

LID Technical Workshop – Puget Sound

Bioretention: Siting and Applications

Presentation Overview

Siting Considerations

Native Soil Characterization

Lessons Leaned

Feasibility & Performance

Applications

ALICE LANCASTER, PE
alancaster@herrerainc.com
HERRERA

September 10, 2014

Siting Considerations

LID Principles

- Manage rain where it falls
  - Distribute LID practices across site → Smaller facilities, managing water from smaller areas
  - Minimize concentrating flows
- Use hydrology to guide site layout
  - Retain natural drainage features/patterns
  - Locate infiltrating BMPs in areas with best soils
- Preserve SW management functions of site
  - Minimize disturbance to vegetation and soil
  - Preserve trees

INFILTRATION SITING CONSIDERATIONS

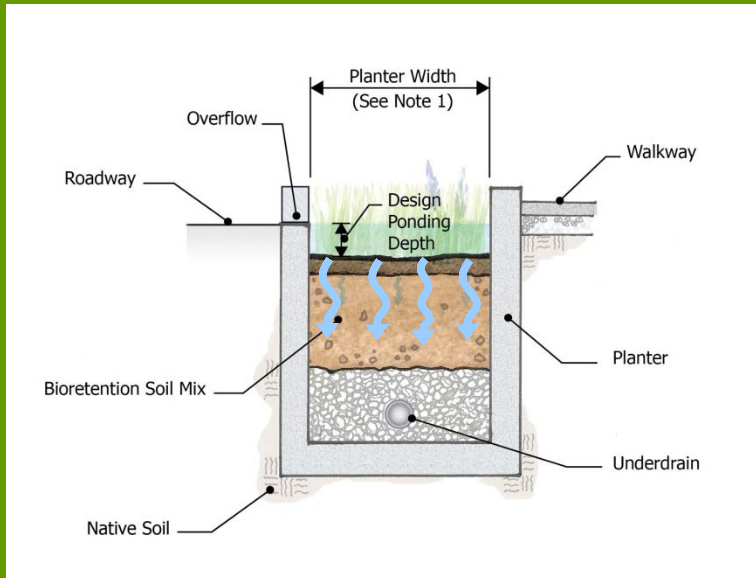
- When do they apply?
- Small vs. large-scale infiltration
- Infiltration restrictions
- Infiltration setbacks

Infiltration Siting Considerations

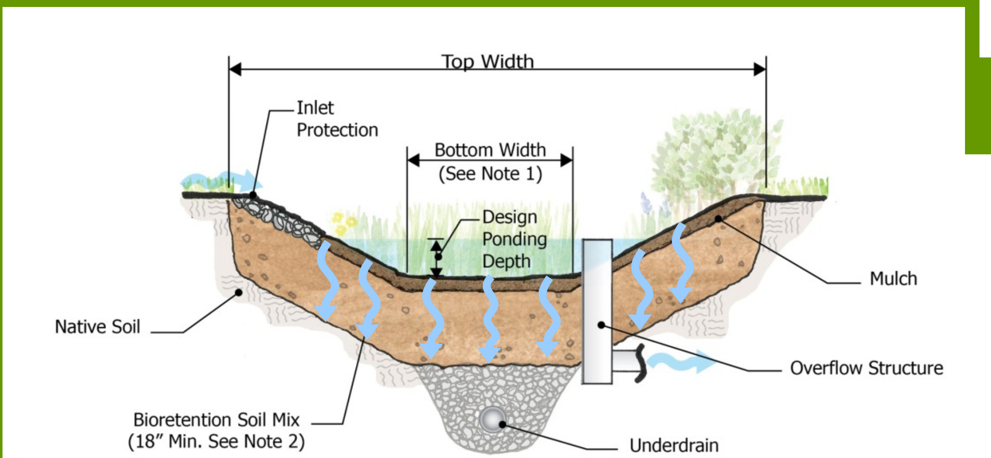
When Do They Apply?

All bioretention facilities:

infiltrate water through bioretention soil for treatment



Planter with Underdrain



Notes:
1. Bottom width shall be a minimum of 2 feet and bottom area shall be flat (0% slope).
2. Imported bioretention soil shall meet City of Seattle specifications (minimum design infiltration rate of 3 inches per hour and 40% porosity).

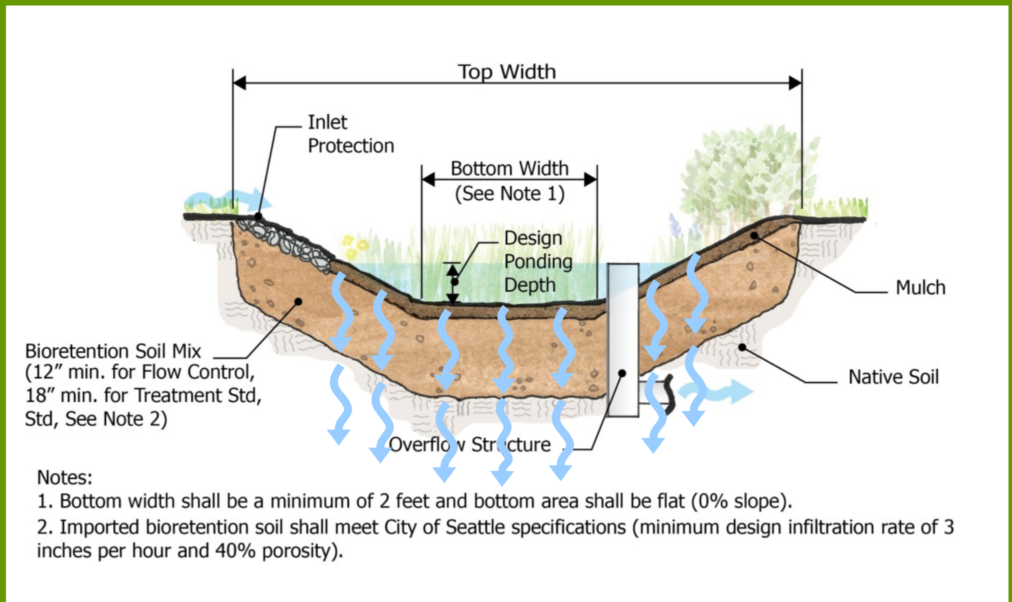
Bioretention with Underdrain

Infiltration Siting Considerations

When Do They Apply?

Infiltration siting considerations apply to facilities that ALSO:

infiltrate water into underlying native soils



Bioretention

Infiltration Siting Considerations

Large –Scale vs Small-Scale

- **Large-scale infiltration BMPs**:
  infiltration basins, dry wells and injection wells concentrate stormwater flows and infiltrate large volumes at discrete points with high infilt. rates
- **Bioretention**:
  should be small and distributed across a site with a hydrologic regime closer to a natural vegetated condition

Infiltration Siting Considerations

Restrictions (sources: SMMWW Infeasibility Criteria)

Infiltration not permitted in:

- Geotechnical evaluation deems imprudent
  - erosion, slope failure, flooding
- Erosion/landslide hazard areas
- Groundwater protection area
- Insufficient vertical separation from bottom of facility to hydraulic restriction layer (water table, bedrock, compacted soil layer)
  - 1 foot clearance if the contributing area is less than:
    - 5,000 square feet of pollution-generating impervious surface
    - 10,000 square feet of impervious area
    - ¾ acres of lawn and landscaped area
  - 3 foot clearance for larger contributing areas

Infiltration Siting Considerations

Setbacks (source: SMMWW Infeasibility Criteria)

Infiltration not permitted within:

- 100 ft of drinking water supply wells or springs
- 10 ft of septic systems or drain fields
- 50 ft from top of slope >20% and over 10 ft relief
- 100 ft contaminated site or landfill
- 10 - 100 ft of USTs (depending on size)
- Local setbacks from structures (e.g., 5 ft to 10ft minimum, increasing with drainage area*)
- Local setbacks from property lines (e.g., 5 ft from property lines without neighbor agreement*)

*Seattle Criteria

Infiltration Siting Considerations

Other Considerations

- Understand fate of infiltrated water
  - Intent is to infiltrate to native underlying soil
  - Arterial ROW with dense underground infrastructure (preferential pathway → utility trenches)
  - Potential for excessive shallow interflow emerging at slopes, development cuts, or in basements
- Use engineering controls
  - Ex. Trench water stops to prevent reinfiltration to pipes
  - Ex. Liners to protect adjacent infrastructure

OTHER SITING CONSIDERATIONS

- Tree preservation
- Site Slopes
  - Cross & Longitudinal Slopes
  - Positive Drainage from drainage area to BR to overflow
- Setbacks (e.g., utilities & other infrastructure)
- May require presettling

LOT LAYOUT, 2012 LID MANUAL

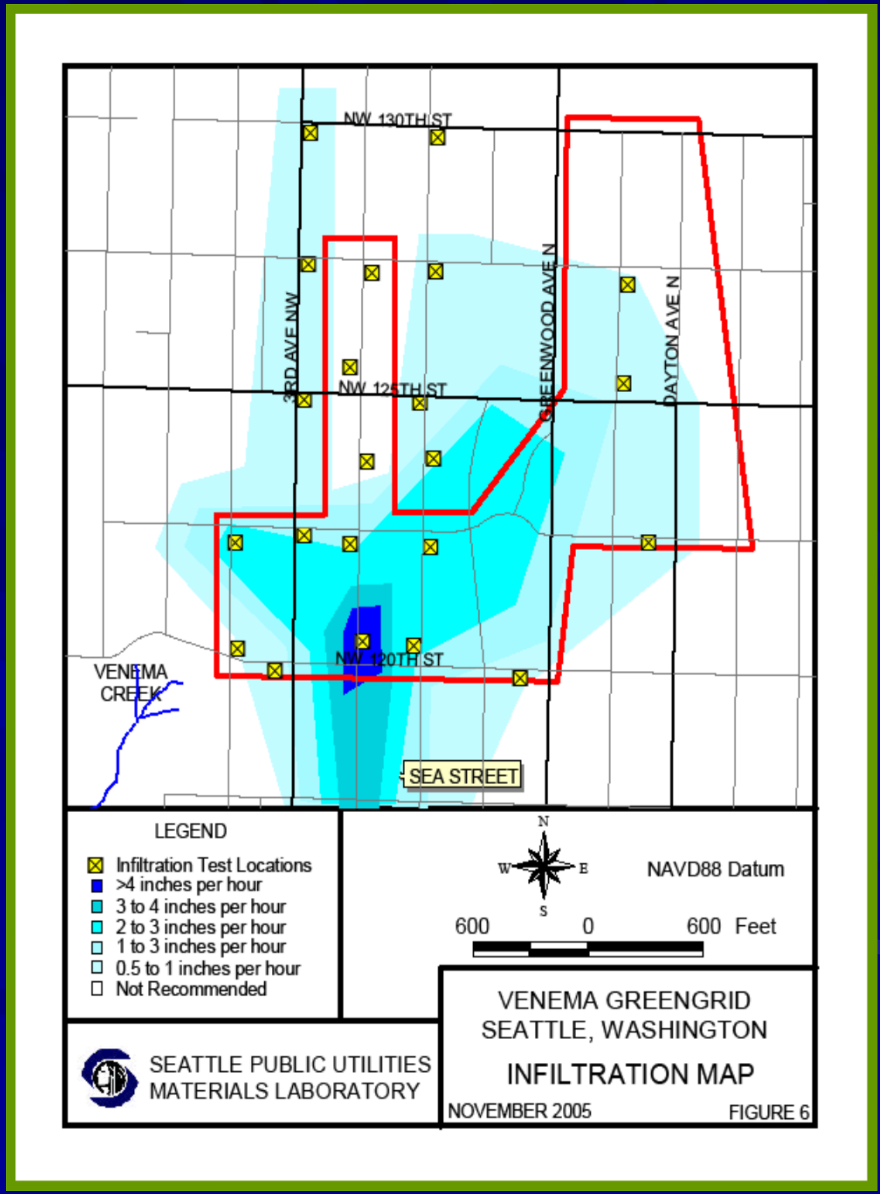
- Public acceptance/ participation (retrofits)
- Transportation/pedestrian safety

Native Soil Characterization

- Why soils affect siting
- Soil variability
- Initial infiltration rates
- Design infiltration rates

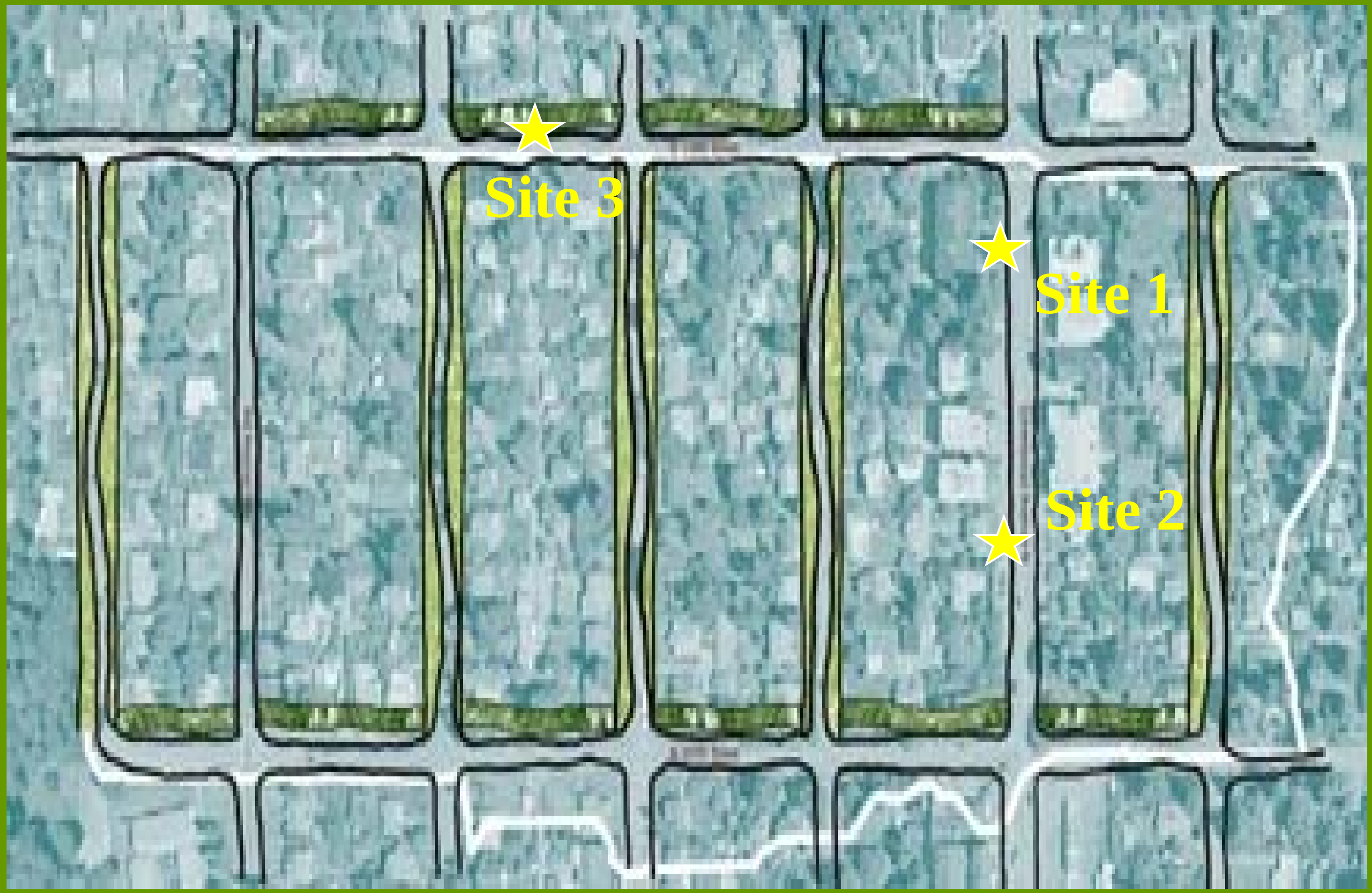
Why Native Soil Affects Siting

- Important for Infiltrating facilities ONLY
- Infiltrating facilities sized based on infiltration rates
- Minimum "feasible" initial infiltration rate of 0.3 in/hr
- Locate infiltrating BMPs in areas with best soils →



Soil Variability

Native Soils Can Vary Widely!!!!!



Broadview Green Grid, Seattle, WA

Soil Variability

Site 1: Loam

Broadview Green Grid, Seattle, WA

Soil Variability

Site 2: Beach Sand

Broadview Green Grid, Seattle, WA

Soil Variability

Site 3: Glacial Till (High Clay Content)

Broadview Green Grid, Seattle, WA

Infiltration Rates

Overview

Measure or estimate initial saturated hydraulic conductivity

Apply correction factor

Long-term (design) infiltration rate

Initial Infiltration Rates

Methods

- Estimate based on soil properties
  - USDA Soil Textural Classification ← Eliminated in 2012 SWWMM
  - Soil Grain Analysis ← Only accepted for soils unconsolidated by glacial advance in 2012 SWWMM
- In-situ field measurements
  - EPA Falling Head ← Not in SWWMM/ Inaccurate
  - Double ring infiltrometer test ← Not in SWWMM/ Inaccurate
  - Small Scale Pilot Infiltration Test (PIT)
  - Large Scale PIT

INITIAL INFILTRATION RATES

METHODS

- Estimate based on soil properties
  - USDA Soil Textural Classification
  - Soil Grain Analysis

Use for soils unconsolidated by glacial advance

- In-situ field measurements
  - EPA Falling Head
  - Double ring infiltrometer test
  - Small Scale Pilot Infiltration Test (PIT)
  - Large Scale PIT

Use for all other soils

Pilot Infiltration Test

Ecology Small Scale PIT Method

- Excavate Pit
  - Depth ~ surface elevation of native soil (before BSM placement)
  - Horizontal bottom area ~ 12 to 32 sf
  - Side slopes laid back, but vertical for test ponding depth (6 – 12in)
- Install Vertical Measuring Rod
- Install Splash Plate
  - Reduce side wall erosion and disturbance of bottom (clogging)
- Fill Pit for Pre-Soak Period
  - Standing water (at least 12 inches) for 6 hours
- Adjust Flow Rate for Steady State Period
  - Constant water depth (6 – 12 inches) for 1 hour
- Turn off Water and Record Rate of Infiltration
  - Until Empty

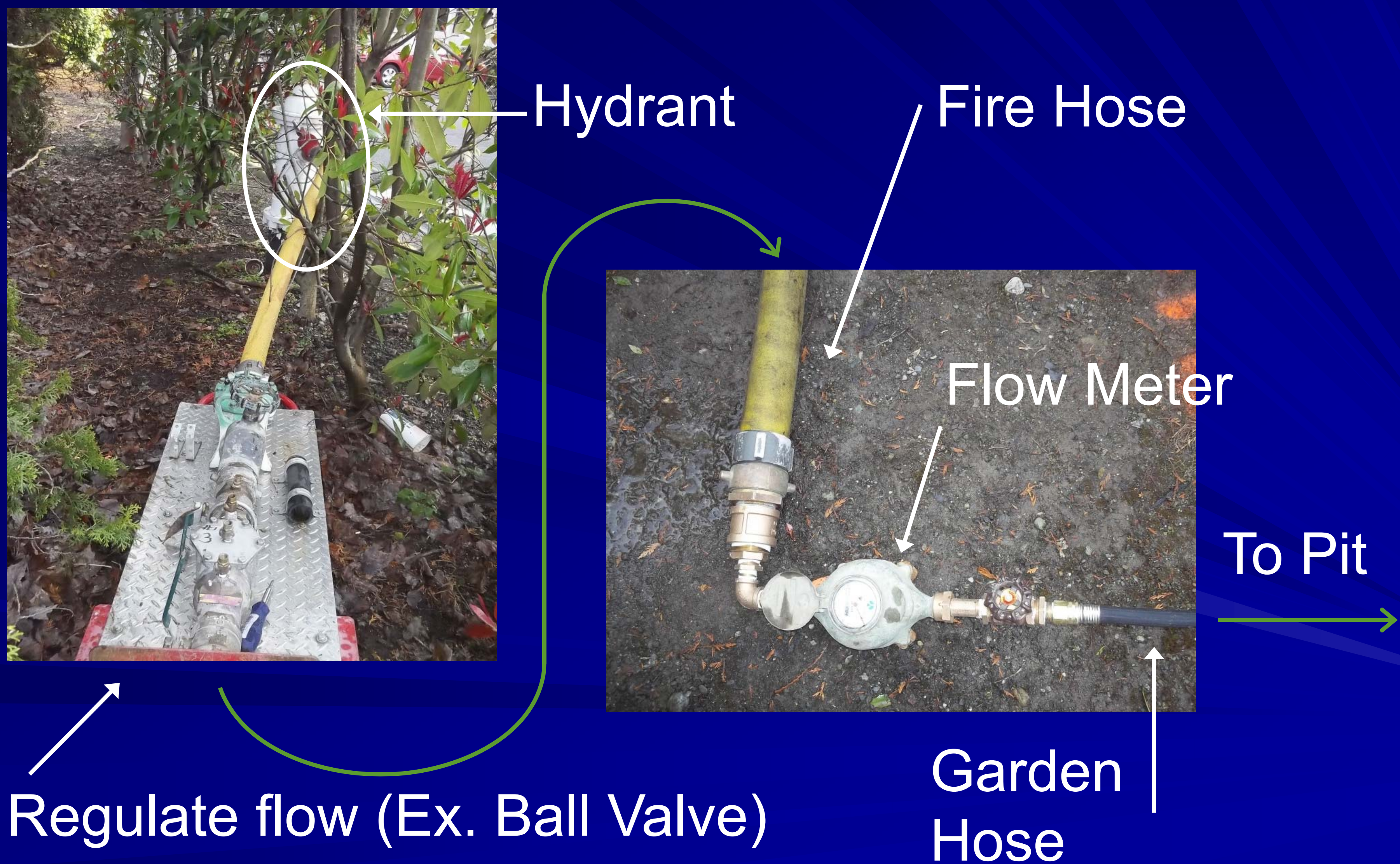
Pilot Infiltration Test

Ecology Small Scale PIT Method (Continued)

- Depth to Groundwater
  - Over excavate 3 feet below pit bottom to check for hydraulic restrictive layers (e.g., bed rock, till/clay lenses) or groundwater
  - Alternatively, monitor groundwater through wet season
- PIT Timing
  - Test between December 1 and April 1
- Number of PITs
  - Recommend one PIT at each bioretention site
  - For larger site, one PIT every 5,000 sf
  - For long narrow facilities, one PIT every 200 lineal feet (unless borings indicate consistent soil characteristics)

Pilot Infiltration Test

PIT Example



Pilot Infiltration Test

PIT Example

Vertical Measuring Rod

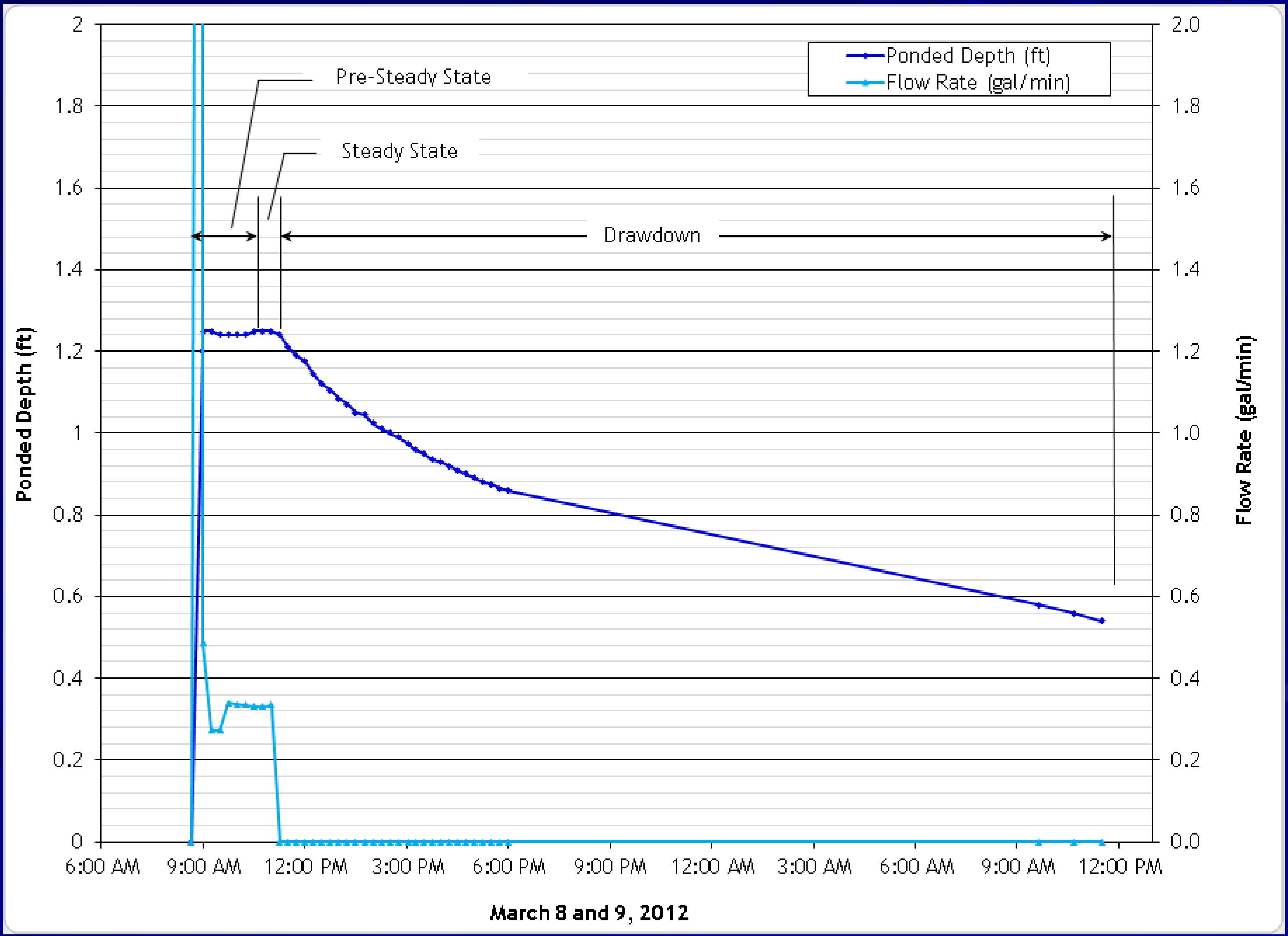
Pit (lay back side slopes)

5 gal. Bucket (energy dissipation)

Water level recorded every 15 minutes

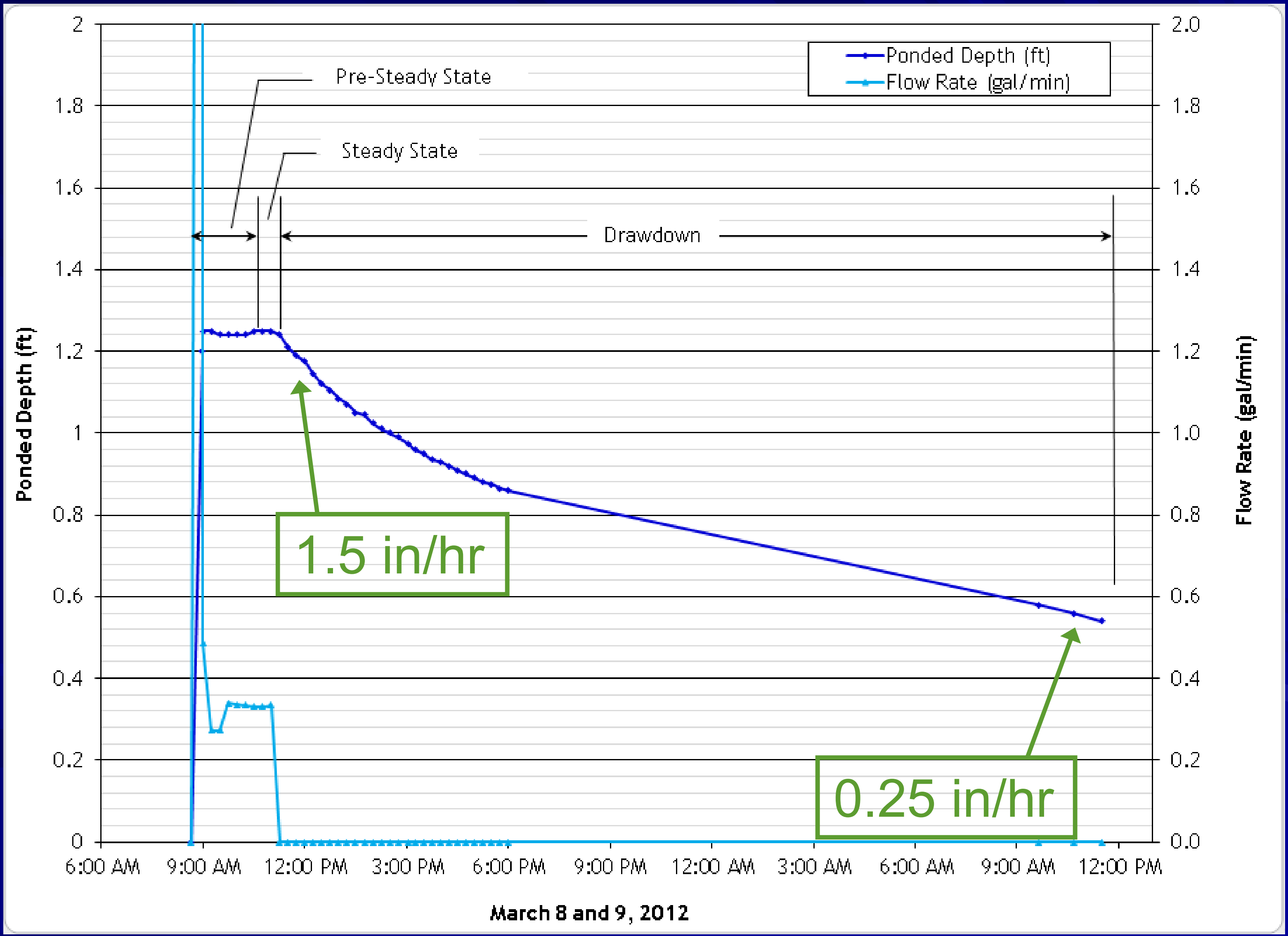
Pilot Infiltration Test

PIT Example



PILOT INFILTRATION TEST

PIT EXAMPLE



Design Infiltration Rates

Calculate from Initial Rates

- Correction factors applied to <u>initial</u> rate to estimate <u>long-term</u> rate for design
- Correction factors:
  - Site variability and number of locations tested = 0.33 to 1
  - Degree of influent control to prevent siltation and bio-buildup = none required (overlying BSM provides excellent protection)
- Design rate = Initial Rate x CF (0.33 to 1)

Additional Site Characterization

- Seasonal High Groundwater
  - Monitoring well or excavated pit
  - Assess during wet season
- Groundwater Mounding Analysis
  - For drainage area > 1 acre contributing to one facility
- Soil Characterization
  - Grain size analysis

Site Characterization Lessons Learned

Ballard Roadside Rain Gardens, SPU

- Bioretention pilot for CSO control
- Funded by stimulus money → fast timeline
- Many rain gardens not draining
  - Poorly infiltrating soils
  - Perched/mounded groundwater
  - Springs
- What went wrong:
  - Communication/Public Involvement Strategy
  - Site Characterization → Final geotech report not complete until after 90% design
  - Design
  - Construction Practices

Site Characterization Lessons Learned

28th Ave NW between NW 65th & 67th St

Raingardens not exactly to scale.

Raingarden Post-Construction Performance

- Infiltrating (drains in < 24 hours)
- Not infiltrating or infiltrating very slowly

Seattle Public Utilities

Site Characterization Lessons Learned

Lessons from SPU

- Be aware of the level of data required vs risk and costs
- Consider potential of GW mounding on top of glacial till
  - Indicators of high seasonal GW: seeps, wet pavement, saturated planting strips
  - Ask community about evidence of GW springs, basement flooding
- Timing of subsurface evaluation
  - Clearly communicate risks of accelerating schedule
  - Include formal geotech review at 30% design
  - Leave time for 2nd round of tests if 1st round indicates high variability
- Measured infiltration rate
  - < 0.75 in/hr → conduct more in-depth subsurface evaluation
  - 0.25 – 0.75 in/hr → redundant design (e.g., underdrains)
  - <0.25 in/hr → infiltrate?

Feasibility

Not Solution For Every Site

- Grade < 8%
- Positive grade from drainage to BMP to overflow
- Bioretention with infiltration also subject to:
  - Infiltration restrictions and setbacks
  - Minimum vertical separation to GW/impermeable layer*

* New permit feasibility criteria: Vertical separation of 3 feet for larger contributing areas is only allowed as proof of infeasibility when contributing area cannot reasonably be broken down into smaller areas

PERFORMANCE

STANDARDS

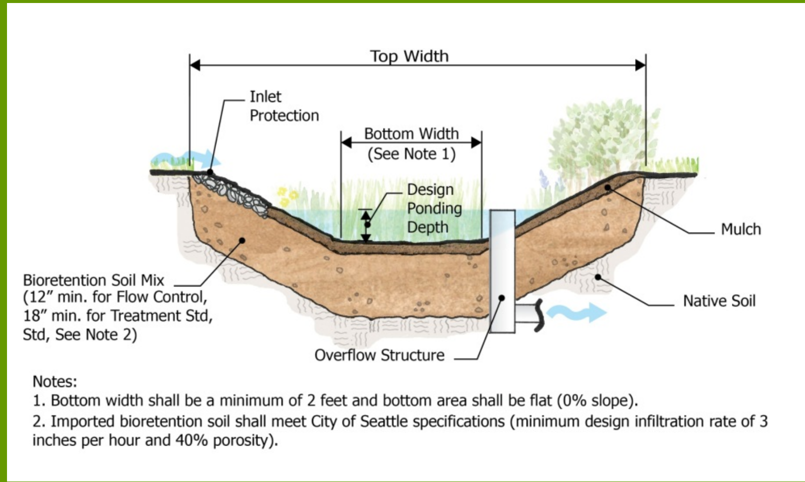
- Flow Control:
  - Non Exempt Receiving Water (Most Creek Basins)- Ecology requirement to match the peaks and duration to predeveloped condition (usually forest)
  - Combined Sewer or Capacity Constrained Basins- Local requirements are typically peak-control based
- Water Quality:
  - Infiltrate 91 percent of the total runoff volume through soil meeting Ecology treatment criteria

PERFORMANCE

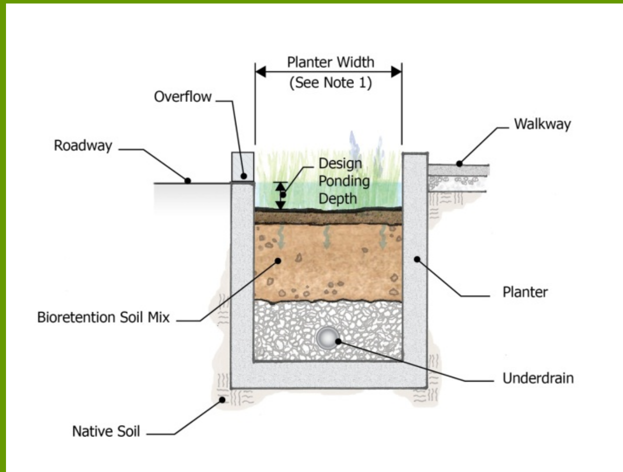
CAPABILITIES

- Bioretention with Infiltration
  - – Full Flow Control
    (with permeable soils)
  - – Full Treatment
    (with 18” BRS)*
- Bioretention without Infiltration
  (e.g., underdrain & liner/impermeable reservoir)
  - – Partial Flow Control
  - – Full Treatment
    (with 18” BRS)*

* Meets basic & enhanced treatment when infiltrates through soil meeting Ecology treatment soil requirements



BIORETENTION



PLANTER WITH UNDERDRAIN

APPLICABILITY

SETTINGS

- Residential Parcels
  - Landscaped areas
  - Planters
- Commercial Parcels
  - Landscaped areas
  - Planters
  - Parking Lots
- Right-of-Way
  - Planting strip
  - Curb bulbs
  - Medians

SINGLE FAMILY

RAINGARDENS

SINGLE FAMILY

STORMWATER PLANTERS

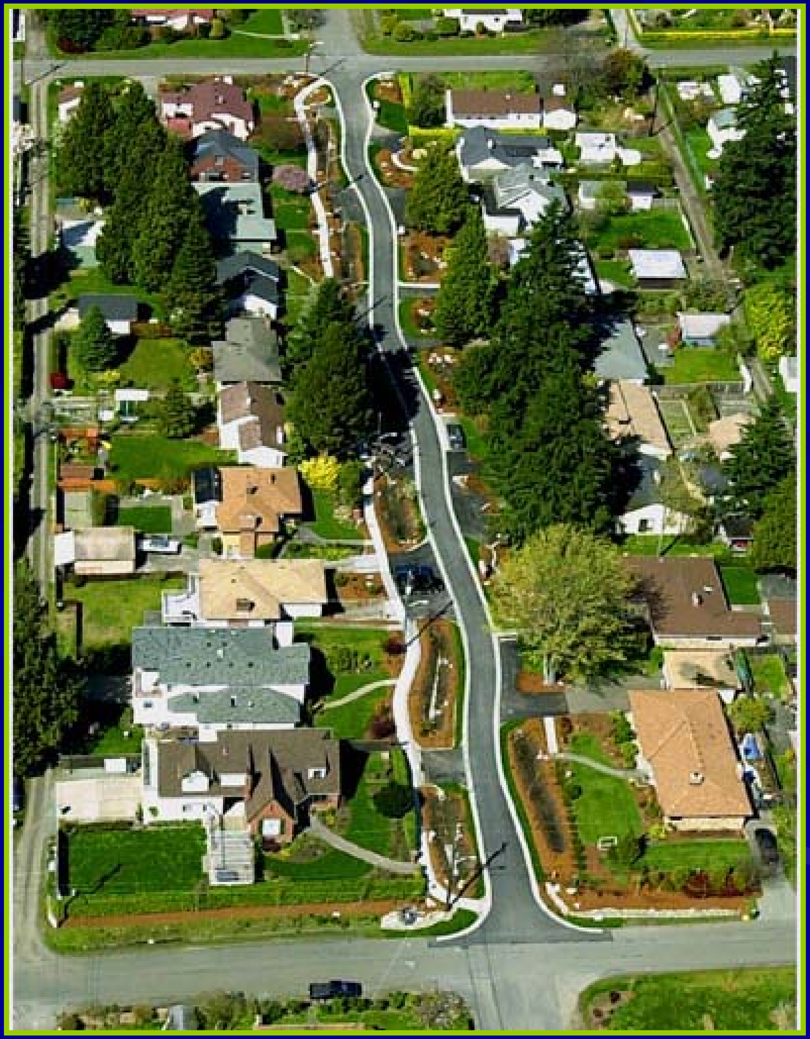
Inflow Conveyance

Overflow

Residential Right-of-Way

Seattle SEAStreets

Before



After

Residential Right-of-Way

Seattle SEAstreets

Residential Right-of-Way

Curb Bulbs

NE Siskiyou Green Street
Portland, OR

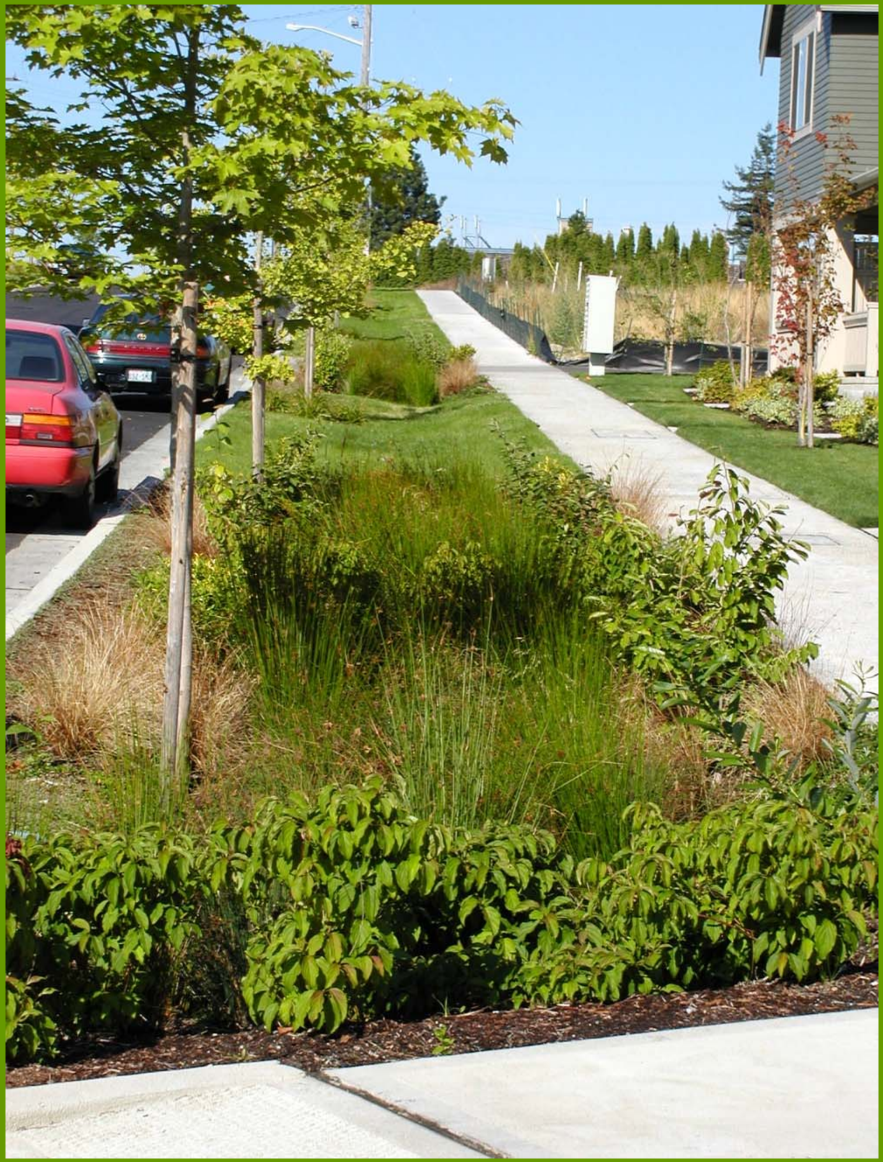
23rd Ave SE & 171st Pl SE

MULTI FAMILY DEVELOPMENTS

HIGH POINT, SEATTLE, WA

MULTI FAMILY DEVELOPMENTS

BLOCK-LEVEL DESIGN



HIGH POINT, SEATTLE, WA

Multi Family Developments

Block-Level Design

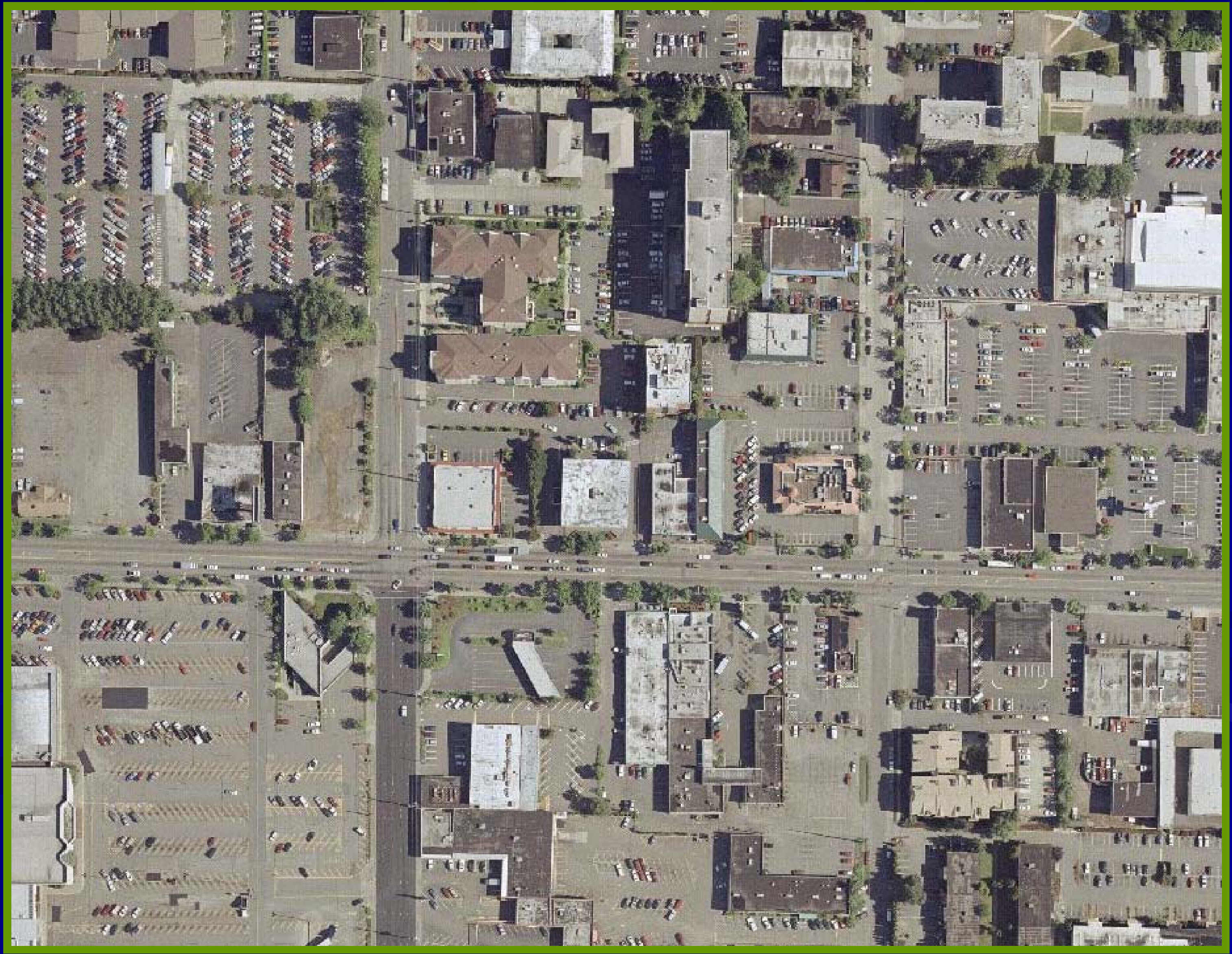
High Point, Seattle, WA

Multi Family Developments

Block-Level Design

High Point, Seattle, WA

COMMERCIAL PARCELS



COMMERCIAL PARCELS

CONVEYANCE

Downtown CSO Demand Management, Seattle, WA

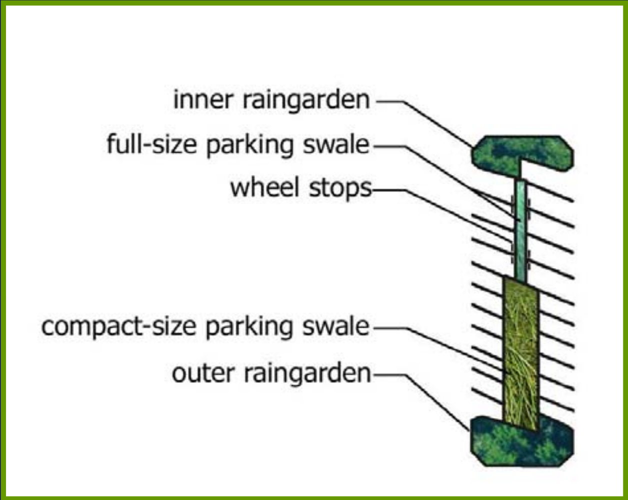
Commercial Parcels

Parking Lots

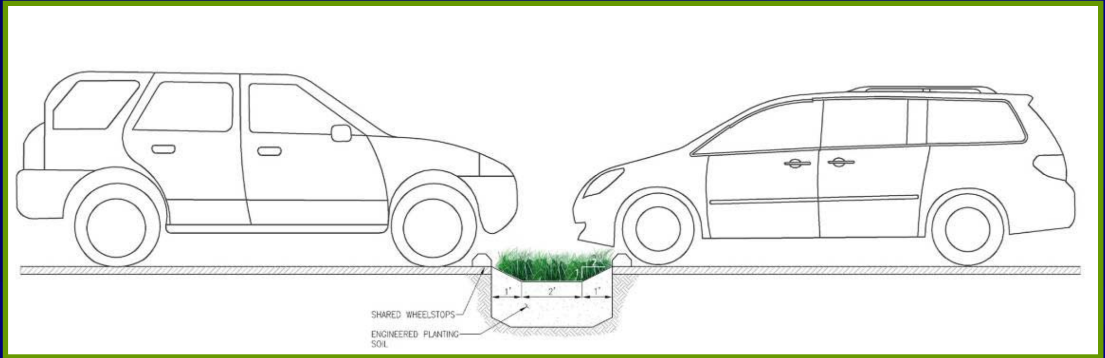
Northgate Mall, Seattle, WA

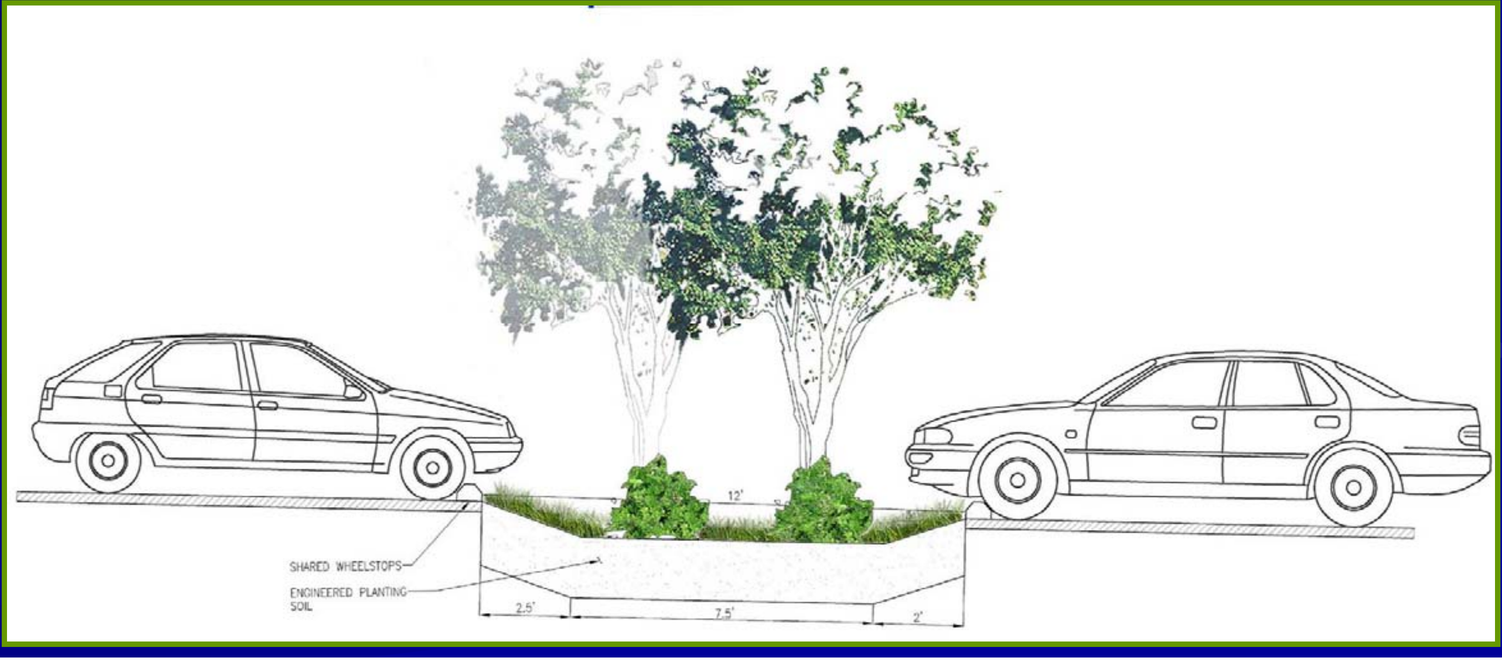
Commercial Parcels

Parking Lots – Telescope Swale Details



Northgate Mall, Seattle, WA





Commercial Parcels

Parking Lots

Northgate Mall, Seattle, WA

Commercial Parcels

Parking Lots

Lewis Creek Park, Bellevue, WA

Combining Landscape Requirements with Bioretention

COMMERCIAL PARCELS

PARKING LOTS

Combining Conveyance with Bioretention

Bagley Elementary, Seattle, WA

COMMERCIAL PARCELS

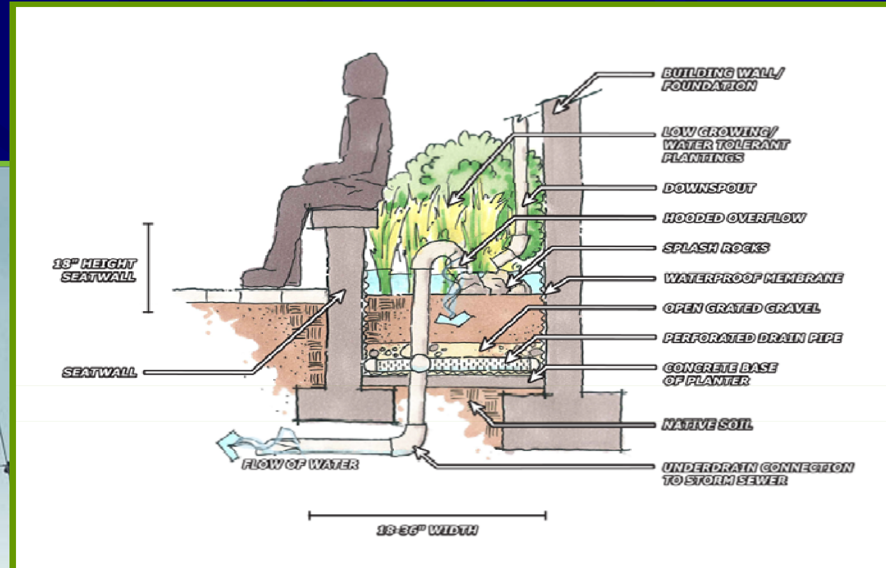
RAIN GARDENS

Villanova Campus

YMCA Silverdale, WA

Commercial Parcels

Stormwater Planters



Downtown CSO Demand Management, Seattle, WA

Right-of-Way

Portland's Green Streets

New Seasons Market, Portland

SW 12th Avenue Green St

Photos courtesy of Kevin Perry, BES

Contact Information

Alice Lancaster, PE

alancaster@herrerainc.com
http://www.herrerainc.com/
phone: 206-441-9080

HERRERA