



Evaluation of Publicly Maintained Bioretention Facilities

Does good maintenance guarantee optimum performance?

Phase I and II studies

Prepared for:
 The Department of Public Works and Environmental Services,
 Maintenance and Stormwater Management Division By
 The Northern Virginia Soil & Water Conservation District



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Facts:

- In Fairfax County there are close to 130 publicly and 550 privately maintained bioretention facilities
- Currently 80%-90% of infill lots and 50%-60% of SP and SD plans include bioretention as their main SWM practice
- Bioretention facilities are a widely used and accepted BMP.

Questions:

- What if the newly commissioned facilities are not performing as expected?
- Do we have the right tools to determine the inadequate performance?
- What are the main reasons for inadequate performance?
- Can the current inspection and maintenance guidelines detect these inadequacies?

Main purpose of this study:

To develop protocols to assess the structural and nonstructural elements that determine the performance of a bioretention facility early in its lifespan.

With the goal of:

Using the findings to create design and construction recommendations that, if implemented, may decrease the frequency and costs of routine maintenance, partial facility repairs and full rehabilitation.

Inventory of Facilities Evaluated			
Evaluation Phase	No. of Facilities	Year evaluated	Facility Age
Phase I	63	2014	2000-2009
Phase II	27	2015	2010-2014
Phase III	40	2016	2015-2016

- *All are publicly maintained (Fairfax County DPWES maintains them)*
- *All built in compliance with SWM requirements for a new development or redevelopment or in compliance with the County's MS4 obligations*

The Process

1. *Developing an evaluation protocol:*
2. *Performing the physical survey*
 - I. *Ponding area*
 - II. *Soil media*
 1. *Infiltration rate*
 2. *Media particle size distribution (sand, silt, clay)*
 3. *Soil media depth*
 - III. *Surface area (footprint)*
 - IV. *Structural components of the facility*
3. *Performing plants survey*
4. *Findings, conclusions, and recommendations*

Evaluation Protocol

Standard Operating Procedures (SOP)

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STANDARD OPERATING PROCEDURES FOR BIORETENTION EVALUATION

PREPARED FOR:
FAIRFAX COUNTY DEPARTMENT OF
PUBLIC WORKS AND
ENVIRONMENTAL SERVICES
MAINTENANCE AND STORMWATER
MANAGEMENT DIVISION

BY:
NORTHERN VIRGINIA SOIL & WATER
CONSERVATION DISTRICT

February 2015

Evaluation Protocol

Evaluation Survey Form

Field Evaluation Cont.

Structural Evaluation Cont.	
Overflow Structure	Sign of deterioration: <input type="checkbox"/> yes <input type="checkbox"/> No Erosion/scour: <input type="checkbox"/> yes <input type="checkbox"/> No Blockage: <input type="checkbox"/> yes <input type="checkbox"/> No
Cleanout pipes	Capped: <input type="checkbox"/> yes <input type="checkbox"/> No Perforated: <input type="checkbox"/> yes <input type="checkbox"/> No Signs of defect: <input type="checkbox"/> yes <input type="checkbox"/> No (if yes describe):
Access Road	Accessible: <input type="checkbox"/> yes <input type="checkbox"/> No Signs of encroachment: <input type="checkbox"/> yes <input type="checkbox"/> No
Nonstructural evaluation	
Planting	Number of existing plants: (locate on the attached planting plan) Type of existing plants: (highlight on the attached planting list) Presence of invasive plants: <input type="checkbox"/> yes <input type="checkbox"/> No Presence of weeds: <input type="checkbox"/> yes <input type="checkbox"/> No Presence of dead and/or dying plants: <input type="checkbox"/> yes <input type="checkbox"/> No Need for pruning: <input type="checkbox"/> yes <input type="checkbox"/> No Wetland plants present: <input type="checkbox"/> yes <input type="checkbox"/> No
Overall evaluation	
Mulch	Average thickness (inches): Bare surface present: <input type="checkbox"/> yes <input type="checkbox"/> No (if yes, approx. percentage of total area):
Sediment accumulation inside ponding area	<input type="checkbox"/> yes <input type="checkbox"/> No
Was there base flow coming into the bioretention at the time of the visit? <input type="checkbox"/> yes <input type="checkbox"/> No	
Contributing Drainage Area: Signs of Erosion: <input type="checkbox"/> yes <input type="checkbox"/> No	
Observations:	

Note: Please take pictures of any structural and nonstructural deterioration

* Not for all bioretentions. Infiltration rate will be measured as needed

** Ensure that standing water is not due to a recent rainfall. Bioretention facilities are allowed to have standing water up to 24 hours following a storm event.

Fairfax County DPWES, MSMD
Publicly Maintained Bioretention Facilities
Bioretention Evaluation Checklist

General information

MSMD facility ID:
Location address:
Weather conditions at the time of the visit:
Date the facility became operational:
Date evaluated:
Evaluated by:

Design Specs: Should be completed prior to field evaluation using the approved site plan

Surface area (sf):	Ponding depth (ft):	Soil depth (ft):
Underdrain: <input type="checkbox"/> Yes <input type="checkbox"/> No	Pre-treatment: <input type="checkbox"/> Yes <input type="checkbox"/> No	Type:
Geotextile: <input type="checkbox"/> Yes <input type="checkbox"/> No if yes, where?		
Inflow: <input type="checkbox"/> Pipe <input type="checkbox"/> Open channel <input type="checkbox"/> Sheet flow <input type="checkbox"/> Others		
Overflow: <input type="checkbox"/> Pipe <input type="checkbox"/> Berm <input type="checkbox"/> Others		
A copy of planting plan and plants types and numbers' table are attached		

Field Evaluation:

Measurements:

Surface Area (sf):	Depth of Planting Soil (in):	Soil sample taken: <input type="checkbox"/> yes <input type="checkbox"/> No					
In situ infiltration Rate (in/hr)*:							
Profile survey: Reference point is the elevation of the overflow structure:							
Distance (ft)	Elev. (ft)	Distance (ft)	Elev. (ft)	Distance (ft)	Elev. (ft)	Distance (ft)	Elev. (ft)

Structural Evaluation:

Pretreatment	N/A <input type="checkbox"/> Sediments accumulation: <input type="checkbox"/> yes <input type="checkbox"/> No Sign of deterioration: <input type="checkbox"/> yes <input type="checkbox"/> No
Ponding Area	Sediment accumulation: <input type="checkbox"/> yes <input type="checkbox"/> No Slope erosion: <input type="checkbox"/> yes <input type="checkbox"/> No Debris: <input type="checkbox"/> yes <input type="checkbox"/> No Evidence of waterlogging/wet spots***: <input type="checkbox"/> yes <input type="checkbox"/> No (if Yes % of area covered): Evidence of short circuiting: <input type="checkbox"/> yes <input type="checkbox"/> No
Inflow Structure	Sign of deterioration: <input type="checkbox"/> yes <input type="checkbox"/> No Erosion/scour: <input type="checkbox"/> yes <input type="checkbox"/> No Blockage: <input type="checkbox"/> yes <input type="checkbox"/> No

Evaluation Protocol

Data Organization and Access

- Missing <0.5 feet depth: 0 points
- Missing 0.5-1.0 feet depth: 1 points
- Missing 1.0-1.5 feet depth: 3 points
- Missing 1.5-2.0 feet depth: 5 points

BR ID	District	Age of Facility (Yr.)	Inventory Date	Date Visited	Address	City, State, Zip	
BR0299	Braddock	3.64109589	12/17/2010	06/30/14	7825 Heritage Dr	Annandale, VA 22003	BRADDOCK ELEMENTARY SCHOOL - 10 CLASSROOM MODULAR ADDITION
BR0300	Braddock	3.64109589	12/17/2010	06/30/14	7825 Heritage Dr	Annandale, VA 22003	BRADDOCK ELEMENTARY SCHOOL - 10 CLASSROOM MODULAR ADDITION

Observations

- Potential for weed growth, looks like recently cleaned
- Inflow pipes and overflow berms are within close proximity, majority of flow occurs at narrow end of facility
- Very little ponding depth available due to the berm elevation (ex. Ponding average depth = 0.06 ft.)
- It appears that there is an opening in the overflow berm along station 0+50 feet (Station 0+00 is on the opposite side of the parking area). The opening is approximately 2 feet at bottom and 4 feet at top, graded nicely.
- The present elevation of the overflow berm (at two locations) does not provide the design ponding depth of 0.5 ft. The inflow pipes (2 pipes, 4" and 6") are broken

Recommendations

- This facility at the present is not functioning due to absence of ponding area
- The design ponding depth (0.5 ft.) can be improved by either of the following options:
 - Correcting the elevation of top of the berm. This should be done by opening a stable spillway at a right elevation along the berm preferably in the middle of the perm. If this option is chosen, still the surface of the facility needs to be graded to have a flat surface.
 - Or, by shallow excavation inside the facility. The existing planting soil depth is 3.5 ft. this is much more the minimum requirement of 2.5 ft. By removing the top 0.5 ft. the facility still complies with the new VA SW guidelines for bioretentions (Design Level 1).
- The inflow pipes (2 pipes, 4" and 6") are broken and need to be repaired (see pictures in the photo folder)
- The pipe outfall needs to be protected. A small plunge pool at the outfall can protect the RG surface (proposed pool diameter approx. 2.0 ft)
- The cleanout pipe is broken and is uncapped. Needs to be repaired
- Flow from the sidewalk enters top of the rain garden next to the parking lot and bypass the rain garden. Slight erosion has happened. This can be repaired by grading to allow runoff entering the garden instead of bypassing (see picture in the photo folder).

Surface Area (s.ft.)			
Design	Actual	% Missing	Points
927.0	730.0	21.3	3.0
842.0	738.0	12.4	2.0

Soil Media Composition (%)				
Depth 1	Depth 2			
	clay	sand	silt	clay
0	4.0			
0	4.0			

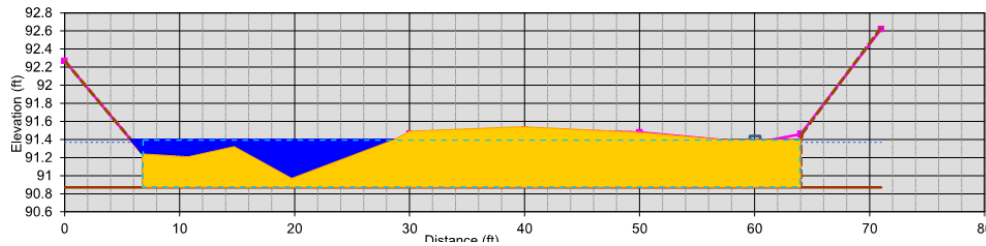
Standing water	Cleanout pipe	Inflow	
		channel	she
		1.0	
		1.0	1.0

Total Points
4.0
2.0
7.0
7.0



Evaluation Protocol

Repair priority rating criteria 1345BR



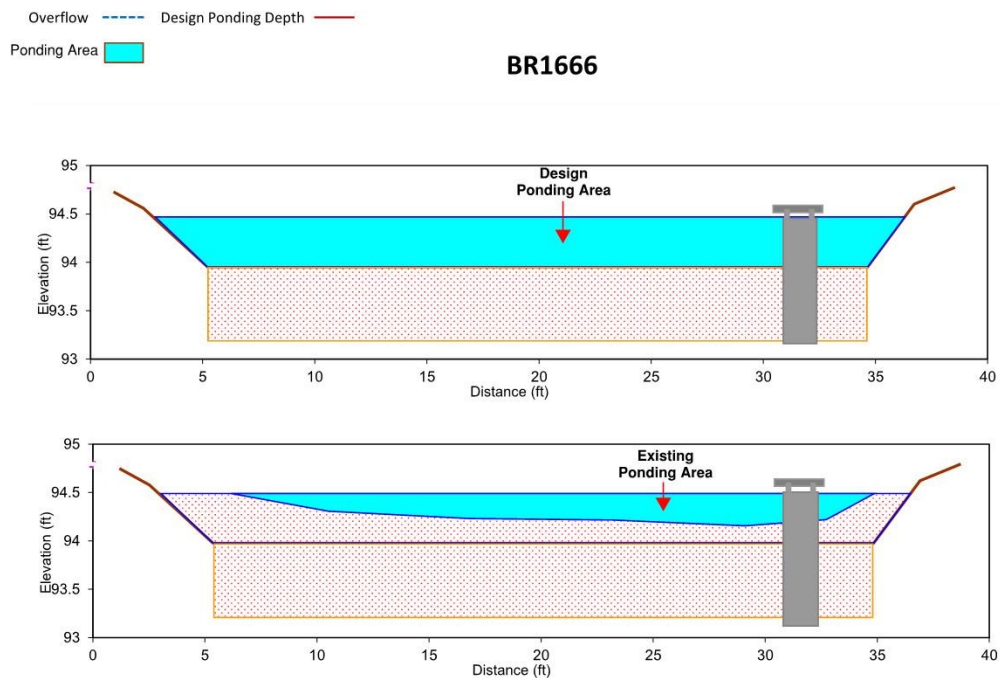
Evaluation	Design	Actual	Missing	Points
Ponding depth	0.5 ft.	0.1 ft.	80%	7.5
Infiltration rate	8.0 in/hour	24.0 in/hour	-	2
Structural damage				2
Total Points				11.5

Physical Survey

- *Ponding area*
- *Soil media*
 - *Soil media depth*
 - *Infiltration rate*
 - *Media particle size distribution (sand, silt, clay)*
- *Surface area (footprint)*
- *Structural components of the facility*

Physical Survey

Topographic survey of the ponding area



Top of the berm seems to serve as the overflow

Overflow (ft.) = 94.21



Physical Survey

Soil media infiltration rate



Date: 07/20/2014				
Number of Measurements		4		
#	Time (min)	intervals (min)	Readings (ft)	Rate (in/hour)
1	0	5	0.44	0
2	5	5	0.42	2.88
3	10	5	0.38	5.76
4	15	5	0.32	8.64
		I Rate (in/hour)		5.76
% sand	82			
% silt	12			
% clay	6			
%org. matter	2.4			
Textural Class	loamy sand			

Physical Survey

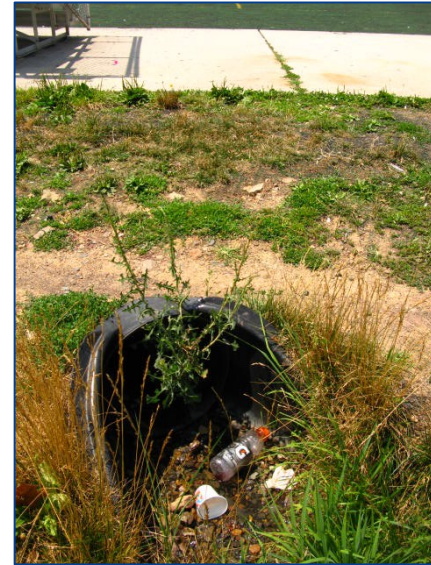
Soil media depth & particle size

% sand	82
% silt	12
% clay	6
%org. matter	2.4
Textural Class	loamy sand



Physical Survey

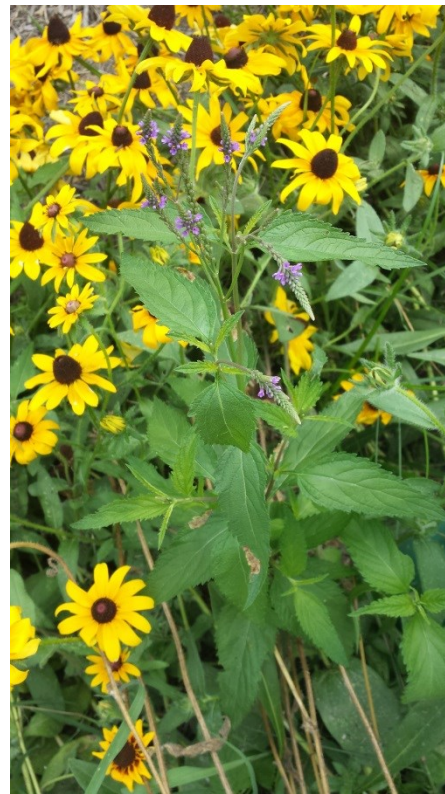
Structural Survey



Plants Survey

*Survey existing plant population
with the intention of finding:*

- The survival rate of the original plantings*
- Plant species that survived best*
- Dominant voluntary plants (weeds, perennials, shrubs, and trees)*



Findings

Compliance with the original design ***Ponding depth***

Phase I

67% of evaluated facilities did not comply with the original design

% of Total	Missing Ponding Depth
33%	None
20%	<25%
20%	25%-50%
13%	50%-75%
14%	>75%

Phase II

56% of evaluated facilities did not comply with the original design

% of Total	Missing Ponding Depth
44%	None
37%	<25%
11%	25%-50%
4%	50%-75%
4%	>75%

Findings

Compliance with the original design Soil media depth

Phase I

59% of bioretention did not comply with design soil media depth

% of Total	Missing Soil Media Depth
41%	None
11%	<0.5 ft.
24%	0.5-1.0 ft.
17%	1.0-1.5 ft.
8%	1.5-2.0 ft.

Phase II

52% of evaluated facilities did not comply with the original design

% of Total	Missing Soil Media Depth
48%	None
15%	<0.5 ft.
19%	0.5-1.0 ft.
3%	1.0-1.5 ft.
15%	1.5-2.0 ft.

Findings

Compliance with the original design Infiltration rate

Phase I Evaluation Study

Number of Facilities	Rate (inches/hour)
5% (3)	<0.5*
40% (27)	0.5-8
15% (9)	8-12
22% (13)	12-20
8% (5)	20-30
10% (6)	>30

Phase II Evaluation Study

Number of Facilities	Rate (inches/hour)
12.5% (5)	<0.5*
37.5% (9)	0.5-8
17.0% (4)	8-12
12.5% (3)	12-20
8.0% (2)	20-30
4.0% (1)	>30

* 0.5 in/hour is the minimum acceptable saturated hydraulic conductivity (VA SWM BMP Clearing House)
8.0 in/hour Maximum infiltration rate (Bill Hunt, NC State University, personal communication). 24 facilities comply

Findings

Compliance with the original design Soil media particle size analysis (Phase I)

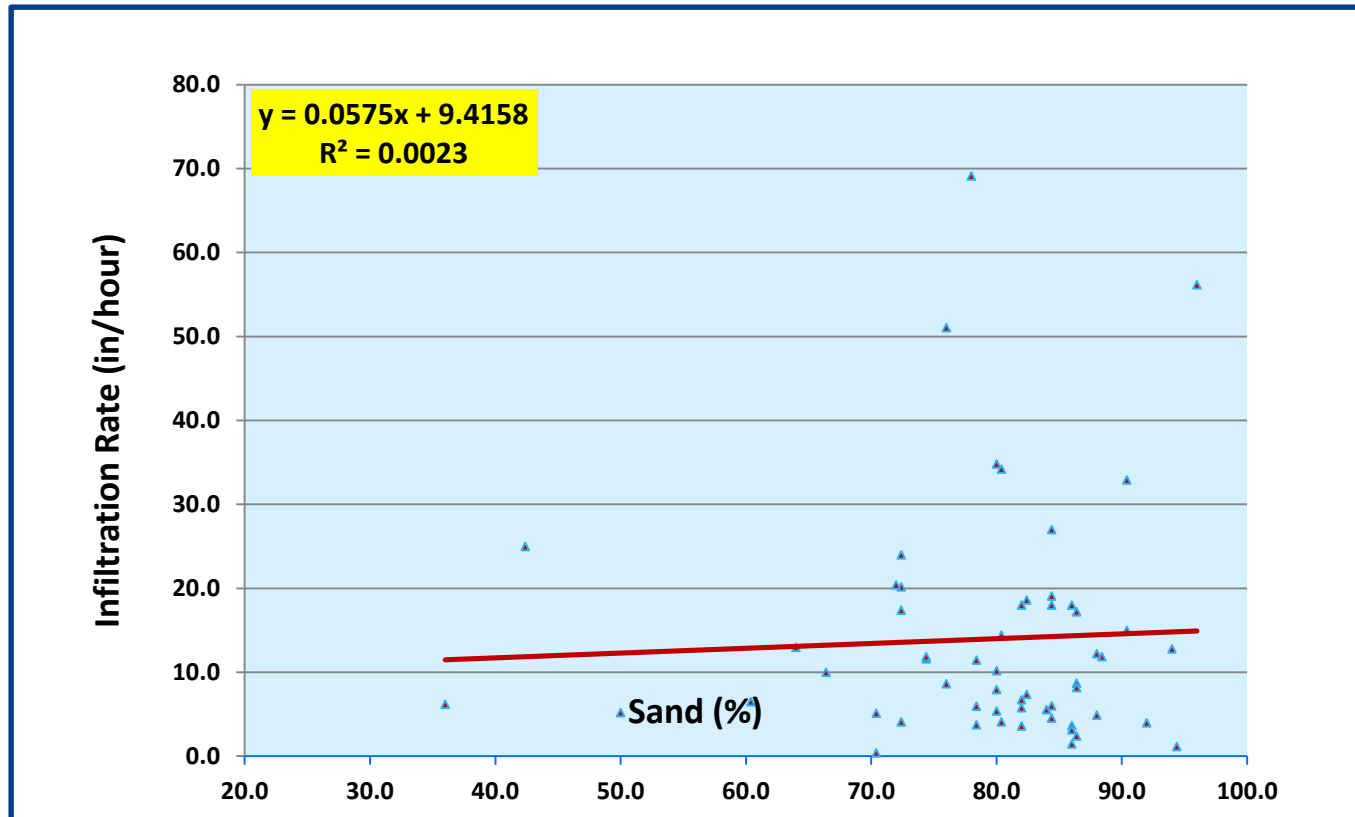
Particle Type	Measurements	VA SWM BMP Clearing House	PFM	VA SWM Handbook (1999)
Sand	36% to 96 %	85% - 90%	60%-75%	50%
Silt + Clay	2% to 42 %	<20%		-
Clay	2% to 25%	<10%	<8%	<5%
<i>Organic matter</i>	<i>0.5%-22.6%</i>	<i>3%-5%</i>	<i>5%-15%*</i>	<i>20%*</i>

* Compost

Findings

Compliance with the original design

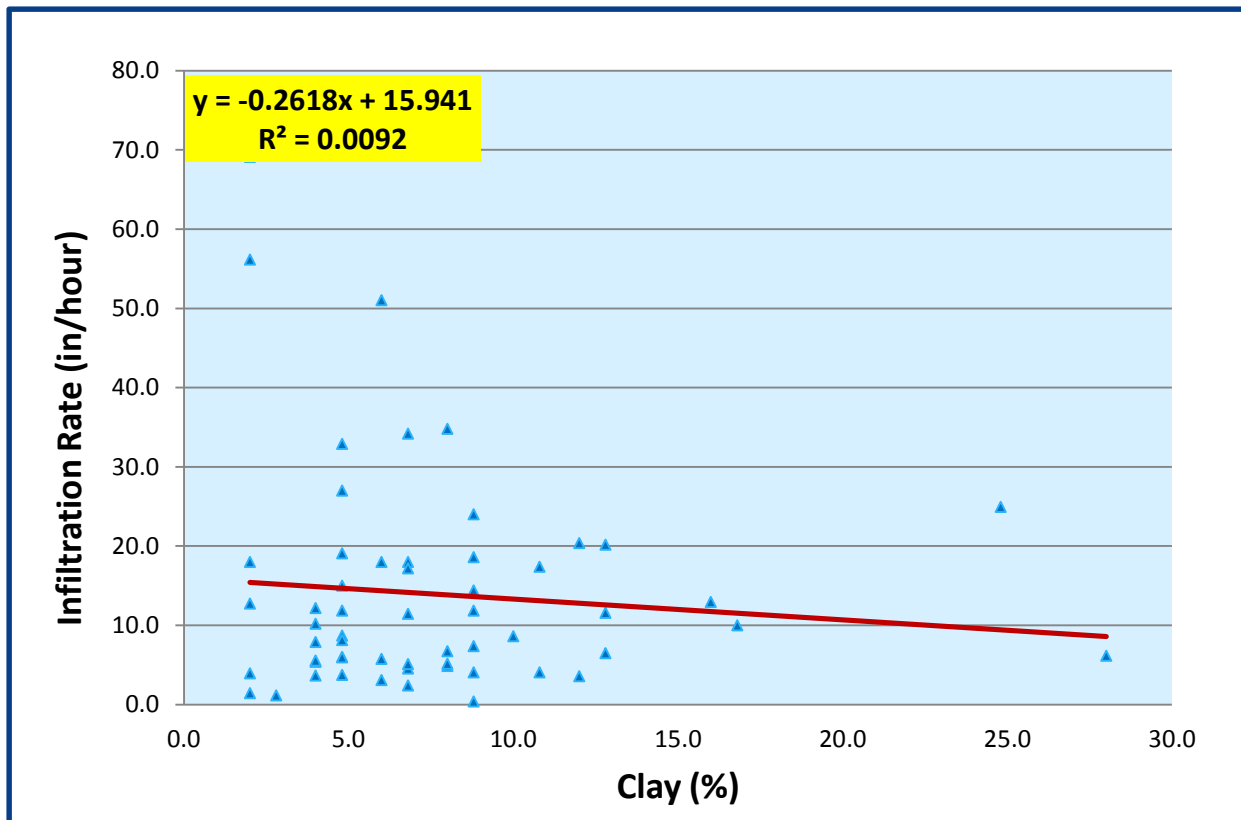
Soil media particle size analysis



Findings

Compliance with the original design

Soil media particle size analysis



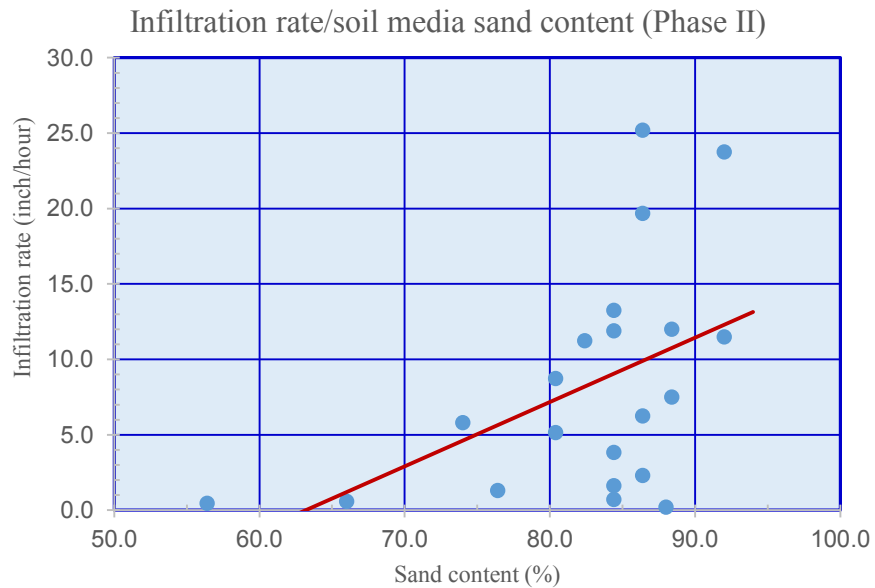
Findings

Compliance with the original design Soil media particle size analysis (Phase II)

Particle Type	VA SWM BMP Clearing House	PFM	VA SWM Handbook (1999)
Sand	91.0%	8.8%	0.0%
Clay	91.0%	87.0%	34.0%

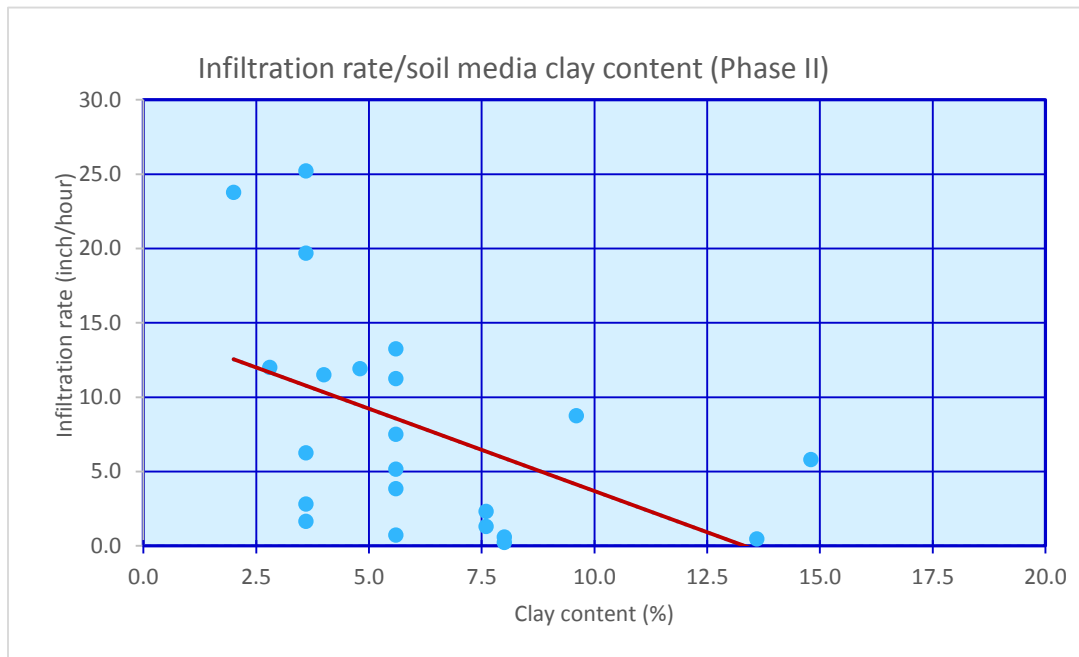
Findings

Compliance with the original design Soil media particle size analysis



Findings

Compliance with the original design Soil media particle size analysis



Findings

Compliance with the original design Soil media particle size analysis

Sand particle size distribution (ASTM-C33)

Washed Concrete Sand

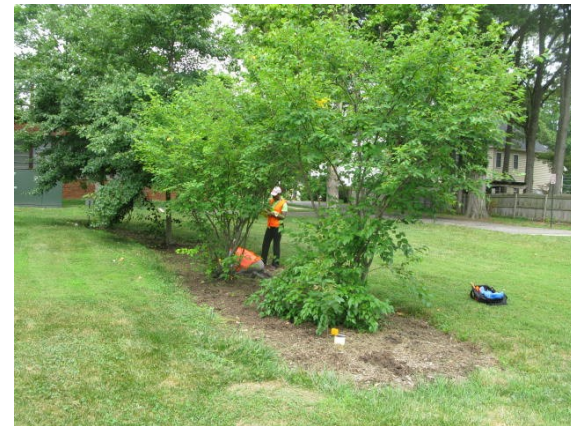
Sieve Size	3/8"	#4	#8	#16	#30	#50	#100	#200
% Passing	100.0	98.9	95.7	84.3	54.2	14.1	1.8	.62
Limits	100-100	95-100	80-100	50-85	25-60	5-30	0-10	0-3
Absorption	0.07							
Unit Wt (Loose)	95.5							
SPGR	2.62							
Unit Wt (Rodded)						100.8		
Soundness						3.3		

Handwritten notes:
 Above #4: 4.75 mm, 2.4
 Above #8: 2.36 mm, 11.0%
 Above #16: 1.18 mm, 15.7%
 Above #30: 0.6 mm, 45.8%
 Above #50: 0.30 mm, 85.9%
 Above #100: 0.15 mm, 98.2%
 Above #200: 0.075 mm, 99.38%
 Under Absorption: re-faired → 0%
 Under Unit Wt (Loose): 1.1%, 4.3%
 Under Unit Wt (Rodded): 15.7%, 45.8%
 Under Soundness: 85.9%, 98.2%, 99.38%
 Under Soundness: N 0.02 - 0.04" Or 0.5 mm or 0.04 mm
 Under Soundness: nothing through

Gradation is based on an average of several tests. Individual results may vary.

Findings

Inadequate structural type



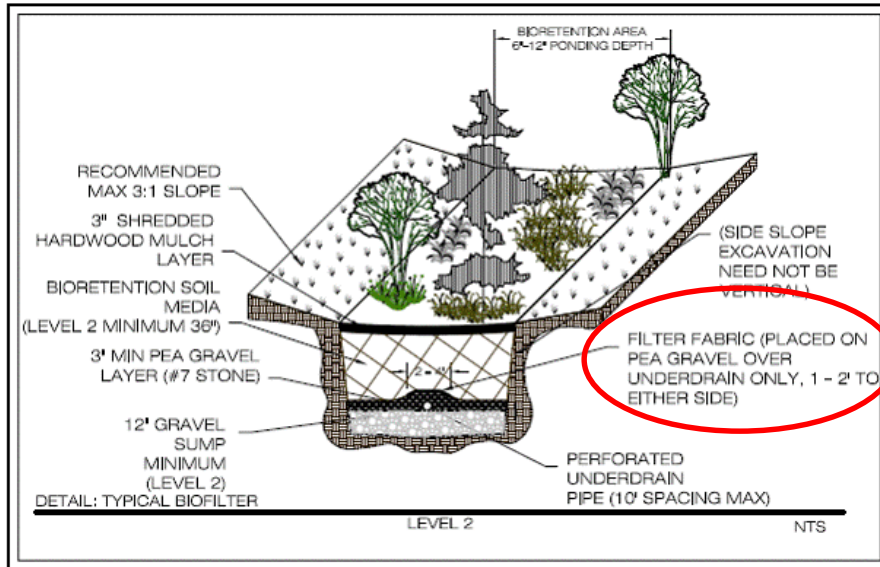
Findings

Damaged structural components



Findings

The Impact of filter fabric on hydrodynamic performance



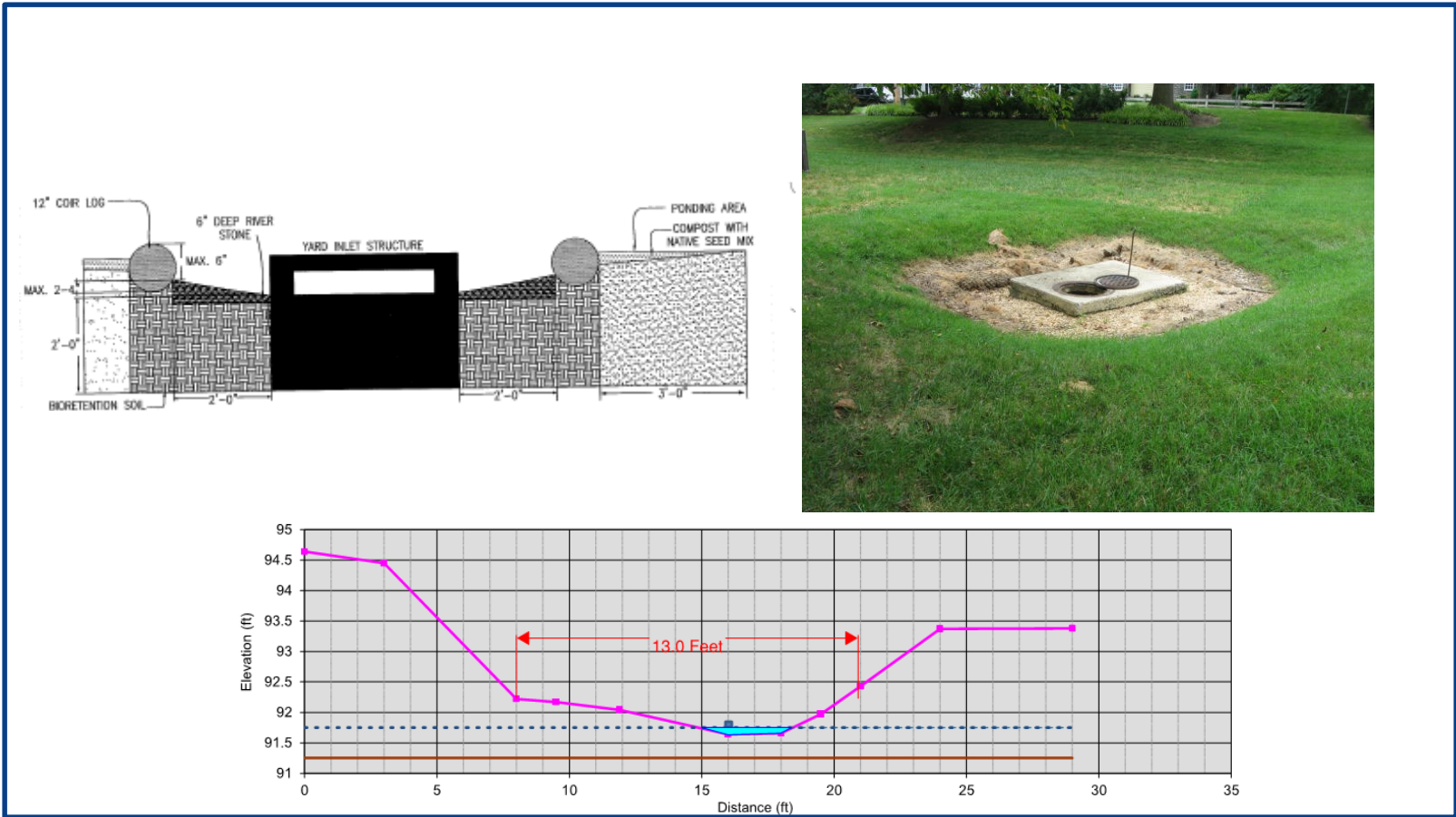
Findings

Seepage or continuous base flow into bioretention facility might develop localized wetlands.



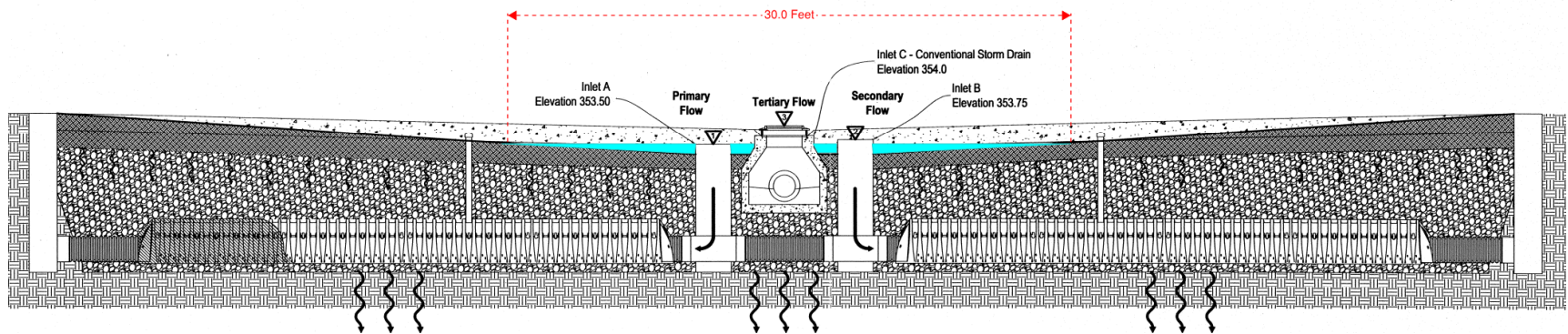
Findings

Facilities that might not qualify as bioretention



Findings

Facilities that might not qualify as bioretention



Recommendations

Lack of compliance is a major construction issue:

- *Improvement in construction oversight*
 - *Guidelines for construction sequencing and inspection*
 - *Guidelines for preparing the as-built*
 - *Trained construction inspectors*
 - *Documentation (as-built) during construction including guidelines*
- *Local inspection certification program*

Recommendations

- *Restoring missing ponding depth for facilities built prior to new VA SWM plan guidelines might not be required.*
- *Restoring the soil media depth will be complicated.*
 - *More than one foot depth loss might need to be reviewed.*
 - *The BMP credit could be revised.*
- *High infiltration rate impacts BMP and runoff reduction performance (under drain).*
 - *Outflow rate could be adjusted to provide the inflow residency time.*

Recommendations

- *Eliminate or divert continuous base flow into the bioretention.*
- *Although filter fabric did not have a negative impact on vertical flow, 6.0" of pea gravel is a preferred option.*
- *Within 6 months after construction is complete, survey/evaluate the facility using the SOP developed during this study, and at least every 5 years thereafter.*
- *Share the results with other DPWES divisions, private industry, other jurisdictions.*