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Stormwater Management Plan Review Course

Class Exercise Solutions

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Exercise 1A

Environmental Site Design

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Exercise 1A

Given:

- Project Area = 6.7 acres
- Post Development Land Cover:
  - Managed Turf = **4.75 acres**
  - Impervious Cover = **1.95 acres**
- Assume "C" Soils

Determine for New Development:

- Total Phosphorus Load
- Target Tv
- Pollutant Removal Requirement
- Average Efficiency Required

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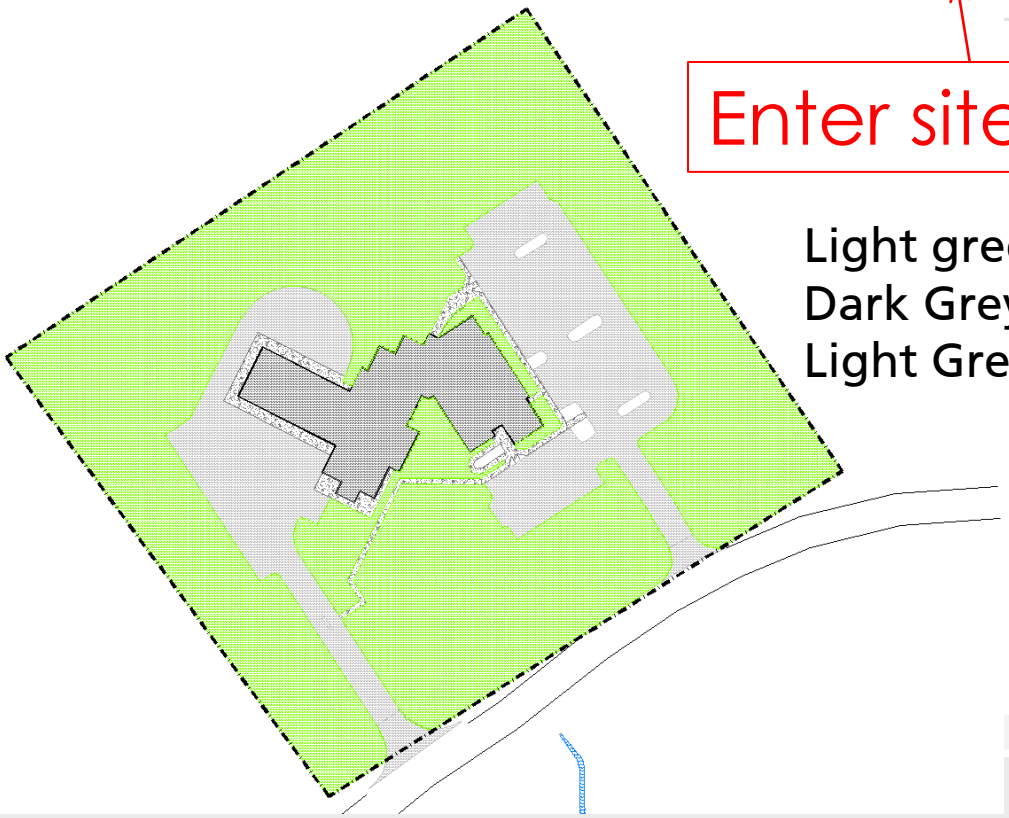
On Screen Demo

Land Cover (acres)					
	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	4.75	0.00	4.75
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95
				Total	6.70

Enter site data



Light green = Managed Turf
Dark Grey = Building
Light Grey = Parking & Sidewalks

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Results

Land Cover Summary			
Forest/Open Space Cover (acres)	0.00		
Weighted Rv(forest)	0.00		
% Forest	0%		
Managed Turf Cover (acres)	4.75		
Weighted Rv(turf)	0.22		
% Managed Turf	71%		
Impervious Cover (acres)	1.95		
Rv(impervious)	0.95		
% Impervious	29%		
Total Site Area (acres)	6.70		
Site Rv	0.43		
Post-Development Treatment Volume (acre-ft)	0.24		
Post-Development Treatment Volume (cubic feet)	10,518		
Post_Development Load (TP) (lb/yr)	6.61	Post_Development Load (TN) (lb/yr)	47.28
Total Load (TP) Reduction Required (lb/yr)	3.86		

- ✓Total TP Load = 6.61 lb/yr
  Reduction Required = 3.86 lb/yr
  Required Treatment Volume
  = 10,518 c.f.

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Results

Land Cover Summary			
Forest/Open Space Cover (acres)	0.00		
Weighted Rv(forest)	0.00		
% Forest	0%		
Managed Turf Cover (acres)	4.75		
Weighted Rv(turf)	0.22		
% Managed Turf	71%		
Impervious Cover (acres)	1.95		
Rv(impervious)	0.95		
% Impervious	29%		
Total Site Area (acres)	6.70		
Site Rv	0.43		
Post-Development Treatment Volume (acre-ft)	0.24		
Post-Development Treatment Volume (cubic feet)	10,518		
Post_Development Load (TP) (lb/yr)	6.61	Post_Development Load (TN) (lb/yr)	47.28
Total Load (TP) Reduction Required (lb/yr)	3.86		

- ✓ Total TP Load = 6.61 lb/yr
- ✓ Reduction Required = 3.86 lb/yr

Required Treatment Volume
= 10,518 c.f.

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Results

Land Cover Summary			
Forest/Open Space Cover (acres)	0.00		
Weighted Rv(forest)	0.00		
% Forest	0%		
Managed Turf Cover (acres)	4.75		
Weighted Rv(turf)	0.22		
% Managed Turf	71%		
Impervious Cover (acres)	1.95		
Rv(impervious)	0.95		
% Impervious	29%		
Total Site Area (acres)	6.70		
Site Rv	0.43		
Post-Development Treatment Volume (acre-ft)	0.24		
Post-Development Treatment Volume (cubic feet)	10,518		
Post_Development Load (TP) (lb/yr)	6.61	Post_Development Load (TN) (lb/yr)	47.28
Total Load (TP) Reduction Required (lb/yr)	3.86		

- ✓Total TP Load = 6.61 lb/yr
- ✓Reduction Required = 3.86 lb/yr
- ✓Required Treatment Volume = 10,518 c.f.

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Results

Land Cover Summary			
Forest/Open Space Cover (acres)	0.00		
Weighted Rv(forest)	0.00		
% Forest	0%		
Managed Turf Cover (acres)	4.75		
Weighted Rv(turf)	0.22		
% Managed Turf	71%		
Impervious Cover (acres)	1.95		
Rv(impervious)	0.95		
% Impervious	29%		
Total Site Area (acres)	6.70		
Site Rv	0.43		
Post-Development Treatment Volume (acre-ft)	0.24		
Post-Development Treatment Volume (cubic feet)	10,518		
Post_Development Load (TP) (lb/yr)	6.61	Post_Development Load (TN) (lb/yr)	47.28
Total Load (TP) Reduction Required (lb/yr)	3.86		

Save Results As: EX1A.xlsm

- ✓Total TP Load = 6.61 lb/yr
- ✓Reduction Required = 3.86 lb/yr
- ✓Required Treatment Volume = 10,518 c.f.

Overall Efficiency = 100*(3.86/6.61)
Required **= 58%**

High Overall Reduction Efficiency for a 30% Impervious site

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Exercise 1B

Environmental Site Design

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Exercise 1B

Given:

- Project Area = 6.7 acres
- Post Development Land Cover:
  - Open Space/Forest = **3 acres**
  - Managed Turf = **1.75 acres**
  - Impervious Cover = **1.95 acres**
- Assume "C" Soils

Determine for New Development:

- Total Phosphorus Load
- Target Tv
- Pollutant Removal Requirement
- Average Efficiency Required

**Assume 3 acres of turf from Exercise 1A can ether remain as undisturbed open space, or will be amended/restored/re-vegetated, etc.)

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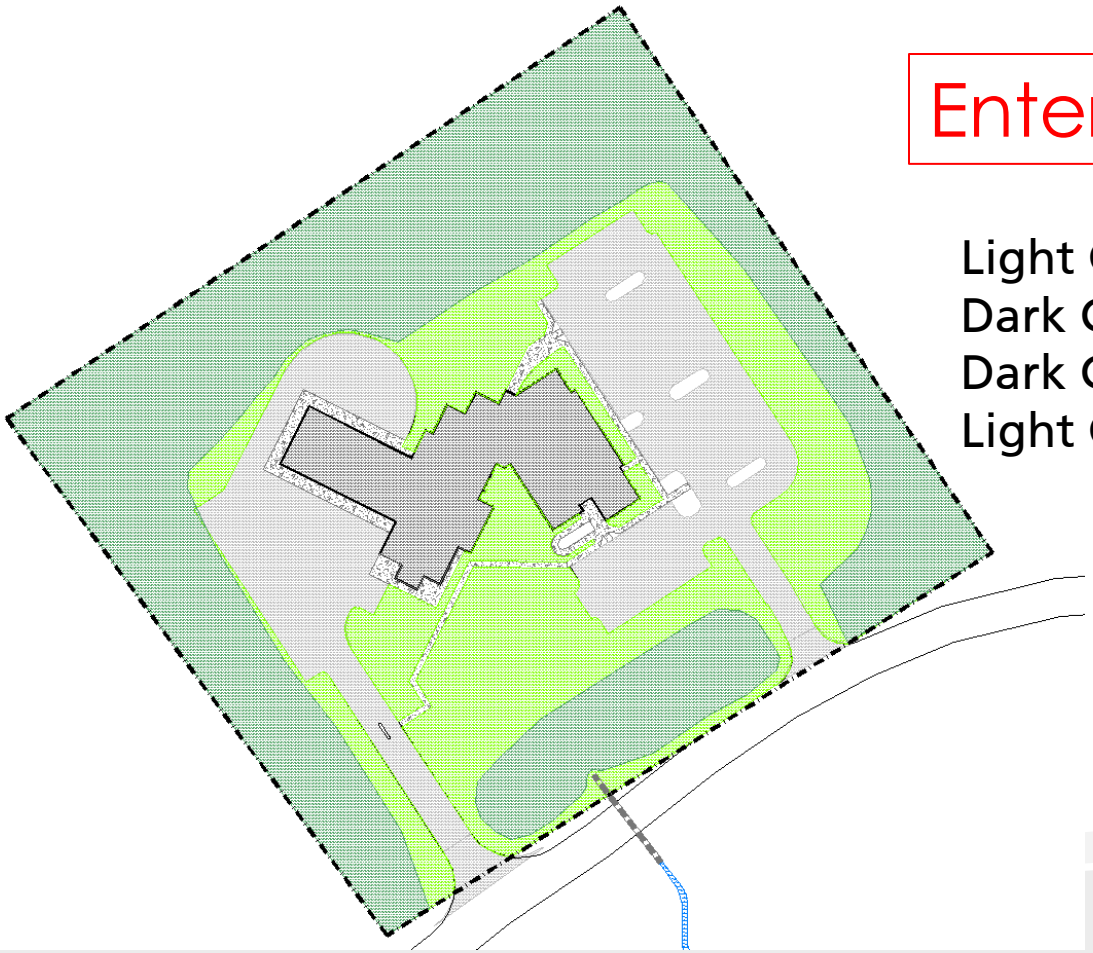
Land Cover (acres)					
	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	3.00	0.00	3.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	1.75	0.00	1.75
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95
				Total	6.70

Enter site data



Light Green = Turf
Dark Green = Forest/Open Space
Dark Grey = Building
Light Grey = Sidewalks/Parking

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Results

Land Cover Summary			
Forest/Open Space Cover (acres)	3.00		
Weighted Rv(forest)	0.04		
% Forest	45%		
Managed Turf Cover (acres)	1.75		
Weighted Rv(turf)	0.22		
% Managed Turf	26%		
Impervious Cover (acres)	1.95		
Rv(impervious)	0.95		
% Impervious	29%		
Total Site Area (acres)	6.70		
Site Rv	0.35		
Post-Development Treatment Volume (acre-ft)	0.20		
Post-Development Treatment Volume (cubic feet)	8,558		
Post_Development Load (TP) (lb/yr)	5.38	Post_Development Load (TN) (lb/yr)	38.46
Total Load (TP) Reduction Required (lb/yr)	2.63		

Save Results As: EX1B.xlsm

- ✓ Total TP Load = 5.38 lb/yr
- ✓ Reduction Required = 2.63 lb/yr
- ✓ Required Treatment Volume = 8,558 c.f.

Overall Efficiency = 100*(2.63/5.38)

Required **= 49%**

Reduced Overall Efficiency Requirement compared to Exercise 1A

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Exercise 1A & 1B Compared

	Exercise 1A	Exercise 1B
Total TP Load	**6.61 lb/yr**	**5.38 lb/yr**
Reduction Required	**3.86 lb/yr**	**2.63 lb/yr**
Required Treatment Volume	**10,518 c.f.**	**8,558 c.f.**
Overall Efficiency Required	**58%**	**49%**

Environmental Site Design reduces:

- ✓ Phosphorus leaving the site and
- ✓ Required amount of reduction

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Exercise 1C

Environmental Site Design

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Exercise 1C

- Project Area = 6.7 acres
- Assume "C" Soils throughout

Evaluate each of the following three treatments:

I. Extended Detention – Level 2 (Standalone)
[Surface Area = 0.25 Acres]

II. Composted Amended Grass Channel (Standalone)
[Surface Area = 0.25 Acres]

III. Compost Amended Channel to Extended Detention
[Surface Area = 0.5 Acres]

TP Reduction Achieved:	**TP Reduction Required:**
Water quality treatment requirements met?	

I. Extended Detention (L2)

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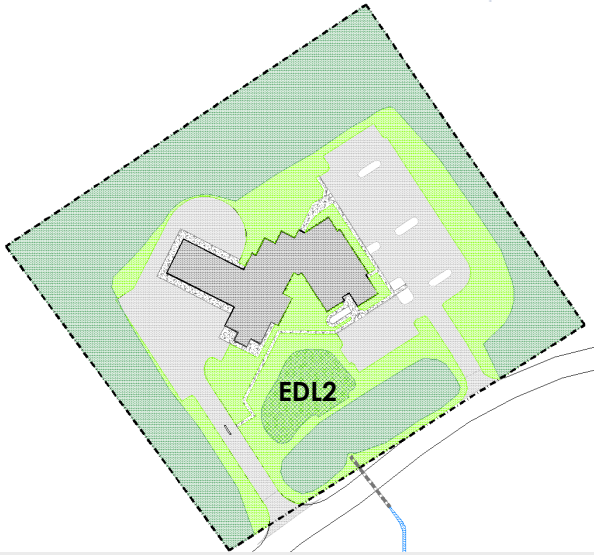
DEFINITION: FOREST & OPEN SPACE

Land that will remain undisturbed OR that will be restored to a hydrologically functional state:

- Portions of residential lots that will NOT be disturbed during construction
- Portions of roadway rights-of-way that, following construction, will be used as filter strips, grass channels, or stormwater treatment areas; MUST include soil restoration or placement of engineered soil mix as per the design specifications
- Community open space areas that will not be mowed routinely, but left in a natural vegetated state (can include areas that will be bush hogged no more than four times per year)
- Utility rights-of-way that will be left in a natural vegetated state (can include areas that will be bush hogged no more than four times per year)
- **Surface area of stormwater BMPs that are NOT wet ponds, have some type of vegetative cover, and that do not replace an otherwise impervious surface. BMPs in this category include bioretention, dry swale, grass channel, ED pond that is not mowed routinely, stormwater wetland, soil amended areas that are vegetated, and infiltration practices that have a vegetated cover.**
- Other areas of existing forest and/or open space that will be protected during construction and that will remain undisturbed. These include wetlands.

Step 1. Enter site data (Transfer 0.25 acres from Managed Turf to Forest/Open Space to account for 0.25 acre surface area of ED2

Land Cover (acres)					
	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	3.25	0.00	3.25
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	1.50	0.00	1.50
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95
				Total	6.70



Light Green = Turf
Dark Green = Forest/Open Space
Dark Grey = Building
Light Grey = Sidewalks/Parking

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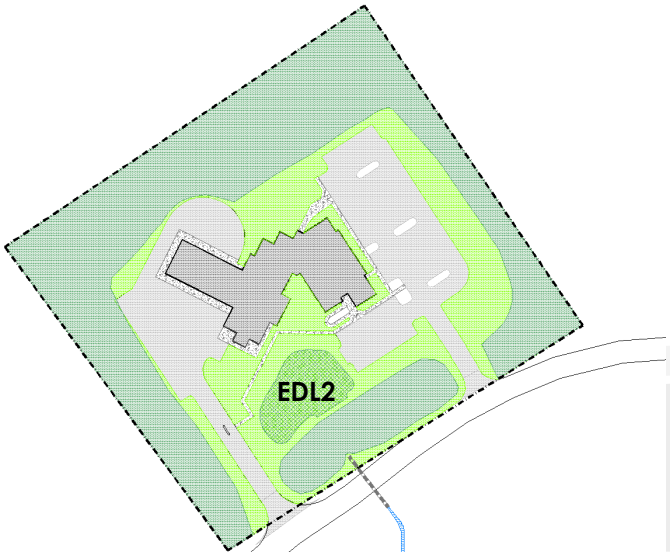
I. Extended Detention (L2)

Step 2. Transfer all site data to Drainage Area A

Drainage Area A Land Cover	(acres)					
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	3.25	0.00	3.25	0.04
Managed Turf (acres)	0.00	0.00	1.50	0.00	1.50	0.22
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	0.95
				Total	6.70	

*Assume all of the site is treated by practice



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I. Extended Detention (L2)

Drainage Area A Land Cover	(acres)					
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	3.25	0.00	3.25	0.04
Managed Turf (acres)	0.00	0.00	1.50	0.00	1.50	0.22
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	0.95
				Total	6.70	

8. Extended Detention Pond				
8.a. ED #1 (Spec #15)	impervious acres draining to ED	0% runoff volume reduction	0.00	0.00
	turf acres draining to ED	0% runoff volume reduction	0.00	0.00
8.b. ED #2 (Spec #15)	impervious acres draining to ED	15% runoff volume reduction	0.15	1.95
	turf acres draining to ED	15% runoff volume reduction	0.15	1.50

Step 3. Enter area treated by practice (assume 100% of both impervious cover and turf treated by practice)

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I. Extended Detention (L2)

Drainage Area A Land Cover	(acres)					
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	3.25	0.00	3.25	0.04
Managed Turf (acres)	0.00	0.00	1.50	0.00	1.50	0.22
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	0.95
				Total	6.70	

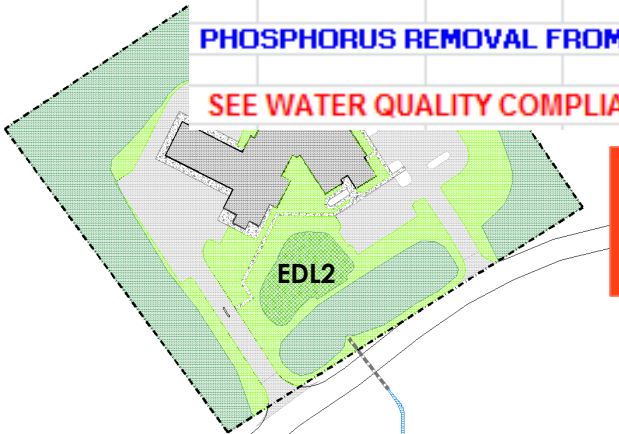
8. Extended Detention Pond				
8.a. ED #1 (Spec #15)	impervious acres draining to ED	0% runoff volume reduction	0.00	0.00
	turf acres draining to ED	0% runoff volume reduction	0.00	0.00
8.b. ED #2 (Spec #15)	impervious acres draining to ED	15% runoff volume reduction	0.15	1.95
	turf acres draining to ED	15% runoff volume reduction	0.15	1.50

TOTAL PHOSPHORUS REMOVAL REQUIRED ON SITE (lb/yr)	2.53
TOTAL RUNOFF REDUCTION IN D.A. A (cf)	1,188
PHOSPHORUS REMOVAL FROM RUNOFF REDUCTION PRACTICES IN D.A. A (lb/yr)	1.38

SEE WATER QUALITY COMPLIANCE TAB FOR SITE COMPLIANCE CALCULATIONS

TP Load Reduction Requirement = 2.53 lb/yr

TP Load Reduction = 1.38 lb/yr



DOES **NOT** MEET WATER QUALITY TREATMENT REQUIREMENTS

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I. Extended Detention (L2)

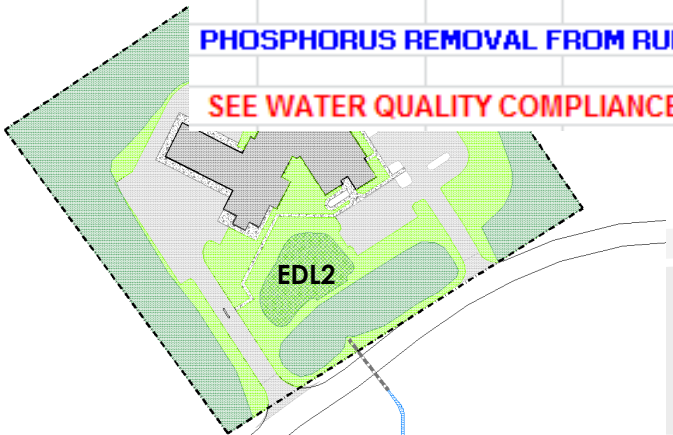
Drainage Area A Land Cover	(acres)					
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	3.25	0.00	3.25	0.04
Managed Turf (acres)	0.00	0.00	1.50	0.00	1.50	0.22
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	0.95
				Total	6.70	

8. Extended Detention Pond				
8.a. ED #1 (Spec #15)	impervious acres draining to ED	0% runoff volume reduction	0.00	0.00
	turf acres draining to ED	0% runoff volume reduction	0.00	0.00
8.b. ED #2 (Spec #15)	impervious acres draining to ED	15% runoff volume reduction	0.15	1.95
	turf acres draining to ED	15% runoff volume reduction	0.15	1.50

TOTAL PHOSPHORUS REMOVAL REQUIRED ON SITE (lb/yr)	2.53
TOTAL RUNOFF REDUCTION IN D.A. A (cf)	1,188
PHOSPHORUS REMOVAL FROM RUNOFF REDUCTION PRACTICES IN D.A. A (lb/yr)	1.38

SEE WATER QUALITY COMPLIANCE TAB FOR SITE COMPLIANCE CALCULATIONS

Delete ED L2 credit areas before proceeding to Exercise 1C Part II



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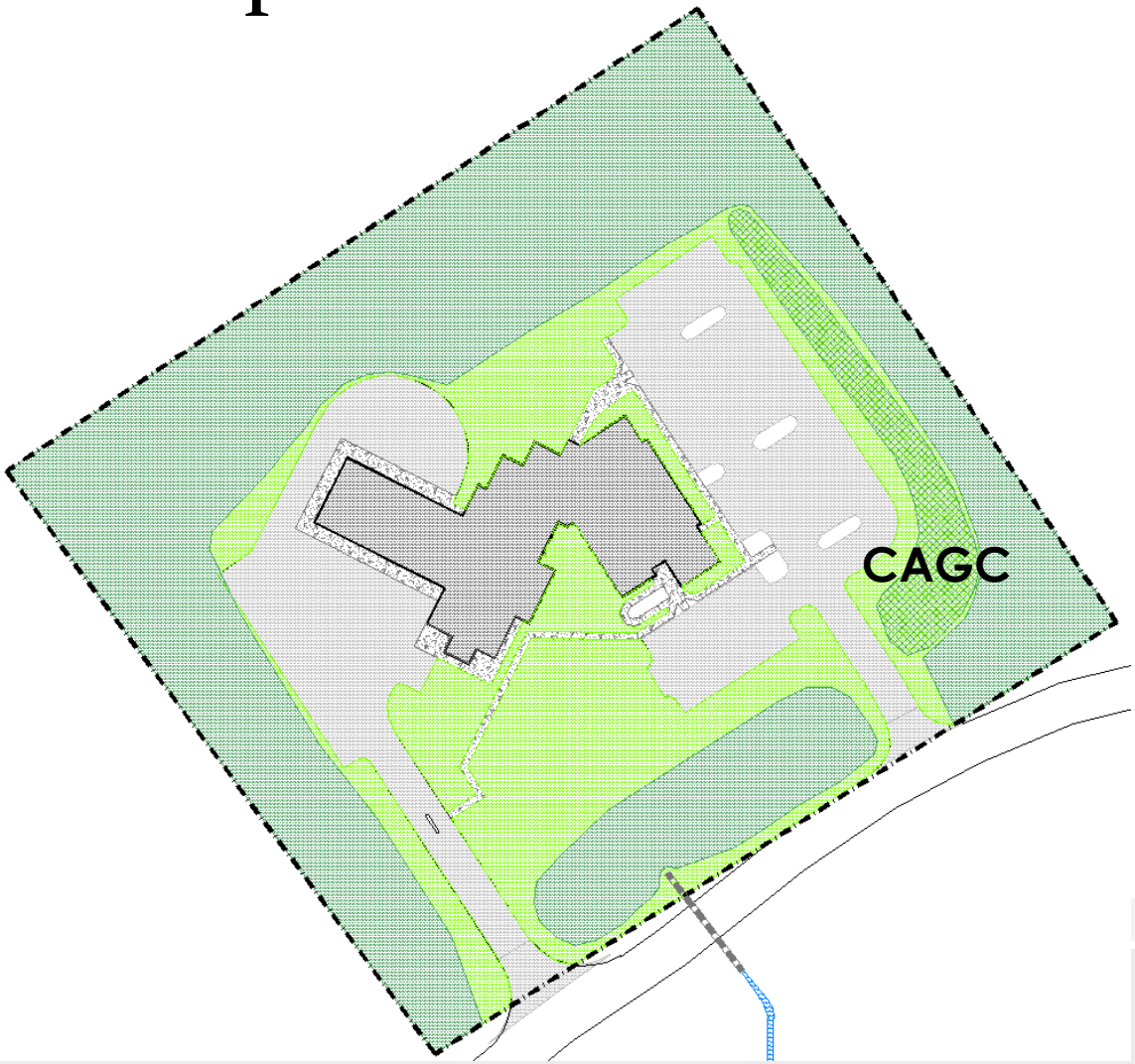
II. Compost Amended Grass Channel



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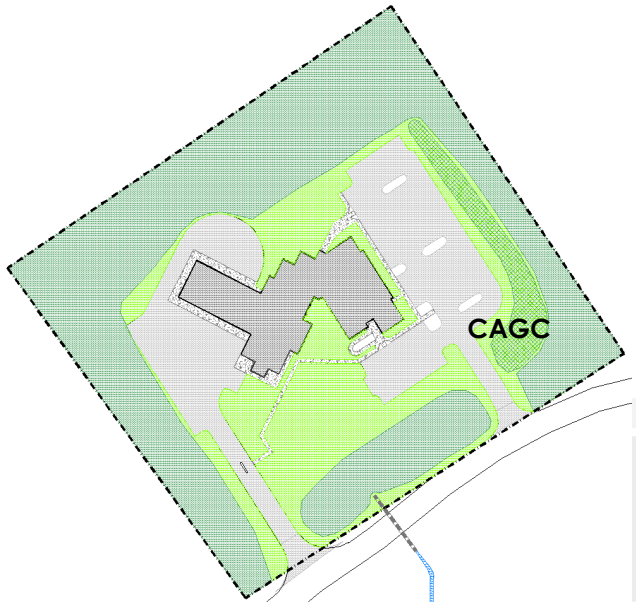
II. Compost Amended Grass Channel

Drainage Area B Land Cover	(acres)					
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	3.25	0.00	3.25	0.04
Managed Turf (acres)	0.00	0.00	1.50	0.00	1.50	0.22
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	0.95
				Total	6.70	

Same site and drainage land cover areas as in Part I



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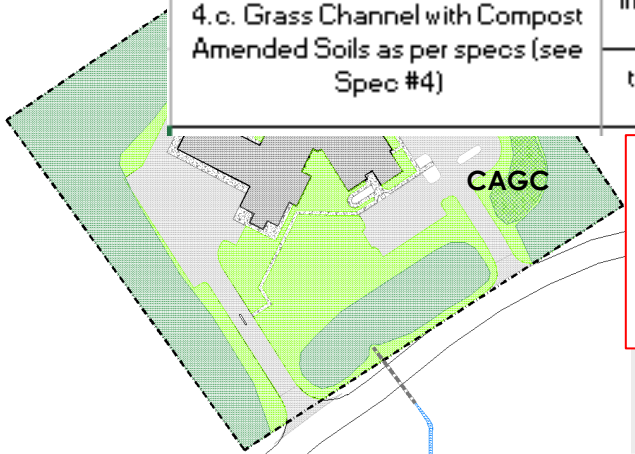
II. Compost Amended Grass Channel

Drainage Area B Land Cover	(acres)					
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	3.25	0.00	3.25	0.04
Managed Turf (acres)	0.00	0.00	1.50	0.00	1.50	0.22
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	0.95
				Total	6.70	

4. Grass Channel				
4.a. Grass Channel A/B Soils (Spec #3)	impervious acres draining to grass channels	20% runoff volume reduction	0.20	0.00
	turf acres draining to grass channels	20% runoff volume reduction	0.20	0.00
.b. Grass Channel C/D Soils (Spec #:	impervious acres draining to grass channels	10% runoff volume reduction	0.10	0.00
	turf acres draining to grass channels	10% runoff volume reduction	0.10	0.00
4.c. Grass Channel with Compost Amended Soils as per specs (see Spec #4)	impervious acres draining to grass channels	30% runoff volume reduction	0.30	1.95
	turf acres draining to grass channels	30% runoff volume reduction	0.30	1.50



Step 4. Enter area treated by practice (assume 100% of both impervious cover and turf treated by practice)

II. Compost Amended Grass Channel

Drainage Area B Land Cover	(acres)					
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	3.25	0.00	3.25	0.04
Managed Turf (acres)	0.00	0.00	1.50	0.00	1.50	0.22
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	0.95
				Total	6.70	

4. Grass Channel				
4.a. Grass Channel A/B Soils (Spec #3)	impervious acres draining to grass channels	20% runoff volume reduction	0.20	0.00
	turf acres draining to grass channels	20% runoff volume reduction	0.20	0.00
.b. Grass Channel C/D Soils (Spec #:	impervious acres draining to grass channels	10% runoff volume reduction	0.10	0.00
	turf acres draining to grass channels	10% runoff volume reduction	0.10	0.00
4.c. Grass Channel with Compost Amended Soils as per specs (see Spec #4)	impervious acres draining to grass channels	30% runoff volume reduction	0.30	1.95
	turf acres draining to grass channels	30% runoff volume reduction	0.30	1.50

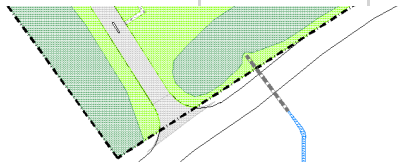
TP Load Reduction Requirement = 2.53 lb/yr

TP Load Reduction = 2.01 lb/yr

TOTAL PHOSPHORUS REMOVAL REQUIRED ON SITE (lb/yr)	2.53
TOTAL RUNOFF REDUCTION IN D.A. A (cf)	2,377
PHOSPHORUS REMOVAL FROM RUNOFF REDUCTION PRACTICES IN D.A. A (lb/yr)	2.01

SEE WATER QUALITY COMPLIANCE TAB FOR

DOES **NOT** MEET WATER QUALITY TREATMENT REQUIREMENTS



II. Compost Amended Grass Channel

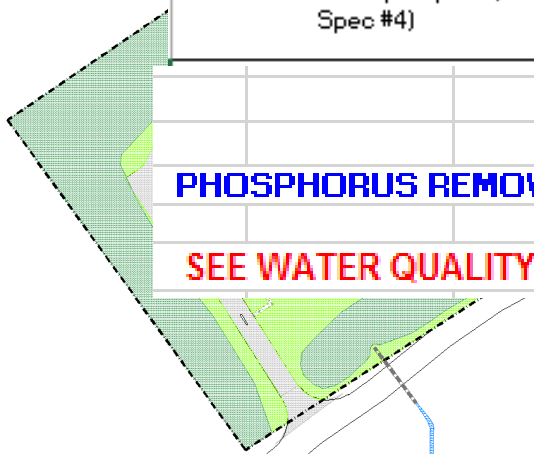
Drainage Area B Land Cover	(acres)					
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	3.25	0.00	3.25	0.04
Managed Turf (acres)	0.00	0.00	1.50	0.00	1.50	0.22
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	0.95
				Total	6.70	

4. Grass Channel				
4.a. Grass Channel A/B Soils (Spec #3)	impervious acres draining to grass channels	20% runoff volume reduction	0.20	0.00
	turf acres draining to grass channels	20% runoff volume reduction	0.20	0.00
.b. Grass Channel C/D Soils (Spec #:	impervious acres draining to grass channels	10% runoff volume reduction	0.10	0.00
	turf acres draining to grass channels	10% runoff volume reduction	0.10	0.00
4.c. Grass Channel with Compost Amended Soils as per specs (see Spec #4)	impervious acres draining to grass channels	30% runoff volume reduction	0.30	1.95
	turf acres draining to grass channels	30% runoff volume reduction	0.30	1.50

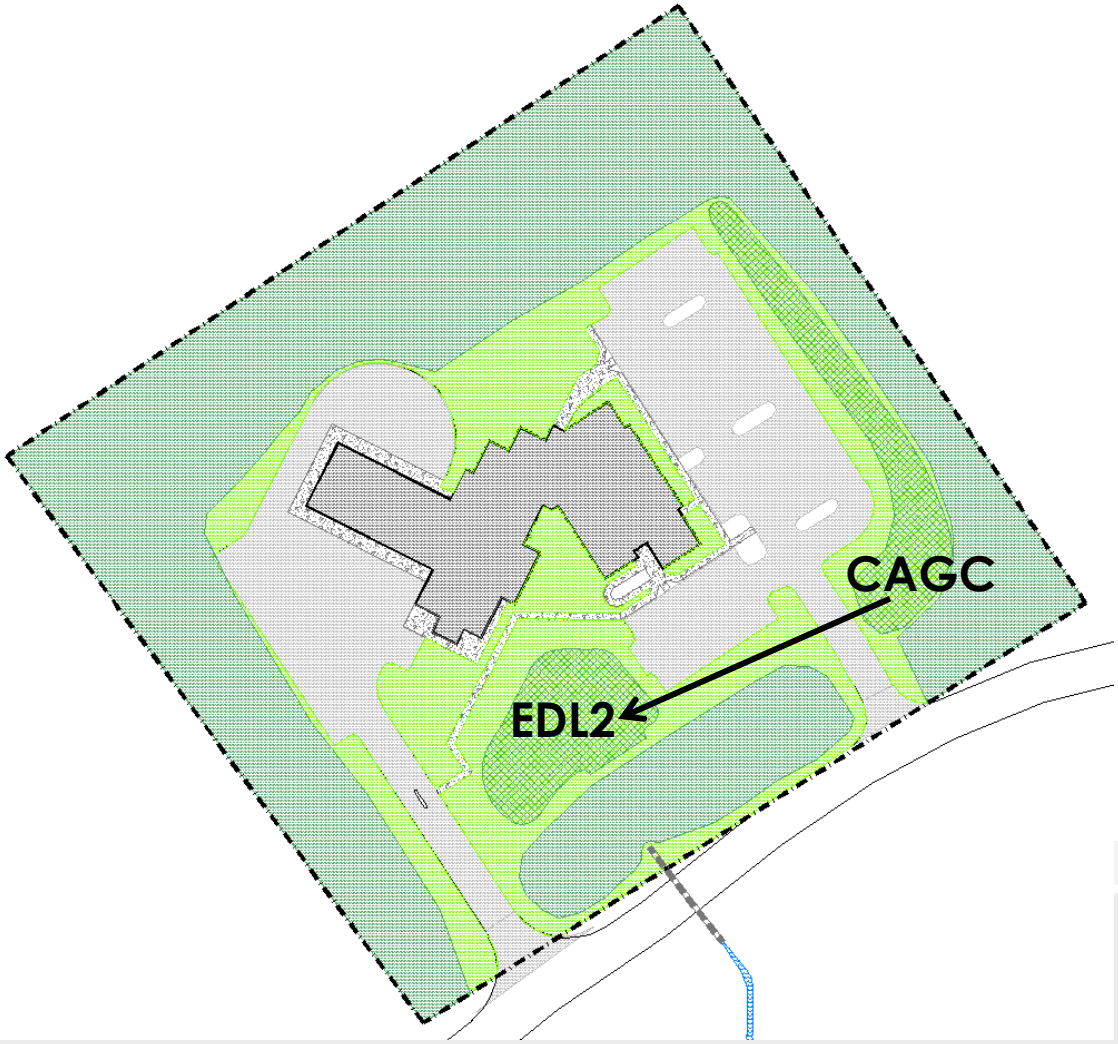
Delete ED L2 credit areas before proceeding to Exercise 1C Part III

TOTAL PHOSPHORUS REMOVAL REQUIRED ON SITE (lb/yr)	2.53
TOTAL RUNOFF REDUCTION IN D.A. A (cf)	2,377
PHOSPHORUS REMOVAL FROM RUNOFF REDUCTION PRACTICES IN D.A. A (lb/yr)	2.01

SEE WATER QUALITY COMPLIANCE TAB FOR SITE COMPLIANCE CALCULATIONS



III. Compost Amended Grass Channel to Extended Detention (L2)



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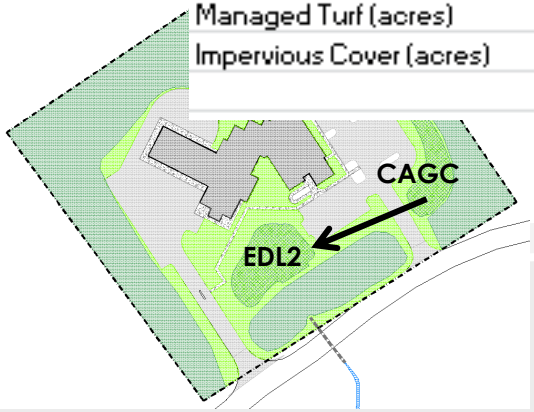
III. Compost Amended Grass Channel to Extended Detention (L2)

Step 5. Transfer another 0.25 acres from Turf to Forest/Open Space to account for total surface area of 0.5 acres for both practices in both Site Data tab and Drainage Area A tab

Land Cover (acres)					
	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	3.50	0.00	3.50
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	1.25	0.00	1.25
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95
				Total	6.70

Drainage Area C Land Cover (acres)						
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	3.50	0.00	3.50	0.04
Managed Turf (acres)	0.00	0.00	1.25	0.00	1.25	0.22
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	0.95
				Total	6.70	



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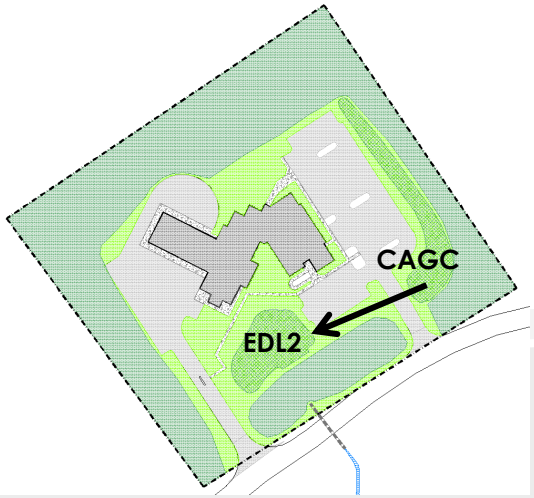
III. Compost Amended Grass Channel to Extended Detention (L2)

Drainage Area C Land Cover	(acres)					
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	3.50	0.00	3.50	0.04
Managed Turf (acres)	0.00	0.00	1.25	0.00	1.25	0.22
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	0.95
				Total	6.70	

4. Grass Channel													
4.a. Grass Channel A/B Soils (Spec #3)	impervious acres draining to grass channels	20% runoff volume reduction	0.20	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
	turf acres draining to grass channels	20% runoff volume reduction	0.20	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
.b. Grass Channel C/D Soils (Spec #:	impervious acres draining to grass channels	10% runoff volume reduction	0.10	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
	turf acres draining to grass channels	10% runoff volume reduction	0.10	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
4.c. Grass Channel with Compost Amended Soils as per specs (see Spec #4)	impervious acres draining to grass channels	30% runoff volume reduction	0.30	1.95	0	2017	4707	15	0.00	4.22	1.71	2.51	8.b. ED #2
	turf acres draining to grass channels	30% runoff volume reduction	0.30	1.25	0	299	699	15	0.00	0.63	0.25	0.37	8.b. ED #2



Step 6. Enter area treated by Compost Amended Grass Channel (assume 100% of both impervious cover and turf treated by practice)

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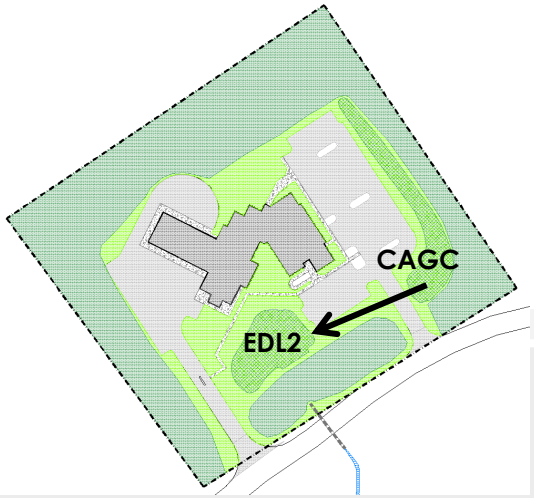
III. Compost Amended Grass Channel to Extended Detention (L2)

Drainage Area C Land Cover	(acres)					
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	3.50	0.00	3.50	0.04
Managed Turf (acres)	0.00	0.00	1.25	0.00	1.25	0.22
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	0.95
				Total	6.70	

4. Grass Channel												
4.a. Grass Channel A/B Soils (Spec #3)	impervious acres draining to grass channels	20% runoff volume reduction	0.20	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
	turf acres draining to grass channels	20% runoff volume reduction	0.20	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
.b. Grass Channel C/D Soils (Spec #:	impervious acres draining to grass channels	10% runoff volume reduction	0.10	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
	turf acres draining to grass channels	10% runoff volume reduction	0.10	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
4.c. Grass Channel with Compost Amended Soils as per specs (see Spec #4)	impervious acres draining to grass channels	30% runoff volume reduction	0.30	1.95	0	2017	4707	15	0.00	4.22	1.71	2.51	8.b. ED #2
	turf acres draining to grass channels	30% runoff volume reduction	0.30	1.25	0	299	699	15	0.00	0.63	0.25	0.37	8.b. ED #2

Downstream Practice



Step 7. Then add downstream ED L2 practice via drop down menu

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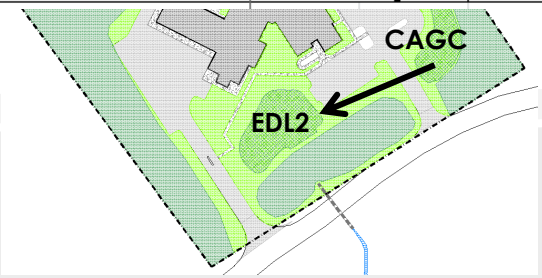
III. Compost Amended Grass Channel to Extended Detention (L2)

Drainage Area C Land Cover	(acres)					
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	3.50	0.00	3.50	0.04
Managed Turf (acres)	0.00	0.00	1.25	0.00	1.25	0.22
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	0.95
				Total	6.70	

4. Grass Channel												
4.a. Grass Channel A/B Soils (Spec #3)	impervious acres draining to grass channels	20% runoff volume reduction	0.20	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
	turf acres draining to grass channels	20% runoff volume reduction	0.20	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
.b. Grass Channel C/D Soils (Spec #3	impervious acres draining to grass channels	10% runoff volume reduction	0.10	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
	turf acres draining to grass channels	10% runoff volume reduction	0.10	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
4.c. Grass Channel with Compost Amended Soils as per specs (see Spec #4)	impervious acres draining to grass channels	30% runoff volume reduction	0.30	1.95	0	2017	4707	15	0.00	4.22	1.71	2.51	8.b. ED #2
	turf acres draining to grass channels	30% runoff volume reduction	0.30	1.25	0	289	699	15	0.00	0.63	0.25	0.37	8.b. ED #2

8. Extended Detention Pond												
8.a. ED #1 (Spec #15)	impervious acres draining to ED	0% runoff volume reduction	0.00	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
	turf acres draining to ED	0% runoff volume reduction	0.00	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
8.b. ED #2 (Spec #15)	impervious acres draining to ED	15% runoff volume reduction	0.15	0.00	80	807	4573	15	2.87	0.00	0.80	2.07	
	turf acres draining to ED	15% runoff volume reduction	0.15	0.00	299	120	679	15	0.43	0.00	0.12	0.31	

Downstream Practice



Do not enter here – will double drainage area

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III. Compost Amended Grass Channel to Extended Detention (L2)

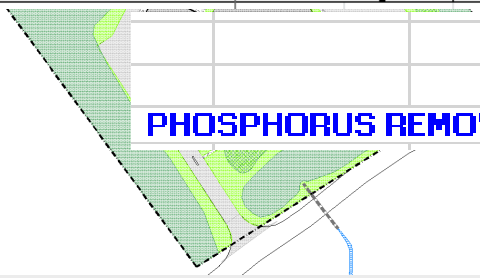
Save Results As: EX1C.xlsm

Drainage Area C Land Cover (acres)	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	3.50	0.00	3.50	0.04
Managed Turf (acres)	0.00	0.00	1.25	0.00	1.25	0.22
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	0.95
				Total	6.70	

4. Grass Channel												
4.a. Grass Channel A/B Soils (Spec #3)	impervious acres draining to grass channels	20% runoff volume reduction	0.20	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
	turf acres draining to grass channels	20% runoff volume reduction	0.20	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
.b. Grass Channel C/D Soils (Spec #3	impervious acres draining to grass channels	10% runoff volume reduction	0.10	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
	turf acres draining to grass channels	10% runoff volume reduction	0.10	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
4.c. Grass Channel with Compost Amended Soils as per specs (see Spec #4)	impervious acres draining to grass channels	30% runoff volume reduction	0.30	1.95	0	2017	4707	15	0.00	4.22	1.71	2.51	8.b. ED #2
	turf acres draining to grass channels	30% runoff volume reduction	0.30	1.25	0	299	699	15	0.00	0.63	0.25	0.37	8.b. ED #2

Downstream Practice

8. Extended Detention Pond												
8.a. ED #1 (Spec #15)	impervious acres draining to ED	0% runoff volume reduction	0.00	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
	turf acres draining to ED	0% runoff volume reduction	0.00	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
8.b. ED #2 (Spec #15)	impervious acres draining to ED	15% runoff volume reduction	0.15	0.00	5380	807	4573	15	2.87	0.00	0.80	2.07	
	turf acres draining to ED	15% runoff volume reduction	0.15	0.00	799	120	679	15	0.43	0.00	0.12	0.31	



TOTAL PHOSPHORUS REMOVAL REQUIRED ON SITE (lb/yr)	2.42
TOTAL RUNOFF REDUCTION IN D.A. A (cf)	3,128
PHOSPHORUS REMOVAL FROM RUNOFF REDUCTION PRACTICES IN D.A. A (lb/yr)	2.76

Summary of Results

Treatment	Reduction	Remaining
Extended Detention L2	**1.38 lb/yr**	**1.15 lb/yr**
Compost Amended Grass Channel	**2.01 lb/yr**	**0.52 lb/yr**
Compost Amended Grass Channel draining to Extended Detention L2	**2.76 lb/yr**	**None!**

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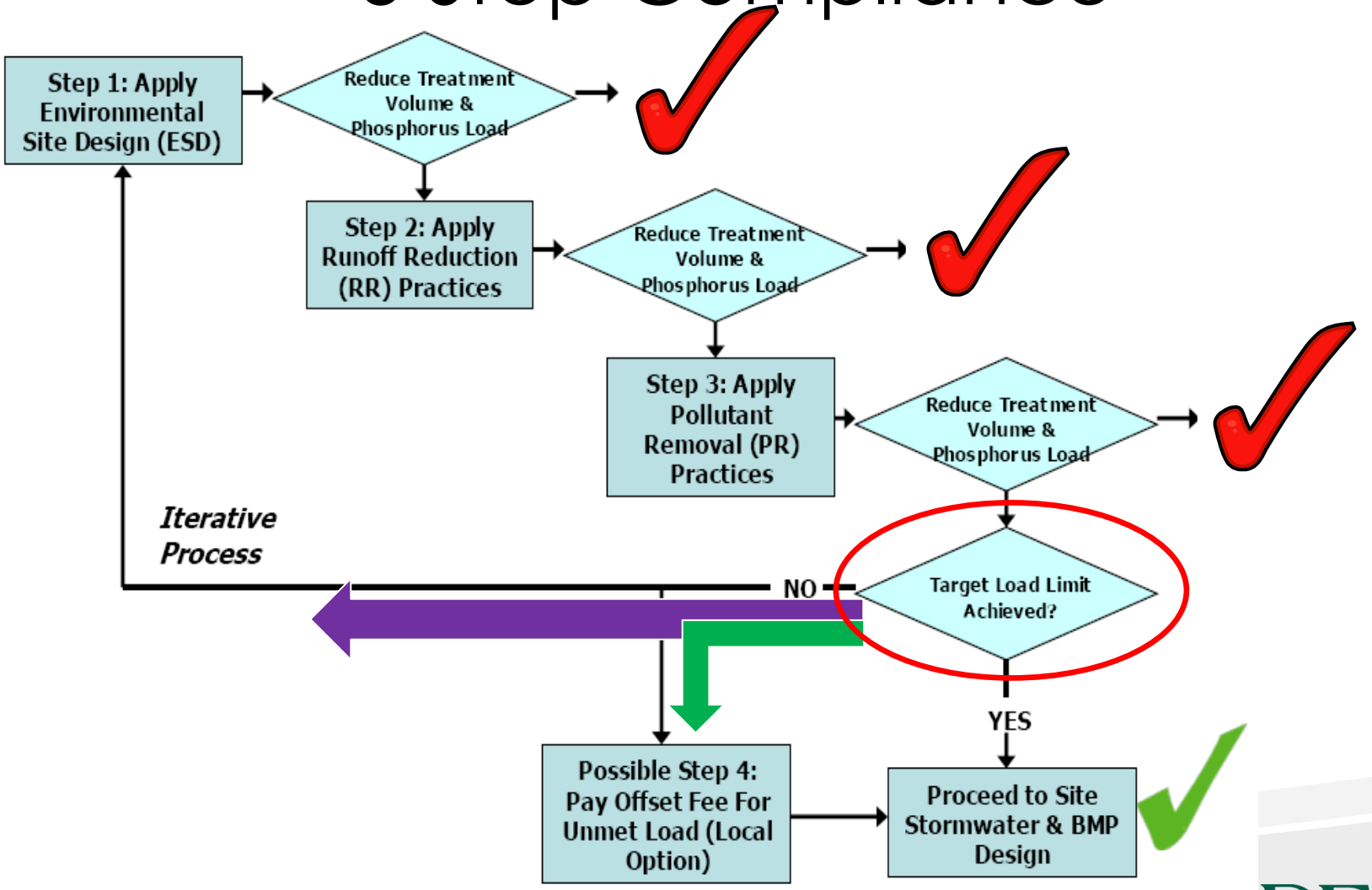
Virginia Runoff Reduction Method: 3 Step Compliance



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Exercise 2A

Post-CN

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Exercise 2A (Post- CN)

Given (Example 1A):

- Project Area = 6.7 acres
- Post Development Land Cover:
  - Managed Turf = **4.75 acres**
  - Impervious Cover = **1.95 acres**
- Assume "C" Soils
- 1-yr Rainfall 2.6 inches

Determine:

- Approximate **Curve Number** for a 1-yr storm
- Post-development 1-yr **Runoff Volume** (watershed-inches)

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Ex 2A (Post- CN)

1. Enter site data

Land Cover (acres)					
	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	4.75	0.00	4.75
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95
				Total	6.70

2. Copy site data to D.A. A tab

Drainage Area A						
Drainage Area A Land Cover (acres)						
	A soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres)	0.00	0.00	4.75	0.00	4.75	0.22
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	0.95
				Total	6.70	

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Ex 2A (Post- CN)

3. Go to the "Channel and Flood Protection" tab

4. Enter **2.6** for the 1-year storm rainfall amount

		1-year storm	2-year storm	10-year storm
Target Rainfall Event (in)		2.60	0.00	0.00
Drainage Area A				
Drainage Area (acres)	6.70			
Runoff Reduction Volume (cf)	0			

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5. Review Drainage Area A summary information

Drainage Area A		A soils	B Soils	C Soils	D Soils
Forest/Open Space -- undisturbed, protected forest/open space or reforested land	Area (acres)	0.00	0.00	0.00	0.00
	CN	30	55	70	77
Managed Turf -- disturbed, graded for yards or other turf to be mowed/managed	Area (acres)	0.00	0.00	4.75	0.00
	CN	39	61	74	80
Impervious Cover	Area (acres)	0.00	0.00	1.95	0.00
	CN	98	98	98	98

Weighted CN	S
81	2.35

	1-year storm	2-year storm	10-year storm
$RV_{Developed}$ (in) with no Runoff Reduction	1.01	0.00	0.00
$RV_{Developed}$ (in) with Runoff Reduction	1.01	0.00	0.00
Adjusted CN	81	100	100

Weighted or composite curve number (CN) = 81

This CN and associated S value are not adjusted for proposed BMPs

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Curve Number = 81

Drainage Area A		A soils	B Soils	C Soils	D Soils
Forest/Open Space -- undisturbed, protected forest/open space or reforested land	Area (acres)	0.00	0.00	0.00	0.00
	CN	30	55	70	77
Managed Turf -- disturbed, graded for yards or other turf to be mowed/managed	Area (acres)	0.00	0.00	4.75	0.00
	CN	39	61	74	80
Impervious Cover	Area (acres)	0.00	0.00	1.95	0.00
	CN	98	98	98	98

Weighted CN	S
81	2.35

	1-year storm	2-year storm	10-year storm
$RV_{Developed}$ (in) with no Runoff Reduction	1.01	0.00	0.00
$RV_{Developed}$ (in) with Runoff Reduction	1.01	0.00	0.00
Adjusted CN	81	100	100

No effective adjustment of CN

(BMPs not yet added – no runoff reduction)

Weighted or composite curve number (CN) = 81

This CN and associated S value are not adjusted for proposed BMPs

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6. Determine post-development 1-year **Runoff Volume** in watershed inches

	1-year storm	2-year storm	10-year storm
$RV_{Developed}$ (in) with no Runoff Reduction	1.01	1.79	3.52
$RV_{Developed}$ (in) with Runoff Reduction	1.01	1.79	3.52
Adjusted CN	81	81	81

Step 1. Calculate S using CN=81

$$S = \frac{1000}{CN} - 10 = \frac{1000}{81} - 10 = 2.35\,in$$

TR-55 Runoff Equations 2-3 & 2-4 (Module 5, p. 14 and Module 3, p.18)

S = potential maximum retention after runoff begins, inches

CN = runoff curve number

6. Determine post-development 1-year **Runoff Volume** in watershed inches

	1-year storm	2-year storm	10-year storm
$RV_{Developed}$ (in) with no Runoff Reduction	1.01	1.79	3.52
$RV_{Developed}$ (in) with Runoff Reduction	1.01	1.79	3.52
Adjusted CN	81	81	81

1-year storm	2-year storm	10-year storm
2.60	3.60	5.60

Step 1. Calculate S using CN=81

Step 2. Calculate Q using P=2.6 and calculated S value

$$S = \frac{1000}{CN} - 10 = \frac{1000}{81} - 10 = 2.35\,in$$

TR-55 Runoff Equations 2-3 & 2-4 (Module 5, p. 14 and Module 3, p.18)

S = potential maximum retention after runoff begins, inches

CN = runoff curve number

Post-Development 1-YR Runoff Volume = 1.0 in.

	1-year storm	2-year storm	10-year storm
$RV_{Developed}$ (in) with no Runoff Reduction	1.01	1.79	3.52
$RV_{Developed}$ (in) with Runoff Reduction	1.01	1.79	3.52
Adjusted CN	81	81	81

1-year storm	2-year storm	10-year storm
2.60	3.60	5.60

Step 1. Calculate S using CN=81

Step 2. Calculate Q using P=2.6 and calculated S value

TR-55 Runoff Equations 2-3 & 2-4 (Module 5, p. 14 and Module 3, p.18)

$$S = \frac{1000}{CN} - 10 = \frac{1000}{81} - 10 = 2.35\ in$$

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{[2.6 - (0.2 \times 2.35)]^2}{2.6 + (0.8 \times 2.35)} = 1.0\ in$$

S = potential maximum retention after runoff begins, inches

Q = runoff depth, inches (Runoff volume also expressed as runoff depth)

CN = runoff curve number

P =rainfall, inches

Post-Development 1-YR Runoff Volume* = 1.0 in.

	1-year storm	2-year storm	10-year storm
$RV_{Developed}$ (in) with no Runoff Reduction	1.01	1.79	3.52
$RV_{Developed}$ (in) with Runoff Reduction	1.01	1.79	3.52
Adjusted CN	81	81	81

1-year storm	2-year storm	10-year storm
2.60	3.60	5.60

Step 1. Calculate S using CN=81

Step 2. Calculate Q using P=2.6 and calculated S value

***RV in VRRM CN adjustment synonymous with Q in TR-55 Runoff Equation**

$$S = \frac{1000}{CN} - 10 = \frac{1000}{81} - 10 = 2.35\ in$$

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{[2.6 - (0.2 \times 2.35)]^2}{2.6 + (0.8 \times 2.35)} = 1.0\ in$$

TR-55 Runoff Equations 2-3 & 2-4 (Module 5, p. 14 and Module 3, p.18)

S = potential maximum retention after runoff begins, inches

Q = runoff depth, inches (Runoff volume also expressed as runoff depth)

CN = runoff curve number

P =rainfall, inches

Exercise 2B

Energy Balance Equation

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Exercise 2B (Energy Balance Equation)

Given (Exercise 1A, No runoff reduction or ESD):

- Pre-development CN of 74:
  - **Peak Q1 = 2.3 cfs**
  - **Runoff Volume = 0.62 in**
- Results from Exercise 2A for post-development where we found
  - **Post-development curve number = 81**
  - **Runoff Volume = 1.01 inches**

Determine:

- Allowable discharge from site for a 1-year storm using the energy balance equation

IF = Improvement Factor

0.8 for sites > 1 acre
0.9 for sites ≤ 1 acre

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Results

Step 1. Recall S and Q from Exercise 2A:

$$S = \frac{1000}{CN} - 10 = \frac{1000}{81} - 10 = 2.35\,in$$

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{[2.6 - (0.2 \times 2.35)]^2}{2.6 + (0.8 \times 2.35)} = 1.0\,in$$

***Remember: RV in VRRM CN adjustment (Channel and Flood Protection tab) equivalent to Q in TR-55 Runoff Equation**

Results

Step 1. Recall S and Q from Exercise 2A:

$$S = \frac{1000}{CN} - 10 = \frac{1000}{81} - 10 = 2.35\,in$$

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{[2.6 - (0.2 \times 2.35)]^2}{2.6 + (0.8 \times 2.35)} = 1.0\,in$$

Step 2. Calculate Pre and Post Runoff Volume

$$Vr_{post1} = Q \times A \times \frac{1}{12}$$

$$Vr_{pre1} = Q \times A \times \frac{1}{12}$$

Volume = Area x Depth

***RV (ft^3 or ac.ft) in VSMP Regs EB equation equivalent to Vr in TR-55**

Results

Step 1. Recall S and Q from Exercise 2A:

$$S = \frac{1000}{CN} - 10 = \frac{1000}{81} - 10 = 2.35\ in$$

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{[2.6 - (0.2 \times 2.35)]^2}{2.6 + (0.8 \times 2.35)} = 1.0\ in$$

Step 2. Calculate Pre and Post Runoff Volume

$$Vr_{post1} = Q \times A \times \frac{1}{12} = 1.0\ in \times 6.7\ Ac \times \frac{1\ ft}{12\ in}$$

$$Vr_{pre1} = Q \times A \times \frac{1}{12} = 0.62\ in \times 6.7\ Ac \times \frac{1\ ft}{12\ in}$$

Given

Equivalent to RV in VRRM CN adjustment (Channel and Flood Protection tab)

Results

Step 1. Recall S and Q from Exercise 2A:

$$S = \frac{1000}{CN} - 10 = \frac{1000}{81} - 10 = 2.35\ in$$

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{[2.6 - (0.2 \times 2.35)]^2}{2.6 + (0.8 \times 2.35)} = 1.0\ in$$

Step 2. Calculate Pre and Post Runoff Volume

$$Vr_{post1} = Q \times A \times \frac{1}{12} = 1.0\ in \times 6.7\ Ac \times \frac{1\ ft}{12\ in} = 0.56\ Acre\text{-}ft$$

$$Vr_{pre1} = Q \times A \times \frac{1}{12} = 0.62\ in \times 6.7\ Ac \times \frac{1\ ft}{12\ in} = 0.35\ Acre\text{-}ft$$

Given

Results

Step 1. Recall S and Q from Exercise 2A:

$$S = \frac{1000}{CN} - 10 = \frac{1000}{81} - 10 = 2.35\ in$$

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{[2.6 - (0.2 \times 2.35)]^2}{2.6 + (0.8 \times 2.35)} = 1.0\ in$$

Step 2. Calculate Pre and Post Runoff Volume

$$Vr_{post1} = Q \times A \times \frac{1}{12} = 1.0\ in \times 6.7\ Ac \times \frac{1\ ft}{12\ in} = 0.56\ Acre\text{-}ft$$

$$Vr_{pre1} = Q \times A \times \frac{1}{12} = 0.62\ in \times 6.7\ Ac \times \frac{1\ ft}{12\ in} = 0.35\ Acre\text{-}ft$$

Step 3. Calculate Allowable Peak Discharge

$$q_{1post} \le q_{1pre}\left(\frac{Vr_{pre1}}{Vr_{post1}}\right)(IF)$$

Results

Step 1. Recall S and Q from Exercise 2A:

$$S = \frac{1000}{CN} - 10 = \frac{1000}{81} - 10 = 2.35\ in$$

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{[2.6 - (0.2 \times 2.35)]^2}{2.6 + (0.8 \times 2.35)} = 1.0\ in$$

Step 2. Calculate Pre and Post Runoff Volume

$$Vr_{post1} = Q \times A \times \frac{1}{12} = 1.0\ in \times 6.7\ Ac \times \frac{1\ ft}{12\ in} = 0.56\ Acre\text{-}ft$$

$$Vr_{pre1} = Q \times A \times \frac{1}{12} = 0.62\ in \times 6.7\ Ac \times \frac{1\ ft}{12\ in} = 0.35\ Acre\text{-}ft$$

Step 3. Calculate Allowable Peak Discharge

$$q_{1post} \le q_{1pre}\left(\frac{Vr_{pre1}}{Vr_{post1}}\right)(IF) \le 2.3 \times \left(\frac{0.35}{0.56}\right) \times 0.8$$

Given

Recall: Site acreage >1 acre → IF = 0.8

Results

Step 1. Recall S and Q from Exercise 2A:

$$S = \frac{1000}{CN} - 10 = \frac{1000}{81} - 10 = 2.35\,in$$

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{[2.6 - (0.2 \times 2.35)]^2}{2.6 + (0.8 \times 2.35)} = 1.0\,in$$

Step 2. Calculate Pre and Post Runoff Volume

$$Vr_{post1} = Q \times A \times \frac{1}{12} = 1.0\,in \times 6.7\,Ac \times \frac{1\,ft}{12\,in} = 0.56\,Acre\text{-}ft$$

$$Vr_{pre1} = Q \times A \times \frac{1}{12} = 0.62\,in \times 6.7\,Ac \times \frac{1\,ft}{12\,in} = 0.35\,Acre\text{-}ft$$

Step 3. Calculate Allowable Peak Discharge

$$q_{1post} \le q_{1pre}\left(\frac{Vr_{pre1}}{Vr_{post1}}\right)(IF) \le 2.3 \times \left(\frac{0.35}{0.56}\right) \times 0.8$$

$$\le 1.1\,cfs$$

Post-Development Release Rate cannot exceed 1.1 cfs

Exercise 2C

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Exercise 2C

Given:

- Runoff Reduction/ESD approach (CAGC to ED-L2) (as in Exercise 1C)
- Post Development (Ex. 1C):
  - Impervious Cover = **1.95 acres**
  - Open Space = **3.5 acres**
  - Managed Turf = **1.25 acres**
- 1-yr Rainfall 2.6 inches
- Pre-development CN of 74:
  - **Peak Q1 = 2.3 cfs**
  - **Runoff Volume = 0.62 in**

Determine:

- Allowable discharge from site using the energy balance equation

Exercise 2C

Step 1. Open Exercise 1C Spreadsheet (Site Data and Drainage Area A land cover areas stay the same):

Impervious Cover	Open Space	Managed Turf
1.95 acres	3.5 acres	1.25 acres

Step 2. Enter 1-yr rainfall in Channel and Flood Protection tab:

1-year storm	2-year storm	10-year storm
2.60	3.60	5.60

Step 3. Note adjusted CN and Runoff Volume (with RR) in Channel and Flood Protection tab:

	1-year storm	2-year storm	10-year storm
$RV_{Developed}$ (in) with no Runoff Reduction	0.91	1.64	3.32
$RV_{Developed}$ (in) with Runoff Reduction	0.78	1.52	3.20
Adjusted CN	76	77	78

Final Answer

Step 4. Calculate Pre and Post Dev Runoff Volumes (Vr) in ac-ft:

$$Vr_{post1} = Q \times A \times \frac{1}{12} = 0.78\,in \times 6.7\,Ac \times \frac{1\,ft}{12in} = 0.44\,Acre - ft$$

$$Vr_{pre1} = Q \times A \times \frac{1}{12} = 0.62\,in \times 6.7\,Ac \times \frac{1\,ft}{12in} = 0.35\,Acre - ft$$

Final Answer

Step 4. Calculate Pre and Post Dev Runoff Volumes (Vr) in ac-ft:

Use RV in VRRM CN adjustment (Channel and Flood Protection tab)

$$Vr_{post1} = Q \times A \times \frac{1}{12} = 0.78\,in \times 6.7\,Ac \times \frac{1\,ft}{12in} = 0.44\,Acre - ft$$

$$Vr_{pre1} = Q \times A \times \frac{1}{12} = 0.62\,in \times 6.7\,Ac \times \frac{1\,ft}{12in} = 0.35\,Acre - ft$$

Given

Final Answer

Step 5. Calculate Allowable Peak Discharge:

$$Vr_{post1} = Q \times A \times \frac{1}{12} = 0.78\,in \times 6.7\,Ac \times \frac{1\,ft}{12in} = 0.44\,Acre - ft$$

$$Vr_{pre1} = Q \times A \times \frac{1}{12} = 0.62\,in \times 6.7\,Ac \times \frac{1\,ft}{12in} = 0.35\,Acre - ft$$

$$q_{1post} \le q_{1pre}\left(\frac{Vr_{pre1}}{Vr_{post1}}\right)(IF)$$

Recall: Site acreage >1 acre → IF = 0.8

Given

$$\le 2.3 \times \left(\frac{0.35}{0.44}\right) \times 0.8 \le 1.5\,cfs$$

Post-Development Release Rate cannot exceed 1.5 cfs

Comparison

Exercise	RR or ESD?	Runoff Volume (acre-ft)	Peak Discharge (cfs)
2B	None	0.56	1.1
2C	Both	0.44	1.5

Runoff Reduction Practices and Environmental Site Design allow developers to have a higher discharge rate leaving the site due to the reduction in runoff volume.

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Exercise 2D

Facilitated Exercise

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Exercise 2D – Facilitated Exercise

Given:

- Results from Exercises 2B and 2C and following post-developed runoff rates for 1-year event:
  - **2B (no runoff reduction) = 6.7 cfs**
  - **2C (ESD and RR) = 4.2 cfs**

Estimate:

- Detention storage needed to satisfy allowable release rate

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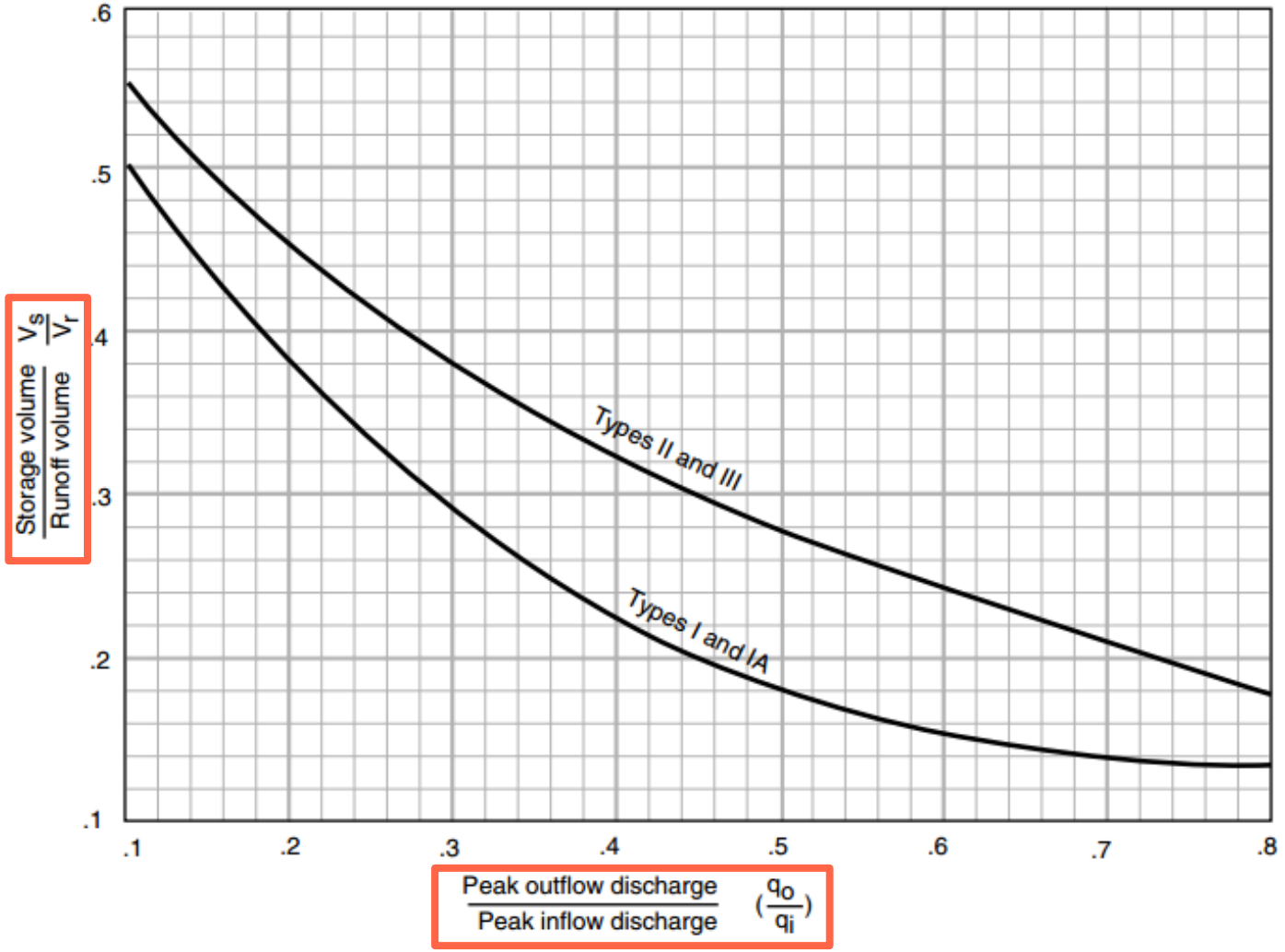
Fig 6-1, TR-55

Figure 6-1 Approximate detention basin routing for rainfall types I, IA, II, and III



Storage Required?

- Remember we calculated the allowable rates in Exercises 2B & 2C

Using the post-developed peak flow rates for the site from each exercise:

1. Determine $\mathbf{q_o/q_i}$.
2. Then estimate the allowable $\mathbf{V_s/V_r}$ from Fig. 6.1, TR-55 *(page 23 of Module 5 of the Participant Guide)*

2B (no runoff reduction): $q_i = 6.7$ cfs, $q_o = 1.1$ cfs
2C (ESD and RRM): $q_i = 4.2$ cfs, $q_o = 1.5$ cfs

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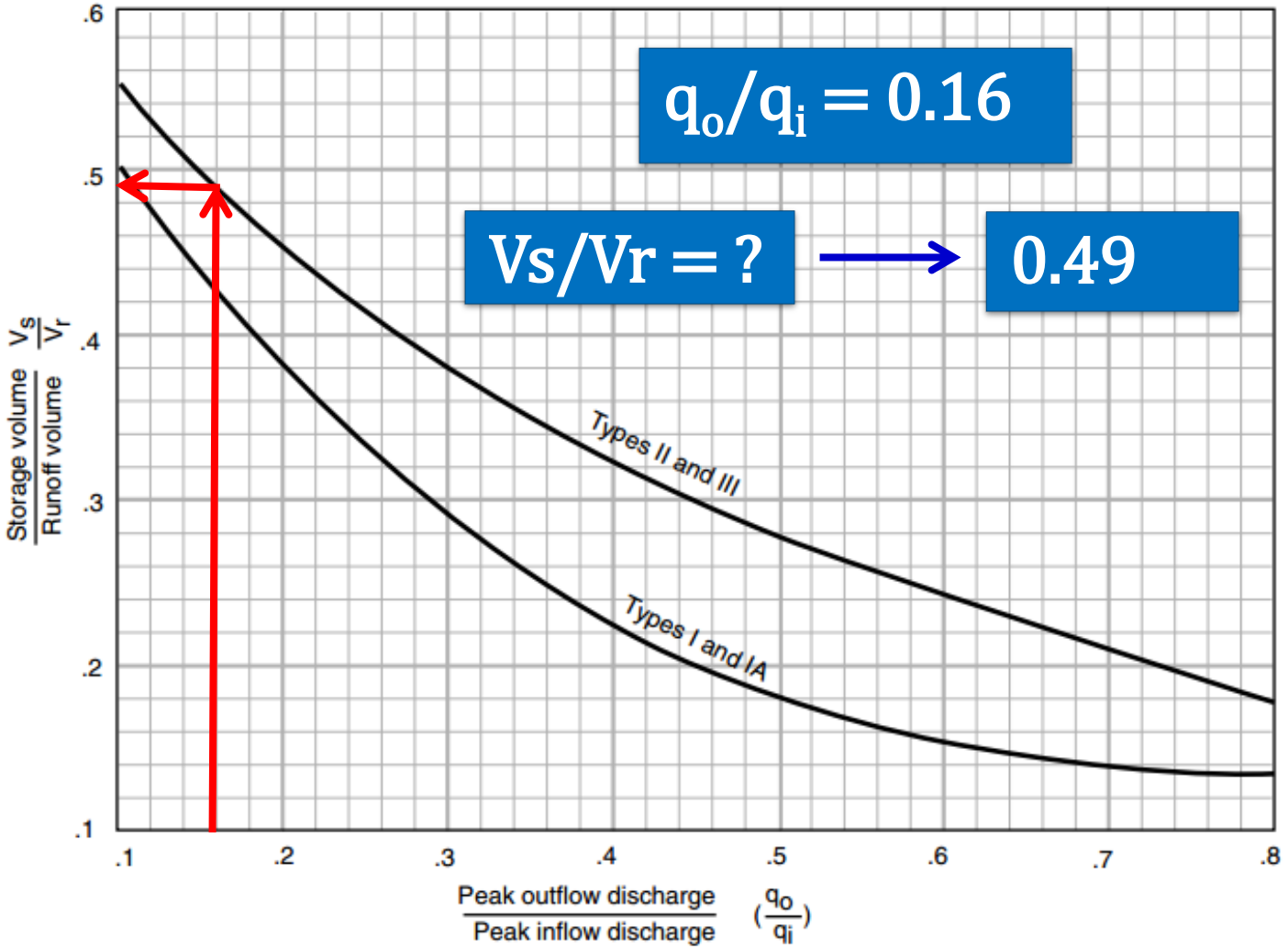
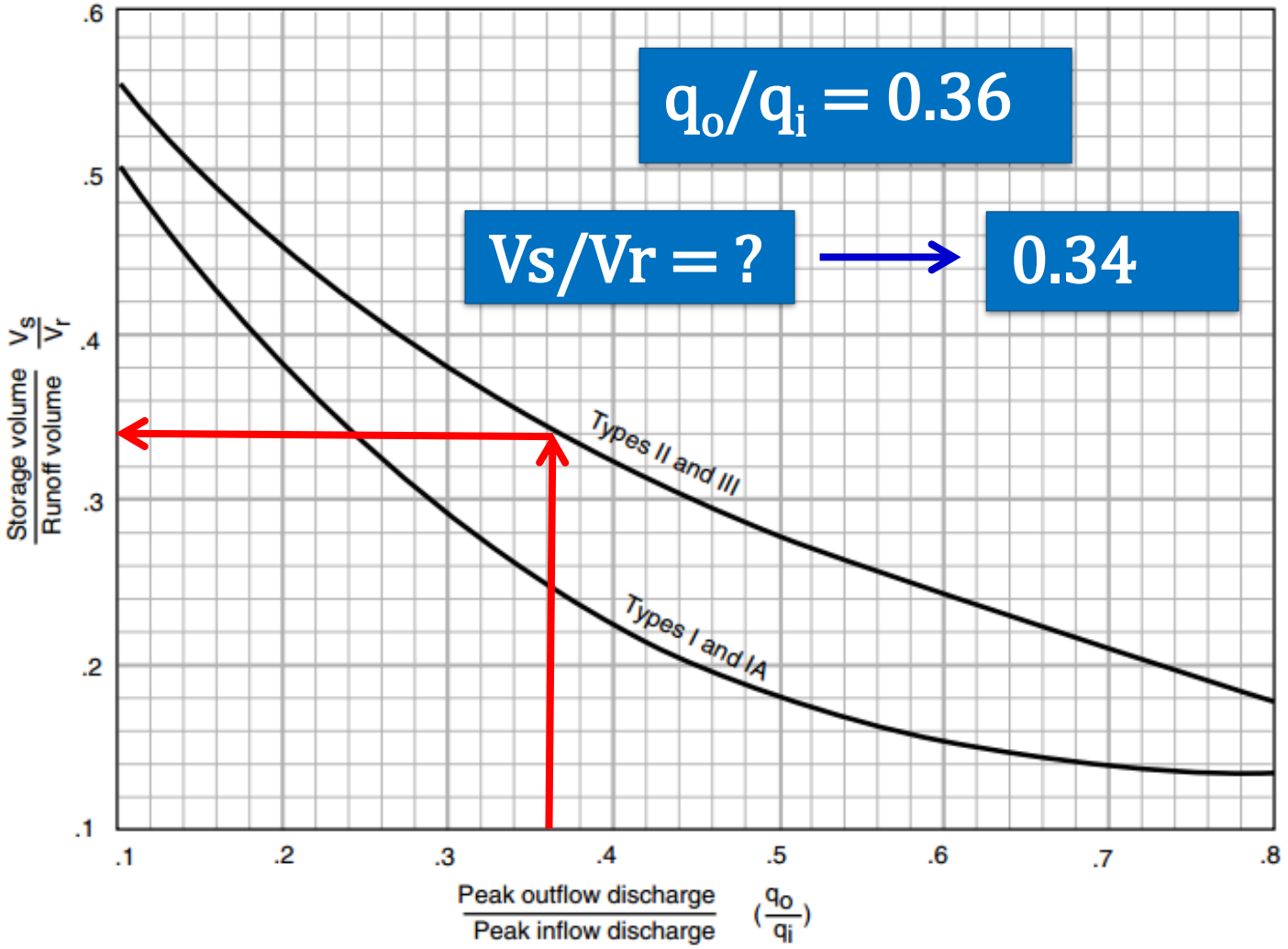
Exercise 2B Result

Figure 6-1 Approximate detention basin routing for rainfall types I, IA, II, and III



Exercise 2C Result

Figure 6-1 Approximate detention basin routing for rainfall types I, IA, II, and III



Results

Using the V_s/V_r calculate the approximate storage:

Exercise 2B Storage Required:

$$\frac{V_s}{V_r} = 0.49, V_r = 0.56\ acre\text{-}ft \longrightarrow V_s = 0.27\ \ acre\text{-}ft$$

Exercise 2C Storage Required:

$$\frac{V_s}{V_r} = 0.34, V_r = 0.42\ acre\text{-}ft \longrightarrow V_s = 0.15\ acre\text{-}ft$$

Runoff Reduction and ESD:

***Allow greater discharges from site and**

***Reduce overall storage requirement on site**

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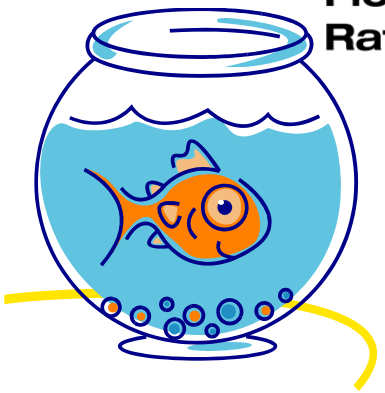
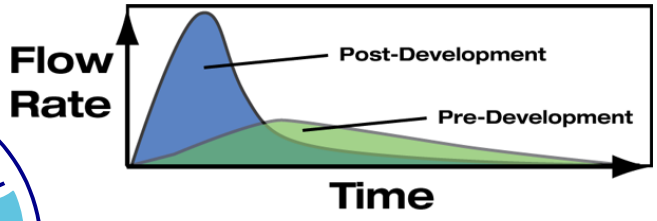
Benefits of Runoff Reduction

Water Quality → Higher Allowable Release Rates → Less Runoff Generation → Smaller Basins





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Exercise 2 Summary

- Relatively simple methodology to check basic design constraints
- Environmental Site Design and Runoff Reduction Methods can allow for higher discharges leaving site and reduce necessary storage on site
- Reviewer can provide suggestions for compliance to designer using these simple techniques

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Exercise 3

Group Review

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Exercise 3 – Group Review

Given:

- A 6.7 acre site with treatment by a **single bioretention level 1 facility** is proposed

Determine:

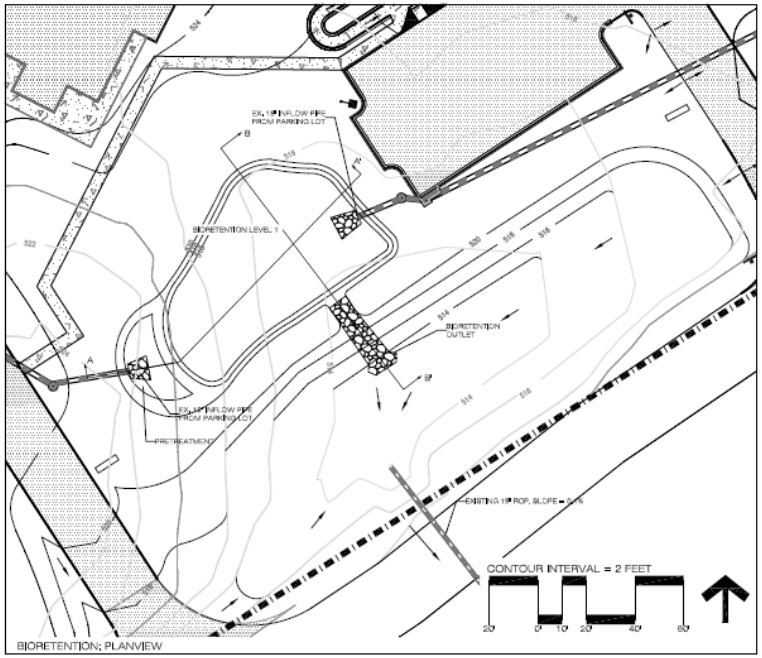
- If the facility is designed properly

Group materials:
One 24" x 36" laminated plan sheet
Duplicate 8.5" x 11" laminated sheets (2)

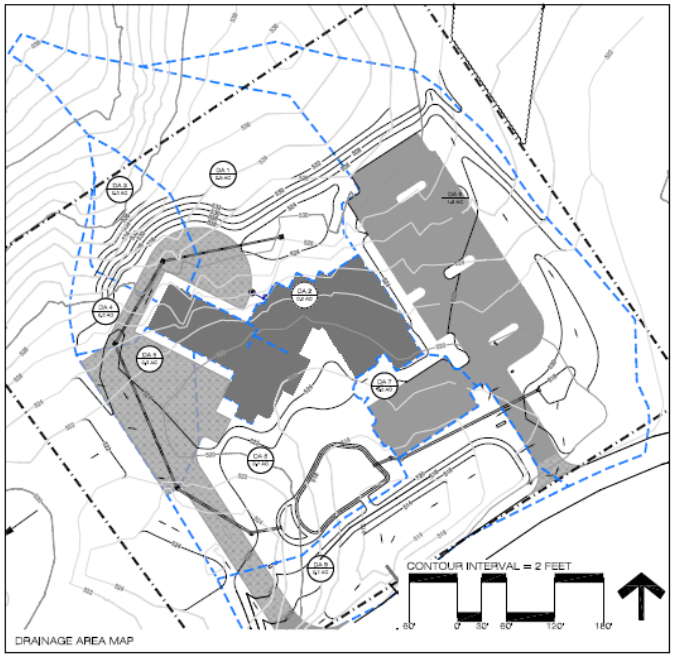
Land Use & Drainage Information:

	Impervious	Managed Turf	Open Space	Total
Site Data	1.95	1.25	3.50	6.70
Drainage Data	1.9	1.10	1.67	4.67

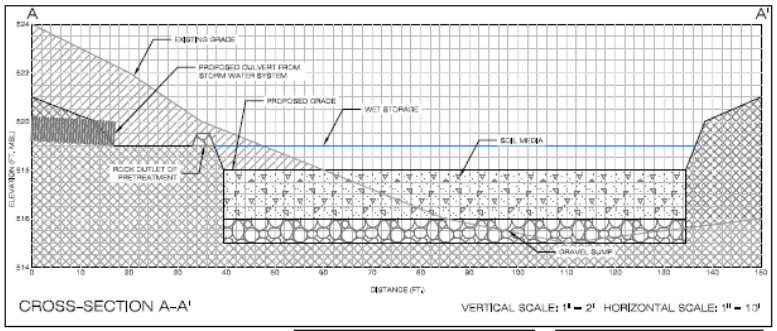
Bioretention Design to Review



BIORETENTION: PLANVIEW

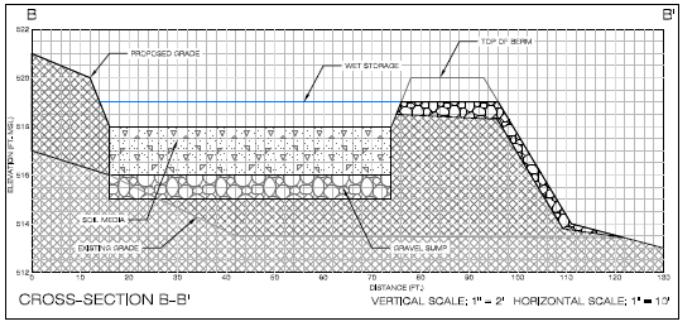


DRAINAGE AREA MAP



CROSS-SECTION A-A'

VERTICAL SCALE: 1" = 2' HORIZONTAL SCALE: 1" = 10'



CROSS-SECTION B-B'

VERTICAL SCALE: 1" = 2' HORIZONTAL SCALE: 1" = 10'

PROPOSED DRAINAGE AREA CHARACTERISTICS:
AREA = 4.67 ACRES
IMPERVIOUS ACREAGE = 1.26 ACRES
OPEN SPACE/ FOREST ACREAGE = 1.67 ACRES
MANAGED TURF ACREAGE = 1.10 ACRES

CURVE NUMBER: 83
TIME OF CONCENTRATION: 5 MINUTES

SITE CONDITIONS:
AREA = 5.7 ACRES
IMPERVIOUS ACREAGE = 1.26 ACRES
OPEN SPACE/ FOREST ACREAGE = 3.5 ACRES
MANAGED TURF ACREAGE = 1.25 ACRES

PHOSPHOROUS REDUCTION CALCULATIONS:
POST DEVELOPMENT PHOSPHOROUS LOAD = 5.17 LB/YR

TOTAL LOAD REDUCTION REQUIRED =2.42 LB/YR

RUNOFF REDUCTION BY PRACTICE =0.372 C.F.

TOTAL LOAD REDUCTION BY PRACTICE =2.58 LB/YR

SIZING CALCULATIONS, BIORETENTION LEVEL 1:
POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED
BMP T_v=3,231 C.F.

SOIL MEDIA DEPTH = 24 IN
GRAVEL SUMP = 12 IN
WET STORAGE = 12 IN
STORAGE DEPTH = DEPTH x VOID RATIO
=(24X0.25)+(12X0.4)+(12X1) = 22.8 IN = 1.9 FT
BIORETENTION SURFACE AREA
=Tv/ STORAGE DEPTH = 3,231/1.9 = 4,332 S.F.
SURFACE AREA PROVIDED = 4,345 S.F.
TREATMENT VOLUME PROVIDED = 3,255 C.F.

SPILLWAY CALCULATIONS:
Q2 = 8.5 CFS, Q10 = 13.2 CFS

SLOPE = 33%
DIMENSIONS: BOTTOM WIDTH = 5 FT
SIDE SLOPES = 2:1

SHEAR STRESS = Rh X SLOPE X Sw WATER
=0.25 X 0.33 X 62.4 = 5.77 LB/SF

CLASS II RIPRAP FOR CHANNEL LINING

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APRIL 2014

DEPARTMENT OF PUBLIC WORKS AND ENVIRONMENTAL SERVICES
SMALLTOWN, VIRGINIA

STORMWATER PLANNING DIVISION

VA COMMERCIAL DEVELOPMENT
SITE PLAN

DEQ TRAINING CASE STUDY

SCALE 1"=40'

NO.	DESCRIPTION	BY	APPROVED	DATE

Building Setback

Surface Area Sizing

SA greater than required – but OK

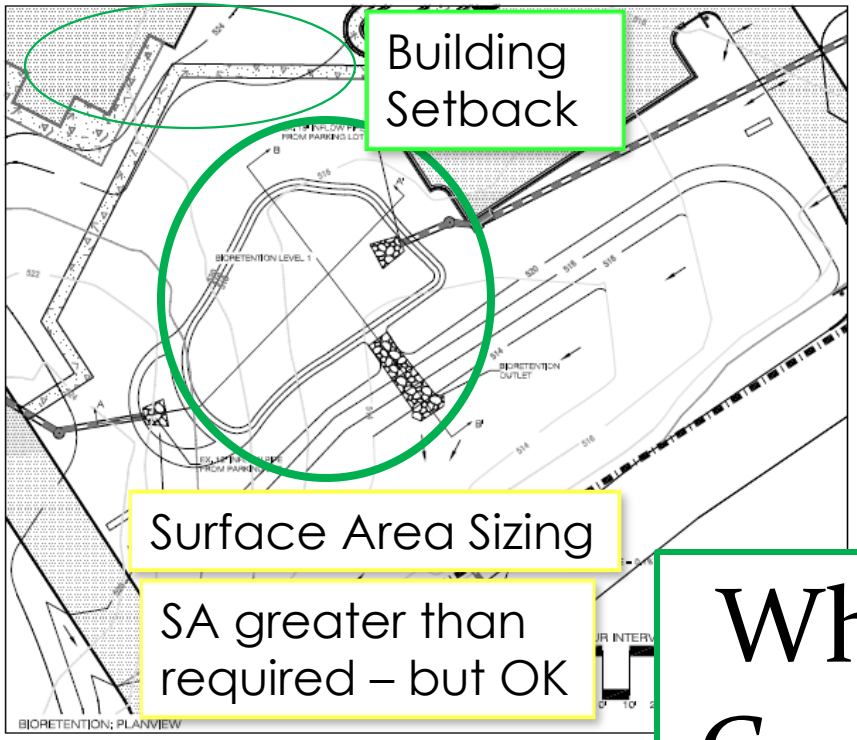
What is Correct?

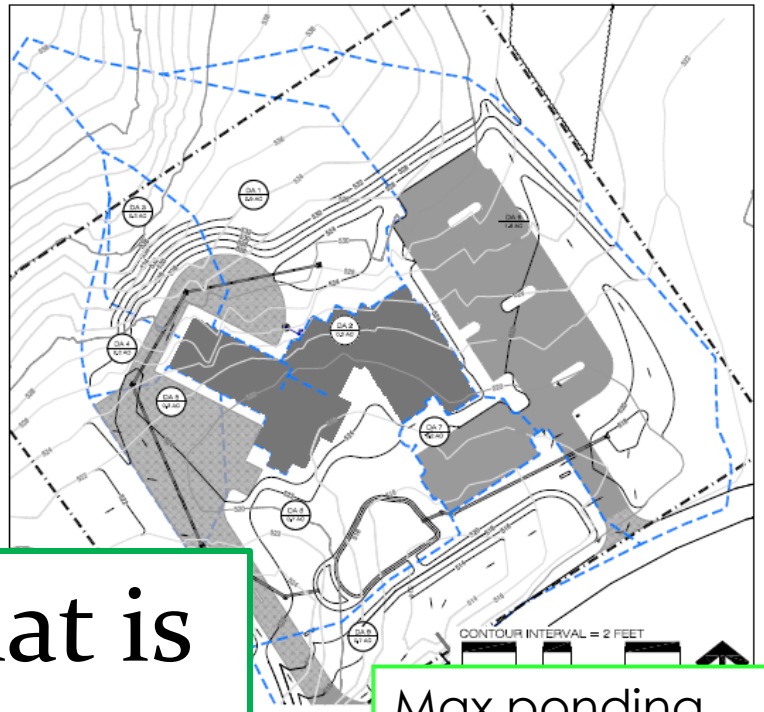
Max ponding depth given as 12"

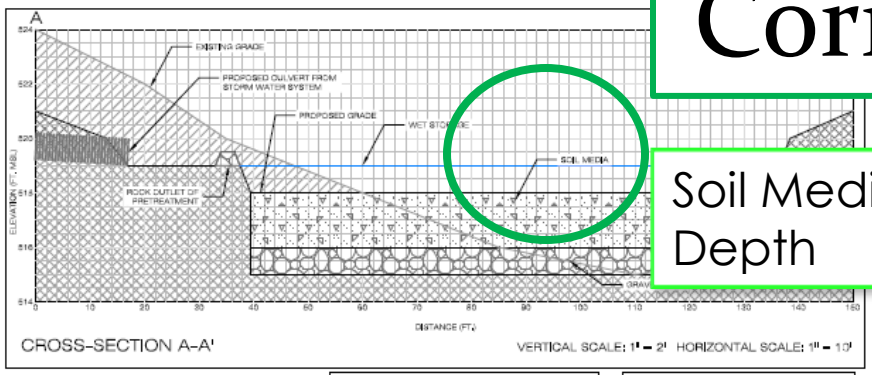
Soil Media Depth

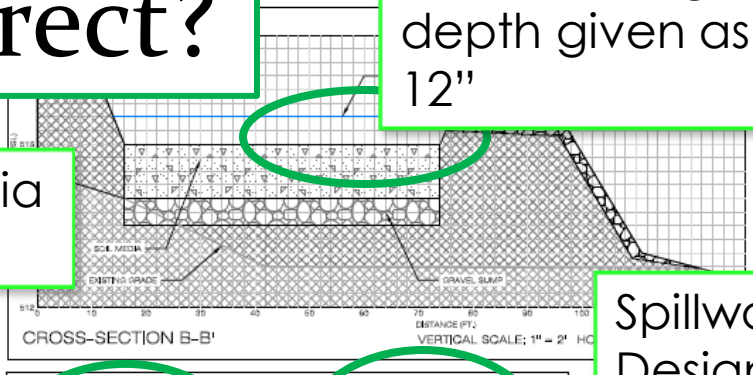
Spillway Designed for up to 10-year storm discharge

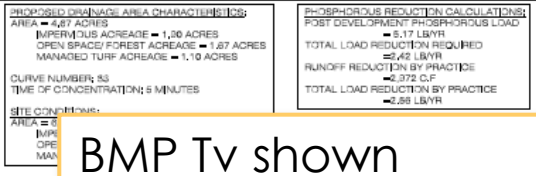
BMP Tv shown includes F/O areas

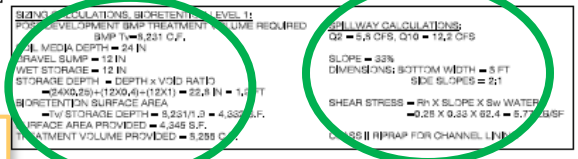










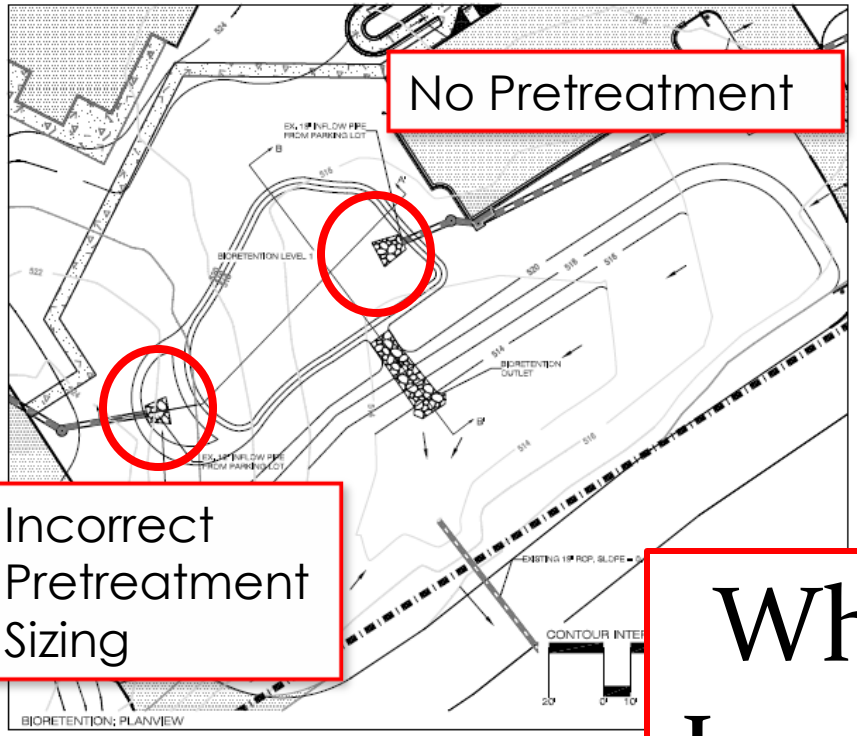


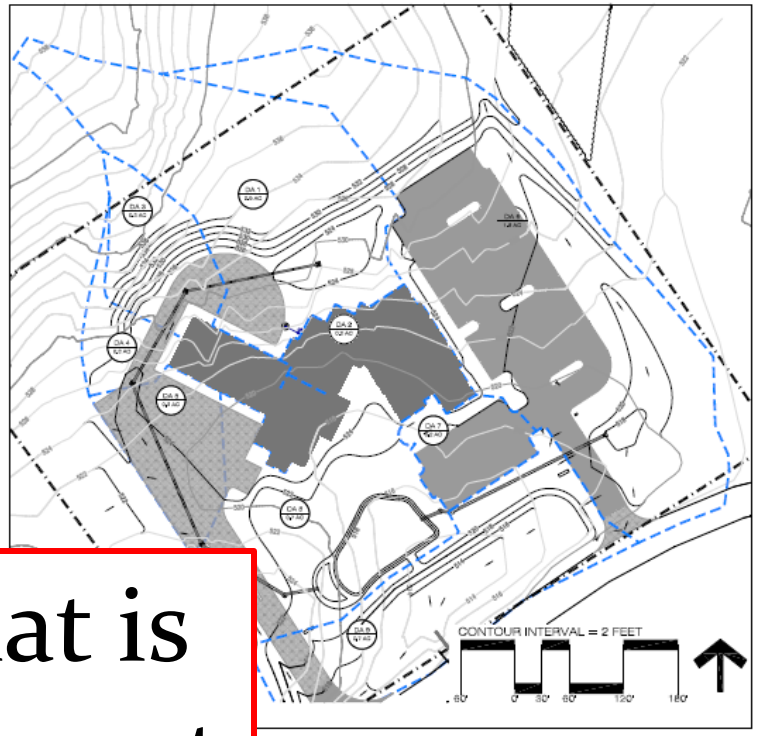
No Pretreatment

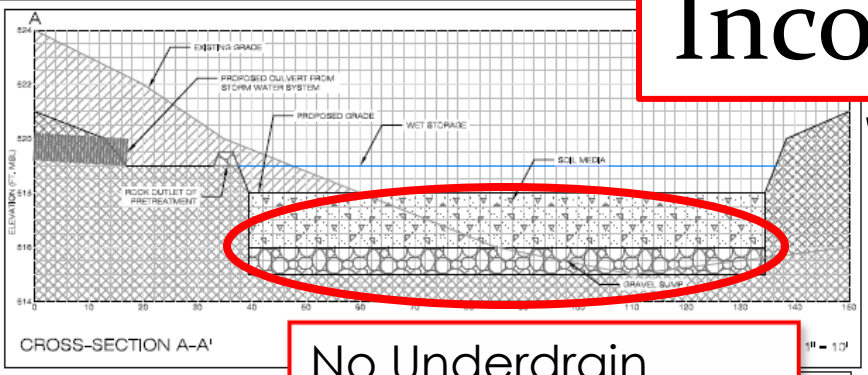
Incorrect Pretreatment Sizing

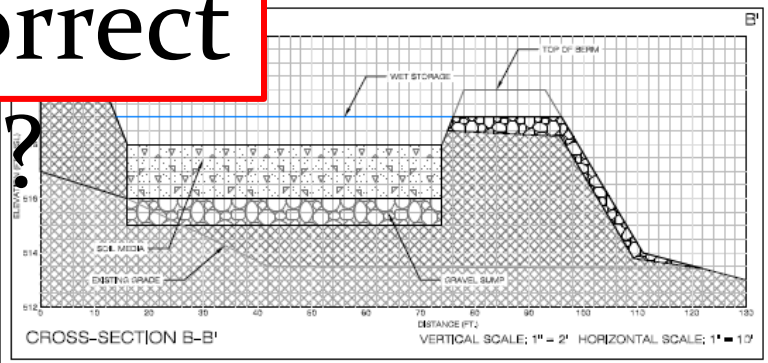
What is Incorrect ?

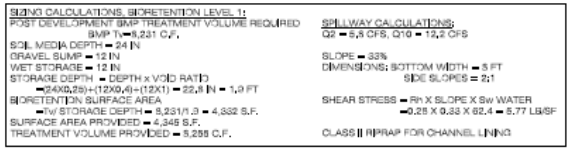
No Underdrain Design

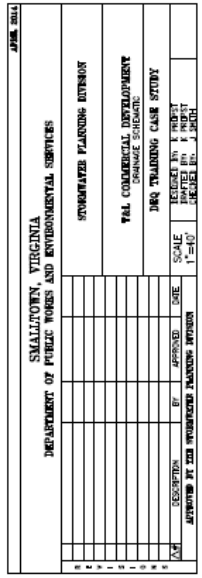








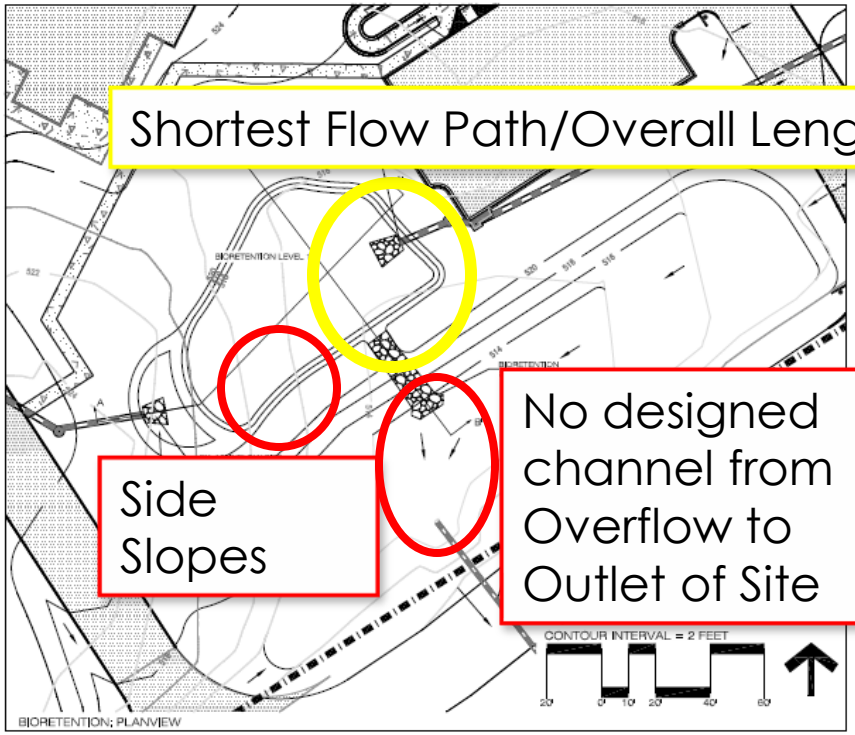




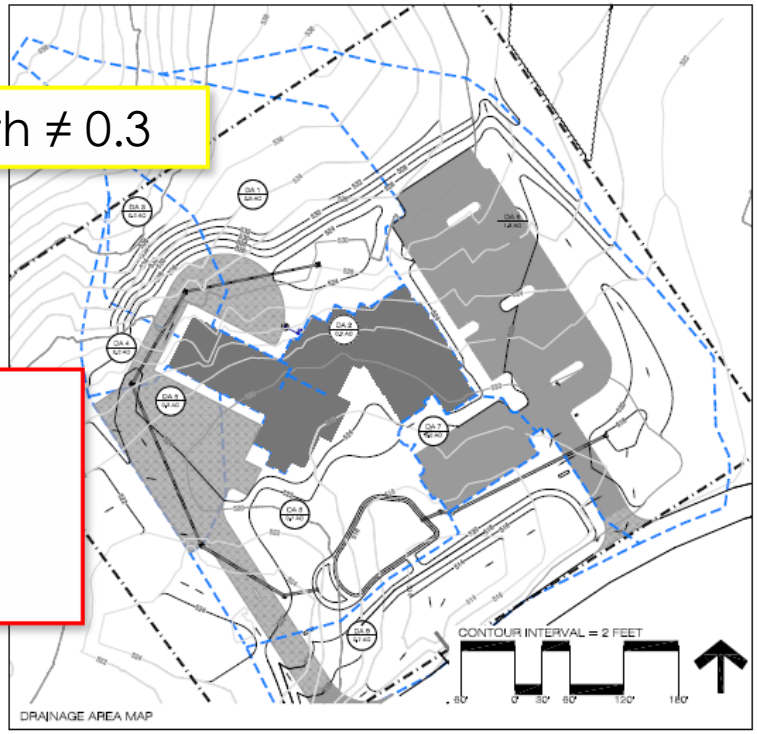
Shortest Flow Path/Overall Length ≠ 0.3

Side Slopes

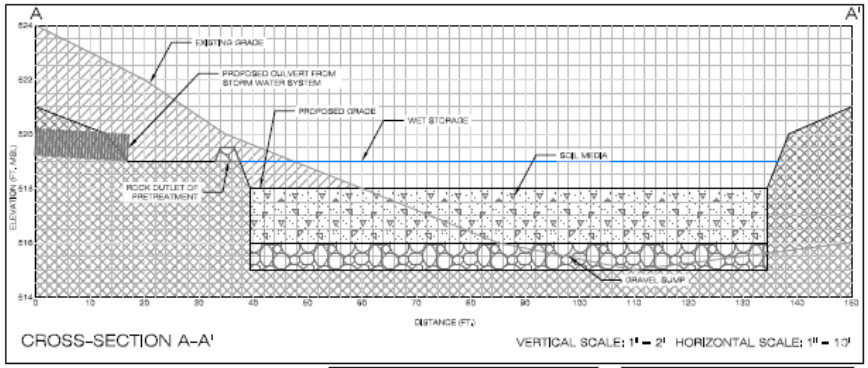
No designed channel from Overflow to Outlet of Site



BIORETENTION; PLAN|VIEW

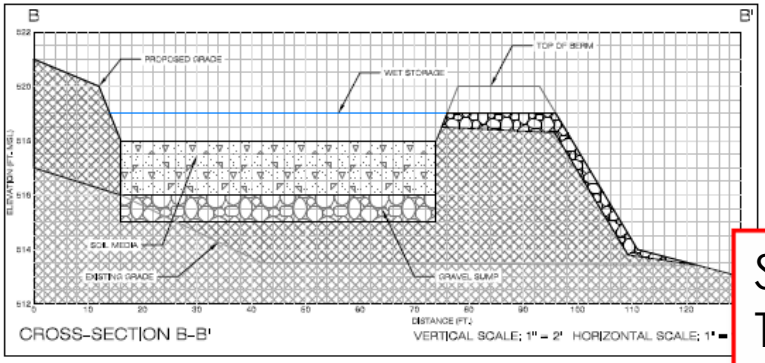


DRAINAGE AREA MAP



CROSS-SECTION A-A'

VERTICAL SCALE: 1" = 2' HORIZONTAL SCALE: 1" = 10'



CROSS-SECTION B-B'

VERTICAL SCALE: 1" = 2' HORIZONTAL SCALE: 1" =

PROPOSED DRAINAGE AREA CHARACTERISTICS:
AREA = 4.67 ACRES
IMPERVIOUS ACREAGE = 1.26 ACRES
OPEN SPACE/ FOREST ACREAGE = 1.87 ACRES
MANAGED TURF ACREAGE = 1.10 ACRES

CURVE NUMBER: 83
TIME OF CONCENTRATION: 5 MINUTES

SITE CONDITIONS:
AREA = 8.7 ACRES
IMPERVIOUS ACREAGE = 1.26 ACRES
OPEN SPACE/ FOREST ACREAGE = 3.5 ACRES
MANAGED TURF ACREAGE = 1.25 ACRES

PHOSPHOROUS REDUCTION CALCULATIONS:
POST DEVELOPMENT PHOSPHOROUS LOAD = 5.17 LB/YR

TOTAL LOAD REDUCTION REQUIRED =2.42 LB/YR

RUNOFF REDUCTION BY PRACTICE =2,372 C.F

TOTAL LOAD REDUCTION BY PRACTICE =2.56 LB/YR

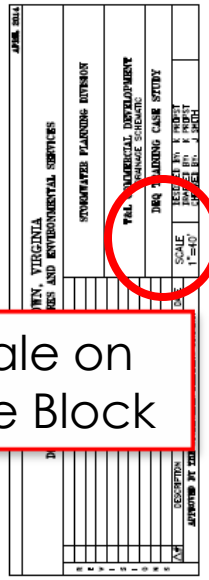
SIZING CALCULATIONS, BIORETENTION LEVEL 1:
POST DEVELOPMENT SMP TREATMENT VOLUME REQUIRED
SMP Tv=5,231 C.F.
SOIL MEDIA DEPTH = 24 IN
GRAVEL SUMP = 12 IN
WET STORAGE = 12 IN
STORAGE DEPTH = DEPTH x VOID RATIO
=(24X0.25)+(12X0.4)+(12X1) = 22.8 IN = 1.9 FT
BIORETENTION SURFACE AREA
=Tv/ STORAGE DEPTH = 5,231/1.9 = 4,932 S.F.
SURFACE AREA PROVIDED = 5,345 S.F.
TREATMENT VOLUME PROVIDED = 5,255 C.F.

SPILLWAY CALCULATIONS:
Q2 = 5.5 CFS, Q10 = 12.2 CFS

SLOPE = 33%
DIMENSIONS: BOTTOM WIDTH = 5 FT
SIDE SLOPES = 2:1

SHEAR STRESS = Rh X SLOPE X Sw WATER
=0.28 X 0.33 X 62.4 = 5.77 LB/SF

CLASS II RIPRAP FOR CHANNEL LINING



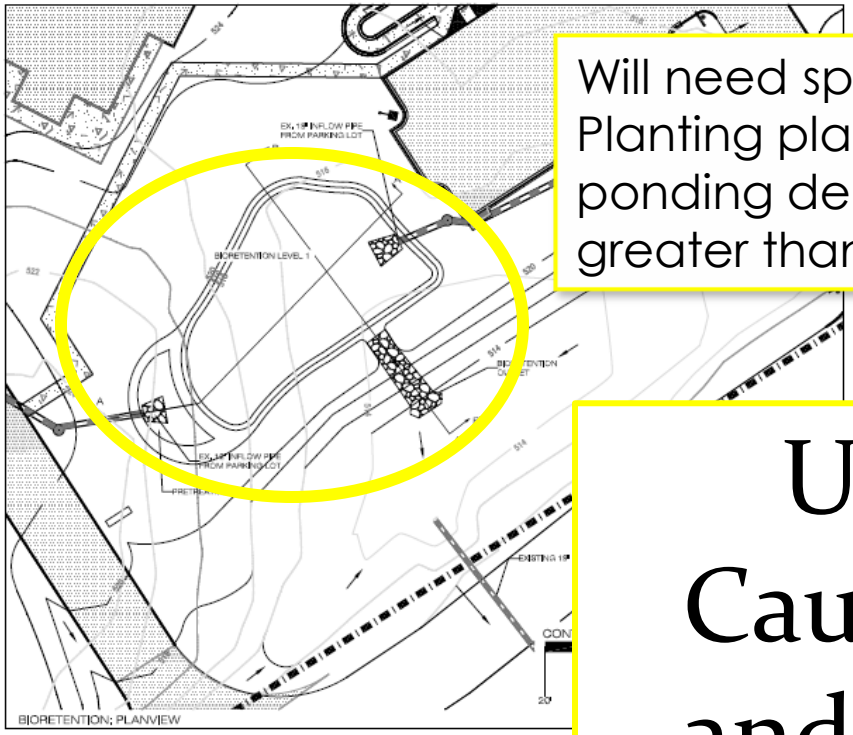
Scale on Title Block

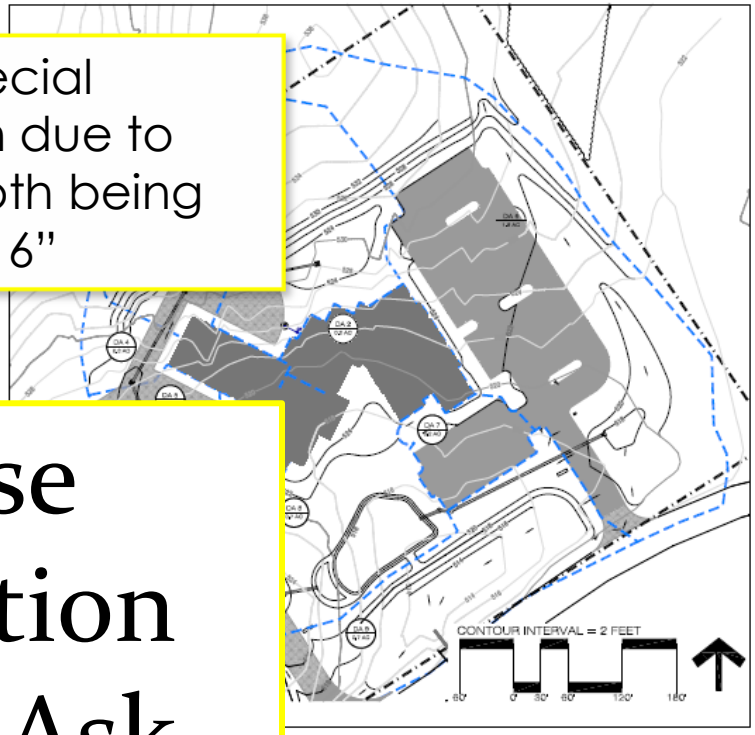
Will need special Planting plan due to ponding depth being greater than 6”

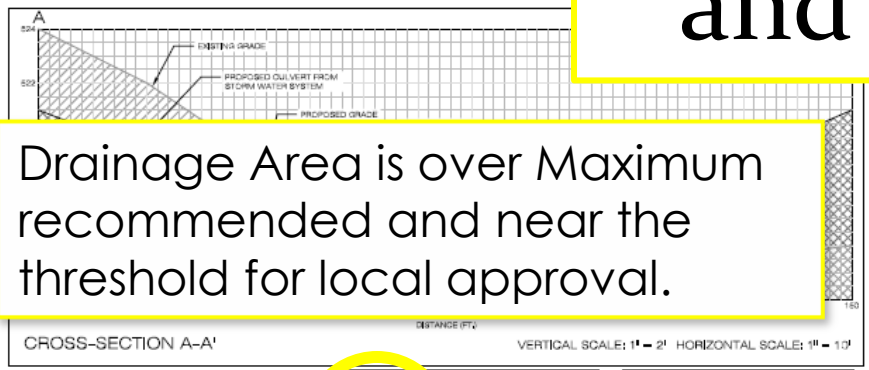
Use Caution and Ask

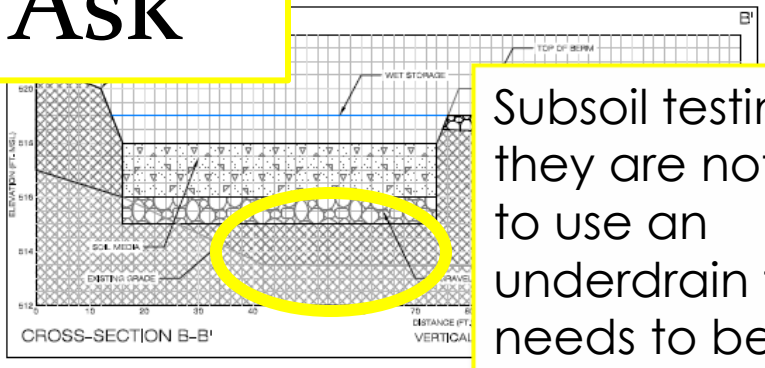
Drainage Area is over Maximum recommended and near the threshold for local approval.

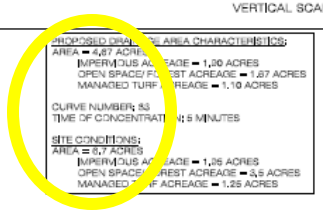
Subsoil testing – If they are not going to use an underdrain testing needs to be required

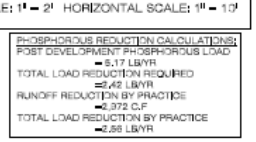


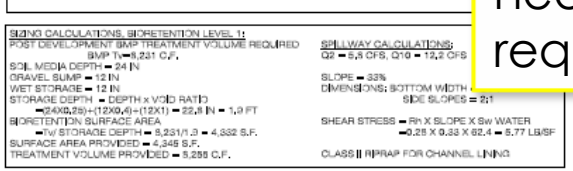


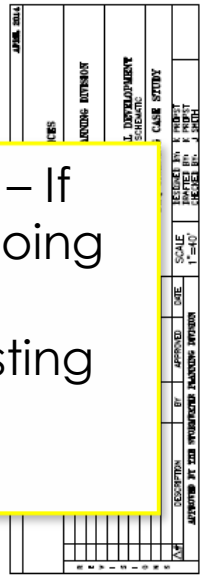












Exercise 4

Complexity

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Exercise 4 – Complexity

- Development sites can be complex on a variety of levels
  - Soil Types
  - Treatment Trains
  - Multiple Outlets and Drainage Areas
- Complexities at times can be simplified, but should always be handled carefully to ensure they are accounted for

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Differing Soils

- When variety of soils exist on site, Runoff Reduction spreadsheet must reflect differences
- Incorrect soil types can drastically effect results

Land Cover (acres)					
	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	3.50	0.00	3.50
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	1.25	0.00	1.25
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95
				Total	6.70

Post-Development Treatment Volume (acre-ft)	0.19		
Post-Development Treatment Volume (cubic feet)	8,231		
Post_Development Load (TP) (lb/yr)	5.17	Post_Development Load (TN) (lb/yr)	37.00
Total Load (TP) Reduction Required (lb/yr)	2.42		

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Change Soils

Land Cover (acres)	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.25	3.25	3.50
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.25	1.00	1.25
Impervious Cover (acres)	0.00	0.00	0.45	1.50	1.95
				Total	6.70

2.7%

Post-Development Treatment Volume (acre-ft)	0.19		
Post-Development Treatment Volume (cubic feet)	8,458		
Post_Development Load (TP) (lb/yr)	5.31	Post_Development Load (TN) (lb/yr)	38.02
Total Load (TP) Reduction Required (lb/yr)	2.57		

Land Cover (acres)	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	3.25	0.25	0.00	0.00	3.50
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	1.00	0.25	0.00	0.00	1.25
Impervious Cover (acres)	1.50	0.45	0.00	0.00	1.95
				Total	6.70

6.2%

Post-Development Treatment Volume (acre-ft)	0.18		
Post-Development Treatment Volume (cubic feet)	7,714		
Post_Development Load (TP) (lb/yr)	4.85	Post_Development Load (TN) (lb/yr)	34.67
Total Load (TP) Reduction Required (lb/yr)	2.10		

Multiple Drainage Areas

Multiple Drainage areas
add to complexity of spreadsheet entry

*Important Note:	Site area will not always match entire drainage from project

All drainage should be accounted for when designing BMPs

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Multiple Drainage Areas

LEGEND:

- PROJECT LIMITS
- PROPOSED DRAINAGE AREA
- EXISTING CULVERT
- PROPOSED SITE BMP

PROPOSED PROJECT AREA DATA:

PROJECT AREA	6.7 ACRES ±
OPEN SPACE (PROJECT LIMITS)	3.50 ACRES ±
MANAGED TURF (PROJECT LIMITS)	1.25 ACRES ±
IMPERVIOUS (PROJECT LIMITS)	1.95 ACRES ±
CURVE NUMBER	79

PROPOSED SITE DATA

DA	AREA (AC)	TREATED IN DA?	TREATMENT	IMPERVIOUS AREA (AC)	OPEN SPACE (AC)	MANAGED TURF (AC)
1	0.3	NO	-	0.10	0.75	0.05
2	0.2	YES	CISTERN	0.20	0.00	0.00
3	0.3	NO	-	0.1	0.20	0.00
4	0.3	NO	-	0.15	0.07	0.05
5	0.3	YES	PERM. PAVEMENT	0.3	0.00	0.00
6	1.8	YES	DRY SWALE	0.65	0.65	0.50
7	0.2	YES	PERM. PAVEMENT	0.2	0.00	0.00
8	0.7	YES*	EXTENDED DETENTION	0.2	0.00	0.50
9	0.7	NO	-	0.05	0.46	0.18
TOTAL	5.4	-	-	1.95	2.13	1.28

NOTE: ASSUME 5 MINUTES FOR TIME OF CONCENTRATION FOR EACH WATERSHED. ASSUME ALL SOILS ARE "C."
*BIORETENTION IN DA 8 CAPTURES DRAINAGE FROM DAS 1-7 AS WELL. THESE ADDITIONAL AREAS ARE NOT INCLUDED IN THE DA 8 AREA.

BMP LIST

ID	TYPE
1	CISTERN
2	PERMEABLE PAVEMENT L1
3	DRY SWALE L2
4	PERMEABLE PAVEMENT L1
5	EXTENDED DETENTION L1

Drainage extends outside of project limits

Drainage areas flow into each other impacting what happens downstream

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Water Quantity Compliance

Energy Balance for each site drainage point

Water Quality Compliance

Demonstrated at site level

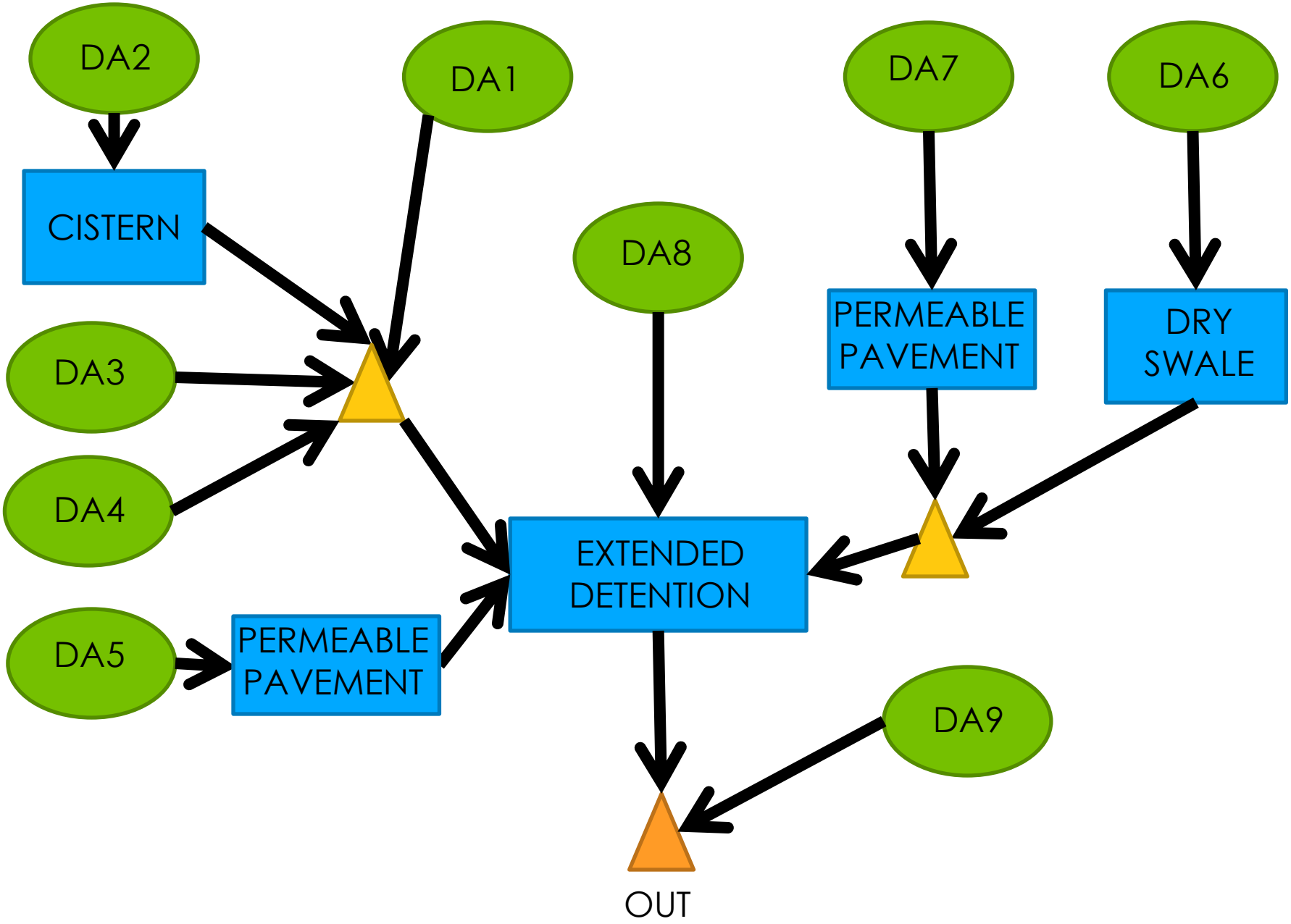
Many site drainage points:

More complex analysis

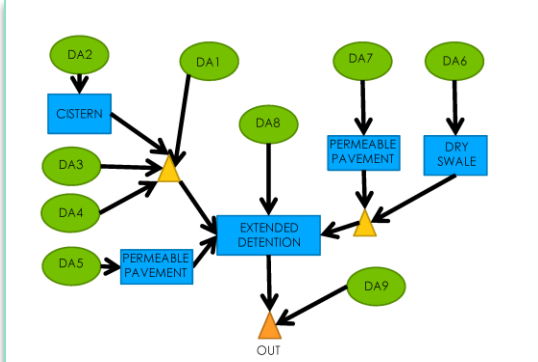
Calculations typically not affected

Complex Treatment Trains

- When several BMPs treat same runoff, complexity of spreadsheet entry increases
- Several different correct ways to enter information to get same result


DA2
DA1
DA7
DA6
CISTERN
DA8
PERMEABLE PAVEMENT
DRY SWALE
DA3
DA4
EXTENDED DETENTION
DA5
PERMEABLE PAVEMENT
DA9
OUT

GROUP EXERCISE



FIND:

- Which Drainage Areas can be grouped together?
- Total Drainage Area to BMP 5?
- What is the total volume remaining from Upstream BMPs to BMP 5?
- What is the Treatment Volume for BMP 5?
- Does the site meet the phosphorus load reduction requirement?

Group materials: One 24" x 36" laminated plan sheet

What DA's can be grouped together?

- Untreated to Extended Detention
  - DA 1
  - DA 3
  - DA 4
  - DA 8
- Permeable Pavement to Extended Detention
  - DA 5
  - DA 7

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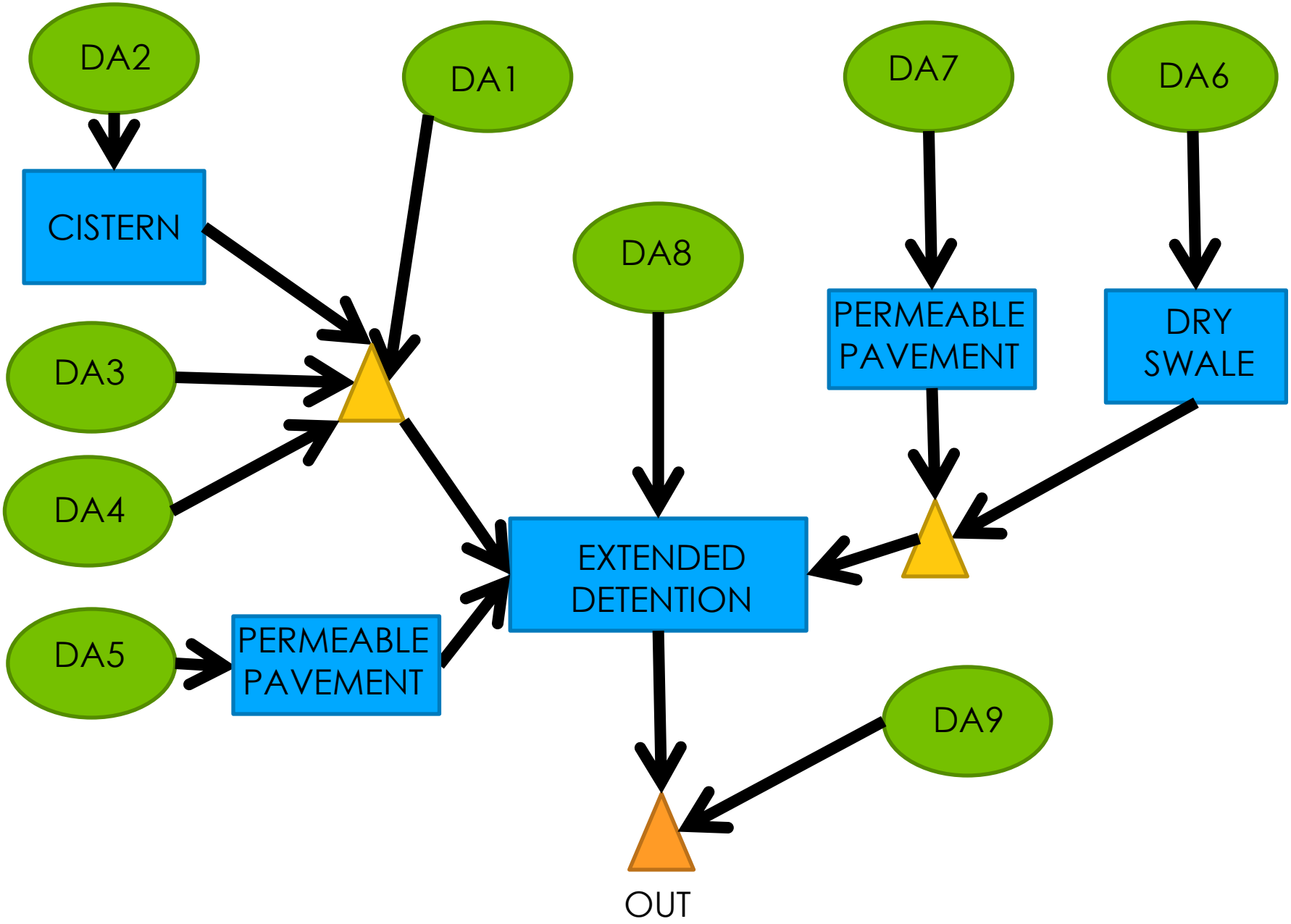
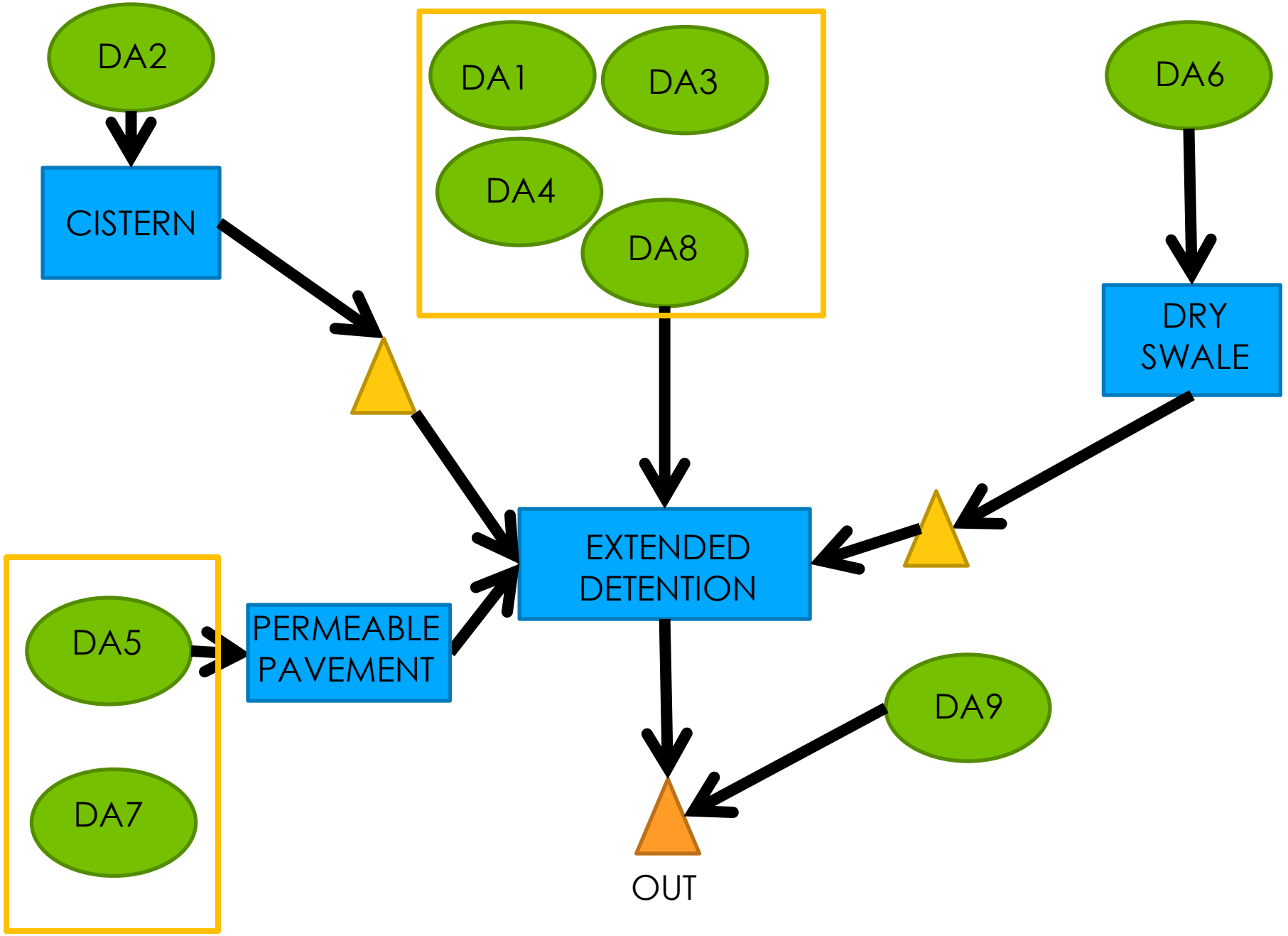

DA2
DA1
DA7
DA6
CISTERN
DA8
PERMEABLE PAVEMENT
DRY SWALE
DA3
DA4
EXTENDED DETENTION
DA5
PERMEABLE PAVEMENT
DA9
OUT


DA2
DA1
DA3
DA4
DA8
DA6
CISTERN
DRY SWALE
EXTENDED DETENTION
DA5
PERMEABLE PAVEMENT
DA7
DA9
OUT

Total DA to BMP 5?

- Drainage Areas 1 through 8 drain to BMP 5
  - Total DA = 4.67 Acres

PROPOSED SITE DATA						
DA	AREA (AC)	TREATED IN DA?	TREATMENT	IMPERVIOUS AREA (AC)	OPEN SPACE (AC)	MANAGED TURF (AC)
1	0.9	NO	–	0.10	0.75	0.05
2	0.2	YES	CISTERN	0.20	0.00	0.00
3	0.3	NO	–	0.1	0.20	0.00
4	0.3	NO	–	0.15	0.07	0.05
5	0.3	YES	PERM . PAVEMENT	0.3	0.00	0.00
6	1.8	YES	DRY SWALE	0.65	0.65	0.50
7	0.2	YES	PERM. PAVEMENT	0.2	0.00	0.00
8	0.7	YES*	EXTENDED DETENTION	0.2	0.00	0.50
~~9~~	~~0.7~~	~~NO~~	~~–~~	~~0.65~~	~~0.40~~	~~0.15~~
~~TOTAL~~	~~5.4~~	~~–~~	~~–~~	~~1.95~~	~~2.12~~	~~1.25~~

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What is the remaining runoff from upstream BMPs?

Necessary treatment volume for BMP5? Add remaining runoff from upstream BMPs to runoff directly entering BMP5 to properly size BMP

Practice	Unit	Description of Credit	Credit	Credit Area (acres)	Volume from Upstream RR Practice (cf)	Runoff Reduction (cf)	Remaining Runoff Volume (cf)	Phosphorus Efficiency (%)	Phosphorus Load from Upstream RR Practices	Untreated Phosphorus Load to Practice	Phosphorus Removed By Practice	Remaining Phosphorus Load (lbs.)	Downstream Treatment to be Employed
2.h. To Rainwater Harvesting (Spec #6)	impervious acres captured	based on tank size and design spreadsheet (See Spec #6)	0.90	0.20	0	621	69	0	0.00	0.43	0.39	0.04	8.a. ED #1
3.a. Permeable Pavement #1 (Spec #7)	acres of permeable pavement + acres of "external" (upgradient)	45% runoff volume reduction	0.45	0.50	0	776	948	25	0.00	1.08	0.64	0.45	8.a. ED #1
5.b. Dry Swale #2 (Spec #10)	impervious acres draining to dry swale	60% runoff volume reduction	0.60	0.65	0	1345	897	40	0.00	1.41	1.07	0.34	8.a. ED #1
	turf acres draining to dry swale	60% runoff volume reduction	0.60	0.50	0	240	160	40	0.00	0.25	0.19	0.06	8.a. ED #1

The runoff remaining from upstream BMPs = 2,074 C.F.

Practice	Volume from Upstream RR Practice (cf)
8. Extended Detention Pond	
8.a. ED #1 (Spec #15)	1914
	160

At ED L1 Row – Volume from upstream practices also equals 2,074 C.F.

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What is Total Tv for BMP5?

The total Treatment Volume for BMP5 = 4,450 C.F.

Runoff Reduction column + **Remaining Runoff Volume column**

Practice	Unit	Description of Credit	Credit	Credit Area (acres)	Volume from Upstream RR Practices (cf)	Runoff Reduction (cf)	Remaining Runoff Volume (cf)	Phosphorus Efficiency (%)	Phosphorus Load from Upstream RR Practices	Untreated Phosphorus Load to Practice	Phosphorus Removed By Practice	Remaining Phosphorus Load (lbs.)	Downstream Treatment to be Employed
8. Extended Detention Pond													
8.a. ED #1 (Spec #15)	impervious acres draining to ED	0% runoff volume reduction	0.00	0.55	1914	0	3811	15	0.83	1.19	0.30	1.71	
	turf acres draining to ED	0% runoff volume reduction	0.00	0.60	160	0	639	15	0.06	0.30	0.05	0.31	

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Does the Site Comply with Water Quality Criteria?

YES – the Cistern, Permeable Pavement L1, Dry Swale L2 and Extended Detention L1 all work together to make site water quality compliant

Phosphorus	
TOTAL TREATMENT VOLUME (cf)	8,231
TOTAL PHOSPHORUS LOAD REDUCTION REQUIRED (LB/YEAR)	2.42
RUNOFF REDUCTION (cf)	2981
PHOSPHORUS LOAD REDUCTION ACHIEVED (LB/YR)	2.64
ADJUSTED POST-DEVELOPMENT PHOSPHORUS LOAD (TP) (lb/yr)	2.53
REMAINING PHOSPHORUS LOAD REDUCTION (LB/YR) NEEDED	CONGRATULATIONS!! YOU EXCEEDED THE TARGET REDUCTION BY 0.2 LB/YEAR!!

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Exercise 5

Bringing it all together

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Exercise 5 – Bringing it all Together

Review a set of plans and determine:

1. Post development total Phosphorus load & reduction required
2. Target Tv and average efficiency needed
3. Allowable discharge for the 1–Year Storm from the site & whether Energy Balance Criteria are satisfied
4. Any issues associated with proposed BMPs

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Exercise 5 – Bringing it all Together

Given:

- Existing and proposed site plans
- Booklet containing narrative and design details
- Details for each proposed BMP

HINT!

Use your previous exercises to help find the answers

Group materials: Two 24" x 36" laminated plan sheets
Four 11" x 17" laminated detail sheets
Industrial Park Narrative Booklet

Questions 1 & 2

1. Post development total Phosphorus load & reduction required

2. Target Tv and average efficiency needed

Proposed Total Phosphorous Load & Required Reduction

Land Cover (acres)					
	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	3.50	0.00	3.50
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	1.25	0.00	1.25
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95
				Total	6.70

Land Cover Summary			
Forest/Open Space Cover (acres)	3.50		
Weighted Rv(forest)	0.04		
% Forest	52%		
Managed Turf Cover (acres)	1.25		
Weighted Rv(turf)	0.22		
% Managed Turf	19%		
Impervious Cover (acres)	1.95		
Rv(impervious)	0.95		
% Impervious	29%		
Total Site Area (acres)	6.70		
Site Rv	0.34		
Post-Development Treatment Volume (acre-ft)	0.19		
Post-Development Treatment Volume (cubic feet)	8,231		
Post_Development Load (TP) (lb/yr)	5.17	Post_Development Load (TN) (lb/yr)	37.00
Total Load (TP) Reduction Required (lb/yr)	2.42		

Target Tv & Average Efficiency Needed

Land Cover (acres)					
	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	3.50	0.00	3.50
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	1.25	0.00	1.25
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95
				Total	6.70

Average Efficiency
= Reduction Required/Phosphorous Load

= 2.42/5.17 = 47%

Land Cover Summary			
Forest/Open Space Cover (acres)	3.50		
Weighted Rv(forest)	0.04		
% Forest	52%		
Managed Turf Cover (acres)	1.25		
Weighted Rv(turf)	0.22		
% Managed Turf	19%		
Impervious Cover (acres)	1.95		
Rv(impervious)	0.95		
% Impervious	29%		
Total Site Area (acres)	6.70		
Site Rv	0.34		
Post-Development Treatment Volume (acre-ft)	0.19		
Post-Development Treatment Volume (cubic feet)	8,231		
Post_Development Load (TP) (lb/yr)	5.17	Post_Development Load (TN) (lb/yr)	37.00
Total Load (TP) Reduction Required (lb/yr)	2.42		

Question 3

3. Allowable discharge from site for the 1–Year Storm & whether Energy Balance Criteria satisfied

Curve Number

A Pre-Development Curve Number of **79** was given for site on Existing Conditions Sheet.

Drainage Area A		A soils	B Soils	C Soils	D Soils	
Forest/Open Space -- undisturbed, protected forest/open space or reforested land	Area (acres)	0.00	0.00	2.13	0.00	
	CN	30	55	70	77	
Managed Turf -- disturbed, graded for yards or other turf to be mowed/managed	Area (acres)	0.00	0.00	1.25	0.00	
	CN	39	61	74	80	
Impervious Cover	Area (acres)	0.00	0.00	1.95	0.00	
	CN	98	98	98	98	
					Weighted CN	S
					81	2.35
		1-year storm	2-year storm	10-year storm		
$RV_{Developed}$ (in) with no Runoff Reduction		1.01	1.79	3.52		
$RV_{Developed}$ (in) with Runoff Reduction		0.86	1.64	3.37		
Adjusted CN		78	79	79		

Using Curve Numbers in Channel & Flood Protection: composite post development Curve Number is **78**

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Existing Curve Number

From Report: "… the curve number (CN) equal to 79 based on fair existing site conditions."

Wrong: Curve Number for existing conditions should be calculated assuming **good** existing site conditions.

When reviewing Table 2-2A from TR-55 User's Manual, curve number for good existing site conditions is at most **74**.

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Water Quantity

Curve Numbers can then be used to find water quantity requirements for site.

$$\text{Post } S = \frac{1000}{CN} - 10 = \frac{1000}{78} - 10 = 2.8\,in$$

$$Q_{post} = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{(2.6 - (0.2 \times 2.8))^2}{2.6 + (0.8 \times 2.8)} = 0.86\,in$$

$$\text{Pre } S = \frac{1000}{CN} - 10 = \frac{1000}{74} - 10 = 3.5\,in$$

$$Q_{pre} = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{(2.6 - (0.2 \times 3.5))^2}{2.6 + (0.8 \times 3.5)} = 0.67\,in$$

$$Vr_{post1} = Q \times A \times \frac{1}{12} = 0.86\,in \times 5.3Ac \times \frac{1\,ft}{12in} = 0.38\,Acre - ft$$

$$Vr_{pre1} = Q \times A \times \frac{1}{12} = 0.67\,in \times 5.7\,Ac \times \frac{1\,ft}{12in} = 0.32\,Acre - ft$$

Allowable Discharge

Does the proposed discharge leaving the site meet the allowable discharge?

$$q_{1post} \leq q_{1pre}\left(\frac{Vr_{pre1}}{Vr_{post1}}\right)(IF)$$

$$= 3.6 \times \left(\frac{0.32}{0.38}\right) \times 0.8 = 2.4\,cfs$$

NO → - Proposed design discharge is 3.56 cfs

- Less than existing site discharge of 3.6 cfs

BUT not low enough to meet Energy Balance requirements

What volume will be needed for site to meet Energy Balance criteria?

Figure 6-1 TR-55

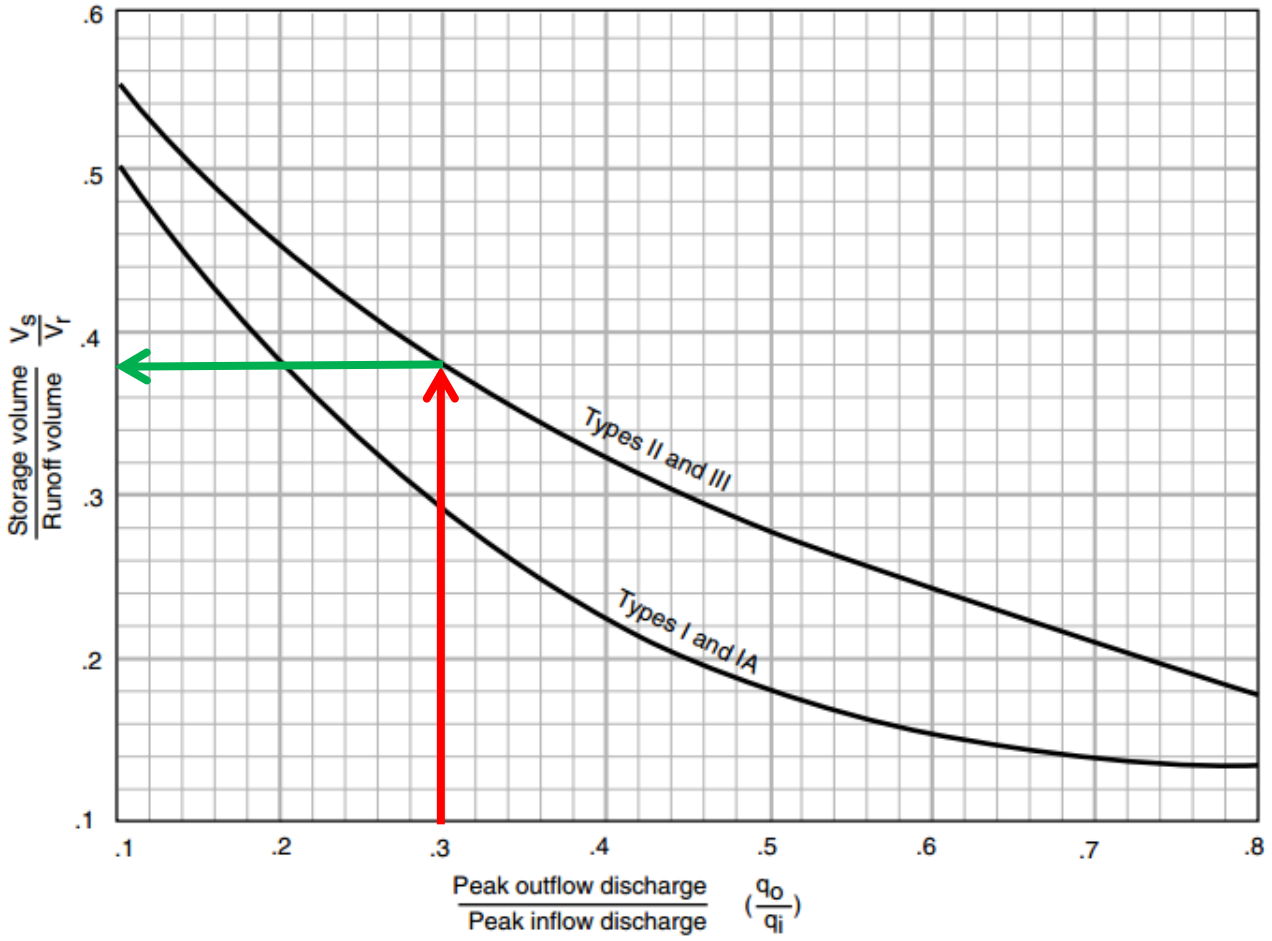
$q_o/q_i = 2.4/7.93 = 0.3$

$V_s/V_r = ?$ → 0.38

Add 1-Year Discharges from Pondpack model results for each Drainage Area

Volume needed?

Figure 6-1 Approximate detention basin routing for rainfall types I, IA, II, and III



Required Volume for 1-Year Storm

$$V_s/V_r = 0.38$$

$$Vr_{post1} = Q \times A \times \frac{1}{12} = 0.86\,in \times 5.3Ac \times \frac{1\,ft}{12in} = 0.38\,Acre - ft \longrightarrow V_r$$

Storage Volume

(V_s) $= 0.38 \text{ X } 0.38$

$=0.14$ acre-ft

$=6{,}290$ c.f.

The one year storage volume provided does not meet estimated storage from TR-55

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
Extended Detention (IN)	1-Year	1	0.404	11.930	5.99	(N/A)	(N/A)
Extended Detention (OUT)	1-Year	1	0.441	12.080	3.17	518.70	0.080
Extended Detention (IN)	2-Year	2	0.703	11.930	9.57	(N/A)	(N/A)
Extended Detention (OUT)	2-Year	2	0.738	12.040	7.08	519.22	0.121
Extended Detention (IN)	10-Year	10	1.375	11.930	17.23	(N/A)	(N/A)
Extended Detention (OUT)	10-Year	10	1.405	12.020	13.54	519.77	0.173

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Where did the other 0.4 acres go?

Important to evaluate all outfalls from site, even if they are not the primary outfall.

Other outfalls could be negatively affected if more drainage is being forced to flow to other areas.

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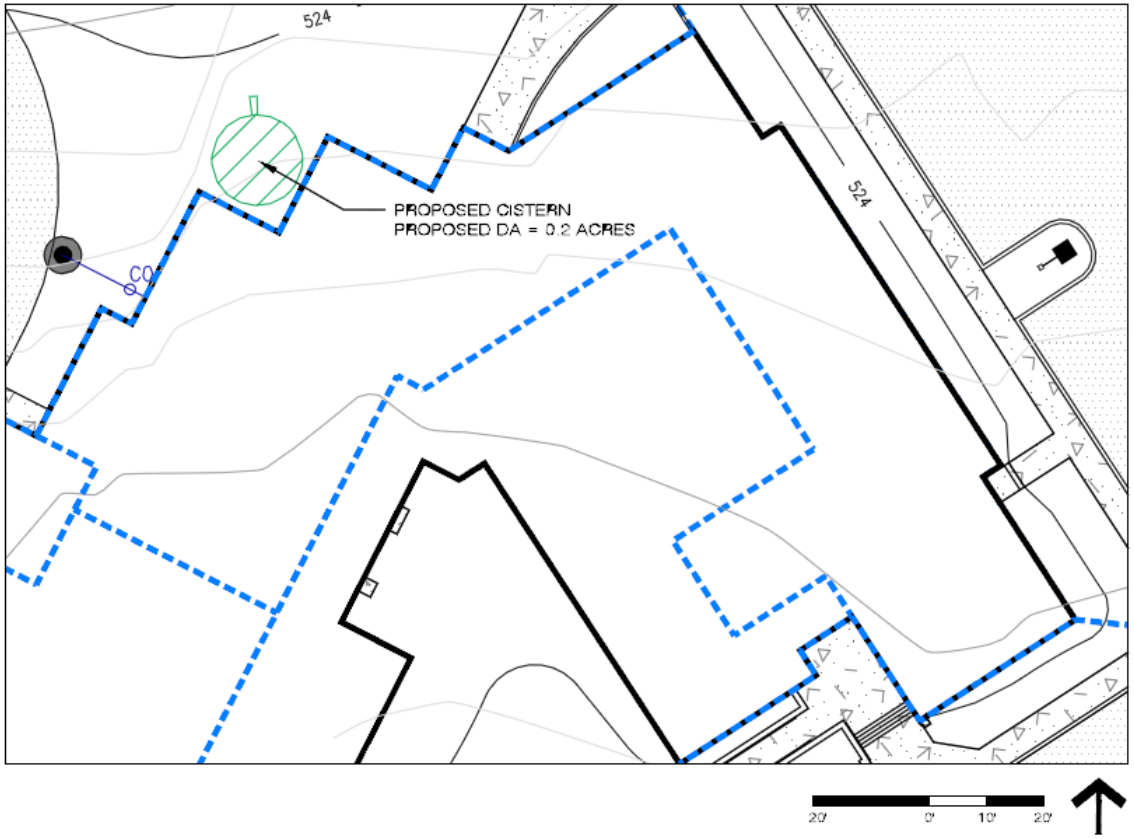


PROPOSED DRAINAGE AREA CHARACTERISTICS:
AREA = 0.2 ACRES
IMPERVIOUS ACREAGE = 0.2 ACRES
CURVE NUMBER: 98
TIME OF CONCENTRATION: 5 MINUTES
1 YR DISCHARGE = 0.51 CFS
2 YR DISCHARGE = 0.78 CFS
10 YR DISCHARGE = 1.33 CFS

CISTERN:
DESIGNED USING VA DEQ CISTERN DESIGN SPREADSHEET
ASSUMED:
- 0.2 ACRES OF ROOF DRAINAGE TO CONTRIBUTE TO CISTERN RUNOFF
- ASSUMED THAT MANAGED TURF AREA IN PROJECT SITE WOULD BE IRRIGATED DURING GROWING SEASON
-ASSUMED 70 PEOPLE WORK IN BUILDING
CISTERN REQUIRED TO HAVE 90% EFFICENCY

Cistern Storage Associated with Design Volume (gallons)	Average Annual Overflow days for storms <=1" (days/year)*	Average Annual Overflow Volume for storms <= 1" (1000's gal/year)*	Runoff Reduction Volume Credit
1,000	39	54	50%
2,000	28	35	67%
3,000	21	24	78%
5,000	12	14	87%
7,000	9	11	90%
10,000	7	8	92%
12,000	5	7	94%
15,000	4	5	95%

ACCORDING TO SPREADSHEET, THE TANK MUST BE 7,000 GALLONS IN ORDER TO BE 90% EFFICIENT

SEE FIGURE 1 ON THIS SHEET TO REVIEW SPREADSHEET TANK ASSUMPTIONS

PHOSPHOROUS REDUCTION CALCULATIONS:
LOAD TO BMP = 0.43 LBS
EFFICIENCY OF BMP = 90%
VOLUME TO BMP = 690 C.F.
RUNOFF REDUCTION BY PRACTICE
=621 C.F.
TOTAL PHOSPHOROUSLOAD REDUCTION BY PRACTICE
=0.40 LB/YR
REMAINING PHOSPHOROUS LOAD AFTER TREATMENT
=0.04 LBS

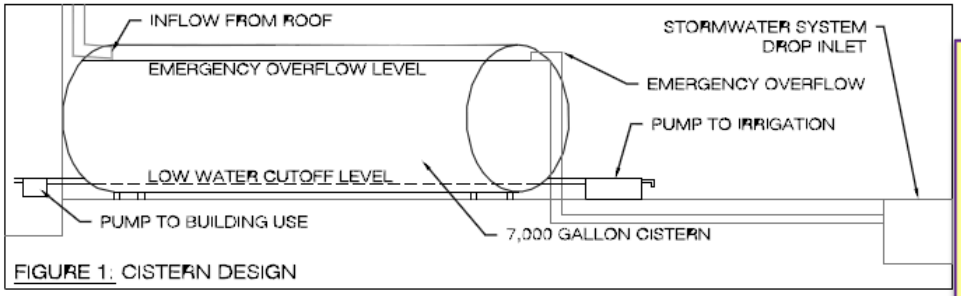
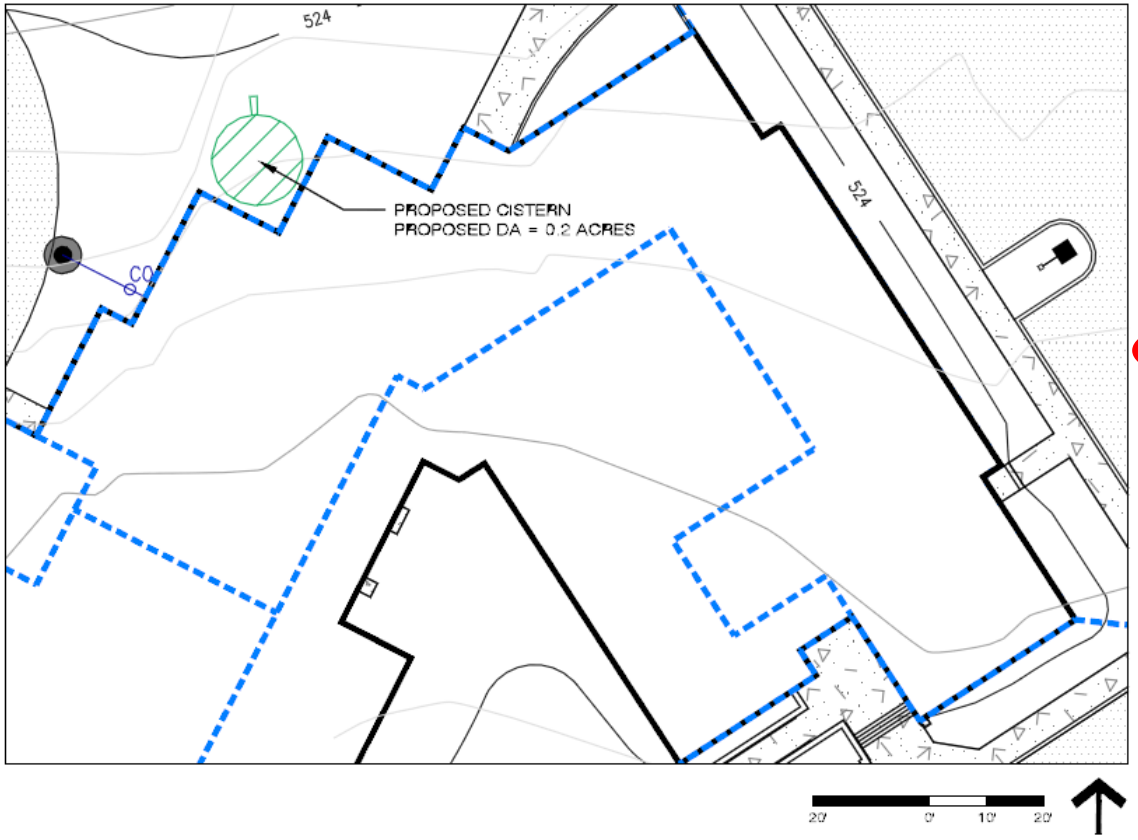


FIGURE 1: CISTERN DESIGN

APRIL 2014
TOWN, VIRGINIA
PUBLIC WORKS AND ENVIRONMENTAL SERVICES
STORMWATER PLANNING DIVISION
T&L COMMERCIAL DEVELOPMENT
CISTERN DESIGN
DEQ TRAINING CASE STUDY
SCALE 1"=40'
DESIGNED BY: K. PROJECT MANAGER: K. PROJECT ENGINEER: J. SMITH
NO. DESCRIPTION BY APPROVED DATE
APPROVED BY THE STORMWATER PLANNING DIVISION

The Cistern Design is correct, however, always check the design assumptions and spreadsheet. For example, if they say 70 people will be working in the building, is there parking for 70 people?



PROPOSED DRAINAGE AREA CHARACTERISTICS:
AREA = 0.2 ACRES
IMPERVIOUS ACREAGE = 0.2 ACRES
CURVE NUMBER: 98
TIME OF CONCENTRATION: 5 MINUTES
1 YR DISCHARGE = 0.51 CFS
2 YR DISCHARGE = 0.78 CFS
10 YR DISCHARGE = 1.33 CFS

CISTERN:
DESIGNED USING VA DEQ CISTERN DESIGN SPREADSHEET
ASSUMED:
- 0.2 ACRES OF ROOF DRAINAGE TO CONTRIBUTE TO CISTERN RUNOFF
- ASSUMED THAT MANAGED TURF AREA IN PROJECT SITE WOULD BE IRRIGATED DURING GROWING SEASON
- ASSUMED 70 PEOPLE WORK IN BUILDING
CISTERN REQUIRED TO HAVE 90% EFFICENCY

Cistern Storage Associated with Design Volume (gallons)	Average Annual Overflow days for storms <=1" (days/year)*	Average Annual Overflow Volume for storms <= 1" (1000's gal/year)*	Runoff Reduction Volume Credit
1,000	39	54	50%
2,000	28	35	67%
3,000	21	24	78%
5,000	12	14	87%
7,000	9	11	90%
10,000	7	8	92%
12,000	5	7	94%
15,000	4	5	95%

ACCORDING TO SPREADSHEET, THE TANK MUST BE 7,000 GALLONS IN ORDER TO BE 90% EFFICIENT

SEE FIGURE 1 ON THIS SHEET TO REVIEW SPREADSHEET TANK ASSUMPTIONS

PHOSPHOROUS REDUCTION CALCULATIONS:
LOAD TO BMP = 0.43 LBS
EFFICIENCY OF BMP = 90%
VOLUME TO BMP = 690 C.F.
RUNOFF REDUCTION BY PRACTICE
=621 C.F.
TOTAL PHOSPHOROUSLOAD REDUCTION BY PRACTICE
=0.40 LB/YR
REMAINING PHOSPHOROUS LOAD AFTER TREATMENT
=0.04 LBS

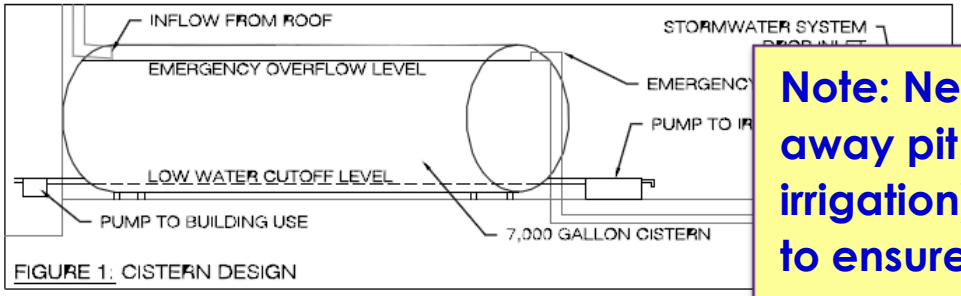
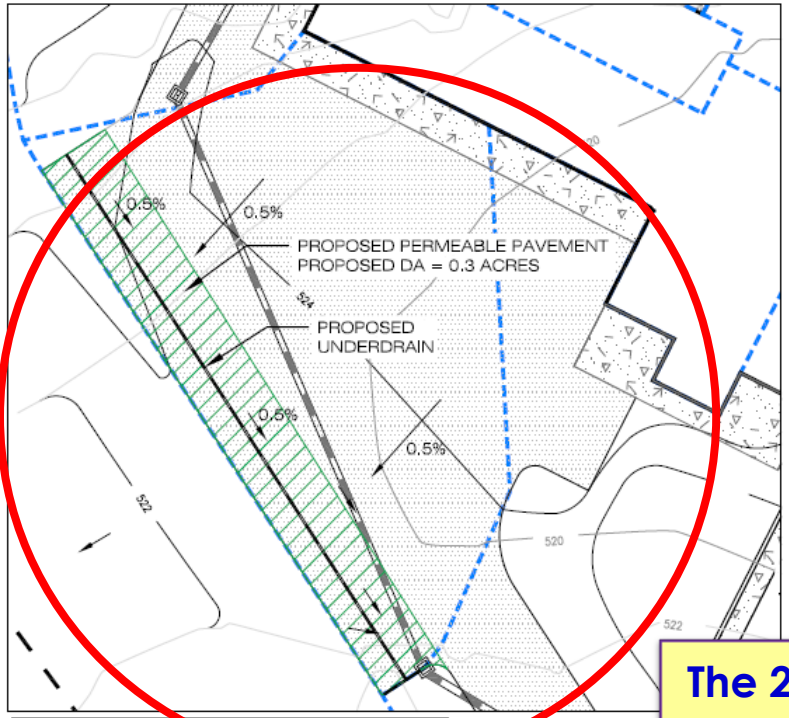
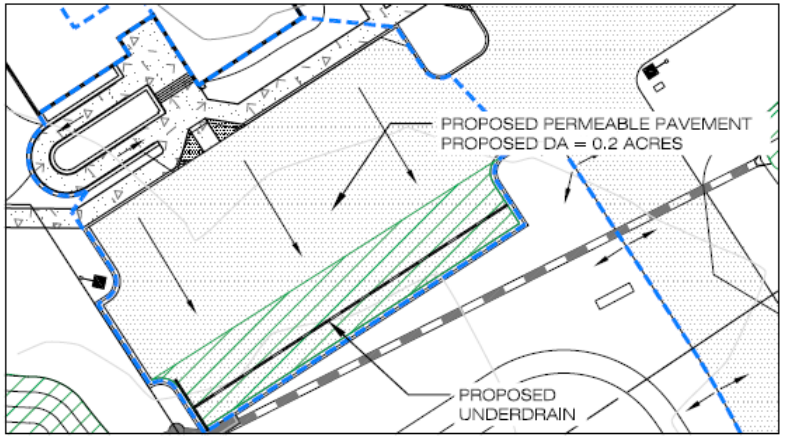


FIGURE 1: CISTERN DESIGN

APRIL 2014
TOWN, VIRGINIA
PUBLIC WORKS AND ENVIRONMENTAL SERVICES
STORMWATER PLANNING DIVISION
T&L COMMERCIAL DEVELOPMENT
CISTERN DESIGN
DEQ TRAINING CASE STUDY
DATE
SCALE 1"=40'
DESIGNED BY: K. PROJECT ENGINEER: PM: K. PROJECT CHECKED BY: PM: J. SMITH

Note: New specifications will recommend a soak away pit when demands are seasonal (such as irrigation). Keep up with the changing regulations to ensure that designers are also using the correct requirements for site design. Using old requirements for review may cause the design to be inadequate.





PROPOSED DA 7 CHARACTERISTICS:
AREA = 0.2 ACRES
IMPERVIOUS ACREAGE = 0.2 ACRES
CURVE NUMBER: 98
TIME OF CONCENTRATION: 5 MINUTES
1 YR DISCHARGE = 0.60 CFS
10 YR DISCHARGE = 1.41 CFS

PROPOSED DA 4 CHARACTERISTICS:
AREA = 0.3 ACRES
IMPERVIOUS ACREAGE = 0.3 ACRES
CURVE NUMBER: 98
TIME OF CONCENTRATION: 5 MINUTES
1 YR DISCHARGE = 0.42 CFS
10 YR DISCHARGE = 1.57 CFS

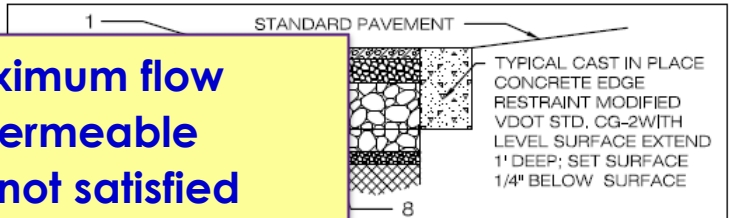
PHOSPHOROUS REDUCTION CALCULATIONS:
LOAD TO BMP = 0.65 LBS
EFFICIENCY OF BMP = 25%
VOLUME TO BMP = 1035 C.F.
RUNOFF REDUCTION BY PRACTICE
=466 C.F
TOTAL PHOSPHOROUSLOAD REDUCTION
=0.38 LB/YR
TOTAL PHOSPHOROUS LOAD REMAINING
=0.27 LBS

PERMEABLE PAVEMENT SIZING
DESIGNED IN ACCORDANCE WITH LEVEL 1
DESIGN GUIDELINES
CONTRIBUTING TOTAL AREA = 0.3 ACRES
SURFACE AREA PROVIDED = 3,030 S.F.
Tv PROVIDED = 196 C.F.

The 2.5:1 maximum flow area to the permeable pavement is not satisfied

PHOSPHOROUS REDUCTION CALCULATIONS (DA7):
LOAD TO BMP = 0.43
EFFICIENCY OF BMP = 25%
VOLUME TO BMP = 689 C.F.
RUNOFF REDUCTION BY PRACTICE
=310 C.F
TOTAL PHOSPHOROUSLOAD REDUCTION
=0.0.25 LB/YR
TOTAL PHOSPHOROUS LOAD REMAINING
=0.18 LBS

PERMEABLE PAVEMENT SIZING (DA7):
DESIGNED IN ACCORDANCE WITH LEVEL 1
DESIGN GUIDELINES
CONTRIBUTING TOTAL AREA = 0.2 ACRES
SURFACE AREA PROVIDED = 1,706 S.F.
Tv PROVIDED = 111 C.F.



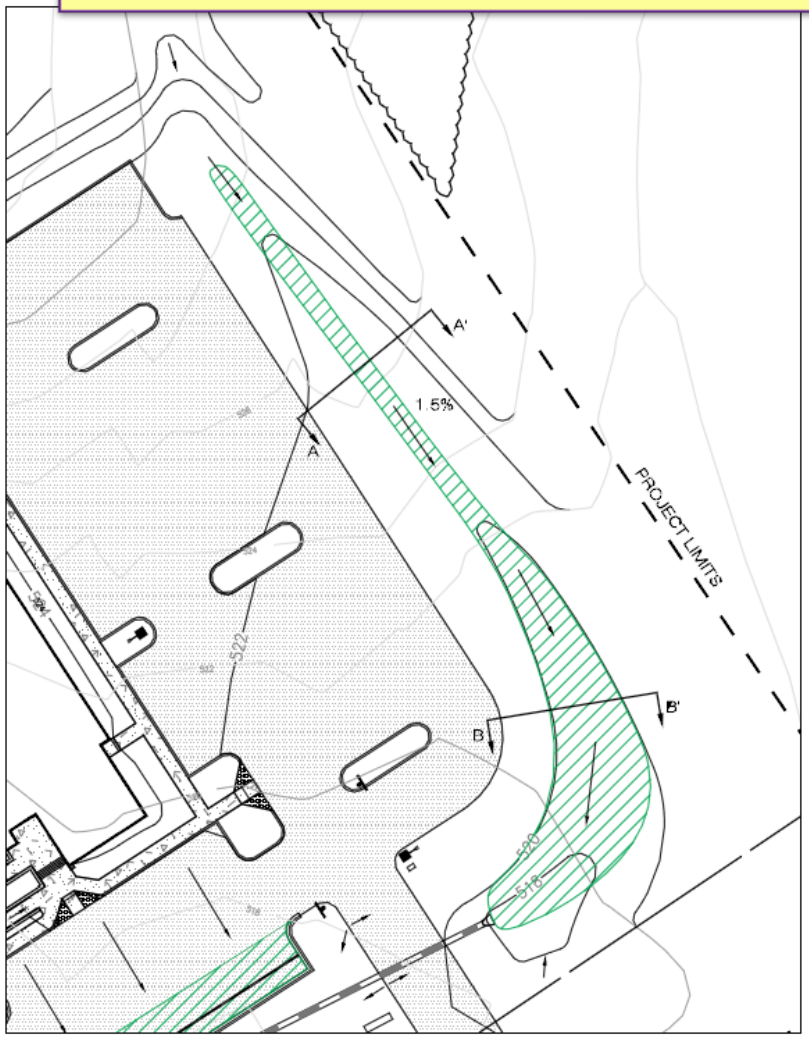
PAVEMENT LAYERS		
1	SURFACE LAYER	POROUS ASPHALT
2	BEDDING	4" NO. 57 STONE
3	RESERVOIR	12" NO. 2 STONE
4	INFILTRATION SUMP	SAME AS RESERVOIR LAYER
5	BOTTOM FILTER	4' NO. 8 STONE
6	IMPERMEABLE LINER	NECESSARY DUE TO PLACEMENT ON FILL
7	UNCOMPACTED SYBGRADE	4' TO BE SCARIFIED PRIOR TO INSTALLATION
8	UNDERDRAIN	6" PVC, SCHEDULE 40

PERMEABLE PAVEMENT TYPICAL CROSS-SECTION

APRIL 2014
SMALLTOWN, VIRGINIA
DEPARTMENT OF PUBLIC WORKS AND ENVIRONMENTAL SERVICES
STORMWATER PLANNING DIVISION
T&L COMMERCIAL DEVELOPMENT
PERMEABLE PAVEMENT DESIGN
DEQ TRAINING CASE STUDY
SCALE 1"=40'
DESIGNED BY: K. PROJECT
DRAFTED BY: K. PROJECT
CHECKED BY: J. SMITH
DESCRIPTION BY APPROVED DATE
AS APPROVED BY THE PLANNING & ZONING BOARD

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

This Design is allowable, however, a geotechnical report should be requested to ensure that the soil meets the minimum infiltration rate for designs without underdrains



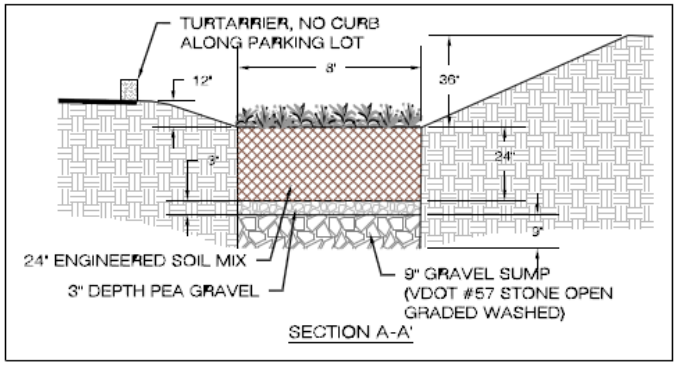
PROPOSED DRAINAGE AREA CHARACTERISTICS:
AREA = 1.9 ACRES
IMPERVIOUS ACREAGE = 0.6 ACRES
OPEN SPACE/ FOREST ACREAGE = 0.65 ACRES
MANAGED TURF ACREAGE = 0.50 ACRES
CURVE NUMBER: 81
TIME OF CONCENTRATION: 5 MINUTES
1 YR DISCHARGE = 2.33 CFS
2 YR DISCHARGE = 4.43 CFS
10 YR DISCHARGE = 9.13 CFS

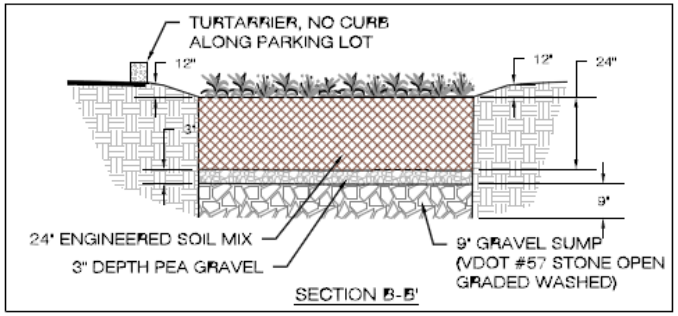
PHOSPHOROUS REDUCTION CALCULATIONS:
LOAD TO BMP = 1.66 LBS
EFFICIENCY OF BMP = 40%
VOLUME TO BMP = 2642 C.F.
RUNOFF REDUCTION BY PRACTICE
=1,585 C.F.
TOTAL LOAD REDUCTION BY PRACTICE
=1.26 LB/YR
TOTAL PHOSPHOROUS LOAD REMAINING
=0.40 LBS

SIZING CALCULATIONS, DRY SWALE LEVEL 2:
POST DEVELOPMENT TREATMENT VOLUME REQUIRED
Tv=2,735 C.F.
SOIL MEDIA DEPTH = 24 IN
PEA GRAVEL = 3 IN
GRAVEL SUMP = 9 IN
STORAGE DEPTH = DEPTH x VOID RATIO
=(24X0.25)+(12X0.4) = 10.8 IN = 0.9 FT
DRY SWALE LEVEL 2 SURFACE AREA REQUIRED
=(1.1xTv)/ STORAGE DEPTH = 2,735/0.9 = 3,342 S.F.
SURFACE AREA PROVIDED = 4,782 S.F.
TREATMENT VOLUME PROVIDED = 4,303 C.F.

VELOCITY COMPUTATIONS:
CROSS-SECTION A-A' MODELED
SLOPE = 1.5%
DIMENSIONS:
SIDE SLOPES = 3:1, BOTTOM WIDTH = = 8'
DEPTH 10 YR = 0.42 FT
RH 10 YR = 0.37
SHEAR STRESS 10 YR = 0.35 LB/S.F.
VELOCITY 10 YR = 2.33 FT/S

VELOCITY AND SHEAR STRESSES MEET TURF AND VEGETATION ALLOWABLE VALUES





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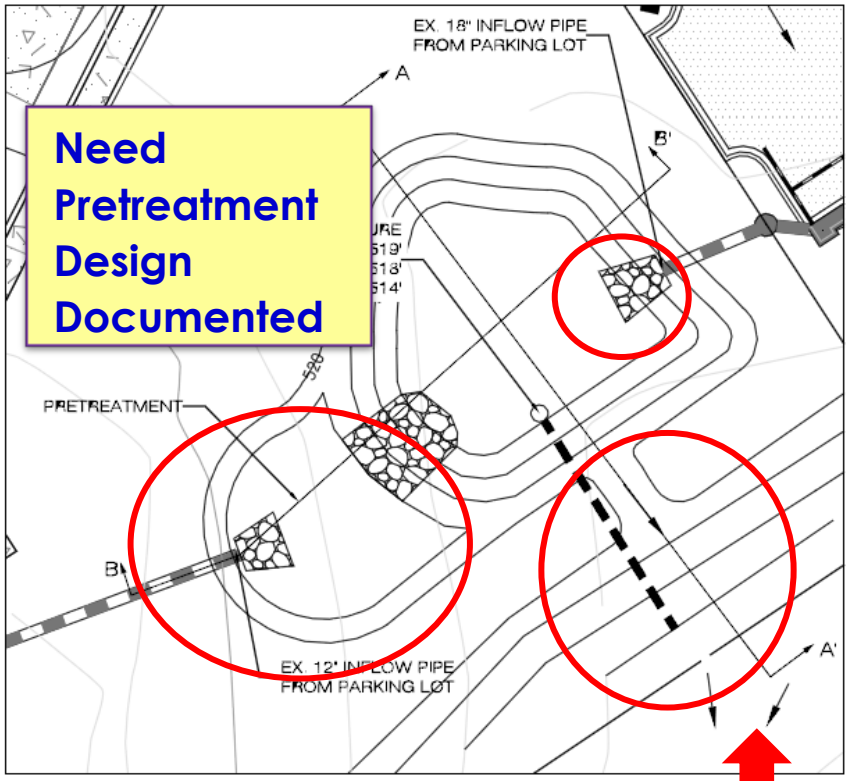
APRIL 2014
SMALLTOWN, VIRGINIA
DEPARTMENT OF PUBLIC WORKS AND ENVIRONMENTAL SERVICES
STORMWATER PLANNING DIVISION
T&L COMMERCIAL DEVELOPMENT
DRY SWALE DESIGN
DEQ TRAINING CASE STUDY
SCALE 1"=40'
DESIGNED BY: L PROFFIT
DRAFTED BY: L PROFFIT
CHECKED BY: J SMITH
APPROVED BY THE STORMWATER PLANNING DIVISION

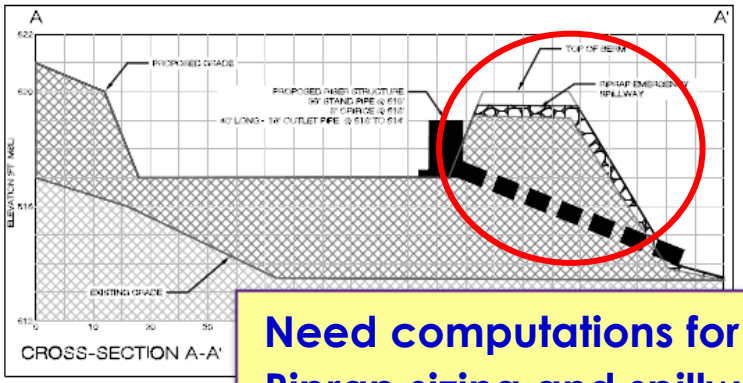


Need Pretreatment Design Documented

PHOSPHOROUS REDUCTION CALCULATIONS:
LOAD TO BMP = 2.4 LBS
EFFICIENCY OF BMP = 15%
VOLUME TO BMP = 6,524 C.F.
RUNOFF REDUCTION BY PRACTICE
=0 C.F.
TOTAL LOAD REDUCTION OF PRACTICE
=0.7 LB/YR

SIZING CALCULATIONS, EXTENDED DETENTION (L1):
POST DEVELOPMENT TREATMENT VOLUME REQUIRED
Tv=(Rv(A)/12)
+ REMAINING RUNOFF FROM US BMPS
=[(0.32X(2.17X43,560)/12]+2074
=4598 C.F.

TOTAL TREATMENT VOLUME PROVIDED =7,536 C.F.



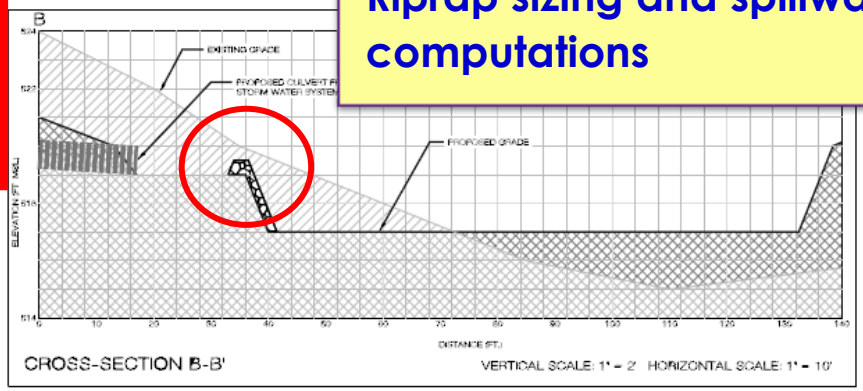
Need computations for Riprap sizing and spillway computations

Need channel from outlet of basin to exit of site

PROPOSED DRAINAGE AREA
AREA = 4.67 ACRES
IMPERVIOUS ACREAGE =
OPEN SPACE/ FOREST A
MANAGED TURF ACREA
CURVE NUMBER: 81
TIME OF CONCENTRATION: 5

BMP DESIGN DIS

	IN	OUT	
Q1	5.99	3.17	518.7
Q2	9.57	7.08	519.2
Q10	11.93	12.02	519.8



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VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

APRIL 2014

STORMWATER PLANNING DIVISION

T&L COMMERCIAL DEVELOPMENT
EXTENDED DETENTION DESIGN

DEQ TRAINING CASE STUDY

Answer Summary:

- Post development total Phosphorous load & reduction required
  - 5.17 lb/yr and 2.42 lb/yr
- Target Tv and average efficiency needed
  - 8,231 c.f. and 47%
- Allowable discharge from site & storage volume required to satisfy water quantity requirements
  - 2.4 cfs and 0.15 acre-ft (6,455 C.F.)

DEQ
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Answer Summary

Post development Total Phosphorous Load	5.17 lb/yr
Total Phosphorus Load Reduction Required	2.42 lb/yr
Target Tv	8,231 c.f.
Average Efficiency Needed	47%
Allowable Discharge from Site	2.4 cfs
Storage Volume Required to comply with Water Quantity Requirements	0.15 acre-ft (6,455 c.f.)

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