Technical Evaluation Report

BayFilter^{TM} EMC System

Woodinville Sammamish River Outfall, Woodinville, Washington

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Acronyms and Abbreviations

ASTM	American Society for Testing and Materials
BayFilter™ EMC	BayFilter™ Enhanced Media Cartridge
BaySaver	BaySaver Technologies, LLC
BMP	Best Management Practice
cfs	Cubic Feet per Second
CULD	Conditional Use Level Designation
d_{10}	Diameter of Particles that Comprise 10 Percent or Less of the Mass
d_{50}	Diameter of Particles that Comprise 50 Percent or Less of the Mass
d_{90}	Diameter of Particles that Comprise 90 Percent or Less of the Mass
DOE	Department of Ecology
gpm	Gallons per Minute
GULD	General Use Level Designation
HDPE	High Density Polyethylene
in/hr	Inches per Hour
Isco	Teledyne Isco
MASWRC	Mid-Atlantic Stormwater Research Center
ug/L	Micrograms per Liter
mg/L	Milligrams per Liter
mL	Milliliter
MTR	Maximum Treatment Rate
ND	Non-Detect
%	Percent
PSD	Particle Size Distribution
PULD	Pilot Use Level Designation
PVC	Poly Vinyl Chloride
QAPP	Quality Assurance Project Plan
QA/QAC	Quality Assurance/Quality Control
site	BayFilter™ System Drainage Area
SSC	Suspended Sediment Concentration
TAPE	Technology Assessment Protocol – Ecology

TARP	New Jersey Department of Environmental Protection Technology Assessment and Reciprocity Program
TER	Technical Evaluation Report
TP	Total Phosphorus
TSS	Total Suspended Solids

1.0 Introduction

BaySaver Technologies, LLC, is seeking approval from the State of Washington Department of Ecology (DOE) for the BayFilter™ Enhanced Media Cartridge (EMC) for use as a stand-alone storm water treatment device. A field monitoring program was conducted from November 11, 2013 to March 30, 2015 at Woodinville Sammamish River Outfall in Woodinville, Washington to assess the compliance of the EMC system with DOE Technology Assessment Protocol – Ecology (TAPE) requirements on total phosphorous (TP) and basic (TSS) removal. Site precipitation, flow rate, and influent and effluent data from the EMC system were collected over a series of twelve qualifying rainfall events. This report contains these data and an evaluation of BaySaver's treatment performance claims.

Since 1997, BaySaver has been protecting lakes, streams, and waterways from the harmful effects of polluted stormwater. The historical use of sand filters in wastewater and storm water treatment influenced the design of BaySaver's EMC, which was introduced in 2010. The EMC has approximately 90 square feet of active filtration area, with a designed flow rate of 0.5 gallons per minute per square foot (gpm/sf). System design is completely off-line with an external bypass that routes high intensity flows away from the cartridges, thereby minimizing sediment re-suspension. In the field, the cartridges are housed in a concrete structure that evenly distributes the flow between EMCs. Flow through the cartridges is gravity-driven and self-regulating, which makes the BayFilter™ EMC system a low-maintenance, high-performance option for stormwater treatment technology.

Previously, the BayFilter™ EMC system was approved by the DOE for a Pilot Use Level Designation (PULD, **Appendix B**), and subsequently for a Conditional Use Level Designation (CULD, **Appendix C** and **D**). In accordance with the Quality Assurance Project Plan (QAPP) and TAPE requirements, a field monitoring program was conducted in Grandview, Washington. After this data was reviewed, the State of Washington DOE granted the BayFilter™ EMC System a General Use Level Designation (GULD) for basic treatment (TSS removal).

This technical evaluation report (TER) is a comprehensive compilation and evaluation of monitoring and analytical data collected from an additional field monitoring program in Woodinville, Washington. It includes data summaries from each individual rainfall event, a statistical evaluation of the collected data (bootstrap method with 95% confidence interval), a detailed discussion of the analytical and field monitoring results, and conclusions regarding the removal capabilities of the BayFilter™ EMC system. These field monitoring activities were conducted under the guidelines set by the Woodinville Sammamish QAPP, which was submitted to the DOE on September 28, 2013 and revised on March, 15 2015 (**Appendix A**).

During this field testing program, twelve qualified rainfall events were monitored and sampled. The test equipment was installed by BaySaver and all sampling and analysis was performed by an independent third party in accordance with the QAPP. Based on the analytical results reported, the BayFilter™ EMC system exceeded the requirements for a GULD in TSS removal by achieving, on average, an 89.7% removal rate (influent TSS >100 mg/L) and 7.25 mg/L average effluent TSS concentration (influent TSS < 100 mg/L). For all twelve qualified events, the BayFilter™ EMC achieved an average removal rate of 86.4% (80.7% - 91.6%, 95% CI) for TSS. Over the course of twelve qualifying rainfall events with influent concentrations between 0.1 and 0.5 mg/L, the BayFilter EMC achieved a mean TP removal efficiency of 64.1% (59.8% - 68.3%, 95% CI), which exceeds the TAPE guideline of 50%.

In light of these findings, it is recommended that the Washington DOE grant the BayFilter™ EMC system a GULD approval for TP removal.

2.0 Roles

BaySaver and the Mid-Atlantic Storm Water Research Center (MASWRC) managed the field monitoring activities. Collection of influent and effluent stormwater samples, rainfall data, and flow data was conducted by field personnel from Terracon, located in Mountlake Terrace, WA. Influent and effluent stormwater samples were submitted by Terracon to the ALS (formerly CAS) Life Science Division and analyzed at the ALS Laboratory in Everett, WA.

3.0 Site Description

The field testing occurred at the Woodinville Sammamish test site located near the intersection of NE 175th Street and 131st Ave NE in Woodinville, Washington. The treatment area spans 52 acres, 49 of which are occupied by completely constructed office, commercial, and transportation facilities. The remaining three acres are covered by ground vegetation. **Appendix E** shows the project site and the three major drainage basins (A, B, and C). The region highlighted in red was identified by the city as a 100% infiltration area and is labeled as such.

Soil boring data provided by Perteet, Inc. from January 2009 indicates that the groundwater level at the site is approximately 21 feet above sea level (**Appendix E**). The Sammamish River high water mark at the project location is at 21.4 ft. The available maximum drop (head drop) between the inlet of the new facility and the discharge point (elevation 21.75 ft) is approximately 2.6 ft. The NRCS Soil Survey maps revealed that the underlying soil is in hydrologic soil group A, which has a high infiltration capacity.

Storm water runoff from the Woodinville site is directed into a pretreatment unit (a 5K BaySeparator) via high density polyethylene (HDPE) corrugated stormwater inlet pipe.

After passing through the separator, effluent flow is diverted to the BayFilter™ EMC system where it is treated and released to an outlet structure through a single HDPE pipe. High flows bypass the BayFilter™ system and are conveyed through the BaySeparator to a manhole downstream. A set of site plans is also included in **Appendix E**.

4.0 BayFilter™ Treatment Technology

The BayFilter™ system is a storm water quality treatment device that removes contaminants from storm water runoff via media filtration. Media filtration has long been used in drinking water and wastewater treatment processes. This technology has proven effective at removing sediments, nutrients, heavy metals, and a wide variety of organic contaminants. BayFilter™ removes pollutants from water by three mechanisms: separation, interception, and adsorption. Separation occurs before the influent water enters the filter cartridge, and is the differential density settlement of large, coarse particulate to the floor of the filter vault. Interception occurs when a pollutant is carried into the filter via water flow and becomes trapped in the media fabric or the media itself. Particles will typically remain trapped until the media is removed or through backwash. Adsorption is the process by which dissolved ions chemically bind themselves to the surface of the media. This occurs when the surface of the filter media particle contains sites that are chemically attractive to the dissolved ions. BayFilter™ uses a proprietary media containing activated alumina to enhance adsorption of anions, such as phosphates.

4.1 BayFilter™ Treatment System

At the Woodinville site, runoff is conveyed to the BayFilter™ EMC system after it enters the separator unit via a 48” diameter corrugated polyethylene stormwater inlet pipe. Low and moderate effluent flows are then directed by an 18” HDPE inlet pipe to a 44’x10’ precast vault (**Figure 1**), where the EMCs are situated. Inside the vault, the filter cartridges are connected to an outlet pipe by a PVC under-drain. Flows greater than 4 cfs are diverted within the BaySeparator and bypass the filter system entirely. The bypass flow if conveyed into a 4’ diameter manhole located downstream of the filter valut.

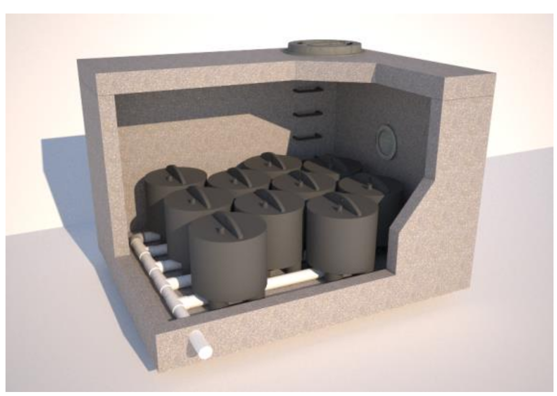

Figure 1 Simple Schematic of a Typical BayFilter™ Setup

4.1A BayFilter™ Component Construction Materials

The exterior casing of the BayFilter™ EMC Filter Cartridge is manufactured out of High Density Polyethelyne (HDPE). The top of the cartridge is equipped with a vertical fin, which allows it to be lifted in and out of position during installation and maintenance. An HDPE inlet plate, which allows stormwater to enter the EMC, is located on the bottom of the cartridge. Polymer seals are used to attach the spiral-wound filtration layers and outlet drainage channels to the inlet plate (**Figure 2**).

A 3/8-inch thick layer of media is sandwiched between layers of filter fabric. This filtration layer is placed between layers of plastic drainage media, which form inlet and outlet drainage channels. As the water level inside the vault rises, influent stormwater fills the bottom of the cartridge and flows vertically up through the inlet channels. Stormwater is then forced horizontally through the inlet filtration layer, which is a 4-ounce filter fabric encasing a 3/8-inch layer of blended media, and the outlet filtration layer, which is a 10-ounce filter fabric encasing a 3/8-inch layer of blended media (Figure 2).

The treated stormwater is conveyed vertically to the top of the BayFilter™ EMC via the outlet drainage channels. A one-way air release valve, which expels air from the outlet chamber as the water level rises inside the cartridge, is located on the top of the BayFilter™ EMC. The outlet chamber is drained by a 2.5-inch diameter outlet pipe in the center of the BayFilter™ EMC, which forces treated stormwater through a flow-control orifice and to the under-drain manifold (**Figure 2**).

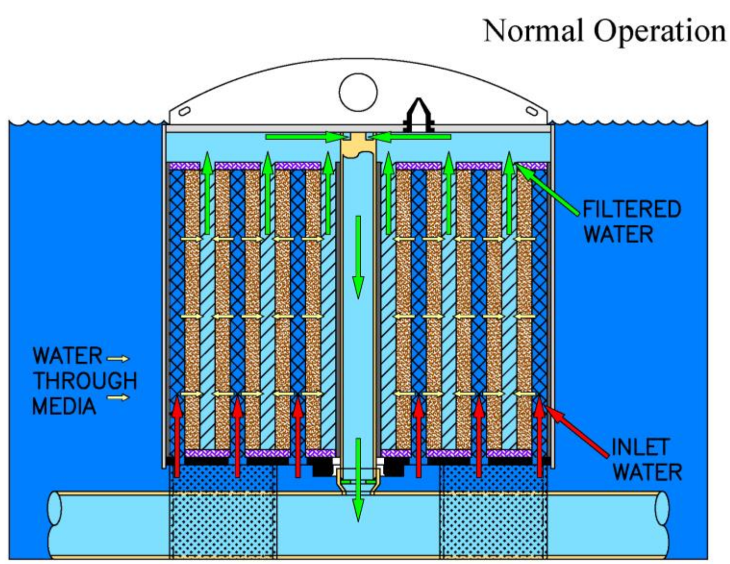

Figure 2 Cut-Away View of the System and Relevant Piping Connections, Including the Vertical Drain (Center)

4.1B BayFilter™ Component Dimensions

Each standard cartridge is approximately 28 inches in diameter and 30 inches in height. The containment structure varies in size according to the anticipated flow rates and the associated number of necessary cartridges. In Woodinville, 40 EMCs were installed in a 44'x10' pre-cast concrete vault.

4.1C BayFilter™ Component Capacity

Influent storm water is distributed evenly through the cartridges, which have 90 square feet of active filtration area apiece. The BayFilter™ cartridges operate at 0.5 gpm per square foot which equates to 45 gpm per cartridge. The BayFilter™ System Technical and Design Manual (**Appendix F**) contains detailed sizing information and further design details.

4.1D BayFilter™ Treatment Functions

The filter media, comprised of zeolite, perlite, and activated alumina, is packaged in a patented spiral-wound configuration and contained within layers of polymer fabric (filter fabric) for media containment and additional filtration performance. Two drainage spirals provide for inlet and outlet flow paths.

When the water level in the containment structure (filter vault) reaches 28 inches (full flow), water begins to flow through the cartridges. As storm water enters an EMC through the inlet plate located at the bottom of the cartridge and enters into the inlet spiral. As this occurs air is expelled through the air-release valve located at the top of the cartridge. From the inlet spiral, water flows horizontally through the thin layer of fabric into the filter media. The filtered stormwater flows through thicker fabric to the outlet drainage spiral, which is also a single spiral wrap of outlet material. The stormwater then flows vertically to the outlet chamber located on the inside top of the filter. From there, water flows to the center outlet drain and through the under-drain manifold below the inlet plate.

The storm water is driven by gravity and hydraulic head through the BayFilter™ EMC, where the media and filter fabric trap suspended solids, and dissolved contaminants are adsorbed onto the surface of the media particles. The adsorption is aided by the high surface area of the media particles and the ionic interactions between the media particles and contaminants.

When the inflow of stormwater stops or the rate of inflow is below the rate of outflow, the BayFilter™ EMC system will continue to operate via siphon. The flow rate through the cartridges is gradually reduced toward the end of the siphon cycle. This allows the BayFilter™ EMCs to remain in siphon until the water level in the containment structure falls to the bottom of the BayFilter™ housing and media. Once the water reaches the bottom of the cartridge, air enters the BayFilter™ EMC, thereby breaking the siphon. The water remaining in the BayFilter™ cartridge reverses flow and backwashes the intercepted pollutants from the cartridge. This backwash has the effect of dislodging particles captured in the filter media layers and reestablishing filter media porosity. Dislodged particles are transported by the backwash and accumulate on the filter manhole/vault floor.

4.2 BayFilter™ Pretreatment Requirements

The BayFilter™ EMC system is able to act as a stand-alone, flow-based treatment technology and its efficiency is not affected by the installation of a pretreatment device. As a result, in the absence of a pretreatment device, the removed sediment would instead settle to the floor of the filter vault with no reduction in efficiency.

Pretreatment by a separator or similar device does, however, significantly extend the lifespan of the EMCs, because larger solids settle in the pretreatment system rather than accumulating on the floor of the filter vault. Additionally, a pretreatment device can be configured to collect the larger pollutants during peak flows that are beyond the treatment capacity of the BayFilter™ system

4.3 BayFilter™ Installation Requirements

BayFilter™ EMCs, as part of the BayFilter™ system, are housed in an underground structure such as a vault or manhole. The small footprint for placement of the BayFilter™ EMC system with minimal site disturbance or modifications. The filter structure must allow for at least 28 inches of water to accumulate in order to drive the filtration process and siphon. The BayFilter™ system has no electrical components and functions under the principles of gravity flow (drainage and pressure head).

4.4 BayFilter™ Sizing Methodology

To determine the number of cartridges required for a BayFilter™ EMC installation, three factors must be considered:

1. The anticipated maximum flow rate of the site
2. The anticipated sediment load of the site
3. Specific sizing requirements of the jurisdiction (ex: water quality volume)

Each of the above factors, when evaluated, will determine a minimum number of cartridges required to address each design parameter. Calculations for all three factors need to be done to determine which design factor is limiting. The system configuration will then become the greatest number of cartridges determined by the above calculations.

When sizing in Western Washington, the Western Washington Hydrology Model (WWHM) is used. The WWHM sizes a BMP based on the water quality volume or the flow rate. We will utilize the WWHM software to calculate sizing for different sites based on the drainage area, soil characteristics, vegetation cover and local rainfall patterns. Stormwater treatment systems installed downstream of the detention system, will be sized to handle full 2-year release rates. Runoff from the stormwater technology will be compared with pre-development to comply with the Ecology standard.

When sizing in Eastern Washington, we will utilize the methods outlined in the "Stormwater Management Manual for Eastern Washington". According to this document, each treatment BMP will be sized based on a water quality design volume or water quality design flow rate. Specific jurisdictions will adopt criteria for sizing. For volume-based stormwater treatment we will predict the volume of runoff for the proposed development condition from the regional storm with a 6-month return frequency for Regions 1 and 4. For volume-based stormwater treatment we will predict the volume of runoff for the proposed development condition from the SCS Type IA 24-hour storm with a 6–month return frequency for regions 2 and 3. For water quality design flow rates, the design will depend on whether the stormwater treatment is located downstream or upstream of the detention system. Typically, BaySaver Technologies sizes their stormwater treatment downstream of the detention system. For regions 1 and 4, the runoff flow rate will be predicted for the proposed development condition from the short duration storm with at 6-month return frequency. For regions 2 and 3, the runoff flow rate will be predicted for the proposed development condition from the SCS Type II 24-hour storm with a 6-month return frequency.

4.5 BayFilter™ Expected Treatment Capabilities

The BayFilter™ EMC system has been extensively tested in the laboratory using SIL-CO-SIL 106 as a surrogate sediment. SIL-CO-SIL 106 is an engineered silica product containing approximately 90% fine sediments (the diameter at which 50% of the particles are smaller [d_{50}] is 23 microns). It has been widely accepted as a sediment source for stormwater laboratory testing by regulatory agencies such as the Washington State DOE TAPE program and the New Jersey Department of Environmental Protection Technology Assessment and Reciprocity Program (TARP).

The BayFilter™ EMC system is designed to achieve a TSS removal efficiency that exceeds 80% at the design flow rate. The cartridge media also removes dissolved metals and phosphorus through adsorption. As a result of the combined fine particle removal and dissolved particle removal ability, TP removal rates greater than 60% are expected. The lab summary report on the BayFilter™ EMC can be found in **Appendix F**.

4.6 BayFilter™ Maintenance Procedures

Maintenance was completed prior to the start of testing and no maintenance was necessary during the testing time frame, which spanned two wet seasons.

4.6A BayFilter™ Maintenance Inspections

Like any other structural stormwater Best Management Practice (BMP), the BayFilter™ EMC system requires routine maintenance to operate at its design capability. Inspection is the key to effective maintenance, and it is particularly useful to keep a record of each inspection. It should be noted that sediment accumulation may be especially variable during the first year after installation as construction disturbances and landscaping stabilize.

4.6B BayFilter™ Maintenance Operations

The BayFilter™ EMC system should be periodically monitored to ensure that it is operating correctly. When the system exhibits flows below design levels, does not completely drain between storm events, or accumulates sediment up to the top of the manifold pipes maintenance should be performed.

Maintenance should always be performed when there is no flow entering the system. For this reason, cleanouts should be scheduled during dry weather or between rainfall events. The spent cartridges should be removed and replaced, and any accumulated sediment should be cleaned out with a vacuum truck.

4.6C BayFilter™ Life Span

BaySaver recommends that the BayFilter™ system be sized to last a minimum of one to three years under normal conditions. If the system does not drain down within 24 hours of the conclusion of a rainfall event, the filter cartridges likely need to be replaced. Each site has unique contaminant characteristics and those sites with high sediment, excessive organics, and/or petroleum hydrocarbons will likely require more frequent maintenance.

5.0 Sampling Procedures

Storm water influent and effluent samples for water quality analysis were collected during the qualifying rainfall events by field personnel from Terracon. Water quality samples were submitted to the ALS Life Sciences Division Laboratory (ALS) for analysis. The collection procedures, sampling equipment, analytical methods, quality control and quality analysis, and statistical goals used as part of the field monitoring program are described below.

5.1 Sample Collection Procedure

Influent and effluent water quality samples were collected by four Isco auto-samplers. The automatic sampler which collects the influent stormwater prior to the pre-treatment unit (BaySeparator 5K) is referred to as Sep-IN. The sampler that collects this BaySeparator effluent is known as Fil-IN. The sampler which collects the BayFilter effluent is known as Filt-OUT. The sampler known as Sep High OUT collects the stormwater which has bypassed the BayFilter™ system during high intensity storms. The samplers collected flow-paced samples by withdrawing a 230 milliliter (mL) aliquot for a pre-programmed volume. The volume of pacing was predetermined based upon the expected total volume of the rainfall event. Each 1000 mL sample bottle contained a composite 4 aliquots for a total of 920 mL. A minimum of 10 aliquots were collected and submitted to ALS from each rainfall event.

Terracon staffs are aware that during the sampling process it is imperative that samples be collected, shipped and preserved as soon as possible. Given the parameters to be tested for, the Terracon field technician will follow standards to deliver the samples to ALS. In some instances, such as in the case of weekend storm events, sample bottles were collected at their earliest convenience. The sample bottles were placed on ice in a cooler kept below 4 degrees Celsius and were transported to the ALS Laboratory under a chain of custody for analysis of the selected water quality parameters.

In accordance with protocol, ALS sub-sampled the influent and effluent composite samples immediately after compositing for each of the selected individual water quality constituents. Preservation methods for sub-samples depended on the type of testing they were selected to undergo, but were enacted according to protocol. ALS also prepared duplicate water quality samples by sub-sampling the influent and effluent composite samples.

5.2 Sampling Equipment

The site was equipped with a RainWise® rain gauge (RAINEW 111) and HOBO® data logger. The rain gauge collected and recorded precipitation data in 0.01-inch increments using the tipping bucket method. The data were downloaded from each device by Terracon after each rainfall event.

The flow-paced water quality samples were collected using four(4) Teledyne Isco auto-samplers (Isco 6712) that were connected to Isco 4250 area/velocity flow meters. The auto-samplers and flow meters were mounted with L-brackets inside the influent manhole. The influent flow meter sensor and influent sampling tubing were located in the inlet pipe to the influent manhole. This flow meter sensor controlled the flow-paced sampling by the influent auto-sampler.

The influent and effluent stormwater samples were collected using a 3/8-inch diameter silicon tubing suction line, which was positioned approximately 0.5 inches off the bottom of the pipe (invert). The auto-samplers were programmed to purge and rinse the suction line between samples, reducing the potential for cross contamination between aliquot collections. Terracon personnel downloaded flow and sampling data after each rainfall event.

Terracon calibrated the flow meters and auto-samplers prior to installation. Terracon staffs are responsible for operation, inspection and maintenance of the sampling equipment including samplers, flow modules and batteries. The deep cycle marine batteries used to power the monitoring and sampling instruments were checked and replaced regularly.

A schematic showing the treatment system and monitoring equipment locations is detailed in **Figure 4.4** of the Woodinville QAPP (**Appendix A**).

A cellular sampler controller system developed by Micro Systems Engineering, Inc., provided remote control and status monitoring capability for Teledyne Isco 6712 series samplers. The system consisted of a single programmable GSM cellular base unit and 1 wireless remote unit for each sampler. The base unit provided both the cellular network connection and a local wireless link to each sampler. The base unit allowed authenticated users to initiate programs and retrieve data and status from each sampler via simple SMS text messages. A reply SMS message was sent with either the requested data or command execution status.

The effluent flow meter sensor and effluent sampling tubing were located inside the 18" HDPE filter vault outlet pipe and were accessed through the downstream manhole.

5.3 Analytical Methods

The ALS Laboratory in Everett, Washington is a Washington DOE-certified laboratory for drinking water, waste water, and solid/hazardous waste analyses. Reporting limits and other details are listed in **Table 1**.

Table 1 - Constituents, Analytical Methods, and Method Reporting Limits
Woodinville, Washington

Constituents	Analytical Method	Unit	Method Reporting Limit
Total Suspended Solids	SM2540D	mg/L	5.0
pH	SM4500H	S.U.	1.00
Orthophosphate as P	EPA-300.0	mg/L	0.10
Copper	EPA-200.8	ug/L	2.0
Hardness	EPA-200.8	mg/L	1.0
Zinc	EPA-200.8	ug/L	2.5
Copper (Dissolved)	EPA-200.8	ug/L	2.0
Zinc (Dissolved)	EPA-200.8	ug/L	2.5
Ammonia as N	EPA-350.1	mg/L	0.05
Total Kjedahl Nitrogen (TKN)	EPA-351.1	mg/L	0.40
Total Phosphorus	EPA-365.1	mg/L	0.010
Nitrate/Nitrite as N	EPA-353.2	mg/L	0.050
Suspended Sediment Concentration	ASTM D3977-97	mg/L	1.0
Total Nitrogen	351.4/350.1	mg/L	0.10

5.4 Quality Assurance/Quality Control

The QAPP (**Appendix A**) was developed by BaySaver to provide guidance to Terracon field personnel when conducting the field testing of the BayFilter™ EMC system. The QAPP was site-specific and was meant to ensure that sampling and analysis of field data was done safely and accurately. According to the QAPP, Terracon was to conduct quality assurance/quality control (QA/QC) on the water quality samples throughout the duration of the field testing program. Specific QA/QC measures are described in detail below.

5.4A Equipment Field Blanks

Equipment field blanks (termed "field blanks" in the QAPP) were used to evaluate whether contamination was introduced during field sampling activities. Two rounds of field blanks were conducted at the beginning and middle of the testing period (October 31, 2013 and July 15, 2014). Reagent-grade water was pumped through the influent and effluent auto-samplers at all four sampling locations to mimic an event without introducing TSS. Samples were taken, handled, and transported according to protocol for storm water samples. If the results of the field blanks showed TSS concentrations above the method-reporting limit, introduction of sediment from the auto-samplers would be the likely cause.

The ALS Laboratory determined a method-reporting limit for each constituent, above which it can be routinely detected. There are often minor variations in precision, sensitivity, accuracy, and variability in instruments and among multiple instruments that are used for analysis. When the ALS Laboratory did not detect a constituent concentration greater than their method-reporting limit, a value of non-detect (ND) was recorded.

Results of the two field blanks can be found in **Tables 2** and **3**, with lab reports in **Appendix M**. Field blanks showed trace amounts of metals in the reagent water, resulting in concentrations above the method-reporting limit. Since this Technical Evaluation Report is not addressing metal removal and since these trace amounts are not expected to affect the associated stormwater samples as it relates to TSS and TP removals, it was determined the trace metals were inconsequential.

Table 2 – Field Blank Analytical Results (October 31, 2013)

Constituents	Unit	Method Reporting Limit	Sys-IN	Sep Low-OUT	Sep High-OUT	Filt-OUT
TPH-Diesel Range	ug/L	130	ND	ND	ND	ND
TPH-Oil Range	ug/L	250	ND	ND	ND	ND
Total Suspended Solids	mg/L	5.0	ND	ND	ND	ND
pH	S.U.	1.00	4.42	4.92	4.29	4.38
Orthophosphate as P	mg/L	0.29	ND	ND	ND	ND
Copper	ug/L	2	12	8.9	2.9	5.9
Hardness	mg/L	1	ND	2.9	1.1	ND
Zinc	ug/L	2.5	ND	2.8	ND	2.7
Copper (Dissolved)	ug/L	2.0	12	8.5	3.0	5.9
Zinc (Dissolved)	ug/L	2.5	ND	2.7	ND	ND
Total Phosphorus	mg/L	0.010	ND	ND	ND	ND
Suspended Sediment Concentration	mg/L	1.0	ND	ND	ND	ND

Table 3 – Field Blank Analytical Results (July 15, 2014)

Constituents	Unit	Method Reporting Limit	Sys-IN	Sep Low-OUT	Sep High-OUT	Filt-OUT
TPH-Diesel Range	ug/L	130	ND	ND	ND	ND
TPH-Oil Range	ug/L	250	ND	ND	ND	ND
Total Suspended Solids	mg/L	5.0	ND	ND	ND	ND
pH	S.U.	1.0	5.6	5.65	5.58	5.79
Orthophosphate as P	mg/L	0.29	ND	ND	ND	ND
Copper	ug/L	2.0	ND	ND	ND	ND
Hardness	mg/L	1.0	ND	ND	ND	ND
Zinc	ug/L	2.5	4.0	4.2	3.9	12.0
Copper (Dissolved)	ug/L	2.0	ND	ND	ND	ND
Zinc (Dissolved)	ug/L	2.5	5.0	3.5	5.2	9.9
Total Phosphorus	mg/L	0.01	ND	ND	ND	ND
Suspended Sediment Concentration	mg/L	1.0	ND	ND	4.0	ND

5.4B Duplicate Samples

Influent and effluent water quality samples were collected on a flow-paced basis and also sub-sampled the influent and effluent composite containers for specific constituents. At the same time, the laboratory duplicate samples were collected and analyzed along with the original composite samples. The analytical results of the duplicate and composite samples were compared to detect variations in the compositing process and related sub-sampling procedures. Laboratory duplicate samples were collected for some of the composite samples submitted by Terracon. However, all batches of samples being analyzed, including these monitoring samples, had a laboratory duplicate analyzed and reviewed for relative percent difference (RPD) with the original sample. Even if the original and duplicate samples were not one of the influent or effluent samples submitted, the batch they were being analyzed in was subject to the analytical laboratory's QA/QC program. More details are provided in **Appendices I** and **J**.

5.4C Laboratory QA/QC

The ALS Laboratory is an EPA-certified analytical laboratory. As such, it is required to maintain its own QA/QC procedures. These include checking for analytical anomalies and conducting data validation. Method blanks, laboratory control samples (LCS), and matrix spike samples and duplicates (MS/MSD) were prepared and analyzed as part of each analytical batch of water quality samples. The analytical laboratory provided BaySaver with Tier III analytical reports (**Appendix H**), which included all the raw data, quality control results, and submitted water quality samples' analytical results.

5.5 Removal Rate Calculations

The removal efficiency calculations are based on the EMC's TSS values, metals, phosphorus, oil, and grease values which are derived from the flow-weighted composite samples. Removal efficiency was calculated for each qualifying event using equation 7-1. A bootstrap statistical analysis was performed on the complete data set to determine overall average removal efficiency at a 95% confidence level.

$$E = 100\left(1 - \frac{EMC_{Effluent}}{EMC_{Influent}}\right)$$

Individual storm reduction in pollutant concentration was calculated as:

$$E = \left(-\frac{100[A - B]}{A}\right)$$

Where:

A = flow proportional influent concentration

B = flow proportional effluent concentration

6.0 Qualified Events

Overall, TAPE requires at least 12 qualified rainfall events be analyzed to assess the performance of a stormwater treatment technology. The criteria for qualified events, the field-monitoring requirements of TAPE, the hydrological data, and the analytical results for individual rainfall events are discussed below. BaySaver provided the rainfall, flow, and analytical data for evaluation and analysis to determine the treatment capabilities of the BayFilter™ system. Copies of these data are included in **Appendix I**.

A qualified event was defined as:

- having at least 6 hours with less than 0.04 inches of rain prior
- having an average rainfall intensity that was greater than 0.03 inches per hour (in/hr) for at least 50% of the duration
- having a minimum duration of 1 hour;
- having greater than 0.15 inches of precipitation

Additionally, events were included only if more than 75% of the stormwater runoff volume was sampled and no fewer than 10 aliquots were collected for analysis. Two aliquots were collected per sample bottle during each rainfall event, so any event during which 5 sample bottles were collected met this requirement.

Hydrologic data for fourteen events were collected and recorded as part of this study. Events are identified and organized by the date that precipitation began, and are displayed in **Table 4** along with their respective hydrological data (precipitation amount, antecedent dry period, duration, and mean rainfall intensity) and the TAPE guidelines for each parameter. The general sampling characteristics (influent and effluent volume sampled, influent and effluent aliquots collected, and volume of the rainfall event treated) for each of the rainfall events is provided in **Table 5**.

Table 4 – Rainfall Event Hydrological Data

Rainfall Event	Precipitation (Inches)	Antecedent Dry Period (hours)	Rainfall Duration (hours)	Mean Rainfall Intensity (in/hr)
November 11, 2013	0.37	48	5	0.07
November 18, 2013	0.26	84	3	0.09
December 13, 2013	0.20	336	6	0.04
December 17, 2013	0.24	48	4	0.06
February 13, 2014	0.68	36	14	0.05
February 25, 2014	0.43	216	7	0.06
May 12, 2014	0.45	48	7	0.07
May 27, 2014	0.46	84	8	0.06
June 19, 2014	0.24	12	7	0.03
July 30, 2014	0.21	48	6	0.03
March 17, 2015	0.22	168	6	0.04
March 30, 2015	0.31	120	7	0.06
TAPE Guideline	**0.15**	**6**	**1**	**0.03**

Table 5 – Rainfall Event Sampling Requirements
Woodinville, WA

Rainfall Event	Volume of Influent Sampled (percent)	Volume of Effluent Sampled (percent)	Influent Sample Aliquots (number)	Effluent Sample Aliquots (number)	Volume of Stormwater Treated (percent)[1]
November 11, 2013	100	100	40	20	100
November 18, 2013	100	100	21	12	91
December 13, 2013	100	90	32	24	100
December 17, 2013	97	95	48	24	100
February 13, 2014	100	100	40	18	100
February 25, 2014	100	100	40	18	100
May 12, 2014	100	100	28	14	100
May 27, 2014	100	100	32	22	100
June 19, 2014	100	100	38	21	100
July 30, 2014	100	100	31	22	100
March 17, 2015	100	100	29	29	100
March 30, 2015	100	100	48	48	100
TAPE Guideline	**75**	**75**	**10**	**10**	**91**

7.0 BayFilter™ Analytical Results

The analytical results (influent and effluent concentrations and removal efficieny) for each qualified rainfall events are compiled by constituent and summarized in **Table 6**. The individual rainfall event summaries, which include the general rainfall event information, recorded hydrologic data, flow data, sampling information, analytical results, and constituent removal efficiencies are summarized and included as **Appendix J**. The mean value of the original and duplicate sample results are reported in the tables below.

Bootstrap analyses were conducted for TSS and TP and can be found in **Appendix K**. The column labeled "P5" in the bootstrap analysis tables indicates the lower 95% confidence limit and the column labeld "P95" indicates the upper 95% confidence limit.

7.1 TSS

Basic (TSS) treatment by the BayFilter™ EMC system involves reducing the sediment concentration in the influent stormwater flow. TAPE's requirements state that if the influent TSS concentration is greater than 100 mg/L, an approved treatment device must achieve a minimum removal efficiency of 80%. If the influent TSS concentration is between 20 and 100 mg/L, the treatment device must produce an effluent TSS concentration below 20 mg/L.

Twelve rainfall events qualified for inclusion based on their compliance with TAPE requirements for influent TSS and TP concentrations. For the three events with influent TSS concentrations above 100 mg/L, the average removal efficiency was 89.7%. For the remaining nine events with influent TSS concentrations less than 100 mg/L, the average effluent TSS concentration was 5.4 mg/L. It also should be noted that the effluent TSS concentrations for all twelve events are below 20 mg/L. Results are presented in detail in **Table 6**.

Table 6 - Total Suspended Solids Analytical Results

Rainfall Event	Influent Concentration (mg/L)	Effluent Concentration (mg/L)	Removal Efficiency
November 11, 2013	34.0	ND	92.6%
November 18, 2013	20.0	ND	87.5%
December 13, 2013	120.0	14.0	88.3%
December 17, 2013	51.0	10.0	80.4%
February 13, 2014	140.0	13.0	90.7%
February 25, 2014	22.0	ND	88.6%
May 12, 2014	61.0	ND	95.9%
May 27, 2014	35.0	ND	92.9%
June 19, 2014	17.0	9.0	47.1%
July 30, 2014	90.0	15.0	83.3%
March 17, 2015	55	ND	95.4%
March 30, 2015	110	11	90.0%
12 Qualified Events		**Average**	**86.1%**

Note: in the case of a non-detectable (ND) effluent TSS concentration, half the reporting limit (2.5) was used

The bootstrap analysis conducted on the BayFilter™ influent TSS concentrations for the twelve qualifying events are shown in **Table 7**. The estimated mean was 62.9 mg/L (45.0 – 81.9 mg/L, 95% CI), with a standard deviation of 11.66. The table also shows median, midrange, mode, and mode k. density for each percentile, quartile, and interquartile range. More detailed bootstrap results are included in **Appendix K**.

Table 7 – Bootstrap Results of BayFilter™ Influent TSS Concentrations

Estimation Results of Bootstrap									
statistic	P1	P5	Q1	Estimate	Q3	P95	P99	S.D.	IQR
mean	38.412	45.046	53.729	62.917	71.167	81.942	87.807	11.658	17.438
median	22	28.5	43	53	61	85.725	100	16.853	18
midrange	40.485	63.5	68.5	78.5	78.5	81	87.5	7.9668	10
mode	17	20	34.75	62.917	85.275	140	140	34.218	50.525
mode k.dens	18.822	20.321	26.514	35.161	53.369	117.81	128.4	26.136	26.854

Table 8 shows the bootstrap results for the effluent concentrations of TSS for all twelve events. These results show the estimate mean at 7.25 mg/L (5.17 – 9.55 mg/L, CI) with a standard deviation of 1.35 mg/L. The table also shows median, midrange, mode, and mode k. density for each percentile, quartile, and interquartile range.

Table 8 – Bootstrap Results of BayFilter™ Effluent TSS Concentrations

Estimation Results of Bootstrap									
statistic	P1	P5	Q1	Estimate	Q3	P95	P99	S.D.	IQR
mean	4.7075	5.1667	6.1562	7.25	8.0833	9.5458	10.834	1.3509	1.9271
median	2.5	2.5	2.5	5.75	9.5	11	13.005	3.4225	7
midrange	7.75	7.75	8.25	8.75	8.75	8.75	8.75	0.32485	0.5
mode	2.5	2.5	2.5	2.5	2.5	8.275	13.01	2.0208	0
mode k.dens	2.5	2.5	2.5	2.5	10.317	14.069	14.715	4.6911	7.8173

Table 9 below shows the Bootstrap results for TSS removal at Woodinville for the twelve (12) qualified events. These results show the estimate mean at 86.4% (80.7% – 91.6%, 95% CI) with a standard deviation of 3.56. The table also shows median, midrange, mode, and mode k. density for each percentile, quartile, and interquartile range.

Table 9 – Bootstrap Results of BayFilter™ TSS Removal

Estimation Results of Bootstrap									
statistic	P1	P5	Q1	Estimate	Q3	P95	P99	S.D.	IQR
mean	74.846	80.713	84.61	86.442	89.367	91.554	92.436	3.5551	4.7562
median	84.34	87.5	88.45	89.3	91.3	92.9	95.3	2.1384	2.85
midrange	69.998	71.2	71.5	71.5	88.15	89.6	92.1	8.3877	16.65
mode	47.1	69.992	85.4	86.442	92.6	95.663	95.9	9.8898	7.2
mode k.dens	84.543	87.859	88.558	91.685	93.685	95.465	95.769	2.7748	5.1276

As shown in the Table 6 above, one of the twelve events has the influent TSS below 20 mg/L. In table 10 below, the TSS removal for the events with influent concentrations above 20 mg/L are presented. The eleven rainfall events had an average removal efficiency of 89.6% (87.1% - 91.8%, 95% CI) with a standard deviation of 1.43.

Table 10 – Bootstrap Results of BayFilter™ TSS Removal (Influent > 20 mg/L)

Estimation Results of Bootstrap									
statistic	P1	P5	Q1	Estimate	Q3	P95	P99	S.D.	IQR
mean	86.333	87.071	88.716	89.6	90.723	91.824	92.728	1.4344	2.0068
median	87.5	87.5	88.6	90	90.7	92.9	92.925	1.7069	2.1
midrange	85.55	86.65	87.938	88.15	89.6	91.7	92.1	1.4336	1.6625
mode	80.4	83.155	87.944	89.6	92.9	95.9	95.9	3.9653	4.9563
mode k.dens	82.923	87.986	88.686	90.233	92.471	95.431	95.737	2.6716	3.7852

7.2 Phosphorus

Total phosphorus treatment by the BayFilter™ EMC system involves reducing the TP concentration in the influent stormwater flow. Events that meet TAPE's requirements must have an influent TP concentration that exceeds 0.1 mg/L, and the removal rate by the treatment technology should be greater than 50%. BayFilter™ achieved an average removal efficiency of 64.1%.

Table 11 - Total Phosphorus Analytical Results

Rainfall Event	Influent Concentration (mg/L)	Effluent Concentration (mg/L)	Removal Efficiency
November 11, 2013	0.140	0.043	69.3%
November 18, 2013	0.110	0.054	50.9%
December 13, 2013	0.320	0.140	56.3%
December 17, 2013	0.130	0.068	47.7%
February 13, 2014	0.220	0.055	75.0%
February 25, 2014	0.073	0.021	71.2%
May 12, 2014	0.170	0.037	78.5%
May 27, 2014	0.150	0.045	70.0%
June 19, 2014	0.140	0.067	52.1%
July 30, 2014	0.240	0.077	67.9%
March 17, 2015	0.170	0.049	71.2%
March 30, 2015	0.290	0.120	58.6%
12 Qualified Events		**Average**	**64.1%**

Table 12 shows the bootstrap results of Influent TP concentrations for all twelve qualifying events. These results show the estimate mean at 0.18 mg/L (0.15 – 0.22 mg/L, 95% CI) with a standard deviation of 0.019 mg/L. The table also shows median, midrange, mode, and mode k. density for each percentile, quartile, and interquartile range.

Table 12 – Bootstrap Results of BayFilter™ Influent TP Concentrations

Estimation Results of Bootstrap									
statistic	P1	P5	Q1	Estimate	Q3	P95	P99	S.D.	IQR
mean	0.13489	0.14846	0.16748	0.17942	0.1925	0.215	0.22417	0.019056	0.025021
median	0.13485	0.14	0.145	0.16	0.17	0.22	0.23	0.024741	0.025
midrange	0.1215	0.1565	0.1965	0.1965	0.21	0.225	0.23	0.019261	0.0135
mode	0.073	0.073	0.14	0.155	0.1875	0.29	0.32	0.053699	0.0475
mode k.dens	0.089691	0.12026	0.13754	0.14496	0.15696	0.23004	0.29659	0.035237	0.019427

Table 13 shows the bootstrap results of Effluent TP concentrations for all twelve qualifying events. These results show the estimate mean at 0.06 mg/L (0.05 – 0.08 mg/L, 95% CI) with a standard deviation of 0.009 mg/L. The table also shows median, midrange, mode, and mode k. density for each percentile, quartile, and interquartile range.

Table 13 – Bootstrap Results of BayFilter™ Effluent TP Concentrations

Estimation Results of Bootstrap									
statistic	P1	P5	Q1	Estimate	Q3	P95	P99	S.D.	IQR
mean	0.04175	0.047992	0.057396	0.064667	0.069875	0.079012	0.082167	0.0092503	0.012479
median	0.04297	0.045	0.05	0.0545	0.061	0.0675	0.072545	0.007342	0.011
midrange	0.04449	0.049	0.0785	0.0805	0.0885	0.08865	0.09151	0.011987	0.01
mode	0.021	0.021	0.044	0.064667	0.071354	0.12	0.14	0.025129	0.027354
mode k.dens	0.03458	0.041266	0.046238	0.051479	0.054204	0.068001	0.074193	0.0096632	0.0079659

The Bootstrap results for TP removal at Woodinville for the twelve (12) qualified events are shown in the Table 14 below. These results show the estimate mean at 64.1% (59.8% - 68.3%, 95% CI) with a standard deviation of 2.61. The table also shows median, midrange, mode, and mode k. density for each percentile, quartile, and interquartile range.

Table 14 – Bootstrap Results of BayFilter™ TP Removal

Estimation Results of Bootstrap									
statistic	P1	P5	Q1	Estimate	Q3	P95	P99	S.D.	IQR
mean	57.434	59.781	62.423	64.058	65.573	68.262	70.109	2.6116	3.15
median	54.179	56.3	63.25	68.6	69.65	70.63	71.2	4.8555	6.4
midrange	59.45	59.45	61.35	63.1	63.1	65.3	67.4	1.6637	1.75
mode	47.7	50.9	58.6	71.2	71.2	75	78.5	8.1105	12.6
mode k.dens	50.158	51.326	68.758	70.661	70.853	73.124	74.616	7.7942	2.0941

7.3 Particle Size Distribution (PSD)

PSD analysis was conducted on the influent stormwater samples collected from eight rainfall events as part of these field testing activities (data in **Appendix L**, summarized below). Under TAPE guidelines, rainfall events with influent TSS concentrations that contain particles less than 500 microns in diameter meet the requirement for determining basic treatment (TSS removal). Medium sands, according to the United States Department of Agriculture (USDA) soil classification system, have an upper diameter size limit of 500 microns. Generally, according to TAPE, TSS from rainfall events in the Pacific Northwest consists of silts, clays, and fine sands. **Table 15** contains the USDA soil classification system designations for soil particle size.

Table 15 – Soil Classification

Classification	Particle Size (microns)
Colloids	<1
Clay	1 to 2
Silt	2 to 50
Very Fine Sand	50 to 100
Fine Sand	100 to 250
Medium Sand	250 to 500
Coarse Sand	500 to 1,000

Notes:
1. Soil classification based on United States Department of Agriculture soil system.

The rainfall events that were analyzed for PSD at had a TSS influent concentration that consisted primarily of silts and fine sands. The diameter of particles that comprise ten percent or less of the sample (d_{10}) was 10.51 microns (flow-weighted basis). The diameter of the particles that comprise ninety percent or less of the sample (d_{90}) was approximately 236 microns. The median diameter (particle that comprise fifty percent or less of the sample) (d_{50}) was 51.53 microns (silts).

Table 16 shows the mean particle size distribution for the influent TSS particles entering the BayFilter™ EMC system. Stormwater runoff is a mixture of sediment and organic particles, which are all measured based on their optical properties (assumed to be spherical, isotropic, and homogeneous). However, the PSD analysis does not account for the presence of organic particles, which are often irregularly shaped, heterogeneous, and can have darker coloration than sediments. This can cause large organic particles being represented in the data as large diameter sediments, which can skew the reported particle sizes (diameters). By extension these organic particles are reported with a higher mass when the specific gravity of sediments (nominally 2.65) is used in conjunction with the reported diameter.

Table 16 – Particle Size Distribution Influent Concentration

Parameter	Mean	Flow-Weighted Mean
Median Particle Size (microns)	53.81	54.22
d^{10} (microns)	9.49	9.30
d^{50} (microns)	53.81	54.22
d^{90} (microns)	200.97	192.25

7.4 Field Duplicate Results

Field Duplicates were collected at Woodinville site for analysis and comparison for quality assurance. Field duplicates were compared against the field duplicate relative percent difference (RPD) in order to ensure that data adhered to the method quality objectives. The data presented below in Tables 17 and 18 show the field duplicate results and average RPD for Woodinville as shown in Table 19.

Table 17 – Field Duplicates on December 13, 2013 in Woodinville, WA

	Unit	Detection Limit	BSEP-IN	BSEP-IN	BFIL-IN	BFIL-IN	BFIL-OUT	BFIL-OUT
TSS	mg/L	5.0	200	190	120	120	15	13
PH		1.0	6.84	6.79	7.00	7.01	6.78	6.91
Orthophosphate as P	mg/L	0.10	0.24	0.17	ND	ND	ND	ND
Total P	mg/L	0.01	0.44	0.5	0.32	0.32	0.14	0.14
Copper (Dissolved)	ug/L	2.0	23	24	29	30	15	15
Zinc (Dissolved)	ug/L	2.5	280	290	300	320	86	96
Ammonia	mg/L	0.05	2.6	2.6	3.4	3.4	0.23	0.23
TKN	mg/L	0.40	4.7	4.4	0.4	5.9	1.7	1.6
TN	mg/L	0.05	5.2	4.9	6.3	6.5	6.5	6.4
SSC	mg/L	1.00	130	150	110	140	15	12

Table 18 – Field Duplicates on May 12, 2014 in Woodinville, WA

	Unit	Detection Limit	BSEP-IN	BSEP-IN	BFIL-IN	BFIL-IN	BFIL-OUT	BFIL-OUT
TSS	mg/L	5.0	60	70	64	58	U	U
PH		1.0	6.64	6.64	6.8	6.9	7.4	7.4
Orthophosphate as P	mg/L	0.10	U	U	U	U	U	U
Total P	mg/L	0.01	0.17	0.22	0.15	0.19	0.038	0.035
Copper (Dissolved)	ug/L	2.0	15	14	12	11	7.3	11
Zinc (Dissolved)	ug/L	2.5	97	96	82	78	40	39
Ammonia	mg/L	0.05	0.61	0.48	0.63	0.59	0.094	0.096
TKN	mg/L	0.40	2	2.2	1.9	1.9	3.2	0.96
TN	mg/L	0.05	2.5	2.8	2.8	2.9	5.6	3.3
SSC	mg/L	1.00	65	54	71	53	2.4	2

Table 19 – Field Duplicates RPD in Woodinville, WA

	Unit	Detection Limit	Average BSEP-IN RPD	Average BFIL-IN RPD	Average BFIL-OUT RPD
TSS	mg/L	5.0	9.7%	4.9%	14.3%
PH		1.0	0.8%	0.8%	1.9%
Orthophosphate as P	mg/L	0.10	0.0%	0.0%	0.0%
Total P	mg/L	0.01	8.4%	11.8%	0.0%
Copper (Dissolved)	ug/L	2.0	12.2%	6.0%	0.0%
Zinc (Dissolved)	ug/L	2.5	5.1%	5.7%	11.0%
Ammonia	mg/L	0.05	0.5%	3.3%	0.0%
TKN	mg/L	0.40	31.7%	87.3%	6.1%
TN	mg/L	0.05	16.3%	3.3%	1.6%
SSC	mg/L	1.00	17.2%	26.5%	22.2%

8.0 Data Validation

A review of the ALS analytical laboratory reports (**Appendix H**) was conducted to identify any deviations of the testing procedure from the QAPP. The ALS laboratory used the analytical methods and reporting limits specified in the Table 1. ALS had all method reporting limits which were below the DOE's effluent concentration limits.

Field duplicates were collected for both influent and effluent samples at a rate of 10 percent of the stormwater samples collected. Further information on specific collection procedures can be found in the QAPP.

9.0 Conclusion

Over the course of this field testing program, BaySaver monitored and sampled 12 rainfall events in Woodinville, WA, that met TAPE's guidelines for precipitation amount, duration, and intensity, as well as individual qualifications for influent TSS and TP concentrations. Testing took place from November 2013 to March 2015, and was meant to demonstrate the ability of the BayFilter™ EMC system to meet DOE TAPE requirements for basic treatment (TSS) and phosphorus removal. The resulting data show that this system exceeds these goals and, as a result, meets the qualifications for a GULD.

For a system to receive a GULD for basic treatment, it must achieve a minimum average removal rate of 80% when influent TSS concentrations exceed 100 mg/L and a maximum effluent concentration of 20 mg/L when influent concentrations are below 100 mg/L. The BayFilter™ EMC system achieved a 89.7% removal rate when influent TSS concentrations were above 100 mg/L and an average effluent concentration of 5.4 mg/L when influent concentrations were below 100 mg/L. Based on the analytical bootstrap results reported, the BayFilter™ achieved 86.4% (80.7% – 91.6%, 95% CI) removal for all twelve (12) qualified events. All filter effluent was less than 20mg/L independent of influent concentration.

The TAPE filtration device target treatment goal for total phosphorus is 50% removal for influent concentrations between 0.1 mg/L and 0.5 mg/L. The BayFilter achieved an average removal efficiency of 64.1% (59.8% - 68.3%, 95% CI) TP removal for all twelve (12) qualified events.

The field monitoring program conducted from November 2011 until March 2015 by BaySaver showed that BayFilter™ was capable of meeting DOE TAPE requirements for basic treatment (TSS removal) and phosphorus treatment (TP removal).

10.0 References

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