Making the Invisible Visible:
Seattle's Green Stormwater Infrastructure

Presented by:

Tracy Tackett , PE, Green Stormwater Infrastructure Program Manager
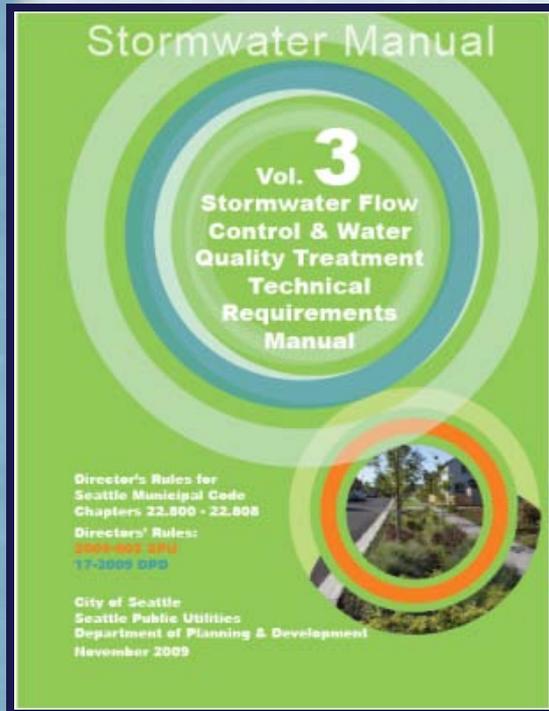**Craig Chatburn, Green Stormwater Infrastructure Specialist**
Shane DeWald, LA, SDOT
Seattle Public Utilities

Presentation Overview

Stormwater Manual

Vol. **3**
Stormwater Flow
Control & Water
Quality Treatment
Technical
Requirements
Manual

Director's Rules for
Seattle Municipal Code
Chapters 22.800 - 22.808
Directors' Rules:
2009-003 SPU
17-2009 DPD

City of Seattle
Seattle Public Utilities
Department of Planning & Development
November 2009

➲ Overview of Green Stormwater Infrastructure in Stormwater Code

➲ Why

➲ What is GSI to the MEF

➲ How tree credits were developed
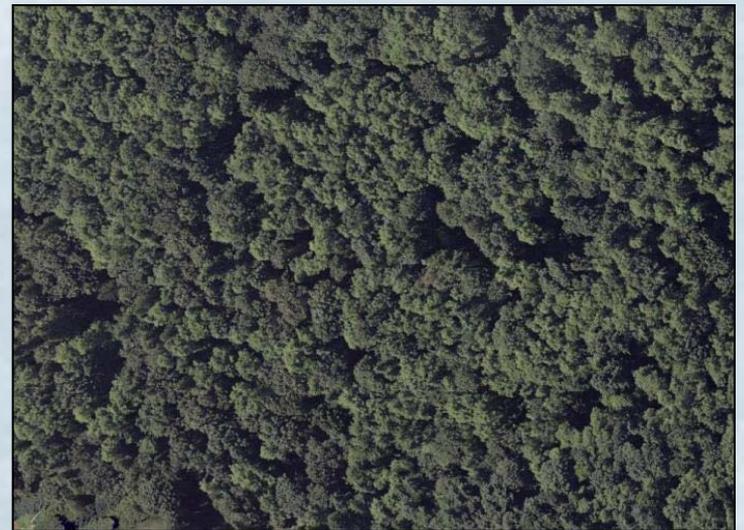
What is GSI?

Green Stormwater Infrastructure

"**Green stormwater infrastructure** means a drainage control facility that uses infiltration, evapotranspiration, or stormwater reuse."

Tries to make   …function more

this…   like this.

Green Stormwater Infrastructure BMPs

| GSU Category	GSI BMP
Runoff Reduction Methods (low tech)	Maintain Existing Trees Dispersion Plant New Trees
Infiltrating and Reuse Facilities	Bioretention Permeable Pavement Rainwater Harvesting
Impervious Surface Reduction Methods	Permeable Pavement Surfaces Green Roofs Bioretention Cells (with detention)
Non-infiltrating facilities	Bioretention cells (with underdrain) Detention Cisterns (part of GSI for SFR only)

Trees, Retain Existing

Dispersion

- Likely only Parks will have sites that qualify for this credit

Trees, Plant New Trees
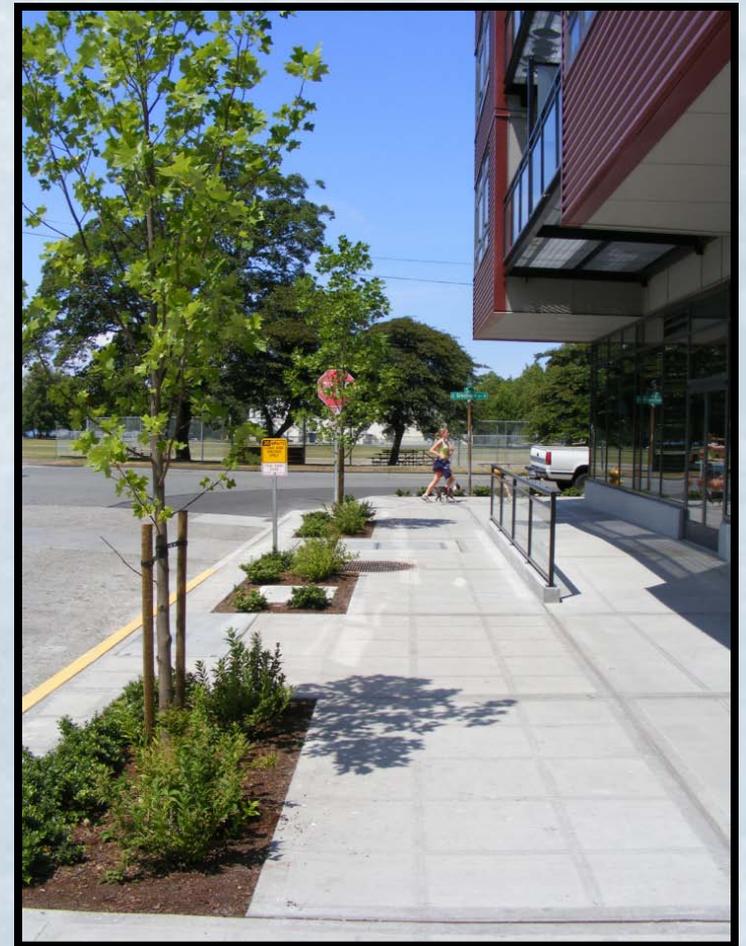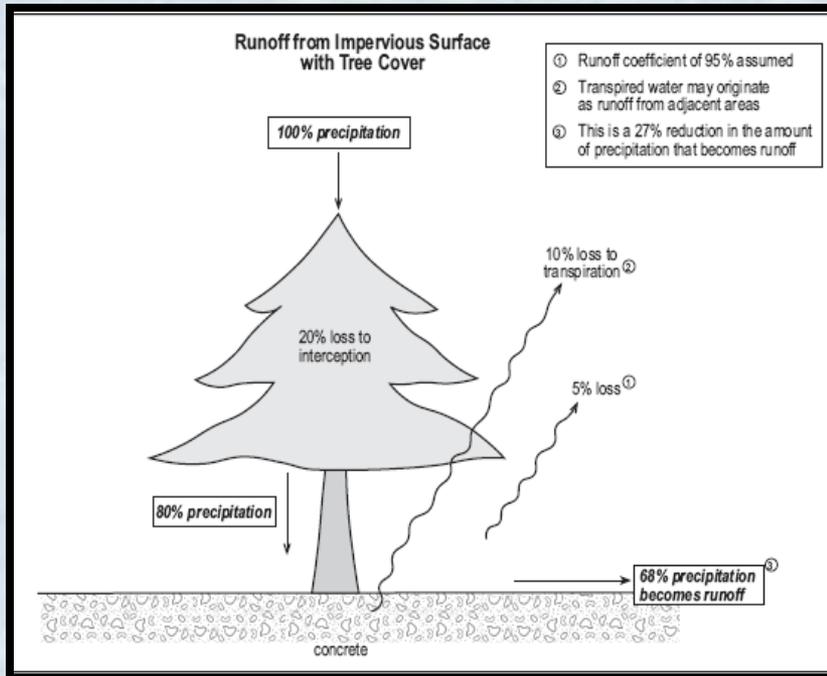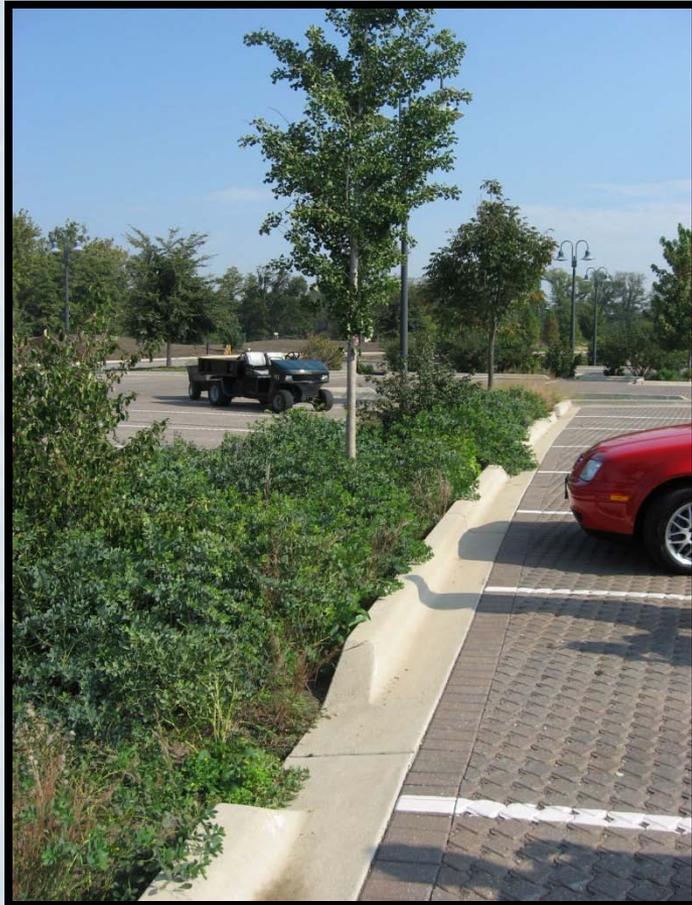
Bioretention Cells, without Underdrain

Rainwater Harvesting

Permeable Pavement Facilities
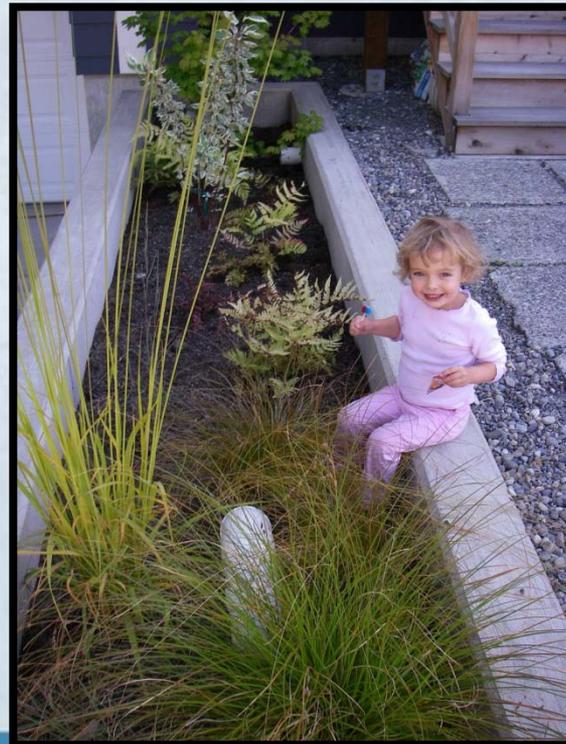
Permeable Pavement Surfaces

Green Roofs

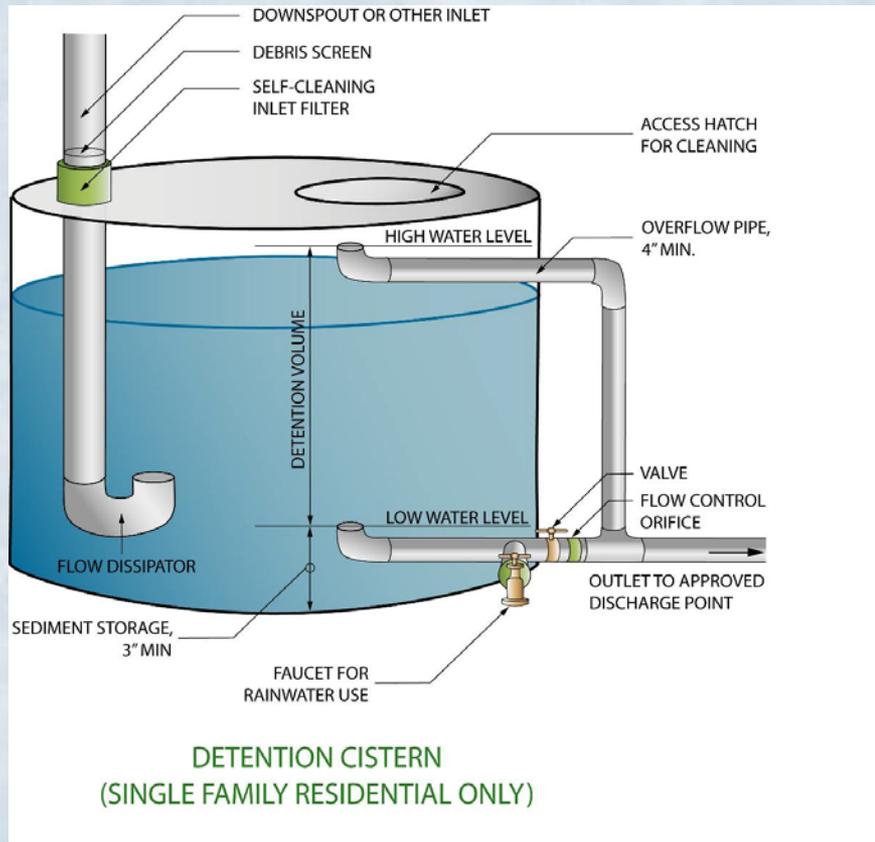*Ballard Library*

Seattle City Hall

Justice Center

Bioretention Cells, with underdrain

Detention Cisterns

DOWNSPOUT OR OTHER INLET

DEBRIS SCREEN

SELF-CLEANING INLET FILTER

ACCESS HATCH FOR CLEANING

HIGH WATER LEVEL

OVERFLOW PIPE, 4" MIN.

DETENTION VOLUME

VALVE

FLOW CONTROL ORIFICE

LOW WATER LEVEL

FLOW DISSIPATOR

SEDIMENT STORAGE, 3" MIN

FAUCET FOR RAINWATER USE

OUTLET TO APPROVED DISCHARGE POINT
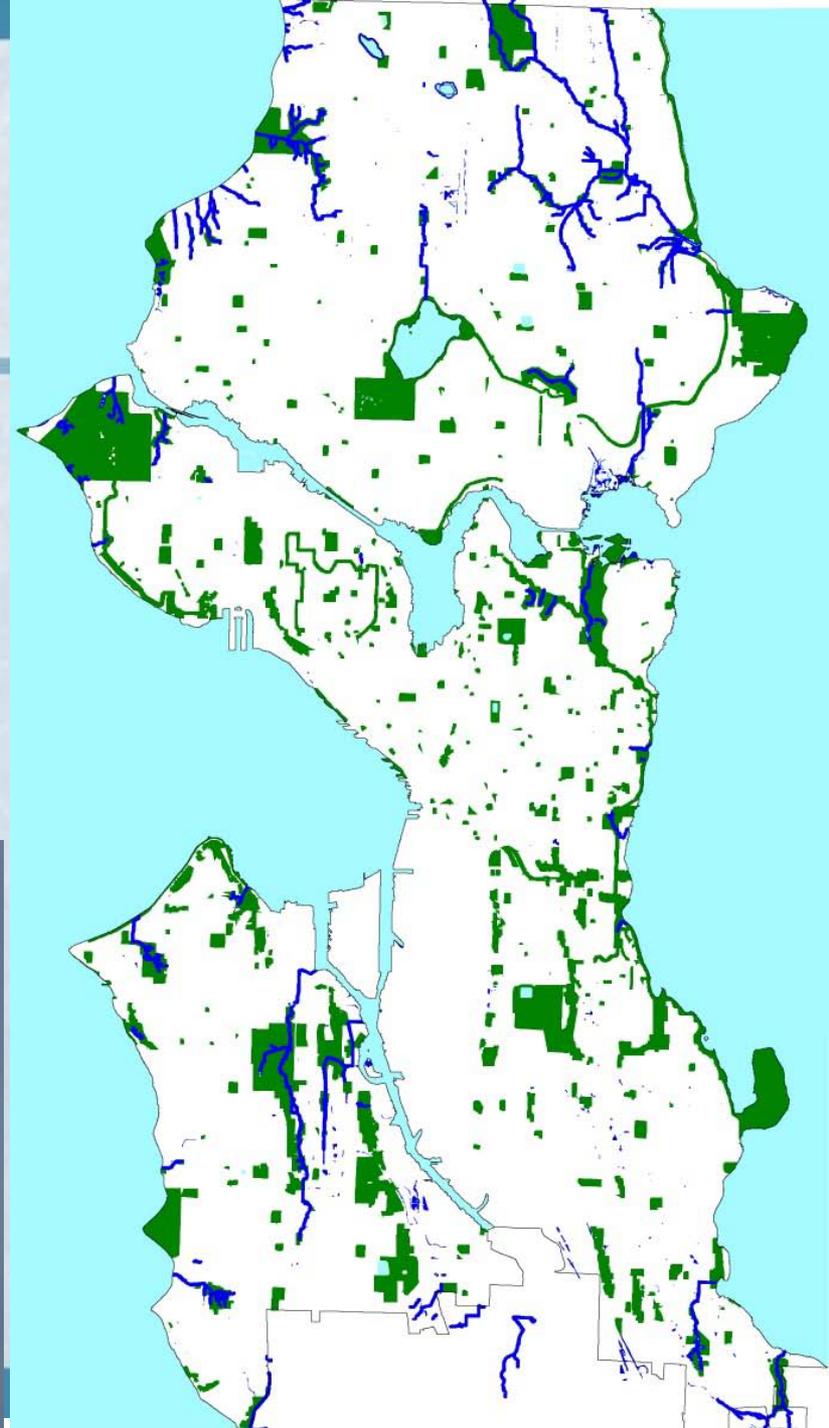
DETENTION CISTERN
(SINGLE FAMILY RESIDENTIAL ONLY)
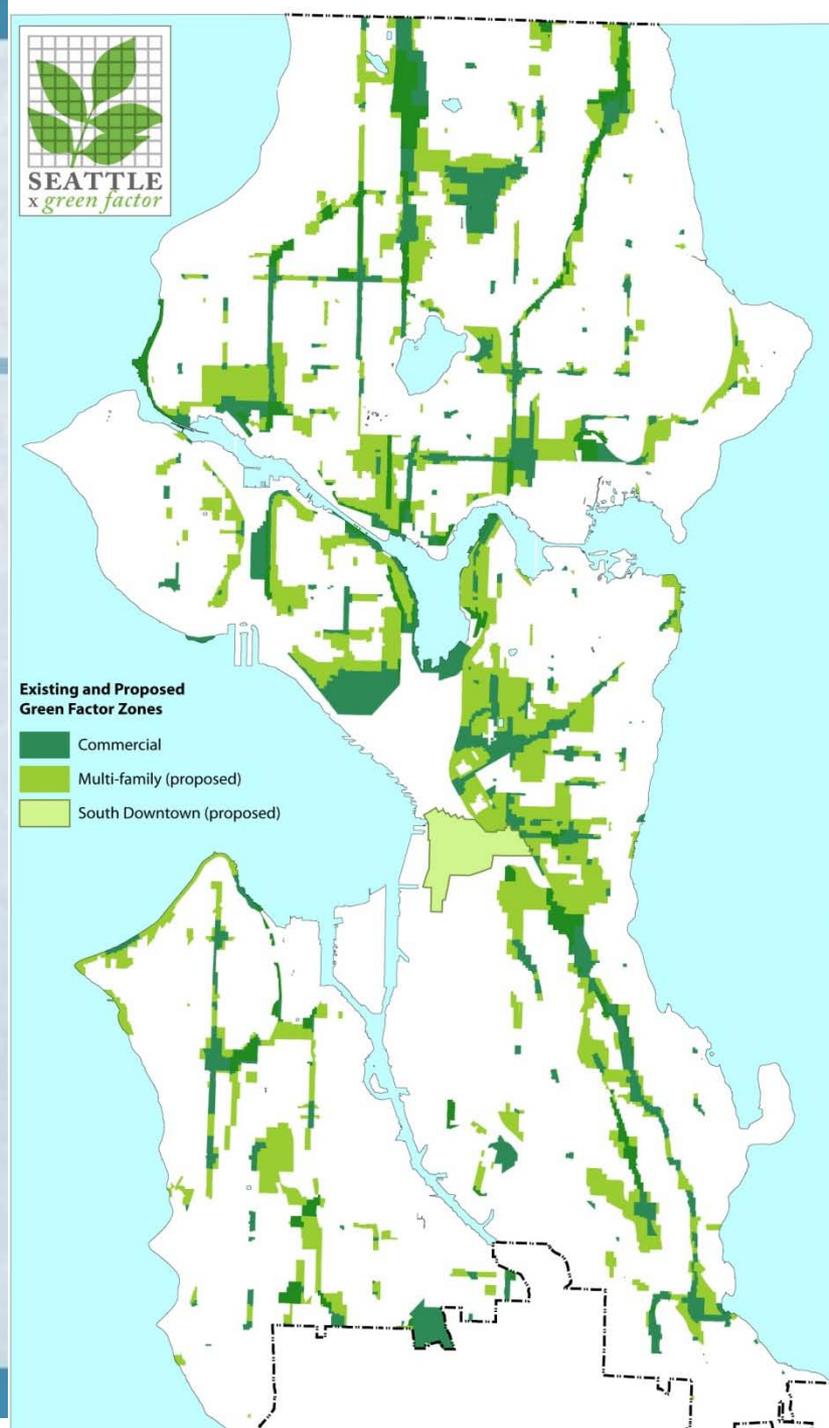
Synergies: The Emerald City

- 6,200 acres of parks
- Environmentally Critical Areas
- 72 community gardens
- Bike Master Plan
- Pedestrian Master Plan

Synergies: Seattle Green Factor

- A landscape requirement intended to improve ecological function and urban aesthetics

- Increases total landscaped area while providing greater design flexibility.

- Adopted for Seattle's commercial zones in 2006.

SEATTLE x *green factor*

Existing and Proposed Green Factor Zones

- Commercial
- Multi-family (proposed)
- South Downtown (proposed)

Synergies: Seattle CIP projects

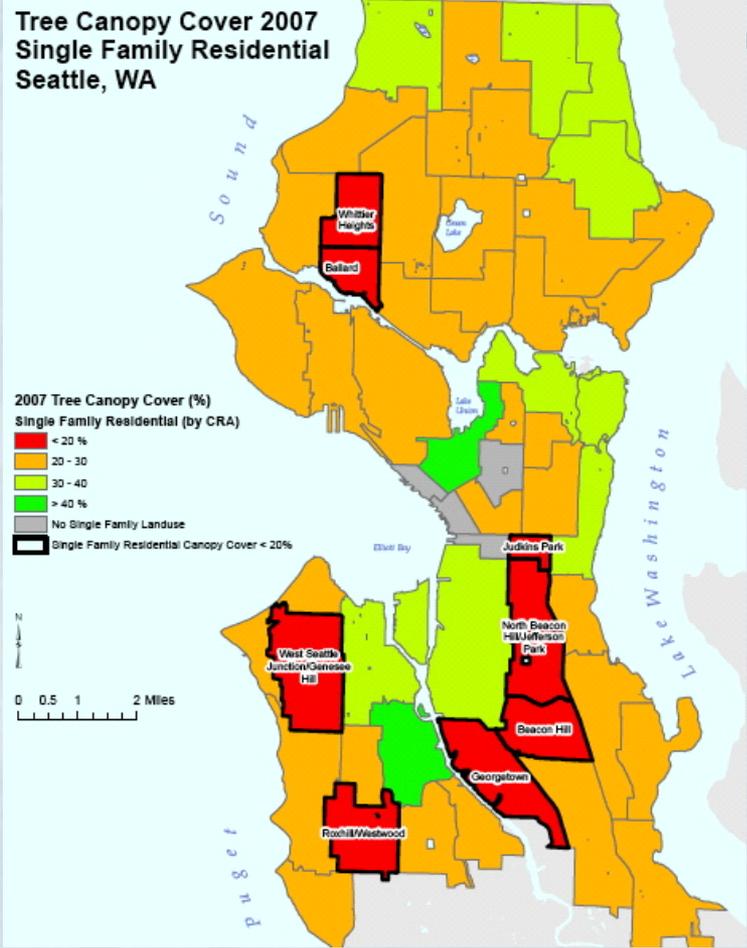➲ Natural Drainage Systems used to control 230-acres of creek watershed

CIP Priority is in Targeted CSO Basins

- Ballard
- North Union Bay
- Interbay
- Evaluating additional basins
  - *Barton (lead by King County)*
  - *Genesee*
  - *Henderson*
  - *Montlake*
  - *Lake Union*
  - *West Seattle*
  - *Fremont/Wallingford*

20

Nexus between Urban Forestry goals and CSO goals

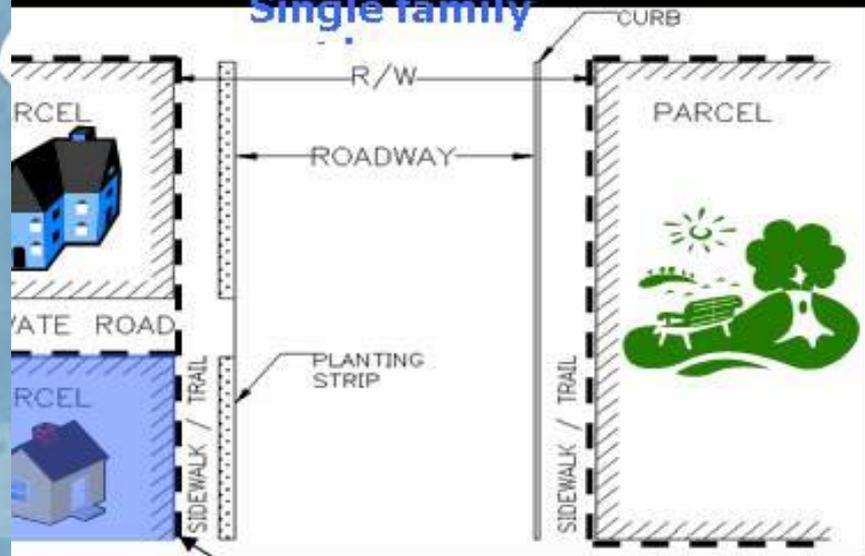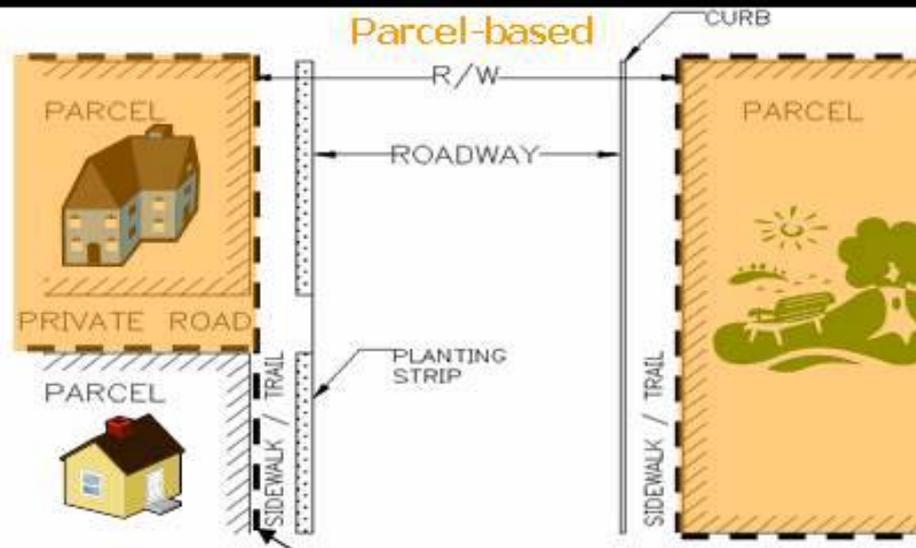# Seattle Stormwater Manual Requirements - What projects trigger GSI to MEF?

➲ Any Single Family Residential Parcels (<10,000sf new plus replaced impervious surface): GSI to MEF

➲ Any project >2000sf new plus replaced impervious surface: GSI to MEF

➲ All parcel-based projects, roadway projects, and joint projects that trigger minimum requirements for flow control or treatment. These projects must fulfill flow control requirements. GSI to MEF then traditional infrastructure may need in addition to achieve performance thresholds
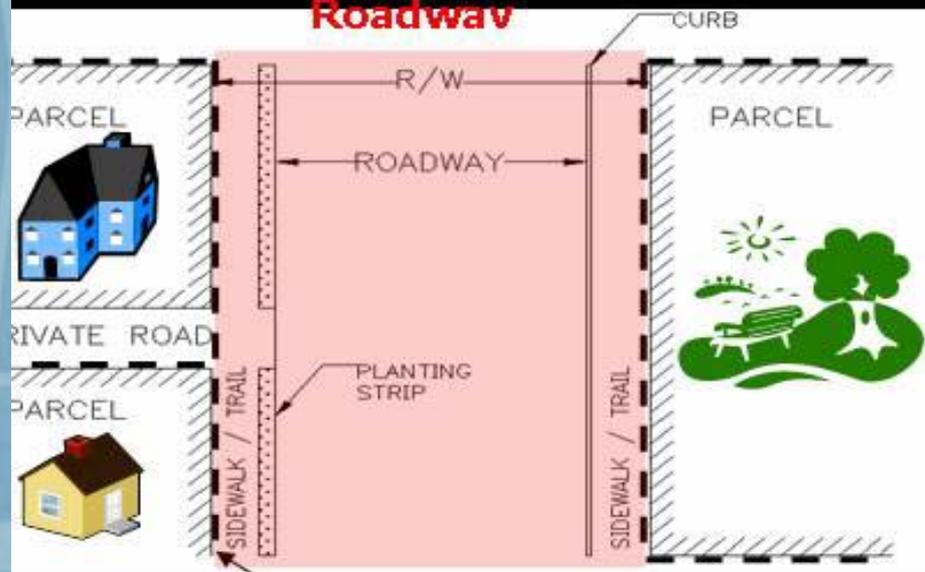
Single family

CURB

R/W

PARCEL

ROADWAY

PRIVATE ROAD

PARCEL

PLANTING STRIP

SIDEWALK / TRAIL

SIDEWALK / TRAIL

Parcel-based

CURB

PARCEL

R/W

PARCEL

ROADWAY

PRIVATE ROAD

PARCEL

PLANTING STRIP

SIDEWALK / TRAIL

SIDEWALK / TRAIL

Roadway

CURB

PARCEL

R/W

PARCEL

ROADWAY

PRIVATE ROAD

PARCEL

PLANTING STRIP

SIDEWALK / TRAIL

SIDEWALK / TRAIL

Sidewalk /Trail

CURB

PARCEL

R/W

PARCEL

ROADWAY

PRIVATE ROAD

PARCEL

PLANTING STRIP

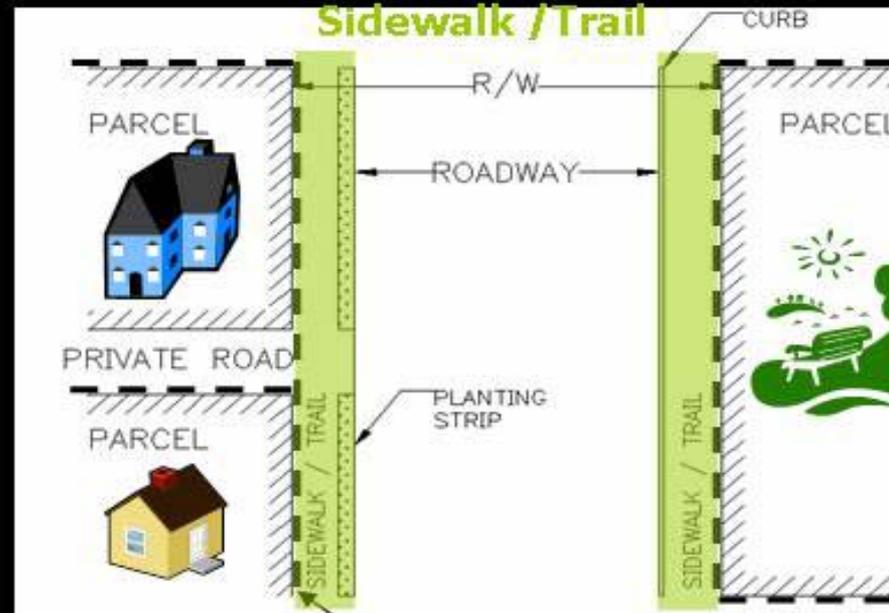SIDEWALK / TRAIL

SIDEWALK / TRAIL

What is "Feasible"?

➲ Physical limitations of the site
➲ Practical considerations of engineering design
➲ Reasonable considerations of financial costs

Tree specific portion

Anticipate GSI to MEF to result in significantly more vegetated controls for stormwater

City of Seattle Green Stormwater Infrastructure Requirement Calculator (01-04-10)

Project Type ⟶ [ ]
Project Area ⟶ [ ] sf
New plus Replaced Impervious Area ⟶ [ ] sf
Area Requiring Mitigation ⟶ _____ sf
(1,500 sf credit for SFR projects)

Runoff Reduction Methods		Facility Size				Credit		Area Mitigated	
Retained Trees									
Existing Evergreen	# Trees [ ]	Total Canopy Area of Trees	[ ] sf	x		20% (or min 100 sf/tree)		- _____	sf
Existing Deciduous	# Trees [ ]	Total Canopy Area of Trees	[ ] sf	x		10% (or min 50 sf/tree)		- _____	sf
New Trees									
New Evergreen		# Trees	[ ]	x		50 sf		- _____	sf
New Deciduous		# Trees	[ ]	x		20 sf		- _____	sf
Dispersion [1]									
Downspout or Sheet Flow Dispersion		Dispersed Impervious Area	[ ] sf	x		86.0%		- _____	sf

Infiltrating and Reuse Facilities	Facility Size				Sizing Factor	Area Mitigated	
Infiltrating Facilities							
Bioretention Cell (without Underdrain)							
Ponding Depth [ ] in	Bioretention Bottom Area	[ ] sf	÷		Select Depth	- _____	sf
Design Infiltration Rate [ ] in/hr							
Permeable Pavement Facility (may receive run-on)							
Ponding Depth [2] [ ] in	Permeable Pavement Area	[ ] sf	÷		Select Depth	- _____	sf
Design Infiltration Rate [ ] in/hr							
Reuse Facilities [1]							
Rainwater Harvesting	Applicant must provide documentation of mitigation					[ ]	sf

Impervious Surface Reduction Methods	Facility Size				Credit	Area Mitigated	
Alternative Pavement Surfaces							
Permeable Pavement Surface (Subgrade Slope ≤2%)	Permeable Pavement Area	[ ] sf	x		100.0%	- _____	sf
Permeable Pavement Surface (Subgrade Slope 2-5%)	Permeable Pavement Area	[ ] sf	x		60.0%	- _____	sf
Alternative Roof Surfaces [1]							
Green Roof (Single-Course / 4" Growth Medium)	Green Roof Area	[ ] sf	x		59.0%	- _____	sf
Green Roof (Multi-Course / 4" Growth Medium)	Green Roof Area	[ ] sf	x		59.0%	- _____	sf
Green Roof (Multi-Course / 8" Growth Medium)	Green Roof Area	[ ] sf	x		70.0%	- _____	sf
Partial Infiltration [1]							
Bioretention Cell with Detention (without Underdrain)							
Contributing Area [ ] sf							
Ponding Depth [ ] in	Bioretention Bottom Area	_____ sf			Select Depth	- _____	sf
Design Infiltration Rate [ ] in/hr							

Non-Infiltrating Facilities	Facility Size				Sizing Factor/Credit	Area Mitigated	
Non Infiltrating Facilities							
Bioretention Planter (with underdrain)							
Contributing Area [ ] sf							
Ponding Depth [ ] in	Bioretention Bottom Area	_____ sf	÷		Select Depth	- _____	sf
Detention Cistern with Harvesting Capacity [3]							
Contributing Area [ ] sf	Min Cistern Area	_____ sf				- _____	sf
	Min Live Cistern Volume	_____ gal					

Total Area Mitigated ⟶ _____ 0 sf
Area Requiring Mitigation ⟶ _____ sf
% Impervious Area Mitigated ⟶ _____ %

GSI Requirement Achieved? ⟶ _____

Notes:
GSI - Green Stormwater Infrastructure   sf - square feet   in - inch   NA - not applicable   eqn - equation
min - minimum   ft - feet   in/hr - inch per hour   gal - gallons
1. Single family residential projects are not required to evaluate this BMP.
2. Average subsurface ponding depth in aggregate storage reservoir.
3. Cistern area must be rounded up to next commercially available product. Cistern need not have more than 3 feet of live storage volume above orifice.
This calculator does not provide conveyance flow calculations.

28

Trees in CSO control?
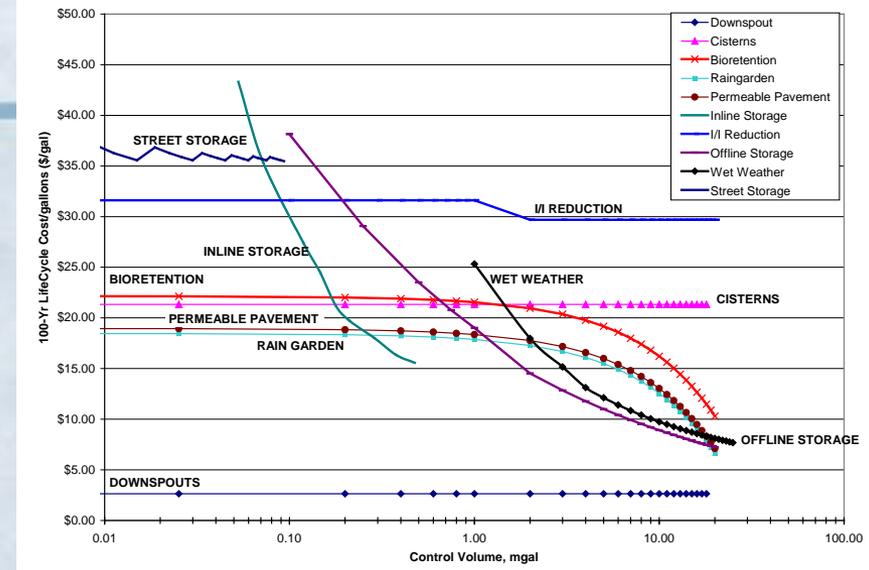
Residential Rainwise

$3/Gal

● Downspout Disconnection

$9-$10/gal

● Remove Impervious

$17-23/gallon

● Cisterns
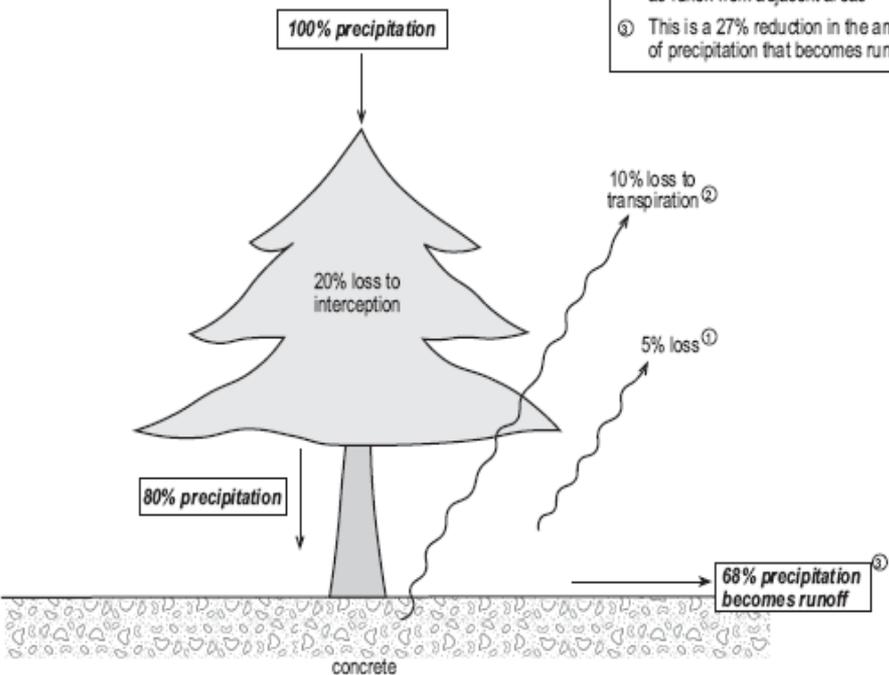
● Raingardens

● (Trees)

Assumptions and Estimated Unit Costs per SF of Managed Impervious Area for Decentralized CSO Control Measures (With Allowances for Environmental and Ancillary Benefits)										
Cost Calculation Assumption or Parameter	Residential Downspout Disconnect	Residential Rain Harvest Cistern	ROW Bioretention NDS	ROW Bioretention Curb Bulb	Rain Garden	Alley/Sidewalk Perm Paving Retrofit	Remove Impervious Areas	Commercial Green Roof, New Roof	Alley/Sidewalk Perm Paving New Project	Funding Tree Planting
Construction Cost	$0.85	$55.60	$85.88	$32.39	$32.39	$8.00	$2.04	$10.25	$1.85	$126.00
Capital Cost per SF Managed	$1.15	$1.50	$7.83	$5.44	$5.44	$6.39	$2.75	$13.84	$1.38	$2.54

Department Of Ecology devalues trees role in mitigating runoff
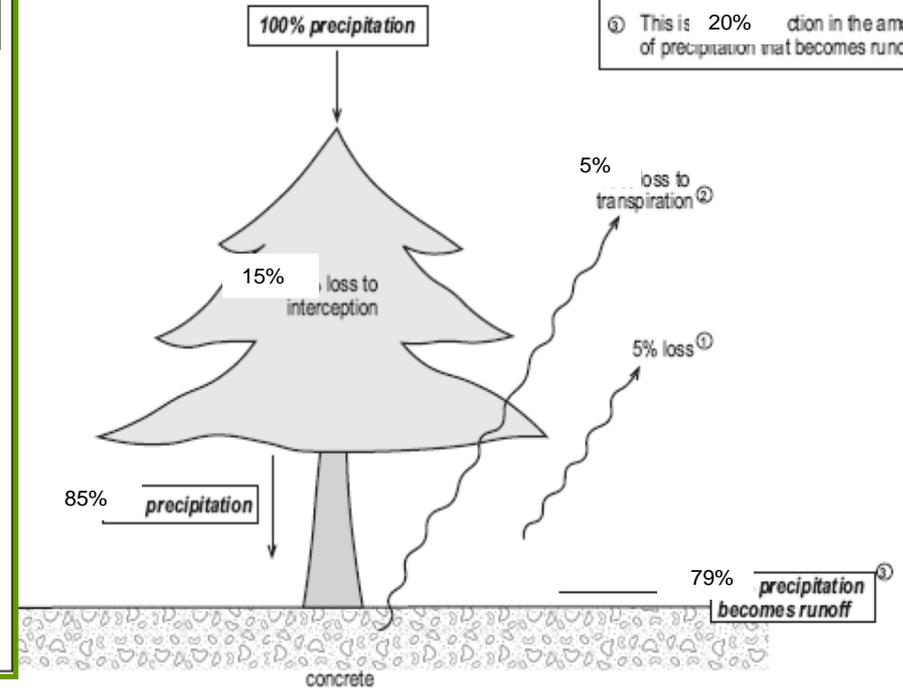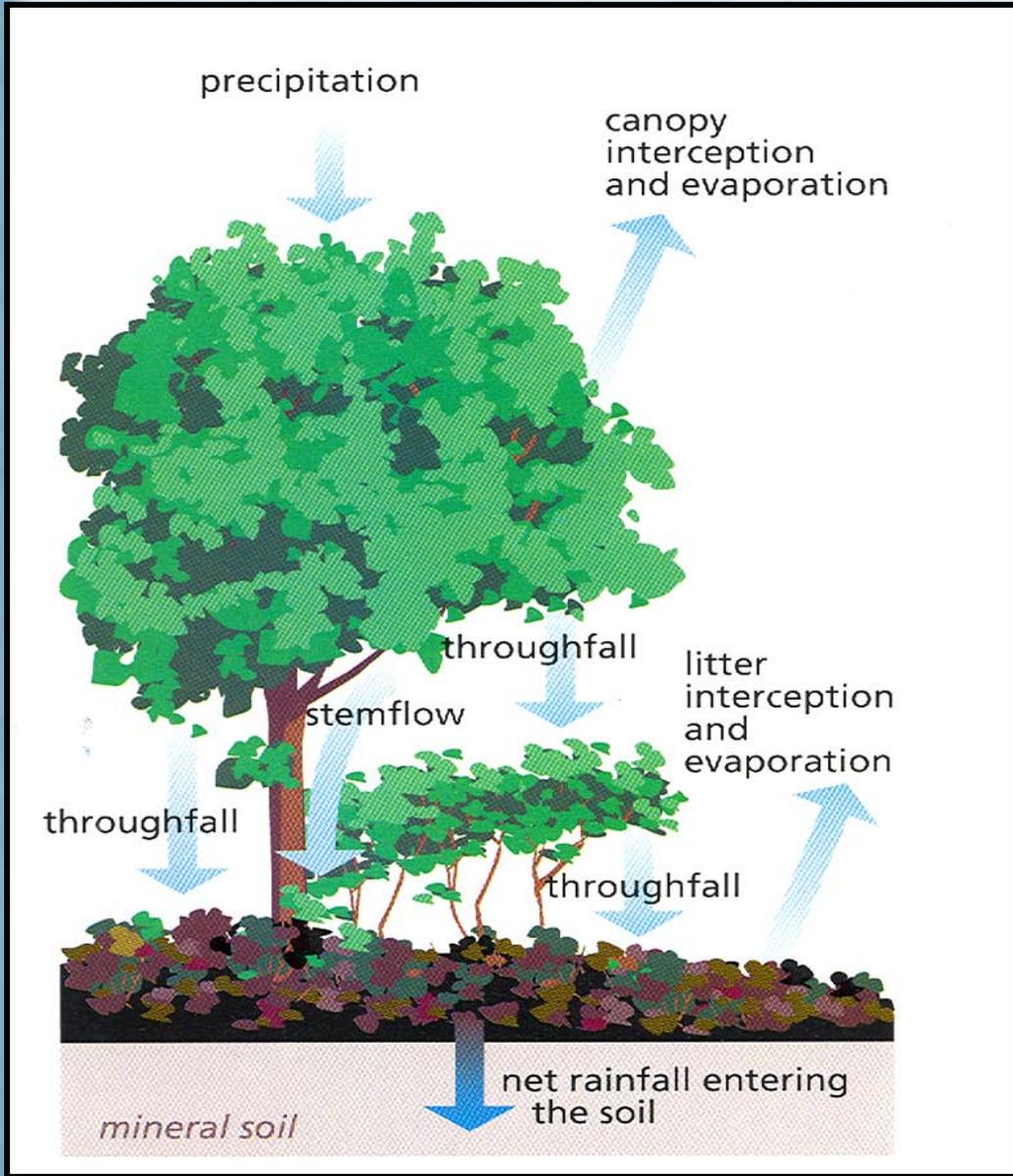
The forest hydrologic cycle

Source: Federal Interagency Stream Restoration Working Group, 1998

Flow Control Credits

Facility Type	Design Variable	Flow Control Credit	
		Creek Standard	**Capacity Standard**
Retained Trees	Evergreen	20% canopy area (min 100 sf/tree)	
	Deciduous	10% canopy area (min 50 sf/tree)	
New Trees	Evergreen	50 sf / tree	
	Deciduous	20 sf / tree	
Green Roof	4 inch depth	46%	71%
	8 inch depth	54%	79%
Dispersion	NA	90%	100%
Permeable Pavement Surface (3″ subbase)	Slope ≤ 2%	100%	100%
	Slope 2% - 5%	45%	70%

Regulatory Protection for Trees

- **LAND USE CODE (SMC 23.43-50)**

  Establishes Development Requirement for Street Trees

- **MUP (SMC 23.76) & DESIGN REVIEW / APPROVAL PROCESS**

  Required for most Commercial, Mixed Use, & Multi-Family Developments

- **SDOT ROW MANUAL (On Line Section 4.14) /STREET TREE ORDINANCE (SMC 15.42)**

  Establishes SDOT Requirements for Street Trees

   --Protection of Existing Street Trees

   --Layout, Selection & Planting of New Street Trees

- **GREEN FACTOR (SMC 23.47A.016)**

  Establishes Credit for Trees –High to Low: Preserved Trees /New Trees Large, Med, Small

- **(INTERIM) TREE PROTECTION ORDINANCE & ECA CODE (SMC 25.09 & 25.11)**

  Establishes Protection for Existing Trees on Developed Lots (Exceptional/ 3 max per yr).

Does Size Really Matter?

At 10 years	Small Canopy Tree	Medium CanopyTree	Large Canopy Tree	Columnar Evergreen	All Tree Average
Dripline radius*	9	11.75	15	8.5	11.1
SF Canopy Area	254.3	433.5	706.5	226.9	405.3
Cost per tree	$126.00	$126.00	$126.00	$126.00	$126.00
Cost per SF	$0.50	$0.29	$0.18	$0.56	$0.38
Cost per SF of Managed impervious- DOE Assumed no infiltration	$4.95	$2.91	$1.78	$2.78	$3.11
Costs per SF managed omitting small trees from funding.		$2.91	$1.78	$2.78	$2.49
Costs per SF managed with likely tree preference (50% Med,30% large, 20% Conifer)		$2.91	$1.78	$2.78	$2.54

**Canopy credit may undervalues the role of columnar evergreens by 2X.**
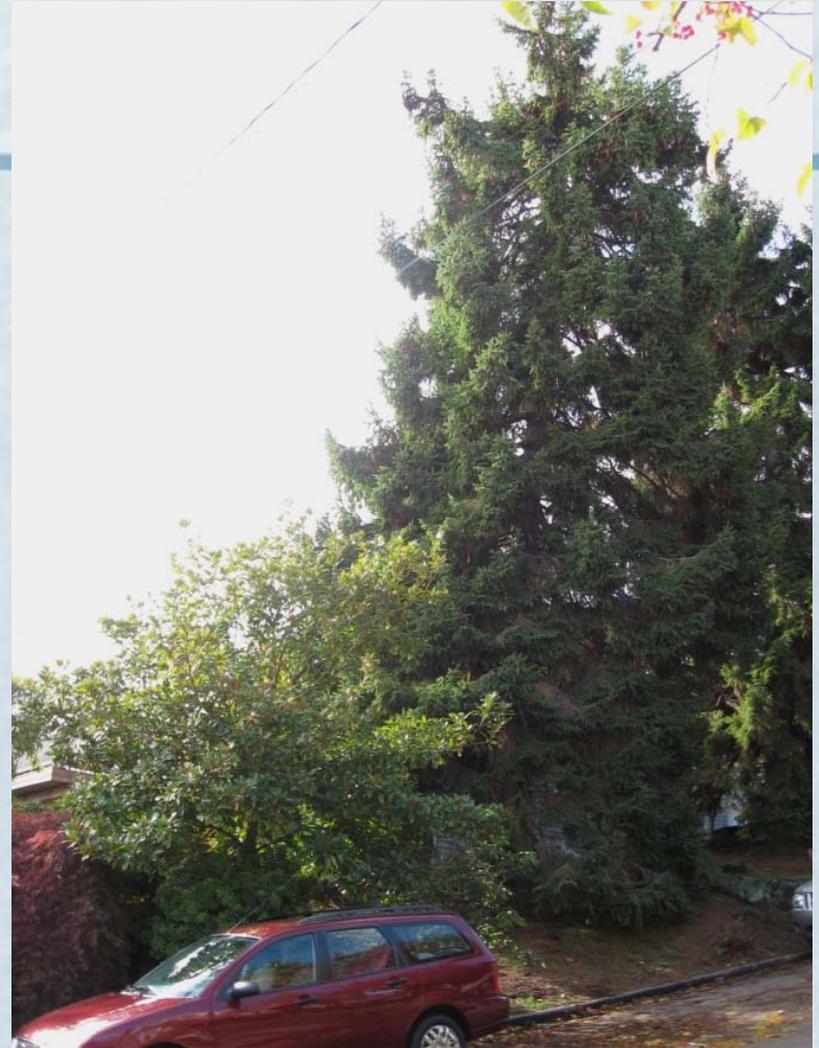
Urban Tree's Stormwater Function:
How is it Measured?

- ✓ ability to intercept and store rainfall and runoff
- ✓ ability to moderate stream flow
- ✓ ability to hold on to and recycle nutrients
- ✓ soils are protected from erosion
- ✓ supports a healthy aquatic systems
- ✓ has the capacity for self-repair

Soil BMP's can hold and infiltrate more stormwater
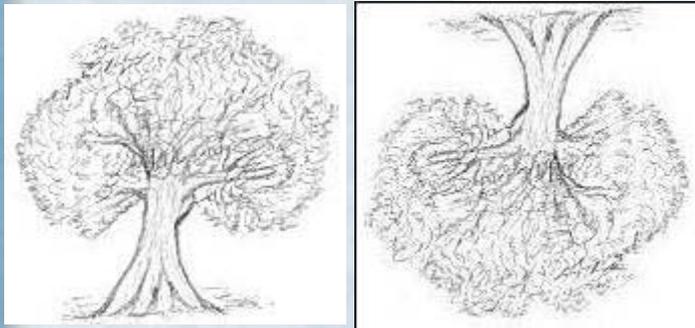
- "3 year study of organic farming vs. conventional saw 40% less annual runoff in organic soil."(Strock, 2005)

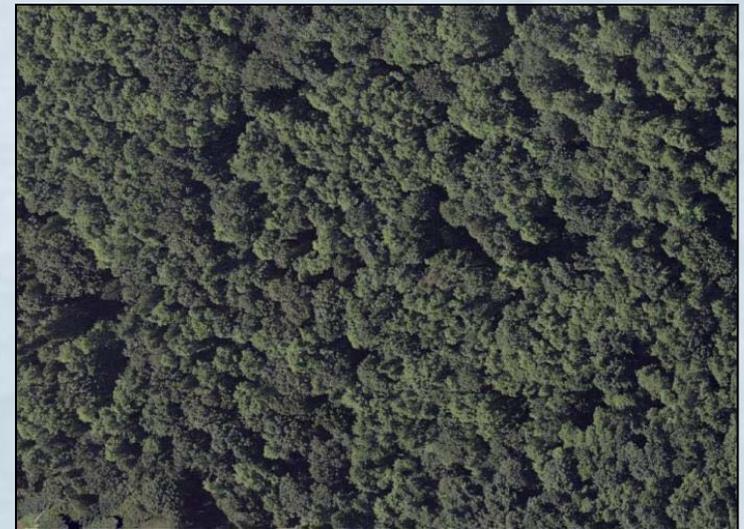- Organic landscape management at Harvard reduces annual irrigation by 30% (Barker, 2009)

Strategic Tree Selection And Soil Stewardship May Be Essential To Getting ....

This

....

…to function more

like this.

Questions?

By the numbers...

- **Rainfall Interception**
  - *10 - 40% of annual rainfall (Zinke, 1967)*
  - *Canopy interception ave. 35-40% (Calder 1990, 2003)*
  - *Even in winter? Yes!*
    - *15% for a deciduous tree (Xiao et al 2000).*
    - *27% for an evergreen species (Xiao et al 2000).*
- **Infiltration**
  - *12.4 in/hr for forest, 4.4 in/hr for lawn*
  - *1.9 in/hr for suburban development (Kays, 1982)*
  - *Disturbed soils show only 35% of the infiltration rate of soils with intact profiles (Kelling et al, 1975)*