

Diving Deeper Into GI

Details and Care of GI Practices

2014 Southeast NY Stormwater Conference

October 15, 2014

John Dunkle, PE, CPESC, CMS4S

GI Practices

- Green Space
- Riparian Buffers/Grass Filter Strips
- Tree Planting/Preservation
- Rooftop Disconnect
- Porous /Permeable Pavement
- Green Roofs
- Swales
- Bioretention/rain gardens/planters
- Infiltration
- Rain barrels/cisterns

The GI Common Threads:

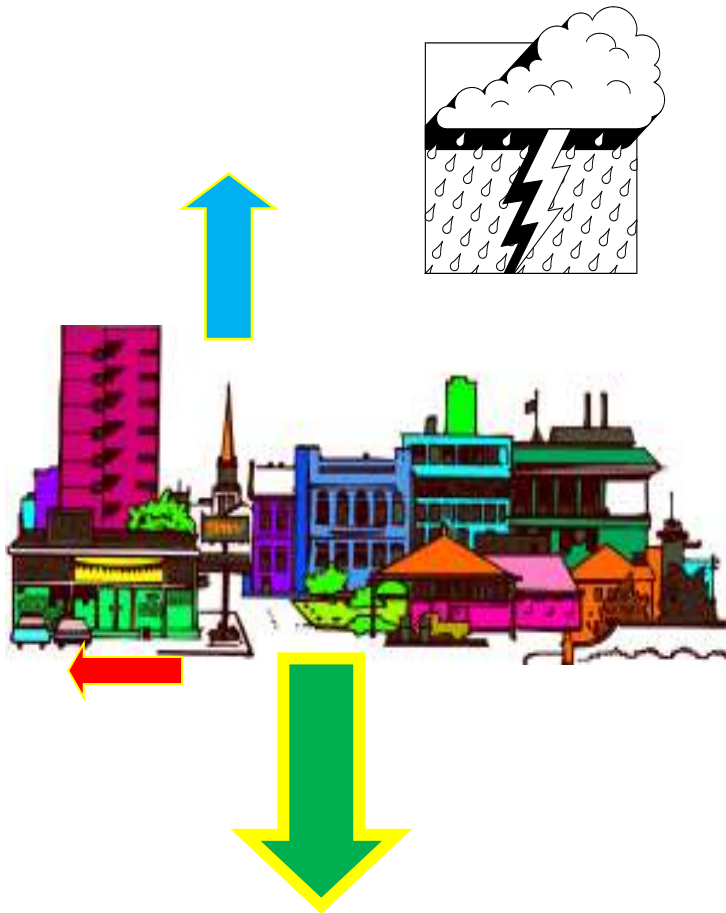


All GI Practices

Provide

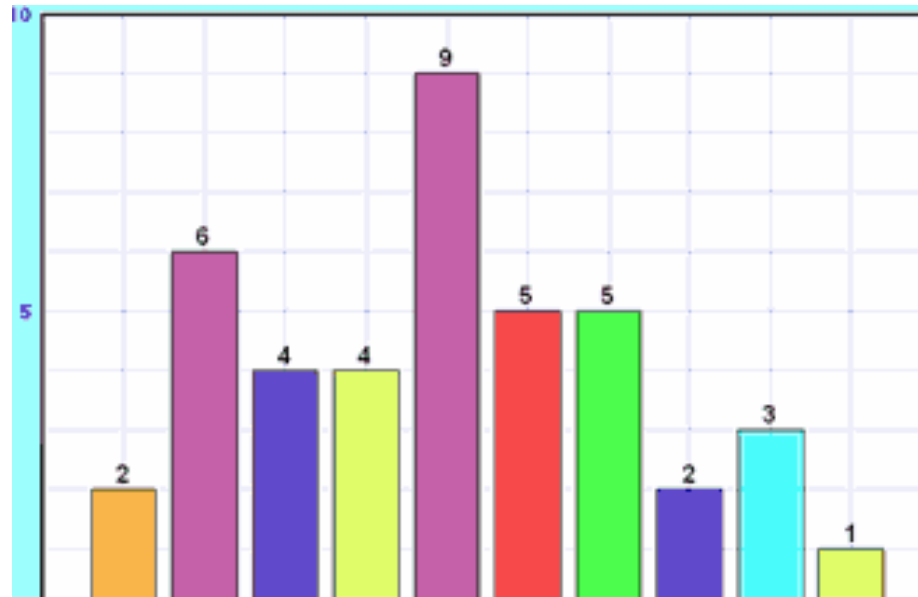
Runoff Reduction

Runoff Reduction Pathways



- Evaporation
- Evapotranspiration
- Absorption
- Infiltration
- Reuse

GI Treatment Practices
have variable
Runoff Reduction rates.



The GI Common Threads:



All GI Practices

Provide

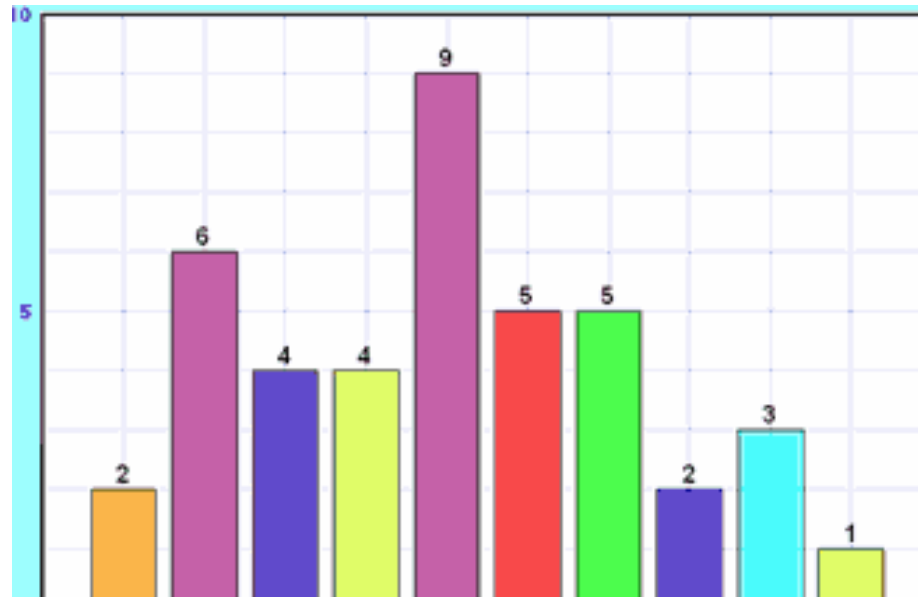
Pollutant Removal

Pollutant Removal Pathways

- Storage
- Evaporation
- Nutrient uptake
- UV treatment
- Settling
- Biology
- Infiltration
- Dilution
- Soil Stabilization



GI Treatment Practices provide variable pollutant removal.



The GI Common Threads:



GI Practices

Provide

Climate Change Resilience



The GI Common Threads:



All GI Practices

Need

Storage Volume

Storage – Above Ground



Storage – Underground Pipe Chambers



Storage – Infiltration Chambers



Storage - Tanks



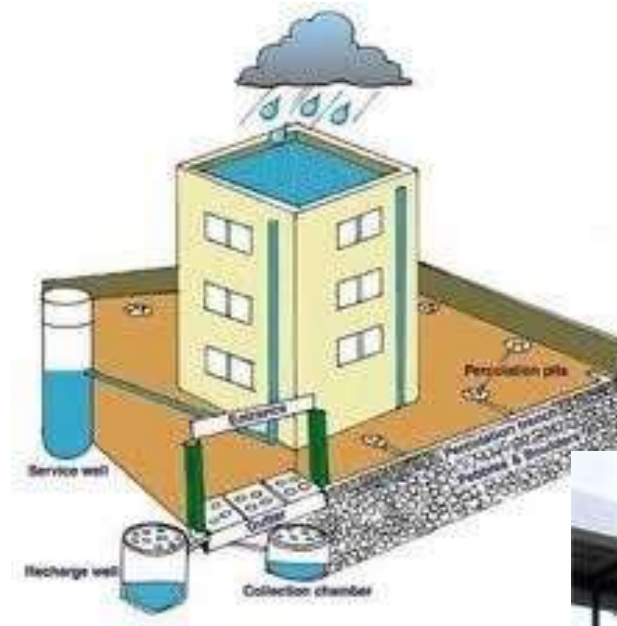
Vaults



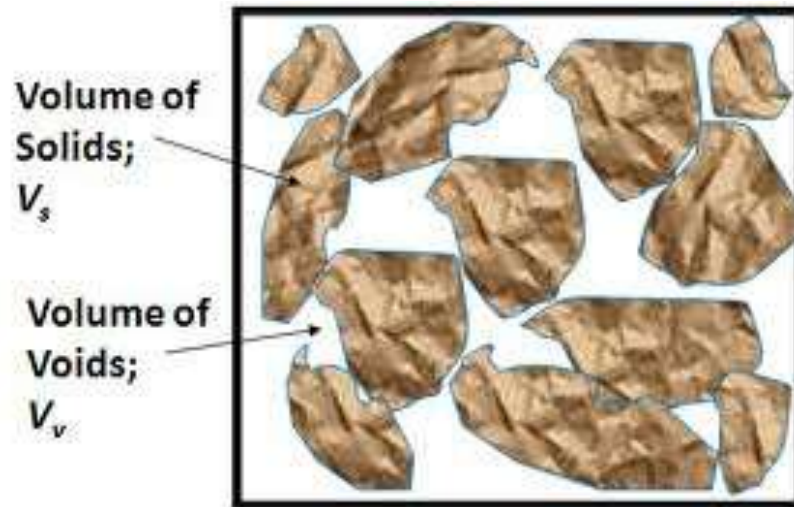
Vaults/Tunnels



Blue Roofs/Cisterns



Storage Volume in soils



Storage - Soils



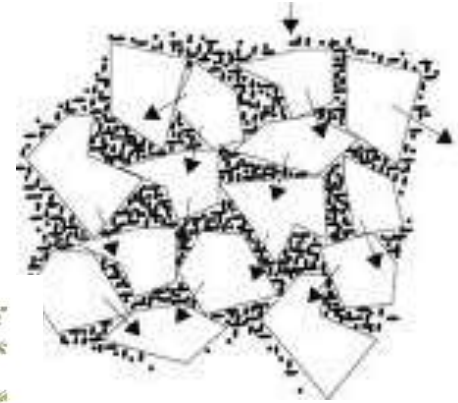
20 % Voids

Storage – Stone(uniformly graded)



40% Voids

Storage - Structural Soils



26% Voids



Using CU-Structural Soil™ in the Urban Environment



Cornell University

Urban Horticulture Institute
Cornell University
Department of Horticulture
134A Plant Science Building
Ithaca, NY 14853
www.hort.cornell.edu/UHI

The GI Common Threads:



Most GI Practices

Need

Permeability

Got Permeability?



NOPE.



Infiltration

YUP



Be Careful



GI Practices Utilizing Infiltration

- Infiltration Basin
- Infiltration Trench
- Dry Well
- Bio-retention
- Rain garden
- Permeable/porous pavement
- Planter
- Dry Swale
- Vegetated swale
- Tree planting
- Buffers/filter strips
- Green Space

Minimum infiltration rate for
infiltration based practices:

1/2" per hour

@ 2' below the design bottom

Must be established through testing.



The GI Common Threads:



Most GI Practices

Need

Green

GI Green



?



The GI Common Threads:



All GI Practices

Need

Care

Some Typical GI Stormwater Maintenance Issues:

Excess Sedimentation



Clogging at Inlets & Outlets



Erosion: Inlets, slopes, Practice surface



Vegetation



Little vegetation, no diversity



Too much vegetation, no diversity

Vegetation:

The Wrong Kind



Problems with Pretreatment

- Sedimentation & Loss of Settling Volume/Retention Time
- Contamination



Structural Integrity



Loss of Permeability

- Compaction
- Sedimentation
- Organic Degradation



Other Maintenance Problems



Typical GI Maintenance Tasks

- Mowing
- Sediment removal
 - (excavation, vacuuming, raking sweeping, washing)
- Pruning
- Weeding
- Planting
- Fertilizing
- Re-grading
- Soil restoration
- Structural Repairs




Onondaga County, New York Save the Rain Program Green Infrastructure Maintenance Training



Prepared for
Onondaga County, New York

savetherain.us

Prepared by
 CH2M-HILL


March 9, 2012

The logo for "Save the Rain" features a green horizontal bar on the left. To its right, the words "Save the Rain" are written in a blue, sans-serif font. Above the word "Rain", there is a graphic of three blue raindrops falling onto a green leaf.

Save the Rain

GI Practice Design and Care Details



- 
- No nutrients
 - No organics
 - No permeability

Soil Restoration

Restore Compacted Soils



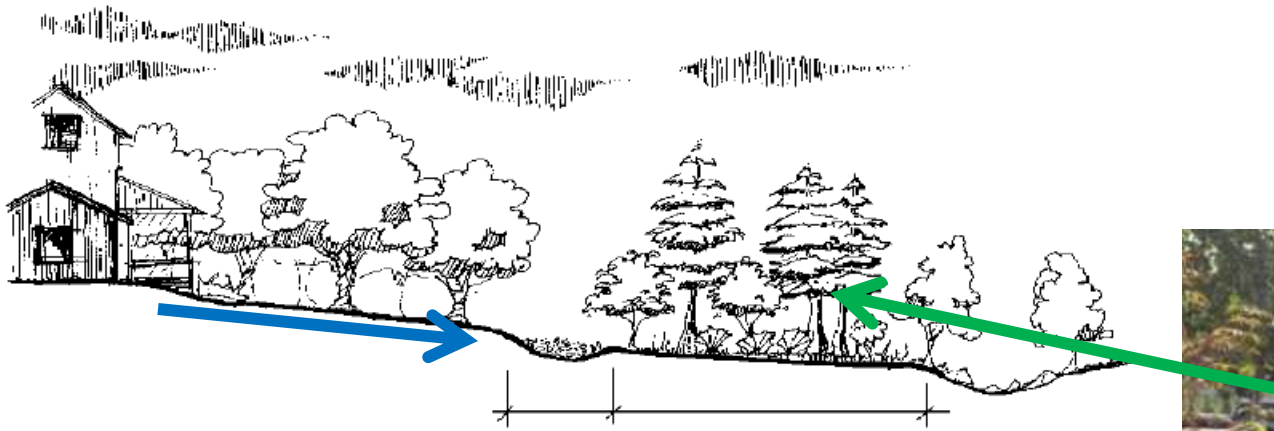
How and when to restore Soil:



p 5-22

Table 5.3 Soil Restoration Requirements		
Type of Soil Disturbance	Soil Restoration Requirement	
No soil disturbance	Restoration not permitted	
Minimal soil disturbance	Restoration not required	
Areas where topsoil is stripped only - no change in grade	HSG A & B	HSG C & D
	apply 6 inches of topsoil	Aerate* and apply 6 inches of topsoil
Areas of cut or fill	HSG A & B	HSG C & D
	Aerate and apply 6 inches of topsoil	Apply full Soil Restoration **
Heavy traffic areas on site (especially in a zone 5-25 feet around buildings but not within a 5 foot perimeter around foundation walls)	Apply full Soil Restoration (de-compaction and compost enhancement)	
Areas where Runoff Reduction and/or Infiltration practices are applied	Restoration not required, but may be applied to enhance the reduction specified for appropriate practices.	Keep construction equipment from crossing these areas. To protect newly installed practice from any ongoing construction activities construct a single phase operation fence area
Redevelopment projects	Soil Restoration is required on redevelopment projects in areas where existing impervious area will be converted to pervious area.	

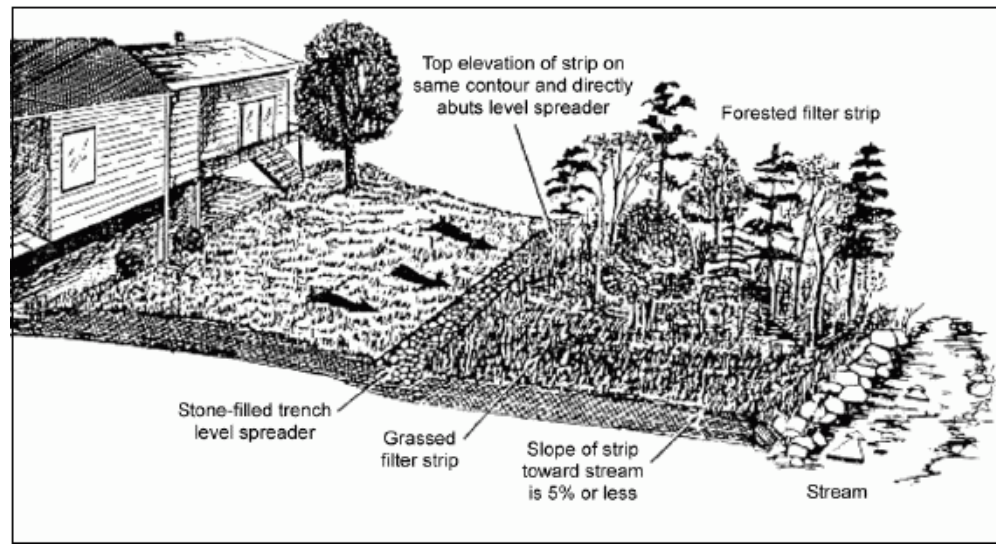
Green Space/Buffers/Filter Strips



Green Space/Buffers/Filter Strips

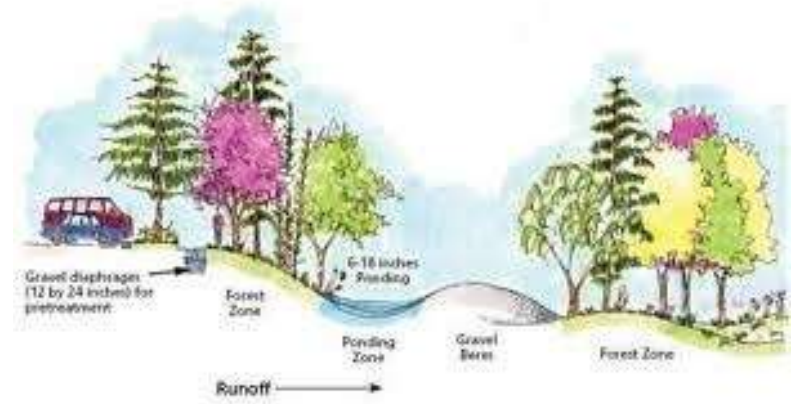
Some Critical Elements

- Pavement Removal
- Flow dissipation
- Vegetation
- Contributing length
- Width
- Soils
- Slope
- Protection



Maintenance of Green Space/Buffers/Filter Strips

- Delineation
- Protection
- Enforcement
- Maintain Health and Diversity
- Debris removal



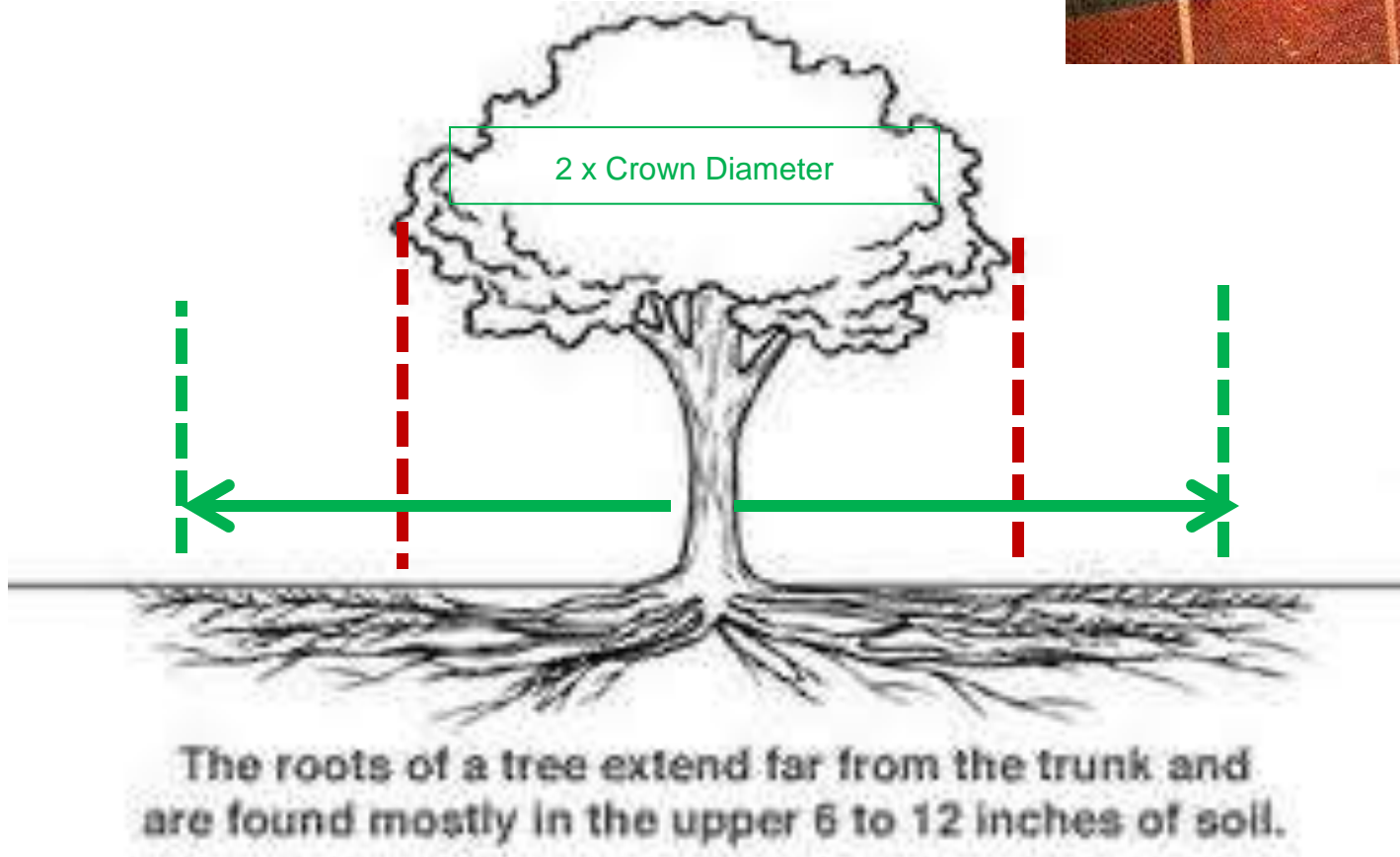
Tree Preservation/Planting

Some Critical Elements

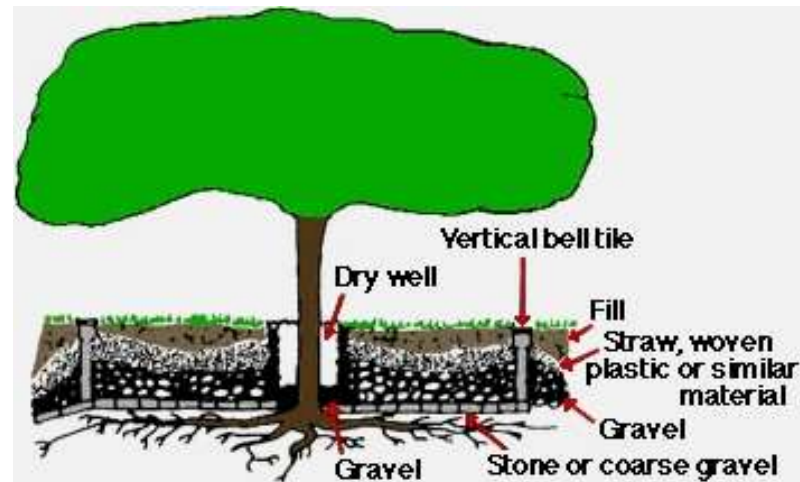
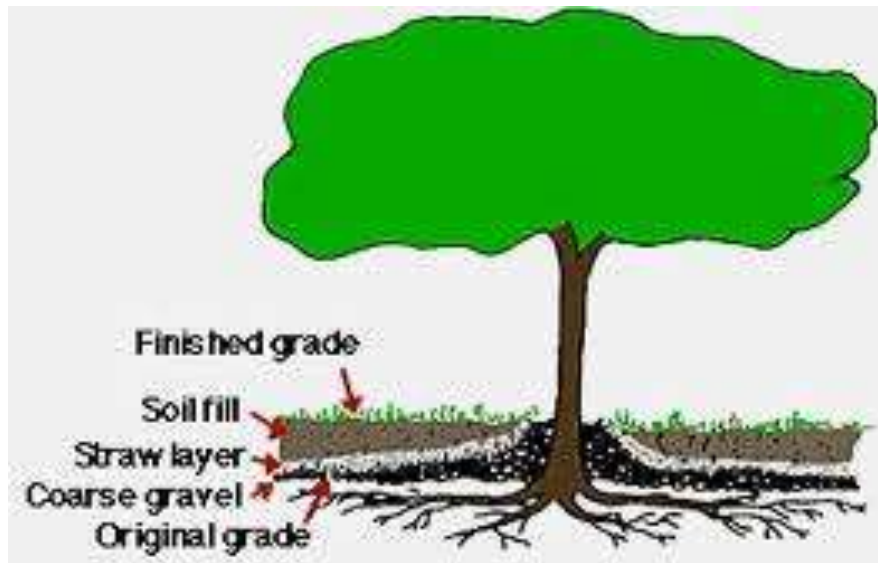
- Tree species
- Size/age
- Contributing DA
- Soil media (new plantings)



Protecting Trees



Protection of Trees



Trees

Tree Planting

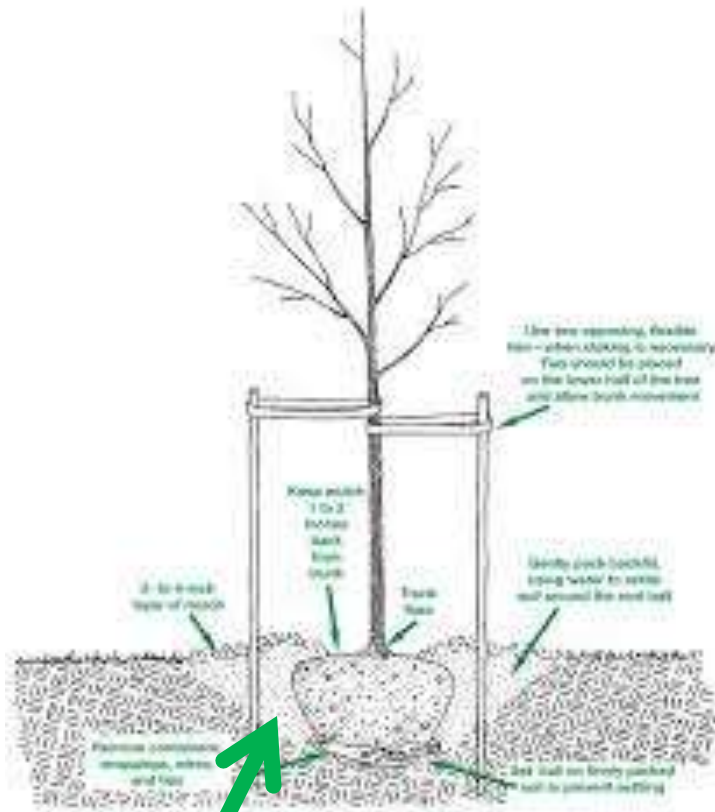
Nope



YUP



Tree Planting



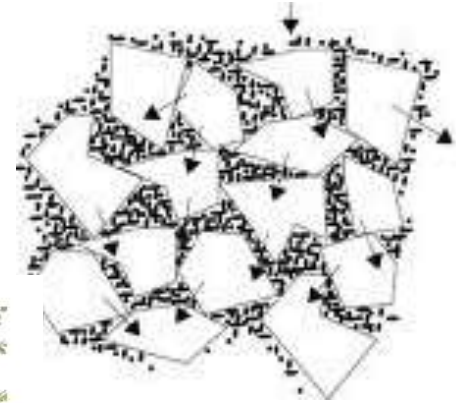
2 c.f. / sf. of crown projection

Planting Soil

- PH range 5.2 to 7.00
- Organic matter 1.5 to 4.0%
- Magnesium 35 lbs. per acre, minimum
- Phosphorus (P_2O_5) 75 lbs. per acre, minimum
- Potassium (K_2O) 85 lbs. per acre, minimum
- Soluble salts 500 ppm
- Clay 10 to 25%
- Silt 30 to 55%
- Sand 35 to 60%



Planting Soil using Structural Soils



26% Voids



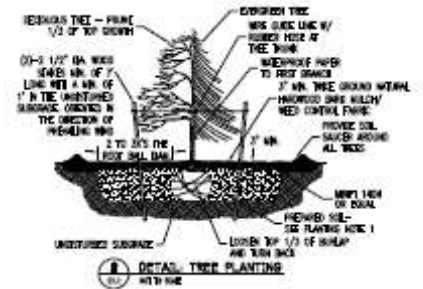
Using CU-Structural Soil™ in the Urban Environment



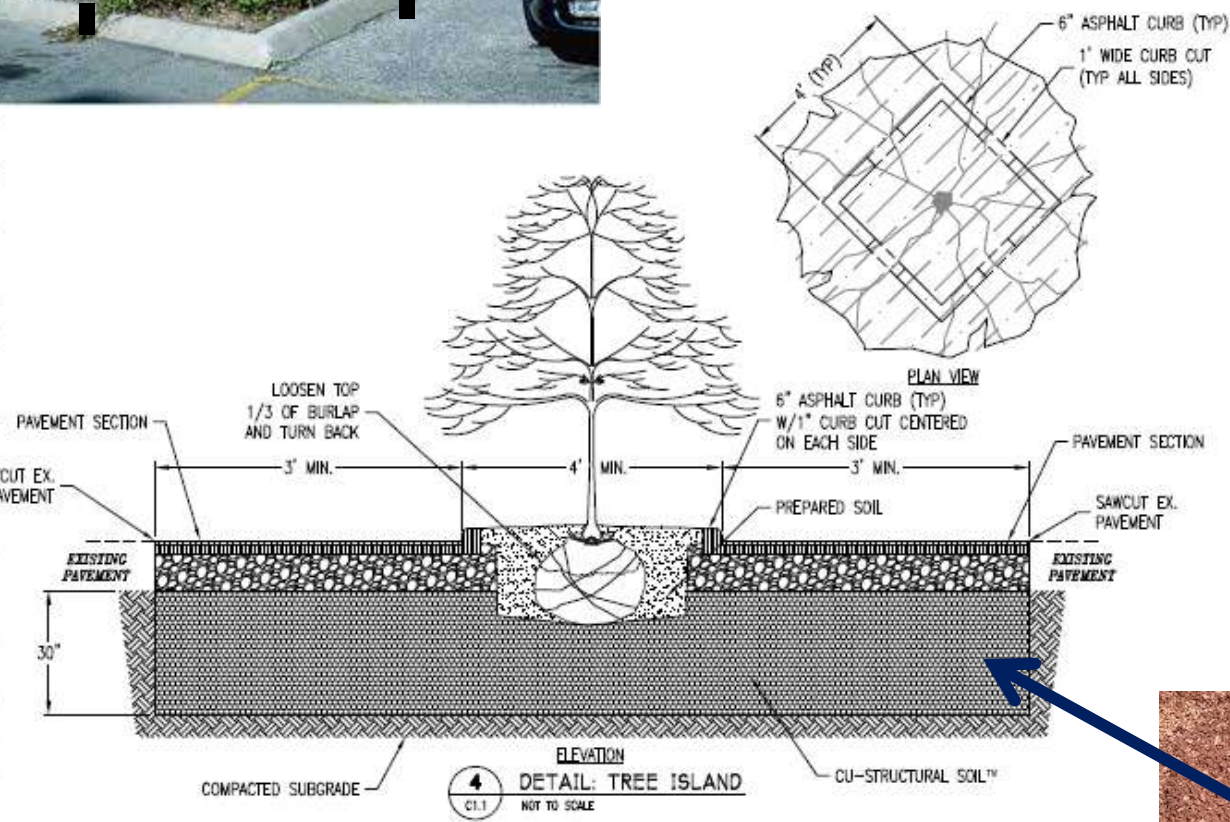
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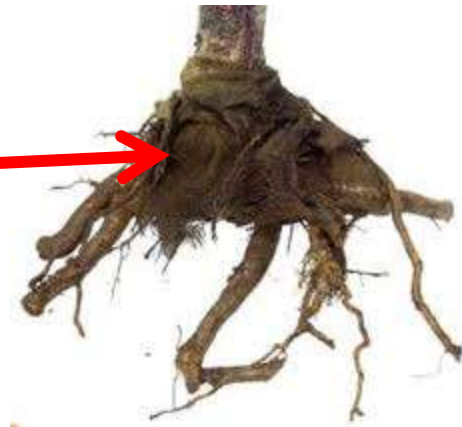
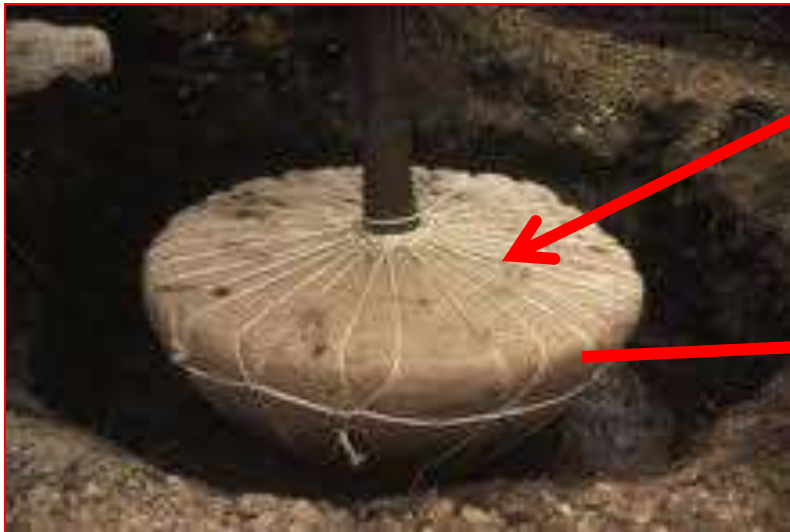
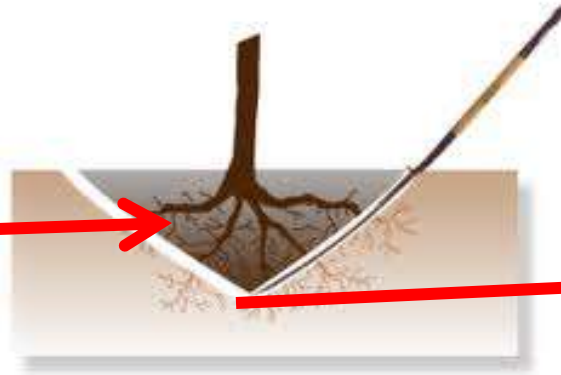
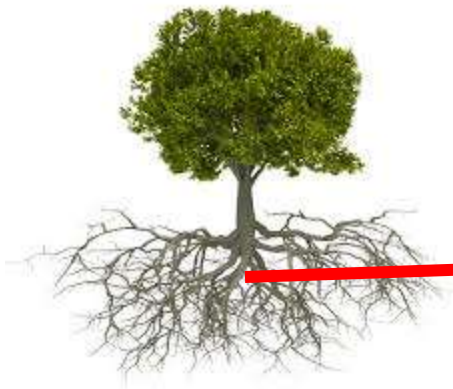
Tree Planting



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B&B



Bare Root and Container

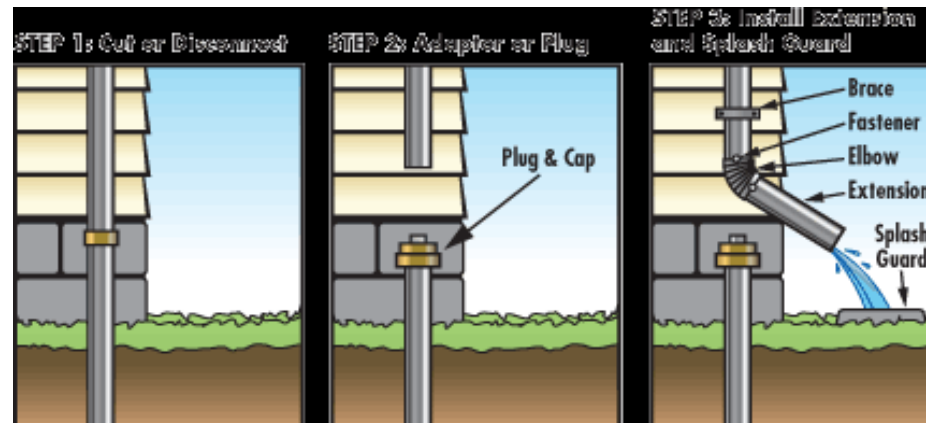


Maintenance of Tree Planting/Preservation

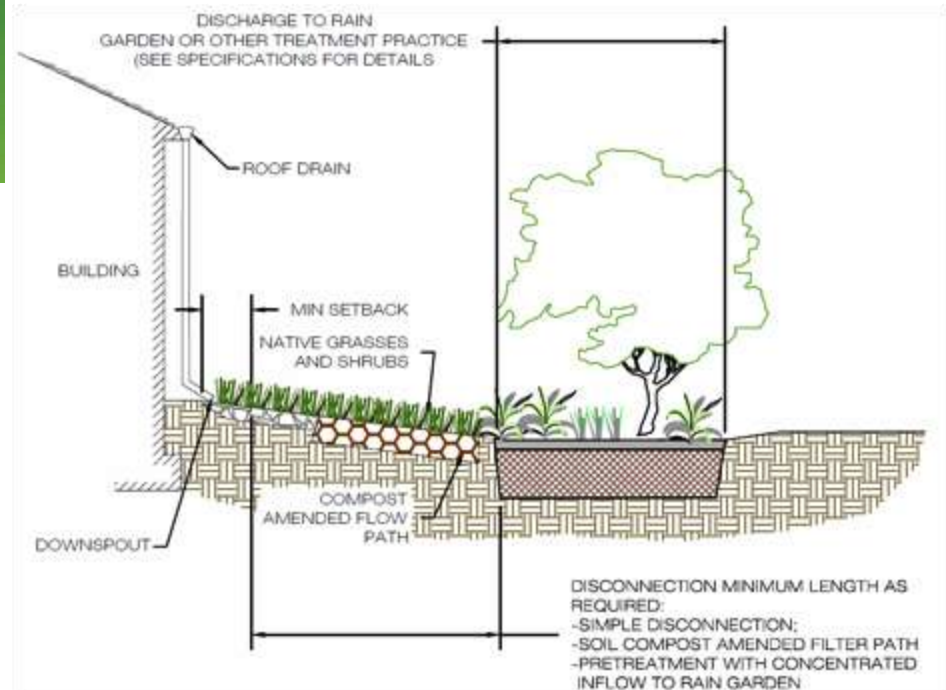
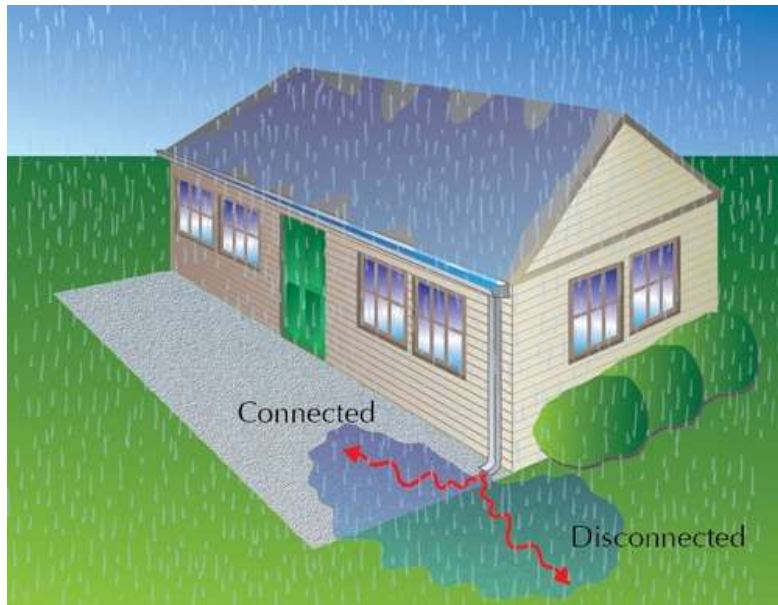
- Mulching/fertilizing
- Watering
- Pruning
- Protection
- Remediation of natural and human damage



Disconnect Rooftop Areas



Rooftop Disconnection



Rooftop Disconnection

Some Critical Elements

- Flow Dissipation
- Contributing surface area
- Flow distance
- Soils



Disconnect

Yes, or No?



Disconnect

Nope.



Disconnect

Yup.



Maintenance of Rooftop Disconnection

- Delineation
- Protection
- Enforcement
- Maintain Health
- Repair downspout erosion



Porous/Permeable Pavement



A porous pavement parking lot (Source: Invisible Structures, no date)



Porous /Permeable Pavement

Some Critical Elements

- Porosity
- Underlying soils
- Sub base
- Contributing DA
- Cross Section
- Climate
- Use



Porous/Permeable Pavement Materials



P. Pavement



Cross Sections

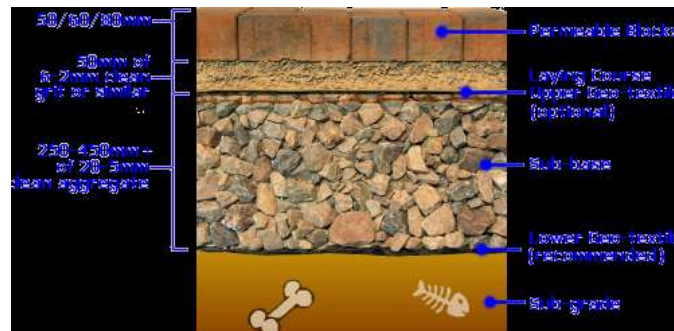
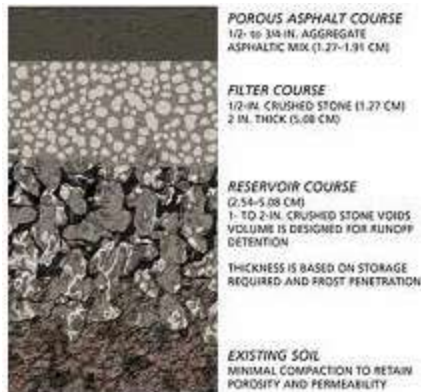
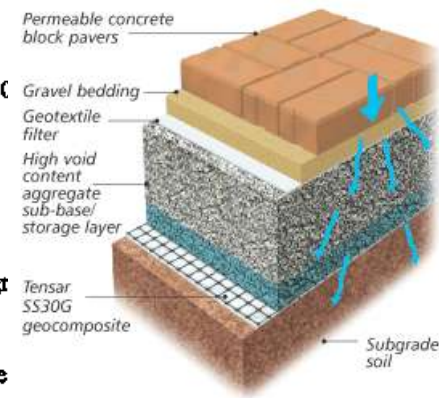
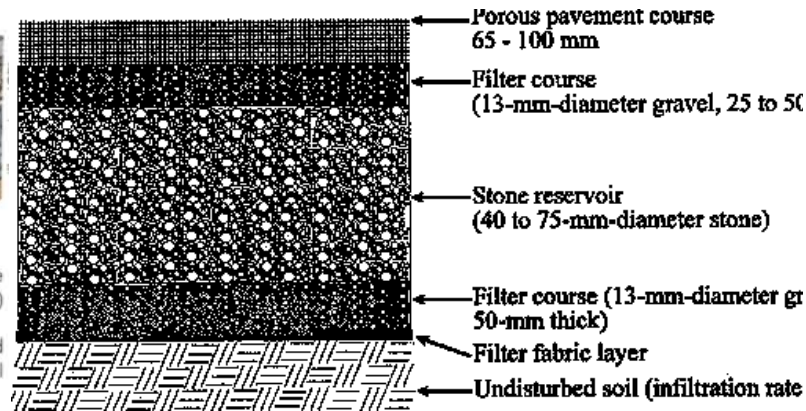
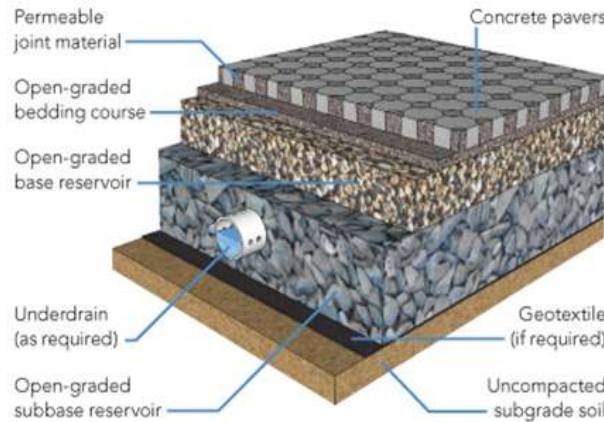


Figure 2. Walden Lot Cross-Section



NYDOT No. 3A or ASTM No. 2 Stone



Maybe a Filter, too



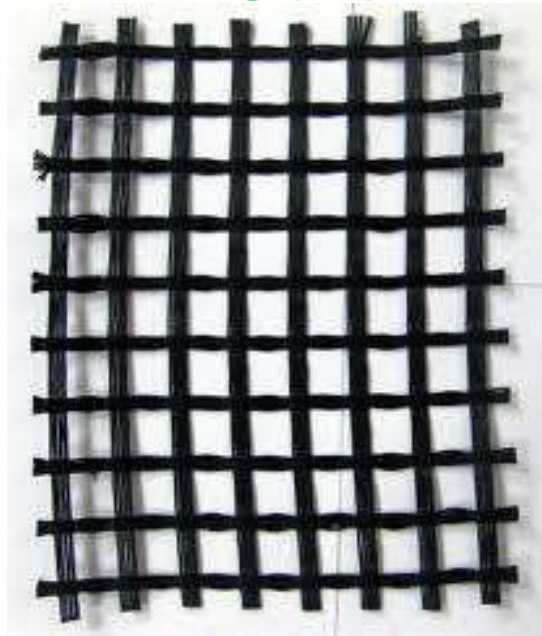
P. Pavement



?



Sure.



No, or Yes, and Where?



Not much Treatment gonna
happen here:



Articulated/Precast Porous Pavers



NYDOT

- Top Course Porous Asphalt
 - 475.5003
 - 475.5013
 - 475.5103
- Binder Course Porous Asphalt
 - 475.7009
 - 475.7019



Beach Road, Lake George



Cost Comparisons

Pavement	Cost per sq.ft. material (surface material only)
Standard Asphalt	\$2.40 to \$4.25
Porous Asphalt	\$2.75 to \$5.00 (\$9.50 for excavation, subgrade materials and labor)
Porous Concrete (8-in)	\$5.50 to \$9.00
Grass / gravel pavers	\$5.75 to \$7.25
Permeable Pavers	\$5.00 to \$12.00

- Costs for conventional paving do not incorporate SW mgmt costs (i.e reinforced concrete pipes, catch basins, outfalls)
 - \$9.50 and \$11.50 per square foot.



Permeable Pavers in the right situation



Permeable Pavers in the wrong situation

Source: Bill Hunt, NCSU

Movement of Sediment



Maintenance of Porous and Permeable Pavement

- Check voids
- Removal of Debris and sediment
- Vacuuming
- Power washing
- Sweeping
- Ability to De-water
- Repairs of deterioration, spalling, displacement
- Maintaining adjacent areas of run-on
- Restore paver block aggregate



Winter Maintenance of Porous and Permeable Pavement

- Raise plow blade for pavers
- No road abrasives
- Reduced salt use
- No snow piles on PP



Green Roofs



Green Roofs

Some Critical Elements

- Roof design
- Climate
- Irrigation
- Access
- Soil media
- Cross section
- Drainage
- Vegetation



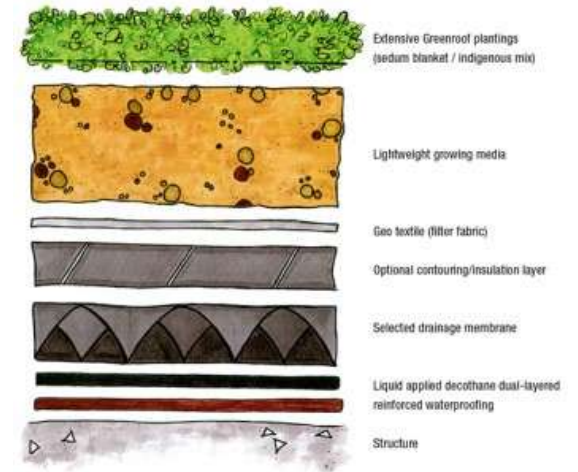
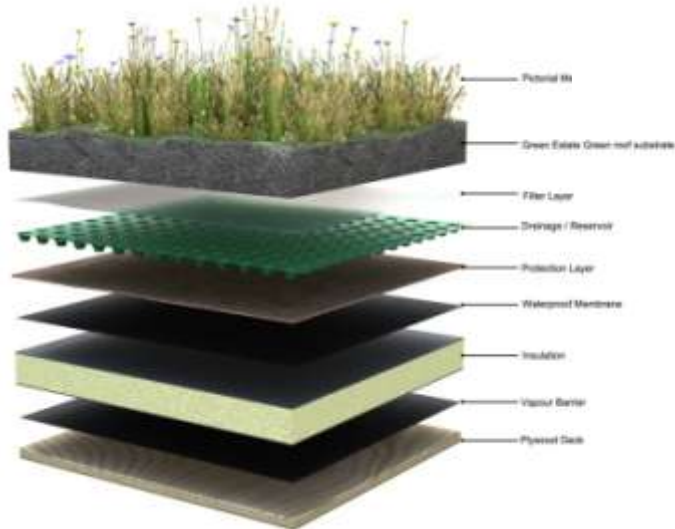
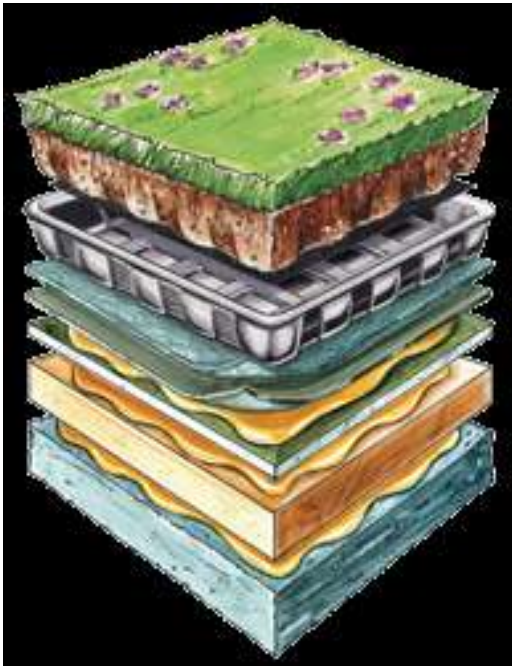
Green Roof

Extensive



Intensive

Cross Section



Green Roof

Plant materials



Soil Media



Green Roof



Modular Systems



Green Roots



Green Roofs



Maintenance of Green Roofs

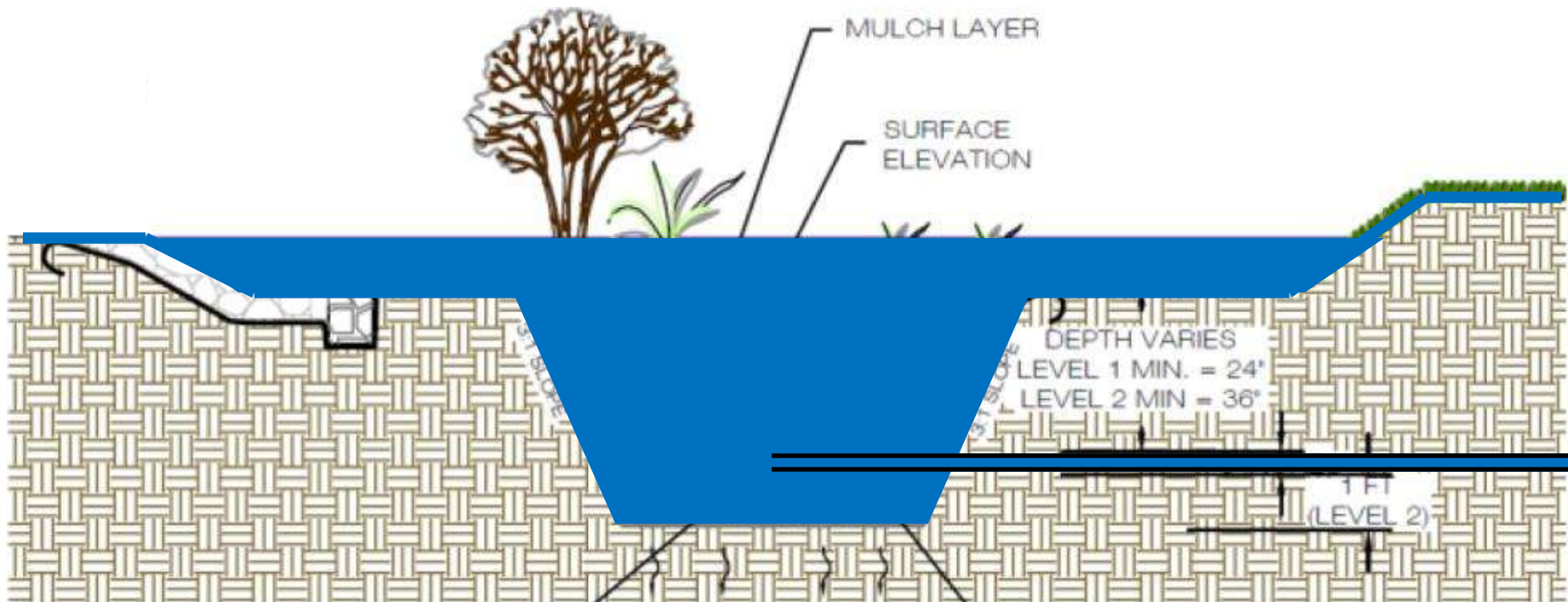
- Irrigation
- Weeding
- Fertilizing
- Drainage maintenance
- Plant replacement
- Membrane integrity



Bioretention , Rain Gardens, Tree Trenches, Planters



Bio-retention: How it Works



Runoff flows into a bioretention facility and temporarily ponds. Water then slowly filters through the filter bed and either is collected by the underdrain and sent to the storm sewer system or infiltrates into the surrounding area.

Bioretention Areas



Planters



Tree Trench



Rain Gardens/Bio-retention/Planters/Tree Trenches

Some Critical Elements

- Inflow dissipation
- Flow bypass
- Soil media
- Surface area
- Ponding depth
- Geometry
- Vegetation
- Native soils
- Location
- Pre-treatment
- Drainage Area



No, or Yes, and Where?

Bio-Rain



Bio/Rain

Soil Mixture



New york state criteria: bioretention media



- **Parameter Value**
- PH range 5.2 to 7.00
- Organic matter 1.5 to 4.0%
- Magnesium 35 lbs. per acre, minimum
- Phosphorus (P_2O_5) 75 lbs. per acre, minimum
- Potassium (K_2O) 85 lbs. per acre, minimum
- Soluble salts 500 ppm
- Clay 10 to 25%
- Silt 30 to 55%
- Sand 35 to 60%

- Appendix H.



New Recommendations for Media Recipe*



- Recipe for sand, soil and compost mix
 - 85% to 88% sand;
 - 8% to 12% soil fines; and
 - 3% to 5% organic matter.
 - More organic where trees are planted
 - Soil P Index less than 30

* CWP et al....Differs from the NYSDEC Stormwater Design Manual



Nope



Pretreatment



Grass Filter Strip



Grass Channel



Forebay



Stone Flow Spreader



Stone/Rip Rap Apron



Mulch

'Bio-Typologies'

Typology: "The taxonomic classification of characteristics common to buildings or spaces ..."



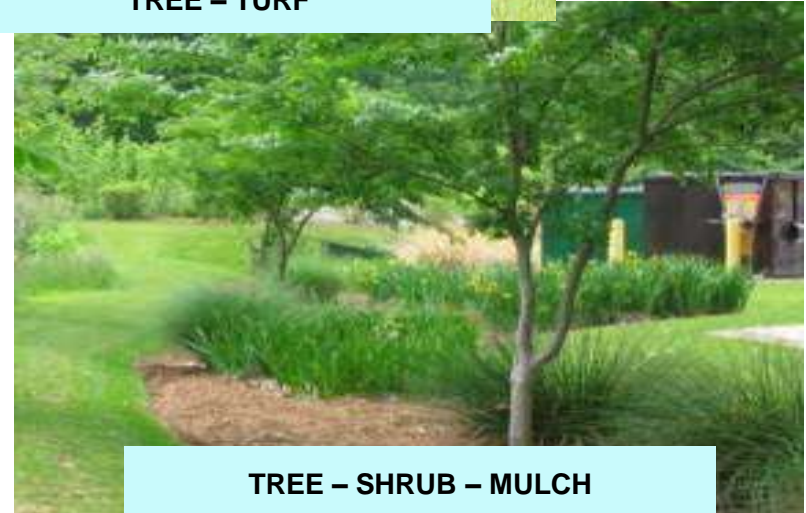
PERENNIAL GARDEN



TREE – TURF



PERENNIAL - SHRUB



TREE – SHRUB – MULCH

Other Types of Surface Cover



Stone/cobble



Stepping stones for pedestrian flow



Concrete cells -- herbaceous

No



NO



The LA Touch

Aesthetics of Bioretention



Aesthetics of Bioretention



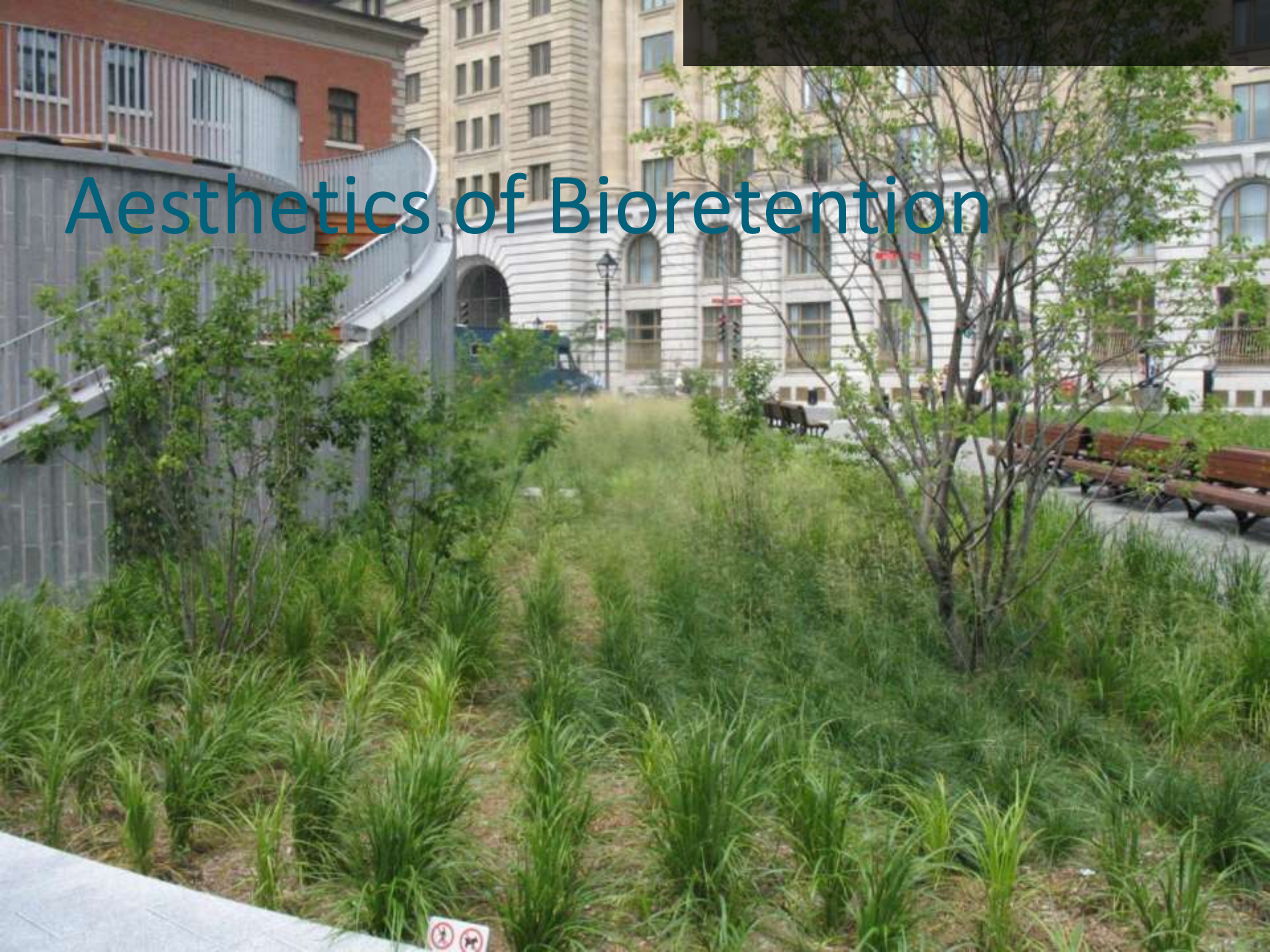
Aesthetics of Bioretention



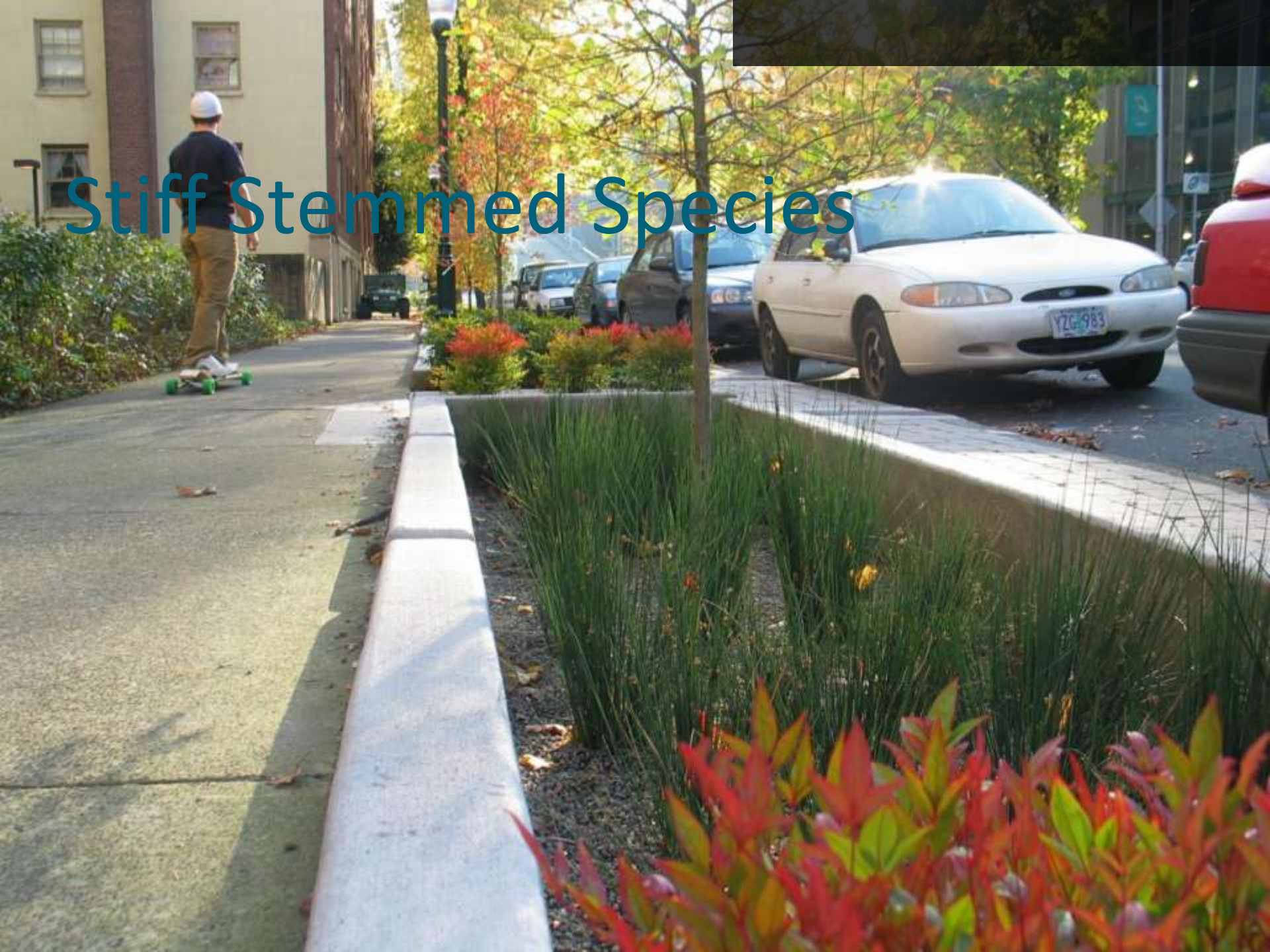
Aesthetics of Bioretention



Aesthetics of Bioretention



Stiff Stemmed Species





Succession and Break- in Periods









Aesthetics



Infancy to Maturity



Maintenance of Rain Garden/Biofilter/Tree Trench/Planters



- Occasional replacement of plants, mulching, weeding and thinning
- Watering essential the first year
- Keep plants pruned if they start to get “leggy” and floppy
- Cut off old flower heads after a plant is done blooming
- Keep free of bare areas except where stepping stones are located
- Inspect for sediment accumulations
- Replace top few inches of soil when water ponds for more than 48 hours
- Check for damage/failure of any wall, dam or berm and repair
- Correct any settlement or low spots
- Inspect and clean
- Debris and trash removal on a weekly or monthly basis
- Pruning and replacing dead or dying vegetation, plant thinning, and erosion repair

Rain barrels/Cisterns



Rain barrels/Cisterns

Some Critical Elements

- Volume
- Climate
- Use
- Overflow



Barrels

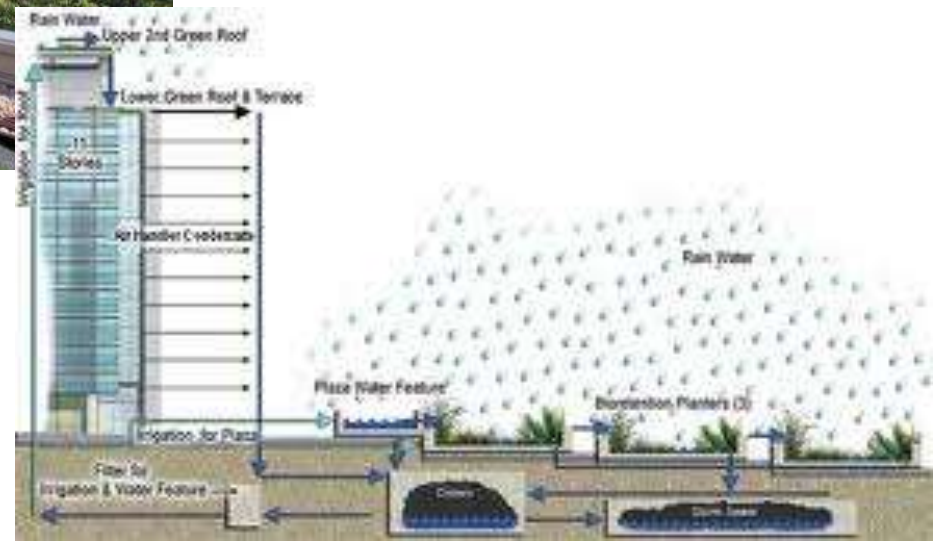
USE IT !



Rain Barrel/Planter



Cisterns and Green Roofs



Crime Lab in Monroe County
CISTERN, RAIN GARDEN,
POROUS PAVEMENT



**1,500 Gallon
Cistern**

**Collects Roof Water
for Toilets and
Mop Sinks**



Finished Garden



Civic Center Parking Garage

GREEN ROOF, CISTERN



Sod and Sedum



2 x 10,000
Gallon Cisterns

War Memorial Cistern Reuse System



Reusing rainwater appears to allow the ice making to occur one to two degrees warmer than using potable water resulting in energy savings

THE POST-STANDARD

SUNDAY, JANUARY 6, 2013

syracuse.com

AN ECO SLAM-DUNK: FLUSHING WITH RAINWATER

ORANGE
GOES
GREEN BY
DIVERTING
SOME DOME
RUNOFF
TO TOILET
SYSTEM

By Rick Mearlarty
Staff writer

The sea of orange inside Syracuse University's Carrier Dome on game days may soon flow like never before.

The university last month received a \$1.35 million state grant to install a system to collect the rainwater that runs off the fabric roof of the Carrier Dome, the 49,262-seat arena where SU's basketball, football and other teams play.

Approximately 880,000 of the 6.6 million gallons of water that pours off the Dome's 7-acre roof each year will be captured by the system and stored in tanks hung from the bottom of the arena's upper bleachers. During events at the Dome, the water

will be used to flush the toilets and urinals in the building's 16 public restrooms. Building codes require the water to be dyed to avoid confusion with drinking water, even though the water will only be used in toilets and urinals. So university officials are considering coloring the water orange, the school's official color since 1890.

"We've been joking, wouldn't it be neat if we could color it orange?" said Eric Beattie, the university's director of campus planning, design and construction. "There's probably some room for discussion."

Blue, which SU uses as an unofficial accent color, is also a possibility, he said.

The university wants the public to notice the water harvesting system, and orange-colored water in the Dome's toilets and trough-style urinals would be hard to miss. Beattie said the project is intended as a demonstration of how such systems can conserve municipal water.

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FAST FACTS

Each of the four 5,000-gallon tanks that will hold rainwater captured from the Carrier Dome's roof will be about 8 feet in diameter and 10 feet long and weigh 42,000 pounds when full.



■ The tanks will hold enough water to flush the Dome's toilets and urinals during two major sporting events before they'll need more rainwater.



■ Enough rainwater and snowmelt runs off the Dome's 7-acre roof each year to fill 10 Olympic-size swimming pools.



■ The gutter that rings the bottom of the Dome's roof is wide enough to hold a car.



A 10-FOOT-WIDE GUTTER ringing the bottom of the Carrier Dome roof captures runoff and sends it into 36 drains that carry the water to the city's stormwater system. The water then goes to the county wastewater treatment plant and on to Onondaga Lake. Syracuse University plans to divert nearly 15 percent of the roof runoff and use it to flush Dome toilets and urinals.

Lucien Long / The Post-Standard, 2012

SYSTEM, PAGE A-8

Maintenance of Rain Barrels

- Maintenance requirements vary depending on the end use
- Winterization maintenance may be necessary
- Routine inspections to ensure the system is available for rain events
- Inspect roof catchments for particulate matter or other contaminants
- Inspect the gutters and downspouts for leaks or obstructions
- Inspect diverts, cleanout plugs, screens, covers, and overflow pipes
- Inspect inflow and outflow pipes
- Inspect connectors to adjacent storage containers or a water pump



Infiltration Practices



INFILTRATION

Some Critical Elements

- Soils
- Groundwater
- Pre-treatment
- Surface Area
- By - pass



Underground Infiltration



Infiltration Pre-treatment



Forebay

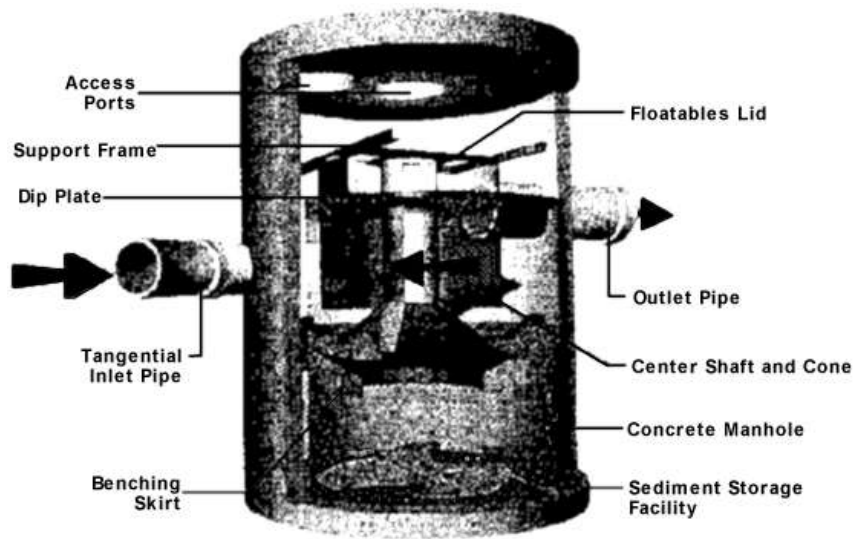


Infiltration Pre-treatment



STONE
TRENCH

Infiltration Pre-treatment



SETTLING CHAMBERS AND MECHANICAL SEPARATORS



No Infiltration Practices Here

(At least not without “enhanced” pretreatment)



How Not to Build an Infiltration Practice





Not Going to
Work!

08.14.2013

When Not to Build an Infiltration Practice



Maintenance of Infiltration Practices

- Inspect and clean pre-treatment
- Monitor water levels
- Remove debris from exposed infiltration surfaces
- Maintain flow pathways



Monitoring Ports for all Infiltration and Filtering Practices



Swales





Swales

Vegetated Swales



Vegetated Swale



Swales

Some Critical Elements

- Flow volume and rate
- Soils
- Vegetation
- Geometry
- Slope
- Length
- Design



Swales - Maintenance



Maintenance Requirements

- Fertilize and lime as needed to maintain dense vegetation.
- Mow as required during the growing season to maintain grass heights at 4 inches to 6 inches.
- Remove any sediment or debris buildup by hand if possible in the bottom of the channel when the depth reaches 2 inches.
- Inspect for pools of standing water. Regrade to restore design grade and revegetate.
- Repair rills in channel bottom with compacted topsoil, anchored with mesh or filter fabric. Seed and mulch.

Putting it all together

Infiltrating/Filtering Tree Trench w Permeable Pavement



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Buying In To It!

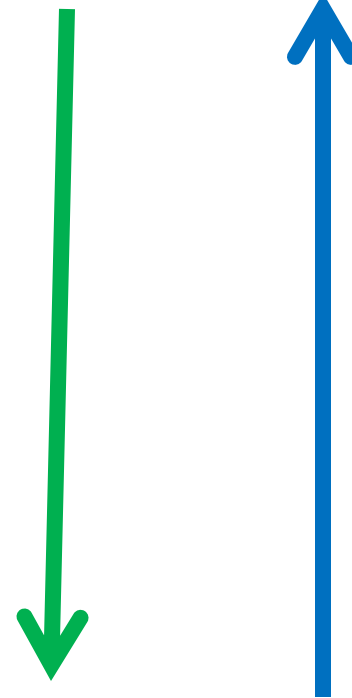


GI is essential and Important!



- Green Roof
- Perm./porous pave
- Rain Garden
- Planters
- Rain Barrel/Cistern
- Infiltration
- Swales
- Bioretention
- Trees
- Filter strip
- Disconnection

\$200/c.f. of treatment.



\$1/c.f. of treatment.

Typical GI unit costs:

- Rain garden - \$10/s.f.
- Bioretention - \$15/s.f.
- Underground infiltration - \$25/s.f.
- Green Roof - \$8/s.f.
- Porous Pavement - \$12/s.f.
- Tree planting - \$400 ea
- Tree trench/planter - \$25/s.f.
- Cistern - \$10/gal
- Drywell - \$10/gal
- Green space - \$5/s.f.



Making GI Last

Legal Agreements

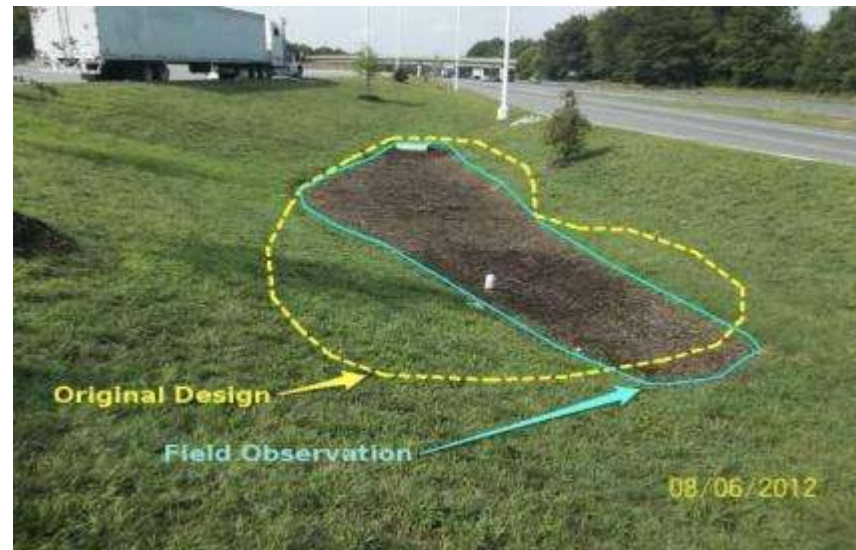
- Define responsibility
- Municipal Back-up
- Break in period
- Security Posting
- Annual reporting
- Enforcement/Monitoring
- Assessment District



As-Built Surveys

Confirm:

- Area
- Volume
- Hydraulics
- Plant materials



In Situ Confirmation of Permeability



Filter media and Underlying Soil

Qualified Maintainers



We All Have a Part





Contact Info:

John Dunkle PE, CPESC, CMS4S

jdunkle@dunnandsgromo.com

315 449 4940