Endangered and threatened species of Puget Sound – orca, chinook (steelhead, chum, coho, etc.)

Natural Drainage Systems
Tries to make this... ...function like this.

Seattle’s Natural Drainage System Program
City Right-of-Way
- Residential Neighborhood – NDS Grids
- SEA Street Prototype
- Cascade Prototype
- Lessons Learned through projects
- High density Neighborhood – High Point
- Commercial Area – Swale on Yale
- Private Property
- Private Parking Lots – Northgate Mall
- Stormwater Code Revisions to encourage LID
- Lakewood Pilot Project
- Private Incentives – RainWise Program

Tracy Tackett, Low Impact Development Program Manager
Before After
SEA St: 2nd Ave NW between 117th & 120th Streets, aerial looking north

Who to Involve
Street Design, Landscape Architects, Other Utilities, …

SEA Street monitoring results for two years:
99% reduction in total runoff volume

Curvilinear Template

NW110th Carkeek Cascade
Existing Systems

Carkeek Cascade at NW 110th
Combined with flow through water quality channel
Different from SEA Street – lots more water, steeper slopes

Major Lesson Learned, Street Guidelines

Water Quantity and Quality Monitoring by UW (Cameron Chapman) – great performance

Major Lesson Learned, modeling
- Less runoff than anticipated
- Higher average annual infiltration rate

Major Lesson Learned, Soil Wrap Wall specs
Broadview Green Grid

Sub-basin drainage area = 32 acres
SEA Streets and Cascades

Major Design Change

Sidewalk adjacent street

Major Lesson Learned, Native Soils

Major Lesson Learned, Native Soils

Major Lesson Learned, Native Soils

Major Lesson Learned, Native Soils
Major Lesson Learned, Native Soils

Sub-basin drainage area = **32 acres**

Native Soil Infiltration Rates

Modified Full Scale Field Testing (PIT)

Field flexibility - Subsurface Pipe

Major Lesson Learned, Bioretention Soils

November 11?, 2004

Major Lesson Learned, need better modeling

Pinehurst Project Area

- Kramer drainage = 134 acres
- Pinehurst project = 49 acres

November 11?, 2004
Offset Template

Block Scale Template Cost/Benefit Comparison

Evaluate Construction Cost per Block ($1000)

- Template I: Curvilinear
- Template II: Offset
- Template III: Existing

Potential Infiltration Surface Area (SF/block)

<table>
<thead>
<tr>
<th>Template</th>
<th>Infiltration Surface Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1465 SF</td>
</tr>
<tr>
<td>II</td>
<td>863 SF</td>
</tr>
<tr>
<td>III</td>
<td>440 SF</td>
</tr>
</tbody>
</table>

Construction Costs

- $280,000 for 660’ block
- 42% Stormwater elements (including soil)
- 45% Street improvements (road, curb, sidewalk)
- 13% Landscaping

Note: correlates to approximate $200/ LF for stormwater elements

Major impact to residents during construction!
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More Project Information:
http://www.ci.seattle.wa.us/util/naturalsystems/

Natural System Program
High Priority Watersheds

North: Piper’s Creek Watershed

South: Longfellow Creek Watershed

Longfellow Creek Watershed
High Point Redevelopment
• 130-acre site
• new right-of-way
• 1,600 units
• 65% impervious area
• 9% of watershed

High Point Natural Drainage Strategies
Housing: Block-level Design

Pop Up Emitter
Gravel Pave
Splash Blocks
High Point Neighborhood

Case Study: High Point Redevelopment, Seattle, WA

Comparison of Flow Duration

Forest Pasture Current Redeveloped, no NSS Redeveloped, with NSS Condition

Duration that 2-year peak flow rate, based on pasture conditions, is exceeded (hours/year)

Porous Concrete Roadway Demonstration
Who to work with – Permitting and enforcement procedures in place prior to construction

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Right-of-Way - Commercial Neighborhood
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Private Property: parking lots

Rainwise Incentives Program

• Rainwater cisterns
• Green roofs
• Bioretention
• Bioswales
  - Peak reduction
  - Peak and volume reduction
• Compost amended soil
• Porous pavement
• Reduction of impervious surface area

http://www.ci.seattle.wa.us/dpd/Sustainable_Building
More Project Information:

http://www.ci.seattle.wa.us/util/naturalsystems/

Major Lesson Learned, Stewardship

Water Quality Monitoring by UW

Results: runoff retention

- System retains at least 48% of all inflows

Results: outlet hydrology

- Discharge in only 49 of 235 storms
- Fully retains storms up to 1” in dry conditions
- Fully retains storms up to 0.3” in any condition

Results – peak flow reduction

- All storms
- Peak flow rate inlet vs. outlet
Water Quality Results:
Conservative estimates of percent reduction in mass loading

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Method 1</th>
<th>Method 2, 3*</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS</td>
<td>84 (72-92)</td>
<td>89, 86*</td>
</tr>
<tr>
<td>TN</td>
<td>63 (53-74)</td>
<td>67</td>
</tr>
<tr>
<td>TP</td>
<td>63 (49-74)</td>
<td>73</td>
</tr>
<tr>
<td>Copper</td>
<td>83 (77-88)</td>
<td>83</td>
</tr>
<tr>
<td>Zinc</td>
<td>76 (46-85)</td>
<td>84</td>
</tr>
<tr>
<td>Lead</td>
<td>90 (84-94)</td>
<td>89</td>
</tr>
<tr>
<td>Motor oil</td>
<td>92 (86-97)</td>
<td>93</td>
</tr>
</tbody>
</table>

Results: typical outflow quality from 110th Cascade (mg/L)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS</td>
<td>10 – 40</td>
</tr>
<tr>
<td>TN</td>
<td>0.6 – 1.4</td>
</tr>
<tr>
<td>TP</td>
<td>0.09 – 0.23</td>
</tr>
<tr>
<td>SRP</td>
<td>0.02 – 0.05</td>
</tr>
<tr>
<td>Total copper</td>
<td>0.004 – 0.008</td>
</tr>
<tr>
<td>Dissolved copper</td>
<td>0.002 – 0.005</td>
</tr>
<tr>
<td>Total zinc</td>
<td>0.04 – 0.11</td>
</tr>
<tr>
<td>Dissolved zinc</td>
<td>0.02 – 0.06</td>
</tr>
<tr>
<td>Total lead</td>
<td>0.002 – 0.007</td>
</tr>
<tr>
<td>Dissolved lead</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Motor oil</td>
<td>0.11 – 0.33</td>
</tr>
</tbody>
</table>

High Point Neighborhood

Swale Cross Sections

- Vegetated swale
- 10” ponding
- 18” deep

- Grass-lined swale
- 2” ponding
- 8” deep
Porous Concrete Roadway