OVERVIEW OF PROGRAM

- 2012: Direction and resources from the state legislature
- June 2012: LID Training Steering Committee
- 2012-2013: Surveys to identify training needs and service providers

PROJECT LEAD

CORE TEAM

ADDITIONAL TRAINING SUPPORT
**Statewide LID Training Program**

### Overview of Program

- Implementation of first round of trainings (September 2014 through May 2015)
- Three levels: Introductory, Intermediate, and Advanced
- Train the Trainer program for service providers and LID topic experts

### Introductory

<table>
<thead>
<tr>
<th>Topic</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to LID in Eastern Washington</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### Intermediate

<table>
<thead>
<tr>
<th>Topic</th>
<th>3.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductory LID Design</td>
<td>3.1</td>
</tr>
<tr>
<td>Advanced Topics in LID Design</td>
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### Advanced

<table>
<thead>
<tr>
<th>Topic</th>
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</thead>
<tbody>
<tr>
<td>Advanced Topics in Hydrologic Modeling</td>
<td>6.1</td>
</tr>
<tr>
<td>Advanced Topics in LID Design</td>
<td>6.1</td>
</tr>
</tbody>
</table>

### Train the Trainers

<table>
<thead>
<tr>
<th>Topic</th>
<th>9.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Providers</td>
<td>9.1</td>
</tr>
<tr>
<td>LID Topic Experts</td>
<td>9.1</td>
</tr>
</tbody>
</table>

---

**Statewide LID Training Program**

### Today’s Training

<table>
<thead>
<tr>
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</tr>
<tr>
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<td>5.1</td>
</tr>
</tbody>
</table>
INTRODUCTION TO LID
EASTERN WASHINGTON

INSTRUCTORS

DUSTIN ATCHISON, PE
Water Resources Project Manager
Key project experience: LID design, stormwater master planning, stream and wetland restoration design, hydrologic and hydraulic modeling

HILARY WILKINSON
Principal
Key project experience: Facilitation, education and outreach, designing and implementing technical workshops and training programs

AGENDA

1. introduction
2. regulatory & Eastern WA overview
3. purpose and principles of LID
4. BMP specifics
5. wrap up
LEARNING OBJECTIVES

1. Understand basic LID principles and practices.
2. General knowledge of on-the-ground LID practices applicable to Eastern Washington, common approaches and procedures for design, installation, operations, maintenance, and inspection.
3. Understand the current permit requirements for encouraging and implementing LID.
4. Know where to find resources to help further advance understanding of LID, as well as how this course is nested in the larger LID training program in Washington State.

LOGISTICS

SCHEDULE
• 4-hour training with one break

OTHER LOGISTICS
• Restroom location
• Food
• Turn off cell phones
• Q&A at end of each section
**REGULATORY AND EASTERN WA OVERVIEW**

**REGULATORY REQUIREMENTS**

- Department of Ecology
  - NPDES Municipal SW Permit (Eastern WA)
  - Flow control & treatment performance standards
  - LID requirements
- Other Standards
  - Combined Sewer Overflow limits
  - Local Jurisdictions

<table>
<thead>
<tr>
<th>Permit</th>
<th>Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Water Act (1972)</td>
<td>Fishable, swimmable waters, prevent release of toxics</td>
</tr>
<tr>
<td>NPDES Permit</td>
<td>National Pollutant Discharge Elimination System</td>
</tr>
<tr>
<td>Four main categories of NPDES</td>
<td>Municipal, Construction, Industrial, Boatyards</td>
</tr>
<tr>
<td>Permit Authority</td>
<td>Delegated to the Washington State Department of Ecology by EPA</td>
</tr>
</tbody>
</table>
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*

NPDES PERMIT REQUIREMENTS

<table>
<thead>
<tr>
<th>Phase II Cities</th>
<th>Phase II Counties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asotin</td>
<td>Austin</td>
</tr>
<tr>
<td>Clarkston</td>
<td>Chelan</td>
</tr>
<tr>
<td>East Wenatchee</td>
<td>Douglas</td>
</tr>
<tr>
<td>Ellensburg</td>
<td>Spokane</td>
</tr>
<tr>
<td>Kennewick</td>
<td>Spokane Valley</td>
</tr>
<tr>
<td>Moses Lake</td>
<td>Sunnyside</td>
</tr>
<tr>
<td>Pasco</td>
<td>Union Gap</td>
</tr>
<tr>
<td>Pullman</td>
<td>Walla Walla</td>
</tr>
<tr>
<td>Richland</td>
<td>Wenatchee</td>
</tr>
<tr>
<td>Selah</td>
<td>Walla Wenatchee</td>
</tr>
<tr>
<td>West Richland</td>
<td>Yakima</td>
</tr>
</tbody>
</table>

REGULATORY AND EASTERN WA OVERVIEW

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
INTRODUCTION & REGULATIONS
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

REGULATORY AND EASTERN WA OVERVIEW
CORE ELEMENT # 5 (RUNOFF TREATMENT)

• New development with ≥ 5,000 sf of pollution-generating impervious surfaces (PGIS)

• Redevelopment with ≥ 5,000 sf of PGIS for specific industrial, commercial, high-use, and high traffic sites

REGULATORY AND EASTERN WA OVERVIEW
CORE ELEMENT # 5 (RUNOFF TREATMENT)

• Standards
  • Treat 90% of annual runoff
  • Specific treatment required depending on site type and/or location:
    • Basic (TSS)
    • Metals (dissolved Cu and Zn)
    • Phosphorus
    • Oil
CORE ELEMENT # 5 (RUNOFF TREATMENT)

- Basic Treatment Exemptions
  - Satisfies full dispersion
  - Discharges to a qualified UIC facility
- Metals Treatment Exemptions
  - Discharges to non-fish-bearing streams
  - Direct discharges to the main channels of certain rivers and lakes
  - Subsurface discharges
  - Restricted residential and employee-only parking areas

CORE ELEMENT # 6 (FLOW CONTROL)

- New development with ≥ 10,000 sf of new impervious surfaces
- Not required for redevelopment unless required under a basin plan or other federal, state, or local requirement

CORE ELEMENT # 6 (FLOW CONTROL)

- Standard
  - Based on a pre-developed condition (prior to settlement) or existing condition
REGULATORY AND EASTERN WA OVERVIEW

CORE ELEMENT # 6 (FLOW CONTROL)

• Exemptions
  • Disperse total 25-year runoff volume without discharge
  • Discharge to irrigation return flow stream reaches
  • Direct discharge to flow control "exempt surface waters" (Large rivers & streams, lakes & reservoirs with > 100 sq. mi. drainage area, reservoirs with outlet controls)

NPDES PERMIT REQUIREMENTS: LID

New development and redevelopment
Permittees shall allow nonstructural preventive actions and source reduction approaches such as:
  • LID techniques
  • Measures to minimize the creation of impervious surfaces
  • Measures to minimize the disturbance of native soils and vegetation
NPDES PERMIT REQUIREMENTS: LID

- Some Eastern WA jurisdictions already require stormwater to be retained onsite.
- A majority of Eastern WA permittees have adopted ordinances that meet or closely approximate the EPA LID standard.
- LID projects funded by Ecology grants have heightened interest in advancing LID for Eastern WA.

OTHER STANDARDS

- Combined Sewer Overflow Limits
- Local Jurisdictions
  - CSO reduction efforts
  - Conveyance capacity

HYDROLOGY AND CLIMATE: Regions
HYDROLOGY AND CLIMATE: Precipitation

- 6 - >60 in/year
- Most regions semi-arid or arid

HYDROLOGY AND CLIMATE: Snowfall

<table>
<thead>
<tr>
<th>Location</th>
<th>Average Annual Snowfall (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asotin</td>
<td>14.5</td>
</tr>
<tr>
<td>Ellensburg</td>
<td>27.7</td>
</tr>
<tr>
<td>Kennewick</td>
<td>6.9</td>
</tr>
<tr>
<td>Pullman</td>
<td>28.1</td>
</tr>
<tr>
<td>Richland</td>
<td>8.5</td>
</tr>
<tr>
<td>Spokane</td>
<td>41.4</td>
</tr>
<tr>
<td>Walla Walla</td>
<td>17.4</td>
</tr>
<tr>
<td>Wenatchee</td>
<td>27.6</td>
</tr>
<tr>
<td>Yakima</td>
<td>24.1</td>
</tr>
</tbody>
</table>

NATIVE VEGETATION

- Prairie
- Pine forests
- Shrub-Steppe
- Channeled scabland
- Dry & irrigated agricultural land
SOILS

Legend
- County boundaries
- Soil classification (NRCS)

SIMILAR CLIMATES: Snowfall

Source: CWP BMP Design Supplement for Cold Climates

SIMILAR CLIMATES: Temperature

Source: CWP BMP Design Supplement for Cold Climates
SIMILAR CLIMATES: Growing Season

WHAT IS LOW IMPACT DEVELOPMENT?

- A land use development strategy that emphasizes protection and use of on-site natural features to manage stormwater
- Integrates engineered, small scale stormwater controls into the site design
WHAT IS LOW IMPACT DEVELOPMENT?

- Used at the parcel and subdivision scale. Site scale necessary but not sufficient. Regional land use planning critical for effective stormwater management.

- Primary goal: no measurable impacts to receiving waters by maintaining or approximating pre-development surface flow volumes and durations.

PREDEVELOPED CONDITION

DEVELOPED CONDITION
PRINCIPLES: LID Objectives

• Reduce the development envelope
• Reduce impervious surfaces
• Protect and restore native soils/vegetation
• Manage stormwater as close to its origin as possible
• Reduce concentrated surface flow, minimize stormwater contact with impervious surfaces, and increase stormwater contact with soils and vegetation

PURPOSE: LID BMPs

<table>
<thead>
<tr>
<th>BMP</th>
<th>Flow Control</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Amendment</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Dispersion</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Retaining &amp; Planting Trees</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Bioretention</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Bioretention (underdrain)</td>
<td>X*</td>
<td>X</td>
</tr>
<tr>
<td>Permeable Pavement</td>
<td>X</td>
<td>X*</td>
</tr>
<tr>
<td>Green Roofs</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Rainwater Harvesting</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

PRINCIPLES: LID BMPs

• Infiltration
• Filtration
• Storage
• Evaporation
• Transpiration

Replace pre-developed hydrologic functions
**PRINCIPLES: Conventional vs. LID**

Convey runoff quickly to:

<table>
<thead>
<tr>
<th>Conventional</th>
<th>LID BMPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>• End-of-pipe large-scale infiltration (e.g., infiltration basins)</td>
<td>• Small-scale surface infiltration (e.g., bioretention swales)</td>
</tr>
<tr>
<td>• Small-scale subsurface infiltration (e.g., dry wells)</td>
<td>• Dispersion &amp; vegetated filter strips</td>
</tr>
</tbody>
</table>

**Q&A**
AMENDED SOILS: Definition

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

- Builds soil structure, moisture-holding capacity
- Increases surface porosity
- Biofiltration of urban pollutants
- Reuses "wastes" (yard waste, manure, biosolids, construction, land clearing waste)
- Reduces summer irrigation needs

**AMENDED SOILS: Benefits**

- Improves fertility & plant vigor:
  - Reduces need for fertilizers and pesticides
  - Reduces maintenance costs
  - Increases regrowth of protective canopy

**AMENDED SOILS: Applications**

- All pervious areas
- Incorporated into designs for dispersion BMPs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Design Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic matter content (non-turf)</td>
<td>6 to 8%</td>
</tr>
<tr>
<td>Organic matter content (turf)</td>
<td>3 to 5%</td>
</tr>
<tr>
<td>pH</td>
<td>6.0 to 8.0</td>
</tr>
</tbody>
</table>
AMENDED SOILS: Limitations

- Not applicable to till soils with slopes greater than 33%
- Imported topsoils should not have an excessive percent of clay fines

AMENDED SOILS: Design Considerations

Option 1: Leave native vegetation and soil undisturbed, and protect from compaction during construction.

Option 2: Amend existing site topsoil or subsoil with compost to meet the soil organic matter requirements:
- Till 3” of compost in to an 8” depth for planting beds
- Till 1.75” of compost in to an 8” depth for turf
- Scarify subsoil to a 12” depth
Option 3: Stockpile existing topsoil during grading, and replace 8” of topsoil before planting:

- Amend if needed to meet the organic matter requirement
- Scarify subsoil to a 12” depth

Option 4: Import a topsoil mix that meets the organic content and depth requirements:

- Scarify subsoil to a 12” depth or till in some of the topsoil
**DISPERSION: Definition and Types**

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

**Types:**
- Concentrated flow dispersion
- Sheet flow dispersion
- Full dispersion

**DISPERSION: Concentrated Flow**

- Steep impervious surfaces
- Driveways, sport courts, patios, and roofs without gutters
- Single-family residential and rural development applications

- Spreads flows through a vegetated pervious area
- Reduces peak flows
- Some water quality benefits
**BMP SPECIFICS**

**DISPERSION: Sheet Flow**
- Flat or moderately sloping (<15% slope) impervious surfaces
- Flows are already dispersed
- Vegetated flow path < 8% slope

**DISPERSION: Full**
- Up to 10% of impervious area can be treated
- Can avoid triggering a flow control facility by leaving natural vegetation onsite
- Primarily for new development
- Commercial and residential applications

**DISPERSION: Benefits**
- Restores natural drainage patterns of sheet flow and infiltration
- Cost-effective when sufficient space is available (e.g., large lots, rural short plats)
- Limited installation requirements & maintenance

---

**Eastern WA LID Manual**

09/08/14

SR 231 – Aimee S. Navickis-Brasch
- Urban lots are generally too small for dispersion of driveway runoff.
- Steep slopes (≥ 20%) are not suitable.
- Landslide and erosion hazard areas (evaluated by a geotechnical engineer or qualified geologist).

**Q&A**

**Break**
BIORETENTION: 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

BIORETENTION: Components

- Pre-Settling / Flow Entrance
- Bioretention Soil/Amended Soil
- Mulch/compost
- Native Vegetation
- Ponding Area (earthen depression or impermeable reservoir)
- Underdrain (optional)
- Overflow
**BIORETTENTION: Bioretention vs. Rain Garden**

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

- **Soil mixes**
  - Bioretention: Designed
  - Rain Garden: Less restrictive

---

**BIORETTENTION: Bioretention vs. Rain Garden**

- **Sizing**
  - Bioretention facilities are sized for specific treatment and flow control objectives

- **Maintenance**
  - Rain gardens have similar, but somewhat less extensive, maintenance requirements

---

**BIORETTENTION: Benefits**

- **Infiltration**
- **Storage**
- **Filtration**
- **Slow release of stormwater flows**
- **Landscape amenity**
- **Integration with other LID practices**
BIORETENTION: Benefits

- Can be used for snow storage in cold climates
- Protection of cold water streams sensitive to temperature changes

BIORETENTION: Applications

- Individual lots for managing rooftop, driveway, and other impervious surfaces
- Shared facilities for multiple lots (in common areas)
- Within loop roads or cul-de-sacs
- Landscaped parking lot islands
- Within right-of-ways along roads

BIORETENTION: Limitations

- Relatively small drainage areas
- Potential impact on other site uses (sidewalks or parking spaces)
- Designs with underdrains can result in conflicts with existing or future utilities
### BMP SPECIFICS

#### BIORETENTION: Site Suitability Criteria

<table>
<thead>
<tr>
<th>Feature</th>
<th>Setback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinking water well</td>
<td>100 feet</td>
</tr>
<tr>
<td>Spring used for drinking water</td>
<td>100 feet</td>
</tr>
<tr>
<td>Known deep soil contamination</td>
<td>100 feet</td>
</tr>
<tr>
<td>Closed or active landfill</td>
<td>100 feet</td>
</tr>
<tr>
<td>Small on-site septic drainfield</td>
<td>10 feet</td>
</tr>
<tr>
<td>Wellheads, on-site septic systems, basements, foundations, utilities, slopes, contaminated areas, and property lines</td>
<td>Consult local jurisdiction guidelines</td>
</tr>
</tbody>
</table>

#### BIORETENTION: Site Suitability Criteria

<table>
<thead>
<tr>
<th>Feature</th>
<th>Setback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building foundations</td>
<td></td>
</tr>
<tr>
<td>Downslope</td>
<td>≥ 20 feet</td>
</tr>
<tr>
<td>Upline</td>
<td>100 feet</td>
</tr>
<tr>
<td>Native Growth Protection Easement</td>
<td>≥ 20 feet</td>
</tr>
<tr>
<td>Top of slopes &gt;15%</td>
<td>≥ 50 feet</td>
</tr>
</tbody>
</table>

#### BIORETENTION: Site Suitability Criteria

- **Groundwater Protection Areas**
  - Not allowed if it will cause a violation of GW quality stds.
- **Depth to bedrock, seasonal high-water mark, or impermeable layer**
  - ≥ 5 feet from facility base
  - ≥ 3 feet on case-to-case basis
- **Infiltration rate/Drawdown time**
  - 0.5 in/hr to 2.4 in/hr
  - Soil groups B & C
  - 72 hr drawdown

Consult local jurisdiction guidelines.
BIORETENTION: Design Considerations

Erosion & Sediment Control

- Construction activity sloping to bioretention facility
  - Good construction and sediment and erosion practice
  - Stabilize upslope
  - Divert flows around bioretention areas

Plant Considerations

- Soil moisture conditions
- Sun exposure
- Above and below ground infrastructure
- Site distances and setbacks along roadways

Plant Considerations (continued)

- Pedestrian use
- Adjacent plant communities and potential invasive species control
- Visual buffering
- Aesthetics
**BIORETENTION: Design Considerations**

**Mulch**

- **Purpose**
  - Reduces weed establishment
  - Regulates soil temp & moisture
  - Attenuates heavy metals
  - Adds organic matter to soil

- **Depth**
  - Max 3 inches compost or 4 inches wood chips

---

**Composition**

- Compost in the bottom of the facilities
- Wood chip mulch composed of shredded or chipped hardwood / softwood on cell slopes

---

**Eastern WA LID Manual**

City of Spokane
**BIORETENTION: Basic Maintenance**

<table>
<thead>
<tr>
<th>Item</th>
<th>Maintenance Frequency</th>
<th>Annual O&amp;M Cost for 5,000 SF (Medium)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation management</td>
<td>Every 3 years</td>
<td>Low: 1/year</td>
</tr>
<tr>
<td>Replace mulch</td>
<td>Every 5 years</td>
<td>Low: 1/year</td>
</tr>
<tr>
<td>Till soil</td>
<td>Every 10 years</td>
<td>Low: 1/year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total: 3/year</td>
</tr>
</tbody>
</table>

**3 Year Establishment Period**

<table>
<thead>
<tr>
<th>Year</th>
<th>Irrigation Frequency</th>
<th>Trees</th>
<th>Shrubs</th>
<th>Groundcovers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer – Year 1</td>
<td>Once every 1-2 weeks</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</td>
<td>10-15 gal</td>
<td>3-5 gal</td>
<td>2 gal/sf</td>
</tr>
</tbody>
</table>

- **Irrigation after 3 year establishment period:**
  - Good construction and sediment and erosion practice
  - 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, senescence, etc.
  - Water during drought conditions
CASE STUDY

Components

- Trees
- Planting Soil
- Structural Soil
- Drainage (Sand Base)

BMP SPECIFICS

Eastern WA LID Manual

4.5 TREES

- Aeration Zone
- Sidewalk/Street
- Planter
- Compacted Subgrade

Eastern Washington LID Program
**TREES: Benefits**

- Flow control benefits:
  - Transpiration
  - Evaporation
  - Increases infiltration
- Benefits vary by:
  - Established or new
  - Type of tree
  - Canopy size
  - Overlap with impervious area

**Tree Type** | **Flow Control Credits**
---|---
Evergreen | 10% of canopy area (min of 100 sf/tree)
Deciduous | 10% of canopy area (min of 50 sf/tree)

**Retained Trees**

**Tree Type** | **Flow Control Credits**
---|---
Evergreen | 50 sf/tree
Deciduous | 20 sf/tree

**Newly Planted Trees**

**Applications**

- Reduce surface flow on streets, parking lots, sidewalks, and plazas
- Large mature trees provide more stormwater reduction (and other benefits) than small trees
**TREES: Limitations**

- Adjacent structures or overhead utilities can restrict tree growth
- Trees surrounded by or located near impervious surfaces can experience limited soil moisture, nutrients, and gas exchange
- Protect trees when located near plowed snow storage areas
- Drying winds can dehydrate plants growing in frozen soils

**PERMEABLE PAVEMENT: Definition and Types**

- Paved surfaces that allow infiltration, treatment, and storage of stormwater
- Can be designed to accommodate pedestrian, bicycle, and auto traffic
- Types
  - Porous asphalt or warm-mix asphalt pavement (**porous asphalt**)
  - Pervious Portland cement concrete (**pervious concrete**)
  - Permeable interlocking concrete pavers (**PICPs**)
  - Grid systems made of concrete or plastic (reinforced grass and gravel)
PERMEABLE PAVEMENT: Types

- Porous Asphalt
- Pervious Concrete

PERMEABLE PAVEMENT: Types

- Permeable Interlocking Concrete Pavers
- Reinforced Grass & Gravel

PERMEABLE PAVEMENT: Components

- Wearing Course
- Leveling/Choker Course
- Aggregate Storage Reservoir
- Native Underlying Soil
- Subsurface Berms

Native Underlying Soil
Subsurface Berms
PERMEABLE PAVEMENT: Benefits

- Reduces impervious area
  - Pavement for vehicular and pedestrian travel = 2x building cover
- Reduces peak flow and flow duration
- Mitigates habitat degradation of streams and wetlands
- Can be an effective design solution in cold weather and arid climates

PERMEABLE PAVEMENT: Applications

- Industrial site employee parking
- Commercial parking
- Sidewalks
- Pedestrian and bicycle trails
- Driveways
- Residential access roads
- Emergency and facility maintenance roads
- Overflow parking area

PERMEABLE PAVEMENT: Limitations

- Limited applicability for thoroughfares, highways, and other roads with high vehicle loads and high speed traffic
- No treatment credit provided for standard permeable pavement
Permeable pavement: Limitations

- Should not be used in areas with:
  - Excessive sediment deposition (e.g., construction and landscaping material yards)
  - Erosion hazards
  - Steep slopes (> 12%)
  - Potential for pollutant spills (e.g., gas stations, truck stops, industrial chemical storage sites)

Permeable pavement: Design Considerations

- Establish proper snow removal and deicing procedures
- Underlying stone bed tends to absorb and retain heat so that freezing rain and snow melt faster on permeable pavement

- Consider the soil frost line when developing infiltration bed design
- Recent research has shown permeable pavement to be successful in cold climates when properly installed and maintained, and when sanding is kept to a minimum
## PERMEABLE PAVEMENT: Basic Maintenance

<table>
<thead>
<tr>
<th>Item</th>
<th>Maintenance Frequency</th>
<th>Annual O&amp;M Cost for 5,000 SF (Medium)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection, reporting, and data management</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>12/year</td>
</tr>
<tr>
<td>Sweeping</td>
<td>Every 3 years</td>
<td>12/year</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Total $247</td>
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</tbody>
</table>

**WERF LID Cost Calculator (last updated 5/9/2009)**

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**CASE STUDY**

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**Break**

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VEGETATED ROOFS: Definition and Types

- Thin layers of engineered soil and vegetation constructed on top of conventional flat or sloped roofs

Types

- Green roofs
- Living roofs
- Eco-roofs
- Roof gardens

VEGETATED ROOFS: Types

- Intensive (≥ 6" of growth medium)
- Semi-intensive (25% above or below 6" growth medium)
- Extensive (< 6" growth medium)
VEGETATED ROOFS: Components

- Plants
- Mulch or Fabric
- Growth Medium (4" min)
- Filter Fabric
- Drainage Layer
- Root Barrier
- Waterproof Membrane
- Roof Structure

VEGETATED ROOFS: Benefits

- Wildlife habitat
- Improved air quality
- Noise reduction
- Social
  - Happier workers
  - Lower stress levels
  - Increases productivity
  - Reduces sick days

VEGETATED ROOFS: Benefits

- Economic
  - Energy cost savings
  - Reduces size of HVAC equipment
  - Extends roof membrane life
  - Higher lease rates
  - Multi-functional (can be used for stormwater flow control, food growth)
VEGETATED ROOFS: Applications

- Office, industrial, and warehouse structures with large, flat roofs
- Intensive commercial designs can accommodate foot traffic
- Rooftop gardens for growing food

VEGETATED ROOFS: Limitations

- Single-family residential roof structures typically require structural buttressing to support wet soil loads
- Steeply pitched roofs (10 to 40 degrees) require additional analysis and can be technically or economically infeasible
- >40 degree sloped roof is considered infeasible

VEGETATED ROOFS: Design Considerations

- Applicable snow load must be considered in the design of the roof structure (Michigan LID Manual)
- Irrigation (Yakima LID Manual)
  - Drip and tube systems are preferred
  - Ensure system is properly winterized

Irrigation system and rooftop garden images are included.
VEGETATED ROOFS: Design Considerations

- Fire protection (Yakima LID Manual)
  - Avoid use of flammable materials
  - Maintain a stone or gravel border around edges
  - Specify fire-resistant vegetation

Q&A
RARINWATER HARVESTING: Definition and Types

• Typical in environments where rainfall or other conditions limit water supply
• Rainwater harvesting collects and stores runoff from roofs, or other surfaces
• Above or below ground cisterns
• Various materials:
  - Fiberglass
  - Metal
  - Polyethylene
  - Wood
  - Concrete

RARINWATER HARVESTING: Components

• Downspout Connection
• Overflow Pipe
• Filter
• Flow Control Orifice
• Flow Dissipater
• Outlet

RARINWATER HARVESTING: Benefits

• Reduces Runoff:
  - Can help reduce flooding and erosion in small streams by reducing runoff volume
• Healthier Plants:
  - Rainwater does not contain chlorine and fluoride, both of which can be found in tap water and are not necessary for plant growth
**RAINWATER HARVESTING: Benefits**

- Water Savings:
  - Can conserve water and reduce water bills
  - Savings depend on the storage capacity of the system & proper use and maintenance
  - Can augment limited groundwater supplies
  - Sustainable source for irrigation and non-potable uses

**RAINWATER HARVESTING: Applications**

- Arid and semi-arid climates where water availability is scarce
- Residential and commercial sites with high irrigation and/or non-potable water demands
- Indoor re-use for toilet flushing and laundry
- Exterior re-use for cleaning, irrigation, and other non-potable uses

**To use harvested water for other purposes (toilet flushing, laundry, etc.) refer to:**
- Georgia Rainwater Harvesting Guidelines (Chapter 5)
- Texas Manual on Rainwater Harvesting (Chapter 3)

**Water level**
- Lower at the beginning of winter in order to prevent damage or cracking from water freezing
• Avoid watering vegetables and herbs with water collected from asphalt-shingle roofs
• Only appropriate for collection of stormwater runoff from roofs (not from other impervious areas)
• Pumping and treatment costs associated with indoor re-use can be high

RAINWATER HARVESTING: Limitations

RAINWATER HARVESTING: Water Rights

October 12, 2009 - Ecology issued an Interpretive Policy Statement clarifying that a water right is not required for rooftop rainwater harvesting

Rainwater harvesting systems collecting > 5,000 gallons/day require a water right

CASE STUDY
BMF SPECIFICS
LID RESOURCES

• Eastern WA LID Guidance Manual
• Yakima Regional LID Stormwater Design Manual
• Stormwater Management Manual for Eastern Washington (Ecology)
• Truckee Meadows LID Handbook (Reno, NV)
• Central Oregon Stormwater Manual
• LID Manual for Michigan
• Stormwater BMP Design Supplement for Cold Climates (Center for Watershed Protection)
### Statewide LID Training Program

#### OTHER COURSE OFFERINGS

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tr>
<td>INTRODUCTORY</td>
<td>INTERMEDIATE</td>
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<tr>
<td>1.0</td>
<td>Introduction to LID for Service Providers</td>
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<tr>
<td>2.1</td>
<td>Introduction to LID for Inspection &amp; Maintenance Staff</td>
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<tr>
<td>2.2</td>
<td>Introduction to LID for Developers &amp; Contractors: Make Money be Green</td>
</tr>
<tr>
<td>3.1</td>
<td>Intermediate LID Topics: NDS Plate &amp; Requirements</td>
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<td>3.2</td>
<td>Intermediate LID Designs: Management</td>
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<tr>
<td>3.3</td>
<td>Intermediate LID Design: Vegetative Solutions &amp; Separated Storm</td>
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<td>3.4</td>
<td>Intermediate LID Design: Site Assessment, Planning &amp; Layout</td>
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<tr>
<td>4.1</td>
<td>Intermediate LID Design: Hydrologic Modeling</td>
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<tr>
<td>4.2</td>
<td>Intermediate LID Design: Train the Trainers</td>
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<tr>
<td>4.3</td>
<td>Intermediate LID Design: Highways Systems &amp; Separated Storms</td>
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<tr>
<td>4.4</td>
<td>Intermediate LID Design: Hydrologic Modeling</td>
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<td>Train the Trainers</td>
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</tbody>
</table>

#### Statewide LID Training Program

#### ONLINE EVALUATION

- An on-line evaluation will be sent to you within 5 days following this training

#### CERTIFICATE

Two certificates:
- LID Design certificate
- Long-term LID Operations certificate
- Stay tuned for development of certificate policy details

Sign out!

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*Image of a person with a garden and a sign that says: Hazel's Creek City of Spokane*
For information on training and other resources, visit the Washington Stormwater Center website:
http://www.wastormwatercenter.org

Stay connected through Social Media
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• Sign up to follow and get Tweets

Further questions? Contact:
training@cascadiaconsulting.com
(206) 449-1163