Soil Strategies

for Stormwater Management, Erosion Control, and Landscape Success

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Presentation at "Landscape Stormwater Strategies – A Practical Design Workshop" (advanced) 1/26/06 at UW CUH

Summary of Soil Best Management Practices

New Construction

- Retain and protect native topsoil & vegetation (esp. trees!)
  - Minimize construction footprint
  - Store and reuse topsoil from site
  - Retain "buffer" vegetation along waterways
- Restore disturbed soils by tilling 2-4" of compost into upper 8-12" of soil. Rip to loosen compacted subsoil.

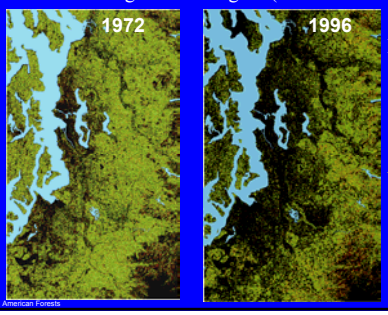
Existing Landscapes

- Retrofit soils with tilled-in compost when re-landscaping
- Mulch beds with organic mulches (leaves, wood chips, compost), and topdress turf with compost
- Avoid overuse of chemicals, which may damage soil life

Why a Soil Strategy is Essential: The Connection Between Soil and Water

The Stormwater Problem:
Impacts of turning spongy forests into cities

1972-1996: Amount of land with 50% tree cover decreased by 37% in Puget Sound region (from 42% of land down to 27%).



American Forests

Impervious surface (roads, buildings) increased proportionately.

WA population doubled 1962-98.

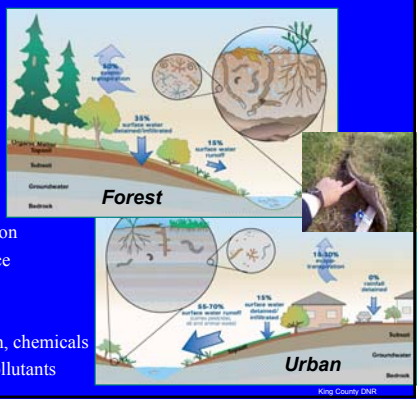
2.7 million more people by 2020!

What happens to soil functions as we turn forests into cities?

↑compaction
↑erosion
↑loss of topsoil
↓soil organisms
↓soil structure
↓natural fertility & disease prevention
↑impervious surface

cause:

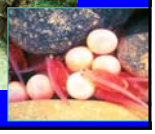
↑winter runoff
↑need for irrigation, chemicals
↓biofiltration of pollutants



King County DNR

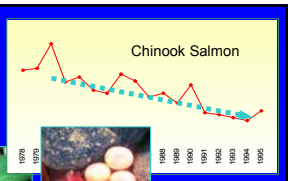
What happens to streams as we turn forests into cities?

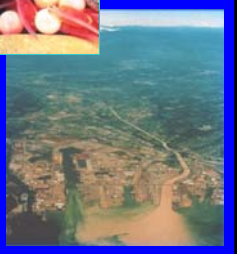
↑runoff = ↑peak storm flows
↑erosion of stream bank and bed
↑fine sediment choking spawning gravels
↑pollutants (automotive, landscape fertilizer and pesticides)
↓groundwater recharge
↓summer low flows
↑summer stream temperature
↓oxygen in spawning gravels
↓LWD - logs and rootwads that young salmon need
↓food supply for young salmon



What are the impacts?

- Salmon decline
- Pollution
- Erosion
- Flooding & property damage
- Failing landscapes, resulting in more chemical use





What does current science tell us?

- Biological integrity of streams decreases rapidly when total impervious area in watersheds exceeds 5-10%.
- Traditional stormwater detention structures in developed areas are insufficient to prevent storm damage to streams.
- Salmon are in trouble unless we change our development practices.
- We need to:
  - decrease construction footprint
  - decrease impervious area (roads, houses)
  - maintain natural "buffer zones" along streams
  - preserve native soils and forests
  - restore ability of disturbed landscapes to detain & infiltrate rainwater
- A soil strategy can help.

Try to make this….. function like this.

Restoring Soil Functions with Organic Amendments

Stormwater management

- Incorporate 15-30% compost (by volume) into soil before planting
- Compost amendment builds soil structure, moisture-holding capacity
- Increases surface porosity

UW trials, turf on glacial till soil

Compost-amended till soil – up to 50% reduction in storm water runoff

Erosion and sediment management

- Compost berms or blankets – slow water, bind surface soil, and reduce erosion immediately
- Enhance survival/growth of plantings, helping to stabilize slopes over long term.

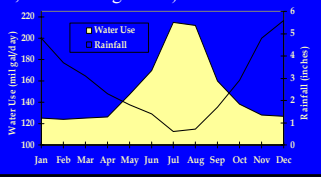
Berms instead of silt fence

Compost blankets on steep slopes

Added benefits of soil amendment

- Bio-filtration of urban pollutants
- Improved fertility & plant vigor:
  - less need for fertilizers and pesticides
  - reduced maintenance costs
- Reusing "wastes" (yard waste, manure, biosolids, construction, landclearing waste)

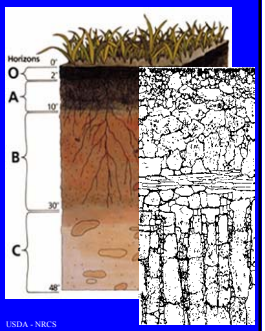
- Reduced summer irrigation needs



Understanding Soil: development from parent "dirt" & rock

Soil horizons & their evolution

- Substratum (C) or bedrock (R) weathers physically & chemically to subsoil (B)
- Primarily biological processes create topsoil (A) and organic (O) horizons



USDA - NRCS
http://soils.usda.gov

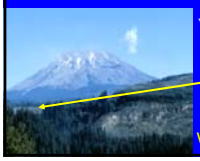
Sub-Soils in the Puget Sound Basin: Leftovers from glaciers & volcanoes

glacial till: unsorted, unstratified mixtures of clay, silt, sand, gravel, and boulders; deposited under ice, or in moraines

hardpan: till compacted under glacier

outwash soils: layers sorted by particle size by water - sand / gravel / rocks

lake/marine bed soils: clay or silt that settled out in lakes & estuaries



volcanic ash: light, fertile, holds moisture - mostly blown east of Cascades

mudflows: mixed size, compact - like till

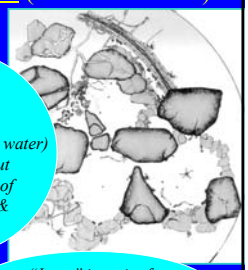
Learn about Puget Sound soils at:
www.puyallup.wsu.edu/soilmgmt/Soils.htm

Understanding soil: texture, structure, & pore space (thus infiltration)

Soil components:

- "The Dirt" (mineral part)
  - sand
  - silt
  - clay
- Air and Water
- Organic Matter and Soil Life (create aggregates & pores)

Good soil is about
- half mineral
- half space (air & water)
- plus a smaller but essential amount of organic matter & soil life

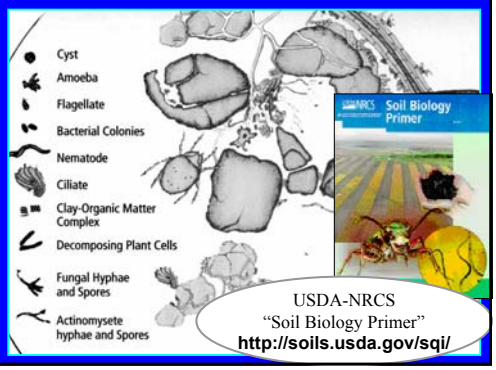


"Loam" is a mix of sand, silt, clay and organic, formed over time by nature

Understanding Soil Biology

Soil life provides essential functions

Soil is alive!

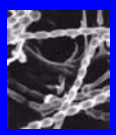


S. Rose & E.T. Elliott

USDA-NRCS
"Soil Biology Primer"
http://soils.usda.gov/sqi/

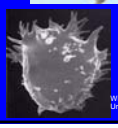
Common organisms in the soil foodweb

- Bacteria



- Fungi

- Protozoa



- Nematodes

Soil Foodweb Inc.

- Arthropods

SSSA

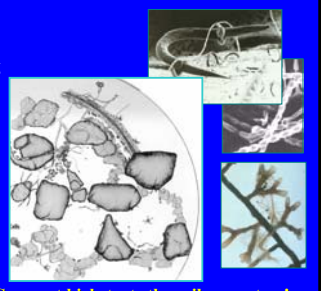
- Earthworms

Wilhelm Foissner, University of Salzburg

Restoring soil life, to restore soil functions

Soil organisms create:

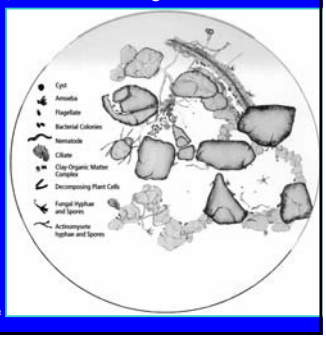
- soil structure
- fertility = nutrient cycling
- plant disease protection
- biofiltration
- erosion control
- stormwater detention



Compost kickstarts the soil ecosystem!
(Provides food and home for organisms)

How does soil life create soil structure?

- Bacteria secretions glue clays, silts and sands together into micro-aggregates.
- Micro-aggregates are bound together by fungal hyphae, root hairs and roots.
- Spaces are made by moving arthropods & earthworms, and decaying roots.
- Only when all organisms are present can roots and water move into the soil with ease.



S. Rose & E.T. Elliott

How does soil life provide fertility (nutrient cycling)?

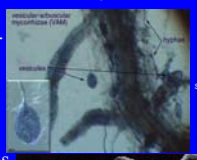
- Soil foodweb stores nutrients in living & dead organic matter
- Nutrients are released in root zone as organisms eat and excrete "waste" (nitrogen, etc.)
- Mycorrhizal fungi bring nutrients and water to roots of plants

Dr. Michael P. Amaranthus, Mycorrhizal Applications Inc.

How does soil life provide plant disease protection?

Diversity ⇒ predation, parasitization & competition with the few disease-causing organisms

- Bacteria cover leaf surfaces, block infection
- Ecto- and endo-mycorrhizae prevent root infection
- Many organisms prey on the few disease-causing organisms



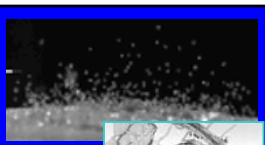
Soil Foodweb Inc.

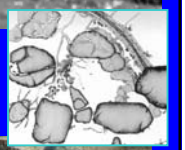
SSSA

How does soil life filter out urban pollutants?

- Creates structure
- Breaks down hydrocarbons, pesticides
- Converts fertilizers to stable forms, so they are available to plants but won't wash away
- Binds heavy metals in soil, so they don't wash into streams

How does soil life control erosion?

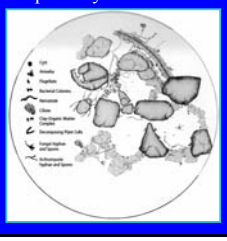




- Creates pore spaces, increases infiltration
- Sticks soil particles & aggregates together with bacterial slime, fungal hyphae, & root hairs (bigger aggregates are harder to move)
  → "aggregate stability"
- Promotes rapid plant growth & deep root development

How does soil life provide stormwater detention / infiltration?

- Builds soil structure, moisture-holding capacity
- Increases surface porosity



UW trials, turf on glacial till soil

Compost-amended till soil – up to 50% reduction in storm water runoff

How can we enhance & restore soil biodiversity, to improve plant growth, water quality, and reduce runoff?

- Prevent /reduce compaction (keep heavy machinery off)
- Reduce intensive use of pesticides & soluble fertilizers
- Incorporate compost into soil to feed soil life

organic matter + soil organisms + time
creates ⇒
soil structure, biofiltration, fertility, & stormwater detention

Soil Amendment: A cost-effective solution for new development

- Much better plant survival = fewer callbacks

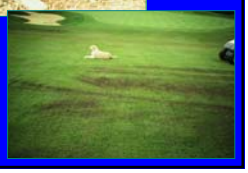
- Easier planting

- Can cut irrigation needs by 50% = 3-7 year payback on irrigation savings alone

Improving soil function in existing development

- Amend soil when re-landscaping
- Plant native trees & shrubs, especially near waterways

- Mulch beds annually with leaves, chips, compost, etc.
- Topdress turf areas with compost (aerate, topdress, rake in)



Summary of Soil Best Management Practices

New Construction

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  - Minimize construction footprint
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- Restore disturbed soils by tilling 2-4" of compost into upper 8-12" of soil. Rip to loosen compacted layers.

Existing Landscapes

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WA State Guidance on soil & LID BMPs: DOE *Stormwater Mgmt. Manual for Western WA*

- Equivalency required for Phase 1 NPDES permittees
- Volume V, Chapter 5 - "On-Site Stormwater Mgmt."
  - Downspout, sheet, & concentrated flow dispersion
  - **BMP T5.13 Post-Construction Soil Quality and Depth**
  - Other Site Design BMP's including preserving vegetation, cisterns, roofs, rain gardens, porous paving, soil compaction protection, & T5.35 "Engineered Soil/Landscape Systems"
- Volume III, Chapter 3 - "Flow Control Design"
  - Downspout infiltration and dispersion
- Flow model credits for runoff dispersion into amended soils

www.ecy.wa.gov/programs/wq/stormwater/manual.html

DOE BMP T5.13
Post-Construction Soil Quality and Depth

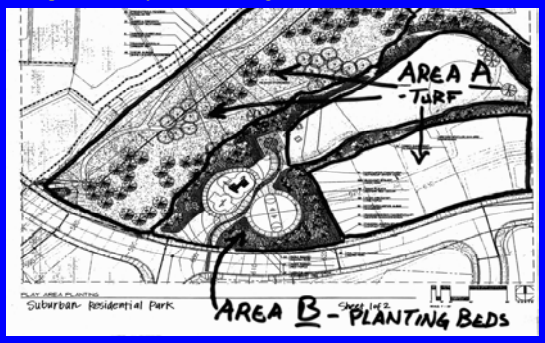
- Retain native soil and duff wherever possible
- All areas cleared and graded require 8 inch soil depth:
  - Soil organic matter content ≥ 10% dry weight by loss on combustion method (now ≥ 5% for turf areas)
    - 10% O.M. results from roughly 30% compost by volume added to low-organic subsoil).
    - May use native topsoil, incorporate organic amendments into existing soil, or bring in topsoil blend to meet spec
  - pH 6-8, or original pH
  - Subsoil scarified 4 inches below 8-inch topsoil layer
  - Protected from compaction after amendment
  - Mulched after planting, & maintained by leaving organic debris

Guidelines Manual for Implementing BMP T5.13

- Manual developed regionally in consultation with experts
- Proposed 10% O.M. for landscape beds, but 5% for turf
- Develop a "Soil Management Plan" for each site
- Four options for soil management in different areas of site:
  1) Leave native soil & vegetation undisturbed, protect from compaction
  2) Amend existing soil in place (with compost or other organic)
  3) Stockpile site topsoils prior to grading for reapplication
  4) Import topsoil meeting organic matter content standards
- Choose pre-approved or custom calculated amendment rates
- Simple field inspection and verification procedures
- Includes model specs written in CSI and APWA formats
- Available at: **www.soilsforsalmon.org**

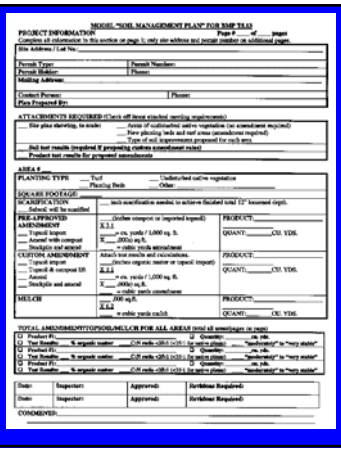
Develop a "Soil Management Plan"

step 1: Identify areas needing different soil treatments



Soil Management Plan

step 2:
Compute amendment or amended topsoil and mulch needed for each area



Clearing up the confusion about "% organic"

"% Soil Organic Matter Content" (S.O.M.) in lab soil tests is by loss-on-combustion method

- Most composts are 40-60% organic content by this method

Recommended soil amendment rates (for low-organic soils):

- 5% Soil Organic Matter Content for Turf
  - produced by 15-20% compost amendment by volume
- 10% Soil Organic Matter Content for Landscape Beds
  - produced by 25-35% compost amendment by volume

How to Select Compost

Know your supplier!

- Field tests:
  - earthy smell - not sour, stinky, or ammonia
  - brown to black color
  - uniform particle range
  - stable temperature (does not get very hot if re-wetted)
  - moisture content
- Standards & Specs
  - US Compost Council "Seal of Testing Assurance" (STA)
  - State & DOT specs
- Mfr.-supplied info:
  - Meets state std. or USCC STA
  - C:N ratio
  - Weed-seed trials
  - Nutrients, salinity, contaminants
  - Size: "screen", % fines
- Soil/compost lab test info:
  - Nutrients
  - Salinity
  - pH
  - % organic content (OM)

Selecting composts and application rates

- Salinity basis: salinity of finished soil/compost mix should not exceed 4.0 dS/m
  - animal manure's & biosolids (sludge) have higher salinity
  - yard waste (plant) compost typically lower salinity
- Nutrient basis: 10-15% of N in compost released in first year, more over long term
  - Soil lab can test soil & compost separately, or as final mix
  - Mfr.'s info may include "available nutrients"
  - Compost provides nutrients needed for first year growth
- Particle size: mostly 1/2" minus, few fines (< 500 micron)
  - excess fines can plug soil
  - coarser composts (> 3/4-1") are better for erosion control
  - coarser, woodier composts are better for native plantings

Carbon to Nitrogen ratio of composts

- For turf & most landscapes
  C:N ratio of 20:1 to 25:1 - good nutrient availability for first year of growth (no other fertilizer needed)
- For native plants and trees
  C:N ratio of 30:1 to 35:1, and coarser (1" minus screen)
  - less Nitrogen better for NW natives, discourages weeds
  - for streamside, unlikely to leach nitrogen

Compost Application Methods

Four options for soil management in different areas of site:

- 1) Leave native soil & vegetation undisturbed, protect from compaction
- 2) Amend existing soil in place (with compost or other organic)
- 3) Stockpile site topsoils prior to grading for reapplication
- 4) Import topsoil meeting organic matter content standards

Compost application & incorporation methods:

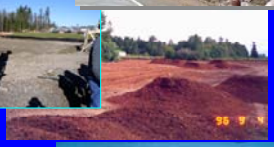
- Blowing
- Spreading
- Tilling / ripping
- Blending off-site



Blowing & spreading

- Blower trucks
- Various construction grading equipment
- Other equipment : golf course & farm spreaders





Incorporating amendments into soil

- Range of equipment for different-sized sites
- Till in to 8" depth
- If compacted, rip to 12" depth before/while amending



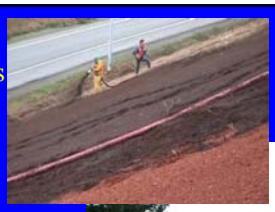

Stockpile site soils & amend, (or import amended topsoil) after road & foundation work

- Allows mass grading
- Can reduce hauling & disposal costs
- Set grade to allow re-addition of topsoil & allow for settling
- Amend to spec offsite
- Spread after concrete work
- Rip in first lift, to reduce sub-grade compaction

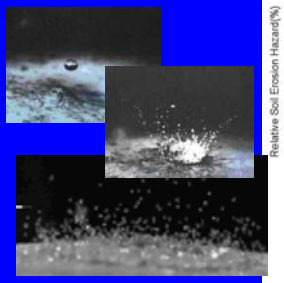


Erosion Control Compost Applications for the Northwest

- Blankets
- Berms
- "Socks" (tubes)



How Erosion Starts…



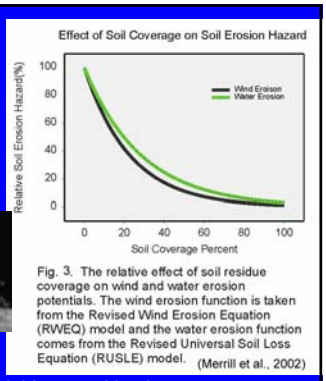


Fig. 3. The relative effect of soil residue coverage on wind and water erosion potentials. The wind erosion function is taken from the Revised Wind Erosion Equation (RWEQ) model and the water erosion function comes from the Revised Universal Soil Loss Equation (RUSLE) model. (Merrill et al., 2002)

and Stops!

Compost particles are much bigger and harder to move than most soil particles, and much stickier

Combine methods as needed for best water quality and flow control

WsDOT - Protecting Wetland Area from I-5 Runoff

Selling soil BMP's to builders, landscape contractors, & homeowners:

Value to builder/contractor

- Less plant loss = fewer callbacks
- Making money on materials and labor
- Quicker planting in prepped soil
- Easier maintenance
- Better appearance sells next job

Sell quality & savings to customer

- Better plant survival/ health/ growth/ appearance
- Lower water bills
- Lower maintenance costs
- Reduced chemical needs
- Better for salmon because:
  - reduced storm runoff
  - improved water quality

Links to useful soil specs:

Guidelines Manual for Implementing WDOE Soil Quality & Depth BMP (includes APWA & CSI specs)
www.soilsforsalmon.org

Puget Sound Action Team, LID Technical Manual
www.psat.wa.gov/Programs/LID.htm

WsDOT "Soil Bioengineering" specs
http://www.wsdot.wa.gov/eesc/design/roadside/sb.htm

Seattle "Natural Drainage Systems" specs
www.seattle.gov/util/NaturalSystems

Texas DOT specs
http://www.dot.state.tx.us/DES/landscape/compost/topsoil.htm

Low Impact Development Center
http://www.lowimpactdevelopment.org/

USING MULCHES

After planting and for annual maintenance

BENEFITS:

Mulches limit weed growth, and make weeds that sprout easier to pull or cultivate.

Mulches conserve water, moderate soil temperature, and reduce erosion.

Mulches replenish soil organic matter, enhancing soil biodiversity, structure, and nutrient cycling = increased plant vigor.

Mulching

WHEN After planting, and once every year or two:
- Spring on trees and shrubs to prevent weeds.
- Early summer on gardens to hold moisture, stop weeds, and feed plants. (Let soil warm up.)
- Fall on beds to prevent erosion and winter weeds.

WHERE Whole beds, paths, 3 ft. or larger ring around trees & shrubs in lawns.

HOW Remove weeds & grass before spreading mulch. Keep mulch away from plant stems. Use weed barriers like newspaper or cardboard to control aggressive weeds.

Mulching

WHAT

Woody mulches (wood chips, bark) for woody plants (trees & shrubs).

Non woody mulches (compost, leaves grass clippings, composted manure or biosolids) for non-woody plants (annuals, perennials, berries, roses).

HOW MUCH

Compost, leaves, sawdust, fine bark, grass clippings: 1-2" deep.

Wood chips or coarse bark: 2-4" deep.

Putting Organic Amendments to Work:
- Restoring soil functions
- Protecting watersheds

Redmond Ridge, Quadrant Corp.

- Large, master-planned development
- Forest left undisturbed where possible - no compaction
- Cleared vegetation & duff stockpiled for use as soil amendment
- Removed topsoils stockpiled
- All soils amended to 12" depth with organics
- **Early Problems:** Too much organic esp. for turf areas, organic materials not composted (landclearing & duff) - soft soil, excessive water retention, low N, plant/turf problems as result

Redmond Ridge: current method

- Grade site 12 in. below finish
- Install foundation, along with driveway & walkway rock pads
- Spread 14 in. amended soil mix, (will settle to 12 inches) rip in first lift to mix with subsoil
- Soils blended offsite from native duff plus compost
- Soil organic matter controlled to ~10%, pH and C:N ratio for optimal plant growth

Putting organics to work - SEA Streets

Street Edge Alternative onsite detention demo, Seattle Public Utilities and SDOT.

- Compost in wet and dry zones
- **98% reduction in runoff.**

www.seattle.gov/util/NaturalSystems/

Broadview Green Grid, Seattle

Compost-amended soil in bio-retention swales

Broadview -

Erosion control with compost blankets, berms, and socks

WsDOT projects around Washington

Erosion control and plant establishment on steep site using compost blankets

Chelan

Photos courtesy of Sandy Salisbury, WSDOT

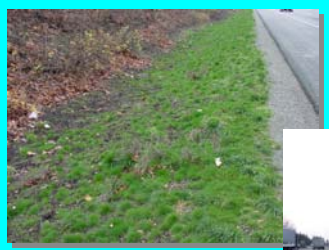
WsDOT: Erosion control, water quality, successful landscapes with lower mtce. costs

SR 14, Vancouver
Coarse compost, blown in
Note erosion where not applied

Compost amendment, ripped in

Extensive soil bio-engineering info at:
http://www.wsdot.wa.gov/eesc/design/roadside/sb.htm

WsDOT: Compost Amended Vegetated Filter Strip - 2004 pollutant & flow reduction trials along I-5



These slides courtesy of:
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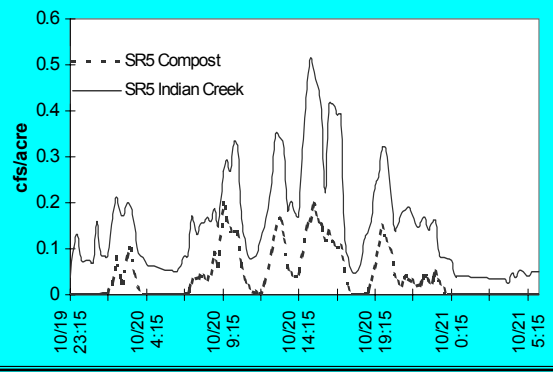

10 ft wide compost strip treats stormwater from 2 lanes of roadway

Parameter	Untreated Runoff	Compost filter strip treated	% Concentration Reduction	% Load Reduction
	mg/l			
TDS	52.7	55.5	-5	63
T. Phosphorus	0.089	0.26	-192	-2
COD	73.5	49.6	33	76
TSS	81	23	72	90
	ug/l			
Total Copper	28.18	9.14	68	89
Dissolved Copper	7.85	5.77	26	74
Total Lead	12.62	3.54	72	90
Dissolved Lead	0.5	0.05	90	97
Total Zinc	129.70	31.57	76	91
Dissolved Zinc	64.22	20.71	68	89

TDS=Total Dissolved Solids, COD=Chemical Oxygen Demand, TSS=Total Suspended Solids

Compost

No Compost

I-5 Marvin Rd. Interchange

A natural solution - for healthier streams, and healthier landscapes

- Conserve existing soils and vegetation where possible.
- Restore natural functions in disturbed soils by reducing compaction and using organic amendments.

more information:
Washington Organic Recycling Council at www.SoilsforSalmon.org