESS

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)
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)

Q&A
introduction

permeable pavement O&M

O&M costs

tools for success

wrap up & field exercises
# Statewide LID Training Program

## Other Course Offerings

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<th>Introductory</th>
<th>Intermediate</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.0</strong> Introduction to LID for Eastern Washington</td>
<td><strong>3.1</strong> Intermediate LID Topics: NPDES Phase I &amp; II Requirements</td>
<td><strong>5.1</strong> Advanced Topics in LID Design: Bioretention</td>
</tr>
<tr>
<td><strong>2.1</strong> Introduction to LID for Inspection &amp; Maintenance Staff</td>
<td><strong>3.2</strong> Intermediate LID Design: Bioretention</td>
<td><strong>6.0</strong> Advanced Topics in LID Design: Hydrologic Modeling</td>
</tr>
<tr>
<td><strong>2.2</strong> Introduction to LID for Developers &amp; Contractors: Make Money be Green</td>
<td><strong>3.3</strong> Intermediate LID Design: Permeable Pavement</td>
<td><strong>5.2</strong> Advanced Topics in LID Design: Permeable Pavement</td>
</tr>
<tr>
<td></td>
<td><strong>3.4</strong> Intermediate LID Design: Site Assessment, Planning &amp; Layout</td>
<td><strong>7.0</strong> Advanced Topics in LID Design: Site Assessment, Planning &amp; Layout</td>
</tr>
<tr>
<td><strong>4.1</strong> Intermediate LID Design: Rainwater Collection Systems &amp; Vegetated Roofs</td>
<td></td>
<td><strong>8.1</strong> Advanced Topics in LID Design: Rainwater Collection Systems &amp; Vegetated Roofs</td>
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<tr>
<td><strong>4.2</strong> Intermediate LID Design: Hydrologic Modelling</td>
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<td><strong>8.2</strong> Advanced Topics in LID Design: Bioretention Media</td>
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</table>

## Train the Trainers

| **9.1** Service Providers | **9.2** LID Topic Experts |
• 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

Sign out!
For information on training and other resources, visit the Washington Stormwater Center website:

http://www.wastormwatercenter.org

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Further questions? Contact:
training@cascadiaconsulting.com
(206) 449-1163
Field Exercises
Site Inspection
Infiltration Tests
Equipment Demos