

The Stormwater Management StormFilter® with PhosphoSorb®

Field Performance Technical Summary

A three year field performance evaluation of The Stormwater Management StormFilter® (StormFilter) with PhosphoSorb® media operating at a specific flow rate of 1.67 gpm/ft² was completed at a 0.06 impervious acre roadway site in Zigzag, Oregon. The Quality Assurance Project Plan (QAPP) for this evaluation followed the Guidance for Evaluating Emerging Stormwater Treatment Technologies: Technology Assessment Protocol – Ecology (TAPE, 2011). The StormFilter with PhosphoSorb Technical Evaluation Report resulted in a General Use Level Designation from Washington State Department of Ecology for Total Suspended Solids (TSS) and Total Phosphorus removal.

Technology Description

The Stormwater Management StormFilter (StormFilter) is a Best Management Practice (BMP) that is provided by Contech Engineered Solutions, LLC (Contech). The StormFilter improves the quality of stormwater runoff before it enters receiving waterways through the use of its customizable filter media, which removes non-point source pollutants. The StormFilter is typically comprised of a vault that houses rechargeable, media-filled filter cartridges. Stormwater entering the system percolates through these media-filled cartridges, which trap particulates and remove pollutants. Once filtered through the media, the treated stormwater is discharged through an outlet pipe to a storm sewer system or receiving water.

Depending on the treatment requirements and pollutant characteristics of the influent stream at an individual site, the filtration rate through a typical StormFilter cartridge at the design driving head can be adjusted. The flow rate is individually controlled for each cartridge by a restrictor disc located at the connection point between the cartridge and the underdrain manifold.

The StormFilter is offered in multiple configurations including plastic, steel, and concrete catch basin, precast manhole, precast vault, panel vault, CON/SPAN, box culvert, and curb inlet. These configurations can include up to 3 different cartridge heights at 12, 18, and 27 inches. Increasing the height of the cartridge allows for an increase in the available surface area and volume of the media per cartridge, but also requires a greater hydraulic drop (head loss) across the system.

The StormFilter cartridge can use different types of media. The 3 year field evaluation used PhosphoSorb media at a 1.67 gpm/ft² specific flow rate. PhosphoSorb is a lightweight expanded ore coated with activated alumina. The expanded rock is excellent at fine particulate removal and the activated alumina allows for adsorption of soluble phosphorus. The cartridge flow rate for the 3 different cartridge heights are shown in Table 1.

Table 1. Cartridge Flow Rates at 1.67 gpm/ft²

StormFilter Cartridge	Per Cartridge Flow Rate
Low Drop (12 inch)	8.4 gpm
18 inch	12.5 gpm
27 inch	18.8 gpm

Sampling Procedures

Influent and effluent flows were measured using Large 60°V Trapezoidal Flumes in conjunction with individual ISCO 750 Bubbler Flow Modules. Influent and effluent flows were monitored continuously throughout the evaluation period on a 5 minute time step data interval.

Discrete flow-sampling was used to collect influent and effluent samples using individual ISCO 6712 Portable Automated Samplers configured for standard, individual, round, wide-mouth 1-L HDPE bottles sample bottles. Sample tubing, 3/8" ID Acutech Duality FEP/LDPE tubing, was routed from each automated sampler to influent and effluent sample locations. Sample intakes were located at the invert of both the influent and effluent sample locations.

Hydraulic Evaluation

Over the entire 37 month evaluation period, the total effluent volume recorded at the site was 376,244 gallons. There were some data gaps due to weather, equipment issues, and back-up data storage errors. A total of 14,060 gallons were bypassed through the system accounting for 4% of the total recorded volume. A total of 26 events contained bypass flow, with 23 of those events producing peak flows exceeding the design treatment capacity of the system. The three events with bypass flows occurring below the design treatment capacity triggered maintenance. Figure 1 shows the 26 bypass events and the point of system maintenance.

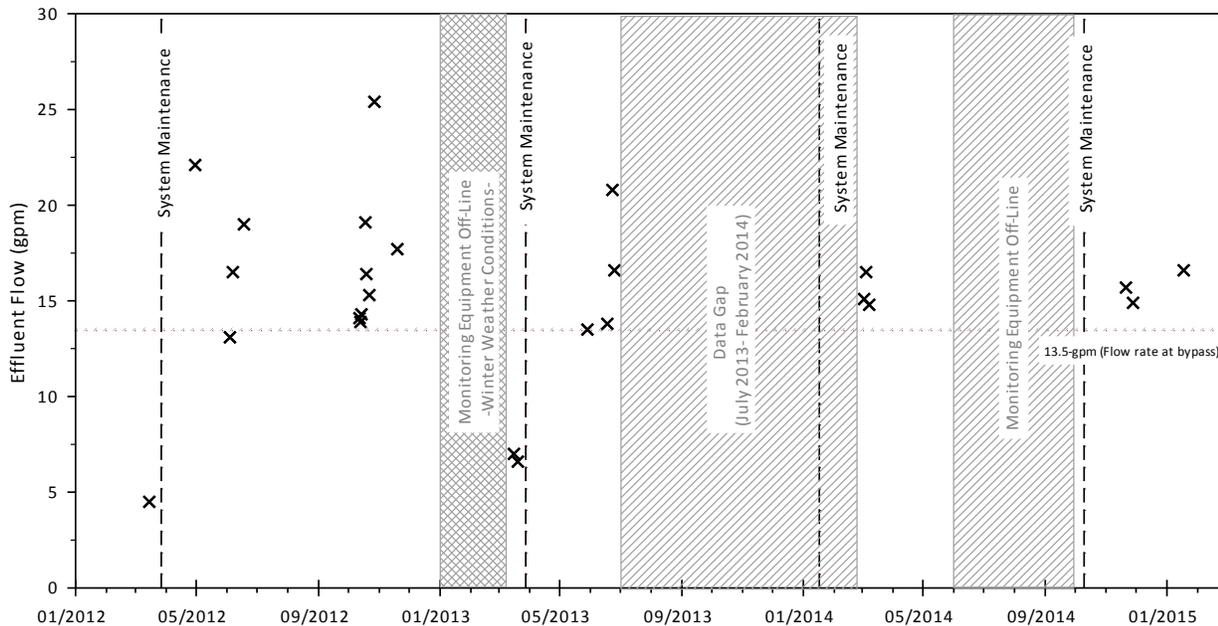


Figure 1. Flow rate at the time of bypass during the evaluation period.

The StormFilter system contains an internal bypass, allowing flows exceeding the treatment capacity of the filter cartridges to pass through the system untreated. The system goes into bypass when the water level in the unit rises to approximately 3 inches above the top of the StormFilter cartridge. The StormFilter has a calibrated orifice at the base of the cartridge that controls the flow rate until the media becomes occluded. The 3 inches of driving head increases the operating rate of the system from a specific flow rate of 1.67 gpm/ft² to 1.8 gpm/ft².

Treated flows greater than 90% of the water quality design flow rate were observed in 8 of the 17 events. Five of the 17 qualified events evaluated contained bypass flow with the water quality treatment flow rate greater than 100% design (specific flow rate of 1.67 gpm/ft²). Four of these five bypass events satisfied the TSS and total phosphorus treatment objectives.

Table 2. Storm Event and Sample Collection Criteria

Event ID	Storm Event Guidelines						Sample Collection Criteria					
	Precipitation				Antecedent Dry Period		Number of Aliquots		Storm Event Coverage		Sampling Duration	
	Total Depth (in)	Max. Intensity (in/hour)	Avg. Intensity (in/hour)	Duration (hours)	Before Event (hours)	Post Event (hours)	Influent	Effluent	Influent	Effluent	Influent (hours)	Effluent (hours)
LPR021412	0.34	0.06	0.01	18	21	36	7	7	81%	78%	14	14
LPR021712	1.34	0.14	0.02	46	18	14	40	32	94%	97%	29	31
LPR022412	0.80	0.13	0.04	11	31	11	23	17	100%	91%	10	10
LPR031212	0.44	0.10	0.03	6	28	16	14	12	83%	95%	6	6
LPR052412	0.48	0.13	0.04	5	4	48	13	15	85%	80%	2	3
LPR060112	0.86	0.15	0.08	7	104	10	32	37	97%	99%	5	5
LPR060412	0.77	0.15	0.04	13	5	5	24	25	84%	96%	9	10
LPR060712	0.73	0.14	0.04	12	36	8	24	25	96%	87%	12	12
LPR110612	0.47	0.36	0.03	7	117	55	13	16	99%	94%	7	7
LPR113012	0.69	0.26	0.03	16	7	9	27	15	79%	100%	15	15
LPR051713	0.26	0.07	0.02	9	13	9	16	13	74%	77%	13	13
LPR052113	0.70	0.18	0.08	6	9	7	35	28	99%	98%	7	5
LPR062513	0.71	0.29	0.10	4	2	2	26	24	93%	96%	3	3
LPR013014	0.51	0.09	0.02	21	5	8	36	41	96%	94%	23	23
LPR030314	0.76	0.30	0.05	9	6	9	31	43	100%	100%	9	11
LPR011815	2.62	0.24	0.07	26	18	8	35	38	97%	98%	15	18
LPR020215	0.43	0.12	0.04	5	13	21	16	14	91%	90%	5	5
Min	0.26	0.06	0.01	4	2	2	7	7	74%	77%	2	3
Max	2.62	0.36	0.10	46	117	55	40	43	100%	100%	29	31
Mean	0.76	0.17	0.04	13	26	16	24	24	91%	92%	11	11

Storm Event Criteria

A total of 25 events were sampled at the site from February 2012 to February 2015. There were zero disqualifications to the sample population (n=25) related to the storm event criteria. Six events did contain an antecedent dry period that was less than 6 hours but were included in the data set as discrete storm events.

The following findings summarize compliance with the storm event criteria:

- Storm event depth was greater than 0.15-inches for all events sampled.
- Minimum storm duration was greater than 1-hour for all events sampled.
- A range of average rainfall intensities were observed from 0.01 to 0.1 inches per hour.
- Antecedent times greater than 6 hours for pre-storm and post-storm satisfied the 6 hours with rainfall less than 0.04 inches with exception of:
 - Pre-storm: LPR052412, LPR060412, LPR062513, and LPR013014
 - Post-storm: LPR060412 and LPR062513

Sample Collection Criteria

The sample collection criteria were satisfied for 17 storm events. Seven events were disqualified as the 75% storm event coverage criteria were not satisfied. Table 2 provides a summary of the storm event and sample collection criteria.

- A minimum of 10 aliquots were collected for each event with exception of event LPR021412.
- A minimum storm event coverage goal of 75% was met for each event listed in Table 7, with exception of LPR051713 which was 74% for the influent.
- The sampling duration was less than 36 hours for all events sampled.

Results

A total of 17 events met the storm event and sampling criteria from February 2012 to February 2015. Suspended solids, nutrients, and metals performance is provided in Table 3. The solids parameters reported are Total Suspended Solids (TSS), Suspended Sediment Concentration less than 500 microns (SSC<500 μm), and solids representing the silt and clay fraction (SSC less than 62.5-μm). Nutrient results are comprised of total phosphorus and total nitrogen. Ortho-Phosphorus (n=4) and dissolved phosphorus (n=3) were sampled and presented in the Technical Evaluation Report. Metal parameters analyzed include total and dissolved copper and zinc, and total aluminum and lead.

Aggregate pollutant load reduction over the evaluation period was calculated by multiplying the volume of each storm by the influent and event mean concentrations for each storm to derive a cumulative mass load entering and leaving the system respectively. The difference between these two values is the retained mass of material.

Table 3. StormFilter PhosphoSorb Performance Results

	Parameter	Sample population (n)	Average Influent (mg/L)	Average Effluent (mg/L)	Average Removal (%)	Aggregate Pollutant Load Reduction ¹ (%)
Solids	TSS	17	380	40	88	89
	SSC<500 μm	15	325	40	87	89
	Silt and Clay ²	16	153	32	78	82
Nutrients	Total Phosphorus	17	0.33	0.07	73	82
	Total Nitrogen	17	1.14	0.57	43	50
Metals	Total Zinc	15	0.129	0.024	78	81
	Dissolved Zinc	7	0.016	0.01	28	32
	Total Copper	15	0.026	0.005	79	82
	Dissolved Copper	7	0.004	0.003	30	28
	Total Aluminum	16	5.85	1.08	83	83
	Total Lead	15	0.009	0.003	64	70

¹ Treatment Efficiency Calculation, Method #2 (TAPE, 2008)

² Suspended Solids less than 62.5 microns

6.9 Statistical evaluation of performance goals

The TAPE (2011) requires bootstrapping to be used to compute the lower one-sided 95% confidence limit (LCL95) for pollutant removal efficiency for TSS and Total Phosphorus when pursuing Basic Treatment and Phosphorus Treatment use level designations. Data from the 17 events were analyzed using the 2011-08 TAPE bootstrap confidence interval calculator (bootstrap calculator) for TSS, SSC<500 µm, Silt and Clay, and total phosphorus.

Table 4. Bootstrap Lower One-Sided 95% Confidence Limits

Analyte	Sample Population (n)	Lower 95% confidence limit
TSS	15	85%
SSC<500 µm	14	85%
Silt and Clay	16	73%
Total Phosphorus	16	67%

LCL95 bootstrap results presented in Table 4 are suspended solids (TSS, SSC<500 µm, Silt and Clay) influent concentrations greater than 100 mg/L and for total phosphorus influent concentrations between 0.1 to 0.5 mg/L as required by the TAPE. Of the 17 events sampled, 12 had influent total phosphorus concentrations between 0.1 and 0.5 mg/L. Additionally, 4 events had influent total phosphorus concentrations greater than 0.5 mg/L. For these four events, an influent concentration of 0.5 mg/L was substituted for the reported concentration to allow for a conservative addition of these data points.

System Maintenance

Full maintenance of the system was performed on February 2, 2012 marking the beginning of the monitoring period for the Lolo Pass Road StormFilter. Maintenance involved removal of sediment from the unit and replacement of the StormFilter cartridge. Following maintenance, monitoring equipment was installed and the field evaluation was initiated.

The system was maintained four times throughout the 37 month evaluation period. Each of the maintenance events involved the removal of sediment within the system, removal of the used cartridge, and the installation of a new cartridge. Maintenance was performed on March 27, 2012, March 28, 2013, January 17, 2014, and October 10, 2014. With the exception to the March 27, 2012 maintenance event, maintenance events were 10 to 12 months apart.

The March 27, 2012 maintenance event occurred two months after monitoring began. This was the result of a large and unusual precipitation event in the area. A bridge located one mile downstream from the evaluation site washed out. In the weeks following this event, numerous construction vehicles were present within the drainage area being tested. Large amounts of sand and gravel were deposited in the drainage area. Approximately 13 inches of sediment accumulated within the system and the system was maintained.

Conclusion

The StormFilter with PhosphoSorb media operating at a specific flow rate of 1.67 gpm/ft² was evaluated at a roadway site in ZigZag, OR. Over a 37 month evaluation period, 25 storm events were sampled. Of these 25 events, 17 met the storm event and sampling collection criteria.

The suspended solids concentrations (TSS, SSC<500, silt and clay), total phosphorus, total aluminum, copper, and zinc all exhibited an aggregate pollutant load reduction greater than 80%. The TSS and sub-500 microns LCL95 removal was 85%. The LCL95 removal efficiency for silt and clay fraction was 73% and total phosphorus was 67%. The aggregate load reduction

of total nitrogen was 50%. The system exhibited these removal rates up to and exceeding the 1.67 gpm/ft² specific flow rate.

The StormFilter system evaluated was designed as a flow-based system in an online configuration. The flow-based system can be configured as either an on-line system with internal bypass or as an off-line configuration with external bypass and can provide excellent reduction of stormwater pollutants including solids, nutrients, and heavy metals.

References

Contech Engineered Solutions, LLC. (2015). The Stormwater Management StormFilter® PhosphoSorb® at a Specific Flow Rate of 1.67 gpm/ft² General Use Level Designation Technical Evaluation Report. Portland, OR. Author.

Washington State Department of Ecology (Ecology). (2011). Guidance for Evaluating Emerging Stormwater Treatment Technologies: Technology Assessment Protocol – Ecology (TAPE). Olympia, Washington. (Referred to as TAPE, 2011)

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