Planning the BMP

Region 2000 Planning District Commission

Lynchburg, VA

December 13, 20013

CENTER FOR WATERSHED PROTECTION

PLANNING THE BMP

AGENDA

BMP Selection

BMP Design

SWM Plan Preparation

BMP SELECTION

- Types of BMPs
  - Structural BMPs
  - Non-structural BMPs
- BMP Performance
  - Runoff Reduction (RR) BMPs
  - Pollutant Removal (PR) BMPs
  - Total Load Reduction (TR = RR + PR)

COMMONWEALTH OF VIRGINIA

Virginia Stormwater Management Handbook

Second Edition
2011

PART 1 & PART 2 & PART 3

DEQ

Virginia Department of Conservation and Recreation
Division of Stormwater Management
203 Governor Street, Suite 206
Richmond, VA 23219-2094
Phone: *(804) 786-2064*

BMP SELECTION

Relevant guidance in the VA SWM handbook:

CHAPTER 6: Environmental Site Design

- Appendix 6-B: SW Design in Karst;
- Appendix 6-C: Sustainable Sites Initiative (SSI)

Chapter 8: BMP Overview and Selection

Spec No.	Practice	Design Level	Runoff Reduction	TN EMC Removal[3]	TN Mass Load Removal	TP EMC Removal	TP Mass Load Removal [6]
1	Rooftop Disconnect	1 [2]	25 to 50 [1]	0	25 to 50 [1]	0	25 to 50 [1]
		No Level 2 Design					
2	Sheet Flow to Veg. Filter or Conserv. Open Space	1	50	0	50	0	50
		2 [5]	50 to 75 [1]	0	50 to 75 [1]	0	50 to 75 [1]
3	Grass Channels	1	10 to 20 [1]	20	28 to 44 [1]	15	24 to 41 [1]
		No Level 2 Design					
4	Soil Compost Amendment	Can be used to Decrease Runoff Coefficient for Turf Cover at Site. See the design specs for Rooftop Disconnection, Sheet Flow to Vegetated Filter or Conserved Open Space, and Grass Channel					
5	Vegetated Roof	1	45	0	45	0	45
		2	60	0	60	0	60
6	Rainwater Harvesting	1	Up to 90 [3, 5]	0	Up to 90 [3, 5]	0	Up to 90 [3, 5]
		No Level 2 Design					
7	Permeable Pavement	1	45	25	59	25	59
		2	75	25	81	25	81
8	Infiltration Practices	1	50	15	57	25	63
		2	90	15	92	25	93
9	Bioretention Practices	1	40	40	64	25	55
		2	80	60	90	50	90
9A	Urban Bioretention	1	40	40	64	25	55
		No Level 2 Design					
10	Dry Swales	1	40	25	55	20	52
		2	60	35	74	40	76
11	Wet Swales	1	0	25	25	20	20
		2	0	35	35	40	40
12	Filtering Practices	1	0	30	30	60	60
		2	0	45	45	65	65
13	Constructed Wetlands	1	0	25	25	50	50
		2	0	55	55	75	75
14	Wet Ponds	1	0	30 (20) [4]	30 (20) [4]	50 (45) [4]	50 (45) [4]
		2	0	40 (30) [4]	40 (30) [4]	75 (65) [4]	75 (65) [4]
15	Ext. Det. Ponds	1	0	10	10	15	15
		2	15	10	24	15	31

BMP SELECTION

DEQ Stormwater Design Specifications (Version 2.0; 2013)

1. Description
2. Performance:

Table 1 – Summary of Stormwater Functions

Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	40%	80%
Total Phosphorus (TP) EMC Reduction[1] by BMP Treatment Process	25%	50%
Total Phosphorus (TP) Mass Load Removal	55%	90%
Total Nitrogen (TN) EMC Reduction[1] by BMP Treatment Process	40%	60%
Total Nitrogen (TN) Mass Load Removal	64%	90%
Channel and Flood Protection	• Use the Virginia Runoff Reduction Method (VRRM) Compliance Spreadsheet to calculate the Curve Number (CN) Adjustment *OR* • Design extra storage (optional; as needed) on the surface, in the engineered soil matrix, and in the stone/underdrain layer to accommodate a larger storm, and use NRCS TR-55 Runoff Equations[2] to compute the CN Adjustment.	

Table 2 – Potential LEED Credits

BMP SELECTION (CONTINUED)

DEQ Stormwater Design Specifications (Version 2.0; 2013)

3. Design Tables: Level 1 and Level 2

Table 3 or 4 – Design Criteria

General Rules:

Sizing;

Max DA

Surface Area;

Ponding Depth;

Filter Media;

Soil Testing;

Geometry;

Pre-Treatment;

Conveyance

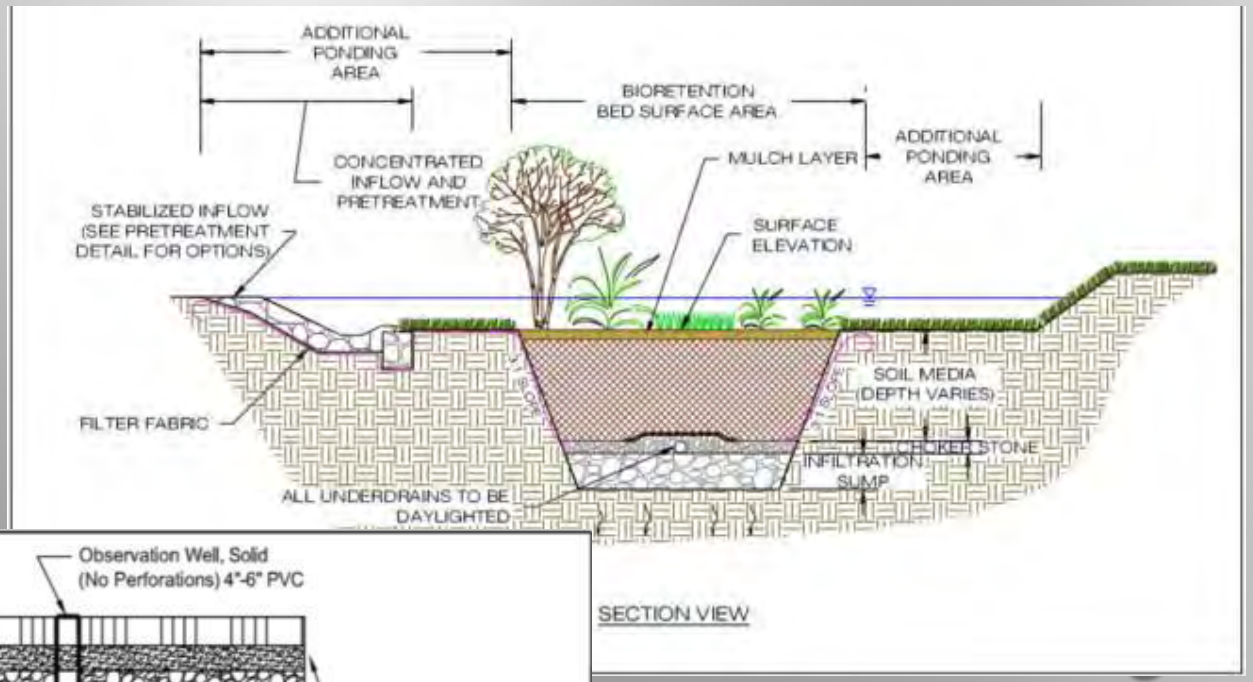
Planting Plan

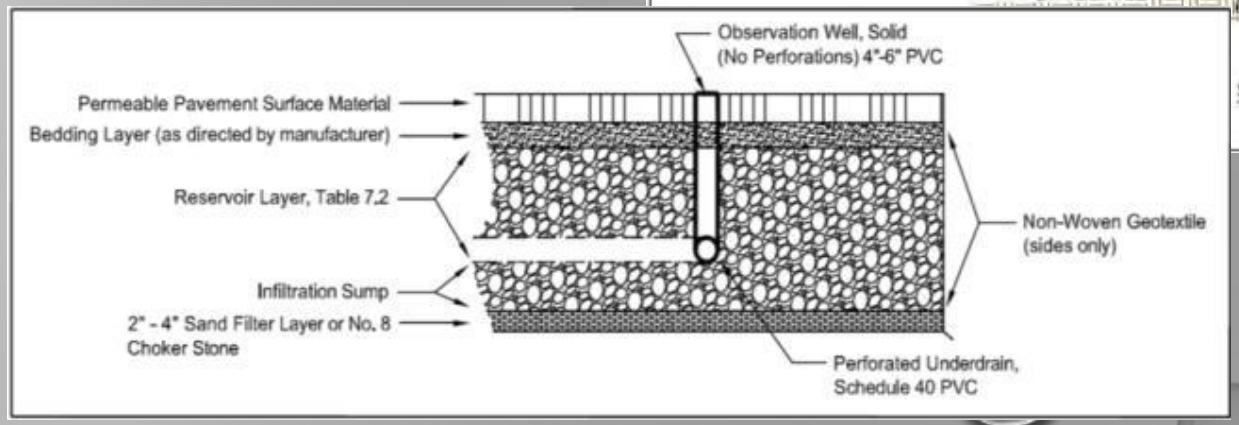
Level 1 Design (RR 40 TP: 25)	Level 2 Design (RR: 80 TP: 50)
Sizing (Section 6.1): T_{VBMP} = [(1)(Rv)(A) / 12] + any remaining volume from upstream BMP Surface Area (sq. ft.) = T_{VBMP} / Storage Depth [1]	**Sizing (Section 6.1):** T_{VBMP} = [(1.25)(Rv)(A) / 12] + any remaining volume from upstream BMP Surface Area (sq. ft.) = T_{VBMP} /Storage Depth [1]
Recommended maximum contributing drainage area = 2.5 acres, or with local approval up to 5 acres and a maximum of 50% impervious	
Maximum Ponding Depth = 6 to 12 inches [2]	**Maximum Ponding Depth** = 6 to 12 inches [2]
Filter Media Depth minimum = 24 inches; recommended maximum = 48 inches	**Filter Media Depth** minimum = 36 inches; recommended maximum = 48 inches
Media & Surface Cover (Section 6.6) = supplied by vendor; tested for acceptable hydraulic conductivity (or permeability) and phosphorus content	
Sub-soil Testing (Section 6.2): not needed if an underdrain used; Min infiltration rate > 1/2 inch/hour in order to remove the underdrain requirement.	**Sub-soil Testing (Section 6.2):** one soil profile and two infiltration tests per facility (up to 2,500 ft² of filter surface); Min infiltration rate > 1/2 inch/hour in order to remove the underdrain requirement.
Underdrain (Section 6.7) = Schedule 40 PVC with clean-outs	**Underdrain & Underground Storage Layer (Section 6.7)** = Schedule 40 PVC with clean outs, and a minimum 12-inch stone sump below the invert; ***OR***, none, if soil infiltration requirements are met (**Section 6.2**)
Inflow: sheetflow, curb cuts, trench drains, concentrated flow, or the equivalent	
Geometry (Section 6.3): Length of shortest flow path/Overall length = 0.3; ***OR***, other design methods used to prevent short-circuiting; a one-cell design (not including the pre-treatment cell).	**Geometry (Section 6.3):** Length of shortest flow path/Overall length = 0.8; ***OR***, other design methods used to prevent short-circuiting; a two-cell design (not including the pretreatment cell).
Pre-treatment (Section 6.4): a pretreatment cell, grass filter strip, gravel diaphragm, gravel flow spreader, or another approved (manufactured) pre-treatment structure	**Pre-treatment (Section 6.4):** a pretreatment cell *plus* one of the following: a grass filter strip, gravel diaphragm, gravel flow spreader, or another approved (manufactured) pre-treatment structure
Conveyance & Overflow (Section 6.5)	**Conveyance & Overflow (Section 6.5)**
Planting Plan (Section 6.8): a planting template to include turf, herbaceous vegetation, shrubs, and/or trees to achieve surface area coverage of at least 75% within 2 years.	**Planting Plan (Section 6.8):** a planting template to include turf, herbaceous vegetation, shrubs, and/or trees to achieve surface area coverage of at least 90% within 2 years. If using turf, must combine with other types of vegetation.
Building Setbacks [3] (Section 5): 10 feet if down-gradient from building or level (coastal plain); 50 feet if up-gradient. (Refer to additional setback criteria in **Section 5**)	
Deeded Maintenance O&M Plan (**Section 8**)	

BMP SELECTION (CONTINUED)

- DEQ Stormwater Design Specifications (Version 2.0; 2013)

  Section 4: Typical Details





BMP SELECTION (CONTINUED)

DEQ Stormwater Design Specifications (Version 2.0; 2013)

5. **Physical Feasibility:**
   - Available Space
   - Site Topography
   - Contributing Drainage Area
   - Available Hydraulic Head
   - Depth to Water Table / Bedrock
   - Utilities
   - Soil
   - Hotspots
   - Setbacks

BMP DESIGN

DEQ Stormwater Design Specifications (Version 2.0; 2013)

Section 6: Design

Additional Guidance:

- SWM Handbook Chapter 8 **-** BMP Overview and Selection
- Appendix 8-A: BMP Design Checklists

BMP DESIGN

CONTRIBUTING DRAINAGE AREA

The little infiltration trench that could . . . .

BMP DESIGN

CONTRIBUTING DRAINAGE AREA

The big Bio-detention basin that could'nt . . . .

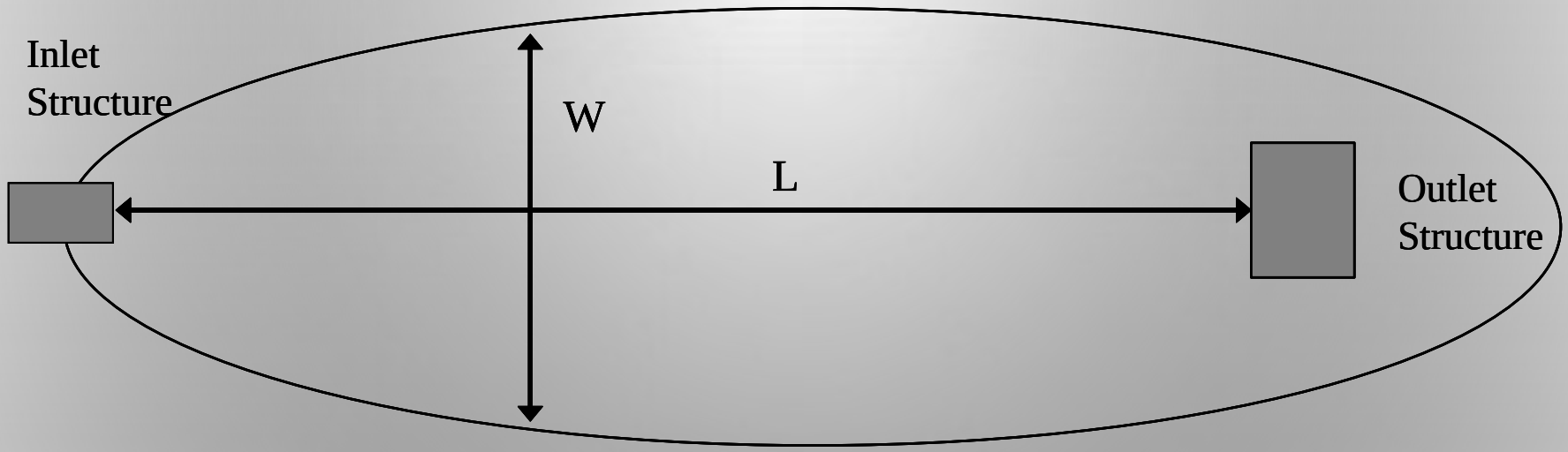
BMP DESIGN

BMP GEOMETRY

- General flow path
- Relation of inlets to outlets
- Length/width ratio
- Shortest flow path

BMP DESIGN

LENGTH-TO-WIDTH RATIO



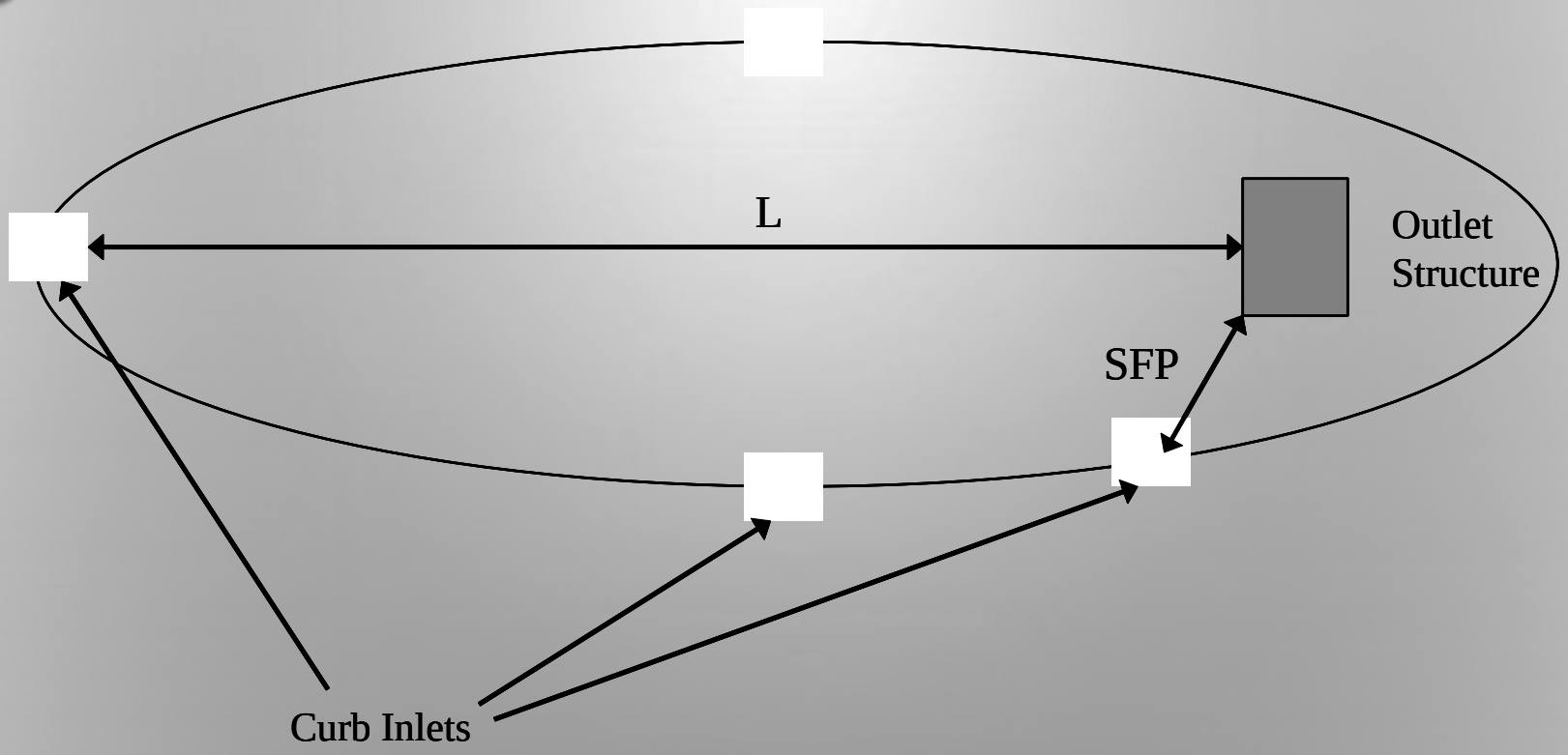
Length/Width Ratio = L/W, where:

L = Length from inlet to outlet

W = Average width

BMP DESIGN

SHORTEST FLOW PATH

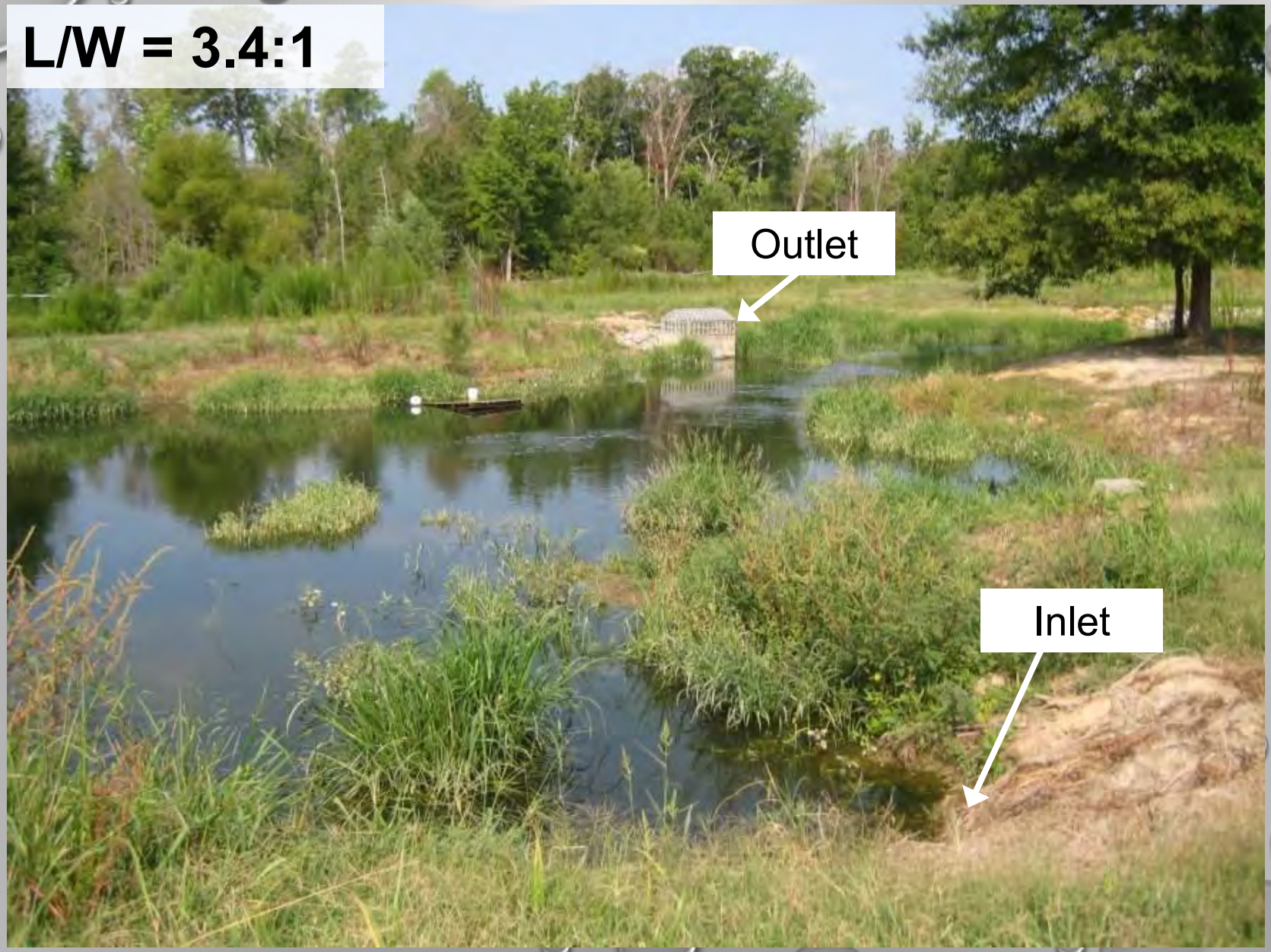


Shortest Flow Path Ratio = SFP/L

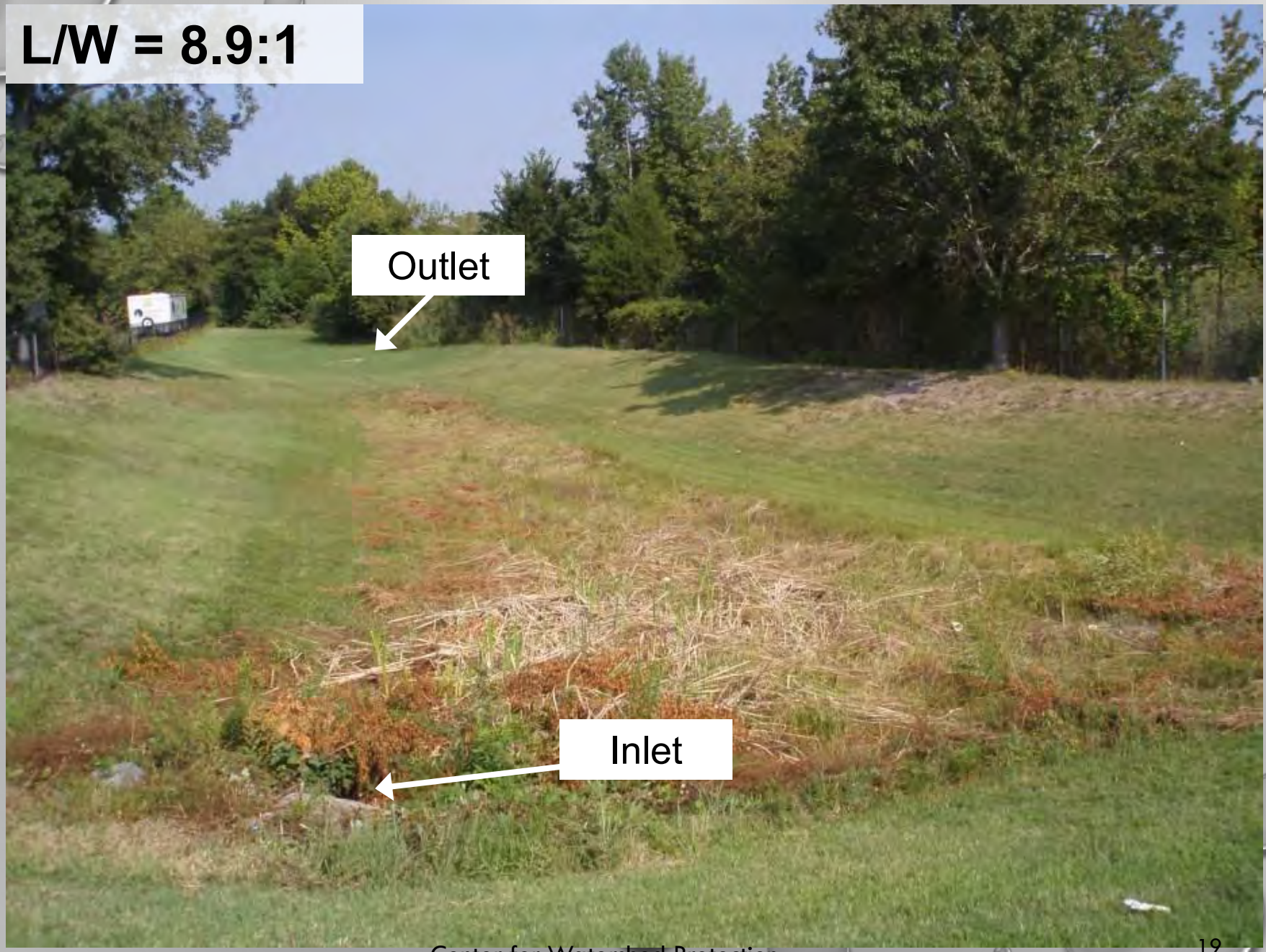
SFP = Length of shortest flow path from an inlet to outlet

L = Overall length of facility

L/W = 3.4:1

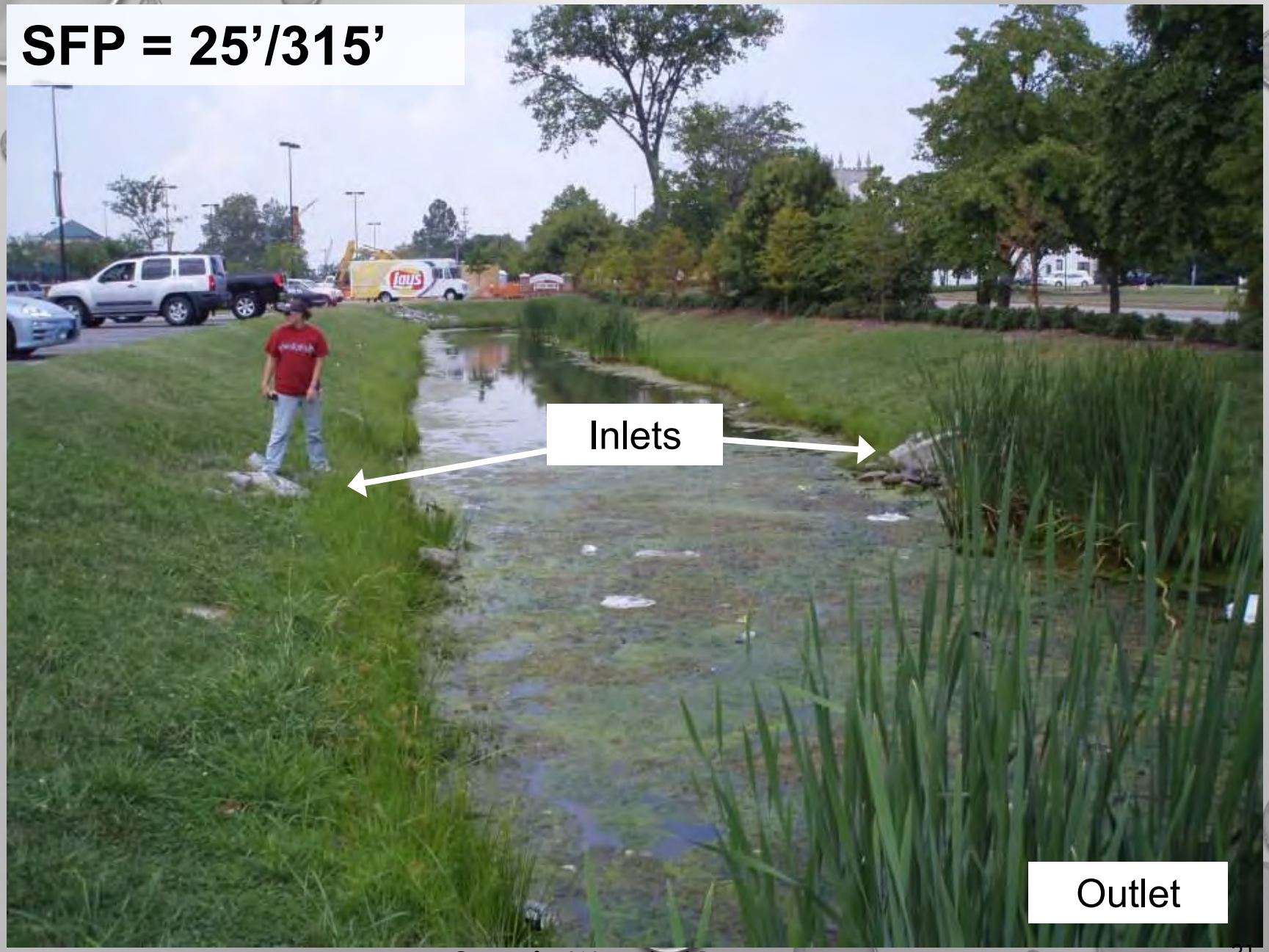


L/W = 8.9:1



Multiple Cells

SFP = 25’/315’



SFP = almost none


Outlet
Last Curb Cut

BMP GEOMETRY RECOMMENDATIONS

BMP Type	L/W Ratio	Shortest Flow Path Ratio
Wet Pond	Level 1 = 2.0 Level 2 = 3.0 or multi-cell	Level 1 = 0.5 Level 2 = 0.8
Dry Pond	Level 1 = 2.0 Level 2 = 3.0 or multi-cell	Level 1 = 0.4 Level 2 = 0.7
SW Wetland	Level 1 = 2.0 Level 2 = 3.0 or multi-cell	Level 1 = 0.5 Level 2 = 0.8
Bioretention	Level 1 = 3.0 Level 2 = 3.5	Level 1 = 0.3 Level 2 = 0.8 OR flow distribution

BMP DESIGN

PRETREATMENT MEASURES

Rip-rap aprons / channels

BMP DESIGN

FILTER STRIPS

- Works as a BMP;
- Should work for pre-treatment

BMP DESIGN

PRETREATMENT MEASURES

Feasibility: Grass filter strips

BMP DESIGN

PRETREATMENT MEASURES

Feasibility: Sediment forebays

BMP DESIGN

PRETREATMENT MEASURES

Feasibility: Sediment forebays

BMP DESIGN

PRETREATMENT BY DESIGN

PERMEABLE PAVEMENT DESIGN

Limit 'Run-on' to:

- Impervious cover; and
- a ratio of 2.5:1 (allows for the opposite parking space and the drive aisle to drain into one parking space of permeable pavement).

'Run-on' Ratio (R) = A_c/A_p where

- A_c = contributing area; and
- A_p = permeable pavement area

BMP DESIGN

CONVEYANCE

- On-line; Off-line;
- Design storm;
- Inlet Channel
- By-pass
- Overflow

BMP DESIGN

CONVEYANCE

ED Pond (L2) wet features:

- Forebay
- Outlet 'Micro-pool'
- Shallow marsh/wetland

BMP DESIGN (CONTINUED)

DEQ Stormwater Design Specifications (Version 2.0; 2013)

7. **Design Adaptations**
   - Coastal Plain;
   - Karst;
   - Steep terrain;
   - Cold Climate;
   - Linear Design

SWM PLAN PREPARATION

Chapter 8: BMP Overview and Selection

- Appendix 8-A: BMP Design Checklists

STORMWATER MANAGEMENT PLANS

SWM PLAN PREPARATION

9VAC25-870-55: Stormwater Management Plans

B. A **complete** SW Plan includes the following elements:

General Info:

1. Information on the type and location of discharges, with Pre- and post-developed drainage areas;
2. Owner contact information;
3. A narrative (or documentation) of the pre- and post-developed site conditions;
4. A general description of the proposed BMPs and long term maintenance provisions;
5. BMP Data: i) type; ii) location (coordinates); iii) acres treated; and iv) surface waters into which they discharge.

SWM PLAN PREPARATION

9VAC25-870-55: Stormwater Management Plans

B. A **complete** SW Plan includes the following elements **(contd.)**:

BMP Design Info:

6. Hydrologic & Hydraulic Computations;
7. Documentation and calculations verifying compliance with quality and quantity requirements;
8. Map(s) showing topography and the following:
   a. Drainage areas;
   b. Streams, ponds, wetlands, culverts, floodplains, etc.;
   c. Soil types, geologic formations, trees and/or vegetative cover;
   d. Current land use (and any improvements on the land);

SWM PLAN PREPARATION

9VAC25-870-55: Stormwater Management Plans

B. A **complete** SW Plan includes the following elements **(contd.)**:

BMP Design Info (continued):

8. Map(s) showing topography and the following **(contd.)**:
   e. Sufficient information on adjacent parcels to assess any stormwater impacts;
   f. Limits of clearing and grading (ESC plan - ELGs), and proposed drainage patters;
   g. Proposed improvements: buildings, roads, parking, utilities, drainage, and SWM facilities;
   h. Tabulation of the percentage of proposed land uses:
9. Offsite compliance information (if applicable)
10. Plan review fee form

9VAC25-870-55. STORMWATER MANAGEMENT PLANS

1. A stormwater management plan shall apply the stormwater management technical criteria to the entire **common plan of development** or sale where applicable. Individual lots or parcels in a residential, commercial, or industrial common plan of development or sale shall not be considered to be separate land-disturbing activities. Instead, the common plan, as a whole, shall be considered to be a single land-disturbing activity.

COMMON PLAN OF DEVELOPMENT OR SALE

- Means a contiguous area where separate and distinct construction activities may be taking place at different times on different schedules.

COMMON PLAN OF DEVELOPMENT

Individual LDA's within a larger common plan of development require permit coverage, e.g.:

- Building on four ½-acre lots in a 20 acre development, or
- Building a fast-food restaurant on a ¾ acre pad that is part of a 20 acre retail center

9VAC25-880-50. STATE PERMIT APPLICATION (REGISTRATION STATEMENT).

C. Construction of a **single-family residence** separately built, disturbing less than one acre and part of a larger common plan of development or sale **is authorized to discharge** under this general permit and **is not required to submit a registration statement or the department portion of the permit fee**, provided that the stormwater management plan for the larger common plan of development or sale provides permanent control measures (i.e., Stormwater management facilities) encompassing the single-family residence.

PROJECT EXAMPLE

20 acre residential subdivision development

- 45 1/4 to 1/3 acre lots (zoned R3)

COMMON PLAN OF DEVELOPMENT

- 20 acre Common Plan of Development
- **13 acres of lots**
  - 35% impervious (~4.5 ac)
  - 50% (avg) managed turf (~6.5 ac)
  - 15% open space (undisturbed buffers) (~2 ac)
- **3 acres right of way**
  - 18 ft pavement width; 6 ft shoulder (~ 2.4 ac)
  - 30 ft right of way; (~0.6 ac turf/grass channel)
- **4 acres open space** (buffers, park, floodplain)
- **Total**: 6.0 acres forest/open space
  7.1 acres managed turf
  6.9 acres impervious

21	**Land Cover (acres)**				
22		**A soils**	**B Soils**	**C Soils**	**D Soils**	**Totals**
23	Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	6.00	0.00	6.00
24	Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	7.10	0.00	7.10
25	Impervious Cover (acres)	0.00	0.00	6.90	0.00	6.90
26					**Total**	20.00
27						
28	**Rv Coefficients**					
29		**A soils**	**B Soils**	**C Soils**	**D Soils**	
30	Forest/Open Space	0.02	0.03	0.04	0.05	
31	Managed Turf	0.15	0.20	0.22	0.25	
32	Impervious Cover	0.95	0.95	0.95	0.95	
33						
34						
35						
36	**Land Cover Summary**					
37	Forest/Open Space Cover (acres)	6.00				
38	Weighted Rv(forest)	0.04				
39	% Forest	30%				
40	Managed Turf Cover (acres)	7.10				
41	Weighted Rv(turf)	0.22				
42	% Managed Turf	36%				
43	Impervious Cover (acres)	6.90				
44	Rv(impervious)	0.95				
45	% Impervious	35%				
46	**Total Site Area (acres)**	20.00				
47	**Site Rv**	0.42				
48						
49	Post-Development Treatment Volume (acre-ft)	0.70				
50	Post-Development Treatment Volume (cubic feet)	30,336				
51	Post_Development Load (TP) (lb/yr)	19.06		Post_Development Load (TN) (lb/yr)		136.35
52	Total Load (TP) Reduction Required (lb/yr)	10.86				

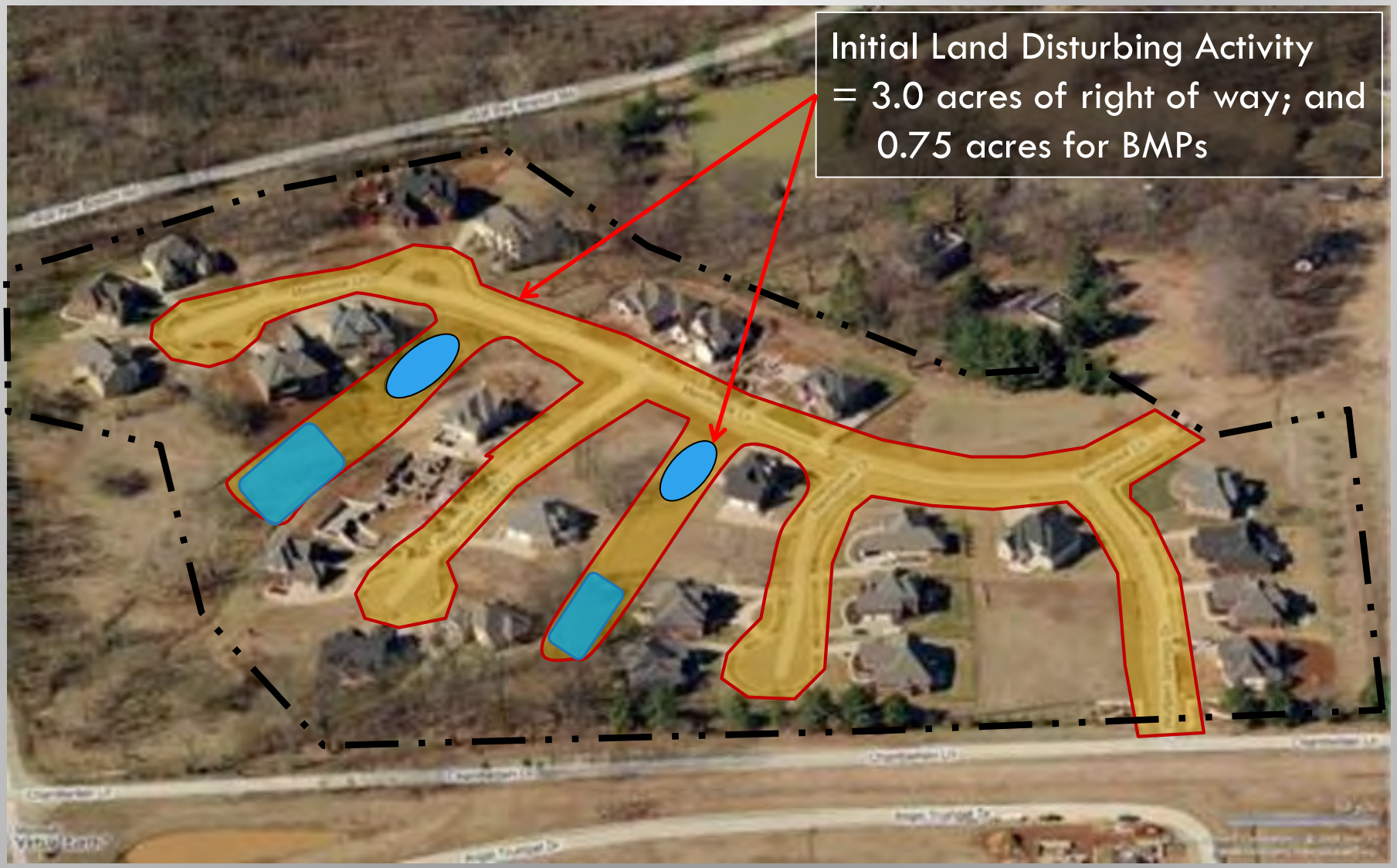
TP Reduction Requirement
= 10.86 lb/yr

INITIAL PLAN SUBMITTAL & PERMIT REGISTRATION

~ 3.75 acres of land disturbance

- 3 ac right-of-way
  - Impervious; pavement & shoulders ~ 2.4 ac;
  - Grass drainage ditch ~0.6 ac turf; or BMP??
- 0.75 ac BMP footprint ~ 0.75 ac open space.

INITIAL PLAN SUBMITTAL & PERMIT REGISTRATION



INITIAL PLAN SUBMITTAL & PERMIT REGISTRATION

BMP Design: 2 x (Bioretention Level 2 & ED L2)

- Entire acreage of right of way (½ to each);
- 12 lots (~3.2 ac); 6 to each practice:
  - Impervious ~ 1.1 ac;
  - Managed Turf ~ 1.6 ac;
  - Forest/Open Space ~0.5 ac.
- Total acreage to Combined BMP: 12 lots plus right of way
  - 2.4 + 1.1 = 3.5 ac impervious
  - 0.6 + 1.6 = 2.2 ac managed turf;
  - 0.75 + 0.5 = 1.25 ac Forest/Open Space

Total DA A = 6.95 acres

INITIAL PLAN SUBMITTAL & PERMIT REGISTRATION

INITIAL PLAN SUBMITTAL & PERMIT REGISTRATION

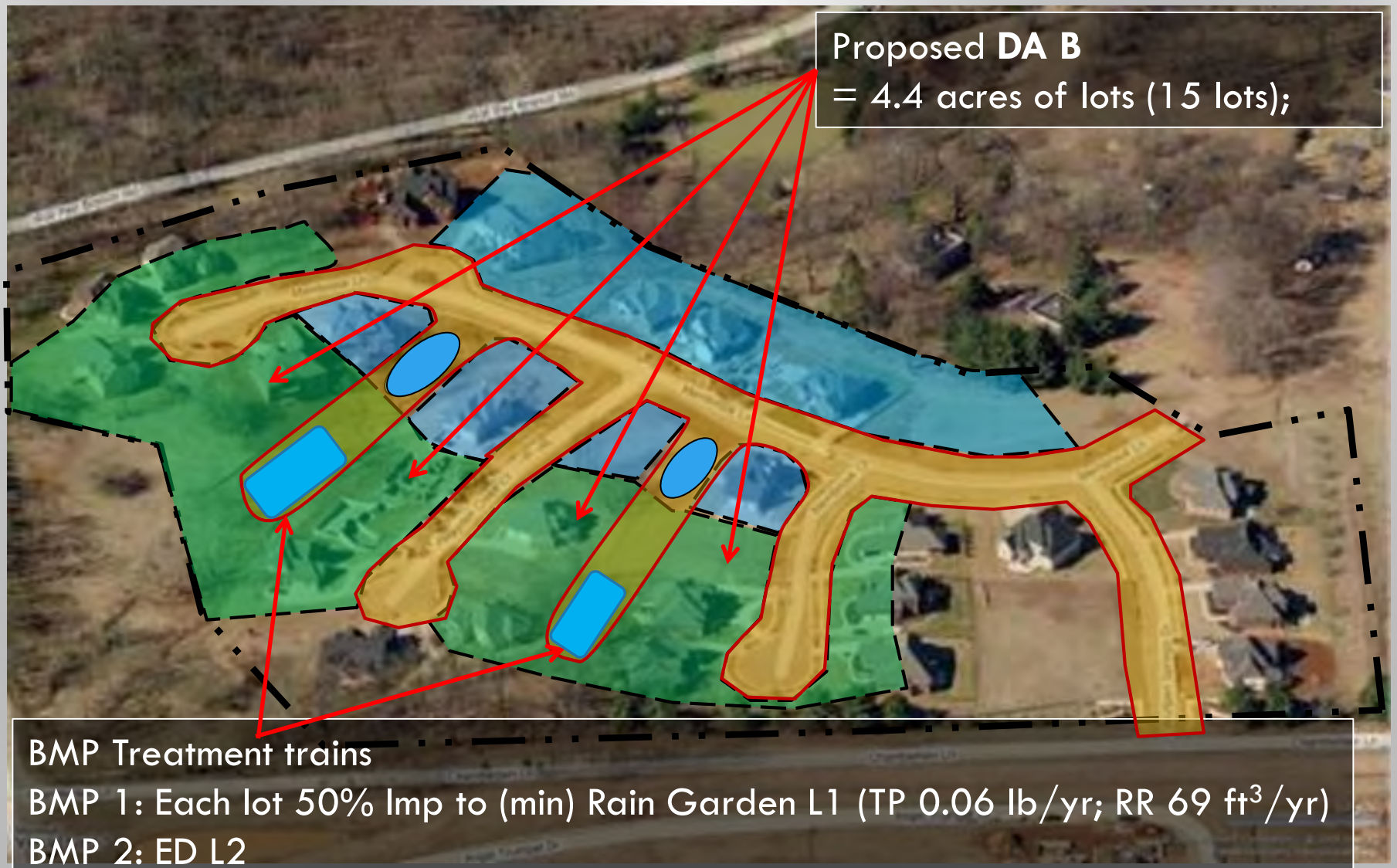
DA B:

- 15 lots draining to ED L2 (~4.4 ac: 2.2 ac to each ED)
  - Impervious ~ 1.5 ac;
  - Managed Turf ~ 2.2 ac;
  - Forest/Open Space ~0.7 ac.

- **Treatment Train Performance Goal (each lot):**
  - Each lot consists of approx 0.1 ac impervious
  - Treat minimum 50% of impervious cover with Rain Garden Level 1; or
  - Equivalent = TP reduction of 0.06 lb/yr and

    RR = 69 ft^3
  - Remaining Imp and Turf drains to ED L2

INITIAL PLAN SUBMITTAL & PERMIT REGISTRATION



INITIAL PLAN SUBMITTAL & PERMIT REGISTRATION

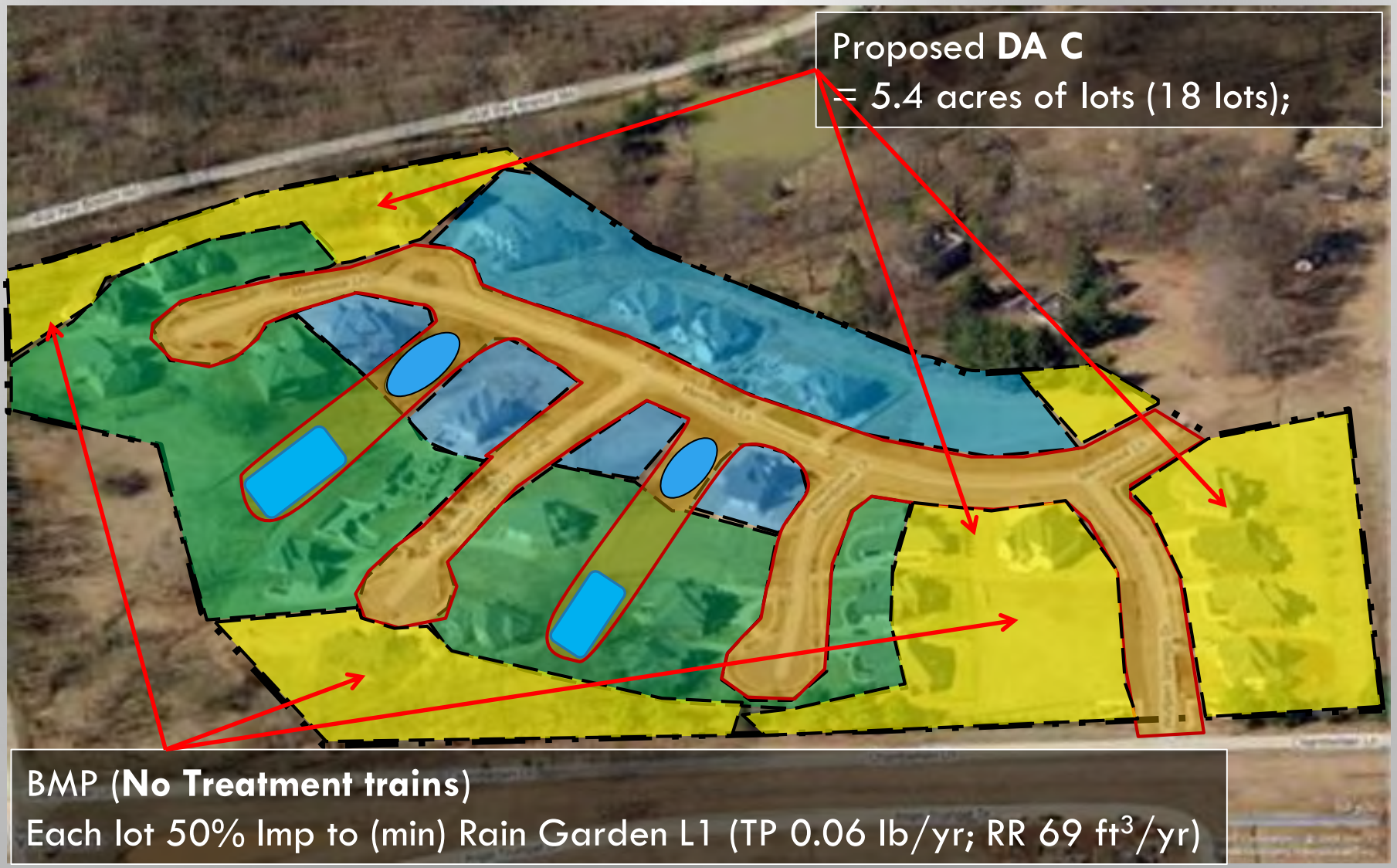
DA C:

- 18 Remaining Lots (~5.4 ac)
  - Impervious ~ 1.9 ac;
  - Managed Turf ~ 2.7 ac;
  - Forest/Open Space ~0.8 ac.

- **Performance Goal (each lot):**
  - Each lot consists of approx 0.1 ac impervious
  - Treat minimum 50% of impervious cover with Rain Garden Level 1; or
  - Equivalent = TP reduction of 0.06 lb/yr and

    RR = 69 ft^3

INITIAL PLAN SUBMITTAL & PERMIT REGISTRATION



Virginia Runoff Reduction Method New Development Worksheet -- v2.7 Revised April 2013

Site Data Summary

Total Rainfall = 43 inches

Site Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest (acres)	0.00	0.00	6.00	0.00	6.00	*30.00*
Turf (acres)	0.00	0.00	7.10	0.00	7.10	*35.50*
Impervious (acres)	0.00	0.00	6.90	0.00	6.90	*34.50*
					20.00	*100.00*

Drainage Area A Summary

Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest (acres)	0.00	0.00	1.25	0.00	1.25	*17.99*
Turf (acres)	0.00	0.00	2.20	0.00	2.20	*31.65*
Impervious (acres)	0.00	0.00	3.50	0.00	3.50	*50.36*
					6.95	

BMP Selections

Practice	Credit Area (acres)		Downstream Practice
6.b. Bioretention #2 (Spec #9)	Impervious:	3.5	8.b. ED #2
	Turf (Pervious):	2.2	8.b. ED #2
8.b. ED #2 (Spec #15)	Impervious:	0	
	Turf (Pervious):	0	

Total Impervious Cover Treated (acres)	3.50
Total Turf Area Treated (acres)	2.20
Total TP Load Reduction Achieved in D.A. A (lb/yr)	8.05
Total TN Load Reduction Achieved in D.A. A (lb/yr)	62.08

Drainage Area B Summary

Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest (acres)	0.00	0.00	0.70	0.00	0.70	*10.07*
Turf (acres)	0.00	0.00	2.20	0.00	2.20	*31.65*
Impervious (acres)	0.00	0.00	1.50	0.00	1.50	*21.58*
					4.40	

BMP Selections

Practice	Credit Area (acres)		Downstream Practice
2.f. To Rain Garden #1 (Micro-Bioretention #1) (Spec #9)	impervious acres disconnected	0.75	8.b. ED #2
8.b. ED #2 (Spec #15)	Impervious:	0.75	
	Turf (Pervious):	2.2	

Total Impervious Cover Treated (acres)	1.50
Total Turf Area Treated (acres)	2.20
Total TP Load Reduction Achieved in D.A. A (lb/yr)	1.85
Total TN Load Reduction Achieved in D.A. A (lb/yr)	31.11

Drainage Area C Summary

Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest (acres)	0.00	0.00	0.80	0.00	0.80	*11.51*
Turf (acres)	0.00	0.00	2.70	0.00	2.70	*38.85*
Impervious (acres)	0.00	0.00	1.90	0.00	1.90	*27.34*
					5.40	

BMP Selections

Practice	Credit Area (acres)		Downstream Practice
2.f. To Rain Garden #1 (Micro-Bioretention #1) (Spec #9)	impervious acres disconnected	0.95	

Total Impervious Cover Treated (acres)	0.95
Total Turf Area Treated (acres)	0.00
Total TP Load Reduction Achieved in D.A. A (lb/yr)	1.13
Total TN Load Reduction Achieved in D.A. A (lb/yr)	14.71

CURVE NUMBER ADJUSTMENT (ENERGY BALANCE)

Channel and Flood Protection

	Weighted CN	1-year storm Adjusted CN	2-year storm Adjusted CN	10-year storm Adjusted CN
Target Rainfall Event (in)		2.66	3.22	4.93
D.A. A CN	85	77	78	80
D.A. B CN	82	80	80	81
D.A. C CN	82	81	81	81
D.A. D CN	70	70	70	70
D.A. E CN	0	43	#N/A	#N/A

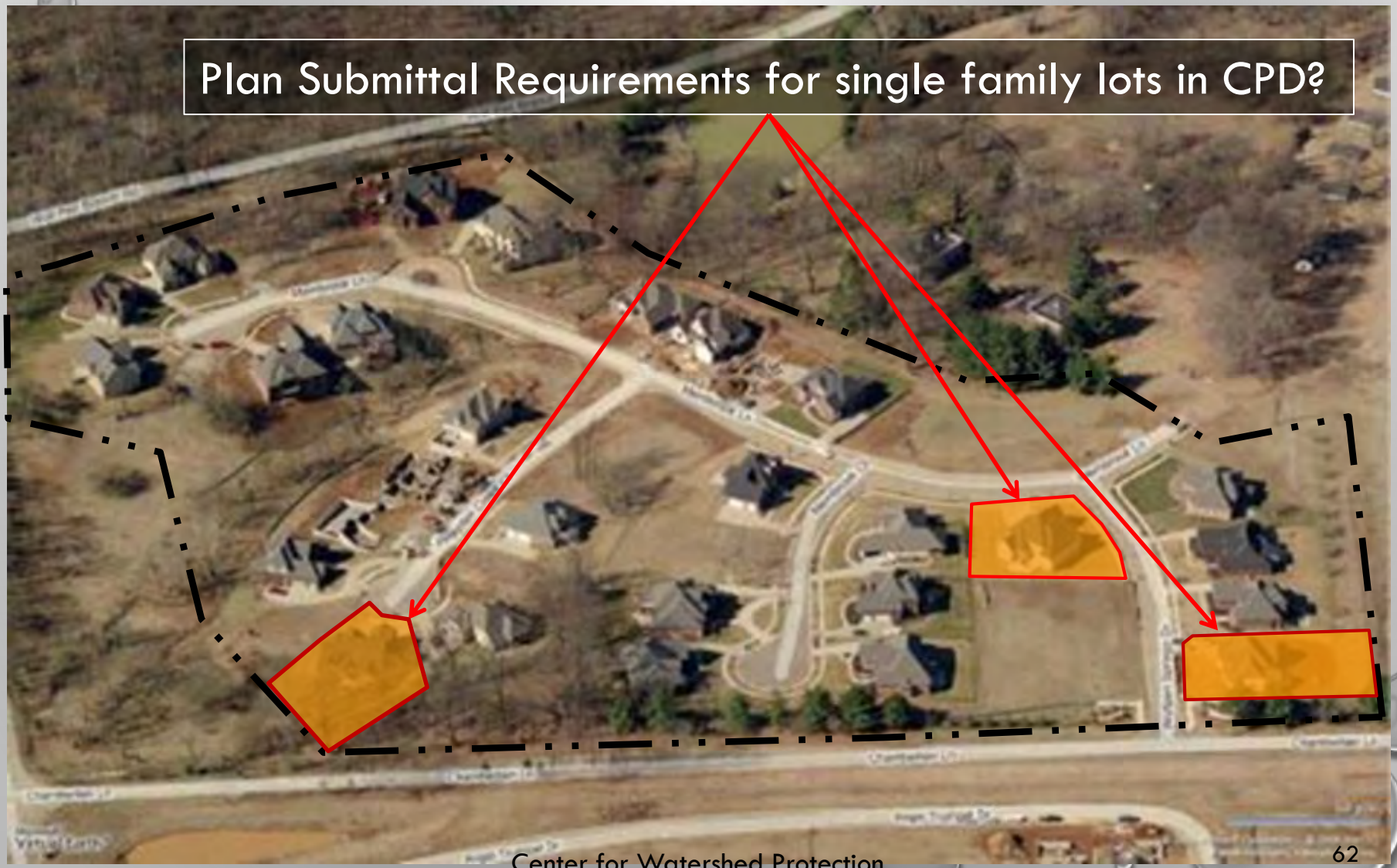
INITIAL PLAN SUBMITTAL & PERMIT REGISTRATION

VSMP land disturbing activity (≥ 1 ac):

STORMWATER POLLUTION PREVENTION PLAN:

- GENERAL REQMTS
- EROSION & SEDIMENT CONTROL PLAN
- STORMWATER MANAGEMENT PLAN
  - Including performance goals/general details for on-lot bmps
- POLLUTION PREVENTION PLAN
- ADDITIONAL MEASURES TO ADDRESS TMDL

COMMON PLAN OF DEVELOPMENT



INDIVIDUAL SF LOT WITHIN LARGER CPD

- Local ESC Permit Application;
- Agreement in Lieu of ESC Plan;
- SWPPP Template;
  - General Information on BMPs;
  - BMP Implementation Plan (found in larger CPD SWPPP; or new SWPPP);
  - PP
- BMP Maintenance Agreement;