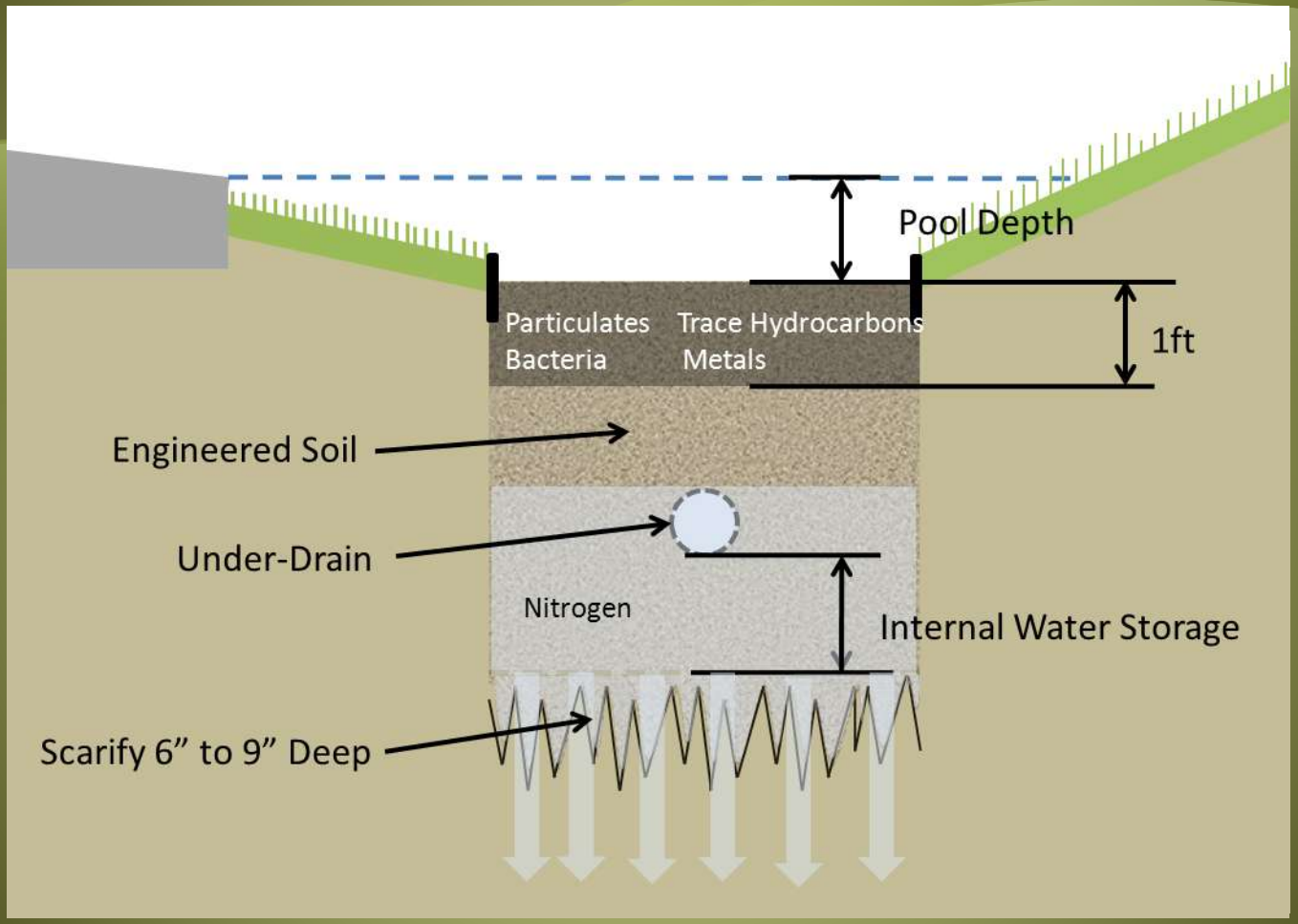
BIORETENTION MEDIA

Mike Isensee, CPESC
Middle St. Croix Watershed Management Organization
Washington Conservation District

Structural- Basin Configuration



Infiltration –Use Compost

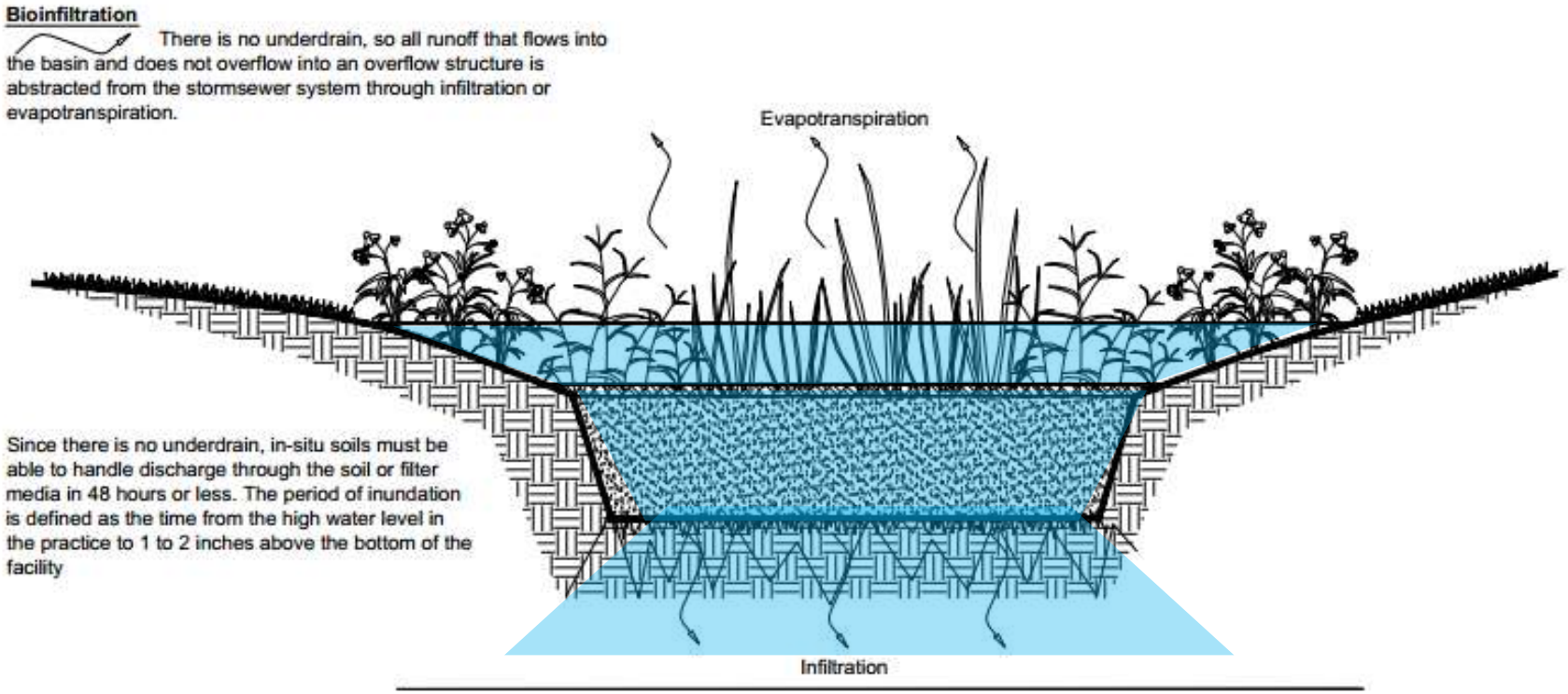
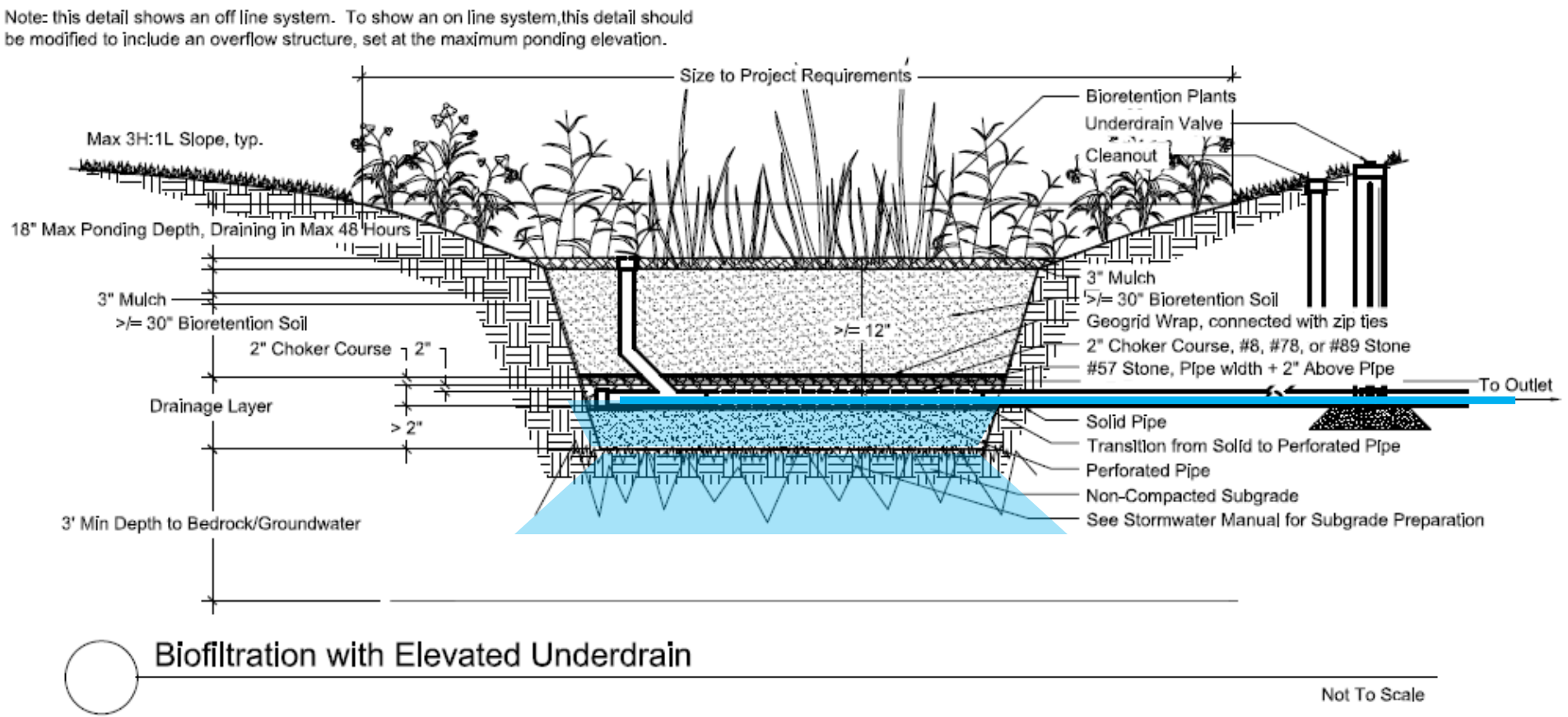


Figure 2-1: Bioinfiltration

Not To Scale

Filtration with Most Infiltration Credit (per MIDS Calculator)

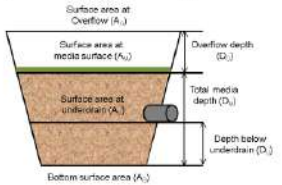


BMP Properties: 1 - Bioretention basin (with underdrain)

Watershed | BMP Parameters | BMP Summary

Bioretention basin (with underdrain)

$$V = \left[V_{inf\_b} \text{ or } \left(\frac{A_U + A_B}{2} * n * D_U\right)\right] + V_{inf\_s} + V_{ET}$$



Required treatment volume	3993	ft³
Is the underdrain elevated above native soils?	No	
Are the sides of the basin lined with an impermeable liner?	No	
Is the bottom of the basin lined with an impermeable liner?	No	
Surface area at overflow [A_O]	1000	ft²
Media surface area [A_M]	1000	ft²
Surface area at underdrain [A_U]	1000	ft²
Bottom surface area [A_B]	1000	ft²
Overflow depth [D_O]	1.5	ft
Total media depth [D_M]	3	ft
Depth below underdrain [D_U]	0	ft
Media field capacity - wilting point [FC - WP](range 0.05-0.17)	0.1	ft³/ft³
Media porosity - field capacity [n - FC](range 0.15-0.35)	0.35	ft³/ft³
Is a tree(s) planted in the BMP?	No	
Bioretention planting media mix	Media Mix B	
Is the P content of the media less than 30 mg/kg?	No	
Is a soil amendment used to attenuate phosphorus?	No	
Underlying soil - Hydrologic Soil Group	6 SM (HSG B, 0.45	
Infiltration rate of underlying soils	0.45	in/hr

OK HELP

BMP Properties: 1 - Bioretention basin (with underdrain)

Watershed | BMP Parameters | BMP Summary

Annual Summary

Annual water volume from direct watershed:	2.7341	acre-ft
Annual water volume from upstream BMPs:	0	acre-ft
Annual retention volume provided by BMP:	0.4871	acre-ft
Annual outflow volume:	2.247	acre-ft
Percent annual runoff volume retained:	**18**	**%**
Percent annual Particulate P reduction (via non volume reduction treatment)	0	%
Particulate P load from direct watershed:	1.227	lbs
Particulate P load from upstream BMPs:	0	lbs
Particulate P load reduction:	0.219	lbs
Total percent annual Particulate P reduction:	**18**	**%**
Percent annual Dissolved P reduction (via non volume reduction treatment)	0	%
Dissolved P load from watershed:	1.004	lbs
Dissolved P load from upstream BMPs:	0	lbs
Dissolved P load reduction:	0.179	lbs
Total percent annual Dissolved P reduction:	**18**	**%**
Total percent annual TP reduction:	**18**	**%**

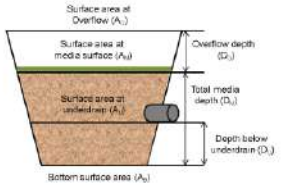
OK HELP

BMP Properties: 1 - Bioretention basin (with underdrain)

Watershed | BMP Parameters | BMP Summary

Bioretention basin (with underdrain)

$$V = \left[V_{inf\_b} \text{ or } \left(\frac{A_U + A_B}{2} * n * D_U\right)\right] + V_{inf\_s} + V_{ET}$$



Required treatment volume	3993	ft³
Is the underdrain elevated above native soils?	Yes	
Are the sides of the basin lined with an impermeable liner?	No	
Is the bottom of the basin lined with an impermeable liner?	No	
Surface area at overflow [A_O]	1000	ft²
Media surface area [A_M]	1000	ft²
Surface area at underdrain [A_U]	1000	ft²
Bottom surface area [A_B]	1000	ft²
Overflow depth [D_O]	1.5	ft
Total media depth [D_M]	3	ft
Depth below underdrain [D_U]	1	ft
Media field capacity - wilting point [FC - WP](range 0.05-0.17)	0.1	ft³/ft³
Media porosity - field capacity [n - FC](range 0.15-0.35)	0.35	ft³/ft³
Is a tree(s) planted in the BMP?	No	
Bioretention planting media mix	Media Mix B	
Is the P content of the media less than 30 mg/kg?	No	
Is a soil amendment used to attenuate phosphorus?	No	
Underlying soil - Hydrologic Soil Group	6 SM (HSG B, 0.45	
Infiltration rate of underlying soils	0.45	in/hr

OK HELP

BMP Properties: 1 - Bioretention basin (with underdrain)

Watershed | BMP Parameters | BMP Summary

Annual Summary

Annual water volume from direct watershed:	2.7341	acre-ft
Annual water volume from upstream BMPs:	0	acre-ft
Annual retention volume provided by BMP:	0.9421	acre-ft
Annual outflow volume:	1.7921	acre-ft
Percent annual runoff volume retained:	**34**	**%**
Percent annual Particulate P reduction (via non volume reduction treatment)	0	%
Particulate P load from direct watershed:	1.227	lbs
Particulate P load from upstream BMPs:	0	lbs
Particulate P load reduction:	0.423	lbs
Total percent annual Particulate P reduction:	**34**	**%**
Percent annual Dissolved P reduction (via non volume reduction treatment)	0	%
Dissolved P load from watershed:	1.004	lbs
Dissolved P load from upstream BMPs:	0	lbs
Dissolved P load reduction:	0.346	lbs
Total percent annual Dissolved P reduction:	**34**	**%**
Total percent annual TP reduction:	**34**	**%**

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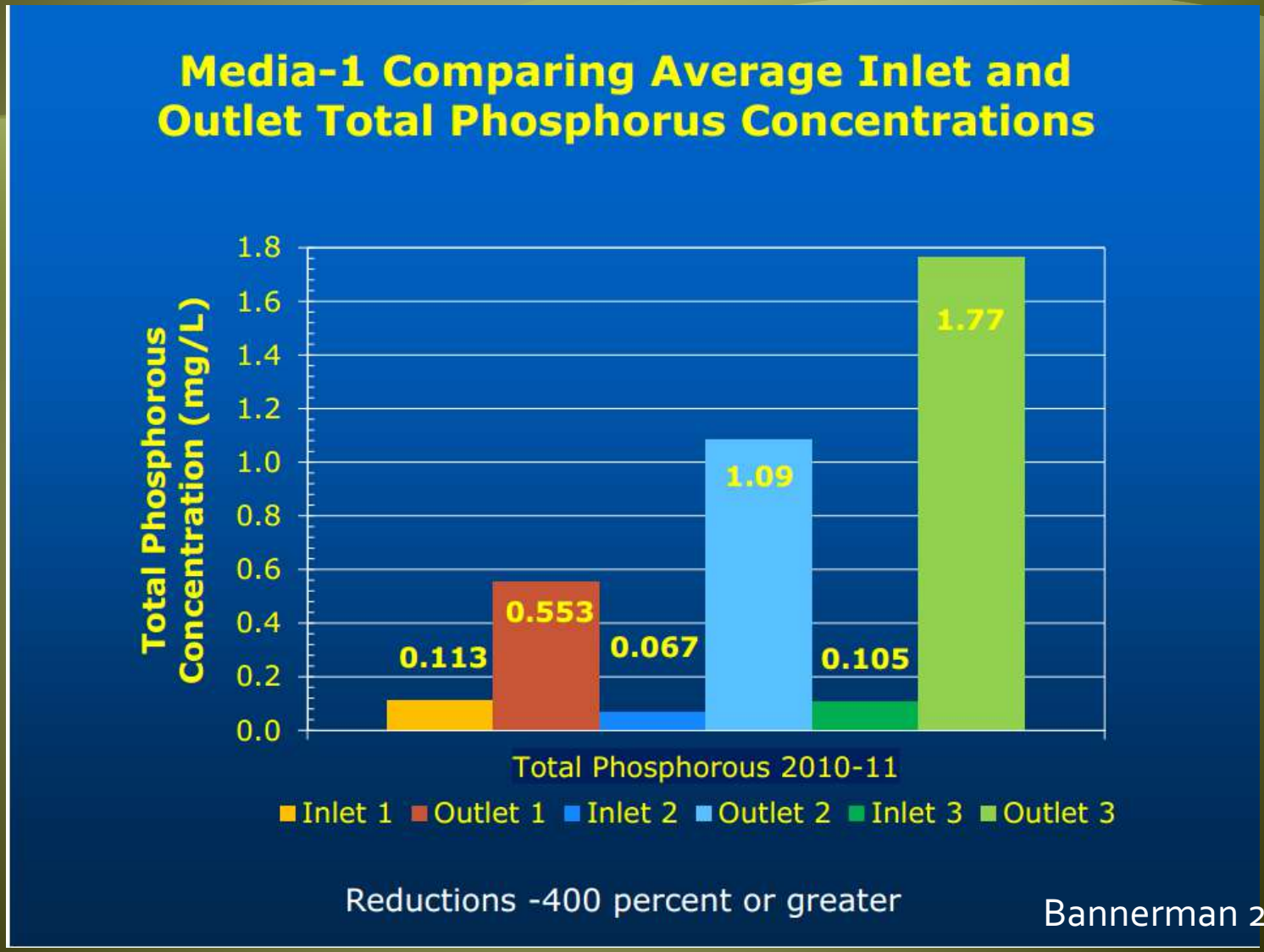
Engineered Media



Bannerman 2013

Engineered Media

1.Ensure Media Mixture to a P content between 12-30 mg/kg (and supports vegetation).

2. Incorporate a soil amendment to facilitate absorption of P (and does not kill vegetation).

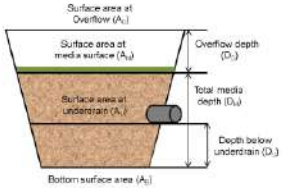
BMP Properties

BMP Properties: 1 - Bioretention basin (with underdrain)

Watershed | BMP Parameters | BMP Summary

Bioretention basin (with underdrain)

$$V = \left[V_{inf\_b} \text{ or } \left(\frac{A_U + A_B}{2} * n * D_U \right) \right] + V_{inf\_s} + V_{ET}$$



Required treatment volume	3993	ft³
Is the underdrain elevated above native soils?	Yes	
Are the sides of the basin lined with an impermeable liner?	No	
Is the bottom of the basin lined with an impermeable liner?	No	
Surface area at overflow [A_O]	1000	ft²
Media surface area [A_M]	1000	ft²
Surface area at underdrain [A_U]	1000	ft²
Bottom surface area [A_B]	1000	ft²
Overflow depth [D_O]	1.5	ft
Total media depth [D_M]	3	ft
Depth below underdrain [D_U]	1	ft
Media field capacity - wilting point [FC - WP] (range 0.05-0.17)	0.1	ft³ / ft³
Media porosity - field capacity [n - FC] (range 0.15-0.35)	0.35	ft³ / ft³
Is a tree(s) planted in the BMP?	No	
Bioretention planting media mix	Media Mix B	
Is the P content of the media less than 30 mg/kg?	No	
Is a soil amendment used to unavailable phosphorus?	No	
Underlying soil - Hydrologic Soil Group	6 SM (HSG B, 0.45	
Infiltration rate of underlying soils	0.45	in/hr

OK HELP

BMP Properties

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Watershed | BMP Parameters | BMP Summary

Annual Summary

Annual water volume from direct watershed:	2.7341	acre-ft
Annual water volume from upstream BMPs:	0	acre-ft
Annual retention volume provided by BMP:	0.9421	acre-ft
Annual outflow volume:	1.7921	acre-ft
Percent annual runoff volume retained:	**34**	**%**
Percent annual Particulate P reduction (via non volume reduction treatment)	0	%
Particulate P load from direct watershed:	1.227	lbs
Particulate P load from upstream BMPs:	0	lbs
Particulate P load reduction:	0.423	lbs
Total percent annual Particulate P reduction:	**34**	**%**
Percent annual Dissolved P reduction (via non volume reduction treatment)	0	%
Dissolved P load from watershed:	1.004	lbs
Dissolved P load from upstream BMPs:	0	lbs
Dissolved P load reduction:	0.346	lbs
Total percent annual Dissolved P reduction:	**34**	**%**
Total percent annual TP reduction:	**34**	**%**

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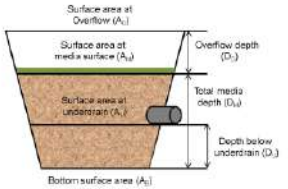
BMP Properties

BMP Properties: 1 - Bioretention basin (with underdrain)

Watershed | BMP Parameters | BMP Summary

Bioretention basin (with underdrain)

$$V = \left[V_{inf\_b} \text{ or } \left(\frac{A_U + A_B}{2} * n * D_U \right) \right] + V_{inf\_s} + V_{ET}$$



Required treatment volume	3993	ft³
Is the underdrain elevated above native soils?	Yes	
Are the sides of the basin lined with an impermeable liner?	No	
Is the bottom of the basin lined with an impermeable liner?	No	
Surface area at overflow [A_O]	1000	ft²
Media surface area [A_M]	1000	ft²
Surface area at underdrain [A_U]	1000	ft²
Bottom surface area [A_B]	1000	ft²
Overflow depth [D_O]	1.5	ft
Total media depth [D_M]	3	ft
Depth below underdrain [D_U]	1	ft
Media field capacity - wilting point [FC - WP] (range 0.05-0.17)	0.1	ft³ / ft³
Media porosity - field capacity [n - FC] (range 0.15-0.35)	0.35	ft³ / ft³
Is a tree(s) planted in the BMP?	No	
Bioretention planting media mix	Media Mix B	
Is the P content of the media less than 30 mg/kg?	Yes	
Is a soil amendment used to unavailable phosphorus?	No	
Underlying soil - Hydrologic Soil Group	6 SM (HSG B, 0.45	
Infiltration rate of underlying soils	0.45	in/hr

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BMP Properties

BMP Properties: 1 - Bioretention basin (with underdrain)

Watershed | BMP Parameters | BMP Summary

Annual Summary

Annual water volume from direct watershed:	2.7341	acre-ft
Annual water volume from upstream BMPs:	0	acre-ft
Annual retention volume provided by BMP:	0.9421	acre-ft
Annual outflow volume:	1.7921	acre-ft
Percent annual runoff volume retained:	**34**	**%**
Percent annual Particulate P reduction (via non volume reduction treatment)	80	%
Particulate P load from direct watershed:	1.227	lbs
Particulate P load from upstream BMPs:	0	lbs
Particulate P load reduction:	1.066	lbs
Total percent annual Particulate P reduction:	**87**	**%**
Percent annual Dissolved P reduction (via non volume reduction treatment)	20	%
Dissolved P load from watershed:	1.004	lbs
Dissolved P load from upstream BMPs:	0	lbs
Dissolved P load reduction:	0.478	lbs
Total percent annual Dissolved P reduction:	**48**	**%**
Total percent annual TP reduction:	**69**	**%**

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MN Stormwater Manual Mixes

	Mix A: Water quality blend	Mix B: Enhanced filtration blend	Mix C: NC State water quality blend	Mix D	Mix E: MnDOT 3877.2 Type G 'Filter Topsoil Borrow'	Mix F: Custom Infiltration Basin Planting Soil
Fine aggregate for Portland Cement Concrete					60-80%	
Construction Sand	55-65%	50-70%				
Sand			85-88%	60-75%		
Loamy Sand						75%
Topsoil	10-20%					
Silt and Clay			8-12%			
Organic Matter	25-35%	30-50%	3-5%			
MnDOT grade 2 compost				20-40%	20-40%	25%

- Growing media must be suitable for supporting vigorous growth of selected plant species.
- The pH range (soil/water 1:1) is 6.0 to 8.5
- Soluble salts (soil/water 1:2) should not to exceed 500 parts per million
- All bioretention growing media must have a field tested infiltration rate between 1 and 8 inches per hour.

Required Testing

Soil media test results and a soil sample must be submitted at least 14 days prior to material delivery.

Analysis	($)	Standard Turnaround Time	Sample Amount Needed
9045 pH Soil	21	4 Hours	50 grams
ASTM D2974 Organic Matter	42	2 Days	50 grams
Phosphorous (Bray)	75	2 Days	60 grams
365.1 Total Phosphorous	32	2 Days	20 grams
CEC	93	3 Days	200 grams
Grain Size	177	5 Days	200 grams

Date	Media	Olsen P	Bray P	Melich3
		ppm	ppm	ppm
9/1/2015	60/40 Sand/Peat	22	26	
9/15/2015	60/40 Sand/Peat		10	
6/9/2015	70/30 Sand/Sphag. Peat			6
6/1/2015	80/20 Sand/Sphag. Peat			12
6/1/2015	70/30 Sand/Sphag. Peat			6
6/1/2015	80/20 Sand/Compost			68
6/1/2015	70/30 Sand/Compost			114
4/1/2014	70/30 Sand/Compost		66	
4/1/2014	70/30 Sand/Reed Sedge Peat		12	
4/1/2014	70/30 Sand/Sphag. Peat		11	
7/1/2013	60/40 Sand/Sphag. Peat			10

Current Standard

- 70/30 Sand/Sphagnum Peat
- Test Results Required

-Deliver sample materials and test results for WCD prior approval prior to delivery of materials to the site. Soil media for infiltration basin shall be Plaisted's 70-30 Raingarden Peat Mix or approved equal. Soil media test results must be submitted to WCD at least 14 days prior to material delivery. Test results must include grain size analysis (sand, silt, clay), pH, organic content, Bray phosphorus test. Prior to beginning the installation, sufficient material quantities shall be onsite to complete the installation and stabilize exposed soil areas without delay.

1.Ensure Media Mixture to a P content between 12-30 mg/kg (and supports vegetation).

2. Incorporate a soil amendment to facilitate absorption of P (and does not kill vegetation).

Iron Enhanced Sand

95% ASTM C-33 Coarse Wash Sand and 5% Iron Aggregate by weight (1,485 lbs. Connelly GPM Inc., ETI CC 1004 or approved equal).

CONNELLY - GPM, INC.
ESTABLISHED 1875
3154 SOUTH CALIFORNIA AVENUE . CHICAGO, ILLINOIS 60608-5176
PHONE: (773) 247-7231 FAX: (773) 247-7239

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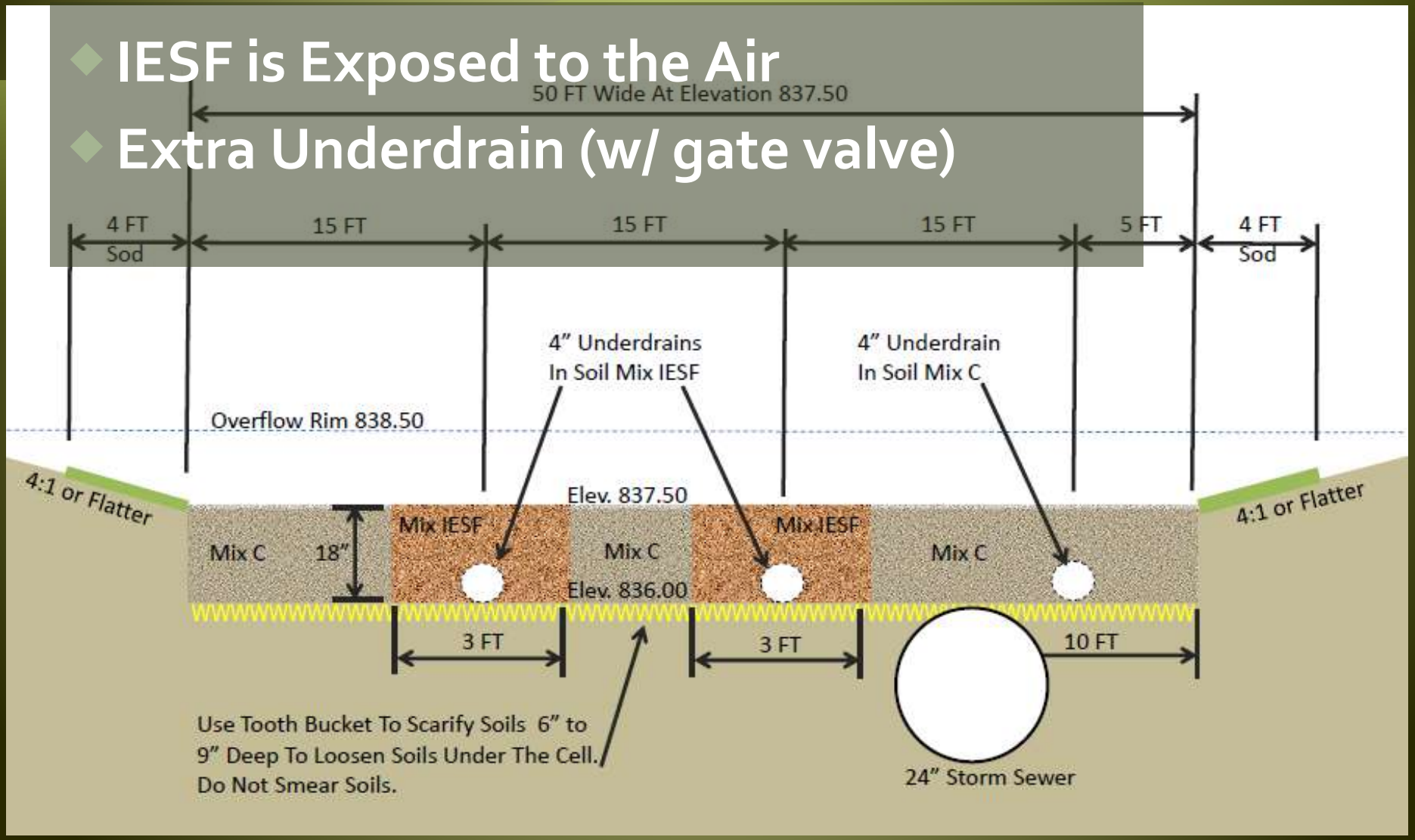
THE SOURCE TO HELP YOU IRON THINGS OUT

Since 1875 CONNELLY-GPM INC. has been creating quality products used to protect the environment and serve the energy and construction industries

Key Design Considerations

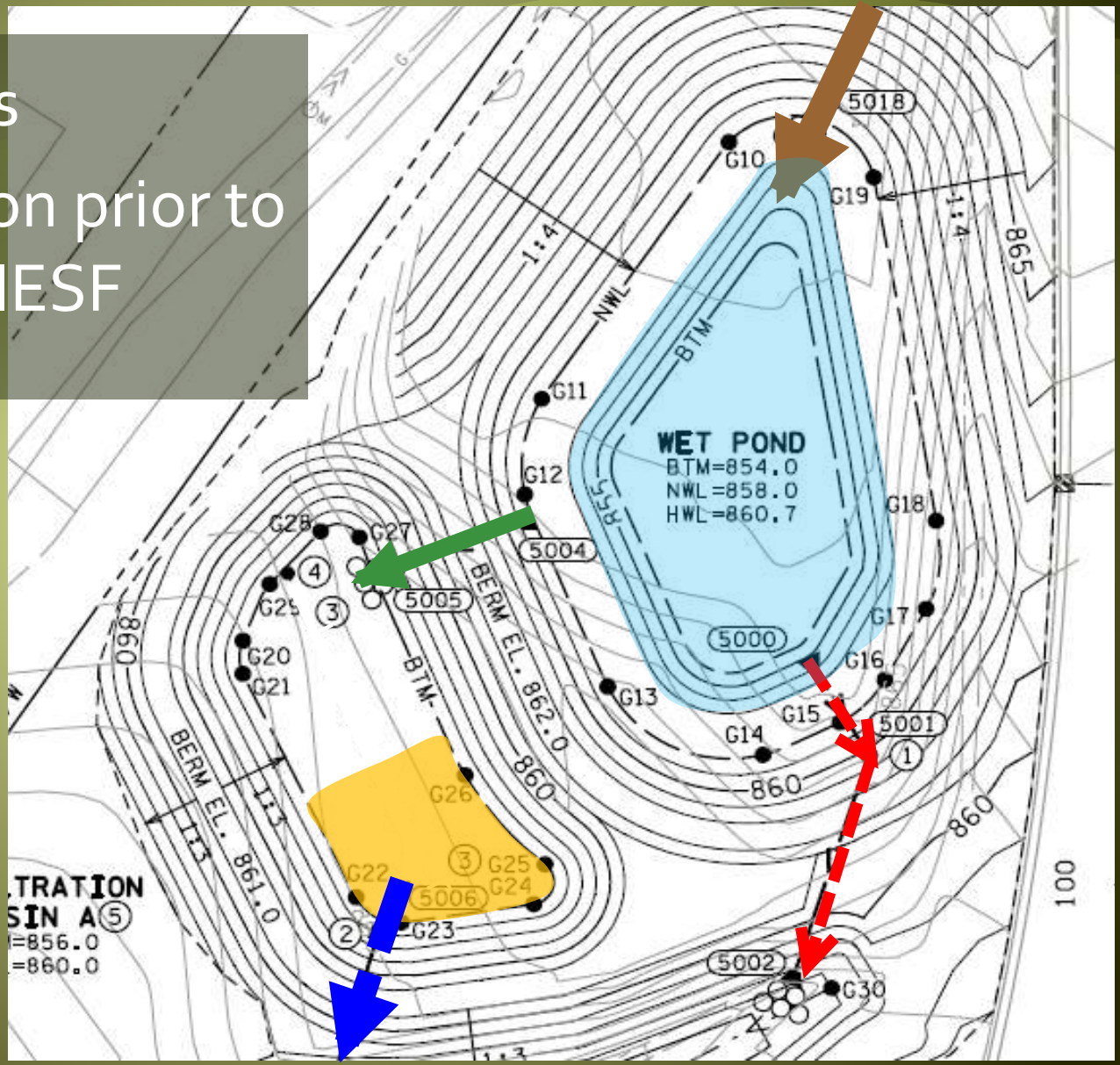
- IESF is Exposed to the Air
- Extra Underdrain (w/ gate valve)



Key Design Considerations

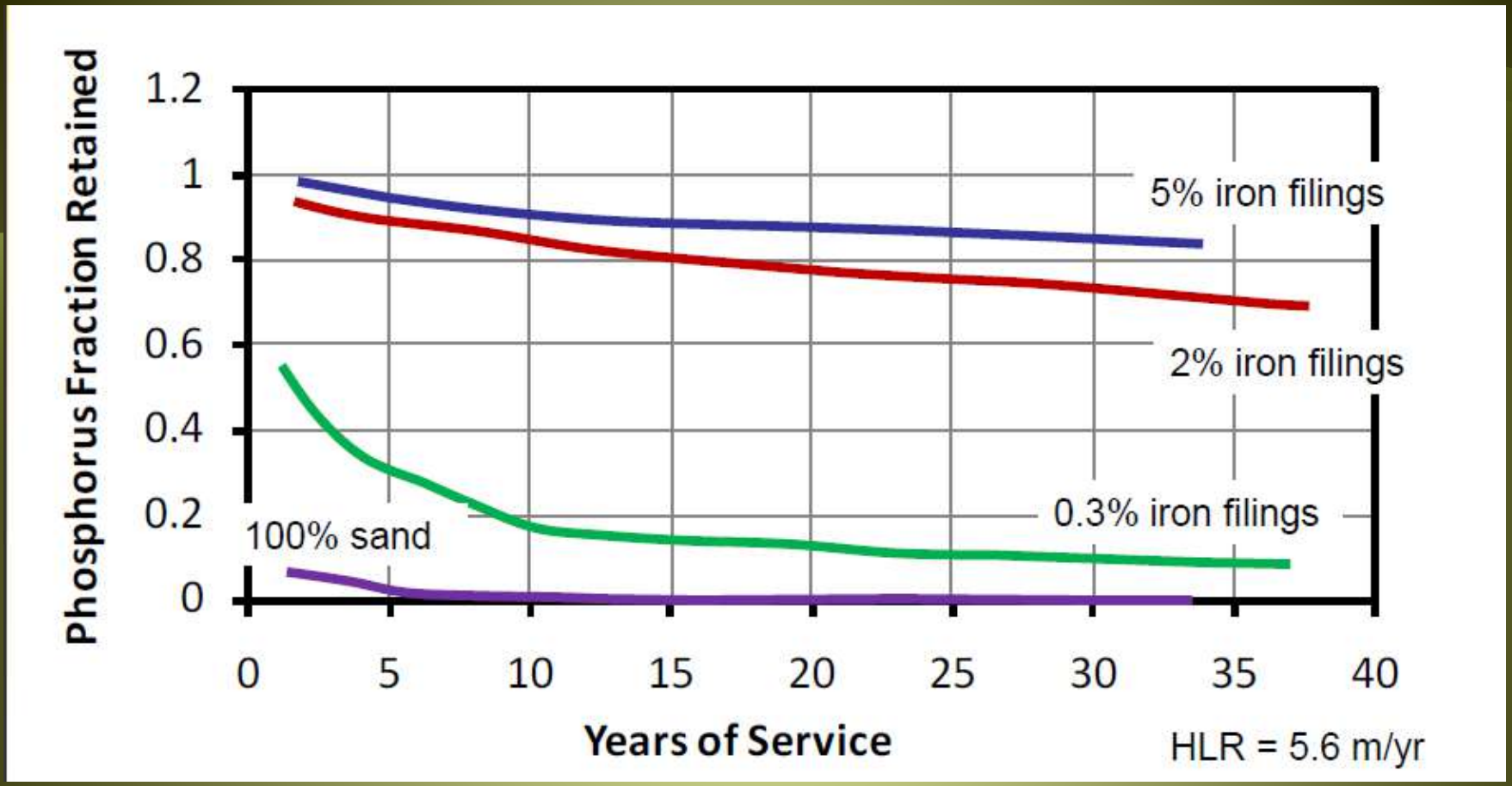
High Flow Bypass

Maximize filtration prior to discharge to the IESF



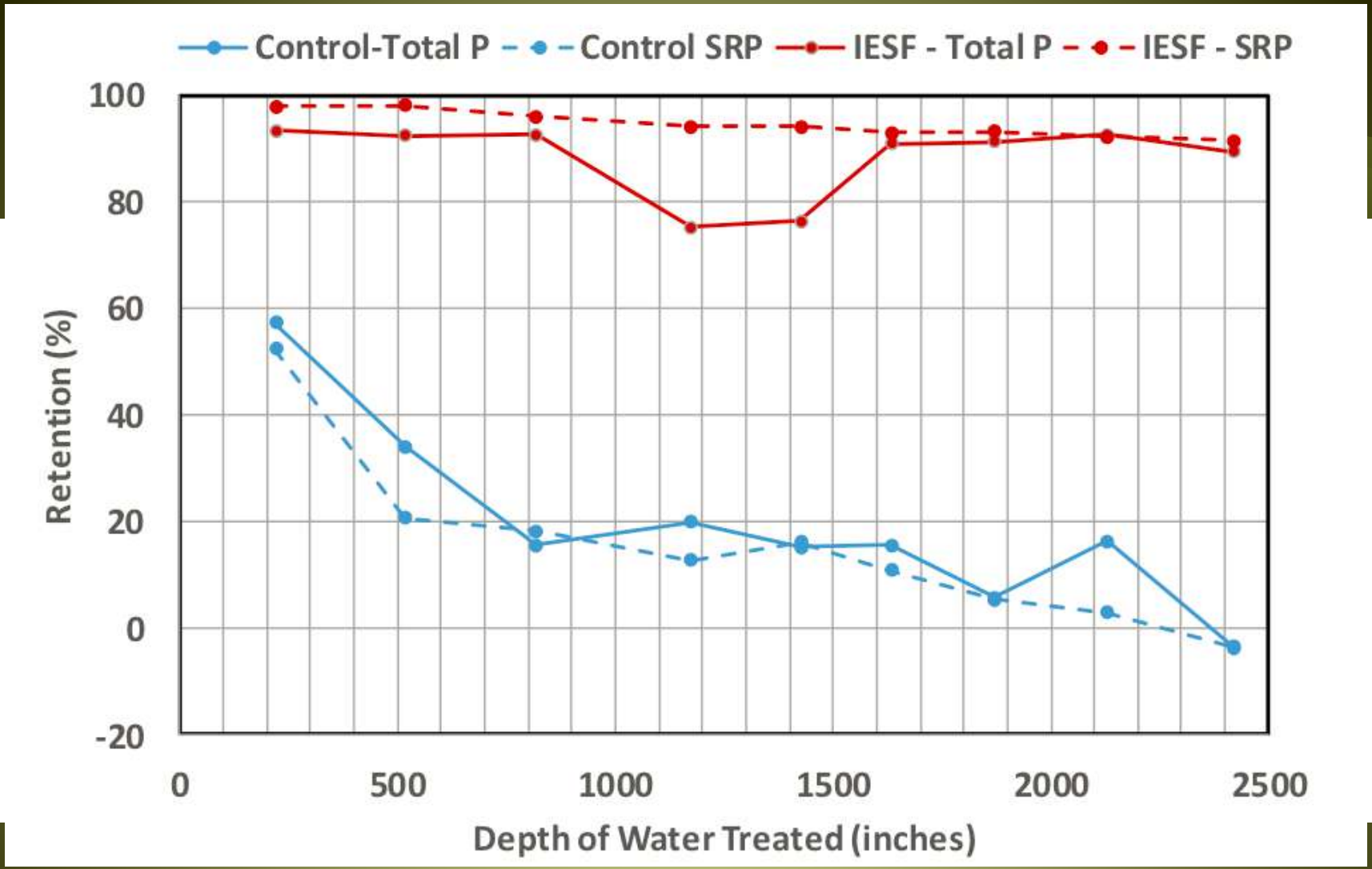
Quality Control

- 5% Iron filings (dry weight)?
- Oven Dry
- 1,000 Gram Media Sample (approximately 2 cups)
- Separate the sample with a magnet
- Weigh abstracted Iron
- Repeat



Erickson, A.J., J.S. Gulliver, and P.T. Weiss. 2007. "Enhanced sand filtration for storm water phosphorus removal, Journal of Environmental Engineering." 133 (5): 485-497.

Erickson, A.J., J.S. Gulliver, and P. T. Weiss. 2012. "Capturing Phosphates with Iron Enhanced Sand Filtration," Water Research, 46(9), 3032–3042.



Weiss, P., Aljobeh, Z., Bradford, C., and Breitzke, E. (2016) An Iron-Enhanced Rain Garden for Dissolved Phosphorus Removal. World Environmental and Water Resources Congress 2016: pp. 185-194. doi: 10.1061/9780784479889.020

BMP Properties

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Watershed | BMP Parameters | BMP Summary

Bioretention basin (with underdrain)

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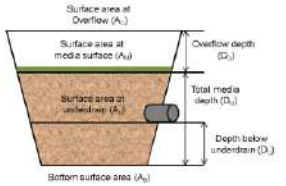

Required treatment volume	3993	ft³
Is the underdrain elevated above native soils?	Yes	
Are the sides of the basin lined with an impermeable liner?	No	
Is the bottom of the basin lined with an impermeable liner?	No	
Surface area at overflow [A_O]	1000	ft²
Media surface area [A_M]	1000	ft²
Surface area at underdrain [A_U]	1000	ft²
Bottom surface area [A_B]	1000	ft²
Overflow depth [D_O]	1.5	ft
Total media depth [D_M]	3	ft
Depth below underdrain [D_U]	1	ft
Media field capacity - wilting point [FC - WP](range 0.05-0.17)	0.1	ft³ / ft³
Media porosity - field capacity [n - FC](range 0.15-0.35)	0.35	ft³ / ft³
Is a tree(s) planted in the BMP?	No	
Bioretention planting media mix	Media Mix B	
Is the P content of the media less than 30 mg/kg?	No	
Is a soil amendment used to attenuate phosphorus?	No	
Underlying soil - Hydrologic Soil Group	B SM (HSG B, 0.45	
Infiltration rate of underlying soils	0.45	in/hr

OK HELP

BMP Properties

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Annual Summary

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Percent annual runoff volume retained:	**34**	**%**
Percent annual Particulate P reduction (via non volume reduction treatment)	0	%
Particulate P load from direct watershed:	1.227	lbs
Particulate P load from upstream BMPs:	0	lbs
Particulate P load reduction:	0.423	lbs
Total percent annual Particulate P reduction:	**34**	**%**
Percent annual Dissolved P reduction (via non volume reduction treatment)	0	%
Dissolved P load from watershed:	1.004	lbs
Dissolved P load from upstream BMPs:	0	lbs
Dissolved P load reduction:	0.346	lbs
Total percent annual Dissolved P reduction:	**34**	**%**
Total percent annual TP reduction:	**34**	**%**

OK HELP

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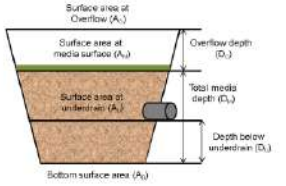

Required treatment volume	3993	ft³
Is the underdrain elevated above native soils?	Yes	
Are the sides of the basin lined with an impermeable liner?	No	
Is the bottom of the basin lined with an impermeable liner?	No	
Surface area at overflow [A_O]	1000	ft²
Media surface area [A_M]	1000	ft²
Surface area at underdrain [A_U]	1000	ft²
Bottom surface area [A_B]	1000	ft²
Overflow depth [D_O]	1.5	ft
Total media depth [D_M]	3	ft
Depth below underdrain [D_U]	1	ft
Media field capacity - wilting point [FC - WP](range 0.05-0.17)	0.1	ft³ / ft³
Media porosity - field capacity [n - FC](range 0.15-0.35)	0.35	ft³ / ft³
Is a tree(s) planted in the BMP?	No	
Bioretention planting media mix	Media Mix B	
Is the P content of the media less than 30 mg/kg?	No	
Is a soil amendment used to attenuate phosphorus?	Yes	
Underlying soil - Hydrologic Soil Group	B SM (HSG B, 0.45	
Infiltration rate of underlying soils	0.45	in/hr

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Percent annual runoff volume retained:	**34**	**%**
Percent annual Particulate P reduction (via non volume reduction treatment)	0	%
Particulate P load from direct watershed:	1.227	lbs
Particulate P load from upstream BMPs:	0	lbs
Particulate P load reduction:	0.423	lbs
Total percent annual Particulate P reduction:	**34**	**%**
Percent annual Dissolved P reduction (via non volume reduction treatment)	40	%
Dissolved P load from watershed:	1.004	lbs
Dissolved P load from upstream BMPs:	0	lbs
Dissolved P load reduction:	0.609	lbs
Total percent annual Dissolved P reduction:	**61**	**%**
Total percent annual TP reduction:	**46**	**%**

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Bioretention basin (with underdrain)

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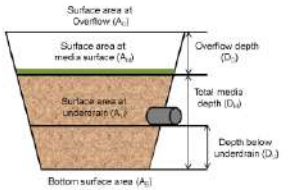


Required treatment volume	3993	ft³
Is the underdrain elevated above native soils?	Yes	
Are the sides of the basin lined with an impermeable liner?	No	
Is the bottom of the basin lined with an impermeable liner?	No	
Surface area at overflow [A_O]	1000	ft²
Media surface area [A_M]	1000	ft²
Surface area at underdrain [A_U]	1000	ft²
Bottom surface area [A_B]	1000	ft²
Overflow depth [D_O]	1.5	ft
Total media depth [D_M]	3	ft
Depth below underdrain [D_U]	1	ft
Media field capacity - wilting point [FC - WP] (range 0.05-0.17)	0.1	ft³ / ft³
Media porosity - field capacity [n - FC] (range 0.15-0.35)	0.35	ft³ / ft³
Is a tree(s) planted in the BMP?	No	
Bioretention planting media mix	Media Mix B	
Is the P content of the media less than 30 mg/kg?	Yes	
Is a soil amendment used to attenuate phosphorus?	No	
Infiltration rate of underlying soils	0.45	in/hr

OK | HELP

BMP Properties

BMP Properties: 1 - Bioretention basin (with underdrain)

Watershed | BMP Parameters | BMP Summary

Annual Summary

Annual water volume from direct watershed:	2.7341	acre-ft
Annual water volume from upstream BMPs:	0	acre-ft
Annual retention volume provided by BMP:	0.9421	acre-ft
Annual outflow volume:	1.7921	acre-ft
Percent annual runoff volume retained:	**34**	**%**
Percent annual Particulate P reduction (via non volume reduction treatment)	80	%
Particulate P load from direct watershed:	1.227	lbs
Particulate P load from upstream BMPs:	0	lbs
Particulate P load reduction:	1.066	lbs
Total percent annual Particulate P reduction:	**87**	**%**
Percent annual Dissolved P reduction (via non volume reduction treatment)	20	%
Dissolved P load from watershed:	1.004	lbs
Dissolved P load from upstream BMPs:	0	lbs
Dissolved P load reduction:	0.478	lbs
Total percent annual Dissolved P reduction:	**48**	**%**
Total percent annual TP reduction:	**69**	**%**

OK | HELP

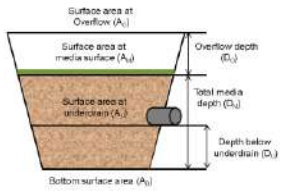
BMP Properties

BMP Properties: 1 - Bioretention basin (with underdrain)

Watershed | BMP Parameters | BMP Summary

Bioretention basin (with underdrain)

$$V = \left[V_{inf\_b} \; or \; \left(\frac{A_U + A_B}{2} * n * D_U\right)\right] + V_{inf\_s} + V_{ET}$$



Required treatment volume	3993	ft³
Is the underdrain elevated above native soils?	Yes	
Are the sides of the basin lined with an impermeable liner?	No	
Is the bottom of the basin lined with an impermeable liner?	No	
Surface area at overflow [A_O]	1000	ft²
Media surface area [A_M]	1000	ft²
Surface area at underdrain [A_U]	1000	ft²
Bottom surface area [A_B]	1000	ft²
Overflow depth [D_O]	1.5	ft
Total media depth [D_M]	3	ft
Depth below underdrain [D_U]	1	ft
Media field capacity - wilting point [FC - WP] (range 0.05-0.17)	0.1	ft³ / ft³
Media porosity - field capacity [n - FC] (range 0.15-0.35)	0.35	ft³ / ft³
Is a tree(s) planted in the BMP?	No	
Bioretention planting media mix	Media Mix B	
Is the P content of the media less than 30 mg/kg?	Yes	
Is a soil amendment used to attenuate phosphorus?	Yes	
Infiltration rate of underlying soils	0.45	in/hr

OK | HELP

BMP Properties

BMP Properties: 1 - Bioretention basin (with underdrain)

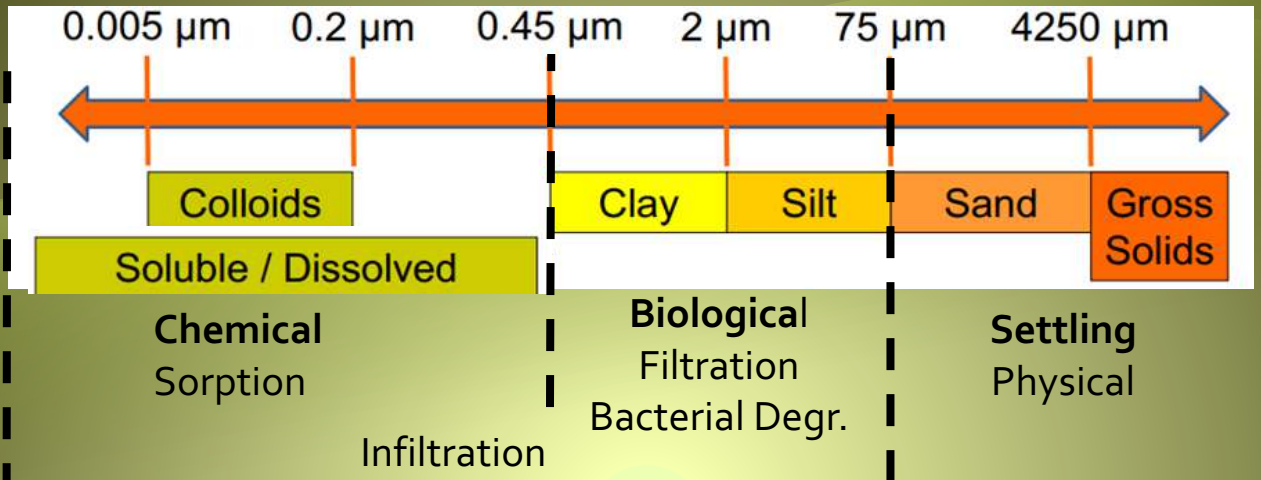
Watershed | BMP Parameters | BMP Summary

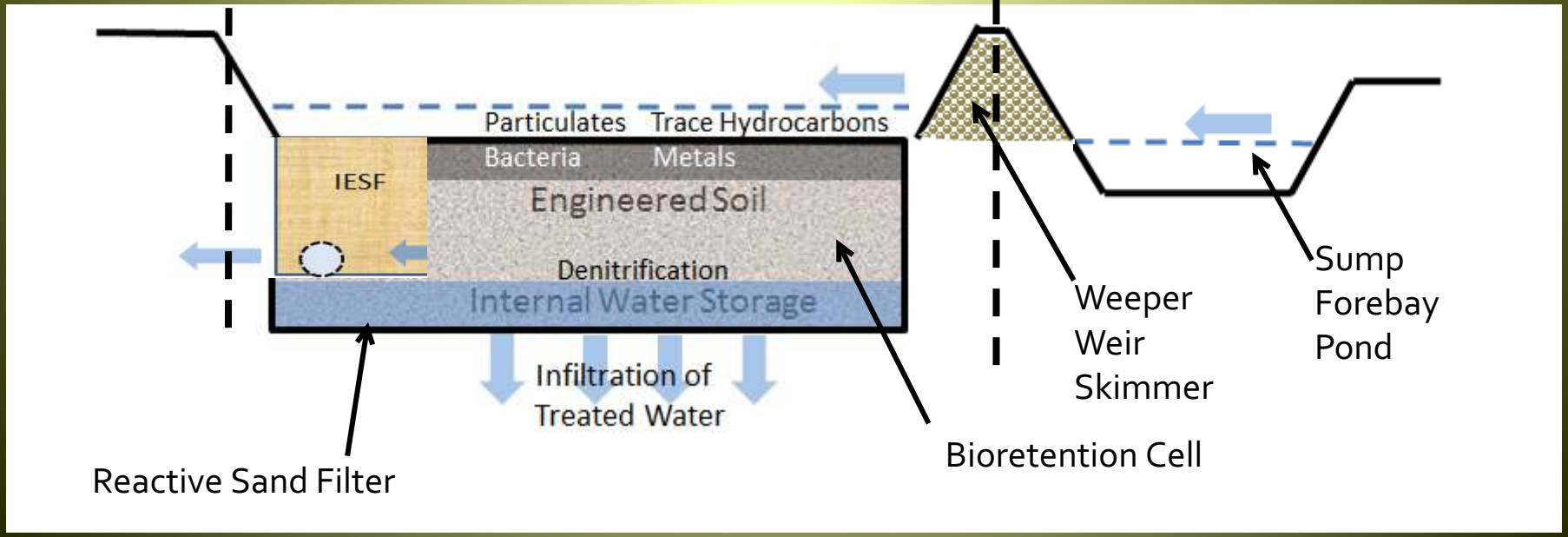
Annual Summary

Annual water volume from direct watershed:	2.7341	acre-ft
Annual water volume from upstream BMPs:	0	acre-ft
Annual retention volume provided by BMP:	0.9421	acre-ft
Annual outflow volume:	1.7921	acre-ft
Percent annual runoff volume retained:	**34**	**%**
Percent annual Particulate P reduction (via non volume reduction treatment)	80	%
Particulate P load from direct watershed:	1.227	lbs
Particulate P load from upstream BMPs:	0	lbs
Particulate P load reduction:	1.066	lbs
Total percent annual Particulate P reduction:	**87**	**%**
Percent annual Dissolved P reduction (via non volume reduction treatment)	60	%
Dissolved P load from watershed:	1.004	lbs
Dissolved P load from upstream BMPs:	0	lbs
Dissolved P load reduction:	0.741	lbs
Total percent annual Dissolved P reduction:	**74**	**%**
Total percent annual TP reduction:	**81**	**%**

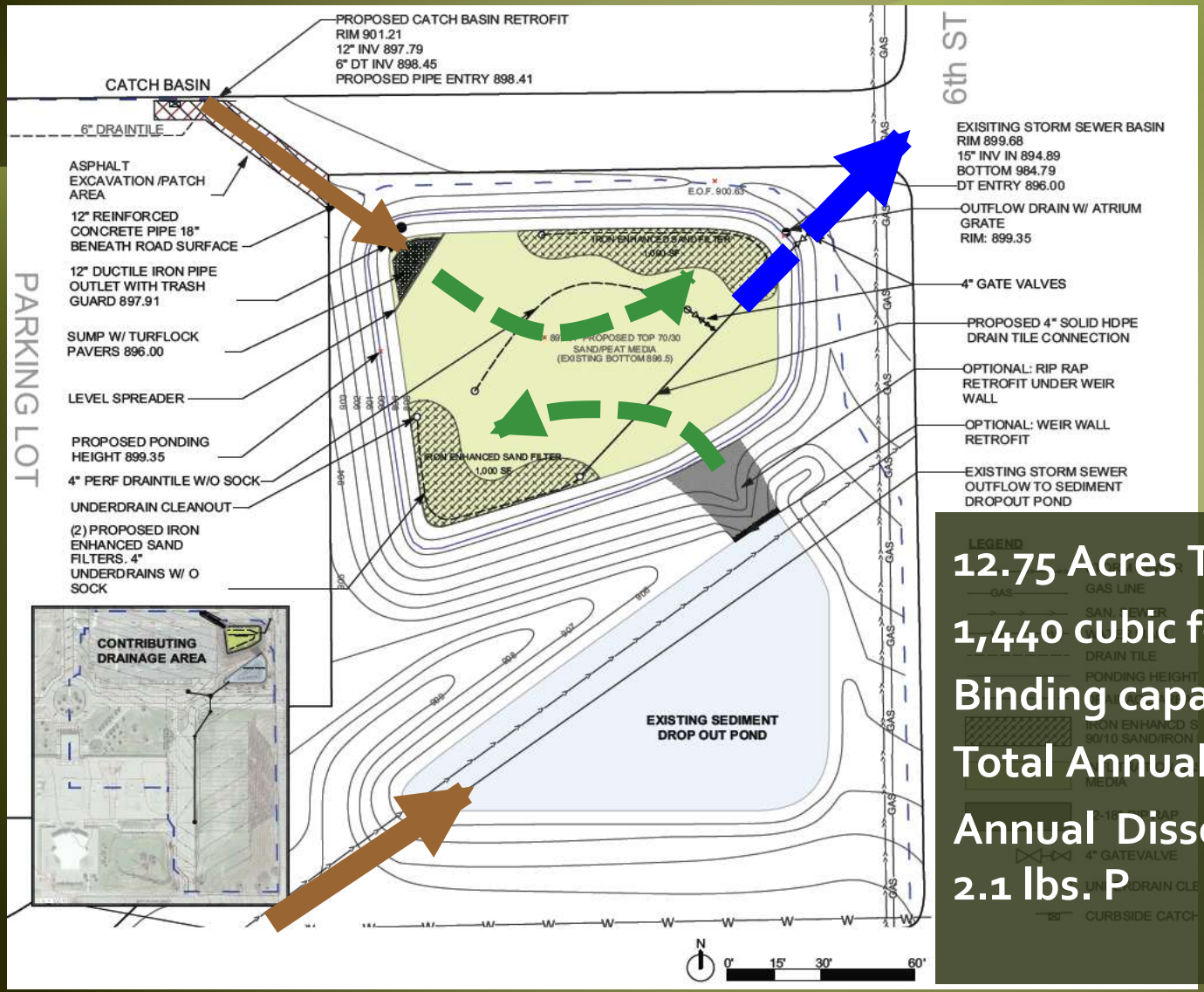
OK | HELP

Targeting Stormwater Pollutants





Lake St. Croix 2017



12.75 Acres Total Watershed

1,440 cubic feet IESF

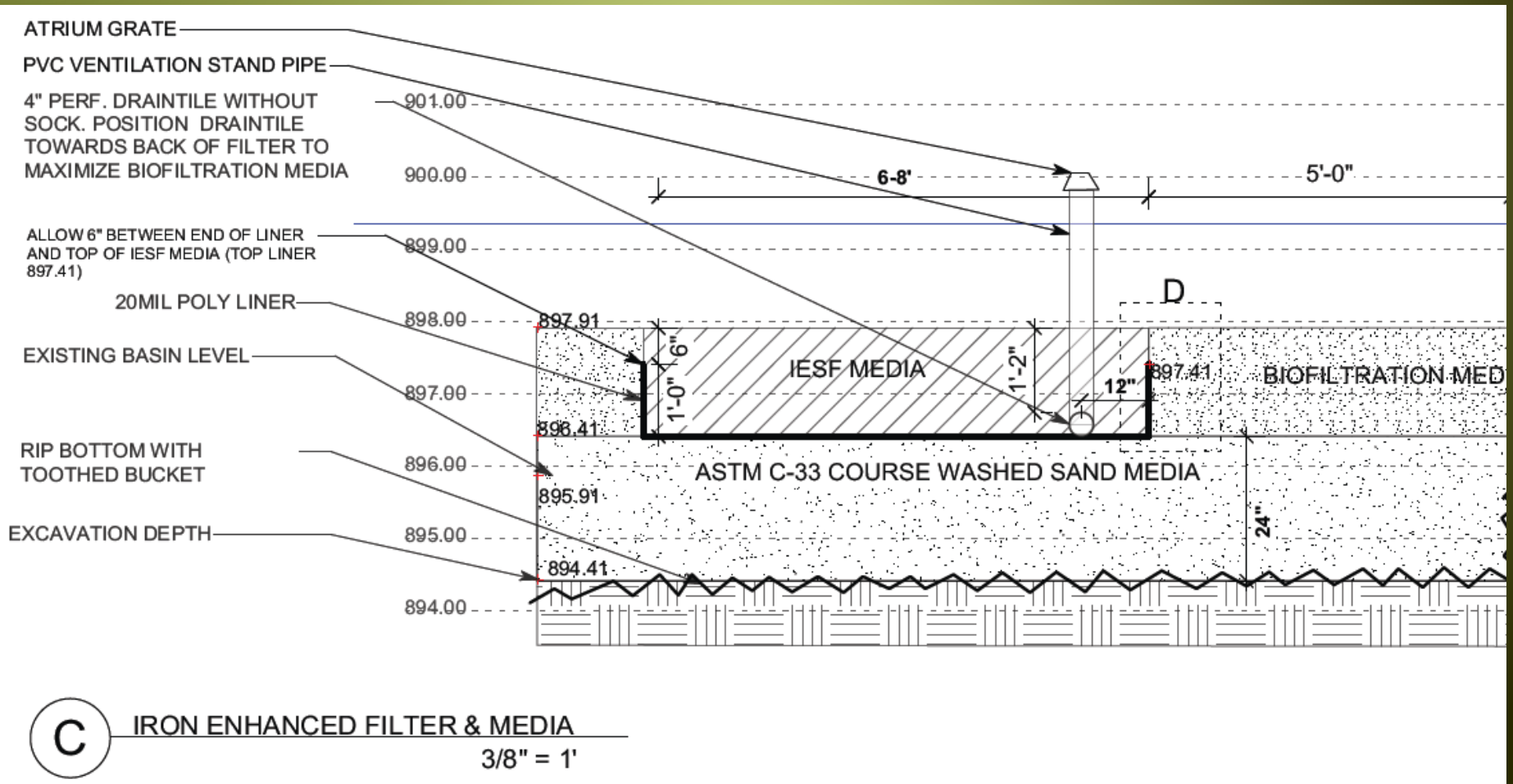
Binding capacity 40 lbs.

Total Annual Load = 12.46 lbs. P

Annual Dissolved P Reduction = 2.1 lbs. P

City of Stillwater 2017 Eng. Estimate $96,000

Engineered Media



C IRON ENHANCED FILTER & MEDIA
3/8" = 1'

Questions?

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Thank You!

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Bryan Pynn, Senior Water Restoration Technician

Jim Davidson, CPSWQ, CPESC, Urban Conservationist
Curt Coudron, CPESC, Senior Resource Conservationist