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Module 6

Environmental Site Design and BMPs

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6a. Environmental Site Design (ESD)

- Careful site planning at the outset of a project is the most effective approach for preventing or reducing the potential adverse impacts from development

ESD Comprehensive Approach

- In the past, "stormwater management" has been defined largely as stormwater *disposal*
- A new and better approach is based on comprehensive understanding of stormwater

ESD = Balance

ESD Goals

- Promote runoff control through the use of natural drainage systems
- Reduce the environmental impact of commonly used land development and drainage methods

ESD for Water Table Level Protection

- In addition to maintaining natural drainage:
  - Provide natural open-space based drainage system using undeveloped flood plains and drainage swales
  - Avoid channelization within the natural drainage system
  - Maintain forest cover and other natural vegetation

ESD Techniques

- Optimize conservation of natural features (Drainage patterns, soil, vegetation, etc.)

ESD Techniques

- Minimize impervious surfaces (Pavement, concrete channels, rooftops, etc.)

ESD Techniques

- Slow down runoff to maintain discharge timing and to increase infiltration and evapotranspiration

ESD Benefits

↓ Runoff volumes and pollutant loads =

- Economic savings
  - Reduced infrastructure requirements
  - Decreased need for site clearing and grading
  - Less expenditure to meet stormwater management requirements
- Environmental benefits
  - Improved water quality!

ESD – Where Can it be Used?

- Environmental Site Design techniques are mostly applied at sites of new development
- It is more difficult to achieve ESD at redevelopment sites due to lack of space, compacted soils, and the constructed drainage system and utilities that are already in place

ESD – 8 Principles

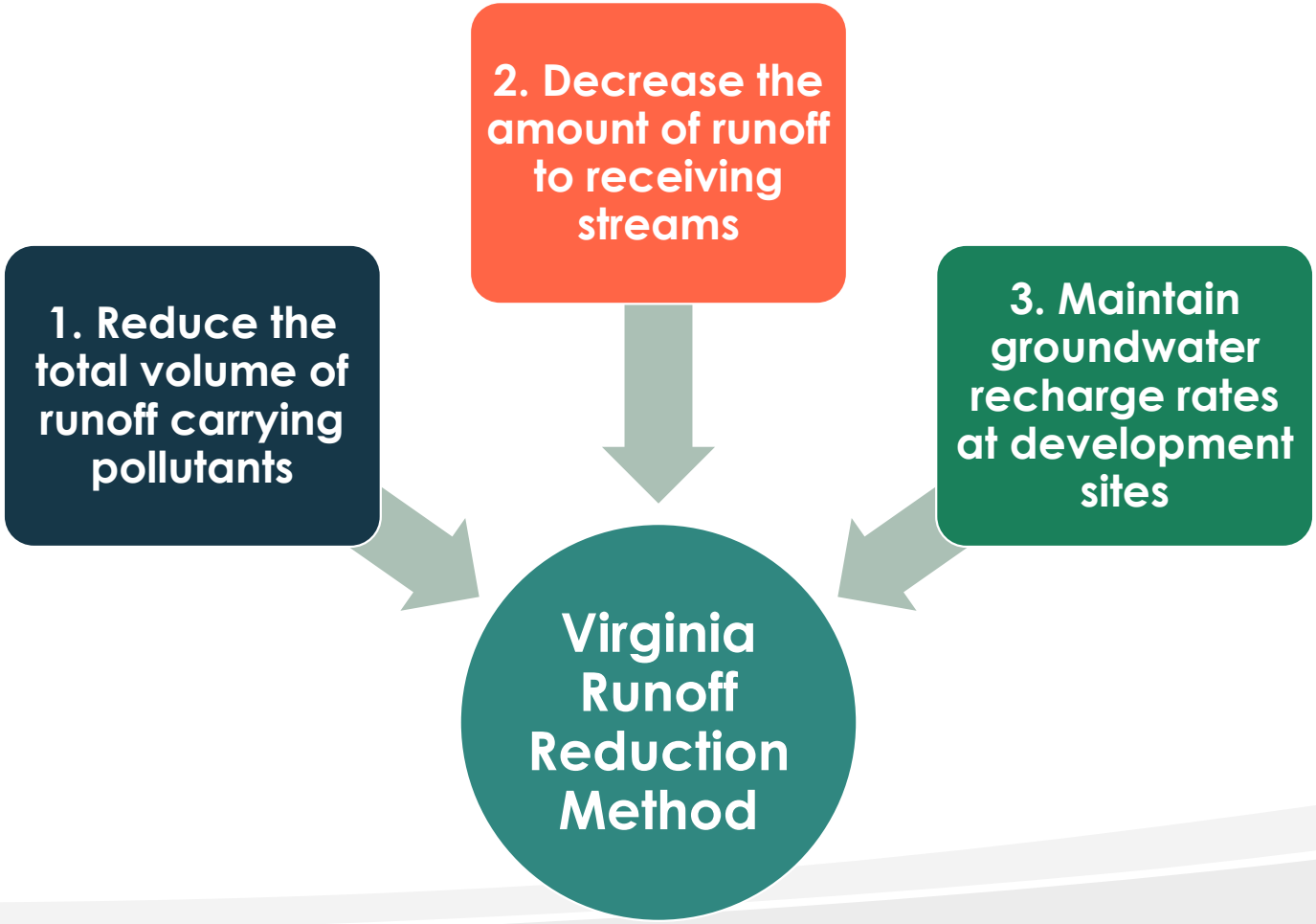
1. Achieve multiple objectives
2. Integrate stormwater management and design early in the site planning and design process
3. Prevent problems to avoid having to mitigate them
4. Conserve resources and minimize land cover changes

ESD – 8 principles

5. Design the development to fit the terrain
6. Apply decisions that have the effect of maintaining the natural site hydrology
7. Manage stormwater as close to the point of origin as possible
8. Rely to the maximum on natural processes that occur within the soil and plant community

6b. Virginia Runoff Reduction Method

RRM


2. Decrease the amount of runoff to receiving streams
1. Reduce the total volume of runoff carrying pollutants
3. Maintain groundwater recharge rates at development sites
Virginia Runoff Reduction Method

Traditional BMPs

1,000,000 liters of stormwater (multiple storm events)

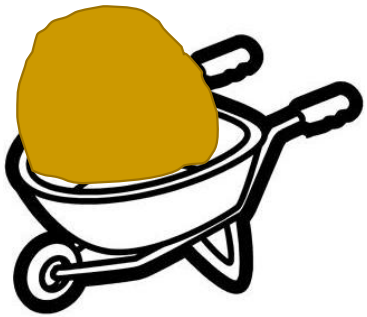
100 mg/L pollutant (average)

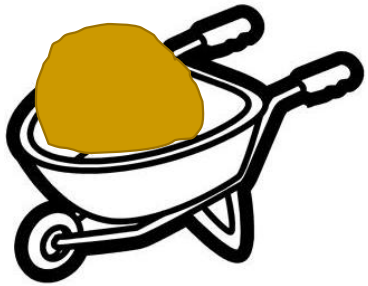
BMP

1,000,000 liters of stormwater (multiple storm events)

50 mg/L of pollutant (average)

100 kg
Total pollutant load





50 kg
Total pollutant load discharged over time

No volume reduction, only load reduction

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RRM, "New" BMPs

1,000,000 liters of stormwater (multiple storm events)

100 mg/L of pollutant (average)

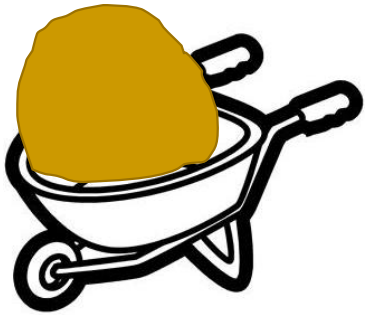
BMP

50% volume reduction

500,000 liters of stormwater (multiple storm events)

50 mg/L pollutants (average)

100 kg
Total load of pollutant



25 kg
Total load of pollutant discharged over time

Volume and load reduction!

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RRM

- **The Runoff Reduction Method rewards the use of volume reducing BMPS**

RRM Principles

- Conserve forested areas/open space
- Conserve soils with high infiltration rates (reserving and limiting compaction)
- Treatment Train / Routing

RRM Spreadsheets

- RRM Compliance Spreadsheet
- RRM Redevelopment Compliance Spreadsheet
- Used to determine BMPs' capacity to reduce the overall volume of runoff as well as pollutant removal
- The BMPs include conventional and non-proprietary
- The method also incorporates built-in incentives for Environmental Site design

RRM: Step 1 – Enter site information

1	**Virginia Runoff Reduction Method Worksheet -- Revised 03/25/2011**					
2	**Site Data**					
3						
4	Project Name:					
5	Date:					
6						
7		data input cells				
8		calculation cells				
9		constant values				
10						
11	**1. Post-Development Project & Land Cover Information**					
12						
13	**Constants**					
14						
15	Annual Rainfall (inches)	43				
16	Target Rainfall Event (inches)	1.00				
17	Phosphorus EMC (mg/L)	0.26		Nitrogen EMC (mg/L)	1.86	
18	Target Phosphorus Target Load (lb/acre/yr)	0.41				
19	Pj	0.90				
20						
21	**Land Cover (acres)**					
22		**A soils**	**B Soils**	**C Soils**	**D Soils**	**Totals**
23	Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
24	Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	0.00	0.00
25	Impervious Cover (acres)	0.00	0.00	0.00	0.00	0.00
26					**Total**	0.00
27						
28	**Rv Coefficients**					
29		**A soils**	**B Soils**	**C Soils**	**D Soils**	
30	Forest/Open Space	0.02	0.03	0.04	0.05	
31	Managed Turf	0.15	0.20	0.22	0.25	
32	Impervious Cover	0.95	0.95	0.95	0.95	

RRM: Step 1 – Enter site information

	A	B	C	D	E	F
14						
15	Annual Rainfall (inches)	43				
16	Target Rainfall Event (inches)	1.00				
17	Phosphorus EMC (mg/L)	0.26		Nitrogen EMC (mg/L)	1.86	
18	Target Phosphorus Target Load (lb/acre/yr)	0.41				
19	Pj	0.90				
20						
21	**Land Cover (acres)**					
22		**A soils**	**B Soils**	**C Soils**	**D Soils**	**Totals**
23	Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	5.00	0.00	0.00	5.00
24	Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	2.00	0.00	0.00	2.00
25	Impervious Cover (acres)	0.00	0.00	10.00	0.00	10.00
26					**Total**	17.00
27						
28	**Rv Coefficients**					
29		**A soils**	**B Soils**	**C Soils**	**D Soils**	
30	Forest/Open Space	0.02	0.03	0.04	0.05	
31	Managed Turf	0.15	0.20	0.22	0.25	
32	Impervious Cover	0.95	0.95	0.95	0.95	
33						
34						
35						
36	**Land Cover Summary**					
37	Forest/Open Space Cover (acres)	5.00				
38	Weighted Rv(forest)	0.03				
39	% Forest	29%				
40	Managed Turf Cover (acres)	2.00				
41	Weighted Rv(turf)	0.20				
42	% Managed Turf	12%				
43	Impervious Cover (acres)	10.00				
44	Rv(impervious)	0.95				
45	% Impervious	59%				
46	**Total Site Area (acres)**	17.00				
47	**Site Rv**	0.59				
48						
49	Post-Development Treatment Volume (acre-ft)	0.84				
50	Post-Development Treatment Volume (cubic feet)	36,482				
51	Post_Development Load (TP) (lb/yr)	22.92		Post_Development Load (TN) (lb/yr)	163.97	
52	Total Load (TP) Reduction Required (lb/yr)	15.95				

RRM: Step 2 – Select the BMPs

G17 | Credit Area (acres)

Apply Runoff Reduction Practices to Reduce Treatment Volume & Post-Development Load in Drainage Area A

Credit	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 (lbs)	Untreated Phosphorus Load to Practice (lbs.)	Phosphorus Removed By Practice (lbs.)
1. Vegetated Roof											
1.a. Vegetated Roof #1 (Spec #5)	acres of green roof	45% runoff volume reduction	0.45	0.00	0	0	0	0	0.00	0.00	0.00
1.b. Vegetated Roof #2 (Spec #5)	acres of green roof	60% runoff volume reduction	0.60	0.00	0	0	0	0	0.00	0.00	0.00
2. Rooftop Disconnection											
2.a. Simple Disconnection to A/B Soils (Spec #1)	impervious acres disconnected	50% runoff volume reduction for treated area	0.50	0.00	0	0	0	0	0.00	0.00	0.00
2.b. Simple Disconnection to C/D Soils (Spec #1)	impervious acres disconnected	25% runoff volume reduction for treated area	0.25	0.00	0	0	0	0	0.00	0.00	0.00
2.c. To Soil Amended Filter Path as per specifications (existing C/D soils) (Spec #4)	impervious acres disconnected	50% runoff volume reduction for treated area	0.50	0.00	0	0	0	0	0.00	0.00	0.00
2.d. To Dry Well or French Drain #1 (Microinfilration #1) (Spec #8)	impervious acres disconnected	50% runoff volume reduction for treated area	0.50	0.00	0	0	0	25	0.00	0.00	0.00
2.e. To Dry Well or French Drain #2 (Micro-Infiltration #2) (Spec #8)	impervious acres disconnected	90% runoff volume reduction for treated area	0.90	0.00	0	0	0	25	0.00	0.00	0.00
2.f. To Rain Garden #1 (Micro-Bioretention #1) (Spec #9)	impervious acres disconnected	40% of volume captured	0.40	0.00	0	0	0	25	0.00	0.00	0.00
2.g. To Rain Garden #2 (Micro-Bioretention #2) (Spec #9)	impervious acres disconnected	80% runoff volume reduction for treated area	0.80	0.00	0	0	0	50	0.00	0.00	0.00
2.h. To Rainwater Harvesting (Spec #6)	impervious acres captured	based on tank size and design	0.00	0.00	0	0	0	0	0.00	0.00	0.00
2.i. To Stormwater Planter (Urban Bioretention) (Spec #9, Appendix A)	impervious acres disconnected	40% runoff volume reduction for treated area	0.40	0.00	0	0	0	25	0.00	0.00	0.00
3. Permeable Pavement											
3.a. Permeable Pavement #1 (Spec #7)	acres of permeable pavement + acres of "external" (upgradient)										

Site Data | D.A. A | D.A. B | D.A. C | D.A. D | D.A. E | Water Quality Compliance | Channel and Flood Protection

Ready | 75%

RRM: Step 3 – Check the site results

	A	B
1	**Site Results**	
2	**Phosphorous**	
3	TOTAL TREATMENT VOLUME (cf)	11,870
4	TOTAL PHOSPHOROUS LOAD REDUCTION REQUIRED (LB/YEAR)	5.00
5		
6	RUNOFF REDUCTION (cf)	2586
7	PHOSPHOROUS LOAD REDUCTION ACHIEVED (LB/YR)	1.62
8		
9	ADJUSTED POST-DEVELOPMENT PHOSPHOROUS LOAD (TP) (lb/yr)	5.83
10		
11	REMAINING PHOSPHOROUS LOAD REDUCTION (LB/YR) NEEDED	3.37
12		
13		
14		
15	**Nitrogen (for information purposes)**	
16	TOTAL TREATMENT VOLUME (cf)	11,870
17		
18		
19	RUNOFF REDUCTION (cf)	2586
20	NITROGEN LOAD REDUCTION ACHIEVED (LB/YR)	11.61
21		
22	ADJUSTED POST-DEVELOPMENT NITROGEN LOAD (TP) (lb/yr)	41.74
23		

RRM: Step 4 – Repeat 2 & 3 until

1	**Site Results**	
2	**Phosphorous**	
3	TOTAL TREATMENT VOLUME (cf)	11,870
4	TOTAL PHOSPHOROUS LOAD REDUCTION REQUIRED (LB/YEAR)	5.00
5		
6	RUNOFF REDUCTION (cf)	8259
7	PHOSPHOROUS LOAD REDUCTION ACHIEVED (LB/YR)	5.58
8		
9	ADJUSTED POST-DEVELOPMENT PHOSPHOROUS LOAD (TP) (lb/yr)	1.88
10		
11	REMAINING PHOSPHOROUS LOAD REDUCTION (LB/YR) NEEDED	
12		
13		
14		
15	**Nitrogen (for information purposes)**	
16	TOTAL TREATMENT VOLUME (cf)	11,870
17		
18		
19	RUNOFF REDUCTION (cf)	8259
20	NITROGEN LOAD REDUCTION ACHIEVED (LB/YR)	40.46
21		
22	ADJUSTED POST-DEVELOPMENT NITROGEN LOAD (TP) (lb/yr)	12.89
23		

CONGRATULATIONS!! YOU EXCEEDED THE TARGET REDUCTION BY 0.6 LB/YEAR!!

- "Congratulations!! You exceeded the target reduction" appears

Module 6c.

BMP Clearinghouse (15 BMPs)

BMP Clearinghouse - vwrrc.vt.edu/swc

- Website serves several key purposes:
  - Design standards and specifications for all Virginia approved BMPs
  - Results of Virginia's process to evaluate and certify the performance claims of manufactured proprietary BMPs
  - Provide information and links to related websites

15 Non-Proprietary BMPs

- Used for complying with the Act and Regulations
- Value reducing runoff volume and maximizing nutrient removal
- Each BMP has a different capacity to reduce runoff volume and remove nutrients

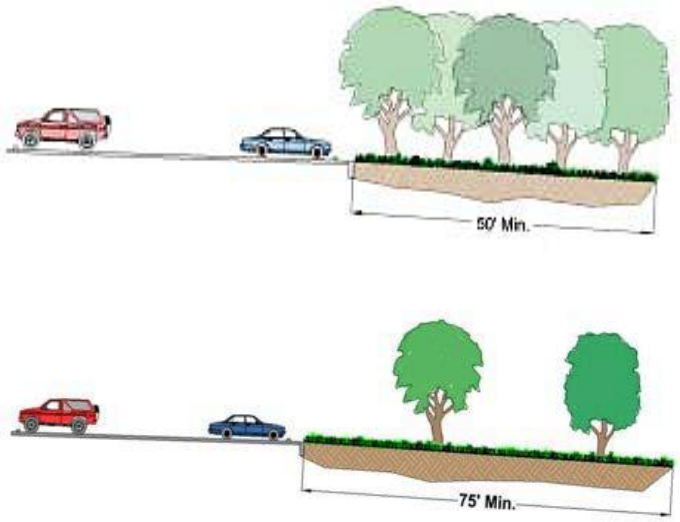
BMP: #1 – Rooftop disconnection

1. Simple disconnection whereby rooftops and/or on-lot residential impervious surfaces are directed to pervious areas
2. Disconnection leading to an alternative runoff reduction practice(s) adjacent to the roof

BMP: #1 – Rooftop disconnection

Benefits	
Removal of TP by Runoff Reduction	**Removal of TP by Treatment**
Yes	No*

BMP: #2 – Sheet flow to vegetated filter strip or conserved open space



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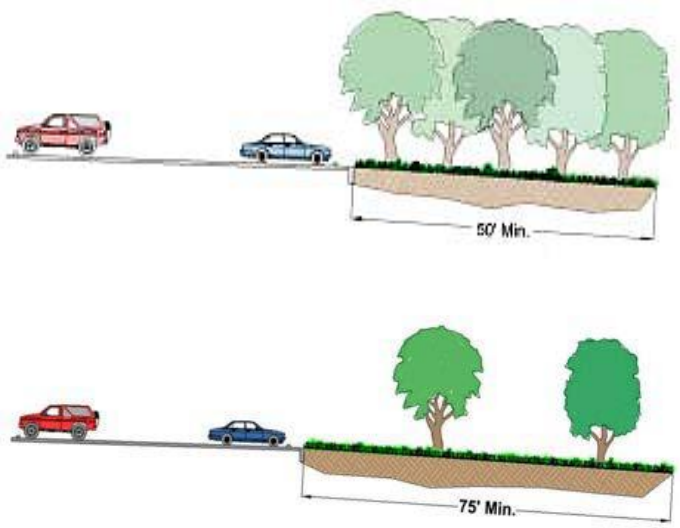
BMP: #2 – Sheet flow to vegetated filter strip or conserved open space



Benefits	
Removal of TP by Runoff Reduction	**Removal of TP by Treatment**
Yes	No

BMP: #3 – Grass channels

- The local street right of way is the prime location to use channels

BMP: #3 – Grass channels

Benefits	
Removal of TP by Runoff Reduction	Yes
Removal of TP by Treatment	Yes

BMP: #4 – Soil compost amendments

- Construction site soils can be compacted to a bulk density similar to concrete
- Compacted or poorly-drained soils on a site can be improved by incorporating organic material such as compost

BMP: #4 – Soil compost amendments

Benefits

Used to enhance performance of soils to allow for infiltration

BMP: #5 – Vegetated roofs

Benefits	
Removal of TP by Runoff Reduction	Yes
Removal of TP by Treatment	No

BMP: #6 – Rainwater harvesting

- Rainwater is collected and conveyed for non potable uses
  - Toilet flushing
  - Landscape irrigation
  - Exterior washing

BMP: #6 – Rainwater harvesting

Benefits	
Removal of TP by Runoff Reduction	Yes
Removal of TP by Treatment	No

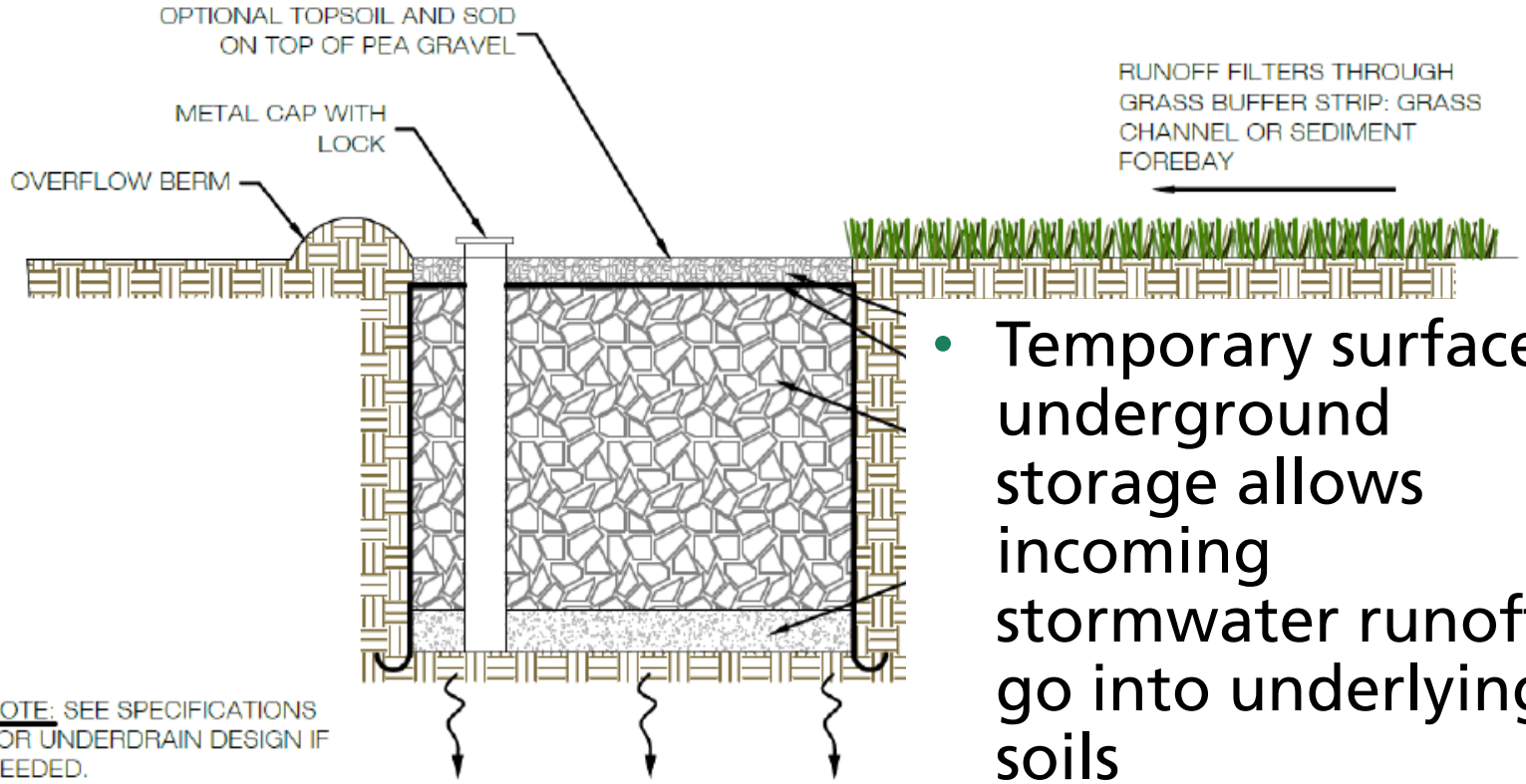
BMP: #7 – Permeable pavement

- Allow rainfall to flow through the surface or surrounding spaces into the stone reservoir below

BMP: #7 – Permeable Pavement

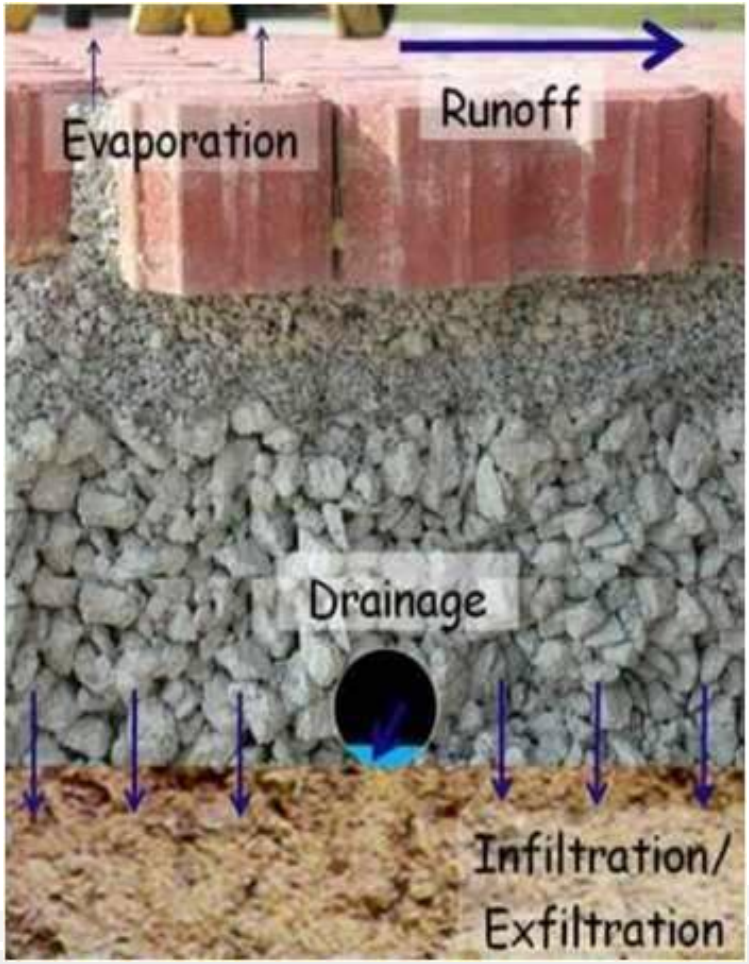
Benefits	
Removal of TP by Runoff Reduction	Yes
Removal of TP by Treatment	Yes

BMP: #8 - Infiltration



- Temporary surface or underground storage allows incoming stormwater runoff to go into underlying soils

BMP: #8 - Infiltration



Benefits	
Removal of TP by Runoff Reduction	Yes
Removal of TP by Treatment	Yes

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BMP: #9 – Bioretention basins

- Surface runoff is directed into a shallow landscaped depression that incorporates many of the pollutant removal mechanisms that operate in forested ecosystems

BMP: #9 – Bioretention basins

Benefits	
Removal of TP by Runoff Reduction	Yes
Removal of TP by Treatment	Yes

BMP: #10 – Dry swales

- Soil filter system that temporarily stores and then filters the desired treatment volume (Tv)

BMP: #10 – Dry swales

Benefits	
Removal of TP by Runoff Reduction	Yes
Removal of TP by Treatment	Yes

BMP: # 11 – Wet swales

- Cross between a wetland and a swale
- Intercept shallow groundwater to maintain a wetland plant community

BMP: # 11 – Wet swales

Benefits	
Removal of TP by Runoff Reduction	No
Removal of TP by Treatment	Yes

BMP: # 12 – Filtering practices

- Useful for treating stormwater runoff from small, highly impervious sites

BMP: # 12 – Filtering practices

Benefits	
Removal of TP by Runoff Reduction	No
Removal of TP by Treatment	Yes

BMP: #13 – Constructed wetlands

- Runoff from each storm displaces runoff from previous storms
- Long residence time allows multiple pollutant processes to occur

BMP: #13 – Constructed wetlands

Benefits	
Removal of TP by Runoff Reduction	No
Removal of TP by Treatment	Yes

BMP: #14 – Wet ponds

- Consist of a permanent pool of standing water that promotes a better environment for gravitational settling, biological uptake, and microbial activity

BMP: #14 – Wet ponds

Benefits	
Removal of TP by Runoff Reduction	No
Removal of TP by Treatment	Yes

BMP: # 15 – Extended detention pond

- Relies on 12 to 24 hour detention of stormwater runoff after each rain event

BMP: # 15 – Extended detention pond

Benefits	
Removal of TP by Runoff Reduction	Level 1: No Level 2: Yes
Removal of TP by Treatment	Yes for both levels