



DOEE Stormwater BMP Construction and Inspection Training

Greg Hoffmann, P.E.
Center for Watershed Protection



Stormwater Overview:

Dirty Water is Bad.

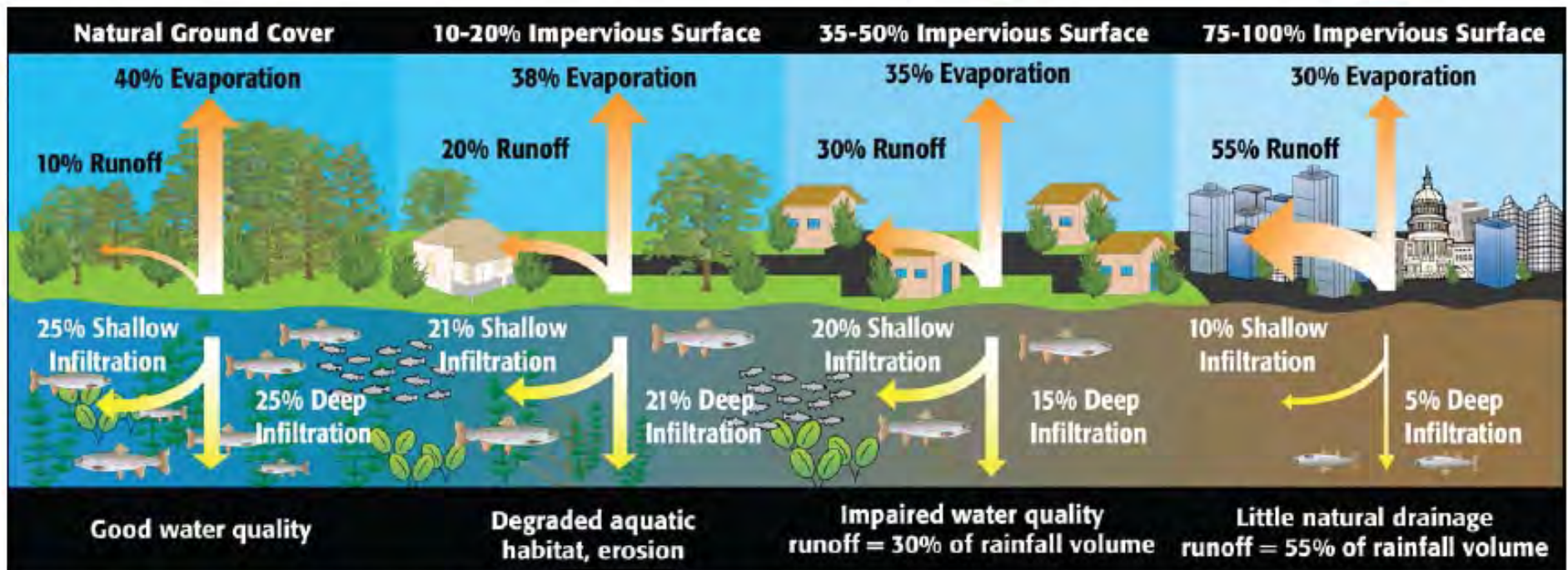
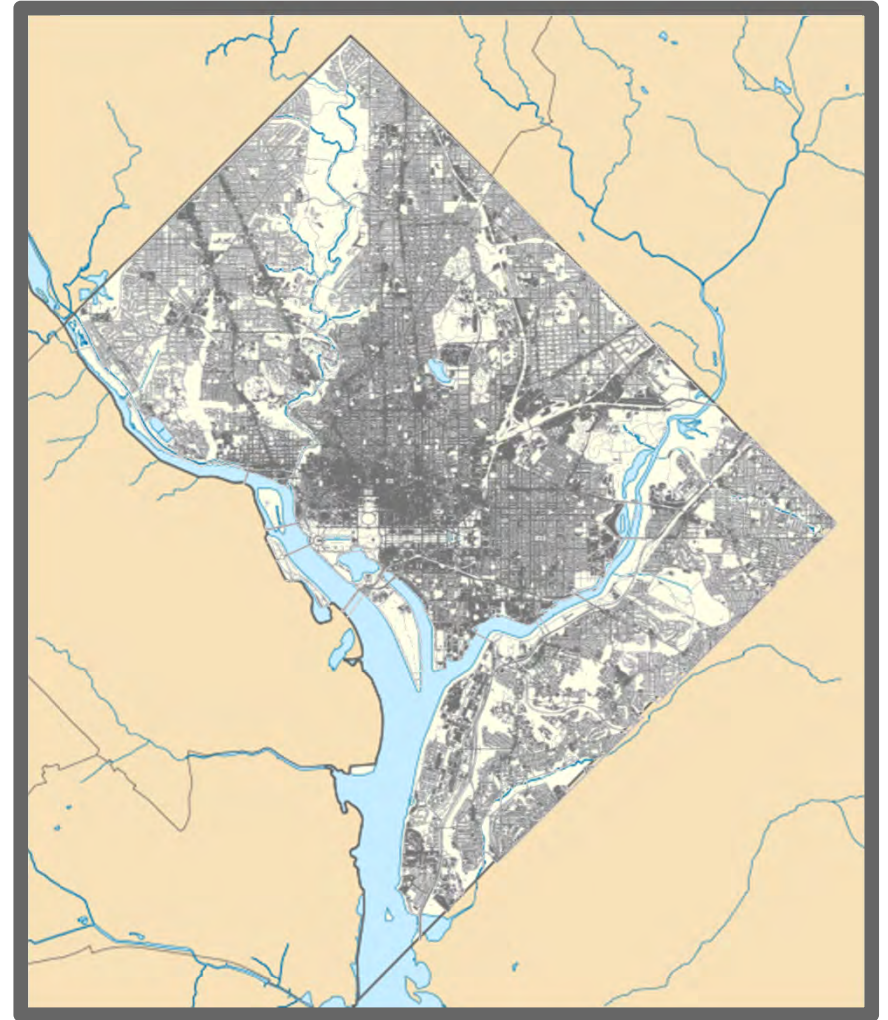


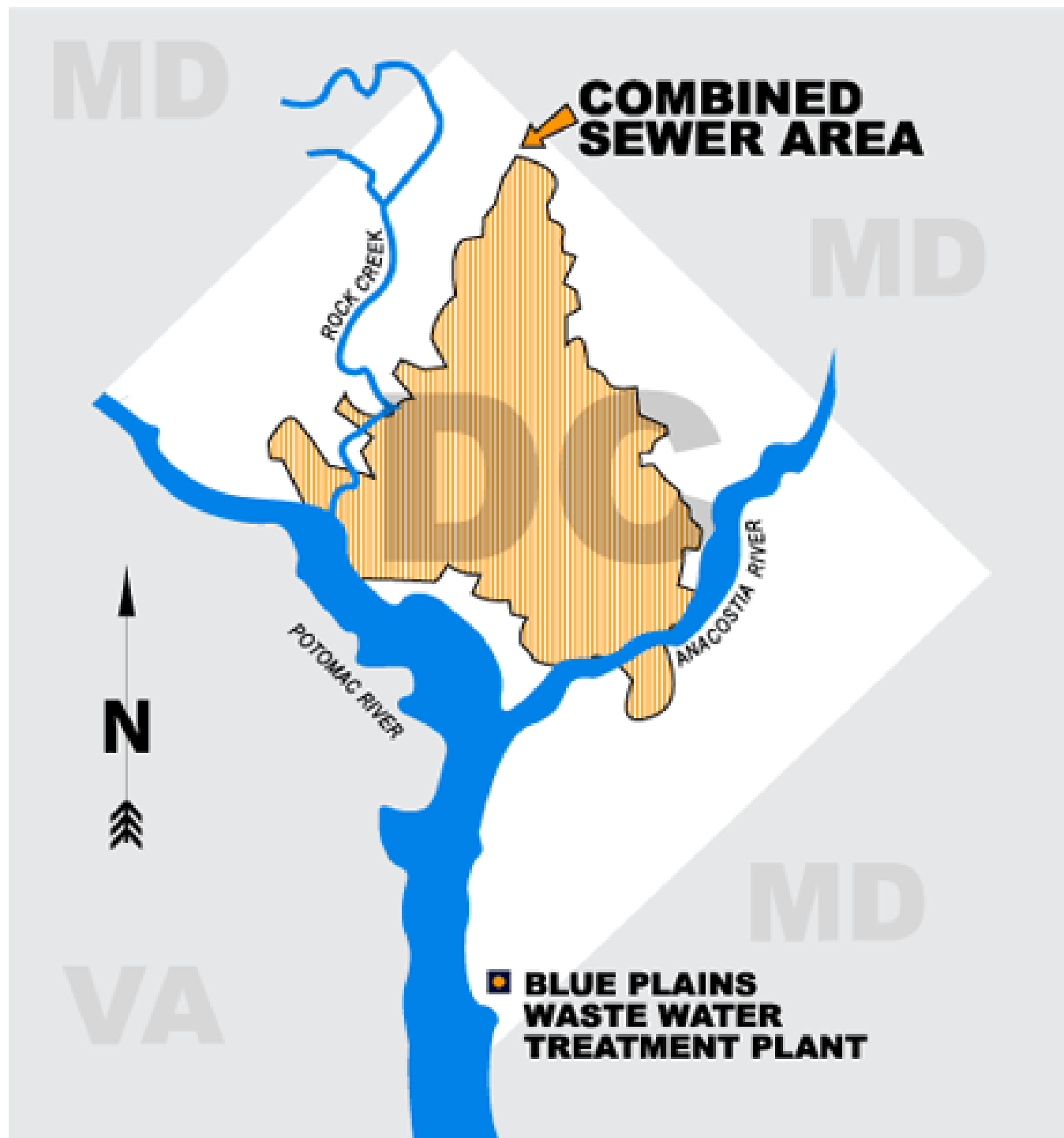
Figure 12.5. Virginia average annual water budget with urbanization.

Source: Potomac Conservancy 2008.

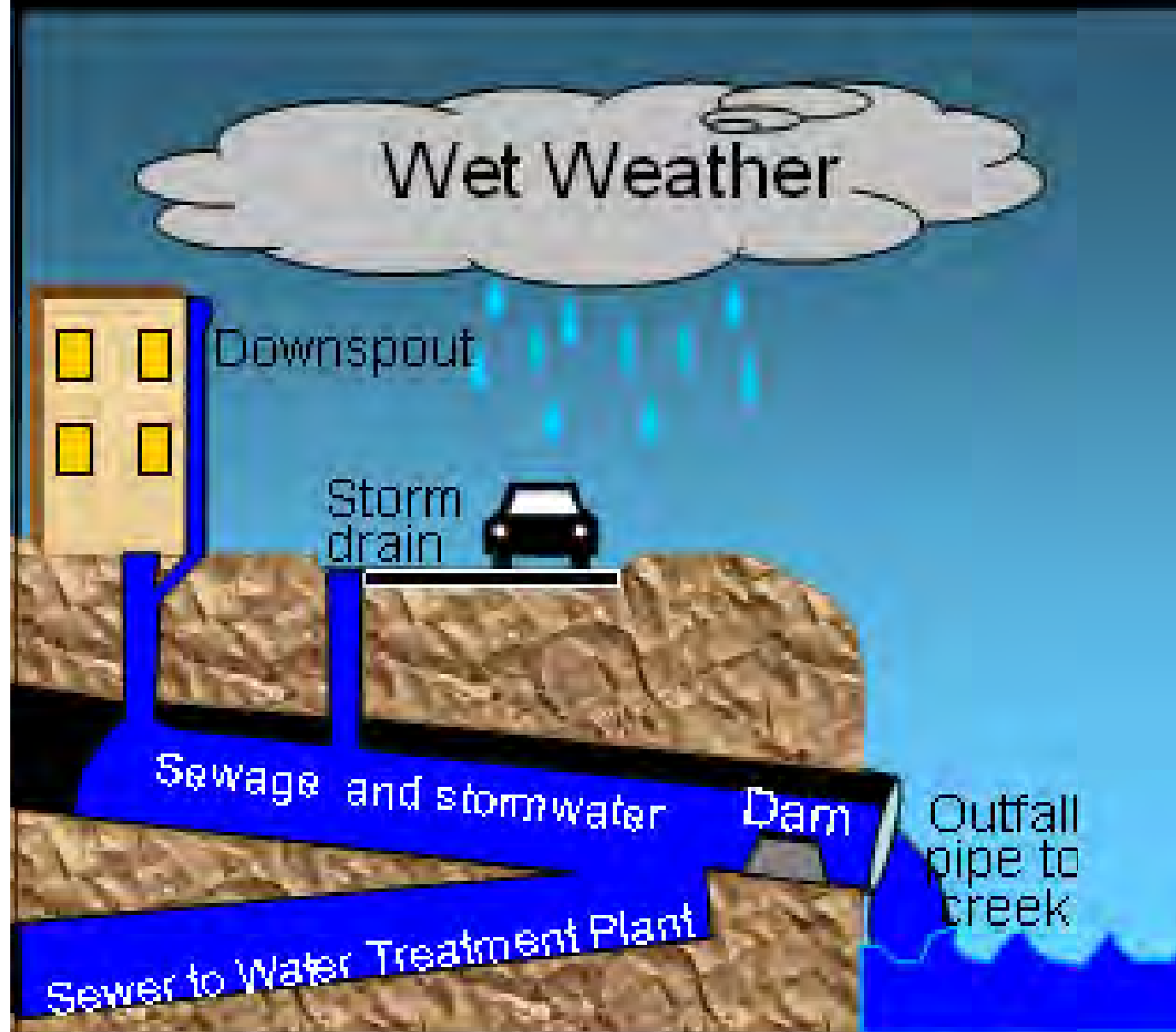
Did you know?

- 43% of the District's land area is impervious.
- A single 1.2 inch storm falling on this area produces about 525 million gallons of stormwater runoff.





Combined Sewer





Water in storm drains does not go to a treatment plant...



Stormwater Management Eras



1. Get rid of it!

Stormwater Management Eras



2. Hold on to it – for a little while.

Stormwater Management Eras

3. Hold on to it indefinitely, remove the pollutants, but don't create flooding problems or let it be a nuisance.



Stormwater in the District

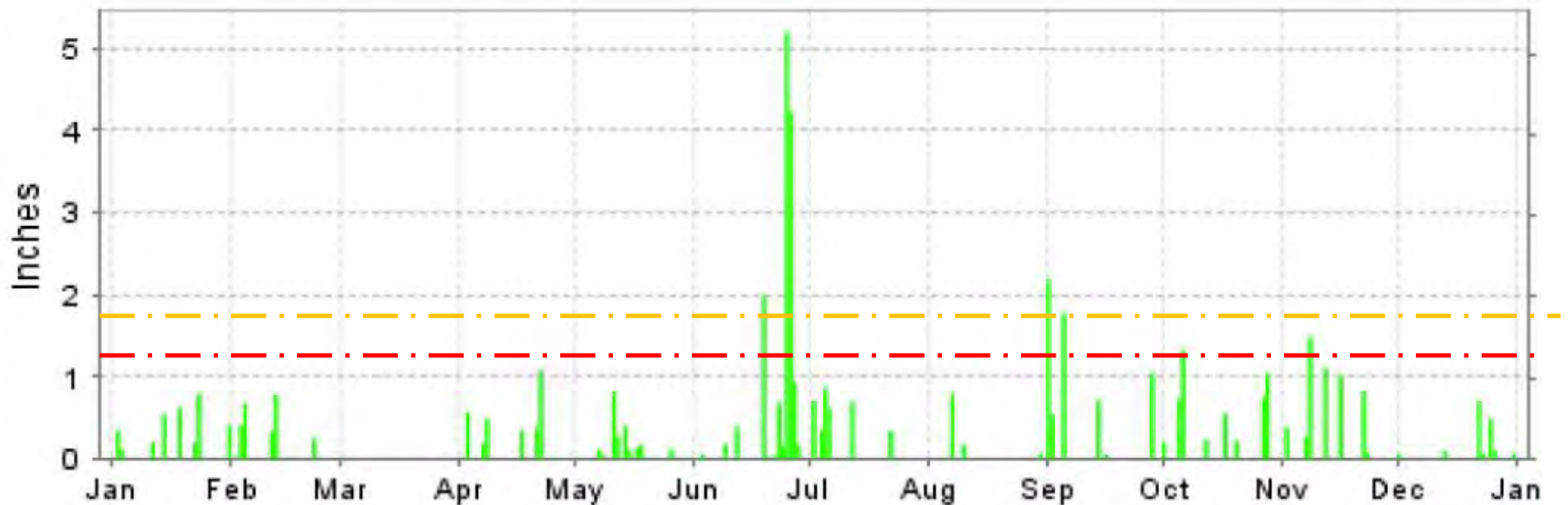
2013 Stormwater Guidebook:
Retain the first 1.2" of rainfall on site or
through off-site mitigation.



Why Retention?

- Reduces runoff volume.
 - Reduces pollutant loads.
 - Mimics pre-development hydrology
 - Groundwater recharge

Why 1.2”?



90th Percentile Event = 1.2”

Retention Options

Retention is not just infiltration!

- ✓ Green Roofs
- ✓ Rainwater Harvesting
- ✓ Impervious Disconnection
- ✓ Permeable Pavement
- ✓ Bioretention
- ✓ Tree Planting and Preservation
- ✓ Infiltration



Stormwater Regulations

Stormwater Retention Volume

$$\text{SWRv} = P (Rv_I * \%I + Rv_C * \%C + Rv_N * \%N) * SA * 7.48 / 12$$

- SWRv = Volume required to be retained on site (gal)
- P = Precipitation (in)
- $Rv_I = 0.95$ (runoff coefficient for impervious cover)
- $Rv_C = 0.25$ (runoff coefficient for compacted cover)
- $Rv_N = 0.0$ (runoff coefficient for natural cover)
- %I = % of site in impervious cover
- %C = % of site in compacted cover
- %N = % of site in natural cover
- SA = Surface area (square feet)

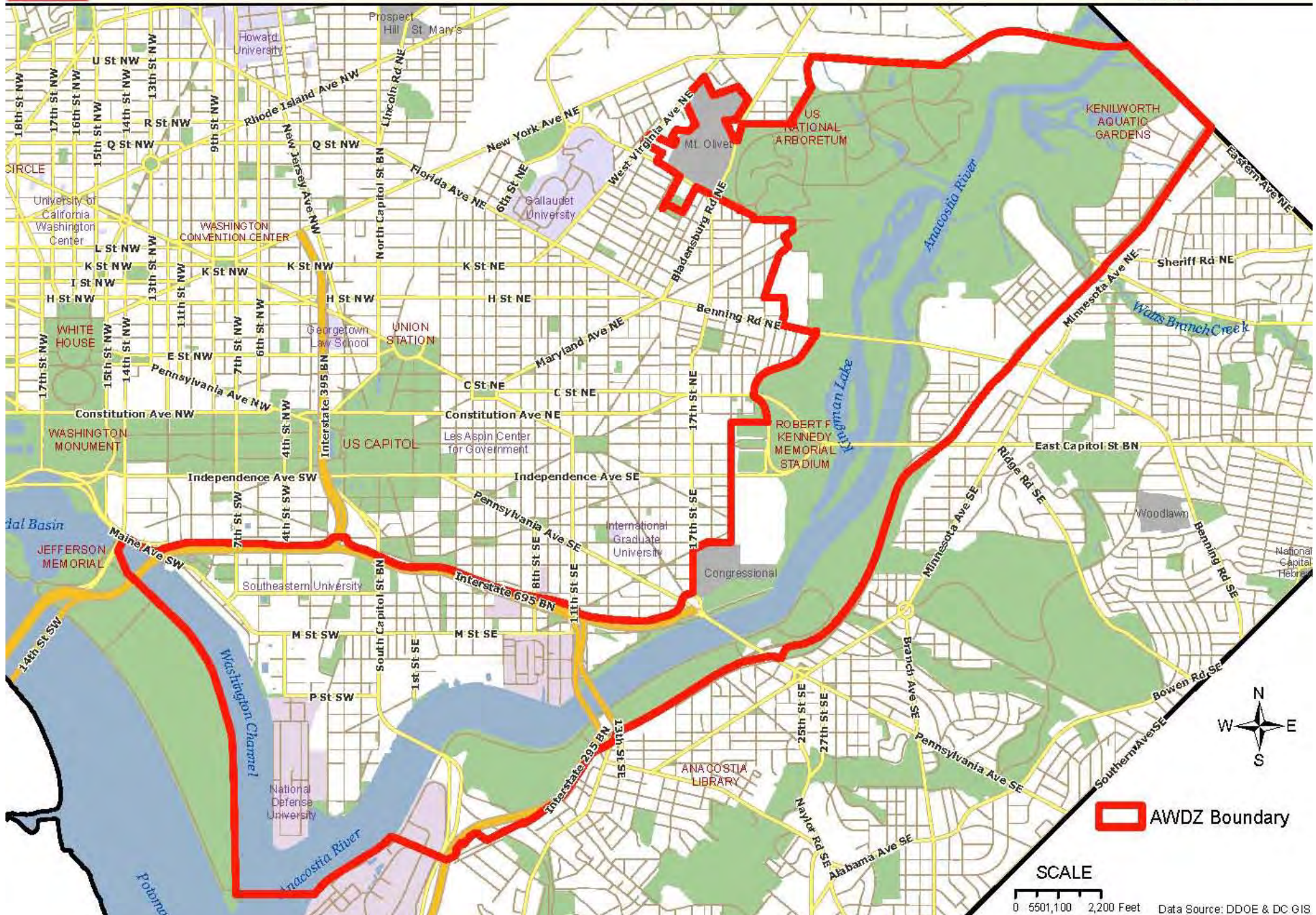
Water Quality Treatment Volume

$$\text{WQTV} = P (Rv_I * \%I + Rv_C * \%C + Rv_N * \%N) * SA * 7.48 / 12 - \text{SWRV}$$

- WQTV = Volume required to be retained or treated, above and beyond the SWRV (gal)
- SWRV = Volume required to be retained on site (gal)
- P = Precipitation (in)
- $Rv_I = 0.95$ (runoff coefficient for impervious cover)
- $Rv_C = 0.25$ (runoff coefficient for compacted cover)
- $Rv_N = 0.0$ (runoff coefficient for natural cover)
- %I = % of site in impervious cover
- %C = % of site in compacted cover
- %N = % of site in natural cover
- SA = Surface area (square feet)



Anacostia Waterfront Development Zone (AWDZ)



AWDZ Boundary

SCALE

0 550,100 2,200 Feet Data Source: DD OE & DC GIS

Quantity Control Requirements:

- 2-year storm: control peak discharge to pre-development conditions.
- 15-year storm: control peak discharge to pre-project conditions.

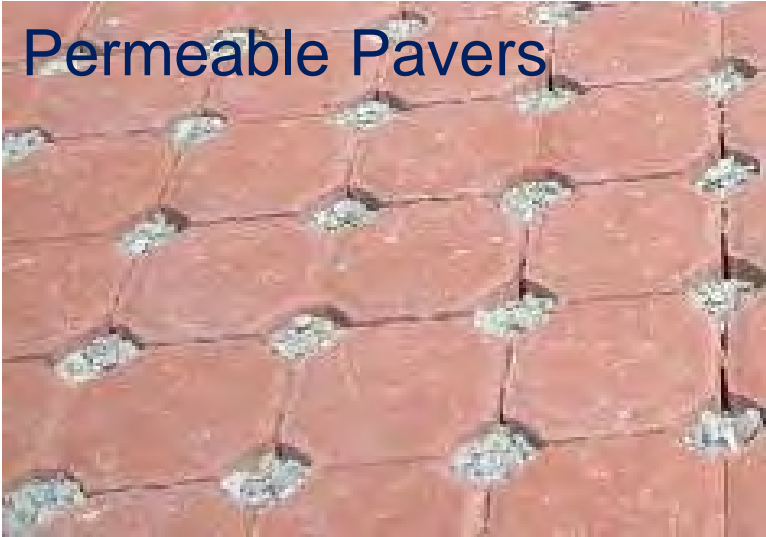
For PROW: These volumes are incorporated into the MEP process.

Don't Forget About ESC!

- Licensed/Certified Responsible Person must be on site at all times.
- New Manual Coming Soon!

Permeable Pavement

Permeable Pavers

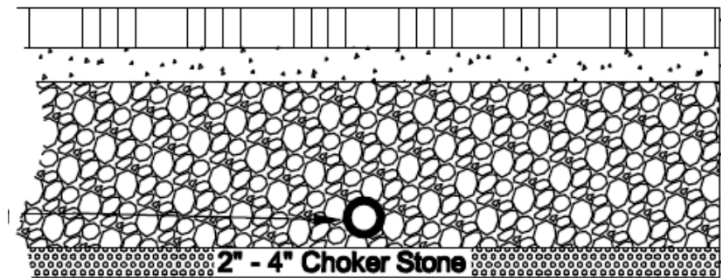


Pervious Concrete



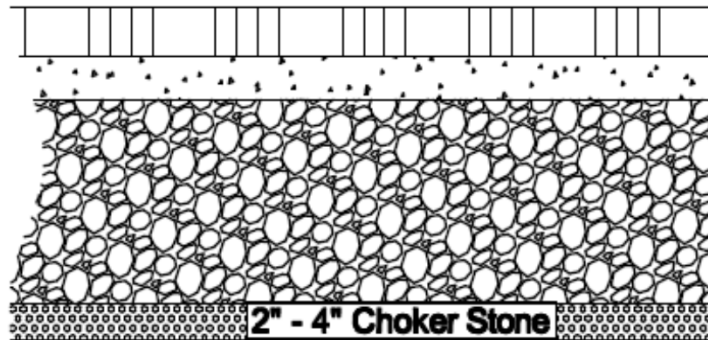
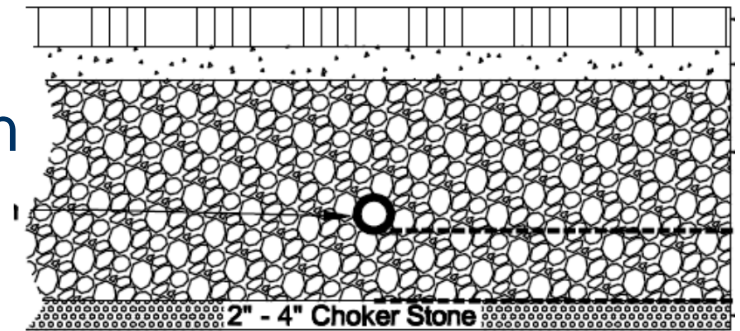
Porous Asphalt

Permeable Pavement Versions



Standard

Enhanced with Underdrain



Enhanced without Underdrain

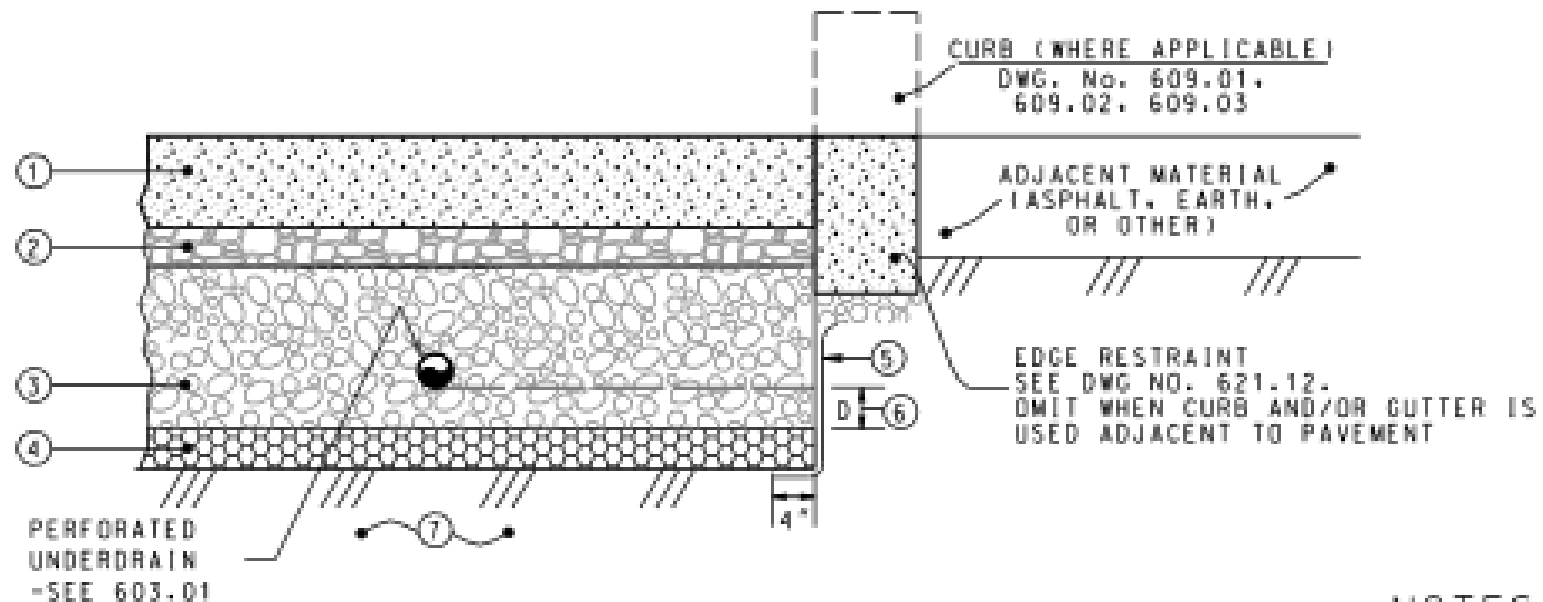
Permeable Pavement Feasibility Criteria

- Ratio of external contributing impervious surface to permeable pavement is **4:1**
- CDA should be impervious
- 2' depth to seasonally high water table
- 5% maximum surface slope
- 10' setback from buildings, unless a impermeable liner is used on edge
- Compaction or vehicle traffic must be avoided if possible.

Permeable Pavement Design Criteria

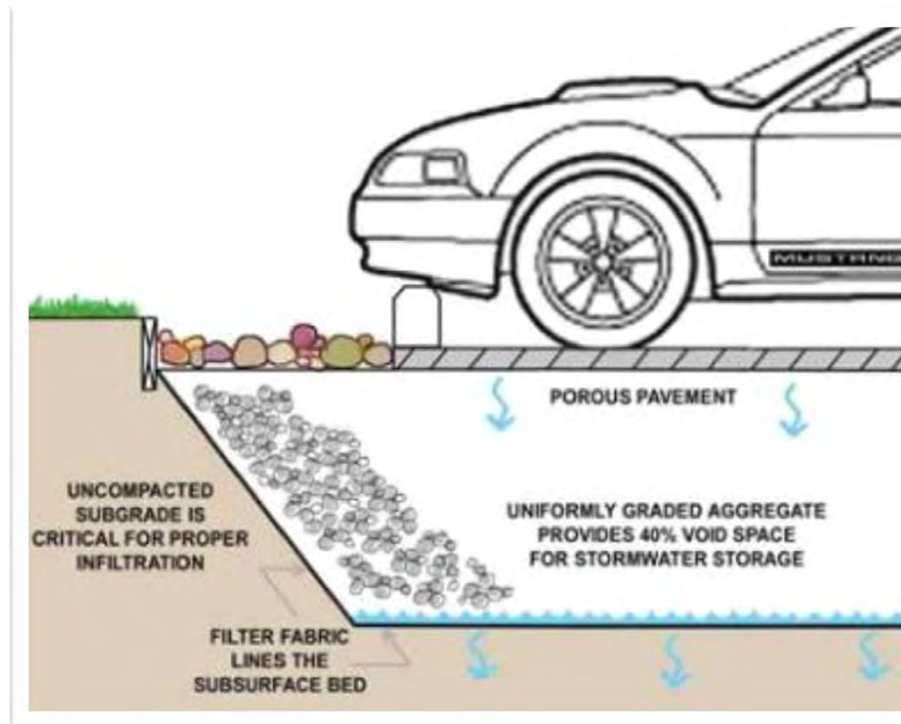
- Structural Design
 - Total traffic
 - In-situ soil strength
 - Bedding and reservoir layer design
- Hydraulic Design
 - Design volume

Permeable Pavement Construction Notes



1. Protect Area from Heavy Equipment & Construction Traffic

- Keep Pavement Area Outside of Limits of Disturbance



2: Stabilize Drainage Area - Divert Water if Necessary – SEDIMENT IS THE ENEMY!



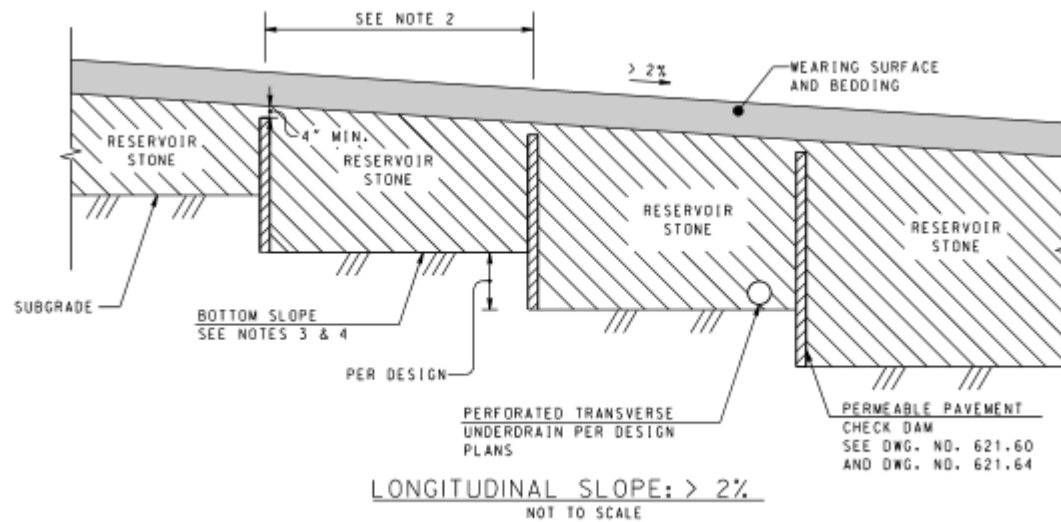
Installed too early during construction; fouled with construction sediment



Clean work area, with curb to divert drainage around work site

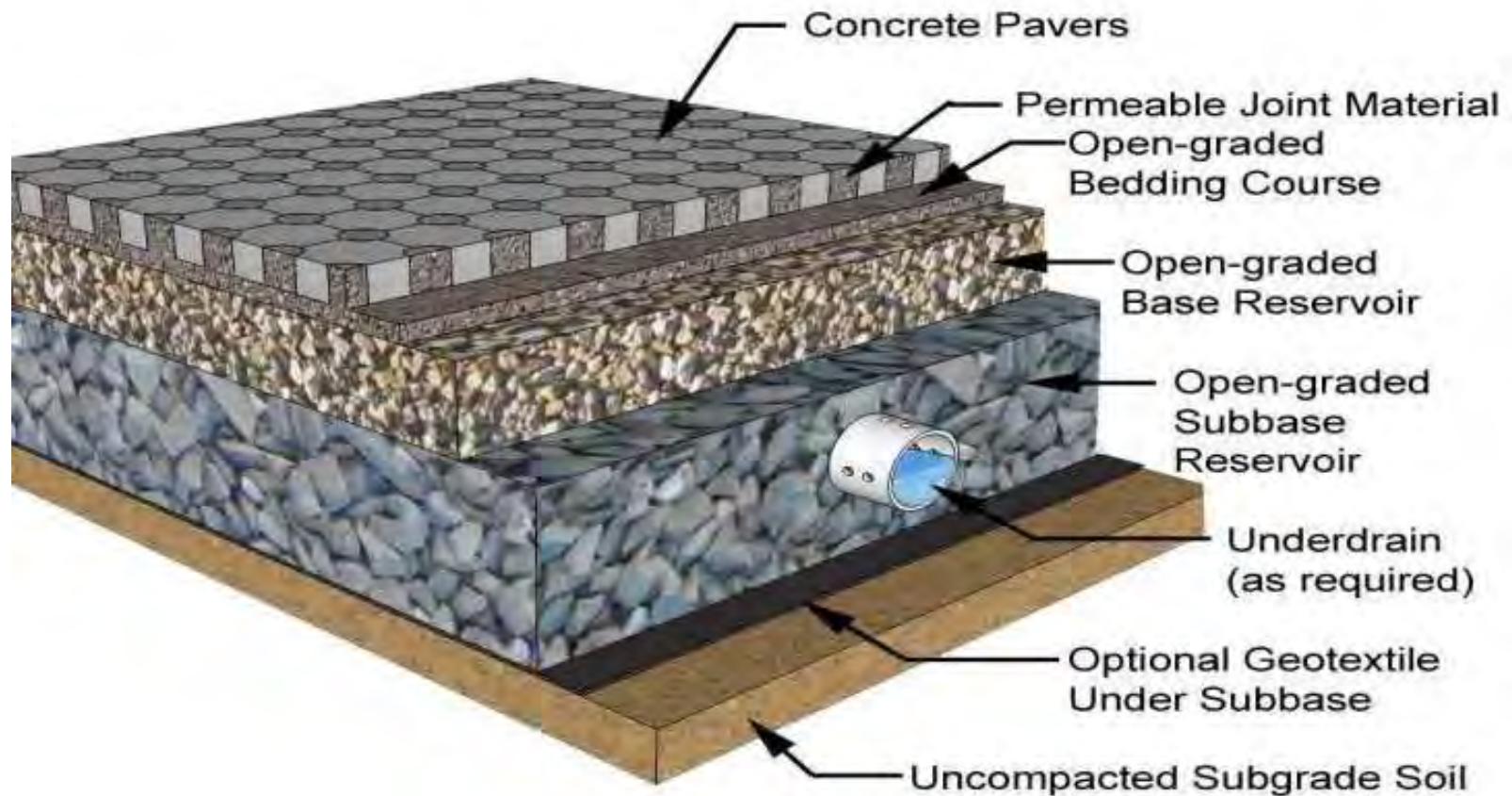
3: Excavation and Stone Reservoir Installation

- Verify with plan: Right stone, right depth, right place



In most cases, bottom of excavation should be FLAT.
On slopes, individual cells should be flat.

4: Reservoir & Bedding Layer



Details vary – check on approved plan

5: Placement of Pavement Surface



Inspection: **POST-CONSTRUCTION**

Common issues:

- Erosion
- Material storage
- Sediment from upgradient areas
- Clogging of pavement surface
- Structural damage



Pavement Surface No-Nos



Structural Damage



Loose Gravel on
Pavement Surface

Pavement Surface: Some Accumulation of Fines Expected, But. . .



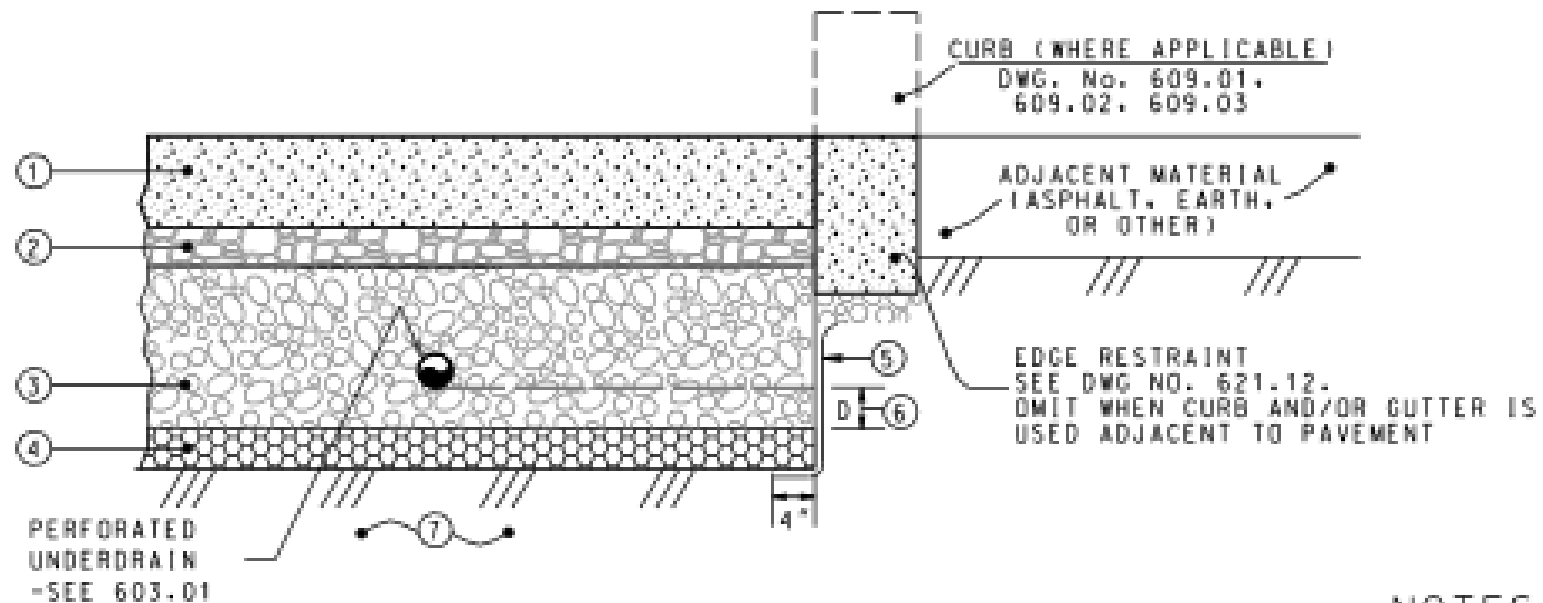
DOEE Inspection Form

Inspection Items
Site Preparation: Have erosion and sediment controls been properly installed and maintained according to approved plans? Is stormwater runoff being diverted around the practice? Has the contributing drainage area been fully stabilized?
Subgrade Preparation: Is subgrade suitable free of debris, standing water, proper grading? If design is for infiltration, verify soils have not been compacted. Excavated soil stockpile is located away from practice with erosion and sediment controls in place?
Filter Layer or Geotextile Fabric (where applicable): The filter layer and/or geotextile fabric have been installed according to the specifications?
Underdrain and Reservoir Layer: Does the underdrain meet specifications with correct perforation pattern, elevation, and slope? Caps are placed on the upstream (but not the downstream) ends of the underdrains? Does the stone reservoir meet specifications (clean, washed, free of fines) and is it installed to design depth? Is at least 2 inches of aggregate provided above and below the underdrains?

DOEE Inspection Form

Inspection Items
Surface Material: Does the surface material meet the specification and has it been properly installed? Is the surface even and can runoff spread evenly across it? Has the surface material had adequate curing time (for porous asphalt and pervious concrete) Is the surface free of fines and areas of clogging?
Over Flow Drain (where applicable): Is overflow invert at correct elevation?
Final Inspection: Can water infiltrate properly into the practice? Does the reservoir storage layer drain within 48 hours?

Questions?



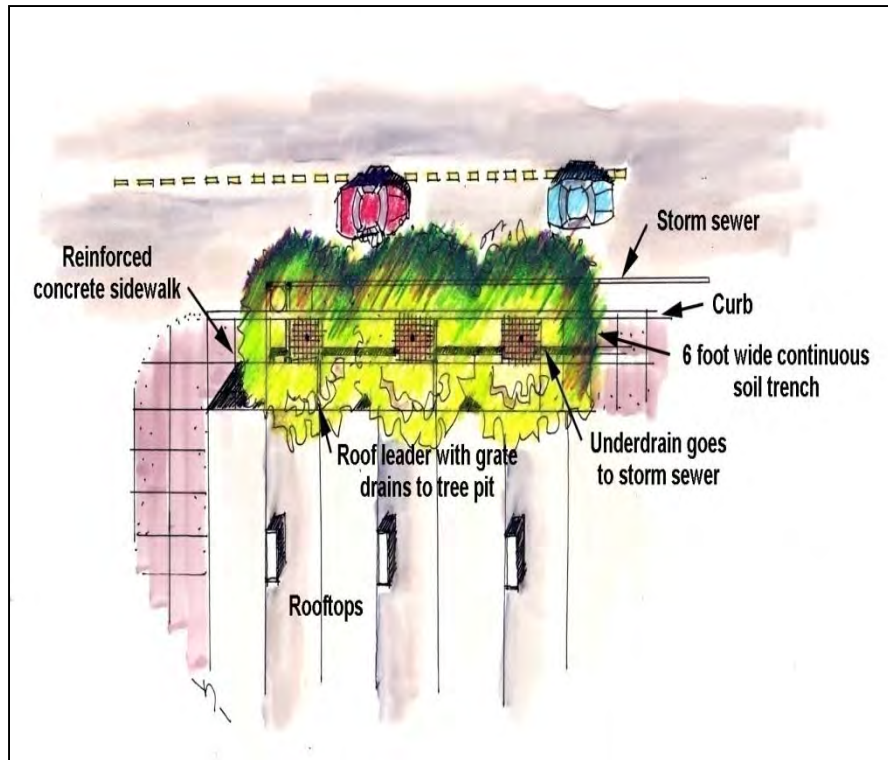
B-1 Traditional Bioretention



B-2 Streetscape Bioretention



B-3 Engineered Tree Pits



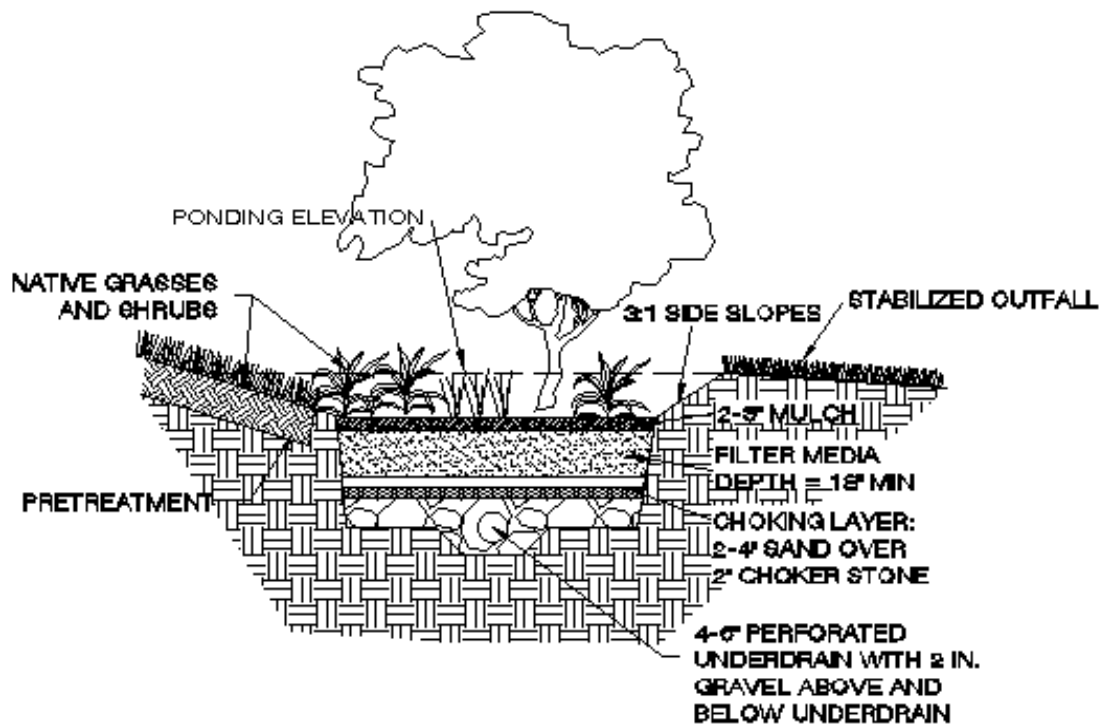
B-4 Foundation Planters



B-5 Residential Rain Gardens



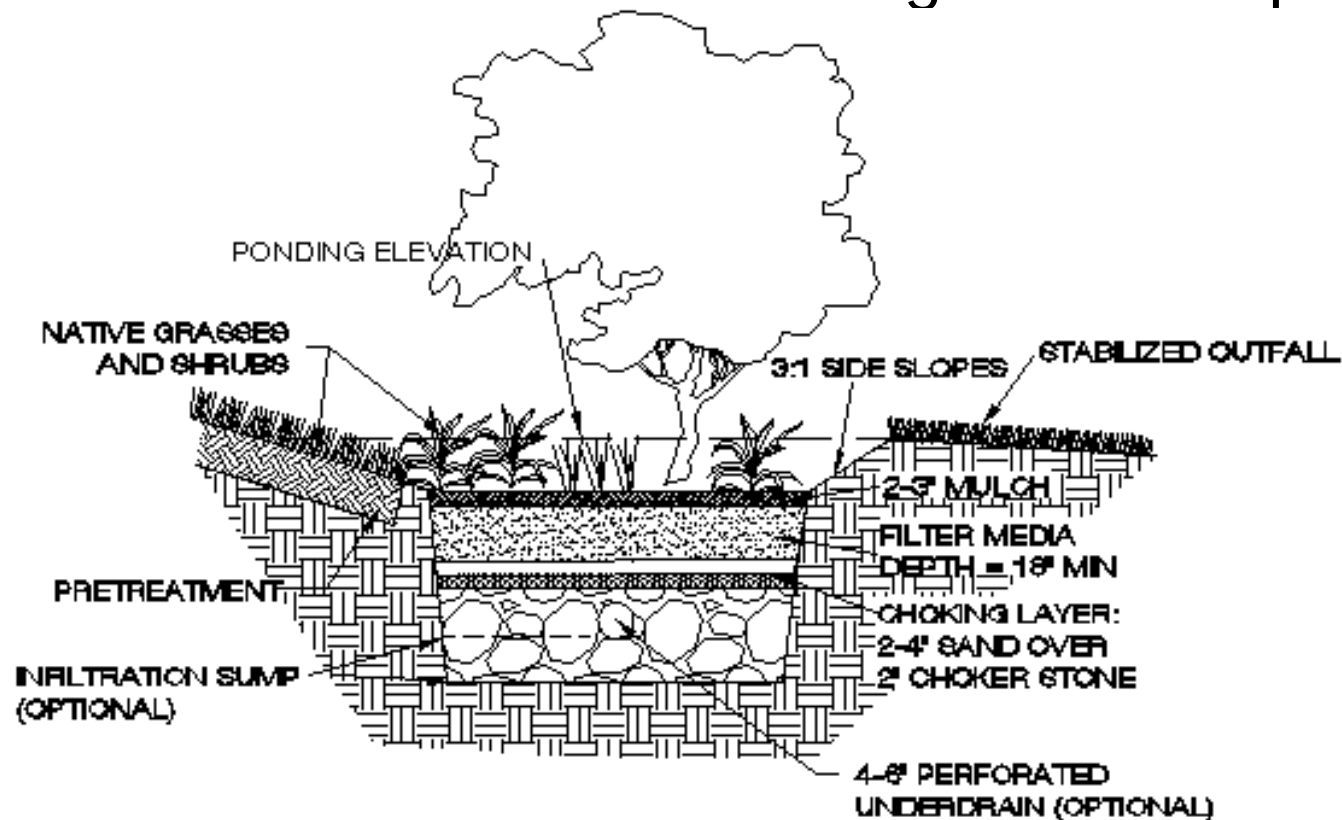
Standard Bioretention Design



- Underdrain designs without enhanced features
- 18" media
- 60% retention value for the design storm captured
- Additional TSS removal
- Oversizing practice can result in meeting full criteria

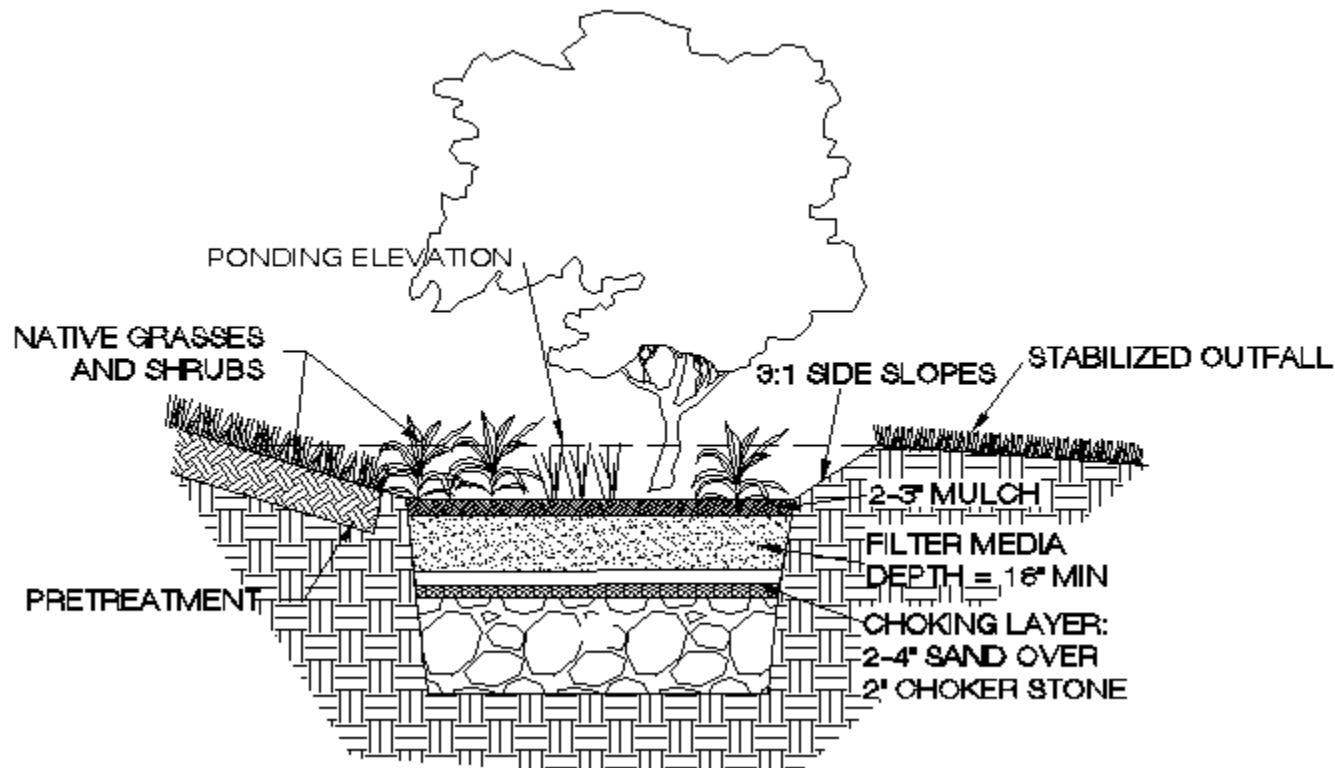
Enhanced Bioretention 1

- Underdrain designs with infiltration sump and 24" media
- 100% retention value for the design storm captured



Enhanced Bioretention 2 (Infiltration)

- For infiltration designs (storage volume must infiltrate within **72 hours**)
- Retention value for the design storm captured



Bioretention Feasibility Criteria

- 2 to 4 feet of head required
- 2' depth to seasonally high water table
- 10' setback from buildings



Conveyance Criteria

- Conveyance: Off-line vs. On-line
 - On-line requires overflow device

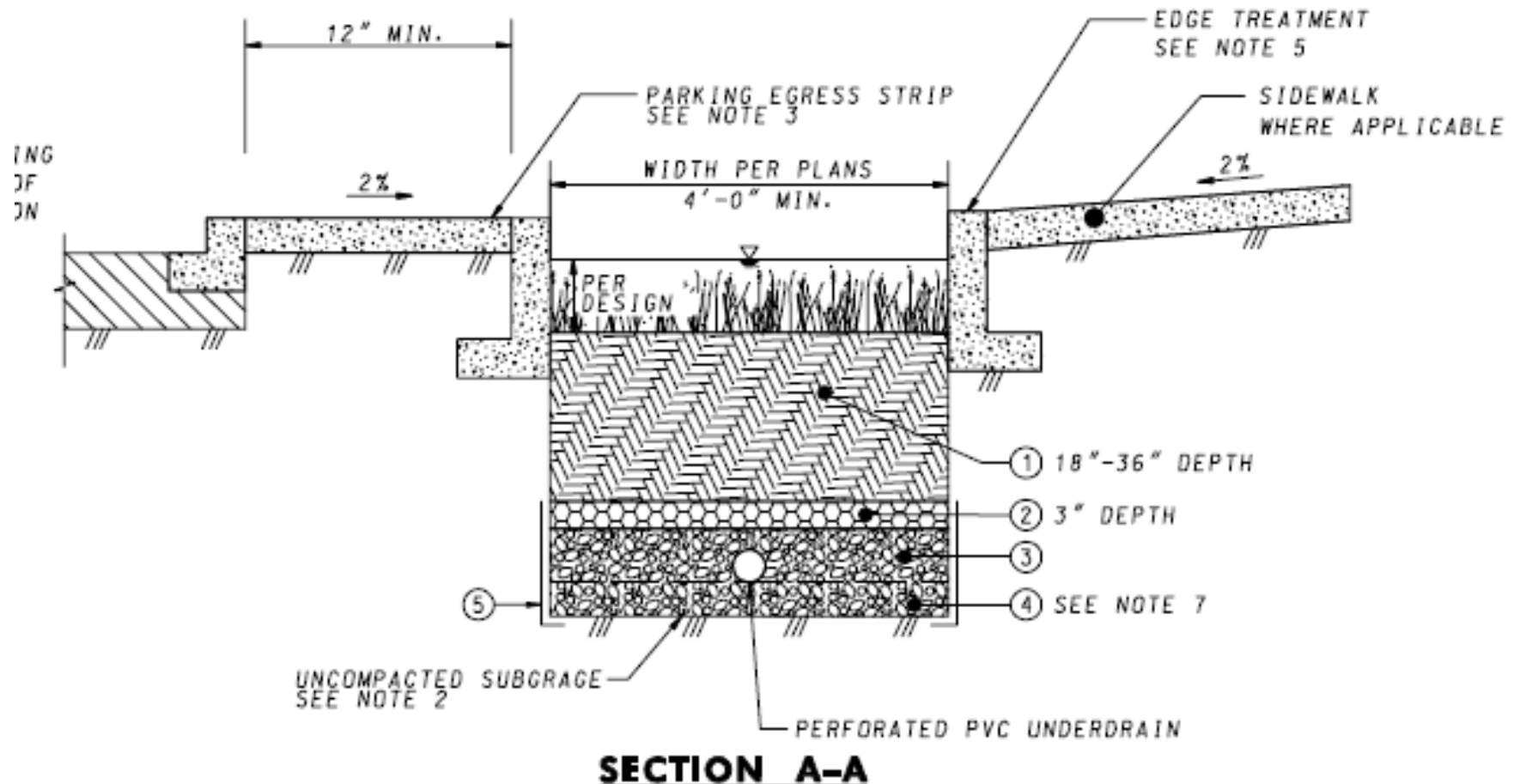


Bioretention Design Criteria

- Surface Cover Options
 - Mulch and perennial vegetation
 - Turf
 - Stone with perennial vegetation



Bioretention Construction Notes



Make Sure Drainage Area is Stabilized. Block Inlets and/or Divert Water if Necessary



Check for Choker Stone Layer Between Underdrain & Soil; Filter Fabric on Sides Only (optional)



Verify Appropriate Soil Media and Depth



Make Sure Water Gets in Inlets!



Check for Level Filter Bed



Unlevel filter bed concentrates water in only one area ; uneven filtering



Level filter bed - even distribution of flow across surface

Slope for Dry Swales: Use Check Dams



**Examples of longitudinal slope
with check dams**

Bioretention

POST-Construction Inspection

- Inlets – Water Still Getting In?
- Filter Bed – standing water, erosion, sinking?
- Vegetation & surface cover – Managed and healthy? Overgrown? Bare spots? Mulch need replacing?
- Check Dams in Dry Swales – By-passing and/or erosion?
- Outlets – erosion, blockages, clogging?
- Refer to construction record drawings (as-builts)

Standing water? Cause?



- Filter fabric, bad soil media, compaction, sediment film on top, clogged underdrain?

Possible Corrective Actions:

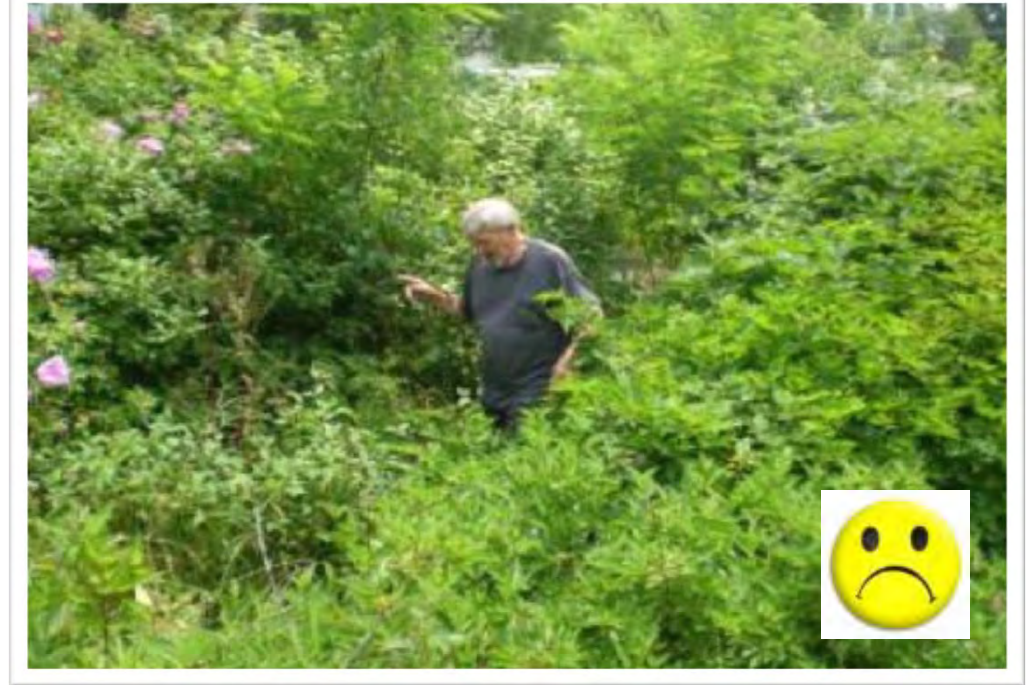
- Remove surface film of sediment; till in sand
- Unclog underdrains (if clogged)
- Punch through filter fabric (if present)
- Install wick drains
- Rebuild

Inlet Clogged With Too Much Mulch



**If a little is
good, more is
not necessarily
better!**

Vegetation being maintained?



Over Time, Plants Should Fill Surface Area



Mix of Herbaceous, Shrubs



Mulch is a temporary surface cover

DOEE Inspection Form

Inspection Items
Inflow/Overflow: Is overflow invert at correct elevation? Is inflow pipe to filter plugged with watertight seal (prior to stabilization)?
Basin and Impermeable Liner (where applicable): Basin graded as per approved plan? Basin liner material and installation meets specification of approved plan? (<i>Attach labeled sample.</i>)
Underdrains: Do collector pipes meet specifications with correct hole pattern? (<i>Attach materials invoice.</i>) Do collector stone and stone beneath sand meet specifications and is installed to design depth?
Filter Media: Does the filter media meet specifications? (<i>Attach lab report and material certification.</i>) Filter media installed to design depth and compacted on _____ (date) and refilled to designed depth?

DOEE Inspection Form

Inspection Item
Bioretention Plant Materials: Do plants meet size and variety specifications? Are all plants installed as per landscape plan? Is mulch and cover crop installed as per plan specifications? Are plant/ trees staked as per specifications? Has watering of plant material been provided once a week during first two months for fourteen consecutive days a planting has been completed , then as needed during first growing season.?
Observation Well Inlets: Is observation well free of construction debris and soil? Is outflow pipe invert at the design elevation?
Notes: <ol style="list-style-type: none">1. A qualified professional must treat disease plants.2. Deficient stakes and wires must be replaced.3. Dead plants or plants diseased beyond treatment must be replaced by plant meeting original specifications.4. New plants must be watered every day for the first 14 days after planting.

Green Roofs



Green Roof Specification

- Preferred practice in high intensity redevelopment areas
- Allow for many different vendors and systems
- Follow ASTM specifications



Intensive



Extensive



Green Roof Feasibility Criteria

- Structural capacity of roof
- Roof pitch
- Setbacks from HVAC, etc.
- Compliance with building codes, fire code

Green Roof Landscaping Criteria

Plants need to resist and withstand

- Drought
- Fire
- Wind
- Snow-loading
- Heat-stress
- Etc.

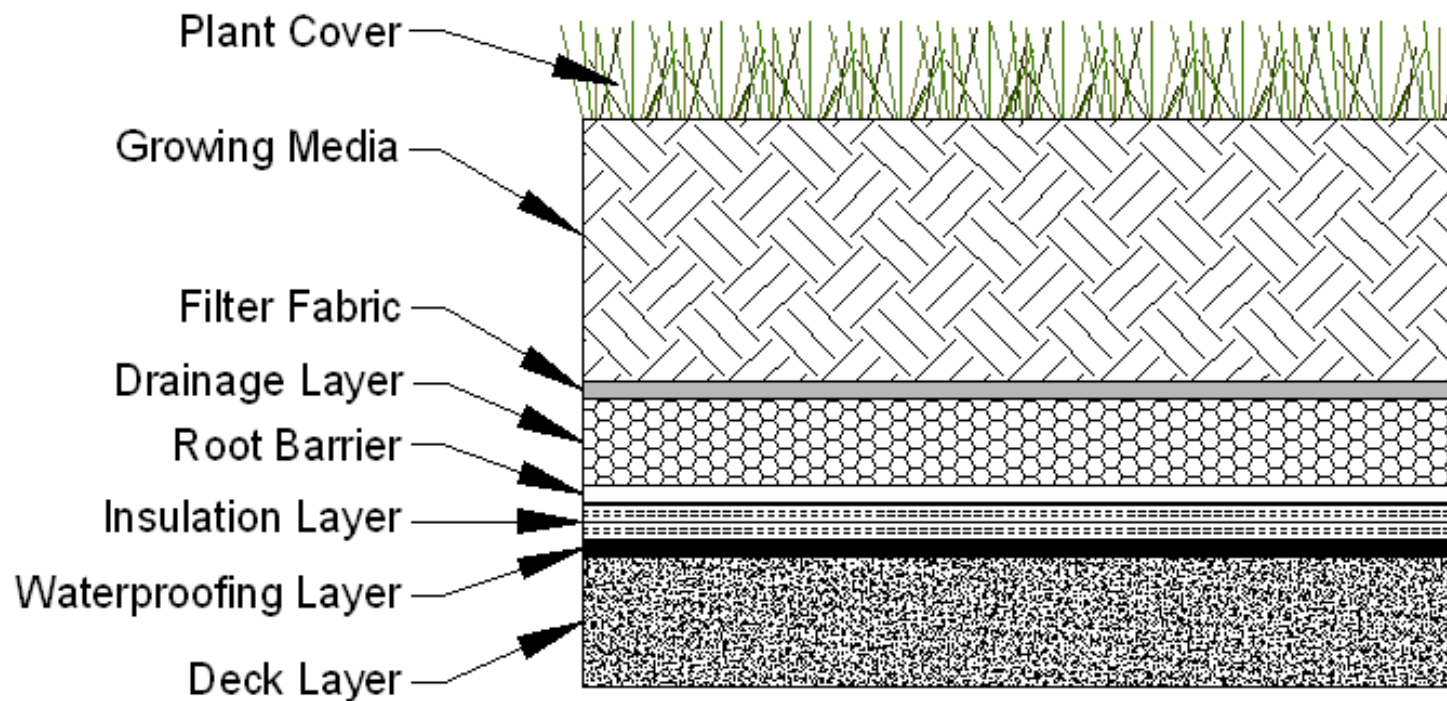


Table 3.1.2. Ground Covers appropriate for Green roofs in the District.

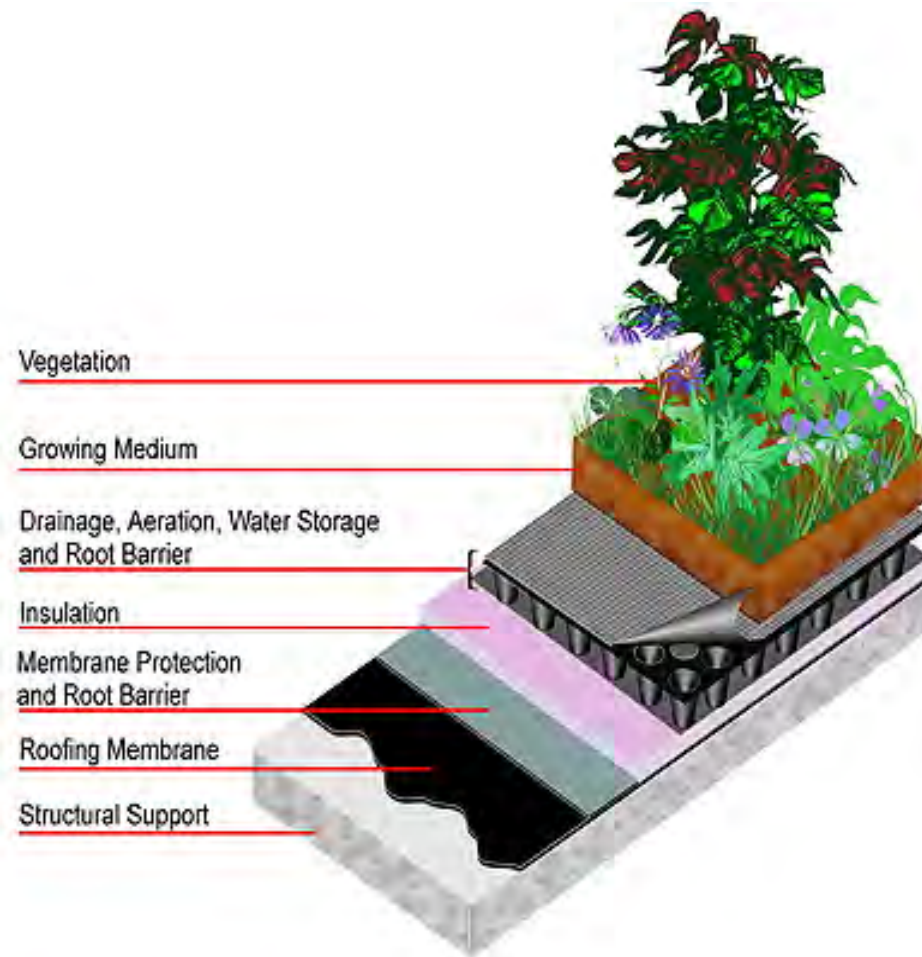
Plant	Light	Moisture Requirements	Notes
<i>Delosperma cooperii</i>	Full Sun	Dry	Pink flowers; grows rapidly
<i>Delosperma Kelaidis</i>	Full Sun	Dry	Salmon flowers; grows rapidly
<i>Delosperma nubigerum</i> 'Basutoland'	Full Sun	Moist-Dry	Yellow flowers; very hardy
<i>Sedum album</i>	Full Sun	Dry	White flowers; hardy
<i>Sedum lanceolatum</i>	Full Sun	Dry	Yellow flowers; native to U.S.
<i>Sedum oreganum</i>	Part Shade	Moist	Yellow flowers; native to U.S.
<i>Sedum stoloniferum</i>	Sun	Moist	Pink flowers; drought tolerant
<i>Sedum telephiodes</i>	Sun	Dry	Blue-green foliage; native to region
<i>Sedum ternatum</i>	Part Shade-Shade	Dry-Moist	White flowers; grows in shade
<i>Talinum calycinum</i>	Sun	Dry	Pink flowers; self-sows
Note: Designers should choose species based on shade tolerance, ability to sow or not, foliage height, and spreading rate. See Snodgrass and Snodgrass (2006) for definitive list of green roof plants, including accent plants.			

Green Roof Retention Value Calculations

Retention Value = S_v = 100% of Storage Volume in Media and Drainage Layer



Green Roof Construction Notes

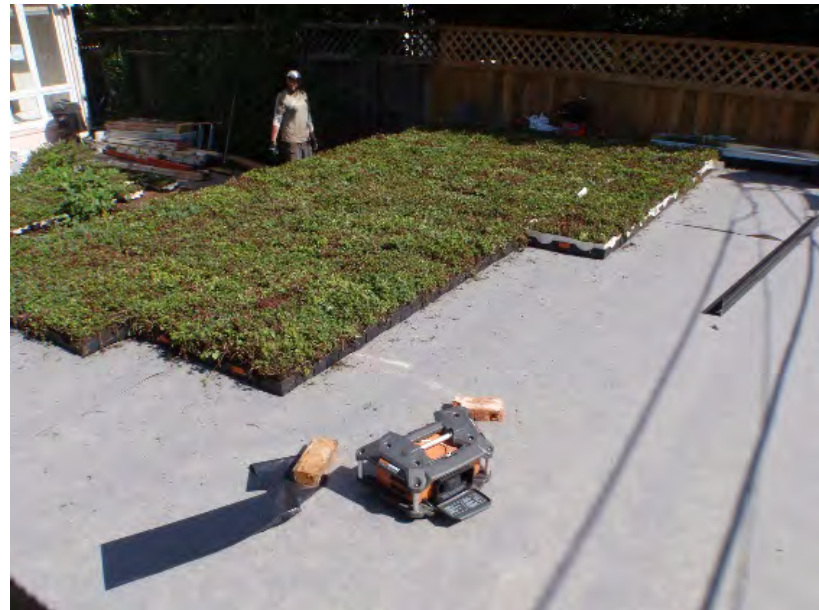


Site Conditions & Access



Types of Green Roofs

- built-in-place
- roll & mat
- modular tray system



Testing the Membrane

Technologies for leak detection:

- Flood testing
- Electric Vector (system installed with membrane)
- Infrared Testing
- Nuclear Testing



DOEE Inspection Form

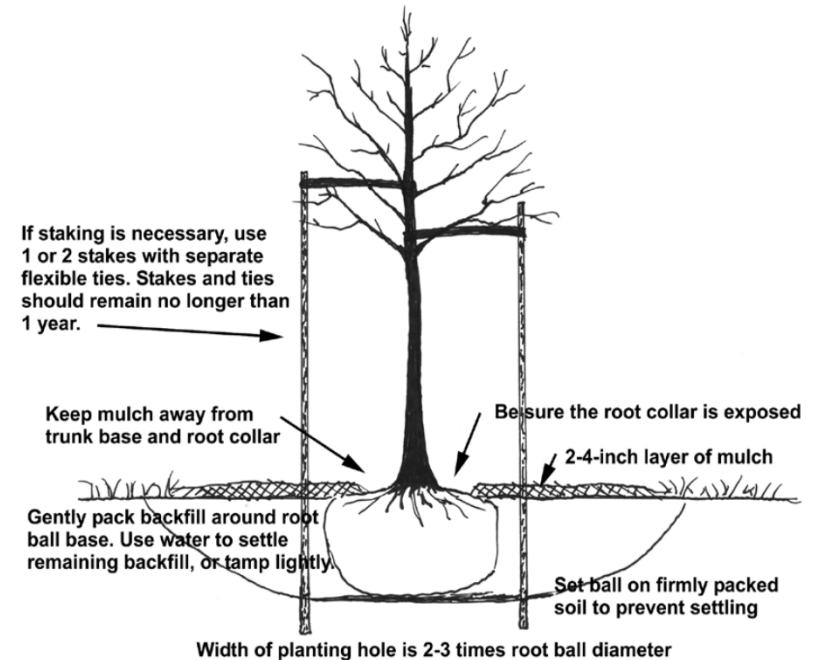
Inspection Item
Water Proofing: Certification: identify type: Hot or Cold applied? Does the waterproofing system require an applicator “certified” by the manufacturer? (<i>Attach certifications.</i>) Have the correct number of water proofing layers been installed (per plan or manufacturer specification)? Does the membrane reinforcement and flashing meet plan specifications? (<i>Attach invoice and/or manufacturer certifications.</i>) Is protection provided for water proofing membrane? (<i>Specify membrane type and indicate the duration between installation of membrane and media.</i>) Do drain boxes, vent pipes, and other penetrations meet plan specifications? Are all seams, joints, and edges caulked and sealed with approved grade of caulk or sealant? Water Test: Has an EFVM or water test been conducted? If a water test, verify the water test is conducted according to test standards demonstrating two inches of water ponding for a 24 – 48 hour period (<i>Attach water test report.</i>)

DOEE Inspection Form

Inspection Item
Green Roof Components: Do the overflow drains and drain boxes meet plan specifications? Were all layers installed per plan cross-section? (<i>Attach manufacturers' certifications</i>) Does the growing media meet plan specifications? (<i>Attach manufacturers' certifications</i>) Does the metal curbing and flashing meet plan specifications? (<i>Attach manufacturers' certifications</i>) Do pedestals and pavers and non-vegetated areas meet plan specifications (type and location)?
Irrigation: Is there an irrigation system? Is the system installed to plan specifications? Verify water source.
Plantings and Housekeeping: Modular System___ Vegetated Mats___ Plugs___ Other___ Do plants meet plan specifications for size and variety? Are all plants installed per plan specifications? Note the planting distribution, depth of media, and whether or not adequate watering was provided. Is temporary netting or wind uplift protection required? Have all planting waste materials and construction trash and debris been removed?

Tree Planting and Preservation

- 1,500 cf of soil volume per tree, or 1,000 cf per tree with shared rooting space
- Preserved trees get 20 cubic foot retention value
- New trees get 10 cubic foot retention value



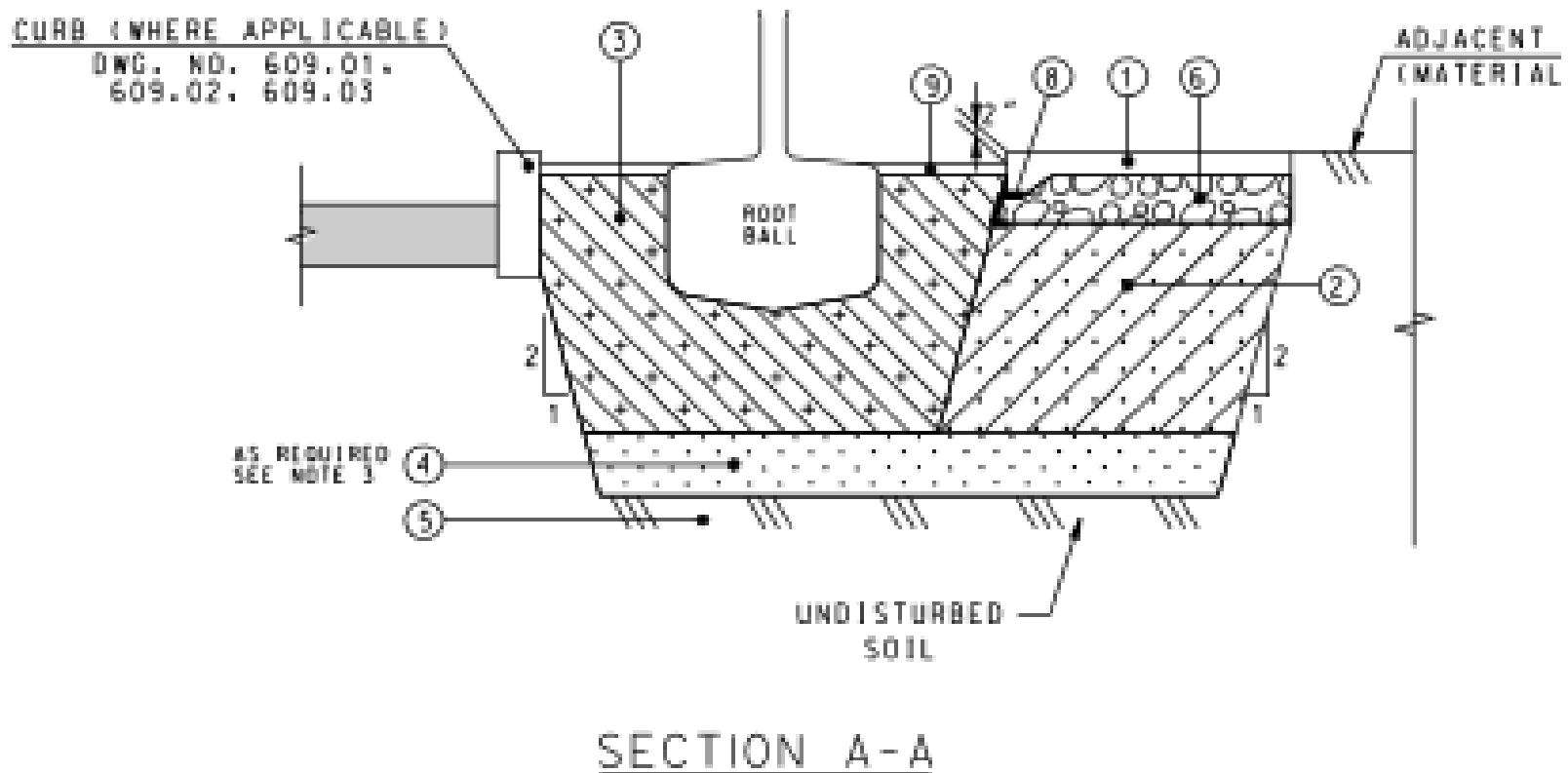
DOEE Inspection Form

Inspection Item
Planted Trees: Do the tree species match the planting plan? Do the trees have a minimum caliper size of 1.5 inches?
Planting Sites: Is there enough overhead clearance for pedestrians and vehicles?
Planting Techniques: Is the root collar exposed? Has the wire and as much of the burlap as possible been removed from ball and burlap trees? Have circular roots been pruned from container-grown trees? Are erosion control blankets or other appropriate practices in place on steep slopes? With slopes steeper than 3:1, are trees planted on a level space on the slope?
Post-Planting Tree Protection: Has 2-4 inches of organic mulch been spread over the soil surface out to the drip line of the tree? Are trees staked only if there is a concern of vandalism or windy exposure?

DOEE Inspection Form

Inspection Item
Planting Sites: Was the appropriate tree planted in the best location based on urban planting constraints? Are clear sight lines provided along street and in parking lots? Is there enough overhead clearance for pedestrians and vehicles? Is there at least 2 cubic feet of useable soil per square foot of average mature tree canopy?
Planting Techniques: Is the root collar exposed? Are erosion control blankets or other appropriate practices in place on steep slopes? With slopes steeper than 3:1, are trees planted on a level space on the slope?
Post-Planting Tree Protection: Has 2–4 inches of organic mulch been spread over the soil surface out to the drip line of the tree? Are trees staked only if there is a concern of vandalism or windy exposure?

Sand-Based Structural Soil (621.71)





BMP / GREEN INFRASTRUCTURE CONSTRUCTION

OCTOBER 18, 2016



AGENDA



➤ Permeable Pavement

- Materials
- Construction

➤ BioRetention

- Materials
- Construction





➤ Permeable Pavement

- Submittals
- Materials
- Construction



SUBMITTAL PROCESS

- Process: similar to typical DDOT & VDOT projects
- Materials
 - Some Green Infrastructure / LID materials require additional testing and lead time
 - Standard materials sent through standard QA/QC
 - Other items, such as soils and landscape materials, have specific approval processes
- Reviewed During Pre-Construction Meeting
 - Submittal details
 - Material testing details
 - Submittal deadlines



PAVEMENT SUBMITTALS



- Test panel size is job-specific
- Require test section panel approval
 - Interlocking Concrete Permeable Pavers
 - Clay/Brick Pavers
 - Cobblestone
- Plant certifications required
- Porous asphalt
 - In most cases, contractor able to provide own mix design for submittal
 - Approved through the QA/QC system
- Pervious concrete
 - Prime contractor will submit their Craftsman's resume for DOT's approval
 - Mix design submitted and approved through QA/QC system
 - Pre-cast panels tested for infiltration at plant

CONSTRUCTION: PRE-PROJECT START UP

- Invite DOT, agencies, contractor, inspectors, utility companies, suppliers, craftsmen
- Identify constructability issues, including review of any pay items and quantities. For example:
 - Use of pre-cast materials in residential areas
 - Full width replacement of alleys vs. center strip placement of pervious pavement
- Discuss utility conflicts
 - Require physical location of all utilities prior to construction
 - Coordinate with utility companies
 - How should lines be protected?



PREPARATORY MEETING

- Review testing requirements and acceptance criteria for each material
- Discuss job-specific construction sequence
 - Look-ahead weekly schedule to ID any potential issues
 - Check sequence:
 - Pre-Construction
 - During Construction
 - Post-Construction
- Include Craftsman and utility companies



CONSTRUCTION: SEQUENCE & METHODS

E & S Control

- Avoid contamination



Erosion & Sediment Control

- Ensure proper installation and maintain according to approved plans
- Divert storm water runoff
- **Stabilize contributing drainage area**



CONSTRUCTION

Make sure to

- Require covering/other measures of protection throughout life of the contract
- Include in specs that a Craftsman is required for pervious concrete placement
- Have Craftsman on-site
- Require trained on-site technician from material supplier

Pervious Concrete

- Buggy vs. pumping concrete in tight areas
- Use of pre-cast vs. cast-in-place concrete
- Verify concrete ticket is the approved mix design
- Check target weight. Loads on either high or low end will affect performance of concrete
- If unit weight isn't within tolerance, reject the load
- Inspector must document each load's unit weight and placement
- Craftsman is responsible for ensuring mix is correct, testing unit weight, and for installation of concrete
- Cut Core sample after recommended cure time for acceptance
- Test section panel approval
- Infiltration test after recommended cure time for acceptance





Testing

- Check special provisions for Infiltration Test requirements
- Require minimum temperature
- Minimum width 8'

CONSTRUCTION

➤ Porous Asphalt

- Verify asphalt ticket is approved mix design
- Test and document temperature of mix
 - When delivered
 - Prior to placement
 - Behind paver after placement
- If asphalt temperature falls below specs, reject the load
- Minimize hand work
- After recommended cure time for acceptance:
 - Core sample
 - Infiltration test
 - Box sample

CONSTRUCTION - INSTALLATION OF PAVEMENT

Make sure to

- Verify type, specific color, shape, width, and thickness of cut pavers as detailed in specs
- Place string lines every 10 feet, discuss at Pre-Con
- Check paver pattern direction 90° vs. 45°



Permeable Pavers

- Edging inside area should be straight
- Verify:
 - Delivered material is what was approved by QA/QC (type, specific color, shape, width, and thickness of cut pavers as detailed in specs)
 - Installation design is per the plans
 - Conduct infiltration test after area is completed
 - Include in specs that a Craftsman (PICP Specialist) is on site when pavers are installed
 - At least one installer should be certified



AGENDA



➤ Permeable Pavement

- Materials
- Construction

➤ BioRetention

- Materials
- Construction



BIO RETENTION SOIL SUBMITTALS

➤ Measuring Bio-Mix Soil

- In percentages:
 - Mass
 - Weight
 - Volume
 - Gradation
- Multiple testing agencies may be required in order to get all of the necessary testing required for submittal

➤ Step One – Individual Parts

- Each *part* of the soil composition must be submitted individually, i.e. sand, silt, clay, etc.
 - Reviewed by CM, and submitted to DOT lab
 - Approved by DOT

➤ Step Two – Completed Mix

- Once combined, a sample of the *completed mix* is sent to DOT labs
- Lab test results from soil supplier are submitted for approval and review
 - Reviewed by CM
 - Approved by DOT

STONE SUBMITTALS

- All double-washed clean
- Standard QA/QC
- Tickets must read “double-washed.”
- Check with suppliers to see if they can offer double-washed stone



FABRIC SUBMITTALS

- Design – be specific about type and locations of fabric
- Geotextile, Class 1
 - Use in high-risk areas, like the bottom of a bio-retention cell
- Geotextile, Class 2
 - Use in areas where there is little to average risk of damage, like sides
- Impermeable Waterproof Membrane
 - Specify mil thickness
 - Use next to roads to protect base and near buildings to act as a shield
 - Construct check dams



PLANT & LANDSCAPE SUBMITTALS

- Plant submittal is a multi-step approval process
 - Job-specific plant list must be submitted and approved prior to nursery visit
- Key item:
 - Identify plant substitutions and ensure plant availability
 - Any plant substitutions must be approved by DOT
 - Involve a landscape experts, such as a landscape architect and inspector

PLANT SPECIFICATIONS				Q&A YEAR	QUANTITY	TYPE	CONDITION	TYPE	MIN SIZE	NATURE CLASS
1	COMMON NAME	Botanical Name				DECIDUOUS	HEAT	ORANGE/RED	8"	ARBOREAL
2	COMMON NAME	Common Name				DECIDUOUS	HEAT TO SHADE	ORANGE	8"	ARBOREAL
3	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL
4	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL
5	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL
6	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL
7	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL
8	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL
9	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL
10	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL
11	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL
12	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL
13	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL
14	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL
15	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL
16	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL
17	COMMON NAME	Common Name				DECIDUOUS	HEAT	ORANGE	8"	ARBOREAL

NOTES:
 1. ALL MATERIAL SHALL BE ILLUSTRATED AND APPROPRIATE AT NEAR SCALE. LANDSCAPE PLANS AND DETAILS ARE BASED ON THESE SPECIFICATIONS AND DO NOT REPRESENT ANY SLOPE OR ELEVATION. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 2. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 3. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 4. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 5. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 6. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 7. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 8. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 9. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 10. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 11. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 12. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 13. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 14. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 15. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 16. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.
 17. THE USER SHALL BE RESPONSIBLE FOR THE PROPER INSTALLATION OF THE PLANT.

CONSTRUCTION: SEQUENCE & METHODS

Excavation



- **Do not compact subgrade**
- Verify subgrade elevation, width, depth, subgrade, and step downs
- Inspect subgrade
 - Example:
 - Geotextile fabric can be used on sandy soil subgrade to help with infiltration
- Subgrade must be scarified prior to stone placement
- Final grade must leave enough room for concrete placement, paver placement, plants and mulch
- Document as-builts

CONSTRUCTION: SEQUENCE & METHODS



Underdrain Pipe and Clean Out

- Verify
 - Connection point
 - Installation is per plan elevation
 - Invert is per plan
 - Submitted underdrain pipe is used
- Check plans to determine what areas get standard pipe vs. perforated pipe

Underdrain Connections

- Connect to existing:
 - Inlet
 - Manhole
 - Storm/Sewer pipe
- All connections need to be made per plan and according to the Authority's requirements/spec
- Discuss at Preparatory Meeting and walk the site



CONSTRUCTION: SEQUENCE & METHODS

Bio-Retention Cells

- Protect cells from contamination

Check Dams - Geotextile Fabric & Waterproof Membrane

- Install per plan and as needs determine in the field.
 - Follow plans
 - Use common sense
- Some retention areas may require different geotextile within the same area.



CONSTRUCTION: SEQUENCE & METHODS

Waterproof Membrane

- Examine all WPM for punctures and/or rips prior to, during, and following installation
- Use WPM to construct check dams
- WPM must be overlapped and lapping must be glued to create seal

Must be watertight



CONSTRUCTION: SEQUENCE & METHODS

Stone Storage

- Prevent contamination of stone at quarry and at job site
- Conduct stock pile inspection at quarry
- Use photos to document stone deliveries
- Have stone supplier at Pre-Con meeting
- Haul stone in clean trucks

Stone Placement

- All layers should be compacted according to locality's Special Provision for Aggregate Base material for permeable pavement and bio-retention areas

1. Filter layer
2. Reservoir layer
3. Base layer
4. Bedding layer



CONSTRUCTION

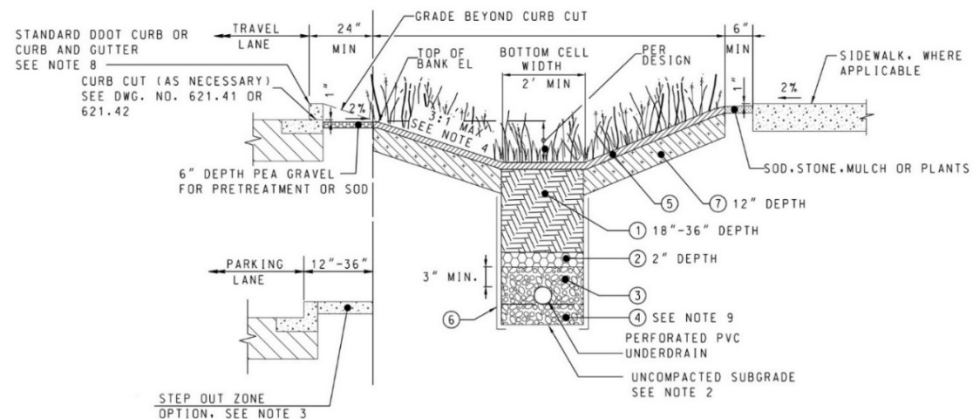
Make sure to

- Check levels
- Check grading
- Tamp, but DO NOT compact
- Verify density as per the plans/specs
- Be careful to avoid soil compaction by equipment, people, etc.



Installation of Bio retention Soil

- Before placing any soil, verify elevations of the curbing and final grading
- Confirm facility drains properly
- Verify delivered mix is the same as the approved mix design
 - Take sample of material – In case independent lab tests are needed.
 - The soil may be placed in no greater than 12" lifts
 - Tamp with a plate tamper to density percentage specified in the plans/special provisions



CLOSED SECTION

CONSTRUCTION

Make sure that

- Job-specific plant list has been approved prior to visit
- All plants match specs
- Plant material should not arrive until the site is approved
- If the plants sit on the truck or if they have to be sent back to the nursery, they could go into shock

Plants & Landscape

- Prior to leaving nursery- plant material must be inspected, approved, and tagged
- Involve a landscape expert such as a landscape architect
- Verify that planting areas are ready for plant installation
- The General Contractor, Construction Manager, and Landscape Subcontractor must be in-sync
- Follow specs and plans when laying out plants
- Use string or spray paint to mark placement and edges (ex.- X for trees, O for shrubs, perennials, and grass)
- Be flexible in layout and placement +/- 1 foot

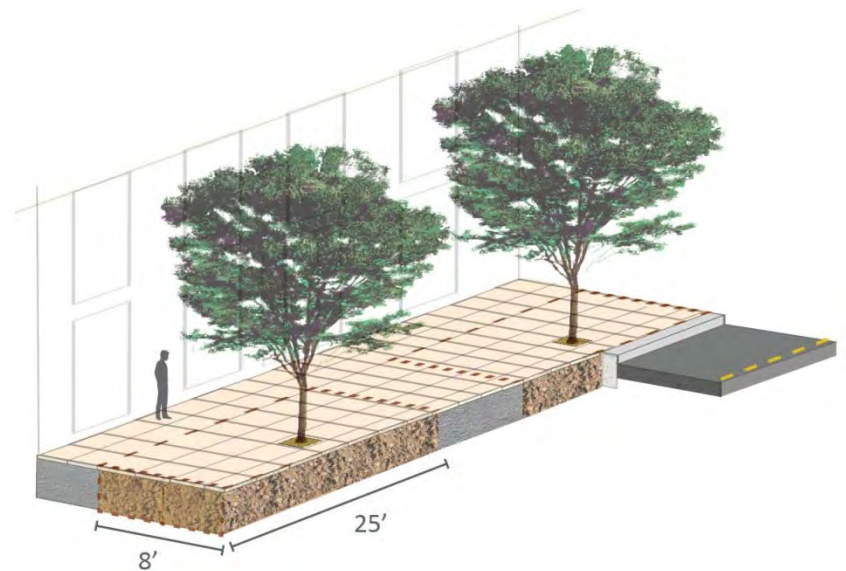


Tree Space Design Standards

- **Soil Volume Requirement**
 - Varies based on size of tree 1500/1000/600 cf
 - Open or covered soil volume options



Large Tree 1500 cu ft



Small Tree 600 cu ft

Tree Soil Volume Requirement

- 25% Volume reduction allowed when trees planted with shared soil (450/750/1250 cf)
- Refer to Green Infrastructure Standards list Trees for Public Space

TREES USED IN PUBLIC SPACE - SMALL TREES

DDOT GREEN INFRASTRUCTURE STANDARDS

TREES FOR USE IN PUBLIC SPACE

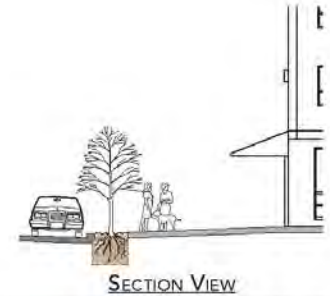
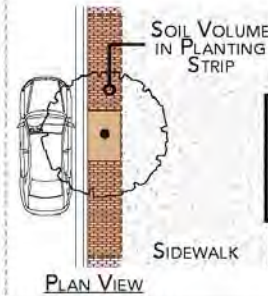
SMALL TREES

<35' tall, minimum soil volume = 600 cubic feet

BOTANICAL NAME	COMMON NAME	HEIGHT (FT.)	SPREAD (FT.)	TRUE FLOWER	BLOOM TIME	FA
<i>Acer buergerianum</i>	Trident Maple	20-25	20-25	Greenish-Yellow	Apr-May	C
<i>Acer campestre</i>	Hedge Maple	25-35	25-35	Green	May	
<i>Acer griseum</i>	Paperbark Maple	20-30	40-50	Green	Apr	Ru

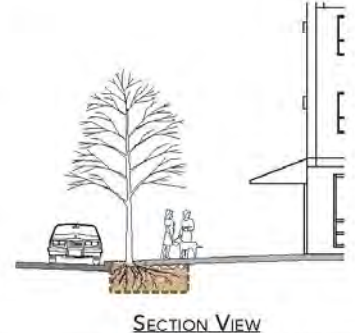
- 600 cubic feet

SMALL TREE
VOLUME REQUIREMENTS:
600 CUBIC FEET



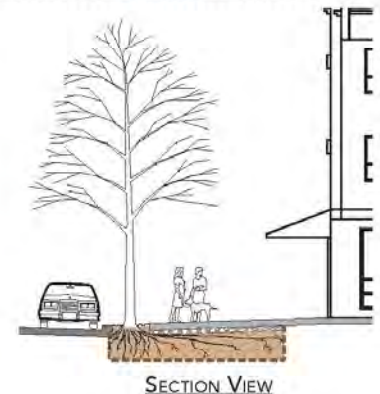
- 1,000 cubic feet

MEDIUM TREE
VOLUME REQUIREMENTS:
1,000 CUBIC FEET



- 1,500 cubic feet

LARGE TREE
VOLUME REQUIREMENTS:
1,500 CUBIC FEET

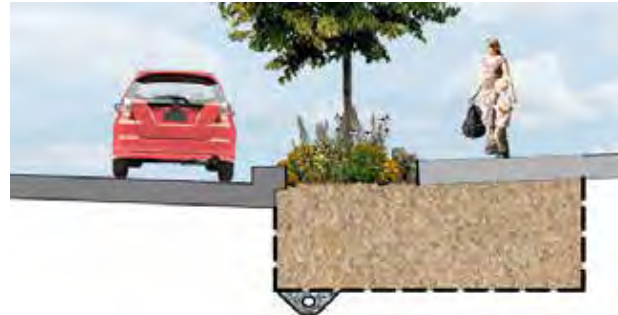


District Department of Transportation

Tree Space Design



- **Types of Tree Space Design**



Structural Soils



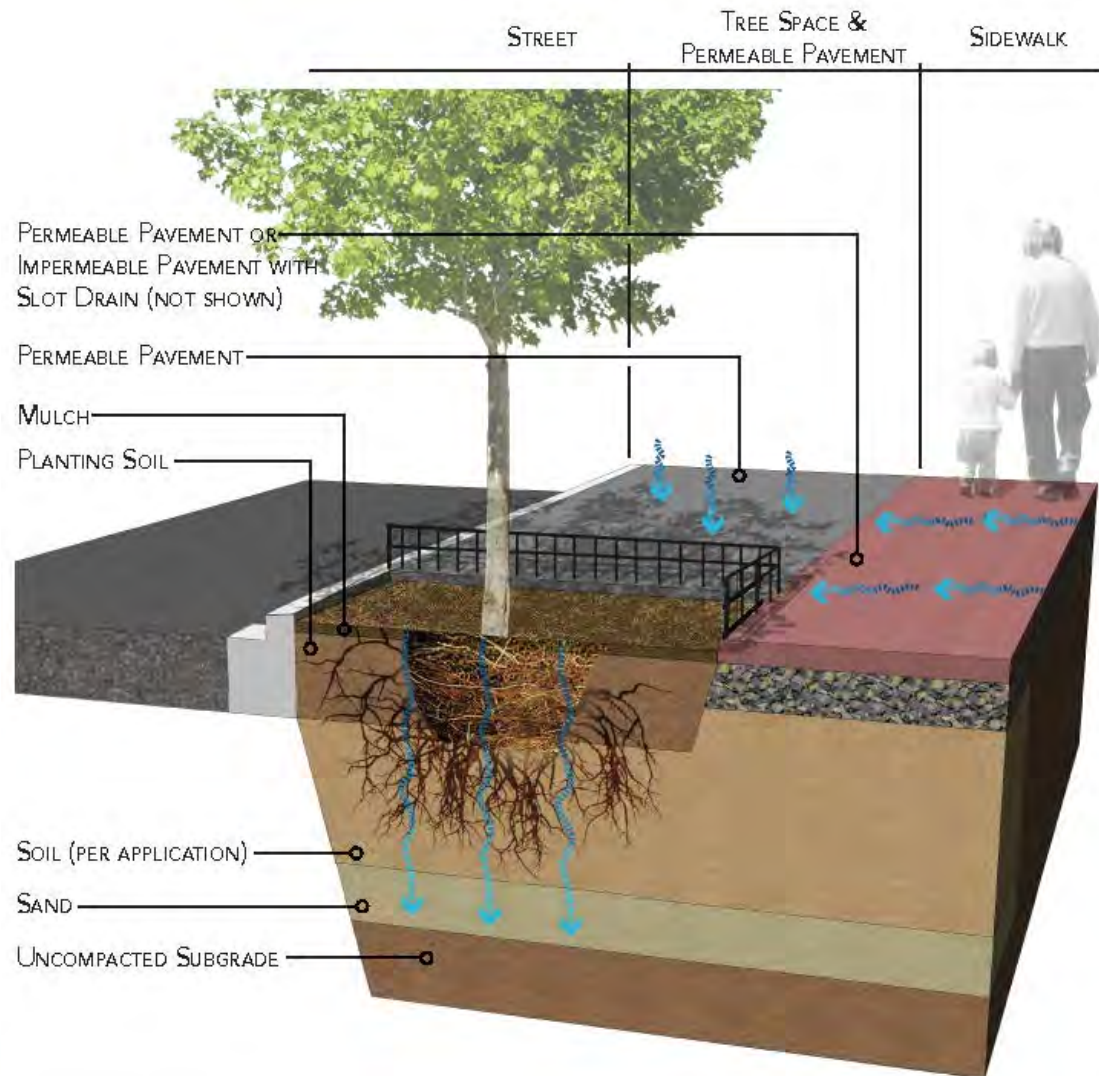
Structural Cells



Suspended Sidewalk

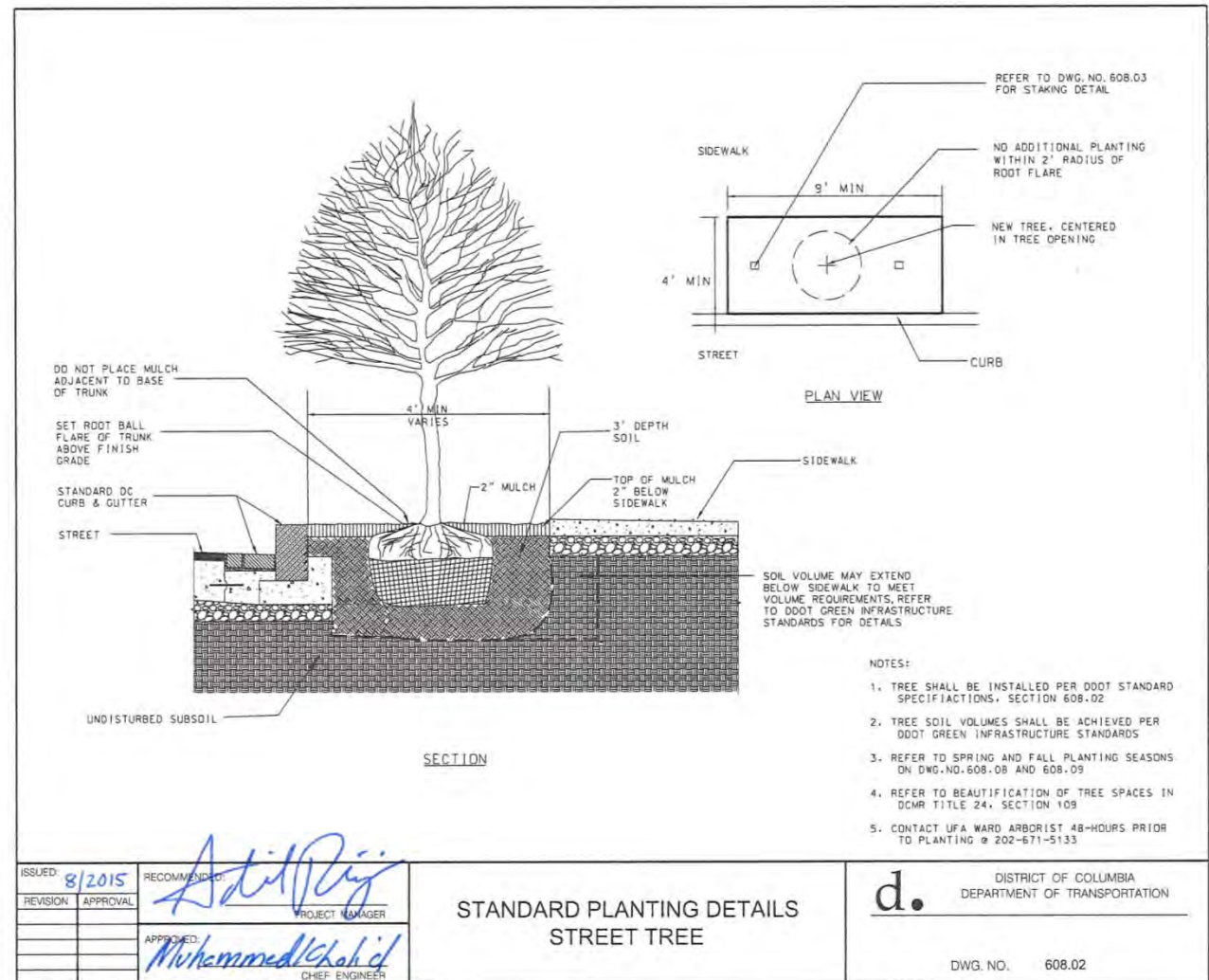
Tree Space – What's below?

- **Permeable Paver:** Permeable pavers allow water to infiltrate into the soil to be used by the trees.
- **Slot Drain:** Can be implemented in conjunction with impermeable pavement to catch runoff and direct it into soils.
- **Mulch:** Shredded hardwood layer to retain water and trap pollutants.
- **Planting Soil:** Uncompacted, soil mix used in open areas or with structural cells or suspended sidewalks and allows root growth.
- **Structural Soil:** Supports pavement and allows root growth.
- **Sand:** Acts as a drainage layer for excess stormwater (when needed).
- **Uncompacted Subgrade:** Existing soil where stormwater infiltrates.



Tree Planting

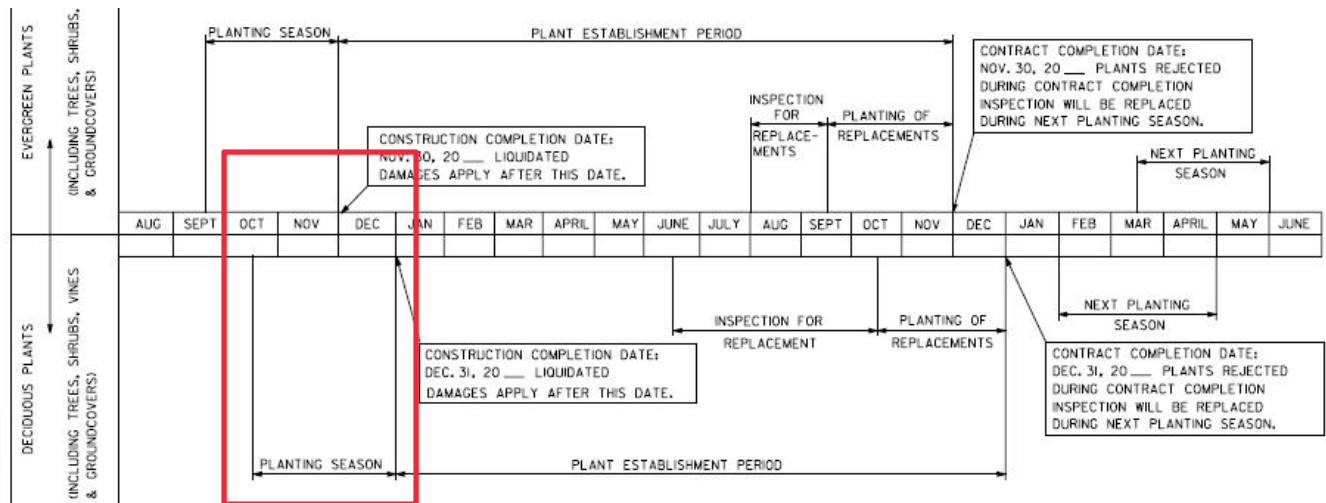
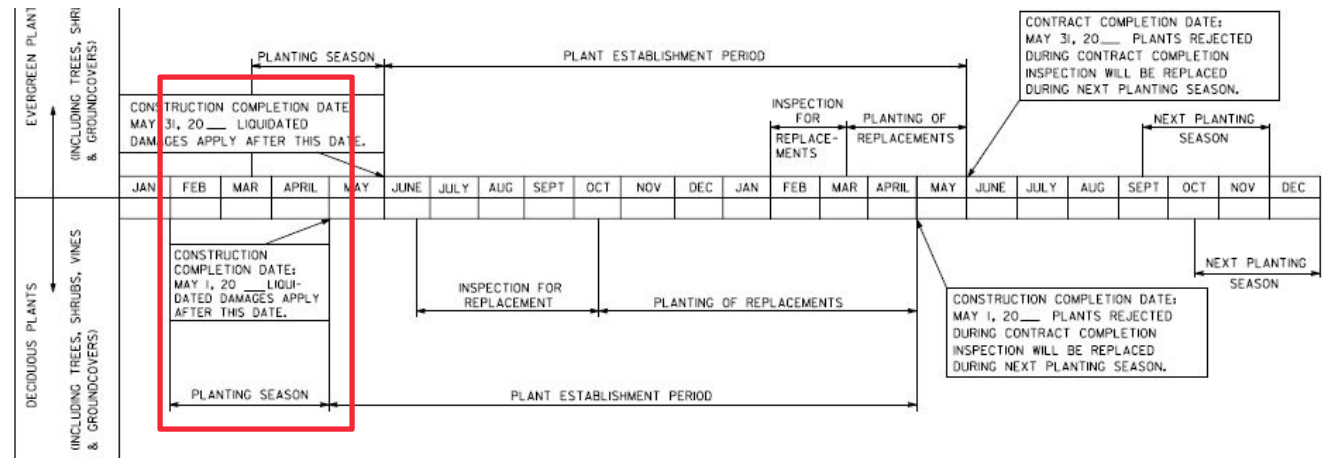
- 2 Planting Seasons
- Spring / Fall
- Contact UFA for a Ward assigned Arborist
- UFA inspections can happen any time



District Department of Transportation

Tree Planting

- 2 Planting Seasons
- Spring / Fall
- Contact UFA for a Ward assigned Arborist
- UFA inspections can happen any time



District Department of Transportation

Tree Protection

- Tree roots are often shallow like a pancake

How a Tree Grows

No



Yes

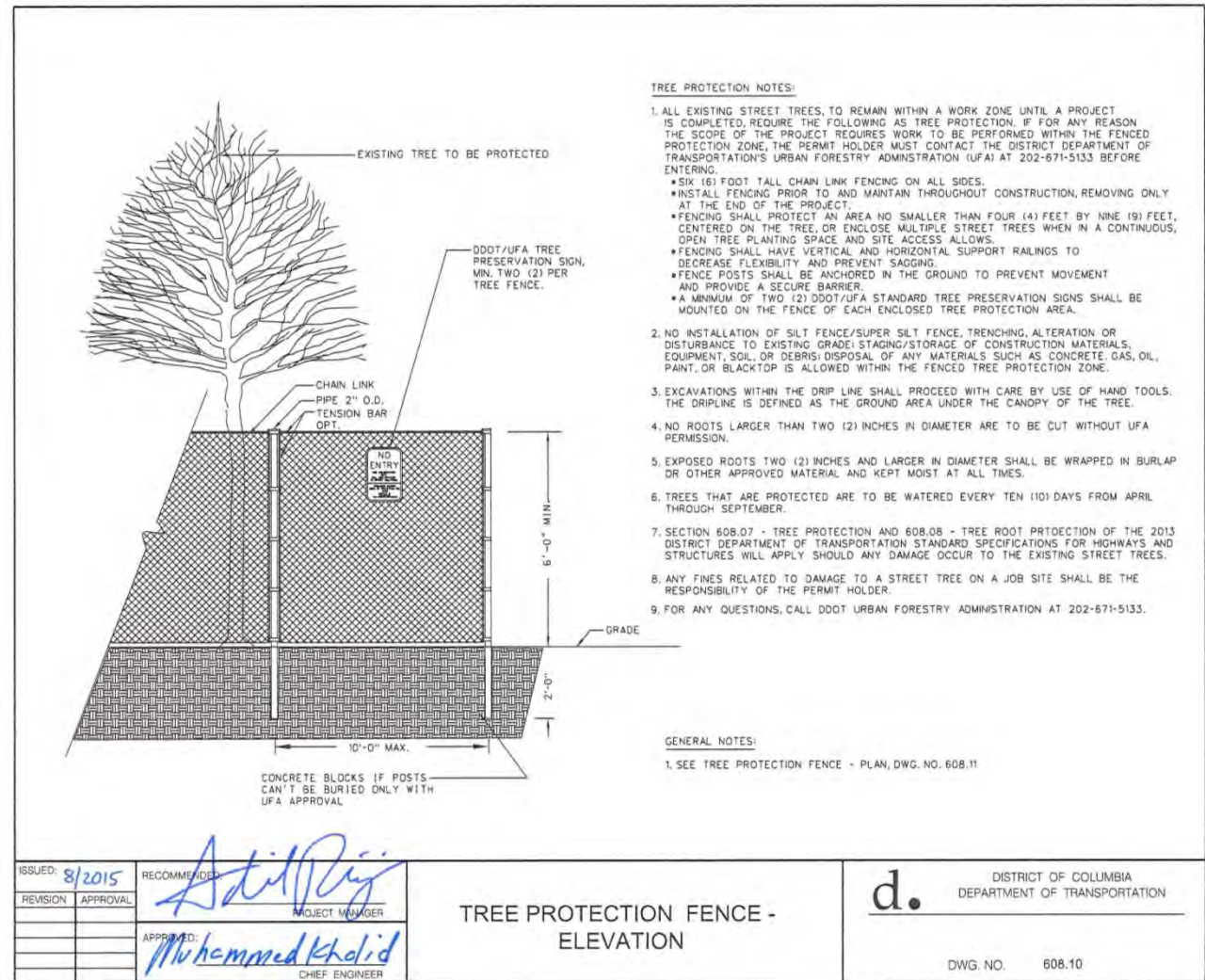


- First and Last phase of construction
- DOEE SWM Regulations implication
 - Preserved Trees: 20 cubic feet retention value
 - Planted Trees: 10 cubic feet retention value



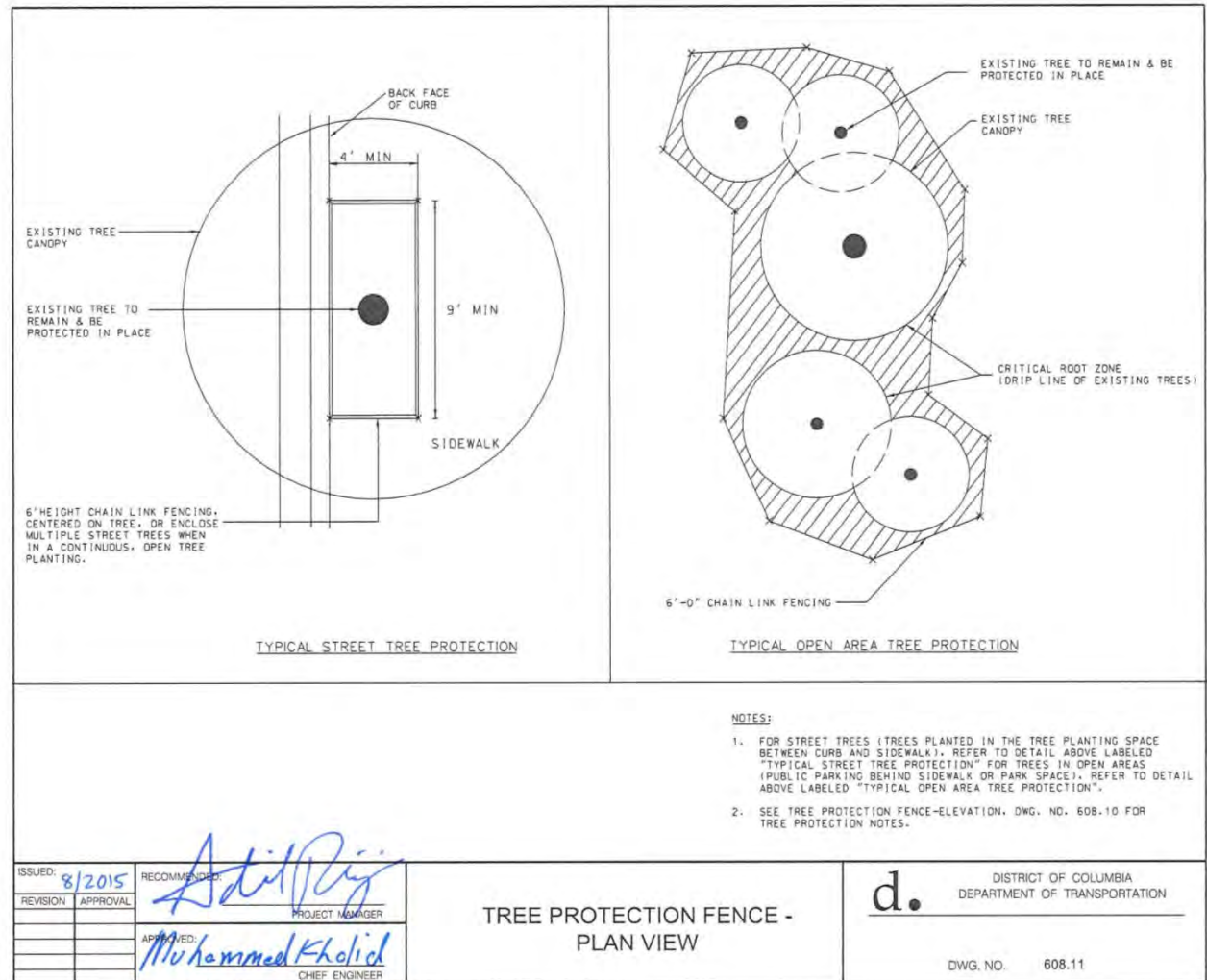
Tree Protection - Drawings

- 6' height chain link fence on all sides of existing tree
- 4' x 9' minimum (tree planting space) area
- Anchored to ground preferred
- Water weekly during construction
- No stocking of materials
- Contact UFA



Tree Protection - Drawings

- 6' height chain link fence on all sides of existing tree
- 4' x 9' minimum (tree planting space) area
- Anchored to ground preferred
- Water weekly during construction
- No stocking of materials
- Contact UFA



Tree Protection Fence - Good

- 6' height chain link fence on all sides of existing tree
- 4' x 9' minimum (tree planting space) area
- Anchored to ground preferred
- Water weekly during construction
- No stocking of materials
- Contact UFA

- 2013 DDOT Standard Specification, 608.07
TREE PROTECTION AND REPLACEMENT



Tree Protection Fence - Poor

- “Snow fence” no longer permitted
- No stocking of materials
- Contact UFA



District Department of Transportation

Tree Preservation Measures

Hand Digging



Air Spade



District Department of Transportation

Porous Rubber Paving

Before



After



District Department of Transportation

Tree Removal (Permit)



- **Street Tree Removal**
 - Located between curb and sidewalk
 - No Size Restrictions
 - TOPS → Const. Permit → Landscape
 - \$200 per inch dia.
 - 15 business days review period
- **Special Tree Permit **Amended Act***
 - Located behind the sidewalk and on private property
 - 44 - 100" circumference (~14 - 31.8" diameter)
 - TOPS → Special Tree Removal Permit
 - \$55/inch circumference or plant to match
 - 40 days from date assigned
- **Heritage Tree 100"+ = No Removal**

The Good, The Bad, and the Ugly

Top Ten Inspection Issues

1. Stone with too many fines (for infiltration and permeable pavement). Designers need to spec “double washed stone.”



Top Ten Inspection Issues

2. Not having the DOEE approved drawing on site
(working copy or latest unapproved revision is missing a
bmp in the PROW or shows a reduction in green roof
area)

?????

Top Ten Inspection Issues

3. Failing to protect a BMP during construction.



Top Ten Inspection Issues

3. Failing to protect a BMP during construction.



Top Ten Inspection Issues

3. Failing to protect a BMP during construction.



Top Ten Inspection Issues

4. Site grading doesn't direct stormwater to the BMP.



Top Ten Inspection Issues

5. Too many pipes/inputs into a stormwater vault (groundwater should be routed into the last vault chamber; condensate needs to be accounted for in the calculations if it comes into the first chamber)



Top Ten Inspection Issues

6. Failing to account for HVAC units/satellite dishes placed on green roofs.



Top Ten Inspection Issues

7. Compacting infiltration areas during construction (heavy equipment storage)



Top Ten Inspection Issues

8. Discharging through a stormwater vault before a final inspection while the site is still disturbed. A discharge permit from D.C. Water is required in the CSS. It is not allowed in the MS4.

9. Changing green roof material suppliers without DOEE approval (green roof media has lower max retention)

10. Submitting as-builts that are just copies of the approved drawing. Cross sections need to be to scale and actual invert elevations need to be provided.