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

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

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 & Contractors: Making Money from Green

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: Hydrologic Modeling

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 for Long-term LID Operations: Vegetated Roofs
5.5 Advanced Topics in LID Design: Rainwater Collection Systems & Vegetated Roofs
6.1 Advanced Topics in LID Design: Hydrologic Modeling

TRAIN THE TRAINERS

Service Providers LID Topic Experts

TODAY’S TRAINING

1.0 Introduction to LID for Eastern Washington
2.1 Introduction to LID for Inspectors & Maintenance Staff
2.2 Introduction to LID for Developers & Contractors: Making Money from Green

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: Hydrologic Modeling

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 for Long-term LID Operations: Vegetated Roofs
5.5 Advanced Topics in LID Design: Rainwater Collection Systems & Vegetated Roofs
6.1 Advanced Topics in LID Design: Hydrologic Modeling

TRAIN THE TRAINERS

Service Providers LID Topic Experts
INTSTRUCTORS

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

GREG GIRALDO, PE
LEED AP
Senior Engineer
Key project experience: 40 LID Projects including rainwater harvesting, bioretention, bifiltration, suburban wetland treatment, permeable paving

AGENDA

1. Introduction and regulations
2. Principles of LID site design
3. LID site design process
4. Site assessment and layout
5. Site planning and infrastructure
6. Trees
7. Exercises
8. Wrap up
AGENDA

- Introduction and regulations
- Principles of LID site design
- LID site design process
- Site assessment and layout
- Site planning and infrastructure
- Trees
- Exercises
- Wrap up

LEARNING OBJECTIVES

1. Participants gain an intermediate level understanding of overall site assessment with particular attention to infiltration capability of soils for roadway, lot and open space layout within the LID context.
2. Participants gain an intermediate level understanding of appropriate layout for roadway, lot and open space to protect site hydrology and create livable and attractive developments.
3. Participants will gain an intermediate level understanding of techniques to protect native soil and vegetation during site development.

LOGISTICS

SCHEDULE
- 8-hour training with two breaks
- Lunch on your own
- Sign in and sign out

OTHER LOGISTICS
- Restroom location
- Food
- 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
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

LID BMPs: Small-Scale Engineering Controls

- Infiltration
- Filtration
- Storage
- Evaporation
- Transpiration

Western WA NPDES Permit

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

<table>
<thead>
<tr>
<th>Municipal Stormwater Permits in Washington State</th>
<th>Western Washington Phase II Permits</th>
<th>Eastern Washington Phase II Permits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I Permits</td>
<td>82 Cities</td>
<td>18 Cities</td>
</tr>
<tr>
<td>Seattle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tacoma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clark County</td>
<td>5 Counties</td>
<td>5 Counties</td>
</tr>
<tr>
<td>King County</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pierce County</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snohomish County</td>
<td></td>
<td></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
**NPDES PERMIT LID REQUIREMENTS:**
Implementation Timeline Varies By Permittee

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

**Timeline for updating local codes**

<table>
<thead>
<tr>
<th>Phase I</th>
<th>Phase II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Section 5E.C.5.b of the Phase I Permit</td>
<td>Per Section 5E.C.6 of the Phase II Permit</td>
</tr>
<tr>
<td>Most Permittees</td>
<td>Lewis Co. and Cowlitz Co.</td>
</tr>
<tr>
<td>June 30, 2016</td>
<td>June 30, 2017</td>
</tr>
</tbody>
</table>

* = Or GMA update deadline

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

| Onsite SW Management BMP | Flow Control Credit | Treatment Credit
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></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>X</td>
</tr>
<tr>
<td>Rainwater Harvesting</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Bioretention4</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Permeable Pavement2</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Vegetated Roofs2</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td></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 BMPs/Facilities; additional requirements in regard to long term inspection, operations, and maintenance apply

**Q&A**
PRINCIPLES OF LID SITE DESIGN: Conventional Site Development Practices and Impacts

- Compaction can extend 24"+ with heavy loads on wet soils.
- Compaction usually in top 6-8 inches of soil for tractors weighing less than 10 tons/axle.
- Track vs tires inflated to higher pressures...compaction appears to increase with increased tire pressure.

The typical construction approach is to strip, cut, fill and pound.
Management of large clearing and grading operations is expensive and time consuming.

**PRINCIPLES OF LID SITE DESIGN: Conventional Site Development Practices and Impacts**

- Stream biota significantly reduced at SS levels of 50-80 mg/L (Corish 1995).
- Schueler reported median TSS concentrations of 4,145 mg/L leaving construction sites with no TESC and 283 mg/L with TESC.

**PRINCIPLES OF LID SITE DESIGN: Value of Native Soils and Vegetation**
PRINCIPLES OF LID SITE DESIGN: Value of Native Soils and Vegetation

- 23.92 acres
- 103 Lots (4,143 sq ft ave.)
- 15 acres (63%) Open space
- Effective impervious area approaching 0%
### PRINCIPLES OF LID SITE DESIGN: Value of Native Soils and Vegetation

<table>
<thead>
<tr>
<th></th>
<th>Detention storage reduced (ft$^3$)</th>
<th>Detention storage required (ft$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td></td>
<td>270,000</td>
</tr>
<tr>
<td>Low impact</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>reduce development envelope</td>
<td>-149,019</td>
</tr>
<tr>
<td></td>
<td>and use bioretention</td>
<td>-40,061</td>
</tr>
<tr>
<td></td>
<td>and use minimal excavation foundation</td>
<td>-7,432</td>
</tr>
<tr>
<td></td>
<td>and use 20’ wide permeable road</td>
<td>-29,988</td>
</tr>
<tr>
<td>Total</td>
<td>-226,500</td>
<td>43,500</td>
</tr>
</tbody>
</table>

Hydrologic modeling comparing a conventional development and the flow reduction benefits from individual practices for a low impact development design.

### PRINCIPLES OF LID SITE DESIGN: Value of Native Soils and Vegetation

**BMP T5.30 Full Dispersion**
- 65/10/0
- Sliding dispersion scale.

### PRINCIPLES OF LID SITE DESIGN: Urban Development and Small Lots

Possible but challenging to conserve and protect native soils and vegetation in dense development settings.
It takes a village...and fines to protect trees and soil.

- Contractor training
- Bonding/fines
- Signage

PRINCIPLES OF LID SITE DESIGN: Protecting Native Trees and Soil

- Conventional street design increases drainage network and efficiency.
- Local street right of ways can constitute over 25 percent of the typical urban watershed.
- Streams with buffers constitute about 10 percent of this sample watershed.

PRINCIPLES OF LID SITE DESIGN: Road Networks
PRINCIPLES OF LID SITE DESIGN: Scale of Analysis

- Home
- Planned Development
- Community
- Watershed
- County/City
- Region

PRINCIPLES OF LID SITE DESIGN: Regional Planning

Avoid open-space fragmentation

- 15,000 sq. ft. lots
- 5,000 sq. ft. lots

PRINCIPLES OF LID SITE DESIGN: Regional Planning

Project vs. regional clustering

- Project by project cluster development
- Regional cluster development
AGENDA

- introduction and regulations
- principles of LID site design
- LID site design process
  - site assessment and layout
  - site planning and infrastructure
- trees
- exercises
- wrap up

10/14/2014

LID SITE DESIGN PROCESS: Overview

1. Project baseline/charter
2. Develop basis of design
3. Develop team and engage stakeholders
4. Site inventory and analysis
5. Site assessment and develop Site Plan

LID SITE DESIGN PROCESS: Project Baseline/Charter

- Project Scope
- Project Schedule
  - Construction
  - Plant Establishment
  - Construction Budget
- Jurisdiction and Code Requirements
- Sustainability Goals defined
- Maintenance Capabilities
LID SITE DESIGN PROCESS: Develop Basis of Design

- Project Background
  - Specification and drawing format
  - Sustainability requirements
  - Property restrictions and easements
  - Permitting and point of compliance
- Site Civil
  - Frontage and Right-of-Way requirements
  - Civil grading criteria
  - Utility criteria
- Landscape Design Criteria
  - Existing tree preservation
  - Buffers

LID SITE DESIGN PROCESS: Develop Team and Engage Stakeholders

- Owner/Developer
- Public agency reviewers
  - Land use Planners/Zoning
  - Transportation
  - Utility department
  - Stormwater Management
  - Other
- Architect
- Civil Engineer
- Surveyor
- Landscape Architect
- Geotechnical Engineer
- Wetland/Biologist
- Arborist
- Outreach
- Community stakeholders
- Fire & Police Department
- Owner’s contractor
- Funding partners
- Maintenance staff
- Other?

LID SITE DESIGN PROCESS: Site Inventory and Analysis

- Gather existing analysis, inventories, and historic information:
  - Soil surveys and analyses
  - Historic records of altering wetlands/ stream channels
  - Aerial photos
  - Maps and site reconnaissance to verify topography
  - Location of groundwater protection areas and/or well head protection zones
  - Descriptions of local site geology
- Site reconnaissance and characterization
  - Characterize hydrologic, geologic and biologic conditions
  - Used to inform overall design and location of infrastructure
  - Investigate steep slopes and landslide hazards near project site
LID SITE DESIGN PROCESS: Stormwater Site Plan

NPDES Permit Minimum Requirement #1 Preparation of Stormwater Site Plans:

• Use site-appropriate development principles to retain native vegetation and minimize impervious surfaces to the extent feasible.
• Local codes will change to incorporate certain LID principles.
• Prepare a Stormwater Site Plan for local government review.

LID SITE DESIGN PROCESS: Stormwater Site Plan

Minimum Requirement #1 Preparation of Stormwater Site Plans

1. Analyze Existing Site Conditions
2. Preliminary Site Layout
3. Off-site Analysis
4. Determine applicable Min. Requirements
5. Prepare Permanent Stormwater Control Plan
6. Prepare Construction SWPPP
7. Complete Plan
8. Check for Compliance

LID SITE DESIGN PROCESS: Stormwater Site Plan

1. Site Analysis: Collect and Analyze Information on Existing Conditions (Volume 1, Section 3.3.1)
   • Survey
   • Soils Report
   • Professional (on-site sewage designer OK if only MR #1 - #5)
   • Surveys, test pits, borings
   • Ksat field tests or grain size analysis
   • Depth to restrictive layer – need winter data
   • Lateral flow assessment (MR #1 - #9)
   • Vegetation survey of any protected areas
LID SITE DESIGN PROCESS: Stormwater Site Plan

Stormwater – related Site Procedures and Design Guidance for Permeable Pavement (Volume 3, Section 3.4)

- Sites where only MR 1 – 5 apply:
  - Infiltration test per 5,000 sq. ft./wet season groundwater

- Commercial sites where MR 1 – 9 apply:
  - Small-scale PIT per 5000 sq. ft., at least 1 per site

- Residential sites where MR 1 – 9 apply
  - Small-scale PIT per 200 ft of road & every lot
  - Criteria for reduction of test frequency
  - Groundwater thru wet season

LID SITE DESIGN PROCESS: Stormwater Site Plan

Stormwater – related Site Procedures and Design Guidance for Bioretention/Rain Garden (Volume 3, Section 3.4)

- Small Commercial: one small-scale PIT
- Large Commercial: small-scale PIT every 5,000 sq. ft.
- Residential: small-scale PIT at each potential site
  - Per 200 feet for long, narrow layout; e.g. road ROW
  - Groundwater thru wet season – adequate clearance?
- Correction factor for native soils: CFv = 0.33 to 1
- WWHM guidance
- Legal Documentation

LID SITE DESIGN PROCESS: Stormwater Site Plan

Stormwater – related Site Procedures and Design Guidance for Permeable Pavement (Volume 3, Section 3.4)

- Assignment of Infiltration Correction Factors
- Soil Suitability Confirmation
- Project Submission Requirements
- WWHM Modeling
- Legal Documentation

Statewide LID Training Program  WESTERN WASHINGTON
ECOLOGY IN.EVENT SITE ASSESSMENT, PLANNING AND LAYOUT  WESTERN WASHINGTON
ECOLOGY IN.EVENT SITE ASSESSMENT, PLANNING AND LAYOUT  WESTERN WASHINGTON
ECOLOGY IN.EVENT SITE ASSESSMENT, PLANNING AND LAYOUT
LID SITE DESIGN PROCESS: Stormwater Site Plan

Minimum Requirement #1 Preparation of Stormwater Site Plans

1. Analyze Existing Site Conditions
2. Preliminary Site Layout
3. Off-site Analysis
4. Determine applicable Min. Requirements
5. Prepare Permanent Stormwater Control Plan
6. Prepare Construction SWPPP
7. Complete Plan
8. Check for Compliance

---

LID SITE DESIGN PROCESS: Stormwater Site Plan

5. Permanent Stormwater Control Plan (Volume 1, Section 3.1.5)
   • Site Hydrology for Projects under MR #1 – #5:
     • Drawings for location of all On-site SW BMPs & drainage areas
     • Design details, figures, maintenance instructions (recordable documents)
     • Justification for infeasibility decisions, OR
     • Demo compliance with LID Performance Standard if applicable

---

LID SITE DESIGN PROCESS: Stormwater Site Plan

5. Permanent Stormwater Control Plan (Volume 1, Section 3.1.5)
   • Site Hydrology for Projects under MR #1-#9:
     • Summary
     • Performance Standards, Treatment, Lists
     • LID Features
     • Flow Control System (MR #7)
     • Water Quality System (MR #6)
     • Conveyance System
LID SITE DESIGN PROCESS: Stormwater Site Plan

Minimum Requirement #1 Preparation of Stormwater Site Plans

1. Analyze Existing Site Conditions
2. Preliminary Site Layout
3. Off-site Analysis
4. Determine applicable Min. Requirements
5. Prepare Permanent Stormwater Control Plan
6. Prepare Construction SWPPP
7. Complete Plan
8. Check for Compliance

LID SITE DESIGN PROCESS: Stormwater Site Plan

7. Complete Stormwater Site Plan (Volume 1, Section 3.1.7)

- O&M manuals for all “stormwater treatment and flow control facilities”
  - Includes bioretention, permeable pavement, & vegetated roofs that help meet MR #6 or #7.
- Declaration of Covenant & Grant of Easement
  - For all stormwater treatment & flow control facilities
  - For all other on-site stormwater management BMPs
  - Signed & recorded for each lot

LID SITE DESIGN PROCESS: Stormwater Site Plan

7. Complete Stormwater Site Plan (Volume 1, Section 3.1.7)

- Track lot obligations
  - Plat/short plat approvals
  - Deed info & restrictions
    - Covenant & Easement
    - Drawings, design details, maintenance instructions
    - Impervious/pervious requirements
SITE ASSESSMENT AND LAYOUT

Use site analysis to guide site planning, reducing environmental impacts and achieve LID design objectives

 Four general objectives:
- Minimize disturbance
- Locate lots for dispersing stormwater to open space areas
- Orient lots to maximize on-lot infiltration or open conveyance
- Locate lots adjacent to, or with views or, open space
Prevalent Strategies:

- Cluster homes
- Narrow lot frontages to reduce road length per home
- Reduce front yard setbacks to reduce driveway length
- For grid or modified grid layouts, lengthen street blocks to reduce the number of cross streets and overall road network per home

SITE ASSESSMENT AND LAYOUT: Optimize Development Envelope

Large lot yield plan

Rural cluster

- 30% reduction in impervious surface when lot size reduced from 1.4 to 0.25 acres (MD Office of Planning).
- Increase in road network and driveways primary driver for impervious increase.
SITE ASSESSMENT AND LAYOUT: Optimize Development Envelope

Increase density, create appropriate building heights and scale, and conserve open space with strategic design.

SITE ASSESSMENT AND LAYOUT: Road Layout

Typical grid road layout
- Impervious coverage: 27-36%
- Less adaptive to site features.
- Promotes transit and connectivity with more direct access to services.

Typical curvilinear road layout
- Impervious coverage: 15-29%
- More adaptive to site features.
- Generally discourages transit with longer, less connected system.
SITE ASSESSMENT AND LAYOUT: Road Layout

Hybrid or LID road layout

- Impervious coverage: similar percentage to other layouts.
- Adaptive to site features and uses site features (particularly water as an organizing theme).
- Can provide good connectivity and fire and safety access.

SITE ASSESSMENT AND LAYOUT: Road Layout

Road width and turnarounds

SITE ASSESSMENT AND LAYOUT: Road Layout

- Design to enhance street scape and buffer pedestrians and homes from roadway
SITE ASSESSMENT AND LAYOUT: Buildings

- Reduce building footprint (build up)
- Orient the long axis of the building along topographic contours to reduce cutting and filling
- Control roof runoff onsite
- Use low impact foundations
- Limit clearing and grading to road, utility, building pad, landscape areas

SITE ASSESSMENT AND LAYOUT: Open Space

- Preserve open space through clustering, building design, site planning

SITE ASSESSMENT AND LAYOUT: Costs and Benefits

- Reduce O&M costs
- Reduce in storm drainage infrastructure
- Reduce paving
- Triple Bottom Line Benefits:
  - Jobs and economic benefits
  - Community livability and neighborhood vitality
  - Sustainable product life cycle
  - Energy impact and production
  - Eco-system benefits
  - Agriculture and food production
  - Innovations and new market development
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- Wrap up

SITE PLANNING AND INFRASTRUCTURE:

Zoning
- Comprehensive Plan goals and policies
- Zoning code
  - Landscaping, Native Vegetation, Tree Protection, and Open Space
  - Impervious Surface Standards
  - Bulk and Dimensional Standards
  - Site Plan Review
  - Parking
- Development Code and Standards
  - Clearing and Grading Standards
  - Engineering and Street Standards
SITE PLANNING AND INFRASTRUCTURE:
Small Lots

- Small lots often require:
  - Flexible code
  - Narrow side and front yard setbacks...consider fire and safety (sprinklers, fireproof siding)
  - Effective use of open space and lot layout
SITE PLANNING AND INFRASTRUCTURE:

Stormwater

- Strategic Stormwater Management
  - Reduce TIA and eliminate EIA where possible
  - Increase infiltration
  - Combined stormwater treatment and open space/landscaping

Utilities

- Place water and sewer lines in disturbed areas
- Cluster water meters to minimize construction disturbance
- Cluster dry utilities under proposed sidewalks in joint trenches
SITE PLANNING AND INFRASTRUCTURE: Circulation Layout

- Integrate pedestrian with storm where possible
- Layout pedestrian to access open space
- Fire and safety!

SITE PLANNING AND INFRASTRUCTURE: Integrating Open Space

- Create open space areas as community amenity and to store and slow stormwater flows during winter when the areas are less active recreationally
- Integrate open space into traffic calming designs
- Use open space to break up visual landscape for homes facing the road/each other
- Create open space pathways between homes (green streets)

SITE PLANNING AND INFRASTRUCTURE: Case Study

St. Thomas School, Media, WA

Site Planning: limit impermeable surface, open space, retained existing trees and soils, reduction in infiltration

- Stormwater management: reduction of impervious surfaces, amended top soil, bioretention, permeable pavement
- Construction: shared infrastructure facilities, adjustments to permeable pavement spec
SITE PLANNING AND INFRASTRUCTURE: Case Study
St. Thomas School, Media, WA
- Stormwater management: reduction of impervious surfaces, amended top soil, bioretention, permeable pavement

SITE PLANNING AND INFRASTRUCTURE: Case Study
St. Thomas School, Media, WA
- Construction: shared TESC and WQ Treatment facilities, testing permeable pavement, reduce impacts on existing trees

Q&A
AGENDA

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- wrap up

**TREES: Integrating Stormwater Management**

Multiple benefits
- Energy conservation
- Air quality
- Carbon sequestration
- Aesthetics and increased property value
- Stormwater flow reduction

**TREES: Integrating Stormwater Management**

- Trees may be used for stormwater management through careful assessment of subgrade soils, groundwater levels, and site drainage patterns
- Volume of storage for stormwater dependent on volume and type of soil
- Preventing compaction and increasing volume of soil increases volume for stormwater storage

LID retrofit in New Jersey includes street trees
Stormwater concepts:
1. Larger mature trees provide more stormwater benefits than small trees
2. Evergreen trees provide more stormwater benefits than deciduous trees
3. Adequate soil volume and quality are critical for healthy long-lived trees
4. Proper drainage design is critical—too much water can kill a tree faster than too little

Site Assessment:
• Available above ground growing space
  • Overhead wires and other utilities
  • Vehicle and pedestrian sight lines

Considerations for location and type of tree (cont’d):
• Below ground root space and ground level planting
  • Proximity to paved areas, utilities, and underground structures
• General:
  • Availability of soil and water
  • Prevailing wind direction and sun exposure
  • Maintenance
  • Shade, windbreak, privacy screening, air quality...
Guidelines for tree placement and protection

- Plant in the best/appropriate places with highest quality soils and adequate soil volume
- Design for larger growing spaces
- Do not restrict trunk flare of mature tree
- Use pervious pavement for hard surfaces around trees
- Protect the tree from surrounding activities
- Drainage

Drainage

- If not directing flow to tree area and seasonally high GW below tree pit subgrade then likely no under-drain needed.
- If directing flow to tree area careful consideration of soils, tree species and under-drain.
- Generally planting pit above rooting zone (18-24 in.) should drain down within 48hrs.
- If under-drains used, incorporate an accessible control structure if possible.
- SilvaCell has GULD for WA.

Reducing soil compaction

- Clearly mark protection areas, soil storage/staging areas, existing tree protection areas on plans and site
- Review plans and coordinate throughout construction with construction foreman and crew
- Robust fencing and signage declaring protection objectives and penalties to violating protection areas

- If access unavoidable:
  - Foot access: 6 inch layer of arborist wood chip mulch (AWC) and water
  - Vehicle access: 1 inch steel plate or 4 inch thick timber plank over 2-3 inches of AWC (min of ¾ inch plywood over 6-8 inches of mulch)
**TREES: Construction Impacts**

Reducing compaction (long-term)

1. New Trees
   - Mulch tree planting bed with 2-4” of AWC. Keep chips 1’ back from trunk. Replenish 1-3 years
   - Barriers
     - Wheel stops.
     - Low fences.
     - Curbs.

2. Existing trees
   - Mechanical
   - Soil amendments (compost and other biological products)

**TREES: Tree Protection Zone**

Tree Protection Zone (TPZ)

- Area (radial distance) based on the radial distance m/ft
- Identified by a certified arborist
- Protect during development

*Figure No. 4. General Illustration of Tree Protection Area*

- Protection zone that covers the trees optimum rooting zone
- Use plywood, chain-link or sheet metal fence
- Fines and penalties for violating the area demarcated by the barrier (included in the contract or specifications)
- Location of the barrier determined by the certified arborist based on species tolerance, condition, and age
- Barrier placement should also account for working space
**TREES:** Tree Protection Zone

- Stripping top of organic surface soil
- Clearing unwanted vegetation
- Demolishing existing structures

Root loss
- Restrict stripping of topsoil around trees
- Install protective shields over roots during excavation
- Any weeds vegetation to be removed adjacent to trees remain should be at any level from root ball or path by equipment
- Different root injury to removing trees may occur
- Arborist may be needed for adjacent tree removal if crowns are intertwined

- Root injury to remaining trees may result
- Arborist may be needed for adjacent tree removal if crowns are intertwined

**TREES:** Construction Impacts

<table>
<thead>
<tr>
<th>Activity</th>
<th>Impact</th>
<th>Methods to minimize damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stripping top of organic surface soil</td>
<td>Root loss</td>
<td>Restrict stripping of topsoil around trees</td>
</tr>
<tr>
<td>Clearing unwanted vegetation</td>
<td>Root loss</td>
<td>Install protective shields over roots during excavation</td>
</tr>
<tr>
<td>Demolishing existing structures</td>
<td>Root loss</td>
<td>Any weeds vegetation to be removed adjacent to trees remain should be at any level from root ball or path by equipment</td>
</tr>
<tr>
<td>Compacted surface soils</td>
<td>Unfavorable conditions for root growth</td>
<td>Fence trees to keep traffic and storage out of root area</td>
</tr>
<tr>
<td>Compressed surface soils</td>
<td>Chronic stress from reduced root systems</td>
<td>Provide a storage area and traffic barriers for construction activity away from trees</td>
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<tr>
<td>Trenching for utilities, stormwater system, drains</td>
<td>Root loss</td>
<td>Avoid open trenching in rooting area</td>
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</tr>
<tr>
<td>Lowering of grade, scarifying</td>
<td>Preparing sub-grade for fill and structures</td>
<td>Before grading, root prunes tree at edge of excavation to a depth required</td>
</tr>
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</table>

- Any woody vegetation to be removed adjacent to trees remain should be cut at ground level and not pulled out by equipment |
- Otherwise root injury to remaining trees may result |
- Arborist may be needed for adjacent tree removal if crowns are intertwined |
- Avoid open trenching in rooting area |
- Tunnel under roots, if possible. If not, within root area, dig trenches by hand, bridging across greater than 5 inches / 12.7 cm |
- Consolidate utilities in one trench |
- Where traffic cannot be diverted, protect soil surface
**TREES: Construction Impacts**

<table>
<thead>
<tr>
<th>Tree diameter</th>
<th>Auger / Trenchless distance from tree</th>
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<tr>
<td>5-9 inches</td>
<td>5 feet</td>
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<tr>
<td>10-14 inches</td>
<td>10 feet</td>
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<tr>
<td>15-19 inches</td>
<td>12 feet</td>
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<tr>
<td>over 19 inches</td>
<td>15 feet</td>
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</tbody>
</table>

**TREES: Integrating Stormwater Management**

- **Soil depth**
  - 30-48" extended for a 10’ radius around tree in lawn areas

- **Soil volume**
  - Recommendations vary
    - Urban: 0.36 m³ soil per 1 m² canopy projection for loam, no irrigation with 30" annual rainfall
    - Lindsey and Bussuk: 0.24 m³ per 1 m² canopy projection

- **Structural Soils require volume for structural component => less available soil**

- **CU Structural Soil™ has ~ 20% available soil**

**TREES: Integrating Stormwater Management**

**Soil and rooting volume strategies**

1. **Rigid cell systems**
   - Modular frames
   - Support high loads
   - Most volume available for soil and tree roots
2. Structural soil
   - Crushed aggregate (typ. 0.75–1.5” fine grained soil and polymer).
   - Good porosity (25–30%) and permeability (>20 in/hr), load bearing. Lower soil availability (~20%).

3. Sand-based structural soil
   - Medium to coarse uniformly graded sand with compost
   - (2–3% by volume) and 2-4 in/hr Ksat typical.
   - Typically 30” deep
   - Non-proprietary.

4. Root paths
   - Guide roots out of confined planting areas.
   - Do not add much soil volume, but interconnect planting areas.
5. Root trenches
   • Increase soil and rooting volume.
   • Typically 5” wide filled with topsoil or designed mix.
   • Reinforce sidewalk to span trench.

TREES: Integrating Stormwater Management
Soil and rooting volume strategies

TREES: Stormwater Management Performance
Interception and evaporation
   • Xia (2000)...Mediterranean climate
     • Deciduous: 15% annual precip intercepted and evaporated.
     • Evergreen: 27% annual precip intercepted and evaporated.
   • Asadian (2009)...Vancouver, BC
     • Evergreens
     • Seven events, 377mm total precip.
     • Interception and evaporation ranged from 17-89%.
     • Note that 89% is high...authors speculate high rate due to increased temps in urban area.

TREES: Stormwater Management Performance
Infiltration
   • Bartens (2008)
     • Black oak (course root structure) and red maple (finer root structure).
     • Both penetrated soils in containers with bulk densities of 1.3 and 1.6 g/cm³.
     • Infiltration rates were 63% higher in lower compaction soil and 153% higher in higher compaction soil compared to control with no plants.
Q&A

AGENDA

- introduction and regulations
- principles of LID site design
- LID site design process
- site assessment and layout
- site planning and infrastructure
- trees
- exercises
- wrap up
### Statewide LID Training Program

#### OTHER COURSE OFFERINGS

<table>
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<tr>
<th>Level</th>
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<td>Introduction to LID for Eastern Washington</td>
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<td>Introduction to LID for Inspection &amp; Maintenance Staff</td>
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<td>Introduction to LID for Developers &amp; Contractors: Make Money Be Green</td>
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#### Course Catalog

- http://www.wastormwatercenter.org/lidwtrainingprogram/

#### Online Evaluation

- An online evaluation will be sent to you within 5 days following this training.
Statewide LID Training Program

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

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QUESTIONS

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