Product Evaluation

Heritage Marketplace Field Evaluation:

Stormwater Management StormFilter with CSF Leaf Media

Introduction

As part of a performance assessment of the Stormwater Management StormFilter® (StormFilter) in Clark County, WA, a StormFilter system using CSF® leaf media installed at Heritage Marketplace was evaluated between March and July of 2002. This StormFilter system treats stormwater runoff draining from the rooftops and parking lots of the Heritage Marketplace shopping center. This StormFilter system was evaluated to determine removal of various pollutants in the runoff, including total suspended solids (TSS), total phosphorus, orthophosphate, total zinc, dissolved zinc, total copper, dissolved copper, total lead, dissolved lead, and oil and grease (O&G). Over the course of the three storm events monitored during this study, the StormFilter system with CSF media, configured for a per-cartridge flow rate of 15 gpm, demonstrated the removal of solids, metals, and nutrients.

Figure 1. View of part of the Heritage Marketplace site drainage area.

Site and System Description

Drainage Area

The StormFilter system under evaluation is one of three systems installed at Heritage Marketplace. Heritage Marketplace is a busy shopping center anchored by a large supermarket and located at the intersection of NE 4th Plain Road and NE 162nd Avenue, Clark County, WA (N 45° 40.249, W 122° 30.368). The StormFilter system treats runoff from 4.0 acres of impervious surface. Primary sources of pollution within this drainage area include solids, metals, and oil from automobiles and their tires, and organic matter from landscaping. 40-ft upstream of the StormFilter system is a 7.0-ft by 5.5-ft pre-settling vault with a storage volume of 1,500-gal and a down-turned outlet pipe that is designed to remove some of the heavier solids from the stormwater runoff prior to filtration by the StormFilter system.

The StormFilter System

The typical StormFilter unit is composed of three bays: the inlet bay, the filtration bay, and the outlet bay. Stormwater first enters the inlet bay of the StormFilter vault through an inlet pipe, which is plumbed to catch basins and rooftop downspouts throughout the drainage area. Stormwater in the inlet bay is then directed through a flow spreader, which traps some floatables, oils, and surface scum, and over the energy dissipater into the filtration bay where treatment will take place. Once in the filtration bay, the stormwater begins to pond and percolate horizontally through the media contained in the StormFilter cartridges. After passing through the media, the treated water in each cartridge collects in the cartridge's center tube from where it is directed into the outlet bay by an under-drain manifold. The treated water in the outlet bay is then discharged through a single outlet pipe to an open channel drainage way.

The StormFilter system installed at Heritage Marketplace consists of a standard, 8.0-ft by 16-ft, pre-cast, concrete StormFilter vault with 23 StormFilter cartridges containing CSF leaf media and configured for a per-cartridge flow rate of 15 gpm. The overall system is designed to treat a peak flow rate of 0.77 cfs (345 gpm), which equates to 0.64 of the 2-yr, 24-hr storm using the Santa Barbara urban hydrograph to determine peak flow.

Sampling Methods

The equipment and sampling techniques used for this study are in general accordance with a Quality Assurance Project Plan developed by Stormwater360 according to the Washington State Department of Ecology (WADOE) TAPE protocol (WADOE, 2002).

Sampling Equipment

Samples were collected using two ISCO 6700-series, portable, automated samplers containing 24 individual polypropylene bottles. Each sampler was powered by a 12V DC battery connected with a fused cable. Samples were taken through a 0.5-in diameter stainless steel sample strainer with 0.25-in openings. This strainer was connected to a sample line of 0.375-in diameter, teflon-lined, vinyl suction tubing (Acutech Duality) that was attached to the sampler's peristaltic pump. Flow measurements were made using ISCO low-profile area velocity probes (flow probes) with a model 750 or 4150 data logger.

Equipment Installation

Under typical circumstances, two automated samplers, two sample lines, and two flow probes were used to monitor the influent entering and effluent exiting the StormFilter system; one flow probe and sample line was placed in the inlet pipe, the other probe and sample line in the outlet pipe. Thus, each sampler was independently controlled; the influent sampler by flow measurements entering the system and the effluent sampler by flow leaving the system.

The flow probes and sample lines were mounted on ISCO stainless steel spring rings (P/N 60-3203-061), which were sized to match the inner pipe diameter at the sampling location. The rings were fitted as far up into the pipe as possible, keeping the suction lines and flow probes stationary within the pipe. The suction lines and flow probe cables were wrapped together and routed out of the pipe to the samplers.

Alternately, when only one flow probe was available for the site, the probe was placed in the influent pipe, and both influent and effluent samplers were controlled by influent flow measurements. In all cases, samples were taken as water entered and exited the StormFilter unit and do not measure pollutant removal associated with treatment by the upstream pre-settling vault or catch basins.

Appendix A details the location of the sampling points at the site. All sampling equipment was installed in the vault for the purpose of security and protection from the elements. Rainfall was monitored using a tipping-bucket type rain gage placed in a level position on the roof of the supermarket.

Sampling Equipment Operation

The influent and effluent pipe diameters were measured and entered in to the sampler flow program before sample collection to allow for accurate flow calculation and sample pacing. The flow meters were set to record flow measurements every 0.5 to 5 minutes and were programmed to begin sample acquisition when a predetermined flow rate was exceeded. This flow rate varied from 5 gpm to 15 gpm throughout the monitoring program and served as a threshold to ensure that low flows from small showers and dry-weather flow were not sampled. Once the samplers were triggered and initial samples were acquired, subsequent samples were collected on a volume-paced basis. This volume was based on an estimate of the cumulative runoff volume to pass through the system, which was in turn based upon forecasted storm size.

Sample Collection and Analysis

After each storm event, a field crew was mobilized to collect the water samples and to download the flow data from the automated samplers using ISCO Flowlink 4 software. A laptop computer was used to collect and temporarily store the hydrograph data. Once back in the office, the data was transferred electronically to a monitoring database.

Table 1. Analytical methods.

Analyte	Sample Matrix	Analytical Method (EPA)	Probable Quantitation Limit (mg/L)
Oil & Grease	Water	1664	< 5
Phosphate, Ortho	Water	365.2	< 0.3
Phosphorus, Total	Water	365.1	< 0.01
Total Suspended Solids	Water	160.2*	< 10
Metals, Dissolved	Water	6010	< 0.05
Metals, Total	Water	6010	< 0.05

** whole sample variation*

Sample bottles were capped, labeled, and transferred from the sampler housing directly to a cooler stocked with gel ice packs. The samples were then taken to the Stormwater360 laboratory, where they were composited according to the hydrograph data to create flow-weighted, event mean concentration (EMC) sub-samples for analysis.

The samples were composited and split using a 14-L churn sample splitter (Bel-Art Products) and sent to Severn-Trent Laboratories, Inc. (STL) in Fife, WA, (Oregon and Washington State accredited laboratory) for analysis. Effluent samples were composited before influent samples so as to further minimize the possibility of cross-contamination. STL analyzed the samples using the methods listed in Table 1.

Field QC

To prevent cross-contamination of samples, the following procedures were followed to decontaminate sampling equipment:

Churn Sample Splitter Washing Procedure

1. Wash all parts with a solution of suitable phosphate-free detergent (RBS-35, Decon, Alconox, etc.)
2. Rinse parts with tap water, then rinse under a stream of DI water

Sample Bottle Washing Procedure

3. Remove all markings from sample bottles with acetone prior to washing.
4. Soak sample bottles in a hot solution of suitable phosphate-free detergent (RBS-35, Decon, Alconox, etc.).
5. Scrub each bottle thoroughly with a bottle brush.
6. Rinse each bottle with tap water until rinsate is free of detergent.
7. Any bottles appearing stained or cracked should be discarded.
8. Using 10% HNO_3 wet all surfaces thoroughly and allow to sit overnight.
9. Collect used acid solution from bottles in a suitable container and neutralize to pH 6 with $NaHCO_3$ before discarding.
10. Rinse each bottle with tap water, then rinse three times under a stream of distilled water.
11. Drip dry bottles in cart or on wall racks.
12. After removing all markings, soak and rinse bottle caps for several hours in phosphate-free detergent, then rinse 3 times with DI water, then allow to air dry.
13. Store dry bottles and lids in closed clean plastic totes between uses.

Sampler and Tubing Cleaning Procedure

1. Visually inspect all tubing, especially peristaltic pump tubing, for cracking, swelling, or brittleness. If excess wear is apparent, replace tubing.
2. Clean all tubing by pumping at least 2L of DI water through each sampler.
3. Remove suction tubing from the influent and effluent pipes and from the sampler and cap both ends with either fitted plastic caps or aluminum foil.
4. Perform routine rinsate blanks to test tubing for contamination

A rinsate blank was collected from the influent set of sampling equipment to ensure that the sampling equipment did not contaminate water samples or tubing. The blank was collected by pumping DI water through the fully assembled sampler after all components had been cleaned according to the decontamination procedures. The blank was then transported as a standard sample and analyzed for TSS, total metals and total phosphorus using the methods listed in Table 1. All rinsate blanks samples associated with this study returned non-detects for all analytes, indicating that the sampling equipment decontamination procedures were effective.

Table 2. Summarized performance of the CSF StormFilter system (15 gpm/cartridge) installed at Heritage Marketplace over the course of 3 storm events.

Analyte	*n*	Range of Influent Concentrations (mg/L)	Range of Discrete Removal Efficiencies (%)	Aggregate Pollutant Loading Reduction (%)
TSS	3	84 to 280	69 to 90	87
Total Zn	3	0.167 to 0.24	50 to 65	61
Total P	3	0.12 to 0.25	33 to 58	46

Results

In Accordance with the Washington State Department of Ecology, system performance over the course of three storm events was determined as "aggregate pollutant loading reduction" (WADOE, 2002 method #2)—the performance of the system over the course of multiple storm events based upon summarized load values—using the influent flow data to determine runoff volume. Performance is summarized in Table 2. Appendix B details system performance on an individual storm basis (discrete removal efficiency) using the Washington State Department of Ecology "individual storm reduction in pollutant concentration" method (WADOE, 2002 method #1)—the performance of the system over the course of a single storm event based upon concentration. Hydrograph data and rainfall totals from the three events are also shown in Appendix B.

TSS, total phosphorus, and total zinc were the only analytes that could be summarized and reported with any analytical significance. This is consistent with previously gathered data from StormFilter systems at similar sites. Hence, analysis only included TSS, zinc, phosphorus, and oil and grease for the first storm event (4/26/02). Due to the adequate TSS concentrations observed during the 4/26/02 event, additional analytes were added to the analysis lists for the subsequent events.

Discussion

The CSF StormFilter system installed at Heritage Marketplace and operating at a per-cartridge flow rate of 15 gpm demonstrated noticeable removal of TSS, total Zn, and total phosphorus. Dissolved zinc removal was modest, however this is most likely explained by the very low influent concentrations that were encountered by the system. Similarly, though ortho-phosphorus analysis yielded non-detect values, the analytical method did not yield sufficient resolution compared to the total phosphorus analysis to allow a determination of the ability of the system to address particulate and dissolved phosphorus compounds. The available analytical method for oil and grease also did not have enough precision to measure the extremely low concentrations encountered by the system.

As mentioned, Heritage Marketplace is a busy shopping center that receives a large volume of traffic on a daily basis. This is evidenced by the high concentrations of influent TSS. These concentrations are unusually high given the presence of a pre-settling vault upstream of the influent sampling point, which should capture the heavier solids. Visual observations of the samples associated with the 4/26/02 event indicated an abundance of low-density, organic particles. To confirm this observation, Total Volatile Solids (TVS) analysis was added to the analysis list for samples from the 5/17/02 event, indicating that 59% of the particulate matter leaving the pre-settling vault and entering the StormFilter system was volatile and thus assumed to be organic. The organic, low density nature of the materials entering the StormFilter system most likely explains their ability to evade capture by the pre-settling vault.

Figure 2. Evidence of low-density solids within the StormFilter system. Notice the floating solids as well as the solids visible on the tops and sides of the StormFilter cartridges as well as the sides of the overflow scum baffle (white object in upper right of picture).

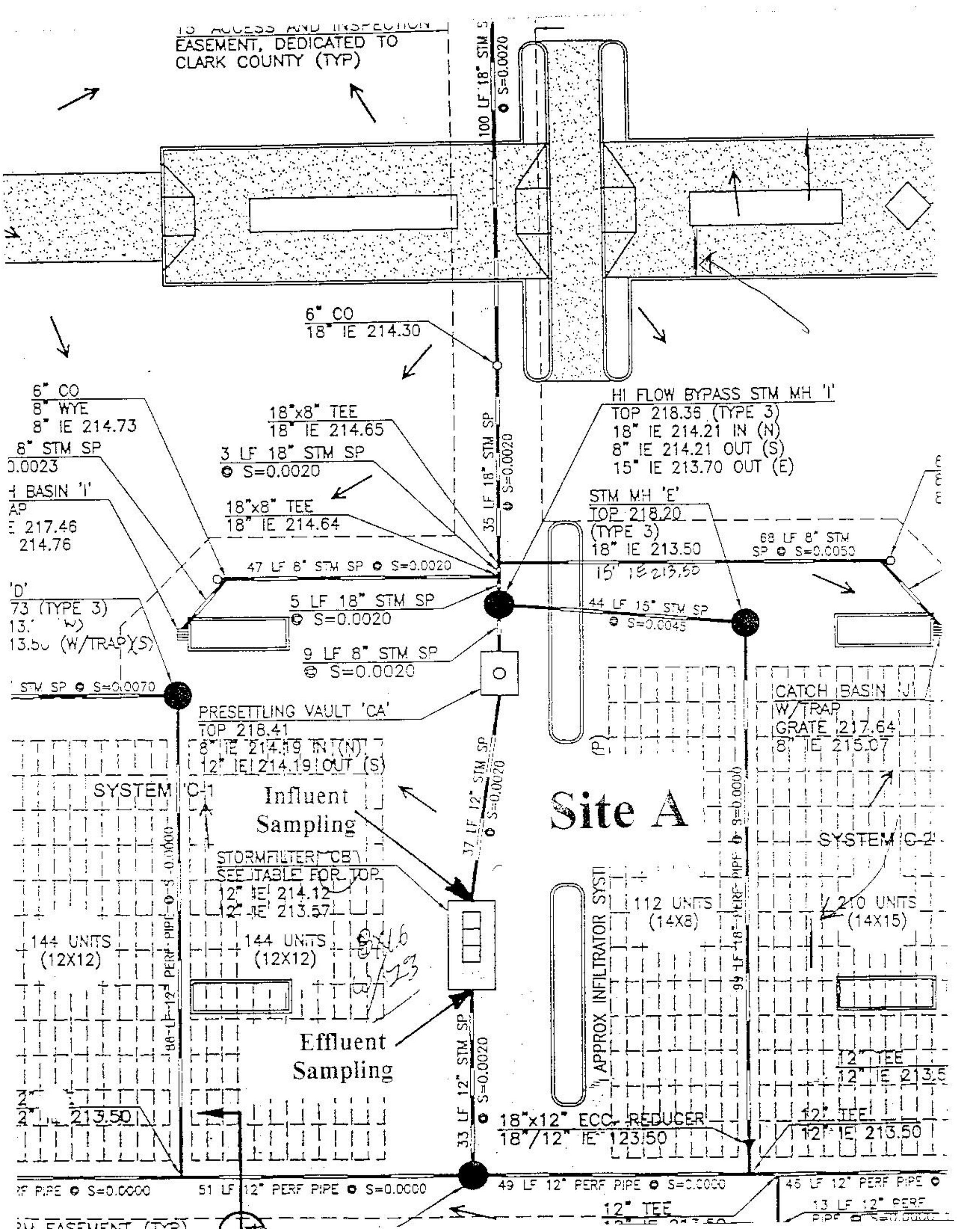
Stormwater360, Stormwater Management Inc, and Vortechnics Inc. are now CONTECH Stormwater Solutions Inc.

References

Washington State Department of Ecology (WADOE). (2002). Guidance for Evaluating Emerging Stormwater Treatment Technologies: Technology Assessment Protocol—Ecology (Publication Number 02-10-037). Olympia, Washington: Author.

Appendix A

Site Plan and Sampling Locations



Appendix B
Product Evaluation Individual Storm Report

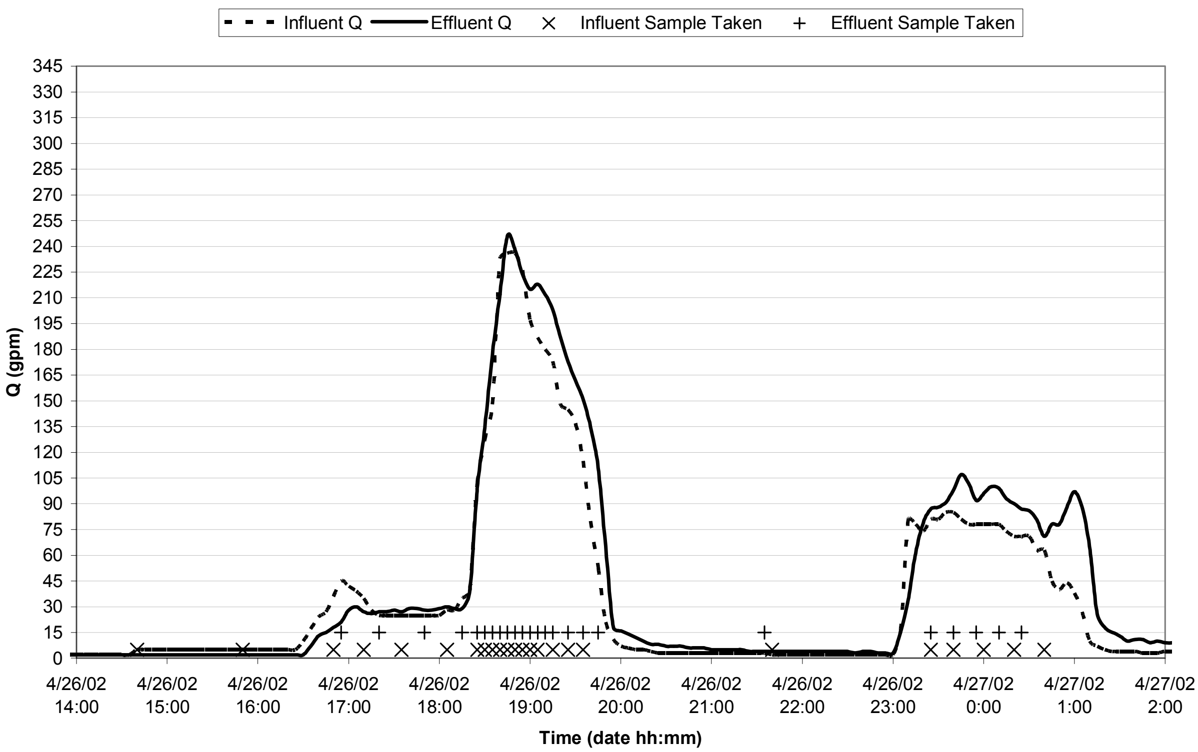
General Information

Site:	Heritage Marketplace (2270), Vancouver, WA
System Description:	8x16 vault, CSF, 23 cartridges @ 15 gpm
Event Date:	4/26/02 to 4/27/02
Date of Last Maintenance:	4/27/01
Antecedent Conditions:	10 days since last rain event

Hydrology

Total Precipitation (in):	0.24
Peak Flow, Influent (gpm):	236
Peak Flow, Effluent (gpm):	246
Total Runoff Volume (gal):	26925

Event Hydrograph



Analytical

Bottles Used:	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	PQL	Dup. RPD	Discrete Removal Efficiency
1-24	TSS	280	27	0.0005	0.9%	90%
	Total Zn	0.167	0.0673	0.01	20.0%	60%
	Dissolved Zn	0.0567	0.0511	0.03	0.0%	10%
	Total P	0.24	0.10	0.01	1.2%	58%
	Ortho-P	ND	ND	0.3	-8.1%	undeterminable
	Oil and Grease	ND	ND	5	1.1%	undeterminable

Notes

None.

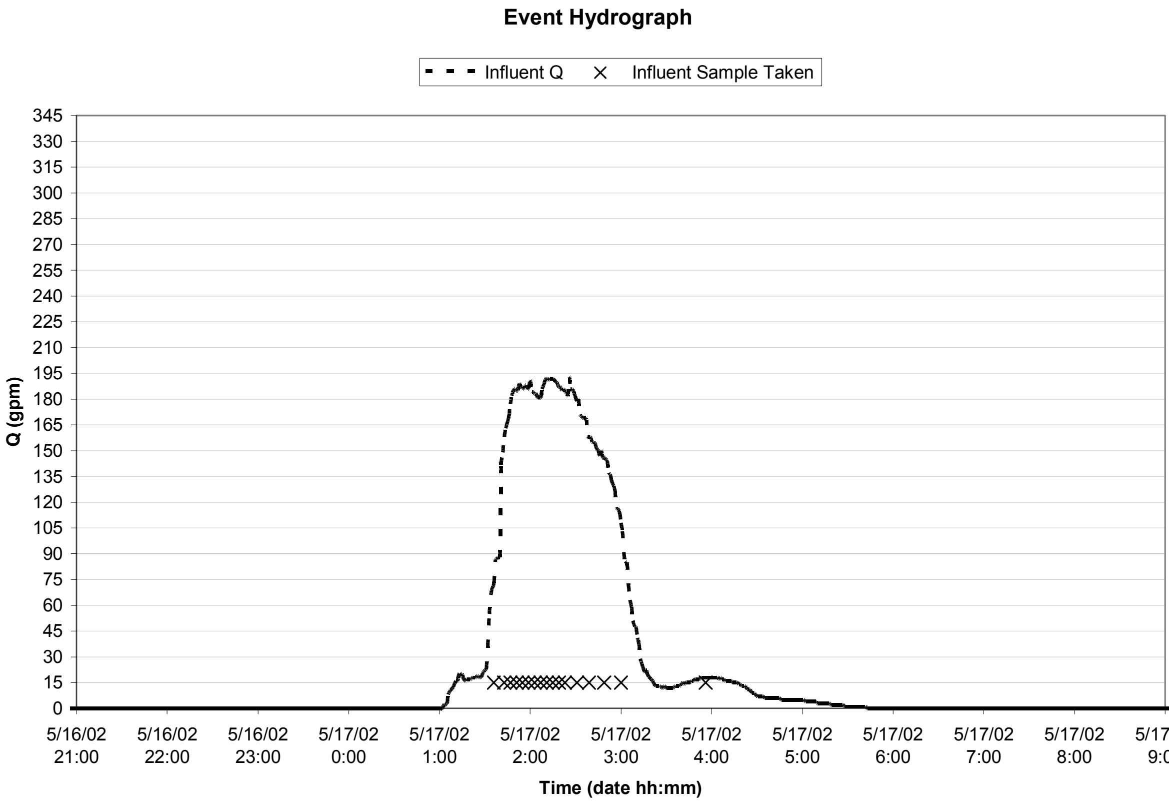
Appendix B
Product Evaluation Individual Storm Report

General Information

Site:	Heritage Marketplace (2270), Vancouver, WA
System Description:	8x16 vault, CSF, 23 cartridges @ 15 gpm
Event Date:	5/17/02
Date of Last Maintenance:	4/27/01
Antecedent Conditions:	2 days since last rain event

Hydrology

Total Precipitation (in):	0.16
Peak Flow, Influent (gpm):	190
Peak Flow, Effluent (gpm):	---
Total Runoff Volume (gal):	16921



Analytical

Bottles Used:	Parameter	Concentrations (mg/L)				Discrete Removal Efficiency
		Influent EMC	Effluent EMC	PQL	Dup. RPD	
1-17	TSS	84	26	4	10.3%	69%
	TVS	49.3	23.1	0.1	0.0%	53%
	Total Zn	0.187	0.093	0.03	20.0%	50%
	Dissolved Zn	0.0772	0.0692	0.03	-19.0%	undeterminable
	Total Cu	0.0164	0.0109	0.01	20.0%	34%
	Dissolved Cu	ND	ND	0.01	20.0%	undeterminable
	Total Pb	0.0082	ND	0.005	20.0%	39%
	Dissolved Pb	ND	ND	0.005	20.0%	undeterminable
	Total P	0.12	0.08	0.01	0.4%	33%
	Oil and Grease	ND	ND	5	1.1%	undeterminable

Notes

Only one flow probe was used; influent and effluent samples were paced by the influent flow. Shaded Dup. RPD values defaulted to 20% standard due to QC complications.

Appendix B

Product Evaluation Individual Storm Report

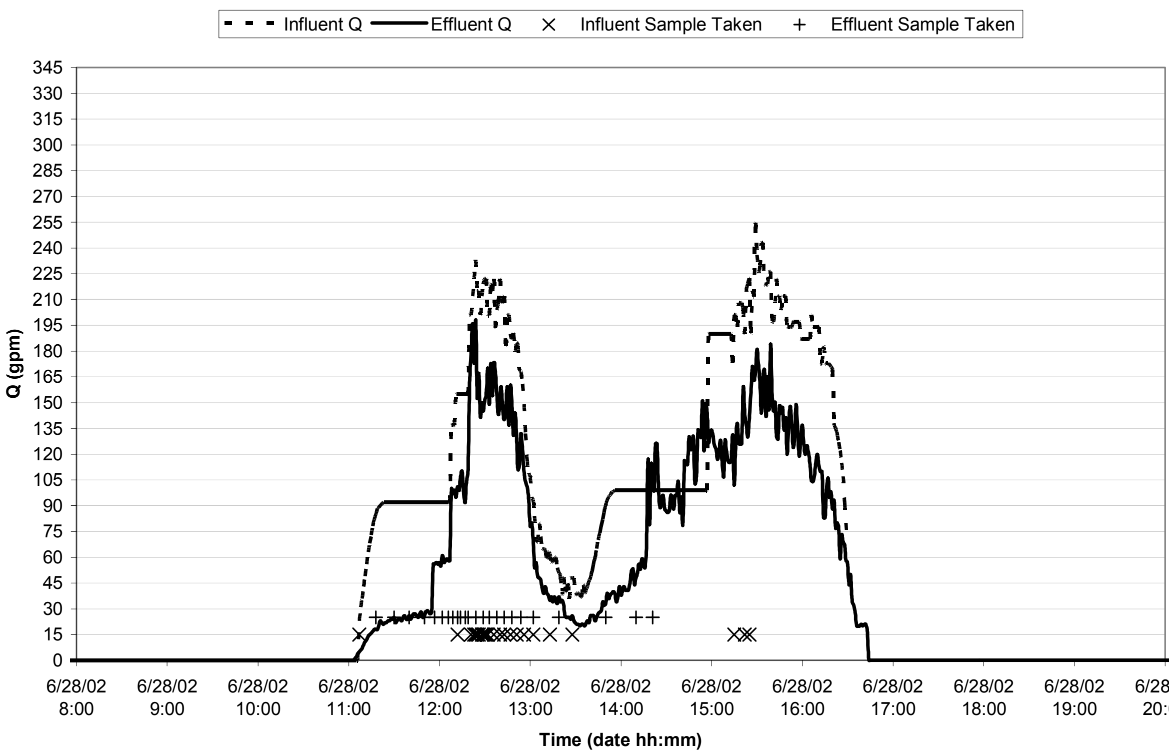
General Information

Site:	Heritage Marketplace (2270), Vancouver, WA
System Description:	8x16 vault, CSF, 23 cartridges @ 15 gpm
Event Date:	6/28/02
Date of Last Maintenance:	4/27/01
Antecedent Conditions:	9 days since last rain event

Hydrology

Total Precipitation (in):	0.82
Peak Flow, Influent (gpm):	254
Peak Flow, Effluent (gpm):	198
Total Runoff Volume (gal):	42047

Event Hydrograph



Analytical

Bottles Used:	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	PQL	Dup. RPD	Discrete Removal Efficiency
1-24	TSS	206	28	2	1.5%	86%
	Total Zn	0.24	0.0829	0.01	20.0%	65%
	Dissolved Zn	0.0419	0.0425	0.01	20.0%	undeterminable
	Total Cu	0.0277	0.0155	0.01	36.0%	undeterminable
	Dissolved Cu	ND	ND	0.01	20.0%	undeterminable
	Total Pb	0.0137	ND	0.01	84.0%	undeterminable
	Dissolved Pb	ND	ND	0.01	20.0%	undeterminable
	Total P	0.25	0.15	0.01	15.0%	40%
	Ortho P	ND	ND	0.15	20.0%	undeterminable
	Oil and Grease	ND	ND	5	2.2%	undeterminable

Notes

Shaded Dup. RPD values defaulted to 20% standard due to QC complications.

Revision Summary

PE-D014
Document rebranded.

PE-D013
Document number changed; document rebranded; no substantial changes.

PE-03-001.2
Product Evaluation Individual Storm Reports in Apprendix B changed such that General Information enhanced, data verified and validated, and format slightly changed; Table 2 enhanced; minor changes to text; conclusions changed slightly due to data verification and validation.

PE-03-001.1
Information in Appendix B enhanced to include antecedent condition information; body text unchanged.

PE-03-001.0
Original.