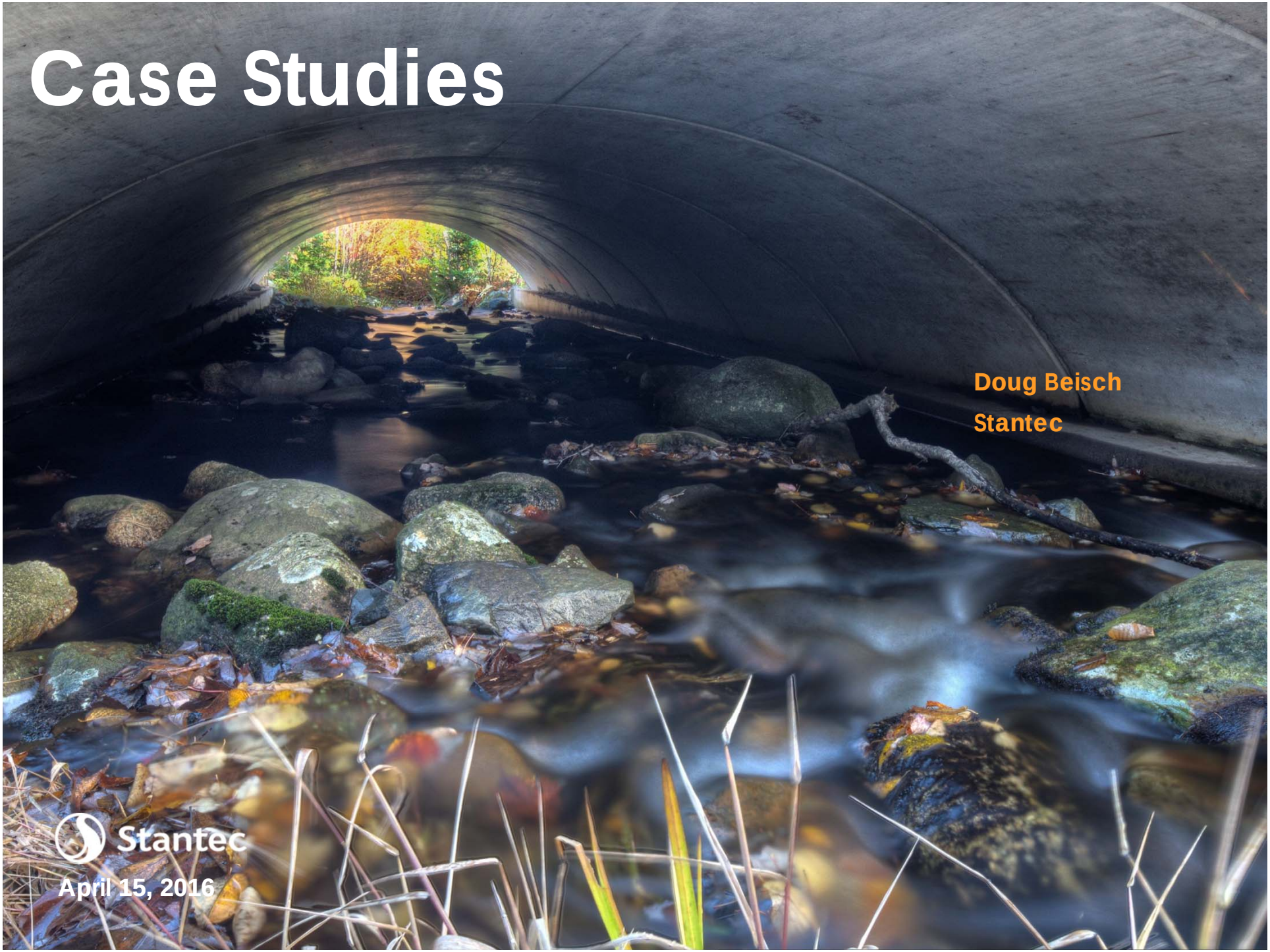
Case Studies



Doug Beisch
Stantec

Stantec

April 15, 2016

LID/Better Site Design Case Study

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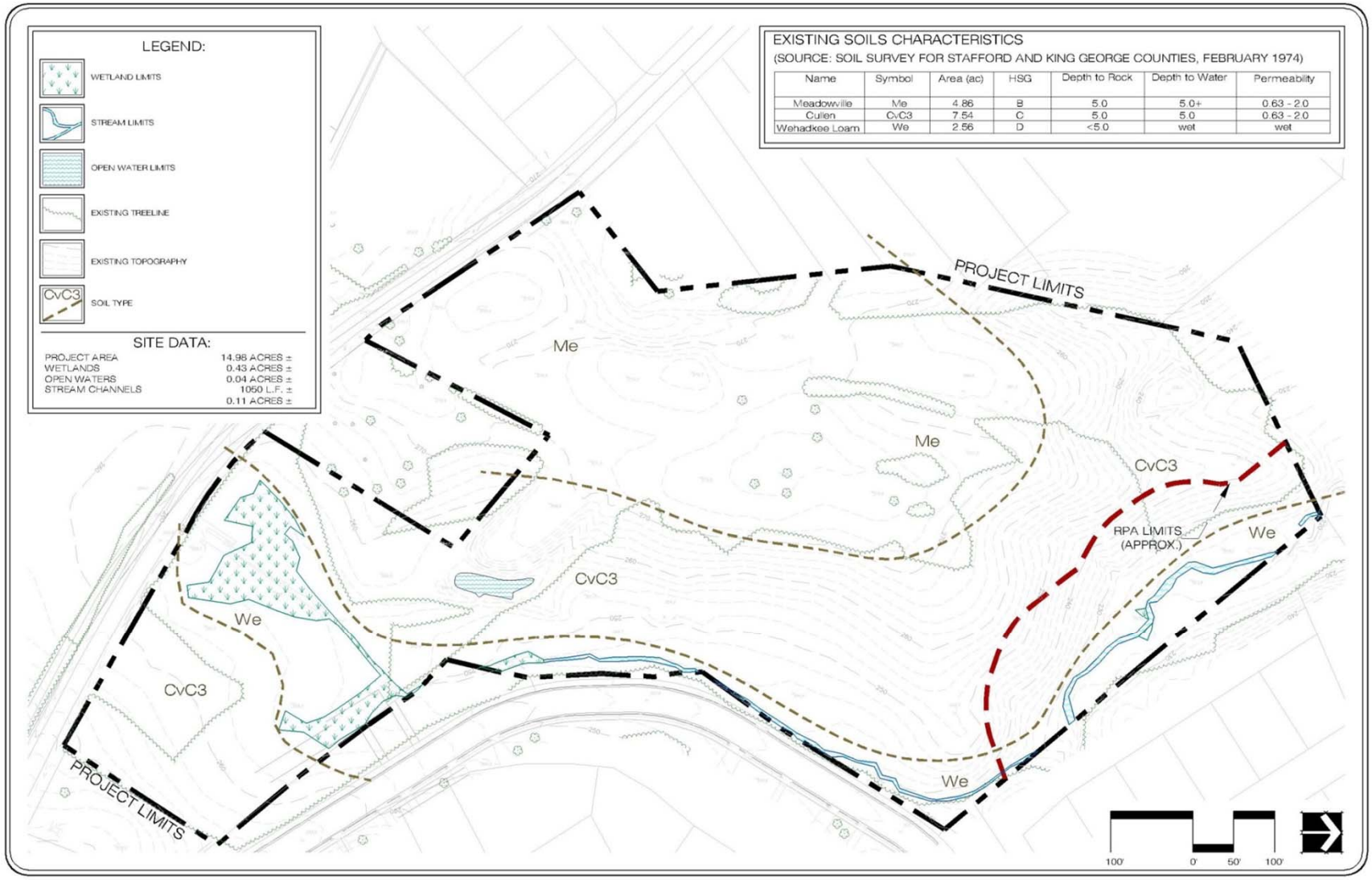
CONSTRAINTS ANALYSIS



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Constraints - Things to Consider

- Riparian Buffers
- Wetlands and Stream Channels
- Existing Woods
- Transitional buffers
- Soils Constraints (Texture, HSG, Perm., Bedrock, Water Table)
- Slope Constraints
- Access to Site

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Constraints Actually Used on the Site

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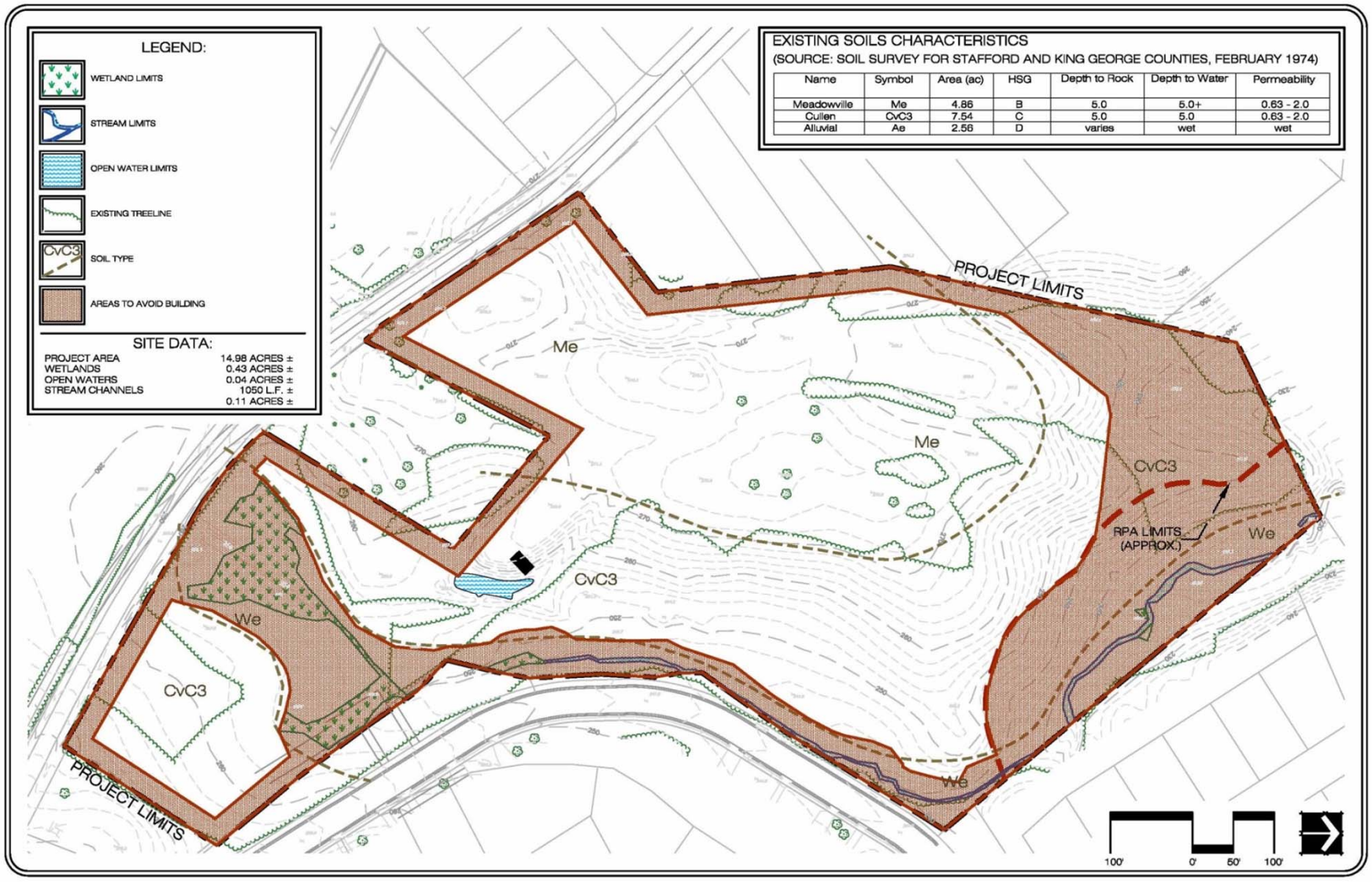
Constraints Used



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Criterion – By Right Layout

- Half Acre Lot – Minimum Lot Size
- Site Yield - up to 25 Lots
- Access from Road to South

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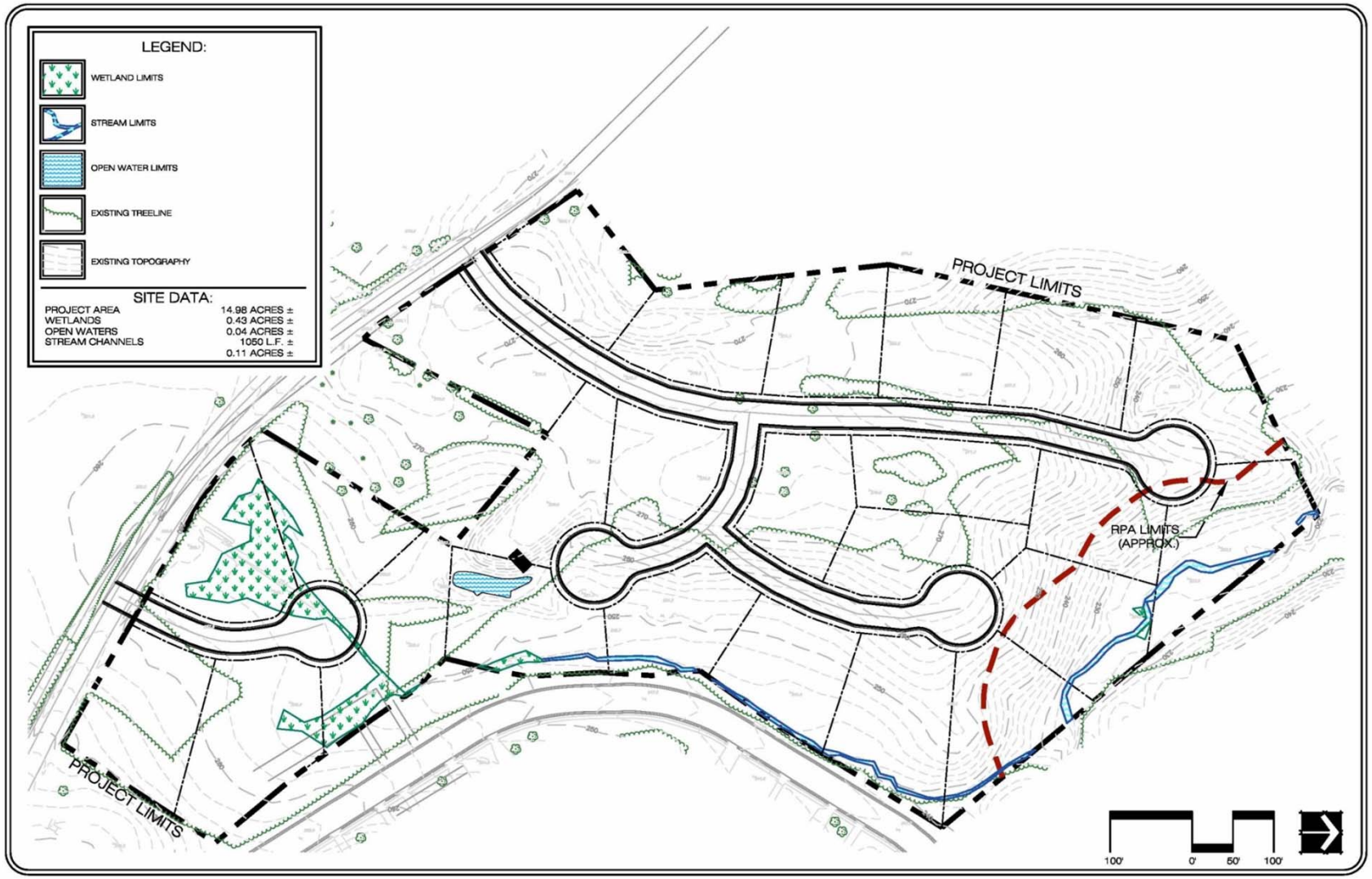
Typical Layout



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Effects of Typical Layout

- Clearing of entire site
- Significant Impacts to Wetlands and Stream Channels
- Impacts to designated Riparian corridors
- Dramatic Increase in Impervious Cover
- Directly Connected Drainage Systems

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Goals and Objectives

- Assume 10,000 s.f. cluster lots can be used
- Assume open section roadways can be used with smaller ROW
- Minimize Land Disturbance
- Minimize Impervious Cover
- Try to Avoid Constraints

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LAYOUT ACTUALLY USED

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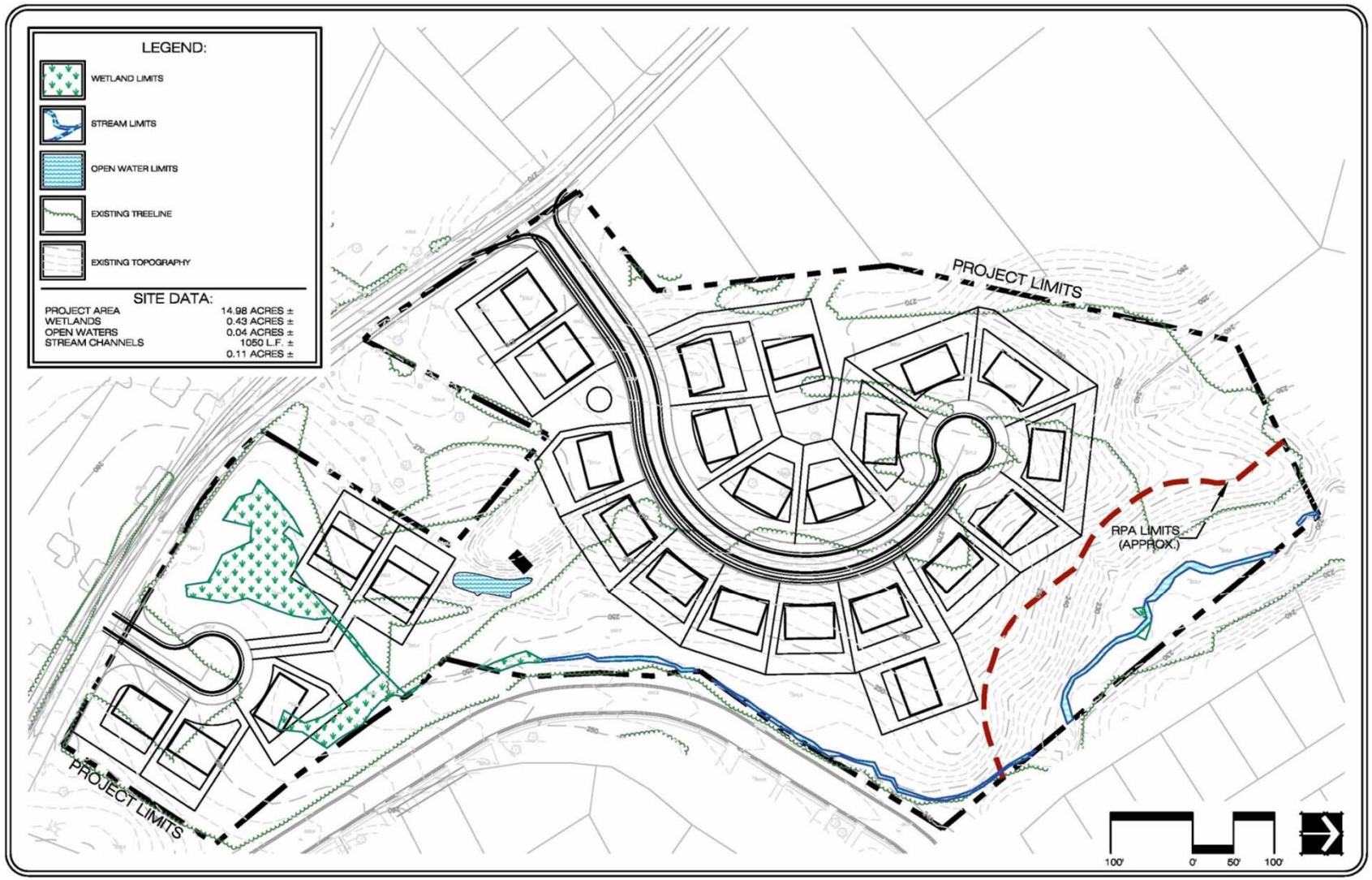
Cluster Layout



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Approach for Analysis/Benchmarking

- Natural Site (Undisturbed Woodland)
- Existing Site (Partially Disturbed/Denuded)
- Developed Site (Typical By-Right Layout)
- Cluster Layout
- Cluster Layout (with Resource Restoration and buffers)
- Then……LID

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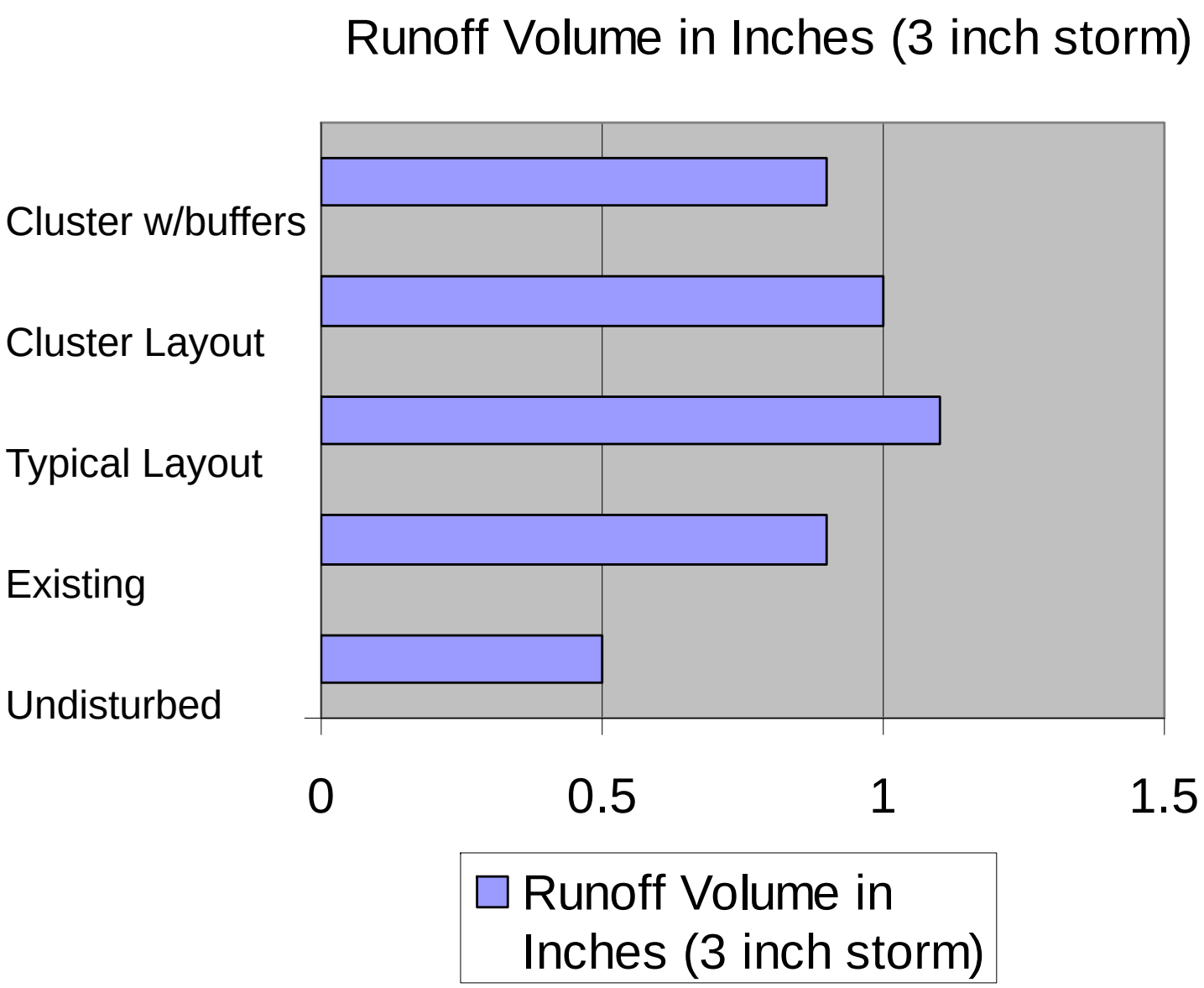
Runoff Volume in Inches (3 inch storm)
Cluster w/buffers
Cluster Layout
Typical Layout
Existing
Undisturbed
0
0.5
1
1.5
Runoff Volume in Inches (3 inch storm)

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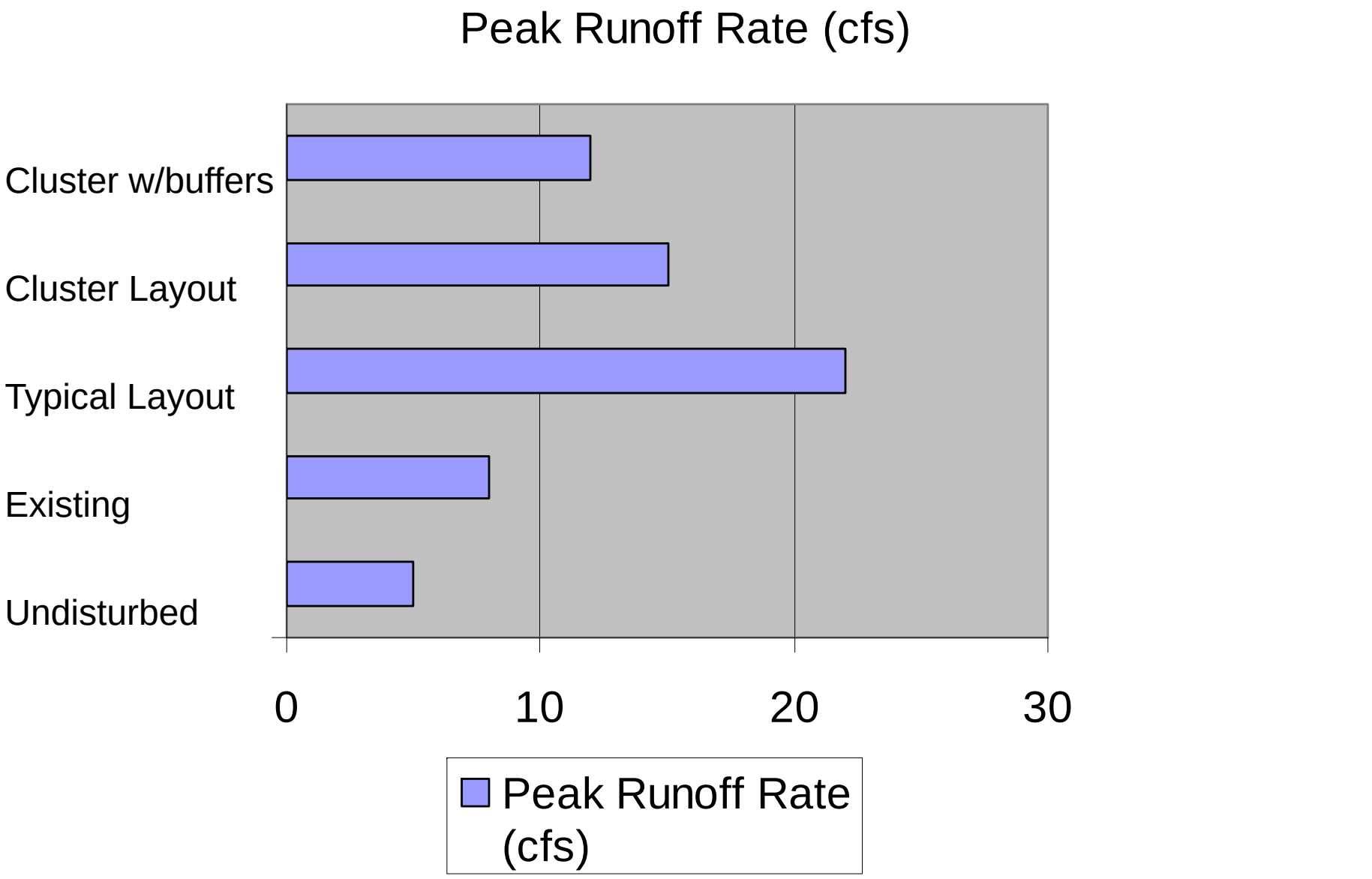
Peak Runoff Rate (cfs)
Cluster w/buffers
Cluster Layout
Typical Layout
Existing
Undisturbed
0
10
20
30
Peak Runoff Rate (cfs)

LID Volume Target

- Utilize LID measures where feasible to bring the site back to the same hydrologic response as an undisturbed site
- Practices are listed on the worksheet
- Runoff Capture Goal has been determined as **22,000 cubic feet**

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LID EXERCISE

GOAL FOR TREATMENT: LOCATE ENOUGH LID PRACTICES TO COVER APPROXIMATELY 22,000 cubic feet of runoff

Practice	Storage Ratio	Limits	Cost
Engineered Swale	1 c.f./l.f. of Swale		$10/lf
Rain Barrel	6 c.f./barrel	(Max 4 per house)	$200/barrel
Soil Amendments	1 c.f./10 s.f.	must receive sheet flow from IC	$1.50/s.f.
Biofilter	1 c.f./s.f.	Min 150 s.f. per filter	$15/s.f.
Vegetated Filter Strip	1c.f/5 s.f	Must be flat Limits on drainage area	$0.75/s.f.
Infiltration Trenches	1 c.f/l.f.	Must be in B type soils Must be level	$7/l.f.
Porous Pavements	1 c.f./6 s.f.	Driveways Only cost are additional to reg. pvmt.	$4/ s.f.
Pocket Wetlands	1 c.f./2-3 s.f.	Doesn't provide volume credit	$4/s.f.

* **Note that the practice costs, limitations and ratios are highly simplified and are for use in this exercise only**

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Final Design Selected

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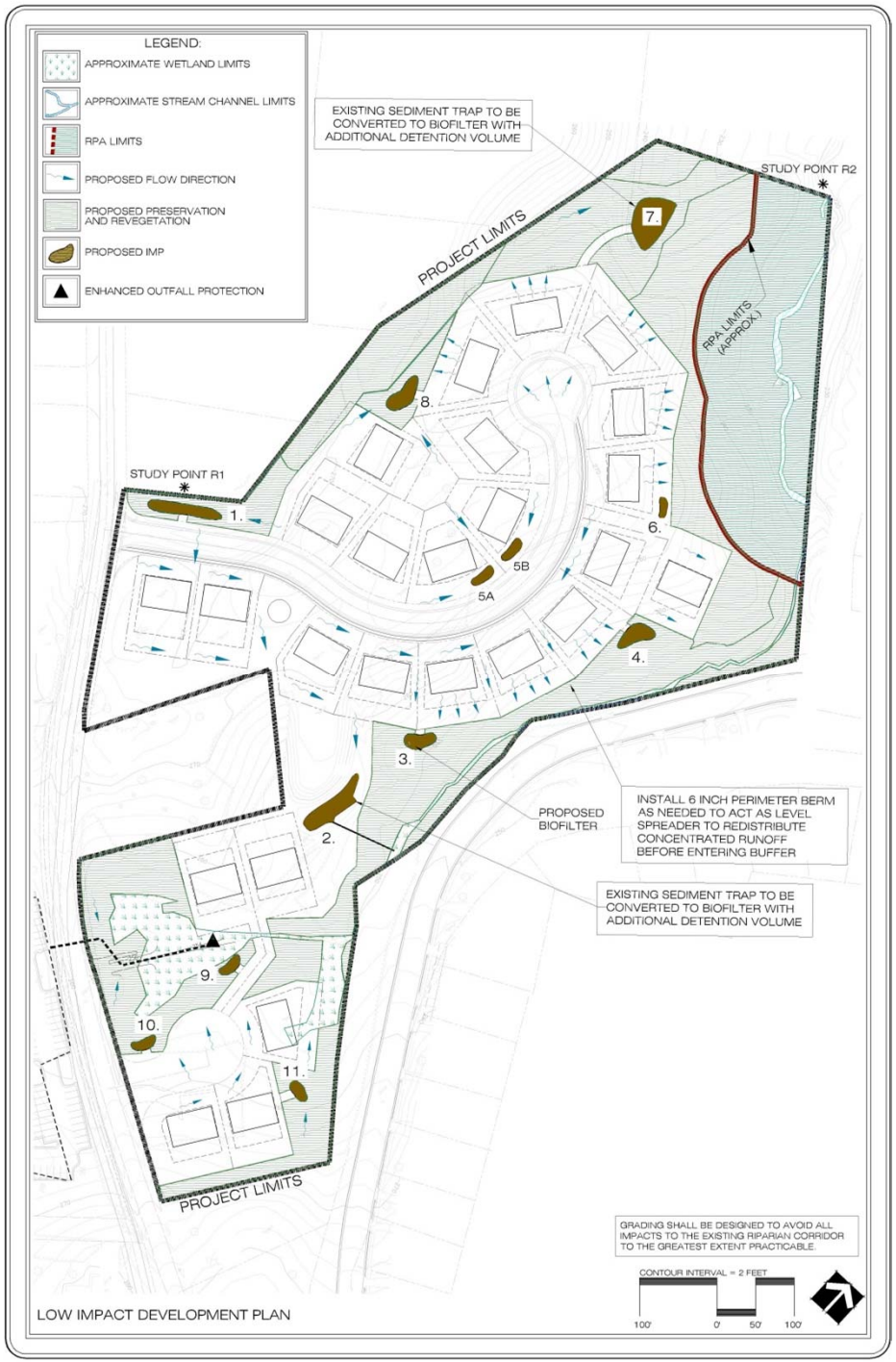

Final Site Design:

- Riparian Buffer Restoration
- Use of Open-section roads
- On-lot and common area practices
- Maintenance of natural drainage patterns
- Use of engineered swales

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Code and Ordinance Barriers

- DOT/County hesitant to allow C&G redux
- PC Review required for cluster
- County hesitant to allow on-lot measures
- Special variance required for C&G redux
- Confusion over design standards
- Requirements much more rigorous than conventional approaches
- DOT entrance requirements required redesign of cluster

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Innovative Site Design Case Study

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Innovative Solutions

- Innovative Site Design
- Municipal Programs:
  - Fee-in-lieu Programs
  - Pro-rata
- Cooperative off-site facilities (developer driven)
- Nutrient Banking
- State or Trust-administered Fund

Site Design Example

Pretreatment with LID Practices

Enhanced Forebays

Stormwater Regional Pond Restoration

Stream Day-lighting and Restoration

Riparian Buffer Restoration

Dam Rehabilitation

Spillway Rehabilitation

Stream Daylighting

Stream Daylighting

Riparian Buffer Restoration

Site Design Case Study

Results

- Expedited Permitting Process
- More Flexible Site Design
- Erosion Hazard Eliminated
- Excess Credits for use in sub-watershed
- Downstream Systems Restored
- Water quality from 200+ acres of contributing area retrofitted
- Project is self-mitigating

Trading Case Study

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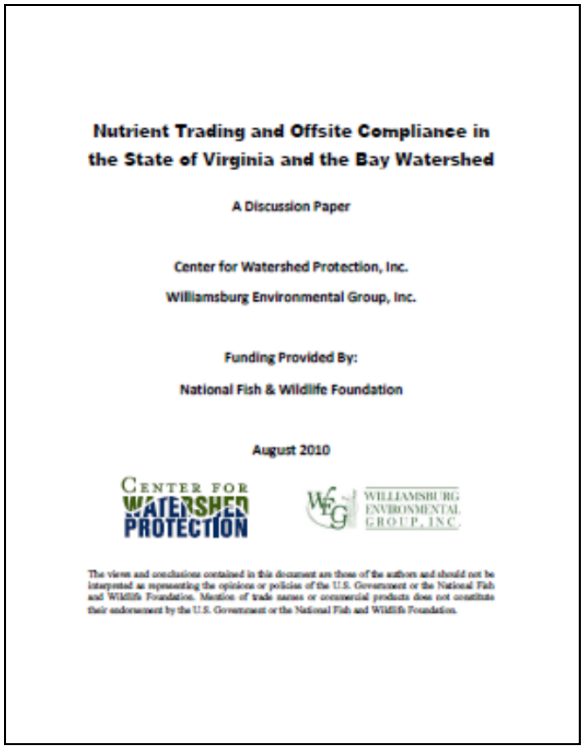
Trading Concepts

- Source Sector Trading
- In-kind trading
- Credits vs. Offsets
- Technologies may vary
- ‘Additionality’
- Trading Ratios



Nutrient Trading and Offsite Compliance in the State of Virginia and the Bay Watershed

A Discussion Paper

Center for Watershed Protection, Inc.

Williamsburg Environmental Group, Inc.

Funding Provided By:

National Fish & Wildlife Foundation

August 2010

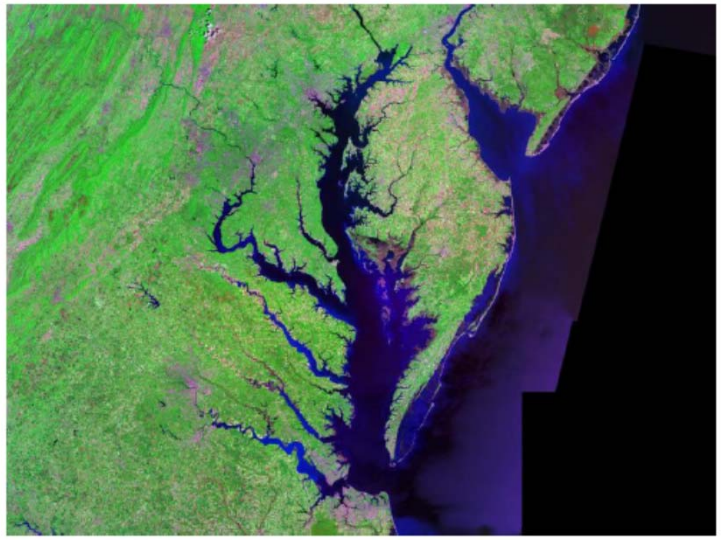
CENTER FOR WATERSHED PROTECTION

WEG WILLIAMSBURG ENVIRONMENTAL GROUP, INC.

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government or the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Government or the National Fish and Wildlife Foundation.

Nutrient Trading in a Nutshell

- Local/Regional/National watershed protection/improvement initiatives
  - Ambitious surface water quality improvement targets
- Costs of on-site treatment are growing/disproportionate
- "Coin of the realm" varies
- Trading Programs are gaining favor throughout U.S.
- Credits derived from treatment, land conversion, reduction of existing discharges

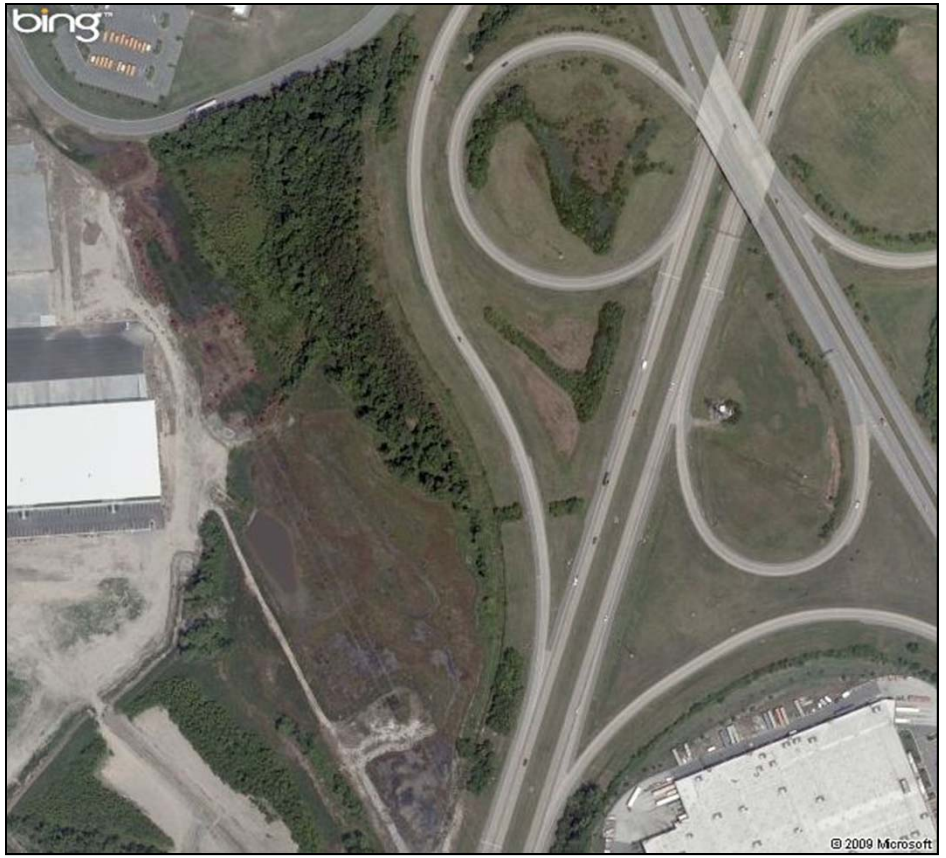


PHOSPHORUS LOADS TO THE BAY BY STATE
(Annually, in millions of pounds)

State	1985	2008	Target
District of Columbia	1.28	0.14	0.13
Delaware	0.53	0.34	0.28
Maryland	6.27	3.10	3.04
New York	1.26	0.83	0.56
Pennsylvania	5.73	3.98	3.16
Virginia	12.42	7.18	7.05
West Virginia	0.93	0.72	0.62
Total	**28.42**	**16.29**	**14.84**

Project Example

- Utility company RE group
- Studied 8000-ac watershed
- Review WQ improvement objectives
- Inventory Offset Opportunities
- Project Feasibility Review



Project Example (cont.)

- 3 treatment areas
- Opportunities focused on marginal, flood-prone land under overhead transmission line
- 10 Ac (+/-) of treatment wetlands
- Credits - Offset 1 square mile of developed land
- **Value of Credits ~ $3-6,000,000**
- Credits utilized w/in ~3 yrs of credit availability

Permeable Pavement and Bioretention Issues/Case Studies

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Background and Why: The Need

- Conflicts in Standards and Special Provisions
  - design vs. construction oriented
  - functional component variations among BMPs
- Standardize BMPs for large agency
  - reduce design/construction cost
  - greater consistency across state
  - reduce confusion & errors
  - lower long term maintenance and cost

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Background and Why: The Need

- Bioretention Soil Media Testing Conflicts
  - Chemical and physical parameters have a push/pull; meeting all constituents can be difficult. (e.g. high sand & low P conc.)
  - Project hold-ups: failure of vendor media to pass 3rd party soil tests OR confusion as to which version of standard to use.
- Porous Pavement
  - Lack of endorsed DOT standard
  - Growing desire in industry to promote porous pavements
  - Growing experience base of installers/materials vendors

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Approach and Framework

- Stormwater BMP Stds & Specs
  - Insertable Sheet:
    - Provide standard and consistent format for designers to complete, for inclusion in overall construction plan sets
  - Special Provisions:
    - Create standard specification for BMP materials, installation procedures, inspection and approval process, measurement and payment
  - Construction Documentation vs. Design
  - Incorporate existing VDOT Road & Bridge Standards & Specs where possible
  - Utilize Existing VDOT Processes and Formats

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Approach and Framework

- VDOT Road & Bridge Stds & Specifications

SECTION 100

DRAINAGE ITEMS

STANDARD	TITLE	PAGE
EC-7	TYPICAL SEDIMENT TRAP	113.11
EC-8	DEWATERING BASIN	113.12
EC-9	TEMPORARY DIVERSION DIKE	113.13
EC-10	TEMPORARY BERM AND SLOPE DRAIN	113.14
EC-11	STABILIZED CONSTRUCTION ENTRANCE	113.15
EC-12	TEMPORARY DIVERSION CHANNEL	113.16
EC-13	RIPRAP WEIRS: LOW FLOW DIVERSION FOR MULTIPLE LINE CULVERTS	113.17
EC-14	TEMPORARY VEHICULAR WATERCOURSE CROSSING	113.18
SWM-1	STORMWATER MANAGEMENT DRAINAGE STRUCTURE	114.01
	PRECAST STORMWATER MANAGEMENT DRAINAGE STRUCTURE	114.02
	STORMWATER MANAGEMENT DRAINAGE STRUCTURE - GRATE DETAILS	114.03
SWM-DR	STORMWATER MANAGEMENT (SWM) DETAILS	114.04
	STORMWATER MANAGEMENT (SWM) DETAILS	114.05
	STORMWATER MANAGEMENT (SWM) DETAILS	114.06
	STORMWATER MANAGEMENT (SWM) DETAILS	114.07
	STORMWATER MANAGEMENT (SWM) DETAILS	114.08

VDOT
ROAD AND BRIDGE STANDARDS

SHEET 6 OF 6	REVISION DATE
100.06	04/09

INDEX OF SHEETS
SECTION 100-DRAINAGE
VIRGINIA DEPARTMENT OF TRANSPORTATION

Approach and Framework

- Ex. VDOT Road & Bridge Stds & Specs

New SWM-8 Dry Swale Special Provision:

"All drainage structures and pipe shall conform to Section 232, unless otherwise specified and approved by VDOT."

Existing VDOT RnB Specifications

SECTION 232—PIPE AND PIPE ARCHES

232.01—Description

These specifications cover materials used for the conveyance of water, including drainage, storm water, sanitary systems, and waste water.

232.02—Detail Requirements

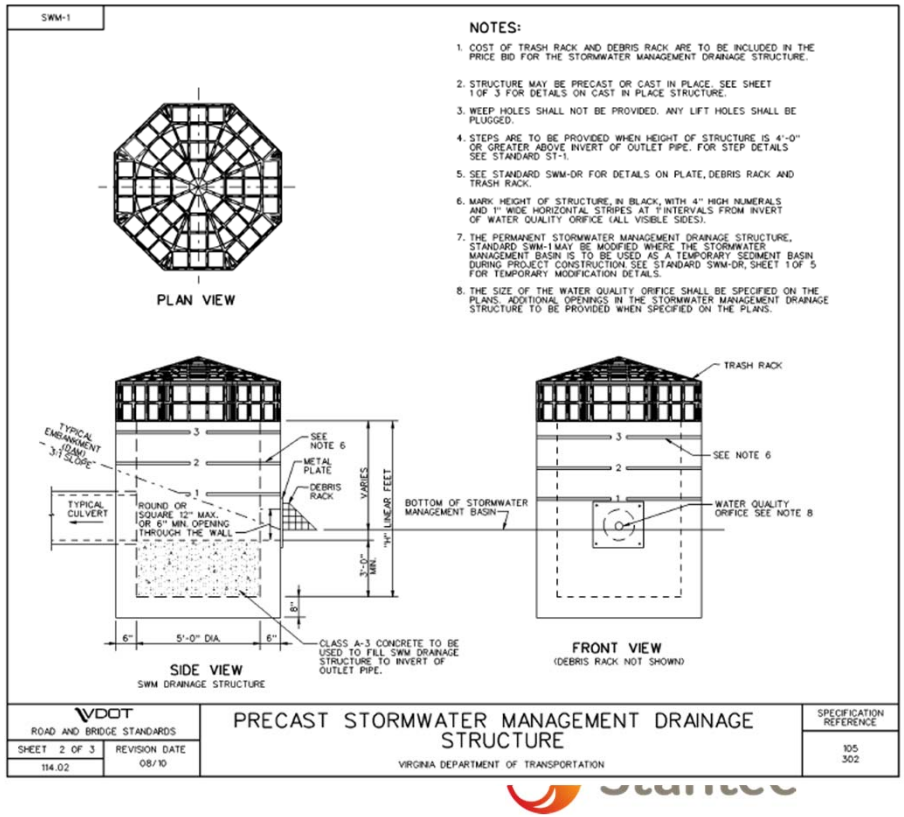
The Contractor shall obtain and provide from his supplier a quality control plan acceptable to the Department for determination of conformance with the applicable requirements in the production of concrete and corrugated metal culvert and underdrain pipe.

(a) **Concrete Pipe:**

1. **Concrete pipe for culverts and sewers** shall be circular or elliptical in cross-section, either plain concrete or reinforced concrete, and of the modified tongue-and-groove de-

SECTION 100

DRAINAGE ITEMS



Stormwater BMPs

- List of DRAFT Stormwater BMP Insertable Sheets & Special Provisions
  - SWM-2: Sheet Flow to Vegetated Filter Strip
  - SWM-3: Grass Channel
  - SWM-4: Soil Compost Amendments
  - SWM-5: Permeable Pavement
  - SWM-6 Infiltration Practices
  - SWM-7: Bioretention
  - SWM-8: Dry Swale
  - SWM-9: Wet Swale
  - SWM-10: Filtering Practice
  - SWM-11: Constructed Wetland
  - SWM-12: Sediment Basin/Trap Conversion to Bioretention
  - SWM-MISC: Stormwater Miscellaneous
  - SWM-PP: BMP Plant Palette
- Associated Material
  - Virginia Test Method for Bioretention Soil Media
  - Pre-approved Porous Asphalt Mix Designs and specifications
- …

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Stormwater BMPs

- Format of BMP Insertable Sheets
  - Plan View
  - Profile
  - Cross-Section
  - Material and Sizing Tables
    - Dimensioning/Depths
    - Elevations/Inverts of BMP/pipes
    - Aggregate Type and Size
  - Direct Reference to Spec Provisions, Field Quality Control Procedures, Maintenance Schedule and Procedure

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SWM-8 Dry Swale Insertable Sheet

SWM-8 DRY SWALE

PROJECT MANAGER:
SURVEYED BY
DESIGN SUPERVISED BY:
DESIGNED BY:

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.			1

DESIGN FEATURES RELATING TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT

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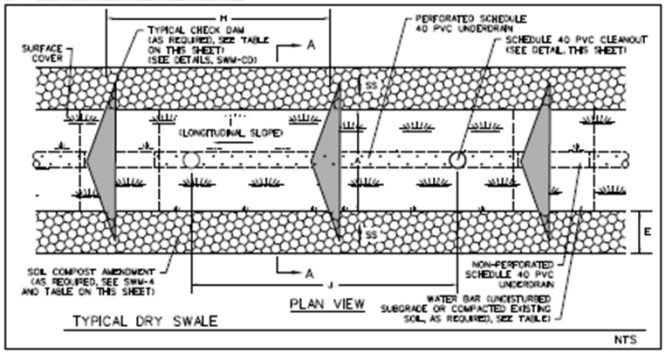


SPECIAL PROVISIONS

SEE BMP SPECIAL PROVISIONS FOR MATERIAL AND CONSTRUCTION PROCEDURE REQUIREMENTS. ANY VARIATIONS, CHANGES OR SUBSTITUTIONS TO THESE STANDARDS AND SPECIFICATIONS MUST BE APPROVED BY THE ENGINEER. APPLICABLE SPECIAL PROVISIONS FOR THIS STANDARD:

1.) SPECIAL PROVISION FOR DRY SWALE.

2.) SPECIAL PROVISION FOR SOIL COMPOST AMENDMENTS.

3.) SPECIAL PROVISION FOR STORMWATER MISCELLANEOUS.

GENERAL NOTES

1.) CONSTRUCTION OF THE DRY SWALE ENGINEERED SOIL MEDIA, UNDERDRAINS, AND SOIL COMPOST AMENDMENTS SHALL ONLY BEGIN AFTER THE ENTIRE CONTRIBUTING DRAINAGE AREA HAS BEEN STABILIZED WITH VEGETATION OR FINAL PAVEMENT.

2.) FINISHED GRADES SHALL HAVE A MINIMUM OF 3" OF TOPSOIL WHERE ANY PLANTING IS PROPOSED, UNLESS OTHERWISE SPECIFIED.

3.) ALL MATERIALS AND PROCEDURES TO BE IN ACCORDANCE WITH VDOT ROAD AND BRIDGE SPECIFICATIONS AND SPECIAL PROVISIONS.

4.) SEE CONSTRUCTION DRAWINGS FOR SPACING AND LAYOUT OF UNDERDRAINS.

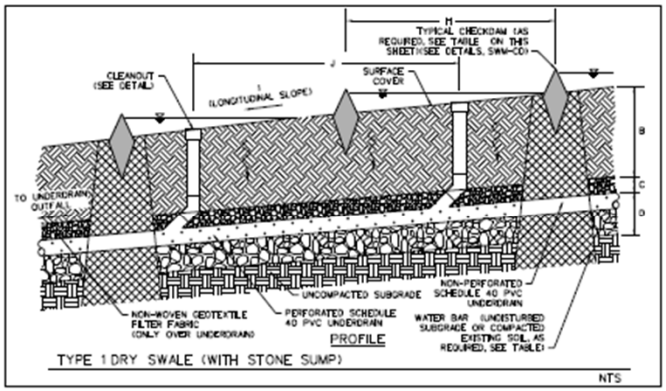
5.) SEE SWM-PT FOR PRETREATMENT OPTIONS.

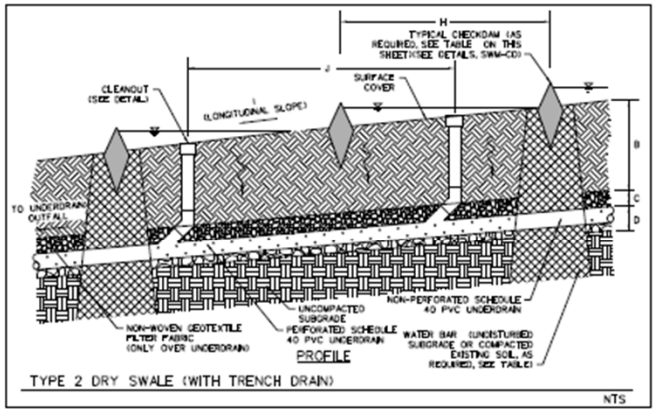
MAINTENANCE SCHEDULE AND PROCEDURE

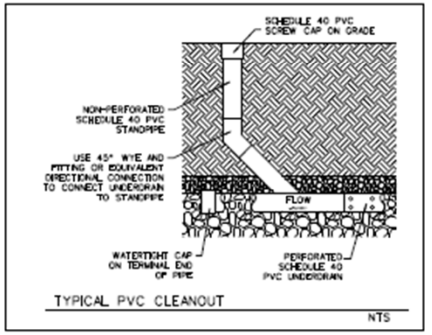
THE MAINTENANCE PROCEDURE SHALL FOLLOW THE VDOT POST-CONSTRUCTION BMP MAINTENANCE MANUAL, UNLESS PRIOR APPROVAL FROM THE ENGINEER IS RECEIVED FOR ALTERNATIVE MAINTENANCE PROCEDURES.

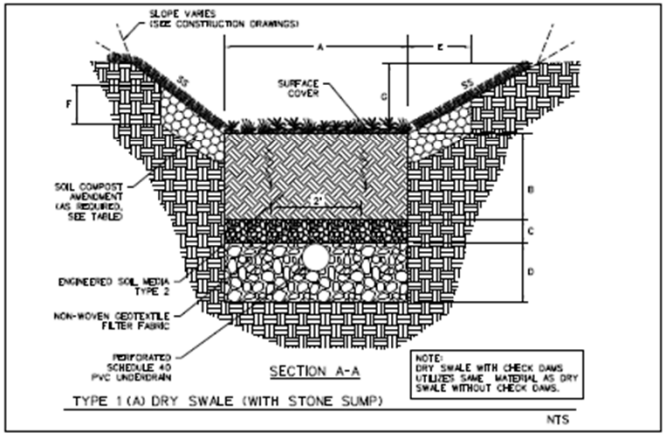
FIELD QUALITY CONTROL PROCEDURE

QUALITY CONTROL PROCEDURE SHALL BE FOLLOWED, SEE VDOT PROCEDURE FOR PRE, DURING, AND POST-CONSTRUCTION REQUIREMENTS.









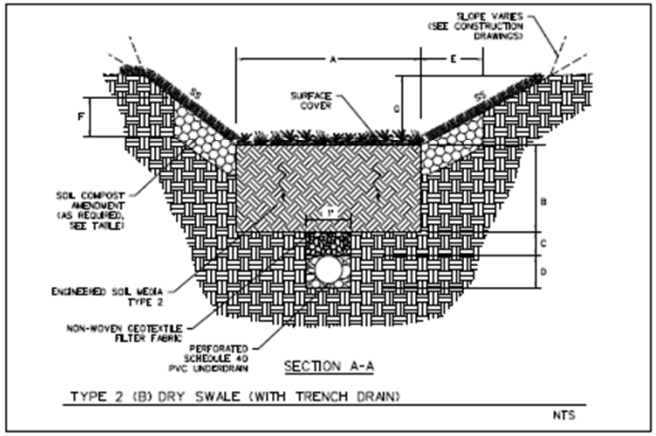


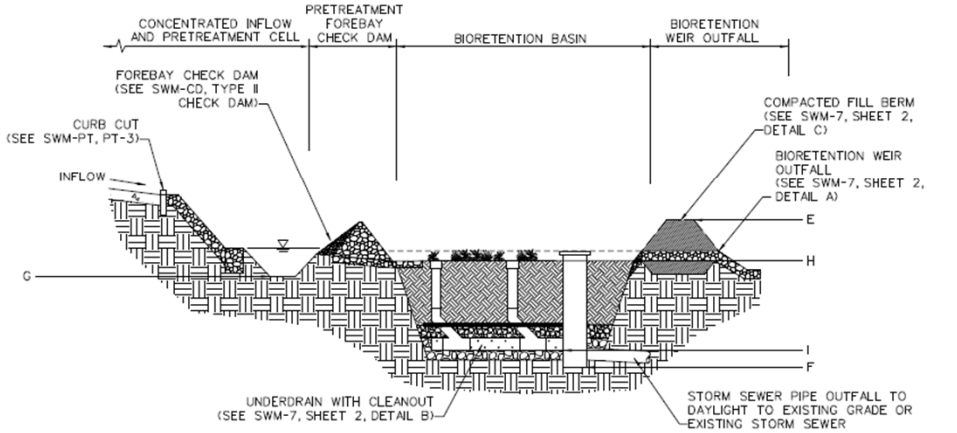
		TABLE: DRY SWALE DIMENSIONING TABLE (DSDT)			
		ELEMENT	UNIT	DIMENSION	NOTES
	A	SWALE BOTTOM WIDTH	FT		
	B	DRY SWALE SOIL MEDIA DEPTH	IN		
	C	CHOKER DEPTH	IN		VDOT #3 STONE
	D	SUMP DEPTH	IN		VDOT #57 STONE
YES / NO		SOIL COMPOST AMENDMENT			SEE SWM-4
	E	SOIL COMPOST AMENDMENT WIDTH	FT		AS REQUIRED
	F	SOIL COMPOST AMENDMENT INCORPORATION DEPTH	IN		AS REQUIRED
	G	SWALE DEPTH	FT		
	H	CHECK DAM SPACING	FT		
	I	LONGITUDINAL SLOPE	% SLOPE		
	J	CLEANOUT SPACING	FT		
	SS	SIDE SLOPES	FT/FT		MAX 3:1, 3:1 PREFERRED UP TO SWALE DEPTH (G)
YES / NO		WATER BAR SPACING	FT		
		DRY SWALE MEDIA/MATERIAL			
YES / NO		CHECK DAM	TYPE		WEEP HOLES AS REQUIRED
		SCHEDULE 40 UNDERDRAIN	DIA (IN)		UNDERDRAIN TO BE POSITIONED IN UPPER PORTION OF SUMP LAYER
		SURFACE COVER			SEE PLANTING PLAN

*DIMENSIONS IN THIS TABLE TO BE COMPLETED BY DESIGN ENGINEER

	PROJECT	SHEET NO.
		1

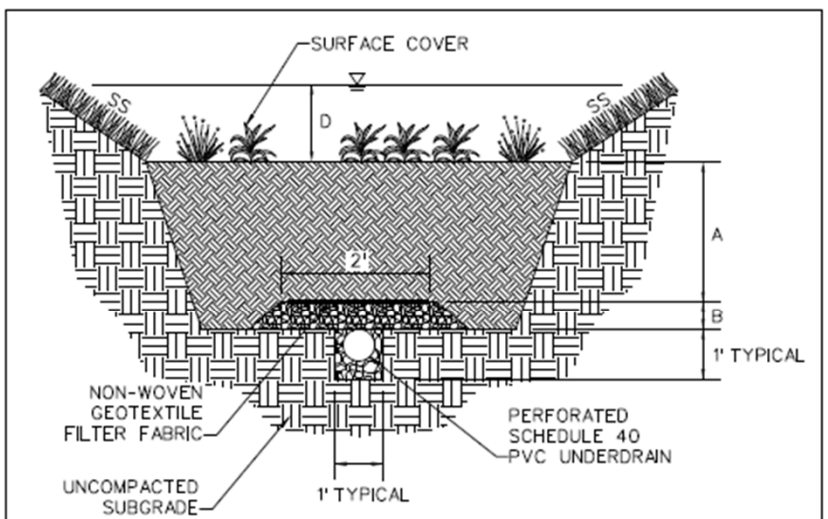
SWM-7 Bioretention

DRAFT



TYPICAL BIORETENTION PROFILE A-A

NTS



TYPE 2 TYPICAL BIORETENTION SUBGRADE CROSS SECTION (TRENCH DRAINED)

NTS

TABLE: BIOFILTER SUBGRADE DIMENSIONING TABLE (BSDT)				
	ELEMENT	UNIT	DIMENSION	NOTES
A	BIORETENTION SOIL MEDIA DEPTH	IN		INCLUDES MULCH (IF SPECIFIED)
B	CHOKER LAYER	IN		MINIMUM 3" DEPTH
C	SUMP LAYER	IN		
D	DEPTH OF PONDING	IN		
SS	SIDE SLOPES	FT/FT		3:1 MAXIMUM
	SURFACE AREA OF FILTER BED	SF		
BIORETENTION ELEVATIONS				
	ELEMENT	ELEVATION		NOTES
E	TOP OF BERM ELEVATION			
F	BOTTOM OF TRENCH SUMP			
G	PRETREATMENT FOREBAY/ CELL ELEVATION			
H	BIORETENTION BED SURFACE ELEVATION			
I	UNDERDRAIN INVERT			
BIORETENTION MEDIA/MATERIAL				
☐ HIGH IN SUMP ☐ LOW IN SUMP	UNDERDRAIN	DIA		PERFORATED SCHEDULE 40 PVC
☐ MULCH ☐ NO MULCH	SURFACE COVER	IN		SEE PLANTING PLAN
	SUMP LAYER	STONE SIZE		
	CHOKER LAYER	STONE SIZE		
	PVC CLEANOUT	DIA		SEE CONSTRUCTION DRAWINGS FOR LOCATION AND QUANTITY
	UNCOMPACTED SUBGRADE SOIL			AVOID COMPACTION OF SUBGRADE: RIPPING/ TILLING MAY BE REQUIRED IF COMPACTED: LINER MAY BE REQUIRED OVER STRUCTURAL FILL
BIORETENTION OUTFLOW TYPE				
☐	SWM RISER OUTFALL			SEE VDOT ROAD/BRIDGE STANDARDS
☐	BIORETENTION WEIR OUTFALL			SEE SWM-7, SHEET 2, DETAIL A

*DIMENSIONS IN THIS TABLE TO BE COMPLETED BY DESIGN ENGINEER

SWM-5 Permeable Pavement

PROJECT MANAGER: Jon Fred, MCP, CEP
SURVEYED BY: _____
DESIGN SUPERVISED BY: W. Douglas Beischel, P.E. (757-220-6669)
DESIGNED BY: Stantec Consulting Services, Inc. (757) 220-6669

SWM-5 PERMEABLE PAVEMENT (PARKING LOTS)

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.			1

DESIGN FEATURES RELATING TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT

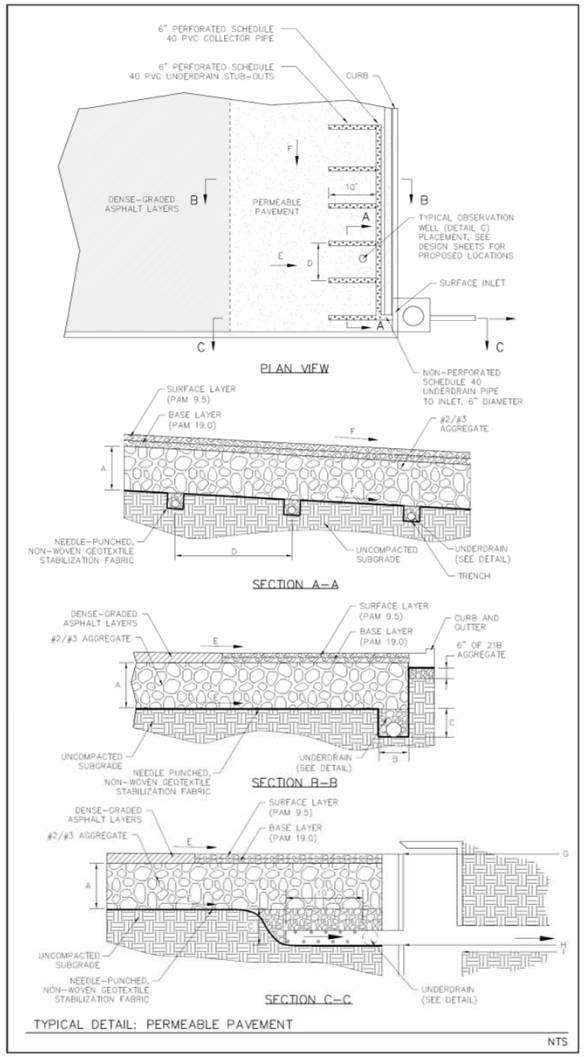


TABLE: PERMEABLE PAVEMENT DIMENSIONING TABLE (PPDT)

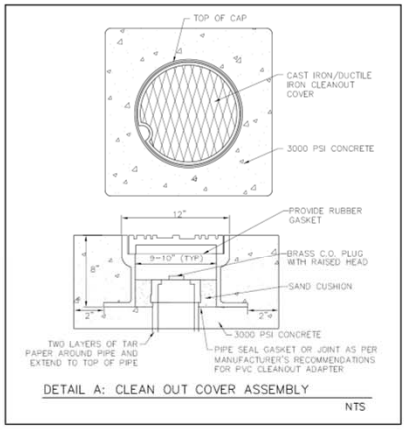
	ELEMENT	UNIT	DIMENSION	NOTES
A	RESERVOIR LAYER THICKNESS	IN		18" MINIMUM
B	TRENCH WIDTH	IN		12" TYP.
C	TRENCH DEPTH	IN		12" TYP.
D	UNDERDRAIN STUB SPACING	FT		
E	LONGITUDINAL SLOPE	% SLOPE		
F	CROSS SLOPE	% SLOPE		

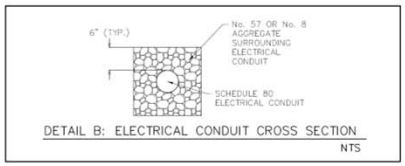
*DIMENSIONS TO BE COMPLETED BY DESIGN ENGINEER
*ALL MATERIALS TO BE IN ACCORDANCE WITH PERMEABLE PAVEMENT SPECIAL PROVISION AND ROAD AND BRIDGE SPECIFICATIONS.

TABLE: PERMEABLE PAVEMENT ELEVATION TABLE (PPET)

	THRESHOLD TYPE	ELEVATION	NOTES
G	SURFACE INLET, INVERT IN		
H	PERMEABLE PAVEMENT UNDERDRAIN OUTLET, INVERT IN		
I	INLET, INVERT OUT		MINIMUM 6" BELOW

*ELEVATIONS TO BE COMPLETED BY DESIGN ENGINEER





GENERAL NOTES

1.) THIS SHEET IS FOR A LEVEL 1 PERMEABLE ASPHALT DESIGN WITH UNDERDRAINS ONLY. A LEVEL 1 DESIGN ASSUMES NO INFILTRATION OF STORM WATER INTO THE SUBGRADE.

2.) MAXIMUM LONGITUDINAL SLOPE OF PARKING SURFACE IS 1%. MAXIMUM CROSS SLOPE OF PARKING SURFACE IS 0.5%. MAXIMUM BOTTOM SLOPE OF PAVEMENT STRUCTURE AT SUBGRADE SURFACE IS 1%. MINIMUM UNDERDRAIN SLOPE IS 0.5% AND A MAXIMUM SLOPE OF 1%.

3.) A LAYER BETWEEN PERMEABLE PAVEMENT AND RESERVOIR MAY BE PROVIDED, HOWEVER WILL BE INCIDENTAL AND FOR THE PURPOSES OF MEASUREMENT AND PAYMENT WILL NOT BE AN EXTRA PAY ITEM. IF A BEDDING LAYER IS PROVIDED, ASTM D448 No. 57 OR No. 8 AGGREGATE SHALL BE USED TO CHOKE THE SURFACE OF THE RESERVOIR LAYER FOR PAVEMENT PLACEMENT. MAXIMUM BEDDING LAYER THICKNESS IS 1".

4.) UNDERDRAIN PERFORATIONS TO BE > OR = TO 0.5"; ANY BENDS IN PIPE SUCH AS CLEAN-OUT TO UNDERDRAIN SHALL BE NO MORE THAN A 45 DEGREE ANGLE. PERFORATED PIPES SHALL TRANSITION TO SOLID PIPE BEFORE EXITING STONE RESERVOIR. NO PERFORATED PVC WILL BE WITHIN 1' OF THE SURFACE.

5.) INSTALLATION OF PERMEABLE PAVEMENT WILL BE LAST STEP IN OVERALL SITE CONSTRUCTION, WITH STRIPING TO FOLLOW. ALL LANDSCAPING SHALL BE PROVIDED PRIOR TO INSTALLATION OF POROUS PAVEMENT.

6.) ALL CONTRIBUTING DISTURBED AREAS MUST HAVE REACHED FINAL STABILIZATION PRIOR TO INSTALLATION OF THE RESERVOIR LAYER AND PAVING SURFACE. MATERIAL THAT HAS BEEN CONTAMINATED SHALL BE REMOVED AND REPLACED PROMPTLY BY THE CONTRACTOR AT NO ADDITIONAL EXPENSE TO THE DEPARTMENT. LIKELY INDICATIONS OF CONTAMINATION INCLUDE, BUT ARE NOT LIMITED TO, THE SURFACE BEING CLOGGED BY DIRT OR OTHER FOREIGN MATERIAL OR OBSERVABLE MATERIAL DAMAGED AS IN THE CASES OF LOSS OF MATERIAL STABILITY.

7.) NO SEDIMENT TRACKING OR DEPOSITION ON PERMEABLE PAVEMENT ALLOWED.

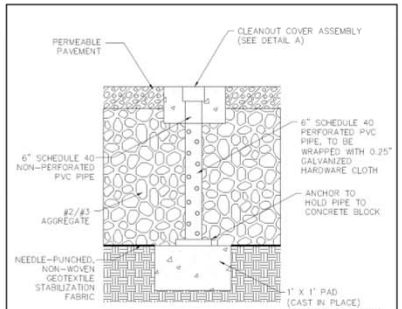
8.) CONTRACTOR SHALL PREVENT CONTAMINATION OF PERMEABLE PAVEMENT SURFACE.

9.) HEAVY CONSTRUCTION EQUIPMENT SHALL BE PROHIBITED FROM TRAVERSING PERMEABLE PAVEMENT.

10.) OBSERVATION WELLS, CLEANOUTS, AND UNDERDRAINS TO BE INSTALLED ACCORDING TO LOCATIONS SHOWN ON CONSTRUCTION DRAWINGS.

11.) ALL MATERIALS AND PROCEDURES TO BE IN ACCORDANCE WITH VDOT ROAD AND BRIDGE SPECIFICATIONS AND SPECIAL PROVISIONS.

12.) A PERMEABLE PAVEMENT LEVEL 2 SYSTEM WITHOUT UNDERDRAINS MAY BE ACCEPTABLE UNDER CERTAIN CIRCUMSTANCES AND ONLY UPON APPROVAL OF THE ENGINEER. SUCH SYSTEMS MUST CONFORM TO MINIMUM INFILTRATION REQUIREMENT AND TESTING PROCEDURES PRIOR TO AND FOLLOWING CONSTRUCTION.



FIELD QUALITY CONTROL PROCEDURE

QUALITY CONTROL PROCEDURE SHALL BE FOLLOWED. SEE VDOT PROCEDURE FOR PRE, DURING, AND POST-CONSTRUCTION REQUIREMENTS.

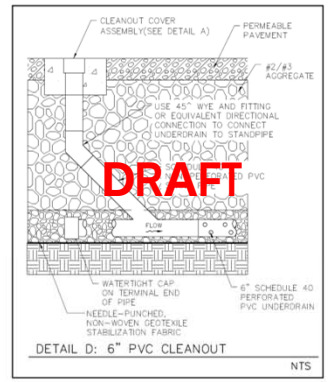
MAINTENANCE SCHEDULE AND PROCEDURE

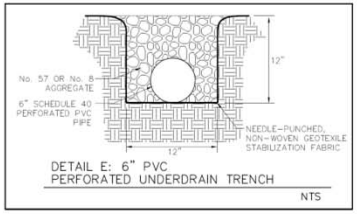
THE MAINTENANCE PROCEDURE SHALL FOLLOW THE VDOT POST-CONSTRUCTION BMP MAINTENANCE MANUAL, UNLESS PRIOR APPROVAL FROM THE ENGINEER IS RECEIVED FOR ALTERNATIVE MAINTENANCE PROCEDURES.

SPECIAL PROVISIONS

SEE BMP SPECIAL PROVISIONS FOR MATERIAL AND CONSTRUCTION PROCEDURE REQUIREMENTS. ANY VARIATIONS, CHANGES OR SUBSTITUTIONS TO THESE STANDARDS AND SPECIAL PROVISIONS MUST BE APPROVED BY THE ENGINEER. APPLICABLE SPECIAL PROVISIONS FOR THIS STANDARD:

1.) SPECIAL PROVISION FOR PERMEABLE PAVEMENT.
2.) SPECIAL PROVISION FOR NEEDLE-PUNCHED, NON-WOVEN GEOTEXTILE STABILIZATION FABRIC.
3.) SPECIAL PROVISION FOR LOW PERMEABILITY LINERS FOR STORMWATER MANAGEMENT FACILITIES.
4.) SPECIAL PROVISION STORMWATER MISCELLANEOUS.
5.) SPECIAL PROVISION FOR POROUS ASPHALT MIXTURES.





PROJECT	SHEET NO.
	1

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SWM-8 Dry Swale Special Provision

- Format of BMP SP
  - I. Description
  - II. Materials
  - III. Procedures
  - IV. Tolerance
  - V. Inspection & Maintenance
  - VI. Measurement & Payment

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
DRY SWALE

DRAFT July 1, 2015

I. DESCRIPTION

This work shall consist of construction, testing inspection and maintenance for dry swale facilities with the requirements herein and in conformity with the lines, dimensions, grades, and thickness as shown on the plans and/or as directed by VDOT. The construction of dry swale facilities shall encompass all activities and materials discussed and specified for explicit proper function of the facilities. Further description and graphical representation is shown on dry swale sheet SWM-8. All referenced sections herein are to the current VDOT Road and Bridge Standards and Specifications, unless otherwise noted.

II. MATERIALS

(a) Excavation shall consist of the design sub-grade for the facility as well as the grading required to achieve design slopes. All excavation shall conform to Section 303.

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Bioretention Soil Media Specs

Parameter	BMP Clearinghouse	VDOT VTM - 134 DRAFT	NOTES
Sand Content	>75% course; see Sieve Table; D10>0.3mm; (D60/D10)<4.0	80-90%; see Sieve Table; D10>0.25mm; (D60/D10)<5.0	VTM specs fine aggregate (sand) and soil fines to be 80-90% fine aggegrate; See separate Sieve Distribution Table
Fines	10%-20% w/ clay <=10%	10%-20% w/ clay <=10%	
Organic Content	3%-5% combined mix; dry weight basis	2%-5% overall mix, by weight	
CEC	>5.0 meq/100g	>5.0 meq/100g	Cation Exchange Capacity
Avail. P	5-15 (M1) or 18-40 (M3)	5-15 (M1) or 10-40 (M3)	M1: Mehlich I procedure
Infiltration rate	None	1 in/hr – 8 in/hr	Clrnghouse only requires for native soils; VTM uses multiple wet/dry cycles

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Bioretention Soil Media Specs

- **DRAFT Virginia Test Method (VTM) – 134**
  Bioretention Soil Media Test
  - Coordinated with VDOT Materials & Geotechnical Divisions, Vendors/Suppliers, CWP, Virginia Tech, WSSI, and others to develop;
  - Scope of VTM:
    - Texture Analysis of mineral soil component (soil fines & fine aggregate);
    - Organic matter content, %, of the biortetention soil media;
    - Cation Exchange Capacity (CEC);
    - Phosphorus (p) adsorptioni capability
    - Bulk density (to obtain conversion factor between tons and CY)
    - Saturated Hydraulic Conductivity (Ksat)

    *NOTE: All above tests must sample 3 times from different parts of the stockpile, blend, and then test and report 1 result, with exception of Ksat which follows different procedure

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Bioretention Soil Media Specs

- **Virginia Test Method (VTM) – 134**
  Measuring Hydraulic Conductivity (Ksat)

  - Annex C: Mesocosm Testing Protocol for Bioretention Soil Media Testing (from Wetland Studies and Solutions, Inc. (WSSI) Fairfax, VA)

  - Mesocom: "An experimental tool that integrates relevant structure and functions of existing or proposed site conditions into a controlled laboratory environment." source: WSSI

  - Wetting/Drying Cycles: Conduct series of cycles to simulate rain/drying conditions and incorporate at least 1 saltwater brine solution into one of the cycles, measuring infiltration rates during each cycle via falling head method

  - Success Criteria: mean overall infiltration rate for each cycle between 1 in/hr and 8 in/hr. If rate for one cycle outside, but returns to range in following cycle or after drying period, media acceptable.

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Bioretention Soil Media Specs

- **Virginia Test Method (VTM) – 134**

  Measuring Hydraulic Conductivity (Ksat)

  - Process
    - Six (6) representative samples of the bioretention soil media shall be sampled per mini-stockpile method per VDOT Materials Division Manual of Instructions Section 308.05(a)
    - Construct typical soil media profile (with remaining bioretention layers) in lab apparatus
    - Fill apartus with water until ponding depth of 6 inches obtained
    - Measure time for ponding depth to equal 0.
    - Repeat ponding and falling head test for 2nd test cycle.
    - Following 2nd cycle, let appartus dry completely for 36 hours
    - Complete total of 8 cycles
    - Report results for each of 6 soil samples

Table 1. Recommended Testing Cycles

Cycle 1 - Freshwater
Cycle 2 - Freshwater
36 hour Drying Period (minimum)
Cycle 3 - Saltwater Brine Solution [1]
Cycle 4 - Freshwater
96 hour Drying Period (minimum)
Cycle 5 - Freshwater
Cycle 6 - Freshwater
36 hour Drying Period (minimum)
Cycle 7 - Freshwater
Cycle 8 - Freshwater

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BMP Plant Palette

- Plant Types Evaluated
  - Ferns, Grasses & Grasslike, Forbs, Shrubs, Understory Trees, Canopy Trees, Species to Avoid
- Fields Evaluated
  - BMP Type
  - Physiographic Region
  - Hydrologic Zone (tolerance to periodic/regular/permanent inundation)
  - Wetland Indicator Status
  - Moisture (plant preference for optimal growth)
  - Shade Tolerance
  - Salinity Tolerance (sensitive, resistant)
  - Max Height (line of sight, security issues)
  - Leaf Type (year-round or searsonal)
  - pH Range (tolerance to acidic soils)
  - Inundation (permant indundation depth (inches) tolerance)
  - Bloom Season/Seasonal Interest
  - Notable Fall Foliage
  - Notable Characteristics (flower, color, bark texture, etc.)

*Special thanks to Daniel Malone, Jonathon Herman, Chris Hale (Stantec Landscape Architects)

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BMP Plant Palette

BOTANICAL NAME	COMMON NAME	WETLAND INDICATOR STATUS AGCP	WETLAND INDICATOR STATUS EMP	MAX HEIGHT	INUNDATION (inches)	NOTABLE CHARACTERISTICS
FERNS						
Adiantum pedatum	northern maidenhair fern	FACU	FAC	18"	0	
Athyrium asplenioides	southern lady fern	FAC	FAC	36"	0	
Dennstaedtia punctilobula	hay-scented fern	UPL	FACU	36"	0	
Dryopteris carthusiana	spinulose woodfern	FACW	FAC	30"	0	
Dryopteris intermedia	intermediate woodfern	FACU	FACU	30"	0	
Dryopteris marginalis	marginal woodfern	FACU	FACU	36"	0	
Onoclea sensibilis	sensitive fern	FACW	FACW	42"	0	
Osmundastrum cinnamomeum	cinnamon fern	FACW	FACW	60"	0	
Osmunda spectabilis	royal fern	OBL	OBL	60"	0	
Polystichum acrostichoides	christmas fern	FACU	FACU	36"	0	
Pteridium aquilinum	northern bracken fern	FACU	FACU	40"	0	
Thelypteris noveboracensis	New York fern	FAC	FAC	18"	0	
Woodwardia areolata	netted chain fern	OBL	FACW	30"	0	
Woodwardia virginica	Virginia chain fern	OBL	OBL	36"	12	
GRASSES & GRASSLIKE PLANTS						
Agrostis perennans	autumn bentgrass	FACU	FACU	40"	0	
Andropogon virginicus	broomsedge bluestem	FAC	FACU	36"	0	
Carex crinita	fringed sedge	FACW	OBL	60"	0	
Carex lurida	shallow sedge	OBL	OBL	40"	3	
Carex stricta	tussock sedge	OBL	OBL	40"	6	
Carex vulpinoidea	fox sedge	FACW	OBL	40"	6	
Chasmanthium latifolium	sea oats	FAC	FACU	60"	0	
Chasmanthium laxum	slender wood-oats	FACW	FAC	60"	0	
Dichanthelium clandestinum	deertongue	FACW	FAC	60"	0	
Distichlis spicata	saltgrass	OBL	FACW	18"	2	
Eleocharis obtusa	blunt spikerush	OBL	OBL	30"	3	
Elymus riparius	riverbank wild rye	FACW	FACW	60"	0	
Elymus virginicus	Virginia wild rye	FAC	FACW	66"	0	
Glyceria striata	fowl mangrass	OBL	OBL	60"	0	
Juncus canadensis	Canda rush	OBL	OBL	48"	3	
Juncus effusus	soft rush	OBL	FACW	48"	12	
Juncus roemerianus	needlegrass rush	OBL	OBL	48"	6	
Leersia oryzoides	rice cutgrass	OBL	OBL	60"	6	
Liriope muscari	lilyturf	NI	NI	6"	0	
Muhlenbergia capillaris	hairawn muhly	FAC	FACU	36"	0	
Ophiopogon planiscapus	black mondo grass	NI	NI	8"	0	
Panicum virgatum	switchgrass	FAC	FAC	72"	0	
Schizachyrium scoparium	little bluestem	FACU	FACU	48"	0	
Schoenoplectus pungens	common three-square	OBL	OBL	48"	6	
Schoenoplectus tabernaemontani	soft stem bulrush	OBL	OBL	120"	12	
Scirpus atrovirens	green bulrush	OBL	OBL	72"	12	
Scirpus cyperinus	woolgrass	OBL	FACW	60"	3	
Sorghastrum nutans	indiangrass	FACU	FACU	72"	0	
Spartina alterniflora	smooth cordgrass	OBL	OBL	84	12	
Spartina cynosuroides	big cordgrass	OBL	OBL	120"	2	
Spartina patens	salt meadow hay	FACW	FACW	36"	0	
Zizania aquatica	wild rice	OBL	OBL	96"	36	
Dichanthelium dichotomum	cypress panicgrass	FAC	FAC	36"	0	
Dichanthelium scoparium	velvet panicum	FACW	FACW	48"	0	
FORBS						
Acorus americanus	sweet flag	OBL	OBL	48"	0	
Acorus calamus	European calamus	OBL	OBL	60"	3	
Ageratina altissima	white snakeroot	FACU	FACU	60"	0	White flower
Alisma subcordatum	water plantain	OBL	OBL	6"	12	White flower, Food source for birds
Aruncus dioicus	goats beard	FACU	FACU	72"	0	
Asarum canadense	Canadian wild ginger	UPL	FACU	6"	0	
Asclepias incarnata	swamp milkweed	OBL	OBL	60"	3	
Asclepias syriaca	common milkweed	---	FAC	78"	0	Purple flower
Asclepias tuberosa	butterfly milkweed	UPL	UPL	36"	0	May be toxic if ingested
Baptisia australis	false blue indigo	---	FACU	60"	0	Blue-purple flower
Caltha palustris	marsh marigold	OBL	OBL	24"	6	Yellow flower
Chelone glabra	turtle head	OBL	OBL	48"	2	White flower
Chelone obliqua	red turtlehead	OBL	OBL	36"	0	Pink flower
Chrysogonum virginianum	green-and-gold	UPL	UPL	12"	0	Yellow flower
Claytonia virginica	spring beauty	FACU	FAC	12"	0	White flower
Conoclinium coelestinum	blue mist flower	FAC	FAC	36"	0	Blue flower
Coreopsis lanceolata	lanceleaf tickseed	UPL	FACU	28"	0	Yellow flower
Coreopsis tripteris	tall coreopsos	FAC	FAC	120"	0	Yellow flower
Coreopsis verticillata	threadleaf coreopsis	UPL	UPL	42"	0	Yellow flower
Echinacea purpurea	purple cone flower	NI	NI	36"	0	Purple flower
Eupatorium perfoliatum	boneset	FACW	FACW	60"	0	White flower

*Special Assistance from Daniel Malone, Jonathon Herman, Chris Hale (Stantec Landscape Architects)

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BMP Plant Palette

BOTANICAL NAME	COMMON NAME	BMP TYPE						REGION				HYDROLOGIC ZONE						WETLAND INDICATOR STATUS		MOISTURE			SUN/ SHADE			SALINITY			MAX HEIGHT
		SOIL COMPOST AMENDMENT	BIORETENTION FACILITIES	DRY SWALE	WET SWALE	CONSTRUCTED WETLAND	WET POND	MOUNTAIN	PIEDMONT	COASTAL	NON-NATIVE	SUBMERGED (1)	SHALLOW WATER (2)	REGULARLY INUNDATED (3)	PERIODICALLY INUNDATED (4)	INFREQUENTLY INUNDATED (5)	NEVER INUNDATED (6)	AGCP	EMP	DRY	MEDIUM	WET	FULL SUN	PART SUN	FULL SHADE (SH)	SENSITIVE	INTERMEDIATE	RESISTANT	
FERNS																												
Adiantum pedatum	northern maidenhair fern	■		■				■	■	■					■	■	■	FACU	FAC		■			■	■				18"
Athyrium asplenioides	southern lady fern	■	■	■	■			■	■	■						■	■	FAC	FAC		■	■		■					36"
Dennstaedtia punctilobula	hay-scented fern	■		■				■	■	■						■	■	UPL	FACU		■	■		■	■				36"
Dryopteris carthusiana	spinulose woodfern	■	■		■			■	■	■				■	■	■	■	FACW	FAC		■	■		■	■				30"
Dryopteris intermedia	intermediate woodfern	■		■				■	■							■	■	FACU	FACU	■	■	■		■	■				30"
Dryopteris marginalis	marginal woodfern	■		■				■	■							■	■	FACU	FACU	■	■			■	■				36"
Onoclea sensibilis	sensitive fern	■	■		■	■	■	■	■	■						■	■	FACW	FACW		■	■	■	■	■				42"
Osmundastrum cinnamomeum	cinnamon fern	■	■		■	■	■	■	■	■					■	■		FACW	FACW		■	■	■	■	■				60"
Osmunda claytoniana	interrupted fern	■	■	■	■			■	■						■	■	■	FAC	FAC		■	■		■	■				72"

Plants grouped by ferns, grasses, and forbs

BMP Type

Plant characteristics

*Special Assistance from Daniel Malone, Jonathon Herman, Chris Hale (Stantec Landscape Architects)

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Questions?

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