DEQ Certification Class Presentations

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August 2024

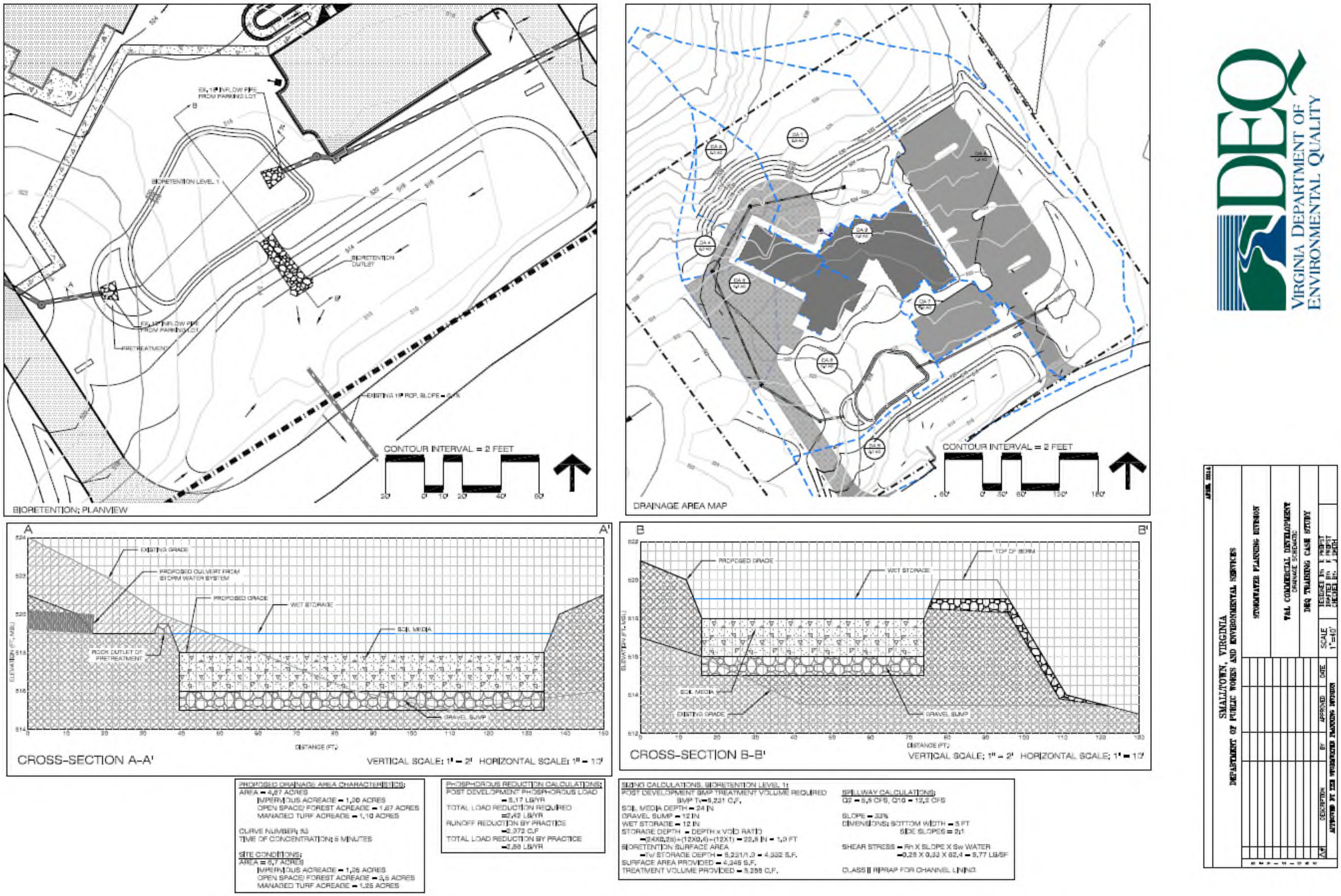
Virginia Department of Environmental Quality

Exercise 3

BMP Review

Virginia Department of Environmental Quality

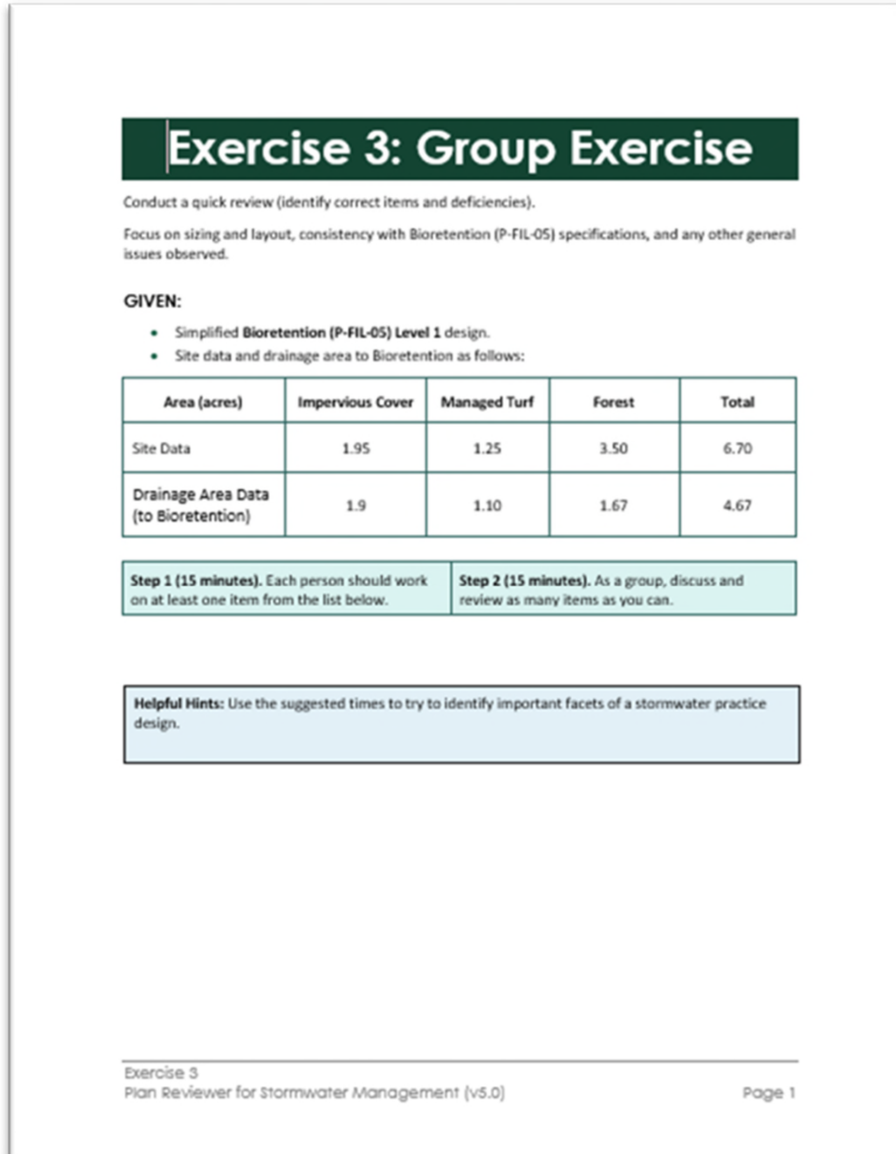
Bioretention Design to Review



Exercise 3 Materials

In your participant guide:

- Exercise 3 Instructions
  – Use this sheet to jot down your results and notes



Exercise 3: Group Exercise

Conduct a quick review (identify correct items and deficiencies).

Focus on sizing and layout, consistency with Bioretention (P-FIL-05) specifications, and any other general issues observed.

GIVEN:

- Simplified **Bioretention (P-FIL-05) Level 1** design.
- Site data and drainage area to Bioretention as follows:

Area (acres)	Impervious Cover	Managed Turf	Forest	Total
Site Data	1.95	1.25	3.50	6.70
Drainage Area Data (to Bioretention)	1.9	1.10	1.67	4.67

Step 1 (15 minutes). Each person should work on at least one item from the list below.	**Step 2 (15 minutes).** As a group, discuss and review as many items as you can.

Helpful Hints: Use the suggested times to try to identify important facets of a stormwater practice design.

Exercise 3
Plan Reviewer for Stormwater Management (v5.0) Page 1

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Exercise 3 Materials

In your participant guide:

- Bioretention BMP checklist
  - Appendix III

APPENDIX III

Example Design/Review Checklist
Bioretention Practices

Plan Submission Date__________________
Project Name____
Site Plan/Permit Number____
Practice No./Location on Site____
Owner______________________________ Phone Number______________
BMP Designer______________________________ Phone Number______________
General Contractor______________________________ Phone Number______________

______ **Signature and stamp of licensed professional design consultant and owner certification**

Plan Status
______ Approved
______ Not Approved

Legend:
✓ - Complete
Inc. - Incomplete/Incorrect
N/A - Not Applicable

Facility Type: Level 1 ______________________ Level 2 ______________________

Hydraulic Configuration:
- ☐ On-line facility
- ☐ Off-line facility

Type of Pre-Treatment Facility:
- ☐ Sedimentation chamber
- ☐ Plunge pool
- ☐ Stone diaphragm
- ☐ Grass filter strip
- ☐ Grass channel
- ☐ Other: ____________

I. SUPPORTING INFORMATION

______ Provide a concise narrative describing the stormwater management strategy, describing how this practice fits into the overall plan, and stating all assumptions made in the design.
______ Show the location of this BMP on the site map, including the following:
  _____ Facility area
  _____ Contributing drainage area (CDA) boundaries and acreage.
  _____ Embankment area
  _____ Delineation of FEMA 100-year floodplain (bioretention should be constructed *outside* the limits of the floodplain).
  _____ Areas of site compensated for in water quality calculations
______ If the Bioretention facility will receive runoff from a hotspot land use, then an underdrain must be used.
______ Bioretention facilities must not be located where they will receive regular dry weather flows or flow from sources such as sump pumps, irrigation water, chlorinated wash-water or swimming pool discharge, or other flows that are not stormwater runoff.
______ Provide topography for the site area, showing that the slope of the CDA is between 1% and 5%.
______ Provide a soil map for site and area of facility, showing CDA and facility boundaries
______ Show the soil boring locations and provide the soil boring logs with Unified Soils Classifications and descriptions (at least one boring must be taken to confirm the underlying soil properties *at the depth where biofiltration or bioinfiltration is designed to occur*, to ensure that depth to the groundwater table/bedrock or karst is identified). HSG-B, C or D soils typically require an underdrain, whereas HSG-A soils generally do not.

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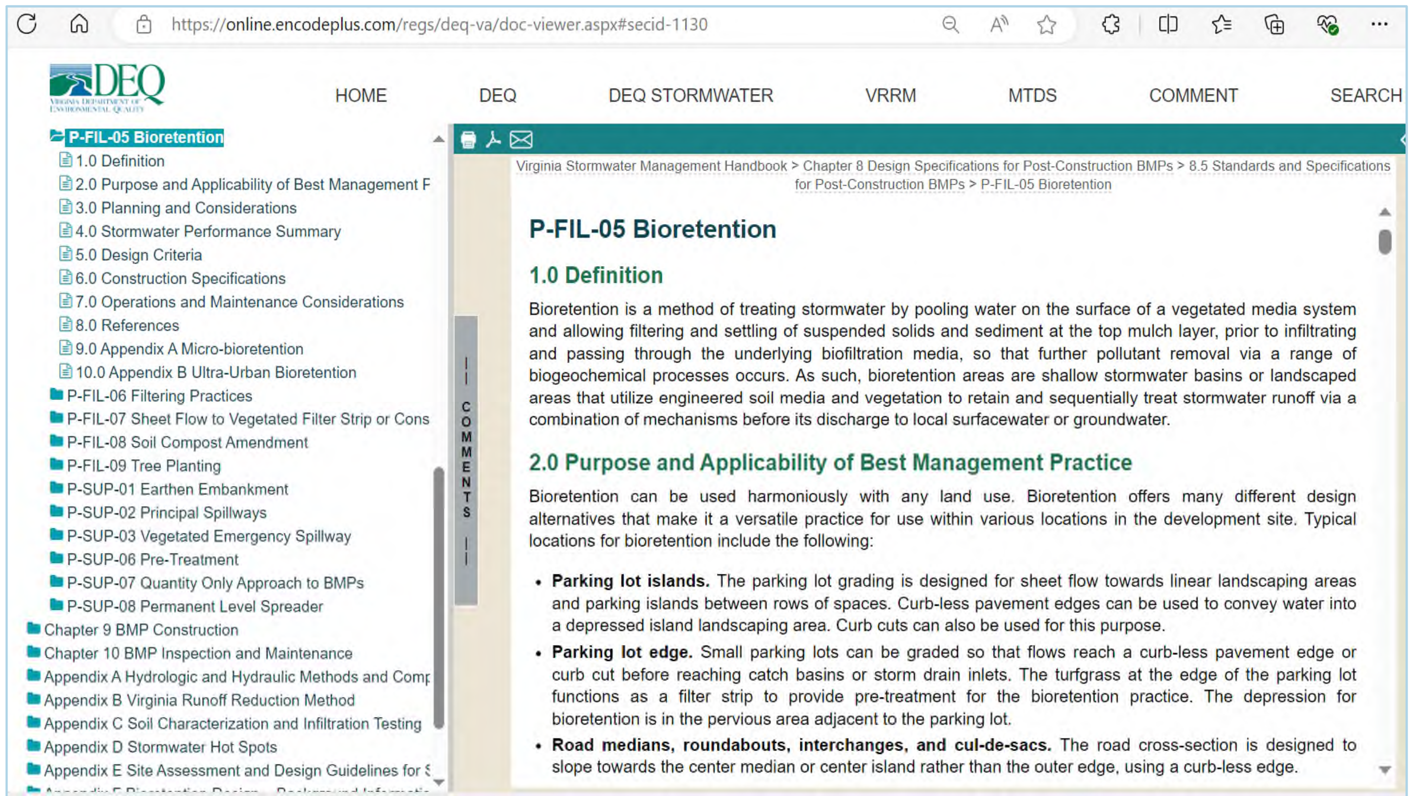
Exercise 3 Materials

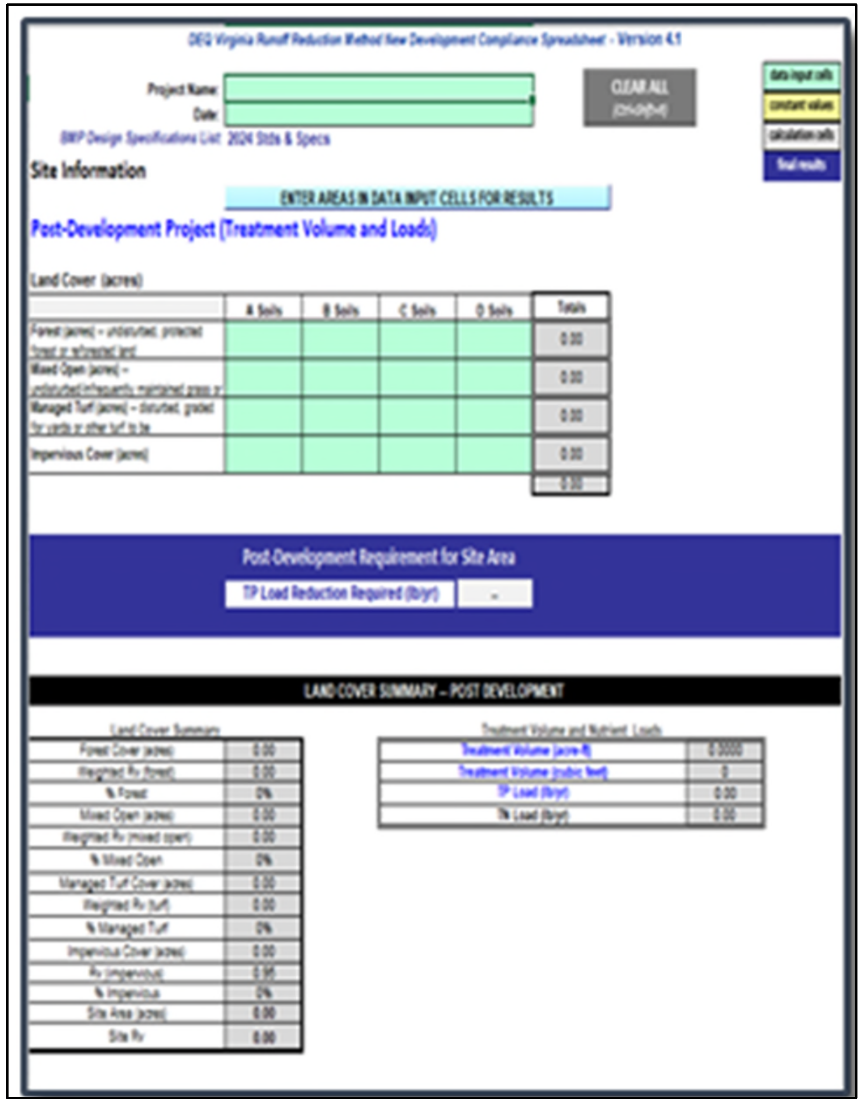
P-FIL-05 Bioretention Specification (and others as applicable)

- VSMHB



Exercise 3 Materials

Virginia Runoff Reduction Method (VRRM) 4.1 New Development Spreadsheet



Exercise 3
BMP Review

Site Information:

- Project area = 6.7 acres
- All “C” soils
- Treatment by a **single Bioretention (P-FIL-05) Level 1 facility**

Determine:

- ❑ If the facility is designed properly

Land Use and Drainage Information:

Area (acres)	Impervious	Managed Turf	Forest	Total
Site Data	1.95	1.25	3.50	6.70
Drainage Area Data (to Bioretention)	1.9	1.10	1.67	4.67

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Exercise 3 BMP Review

Main review areas:

Design for Level 1

(Soil testing, underdrains, contributing drainage area)

Surface area sizing

(VRRM spreadsheet needed)

Soil media, maximum ponding and side slopes

Inlets and flow path

Spillway and outlets

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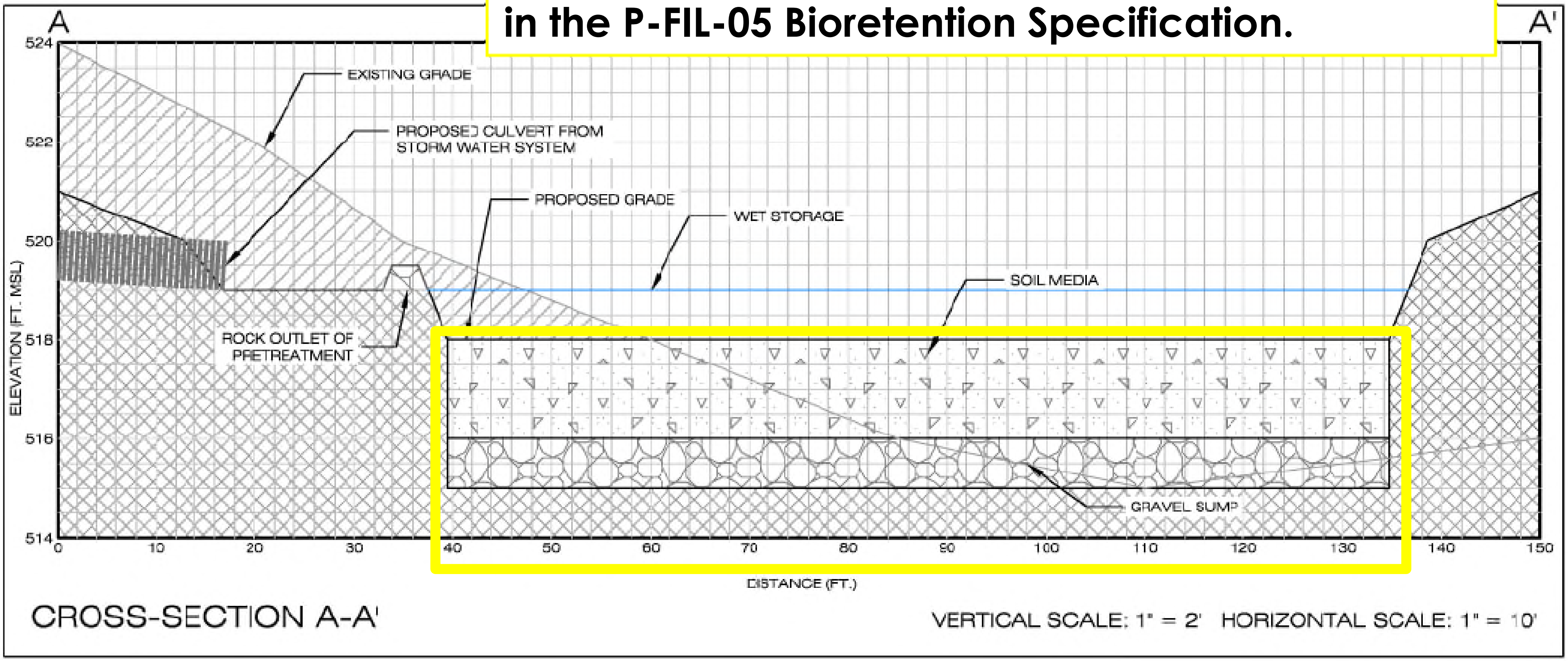
Evaluate:
Design for Level 1

Evaluate: Design for Level 1

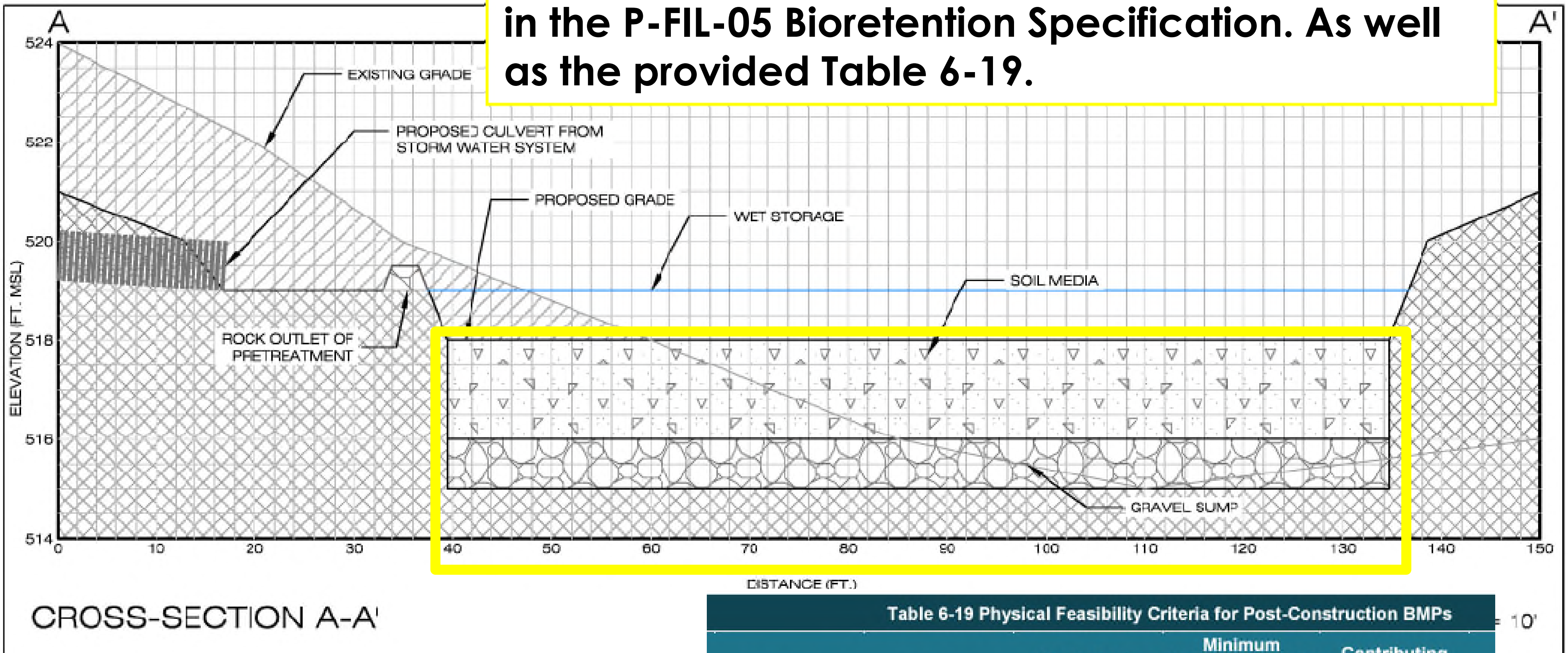
Hint: Look at the design criteria (Table P-FIL-05-3) in the P-FIL-05 Bioretention Specification.



- Subsoil testing
- Underdrain requirements
- Contributing drainage area

Evaluate: Design for Level 1

Hint: Look at the design criteria (Table P-FIL-05-3) in the P-FIL-05 Bioretention Specification. As well as the provided Table 6-19.



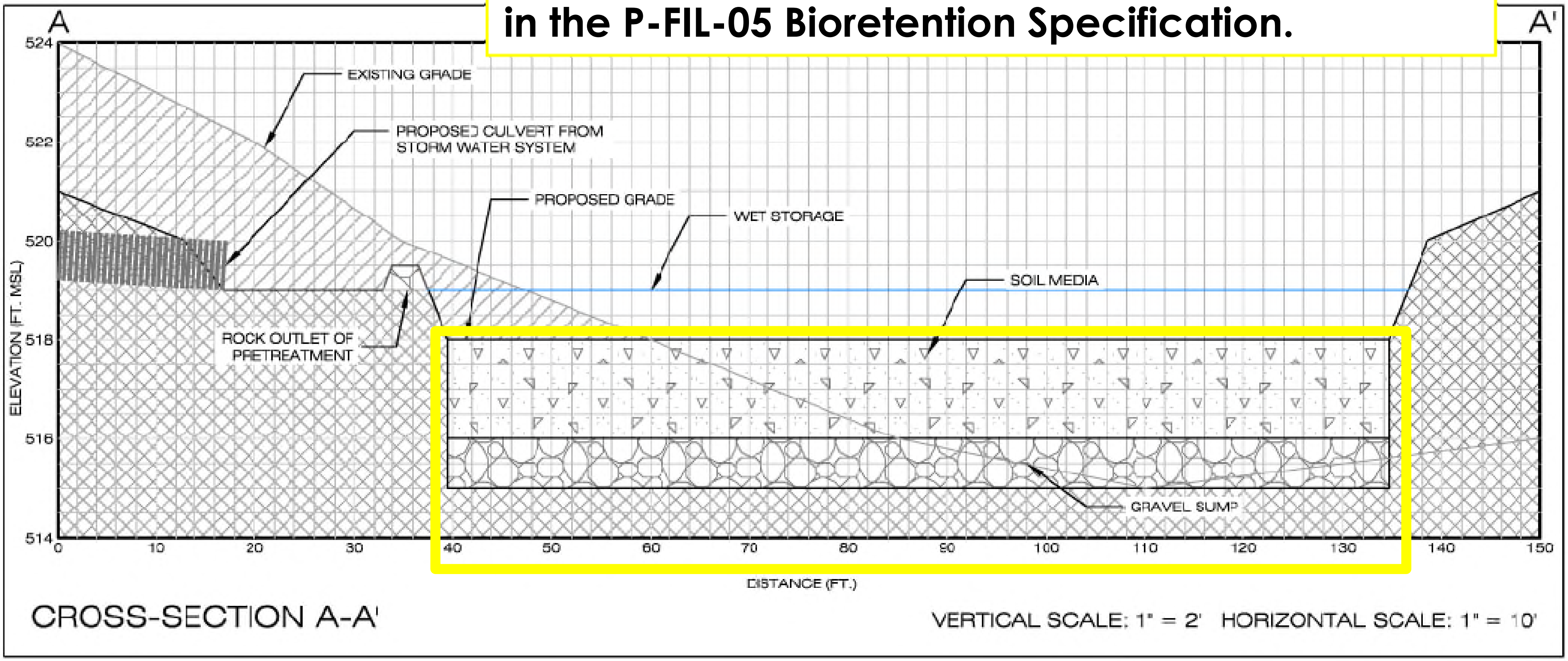
Any concerns?

Table 6-19 Physical Feasibility Criteria for Post-Construction BMPs

Specific BMP	Soils1	Water Table Separation (feet)	Minimum Depth to Bedrock/ Shallow Soils (feet)	Contributing Drainage Area (acres)	L Si
Tree Planting	All soils ok. Recommend using compost amendments for C-D for greater RR	5	5	NA	
Bioretention Level 1 (with underdrain)	See P-FIL-05	2	2	5 maximum; 0.5 to 2 recommended	
Bioretention Level 2 (without underdrain)	See P-FIL-05	3	2	5 maximum; 0.5 to 2 recommended	

Evaluate: Design for Level 1

Hint: Look at the design criteria (Table P-FIL-05-3) in the P-FIL-05 Bioretention Specification.



Level 1 but...

No underdrain

No soil testing

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

P-FIL-05 Bioretention specification

(Table P-FIL-05-3)

Subsoil testing

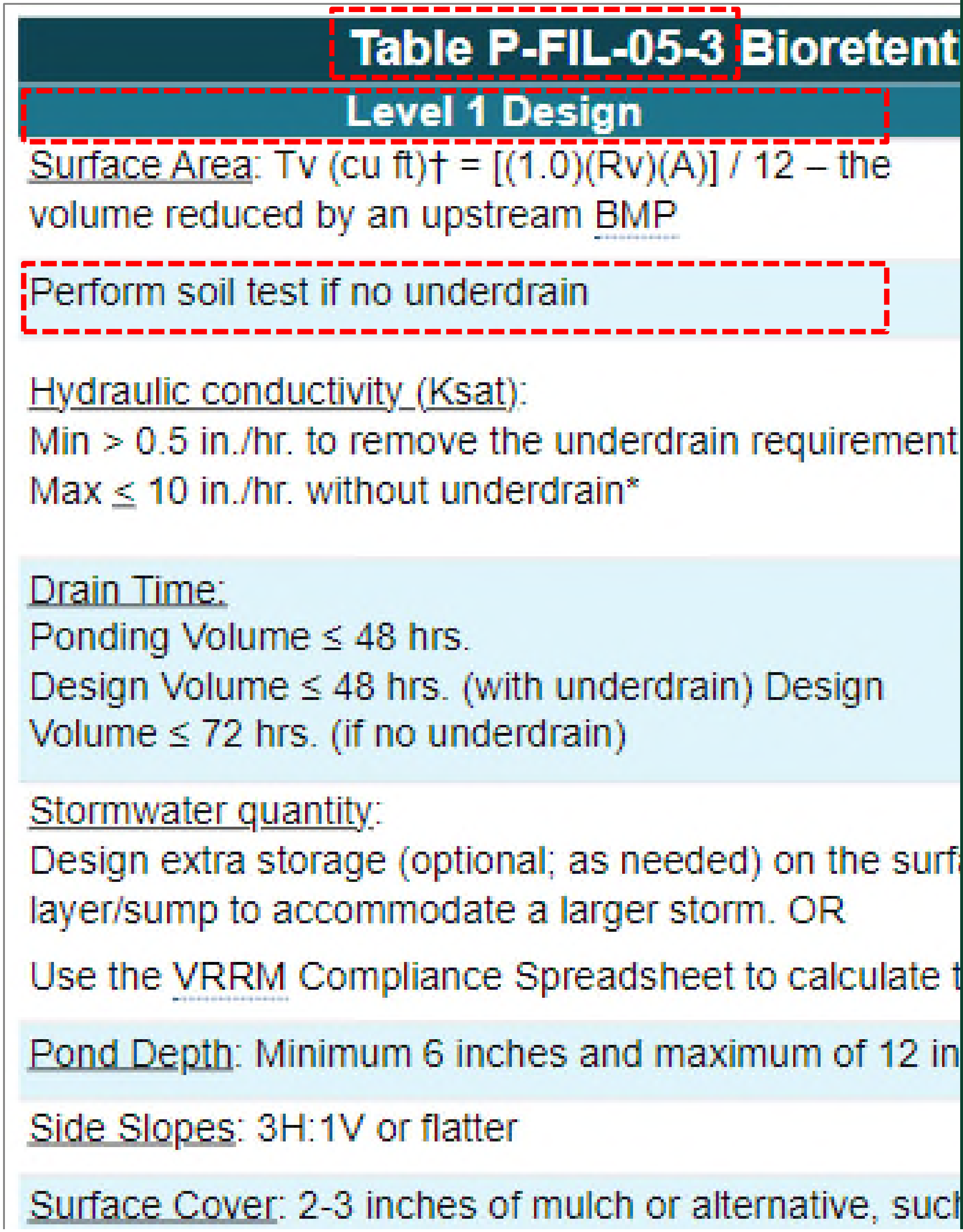
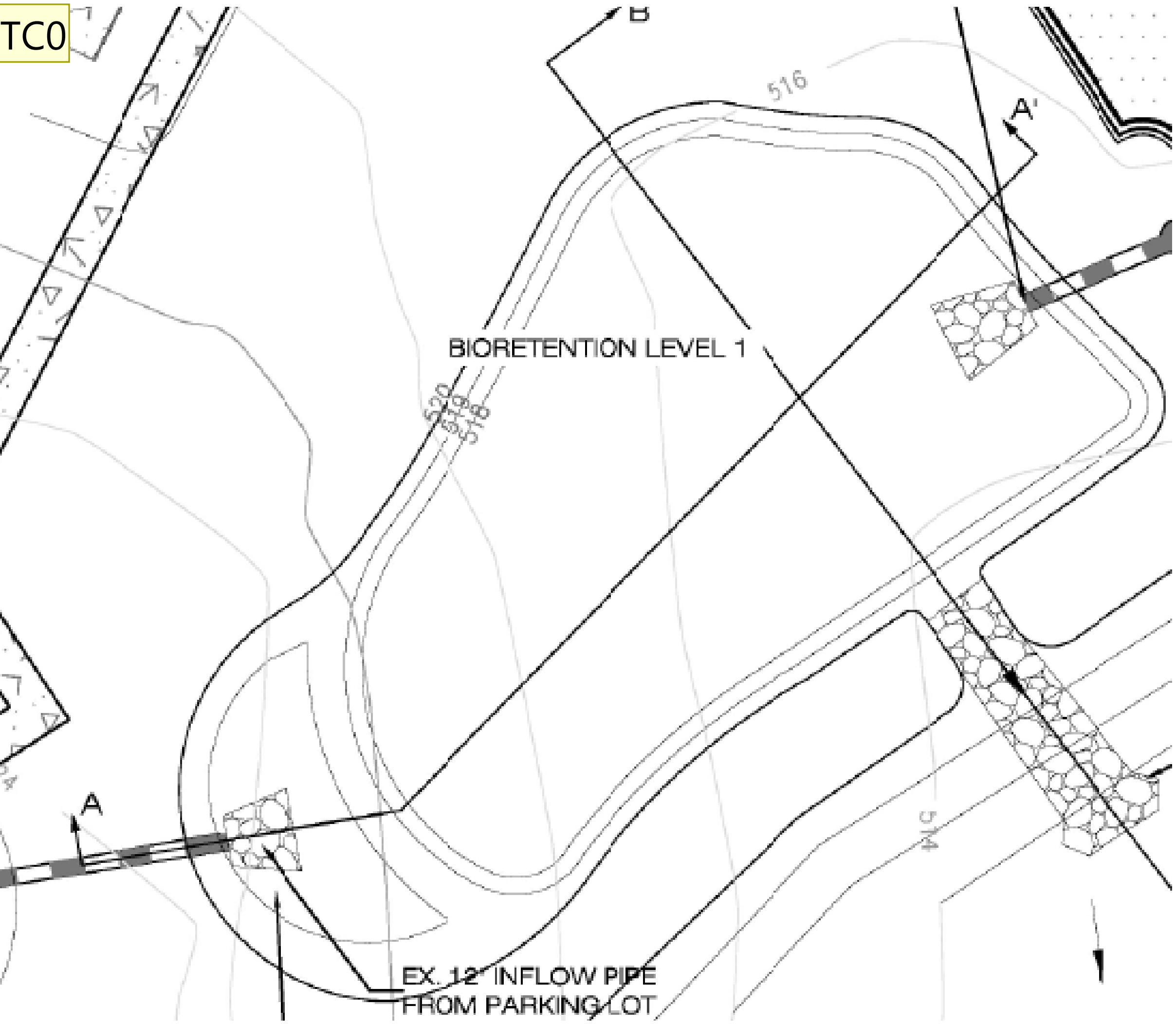


Table P-FIL-05-3 Bioretent
Level 1 Design
Surface Area: Tv (cu ft)† = [(1.0)(Rv)(A)] / 12 – the volume reduced by an upstream BMP
Perform soil test if no underdrain
Hydraulic conductivity (Ksat): Min > 0.5 in./hr. to remove the underdrain requirement Max ≤ 10 in./hr. without underdrain*
Drain Time: Ponding Volume ≤ 48 hrs. Design Volume ≤ 48 hrs. (with underdrain) Design Volume ≤ 72 hrs. (if no underdrain)
Stormwater quantity: Design extra storage (optional; as needed) on the surf layer/sump to accommodate a larger storm. OR Use the VRRM Compliance Spreadsheet to calculate t
Pond Depth: Minimum 6 inches and maximum of 12 in
Side Slopes: 3H:1V or flatter
Surface Cover: 2-3 inches of mulch or alternative, such

Evaluate:

Surface Area Sizing



Evaluate: Surface Area Sizing

- See Table P-FIL-05-03 and Section 5.1.2
- Use VRRM 4.1 New Development spreadsheet to verify volume

Any issues?

SIZING CALCULATIONS, BIORETENTION LEVEL 1:

POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED
BMP Tv=8,231 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 = 8,231/1.9 = 4,332 S.F.

SURFACE AREA PROVIDED = 4,345 S.F.

TREATMENT VOLUME PROVIDED = 8,255 C.F.

SPILLWAY CALCULATIONS:

Q2 = 5.8 CFS, Q10 = 12.2 CFS

SLOPE = 33%

DIMENSIONS: BOTTOM WIDTH = 8 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

Slide 16

TC0 Note to DEQ: Revise if the sizing calculation is no longer in the PG (Module 6)
Tamira Cohen, 2024-08-20T02:29:21.854

Bioretention spec P-FIL-05

Sizing (surface area)

Table P-FIL-05-03 and see section 5.1

Table P-FIL-05-3 Bioretention Design Primary Criteria

Level 1 Design	Level 2 Design
Surface Area: Tv (cu ft)† = [(1.0)(Rv)(A)] / 12 – the volume reduced by an upstream BMP	Surface Area: Tv (cu ft)† = [1.25(Rv)(A)] / 12 – the volume reduced by an upstream BMP
Perform soil test if no underdrain	Soil Test must be performed
Hydraulic conductivity (Ksat): Min > 0.5 in./hr. to remove the underdrain requirement Max ≤ 10 in./hr. without underdrain*	Hydraulic Conductivity (Ksat): Min > 0.25 in./hr. Min > 0.5 in./hr. to remove the underdrain requireme Max ≤ 10 in./hr.*
Drain Time: Ponding Volume ≤ 48 hrs. Design Volume ≤ 48 hrs. (with underdrain) Design Volume ≤ 72 hrs. (if no underdrain)	Drain Time: Ponding Volume ≤ 48 hrs. Design Volume ≤ 72 hrs.
Stormwater quantity: Design extra storage (optional; as needed) on the surface, in the engineered soil matrix, and in the gravel layer/sump to accommodate a larger storm. OR Use the VRRM Compliance Spreadsheet to calculate the Curve Number (CN) Adjustment	
Pond Depth: Minimum 6 inches and maximum of 12 inches‡	
Side Slopes: 3H:1V or flatter	
Surface Cover: 2-3 inches of mulch or alternative, such as managed approved vegetation	
Planting Plan: A planting template to include turfgrass, herbaceous vegetation, shrubs, and/or trees to cover at least 75% of surface area in 2 years.	Planting Plan: A planting template to include turfgrass herbaceous vegetation, shrubs, and/or trees to cover at least 90% of surface area in 2 years. Turfgrass must be combined with shrubs and/or trees.
Filter Media Depth: Min: 24 inches Max: 48 inches§ Min: 36 inches rooting depth for trees**	Filter Media Depth: Min: 36 inches Max: 48 inches§ Min: 36 inches rooting depth for trees**
Filter Media: Supplied and certified by vendor per criteria provided in Appendix F.	
Gravel Layer: Min choker stone layer: 3 in. Min gravel layer with no underdrain: 0 in. Min gravel layer with underdrain: 9 in. Max gravel layer: 12 in.§	Gravel Layer: Min choker stone layer: 3 in. Min sump depth with underdrain: 9 in. Max sump depth: 12 in.§
Underdrain: Schedule 40 PVC or equivalent with clean-outs. Use slotted pipe under the filter bed and closed pipe elsewhere.	

5.1.2 Surface Area Sizing

Surface Area Sizing for Stormwater Quality. Proper sizing of the surface area is important for bioretention for three main reasons:

1. The first is to ensure that the surface area size is not too small to accommodate the expected design volume of flow. If the practice is too small, a portion of the treatment volume will bypass the practice. As an example, runoff volume bypass could occur at 0.7 inches of rainfall or greater depending on rainfall intensity. Local topography and the hydraulic conductivity (K_{sat}) of the soil media or native soil, whichever is the limiting K_{sat} value.
2. The second reason is to confirm that the design storage volume passes through and exfiltrates from the practice within specified drain times. Drain times aim to ensure storage is available within the practice between storm events and to prevent the soil media from being saturated for an extended period.
3. The third reason involves the land use designation within the VRRM spreadsheet. Provided the bioretention practice is designed and maintained as directed in this specification, the surface area is counted as forest and mixed open space in the VRRM spreadsheet (DEQ VRRM User Guide).

The surface area size for any practice will be based on the comparison of two equations. One equation is based on the volumetric requirements of the practice (Volumetric method) and the other is based on the interaction of the practice with its surrounding soil environment (Flow-rate method). Both equations require knowing Tv_{BMP}, which is the treatment volume based on the runoff generated from the 1-inch storm event, and includes runoff from impervious surfaces and managed turf within the contributing drainage area to the BMP plus any remaining runoff volume from upstream runoff reduction practices. Any forest or mixed open space areas included within the contributing drainage area are not part of the Tv_{BMP}. The Tv_{BMP} for Level 1 designs can be obtained from the VRRM spreadsheet. For Level 2 designs, use Equation P-FIL-05-1 to calculate the *TvBMP* :

Bioretention spec P-FIL-05

Table P-FIL-05-03

- Sizing (surface area)
- Also, see section 5.1

Table P-FIL-05-3 Bioretention Design Primary Criteria

Level 1 Design	Level 2 Design
Surface Area: Tv (cu ft)† = [(1.0)(Rv)(A)] / 12 – the volume reduced by an upstream BMP	Surface Area: Tv (cu ft)† = [1.25(Rv)(A)] / 12 – the volume reduced by an upstream BMP
Perform soil test if no underdrain	Soil Test must be performed
Hydraulic conductivity (Ksat): Min > 0.5 in./hr. to remove the underdrain requirement Max ≤ 10 in./hr. without underdrain*	Hydraulic Conductivity (Ksat): Min > 0.25 in./hr. Min > 0.5 in./hr. to remove the underdrain requireme Max ≤ 10 in./hr.*
Drain Time: Ponding Volume ≤ 48 hrs.	Drain Time: Ponding Volume ≤ 48 hrs. Design Volume ≤ 72 hrs.

Eqn. P-FIL-05-1: Treatment Volume Calculation

Tv_{BMP} = (C_{level} x R_V x A) ÷ 12) – the volume reduced by an upstream P-BMP

C_{level} = factor set to 1 inch (for Level 1 designs) or 1.25 inches (for Level 2 designs)

R_V = composite volumetric runoff coefficient from VRRM DA Tab

A = drainage area to BMP (square feet)

5.1 BMP Sizing

To function as designed, a bioretention practice must be sized based on the design criteria in Table P-FIL-02-3. An example of initial sizing calculations is given in Appendix F. The final footprint of the bioretention practice will consist of the pretreatment area and the surface ponding area. The size of the practice is determined by the design level (Level 1 or 2), which will depend on the amount of P to be removed, the hydraulic conductivity (K_{sat}) of the underlying native soils, and whether an underdrain can be daylighted. The size of the practice could also be influenced by storage added to meet water quantity requirements. This section provides the means to properly size a bioretention practice to capture the BMP design treatment volume (T_{vBMP}) and any additional volume to help manage water quantity.

Bioretention spec P-FIL-05
Table P-FIL-05-03 and section 5.1 Sizing (surface area)

Eqn. P-FIL-05-2: Volumetric Approach

Surface Area (sq. ft.) = Tv_{BMP} /ESD

ESD = equivalent storage depth (in feet) representing all the void spaces available for water storage within the surface ponding area, soil media, and gravel layer (if used)

5.1.1 Component Depths

The various layers of the bioretention practice are referred to as components. A bioretention practice must contain a ponding area and soil filter media. A gravel layer can also be added, and designers can choose from different options for the gravel layer. The gravel layer is called a "sump" for Level 2 designs because the underdrain is located at the top of the gravel. Each component has established minimum and maximum depths (Table P-FIL-02-3). The depths of the selected components are used in the computation for the surface area of the practice.

Bioretention spec P-FIL-05
Table P-FIL-05-03 and section 5.1
Sizing (surface area)

Eqn. P-FIL-05-2: Volumetric Approach

Surface Area (sq. ft.) = Tv_{BMP}/ESD

ESD = equivalent storage depth (in feet) representing all the void spaces available for water storage within the surface ponding area, soil media, and gravel layer (if used)

$$ESD\ (\text{ft.}) = (d_{ponding} \times \eta_{ponding}) + (d_{media} \times \eta_{media}) + (d_{gravel} \times \eta_{gravel})$$

d = depth of respective layer (ponding, media, or gravel in feet)

η = available porosity of respective layer (ponding, media or gravel; Table P-FIL-05-04

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Bioretention spec P-FIL-05
Table P-FIL-05-04 and section 5.1
Porosity for Bioretention Components

$$ESD\ (\text{ft.}) = (d_{ponding} \times \eta_{ponding}) + (d_{media} \times \eta_{media}) + (d_{gravel} \times \eta_{gravel})$$

d = depth of respective layer (ponding, media, or gravel in feet)

η = available porosity of respective layer (ponding, media or gravel; Table P-FIL-05-04

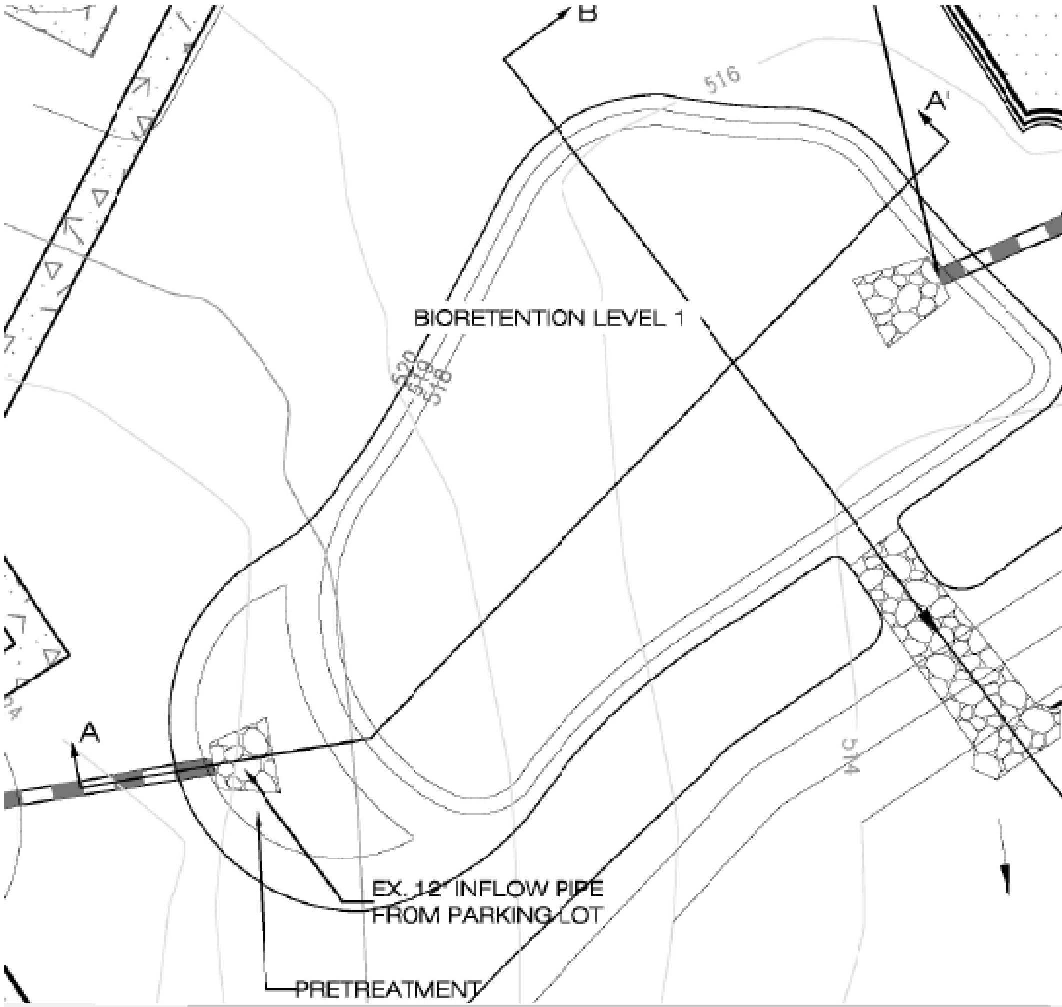
Table P-FIL-05-4 Estimated Porosity for Each Bioretention Component	
Bioretention Component	**Available Porosity (η)**
Ponding Area	1.0
Soil Media	0.25 *
Gravel Layer	0.40

Note:

*Estimated value assuming full media dry-down.

Surface Area Sizing

Bioretention L1



ESD = depth x available porosity

Ponding area η = 1.0

Soil media η = 0.25

Gravel η = 0.40

(2 ft x 0.25) + (1 ft x 0.40) + (1 ft x 1.0) = 1.90 ft

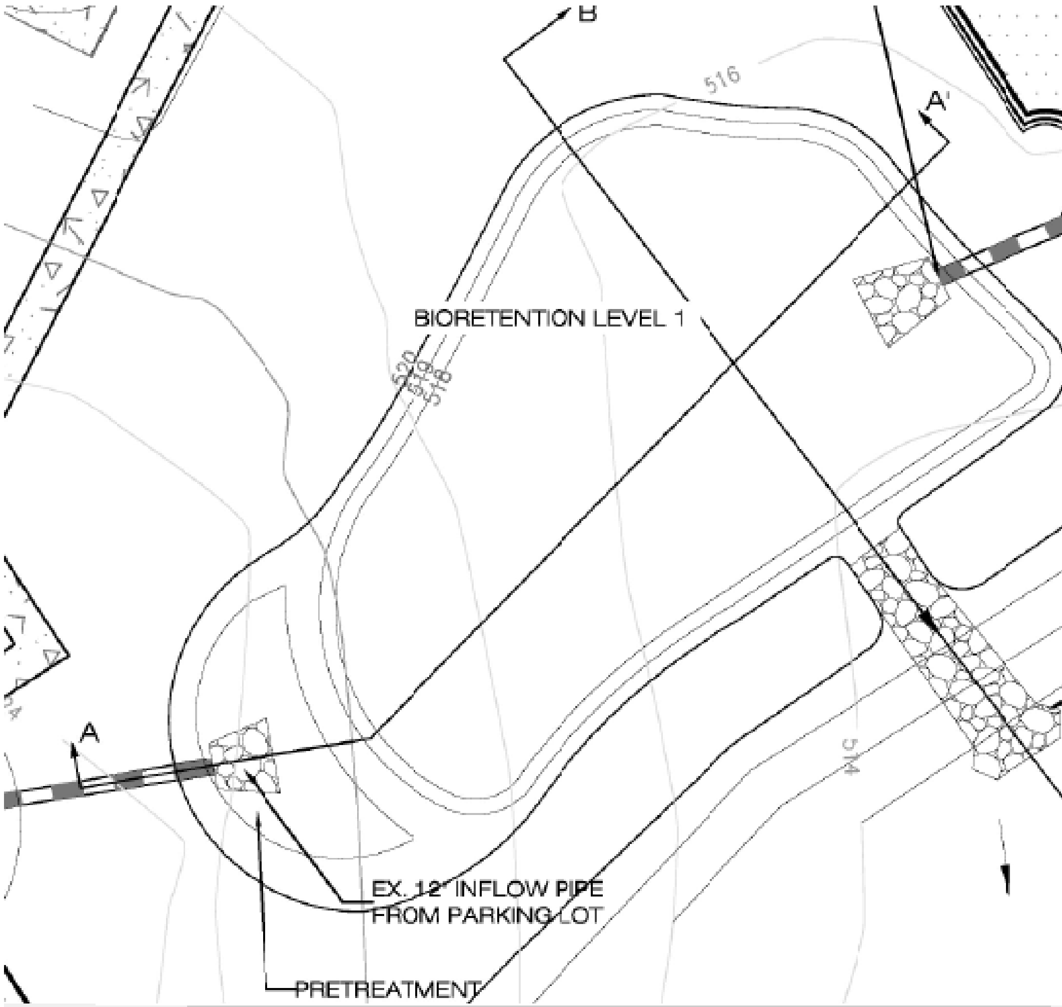
SIZING CALCULATIONS, BIORETENTION LEVEL 1:
POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED
BMP Tv=8,231 C.F.
SOIL MEDIA DEPTH = 24 IN
GRAVEL SUMP = 12 IN
WET STORAGE = 12 IN
STORAGE DEPTH = DEPTH x VOID RATIO
=(24X0.25)+(12X0.4)+(12X1) = 22.8 IN = 1.9 FT
BIORETENTION SURFACE AREA
=Tv/ STORAGE DEPTH = 8,231/1.9 = 4,332 S.F.
SURFACE AREA PROVIDED = 4,345 S.F.
TREATMENT VOLUME PROVIDED = 8,255 C.F.

SPILLWAY CALCULATIONS:
Q2 = 5.8 CFS, Q10 = 12.2 CFS

SLOPE = 33%
DIMENSIONS: BOTTOM WIDTH = 8 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



Surface Area Sizing

Bioretention L1

Surface area (SA) = Tv_{BMP}/ ESD

Tv_{BMP} of 8,231 cubic ft

- Based on entire site
- Includes Forest areas

SIZING CALCULATIONS, BIORETENTION LEVEL 1:
POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED
BMP Tv=8,231 C.F.
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CLASS II RIPRAP FOR CHANNEL LINING

Bioretention spec P-FIL-05
VRRM 4.1 (Drainage Area Tab)

Drainage Area A

Drainage Area A Land Cover (acres)

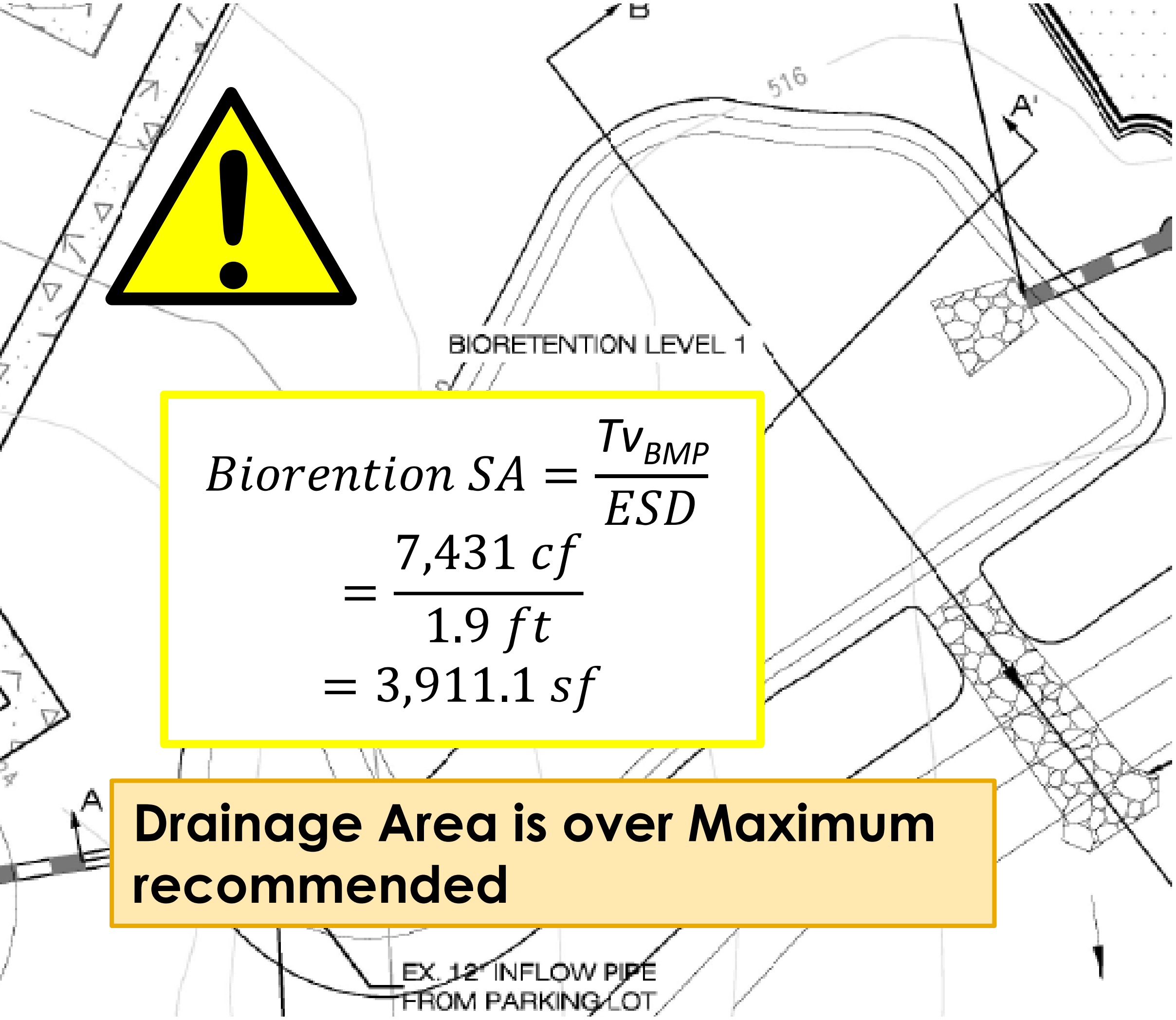
	A Soils	B Soils	C Soils	D Soils	Totals	Land Cover Rv	Composite Loading P
Forest (acres)			1.67		1.67	0.04	0.08
Mixed Open (acres)					0.00	0.00	0.00
Managed Turf (acres)			1.10		1.10	0.22	0.75
Impervious Cover (acres)			1.90		1.90	0.95	0.86
				Total	4.67		

Stormwater Best Management Practices (RR = Runoff Reduction)

Practice	Runoff Reduction Credit (%)	Mixed Open Credit Area (acres)	Managed Turf Credit Area (acres)	Impervious Cover Credit Area (acres)	Volume from Upstream Practice (ft^3)	Runoff Reduction (ft^3)	Remaining Runoff Volume (ft^3)	Total BMP Treatment Volume (ft^3)
6. Bioretention (RR)								
6.a. Bioretention #1 or Micro-Bioretention #1 or Urban Bioretention (P-FIL-05)	40		1.10	1.90	0	2,972	4,458	7,431
6.b. Bioretention #2 or Micro-Bioretention #2 (P-FIL-05)	80				0	0	0	0

Surface Area Sizing

- Should use Tv_{BMP} from DA tab
- Oversized?
- But designed for up to 10-year storm discharge



$$Biorention\ SA = \frac{Tv_{BMP}}{ESD}$$
$$= \frac{7{,}431\ cf}{1.9\ ft}$$
$$= 3{,}911.1\ sf$$

Drainage Area is over Maximum recommended

SIZING CALCULATIONS, BIORETENTION LEVEL 1:
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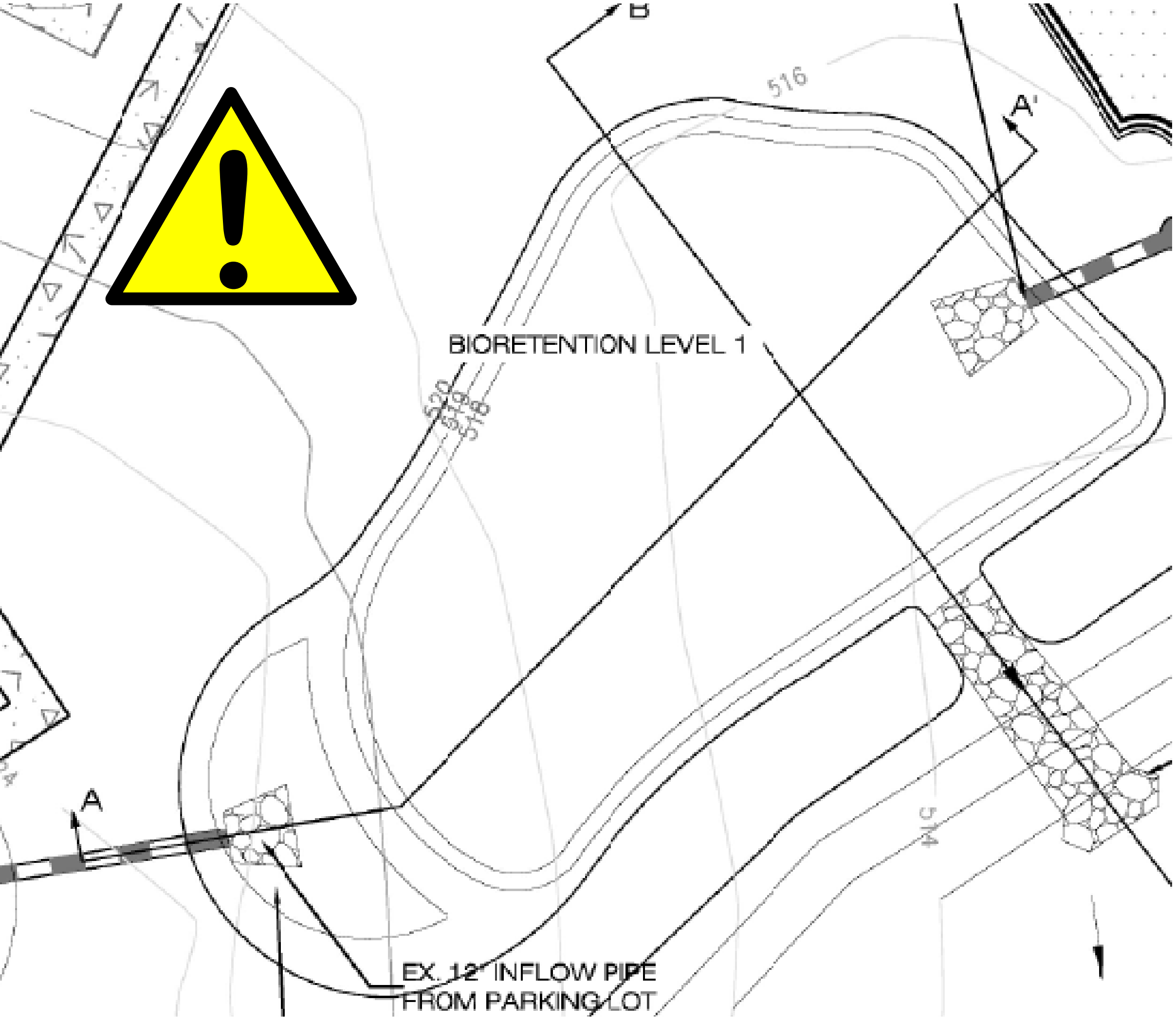
CLASS II RIPRAP FOR CHANNEL LINING



Surface Area Sizing

- Drain times through practice components not provided
- Additional considerations….

<u>SIZING CALCULATIONS, BIORETENTION LEVEL 1:</u>
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CLASS II RIPRAP FOR CHANNEL LINING

P-FIL-05 Bioretention

(Table P-FIL-05-3)

- Ksat?
- Drain time verification?
- Ponding volume must drain in 48 hrs or less
- Design volume must drain in 72 hrs or less with no underdrain

Table P-FIL-05-3 Bioretent
Level 1 Design
Surface Area: Tv (cu ft)† = [(1.0)(Rv)(A)] / 12 – the volume reduced by an upstream BMP
Perform soil test if no underdrain
Hydraulic conductivity (Ksat): Min > 0.5 in./hr. to remove the underdrain requirement Max ≤ 10 in./hr. without underdrain*
Drain Time: Ponding Volume ≤ 48 hrs. Design Volume ≤ 48 hrs. (with underdrain) Design Volume ≤ 72 hrs. (if no underdrain)
Stormwater quantity: Design extra storage (optional; as needed) on the surf layer/sump to accommodate a larger storm. OR Use the VRRM Compliance Spreadsheet to calculate t
Pond Depth: Minimum 6 inches and maximum of 12 in
Side Slopes: 3H:1V or flatter
Surface Cover: 2-3 inches of mulch or alternative, such

Bioretention spec P-FIL-05

Sizing (surface area) – Flow-rate approach

Eqn. P-FIL-05-3: Bioretention Surface Area Using Darcy's Law

(Flow-rate approach, i.e., drain time)

$$Surface\ Area = (12 \times Tv_{BMP} \times d_{media}) \div [td \times K_{sat}\ x\ (d_{ponding} + d_{media})]$$

SA = surface area of bioretention practice (sq. ft.)

TvBMP = treatment volume of the BMP (cu. ft.)

d_{media} *= depth of soil filter media (ft.)*

td = required drain time (hr.); maximum is 48 hours for ponding volume

K_{sat} *= hydraulic conductivity (in./hr.);*

L1 or L2 without underdrain, use K_{sat} *of most restrictive layer (native soil or media)*

$d_{ponding}$ *= depth of ponding area (ft.)*

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Bioretention spec P-FIL-05
Sizing (surface area) – Flow-rate approach

Table P-FIL-05-5 Design Parameters for Drain Time Calculations

Bioretention Component	Unit	Design Criteria
Treatment volume of BMP (TvBMP)	$ft.^3$	Obtain from VRRM spreadsheet*
Ponding volume (PV)	$ft.^3$	Total volume of water in ponding area
Water quantity volume (QV)	$ft.^3$	Volume applied for channel/flood protection
Design volume (DV)	$ft.^3$	Total volume of water that drains within the established drain time (48 or 72 hours) DV = TvBMP + QV
Hydraulic conductivity of soil filter media (media Ksat)	in./hr.	Supplied by vendor or use 0.5
Hydraulic conductivity of native soil (soil Ksat)	in./hr.	No underdrain: ≥ 0.5 and < 10 Level 2 with sump or internal water storage: ≥ 0.25
Maximum drain time of ponding volume	hrs.	48
Maximum drain time of practice	hrs.	72 (or 48 hours if Level 1 with an underdrain)

Note:

* For Level 2 practices, multiple TvBMP from VRRM spreadsheet by 1.25.

Drain time of the surface ponding area: The maximum drain time of the ponding volume is 48 hours. If the two-day limit is exceeded, adjust the sizing of the practice or alter the landcover to reduce the volume to the facility.

Virginia Department of Environmental Quality

Bioretention spec P-FIL-05
Sizing (surface area) – Flow-rate approach

Table P-FIL-05-5 Design Parameters for Drain Time Calculations

Bioretention Component	Unit	Design Criteria
Treatment volume of BMP (TvBMP)	$ft.^3$	Obtain from VRRM spreadsheet*
Ponding volume (PV)	$ft.^3$	Total volume of water in ponding area
Water quantity volume (QV)	$ft.^3$	Volume applied for channel/flood protection
Design volume (DV)	$ft.^3$	Total volume of water that drains within the established drain time (48 or 72 hours) DV = TvBMP + QV
Hydraulic conductivity of soil filter media (media Ksat)	in./hr.	Supplied by vendor or use 0.5
Hydraulic conductivity of native soil (soil Ksat)	in./hr.	No underdrain: ≥ 0.5 and < 10 Level 2 with sump or internal water storage: ≥ 0.25
Maximum drain time of ponding volume	hrs.	48
Maximum drain time of practice	hrs.	72 (or 48 hours if Level 1 with an underdrain)

Note:
* For Level 2 practices, multiple TvBMP from VRRM spreadsheet by 1.25.

Drain time of the surface ponding area: The maximum drain time of the ponding volume is 48 hours. If the two-day limit is exceeded, adjust the sizing of the practice or alter the landcover to reduce the volume to the facility.

Additional drain time equations for practice are included in P-FIL-05 section 5.1.3

- ***Eqn. P-FIL-05-4:*** *Drain Time of Surface Ponding Area*

  $$td\text{-}PV = 12 \times PV / (Ksat \times SA)$$

- ***Eqn. P-FIL-05-5:*** *Drain Time of Treatment Volume*

  $$td\text{-}TV = 12 \times TvBMP / (Ksat \times SA)$$

- ***Eqn. P-FIL-05-6:*** *Volume Available for Quantity Requirements*

  $$QV = (Ksat \times SA \times td\text{-}TV / 12) - TvBMP$$

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

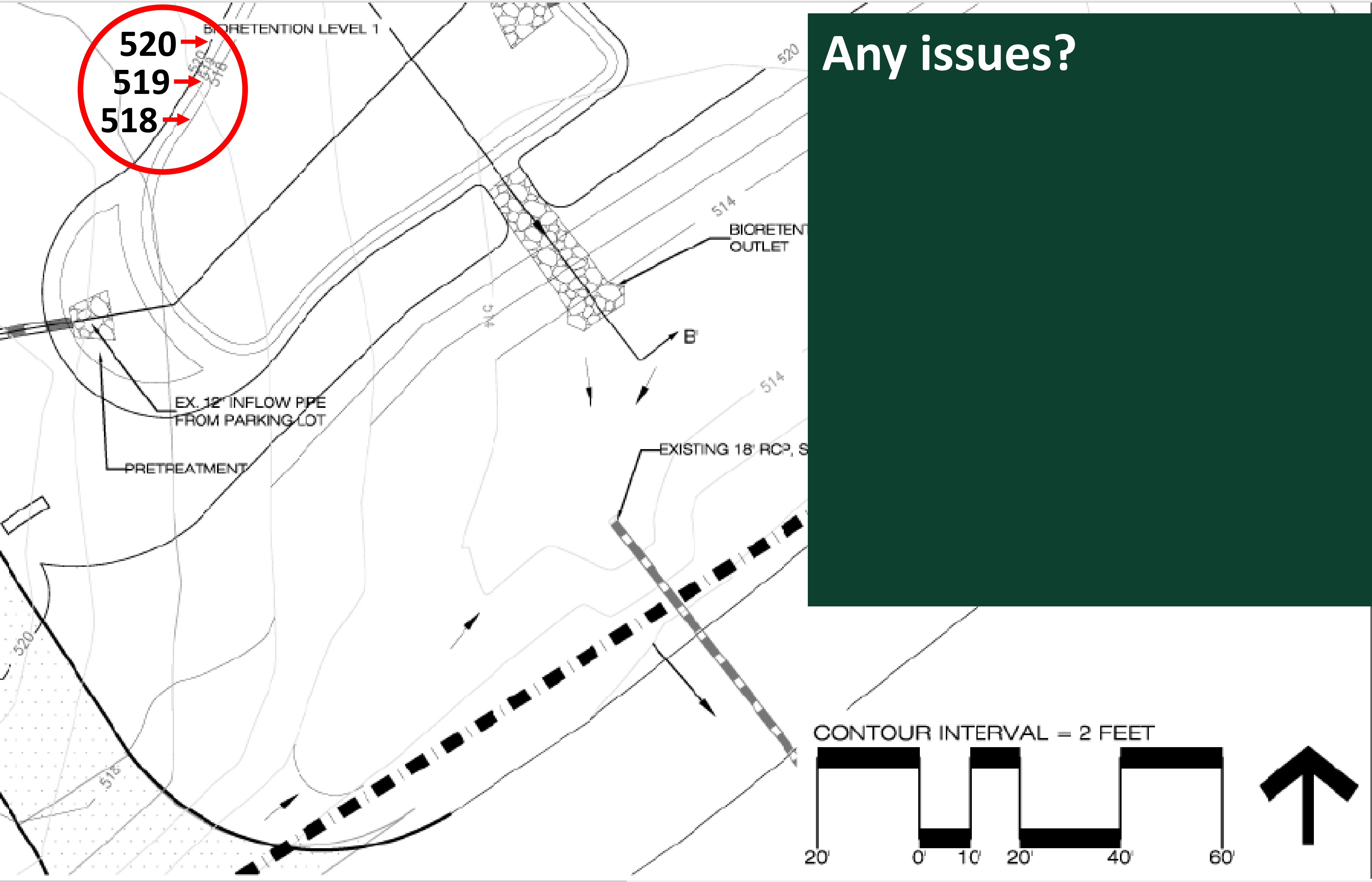
Evaluate:

Side Slopes,

Soil Media, and

Maximum Ponding

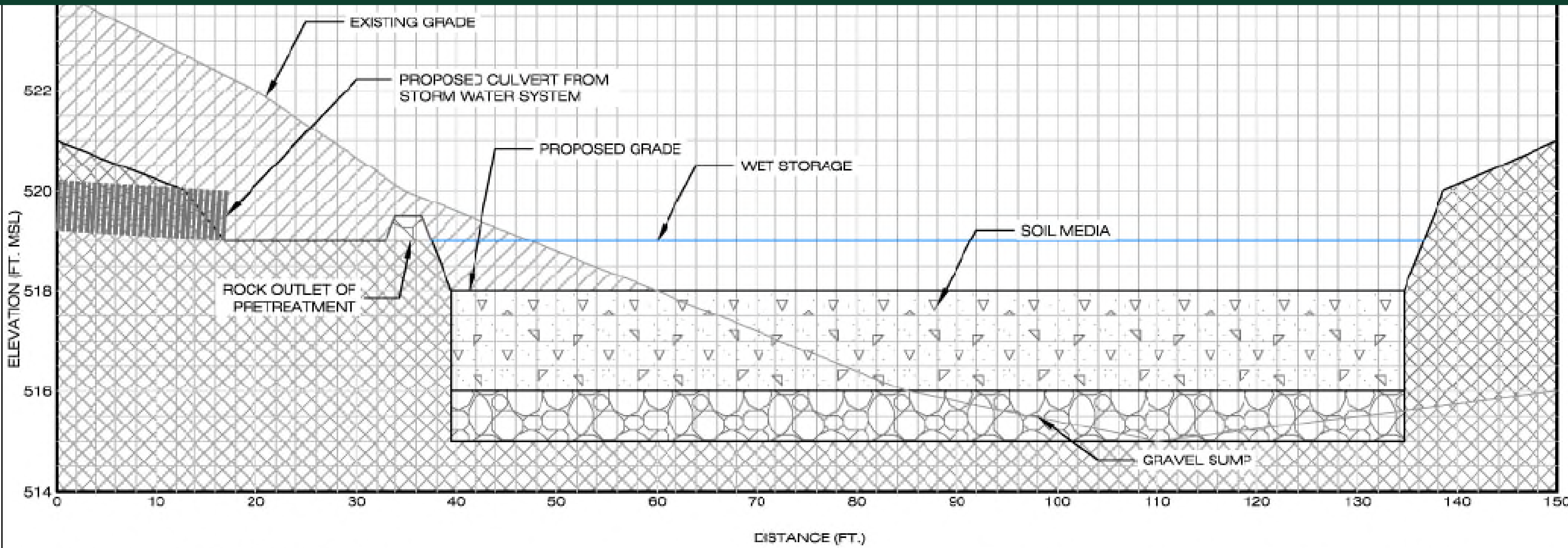
Evaluate: Slopes



Any issues?

Evaluate: Soil Media

Any issues?



CROSS-SECTION A-A'

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

SIZING CALCULATIONS, BIORETENTION LEVEL 1:

POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED

BMP Tv=8,231 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 = 8,231/1.9 = 4,332 S.F.

SURFACE AREA PROVIDED = 4,345 S.F.

TREATMENT VOLUME PROVIDED = 8,255 C.F.

SPILLWAY CALCULATIONS:

Q2 = 5.8 CFS, Q10 = 12.2 CFS

SLOPE = 33%

DIMENSIONS: BOTTOM WIDTH = 8 FT

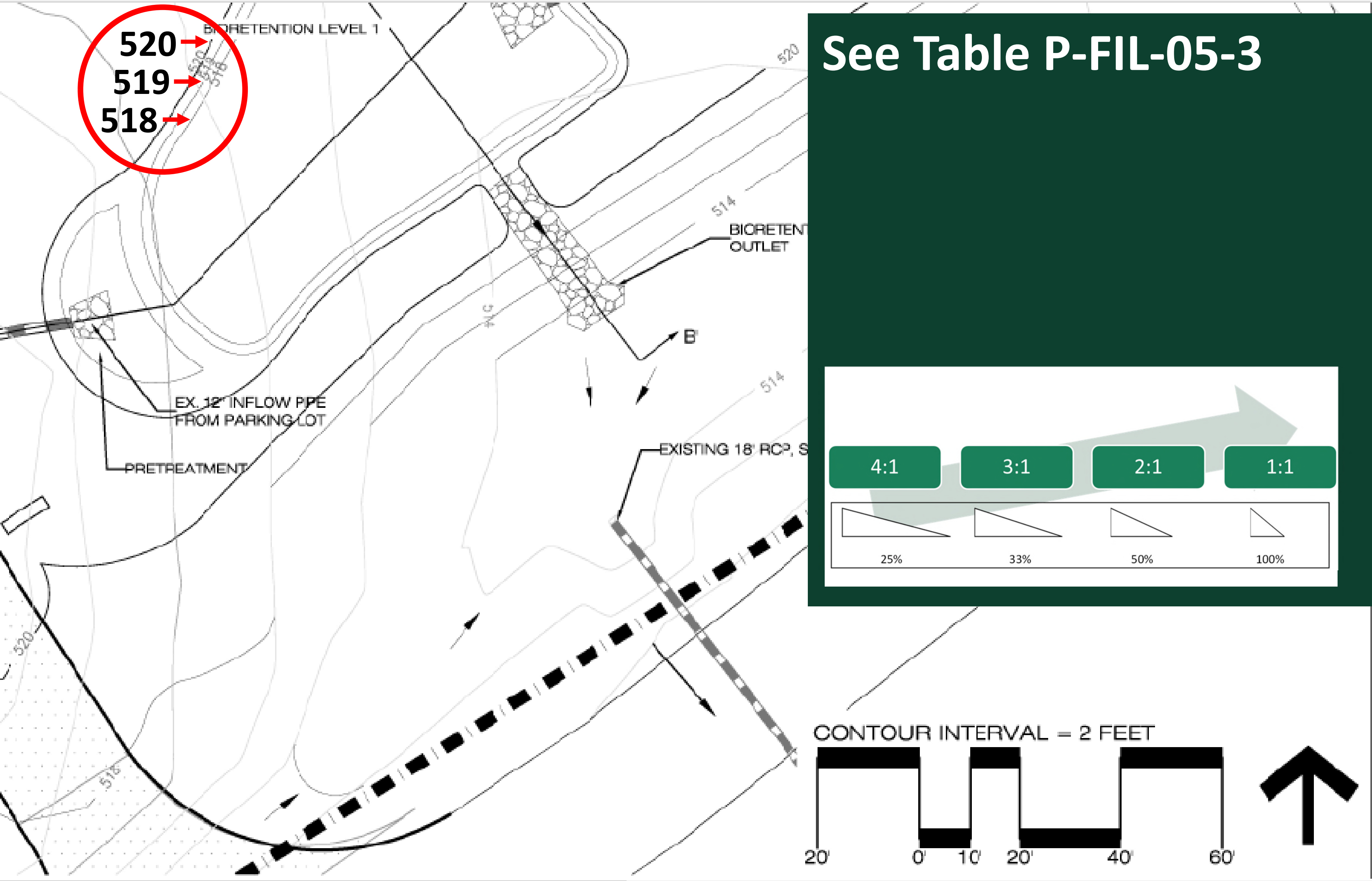
SIDE SLOPES = 2:1

SHEAR STRESS = Rh X SLOPE X Sw WATER

=0.28 X 0.33 X 62.4 = 5.77 LB/SF

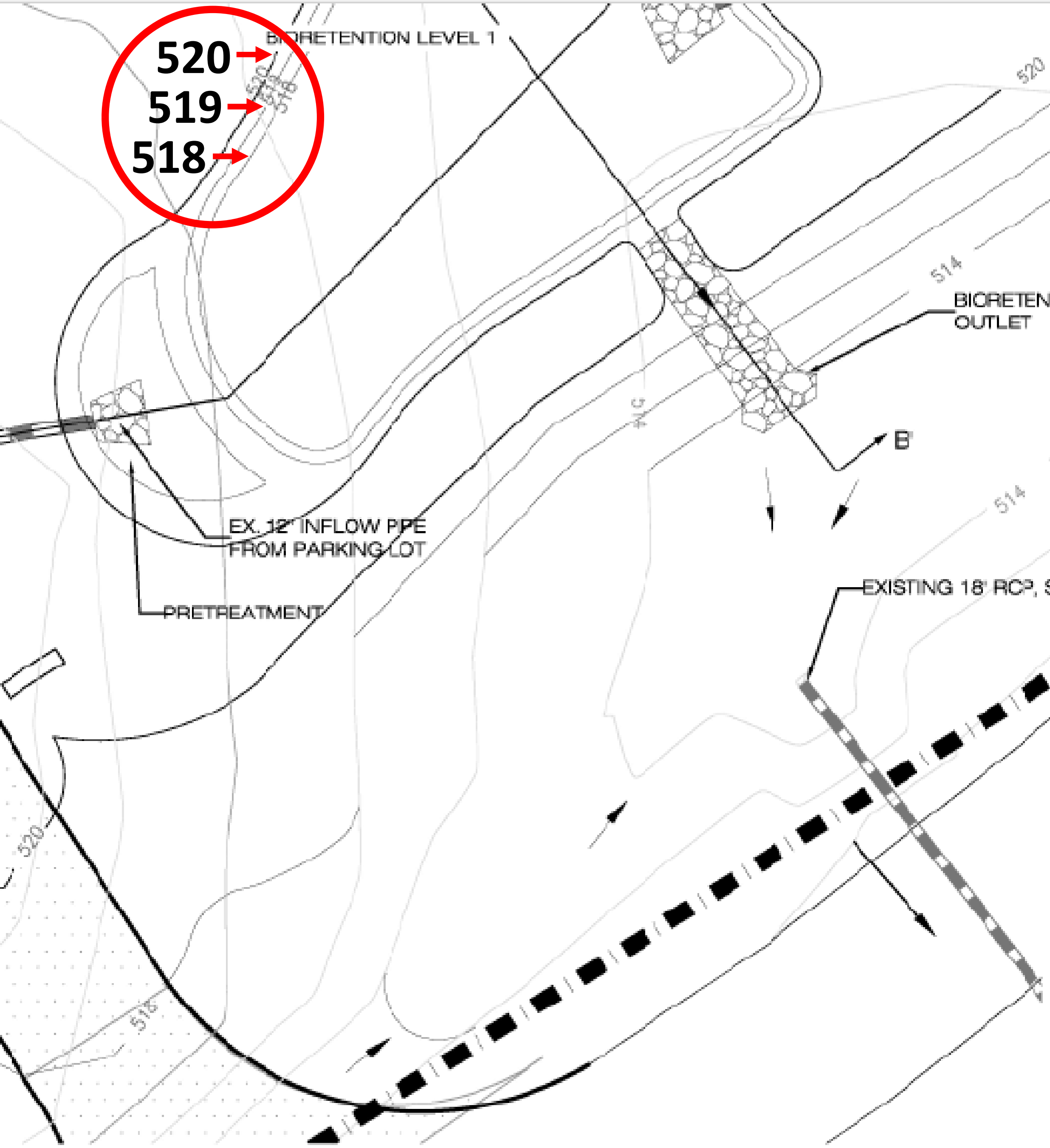
CLASS II RIPRAP FOR CHANNEL LINING

Evaluate: Slopes



See Table P-FIL-05-3

Evaluate: Slopes



Also see P-FIL-05 section 5.2.2 (Side Slopes)

- Side slopes of ponding area are required to be 3H:1V or flatter

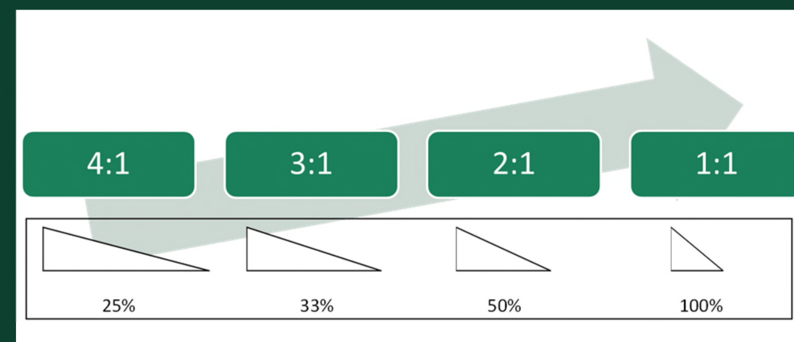


Table P-FIL-05-3 Bioretention De	
Level 1 Design	
Surface Area: Tv (cu ft)† = [(1.0)(Rv)(A)] / 12 – the volume reduced by an upstream BMP	Surfac volume
Perform soil test if no underdrain	Soil Te
Hydraulic conductivity (Ksat): Min > 0.5 in./hr. to remove the underdrain requirement Max ≤ 10 in./hr. without underdrain*	Hydrau Min > (Min > (Max ≤
Drain Time: Ponding Volume ≤ 48 hrs. Design Volume ≤ 48 hrs. (with underdrain) Design Volume ≤ 72 hrs. (if no underdrain)	Drain T Pondin
Stormwater quantity: Design extra storage (optional; as needed) on the surface, in t layer/sump to accommodate a larger storm. OR Use the VRRM Compliance Spreadsheet to calculate the Curv	
Pond Depth: Minimum 6 inches and maximum of 12 inches‡	
Side Slopes: 3H:1V or flatter	
Surface Cover: 2-3 inches of mulch or alternative, such as mar	
Planting Plan: A planting template to include turfgrass, herbaceous vegetation, shrubs, and/or trees to cover at least 75% of surface area in 2 years	Plantin herbac at leas

P-FIL-05 Bioretention specification

(Table P-FIL-05-3)

- Side slopes must be 3H:1V or flatter

Side slopes must be 3H:1V or flatter

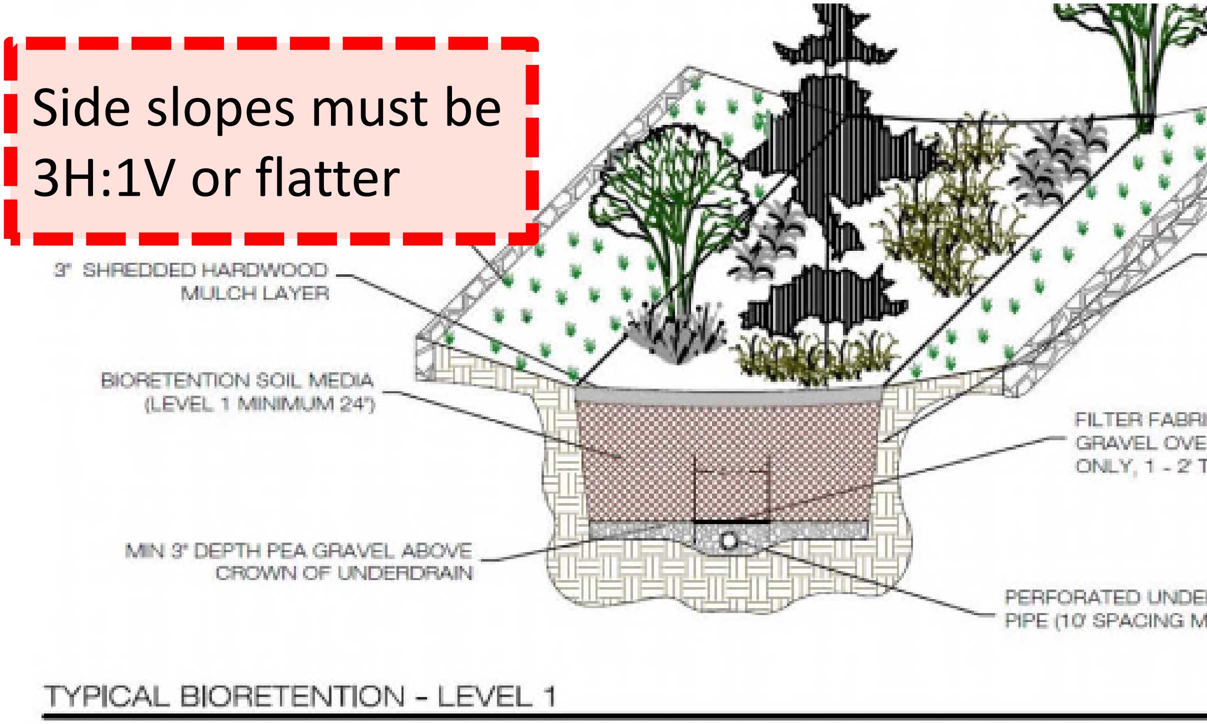
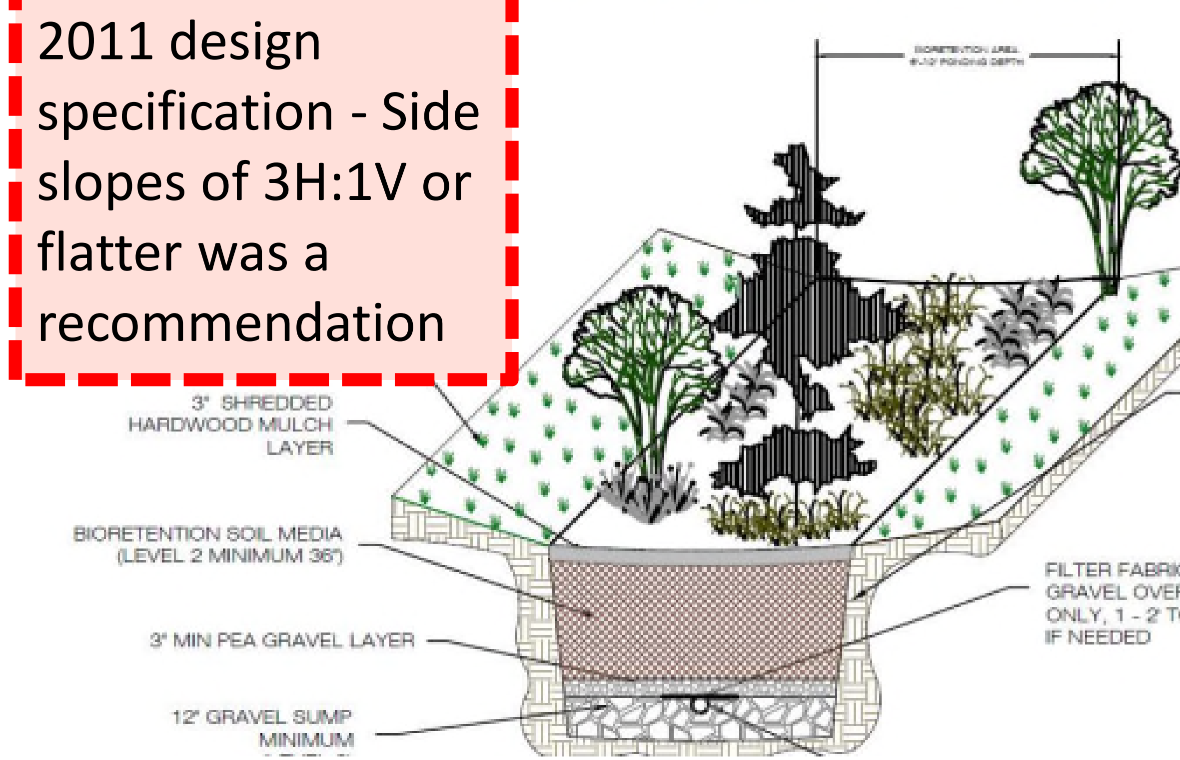


Figure 9.4a: Typical Detail of Bioretention Basin Level 1 Desig

2011 design specification - Side slopes of 3H:1V or flatter was a recommendation

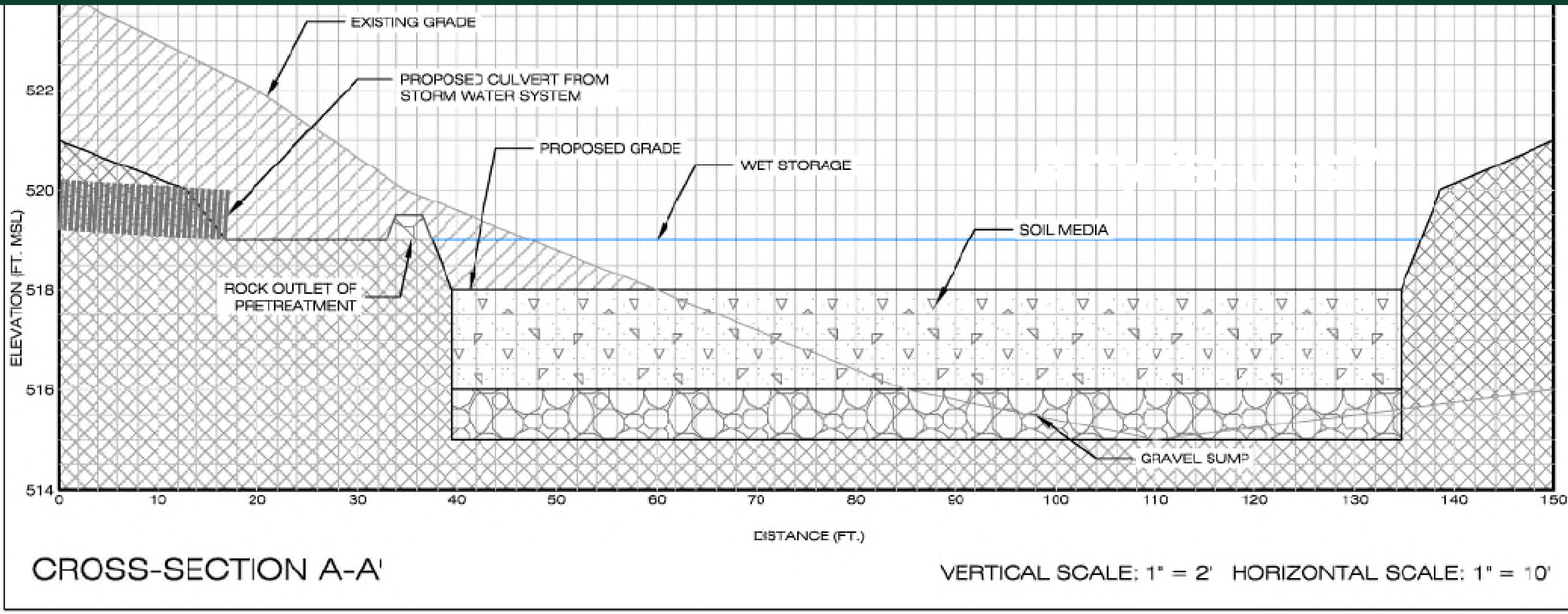


Figs. 9.4A-B from 2011 Bioretention Spec. #9, section 3

Evaluate:

Soil Media

Evaluate: Soil Media
P-FIL-05 Bioretention specification (Table P-FIL-05-3)



SIZING CALCULATIONS, BIORETENTION LEVEL 1:
POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED
BMP Tv=8,231 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 = 8,231/1.9 = 4,332 S.F.
SURFACE AREA PROVIDED = 4,345 S.F.
TREATMENT VOLUME PROVIDED = 8,255 C.F.

SPILLWAY CALCULATIONS:
Q2 = 5.8 CFS, Q10 = 12.2 CFS

SLOPE = 33%
DIMENSIONS: BOTTOM WIDTH = 8 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

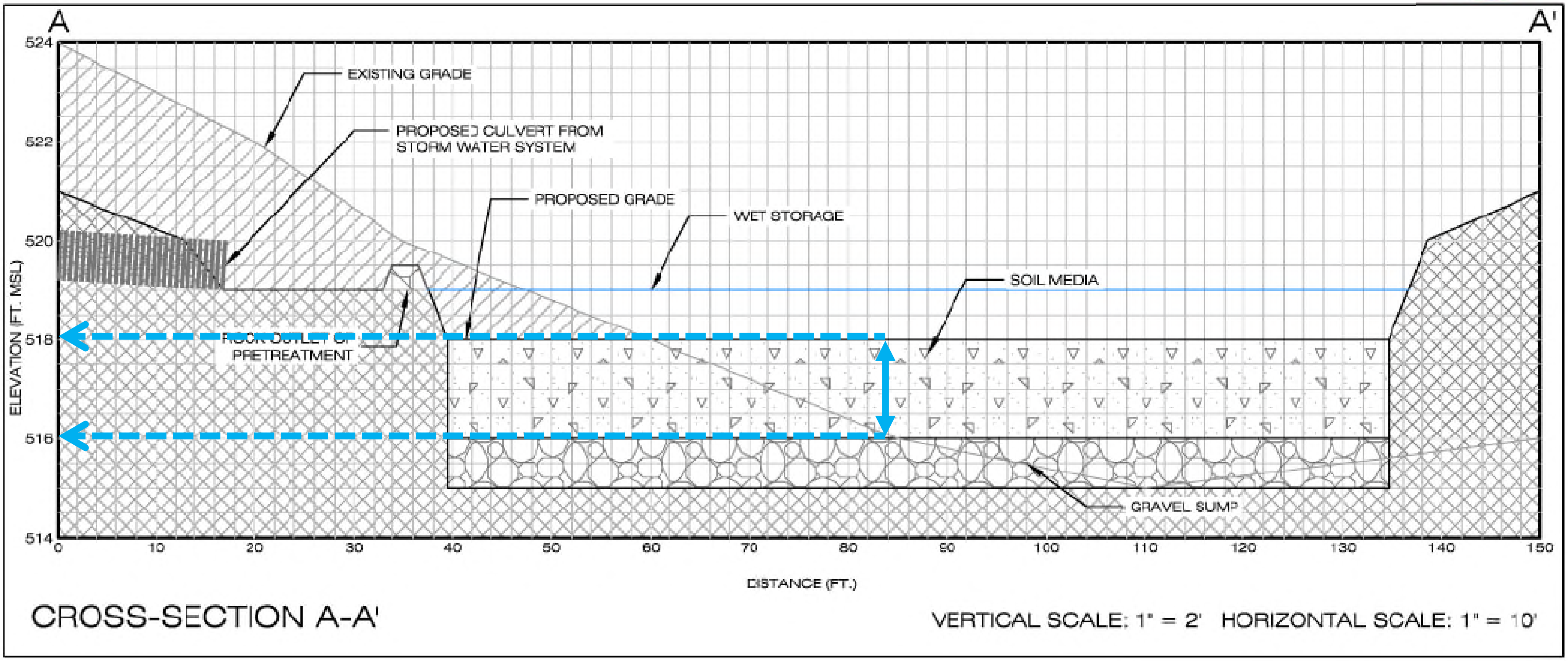
Bioretention spec P-FIL-05

Sizing (surface area)

Table P-FIL-05-03

Table P-FIL-05-3 Bioretention Design Primary Criteria	
Level 1 Design	**Level 2 Design**
Surface Area: Tv (cu ft)† = [(1.0)(Rv)(A)] / 12 – the volume reduced by an upstream BMP	Surface Area: Tv (cu ft)† = [1.25(Rv)(A)] / 12 – the volume reduced by an upstream BMP
Perform soil test if no underdrain	Soil Test must be performed
Hydraulic conductivity (Ksat): Min > 0.5 in./hr. to remove the underdrain requirement Max ≤ 10 in./hr. without underdrain*	Hydraulic Conductivity (Ksat): Min > 0.25 in./hr. Min > 0.5 in./hr. to remove the underdrain requireme Max ≤ 10 in./hr.*
Drain Time: Ponding Volume ≤ 48 hrs. Design Volume ≤ 48 hrs. (with underdrain) Design Volume ≤ 72 hrs. (if no underdrain)	Drain Time: Ponding Volume ≤ 48 hrs. Design Volume ≤ 72 hrs.
Stormwater quantity: Design extra storage (optional; as needed) on the surface, in the engineered soil matrix, and in the gravel layer/sump to accommodate a larger storm. OR Use the VRRM Compliance Spreadsheet to calculate the Curve Number (CN) Adjustment	
Pond Depth: Minimum 6 inches and maximum of 12 inches‡	
Side Slopes: 3H:1V or flatter	
Surface Cover: 2-3 inches of mulch or alternative, such as managed approved vegetation	
Planting Plan: A planting template to include turfgrass, herbaceous vegetation, shrubs, and/or trees to cover at least 75% of surface area in 2 years.	Planting Plan: A planting template to include turfgrass herbaceous vegetation, shrubs, and/or trees to cover at least 90% of surface area in 2 years. Turfgrass must be combined with shrubs and/or trees.
Filter Media Depth: Min: 24 inches Max: 48 inches§ Min: 36 inches rooting depth for trees**	Filter Media Depth: Min: 36 inches Max: 48 inches§ Min: 36 inches rooting depth for trees**
Filter Media: Supplied and certified by vendor per criteria provided in Appendix F.	
Gravel Layer: Min choker stone layer: 3 in. Min gravel layer with no underdrain: 0 in. Min gravel layer with underdrain: 9 in. Max gravel layer: 12 in.§	Gravel Layer: Min choker stone layer: 3 in. Min sump depth with underdrain: 9 in. Max sump depth: 12 in.§
Underdrain: Schedule 40 PVC or equivalent with clean-outs. Use slotted pipe under the filter bed and closed pipe elsewhere.	

Evaluate: Soil Media



SIZING CALCULATIONS, BIORETENTION LEVEL 1:
POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED
BMP Tv=8,231 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 = 8,231/1.9 = 4,332 S.F.
SURFACE AREA PROVIDED = 4,345 S.F.
TREATMENT VOLUME PROVIDED = 8,255 C.F.

SPILLWAY CALCULATIONS:
Q2 = 5.8 CFS, Q10 = 12.2 CFS

SLOPE = 33%
DIMENSIONS: BOTTOM WIDTH = 8 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

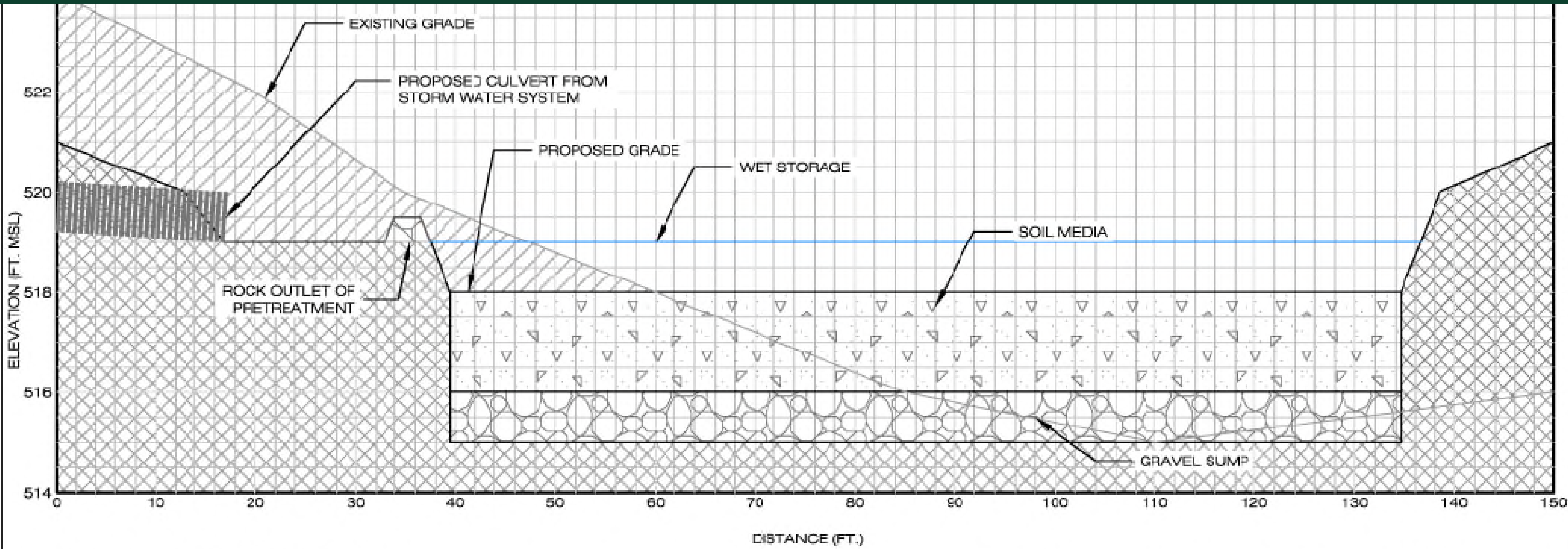
CLASS II RIPRAP FOR CHANNEL LINING

Evaluate:

Maximum Ponding

Evaluate: Maximum Ponding

Any issues?



CROSS-SECTION A-A'

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

SIZING CALCULATIONS, BIORETENTION LEVEL 1:

POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED

BMP Tv=8,231 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 = 8,231/1.9 = 4,332 S.F.

SURFACE AREA PROVIDED = 4,345 S.F.

TREATMENT VOLUME PROVIDED = 8,255 C.F.

SPILLWAY CALCULATIONS:

Q2 = 5.8 CFS, Q10 = 12.2 CFS

SLOPE = 33%

DIMENSIONS: BOTTOM WIDTH = 8 FT

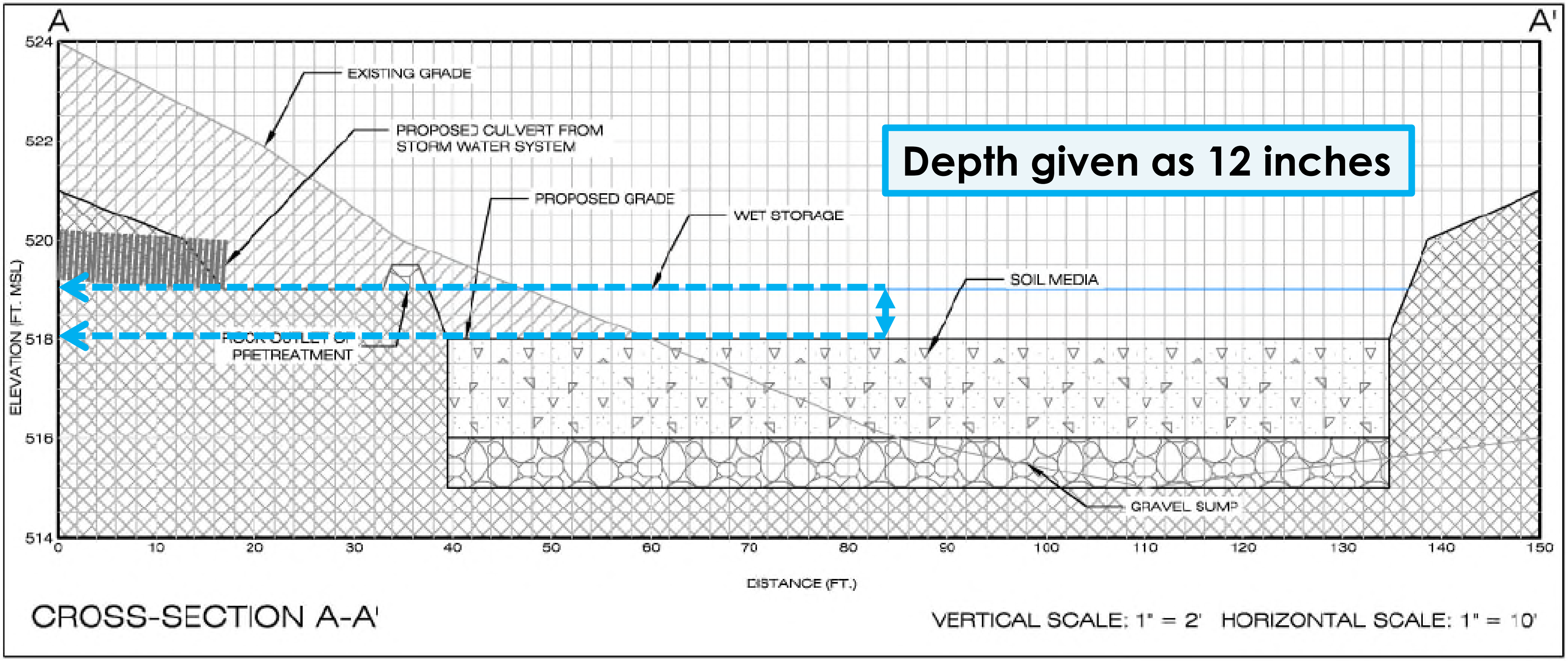
SIDE SLOPES = 2:1

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

Evaluate: Maximum Ponding



SIZING CALCULATIONS, BIORETENTION LEVEL 1:

POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED

BMP Tv=8,231 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 = 8,231/1.9 = 4,332 S.F.

SURFACE AREA PROVIDED = 4,345 S.F.

TREATMENT VOLUME PROVIDED = 8,255 C.F.

SPILLWAY CALCULATIONS:

Q2 = 5.8 CFS, Q10 = 12.2 CFS

SLOPE = 33%

DIMENSIONS: BOTTOM WIDTH = 8 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

Bioretention Specification P-FIL-05
Table P-FIL-05-3 (Maximum Ponding)

Table P-FIL-05-3 Bioretention Design Primary Criteria	
Level 1 Design	**Level 2 Design**
Pond Depth: Minimum 6 inches and maximum of 12 inches‡	
Side Slopes: 3H:1V or flatter	
Surface Cover: 2-3 inches of mulch or alternative, such as managed approved vegetation	
Planting Plan: A planting template to include turfgrass, herbaceous vegetation, shrubs, and/or trees to cover at least 75% of surface area in 2 years.	Planting Plan: A planting template to include turfgrass, herbaceous vegetation, shrubs, and/or trees to cover at least 90% of surface area in 2 years. Turfgrass must be combined with shrubs and/or trees.

Bioretention Specification P-FIL-05
Table P-FIL-05-3 (Maximum Ponding)

Table P-FIL-05-3 Bioretention Design Primary Criteria	
Level 1 Design	**Level 2 Design**
Pond Depth: Minimum 6 inches and maximum of 12 inches‡	
Side Slopes: 3H:1V or flatter	
Surface Cover: 2-3 inches of mulch or alternative, such as managed approved vegetation	
Planting Plan: A planting template to include turfgrass, herbaceous vegetation, shrubs, and/or trees to cover at least 75% of surface area in 2 years.	Planting Plan: A planting template to include turfgrass, herbaceous vegetation, shrubs, and/or trees to cover at least 90% of surface area in 2 years. Turfgrass must be combined with shrubs and/or trees.

Notes:

* The native soil may be amended to lower the hydraulic conductivity below 10 inches per hour (see Appendix F).

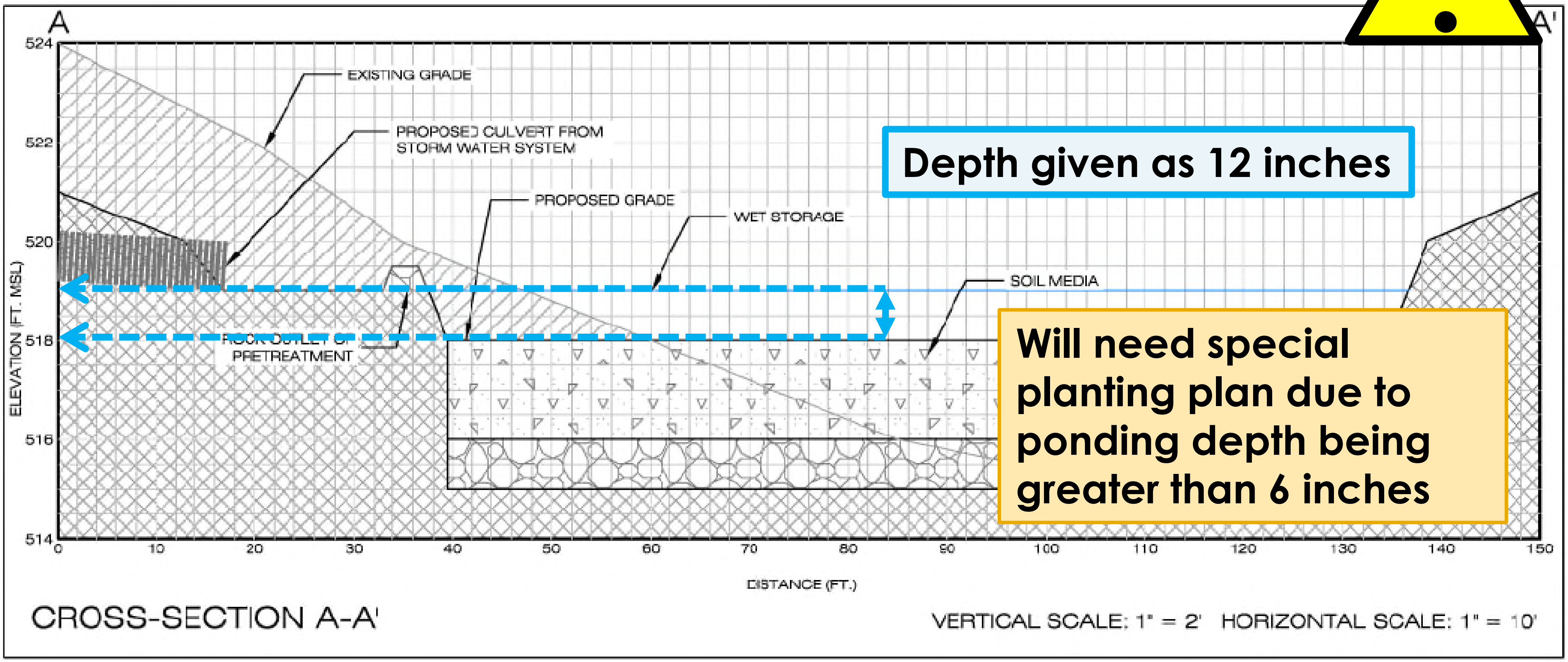
† If part of a treatment train, the treatment volume calculated by the VRRM spreadsheet includes the remaining volume from an upstream practice(s).

‡ Ponding depths between 6-12 inches need to incorporate plants that tolerate widely fluctuating water levels.

§ Additional depth can be added to the filter media and/or gravel layer/sump to help meet water quantity requirements. This additional depth is not used for surface area sizing calculations. See Section 5.2.

**When used in tree planter applications, at least 36" of suitable rooting depth must be maintained. For example, if filter media depth is 24", at least 12" of non-compacted suitable soil that meets overall media Ksat criteria should be employed between the media and the underdrain or soil infiltration zone.

Evaluate: Maximum Ponding



SIZING CALCULATIONS, BIORETENTION LEVEL 1:
POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED
BMP Tv=8,231 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 = 8,231/1.9 = 4,332 S.F.
SURFACE AREA PROVIDED = 4,345 S.F.
TREATMENT VOLUME PROVIDED = 8,255 C.F.

SPILLWAY CALCULATIONS:
Q2 = 5.8 CFS, Q10 = 12.2 CFS

SLOPE = 33%
DIMENSIONS: BOTTOM WIDTH = 8 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

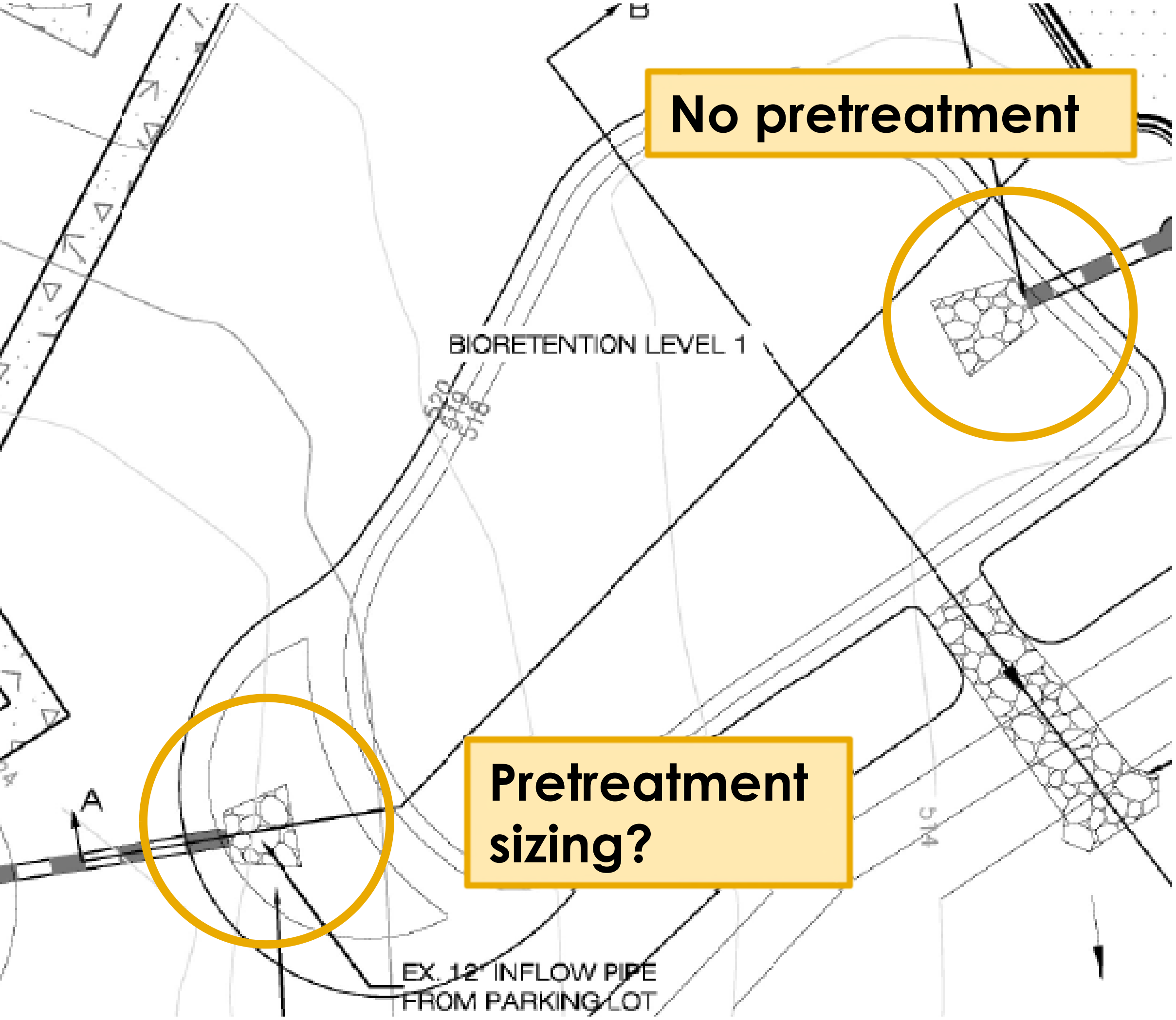
Evaluate:

Inlets

Evaluate: Inlets

Hint: See Pretreatment Specification P-SUP-06

Any issues?



SIZING CALCULATIONS, BIORETENTION LEVEL 1:
POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED
BMP Tv=8,231 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 = 8,231/1.9 = 4,332 S.F.
SURFACE AREA PROVIDED = 4,345 S.F.
TREATMENT VOLUME PROVIDED = 8,255 C.F.

SPILLWAY CALCULATIONS:
Q2 = 5.8 CFS, Q10 = 12.2 CFS

SLOPE = 33%
DIMENSIONS: BOTTOM WIDTH = 8 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

P-FIL-05 Bioretention specification, section 5.1, contributing drainage area

5.9 BMP Geometry

BMP geometry guidelines for bioretention can be found in Table P-FIL-05-9 below.

Table P-FIL-05-9 Geometry Guidelines for Bioretention Practices

Geometry	Guidelines
Flow Path	Design internal flow path such that the treatment mechanisms provided by the bioretention are not bypassed or short-circuited
Inlet flow energy attenuation	Additional emphasis needs to be placed on the peak runoff rate and energy of the inflow when the drainage area has an asymmetric shape or is larger than 2.5 acres
Travel Time for concentrated flows	Flows must have an acceptable internal geometry such that the "travel time" from each inlet to the outlet should be maximized by locating the inlets and outlets as far apart as possible
Travel Time for non-concentrated/sheet flows	Design the practice so that inflows are distributed as evenly as possible across the entire filter surface area.

Virginia Department of Environmental Quality

Bioretention Specification P-FIL-05 Inlets (Pretreatment P-SUP-06)

Table P-SUP-06-3 Forebay Design Considerations	
Element	**Design Consideration**
Location	Forebays should be located at major inflow locations to a BMP. Major inflow locations are those receiving flow from more than 0.25 acre of impervious surface or 1.5 acres of pervious surface.
Storage Volume	The following forebay storage volumes are generally recommended for specific BMP types when not part of a treatment train: • Constructed Wetlands: 10% to 15% of the total permanent pool volume. • Wet Ponds: 10% to 15% of the total permanent pool volume. • Extended Detention Basins: 10% to 15% of volume of the 2-year/24-hour storm. • Infiltration Practices: 25% of the managed volume for any infiltration facility with a contributing drainage area greater than or equal to 21,780 square feet; 15% of the managed volume for any infiltration facility with a contributing drainage area less than 21,780 square feet. • Other BMPs: a minimum of 0.1 inch of runoff from each impervious acre managed by the BMP.

Bioretention Specification P-FIL-05 Inlets (Pretreatment P-SUP-06)

Table P-SUP-06-3 Forebay Design Considerations	
Element	**Design Consideration**
Depth	The following forebay depths are generally recommended for specific BMP types: • Constructed Wetlands: 4- to 5-foot-deep storage at inlet pools (at least as deep as other open water areas). Provide a minimum of 1-foot-deep storage over permanent pool in all forebays. • Wet Basins: 4- to 5-foot-deep storage with a minimum flow length of 10 feet. Provide a minimum of 1-foot-deep storage over permanent pool in all forebays. • Naturalized Detention Basins: As determined to meet storage volume guidance and a minimum flow length of 10 feet. • All other BMPs: Minimum 18 inches deep and meet storage volume guidance and site constraints. Must fully dewater within 72 hours.
Length (in direction of flow)	The length to width ratio of the forebay should be 2:1 or greater. Baffles or low head berm may be used to create a longer flow path.

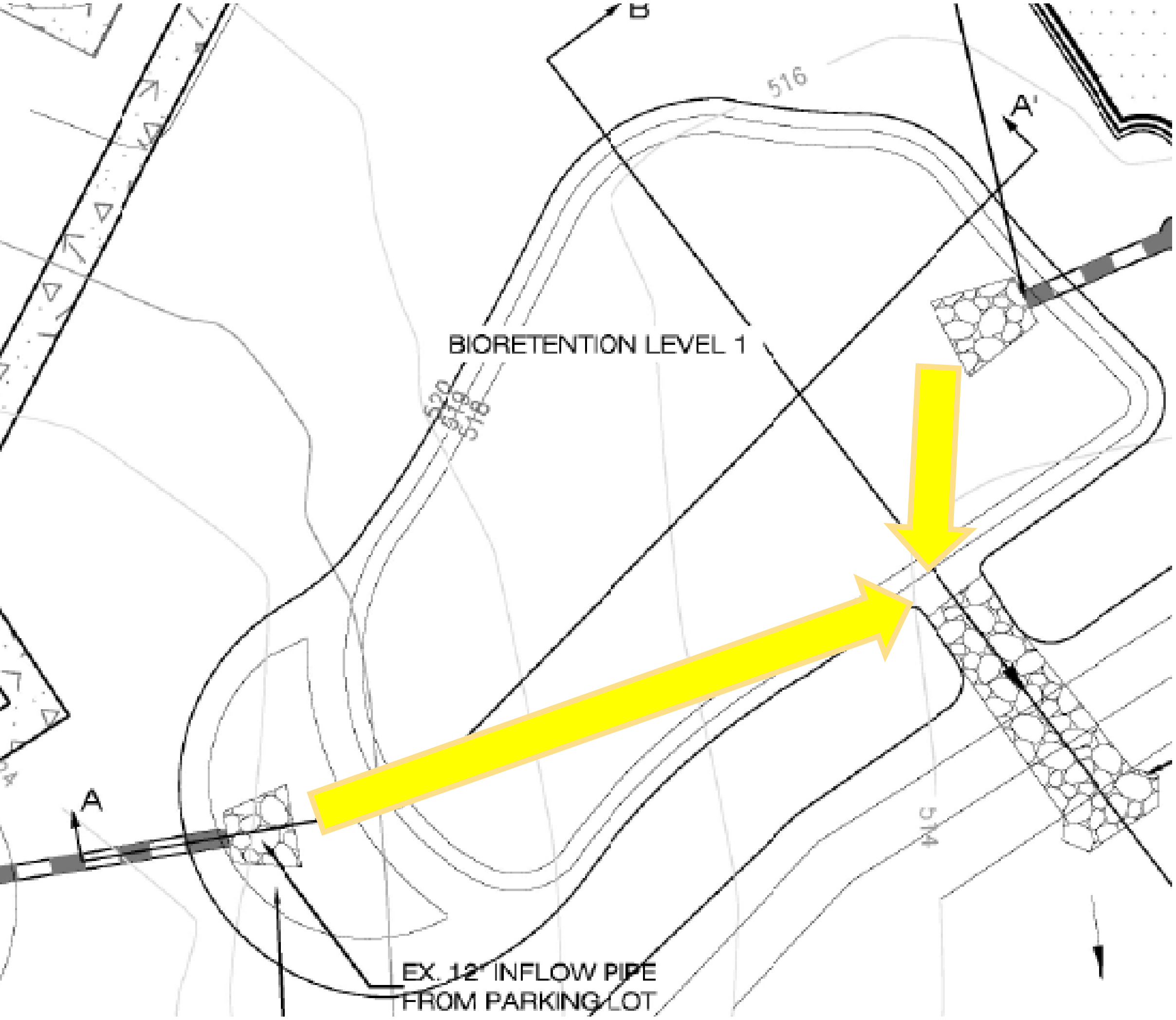
Bioretention Specification P-FIL-05 Inlets (Pretreatment P-SUP-06)

Table P-SUP-06-3 Forebay Design Considerations	
Element	**Design Consideration**
Flow Through Velocity	It is good engineering practice to provide an average velocity through the forebay of less than 2 fps during inflow from a storm event that produces the required volume. The average velocity can be determined using the continuity equation. $V = Q/A$ Where: v = average velocity. Q = average flow rate. A = average cross-sectional area perpendicular to flow assuming the forebay is 50% full of sediment.
Sediment Management	It is generally recommended that the accumulated sediment be removed before it occupies 50% of the forebay volume. It is good engineering practice to install a permanent vertical marker that indicates sediment depth in all forebays. It should be marked with the maximum depth of sediment storage. Virginia Department of Environmental Quality (DEQ) recommends maintenance prior to seasonal rainy periods.
Stabilization	Provide energy dissipators at inflow points within the forebay (see C-ECM-15 Outlet Protection). For high velocity inflows, energy dissipation may cover the entire bottom of the forebay. When an earthen berm is used, stabilize the earthen berm as appropriate.

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Evaluate:

Flow Path



Evaluate:
Flow Path
(Inlet to Outlet)

See Bioretention Specification P-FIL-05, Table P-FIL-03 and section 5.9 (Geometry)

Any issues?

<u>SIZING CALCULATIONS, BIORETENTION LEVEL 1:</u>
POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED
BMP Tv=8,231 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 = 8,231/1.9 = 4,332 S.F.
SURFACE AREA PROVIDED = 4,345 S.F.
TREATMENT VOLUME PROVIDED = 8,255 C.F.

<u>SPILLWAY CALCULATIONS:</u>
Q2 = 5.8 CFS, Q10 = 12.2 CFS

SLOPE = 33%
DIMENSIONS: BOTTOM WIDTH = 8 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

Bioretention Specification P-FIL-05
Table P-FIL-05-3 and Section 5.9 (Geometry)

Table P-FIL-05-3 Bioretention Design Primary Criteria	
Level 1 Design	Level 2 Design
Geometry: Concentrated flow: Locate inlets and outlets as far apart as possible. Non-concentrated flow: Distribute inflow evenly across filter surface area.	
Maintenance: Deeded Maintenance Agreement See Sections 7.11 and 7.12 for routine and non-routine maintenance requirements as well as a maintenance checklist.	

Notes:

* The native soil may be amended to lower the hydraulic conductivity below 10 inches per hour (see Appendix F).

† If part of a treatment train, the treatment volume calculated by the VRRM spreadsheet includes the remaining volume from an upstream practice(s).

‡ Ponding depths between 6-12 inches need to incorporate plants that tolerate widely fluctuating water levels.

§ Additional depth can be added to the filter media and/or gravel layer/sump to help meet water quantity requirements. This additional depth is not used for surface area sizing calculations. See Section 5.2.

**When used in tree planter applications, at least 36" of suitable rooting depth must be maintained. For example, if filter media depth is 24", at least 12" of non-compacted suitable soil that meets overall media Ksat criteria should be employed between the media and the underdrain or soil infiltration zone.

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Bioretention Specification P-FIL-05
Section 5.9 (Geometry)

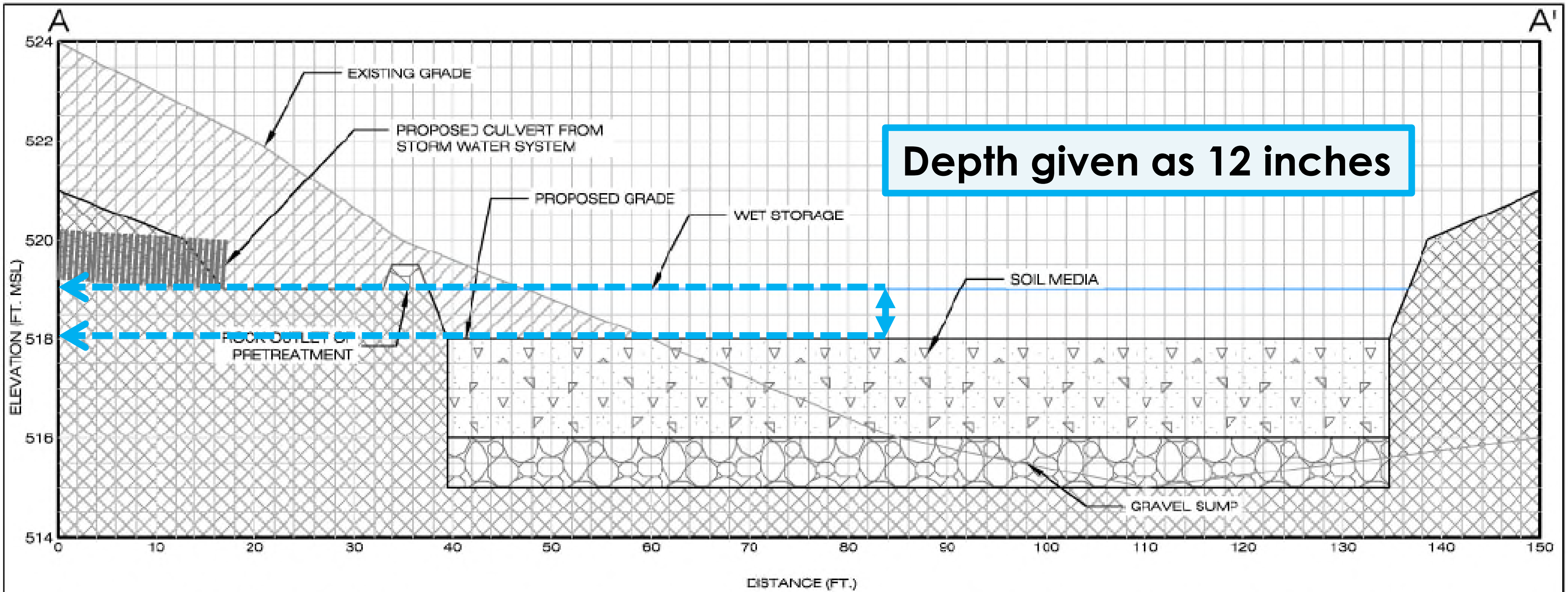
5.9 BMP Geometry

BMP geometry guidelines for bioretention can be found in Table P-FIL-05-9 below.

Table P-FIL-05-9 Geometry Guidelines for Bioretention Practices

Geometry	Guidelines
Flow Path	Design internal flow path such that the treatment mechanisms provided by the bioretention are not bypassed or short-circuited
Inlet flow energy attenuation	Additional emphasis needs to be placed on the peak runoff rate and energy of the inflow when the drainage area has an asymmetric shape or is larger than 2.5 acres
Travel Time for concentrated flows	Flows must have an acceptable internal geometry such that the "travel time" from each inlet to the outlet should be maximized by locating the inlets and outlets as far apart as possible
Travel Time for non-concentrated/sheet flows	Design the practice so that inflows are distributed as evenly as possible across the entire filter surface area.

Bioretention Ponding



CROSS-SECTION A-A'

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

SIZING CALCULATIONS, BIORETENTION LEVEL 1:

POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED

BMP Tv=8,231 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 = 8,231/1.9 = 4,332 S.F.

SURFACE AREA PROVIDED = 4,345 S.F.

TREATMENT VOLUME PROVIDED = 8,255 C.F.

SPILLWAY CALCULATIONS:

Q2 = 5.8 CFS, Q10 = 12.2 CFS

SLOPE = 33%

DIMENSIONS: BOTTOM WIDTH = 8 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

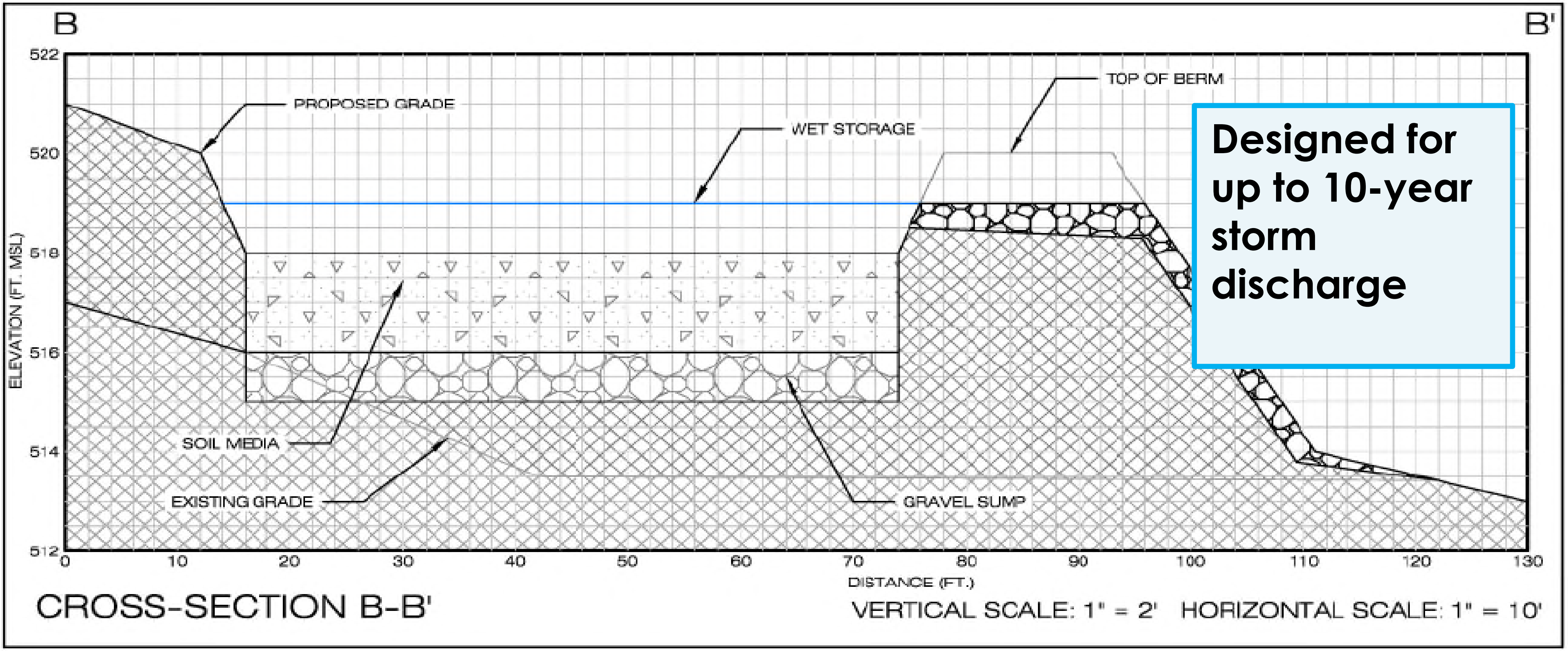
CLASS II RIPRAP FOR CHANNEL LINING

Evaluate:

Spillway

Evaluate: Spillway

Any issues?



Designed for up to 10-year storm discharge

SIZING CALCULATIONS, BIORETENTION LEVEL 1:
POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED
BMP Tv=8,231 C.F.
SOIL MEDIA DEPTH = 24 IN
GRAVEL SUMP = 12 IN
WET STORAGE = 12 IN
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TREATMENT VOLUME PROVIDED = 8,255 C.F.

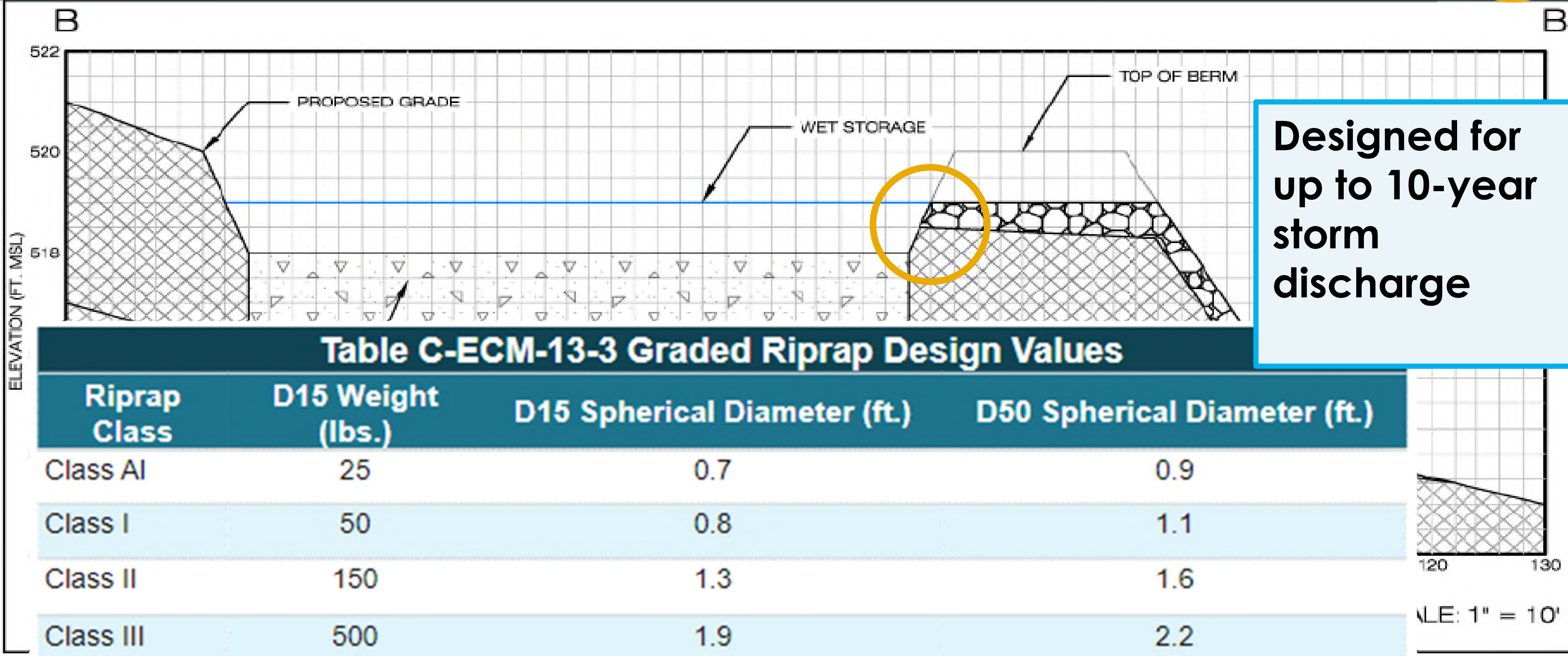
SPILLWAY CALCULATIONS:
Q2 = 5.8 CFS, Q10 = 12.2 CFS

SLOPE = 33%
DIMENSIONS: BOTTOM WIDTH = 8 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

Evaluate: Spillway



Designed for up to 10-year storm discharge

Table C-ECM-13-3 Graded Riprap Design Values			
Riprap Class	**D15 Weight (lbs.)**	**D15 Spherical Diameter (ft.)**	**D50 Spherical Diameter (ft.)**
Class AI	25	0.7	0.9
Class I	50	0.8	1.1
Class II	150	1.3	1.6
Class III	500	1.9	2.2
Type I	1,500	2.6	2.8
Type II	6,000	4.0	4.5

Source: VDOT 2017

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 = 8,231/1.9 = 4,332 S.F.
SURFACE AREA PROVIDED = 4,345 S.F.
TREATMENT VOLUME PROVIDED = 8,255 C.F.

DIMENSIONS: BOTTOM WIDTH = 8 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

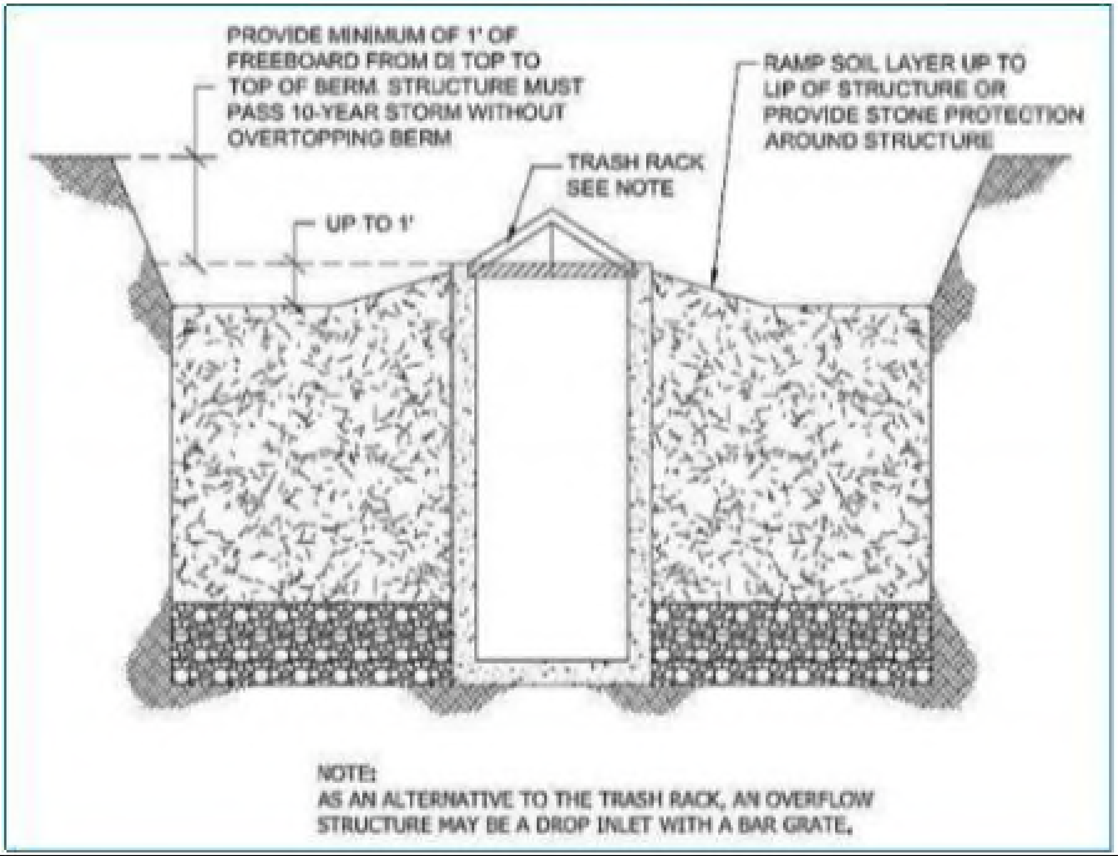
CLASS II RIPRAP FOR CHANNEL LINING

5.8.2 On-line Bioretention

All the discharge from the drainage area flows into the practice. On-line designs require attention to safely convey larger flows in adequate conveyances and with adequate freeboard. At no time during a storm event can the maximum head over the design underdrain or soil infiltration depth be more than 4 - 5 ft. Drainage designs should be based on expected peak discharges assuming that upstream practices may fail and/or provide marginal storage during larger events.

Flows that exceed the water quality design capacity exit the practice via an overflow structure. Field experience has shown that soil media immediately around an overflow structure is prone to scouring and erosion and, thus, short circuiting of the treatment mechanism. For example, water can flow straight down through scour holes or sinkholes to the underdrain system (Hirschman et al. 2009). Design options should be used to prevent this type of scouring. One example is shown in Figure P-FIL-05-8.

Figure P-FIL-05-8 Typical detail of how to prevent bypass or short-circuiting around the overflow structure



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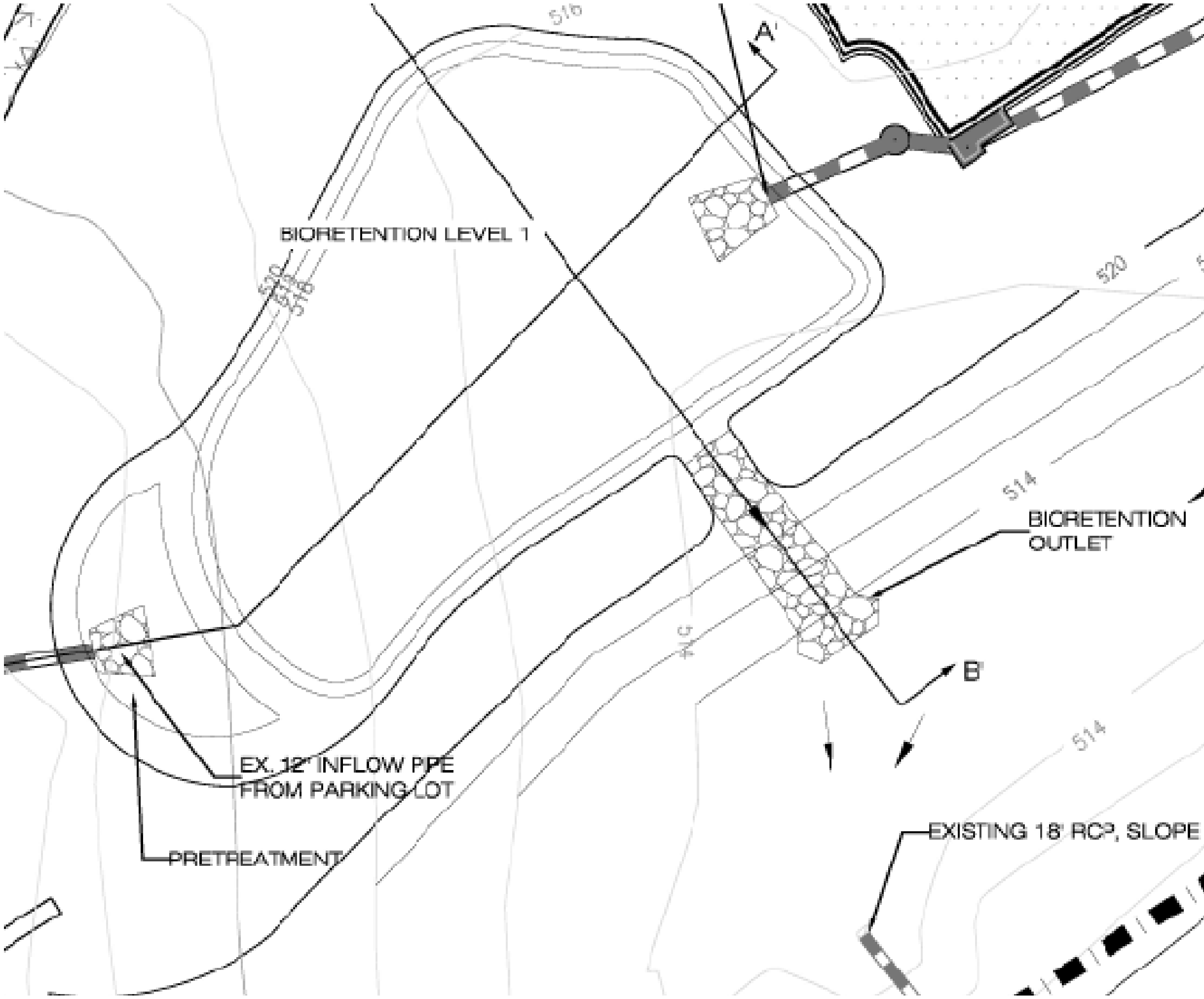
The following criteria apply to overflow structures:

- Inlet velocities for higher return periods need to be quantified in order to prevent erosion and scour from occurring within the practice.
- The ponding surface area should generally be flat so the bioretention area fills up like a bathtub.
- Design the overflow system to control flows associated with the 2- and 10-year design storms so that velocities are non-erosive at the outlet point (i.e., to prevent downstream erosion).
- Common overflow systems within bioretention practices consist of an inlet structure, where the top of the structure is placed at the maximum water surface elevation of the bioretention area, typically 6 to 12 inches above the surface of the filter bed (6 inches is the preferred ponding depth).
- The outlet device should be designed to pass flows greater than the TvBMP discharge and or equal to the 100-year storm event. The outlet structure may be a landscape grate inlet or a commercial-type structure.
- At least 6 inches of freeboard must be provided between the top of the overflow device and the top of the bioretention area to ensure that nuisance flooding will not occur.

Evaluate:

Outlets



Evaluate: Outlets

Any issues?

SIZING CALCULATIONS, BIORETENTION LEVEL 1:

POST DEVELOPMENT BMP TREATMENT VOLUME REQUIRED
BMP Tv=8,231 C.F.

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GRAVEL SUMP = 12 IN

WET STORAGE = 12 IN

STORAGE DEPTH = DEPTH x VOID RATIO
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SURFACE AREA PROVIDED = 4,345 S.F.

TREATMENT VOLUME PROVIDED = 8,255 C.F.

SPILLWAY CALCULATIONS:

Q2 = 5.8 CFS, Q10 = 12.2 CFS

SLOPE = 33%

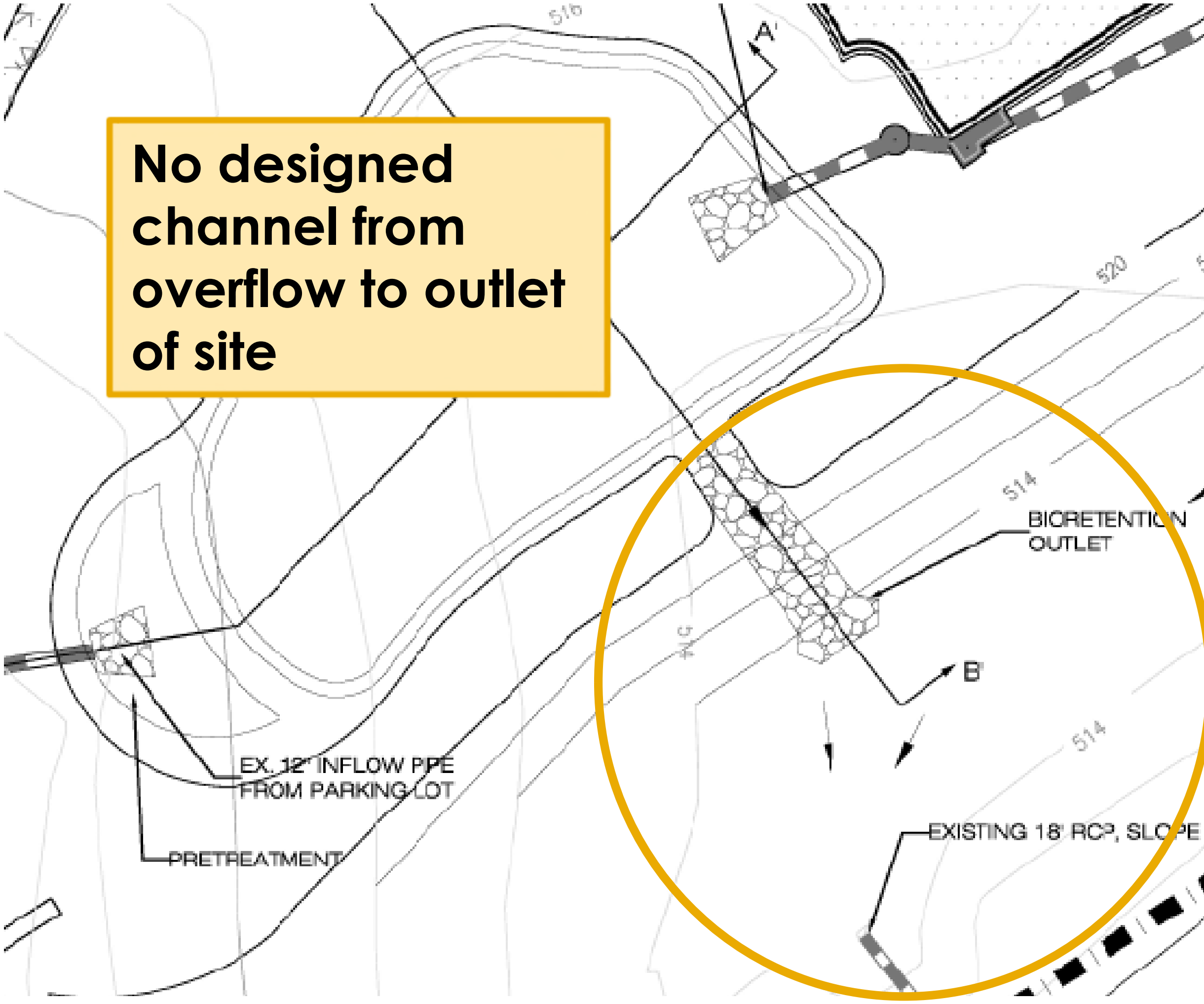
DIMENSIONS: BOTTOM WIDTH = 8 FT
SIDE SLOPES = 2:1

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

Evaluate: Outlet

No designed channel from overflow to outlet of site



SIZING CALCULATIONS, BIORETENTION LEVEL 1:

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CLASS II RIPRAP FOR CHANNEL LINING

Bioretention Specification P-FIL-05 Table P-FIL-05-3 and Section 5.8 (Conveyance and Overflow)

Table P-FIL-05-3 Bioretention Design Primary Criteria	
Level 1 Design	**Level 2 Design**
Conveyance and Overflow: Off-line/On-line option	
Geometry: Concentrated flow: Locate inlets and outlets as far apart as possible. Non-concentrated flow: Distribute inflow evenly across filter surface area.	

5.8 Conveyance and Overflow

There are two basic design approaches for conveying runoff into, through, and around bioretention practices:

1. Off-line: Flow is split or diverted so that only the BMP treatment volume or design flow enters the bioretention area. Larger flows bypass the bioretention treatment.
2. On-line: All runoff from the contributing drainage area flows into the practice. Flows that exceed the design capacity exit the practice via an overflow structure or weir.

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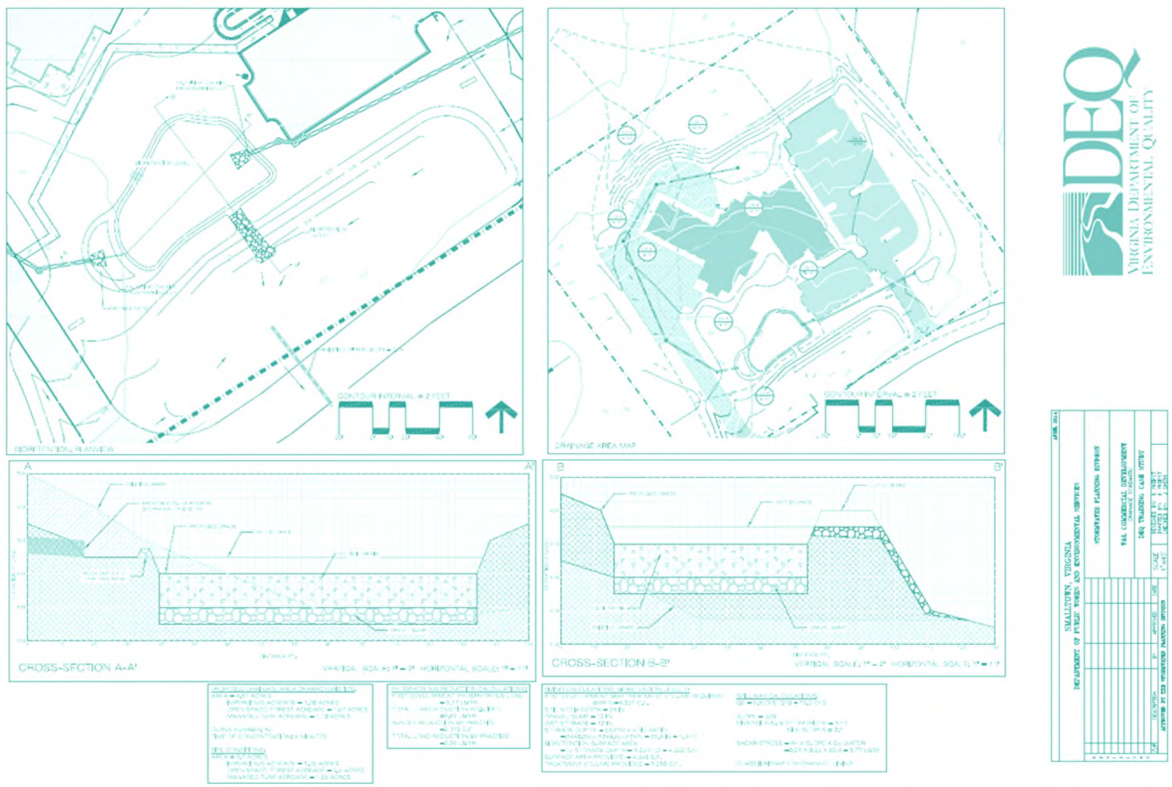
Questions?
Comments?



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