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Stormwater Management Plan Review Course



Module 8

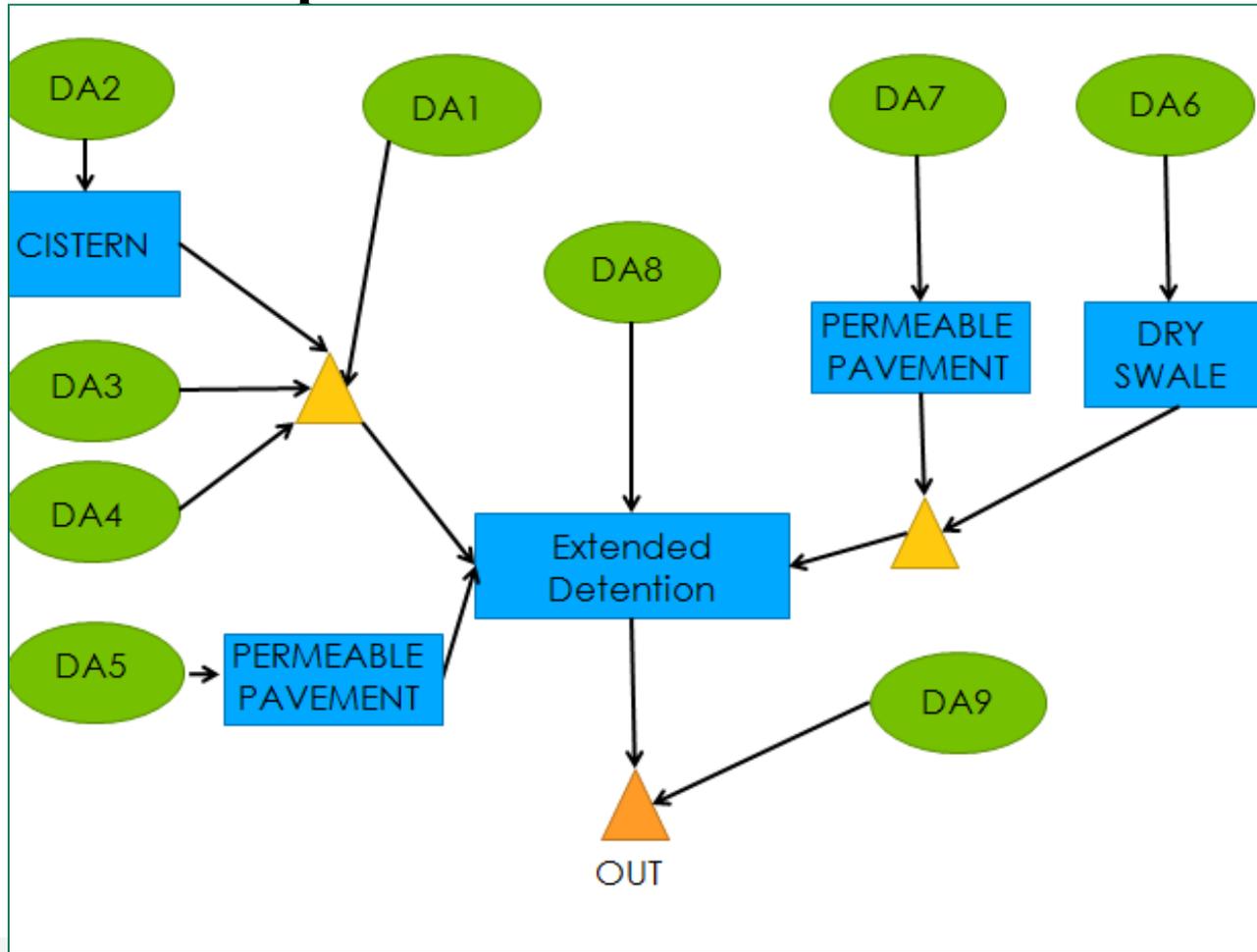
Evaluating Water Quality Compliance



Module 8. Content

- **8a. Evaluating On-site Compliance**
 - Complex Treatment Trains
 - Redevelopment
- **8b. BMP Variations**
 - Online vs Offline Practices
 - Water Quality Flow Rate
 - Specifications
- **8c. Off-site Compliance Options**

Complex Treatment Trains



What is important to track?

Volume
and Load



Variables to Account for:

- **Hydrologic Parameters**
 - **Land Cover:** Forest – Turf - Impervious
 - **HSG:** A – B – C - D
- **Volume and Load**
 - Tracked for **Each Sub-area** and for **Each Practice**
 - Volume to next practice includes **residual volume** from U/S BMP **plus direct volume**
 - Load includes **residual load and direct load**
 - Don't forget **bypass loads**

Volume Tracking

Drainage Area B			
Drainage Area B Land Cover (acres)			
D Soils	Totals	Land Cover Rv	
Forest/Open Space (acres)	0.00	0.00	0.00
Managed Turf (acres)	0.00	1.00	0.22
Impervious Cover (acres)	0.00	1.00	0.95
Total	2.00		

Post Development Treatment Volume (cf) **4247**

Apply Runoff Reductionent Volume & Post-Development Load in Drainage Area B

Practice	on 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 (lbs)	Untreated Phosphorus Load to Practice (lbs.)	Phosphorus Removed By Practice (lbs.)	Remaining Phosphorus Load (lbs.)	Downstream Treatment to be Employed
7. Infiltration												
7.a. Infiltration #1 (Spec #8)	Volume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
	Volume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
7.b. Infiltration #2 (Spec #8)	Volume reduction	0.90	1.00	0	3104	345	25	0.00	2.16	2.00	0.16	
	Volume reduction	0.90	1.00	0	719	80	25	0.00	0.50	0.46	0.04	

Total Tv to the BMP includes both the amount of Runoff "reduced" and the remaining volume

Load Reduction

Drainage Area B

Drainage Area B Land Cover (acres)	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	0.00
Managed Turf (acres)	0.00	1.00	0.22
Impervious Cover (acres)	0.00	1.00	0.95
Total		2.00	

Post Development Treatment Volume (cf) 4247

Apply Runoff Reduction Volume & Post-Development Load in Drainage Area B

Practice	Volume 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 (lbs)	Untreated Phosphorus Load to Practice (lbs.)	Phosphorus Removed By Practice (lbs.)	Remaining Phosphorus Load (lbs.)	Downstream Treatment to be Employed
7. Infiltration												
7.a. Infiltration #1 (Spec #8)	Volume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
	Volume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
7.b. Infiltration #2 (Spec #8)	Volume reduction	0.90	1.00	0	3104	345	25	0.00	2.16	2.00	0.16	
	Volume reduction	0.90	1.00	0	719	80	25	0.00	0.50	0.46	0.04	

$$\{TR: \text{Total Mass Load Efficiency}\} = \{RR \text{ Eff.}\} + \{PR \text{ Eff} \times (1 - R_{\text{reff}})\}$$

$$\{90\% \} + \{25\% \times (1 - 0.90)\} = \{90 + (25 \times 0.1)\} = 92.5\%$$

$$2 / 2.16 = 92.5\%$$

Total Removal Efficiency

Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	50%	90%
Total Phosphorus (TP) EMC Reduction ¹ by BMP Treatment Process	25%	+ 25% × Balance of Tv
Total Phosphorus (TP) Mass Load Removal	63%	= 93%
Total Nitrogen (TN) EMC Reduction ¹ by BMP Treatment Process	15%	15%
Total Nitrogen (TN) Mass Load Removal	57%	92%

Load Tracking

Drainage Area B

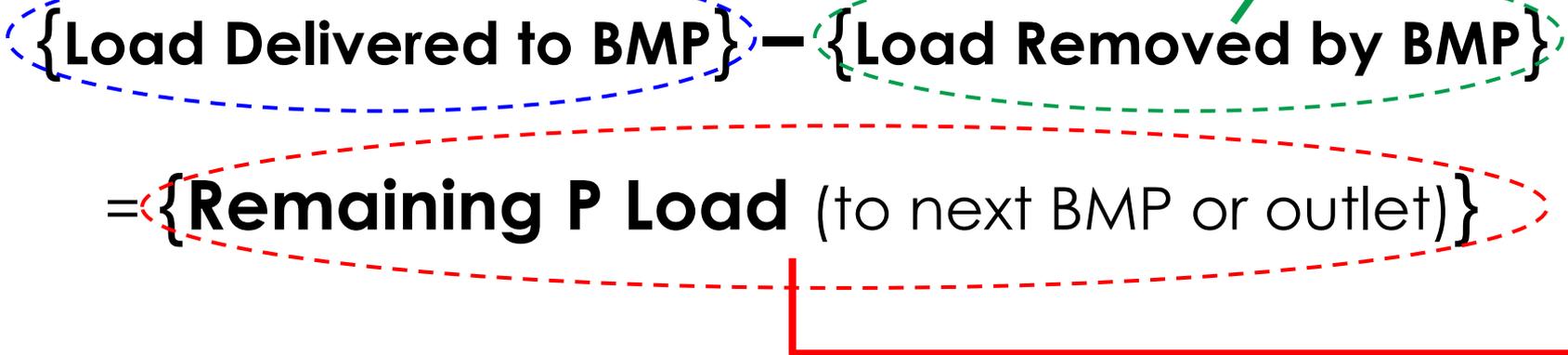
Drainage Area B Land Cover (acres)

	D Soils	Totals	Land Cover Rv
Forest/Open Space (acres)	0.00	0.00	0.00
Managed Turf (acres)	0.00	1.00	0.22
Impervious Cover (acres)	0.00	1.00	0.95
Total		2.00	

Post Development Treatment Volume (cf) 4247

Apply Runoff Reduction Volume & Post-Development Load in Drainage Area B

Practice	Volume 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 (lbs)	Untreated Phosphorus Load to Practice (lbs.)	Phosphorus Removed By Practice (lbs.)	Remaining Phosphorus Load (lbs.)	Downstream Treatment to be Employed
7. Infiltration												
7.a. Infiltration #1 (Spec #8)	Volume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
	Volume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
7.b. Infiltration #2 (Spec #8)	Volume reduction	0.90	1.00	0	3104	345	25	0.00	2.16	2.00	0.16	
	Volume reduction	0.90	1.00	0	719	80	25	0.00	0.50	0.46	0.04	



Load Tracking

Loading to Next BMP will include:
 Residual load from upstream BMPs
 + Additional (direct) untreated load to that BMP

Practice	Volume 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 (lbs)	Untreated Phosphorus Load to Practice (lbs.)	Phosphorus Removed By Practice (lbs.)	Remaining Phosphorus Load (lbs.)	Downstream Treatment to be Employed
7.a. Infiltration #1 (Spec #7)	Volume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
7.b. Infiltration #2 (Spec #8)	Volume reduction	0.90	1.00	0	3104	345	25	0.00	2.16	2.00	0.16	8 b. ED #2
	Volume reduction	0.90	1.00	0	719	80	25	0.00	0.50	0.46	0.04	8 b. ED #2
8. Extended Detention Pond												
8.a. ED #1 (Spec #15)	Volume reduction	0.00	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
	Volume reduction	0.00	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
8.b. ED #2 (Spec #15)	Volume reduction	0.15	1.00	345	569	3224	15	0.16	2.16	0.65	1.68	
	Volume reduction	0.15	0.00	80	12	68	15	0.04	0.00	0.01	0.03	



8a3. Redevelopment Spreadsheet

- Predevelopment
 - Conditions that exist **at time plans are submitted** for land development of a tract of land
 - Multi-phase projects:
 - Conditions that exist at time of original submission for first phase of project

Development on prior developed land: LDA **DOES NOT** increase impervious cover

LDA \geq 1 acre

P must be reduced
at least **20%** below
pre-development
P load

LDA $<$ 1 acre

P must be reduced
at least **10%** below
pre-development
P load

Development on prior developed land: LDA **DOES** increase impervious cover

LDA \geq 1 acre

P load on increased impervious area cannot exceed **0.41 lbs./acre/yr.**

P load on remainder of site must be reduced at least **20%** below pre-development P load

LDA < 1 acre

P load on increased impervious area cannot exceed **0.41 lbs./acre/yr.**

P load on remainder of site must be reduced at least **10%** below pre-development P load

Redevelopment Spreadsheet

Site Data Tab

Post-ReDevelopment Project & Land Cover Information

Total Disturbed Acreage 0.00

Constants

Annual Rainfall (inches)	43
Target Rainfall Event (inches)	1.00
Phosphorus EMC (mg/L)	0.26
Target Phosphorus Target Load (lb/acre/yr)	0.41
Pj	0.90

Nitrogen EMC (mg/L) 1.86

Pre-ReDevelopment 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	0.00	0.00	0.00
Impervious Cover (acres)	0.00	0.00	0.00	0.00	0.00
				Total	0.00

Post-ReDevelopment 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	0.00	0.00	0.00
Impervious Cover (acres)	0.00	0.00	0.00	0.00	0.00
				Total	0.00

Area Check Okay Okay Okay Okay

Redevelopment – Site Data – Ex 1

Post-ReDevelopment Project & Land Cover Information				Total Disturbed Acreage	1.00
Constants					
Annual Rainfall (inches)	43				
Target Rainfall Event (inches)	1.00				
Phosphorus EMC (mg/L)	0.26			Nitrogen EMC (mg/L)	1.86
Target Phosphorus Target Load (lb/acre/yr)	0.41				
Pj	0.90				
Pre-ReDevelopment 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	2.00	0.00	2.00
Impervious Cover (acres)	0.00	0.00	2.00	0.00	2.00
				Total	4.00
Post-ReDevelopment 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	2.00	0.00	2.00
Impervious Cover (acres)	0.00	0.00	2.00	0.00	2.00
				Total	4.00
Area Check	Okay	Okay	Okay	Okay	

Redevelopment – Site Data – Ex 1

Post-ReDevelopment Project & Land Cover Information

Total Disturbed Acreage **1.00**

Constants

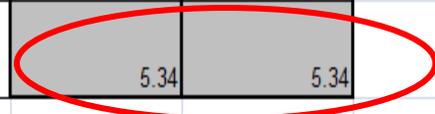
Annual Rainfall (inches)	43
Target Rainfall Event (inches)	1.00
Phosphorus EMC (mg/L)	0.26
Target Phosphorus Target Load (lb/acre/yr)	0.41
Pj	0.90

Nitrogen EMC (mg/L) 1.86

Total Site Area (acres)	4.00	4.00	Total ReDev. Site Area (acres)	4.00	Total New Dev. Site Area (acres)	0.00
Site Rv	0.59	0.59	ReDev. Site Rv	0.59	New Dev. Site Rv	0.95
Pre-Development Treatment Volume (acre-ft)	0.1950	0.1950	Post-ReDevelopment Treatment Volume (acre-ft)	0.1950	Post-Development Treatment Volume (acre-ft)	0.0000
Pre-Development Treatment Volume (cubic feet)	8,494	8,494	Post-ReDevelopment Treatment Volume (cubic feet)	8,494	Post-Development Treatment Volume (cubic feet)	0
Pre-Development Load (TP) (lb/yr)	5.34	5.34	Post-ReDevelopment Load (TP) (lb/yr)	5.34	Post-Development Load (TP) (lb/yr)	0.00

¹Adjusted Land Cover Summary reflects the pre redevelopment land cover minus the previous land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requirement for the new impervious cover to meet the new development load limit is computed in Column I.

Maximum % Reduction Required Below Pre-ReDevelopment Load	20%	TP Load Reduction Required for Redeveloped Area (lb/yr)	1.07	TP Load Reduction Required for New Impervious Area (lb/yr)	0.00
Total Load Reduction Required (lb/yr)	1.07	Pre-Development Load (TN) (lb/yr)	38.18	Post-Development Load (TN) (lb/yr)	38.18



Redevelopment – Site Data – Ex 2

Post-ReDevelopment Project & Land Cover Information		Total Disturbed Acreage
Constants		0.50
Annual Rainfall (inches)	43	
Target Rainfall Event (inches)	1.00	
Phosphorus EMC (mg/L)	0.26	Nitrogen EMC (mg/L)
Target Phosphorus Target Load (lb/acre/yr)	0.41	1.86
Pj	0.90	

Pre-Development Treatment Volume (acre-ft)	0.1950	0.1950	Post-ReDevelopment Treatment Volume (acre-ft)	0.1950	Post-Development Treatment Volume (acre-ft)	0.0000
Pre-Development Treatment Volume (cubic feet)	8,494	8,494	Post-ReDevelopment Treatment Volume (cubic feet)	8,494	Post-Development Treatment Volume (cubic feet)	0
Pre-Development Load (TP) (lb/yr)	5.34	5.34	Post-ReDevelopment Load (TP) (lb/yr)	5.34	Post-Development Load (TP) (lb/yr)	0.00
<p>¹Adjusted Land Cover Summary reflects the pre redevelopment land cover minus the pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requirement for the new impervious cover to meet the new development load limit is computed in Column I.</p>			Maximum % Reduction Required Below Pre-ReDevelopment Load	10%	TP Load Reduction Required for Redeveloped Area (lb/yr)	0.53
			Total Load Reduction Required (lb/yr)	0.53	TP Load Reduction Required for New Impervious Area (lb/yr)	0.00
Pre-Development Load (TN) (lb/yr)	38.18		Post-Development Load (TN) (lb/yr)	38.18		

Redevelopment – Site Data – Ex 3

Post-ReDevelopment Project & Land Cover Information			Total Disturbed Acreage		
			1.50		
Constants					
Annual Rainfall (inches)	43				
Target Rainfall Event (inches)	1.00				
Phosphorus EMC (mg/L)	0.26	Nitrogen EMC (mg/L)	1.86		
Target Phosphorus Target Load (lb/acre/yr)	0.41				
Pj	0.90				
Pre-ReDevelopment 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	2.00	0.00	2.00
Impervious Cover (acres)	0.00	0.00	2.00	0.00	2.00
	Total				4.00
Post-ReDevelopment 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	1.00	0.00	1.00
Impervious Cover (acres)	0.00	0.00	3.00	0.00	3.00
	Total				4.00

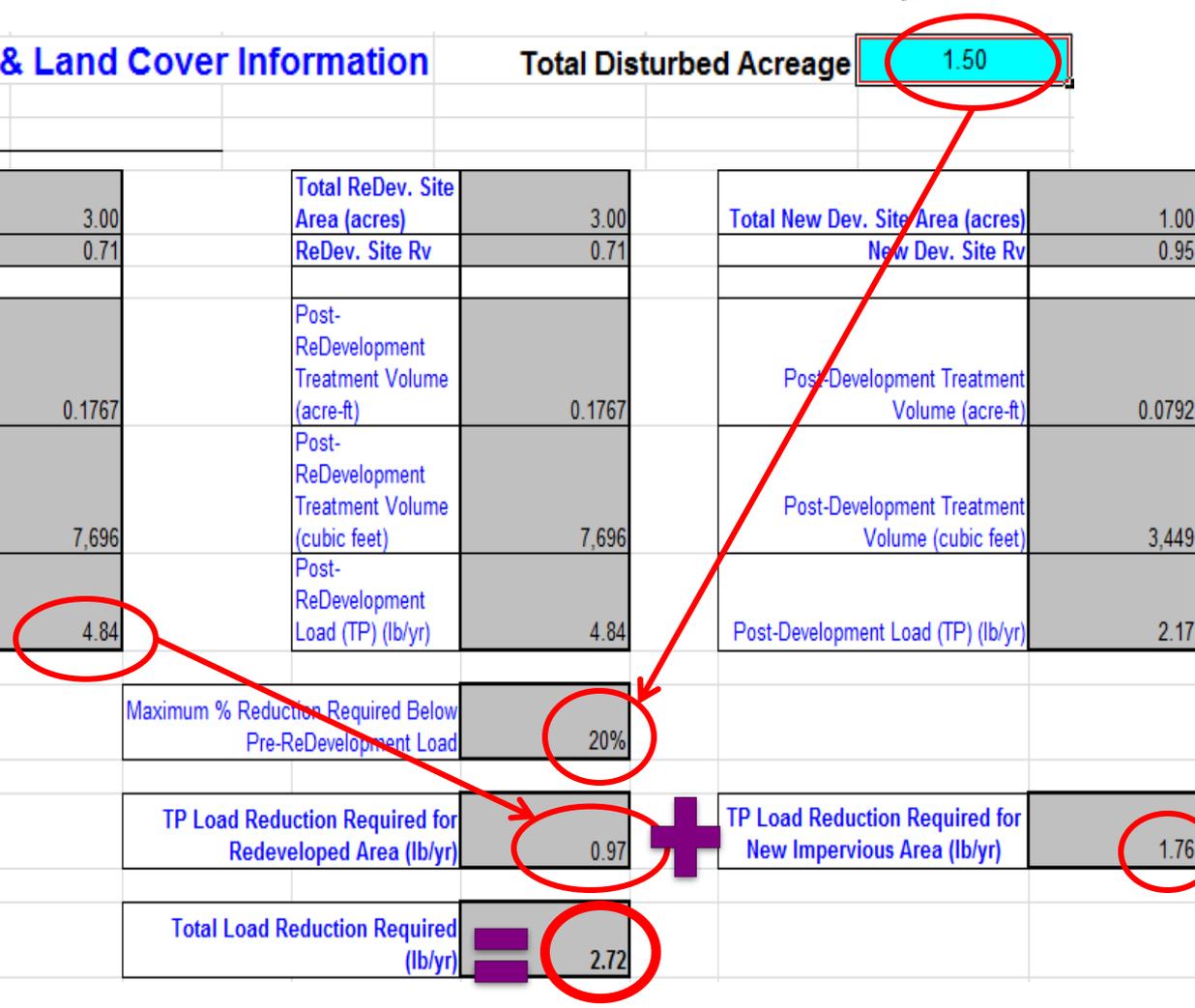
Redevelopment – Site Data – Ex 3

Post-ReDevelopment Project & Land Cover Information		Total Disturbed Acreage	1.50
Constants			

Total Site Area (acres)	4.00	3.00	Total ReDev. Site Area (acres)	3.00	Total New Dev. Site Area (acres)	1.00
Site Rv	0.59	0.71	ReDev. Site Rv	0.71	New Dev. Site Rv	0.95
Pre-Development Treatment Volume (acre-ft)	0.1950	0.1767	Post- ReDevelopment Treatment Volume (acre-ft)	0.1767	Post-Development Treatment Volume (acre-ft)	0.0792
Pre-Development Treatment Volume (cubic feet)	8,494	7,696	Post- ReDevelopment Treatment Volume (cubic feet)	7,696	Post-Development Treatment Volume (cubic feet)	3,449
Pre-Development Load (TP) (lb/yr)	5.34	4.84	Post- ReDevelopment Load (TP) (lb/yr)	4.84	Post-Development Load (TP) (lb/yr)	2.17

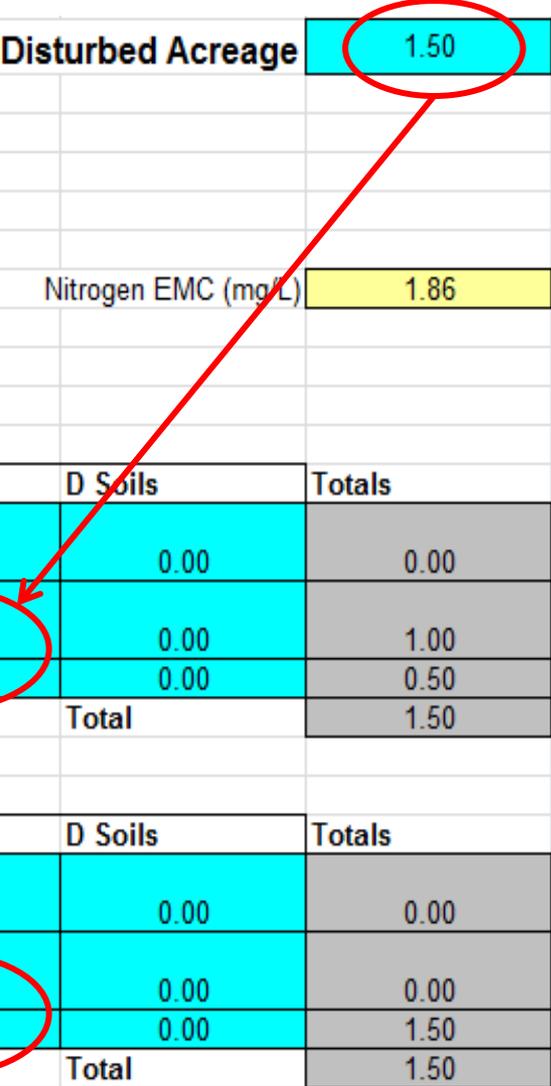
¹Adjusted Land Cover Summary reflects the pre redevelopment land cover minus the pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requirement for the new impervious cover to meet the new development load limit is computed in Column I.

Maximum % Reduction Required Below Pre-ReDevelopment Load	20%			
TP Load Reduction Required for Redeveloped Area (lb/yr)	0.97	+	TP Load Reduction Required for New Impervious Area (lb/yr)	1.76
Total Load Reduction Required (lb/yr)	=			2.72



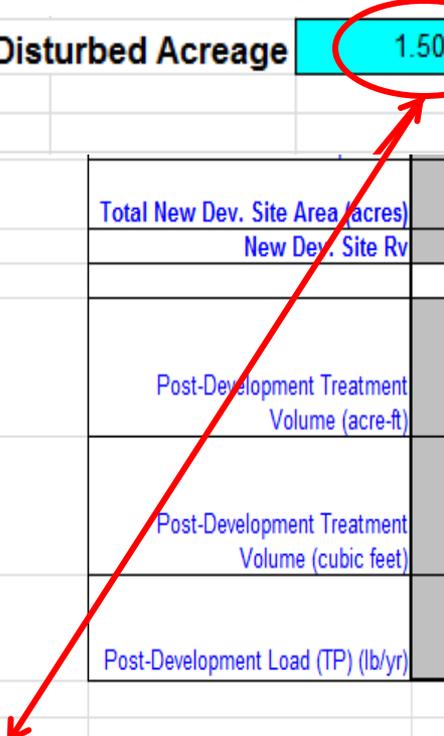
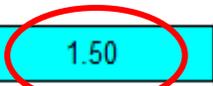
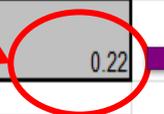
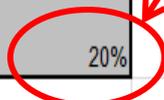
Redevelopment – Site Data – Ex 4

Post-ReDevelopment Project & Land Cover Information			Total Disturbed Acreage		1.50
Constants					
Annual Rainfall (inches)	43				
Target Rainfall Event (inches)	1.00				
Phosphorus EMC (mg/L)	0.26			Nitrogen EMC (mg/L)	1.86
Target Phosphorus Target Load (lb/acre/yr)	0.41				
Pj	0.90				
Pre-ReDevelopment 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	1.00	0.00	1.00
Impervious Cover (acres)	0.00	0.00	0.50	0.00	0.50
				Total	1.50
Post-ReDevelopment 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	0.00	0.00	0.00
Impervious Cover (acres)	0.00	0.00	1.50	0.00	1.50
				Total	1.50



Redevelopment – Site Data – Ex 4

Post-ReDevelopment Project & Land Cover Information				Total Disturbed Acreage			
Constants				1.50			
Total Site Area (acres)	1.50	0.50	Total ReDev. Site Area (acres)	0.50	Total New Dev. Site Area (acres)	1.00	
Site Rv	0.46	0.95	ReDev. Site Rv	0.95	New Dev. Site Rv	0.95	
Pre-Development Treatment Volume (acre-ft)	0.0579	0.0396	Post-ReDevelopment Treatment Volume (acre-ft)	0.0396	Post-Development Treatment Volume (acre-ft)	0.0792	
Pre-Development Treatment Volume (cubic feet)	2,523	1,724	Post-ReDevelopment Treatment Volume (cubic feet)	1,724	Post-Development Treatment Volume (cubic feet)	3,449	
Pre-Development Load (TP) (lb/yr)	1.59	1.08	Post-ReDevelopment Load (TP) (lb/yr)	1.08	Post-Development Load (TP) (lb/yr)	2.17	
<p>¹Adjusted Land Cover Summary reflects the pre redevelopment land cover minus the pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requiriment for the new impervious cover to meet the new development load limit is computed in Column I.</p>			Maximum % Reduction Required Below Pre-ReDevelopment Load	20%			
			TP Load Reduction Required for Redeveloped Area (lb/yr)	0.22	+	TP Load Reduction Required for New Impervious Area (lb/yr)	1.76
			Total Load Reduction Required (lb/yr)	1.97			
			Pre-Development Load (TN) (lb/yr)	11.34		Post-Development Load (TN) (lb/yr)	23.25

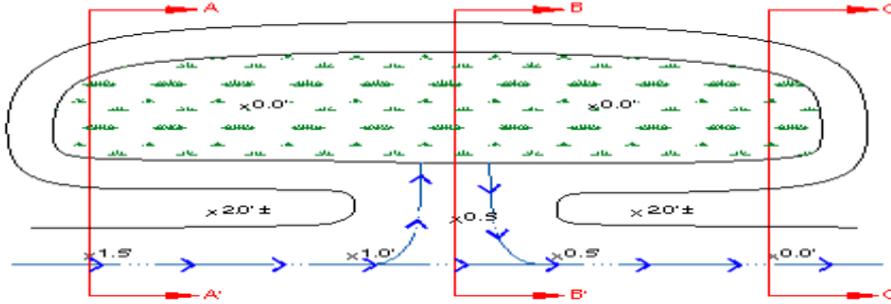


8b.2 Online vs. Offline Practices and Flow Bypass

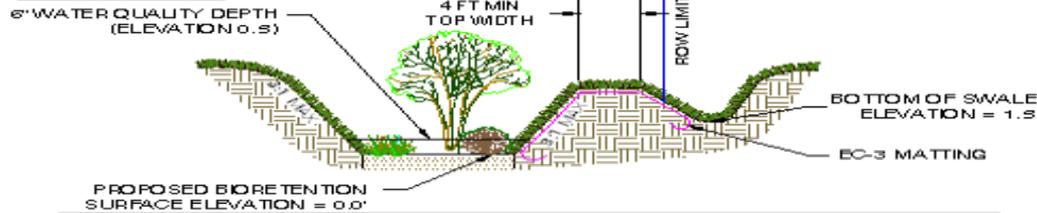
- **Offline** – Inlet is the Outlet
- **Bypass Structures** – Pass by higher flows without flow through BMP
- **Why:**
 - Resolve concerns about hydraulic overloading
 - Reduce footprints for BMPs
 - Other constraints (hydraulic/physical/etc.)

Offline Bioretention

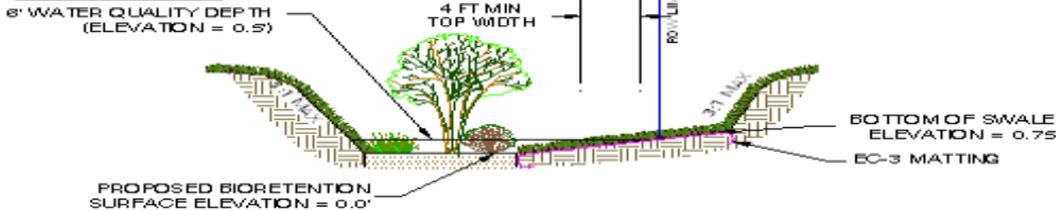
PLAN VIEW



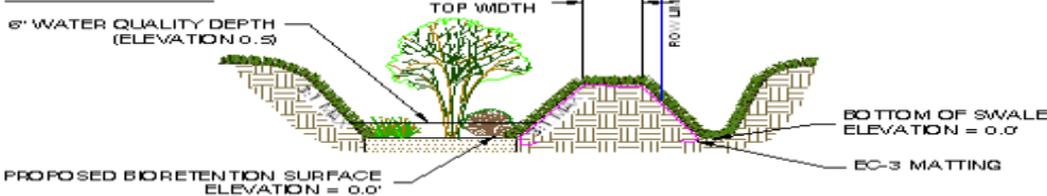
SECTION A-A'



SECTION B-B'



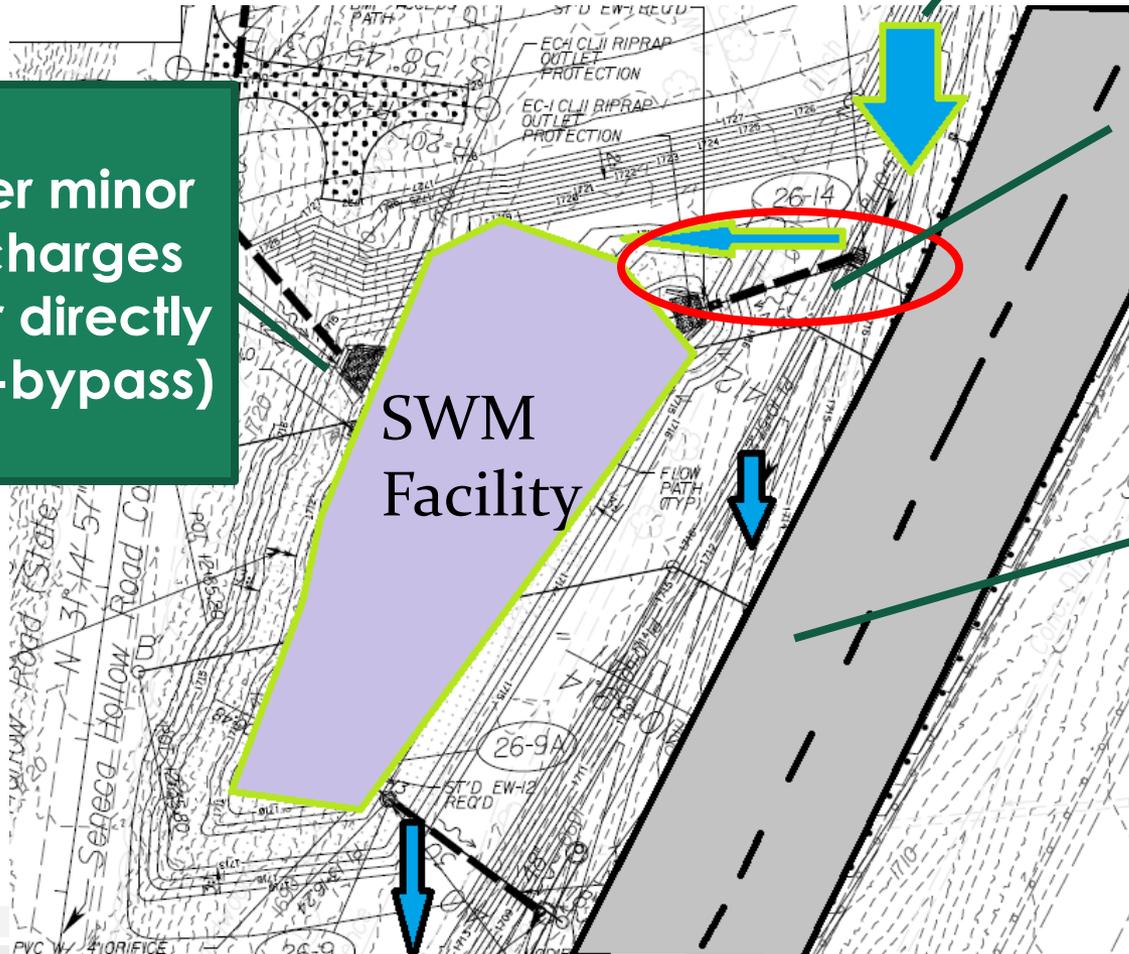
SECTION C-C'



- Depressional (offline) storage
- Flows enter and exit through same opening
- Once practice is "filled" flow continues down normal flow path

Bypass Structures

Other minor discharges enter directly (non-bypass)



Majority of flows enter from ditchline

Bypass structure directs low flows to stormwater practice

High flows continue on normal flow path in ditchline

8b3. Water Quality Treatment Volume (T_v) Peak Flow Rate

- q_{pTv}
- For bypass configuration and facilities which have hydraulic limitations
- Used to estimate flow rate associated with treatment volume
- TR-55 Hydrology not good at estimating discharge from small storms
- Adjusted method suggested
- Many ways to estimate this discharge



8b3. Water Quality Treatment Volume Peak Flow Rate

$$q_{pTv} = q_u \times A \times Q_a$$

q_{pTv} = Treatment Volume peak discharge (cfs)

q_u = unit peak discharge (cfs/mi²/in)

A = drainage area (mi²)

Q_a = runoff volume (watershed inches), equal to T_v/A



8b3. Water Quality Treatment Volume (T_v) Peak Flow Rate

Reference:

Draft Virginia Stormwater
Management Handbook, Chapter 11



BMP Clearinghouse Specifications

- Published specs (2011) allowed for all Part II B projects
- Pending revisions to specifications
 - Adjust some design parameters based on more current information
 - One specification with change in runoff reduction credit



8c. Offsite Compliance Options

Can be used under any of the following conditions:

< 5-acres
land
disturbed

Post-
construction
P control
requirement
is
< 10 lbs/year

75% required
P reductions
achieved
onsite



8c. Offsite Compliance Options

- If at least 75% of required P reductions not achieved onsite, operator must demonstrate to VSMP authority:
 - Alternative site designs considered
 - On-site BMPs considered to maximum extent practicable
 - Appropriate on-site BMPs will be implemented
 - Full compliance with post-development nonpoint nutrient runoff compliance requirements cannot practicably be met on-site



Nutrient Credit & Offsite Option (§62.1-44.15:35)

- Water quality criteria can be met through **nutrient credit** trading in the same tributary
 - Same or adjacent 8 digit HUC
 - Credits outside the same or adjacent 8 digit HUC may be used

Nutrient reductions must be achieved before start of LDA



Nutrient Credit & Offsite Options (§62.1-44.15:35)

- No credits from another tributary
- Cannot be used to address water quantity control requirements
- Cannot be used in violation of local water quality based limits

Questions?

