Statewide LID Training Program

OVERVIEW OF PROGRAM

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

PROJECT LEAD

CORE TEAM

HERRERA

CASCADIA

VEDA

ADDITIONAL TRAINING SUPPORT
OVERVIEW OF PROGRAM

• Implementation of first round of trainings (September 2014 through May 2015)
• 64 trainings offered in current phase (through June 2015)
• Three levels: Introductory, Intermediate, and Advanced
• Train the Trainer program for service providers and LID topic experts

INTRODUCTORY
1.0 Introduction to LID for Eastern Washington
2.1 Introduction to LID for Inspection & Maintenance Staff
2.2 Introduction to LID for Developers & Contractors: Make Money by Growing

INTERMEDIATE
3.1 Intermediate LID Topics: NPDES Phase I & II Requirements
3.2 Intermediate LID Design: Bioretention
3.3 Intermediate LID Design: Permeable Pavement
3.4 Intermediate LID Design: Site Assessment, Planning & Layout
4.1 Intermediate LID Design: Rainwater Collection Systems & Vegetated Roofs
4.2 Intermediate LID Design: Hydrologic Modelling

ADVANCED
5.1 Advanced Topics in LID Design: Bioretention
5.2 Advanced Topics in LID Design: Permeable Pavement
5.3 Advanced Topics for Long-term LID Operations: Permeable Pavement
5.4 Advanced Topics in LID Design: Hydrologic Modelling
5.5 Advanced Topics in LID Design: Site Assessment, Planning & Layout
5.6 Advanced Topics in LID Design: Rainwater Collection Systems & Vegetated Roofs
5.7 Advanced Topics in LID Design: Bioretention Media

TRAIN THE TRAINERS
6.1 Service Providers
6.2 Train the Trainer program for service providers and LID topic experts

TODAY’S TRAINING
7.0 Intermediate LID Topics: NPDES Phase I & II Requirements
7.1 Intermediate LID Design: Bioretention
7.2 Intermediate LID Design: Permeable Pavement
7.3 Intermediate LID Design: Site Assessment, Planning & Layout
7.4 Intermediate LID Design: Rainwater Collection Systems & Vegetated Roofs

ADVANCED
8.1 Advanced Topics in LID Design: Bioretention
8.2 Advanced Topics in LID Design: Permeable Pavement
8.3 Advanced Topics for Long-term LID Operations: Permeable Pavement
8.4 Advanced Topics in LID Design: Hydrologic Modelling
8.5 Advanced Topics in LID Design: Site Assessment, Planning & Layout
8.6 Advanced Topics in LID Design: Rainwater Collection Systems & Vegetated Roofs
8.7 Advanced Topics in LID Design: Bioretention Media
Rainwater Collection Systems & Vegetated Roofs

WESTERN WASHINGTON

INSTRUCTORS

JASON KING, RLA
ASLA LEED AP
Senior Landscape Architect
Key project experience: Stormwater design for development, site design, green roofs, stormwater art, ecological planning

CHRIS WEBB, PE
LEED FELLOW
Associate Engineer
Key project experience: permeable pavement, bioretention, rainwater harvesting

AGENDA

1. Introduction
2. Rainwater Collection Systems
3. Vegetated Roofs
4. Wrap Up
AGENDA

1. Introduction
2. Rainwater Collection Systems
3. Vegetated Roofs
4. Wrap up

LEARNING OBJECTIVES

• Participants gain an intermediate level knowledge necessary to coordinate activities for entry level design and implementation of rainwater collection systems and vegetated roofs in residential and commercial settings (new and retrofit).

• Participants learn basic entry level design and implementation approaches for rainwater collection systems and vegetated roofs in residential and commercial settings.

• Participants learn practical skills necessary for construction of basic rainwater collection systems and vegetated roofs.

LOGISTICS

SCHEDULE
• 4-hour training with one break
• Sign in and sign out

OTHER LOGISTICS
• Restroom location
• Snacks
• Turn off cell phones
• Q&A at end of each section
LID Principles: Pre-developed forest

INTRODUCTION & REGULATIONS

LID Principles: Developed condition

INTRODUCTION & REGULATIONS

LOW IMPACT DEVELOPMENT (LID):
Stormwater Management Strategy

• Site design & planning techniques emphasizing conservation

• Use of small-scale & distributed engineered controls to closely mimic pre-development hydrologic processes

• Minimizing the concentration of stormwater

• Careful assessment of site soils and strategic site planning to best use those soils for stormwater management

INTRODUCTION & REGULATIONS
**LID Principles: Site Design And Planning**

- Minimize disturbance
- Reduce impervious surface
- Protect and restore native soils and vegetation
- Manage stormwater close to the source in a system of distributed practices
- Disconnect impervious surfaces

**Introduction & Regulations**

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

- Infiltration
- Filtration
- Storage
- Evaporation
- Transpiration

Examples for LID BMPs:

- Green Stormwater Infrastructure (GSI)
- Integrated Management Practices (IMPs)
- On-Site Stormwater Management BMPs

**Western WA NPDES Permit**

National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permits (2013-2018 permit cycle)

<table>
<thead>
<tr>
<th>Municipal Stormwater Permittees in Washington State</th>
<th>Western Washington Phase II Permittees</th>
<th>Eastern Washington Phase II Permittees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I Permittees</td>
<td>82 Cities</td>
<td>18 Cities</td>
</tr>
<tr>
<td>Phase II Permittees</td>
<td>5 Counties</td>
<td>5 Counties</td>
</tr>
</tbody>
</table>

Secondary Permittees: Approximately 45; such as ports and universities

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)
NPDES PERMIT LID REQUIREMENTS:
Implementation Timeline Varies By Permittee

Review and revise development related codes, rules & standards (i.e. adopt the 2012 Stormwater Manual)

**INTRODUCTION & REGULATIONS**

**NPDES MUNICIPAL STORMWATER PERMIT:**
Minimum Requirements (MRs)

1. Preparation of Stormwater Site Plans
2. Construction Stormwater Pollution Prevention Plan (SWPPP)
3. Source Control of Pollution
4. Preservation of Natural Drainage Systems and Outfalls
5. On-Site Stormwater Management
6. Run-off Treatment
7. Flow Control
8. Wetlands Protection
9. Operations and Maintenance

**DEFINITIONS**

Subset of On-site Stormwater Management BMPs used to meet MR #6 or MR #7 (may also be used to meet MR #5)

<table>
<thead>
<tr>
<th>Onsite SW Management BMP</th>
<th>Flow Control Credit</th>
<th>Treatment Credit</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>Rainwater Harvesting</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Bioretention</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Permeable Pavement</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Vegetated Roofs</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

1 Meets basic, enhanced and phosphorus treatment when infiltrating through soil per Ecology treatment requirements
2 Where permeable pavement is over soils meeting the suitability criteria or a treatment layer is included
3 Also considered SW Treatment & Flow Control BMP/Facilities (additional requirements in regard to long term inspection, operations, and maintenance apply)
introduction

rainwater collection systems

vegetated roofs

wrap up

Introduction

• What is Rainwater Collection
• History of Rainwater Collection
• Definitions
  • Reclaimed water
  • Greywater
  • Rainwater
• Benefits of Rainwater Harvesting
Introduction

RAINWATER COLLECTION SYSTEMS

System Types

• Non-Potable
  • toilets
  • urinals
  • trap primers for floor drains and floor sinks
  • irrigation
  • industrial processes
  • water features
  • cooling tower makeup

System Types

• Potable
  • Sole Source
  • Redundant
• Gravity or Pumped
  • Commercial / Residential
  • Single Building or Community Scale
• Simple
• Complex
• Hybrid Stormwater Systems
System Components

Roofing
- For potable systems, powder coated metal roofing is preferred
- Others can be considered
- Ecology water quality testing results
- Potable source control (UPC Appendix K)
  - Wood Roofing Materials
  - Lead Flashing
  - Roof paints and coatings with lead, chromium, or zinc

Collection
- Gutters
- Screens
- Wet vs. dry conveyance
- Sumps & relay pumping
- Freeze protection

Pre-Filtration
- Filter Examples
- Pre-filtration vs. roof washer
- 100 micron per UPC 1709.9.11
System Components
Storage (Cistern)

Design requirements
• Structural
• Access
• Overflow
• Isolate and drain for maintenance
• Screen all penetrations for vermin and insects
• Freeze protection

System Components
Storage (Cistern) – Above Grade Metal

System Components
Storage (Cistern) – Recycled
**System Components**

**RAINWATER COLLECTION SYSTEMS**

**Storage (Cistern) – Below Grade Concrete (Pre-Cast)**

- Below Grade Concrete (Pre-Cast)

---

**Storage options with costs**

Approximate cistern costs per gallon stored by tank type

- $0.50
- $1.00
- $2.00
- $4-$6
- $1.50
- $2.00
- $4-$6
- $4-$6

---

**System Components**

**Pumping & Distribution**

- Freeze protection
- Suctions
  - Floating
  - Static
- Float Switches

---
System Components
Pumping & Distribution
• Controls
• Variable Speed vs. single speed with pressure tank
• Jet pumps
• Submersible pumps

Filtration: Non-potable
• Depends on use
• Typically 20-50µ

Filtration: SF Residential Non-Potable Filter example
RAINFALL WATER COLLECTION SYSTEMS

System Components

Filtration: Potable

- Pollutants of Concern
- Filtration
- Disinfection

Filtration: Potable Filter example

Back-up

- Direct Connection
- DCVA / RP Device
- Level Control
- Cistern top off
- Air Gap
Rainwater Collection Systems

Codes and Permitting

Plumbing Code

Governs the piping of water inside and outside of a building
Enforced by health / building departments

- Chapter 17 - Nonpotable RW Catchment Systems
- Appendix K - Potable RW Systems
- WAC 51-56-1700 WA Amendments

Exclusions:
1. A permit is not required for exterior gravity catchment systems used for water use and noninfiltration purposes with a minimum storage capacity of 300 gallons (1136 L).
2. A plumbing permit is not required for exterior gravity drainage systems in single-family dwellings when serving only the house and not the exterior of the building. This does not preclude the need for permits when required for electrical connections, radiators, or anchorage.

Plumbing Code – Cross Connection

- Located on back-up line
- Most important code issue
- Necessary to protect potable supply
- Need to isolate premises or within a premises
- Covered by WAC 246-290-490
- EPA Cross Connection Control Manual (816-R-03-002)
- Local code may vary

Plumbing Code – Cross Connection – Air Gap

EPA Cross Connection Control Manual (816-R-03-002)
RAINWATER COLLECTION SYSTEMS
Codes and Permitting
Plumbing Code – Cross Connection – RP Device / DCVA

• Typical DCVA – For Reference Only
• Typical RP – For Reference Only

RAINWATER COLLECTION SYSTEMS
Codes and Permitting
Plumbing Code – Pipe Labeling

• Requirements vary by jurisdiction
• Label per ASME 13.1
• Black Lettering on yellow background 4’ o/c
• Purple pipe can be allowed

RAINWATER COLLECTION SYSTEMS
Codes and Permitting
Plumbing Code – Fixture Labeling

• Label all plumbing fixtures "CAUTION: NONPOTABLE WATER, DO NOT DRINK"
RAINFALL COLLECTION SYSTEMS
Codes and Permitting
Plumbing Code – Equipment Room Signs

• Equipment Room Signs per code:

“CAUTION NONPOTABLE RAINWATER, DO NOT DRINK. DO NOT CONNECT TO DRINKING WATER SYSTEM. NOTICE: CONTACT BUILDING MANAGEMENT BEFORE PERFORMING ANY WORK ON THIS WATER SYSTEM.”

---

RAINFALL COLLECTION SYSTEMS
Codes and Permitting
Plumbing Code – Building Signs

• Building Signs per code:

“TO CONSERVE WATER, THIS BUILDING USES RAINWATER TO FLUSH TOILETS AND URINALS.”

---

RAINFALL COLLECTION SYSTEMS
Codes and Permitting
Plumbing Code – Tank Labeling

• Tank Signs per code:

“NONPOTABLE RAINWATER.”

“DANGER-CONFINED SPACE.”
Codes and Permitting

RAINWATER COLLECTION SYSTEMS

ANSI/NSF P151

- NSF P151 - Health Effects from Rainwater Catchment System Components
- Plumbing Code Appendix K, 103.1

Rainwater Collection Systems

Codes and Permitting

Water Rights

- Water Law / Water Rights
- WSDOE POL 107 (Oct. 9, 2009)
- Limitations and requirements

Rainwater Collection Systems

Codes and Permitting

ARCSA/ASPE/ANSI 63-2013: Rainwater Catchment Systems

Design and Installation Requirements

- Collection Parameters
- Conveyance System
- Pre-filtration
- Cisterns / Storage
- Pump
- Filtration
- Piping
- System Inspection and Maintenance
- Potable Water Applications
- Operation and Water Quality Maintenance
- Labeling
**Codes and Permitting**

**Local Codes & Guides**

- Varies by jurisdiction
- Rainwater as sole source
- Sizing guidance
- ARCSA Accredited Professional
- Other requirements

---

**Modelling**

**Cistern Sizing (monthly vs. daily)**

---

**Modelling**

**Cistern Sizing (monthly vs. daily)**

---
Modeling
Stormwater (BMP T5.20: Rainwater Harvesting)

- Instances where BMP T5.20 applies is very limited
- Recommendation: Model daily demand as an infiltration rate in a vault
- Stacked hybrid vault or in-line cistern

Operations and Maintenance

- Inspect and clean filters and screens
- Inspect cisterns and clean accumulated sediment
- Inspect pump & controls
- Backflow prevention device inspection
- Water quality testing as required for potable systems
- Document and log all maintenance and testing
Potable Example

- Sole Source
- Retrofit
- 3 bedroom / 5 occupants (183 gpd)
- 200sf irrigated garden
- 2,500sf roof
- High rainfall site (119”/year)
- 13,500 gallon cistern meets 95% of days in the model
- Sump pumps required for collection

NOTES:

1. All written to be detailed per manufacturer’s instructions and local building codes
2. Use of 1/2” copper for sanitary and drainage systems
3. Use of 1/2” copper for irrigation systems
4. Ensure all copper pipe is properly welded
5. Ensure all copper pipe is properly insulated and protected
6. Ensure all copper pipe is properly marked

Chris Webb & Associates, Inc.

Statewide LD Training Program
Hybrid Rainwater / Green Roof?

- Not recommended to collect and re-use rainwater collected from Green Roof areas for potable reuse
- Toilet flushing in some cases/irrigation ok
- Aesthetic issues (i.e. discoloration / tannins)
- Some leaching of nutrients possible with some media
AGENDA

1. introduction
2. rainwater collection systems
3. vegetated roofs
4. wrap up

VEGETATED ROOFS
Types, Functions & Performance
Vegetated Roof?
VEGETATED ROOFS
Types, Functions & Performance

A Range of Benefits
- Improved Stormwater Management
- Urban Heat Island Reduction
- Usable Green Space
- Energy Efficiency/Thermal Insulation
- Roof Longevity
- Biodiversity/Habitat
- Reduction of Noise
- Reduction of Dust & Smog Particles
- Integrated Design Opportunities
- Aesthetics/Views

VEGETATED ROOFS
Types, Functions & Performance

Extensive
Thin, lightweight soil profile for with low maintenance vegetation such as succulents, grasses and perennials for stormwater management. Access paths usually for maintenance only.

Semi-intensive
Hybrid system with slightly more soil, capable of supporting more vegetation including small trees and shrubs. Can include small areas for seating and paths.

Intensive
Thicker soil profile with more robust vegetation including trees and shrubs. Includes paving, structures and other roof terrace elements.

VEGETATED ROOFS
Types, Functions & Performance

Extensive

Types, Functions & Performance

VEGETATED ROOFS
Types, Functions & Performance

Extensive

Types, Functions & Performance

VEGETATED ROOFS
Types, Functions & Performance

Extensive

Types, Functions & Performance

VEGETATED ROOFS
Types, Functions & Performance

Extensive

Types, Functions & Performance

VEGETATED ROOFS
Types, Functions & Performance

Extensive
VEGETATED ROOFS
Types, Functions & Performance
Intensive (Roof Terrace)

VEGETATED ROOFS
Types, Functions & Performance
Intensive (Roof Terrace)

VEGETATED ROOFS
Types, Functions & Performance
Rooftop Agriculture
## Types, Functions & Performance

### Rooftop Agriculture

- **VEGETATED ROOFS**

### Part of an Integrated System – LID Design

- **VEGETATED ROOFS**

### Performance

<table>
<thead>
<tr>
<th>Project</th>
<th>Completed</th>
<th>GM Depth</th>
<th>Area</th>
<th>Volume Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSU Broadway Building</td>
<td>2005-present</td>
<td>15 cm</td>
<td>500 m²</td>
<td>41-48%</td>
</tr>
<tr>
<td>SCIT</td>
<td>2005</td>
<td>75-150 mm</td>
<td>33 m³</td>
<td>29%/25mm (26%/150mm)</td>
</tr>
<tr>
<td>Multnomah</td>
<td>2004-2005</td>
<td>6 in</td>
<td>11,900 ft</td>
<td>30%</td>
</tr>
<tr>
<td>Hamilton (west roof)</td>
<td>2002-2005</td>
<td>5 in (~4&quot;)</td>
<td>2,520 ft</td>
<td>56%</td>
</tr>
<tr>
<td>Zoonazium</td>
<td>2-4/2007</td>
<td>6 in</td>
<td>8,000 ft</td>
<td>38%</td>
</tr>
</tbody>
</table>
VEGETATED ROOFS

Types, Functions & Performance

Performance

- Peak flows reduced by up to 53.3%
- Total runoff reduction of up to 70%
- Reductions of peak flows due to increased travel time of runoff


Factors Influencing Performance

- Size, shape and configuration of vegetated roof
- Soil depth
- Soil moisture conditions
- Magnitude and distribution of rainfall events
- Vegetative Conditions
- Runoff travel path

Additional Performance Values

- 10% reduction in energy use
- Double lifespan of roof (50 years)
- Reduced UV degradation and fluctuation of temperatures
- Reduction of urban heat island (local and modelled cumulative benefit)
- Reduction in particulate matter
### VEGETATED ROOFS

#### Types, Functions & Performance

**Additional Performance Values**

- Improved performance of solar due to cooling from vegetated roof

#### BASE COMPONENTS

- Waterproof Membrane
- Protection Layer
- Root Barrier
- Drainage Layer
- Edging/Curbs
- Maintenance Paths
- Ballast/Gravel
- Filter Fabric
- Growth Media (soil)
- Vegetation/Plants

#### OPTIONAL COMPONENTS

- Insulation
- Moisture Retention Mat
- Leak Detection System
- Rainwater Detention
- Ponds/Detention
- Railings
- Paving
- Lighting

---

#### Design Process

**BASE COMPONENTS**

- Waterproof Membrane
- Protection Layer
- Root Barrier
- Drainage Layer
- Edging/Curbs
- Maintenance Paths
- Ballast/Gravel
- Filter Fabric
- Growth Media (soil)
- Vegetation/Plants

**OPTIONAL COMPONENTS**

- Insulation
- Moisture Retention Mat
- Leak Detection System
- Rainwater Detention
- Ponds/Detention
- Railings
- Paving
- Lighting

---

**Essential for our climate!**

**Irrigation System**
VEGETATED ROOFS
Design Process
Extensive Roof – Typical Layers

a. existing structural roof support
b. existing 5-ply roofing system
c. 1/2” protection board
d. 1/2” drainage mat with root barrier
e. stainless steel edging
f. 6” growth medium
g. green roof vegetation
h. drip irrigation system
i. gravel ballast
j. roof drain
k. monitoring equipment
l. concrete pavers

VEGETATED ROOFS
Design Process
Different Systems

VEGETATED ROOFS
Design Process
Growing Media

standard topsoil
120-160 pounds per square foot (saturated)

lightweight aggregate
40-80 pounds per square foot (saturated)
VEGETATED ROOFS

Design Process

Growing Media

- Light weight (saturated)
- Maintain structure/Limited fines
- Retain moisture
- Environment for plant growth

- expanded shale
- perlite
- pumice
- paper pulp
- organic matter
- polymers

- Grain Size Distribution
- Density
- Water & Air Management
- pH, Lime & Salt Content
- Organics
- Nutrients
- CEC Capacity

http://www.ff-l.de/
### Design Process

#### Structural Considerations

<table>
<thead>
<tr>
<th>Type of Vegetated Roof</th>
<th>Range of Loading (pounds per square foot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extensive</td>
<td>12-40 p.s.f.</td>
</tr>
<tr>
<td>Semi-Intensive</td>
<td>40-80 p.s.f.</td>
</tr>
<tr>
<td>Intensive (Roof Terrace)</td>
<td>80-250 p.s.f. (can be higher depending on use of larger trees)</td>
</tr>
<tr>
<td>Rooftop Agriculture</td>
<td>40-150 p.s.f.</td>
</tr>
</tbody>
</table>

#### Design Process

**Plantings**

*Crassulacean Acidic Metabolism*

Non-Sedums breath through stomata during the day to photosynthesize, thus lose water in large amounts...

CAM plants keep stomata closed during the day and open during the night to absorb CO2, cutting down on transpiration and increasing the ability to survive arid conditions.
VEGETATED ROOFS
Design Process
Plantings: Got CAM?*

Plantings: Pots

Plantings: Cuttings
Design Process

VEGETATED ROOFS

Plantings: Seasonality

Sedum oreganum
(Oregon Stonecrop)

Plantings: Diversity

Sedum acre
(Biting Stonecrop)

Sedum kamtschatcicum
‘Variegatum’
(Variegated Stonecrop)

Sedum oreganum
‘Coral Carpet’
(Coral Carpet Stonecrop)
Design Process

Plantings: Diversity

- Delosperma cooperi (Hardy Iceplant)
- Sempervivum spp. (Hens and Chicks)
- Lewisia columbiana (Columbia Lewisia)
- Hemerocallis spp. (Daylilies)
- Festuca glauca 'Elijah's Blue' (Elijah's Blue Fescue)
- Fragaria chiloensis (Coast Strawberry)
VEGETATED ROOFS

Design Process
Irrigation: Seattle vs. other US Cities (West)

VEGETATED ROOFS

Design Process
Irrigation: Seattle - Precipitation v. Evapotranspiration

VEGETATED ROOFS

Design Process
Irrigation: Demand

• 30-40 day spans without even a trace of precipitation
  • When trace precipitation (less than 0.01 inches) is factored in, the dry spells increase even greater, up to 71 days with only a trace of precipitation.
  • There are a number of recorded 40-60 day spans with only a trace of precipitation, mostly occurring from mid-June to late August.
VEGETATED ROOFS
Design Process
Irrigation: Spray Rotors

VEGETATED ROOFS
Design Process
Irrigation: Capillary Drip System

The RDC system uses 60% less water for irrigation while requiring fewer, more evenly spaced drip emitters, providing a more uniform supply of water. The plant roots are protected from the direct stream of water, reducing water loss through evaporation.

VEGETATED ROOFS
Design Process
Irrigation: Issues with Traditional Spray

The traditional spray irrigation method has been found to be inefficient and wasteful. High water consumption and uneven distribution of water can lead to water waste and potential water shortages.
Construction Process

Inspections
- Pre Construction
- Roofing/Waterproofing
- Plumbing/Mechanical/Electrical (as governed by permitting)
- Initial Layout/edging (design)
- Growing Media (depth)
- Planting (correct plants/density)
- Irrigation (proper operation)
- Final Walkthrough/Punchlist
- Periodic O&M Reviews

Operations & Maintenance

O&M Planning

General Operations & Maintenance
O&M Contacts

Operations and Maintenance Requirements
- Irrigation
- Vegetation Management
- Soil Substrate/Growing Medium
- Aesthetics
- Insect Control
- Structural Components
- Debris & Litter
- Spill Prevention
- Training/Written Guidance
- Access & Safety

O&M Schedule & Documentation
- Activity Matrix
- Maintenance Calendar
- O&M Form

Operations & Maintenance

O&M Planning: Detailed Specs

3c. Soil Substrate/Growing Medium
- Inspection should be conducted to evidence of erosion from wind or water.
  - Any erosion should be backfilled with additional substrate and/or growing medium similar in nature to the original material, not to exceed 6” soil depth.
  - Areas should be staked/marked with appropriate material to avoid soils in place or erosion control netting and/or staked where necessary to provide immediate coverage of erosion.
  - Sources of erosion damage (drifting from other soils, overworking of surface soil, saturation) should be identified and corrected immediately.

3d. Aesthetics
- The landscaped aesthetic of the green roof is to maintain a healthy mix of native vegetation, perennials, annuals per plans, that is free of weeds, and that each bed is not dominated by a single species.
- Urinary/urine maintenance of plant health, and should allow for seasonal variation of plants, not to maintain a soft surface year round.
- Reading and litter control should be done to maintain neat appearance of vegetation and common areas and to avoid contamination by non-native species.
**Operations & Maintenance**

**VEGETATED ROOFS**

**O&M Planning: Activity Matrix**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Budgeted Hours</th>
<th>Schedule Time Period</th>
<th>Remaining Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluating irrigation equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusting irrigation system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring irrigation system</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**O&M Planning: Maintenance Calendar**

<table>
<thead>
<tr>
<th>Month</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>Check for irrigation system leaks and repairs</td>
</tr>
<tr>
<td>February</td>
<td>Monitor and adjust irrigation system</td>
</tr>
</tbody>
</table>

**O&M Planning: O&M Forms/Documentation**

**Table: O&M Forms**

<table>
<thead>
<tr>
<th>Log #</th>
<th>Date</th>
<th>Work Performed</th>
<th>Initial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table: O&M Forms**

<table>
<thead>
<tr>
<th>Description of Work Performed</th>
<th>Initial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table: O&M Forms**

<table>
<thead>
<tr>
<th>Scheduled to Complete</th>
<th>Required Follow-up Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
VEGETATED ROOFS
Codes & Permitting
Ecology Guidelines

• Vegetated Roofs in the 2013-2018 Western Washington Phase II Stormwater Permit

  • Defined as a “Hard Surface”
  • Flow control and on-site stormwater management option
  • Not an option in List #1 or List #2 for meeting Minimum Requirement #5
  • Need to use LID Performance Standard to receive on-site stormwater management (Minimum Requirement #5) or flow control (Minimum Requirement #7) credit

• Vegetated Roofs in the 2013-2018 Western Washington Phase II Stormwater Permit

  • BMP T5.17 (Volume V)
  • Consist of four basic components: waterproof membrane, drainage layer, light-weight growing medium, and vegetation
  • Install on roofs with slopes between 5 and 20 degrees. Roofs with slopes greater than 10 degrees require an analysis of engineered slope stability
  • Refer to LID Technical Guidance Manual for Puget Sound (2012) for additional design guidance, and Appendix III-C of the SWMMWW for modeling guidance

Q&A
AGENDA

1. Introduction
2. Rainwater collection systems
3. Vegetated roofs
4. Wrap up

STATEWIDE LID TRAINING PROGRAM

INTRODUCTORY
1.0 Introduction to LID for Eastern Washington
2.1 Introduction to LID for Inspectors & Maintenance Staff
2.2 Introduction to LID for Developers & Money for Green

INTERMEDIATE
3.1 Intermediate LID Design: Rainwater Collection Systems & Vegetated Roofs
3.2 Intermediate LID Design: Bioretention
3.3 Intermediate LID Design: Permeable Pavement
3.4 Intermediate LID Design: Site Assessment, Planning & Layout
4.1 Intermediate LID Design: Vegetated & Infiltrated Roofs
4.2 Intermediate LID Design: Hydrologic Modeling

ADVANCED
5.1 Advanced Topics in LID Design: Bioretention
5.2 Advanced Topics in LID Design: Permeable Pavement
5.3 Advanced Topics in LID Design: Vegetation Selection
5.4 Advanced Topics in LID Design: Site Assessment, Planning & Layout
5.5 Advanced Topics in LID Design: Vegetated & Infiltrated Roofs
5.6 Intermediate LID Design: Hydrologic Modeling

TRAIN THE TRainers
9.1 Service Providers

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

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

CERTIFICATE

Two certificates:
- Stay tuned for decisions on certificate
- LID Design certificate
- Long-term LID Operations certificate

Sign out!

ONLINE RESOURCES

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?
training@cascadiaconsulting.com
(206) 449-1163