# Catching Rain:

## Low Impact Development & Green Stormwater Strategies *for* Real Estate Professionals

Spring 2013

Presented by:

Funding from:

## LID/Green Stormwater Infrastructure Overview

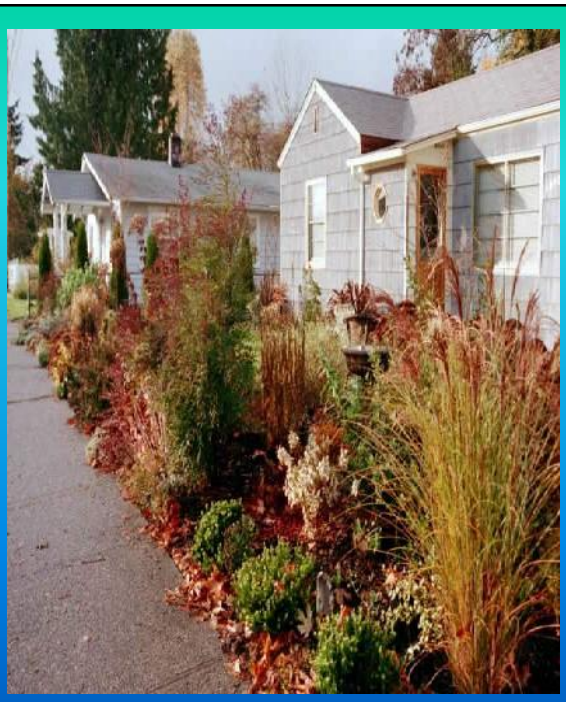
Erica Guttman,WSU Extension
Water Resources Program

**SURVEY OF LANDSCAPING PREFERENCES**

**AMONG RECENT HOMEBUYERS**

**FALL 2001**

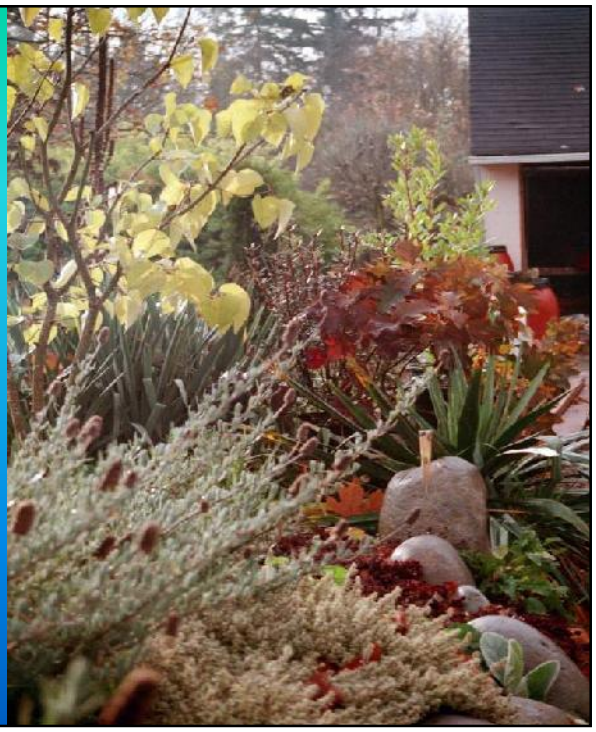
**Summary of Results**



§ Those with the least amount of mature vegetation — "bare dirt," or just a few shrubs — were more likely to have been "somewhat" or "very dissatisfied" with their landscaping upon moving into their house.

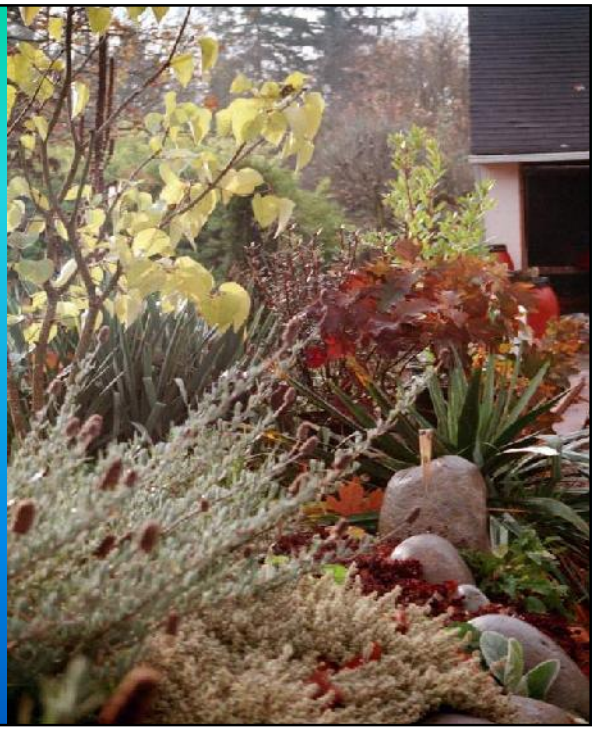
§ Strong interest in **mature** landscapes, with **value** placed on landscapes that are:

- **"natural"**
- **"attract wildlife"**



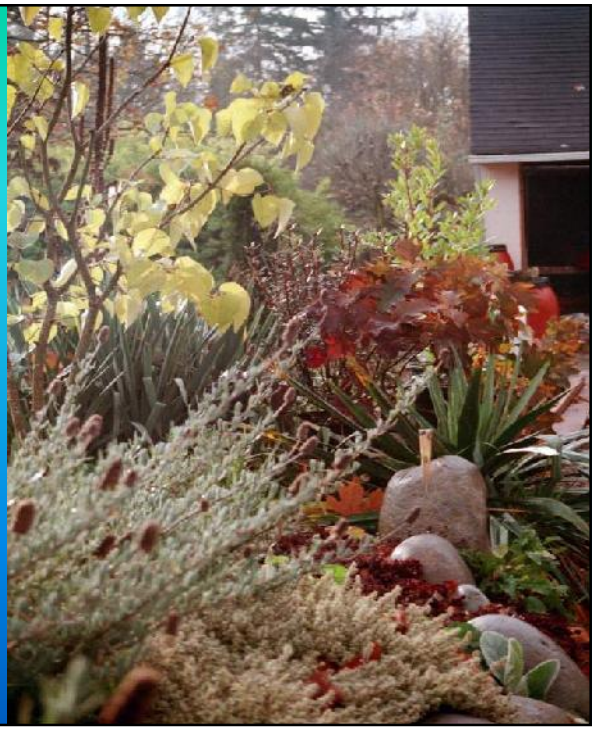
§ Strong interest in **mature** landscapes, with **value** placed on landscapes that are:

- "natural"
- "attract wildlife"
- **"provide privacy and noise screen"**
- **offer a mix of trees, shrubs**



§ Strong interest in **mature** landscapes, with **value** placed on landscapes that are:

- "natural"
- "attract wildlife"
- "provide privacy and noise screen"
- offer a mix of trees, shrubs
- **minimal lawn**
- **with "very low maintenance."**



§ Dissatisfied group **much more likely** to have home over $**250,000 [2000-01]**

§ Much **more likely to have been willing to pay extra** in the purchase price for their preferred landscaping upon moving in.

§ Dissatisfied group more likely to have purchased a newly constructed home, vs. an existing, previously occupied home.

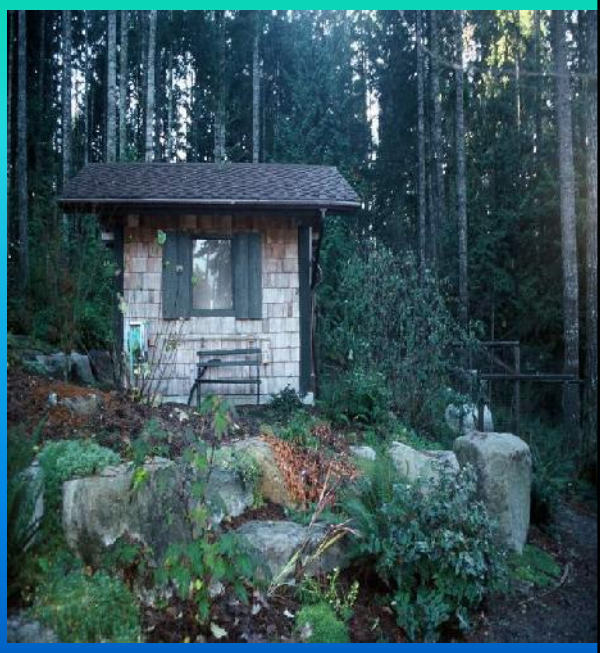
§ Dissatisfied group much more likely to have planted trees, shrubs and native plants since moving in than those in the "satisfied" group.

§ "**Landscaping**" or "**landscaping potential**" rate **higher** as factors in purchase decision than location's relationship to schools, view, privacy, convenience to recreation, and rank almost as high as location's convenience to work.

**Literature Search Conducted by**

**WSU Center for Real Estate Research**

**Summary of Key Added Values for Homes with Mature, Native Landscaping**



- Home sellers report more rapid sales
- More favorable public relations to developers
- Increasing energy efficiency: more cooling in summer & wind barriers
- Reduction of utility bills by up to 30%
- Avoided costs for landscaping installation & maintenance
- Value of privacy screen & noise buffer
- Avoided costs for stormwater management
- Slope-stabilization benefits
- Conserves water
- Mature landscaping may add 3 to 7 percent to home value

## What our clients tell us …

- Low maintenance:
  - ✓ Less time with power equipment
  - ✓ Less water

## What our clients tell us …

- **Weeds manageable**
- **Avoid pesticides – Concern for families & pets**

## What our clients tell us …

- Potential for food crops: veggies, berries, fruit trees
- Concern about exposure to pollutants

## What our clients tell us …

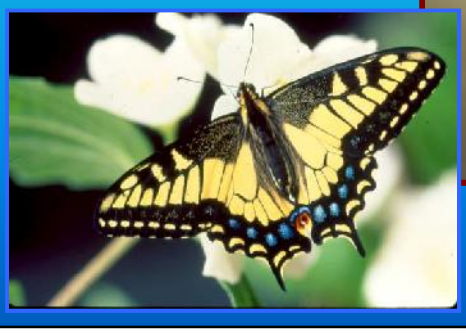
- Good soils

## What our clients tell us …

- Drainage safely managed
- LID techniques for on-site management

## What our clients tell us …

- Attractive to birds & butterflies
- "Sanctuary"

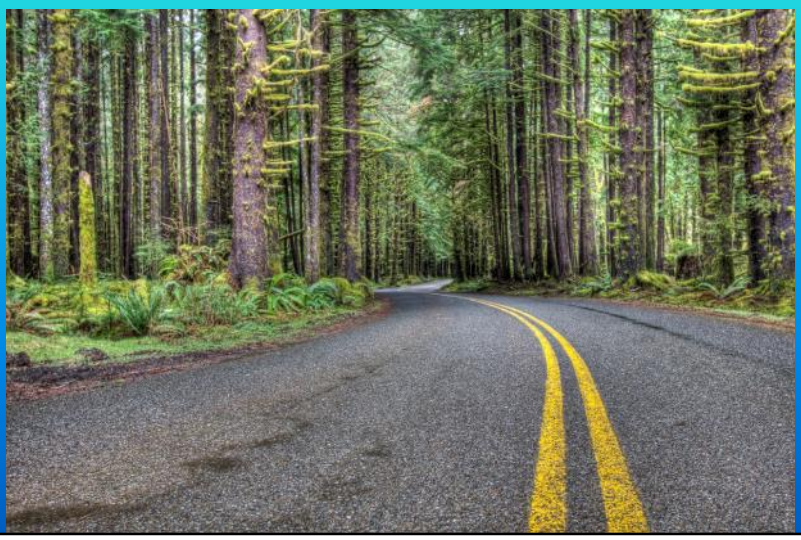


## What our clients tell us …

- Mature landscaping

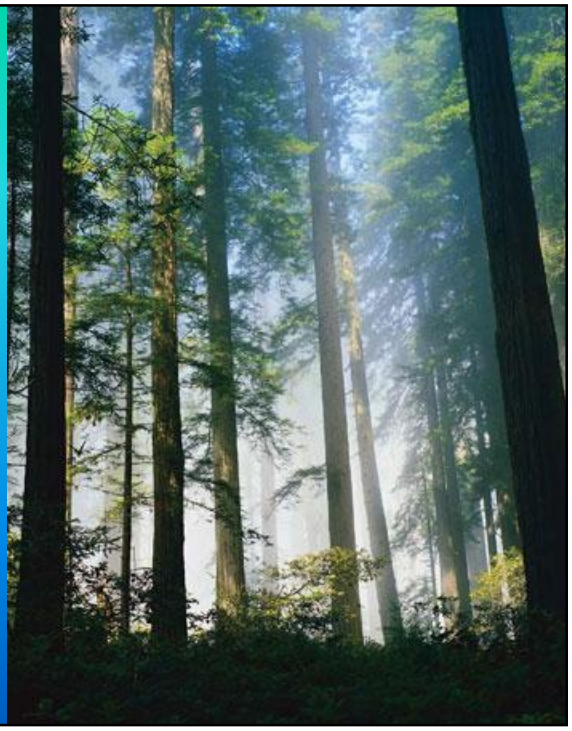
How does it all add up?

## Prevention: Key Preservation Principles

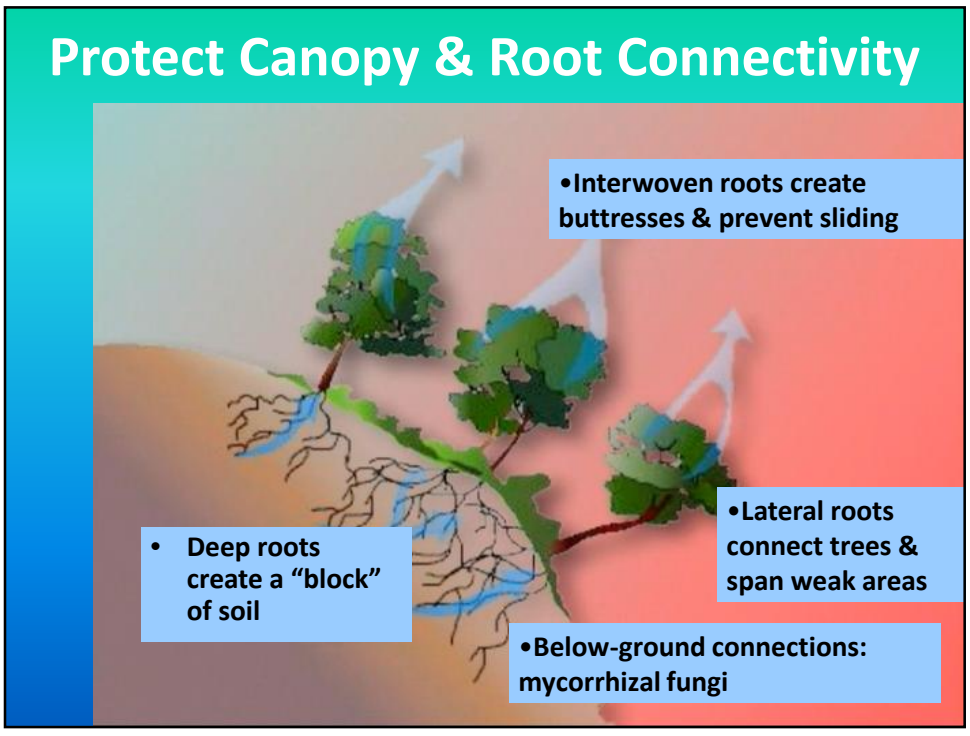


## Prevention BMPs

- Preserve larger trees
- Preserve evergreen trees




Preserve Healthy Trees
Photo: Curtis Hinman, WSU


Protect Canopy & Root Connectivity
•Interwoven roots create buttresses & prevent sliding
•Lateral roots connect trees & span weak areas
• Deep roots create a "block" of soil
•Below-ground connections: mycorrhizal fungi

## Protect from Equipment


## Protect All Roots

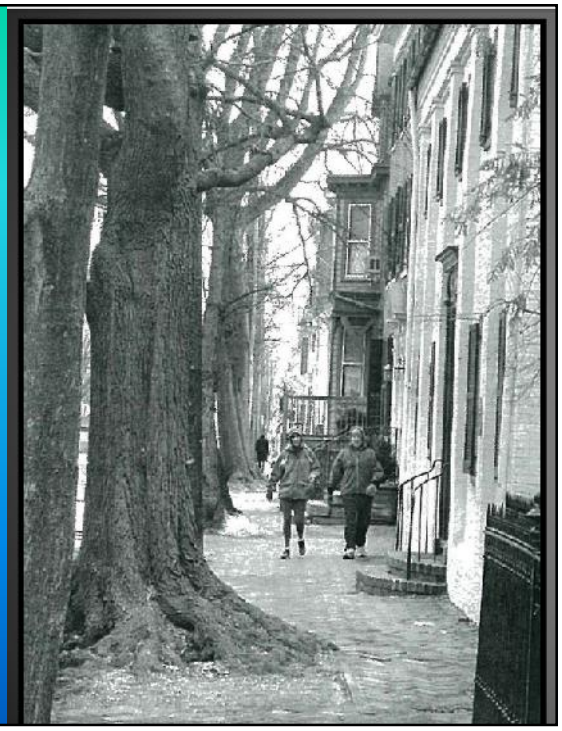
## Caution with Soils & Mulch


## Spokane:

- South Hill storm drainage demands cut in half vs. North Side (AHBL)

## Key Restoration Principles

- Design for mature size
- Consider trunk flare



## Key Restoration Principles

- Use permeable pavements when needed near roots: water & air

FLOW CONTROL CREDITS FOR RETAINED TREES

| TREE TYPE | CREDIT |
|---|---|
| Evergreen | 20% of canopy area (minimum of 100 sq. ft./tree) |
| Deciduous | 10% of canopy area (minimum of 50 sq. ft./tree) |

*Impervious Area Mitigated = ∑ Canopy Area x Credit (%)/100.*

FLOW CONTROL CREDITS FOR NEWLY PLANTED TREES

| TREE TYPE | CREDIT |
|---|---|
| Evergreen | 50 sq. ft. per tree |
| Deciduous | 20 sq. ft. per tree |

*Impervious Area Mitigated = ∑ Canopy Area x Credit (%)/100.*

Source: Eastern Washington Low Impact Develoment Technical Guidance Manual, 2013. AHBL/HDR

## Prevention BMPs

**"… reducing the development envelope and increasing vegetation and soil conservation areas are the most effective techniques to reduce storm flows (AHBL 2002)."**

**-- Curtis Hinman, *LID Technical Guidance Manual*, 2012**

## Prevention BMPs

- "… native vegetation and soils are also the most cost-effective and efficient tools for managing stormwater quantity and quality."

-- Curtis Hinman, *LID Technical Guidance Manual*, 2012

## Example: 24 acres, 103 home sites

| | Detention Storage Reduced (cubic feet) | Detention Storage Required (cubic feet) |
|---|---|---|
| **Conventional Development** | 0 | 270,070 |
| **LID Design** | | |
| Reduce development envelope (24' wide road) | 149,019 | |
| Bioretention swales/cells | 40,061 | |
| Minimal excavation foundations | 7,432 | |
| 20' pervious pavement road | 29,988 | |
| **Total reduction** | 226,500 | 43,570 |

Source: LID Technical Guidance Manual, 2012

# Minimum Street Widths

| WIDTH (FEET) | SOURCE |
|---|---|
| 20 | National Fire Protection Administration |
| 18 (minimum) | Massachusetts State Fire Marshall |
| 22 | American Association of State Highway and Transportation Officials |
| 24 (on-street parking)<br>16 (no on-street parking) | Baltimore County, Maryland |
| 20 | Prince George's County, Maryland |
| 18 (one lane of parking)<br>26 (parking both sides) | Portland, Oregon |

**CWP, 1998**

# Prevention: Sediment & Erosion Control

## Prevention: Sediment & Erosion Control

- Storm drain inlet
- Compost sock

## Prevention: Protection of LID Features

Kathy Gwilym, SvR Design Company

## Construction Sequencing

- BMPs = procedures, not products
- Prioritize process over physical controls

Courtesy of Curtis Hinman, WSU

## Sustainable Landscaping

- Building healthy soils: compost, mulch

Photos: Erica Guttman, Linda Andrews

Lawn and landscaped areas:

• Soil Quality and Depth (T5.13)

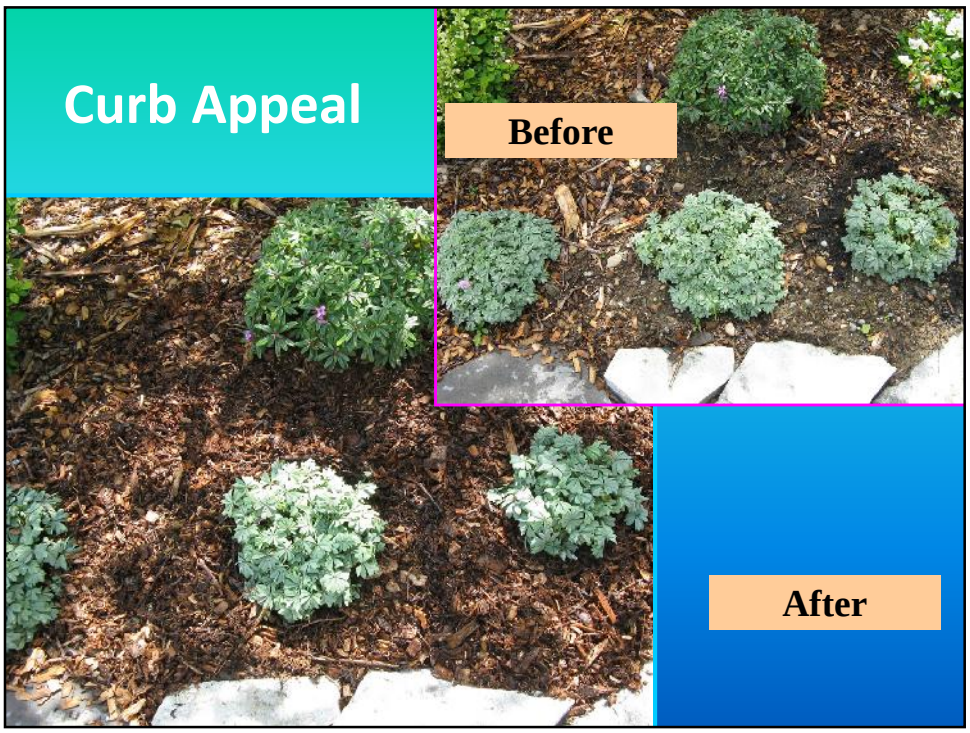
Glacial till: high in runoff and poor turf quality

Photos: UW Test Plots

Same soil with 30% compost added. Up to 50% less runoff. Turf still healthy 4 years later

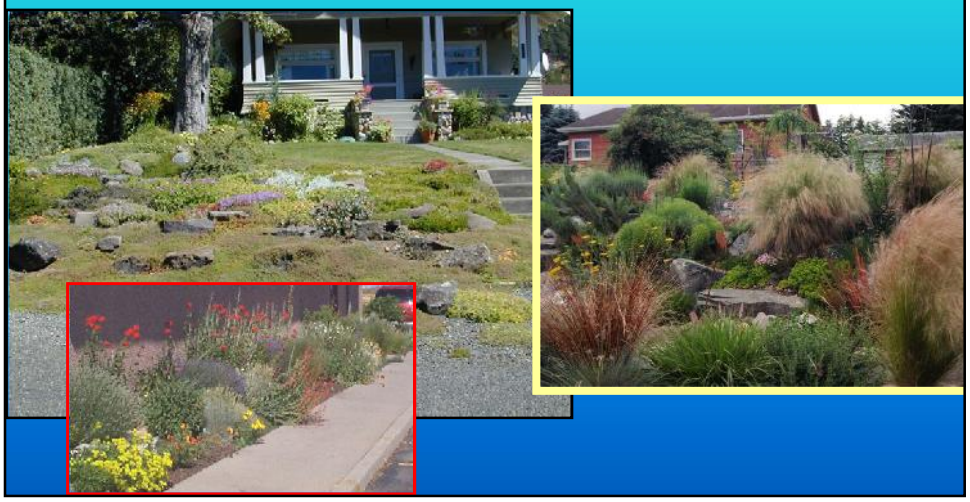
Courtesy of Ed O'Brien, Dept. of Ecology

## Curb Appeal

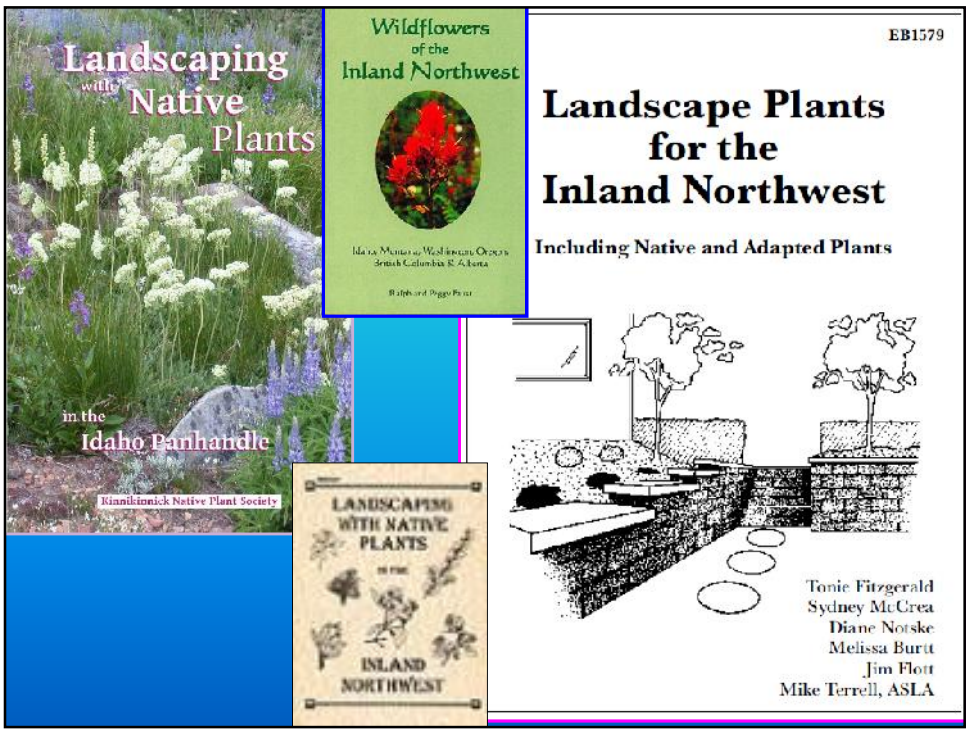


## Sustainable Landscaping

- Building healthy soils: compost, mulch
- **Water-wise plant choices**




kootenaynaturephotos.com


Landscaping with Native Plants
in the Idaho Panhandle
Kinnikinnick Native Plant Society
Wildflowers of the Inland Northwest
LANDSCAPING WITH NATIVE PLANTS
INLAND NORTHWEST
EB1579
Landscape Plants for the Inland Northwest
Including Native and Adapted Plants
Tonie Fitzgerald
Sydney McCrea
Diane Norske
Melissa Burtt
Jim Flott
Mike Terrell, ASLA

## Reducing Unused Lawn Spaces

Tonie Fitzgerald, WSU Spokane County

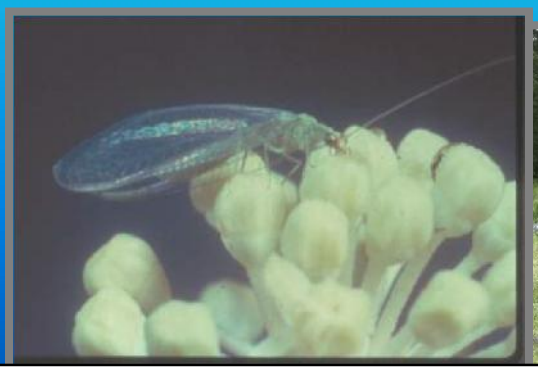
## Reducing Unused Lawn Spaces

- Mowing
- Irrigation
- Yard chemicals
- Reduced polluted runoff
- Native habitat

Tonie Fitzgerald, WSU Spokane County

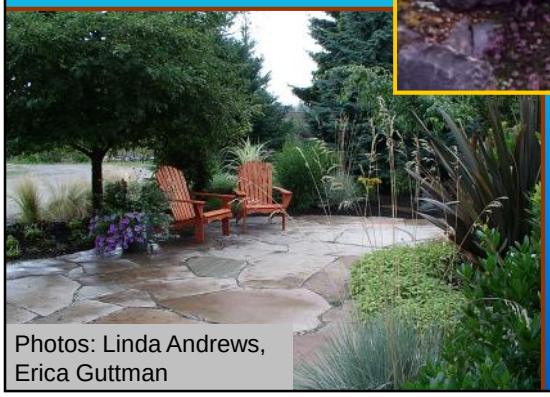
## Sustainable Landscaping

- Building healthy soils: compost, mulch
- Water-wise plant choices
- Reducing Unused Lawn Spaces
- **Safe alternatives to pesticides & fertilizers**



## Sustainable Landscaping

- **Free-draining walkways & patios**

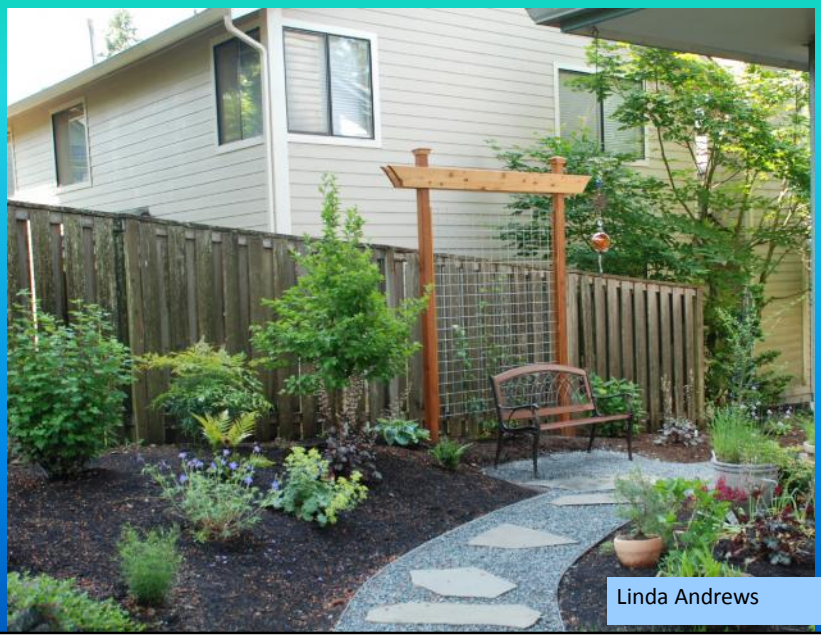


Photos: Linda Andrews, Erica Guttman


green joints, mixed materials with stone, urbanite


Crushed Stone
Linda Andrews

## Crushed stone with flagstone accents



Linda Andrews

## Decking

Linda Andrews

## Composite decks

Linda Andrews

Linda Andrews

## Free-Draining Pavements

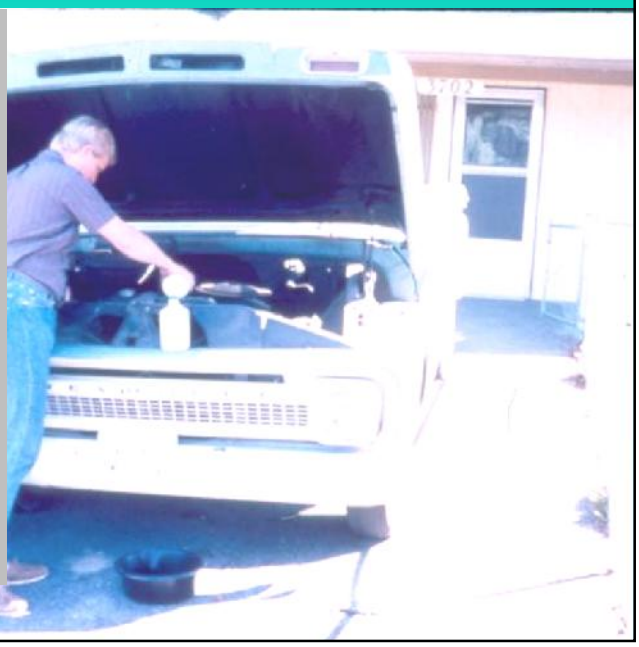
## Share your stories

## Pavement Pollution

**Pollutants & Heavy Metals**

Sources:

- Leaking fluids, spills
- Gradual wear of metal parts
- Washing/repairing cars, mowers, etc.
- Animal wastes

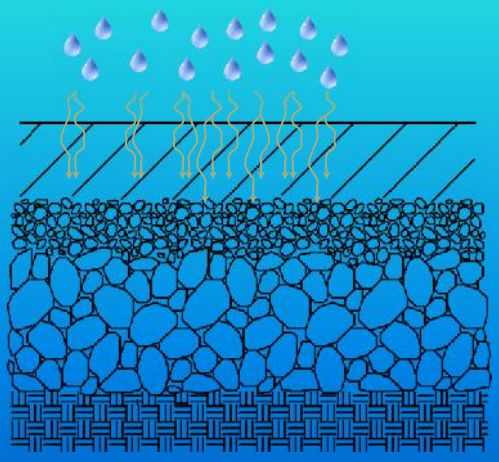


## Driveway Design Options:

- Grade and pitch: rain garden or bioswale
- Reduce length & width
- Share access with neighbors

## Shared Access

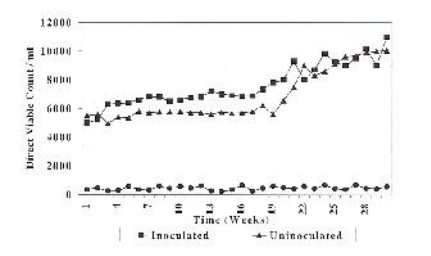
## Pollutant Removal Mechanisms in Permeable Pavements

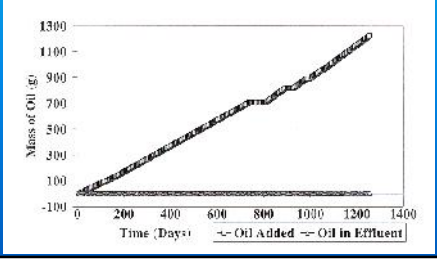


- Biological degradation
- Filtration
- Adsorption
- Volatilization

Curtis Hinman, WSU

## Permeable pavements: highly effective for hydrocarbon biodegradation




- Diversity of microbes (flagelates, amoeba, rotifers) colonize permeable paving immediately
- 97-99% removal capability
- Geotextile primary substrate for microbes

Curtis Hinman, WSU

## High initial infiltration rates in permeable paving will diminish over time, but still effective

**Infiltration Rates Over Time**

- Permeable asphalt hwy: 1986 100 in/hr.; 1990 28 in/hr.
- Florida permeable concrete field evaluation: 6.5 yrs old: 240 in/hr, 8 yrs old: 42 in/hr.
- Borgwardt: reports a long-term infiltration rate for permeable pavers of 4.25 in/hr.
- Worst case: 1,096 cm/hr reduced to 3.32 cm/hr observed. 105 cm/hr after cleaning! (Hinman, 2009)

Courtesy of Curtis Hinman, WSU

## Advantages: LID-Designed Pavements

- Filter pollution & manage runoff
- Allow water to reach plants' roots
- Attractive
- Durable

## Advantages: LID Pavements

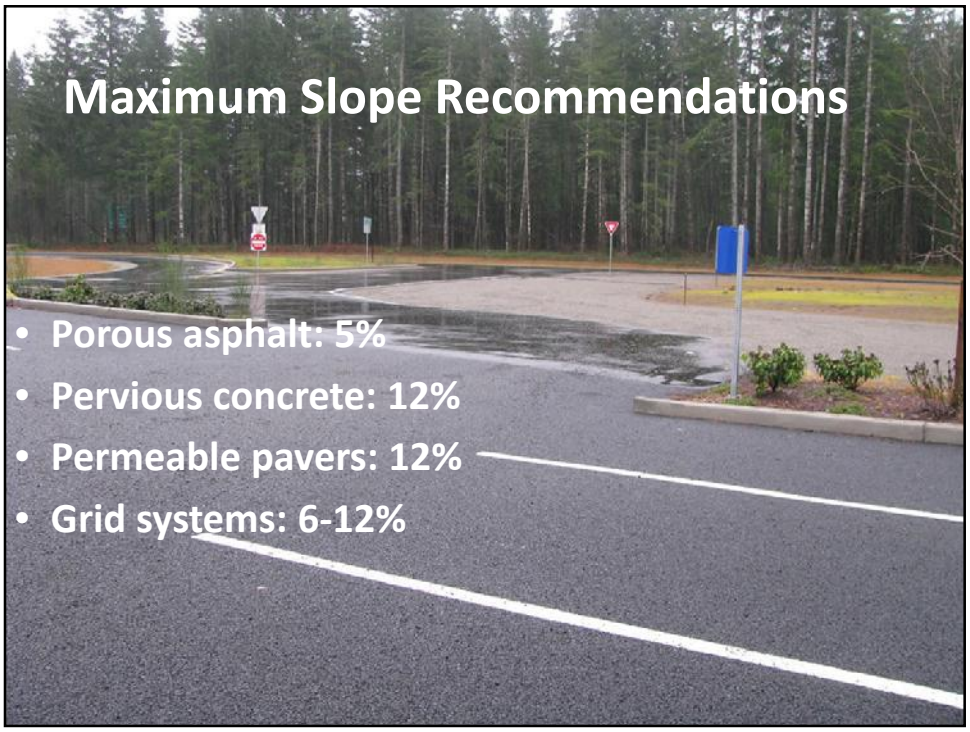
- Snow/ice removal
- Less plowing
- Faster melting
- Resist freeze-thaw

Source: Cahill Associates, 2003


## Winter Maintenance

- Plow with slightly raised or rubber-tipped blade
- Can reduce salt applications up to 75% -- variable factors
- Apply anti-icing prior to storms
- Limit sand application & vacuum at end of season
- De-icing agents not necessary for black ice – water melts through

## Maximum Slope Recommendations



- Porous asphalt: 5%
- Pervious concrete: 12%
- Permeable pavers: 12%
- Grid systems: 6-12%

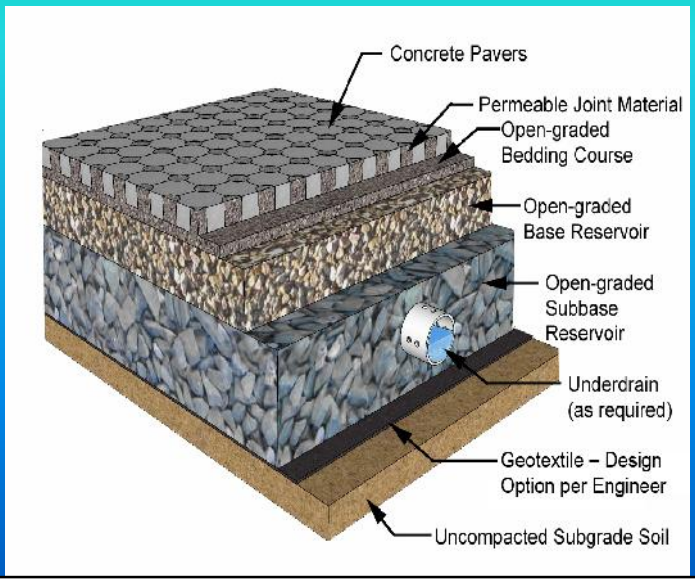
## Permeable Pavements Inappropriate

- Regular sediment deposits (construction, nursery yards)
- Seasonally high ground water within 1 ft.
- Weekly heavy sanding during winter
- Sites subject to contamination

## Permeable Pavers

- Pre-cast concrete
- Immediately ready for traffic
- Handle heavy loads at low speed
- Range of colors
- Offer design flexibility

## Permeable Interlocking Concrete Pavement *(PICP)*



## Typical Paver Shapes for PICP

Drainage joints

## Pervious Concrete Pavers


## KloroStone – Available Soon!


RESCUE EMS
Geotextile Optional

# Spreading Base Material


Compacting base material

Screeding No. 8 stone over No. 57 base


Mechanical placement

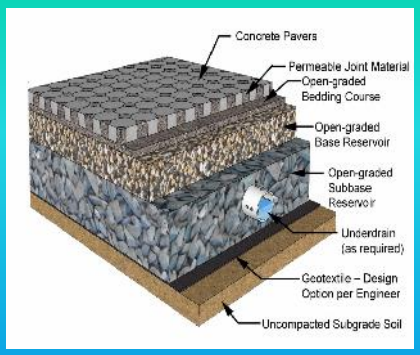
## Compact before sweeping in aggregate

Filling the openings with No. 8 stone, final compaction


## PICP Maintenance & Inspection Checklist

| | |
|---|---|
| Vacuum surface | 1 to 2 times annually, adjust for sediment loading |
| Replenish aggregate in joints | As needed |
| Inspect vegetation around PICP perimeter for cover & stability | Annually, repair/replant as needed |

# PICP Maintenance


# Cost

Furnished and Installed: $5.00 to $12.00 per sq ft

Includes:
-Pavers placed, cut, compacted, & swept

-2” of ASTM #8 Bedding Aggregate

-4” of ASTM #57 Base Aggregate

## Grid/Porous Aggregate Containment

- Interlocking grid contains small aggregate
- High-strength plastic, concrete, non-corrosive metal
- Easy installation

## Grid/Porous Aggregate Containment

- Price: Comparable to traditional concrete; 10-15% more than asphalt
- Lasts 15-20 years; no repaving expenses

## Reinforced Turf Systems

- Best suited to flat areas
- Establish grass prior to cars
- Mow & irrigate as necessary
- Lasts up to 60 years

## Porous Asphalt

- Lasts as long or longer, but must be properly designed, installed, maintained
- Substantial base protects from wear & freeze-thaw cycle

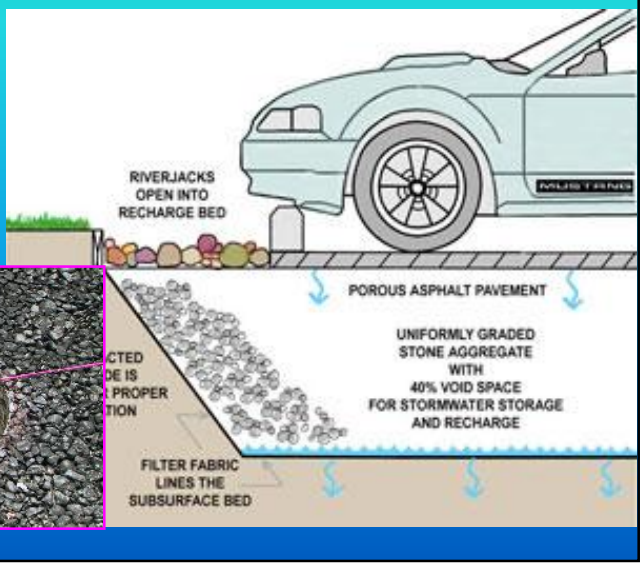
## Conventional Maintenance Problems

## Avoided Maintenance Costs

- No Chip Seal
- No Overlays

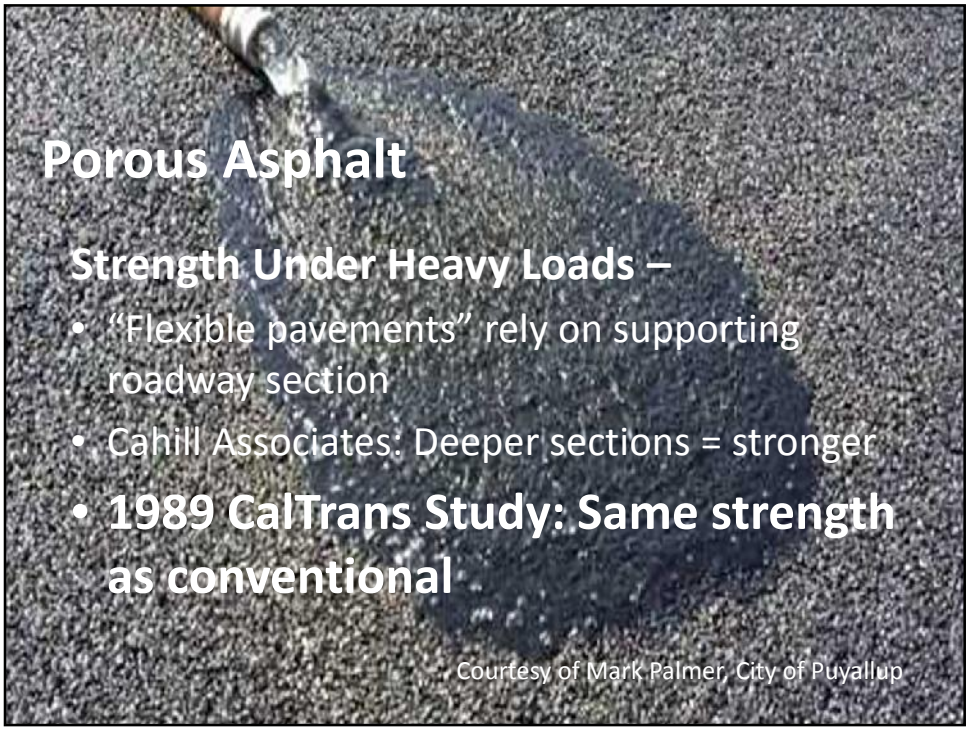
## Porous Asphalt

- Coarse stone aggregate & asphalt binders –polymers & fibers
- Very little fine aggregate = more voids





Porous Asphalt
Strength Under Heavy Loads –
• "Flexible pavements" rely on supporting roadway section
• Cahill Associates: Deeper sections = stronger
Courtesy of Mark Palmer, City of Puyallup


Porous Asphalt
Strength Under Heavy Loads –
• "Flexible pavements" rely on supporting roadway section
• Cahill Associates: Deeper sections = stronger
• 1989 CalTrans Study: Same strength as conventional
Courtesy of Mark Palmer, City of Puyallup

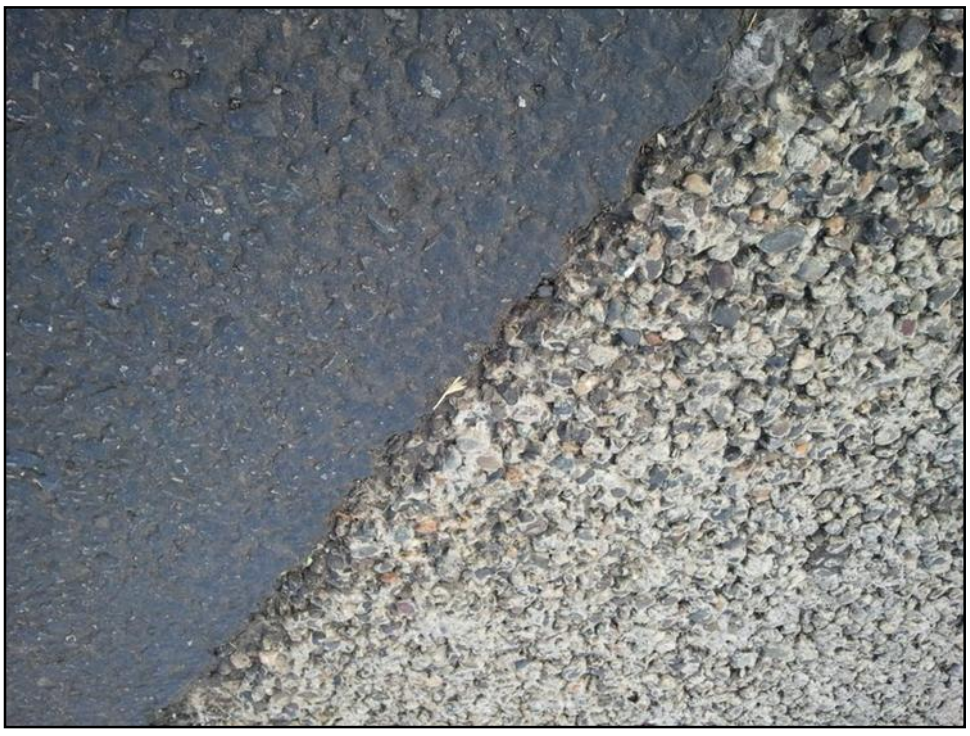
## Porous Asphalt

### Concerns/Issues

- Protection of pavement during building construction

- Design
- Spec (& penalties)
- Communication


Photo: Bob Simmons, WSU
Porous Asphalt with Run On from Conventional



# Porous Asphalt

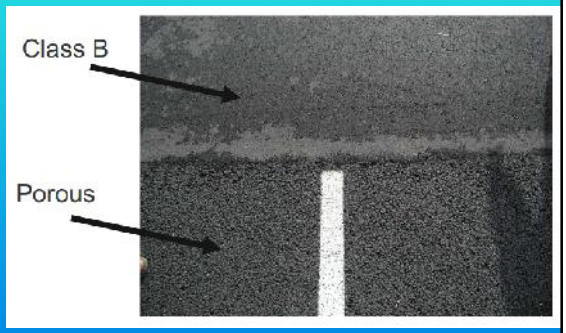
## Concerns/Issues

- Homeowner/ end user care of pavement
- Education of maintenance personnel

# Porous Asphalt

## Concerns

- Utility installations and roadway repairs
- 5-10% can be conventional



## Pervious Concrete

- Filtering & biological removal of pollutants
- Base layer provides storage
- Durable, resists freeze-thaw cycles

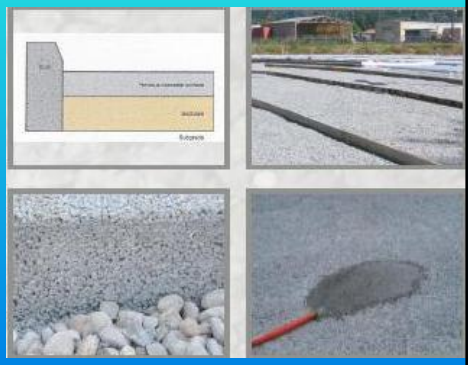
## Pervious Concrete

- High strength
- Rigid pavement – not dependent on soil support value

SeaTac Fire Station Headquarters.
Courtesy of Washington Aggregate & Concrete Assn.

# Pervious Concrete

- Cement, coarse aggregate & water
- Little to no fine aggregates
- Void content of 15-25% (5-7% conventional)



Commercial lot during rainstorm, adjacent conventional asphalt


## The Keys to a Successful Pervious Concrete Installation

**Common errors:**

- Too much cementious
- Too much or not enough water
- Improper field adjustment of water

| Bad Mix Design | Good Mix Design |
| --- | --- |
|  |  |

# Pervious Concrete


Craig Tosomeen, City of Olympia

## Relative cost comparison for porous wearing course layer for parking lot (Note costs vary over time)

| Pavement / Type | Cost per square foot for top wearing course layer (& bedding if required)* | Notes/Comments |
|---|---|---|
| Interlocking permeable pavers & rigid open celled pavers (+ 2" clean bedding layer) | $5.00 to $6.00/sf (installed mechanically)<br>$7.00 to $12.00/sf (hand laid installs) | Based on quantity less than 40,000 sf<br>For 100,000 to 200,000 sf, cost between $3.25 to $3.50/sf<br>Ref. Dave Parisi, Mutual Materials. |
| Flexible open celled/Grid lattice paving systems | $6.75/sf (Grasspave2)<br>$7.25/sf (Gravelpave2) | Cost based on 100 to 10,000 sf quantity. Includes clean gravel fill.<br>Ref. Andy Gersen, Invisible Structures |
| Porous Asphalt | $2.15/sf (3" porous AC over 2" clean choker course) | AC recently has had wide $$ fluctuations over short period of time. Price can vary based on quantity.<br>Ref. Mark Palmer |
| Pervious Concrete (8") | $5.50 to $9.00/sf | Cost can vary among bidders. |
| Stormfilter vault w/cartridges from Contech to provide Basic WQ treatment per DOE | $26,000 to $37,500 | Based on 20,000 sf of parking Ref. Contech rep. |

## How does this pencil out?

Case study:
Lakewood Crossing,
City of Marysville

476,000 sq. ft.
Mall

## LID Options

- Pervious pavement
- Curb cuts to bioretention swales

Photo Credit: NAPA - HotMix.org

## Conventional Alternatives …

- Buy more property – off-site pond
- Discharge into ditch that flows to salmon-bearing stream
- Would require raising site 8 ft. – $1M/ft.

Photo: Washington Dept. of Ecology

## Cost Comparisons: Boulder Hills, NH Subdivision

| ITEM | CONVENTIONAL | LID | DIFFERENCE |
|---|---|---|---|
| Site Preparation | $23,200.00 | $18,000.00 | –$5,200.00 |
| Temp. Erosion Control | $5,800.00 | $3,800.00 | –$2,000.00 |
| Drainage | $92,400.00 | $20,100.00 | –$72,300.00 |
| Roadway | $82,000.00 | $128,000.00 | $46,000.00 |
| Driveways | $19,700.00 | $30,100.00 | $10,400.00 |
| Curbing | $6,500.00 | $0.00 | –$6,500.00 |
| Perm. Erosion Control | $70,000.00 | $50,600.00 | –$19,400.00 |
| Additional Items | $489,700.00 | $489,700.00 | $0.00 |
| Buildings | $3,600,000.00 | $3,600,000.00 | $0.00 |
| PROJECT TOTAL | $4,389,300.00 | $4,340,300.00 | –$49,000.00 |

SFC , 2009


## Greenland Meadows Cost Comparisons

| Item | Conventional Option | LID Option | Cost Difference |
|---|---|---|---|
| Mobilization / Demolition | $555,500 | $555,500 | $0 |
| Site Preparation | $167,000 | $167,000 | $0 |
| Sediment / Erosion Control | $378,000 | $378,000 | $0 |
| Earthwork | $2,174,500 | $2,103,500 | –$71,000 |
| Paving | $1,843,500 | $2,727,500 | $884,000 |
| Stormwater Management | $2,751,800 | $1,008,800 | –$1,743,000 |
| Addtl Work-Related Activity (Utilities, Lighting, Water & Sanitary Sewer Service, Fencing, Landscaping, Etc.) | $2,720,000 | $2,720,000 | $0 |
| Project Total | $10,590,300 | $9,660,300 | –$930,000 |


Precautions
• Qualified, experienced contractors generally required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• Suppliers must meet technical spec's


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• Suppliers must meet technical spec's
• Sediment control essential


Precautions
• Qualified, experienced contractors generally required
• Suppliers must meet technical spec's
• Sediment control essential
• Follow recommended maintenance (sweeping, vacuuming, etc.)


## Resources

- Interlocking Concrete Pavement Institute
- Ecostone Pavers
- Invisible Structures ("Grasspave" "Gravelpave")
- TerraFirm EcoGrid
- Concrete Council
- Asphalt Pavement Alliance

Gary's driveway rain interceptor

**AKA: "DryWel Tredbed™"**

Captures runoff of driveway and roof

Breaks up monotony of asphalt

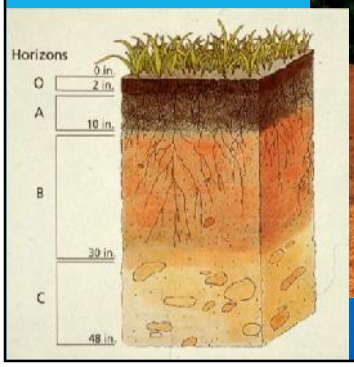

BOXER
BOXER


## Minimal Excavation Foundations

- Minimal footprint
- No or minimal equipment
- No or minimal disturbance
- Soils & vegetation in tact

## "Typical strip, transfer, pound."

-- Rick Gagliano, PIN Foundations Inc.



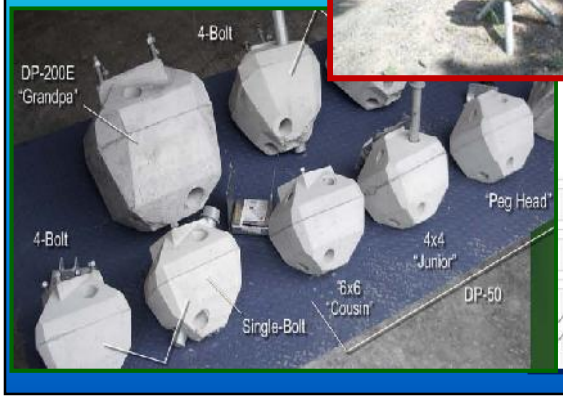

Thanks to Rick Gagliano

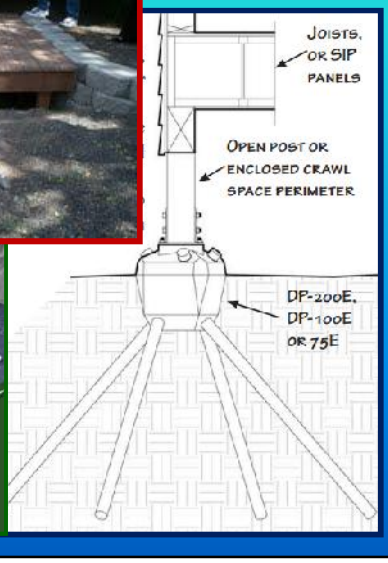
## Typical Foundation

- Heavy equipment
- Site pours
- Disturbance

Thanks to Rick Gagliano

# Pin Foundations




# Minimal Excavation Foundations

- **Natural Hydrology**

Thanks to Rick Gagliano

## Diamond Pier

- 2- to 3-person crew depending on size

Thanks to Rick Gagliano

## Diamond Pier Foundations

- Installation take 20-30 minutes per pier

Thanks to Rick Gagliano

## Pin Construction

Thanks to Rick Gagliano

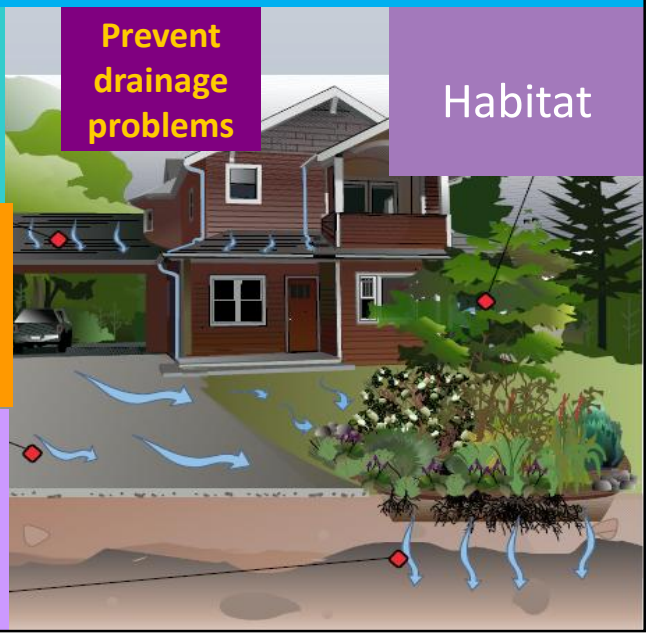
## Rain or Storm Gardens

Protect Streams & Waterways

**Prevent drainage problems**

Habitat

Filter pollution before storm drains & groundwater



**Recharge** Groundwater

# Root Structure & Soil Structure

"Bio-geo-chemical" process

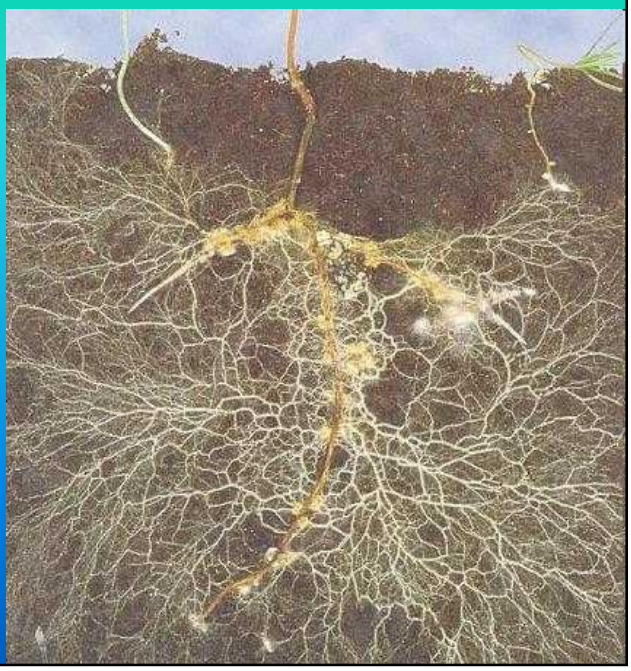
Graphic: Stacey Gianas

# Pollutant Removal Rates

| Pollutant | Removal Rate |
|---|---|
| Total Phosphorous | 70-83% |
| Metals (Cu, Zn, Pb) | 93-98% |
| Total Kjeldahl Nitrogen | 68-80% |
| Total Suspended Solids | 90% |
| Organics (pesticides) | 90% |
| Bacteria | 90% |

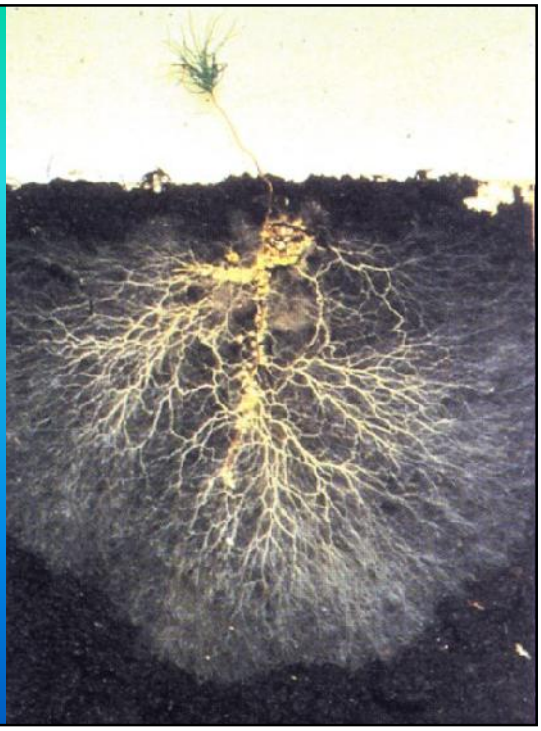
Source: Davis et al. 1998

## Treatment mechanisms:



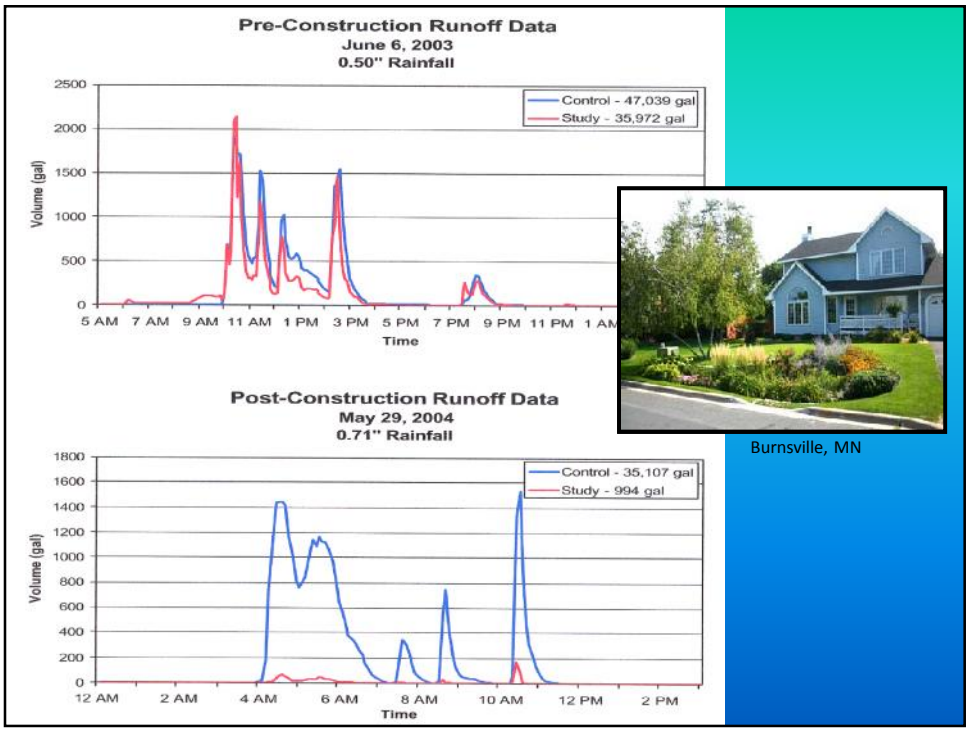
Direct Pathways:
* Nutrient uptake
* Metal uptake
* Uptake, volatilization, transformation of pesticides

## Plants & Water Quality



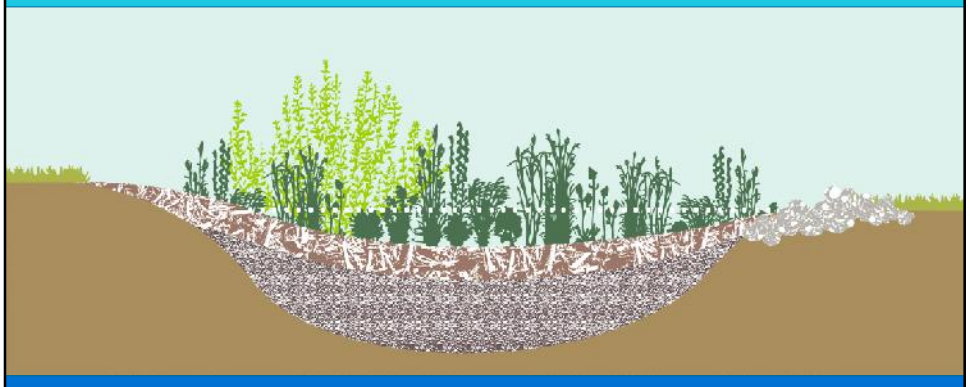
*Soil biota

*Myccorhizal fungi



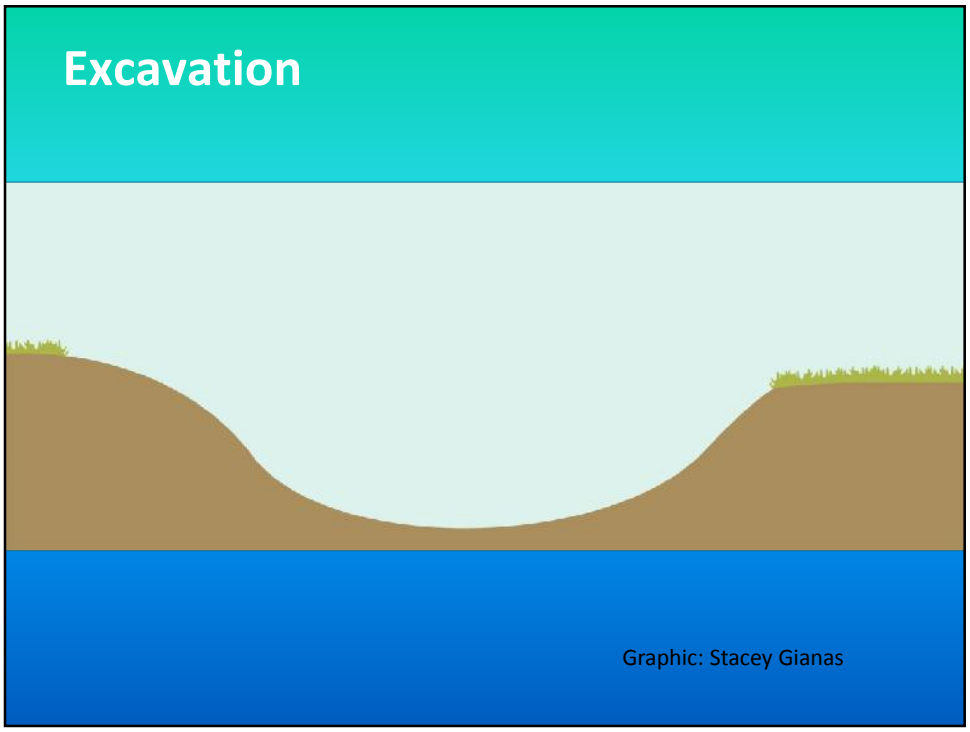

# Anatomy of a rain garden

"Inflow" "Ponding depth" "Overflow"



Graphic: Stacey Gianas

## Excavation



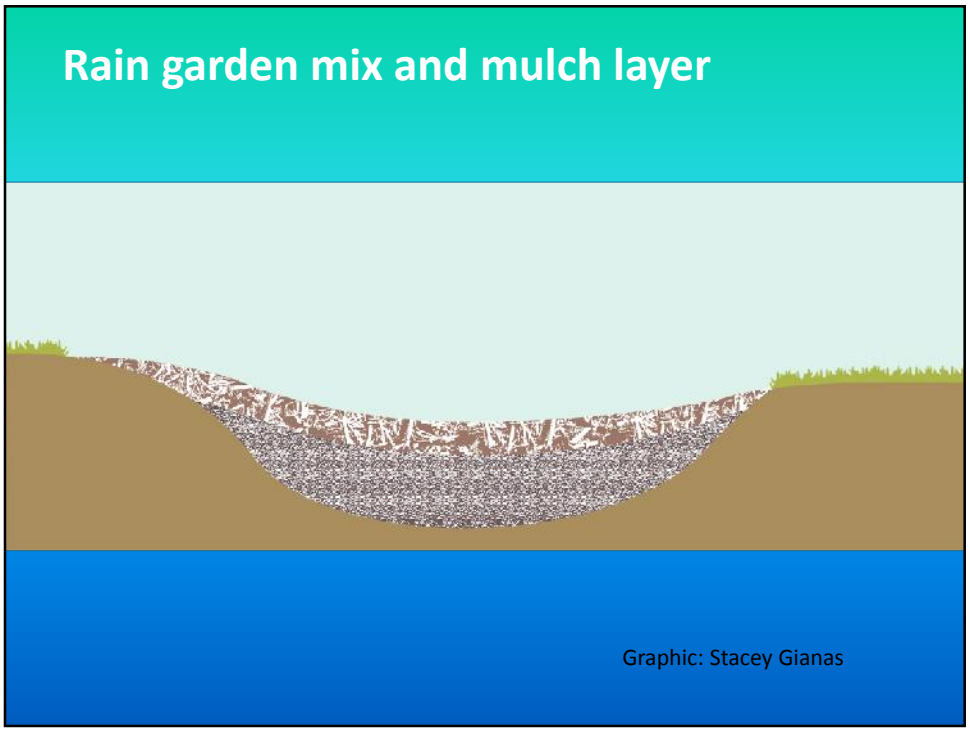
Graphic: Stacey Gianas

- Free-draining soils: Set soil aside to mix with compost
- Poorly draining soils: Will order in special bioretention soil mix


## "Bathtub"

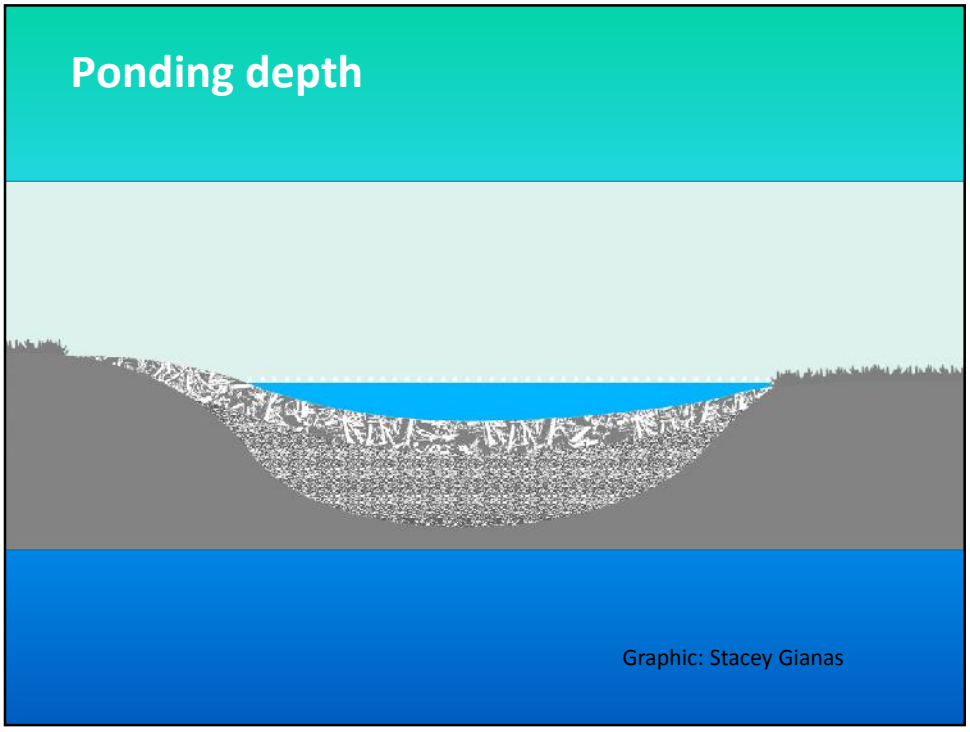
- Poor execution & installation

## Rain garden mix and mulch layer



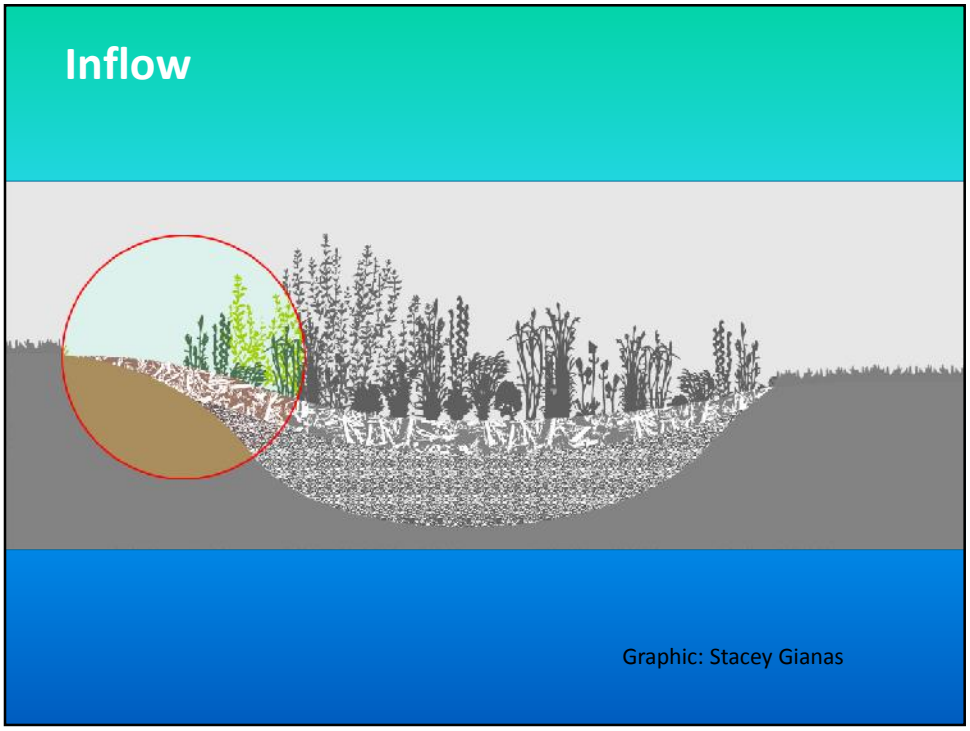
Graphic: Stacey Gianas

## Ponding depth



Graphic: Stacey Gianas

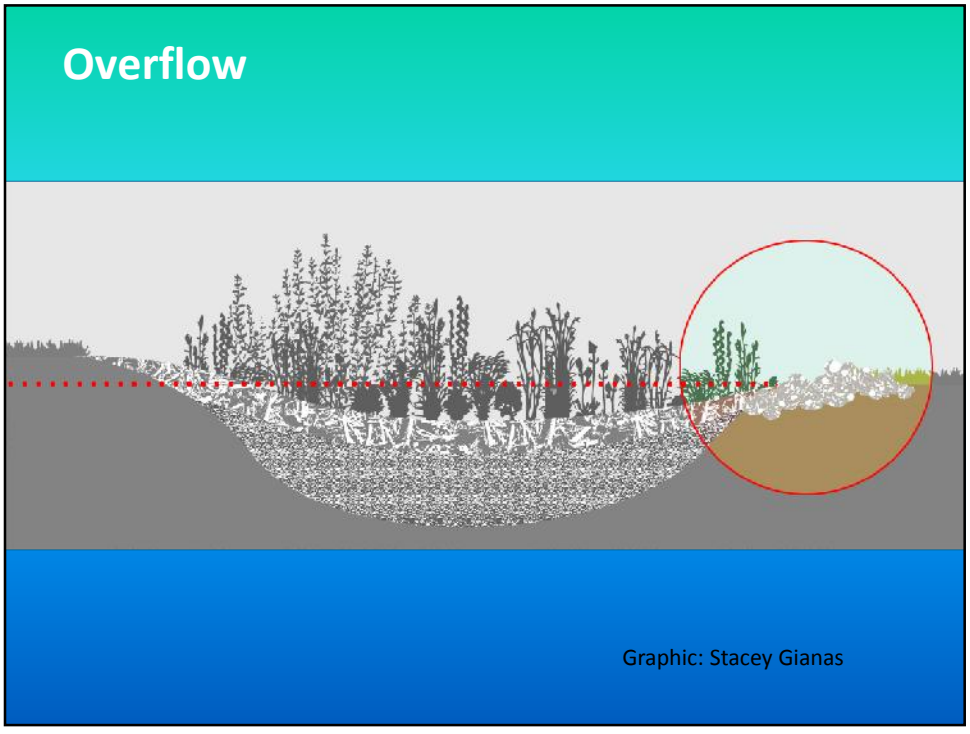
## Inflow



Graphic: Stacey Gianas

## Swale Inflow

## Overflow



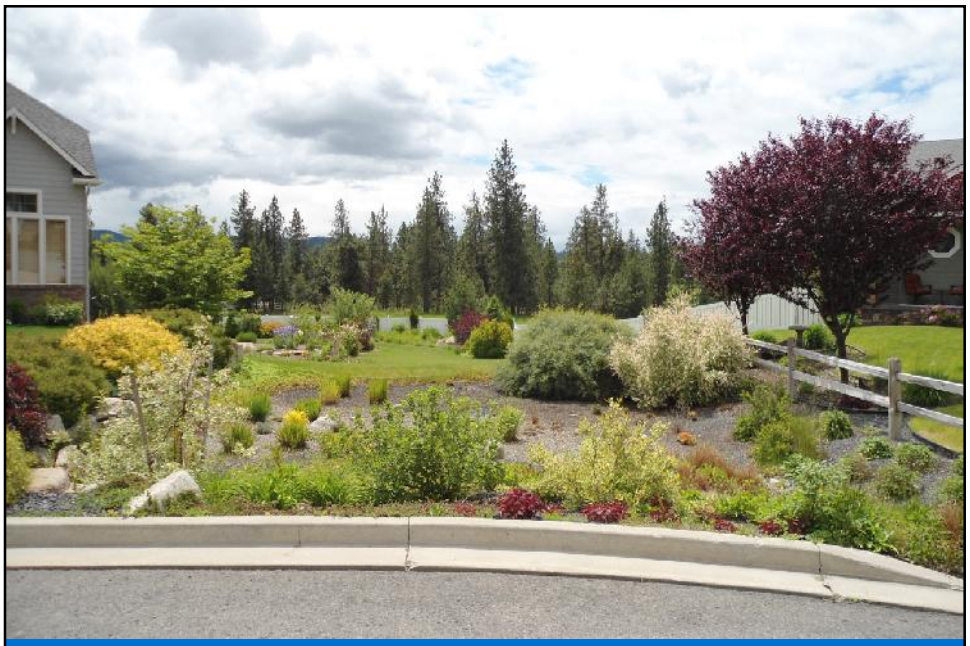
Graphic: Stacey Gianas

## Dry creek connects to rain garden

Linda Andrews Landscape & Design

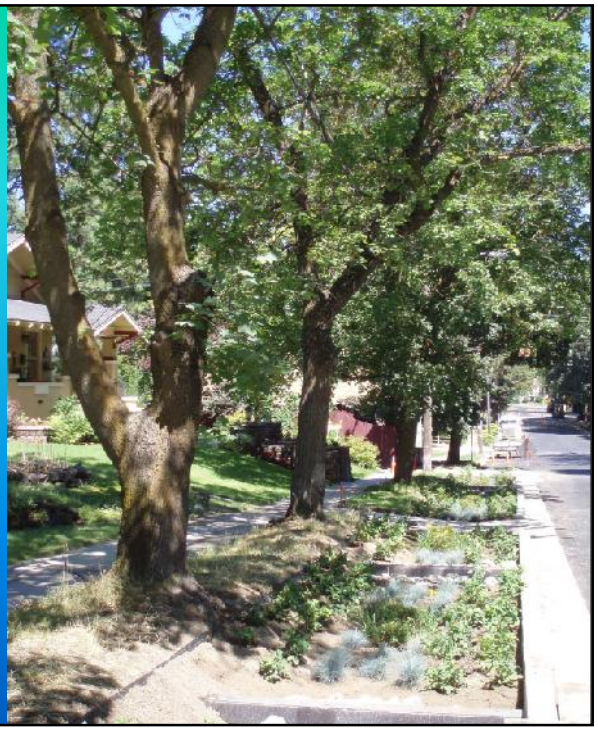
## Managing Overflow

## Spokane County & WSU Extension

Barbara Lien

Lincoln Street, Spokane



AHBL photo

## June 26, 2011

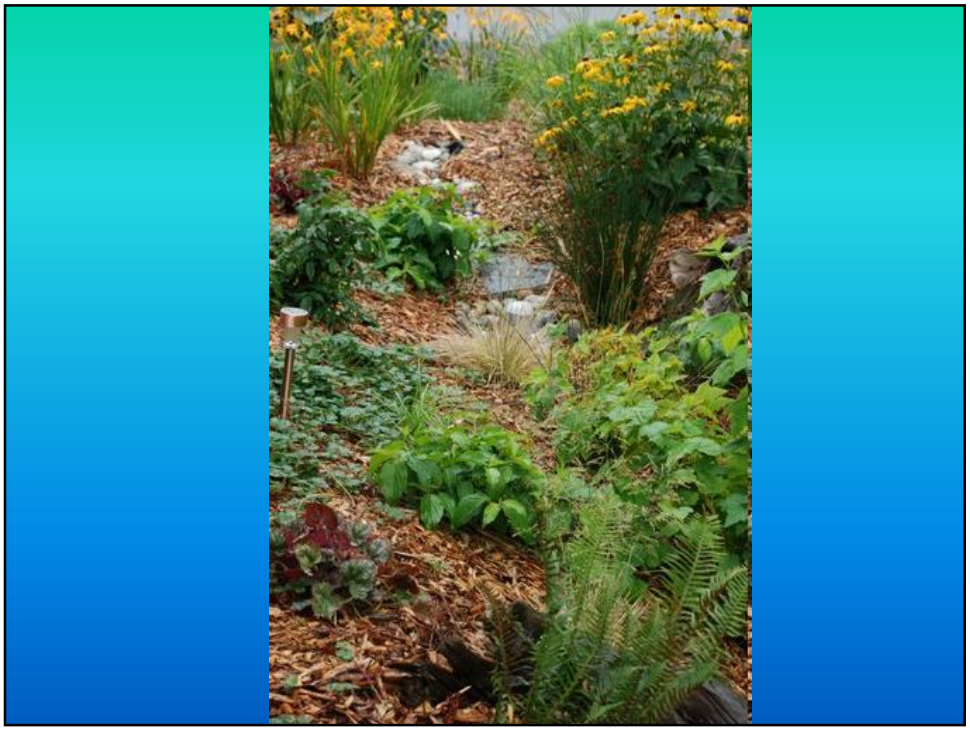
*Photo: Erica Guttman, WSU*

## July 25, 2011

*Photo: Erica Guttman, WSU*

*Photos: Erica Guttman, WSU*


June 26, 2012



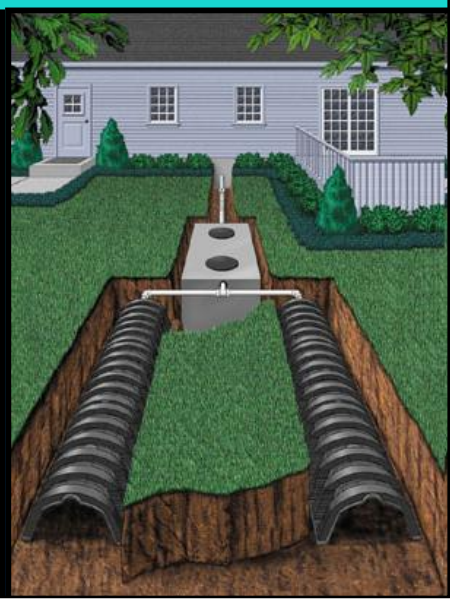
## Location

- At least 10 feet from the house or other structures.

Photo: David Hymel, *Rain Dog Designs*

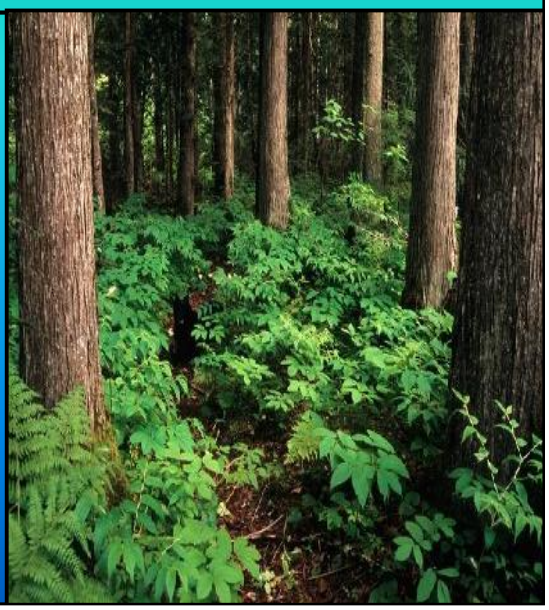
## Location

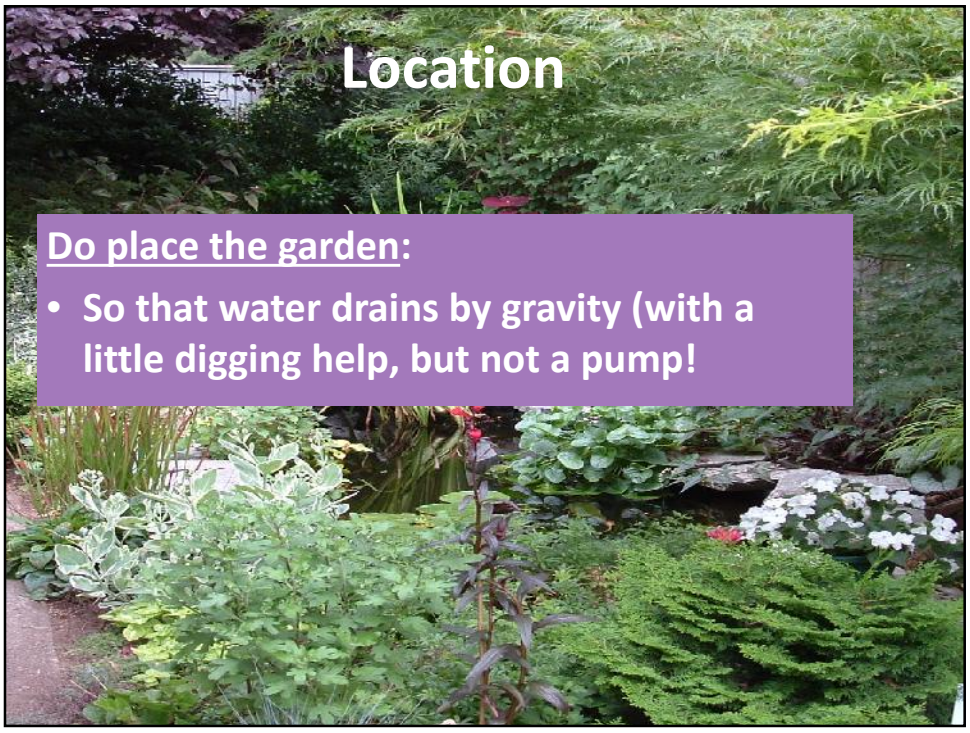
- Not over a septic system.
- Not over perched groundwater



## Location

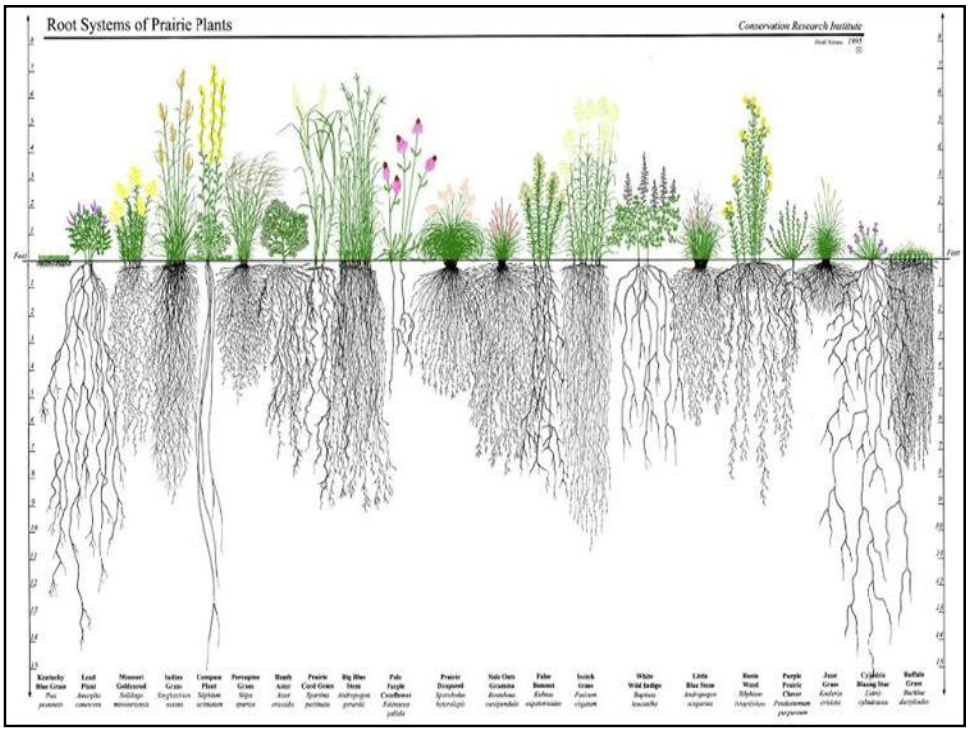
- Not in areas with mature vegetation
- Avoid large tree roots—seek a consultation from an arborist when in doubt.




Location
Do place the garden:
• So that water drains by gravity (with a little digging help, but not a pump!


Designing for Success
•Current conditions & future expectations


Plant Selection
Barbara
Lien




## Plant Selection

- Tolerance for snow, salt

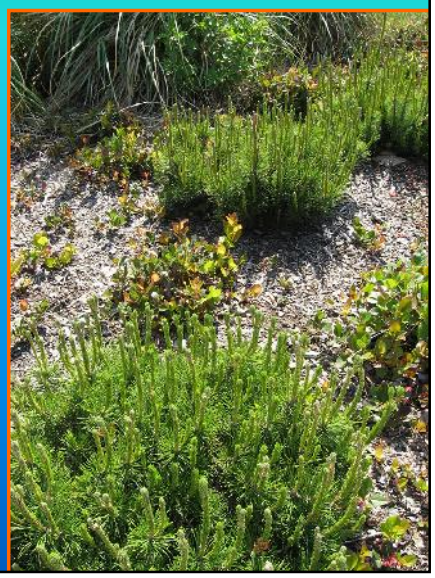
## Snow storage


## Right Plant, Right Place

- Soils

## Right Plant, Right Place

- Sun

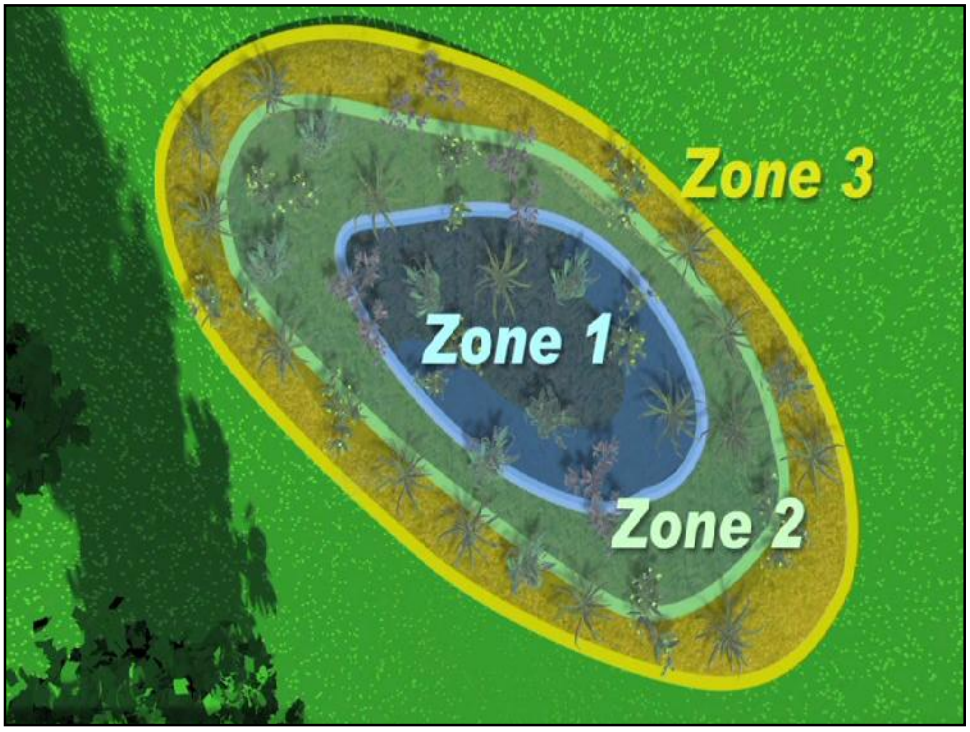


## Right Plant, Right Place

- Microclimate

## Right Plant, Right Place

- Zonation



## Planting Zones

1. Best at bottom level – Saturation & drought
2. Edge of ponding & supporting slope
3. Top - Blends into existing landscape


## Right Plant, Right Place

- Size in scale

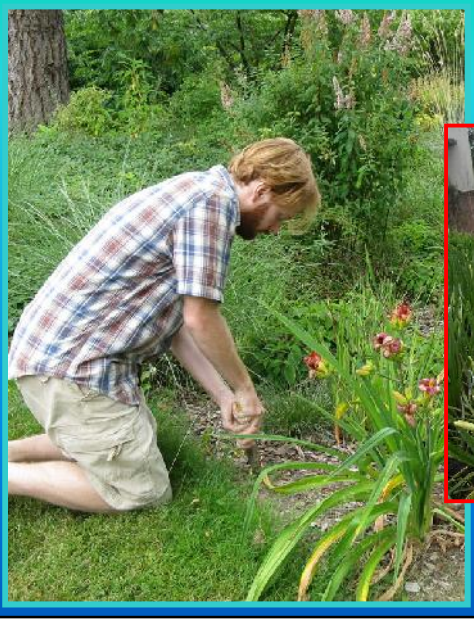
- Prevent plants from blocking sight distances
- Swap out if necessary

## Maintenance: Turf Interfaces?

## Maintain edging with turf border

## Maintenance: Mulching with Coarse Wood Chips or Mineral Mulches

## Hand Cultivation Only



## Early & Often

Photo: Stacey Gianas, Stewardship Partners

## Maintenance:
## Maintain healthy plant cover

David Hymel photo

## Maintenance:
## Maintain protective drain rock

## Water wisely

- Water regularly until plants are established: deeply but infrequently
- Wean plants from supplemental water
- Water early or late
- Use soaker hoses or spot water with shower wand

## Common Errors in New Construction

- **Landscape designers & installers not involved early**
- **Hiring firms with poor knowledge of plants & bioretention**


Common Errors in Construction
• Ignoring native plant palette
• Using guidance from other climates


Rain Garden Cost Considerations
• Soils
• Proximity to materials' suppliers
• Local hauling costs
• Labor costs: Self vs. contractor
• Plants: Big or small, how procured
• Digging: Machine or by hand
• Size of garden
• Drainage systems

## How to reduce costs for retrofits?

- 250 sq. foot garden professionally designed/installed = $2,000-$5,000
- Do-it-yourselfers: $500+


## Reduce Costs


- **Collaborate with neighbors**
- **Excavator = +/- $300/day, $1,000/week**
- **Sod cutter = +/- $40-$70**
- **Hauling costs can be shared for materials**

## Reduce Costs: Many hands …

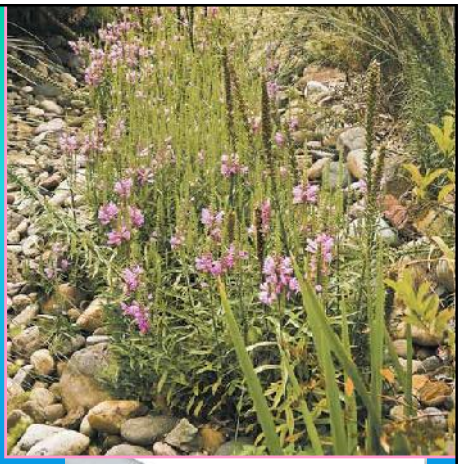
## Reduce Costs

- Make smart plant choices

Photos: Sound Native Plants, Inc.

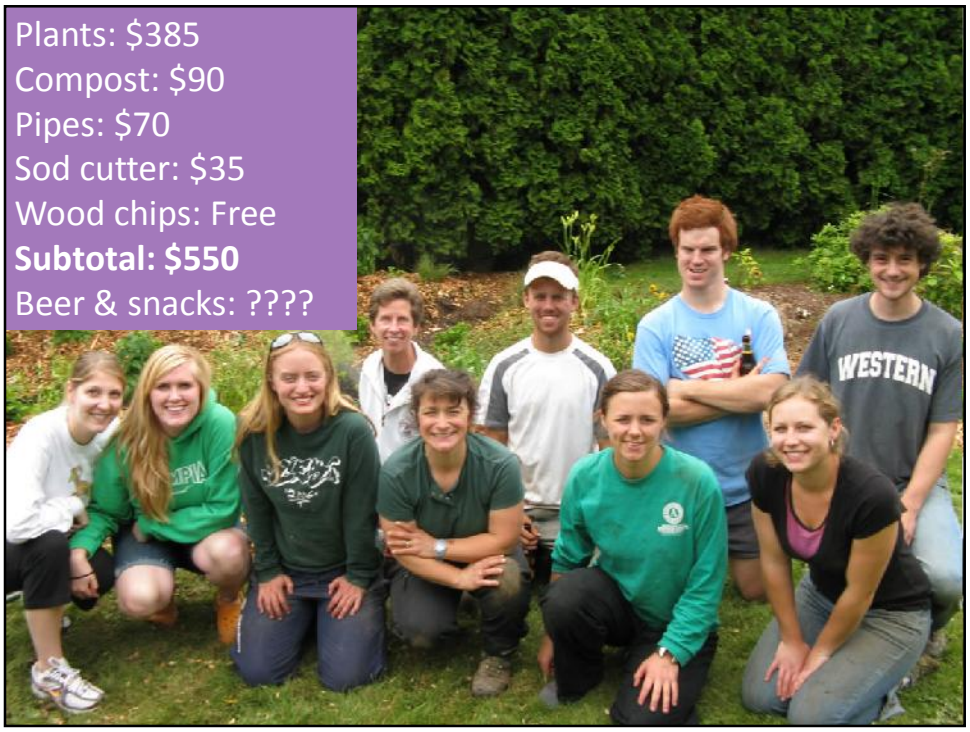
## Reduce Costs

- Simplify drainage systems
- More swales
- Design to avoid need for expensive pipes



## Jennifer's Rain Garden
## 180 Sq. Feet, ½ Rooftop

Plants: $385
Compost: $90
Pipes: $70
Sod cutter: $35
Wood chips: Free
**Subtotal: $550**
Beer & snacks: ????




## Costs: Tom's Rain Garden (2006)
## 600 sq. ft + 140 sq. ft swale

**Equipment**
- Sod Cutter: $40
- Excavator: $350

**Materials**
- Compost, w/delivery: $100
- Rock: $15 (+ delivery)
- Drainpipe: $100

Plants (277): $750
(Wholesale cost)

Labor: 115 hours

Total: $1,355

## Before & After: 9 a.m. to 6 p.m.

Plants: $538. Rocks: $7.
Compost w/delivery: $93
**Total: $638**


## Cost Comparison: Swale v. Storm Garden

*Annual Maintenance Cost Comparison - Grass Swale vs. Storm Garden*

| *Maintenance Item* | Grass-lined Swale | Storm Garden |
|---|---|---|
| Weeding or Mowing | 24 hours[1] mowing[2] = $720 | 8 hours weeding[3] = $240 |
| Mulch | n/a | $100/annually[4] |
| Fertilizer | $30 + 1.5 hours = $70 | n/a |
| Water & Irrigation[5] | $300 + 4 hours = $420 | $150 + 4 hours = $270 |
| **Totals:** | **$1,210 / year** | **$610 / year** |

[1] *A labor rate of $30/hr is used.*
[2] *Mowing is assumed to occur once every week for 1 hours over a 6 month period (April 15 - October 15).*
[3] *Weeding the storm garden is assigned 8 hours per session, once in spring and once in fall.*
[4] *Assumes mulch is applied once every two years at a cost of $100.*
[5] *Labor includes setting controllers in the spring and winterization. Water use for storm gardens is halved.*

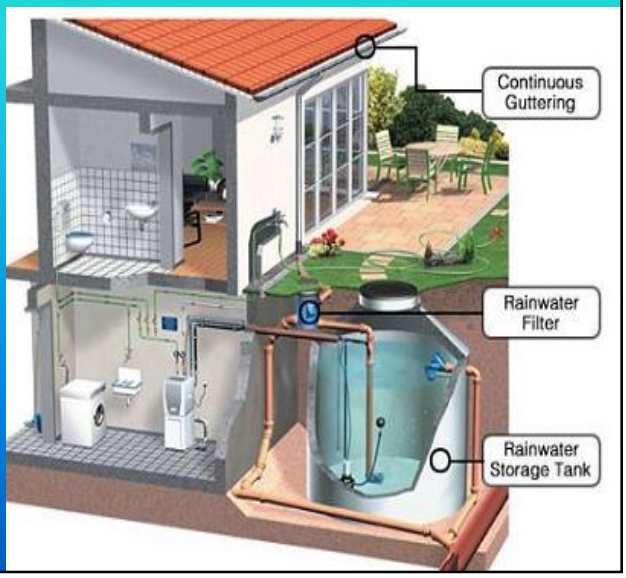
Source: Yakima Low Impact Development Stormwater Design Manual

# Managing Roof Runoff – Rainwater Harvest

Fiona Douglas-Hamilton

# Managing Roof Runoff – Rainwater Harvest

- Cisterns provide stored water for many uses





Mike Brioli, Living Systems Design


Mike Brioli, Living Systems Design

Mike Brioli, Living Systems Design

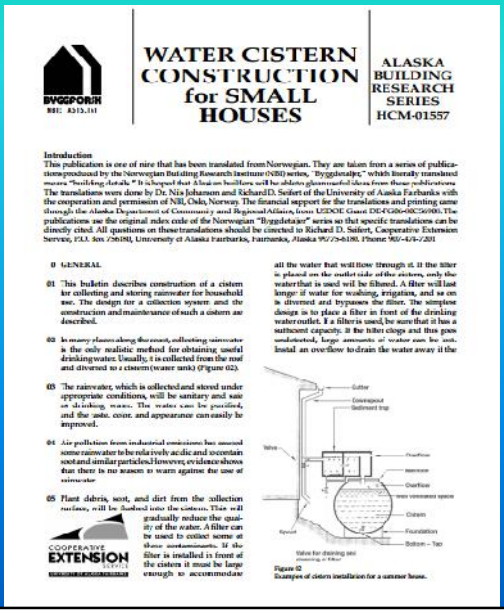
Mike Brioli, Living Systems Design

## Saranac Building, Spokane

- Snow loads and snow storage
- Five 2500-gal cisterns
- Bathrooms & irrigation

## Tacoma's Pacific Plaza: 150,000 gpy storage

# Rainwater Harvest in Cold Climates



BYGGFORSK

WATER CISTERN CONSTRUCTION for SMALL HOUSES

ALASKA BUILDING RESEARCH SERIES HCM-01557

Introduction

This publication is one of nine that has been translated from Norwegian. They are taken from a series of publications produced by the Norwegian Building Research Institute (NBI) series, "Byggdetaljer," which literally translated means "building details." It is hoped that Alaskan builders will be shown [illegible] ideas from these publications. The translations were done by Dr. Nils Johansen and Richard D. Seifert of the University of Alaska Fairbanks with the cooperation and permission of NBI, Oslo, Norway. The financial support for the translations and printing came through the Alaska Department of Community and Regional Affairs, from USDOE Grant DE-FG06-90CS6900. The publications use the original index code of the Norwegian "Byggdetaljer" series so that specific translations can be directly cited. All questions on these translations should be directed to Richard D. Seifert, Cooperative Extension Service, P.O. Box 756180, University of Alaska Fairbanks, Fairbanks, Alaska 99775-6180. Phone 907-474-7201

0 GENERAL

01 This bulletin describes construction of a cistern for collecting and storing rainwater for household use. The design for a collection system and the construction and maintenance of such a cistern are described.

02 In many places along the coast, collecting rainwater is the only realistic method for obtaining useful drinking water. Usually, it is collected from the roof and diverted to a cistern (water tank) (Figure 02).

03 The rainwater, which is collected and stored under appropriate conditions, will be sanitary and safe as drinking water. The water can be purified, and the taste, color, and appearance can easily be improved.

04 Air pollution from industrial emissions has caused some rainwater to be relatively acidic and to contain soot and similar particles. However, evidence shows that there is no reason to warn against the use of rainwater.

05 Plant debris, soot, and dirt from the collection surface, will be flushed into the cistern. This will gradually reduce the quality of the water. A filter can be used to collect some of these contaminants. If the filter is installed in front of the cistern it must be large enough to accommodate all the water that will flow through it. If the filter is placed on the outlet side of the cistern, only the water that is used will be filtered. A filter will last longer if water for washing, irrigation, and so on is diverted and bypasses the filter. The simplest design is to place a filter in front of the drinking water outlet. If a filter is used, be sure that it has a sufficient capacity. If the filter clogs and thus goes undetected, large amounts of water can be lost. Install an overflow to drain the water away if the




Figure 02
Examples of cistern installation for a summer house.

COOPERATIVE EXTENSION SERVICE

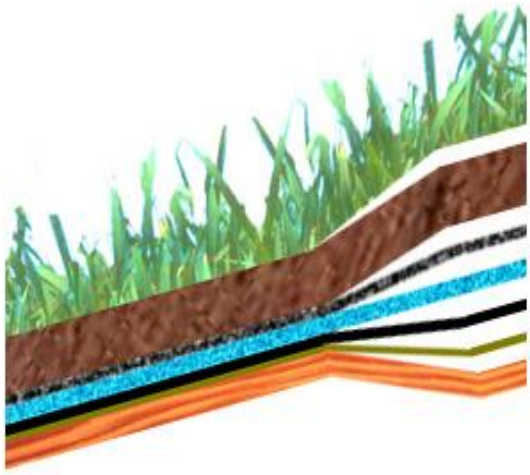
# Rooftops

- Zinc
- Lead
- Chromium
- Arsenic
- Polycyclic aromatic hydrocarbons


## What are Green Roofs?

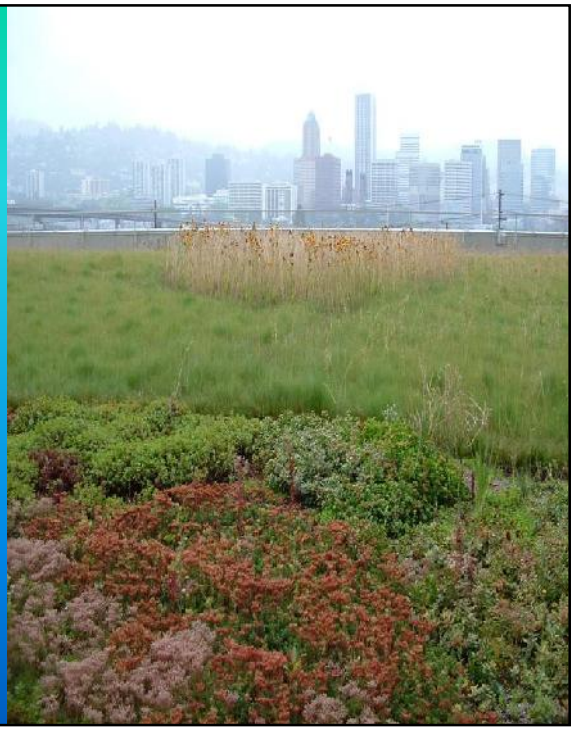
- Also called: eco-roofs, vegetated roofs, living roofs, roof gardens
- Plants = top layer of a composite assembly

## Components




## Overall Benefits

- Stormwater treatment
- Stormwater reductions
- Aesthetic improvements
- Noise reduction
- Heating/cooling cost savings



## Economic Benefits for Landowner

- Potential increase in real estate values of about 20%.
- Potential to reduce the size of HVAC equipment on new or retrofitted buildings.
- Potential to reduce the amount of standard insulation used.

## Long Roof Life & Resource Conservative

- Extended roof life – 50 yrs +
- No UV radiation degradation

## Long Roof Life & Resource Conservative

Reduced thermal expansion/ contraction of membrane—
14 to 22 degrees F mitigation

## Green Roof Applications

- Poor soils
- Limited land availability
- High groundwater
- Other attributes

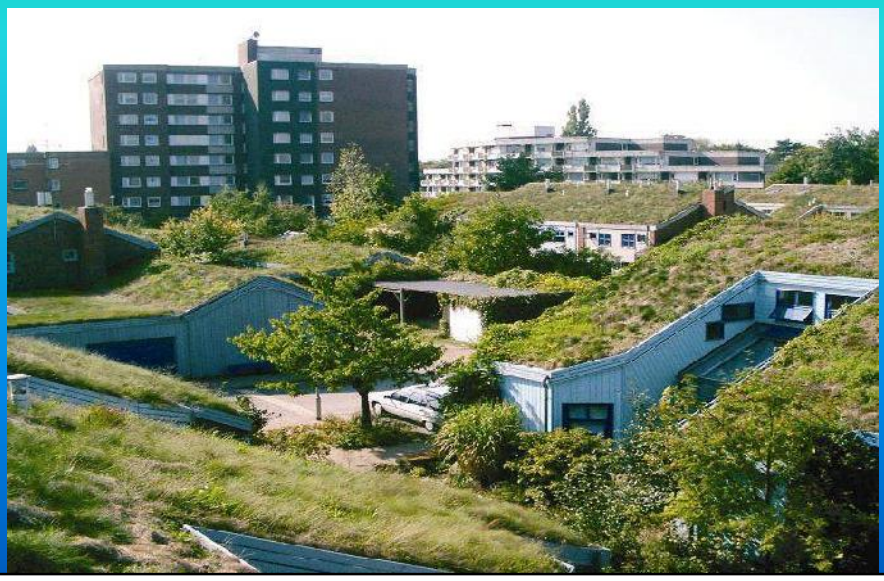
## Green Roof Types

- "Intensive": soil or growth medium base of 6 inches to as deep as 3 feet or more.
- "Extensive": soil or growth medium base of sometimes less than 2 inches to as deep as 6 inches.

## Built in 1834 and still functioning

## Rockefeller Center

## Berlin neighborhood 2001

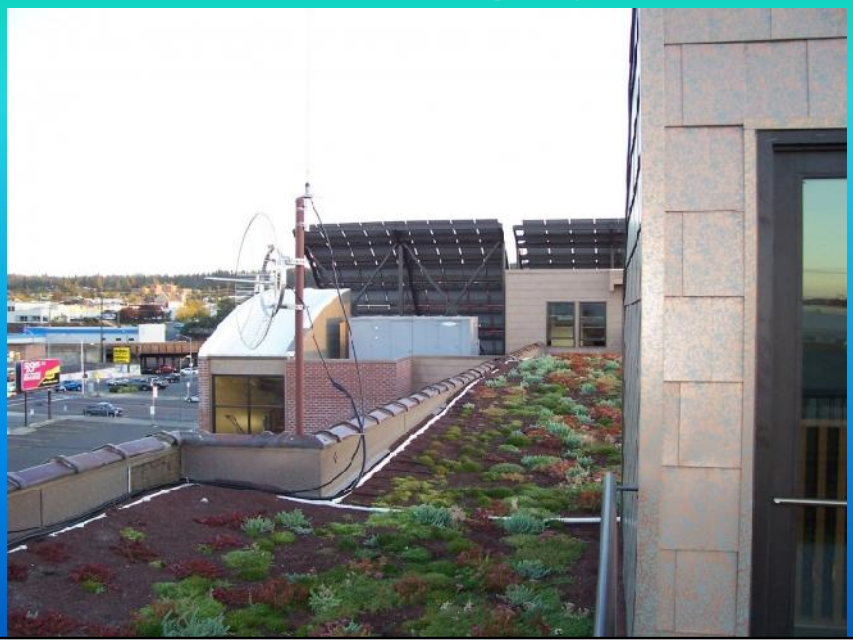


## German residence, 1984

## Ford's Dearborn Plant, 3.8 acres of green roof

## Chicago

## Saranac Building, Spokane



## Residential vs. Commercial Roof Surfaces

6-8 times more residential than commercial in cities

Increases more in suburban & rural areas

Source: Hadj Design/City of Seattle

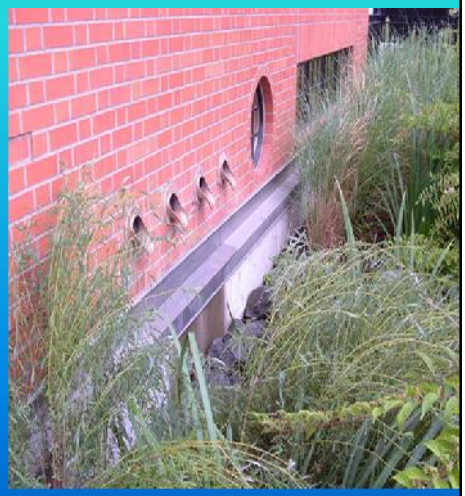
Photo: Janet Jensen, Tacoma News Tribune

## "Phyte Club" Action

## Stormwater Benefits

**What Happens to the Rain?**

1. **Some intercepted by vegetation -- evaporates**

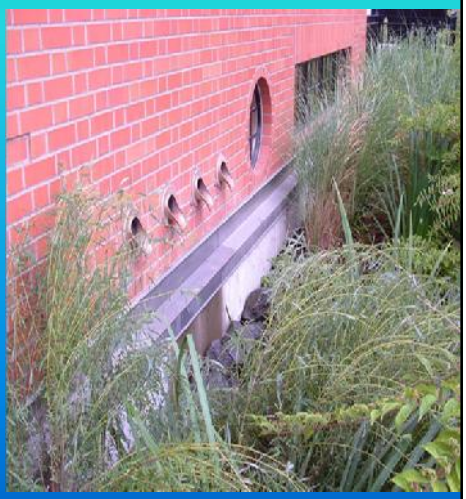


## Stormwater Benefits

**What Happens to the Rain?**

1. Evaporation

2. **Portions are absorbed in the substrate—benefit from soil micro-organisms, soil friction/bonding;**



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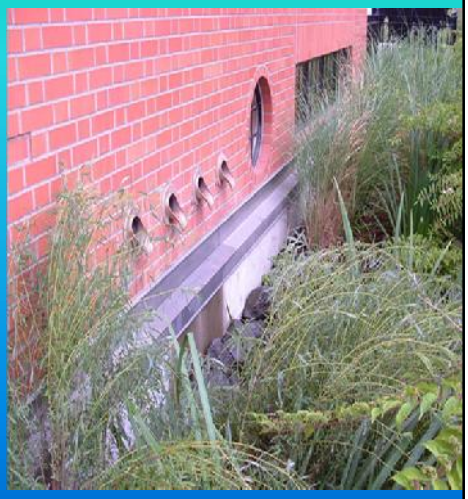
3. **Portions in the substrate are taken into the vegetation and then transpire;**



## Stormwater Benefits

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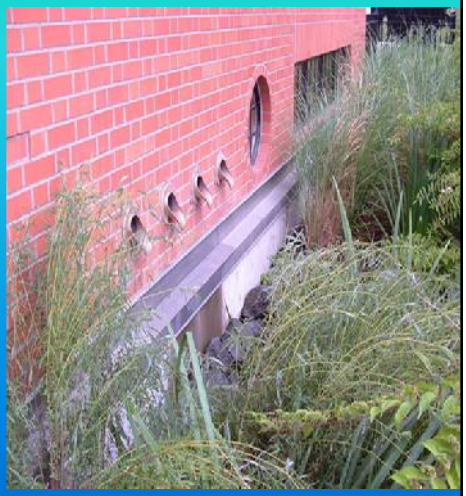

# Stormwater Benefits

**What Happens to the Rain?**

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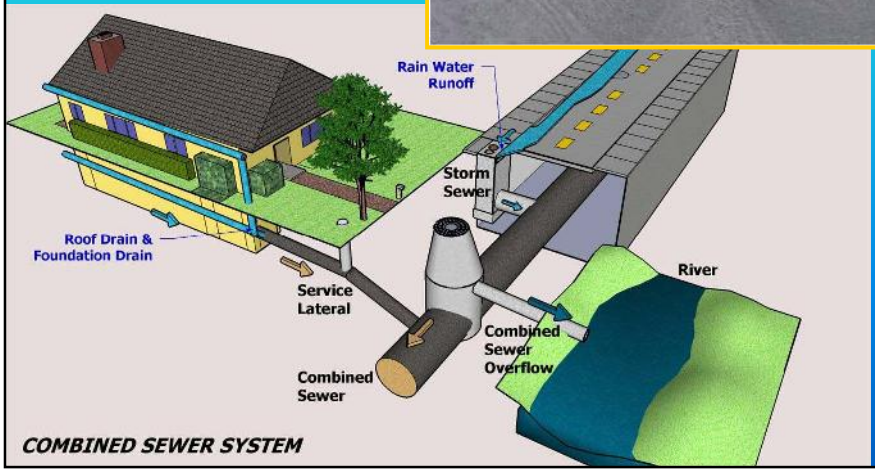
4. Some water evaporates from the substrate; and

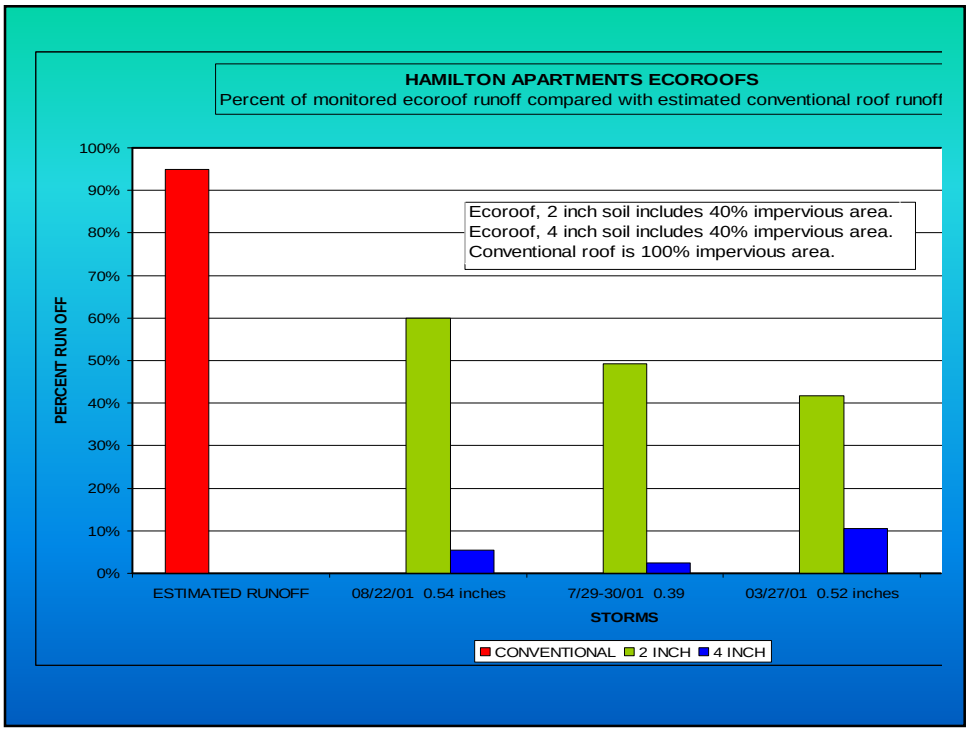
5. **Excess amounts flow through the substrate and become runoff.**

# Peak Flow Reduction




344-FISH
WARNING!
10


MAY 8 2002




## Stormwater Interception

**Influencing Factors**:

- Vegetation maturity
- Substrate maturity
- Rainfall distribution (best at handling intermittent—even heavy—storm events)

## Stormwater Interception

- **Runoff negligible from events of 0.6” or less**

**Portland Roof, with 4 to 4.5-inch substrate:**

- **Retained 20% January to March 2002**
- **Retained 59% January to March 2003**

- **More even rainfall distribution in 2002**
- **More dry periods between storms in 2003**

## Water Filtration Benefits

- Roof runoff treatment
- Delay of flow
- 95% cadmium, copper, lead, 16% zinc reductions
- Clearer of organic matter and debris

## Compatible with Solar

## Habitat

- Stepping stones or Islands
- Mimic endangered habitats
- Inherent protections
- Birds
- Insects
- No slugs

## Building Structure

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- Current energy code encourages deeper roof joists for insulation; also creates stronger roofs
- **Similar in weight to tile or slate**

## Sub-Membrane

- **Provides a cushion for the membrane.**
- **Back-up membrane & temporary protection for the deck before the membrane is installed.**

## Waterproof Membrane

- Commercial-grade waterproofing layer

## Waterproof Membrane

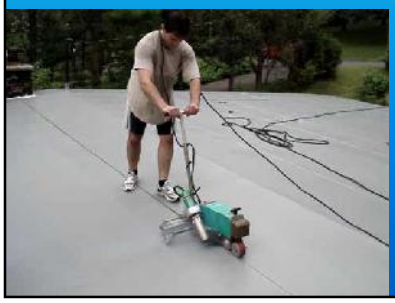
- Many varieties: modified rubber (EPDM), modified plastic (TPO), modified bitumen, PVC, hybrids
- Many forms: Mop down, liquid applied, single-ply, spray

## Waterproof Membrane

Seams waterproofed by:

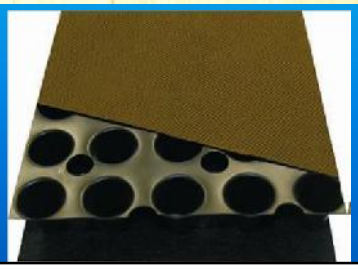
- heat welding
- chemical adhesive
- hot applied bitumen

(depending on membrane material)



## Capillary Mat & Drain Mat

- **Prevent growth media from draining off roof**
- **Various designs**



## Growth Medium ("Engineered Soil Mix"): Structure

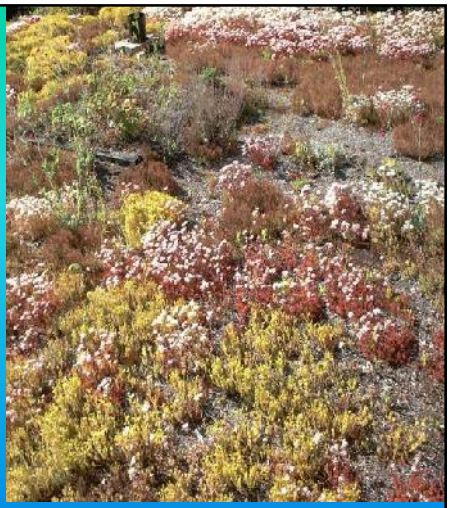
- Can't blow away
- Can't grind to dust
- Porous for water storage
- Allows air flow

## Growth Medium ("Engineered Soil Mix"): Nutrition

- **Trace minerals**
- **Organics – nutrition**
- **pH**

## Plants

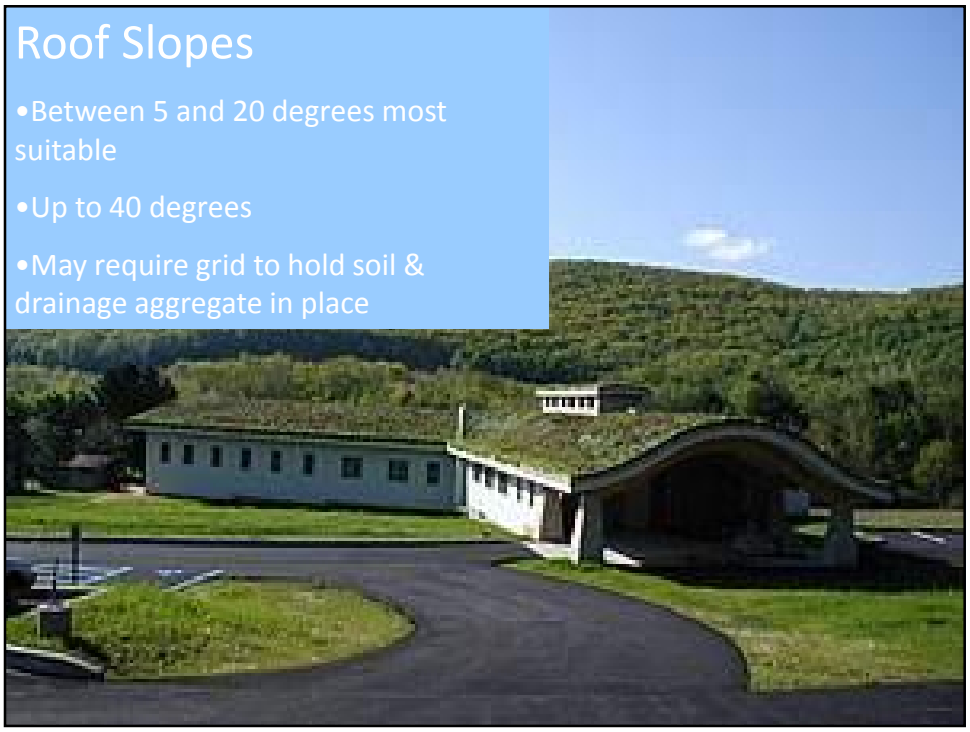
- Fast coverage
- Low maintenance
- Drought tolerant
- Wind and sun tolerant
- Fire resistant
- Attractive



***Examples**: Sedums, hens & chicks, hardy ice plant, creeping herbs, pussytoes, seathrift, bunchgrasses*

## Roof Slopes

- Between 5 and 20 degrees most suitable
- Up to 40 degrees
- May require grid to hold soil & drainage aggregate in place



## Challenges

- **Still a new concept in U.S.**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- Local jurisdictions need to create incentives to reap substantial public benefits
- **Lending institutions should start life-cycle-cost evaluations in loans**