R. Pitt and J. Voorhees
February 28, 2016
Rev February 25, 2019

Description of the Contech StormFilter in WinSLAMM

Contents

Introduction

Contech contracted with PV&Assoc. to incorporate their StormFilter (SF) into WinSLAMM. The SF has been available for many years as a proprietary stormwater treatment device incorporating various media in cartridges. It has been used at many types and scales of locations, from treating runoff from small roofs to large paved areas. The SF has undergone many laboratory and field evaluation performance tests for a variety of conditions. The steps used to incorporate the SF into WinSLAMM were as follows:

- Obtained detailed SF descriptions from Contech, including operational modes, dimensions, media types, etc.
- Collected all available laboratory and field performance evaluation information

- Evaluated the data and identified significant factors affecting SF stormwater treatment performance; prepared performance relationships for these significant factors
- Developed WinSLAMM code describing the hydraulic performance of the SF and the ancillary components (including several on-line and off-line storage and bypass options)
- Developed WinSLAMM code describing the water quality performance (generally influent vs. effluent concentration relationships) for the different configurations and media, based on the available data
- Compared the modeled performance of the SF in WinSLAMM with the observed performance information
- Meet with Contech personnel over the course of the development of these model enhancements to review data, information, and assumptions and to obtain additional clarifying information, as needed.

The following discussions summarize the information and how the SF was incorporated into WinSLAMM

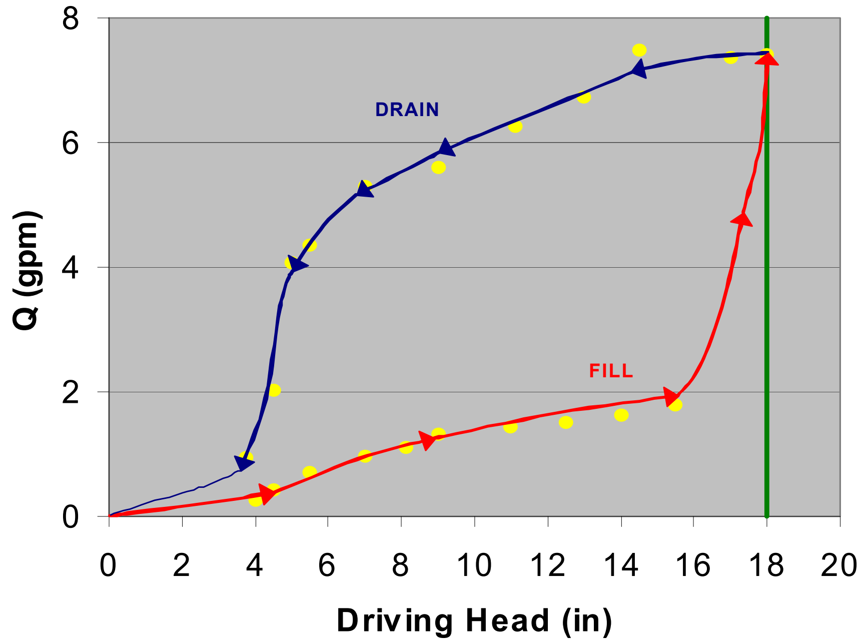
Background Information

This white paper briefly describes some of the available data used to model the performance of the StormFilter in WinSLAMM. It specifically focuses on flow rates, particulate removals by particle size, and filterable pollutant removals, along with some of the performance equations used in WinSLAMM to describe these performance relationships.

Work began on incorporating the StormFilter into WinSLAMM in 2009. On March 26, 2016, WinSLAMM version 10.2.1, which included the StormFilter, was released. Minor modifications or bug fixes were included in some subsequent releases.

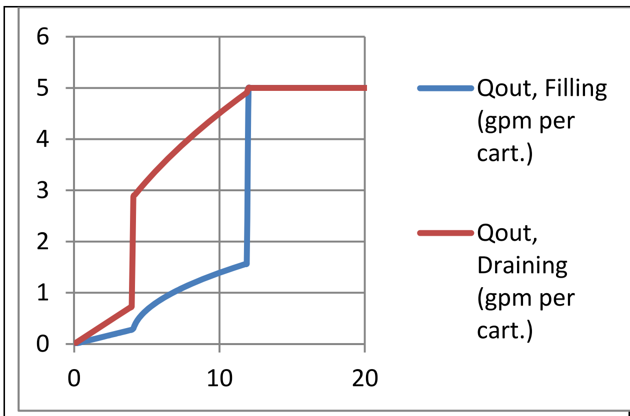
Flowrates of StormFilter Cartridges

The following figure shows the basic flow characteristics for the StormFilter cartridges. For the same water depth, the fill rate is substantially less than the drainage rate (it drains faster than it fills).

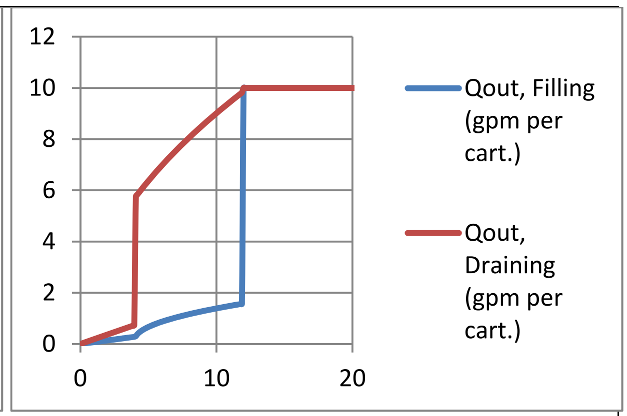


StormFilter cartridge stage-discharge relationship for 18 inch at 1 gpm/ft^2, max 7.5 gpm

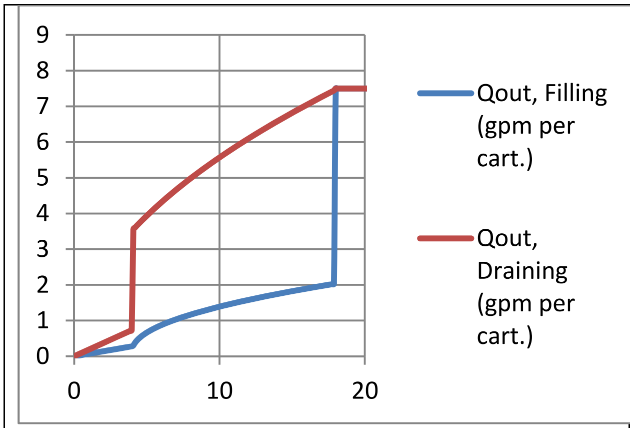
The following figures are from the computer code in WinSLAMM describing the flow rates for the different cartridge heights and flow controlling orifices, based on equations supplies by Contech. These resemble the stage-discharge curve shown above from laboratory tests for an 18 inch cartridge operating at 1 gpm/ft^2. These curves show a distinct hysterias with much greater flows associated with draining of the cartridges compared to filling of the cartridges.



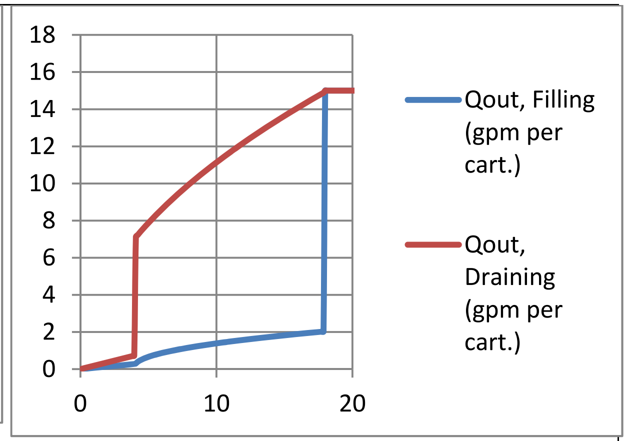
12 inch at 1 gpm/ft^2 (5 gpm max)



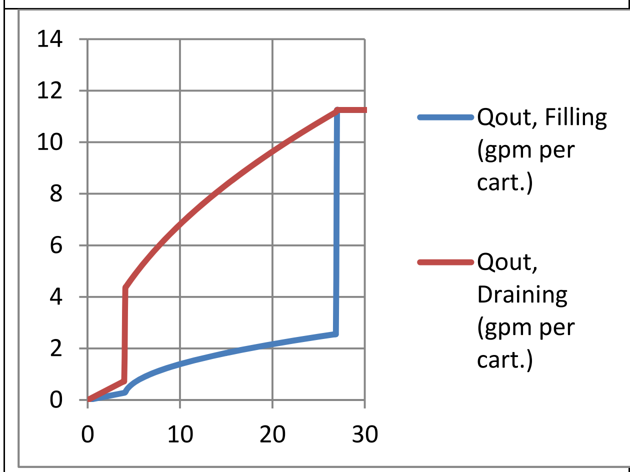
12 inch at 2 gpm/ft^2 (10 gpm max)



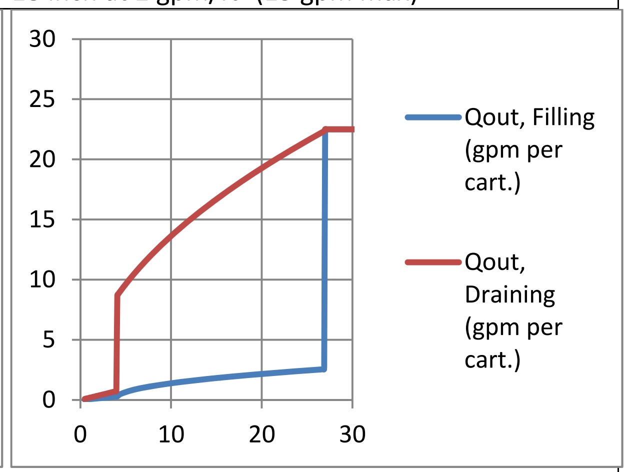
18 inch at 1 gpm/ft^2 (7.5 gpm max)



18 inch at 2 gpm/ft^2 (15 gpm max)



27 inch at 1 gpm/ft^2 (11.25 gpm max)



27 inch at 2 gpm/ft^2 (22.5 gpm max)

Stage-discharge relationships for different StormFilters in WinSLAMM (flow per single cartridge)

Particle Size Distributions of Test Materials

The laboratory tests of particulate solids controls were mostly based on a SilCoSil 106 ground silica challenge material. The following table shows the particle size distribution for this material based on laboratory sieve analyses. About 80% of the material is in the range of 3 to 60 µm, similar to most stormwaters. Locations near eroding soils usually have a greater abundance of large particles, but large particles are not transported in urban drainage systems very well. Performance analyses for the StormFilter were based on particle size ranges, as are the performance equations included in WinSLAMM. If effluent samples were reported in TSS or SSC total particulate concentrations (and not by particle size), it was assumed that the large particles were preferentially removed. These assumptions were verified by some full particle size analyses of effluent samples.

particle size (micrometers)	% of SCS106 in size range
<0.45	2
0.45 to 3	8
3 to 12	22
12 to 30	36
30 to 60	25

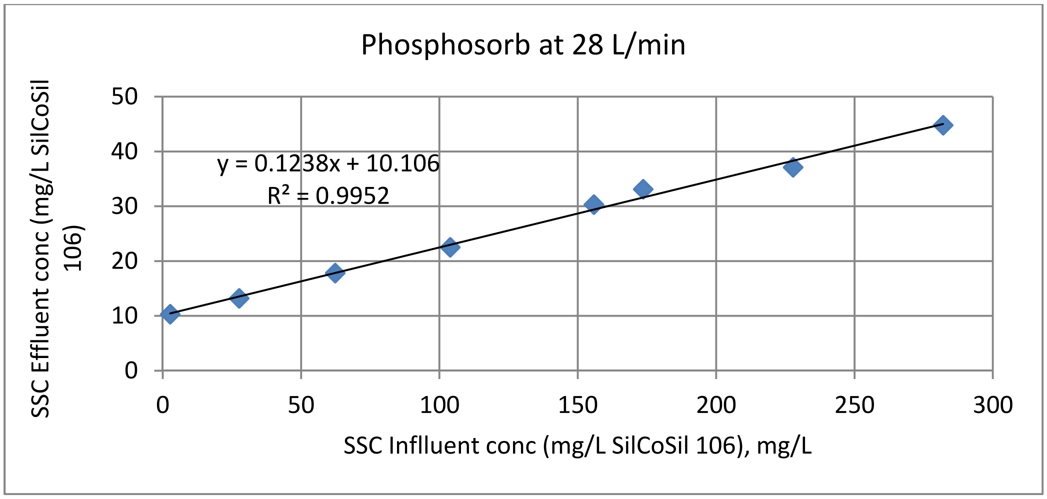
60 to 120	4
120 to 250	2
250 to 1180	1
>1180	0

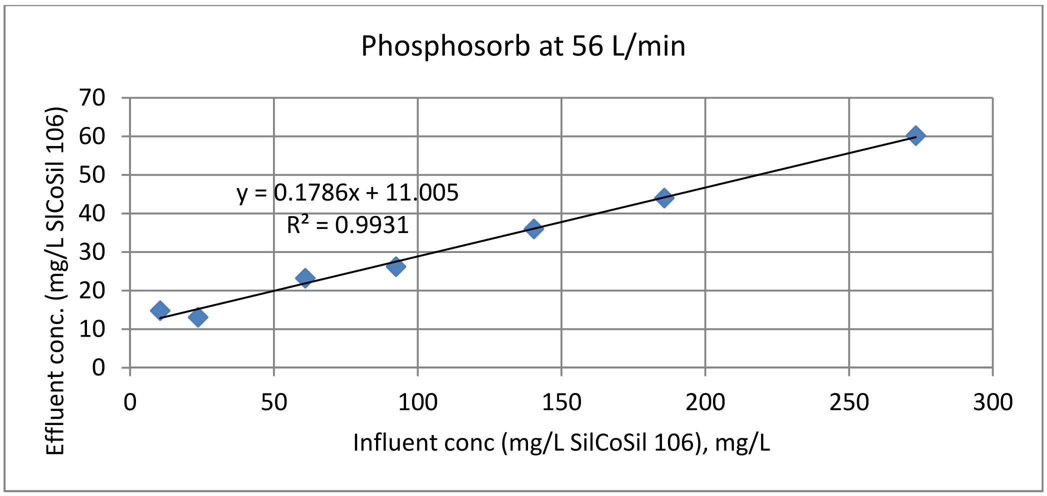
Phosphosorb Laboratory Tests

The following tables and figures summarize the Contech phosphosorb media laboratory tests at different flow rates for overall SSC and by particle size. These data indicate the typical behavior of the StormFilter cartridges. As noted above for the SCS106 media, there are few large particles in the test mixtures, so it is more difficult to statistically show the removal for these large particles. However, it is assumed with reasonable confidence that these large particles would be almost entirely removed by the StormFilter. The exceptions are likely related to some of the media particles being flushed from the cartridges during early and large flows. Similar data for the other media are available but are not shown in this summary paper.

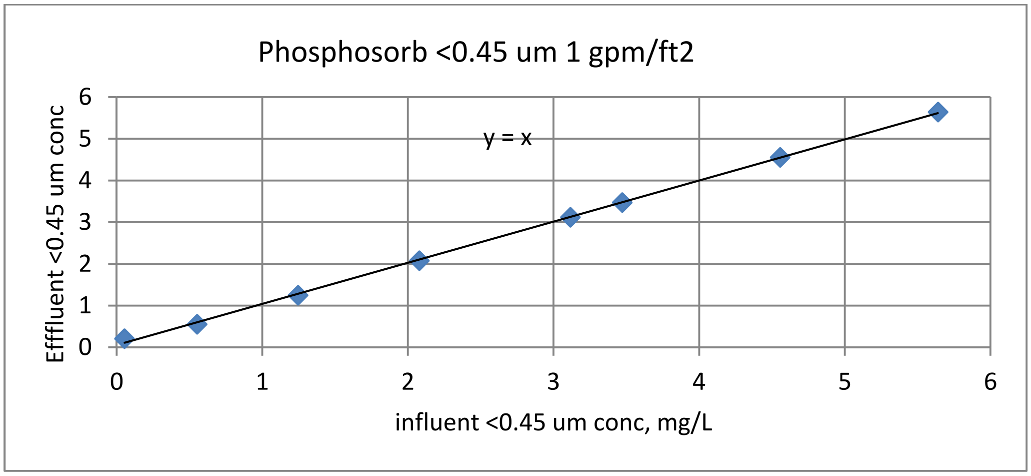
StormFilter tests using Phosphosorb

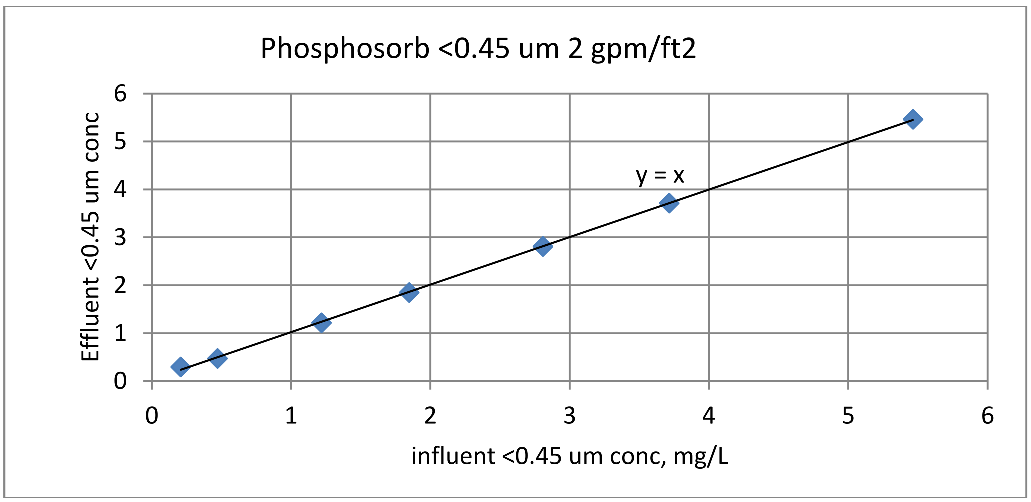
Specific flow rate		Test #	Test Volume	SSC Influent conc.	SSC Effluent conc.	SSC concentration reduction
gpm/ft^2	L/min	#	liters	mg/L	mg/L	(%)
1	28	1	400	27.60	13.20	52.2
1	28	2	400	2.70	10.30	-281.5
1	28	3	400	227.80	37.10	83.7
1	28	4	400	103.90	22.50	78.3
1	28	5	400	62.30	17.80	71.4
1	28	6	400	155.80	30.30	80.6
1	28	7	400	173.60	33.10	80.9
1	28	8	400	282.00	44.80	84.1
			average	129.46	26.14	31.2
			st dev	97.97	12.16	126.8
			COV	0.76	0.47	4.1
2	56	1	400	273.20	60.20	78.0
2	56	2	400	60.90	23.20	61.9
2	56	3	400	140.40	36.00	74.4
2	56	4	400	10.40	14.80	-42.3
2	56	5	400	23.60	13.10	44.5
2	56	6	400	92.40	26.20	71.6
2	56	7	400	185.70	44.00	76.3
			average	112.37	31.07	52.1
			st dev	94.30	16.90	43.2
			COV	0.84	0.54	0.8



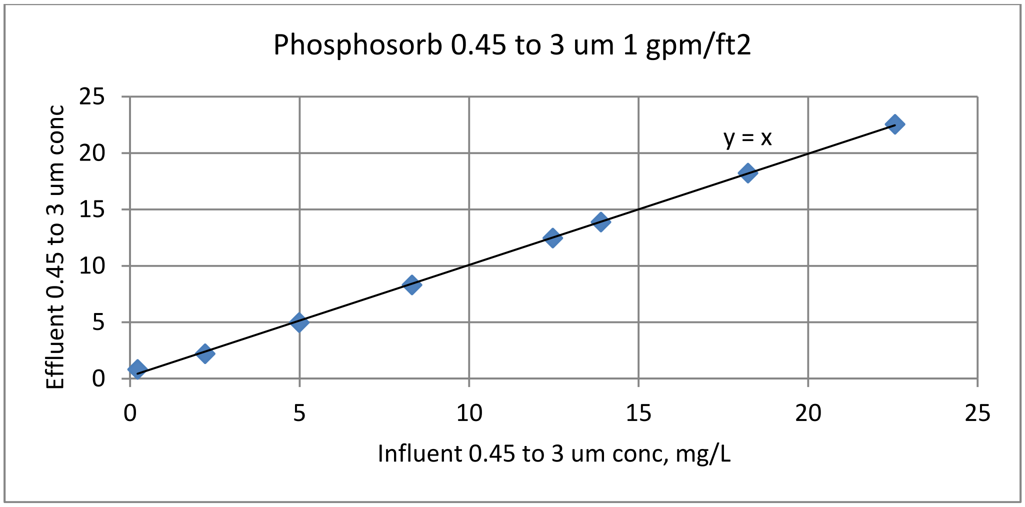


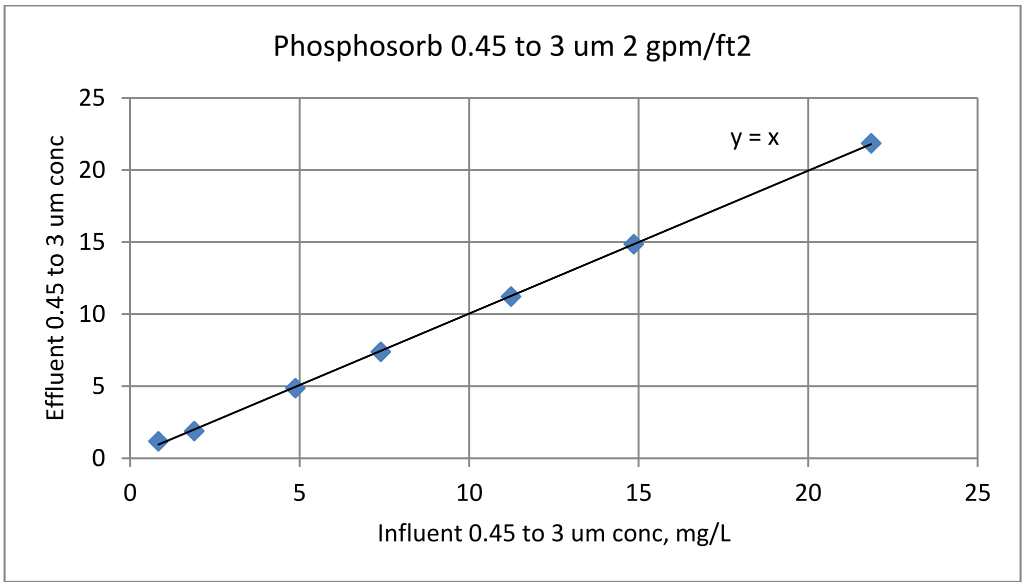
<0.45	1 gpm/ft2			2 gpm/ft2		
test	influent (mg/L)	effluent (mg/L)	removal (%)	influent (mg/L)	effluent (mg/L)	removal (%)
1	0.55	0.55	0.0	5.46	5.46	0.0
2	0.05	0.21	-281.5	1.22	1.22	0.0
3	4.56	4.56	0.0	2.81	2.81	0.0
4	2.08	2.08	0.0	0.21	0.30	-42.3
5	1.25	1.25	0.0	0.47	0.47	0.0
6	3.12	3.12	0.0	1.85	1.85	0.0
7	3.47	3.47	0.0	3.71	3.71	0.0
8	5.64	5.64	0.0			
average	2.59	2.61	-35.2	2.25	2.26	-6.0
st dev	1.96	1.93	99.5	1.89	1.87	16.0
COV	0.76	0.74	-2.8	0.84	0.83	-2.6





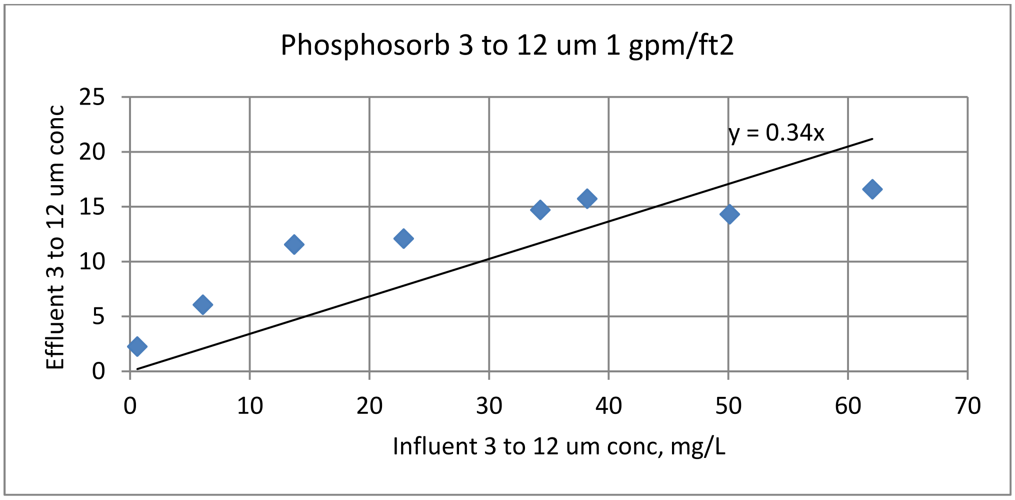
0.45 to 3 µm	1 gpm/ft2			2 gpm/ft2		
test	influent (mg/L)	effluent (mg/L)	removal (%)	influent (mg/L)	effluent (mg/L)	removal (%)
1	2.21	2.21	0.0	21.86	21.86	0.0
2	0.22	0.82	-281.5	4.87	4.87	0.0
3	18.22	18.22	0.0	11.23	11.23	0.0
4	8.31	8.31	0.0	0.83	1.18	-42.3
5	4.98	4.98	0.0	1.89	1.89	0.0
6	12.46	12.46	0.0	7.39	7.39	0.0
7	13.89	13.89	0.0	14.86	14.86	0.0
8	22.56	22.56	0.0			
average	10.36	10.43	-35.2	8.99	9.04	-6.0
st dev	7.84	7.73	99.5	7.54	7.48	16.0
COV	0.76	0.74	-2.8	0.84	0.83	-2.6

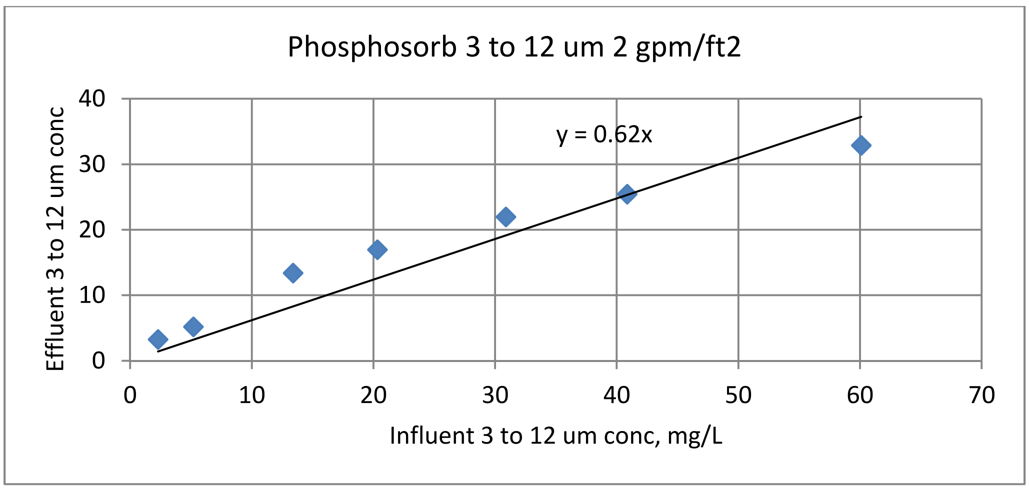




3 to 12 µm	1 gpm/ft2			2 gpm/ft2		
test	influent (mg/L)	effluent (mg/L)	removal (%)	influent (mg/L)	effluent (mg/L)	removal (%)
1	6.07	6.07	0.0	60.10	32.88	45.3
2	0.59	2.27	-281.5	13.40	13.40	0.0
3	50.12	14.32	71.4	30.89	21.96	28.9
4	22.86	12.11	47.0	2.29	3.26	-42.3
5	13.71	11.57	15.6	5.19	5.19	0.0
6	34.28	14.72	57.1	20.33	16.96	16.6
7	38.19	15.74	58.8	40.85	25.43	37.8
8	62.04	16.60	73.2			
average	28.48	11.67	5.2	24.72	17.01	12.3
st dev	21.55	5.03	118.7	20.75	10.72	29.8

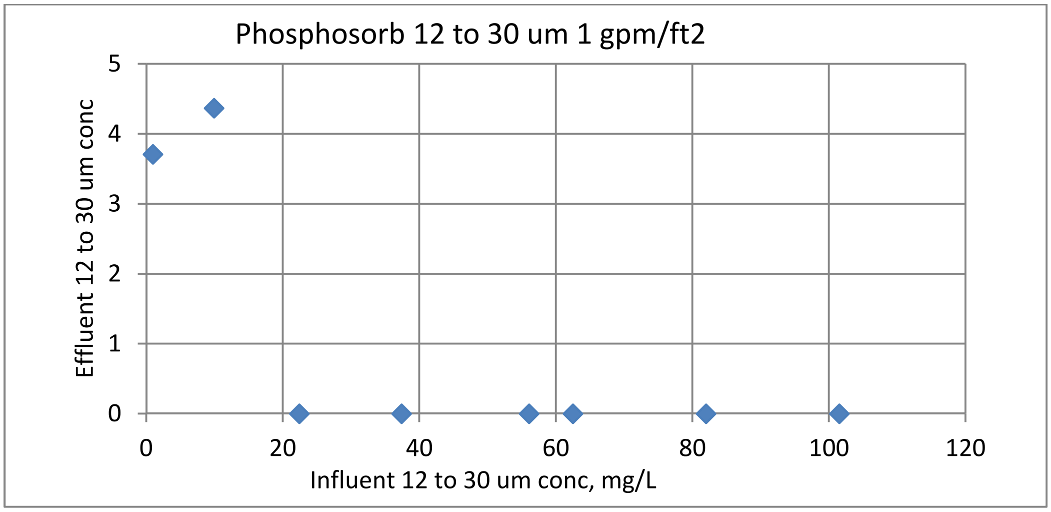
COV	0.76	0.43	22.8	0.84	0.63	2.4

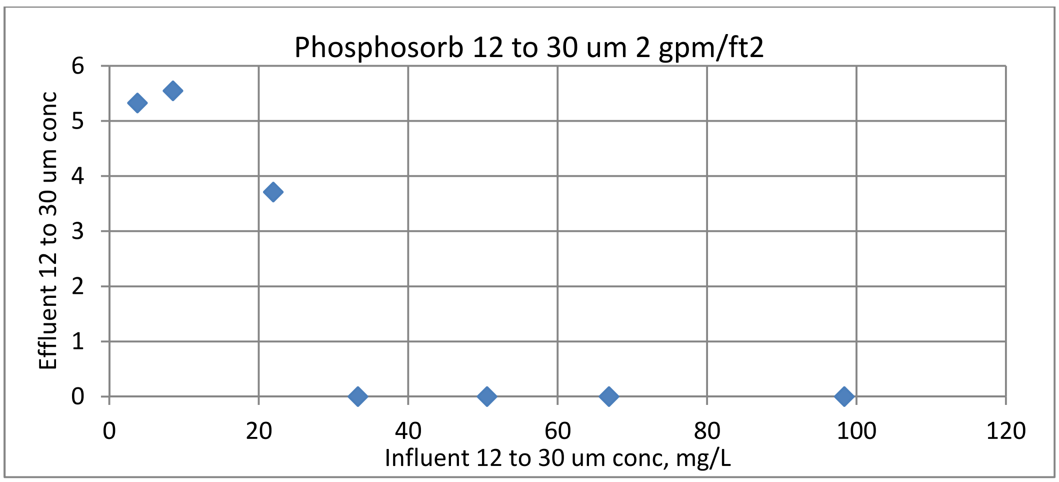




12 to 30 µm	1 gpm/ft2			2 gpm/ft2		
test	influent (mg/L)	effluent (mg/L)	removal (%)	influent (mg/L)	effluent (mg/L)	removal (%)
1	9.94	4.37	56.0	98.35	0.00	100.0
2	0.97	3.71	-281.5	21.92	3.71	83.1
3	82.01	0.00	100.0	50.54	0.00	100.0
4	37.40	0.00	100.0	3.74	5.33	-42.3
5	22.43	0.00	100.0	8.50	5.55	34.7
6	56.09	0.00	100.0	33.26	0.00	100.0
7	62.50	0.00	100.0	66.85	0.00	100.0
8	101.52	0.00	100.0			
average	46.61	1.01	46.8	40.45	2.08	67.9
st dev	35.27	1.88	133.5	33.95	2.66	54.2

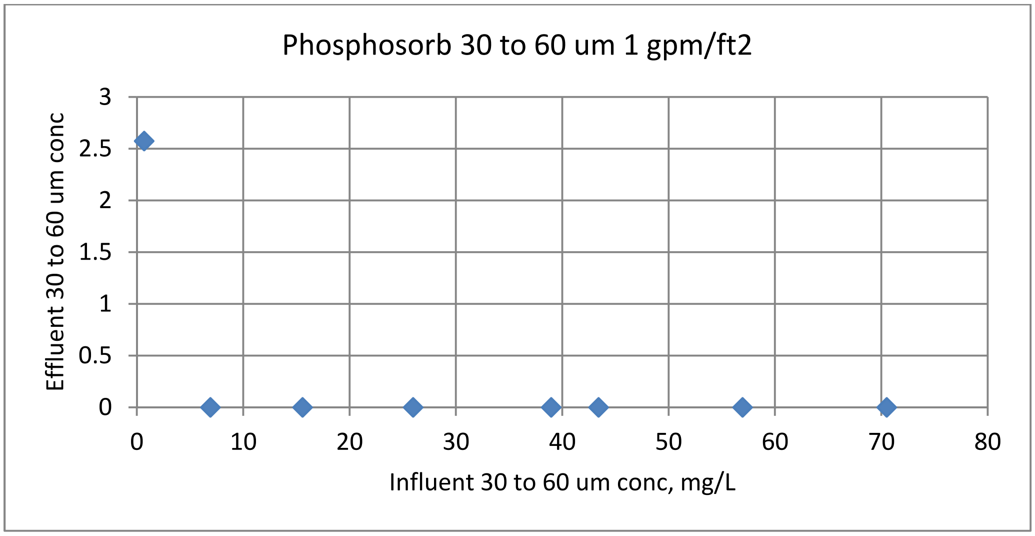
COV	0.76	1.86	2.9	0.84	1.28	0.8

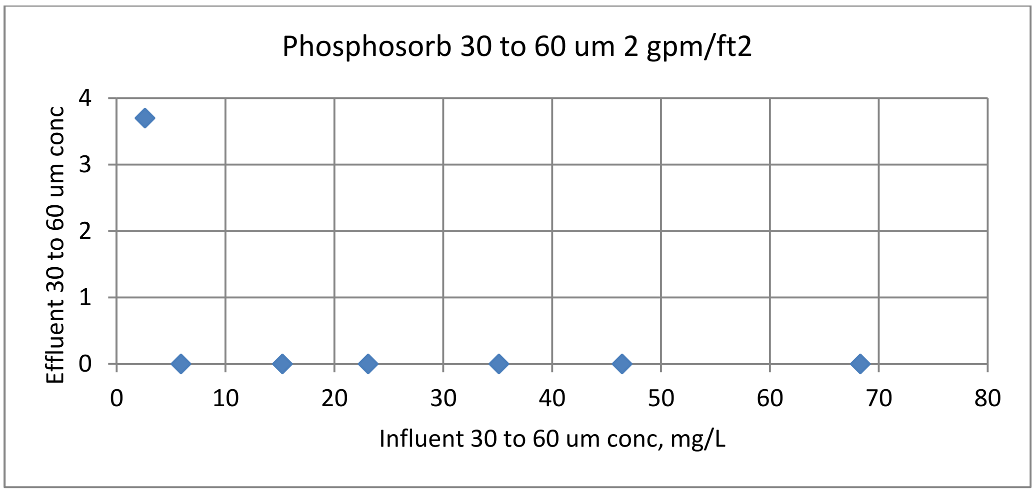




30 to 60 µm	1 gpm/ft2			2 gpm/ft2		
test	influent (mg/L)	effluent (mg/L)	removal (%)	influent (mg/L)	effluent (mg/L)	removal (%)
1	6.90	0.00	100.0	68.30	0.00	100.0
2	0.68	2.58	-281.5	15.23	0.00	100.0
3	56.95	0.00	100.0	35.10	0.00	100.0
4	25.98	0.00	100.0	2.60	3.70	-42.3
5	15.58	0.00	100.0	5.90	0.00	100.0
6	38.95	0.00	100.0	23.10	0.00	100.0
7	43.40	0.00	100.0	46.43	0.00	100.0
8	70.50	0.00	100.0			
average	32.37	0.32	52.3	28.09	0.53	79.7
st dev	24.49	0.91	134.9	23.58	1.40	53.8

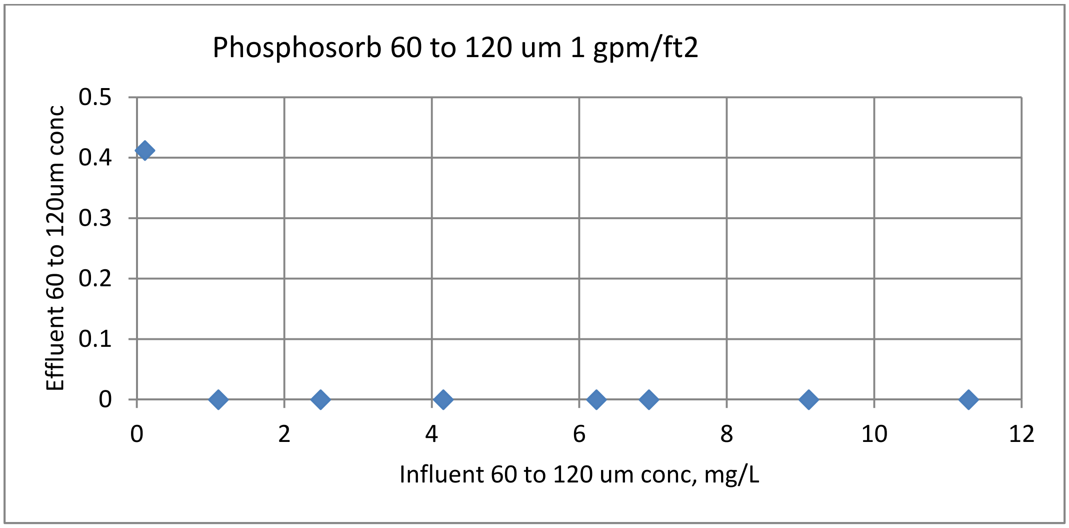
COV	0.76	2.83	2.6	0.84	2.65	0.7

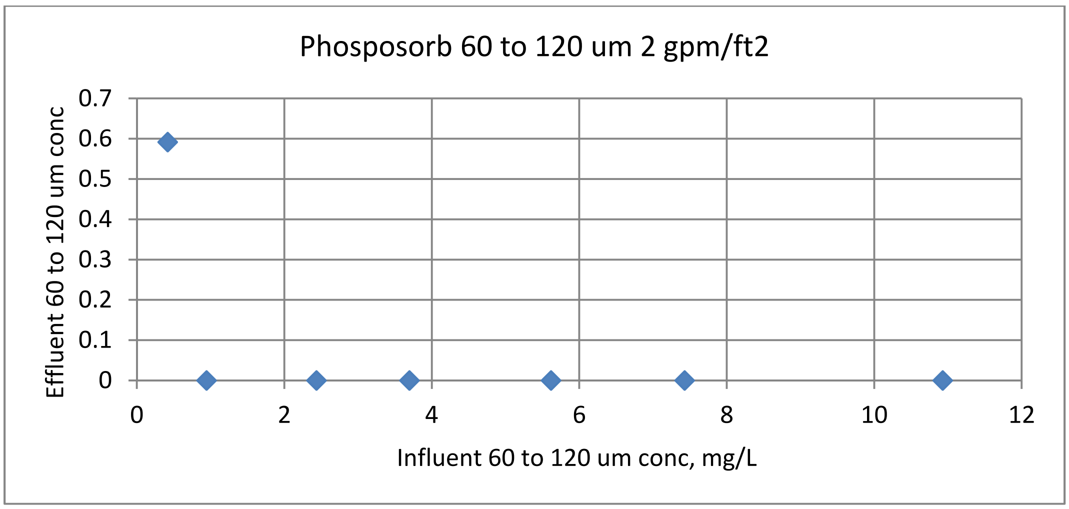




60 to 120 µm	1 gpm/ft2			2 gpm/ft2		
test	influent (mg/L)	effluent (mg/L)	removal (%)	influent (mg/L)	effluent (mg/L)	removal (%)
1	1.10	0.00	100.0	10.93	0.00	100.0
2	0.11	0.41	-281.5	2.44	0.00	100.0
3	9.11	0.00	100.0	5.62	0.00	100.0
4	4.16	0.00	100.0	0.42	0.59	-42.3
5	2.49	0.00	100.0	0.94	0.00	100.0
6	6.23	0.00	100.0	3.70	0.00	100.0
7	6.94	0.00	100.0	7.43	0.00	100.0
8	11.28	0.00	100.0			
average	5.18	0.05	52.3	4.49	0.08	79.7
st dev	3.92	0.15	134.9	3.77	0.22	53.8

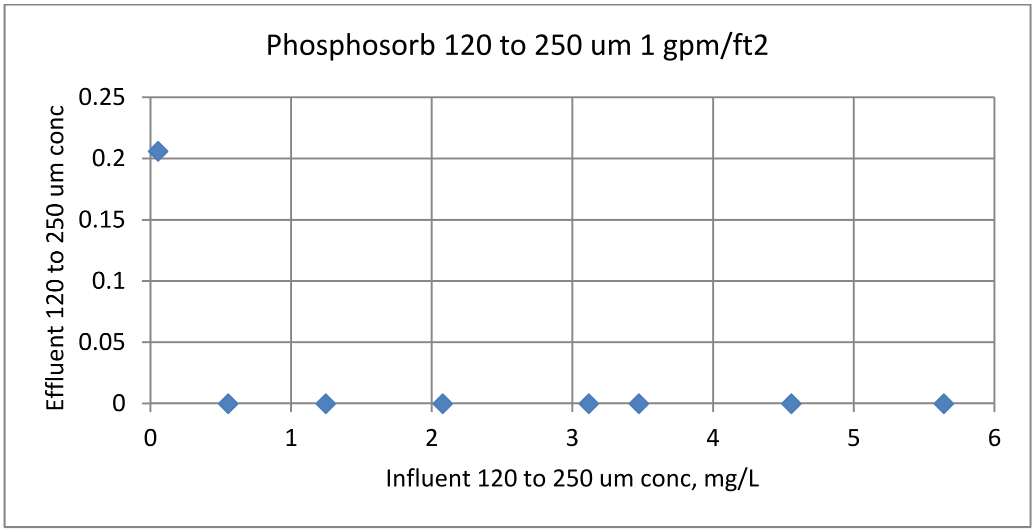
COV	0.76	2.83	2.6	0.84	2.65	0.7

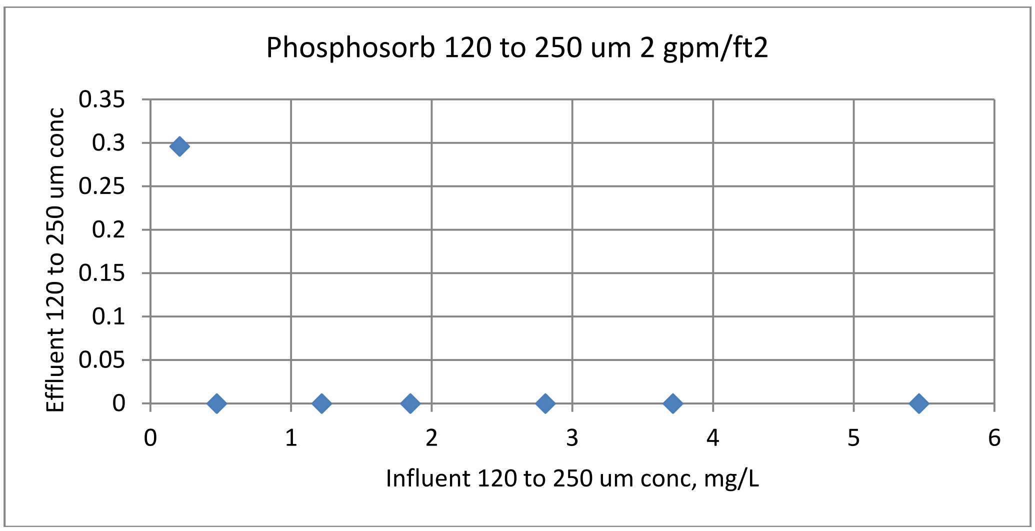




120 to 250 µm	1 gpm/ft2			2 gpm/ft2		
test	influent (mg/L)	effluent (mg/L)	removal (%)	influent (mg/L)	effluent (mg/L)	removal (%)
1	0.55	0.00	100.0	5.46	0.00	100.0
2	0.05	0.21	-281.5	1.22	0.00	100.0
3	4.56	0.00	100.0	2.81	0.00	100.0
4	2.08	0.00	100.0	0.21	0.30	-42.3
5	1.25	0.00	100.0	0.47	0.00	100.0
6	3.12	0.00	100.0	1.85	0.00	100.0
7	3.47	0.00	100.0	3.71	0.00	100.0
8	5.64	0.00	100.0			
average	2.59	0.03	52.3	2.25	0.04	79.7
st dev	1.96	0.07	134.9	1.89	0.11	53.8

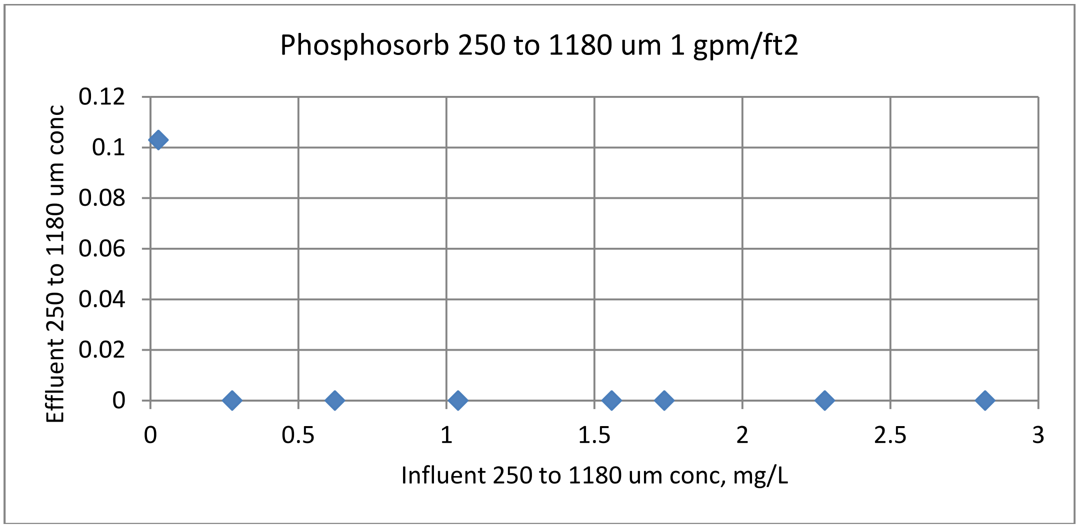
COV	0.76	2.83	2.6	0.84	2.65	0.7

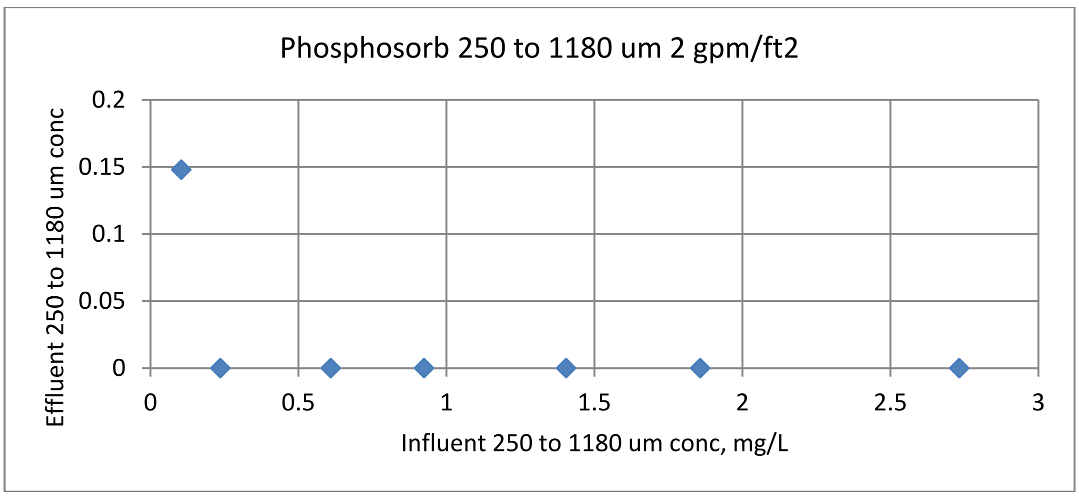




250 to 1180 µm	1 gpm/ft2			2 gpm/ft2		
test	influent (mg/L)	effluent (mg/L)	removal (%)	influent (mg/L)	effluent (mg/L)	removal (%)
1	0.28	0.00	100.0	2.73	0.00	100.0
2	0.03	0.10	-281.5	0.61	0.00	100.0
3	2.28	0.00	100.0	1.40	0.00	100.0
4	1.04	0.00	100.0	0.10	0.15	-42.3
5	0.62	0.00	100.0	0.24	0.00	100.0
6	1.56	0.00	100.0	0.92	0.00	100.0
7	1.74	0.00	100.0	1.86	0.00	100.0
8	2.82	0.00	100.0			
average	1.29	0.01	52.3	1.12	0.02	79.7

st dev	0.98	0.04	134.9	0.94	0.06	53.8
COV	0.76	2.83	2.6	0.84	2.65	0.7





>1180 µm	1 gpm/ft2			2 gpm/ft2		
test	influent (mg/L)	effluent (mg/L)	removal (%)	influent (mg/L)	effluent (mg/L)	removal (%)
1	no data	assumed to be 0	n/a	no data	assumed to be 0	n/a
2	no data	assumed to be 0	n/a	no data	assumed to be 0	n/a
3	no data	assumed to be 0	n/a	no data	assumed to be 0	n/a
4	no data	assumed to be 0	n/a	no data	assumed to be 0	n/a
5	no data	assumed to be 0	n/a	no data	assumed to be 0	n/a
6	no data	assumed to be 0	n/a	no data	assumed to be 0	n/a
7	no data	assumed to be 0	n/a	no data	assumed to be 0	n/a
8	no data	assumed to be 0	n/a			
average	n/a	assumed to be 0	n/a	n/a	assumed to be 0	n/a
st dev	n/a	n/a	n/a	n/a	n/a	n/a

COV	n/a	n/a	n/a	n/a	n/a	n/a

Performance Equations for Particulate Solids by Size Ranges used in WinSLAMM after Calibration

The following tables summarize the equations used in WinSLAMM describing the effluent concentrations by particle size for the different media and flow rates. Performance equations are expressed as effluent as a percentage of the influent, using the significant slope terms of the regression equations (in all cases, the intercepts were not found to be significant). In many cases, even the slope terms and the overall equations were not statistically significant, with the effluent concentration being a constant value (but if greater than the influent concentration, the influent is used, with no removal).

Phosphosorb Media Particulate Removal Equations used in WinSLAMM

Phosphosorb media 1 gpm/ft^2

Particle size range	Effluent conc. fraction of influent conc.	Effluent conc. (if less than influent conc., otherwise use influent conc.)
<3 µm	1.0	n/a
3 to 12 µm	0.34	n/a
12 to 30 µm	n/a	1.01
30 to 60 µm	n/a	0.32
60 to 120 µm	n/a	0.05
120 to 250 µm	n/a	0.03
250 to 1180 µm	n/a	0.01
>1180 µm	n/a	0.0

Phosphosorb media 2 gpm/ft^2

Particle size range	Effluent conc. fraction of influent conc.	Effluent conc. (if less than influent conc., otherwise use influent conc.)
<3 µm	1.0	n/a
3 to 12 µm	0.62	n/a
12 to 30 µm	n/a	2.08
30 to 60 µm	n/a	0.53
60 to 120 µm	n/a	0.08
120 to 250 µm	n/a	0.04
250 to 1180 µm	n/a	0.02
>1180 µm	n/a	0.0

ZPG Media Particulate Removal Equations used in WinSLAMM

ZPG media at both 1 and 2 gpm/ft^2

Particle size range	Effluent conc. fraction of influent conc.	Effluent conc. (if less than influent conc., otherwise use influent conc.)
<3 µm	10 ^ (0.8642 * funLog10(ParticleSizeInfConc(PSNum)) - 0.2831)	n/a
3 to 12 µm	10 ^ (0.7996 * funLog10(ParticleSizeInfConc(PSNum)) - 0.3229)	n/a
12 to 30 µm	10 ^ (0.7678 * funLog10(ParticleSizeInfConc(PSNum)) - 0.2889)	n/a
30 to 60 µm	10 ^ (0.8084 * funLog10(ParticleSizeInfConc(PSNum)) - 0.3663)	n/a
60 to 120 µm	10 ^ (0.7335 * funLog10(ParticleSizeInfConc(PSNum)) - 0.4048)	n/a
120 to 250 µm	n/a	0.34
250 to 1180 µm	10 ^ (0.2869 * funLog10(ParticleSizeInfConc(PSNum)))	n/a
>1180 µm	n/a	0.0

Perlite Media Particulate Removal Equations used in WinSLAMM

Perlite media at 1 gpm/ft^2

Particle size range	Effluent conc. fraction of influent conc.	Effluent conc. (if less than influent conc., otherwise use influent conc.)
<3 µm	1.0	n/a
3 to 12 µm	0.49	n/a
12 to 30 µm	n/a	0.18
30 to 60 µm	n/a	0.13
60 to 120 µm	n/a	0.02
120 to 250 µm	n/a	0.01
250 to 1180 µm	n/a	0.01
>1180 µm	n/a	0.0

Perlite media 2 gpm/ft^2

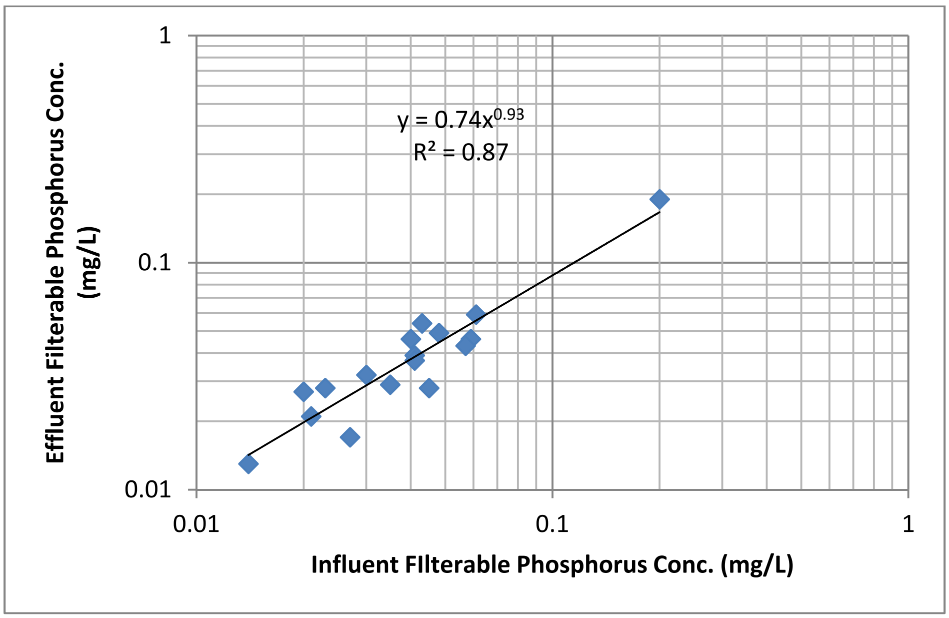
Particle size range	Effluent conc. fraction of influent conc.	Effluent conc. (if less than influent conc., otherwise use influent conc.)
<3 µm	1.0	n/a
3 to 12 µm	0.82	n/a
12 to 30 µm	n/a	3.9
30 to 60 µm	n/a	0.67
60 to 120 µm	n/a	0.03
120 to 250 µm	n/a	0.02
250 to 1180 µm	n/a	0.01
>1180 µm	n/a	0.0

Performance Equations for Filterable Pollutants used in WinSLAMM after Calibration

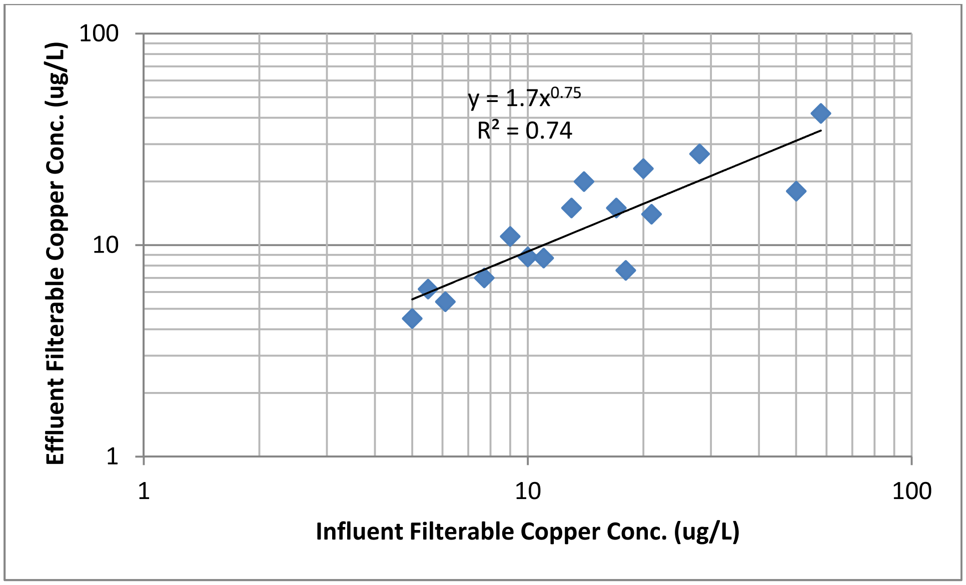
Several field tests of the StormFilter system have been conducted that examined a range of stormwater pollutants. All of these sites used the ZPG media with no information available for the other media selections. Therefore, only the ZPG media includes the removal of these filterable pollutants.

Riverwalk ETV Data

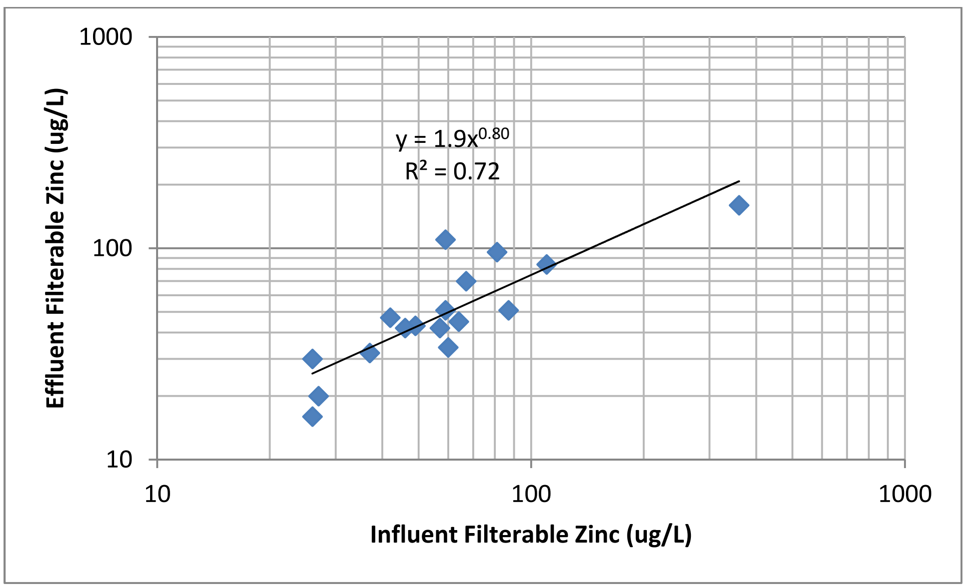
The following are example data plots and equations from the Riverwalk tests as submitted to the US EPA's ETV program. Other locations with filterable pollutant data included Lake Stevens, Olympia, and Heritage Market (data not shown here but summarized by Contech in site reports).



Filterable Phosphorus



Filterable Copper



Filterable Zinc

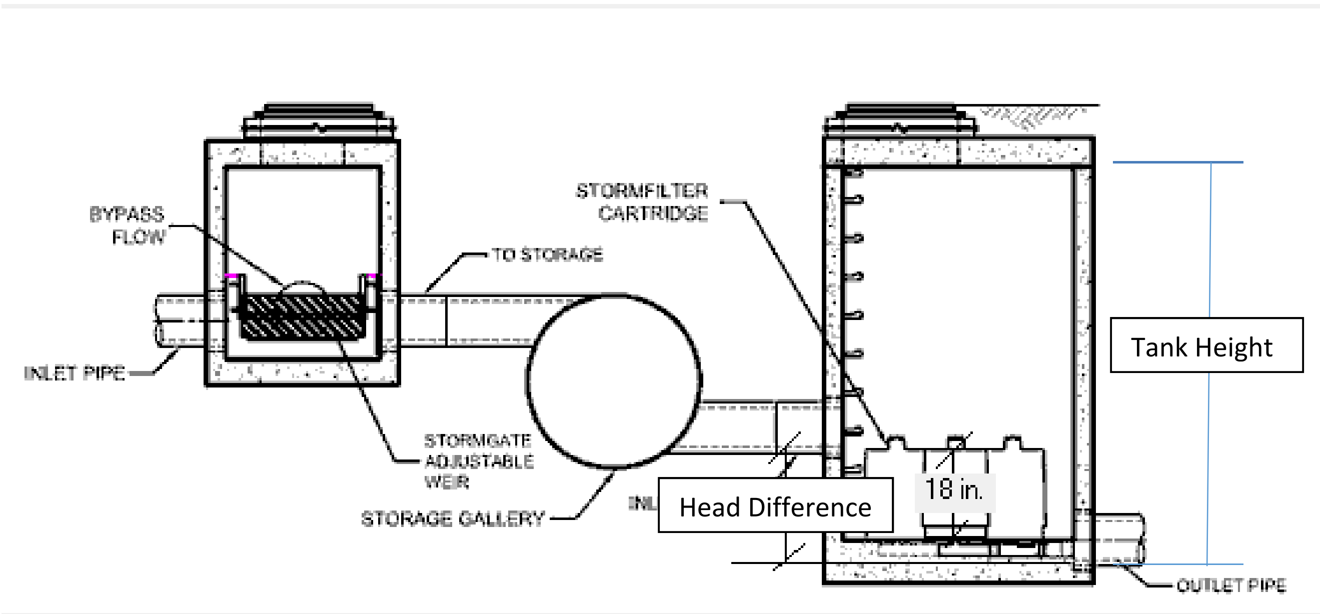
The following are the overall performance equations used in WinSLAMM to describe the reduction in filterable pollutant concentrations when using the ZPG media in the StormFilter.

ZPG media	Effluent concentration
Filterable phosphorus (mg/L)	effluent conc. = 0.93 (influent conc.) + 0.0004
Ammonia N (mg/L)	effluent conc. = 0.66 (influent conc.) + 0.022
Filterable copper (µg/L)	effluent conc. = 0.58 (influent conc.) + 3.17
Filterable zinc (µg/L)	effluent conc. = 0.57 (influent conc.) + 18.6

StormFilter Geometry and Modeling Assumptions

The following are descriptions of the different StormFilter configurations and associated assumptions used in preparing the WinSLAMM code.

The following diagram shows an upstream bypass, inline storage gallery, and the cartridge gallery, along with some typical dimensions and labels used in the program.



The following tables show the different media types and cartridge heights, along with the cartridge specific flow rates and maximum cartridge flow rates, along with chamber elevations and other dimensions for different cartridges.

Flow Rates (used to select appropriate flow rate equation)

Cartridge Height	Cartridge Specific Flow Rate	Maximum Cartridge Flow Rate
Sand Media		
12 inches	0.27 gpm/sf	1.35 gpm
18 inches	0.27 gpm/sf	2.03 gpm
27 inches	0.27 gpm/sf	3.04 gpm
Perlite, ZPG, Phosphosorb		
12 inches	1 gpm/sf	5 gpm
12 inches	2 gpm/sf	10 gpm
18 inches	1 gpm/sf	7.50 gpm
18 inches	2 gpm/sf	15 gpm
27 inches	1 gpm/sf	11.25 gpm
27 inches	2 gpm/sf	22.5 gpm

Chamber Elevations

Cartridge Height	Flow Surface Area per Cartridge	Internal Chamber Overflow Weir Height	Tank Height (1)	Minimum Inlet to Outlet Head Difference
12 inches	5 sf	4.0 ft.	5.5 ft	1.8 ft
18 inches	7.5 sf	4.5 ft	5.5 ft	2.3 ft
27 inches	11.25 sf	5.25 ft	5.5 ft	3.05 ft

(1) If tank height exceeded, then that exceedance is counted and the number of exceedances is entered in the Control Practice Summary grid.

Single Cartridge Top and Bottom Plan View Area (all 18 inches diameter) = 3.14159 * (1.8 / 2) ^ 2 = 2.54 sf

Media Void Volume per Cartridge = Cartridge Height x Cartridge Surface Area x 0.4 (assumed 0.4 porosity)

Chamber Area Needed for Different Numbers of Cartridges

The following table shows the size of the cartridge chambers needed for different numbers of cartridges, based on data supplied by Contech. These dimensions are used in WinSLAMM when calculating sedimentation of particulates in the cartridge chamber before filtering, as described in the next section.

Number of Cartridges	Cartridge Chamber Dimensions
1 to 3	4 ft diameter round
4 to 6	5 ft diameter round
7	6 ft diameter round
8	6' x 8'
9 to 12	6' x 12'
13 to 18	8' x 11'
19 to 25	8' x 14'
26 to 33	8' x 16'
34 to 38	8' x 18'
39 to 43	8' x 20'
44 to 48	8' x 22'
49 to 53	8' x 24'
>53	4 ft^2 per cartridge

Settling Area in Cartridge Chamber

In addition to material captured in the media in the StormFilter, additional particulate-bound material is also captured through physical sedimentation in the cartridge chamber and any upgradient storage chambers. The model calculates this settling in the same manner as applied to other settling processes, using the Surface Overflow Rate procedure in conjunction with standard settling equations. This procedure is dependent on the flow hydrograph of the stormwater being treated and the surface area, in addition to the particles sizes of the particulate matter. The following describes how WinSLAMM calculates the settling area available for these different conditions.

If the water depth is less than the top of the cartridge, then the settling area is the product of the Chamber Dimensions less the Single Cartridge Area times the number of cartridges. If the water depth is greater than the top of the cartridges, the settling area is the product of the Chamber Dimensions. It is assumed that the cartridge bottoms are 8-inches above the cartridge tank floor and that if the accumulated sediment level rises above 8-inches, no filtering will occur due to assumed clogging of the cartridges, though settling in the tank will still occur.

With the Upstream Storage Gallery options:

(1) Volume Based Chamber Size: Calculate available volume from the runoff depth and storage chamber depth. The chamber bottom elevation is set to the head difference between inlet and outlet inverts. No settling for this chamber type is calculated because there is no sump assumed (the settling equations require a certain amount of standing water to retain any previously captured material). The flow rate is controlled by the cartridge flow rate.

(2) Pipe Storage: Calculate volume and area from pipe geometry. The pipe invert elevation is set to the head difference between the inlet and outlet inverts, less the chamber sump depth. If the chamber sump depth is greater than or equal to 1.5 feet, then the pipe storage area, calculated in 0.01 ft stage increments, is added to the cartridge chamber tank area for settling calculations. If the sump depth is less than 1.5 ft, then no settling occurs due to scour. The flow rate is controlled by the cartridge flow rate.

(3) Box Chamber Storage: Calculate volume and area from box storage chamber geometry. The box bottom elevation is set to the head difference between inlet and outlet inverts, less the chamber sump depth. If the chamber sump depth is greater than or equal to 1.5 feet, then the box footprint area is added to the cartridge chamber tank area for settling calculations. If the sump depth is less than 1.5 ft, then no settling occurs. The flow rate is controlled by the cartridge flow rate.

Bypass Structures

There is no internal cartridge chamber bypass structure (overflow weir) if there is an upstream bypass structure or an upstream storage gallery.

Overflow Weir in Cartridge Tank

A broad crested weir (a concrete wall 6-inches wide) set at the elevation listed in the Internal Chamber Overflow Weir Height column of the Chamber Elevations table. The weir length is 2 ft for up to 4 cartridges, 4 ft for up to 16 cartridges and 6 ft for greater than 16 cartridges. All water flowing over this weir is treated by settling in the cartridge tank, but not by the media filters. The calculation assumes that the weir height can be greater than the top of the chamber so that the program will not run into any discontinuities, but the program also counts the number of tank height exceedances, which should be addressed by the user during the modeling analysis.

External Bypass Upstream of Tanks

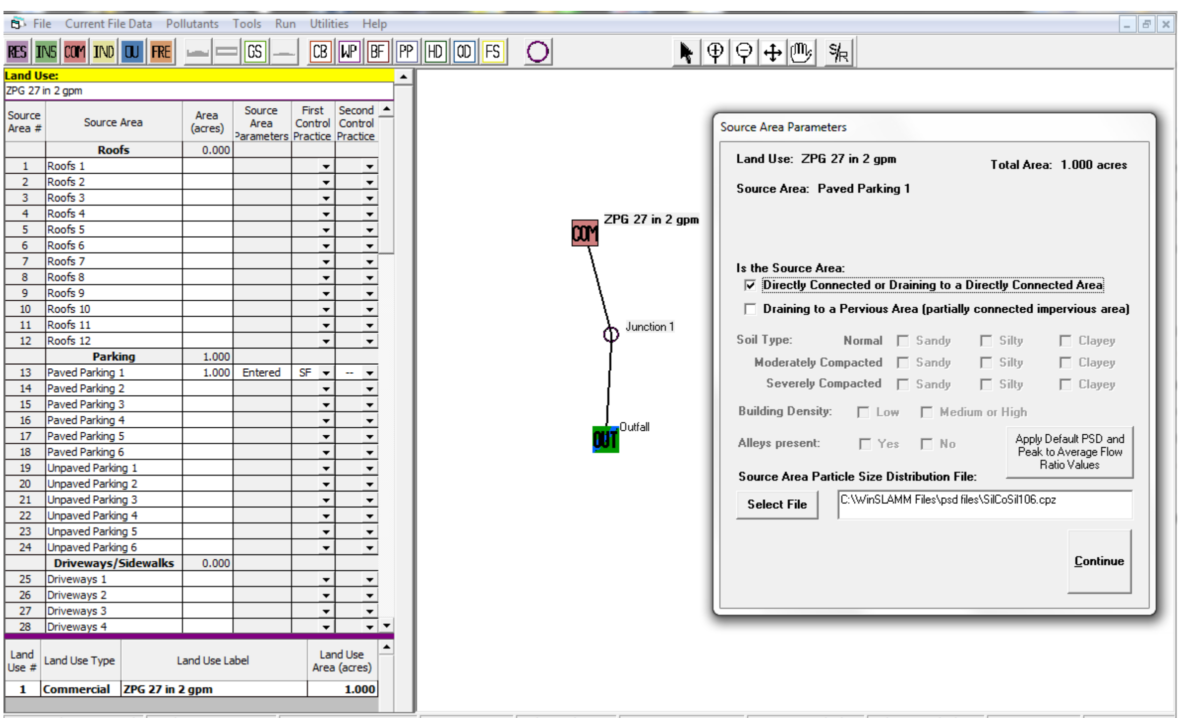
A 4-foot long sharp crested weir is assumed with an invert at the head difference value plus the height of the storage gallery, less any sump depth. A crest height of 0.25 ft is assumed, with no end contractions. The weir coefficient c = 3.27 + 0.4 * NetStage / 0.25, where the NetStage is the height above the weir invert.

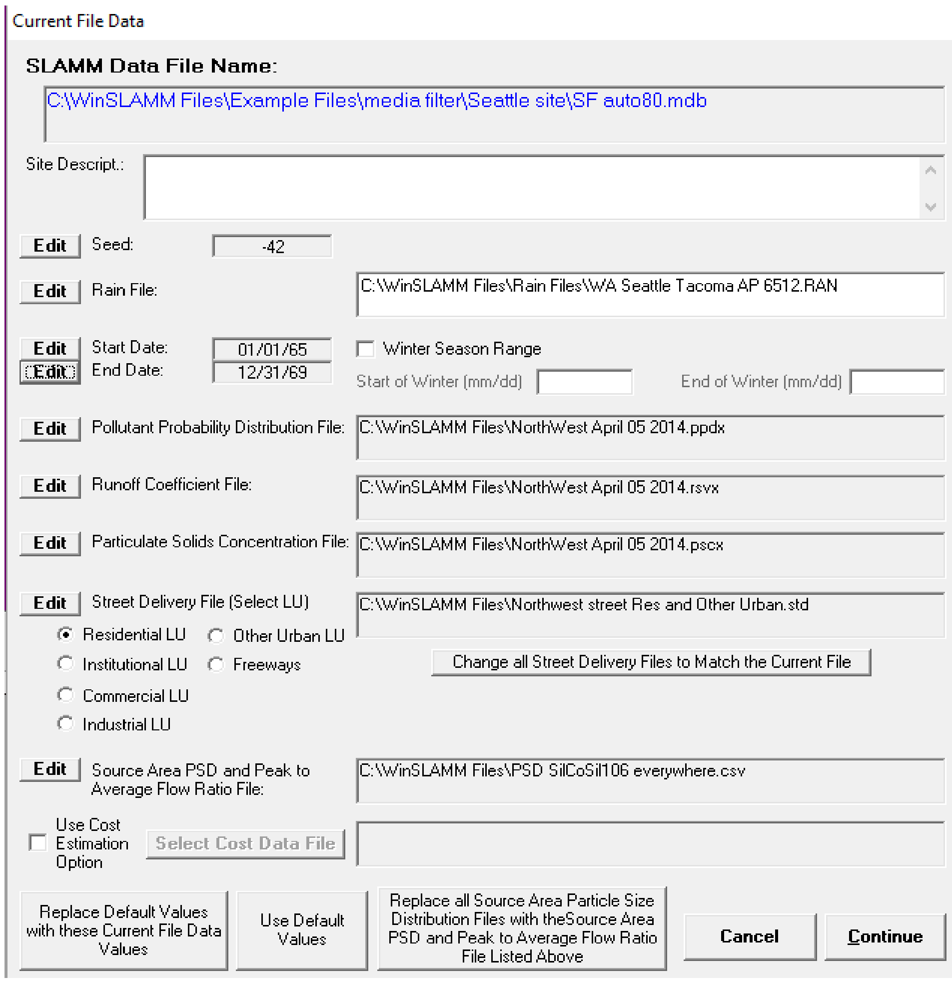
Maintenance

Cleaning consists of replacing the cartridges and removing the settled sediment from the chamber tanks, and will occur if the user checks the cleaning option box on the data input form. The program will automatically activate the cleaning event when either the sediment in the cartridge chamber tank reaches the maximum allowable sediment depth, or if the cartridges are full of sediment. The maximum allowable sediment depth in the cartridge chamber tank is 8 inches. Cartridges are assumed full if the accumulated mass in each cartridge reaches 27 lbs, based on the available monitoring data and product literature provided by Contech.

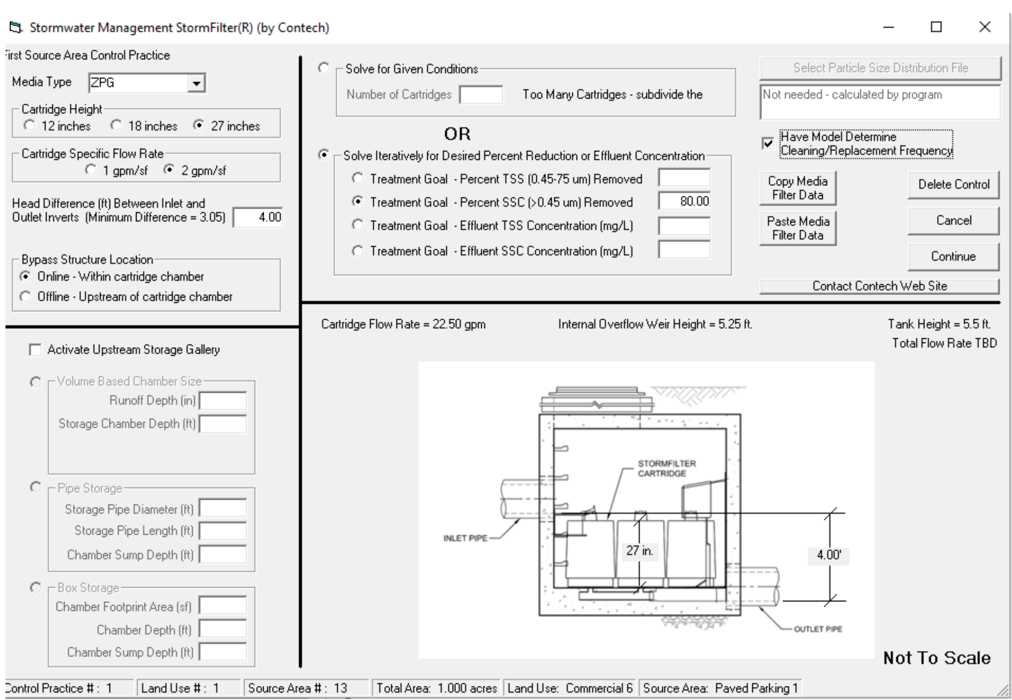
Performance Functions of StormFilter in WinSLAMM under Various Conditions

The Contech StormFilter is described in WinSLAMM using many different options and routines. Great care was taken to simplify the input requirements for the user by coding in standard dimensions and only showing available choices. The stormwater treatment performance of the StormFilter is affected by many different factors, specifically including drainage area/rainfall characteristics and particle size distributions of the particulate solids, along with the fraction of the pollutants in filterable forms. The following is a brief summary showing how these factors can affect the performance of the StormFilter under a range of conditions. The following screens show the site conditions used for these analyses: five year analyses for one acre paved parking areas in Seattle, Cincinnati, Madison, and Atlanta, with four different particle size distributions (psd): NURP psd, SSC psd, TSS psd, and Sil-Co-Sil 106 psd.





Current File Data
SLAMM Data File Name:
C:\WinSLAMM Files\Example Files\media filter\Seattle site\SF auto80.mdb
Site Descript.:
Edit
Seed:
-42
Edit
Rain File:
C:\WinSLAMM Files\Rain Files\WA Seattle Tacoma AP 6512.RAN
Edit
Start Date:
01/01/65
Edit
End Date:
12/31/69
Winter Season Range
Start of Winter (mm/dd)
End of Winter (mm/dd)
Edit
Pollutant Probability Distribution File:
C:\WinSLAMM Files\NorthWest April 05 2014.ppdx
Edit
Runoff Coefficient File:
C:\WinSLAMM Files\NorthWest April 05 2014.rsvx
Edit
Particulate Solids Concentration File:
C:\WinSLAMM Files\NorthWest April 05 2014.pscx
Edit
Street Delivery File (Select LU)
C:\WinSLAMM Files\Northwest street Res and Other Urban.std
Residential LU
Other Urban LU
Institutional LU
Freeways
Commercial LU
Industrial LU
Change all Street Delivery Files to Match the Current File
Edit
Source Area PSD and Peak to Average Flow Ratio File:
C:\WinSLAMM Files\PSD SilCoSil106 everywhere.csv
Use Cost Estimation Option
Select Cost Data File
Replace Default Values with these Current File Data Values
Use Default Values
Replace all Source Area Particle Size Distribution Files with theSource Area PSD and Peak to Average Flow Ratio File Listed Above
Cancel
Continue



Stormwater Management StormFilter(R) (by Contech)
irst Source Area Control Practice
Media Type
ZPG
Cartridge Height
12 inches
18 inches
27 inches
Cartridge Specific Flow Rate
1 gpm/sf
2 gpm/sf
Head Difference (ft) Between Inlet and Outlet Inverts (Minimum Difference = 3.05)
4.00
Bypass Structure Location
Online - Within cartridge chamber
Offline - Upstream of cartridge chamber
Activate Upstream Storage Gallery
Volume Based Chamber Size
Runoff Depth (in)
Storage Chamber Depth (ft)
Pipe Storage
Storage Pipe Diameter (ft)
Storage Pipe Length (ft)
Chamber Sump Depth (ft)
Box Storage
Chamber Footprint Area (sf)
Chamber Depth (ft)
Chamber Sump Depth (ft)
Solve for Given Conditions
Number of Cartridges
Too Many Cartridges - subdivide the
OR
Solve Iteratively for Desired Percent Reduction or Effluent Concentration
Treatment Goal - Percent TSS (0.45-75 um) Removed
Treatment Goal - Percent SSC (>0.45 um) Removed
80.00
Treatment Goal - Effluent TSS Concentration (mg/L)
Treatment Goal - Effluent SSC Concentration (mg/L)
Select Particle Size Distribution File
Not needed - calculated by program
Have Model Determine Cleaning/Replacement Frequency
Copy Media Filter Data
Delete Control
Paste Media Filter Data
Cancel
Continue
Contact Contech Web Site
Cartridge Flow Rate = 22.50 gpm
Internal Overflow Weir Height = 5.25 ft.
Tank Height = 5.5 ft.
Total Flow Rate TBD
STORMFILTER CARTRIDGE
INLET PIPE
27 in.
4.00'
OUTLET PIPE
Not To Scale
Control Practice # : 1
Land Use # : 1
Source Area # : 13
Total Area: 1.000 acres
Land Use: Commercial 6
Source Area: Paved Parking 1

Seattle, WA (38.3 in/yr annual rainfall) with ZPG media 27 inch cartridge at 2 gpm/ft^2

Particle Size Distribution	# of cartridges needed for 80% particulate solids reduction (per acre of paved parking)	average cleaning frequency (yrs)	Residence time in filter (minutes)
NURP	22 for 76%; 40 for 77%	2.9	11
TSS	4	0.5	11
SSC	5	0.8	11
SCS 106	4	0.6	12
SCS 106 10 acres	34 (for 10 acres)	0.4	14

Particulate P reduction: 82%; filterable P reduction: 6%; total P reduction: 51%
Particulate Cu reduction: 82%; filterable Cu reduction; 24%; total Cu reduction: 48%
Particulate Zn reduction: 82%; filterable Zn reduction: 21%; total Zn reduction: 45%

Cincinnati, OH (37.6 in/yr annual rainfall) with ZPG media 27 inch cartridge at 2 gpm/ft^2

Particle Size Distribution	# of cartridges needed for 80% particulate solids reduction (per acre of paved parking)	average cleaning frequency (yrs)	Residence time in filter (minutes)
NURP	22 for 75%; 40 for 76%	1.5	14
TSS	8	0.7	14
SSC	9	1.1	13
SCS 106	8	0.8	13
SCS 106 10 acres	96 (for 10 acres)	0.8	12

Particulate P reduction: 82%; filterable P reduction: 7%; total P reduction: 24%
Particulate Cu reduction: 82%; filterable Cu reduction; 8%; total Cu reduction: 72%
Particulate Zn reduction: 82%; filterable Zn reduction: 0%; total Zn reduction: 42%

Madison, WI (24.4 in/yr annual rainfall; ignoring snowfall) with ZPG media 27 inch cartridge at 2 gpm/ft^2

Particle Size Distribution	# of cartridges needed for 80% particulate solids reduction (per acre of paved parking)	average cleaning frequency (yrs)	Residence time in filter (minutes)
NURP	22 for 77%; 40 for 78%	1.5	12
TSS	8	0.7	13
SSC	8	0.9	13
SCS 106	8	0.9	13
SCS 106 10 acres	80 (for 10 acres)	0.7	12

Particulate P reduction: 81%; filterable P reduction: 5%; total P reduction: 74%
Particulate Cu reduction: 81%; filterable Cu reduction; 11%; total Cu reduction: 54%
Particulate Zn reduction: 81%; filterable Zn reduction: 26%; total Zn reduction: 58%

Atlanta, GA (53.0 in/yr annual rainfall) with ZPG media 27 inch cartridge at 2 gpm/ft^2

Particle Size Distribution	# of cartridges needed for 80% particulate solids reduction (per acre of paved parking)	average cleaning frequency (yrs)	Residence time in filter (minutes)
NURP	22 for 71%; 40 for 72%	3.0	12
TSS	9	1.9	12
SSC	20	4.8	12
SCS 106	9	2.6	11
SCS 106 10 acres	154 (for 10 acres)	2.8	11

Particulate P reduction: 82%; filterable P reduction: 7%; total P reduction: 58%
Particulate Cu reduction: 82%; filterable Cu reduction; 0%; total Cu reduction: 58%
Particulate Zn reduction: 82%; filterable Zn reduction: 0%; total Zn reduction: 24%

The maximum number of StormFilters per acre evaluated is 22, although many more may be needed to provide 80% particulate solids reductions in some situations. As noted in this paper, the StormFilter system reduces particulate solids through both sedimentation in the cartridge chambers and by filtering in the cartridges themselves. It is likely that the very large numbers of needed cartridges for several of the examples are more associated with enlarged cartridge chambers and sedimentation. The detailed program outputs illustrate the removals of the particulates by the different unit processes. It is interesting to note that although Seattle and Cincinnati both have similar annual depths, the number of cartridges needed for 80% particulate solids reductions vary, likely associated with the much different rain intensities and treatment flow rates for these locations. The Atlanta area requires many more cartridges per acre due to the higher peak rain intensities and associated treatment flow rates. Also, as the median particle sizes decrease for the psds, more cartridges are needed for the same conditions otherwise. The maintenance intervals (calculated based on depth of captured sediment in the filter chambers before interference with filter operations) ranged from about 0.5 times per year (for the small filter chambers in Seattle) to about every 3 years (for the larger Atlanta filter chambers). The average residence times of the water in the cartridges ranges from about 11 to 14 minutes for these conditions.