The Stormwater Management StormFilter®

PhosphoSorb® at a Specific Flow Rate of 1.67 gpm/ft^2

GULD Technical Evaluation Report for

Basic & Phosphorus Treatment

Prepared for:

Washington State Department of Ecology

October 2015

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Emerging Stormwater Treatment Technologies
Application for Certification

Applicant Information

Company Name	Contech Engineered Solutions, LLC
Contact Name	Sean Darcy
Address	11815 NE Glenn Widing Dr, Portland, OR 97220
Phone Number	(503) 258-3105
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Email	sdarcy@conteches.com
Website	www.contechES.com
Name of Technology	The Stormwater Management StormFilter® - PhosphoSorb®
Brief Description of the Technology	The StormFilter is a patented passive media filtration system. Media and filtration rate can be customized to target specific pollutants.

NOTE: Applicants should become thoroughly familiar with TAPE guidance and requirements prior to submitting this application. Ecology does **not** require all of the items below; however, we strongly encourage the applicant to submit as much relevant information as possible to help facilitate the review process.

Technology Information

Treatment Performance Goal (check all that apply)	☒ Basic ☒ Phosphorus ☐ Pretreatment	☐ Enhanced ☐ Oil
Detailed Technology Description (check all the boxes that correspond to the information you are including with your application)	☒ Description of physical, chemical, and/or biological treatment functions	
	☒ Design drawings/dimensions	
	☒ Photographs	
	☒ Description of the materials the technology is made of	
	☒ Description of each component's hydraulic capacity	
	☒ Description of hydraulic bypass process	
	☒ Detailed description of the sizing methodology (e.g., sizes of units available, flow per sq. ft., etc.)	
	☒ Explanation of site installation requirements (e.g., necessary soil characteristics, hydraulic grade requirements, depth to groundwater limitations, utility	
	☒ Description of any pretreatment requirements or recommendations	
	☒ Expected treatment capabilities (e.g., % solids reduction)	
	☒ Maintenance procedures	
	☐ Other:	

Testing Information

Laboratory study data available?	☒ Yes ☐ No If yes, briefly describe the study. Suspended solids removal of Sil-Co-Sil 106 has been included.
Check all the boxes that correspond to the study information you are including with your application.	☐ Laboratory study plan/summary of tests ☐ Comparison of size of laboratory unit to typical field units/scaling information ☐ Flow rate(s) used for laboratory testing ☐ Water quality raw data ☐ Statistical analysis ☒ Summary of water quality data and removal calculations ☐ Other:
Field study data available?	☒ Yes ☐ No If yes, briefly describe the study. Additional field studies with the StormFilter and PhosphoSorb media were summarized in the Technical Evaluation Report.
Check all the boxes that correspond to the study information you are including with your application.	☒ Sampling plan/QAPP ☒ Storm event information ☒ Influent and effluent flow data ☒ Water quality raw data ☒ Statistical analysis ☒ Summary of water quality data and removal calculations ☐ Other:

Application Fee

Initial Application fee included?	☐ Yes ☒ No

NOTE: Emerging technologies with limited performance data that show some promise of meeting TAPE performance goals will be evaluated for a pilot use level designation (PULD). Technologies with considerable field performance data that show some promise of meeting TAPE performance goals may be considered for a conditional use level designation (CULD). **Submittal of fee does not guarantee approval of any use-level designation.**

Submit application and payment to:
TAPE Program
Washington State Department of Ecology
Cashiering
P.O. Box 47611
Olympia, WA 98504-7611

For Ecology Reviewers
Date Received:
Received by:
Case no:
Coding: 090-001-5191-TAPE 00

CONTECH ENGINEERED SOLUTIONS

Contech Engineered Solutions LLC
11815 NE Glenn Widing Dr.
Portland, OR 97220
Phone: (800) 548-4667

October 9, 2015

Doug Howie
Stormwater Engineer
Water Quality Section
Washington State Department of Ecology
300 Desmond Drive
Lacey, WA 98503

Subject: The Stormwater Management StormFilter with PhosphoSorb GULD Application

Dear Mr. Howie,

Contech Engineered Solutions would like to apply for a General Use Level Designation (GULD) with the Stormwater Management StormFilter® (StormFilter) using PhosphoSorb® media and operating at a specific flow rate of 1.67 gpm/ft^2.

A field evaluation of the StormFilter with PhosphoSorb media (operating at a 12.5 gpm for an 18-inch cartridge) was initiated in January 2012 at a site in ZigZag, OR. Seventeen qualified storm events satisfied the storm event criteria, sampling collection requirements, and targeted influent concentration ranges listed in the TAPE (2011). The enclosed Technical Evaluation Report and third-party review indicate that the StormFilter system can achieve basic and phosphorus treatment goals.

The Technical Evaluation Report (TER) contains media specifications that are provided and labeled as confidential material that is not intended for public release. Contech will provide a public TER with the media specifications removed at the conclusion of the review period.

Sincerely,

Sean Darcy
Regional Regulatory Manager
CONTECH Engineered Solutions

Enclosures: TAPE Application Form, Technical Evaluation Report, Third Party Review

cc: Vaikko Allen, Contech Engineered Solutions, LLC
Carla Milesi, TAPE Technical Lead, Washington Stormwater Center

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Herrera Environmental Consultants, Inc.

Memorandum

To Douglas Howie, Washington State Department of Ecology

cc Carla Milesi, Washington Stormwater Center
Sean Darcy, Contech Engineered Solutions

From Dylan Ahearn, Herrera Environmental Consultants

Date October 14, 2015

Subject StormFilter with PhosphoSorb TER review and approval

In August 2014, Contech Engineered Solutions LLC (Contech) was re-issued a Conditional Use Level Designation (CULD) from the Washington State Department of Ecology (Ecology) authorizing limited use of the StormFilter with PhosphoSorb for basic and phosphorus treatment in Washington State. From January 2012 to February 2015, a performance evaluation of the system was conducted in Zigzag, Oregon. Herrera Environmental Consultants (Herrera) conducted an independent review of a Data Summary Report in March 2015. In May 2015 Herrera reviewed and commented on the draft Technical Evaluation Report (TER). Finally, in October 2015 Herrera reviewed the final TER submission after comments from the Board of External Reviewers (BER) were incorporated. This memorandum summarizes the result from the TER review and provides a recommendation for the final TER approval.

A detailed review of the data and TER was performed to ensure the specified monitoring procedures conformed to the QAPP and that the resultant data satisfied the requirements of the Technology Assessment Protocol – Ecology (TAPE) (Ecology 2011). Herrera provided review and comments on the following specific elements of the TER:

- The initial bypass analysis was only conducted on sampled events, it is now conducted on all measured events
- Calibration records of the rain gauge and flow gauges were verified
- Sampling and Storm Criteria were verified
- Field notes, lab reports, ISRs, and data tables were cross referenced
- Edits to figures and tables were made to improve clarity
- Numerous editorial revisions to improve clarity
- A review of the particle size distribution analysis was conducted

Herrera submitted consolidated comments on the initial draft of the TER to Contech and subsequently received a revised version with a response to comments (see Attachment A to this memorandum). Representatives from Herrera (Dylan Ahearn) and Contech (Sean Darcy) subsequently participated in a teleconference on June 5, 2015 to discuss and resolve outstanding issues not completely addressed in the response to comments. Finally, on October 14, 2015, Herrera reviewed the response to BER comments and the final TER.

Based on our reading of this TER it is apparent that the system was performing well under very challenging site conditions. The sediment loading was greater than any previously TAPE approved system has encountered, with an average influent TSS concentration of 380 mg/L. This loading consisted of sandy material from nearby construction and road sanding, yet the system only required maintenance 4 times over the 37 month monitoring period. Due to the high influent concentrations and high percentage of coarse suspended solids the BER requested that a treatment efficiency analysis be conducted on two size fractions: suspended solids concentration (SSC) < 500 microns and SSC < 62.5 microns. The mean TSS removal was 88 percent with a lower 95% confidence limit (LCL95) of 85 percent, meeting the 80 percent goal in the TAPE. The mean percent removal for the silt and clay fraction (SSC < 62.5) was 83 and 78 percent for influent concentrations 100 – 200 and >200 mg/L, respectively. There were not enough data available to calculate the LCL95 for these size fractions. The system performed well at removing total phosphorus (TP). With a mean influent TP concentration of 0.33 mg/L, the system achieved a mean treatment efficiency of 73 percent, with a LCL95 of 67 percent, exceeding the TAPE goal of 50 percent TP reduction.

Based on our review of the data and the TER and accounting for Contech's response to our comments, Herrera is satisfied the monitoring conducted on the test system conformed to the requirements for TAPE. The TSS reduction analysis was complicated by the high sediment loading and coarse nature of the suspended solids, however, we feel the proponent provided ample data to indicate that the system would perform as designed under more typical loading conditions. We therefore recommend Ecology approve the specified system in the TER for a GULD for phosphorus and basic treatment at the design flow rate of 1.67 gpm/ft^2 of filtration media.

Attachment A Phosphosorb TER Comments and Responses

TER

General grammatical errors; accepted most suggestions - SD

Added Hydrologic Section. Included Performance Greater than Design in this section (Section 1.4); completed by SD

Replace Figure 8 (higher resolution); completed by SD

Table 7 – Replace 101% with 100%; completed by GT

Table 9 – Enlarge table for readability; completed by SD

Section 6.4 – Add content to where the discussion is on the 7 disqualified events. Completed by SD

Section 6.10 (Function of Flow Rate)

a. Significance of 11.7 gpm (why call it out); changed to 90% of design by SD
b. Did we collect a (grab) sample at bypass (answer is no)
c. Suggest adding (too few data points) regarding linear regression; completed by SD
d. Figures 9 and 10 (Fix weight of dashed line showing design flow rate to be the same); completed by SD

Section 7.3 - Add content regarding pH. pH did not change and put a % on it. Completed by SD.

Section 7.4 – Section is confusing and not required in TAPE (only per QAPP). General comments – pollutant concentrations in water assumed to be equivalent as in the sediment (seems like a rough estimate). Was mass in the cartridges included (answer – no it was not as it was EMC based).

Completed by SD/ split sections into sediment accumulation and estimated cumulative load

Section 9.0 – Suggest moving Hydraulic drop to middle column in Table 18. (no change; consistent with previous section)

Appendices (Appendix A-F, H-N)

Appendix B – suggest adding equipment spec sheets (Contech preference is to reference equipment specs and reduce paper/file size; available by request).

Appendix C – Field Forms

a. Hold times exceeded? (pdf pg 53)
    - GT added notes
b. What sample event is associated with these forms? (pdf pgs 52, 54, 56, 62, 63, 70, 71)
    - GT added storm id to each form
c. Table 7 says 35 aliquots field form says 36. (pdf pg 66)
    - GT verified 35 and corrected field form
d. No Aliquot information (pdf pg 69)
    - corrected

Appendix D - ISR

a. LPR110612: Duration and Intensity are different (pdf pg 95)
    a. GT – ISR is correct.
b. LPR030314: Table 7 indicates 34 influent aliquots; ISR is 31 (pdf pg 108)
    a. GT- ISR is correct.
c. LPR011815: Table 7 indicates 22 hours duration; ISR is 26 (pdf pg 109)
    a. GT – ISR is correct.
d. Suggest highlighting cells which caused disqualification in ISR Disqualified Event Section;
    a. Only going to discuss disqualifications in Section 6.2.
e. Suggest TP % removal should say "undeterminable" in each event that has a Non-Detect. (LPR111112 pdf pg 122);   Contech policy is to use the non-detection value.

Appendix E – QA/QC

051815 Memo (pg 6) add Nitrate/Nitrite qualifier to Table 7. (completed; verified by SD)

Appendix F – Raw Data

a. Make sure ISRs, Table 7, and Raw Data agree (for example duration as noted earlier)

GT- ISRs, Table 7, and Raw Data are in agreement.

b. Change storm event coverage to 100% (instead of 101%)

GT- completed

Appendix M – Field Forms

Confusing, should be called "Maintenance Recordkeeping Field Forms;"   Corrected by SD

The Stormwater Management StormFilter®
PhosphoSorb® at a Specific Flow Rate of 1.67 gpm/ft²
General Use Level Designation Technical Evaluation Report

Prepared by

CONTECH Engineered Solutions
11815 NE Glenn Widing Drive
Portland, OR 97220
Telephone: 800-548-4667

October 9, 2015

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1.0 Executive Summary

A performance evaluation of The Stormwater Management StormFilter® with PhosphoSorb® media operating at a specific flow rate of 1.67 gpm/ft^2 was performed at a roadway site in Zigzag, Oregon. The field evaluation began in January 2012 and sampling continued through February 2015. The approved Quality Assurance Project Plan (QAPP) for this evaluation follows the procedures and guidelines described in the Guidance for Evaluating Emerging Stormwater Treatment Technologies Technology Assessment Protocol Ecology (Ecology, 2011). This document has been prepared with a goal of receiving a General Use Level Designation for basic and phosphorus treatment.

1.1 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 house different types of media including perlite, zeolite, granular activated carbon (GAC), CSF® leaf media, MetalRx™, PhosphoSorb® or various media blends such as ZPG™ (perlite, zeolite, GAC). All of the media use physical straining to remove solids. Active inorganic media provide additional treatment mechanisms such as cation exchange capacity and/or adsorption, and organic media (CSF leaf, MetalRx) provide chelation.

1.2 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.

1.3 TSS and Total Phosphorus Data Summary

A total of 17 qualified storm events have been evaluated to provide field data for a General Use Level Designation for basic and phosphorus treatment. Overall Total Suspended Solids (TSS) data showed a removal efficiency of 88% with a mean influent concentration of 380 mg/L. Total phosphorus removal efficiency is 73% with a mean influent concentration of 0.33 mg/L for the qualified events sampled.

Data was analyzed using the 2011-08 TAPE bootstrap confidence interval calculator for TSS and total phosphorus. The lower 95% confidence interval for TSS removal efficiency was 85%. The lower 95% confidence interval for total phosphorus removal efficiency was 67%. The upper 95% confidence interval for total phosphorus effluent concentration was 0.084 mg/L.

A performance assessment was also included for suspended solids less than 500 microns (SSC<500 µm) and the silt and clay fraction. SSC<500 microns had a mean influent concentration of 325 mg/L and a mean removal efficiency of 87%. The lower 95% confidence interval for SSC<500 µm was 85%. The silt and clay fraction, representing suspended solid concentrations less than 62.5 microns, was also evaluated with a mean influent concentration of 153 mg/L and a removal efficiency of 78%. The lower 95% confidence interval for the silt and clay fraction removal efficiency was 73%.

1.4 Hydraulic Evaluation Summary

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. Three (of 26) bypass events were a result of media occlusion impairing the ability of the system to meet the hydraulic capacity requirements.

Five of the 17 qualified events evaluated contained bypass flow and a water quality treatment flow rate greater than 100% design rate (specific flow rate of 1.67 gpm/ft^2). Four of the five qualified events satisfied the basic and phosphorus treatment goals.

2.0 Introduction

Contech requests a General Use Level Designation for the Stormwater Management StormFilter® (StormFilter) with PhosphoSorb® media operating at a specific flow rate of 1.67 gpm/ft^2. A field evaluation of the StormFilter with PhosphoSorb media, operating at a 12.5 gpm for an 18-inch cartridge, was initiated in January 2012. Seventeen storm events were collected following the approved Quality Assurance Project Plan (QAPP) and show an average TSS removal efficiency of 88% with a mean influent concentration of 380 mg/L. Total phosphorus removal efficiency was 73% with a mean influent concentration of 0.33 mg/L.

The enclosed report, and supporting appendices, follows the Guidance for Evaluating Emerging Stormwater Treatment Technologies Technology Assessment Protocol Ecology (TAPE, 2011) reporting guidelines for a Technical Evaluation Report (TER).

3.0 Technology Description

The Stormwater Management StormFilter® (StormFilter) cleans stormwater through a patented passive filtration process, effectively removing pollutants to meet stringent regulatory requirements. Highly reliable, easy to install and maintain, and with proven performance over time, the StormFilter system is recognized as a versatile BMP for removing a variety of pollutants, such as sediments, oil and grease, metals, organics, and nutrients. The StormFilter comes in variable configurations to match local conditions and is designed for prolonged maintenance intervals to ensure long-term performance and reduce operating costs.

3.1 Physical Description

The StormFilter (Figure 1) is typically comprised of a vault that houses rechargeable, media-filled filter cartridges. Stormwater enters the system and percolates through the cartridges, which trap particulates and remove pollutants such as dissolved metals, nutrients, and hydrocarbons. Once filtered through the media, the treated stormwater is discharge through and outlet pipe to a storm sewer system or a receiving water body.

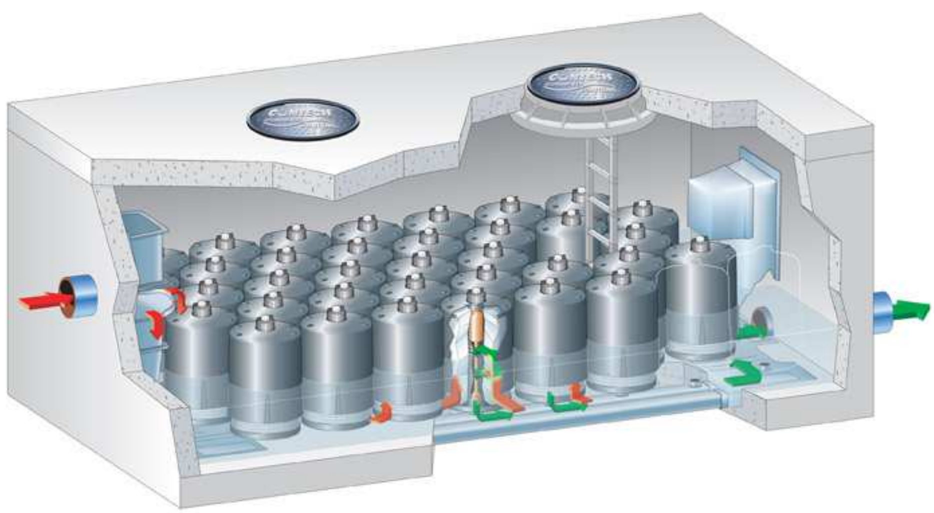

Figure 1. The precast Stormwater Management StormFilter®

Cartridge media can be customized for each site and jurisdiction to target and remove the desired levels of sediments, oils and greases, dissolved metals, nutrients, and organics using different media. In many cases, a combination of media may be recommended to maximize the stormwater pollutant removal.

3.1.1 Operation

During a storm, runoff passes through the filtration media and starts filling the cartridge center tube. Air below the hood is purged through a one-way check valve as the water rises. When water reaches the top of the float, buoyant forces pull the float free and allow filtered water to drain through the cartridge media.

After the storm, the water level in the structure starts falling. A hanging water column remains under the cartridge hood until the water level reaches the scrubbing regulators. Air then rushes through the regulators releasing water and creating air bubbles that agitate the surface of the filter media, causing accumulated sediment to drop to the vault floor. This patented surface-cleaning mechanism helps restore the filter's permeability between storm events.

3.1.2 Cartridge Operation

As the water level in the filtration bay begins to rise, stormwater enters the StormFilter cartridge (Figure 2). Stormwater in the cartridge percolates horizontally through the filter media and passes into the cartridge's center tube, where the float in the cartridge is in a closed (downward) position. As the water level in the filtration bay continues to rise, more water passes through the filter media and into the cartridge's center tube. The air in the cartridge is displaced by the water and purged from beneath the filter hood through the one-way check valve located in the cap.

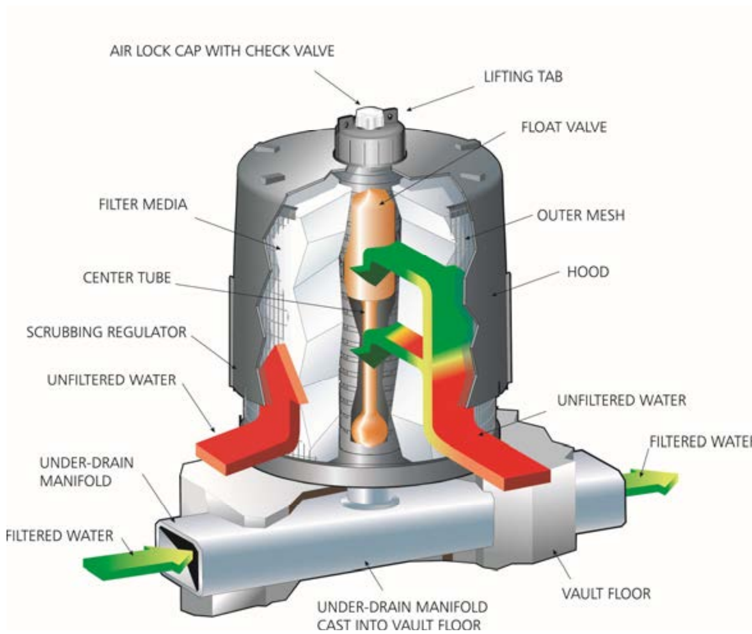

Figure 2. The StormFilter cartridge

Once the center tube is filled with water, there is enough buoyant force on the float to open the float valve and allow the treated water to flow into the under drain manifold. As the treated water drains, it tries to pull in air behind it. This causes the check valve to close, initiating a siphon that draws polluted water throughout the full surface area and volume of the filter media. Thus, the entire filter cartridge is used to filter water throughout the duration of the storm, regardless of the water surface elevation in the filtration bay.

This continues until the water surface elevation drops to the elevation of the scrubbing regulators and the float returns to a closed position. At this point, the siphon begins to break and air is quickly drawn beneath the hood through the scrubbing regulators, causing high-energy turbulence between the inner surface of the hood and the outer surface of the filter. This turbulence agitates the surface of the filter, releasing accumulated sediments on the surface, flushing them from beneath the hood, and allowing them to settle to the vault floor. This surface-cleaning mechanism maintains the permeability of the filter surface and enhances the overall performance and longevity of the system.

3.1.3 Media Choices

The StormFilter can be customized with different filter media to target site-specific pollutants. A combination of media is often recommended to maximize pollutant removal effectiveness. Table 1 shows typical media and associated target pollutants.

CSF® Leaf Media and MetalRx™ use a feed stock of pure deciduous leaf compost that does not contain mixed yard debris (pruning or grass). Mature stable compost is processed into an organic granular media or pellet. CSF is a coarse media with a high hydraulic capacity. MetalRx is a finer media with a lower hydraulic capacity. Both are effective at removing soluble metals, TSS, oil and grease, and buffering acid rain. Both media types are very effective at soluble metals removal, and MetalRx is the most effective.

Granular Activated Carbon (GAC) has a micro-porous structure with an extensive surface area to provide high levels of adsorption. It is primarily used to remove oil and grease and organics such as PAHs and phthalates.

Perlite is a naturally occurring heat-expanded volcanic rock. It is effective for removing TSS, oil and grease.

PhosphoSorb® is comprised of a heat expanded volcanic rock and activated alumina. The lightweight expanded rock provides exceptional removal of fine particulate and the activated alumina allows for adsorption of soluble phosphorus.

Zeolite is a naturally occurring mineral used to remove soluble metals, ammonium and some organics.

ZPG™ is a media blend of perlite, zeolite and granular activated carbon. It is an all-purpose media that is ideal for sites that require removal of the most common pollutants.

Table 1. Typical media and targeted pollutants.

	Perlite	CSF® leaf	MetalRx™	PhosphoSorb®	Zeolite	GAC
Sediment	X	X		X		
Oil & Grease	X	X	X	X		
Soluble Metals		X	X		X	
Organics		X	X			X
Nutrients	X	X	X	X	X	

Note: Indicated media are most effective for pollutant type.
Other media may treat pollutants but to a lesser degree.

3.1.4 Adjustable Flow Rate

Depending on the treatment requirements and the 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. Consisting of a simple orifice disc of a specified diameter, the flow rate through the cartridges can be adjusted to a level that coincides with treatment requirements.

A reduction in flow rate affects the performance of the StormFilter system with regards to both sediment and soluble pollutants. For solids, Stokes' Law predicts the movement of sediment in a fluid and it has been proven that a reduction in the flow velocity through the system will facilitate increased settling and capture of sediments. In addition, some media types have the ability to remove soluble pollutants through chemical processes such as ion exchange. A reduction in the flow velocity through the cartridge will increase the contact time between the stormwater and the media, thereby increasing removal efficiency by increasing the time for a chemical process to take place.

3.1.5 Cartridge Heights

Three different cartridge heights are available at 12, 18, and 27 inches. Increasing the height of the cartridge (ranging from 18 to 27 inches) 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. Similarly, decreasing the cartridge effective height will result in a reduction in the required hydraulic drop but a corresponding reduction in the media surface area and volume per cartridge. Since each cartridge contains an individual orifice control – the calibrated restrictor disc – a consistent specific flow rate is sustained for all cartridge heights.

Projects that have additional hydraulic drop available can opt for a taller cartridge design and gain the benefit of a smaller number of required cartridges and therefore a smaller system footprint, Figure 3. Projects with limited available hydraulic drop can select the Low Drop StormFilter, which is an 18" cartridge containing 12" float. However, more cartridges may be required to provide the required media surface area, which results in a larger system footprint.

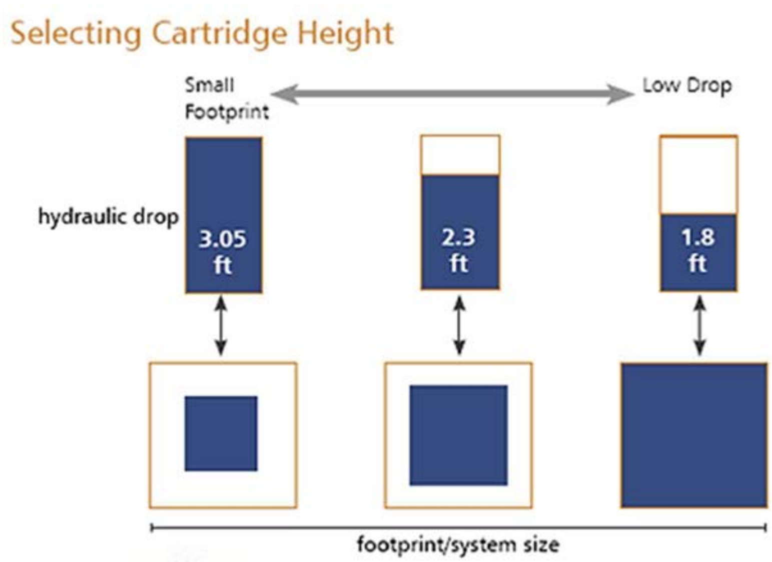

Figure 3. Relationship between cartridge height and system size.

3.1.6 Configurations

Table 2 provides a summary of the available configurations with the StormFilter.

Table 2. Configurations

Model	Description	Photo
Vault/Manhole	• Treats small to medium sized sites • Simple installation; arrives on-site fully assembled	
High Flow	• Treats flows from large sites • Consists of large, precast components designed for easy assembly on-site • Several configurations available, including: CON/SPAN, Panel Vault, Box Culvert, or Cast-In-Place	
Drywell	• Provides treatment and infiltration in one structure • Available for new construction and retrofit applications • Easy installation	
CatchBasin	• Provides a low cost, low drop, point-of-entry configuration • Treats sheet flow from small sites • Uses drop from the inlet grate to conveyance pipe to drive the passive filtration cartridges	
Volume	• Meets volume-based stormwater treatment regulations • Captures and treats site specific Water Quality Volume (WQv) • StormFilter cartridges provide treatment and control the discharge rate • Can be designed to capture all, or a portion, of the WQv	
Curb-Inlet	• Provides a low drop, point-of-entry configuration • Accommodates curb inlet openings from 3 to 10 feet long • Uses drop from the curb inlet to the conveyance pipe to drive the passive filtration cartridges	

3.1.7 Design Drawings

Standard design drawings for the StormFilter are available at ContechES.com and upon request.

3.1.8 Treatment Mechanisms

The StormFilter system utilizes several unit processes to remove pollutants from stormwater. This section includes a brief summary of the media type and the unit process employed in the StormFilter system for each specific contaminant.

Physical Separation

The primary component of the StormFilter is the filtration bay with media-filled cartridges. Residence time within a vault varies with cartridge flow rate and vault size, but as a rule of thumb, is a minimum of 6 minutes. This allows for large solids (coarse sand and grit) to drop to the floor of the system.

Pollutant Removal by the Media-Filled Cartridge

The StormFilter cartridge is the central treatment device within the system. The cartridges are filled with various media depending on the site's runoff and targeted pollutant removal. Removal associated with the media is promoted through physical straining, ion exchange, and adsorption. Physical straining is the primary removal mechanism for suspended solids. Depending on the media used, dissolved pollutant removal is either associated with ion exchange, chelation, or adsorption reactions.

Physical Straining

Physical straining through the media promotes solids removal by trapping solids within interstitial spaces throughout the filtration media. Removal of suspended particles occurs through physical straining as water passes through filtration media. The straining results in the trapping of suspended particles within the media matrix either in microchannels or dead end pores. All Contech media options utilize physical straining.

Also, physical straining promotes non-dissolved metals removal due to the binding of metals to particles. Other attached pollutants removed through straining include total phosphorus and total nitrogen. All Contech media options utilize physical straining for total metals and nutrients.

Cation Exchange

As implied, cation exchange is the exchange of a cation (positively charged atom) for another cation. The process involves the displacement of an atom within the media matrix by an atom within the water column. The displacement occurs if the incoming atom's affinity for the exchange site is higher than that of the current occupying atom. In general, most media have a preference for small hydrated ions with a greater positive charge over larger hydrated ions with a single positive charge.

For commonly found metals in stormwater runoff, predictions can be made using a periodic table of elements. Staying within the same row of the table and proceeding left to right produces an increasing affinity for cation exchange. This trend is promoted due to the metal atom remaining in the same valence state (charge) while the overall diameter of the atom decreases. Since the diameter decreases, the "apparent charge" of the atom increases, thus producing the driving mechanism for cation exchange. For most purposes the following affinity series is true:

$$Al^{3+} > H^{+} > Zn^{2+} > Cu^{2+} > Ni^{2+} > Fe^{2+} > Cr^{2+} > Ca^{2+} > Mg^{2+} > K^{+} > Na^{+}$$

The media-bound ions utilized with cation exchange filtration are calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) with calcium and magnesium being the primary exchange ions due to their abundance within the media matrix. As presented above, zinc, copper and iron (as well as others) will force the displacement of the calcium and magnesium ions from the media. Media promoting cation exchange include: CSF leaf media (93.8 meq/100-grams) and Zeolite (125 meq/100 grams).

Chelation
Chelation refers to the process of a metal being bound by a ligand to form a cyclic compound. Essentially it is the binding of a metal ion to a chemical or complex within the media. Some describe the process as a 'crab claw' grabbing onto a metal ion and holding onto it. Media promoting metal chelation include: CSF leaf media and MetalRx media

Adsorption
Adsorption is the attraction and adhesion of a dissolved contaminant to the media surface. This occurs at the surface as well as within the pores of the media granule. Adsorption requires that a contaminant come in contact with an active surface site on the media and time must be allowed for the contaminant to adhere. These reactions are usually promoted by polar interactions between the media and the pollutant. Adsorption can also occur within the dead end pores and channels of the media but is generally slower than a surface reaction due to limits of the contaminants diffusion into the pore. The contaminant's molecular size will limit diffusion in that the media’s pore opening must be larger than the dissolved contaminant.

Commonly adsorbed pollutants include: gasoline, oil, grease, TNT, polar organics or organically bound metals and nutrients. Media promoting adsorption reactions include: CSF leaf media, PhosphoSorb, Perlite, and Granular Activated Carbon.

3.1.9 Hydraulic Capacity
The StormFilter is typically designed to treat the peak flow of a specified water quality design storm. The on-line or off-line water quality treatment design rate is utilized in conjunction with Ecology’s allowed hydraulic loading rate for the StormFilter system to determine the number of cartridges required.

Since the StormFilter is designed to accommodate the water quality design flow, three situations could occur during a given storm event: 1) flows below the design flow; 2) flows at the design flow; and 3) flows in excess of the design flow. These situations can sometimes occur all within a single storm event.

1) Flows below the design flow: The predetermined flow rate through the StormFilter cartridge is the maximum filtration rate of the cartridge. The head and tail ends of a storm event may have minimal flows. If these low flows don’t provide enough volume to raise the water surface elevation in the vault, these smaller flows may not activate the siphon mechanism of the cartridges (see Figure 4). Stormwater entering the unit will still be treated at a lower flow rate. An increase in performance results due to longer residence time, reduced flow rate, and increased media contact for storms below the water quality design.

2) Flows at the design flow: Once event flows reach the design flow rate, the siphon mechanism of the cartridges is activated and the flow is treated at design capacity for the duration of the event.

3) Flows in excess of the design flow: Flows exceeding the design flows can be bypassed internally through an overflow riser for an on-line system or by using an upstream, external, flow splitter, such as the

StormGate, an adjustable weir for off-line systems. Each StormFilter unit has design guidelines for the maximum allowable internal bypass, which varies by configuration.

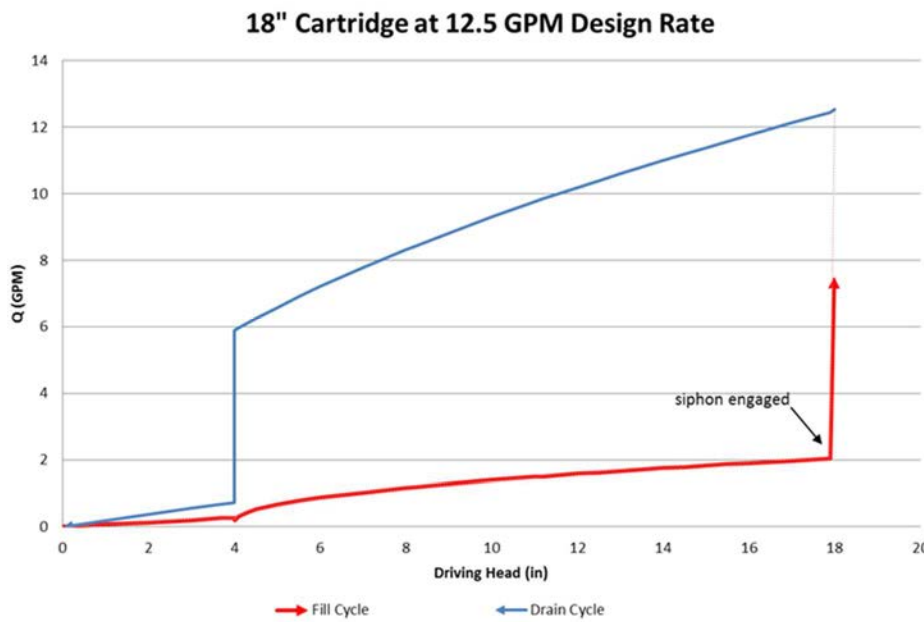

Figure 4. StormFilter fill and drain cycle at 12.5 gpm for an 18” tall cartridge.

3.2 Site Requirements

The following sections address the site requirements for StormFilter applications.

Soil characteristics

The StormFilter typically consists of an underground structure, such as steel catch basins or concrete manholes or vaults. If stabilization of the vault can be assured, soil conditions are not relevant.

Hydraulic grade requirements

Hydraulic grade requirements for the StormFilter vary, depending on the cartridge height used. The following table summarizes the hydraulic drop required for each of the three cartridge heights available.

Table 3. Cartridge Heights

Cartridge Type	Hydraulic Drop
StormFilter 27”	3.05’
StormFilter 18”	2.30’
StormFilter Low Drop	1.80’

Depth to groundwater limitations

Buoyancy calculations relative to groundwater level should be performed to determine if vault flotation is a concern.

Applications that the manufacturer recommends for the technology

The StormFilter can be used for a variety of land uses such as residential, commercial, industrial, and roadway. Depending on the type of land use pretreatment and media selection should be evaluated for each individual project.

Pretreatment requirements

Pretreatment of TSS and oil and grease may be necessary and shall be provided as recommended by local site requirements. Guidance includes evaluating sites that contain high amounts of oil and grease, such as vehicle maintenance yards, and pre-settling of sediment to reduce loading. An example of recommendations for determining the need for pretreatment sedimentation is below.

Table 4. Pretreatment Requirements

Site Type	Recommendation
Roadways with no curb and gutter	Required
Roadways with curb and gutter	Recommended
Development with steep slopes and erosive soils	Required
Single Family Developments	Recommended
Multi-family Developments	Optional
Small 2 acre or less commercial	Optional

List of facilities installed in the US. Include location, land use, and size of each facility.

There have been six StormFilter systems with PhosphoSorb media operating at 1.67 gpm/ft^2 installed in Washington State under a Conditional Use Level Designation. An installation list has been previously provided to Ecology in March 2015.

Other site characteristics:

- Steep slopes: A retaining wall may be required. Evaluate the site for maintenance access.
- High groundwater: If discharge is to infiltration, evaluate the system for potential backwater effects. Also, evaluate for buoyancy concerns
- Seepage or base flows: These may need to be bypassed around the StormFilter. These constant, low flows may cause the growth of algae on filtration media.
- Tidal action: Systems should be evaluated for the potential of tidal action to cause backwater into the system. The impact on design may vary with the amplitude and frequency of tidal action as compared to the frequency and depth of filter inundation. Although tidal valves have been used for these applications in the past, they are typically not recommended due to the additional head required to get flow out of the StormFilter.
- Proximity to wells, septic systems and buildings: Groundwater calculations should be buoyancy issues. Access for maintenance should be evaluated. Refer to receiving water recommendations for selecting media type within wellhead protection zones.
- Facility depth limits for access and safety: StormFilter units have been installed up to a depth of 17 feet, thus far. Access and safety requirements may include standard OSHA confined space entry procedures.

- Risk of hazardous material spills: The StormFilter can be equipped with downstream valves to prevent the loss of material spills. However, the StormFilter is not designed for containment of spills.
- Driving head requirements: Hydraulic grade requirements are dictated by cartridge height and are defined above. These requirements may be adjusted in some circumstances with more knowledge of backwater effects, pipe diameters, and acceptability of pipe submergence.
- Power availability: No power is required for typical applications. For areas that have limited drop, a pump and power source may be required.

3.3 Sizing Methodology

For jurisdictional authorities in Western Washington without a specified water quality design method, the Western Washington Continuous Simulation Hydrology Model (WWHM) will be used to size the StormFilter system in accordance with the latest Washington State Department of Ecology (Ecology) Stormwater Management Manual. For jurisdictions with other design methodologies, such as King County, the StormFilter system will be designed according to their design methodology (for example, KCRTS method outlined in King County).

The primary design methodology for Washington is the flow-based methodology. In general, the StormFilter sizing is based on the water quality design storm designated by the regulatory agency. Water quality flow rates from the design storm are used to calculate the number of cartridges required to accommodate the flow rate. The per-cartridge flow rate is specified by the Use Level Designation. Once the required number of cartridges has been calculated, the size of the facility to accommodate those cartridges can be determined.

Other possible design methods include: volume-based designs, mass-loading designs, and downstream of detention designs.

3.3.1 Design criteria – Expected pollutant removal

Under influent conditions typical of municipal projects in the Pacific Northwest region, the StormFilter with PhosphoSorb media is expected to achieve 80% removal of TSS and greater than 50% total phosphorus at the design flow.

3.3.2 Design criteria – Design hydraulics

Typically, the StormFilter is sized to treat the peak flow of a water quality design storm. The on-line or off-line water quality treatment design rate from WWHM is utilized in conjunction with Ecology's allowed hydraulic loading rate for the StormFilter system to determine the number of cartridges required. The following table summarizes the available cartridge hydraulic loading rates.

Table 5. Hydraulic Loading Rate per Cartridge Height and Specific Flow Rate

StormFilter Cartridge Type	Per Cartridge Flow Rate at 2 gpm/ft^2	Per Cartridge Flow Rate at 1.67 gpm/ft^2	Per Cartridge Flow Rate at 1 gpm/ft^2	Hydraulic Drop Required
Low Drop	10 gpm	8.4 gpm	5 gpm	3.05'
18"	15 gpm	12.5 gpm	7.5 gpm	2.3'
27"	22.5 gpm	18.8 gpm	11.3 gpm	1.8'

Since the StormFilter is designed to the water quality design flow, three conditions exist for incoming storms: flows are below the water quality design flow, equal to the water quality design flow, or in excess of the water quality design flow. All three conditions could occur within a single storm event.

For events producing flows below the water quality design flow (or for the portion of an event, such as the head and tail ends of the hydrograph), the siphon mechanism of the cartridges may not be activated, since the depth of water in the vault may not reach the kick-point of the cartridges. Stormwater entering the unit can only exit through the cartridges, and will be treated at a lower flow rate. An increase in performance could result due to the lower flow rate and thus longer residence time in the system and increased media contact time.

For events producing flows equal to the water quality design flow, the cartridge siphon mechanisms will be activated and the flow will be treated at the design capacity for the duration of the event.

For events producing flows in excess of the water quality design flow, the cartridge siphon mechanisms will be activated, and the system will treat at the design capacity. Once the inflow exceeds the cartridge capacity, additional flows will be diverted through the internal or external flow splitters (depending on which is available). This additional flow will not be treated by the cartridges, but also shall be diverted to prevent resuspension of previously accumulated sediment. Each StormFilter unit has specific design guidelines for the maximum allowable internal bypass capacity to minimize resuspension and/or scour.

3.3.3 Design criteria – Residence time and velocities

As a rule of thumb, the average residence time in the StormFilter system is approximately six minutes. However, the performance of the system is primarily dictated by contact time with the filtration media rather than system residence time.

3.3.4 Design criteria – Treatment limitations

The potential for biofilm development on the media is reduced by preventing standing water within the cartridge bay. This allows the media to dry out between storm events. Also, each StormFilter cartridge has a cartridge hood cover with perforations at the base (scrubbing regulators). As the storm event subsides, and the water surface elevation in the vault drops, air enters the scrubbing regulators and the siphon collapses. The turbulent interchange of water under the cartridge hood being displaced by bubbles entering through the scrubbing regulators agitates and displaces accumulated pollutants on the surface of the filtration media. This provides additional protection from development of biofilm and fouling.

3.3.5 Design criteria – Specific media flow rate

The StormFilter can be designed at multiple media flow rates. The two primary design flow rates are 1 and 2 gpm/ft^2. StormFilter with PhosphoSorb media has been evaluated at 1.67 gpm/ft^2 for this application. Cartridge flow rates vary depending on the application, regulatory approval and targeted pollutants.

3.3.6 Design criteria – Media head loss curves

The nature of the StormFilter cartridge and its operation create a constant radial flow rate throughout the cartridge. Throughout most of the life of the cartridge, flow through the cartridge is controlled by the cartridge restrictor disc and is relatively independent of the media head loss. The total dynamic head loss through the system depends on the cartridge height in use. These losses are summarized in the table in Section 3.3.2 above. The hydraulic drop required is determined from the upstream water surface elevation to the downstream water surface elevation. Over time, as the media begins to occlude, the media head loss could begin to dictate the flow through the cartridge. At this point, the system may need evaluation for determining maintenance.

3.3.7 Design criteria – Media contact time and thickness

The StormFilter cartridges all have the same diameter regardless of height and flow rate. Therefore, the media thickness is consistently 7 inches. Cartridge media volume varies with cartridge height. The filtration media contact time also varies, depending on cartridge flow rate. The StormFilter with PhosphoSorb media operating at a specific flow rate of 1.67 gpm/ft^2 has a media contact time of approximately 46 seconds.

3.3.8 Design criteria – Estimated design life

The design life of the concrete structures is typically 50 years. The design life of the steel structures is typically 20 years. The design life of the cartridges is typically 20 years, assuming annual maintenance has been performed.

3.3.9 Design criteria – Media specifications

Media specifications for the PhosphoSorb media are included in Appendix A.

3.3.10 Western Washington Sizing

In Western Washington, the StormFilter system must be sized to meet applicable performance goals at the design flow rate coinciding with treating at least 91 percent of the total annual runoff volume, using an Ecology-approved continuous simulation model such as WWHM, KCRTS, or MGS Flood. Depending on the configuration of the StormFilter and bypass, the on-line or off-line flow rate should be used as applicable.

If the StormFilter system is located downstream of a detention facility, it must be sized to meet the full 2-year release rate of the detention facility.

3.3.11 Eastern Washington Sizing

In Eastern Washington, the StormFilter typically will be sized to treat the runoff flow predicted for the proposed development condition from the short-duration (3-hour) storm with a 6-month return frequency.

If the StormFilter system is located downstream of a detention facility, it must be sized to meet the full 2-year release rate of the detention facility.

3.4 Installation

3.4.1 Installation Requirements

For precast StormFilter units (such as the vault, manhole, and curb-inlet configurations), the StormFilter is typically delivered to the site with the underdrain manifold in place, as well as internal components including cartridges, flow spreaders, and energy dissipators as specified. The contractor is responsible for base preparation, for providing equipment as needed, and for setting the precast unit as specified. The influent and effluent pipes are then connected by the contractor. If required, the contractor shall also provide ballast as specified on the plans. Backfill material and placement shall be in accordance with the plans. Many precast units are delivered to the site with construction bypass lines in place. Once construction is complete, landscaping is in place, and the site has been stabilized, the contractor is responsible for activating the StormFilter system. Depending on the method of protecting the system from construction runoff, this step may include installation of the cartridges, removal of any inlet pipe plugs, and installation of construction bypass plugs.

For cast-in-place, CON/SPAN, or other high flow units, the contractor is responsible for constructing or installing the vault as specified on the site drawings. Once the vault is complete, the flow kit will be ready for installation. The contractor is responsible for setting the underdrain manifold as specified in the plans; location and spacing of the manifold are critical. The underdrain manifold is then cast in place using a secondary concrete pour by the contractor. Other internal components including cartridges, flow spreaders and energy dissipators shall be installed by the contractor as specified.

3.4.2 Provisions for other factors (structural integrity, water tightness, buoyancy)

- Structural integrity: Most StormFilter systems are designed for an H-20 load rating. For precast units, stamped structural calculations can be provided upon request. For cast-in-place units, structural calculations are the responsibility of the site engineer or contractor.
- Water tightness: For precast units, structure joints are typically filled with Conseal. If applied correctly, vaults can be considered watertight.
- Buoyancy: Buoyancy calculations can be performed for vaults that will be located in areas with suspected high groundwater levels, upon request.

3.4.3 Potential problems that can occur during design and installation
Potential design issues:

- Backwater: If downstream hydraulic conditions are not evaluated during the design process, backwater conditions may impact the filtration capacity of the StormFilter
- Base flows: Base flows or seepage flows should be bypassed around the cartridges to ensure proper functioning and design life of the cartridges and filtration media.
- Excessive solids loading: Usually high sediment loading should be addressed during the design phase of the project to determine if pretreatment is needed.

Potential installation issues:

- Invert elevations: Correct installation of the StormFilter inlet and outlet piping is crucial for proper operation of the system.
- Construction sediment: If the StormFilter is placed online before the site is stabilized, construction sediment may reduce the capacity of the cartridges for the design goal of removing post-construction sediment. If construction sediment is allowed to enter the system, more frequent maintenance of the system may be required.
- Vault placement and floor leveling: It is necessary for the vault to be set or constructed level to ensure proper functioning of the cartridges.

3.4.4 Methods for diagnosing and correcting potential problems

- The Engineering and Customer Service Department at Contech offers full technical support for all applications of our products. During the design phase, Stormwater Design Engineers offer to assist with plan preparation and can provide a technical review of the system. This review provides an opportunity to review elevation requirements, system sizing and placement, backwater evaluation, as well as maintenance access.
- Contech also provides design overview and construction support directly to the contractor and/or owner during the bidding and construction phases of the project.
- If there are problems with the structure or components during delivery, Contech will work to resolve these issues prior to installation of the system.

- If problems develop during or due to the installation of the system, Contech will work with the contractor to effect repairs to ensure proper operation of the system.

3.4.5 Impacts to effectiveness if problems are not corrected

- Backwater: Backwater will reduce the driving head across the filter and will reduce treatment flow. Backwater may also saturate the filtration media for extended periods of time, increasing the possibility of microbial occlusion of the media.
- Base flows: If base flows enter the system, the filtration media may become exhausted prematurely. This could also result in microbial occlusion of the media. This will affect the life of the cartridges and more frequent maintenance will be required. In some cases, base flow bypasses can be installed retroactively.
- Excessive solids loading: Heavy solids loading without pretreatment may cause premature occlusion of the cartridges. Required maintenance frequency may increase in this case.
- Invert elevations: If the StormFilter is incorrectly installed and insufficient drop is provided across the system, the system may experience early bypass and may not be able to fully treat the design flow rate.
- Vault placement and floor leveling: If the unit is not installed level, the design flow rate through the cartridges may not be achieved before early bypass. In addition, some cartridges may treat a disproportionate amount of the flow and thus may occlude more quickly than others.

3.4.6 Technology availability (sourcing and lead time)

- Precast units: For precast units, the concrete structures can be provided by many precasters throughout the region. Typical lead time required is 4 to 6 weeks from shop drawing approval by the contractor to vault delivery.
- Catch basin units: Steel catch basin units are sourced from a supplier in Portland, Oregon. Typical lead time required is 2 to 4 weeks from shop drawing approval by the contractor to catch basin delivery.
- StormFilter components: The cartridges, underdrain manifold, flow spreaders and energy dissipators are supplied by Contech. These components typically require 2 to 3 weeks lead time.

3.5 Operation and Maintenance Requirements

3.5.1 Inspections – Frequency and methodology

At least one scheduled inspection should take place per year with maintenance following as warranted. An inspection should be performed prior to the winter season. During the inspection, the need for maintenance should be determined by checking the accumulated materials in the system. It is also important to check the condition of the StormFilter after major storms for potential damage caused by high flows and for sediment accumulation that may be caused by localized erosion in the drainage area. It may be necessary to adjust the inspection/maintenance schedule depending on the actual operating conditions encountered by the system. In general, inspection activities can be conducted at any time, and maintenance should occur, if warranted in late summer or early fall when flows into the system are less likely to be present.

3.5.2 Maintenance triggers and rationale

The need for maintenance is typically based on results of an inspection. The following criteria should be used as a guideline for when maintenance is required:

- Sediment loading on vault floor could be an indication that the mass loading capacity of the system has been reached. If there is greater than 4” of accumulated sediment, maintenance is required.
- Sediment loading on top of the cartridges could be an indication that the influent water is not passing through the cartridges at the design flow rate (suspended sediment has time to settle out instead of passing through the filtration media). If there is greater than ¼” of accumulated sediment on top of the cartridges, maintenance is required.
- Submerged cartridges could indicate that the cartridges are completely plugged. However, this could also be due to backwater conditions caused by high groundwater, plugged pipes, or high hydraulic grade lines. Completely plugged cartridges could also be associated with heavy oil and grease loading, which might require additional source control measures. If there is greater than 4” of static water in the cartridge compartment for more than 24 hours after the end of the rain event, maintenance is required.
- Plugged media could be an indication that the mass loading capacity of the system has been reached. If pore space between the media granules is absent, maintenance is required.
- Prolonged bypass flow could indicate that the cartridges are in bypass and that the mass loading capacity of the system has been reached. If inspection is conducted during an average rainfall event and the StormFilter remains in bypass condition (water over the internal outlet baffle wall or submerged cartridges), maintenance is required.
- The presence of hazardous materials could indicate a spill. If hazardous material release (automotive fluids or other) is reported, maintenance is required.
- The presence of a pronounced scum line could indicate excessive bypass. If a pronounced scum line (greater than ¼” thick) is present about cartridge top cap, maintenance is required.
- Finally, a history of the maintenance should be kept in maintenance files. This helps provide an understanding of maintenance requirements over time. If a system has not been maintained for 3 years, maintenance is required.

3.5.3 Maintenance methodology

Depending on the configuration of the particular system, maintenance personnel may be required to enter the system to perform maintenance. If this is required, OSHA rules for confined space entry must be followed.

The first step in maintaining the StormFilter system is to open and vent the system (as applicable) and then perform a visual inspection of the system, both internally and externally. Next, the cartridges and spent media are removed from the system. This may be accomplished in several ways: 1) the full cartridges can be detached from the underdrain manifold and removed the vault using appropriate lifting equipment, 2) the cartridges can be detached from the underdrain manifold, tipped to the side to dump the spent media onto the floor of the vault, and then the empty cartridges are manually removed from the vault, or 3) the cartridges can be detached from the underdrain manifold, media from the cartridge is removed directly from the vacuum hose, and then the empty cartridges are manually removed from the vault. Once the cartridges have been removed, the remaining accumulated sediment (and/or spent media) on the floor of the vault and in the forebay (if applicable) are removed. Typically, this is most easily achieved using a vactor truck. The structure should then be inspected for structural conditions and new cartridges are lowered into the system and connected to the underdrain manifold. This is most easily achieved with lifting equipment.

Collected sediment and spent media should then be disposed of in accordance with applicable regulations. Consideration should be made for disposal of both liquid and solid wastes. Empty cartridges are returned to Contech to be cleaned, refurbished, and/or updated for use at another site.

3.5.4 Maintenance area accessibility by people and equipment

Depending on the type of StormFilter system installed, confined space entry may be required. If this is the case, personnel should follow appropriate confined space entry procedures and use appropriate equipment.

Maintenance equipment, such as vactor trucks and/or lifting equipment should have full access to the system.

3.5.5 Estimated maintenance frequency and basis for determination

Generally, the design maintenance frequency for the StormFilter is once per year, based on extensive experience with rainfall conditions, typical site loadings, and multiple system installations in the Pacific Northwest. On a site-by-site basis however, maintenance frequency should be determined during the site evaluation and inspection process.

Additionally, maintenance should be performed in the event of a spill or other unusual loading event.

3.5.6 Estimated media capacity for pollutant removal

All filtration systems have a limited capacity for pollutant removal before a reduction in performance occurs. Typically, sediment is the limiting pollutant for stormwater treatment applications. For the StormFilter, the sediment mass load capacity of the cartridge is inversely proportional to the design flow rate of the cartridge. The lower the filtration rate of the cartridge, the more mass load is removed by that cartridge, due to the increased residence time (and thus settling time) in the structure. The following table summarizes the mass load capacity design parameters for StormFilter.

Table 6. StormFilter Sediment Mass Load Capacities

StormFilter Cartridge Type	Mass Capacity at 2 gpm/ft^2	Mass Capacity at 1.67 gpm/ft^2	Mass Capacity at 1 gpm/ft^2
Low Drop	15 lbs	19 lbs	24 lbs
18”	23 lbs	29 lbs	36 lbs
27”	34 lbs	44 lbs	54 lbs

3.5.7 Estimated design life of facility and components

The design life of the concrete structures is typically 50 years. The design life of the steel structures is typically 20 years. The design life of the cartridges is typically 20 years, assuming annual maintenance has been performed.

3.5.8 Maintenance equipment and materials

Maintenance equipment and materials typically include:

- Equipment for removal of both solid and liquid wastes, such as a vactor truck
- Pump for removal of water due to complete system occlusion, if needed
- Shovel for removal of sediment from structure

- Lifting equipment for removal of old cartridges and installation of new cartridges. A lifting cap (4" PVC threaded end cap with lifting ring) for installations prior to 2004) or a lifting hook for raising or lowering cartridges in the vault.
- Very large systems may assess the need for a boom truck or crane.

3.5.9 Maintenance service contract availability
Maintenance service contracts are available through a list of Preferred Maintenance Service Providers. These providers have been trained to provide inspections and maintenance of all StormFilter systems. Contech can offer replacement cartridges directly to the owner, or to the service provider. The service provider typically provides all field services related to maintenance. Costs vary by size and type of the system, as well as location of the site, and are managed by the service provider.

As a rule of thumb, for a system with greater than 50 cartridges, the cost (2015) of a full-service maintenance is approximately $200 per cartridge for ZPG media. Costs may vary for other filtration media options.

3.5.10 Solids and media disposal
Solids and spent media are analyzed for total metals (Cu, Zn, Pb, As, Hg, Cd, Mo, Ni, Se) and total petroleum hydrocarbons (NWTPH-Dx) as necessary to comply with local disposal regulations and permit requirements. Except in the case of hazardous spills, all disposals have generally been to standard landfills.

3.5.11 Impacts of delayed maintenance
Delayed maintenance has no effect on the performance of the system, with the exception of reduced hydraulic capacity. Restoration of the system typically involves simply removing the accumulated sediments and replacing the cartridges.

3.5.12 History, availability of materials and parts from manufacturer
The history of Contech is available at www.ContechES.com and has been in business for over 100 years. The media-filled cartridges are the primary component required to keep the system functioning properly. Cartridges can be filled with a variety of non-proprietary filtration media that the owner can find "off-the-shelf" and can use to recharge the system to proper working order. Maintenance of the system can be performed by any vactor-truck service provider. In the event that Contech should no longer exist, these maintenance service providers will be able to assist the owners in maintenance of the system.

3.6 Reliability

3.6.1 Other factors that affect performance
Excessive solids loading due to unaccounted sources (such as vehicle washing, disposal of materials in upstream catch basins, generally poor housekeeping on a site) could affect the performance of the system. Addition of surfactants to the influent stream could also prevent the media from providing removal of pollutants as expected.

3.6.2 Circumstances in which the technology can add, transform or release pollutants
Accumulated pollutants may be released during extreme events, as with all treatment systems, unless the system contains an external bypass. However, the first flush from extreme events will be treated through the filtration media even though the entire event runoff may not be treated.

3.6.3 Media decomposition or bacterial growth issues

No filtration media utilized by the StormFilter decompose. In a standard application, since the system drains down completely between rainfall events, the filtration media are not subject to slime or bacterial growth. However, if there are continuous base flows at the site, or if the cartridges remain in standing water due to backwater conditions or occlusion, a biofilm may develop on the cartridges. In order to prevent this condition, a low-flow bypass can be installed.

3.6.4 Sensitivity to sediment loading and pretreatment requirements

Sites with heavy loadings of sediment should provide pretreatment upstream of the StormFilter to prolong the life of the cartridges. This is typically evaluated during the design phase of the project. Pretreatment is not required for every site. Pretreatment should be considered based on land usage and/or for sites that produce heavy oil and grease loadings or high solids loadings.

3.6.5 Diagnosis of underperformance and response

Performance in relation to pollutant removal can be addressed through the use of an alternate media. Finer grain sizes of media can also be selected to provide more surface area and increased pollutant removal capabilities. The cartridge flow rates can also be adjusted to vary the contact time with the media and increase or decrease the pollutant removal efficiency accordingly.

3.6.6 Warranty

A detailed warranty is available at www.ContechES.com.

3.6.7 Provision of user support

Contech provides complete support of all StormFilter systems. This includes support throughout system design phase, product delivery, and installation of the system. Once the system is online, support is also available. The support may pertain to engineering, maintenance, research, or other aspects depending on client's needs.

3.7 Other Benefits or Challenges

3.7.1 Other benefits or challenges in other potentially relevant areas, such as groundwater recharge, thermal effects on surface waters, habitat creation, aesthetics, vectors, safety, community acceptance, recreational use, and efficacy on redevelopment sites.

- The StormFilter does not impact groundwater recharge.
- The StormFilter does not have thermal effects on surface waters.
- The StormFilter does not provide habitat creation.
- The StormFilter can increase the clarity of water and reduce odor associated with anaerobic conditions from standing water, which would benefit aesthetics. Additionally, the use of the StormFilter has prevented the destruction of habitat since when it was used instead of larger, above-ground systems.
- The StormFilter can provide vector control options if needed.
- The StormFilter does not create a safety issue since the vaults are typically underground, completely closed and require a tool for opening access ports.
- Community acceptance of the StormFilter is very strong.
- The StormFilter has been used for recreational sites such as marinas and boatyard applications to reduce toxicity.
- The StormFilter has frequently been used in redevelopment and retrofit applications.

3.7.2 Copper, lead or zinc components

There are no copper, leads or zinc components of the standard StormFilter system that may be exposed to stormwater runoff and could potentially leach into the effluent.

3.7.3 Concrete components

There is no evidence that the concrete vault impacts the pH or causes pH fluctuations in the effluent.

4.0 Results from Previous Studies

A summary of previous studies has been provided to demonstrate the StormFilter with PhosphoSorb media and its ability to remove dissolved phosphorus and Sil-Co-Sil 106 in the laboratory; and field testing using a volume-based StormFilter in North Carolina for TSS, total phosphorus, and total nitrogen.

4.1 Bench testing

In bench testing, PhosphoSorb achieved an average of 50% removal of dissolved phosphorus for the first 1,000 treated bed volumes (CES, 2011). Significant removal was provided through 2,000 treated bed volumes (CES, 2011). In the same test using GAC media, 30% removal was achieved through 1,000 bed volumes.

4.2 Sil-Co-Sil 106 testing

PhosphoSorb media was tested in a StormFilter cartridge to assess its ability to remove suspended solids and decrease turbidity from simulated stormwater. The contaminant surrogate used for these tests was Sil Co Sil 106®, which has a silt texture (25% sand, 65% silt, 10% clay). Utilizing a standardized contaminant surrogate eliminates contaminant characteristics as a variable, thereby allowing comparison of StormFilter performance test results involving different media or treatment systems that used the same contaminant surrogate.

The test included 8 runoff simulations at 7.5 gpm (28 L/min) and 7 simulations at 15 gpm (56 L/min) using influent variable event mean concentrations (EMCs) between 0 and 300 mg/L (Ma, 2009). Regression statistics were used to determine the mean suspended solids concentration (SSC) removal efficiency for each flow rate. For the test at 7.5 gpm, this was calculated as 88% (P=0.05: L1=87%, L2=89%) and for the test at 15 gpm was calculated as 82% (P=0.05: L1=80 %, L2=84%).

4.3 Field Testing

Results from the twenty month field study in North Carolina, representing a total of 13 storm events and 27.73 inches of precipitation, show that the StormFilter system effectively removed solids and nutrients from stormwater runoff. The StormFilter system tested was designed to capture and treat the 1-inch water quality volume, typical for the Piedmont region of North Carolina, at a cartridge specific flow rate of 1 gpm/ft^2 with PhosphoSorb media. The StormFilter system was also designed on a mass-loading basis to meet the annual pollutant loading requirements of the site with a minimum expected interval of 1 year.

Significant reductions for solid and nutrient pollutants were observed between influent and effluent. The Efficiency Ratio calculation method resulted in TSS removal of 90%, total phosphorus removal of 86%, and total nitrogen removal of 56%. The Summation of Load (SOL) efficiency calculation resulted in TSS removal of 91%, total phosphorus removal of 87%, and total nitrogen removal of 50%.

5.0 Sampling Procedures

5.1 Site Description and Vicinity Map

The Lolo Pass Road evaluation site is located in Zigzag, Oregon and is situated at the west protruding end of Zigzag Mountain in the foothills of Mt. Hood, which is part of the Cascade Mountain Range. The site, located on Lolo Pass Road at Bear Creek Bridge, is a 100% impervious medium use road which sits approximately 1400 feet above sea level. The 0.063 acre (2800 square feet) contributing drainage area is comprised of bridge deck and is located at the intersection of Lolo Pass Road and US Highway 26 (Lat: 45.34420862, Lon: -121.94275218). The bridge and adjacent roadway are managed by the Clackamas County Department of Transportation and Development. An aerial view of the site from 2005 is shown in Figure 5.

The site is swept periodically, but significant amounts of sediment and organic debris are typically present on site. Sanding, graveling, and deicing occur on site as necessary during the winter to control ice accumulation and to assist with tire traction. The time of concentration (t_c) on the site is estimated to be 1.4 minutes. A view of the treatment area for the Lolo Pass Site can be seen in Figure 6.

The StormFilter system evaluated at the Lolo Pass Road site is a flow-based treatment unit with no upstream detention or pretreatment. It is located within a larger preexisting vault on site which was modified to house flow monitoring equipment as well. The system is in an online configuration where bypass is directed through the treatment system. A photo of the exterior of the StormFilter system at Lolo Pass Road can be seen in Figure 7.

Figure 5. Aerial view of the Lolo Pass Site.

Figure 6. View of the drainage area of the Lolo Pass Site looking south towards US26.

Figure 7. External view of the StormFilter system at Lolo Pass Road.

5.2 Treatment System Description and Sizing

Stormwater treatment for the site is provided by a StormFilter system containing one 18-inch StormFilter cartridge with PhosphoSorb media operating at a specific flow rate 1.67 gpm/ ft^2 or 12.5 gpm per 18-inch tall cartridge. The TAPE (2011) has placed additional emphasis on analyzing the pollutant removal as a function of flow rate. Previous testing at the site evaluated a system with a higher design flow rate. To facilitate evaluation over a range of treatment flow rates, a single cartridge with a design operating rate of 12.5 gpm was selected. Details on the hydraulic flow rate evaluation, mass loading considerations, and cumulative load analysis are provided in the approved QAPP (Appendix B). In summary, the anticipated load from the site would result in a mass load sizing that was 4 times greater (i.e. 4 cartridges).

5.3 Monitoring Information and Equipment Locations

The equipment and sampling techniques used for this study are in accordance with the 2011 version of the Washington Department of Ecology TAPE (TAPE, 2011). Contech personnel were responsible for the installation, operation, and maintenance of sampling equipment, sample retrieval and system reset, and sample submittal activities. Water sample processing and analysis was performed by Test America and APEX Labs (Analytical Laboratory), both located in Beaverton, Oregon.

Influent and effluent samples were collected using individual ISCO 6712 Portable Automated Samplers configured for standard, individual, round, wide-mouth 1-L HDPE bottles sample bottles. The samplers were connected to individual 12VDC deep cycle batteries that were replaced periodically throughout the project. Influent and effluent flows were measured using Large 60°V Trapezoidal Flumes (primary measurement device) in conjunction with individual ISCO 730 Bubbler Flow Modules (secondary measurement devices). Influent and effluent flow was monitored continuously throughout the evaluation period in 5-minute data intervals. Figure 8 shows the flow measurement locations, flow path within the system, and sampling locations.

Each sampler was also connected to an ISCO SPA 1489 Digital Cell Phone Modem System to allow for remote communication and data access. Rainfall was measured using a 0.01-in resolution Texas Electronics tipping bucket-type rain gage. The location of the rain gage at the monitoring site can be seen in Figure 7. 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.

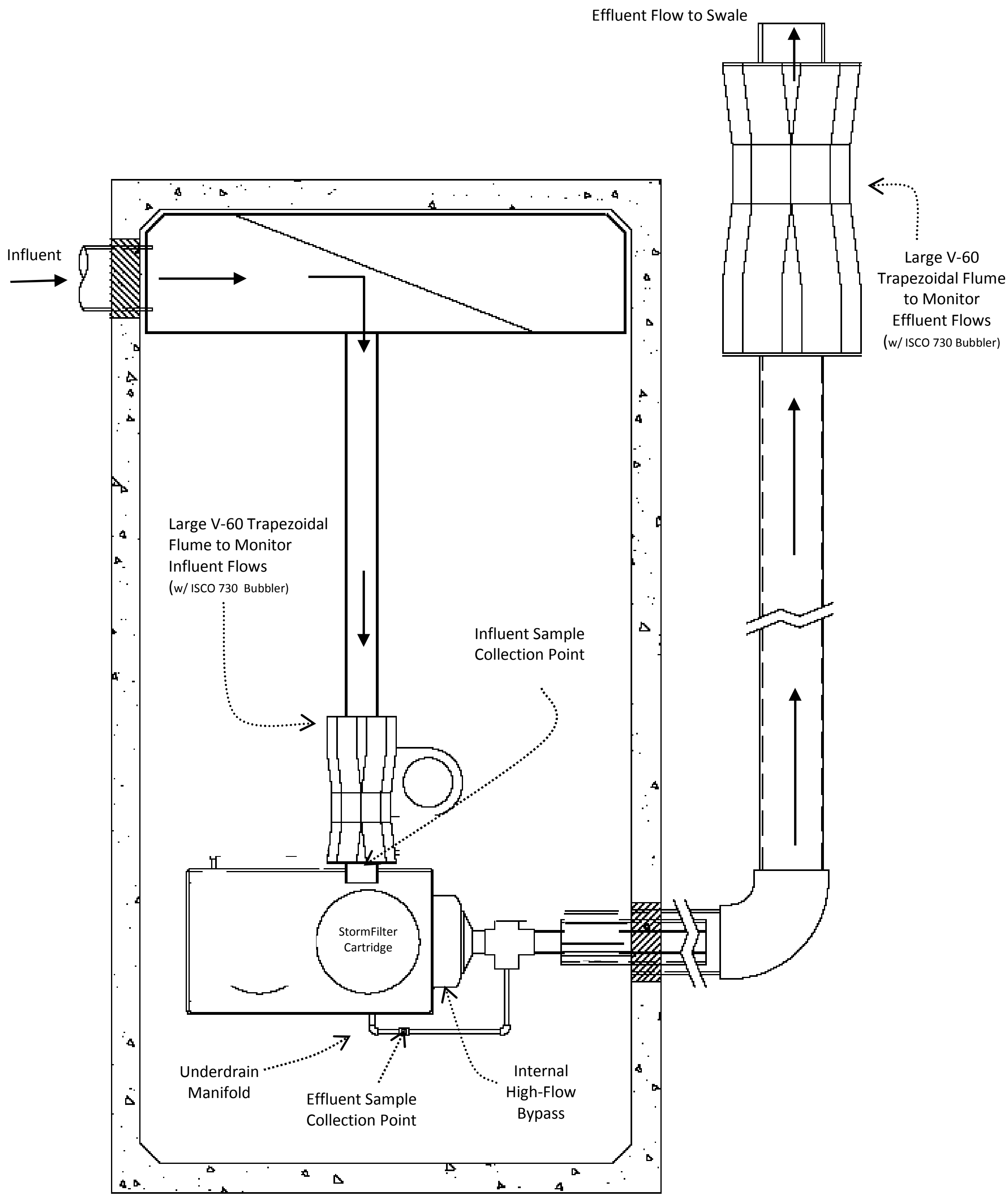

Figure 8. Flow path through the StormFilter system at Lolo Pass Road.

5.4 Approved QAPP

A copy of the approved QAPP can be found in Appendix B of this report.

5.5 Deviations from Approved QAPP

There were no deviations to the water sampling methods from the approved QAPP. Residual solids assessment from the material in the system was not conducted during maintenance. The TAPE (2011) lists sediment sampling as optional.

5.6 Summary of Challenges

There were numerous challenges encountered during the evaluation. A summary of unanticipated events and challenges are below:

- Construction activities from a bridge replacement project downstream (2012). Bridge was washed out by high flows.
- Equipment: Multiple thefts of solar panels which were used to increase battery power during cold weather. Measures to restrict battery power were implemented.
- Analytical laboratory change to obtain consistent lower detection limits for key analytes.
- Data storage drives (network, computer, and replicate storage) malfunction causing loss of hydraulic and precipitation data.

6.0 Data Summaries and Analysis

The section summarizes the water quality data collected during the evaluation. Data have been compiled and compared to the guidelines provided in the TAPE (2011) and outlined in the approved QAPP (Appendix B). None of the events monitored were disqualified due to a storm event criteria variance, however, seven storm events were disqualified due to variance from the sample collection criteria. One additional event, LPR021012, was disqualified as the system had not yet stabilized from a February 2, 2012 maintenance event. A low intensity, small volume event occurred on February 8, 2012 that did not produce sufficient volume to stabilize the media bed.

6.1 Storm Event Criteria

A total of 25 events were sampled at the site from February 2012 to February 2015. Field Recordkeeping forms for these events can be seen in Appendix C. 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. Table 7 provides a summary of storm event criteria.

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

The antecedent condition criteria are intended to allow pollutant concentrations to build-up on the site for evaluation purposes. These events contained influent concentrations within the targeted concentration ranges; therefore, the data were included in the performance evaluation.

6.2 Sampling 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. These events are LPR022012, LPR031012, LPR032912, LPR111112, LPR112312, LPR030814, and LPR042214. Appendix D contains Individual Storm Reports for each event (n=25).

- A minimum of 10 aliquots were collected for each event with exception to 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.
- The minimum number of samples exceeded 12 storm events.

Table 7: Summary of Storm Event and Sampling Requirement Criteria.

	Storm Event Guidelines						Sample Collection Criteria					
	Precipitation				Antecedent Dry Period		Number of Aliquots		Storm Event Coverage		Sampling Duration	
Event ID	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

One event, LPR051713, contained 74% influent storm event coverage. This event contained a small amount of precipitation approximately 3 hours before the first influent and effluent aliquot was sampled. The small amount of precipitation resulted in flow lower than the threshold that was needed to trigger the automated samplers. The paired influent and effluent samples were representative of the entire event and all other storm event and sampling criteria were satisfied. The 1% variance to the storm event coverage was deemed to meet the intent of the criterion.

One event, LPR021412, contained seven influent and effluent aliquots. However, the storm event criteria and all other sample collection requirements were satisfied for this event. The aliquot pacing was representative and greater than 80% storm event coverage was attained for the LPR021412 event. As such, the data were included in the performance evaluation.

6.3 Hydraulic Data

The hydraulic evaluation of the StormFilter with PhosphoSorb includes analysis of the volume and bypass associated with sampled events as well as the entire evaluation period.

6.3.1 Hydraulic Data for Sampled Events

As shown in Table 8, the volume recorded for the sampled events (n=17) ranged between 442 and 3,565 gallons. The grand total volume for all sample events was 24,575 gallons with a mean of 1,446 gallons per event. A grand total of 1,453 gallons were bypassed through the system from 5 of the 17 events. A majority of the bypass was from a single event, LPR062513, with 891 gallons.

Table 8. Hydraulic Data for the 17 events sampled.

		Peak Flow		Average Flow		Bypass	
Event ID	Total Volume (gal)	Influent (gpm)	Effluent (gpm)	Influent (gpm)	Effluent (gpm)	Volume (gal)	Percent Treated
LPR021412	442	7	4	0.3	0.3	0	---
LPR021712	2,127	8	5	0.6	0.5	0	---
LPR022412	1,149	9	6	1.0	0.8	0	---
LPR031212	890	6	5	1.1	0.8	0	---
LPR052412	572	5	5	0.9	1.1	0	---
LPR060112	1,637	12	8	2.5	2.8	0	---
LPR060412	1,319	20	13	1.2	1.2	95	93%
LPR060712	645	31	17	0.6	0.8	89	86%
LPR110612	971	10	9	1.1	1.4	0	---
LPR113012	1,695	12	10	1.0	0.7	0	---
LPR051713	1,208	7	6	1.3	1.0	0	---
LPR052113	1,300	9	9	2.4	1.8	0	---
LPR062513	2,876	80	59	6.8	5.7	891	69%
LPR013014	1,829	15	9	0.9	1.0	0	---
LPR030314	1,648	25	24	1.7	1.7	359	78%
LPR011815	3,565	16	17	1.8	2.0	19	99%
LPR020215	701	5	4	1.2	1.0	0	---
Min	442	5	4	0.3	0.3	0	69%
Max	3,565	80	59	6.8	5.7	891	99%
Mean	1,446	16	12	1.6	1.5	85	85%
Median	1,300	10	9	1.1	1.0		
Sum	24,575					1,453	94%

The influent average flow rates through the system for sampled events ranged from 0.3 to 6.8 gpm, with a mean of 1.6 gpm and a median of 1.1 gpm. The influent peak flow rates through the system for sampled events ranged from 5 to 80 gpm, with a mean of 16 and a median of 10 gpm.

The effluent average flow rates through the system for sampled events ranged from 0.3 to 5.7 gpm, with a mean of 1.5 gpm and a median of 1.0 gpm. The effluent peak flow rates through the system for sampled events ranged from 4 to 59 gpm, with a mean of 12 and a median of 9 gpm.

6.3.2 Overall Hydraulic Data

Over the entire 37 month evaluation period, the total effluent volume recorded was 376,244 gallons. There were several data gaps due to weather, equipment issues, and back-up data storage errors, which are identified in Table 9.

Table 9. Total Volume and Bypass

Date	Total Volume (gal)	Bypass Volume[1] (gal)	Bypass Volume (%)
Feb-12	12,164	155	1%
Mar-12	18,630	114	1%
Apr-12	7,655	128	2%
May-12	3,444	0	0%
Jun-12	12,977	355	3%
Jul-12	0	0	0%
Aug-12	0	0	0%
Sep-12	0	0	0%
Oct-12	105,241	9,739	17%
Nov-12	33,990	775	2%
Dec-12[a]	4,403	0	0%
Jan-13[b]	---	---	---
Feb-13[b]	---	---	---
Mar-13	10,352	411	4%
Apr-13	18,333	0	0%
May-13	9,705	42	0%
Jun-13	21,290	1,664	8%
Jul-13[c] thru Dec-13[c]	Data Gap		
Jan-14[c] Feb-14[c]	Data Gap		
Mar-14	39,846	435	1%
Apr-14	30,181	0	0%
May-14[d]	6,369	0	0%
Jun-14[e]	---	---	---
Jul-14[e]	---	---	---
Aug-14[e]	---	---	---
Sep-14[e]	---	---	---
Oct-14	9,070	0	0%
Nov-14	20,691	222	1%
Dec-14[b]	---	---	---
Jan-15	8,062	19	0%
Feb-15[f]	3,840	0	0%
SUM	**376,244**	**14,060**	**4%**

[1] An internal weir with a single station horizontal switch was used to calculate volume.

[a] Data covers December 1-3, 2012

[b] Monitoring equipment offline due to severe winter weather conditions

[c] Hydraulic and precipitation data were lost due to back-up storage issue.

[d] Data covers May 1-7, 2014

[e] June to September 2014 monitoring equipment was offline.

[f] Data covers February 1-9, 2015

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. A total of three bypass events were a result of media occlusion impairing the ability of the system to meet the hydraulic capacity requirements. The March 2012 event recorded a flow rate of 4.5 gpm and the March 2013 events recorded flow rates of 7.0 and 6.8 gpm at the point of bypass. Maintenance was performed 7-14 days after each occurrence. Additional information regarding maintenance and flow rate during bypass is available in section 7.2.

6.4 Individual Storm Reports

The Individual Storm Reports (ISRs) for the 17 storm events sampled during this evaluation are attached in Appendix D. Appendix D also contains the 8 storm events that were disqualified as these events did not meet the sample collection criteria (per section 6.2). Each ISR contains general site and system information, hydrology information for the specific event, and all raw analytical data collected for the storm event.

6.5 Laboratory Quality Control

Data were reviewed and validated according to the approved QAPP (Appendix B). A detailed quality control/quality assurance analysis is enclosed in Appendix E. The 17 storm events used to evaluate performance did not contain any disqualified data.

6.6 Performance Evaluation

Total Suspended Solids (TSS) and total phosphorus were the primary performance evaluation objectives for the StormFilter with PhosphoSorb investigation. A copy of the raw data in tabular form for all of the parameters evaluated can be seen in Appendix F. Appendix G contains copies of the analytical laboratory reports for each event.

6.6.1 Suspended Solids

A total of 17 events were sampled from February 2012 and February 2015. 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) from these 17 events are shown in Table 10. Additional solids data can be found in the ISRs for each event in Appendix D.

For the 17 events sampled influent Event Mean Concentrations (EMCs) for TSS ranged from 40 mg/L to 780 mg/L with a median of 389 mg/L and a mean of 380 mg/L. Corresponding effluent EMCs ranged from 6 mg/L to 120 mg/L with a median of 32 mg/L and a mean of 40 mg/L.

Influent SSC<500 µm EMCs (n=15) ranged from 41 mg/L to 670 mg/L with a median of 309 mg/L and a mean of 325 mg/L. Corresponding effluent EMCs ranged from 4 mg/L to 120 mg/L with a median of 32 mg/L and a mean of 40 mg/L.

Influent silt and clay EMCs (n=16) ranged from 19 mg/L to 399 mg/L with a median of 156 mg/L and a mean of 153 mg/L. Corresponding effluent EMCs ranged from 5 mg/L to 110 mg/L with a median of 21 mg/L and a mean of 31 mg/L.

Table 10. Suspended Solids (Raw Data) for the 17 Events Sampled.

	TSS-SM				SSC<500 µm				Silt and Clay*			
Event ID	Influent (mg/L)	Effluent (mg/L)	MRL (mg/L)	Removal (%)	Influent (mg/L)	Effluent (mg/L)	MRL (mg/L)	Removal (%)	Influent (mg/L)	Effluent (mg/L)	MRL (mg/L)	Removal (%)
LPR021412	539	32	10	94%		*Not Tested*			*163*	*30*	3.7	*82%*
LPR021712	387	48	10	88%	270	52	5	81%	*208*	*44*	5	*79%*
LPR022412	512	43	10	92%	309	52	2.9	83%	*148*	*46*	3.98	*69%*
LPR031212	150	18	10	88%	190	ND	27	86%	*88*	*ND*	20	*69%*
LPR052412	510	43	10	92%	400	47	22	88%	*200*	*41*	37	*80%*
LPR060112	780	16	10	98%	540	ND	41	92%	*220*	*ND*	40	*80%*
LPR060412	580	32	10	94%	670	28	22	96%	*230*	*23*	22	*90%*
LPR060712	570	120	10	79%	470	120	42	74%	*240*	*110*	47	*54%*
LPR110612	40	10	10	75%	41	9	3	77%	*19*	*6.6*	3	*65%*
LPR113012	230	17	10	93%	150	15	3	90%	*49*	*9.5*	*2.9*	*81%*
LPR051713	94	6	5	94%	94	4	4.1	95%	49	5.0	5	90%
LPR052113	389	24	10	94%	243	22	3.4	91%	121	20	3.4	84%
LPR062513	308	21	10	93%	421	32	3.3	92%	172	15	4.7	91%
LPR013014	170	17	5	90%	131	17	3.2	87%	115	11	3.6	91%
LPR030314	280	95	5	66%		*Not Tested*				*Not Tested*		
LPR011815	529	73	5	86%	536	72	3.7	87%	399	63	10	84%
LPR020215	397	67	5	83%	405	53	4.6	87%	33	14	0.6	58%
Min	40	6	5	66%	41	4	3	74%	19	5	0.6	54%
Max	780	120	10	98%	670	120	42	96%	399	110	47	91%
Median	389	32	10	92%	309	32	4	87%	156	21	5	80%
Mean	380	40	9	88%	325	40	13	87%	153	31	13	78%

*Silt and clay fraction is represented by suspended solid concentrations less than 62.5-um. Events sampled in 2012 were not tested for SSC <62.5-um thus SSC<50-um results are used as a substitute for these events and are shown in italics.

6.6.2 Phosphorus

Total phosphorus and soluble phosphorus results for the 17 events sampled are shown in Table 11. Each sampled event was analyzed for total phosphorus (TP), ortho-phosphate and dissolved phosphorus concentrations. Due to a high occurrence of events with non-detect concentrations for ortho-phosphate and dissolved phosphorus, the two data sets were combined into one set (n=9) and referred to as soluble phosphorus, as seen in Table 11.

For the 17 events, sampled influent EMCs for TP ranged from 0.07 mg/L to 0.69 mg/L with a median of 0.28 mg/L and a mean of 0.33 mg/L. Corresponding effluent EMCs ranged from 0.03 mg/L to 0.14 mg/L with a median of 0.06 mg/L and a mean of 0.07 mg/L.

For the 17events sampled influent EMCs for soluble phosphorus ranged from 0.01 mg/L to 0.099 mg/L with a median of 0.026 mg/L and a mean of 0.051 mg/L. Corresponding effluent EMCs ranged from 0.01 mg/L to 0.012 mg/L with a median of 0.012 mg/L and a mean of 0.011 mg/L.

Table 11. Phosphorus (raw data) for the 17 Sampled Events.

	Total Phosphorus				Soluble Phosphorus				
Event ID	Influent (mg/L)	Effluent (mg/L)	MRL (mg/L)	Removal (%)	Influent (mg/L)	Effluent (mg/L)	MRL (mg/L)	Analyte	Removal (%)
LPR021412	0.22	0.06	0.10	72%	ND	ND	0.010	ORP	
LPR021712	0.31	0.07	0.10	78%	ND	ND	0.010	ORP	
LPR022412	0.42	0.07	0.20	83%	ND	ND	0.010	ORP	
LPR031212	0.15	0.04	0.02	75%	ND	ND	0.010	ORP	
LPR052412	0.17	0.07	0.02	59%	ND	ND	0.010	ORP	
LPR060112	0.20	0.04	0.02	83%	ND	ND	0.010	ORP	
LPR060412	0.21	0.04	0.02	80%	ND	ND	0.010	ORP	
LPR060712	0.17	0.14	0.02	18%	ND	ND	0.010	ORP	
LPR110612	0.07	ND	0.05	26%	0.093	ND	0.050	ORP	46%
LPR113012	0.17	ND	0.05	71%	0.099	ND	0.050	ORP	49%
LPR051713	0.28	0.03	0.01	90%	*0.0260*	*0.0110*	*0.010*	DP	58%
LPR052113	0.56	0.05	0.01	91%	*0.0190*	*0.0118*	*0.010*	DP	38%
LPR062513	0.58	0.05	0.01	92%	ND	ND	0.010	ORP	
LPR013014	0.32	0.05	0.01	83%	ND	0.012	0.010	ORP	-20%
LPR030314	0.42	0.13	0.01	68%	ND	ND	0.010	ORP	
LPR011815	0.65	0.12	0.01	81%	*ND*	*0.0116*	*0.010*	DP	-16%
LPR020215	0.69	0.10	0.05	86%	*0.0156*	*ND*	*0.010*	DP	36%
Min	0.07	0.03	0.01	18%	0.016	0.011	0.01		-20%
Max	0.69	0.14	0.20	92%	0.099	0.012	0.05		58%
Median	0.28	0.06	0.02	80%	0.026	0.012	0.01		38%
Mean	0.33	0.07	0.04	73%	0.051	0.012	0.01		27%

Note: Soluble Phosphorus is defined as either Ortho-Phosphorus (ORP) or Dissolved Phosphorus (DP).
ND - Non-detect

6.7 Statistical comparison of influent and effluent pollutant concentrations

The StormFilter with PhosphoSorb media operating at a specific flow rate of 1.67 gpm/ft^2 was analyzed to determine whether there are significant differences in pollutant concentrations between the influent and effluent across individual storm events. The specific null hypothesis (H_o) and alternative hypothesis (H_a) for these analyses are as follows:

H_o: Effluent pollutant concentrations are equal to or greater than influent concentrations

H_a: Effluent concentrations are less than influent concentrations

A one-tailed Wilcoxon signed-rank test performed on qualified TSS and total phosphorus data indicated there was a statistically significant difference between the influent and effluent concentrations for both parameters based on an alpha (α) level of 0.05. Complete results for this test can be seen in Appendix H.

6.8 Pollutant removal efficiency calculations

Pollutant removal efficiencies for the 17 sampled storm events have been calculated using TAPE Method #1: Individual Storm Reduction in Pollutant Concentration (TAPE, 2011). This method calculates the individual storm reductions in pollutant concentration assuming no water losses in the treatment system between the influent and effluent sampling points.

Individual event removal efficiencies per TAPE Method #1 for TSS for the 17 events can be found in Table 10. The mean and median individual storm reductions for TSS are 88% and 92%, respectively.
The mean and median individual storm reductions for SSC<500 µm are 87%. The silt and clay fraction (less than 62.5 µm) individual storm reductions were also analyzed with a mean and median removal efficiency of 78% and 80%, respectively.

Individual event removal efficiencies per TAPE Method #1 for total phosphorus and soluble phosphorus can be seen in Table 11. The mean individual storm reductions for total phosphorus and soluble phosphorus are 73% and 27%, respectively. The median individual storm reductions for total phosphorus and soluble phosphorus are 80% and 38%, respectively.

Table 12. Basic Treatment Performance (TSS results)

Basic Treatment	Influent: <100 mg/L; Effluent: ≤ 20 mg/L			Influent: 100-200 mg/L; ≥ 80% Removal			Influent: >200 mg/L; ≥ 80% Removal		
Event ID	Influent (mg/L)	Effluent (mg/L)	Removal (%)	Influent (mg/L)	Effluent (mg/L)	Removal (%)	Influent (mg/L)	Effluent (mg/L)	Removal (%)
LPR021412							539	32	94%
LPR021712							387	48	88%
LPR022412							512	43	92%
LPR031212				150	18	88%			
LPR052412							510	43	92%
LPR060112							780	16	98%
LPR060412							580	32	94%
LPR060712							570	120	79%
LPR110612	40	10	75%						
LPR113012							230	17	93%
LPR051713	94	6	94%						
LPR052113							389	24	94%
LPR062513							308	21	93%
LPR013014				170	17	90%			
LPR030314							280	95	66%
LPR011815							529	73	86%
LPR020215							397	67	83%
Min	40	6	75%	150	17	88%	230	16	66%
Max	94	10	94%	170	18	90%	780	120	98%
Median	67	8	84%	160	18	89%	510	43	92%
Mean	67	8	84%	160	18	89%	462	49	89%

6.8.1 Basic Treatment

The basic treatment performance goal is defined as 80% TSS removal for influent concentrations and an effluent TSS concentration of 20 mg/L or less for influent concentrations from 20 to 100 mg/L. Table 12 shows TSS performance for the 17 events grouped by TSS influent concentration. Two of the 17 events had influent TSS concentrations below 100 mg/L. Both of these events had effluent concentrations at 10 mg/L or lower.

Two of the 17 events had an influent TSS concentration between 100 mg/L and 200 mg/L. Both of these events resulted in 88% or greater TSS removal.

Thirteen of the 17 events had influent TSS concentrations greater than 200 mg/L. Of those 13 events, 11 showed removal greater than 80%. The mean and median removal efficiency for the 13 events with influent TSS concentrations greater than 200 mg/L are 89% and 92% respectively.

6.8.2 Suspended Solids Performance

In addition to TSS, a performance assessment was included for suspended solids less than 500 microns (SSC<500 µm) and the silt and clay fraction (SSC<62.5 µm).

The SSC<500 µm fraction with influent concentrations less than 100 mg/L (n=2) resulted in an effluent of 9 mg/L or less. The SSC<500 µm fraction with influent concentrations between 100 and 200 mg/L (n=3) demonstrated 86% removal or greater. The SSC<500 µm fraction with influent concentrations greater than 200 mg/L (n=10) demonstrated a mean and median removal efficiency of 87% and 88%, respectively.

Table 13. SSC < 500 µm Performance

Basic Treatment	Influent: <100 mg/L; Effluent: ≤ 20 mg/L			Influent: 100-200 mg/L; ≥ 80% Removal			Influent: >200 mg/L; ≥ 80% Removal		
Event ID	Influent (mg/L)	Effluent (mg/L)	Removal (%)	Influent (mg/L)	Effluent (mg/L)	Removal (%)	Influent (mg/L)	Effluent (mg/L)	Removal (%)
LPR021412								*Not Tested*	
LPR021712							270	52	81%
LPR022412							309	52	83%
LPR031212				190	**ND**	86%			
LPR052412							400	47	88%
LPR060112							540	**ND**	91%
LPR060412							670	28	96%
LPR060712							470	120	74%
LPR110612	41	9	77%						
LPR113012				150	15	90%			
LPR051713	94	4	95%						
LPR052113							243	22	91%
LPR062513							421	32	92%
LPR013014				131	17	87%			
LPR030314								*Not Tested*	
LPR011815							536	72	87%
LPR020215							405	53	87%
Min	41	4	77%	131	15	86%	243	22	74%
Max	94	9	95%	190	17	90%	670	120	96%
Median	68	7	86%	150	16	87%	413	52	88%
Mean	68	7	86%	157	16	88%	426	53	87%

ND = Non-Detect

Table 14. Silt and Clay Performance

Basic Treatment	Influent: <100 mg/L; Effluent: ≤ 20 mg/L			Influent: 100-200 mg/L; ≥ 80% Removal			Influent: >200 mg/L; ≥ 80% Removal		
Event ID	Influent (mg/L)	Effluent (mg/L)	Removal (%)	Influent (mg/L)	Effluent (mg/L)	Removal (%)	Influent (mg/L)	Effluent (mg/L)	Removal (%)
LPR021412				163	30	82%			
LPR021712							208	44	79%
LPR022412				148	46	69%			
LPR031212	88	ND	69%						
LPR052412				200	41	80%			
LPR060112							220	ND	80%
LPR060412							230	23	90%
LPR060712							240	110	54%
LPR110612	19	7	65%						
LPR113012	49	10	81%						
LPR051713	49	5	90%						
LPR052113				121	20	84%			
LPR062513				172	15	91%			
LPR013014				115	11	91%			
LPR030314					*Not Tested*				
LPR011815							399	63	84%
LPR020215	33	14	58%						
Min	19	5	58%	115	11	69%	208	23	54%
Max	88	14	90%	200	46	91%	399	110	90%
Median	49	8	69%	156	25	83%	230	53	80%
Mean	48	9	73%	153	27	83%	259	60	78%

ND = Non-Detect

The silt and clay fraction is represented of suspended solids less than 62.5 microns. Events sampled in 2012 were not tested for SSC<62.5 µm. SSC<50 µm results are used as a substitute for the 2012 data set.

Five events had silt and clay fraction less than 100 mg/L with a mean effluent concentration of 9 mg/L. Six events had a silt and clay fraction between 100 mg/L and 200 mg/L with a mean and median removal efficiency of 83%. Five events had a silt and clay fraction above 200 mg/L with a mean and median removal efficiency of 78% and 80%, respectively.

6.8.3 Phosphorus Treatment

Phosphorus treatment performance goals include meeting all basic treatment goals as well as demonstrating at least 50% total phosphorus removal for events with influent concentrations between 0.1 and 0.5 mg/L. Table 15 shows total phosphorus removal results for the 17 events grouped by influent concentration range.

One storm event, LPR110612, had an influent concentration less than 0.1 mg/L total phosphorus. Twelve events had an influent total phosphorus concentration between 0.1 and 0.5 mg/L. Four events contained total phosphorus influent concentrations greater than 0.5 mg/L. These four higher concentration events were included in the performance evaluation with a substituted influent value of 0.5 mg/L. A total of 16 events were analyzed for the phosphorus treatment goal.

Fifteen of the 16 storm events with influent concentrations between 0.1 to 0.5 mg/L demonstrated greater than 50% removal. The mean and median total phosphorus removal efficiency for influent concentrations between 0.1 and 0.5 mg/L was 75% and 79%, respectively.

Table 15. Phosphorus Treatment Results

Phosphorus Treatment	Influent < 0.1 mg/L; (no defined goal)			Influent 0.1mg/L to 0.5 mg/L; ≥50% removal			Influent > 0.5 mg/L;		
Event ID	Influent (mg/L)	Effluent (mg/L)	Removal (%)	Influent (mg/L)	Effluent (mg/L)	Removal (%)	Influent (mg/L)	Effluent (mg/L)	Removal (%)
LPR021412				0.22	0.06	72%			
LPR021712				0.31	0.07	78%			
LPR022412				0.42	0.07	83%			
LPR031212				0.15	0.04	75%			
LPR052412				0.17	0.07	59%			
LPR060112				0.20	0.04	83%			
LPR060412				0.21	0.04	80%			
LPR060712				0.17	0.14	18%			
LPR110612	0.07	ND	26%						
LPR113012				0.17	ND	71%			
LPR051713				0.28	0.03	90%			
LPR052113				**0.50**	0.05	**90%**	0.56	0.05	91%
LPR062513				**0.50**	0.05	**91%**	0.58	0.05	92%
LPR013014				0.32	0.05	83%			
LPR030314				0.42	0.13	68%			
LPR011815				**0.50**	0.12	**75%**	0.65	0.12	81%
LPR020215				**0.50**	0.10	**80%**	0.69	0.10	86%
Min	0.07	0.05	26%	0.15	0.03	18%	0.56	0.05	81%
Max	0.07	0.05	26%	0.50	0.14	91%	0.69	0.12	92%
Median	0.07	0.05	26%	0.30	0.06	79%	0.62	0.07	88%
Mean	0.07	0.05	26%	0.32	0.07	75%	0.62	0.08	87%

BOLD - Influent concentrations greater than 0.5 mg/L were substituted with 0.5 mg/L.

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 all parameters associated with the project specific performance goals. This calculated limit is then compared to the associated performance goal for that specific analyte. If the computed limit is higher than the treatment goal, it can be concluded that the stormwater treatment system met the specified performance goal with the required 95% confidence. Data from the 17 events were analyzed using the 2011-08 TAPE bootstrap confidence interval calculator (bootstrap calculator) for TSS (Basic Treatment) and total phosphorus (Phosphorus Treatment). Printed screenshots showing the TSS bootstrap calculator results can be seen in Appendix I.

Fifteen events had influent TSS concentrations greater than 100 mg/L and the LCL95 for TSS removal efficiency was 85% per the bootstrap calculator. Since this computed limit is higher than the basic treatment goal of greater than or equal to 80%, it is concluded that the basic performance goal for this project was met.

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. These 4 events were added to the data set used in the bootstrap calculator. 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.

For these 16 events, the LCL95 for total phosphorus removal efficiency was 67%. The upper 95% confidence interval (UCL95) for effluent concentration was 0.084 mg/L per the bootstrap calculator. Since the computed LCL95 is higher than the specified treatment goal of greater than or equal to 50%, it is concluded that the Phosphorus Treatment goal for this project was met. Printed screenshots showing the total phosphorus bootstrap results can be seen in Appendix I.

6.10 Pollutant Removal as a Function of Flow Rate

To evaluate pollutant removal as a function of flow rate, as per the TAPE (2011), individual event EMCs for both TSS and total phosphorus were compared to the corresponding aliquot-weighted influent flow rate for each of the 17 sampled events. The aliquot-weighted influent flow rate was calculated by determining the influent flow rate at the time each influent aliquot was collected and then taking an average of these values (TAPE, 2011). Removal efficiencies are plotted versus aliquot-weighted influent flow rate for TSS and total phosphorus in Figures 9 and 11 respectively.

The Lolo Pass Road StormFilter has a design treatment flow rate of 12.5 gpm with an internal bypass set to bypass all flows exceeding 13.5 gpm. Treated flows greater than 90% design (11.25 gpm) were observed in 8 of the 17 events and the peak treatment flow measured without bypass was 14.6 gpm during LPR013014. The flow rate at the point of bypass was greater than 13.5 gpm for all five bypass events that were sampled. Relying on the analysis of aliquot-weighted influent flow rates versus EMC removal efficiencies alone does not show what happens during the times of operation at or near peak design capacity. In an effort to better understand operation during peak flows, EMC removal efficiencies for TSS and total phosphorus were also compared to the corresponding peak influent flow recorded for each of the sampled events. Figures 10 and 12 show the maximum recorded influent flow rate versus TSS and total phosphorus EMC removal efficiencies, respectively. In addition, Figures 10 and 12 also show TSS and total phosphorus removal efficiencies versus the effluent flow rate at the time bypass occurred for the five sampled events with bypass. These five bypass events were isolated to illustrate the effluent flow rate at the time that bypass occurred (i.e. treated rate at bypass). These five additional bypass data points (treated rate at bypass) are included in Figures 10 and 12, but are not included in the linear regression analysis (too few data points).

Section 7.2 and Figure 14 provide the flow rate at the time of bypass for the 26 occurrences throughout the evaluation. Only three events were lower than the design rate and the system was maintained within 7-14 days of these observations.

6.10.1 Flow Rate Determination - Basic Treatment

Figure 9 shows the relationship between the TSS removal efficiency for each event (n=17) and the corresponding aliquot-weighted influent flow rate. Two of the events contained influent concentrations less than 100 mg/L. Five of the sampled events contain bypass.

Figure 10 shows the relationship between TSS removal efficiency for each event and the corresponding maximum recorded influent flow rate for the event. The maximum flow rate analysis demonstrates that the system was able to achieve greater than the 100% designed treatment rate for six events. Figure 10 also shows the TSS removal efficiency versus the effluent flow rate (treated rate at bypass) at the time bypass occurred for the five sampled events with bypass. Bypass did not occur for the other 13 events.

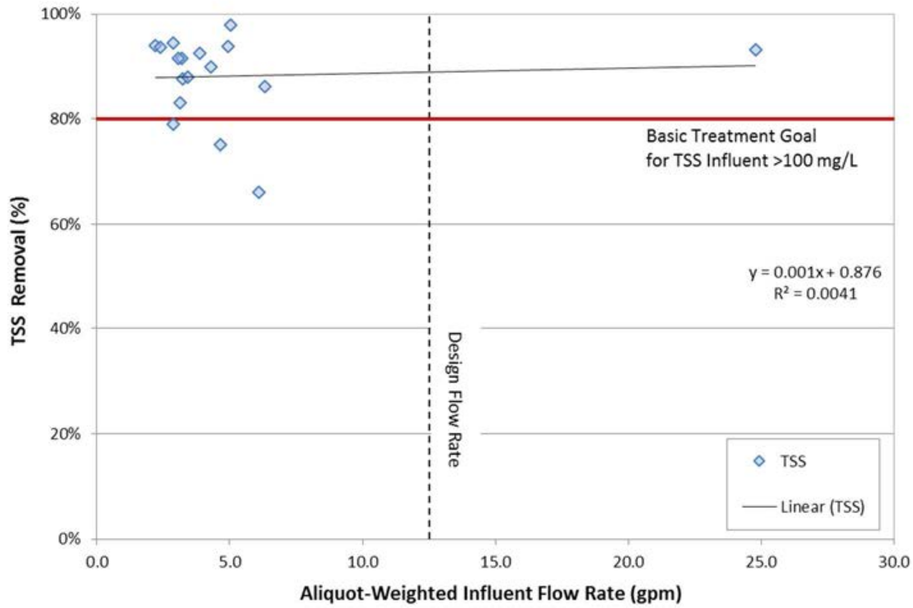

Figure 9. TSS removal (%) as a function of aliquot-weighted influent flow rate (n=17).

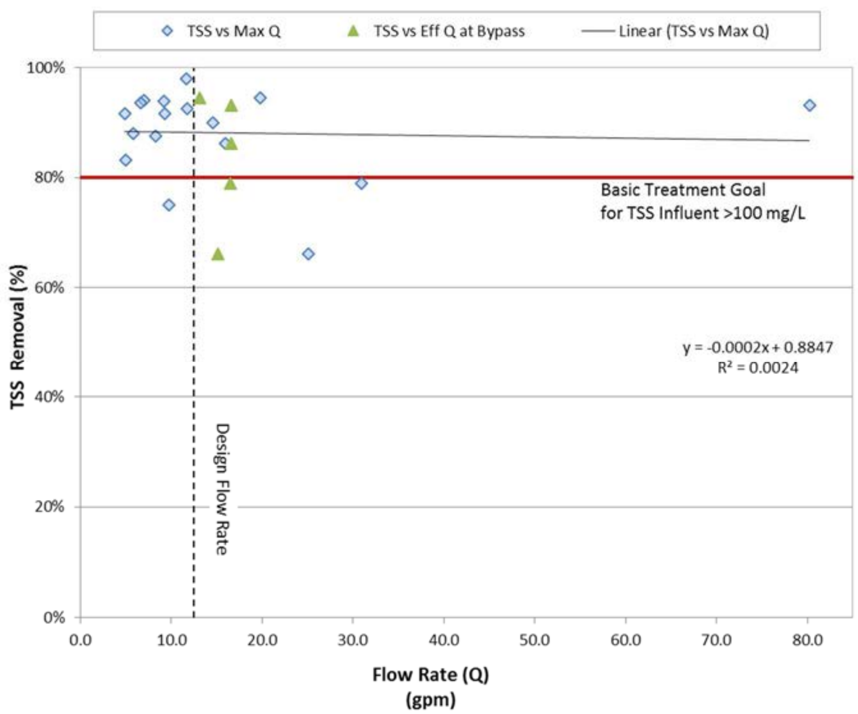

Figure 10. TSS removal (%) as a function of maximum influent flow rate (n=17) and TSS removal (%) as a function of effluent flow rate at the time of bypass (treated rate at bypass) (n=5).

6.10.2 Flow Rate Determination - Phosphorus Treatment

Figure 11 shows the relationship between total phosphorus efficiency for each event (n=17) and the corresponding aliquot-weighted influent flow rate. One event contained influent concentrations less than 0.1 mg/L. Bypass occurred in five events.

Figure 12 shows the relationship between total phosphorus removal efficiency for each event and the corresponding maximum recorded influent flow rate for the event. The maximum flow rate analysis demonstrates that the system was able to achieve greater than the 100% designed treatment rate for six events. Figure 12 also shows the total phosphorus removal efficiency versus the effluent flow rate (treated rate at bypass) at the time bypass occurred for the five sampled events with bypass. Bypass did not occur for the other 12 events.

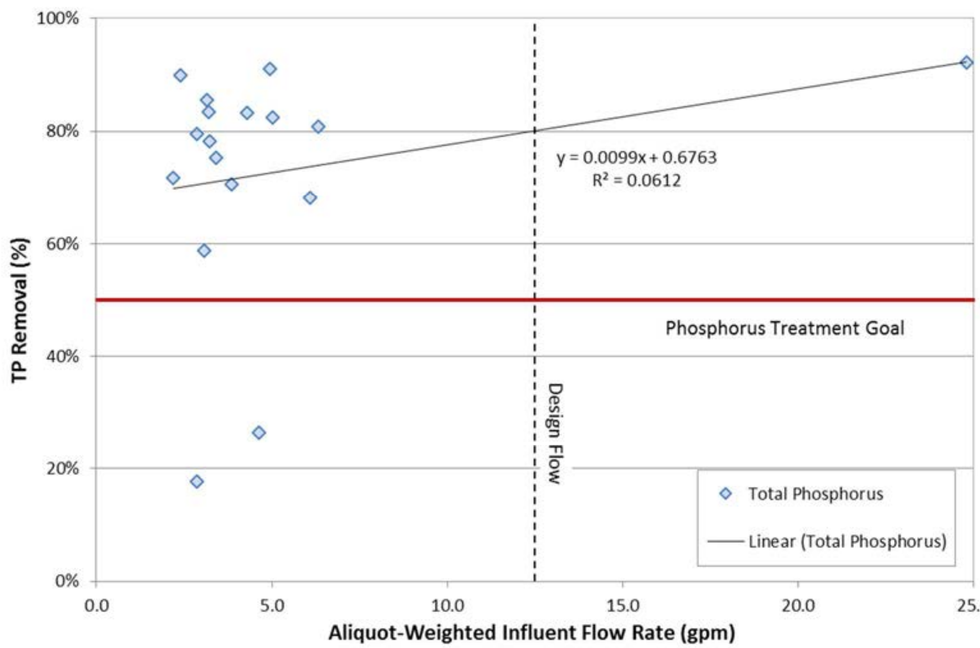

Figure 11. Total Phosphorus removal efficiencies versus corresponding aliquot-weighted influent flow rate for each qualified event sampled (n=17).

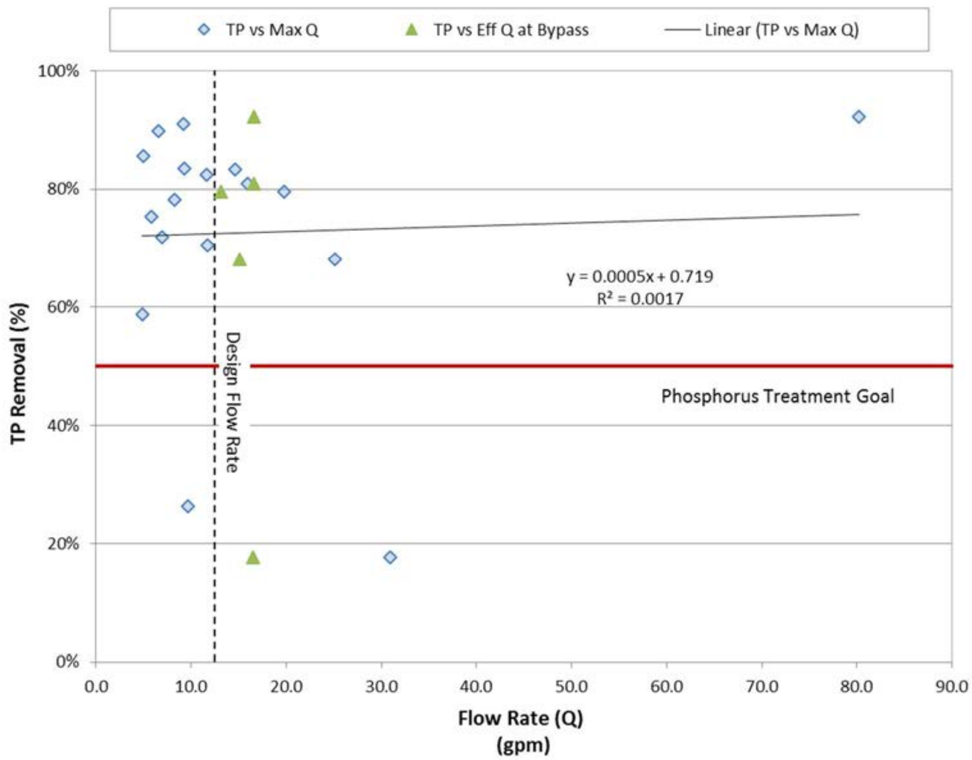

Figure 12. Total phosphorus removal (%) as a function of maximum influent flow rate (n=17) and total phosphorus removal (%) as a function of effluent flow rate at the time of bypass (treated rate at bypass) (n=5).

6.10.3 Regression Analysis

The TAPE (2011) requires regression analysis on the pollutant removal as a function of the influent flow rates. Figures 9 thru 12 contain linear regressions without any modifications to the dataset. The diagnostic reports (scatter plots, residuals, constant variance, etc.) used to determine the suitability for using regression are in Appendix J. Several iterations of the linear regressions were explored in Appendix J. The results of the regression (and each iteration) indicated there is no significant relationship between performance and influent flow rates.

6.11 Particle Size Distribution

Particle Size Distribution (PSD) is listed in the TAPE (2011) as a screening parameter and was required to be sampled for a minimum of three events. The TAPE PSD method is a modification of ASTM Method D3977-97 and defines particles as larger than 250 µm, between 250 and 62.5 µm, and smaller than 62.5 µm in size. Three TAPE influent PSD samples (LPR030814, LPR011815, LPR020215) showed an average of 72% sand and 28% silt with 8% of the silt fraction estimated as clay as seen in Figure 13. Storm event LPR030814 was disqualified for the performance evaluation due to inadequate effluent coverage. However, storm event guidelines and influent sample collection criteria were met thus it was deemed acceptable for the purpose including the data in the PSD analysis, and satisfying the PSD screening parameter. Table 16 shows the storm event and sampling collection characteristics of the event.

Table 16. Storm Event Guidelines and Sample Collection Criteria for LPR030814

	Storm Event Guidelines						Sample Collection Criteria					
	Precipitation				Antecedent Dry		Number of Aliquots		Storm Event		Sampling Duration	
Event ID	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)
LPR030814	1.89	0.36	0.08	18	27	11	47	48	83%	70%	13	9

In addition to the TAPE PSD method, a second PSD procedure – serial filtration, was utilized for the PSD characterization per the QAPP (Appendix B). Samples from 17 events were analyzed for influent PSD using this alternative procedure. For this serial filtration procedure a composite sample was split into subsamples using a cone splitter with different sieves at each outlet. The storm by storm analysis was conducted to understand removal effectiveness on the entire range of particles, 50-µm, 62.5-µm, 100-µm, 250-µm, 500-µm, and 2000-µm sieves were evaluated. Samples passing through each sieve were analyzed using the ASTM D3977-97 method. PSD results utilizing this method showed an average of 61% sand and 39% silt with 10% of the silt fraction estimated as clay, as seen in Figure 13.

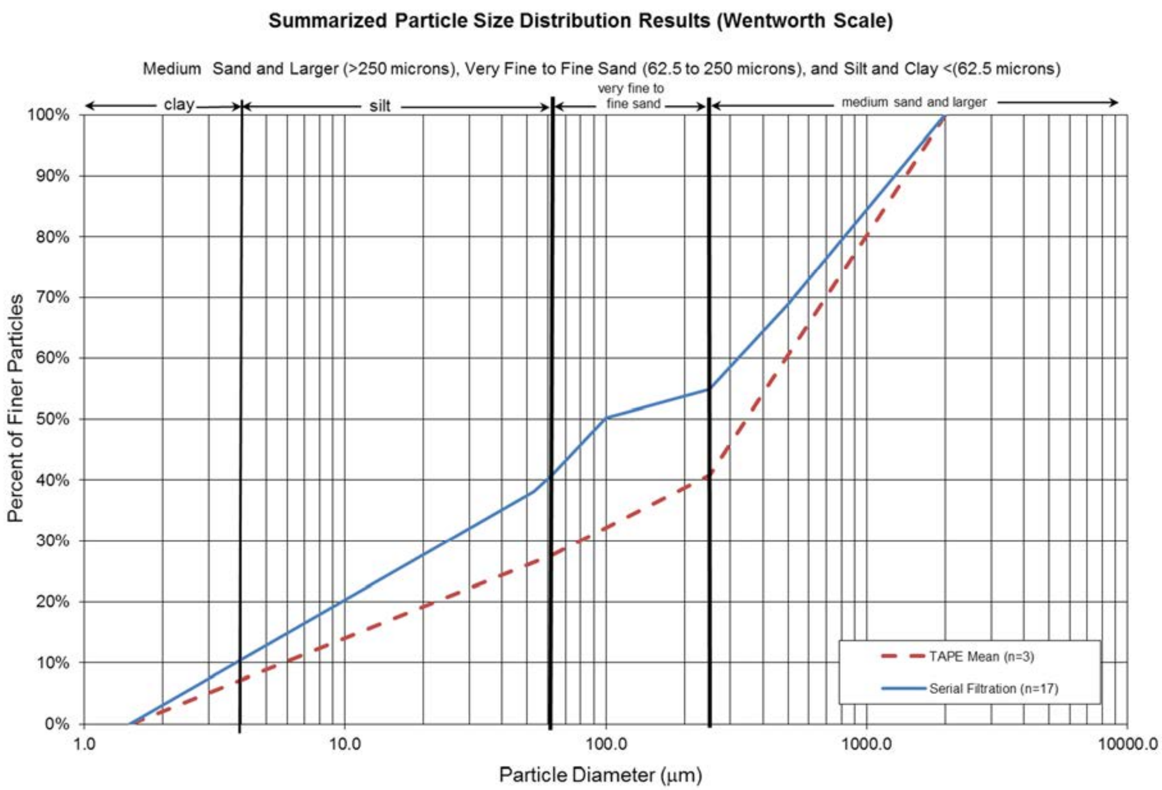

Figure 13. Particle Size Distribution results, plotted on the TAPE (2011) defined scale

Appendix K explores several variations of the particle size distribution data including each individual event, and sub-500 microns PSD characterization. In summary, evaluation of the sub-500 micron data set contained 54% of the suspended solids in the silt and clay sized fraction and resulted in a bootstrap lower 95% confidence limit of 85% removal. Performance of the silt and clay fraction (only) with an average influent concentration of 153 mg/L resulted in an average of 78% removal and a bootstrap 95% confidence lower limit of 73% removal.

In addition, Appendix L contains a memorandum on the deicing applications in the adjacent upstream roadway section that was discussed as a potential link to the coarse sediment. A majority of the deicing applications were not related to sampled events. Another theory to the amount of coarse sediment (greater than 500 microns) was construction activity associated with a bridge replacement one mile downstream in 2012.

7.0 Operation and Maintenance Information

7.1 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, maintenances were 10 to 12 months apart. Field recordkeeping forms for all maintenance events can be seen in Appendix M. The Operation and Maintenance Manual is in Appendix N.

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.

7.2 Bypass

The StormFilter system contains an internal bypass allowing larger flows 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 12.5 gpm to 13.5 gpm before bypass.

Bypass was recorded using an internal weir and a single station horizontal switch. The upper range of flow capacity limit for the cartridge was calculated to be 13.5 gpm, with flows exceeding 13.5 gpm bypassing treatment. The single station horizontal switch measured the duration that the water surface elevation exceeded 21 inches. When the measured effluent flow exceeded 13.5 gpm and the water surface elevation exceeded 21 inches, the system was in bypass and reported as bypass volume.

Over the 37 months of the evaluation period there were some data gaps. Monitoring equipment was offline from January 2013 to February 2013, and December 2014 due to extreme winter weather. The monitoring equipment and system were also offline from June 2014 to September 2014. Hydraulic data from July 2013 to February 2014 (not sampled storm related) were lost due to a malfunction of the network, computer, and replicate storage systems.

Of the data available, a total of 26 events had bypass flow. The flow recorded after the single station horizontal switch was initiated is reported in Figure 14. Figure 14 contains each maintenance event, each period that was off-line, and any data gaps during the evaluation period.

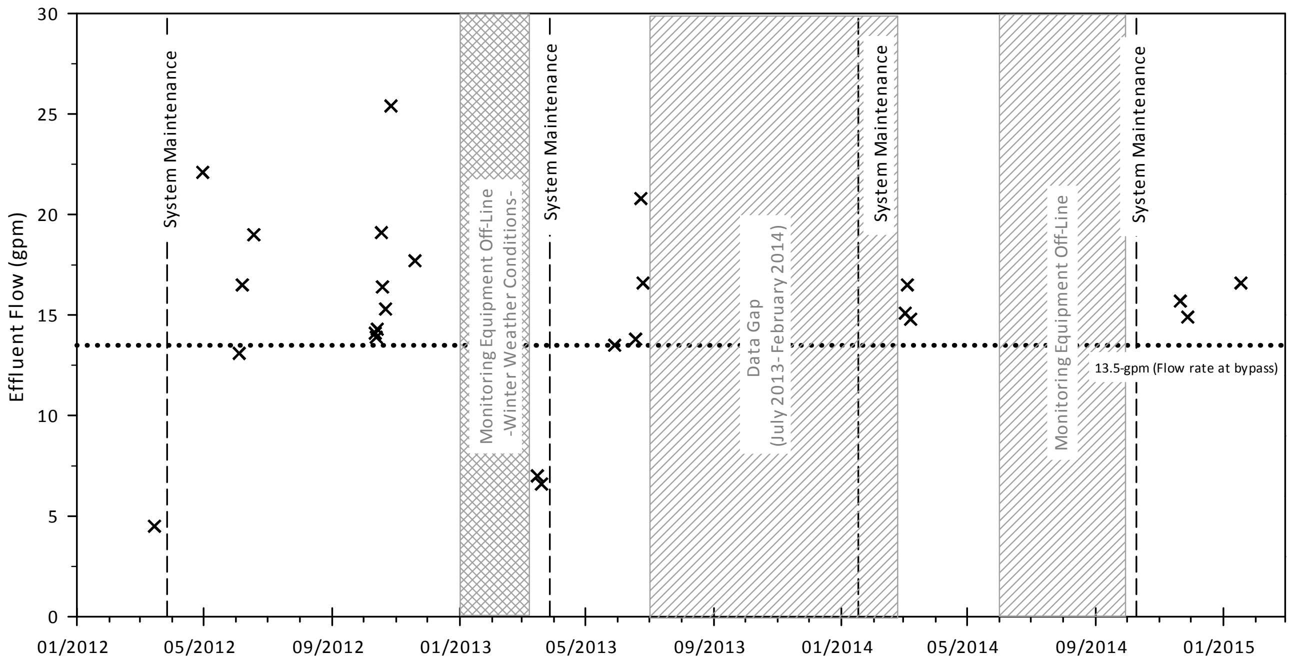

Figure 14. Flow rate at the time of bypass during the evaluation period.

7.3 Screening Parameter Results

Screening parameters were collected for a minimum of 3 sampled events. The analytes evaluated for Basic and Phosphorus Treatment were PSD, pH, total phosphorus, total and dissolved copper, total and dissolved zinc, orthophosphate, and hardness.

The above listed screening parameters were evaluated for five runoff events; LPR060112, LPR060712, LPR013014, LPR030314, and LPR011815. One additional event, LPR030814, did not meet the sample collection criterion for storm event effluent coverage (70%). Results for all screening parameters tested, with the exception of PSD, can be seen in Tables 17 and 18. PSD results are discussed in Section 6.10.

With the exception of three incidences, all screening parameter results showed removal of the specified pollutants for all five sampled events. LPR030314, an event with bypass, showed a release of total phosphorus. LPR011815, an event with bypass, showed a minimal release of both orthophosphate and dissolved zinc. There was a nominal difference between influent and effluent pH of -0.5%.

Table 17. Screening parameter results from the Lolo Pass Road evaluation site for TSS, total phosphorus, orthophosphate, hardness, and pH.

Event	Parameter									
	TSS (mg/L)		Total Phos (mg/L)		Ortho-Phos (mg/L)		Hardness (mg CaCO3/L)		pH	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
LPR060112	780	16.0	0.24	0.036	ND	ND	39	5.8	6.56	6.66
LPR060712	570	120	0.22	0.14	ND	ND	41	14	6.74	6.61
LPR013014	170	17.0	0.301	0.0588	0.042	0.012	44.5	39.6	6.81	6.87
LPR030314	280	95.0	0.128	0.419	ND	ND	18.6	7.22	6.79	6.93
LPR030814	173	26.0	0.264	0.0518	ND	ND	16.4	3.56	6.63	6.63
LPR011815	397	67.0	0.635	0.125	ND	0.006	29.0	11.0	NT	NT

Table 18. Screening parameter results from the Lolo Pass Road evaluation site for total copper, dissolved copper, total zinc, and dissolved zinc.

Event	Parameter							
	Total Cu (mg/L)		Diss Cu (mg/L)		Total Zn (mg/L)		Diss Zn (mg/L)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
LPR060112	0.037	0.0026	ND	ND	0.21	0.012	ND	ND
LPR060712	0.03	0.0096	0.0045	0.0025	0.17	0.049	ND	ND
LPR013014	0.0209	0.00488	0.00224	0.00190	0.109	0.0264	0.0154	0.0131
LPR030314	0.0196	0.00542	ND	ND	0.107	0.0273	0.0079	0.00648
LPR030814	0.0179	0.00220	0.00293	ND	0.0952	0.0114	0.00661	ND
LPR011815	0.0561	0.0079	0.00309	0.00268	0.155	0.0381	0.0118	0.0123

7.4 Sediment Depth Measurements

Sediment depth measurements were taken prior to each full maintenance of the system, with the exception of the maintenance event on February 2, 2012 which marked the beginning of the monitoring period. Average sediment depth measurements were taken on March 27, 2012, March 13, 2013, January 17, 2014, and October 10, 2014. The average recorded sediment depths were 13 inches, 9 inches, 11 inches, and 6 inches respectively. The average recorded sediment depth accumulation between each maintenance event was 9.75 inches. Sediment samples were not collected and analyzed.

7.5 Cumulative Load

Event mean concentration data and measured volume were used to estimate cumulative pollutant load over the entire evaluation period (n=25). Results for estimated mass retained by the system for SSC, total phosphorus, total zinc, and total copper are shown in Table 19. The values listed in Table 19 do not account for flow volume that may have occurred between July 2013 and December 2014.

Table 19. Estimated mass retained throughout evaluation period.

Maintenance Period	SSC (kg)			Total Phosphorus (kg)			Total Zinc (kg)			Total Copper (kg)		
	Influent	Effluent	Retained	Influent	Effluent	Retained	Influent	Effluent	Retained	Influent	Effluent	Retained
Feb 2, 2012 - Mar 27, 2012	37	5.3	32	0.02	0.01	0.02	0.013	0.003	0.010	0.002	0.001	0.002
Mar 28, 2012 - Mar 28, 2013	288	25	262	0.09	0.05	0.04	0.066	0.014	0.052	0.011	0.003	0.008
Mar 29, 2013 - Jan 17, 2014	80	1.9	79	0.08	0.00	0.08	0.018	0.002	0.016	0.004	0.001	0.004
Jan 18, 2014 - Oct 10, 2014	128	13	115	0.12	0.02	0.10	0.034	0.007	0.028	0.007	0.001	0.006
Oct 11, 2014 - Feb 9, 2015	179	7.7	171	0.17	0.01	0.16	0.043	0.005	0.039	0.012	0.001	0.011
Project Total:	**712**	**53**	**659**	**0.49**	**0.10**	**0.39**	**0.175**	**0.031**	**0.145**	**0.036**	**0.006**	**0.030**

8.0 Discussion

The TAPE (2011) requires the following information to be in the discussion section.

8.1 Statistical Data Evaluation

A one-tailed Wilcoxon signed-rank test performed on qualified TSS and total phosphorus data indicated there was a statistically significant difference between the influent and effluent concentrations for both parameters based on an alpha (α) level of 0.05.

The lower 95% confidence limit (LCL95) mean percent reduction for TSS and total phosphorus was 85% and 67%, respectively. The LCL95 mean percent reduction for sub-500 µm solids was 85% and the silt and clay fraction was 73%.

8.2 Explanation of any deviations from sampling procedures

There were no deviations from water sampling procedures. An optional sediment sampling procedure was not implemented as listed in the QAPP.

8.3 Information about anticipated performance in relation to climate, design storm, or site conditions.

As described in the QAPP, the site was selected for evaluation because previous TAPE investigations had shown; a silt loam soil texture; a high frequency of total phosphorus influent concentrations within the range of 0.1 to 0.5 mg/L; and high frequency of TSS influent concentrations in the 200 to 300 mg/L. The system was undersized based on mass load and treatment rate to increase the frequency of bypass. A full range of operating rates were experienced throughout the evaluation to demonstrate performance.

8.4 Information on recommended operation and maintenance schedules

Excluding the first maintenance event, the system exhibited an operational and maintenance cycle of 10 to 12 months. The preliminary design recommendations were for four StormFilter cartridges based on the expected load. The initial recommendations were too conservative, but the estimation tool can be used to conservatively design for an annual maintenance frequency.

8.5 Identification of any special disposal requirements.

There were no special disposal requirements associated with the captured materials in the system. Materials can be disposed of in any municipal solid waste landfills.

9.0 Conclusions

The StormFilter with PhosphoSorb media operating at a specific flow rate of 1.67 gpm/ft^2 was evaluated at a roadway site in ZigZag, OR. Over a 37 months evaluation period, 25 storm events were sampled. Of these 25 events, 17 met the storm event and sampling collection criteria.

Seventeen storm events satisfied the storm event and sampling collection criteria for total suspended solids (TSS). For TSS influent concentrations greater than 100 mg/L, the mean TSS removal efficiency was 88%. The TSS LCL95 mean percent removal was 85%. Additional suspended solid analysis on sub-500 microns and silt and clay fractions showed mean removal efficiencies of 87% and 78% respectively. LCL95 of the mean removal efficiency for sub-500 microns was 85%. The system exhibited greater than 80% removal TSS removal on average for storms with flow rates up to and exceeding the 12.5 gpm design flow.

Thirteen storm events satisfied the storm event criterion, sampling collection criterion, and target total phosphorus influent concentration range of 0.1 to 0.5 mg/L. An additional 4 events had total phosphorus influent concentrations greater than 0.5 mg/L. These events were included in the performance evaluation with a substituted influent value of 0.5 mg/L. The seventeen events demonstrated a total phosphorus mean removal efficiency of 73%. The total phosphorus LCL95 of the mean removal efficiency was 67%. The system exhibited greater than 50% total phosphorus removal for storms with peak flow rates up to and exceeding the 12.5 gpm design flow.

The StormFilter with PhosphoSorb media achieved the Basic and Phosphorus Treatment goals at a specific flow rate of 1.67 gpm/ft^2. The flow-based system was designed 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. Either the Western Washington Hydrology Model (WWHM) or Eastern Washington Manual (using a single event model) can be used to configure the system and achieve the basic and phosphorus treatment goals. The hydraulic loading rate, specific flow rate, and hydraulic drop for each cartridge height are shown in Table 20.

Table 20. Hydraulic Loading Rate per Cartridge Height and Specific Flow Rate

StormFilter Cartridge Type	Per Cartridge Flow Rate at 1.67 gpm/ft^2	Hydraulic Drop Required
Low Drop	8.4 gpm	3.05’
18”	12.5 gpm	2.3’
27”	18.8 gpm	1.8’

Recommendations for designing with pretreatment, mass load, downstream of detention and maintenance frequency should be the same as the StormFilter with ZPG media GULD, which is consistent with The Stormwater Management StormFilter Product Design Manual.

10.0 Appendices

- Appendix A – Media Specifications
- Appendix B – Approved QAPP
- Appendix C – Field Recordkeeping Forms, all 25 events
- Appendix D – Individual Storm Reports, all 25 events
- Appendix E – Quality Control
- Appendix F – Raw Data Tables
- Appendix G – Analytical Laboratory Reports
- Appendix H – Wilcoxon Results
- Appendix I – Bootstrap Results
- Appendix J – Statistics
- Appendix K – Particle Size Distribution
- Appendix L – Deicer Application
- Appendix M – Field Maintenance Recordkeeping Forms
- Appendix N – Operation and Maintenance Manual

11.0 References

Contech Engineered Solutions (CES). 2011. Evaluation of the Removal of Sil-Co-Sil 106 by PhosphoSorb™ in the Stormwater Management StormFilter® at 7.5 gpm (28 L/min) and 15 gpm (56 L/min). Portland, OR Author.

Ma et al. 2009. Phosphorus Removal in Urban Runoff Using Adsorptive Filtration Media. StormCon 2009.

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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APPENDIX A – Media Specifications

Media specifications are proprietary and confidential to Contech Engineered Solutions and prohibited to a public records disclosure request.

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www.contech-cpi.com

Filtration Media Specification

PhosphoSorb™ **Part No: 005.0000.016**

Description: A lightweight media comprised of perlite and activated alumina.

Pellet/granule Size:	6.3 – 2.4 mm 0.25 – 0.09 inch	pH:	7 – 9
Screen Size:	Retained on #8	Adsorption capacity	> 0.002 lb/lb
Moisture Content:	< 3%	Bed Porosity:	50 – 80%
Bulk Density:	15 – 30 lb/ft^3	Specific surface area	15-50 $m^2/gram$ 8137 – 27125 yd^2/lb

Engineering First article approval for new suppliers is required.

Revision	Date	Author/ECO	Change
-	11/30/2010	J. Ma	Release
A			
B			
C			

APPENDIX B – Approved QAPP

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Quality Assurance Project Plan
The Stormwater Management StormFilter®
PhosphoSorb® at a Specific Flow Rate 1.67 gpm/ft^2
Performance Evaluation

Prepared by

Contech Engineered Solutions
11835 NE Glenn Widing Drive
Portland, OR 97220
Telephone: 800-548-4667

September 27, 2013

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Approval Page

Local Regulatory Authority	Douglas Howie, P.E. Washington State Department of Ecology	Date
Project Manager	Gretchen Tellessen CONTECH Engineered Solutions, LLC.	Date
Project QA Manager	John Pedrick CONTECH Engineered Solutions, LLC.	Date
Principal-in-Charge	Michael Hunter CONTECH Engineered Solutions, LLC.	Date
Technical Advisor	Scott A. Wells, PhD, P.E. Portland State University	Date
Analytical Lab	Melissa Armstrong Test America, Inc.	Date
Analytical Lab	Brian Cone APEX Laboratories	Date
Analytical Lab	Greg Conrad Environmental Technical Services	Date

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Table of Contents

1.0 Background

This field evaluation seeks to demonstrate the Total Suspended Solids (TSS) and total phosphorus removal ability of the Stormwater Management StormFilter® (StormFilter) with PhosphoSorb® media operating a specific flow rate 1.67 gpm/ft^2 with the goal of receiving a general use level designation (GULD) for basic and phosphorus treatment from the Washington State Department of Ecology (Ecology).

The performance goals that will be evaluated during this project are specified in Table 1. The data collected during this evaluation will be used to satisfy the requirements outlined by the Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies Technology Assessment Protocol – Ecology (TAPE) as written by the Washington State Department of Ecology, (WADOE, 2011).

Table 1. Treatment performance goals and required water quality parameters for TAPE monitoring that will be used for this field evaluation.

Performance Goals	Influent Range	Criteria	Required Water Quality Parameters
Basic Treatment	20-100 mg/L TSS	Effluent goal ≤ 20 mg/L TSS [a]	TSS
	100-200 mg/L TSS	≥ 80% TSS removal [b]	
	>200 mg/L TSS	≥ 80% TSS removal [b]	
Phosphorus Treatment	Total Phosphorus (TP) 0.1 to 0.5 mg/L	Meet basic treatament goals and ≥ 50% TP removal [b]	TSS, TP orthophosphate

[a] The upper one-sided 95 percent confidence interval around the mean effluent concentration for the treatment system being evaluated must be lower than this performance goal to meet the performance goal with the required 95 percent confidence.

[b] The lower one-sided 95 percent confidence interval around the mean removal efficency for the treatment system being evaluated must be higher than this performance goal to meet the performance goal with the required 95 percent confidence.

2.0 Technology Description

The StormFilter is a Best Management Practice (BMP) that is offered by Contech Engineered Solutions (Contech). The StormFilter, as shown in Figure 1, 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, including sediments (TSS), oil and grease, soluble metals, and phosphorus. The StormFilter is typically comprised of a vault that houses rechargeable, media-filled, filter cartridges. Stormwater entering the system is percolated through these media-filled cartridges, which trap particulates and remove pollutants such as dissolved metals, nutrients, and hydrocarbons. Once filtered through the media, the treated stormwater is directed to a collection pipe or discharged to an open channel drainage way.

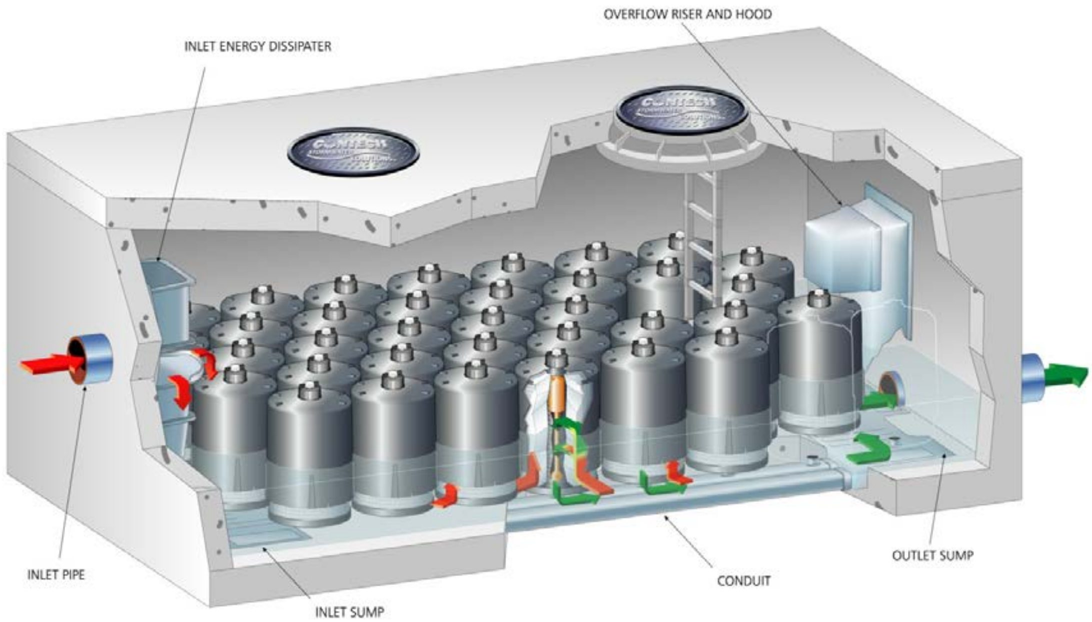

Figure 1. The Stormwater Management StormFilter®.

Cartridge media can be customized for each site and jurisdiction to target and remove the desired levels of sediments, oils and greases, dissolved metals, nutrients, and organics using different media. In many cases, a combination of media may be recommended to maximize the stormwater pollutant removal.

2.1 Operation

During a storm event, runoff passes through the filtration media and starts filling the cartridge center tube. Air below the hood is purged through a one-way check valve as the water rises. When water reaches the top of the float, buoyant forces pull the float free and allow filtered water to drain through the cartridge media.

After the storm event, the water level in the structure starts falling. A hanging water column remains under the cartridge hood until the water level reaches the scrubbing regulators. Air then rushes through the regulators releasing water and creating air bubbles that agitate the surface of the filter media, causing accumulated sediment to drop to the vault floor. This patented surface-cleaning mechanism helps restore the filter's permeability between storm events.

2.2 Cartridge Operation

As the water level in the filtration bay begins to rise, stormwater enters the StormFilter cartridge (Figure 2). Stormwater in the cartridge percolates horizontally through the filter media and passes into the cartridge's center tube, where the float in the cartridge is in a closed (downward) position. As the water level in the filtration bay continues to rise, more water passes through the filter media and into the cartridge's center tube. The air in the cartridge is displaced by the water and purged from beneath the filter hood through the one-way check valve located in the cap.

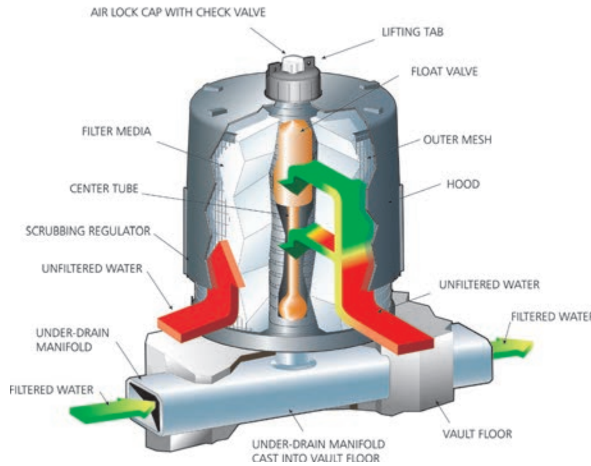

Figure 2. The StormFilter cartridge.

Once the center tube is filled with water, there is enough buoyant force on the float to open the float valve and allow the treated water to flow into the under drain manifold. As the treated water drains, it tries to pull in air behind it. This causes the check valve to close, initiating a siphon that draws polluted water throughout the full surface area and volume of the filter media. Thus, the entire filter cartridge is used to filter water throughout the duration of the storm, regardless of the water surface elevation in the filtration bay.

This process continues until the water surface elevation drops to the elevation of the scrubbing regulators and the float returns to a closed position. At this point, the siphon begins to break and air is quickly drawn beneath the hood through the scrubbing regulators, causing high-energy turbulence between the inner surface of the hood and the outer surface of the filter. This turbulence agitates the surface of the filter, releasing accumulated sediments on the surface, flushing them from beneath the hood, and allowing them to settle to the vault floor. This surface-cleaning mechanism maintains the permeability of the filter surface and enhances the overall performance and longevity of the system.

2.3 Adjustable Flow Rate

Depending on the treatment requirements and the pollutant characteristics of the influent stream at an individual site, the filtration rate through a typical StormFilter cartridge can be adjusted so that it has a maximum flow rate of 2 gpm/ft^2 at the design driving head. 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. Consisting of a simple orifice disc of a specified diameter, the flow rate through the cartridges can be adjusted to a level that coincides with treatment requirements.

2.4 Media Head Loss

The nature of the StormFilter cartridge and its operation create a constant radial flow rate throughout the cartridge. Throughout most of the life of the cartridge, flow through the cartridge is controlled by the cartridge restrictor disc and is relatively independent of the media head loss. The total dynamic head loss through the system is 2.3 feet (for an 18 inch tall cartridge) from the upstream water surface elevation to the downstream water surface elevation. Over time, as the media starts to occlude, the media head loss begins to dictate the flow through the cartridge. At this point, the system requires maintenance.

2.5 Media Contact Time

The thickness of the cartridge media is 7 inches for each available cartridge height. The porosity of the media is approximately 50%. The volume of media for a 12”, 18”, and 27” cartridge effective height is approximately 1.5, 2.3, and 3.5 cubic feet, respectively. The radius of the center tube is 0.162 feet for each effective cartridge height. Depending on the specific flow rate of the cartridge the following table provides the average media contact time:

Specific Flow Rate (gpm/ft^2)	**18” Cartridge Flow Rate** (gpm)	**Media Contact Time** (seconds)
1.0	7.5	75
1.37	10	56
1.67	12.5	45
2.0	15	38

2.6 Treatment mechanisms

The StormFilter utilizes several unit processes to remove pollutants from stormwater. This section includes a brief summary of the media type and the unit process employed in the StormFilter for each specific contaminant.

2.6.1 Physical Separation

The primary component of the StormFilter is the filtration bay with media-filled cartridges. Up to 4 inches of settable solids (sand and grit) can be stored on the floor of the system.

2.6.2 Pollutant removal by the Media-Filled Cartridge

The StormFilter cartridge is the central treatment device within the system. The cartridges are filled with various media depending on the site’s runoff and targeted pollutant removal. Removal associated with the media is promoted through physical straining, ion exchange, and adsorption. Physical straining is the primary removal mechanism for suspended solids. Depending on the media used, dissolved pollutant removal is either associated with ion exchange, chelation, or adsorption reactions.

2.6.3 Physical Straining

Physical straining through the media promotes solids removal by trapping solids within interstitial spaces throughout the filtration media. Removal of suspended particles occurs through physical straining as water passes through filtration media. The straining results in the trapping of suspended particles within the media matrix either in microchannels or dead end pores. All Contech media options utilize physical straining.

Addtionally, physical straining promotes non-dissolved metals removal due to the binding of metals to particles. Other attached pollutants removed through straining include total phosphorus and total nitrogen. All Contech media options utilize physical straining for total metals and nutrients.

2.6.4 Adsorption

Adsorption is the attraction and adhesion of a dissolved contaminant to the media surface. This occurs at the surface as well as within the pores of the media granule. Adsorption requires that a contaminant come in contact with an active surface site on the media and time must be allowed for the contaminant to adhere. These reactions are usually promoted by polar interactions between the media and the pollutant. Adsorption can also occur within the dead end pores and channels of the media but is generally slower than a surface reaction due to limits of the contaminants diffusion into the pore. The contaminant's molecular size will limit diffusion in that the media's pore opening must be larger than the dissolved contaminant.

Commonly adsorbed pollutants include: gasoline, oil, grease, TNT, polar organics or organically bound metals and nutrients. Media promoting adsorption reactions include: CSF leaf media, PhosphoSorb, Perlite, and Granular Activated Carbon.

2.7 Results of Previous Studies

The project described in this QAPP represents the first field evaluation of the StormFilter using PhosphoSorb media operating a specific flow rate 1.67 gpm/ft^2. However, this is not the first BMP evaluation at the site. The site has previously been utilized for the evaluation of the Media Filtration System (MFS) with perlite media operating at a specific flow rate of 1 gpm/ft^2 and 2 gpm/ft^2. The MFS at 1 gpm/ft^2 was evaluated from February 2006 to November 2006. The MFS at 2 gpm/ft^2 was evaluated from October 2007 to December 2009.

Median and mean influent TSS concentrations for the 94 storm events sampled were observed to be 199 mg/L and 330 mg/L respectively. Median and mean influent Total Phosphorus concentrations for the 40 storm events sampled were observed to be 0.18 mg/L and 0.36 mg/L respectively.

2.8 Maintenance

The proper function of a stormwater treatment device is dependent upon regular maintenance activities. Based upon the best available knowledge for each application, systems are sized for annual maintenance activities. The primary factor controlling the timing of maintenance is sediment accumulation, and a properly functioning system will constantly accumulate solids from water by trapping sediment within the media matrix. Eventually the flow through a system will decrease enough to require maintenance and replacement of cartridges. Site conditions greatly influence maintenance requirements.

Two types of maintenance activities may be performed on a system over the course of a monitoring project, inspection and major maintenance. Inspection involves preventative measures such as the cleanup of excessive liter and debris and the inspection of the system to determine whether major maintenance is necessary. Major maintenance involves the removal of captured sediment and cartridge replacement.

Due to the anticipated duration of this project, major maintenance may be required part-way through the project. Any maintenance activities performed by Contech will be noted and reported.

3.0 Project Description

The objective of this field evaluation is to characterize TSS and total phosphorus removal effectiveness of the StormFilter using PhosphoSorb media operating a specific flow rate 1.67 gpm/ft^2 in accordance with the TAPE 2011. Contech will monitor at the site until the 2011 TAPE criteria are satisfied and Ecology can make a confident decision regarding satisfaction of the basic and/or phosphorus treatment goals.

This field evaluation will be carried out at the Lolo Pass Road site located in ZigZag, Oregon. Drainage to the StormFilter being evaluated originates from the bridge deck directly adjacent to the inlet to the StormFilter.

As with any field evaluation, a number of potential constraints exists that may lead to a change in the monitoring program, system setup, or site abandonment. Any changes to the Quality Assurance Project Plan (QAPP) will be communicated to all stakeholders at the time of the change. Site abandonment consideration will be discussed with all stakeholders prior to any actions being taken. Potential constraints identified for this field evaluation include the following:

- Timing of a qualified runoff event and availability of project personnel. If the runoff event occurs on a weekend or during a holiday the Project Manager will not be able to immediately retrieve the samples from the monitoring site. The Project Manager will attempt to collect samples as soon as possible following a runoff event in order to meet holding times. If samples are submitted and analyzed past the specified holding time, the analysis will be flagged as such in the final data set.
- Logistical problems associated with sampling at the site such as, changes in site ownership, vandalism, animal damage, and other impediments to access that may arise and delay or make sampling at the site infeasible.
- Changes in hydrologic conditions that can lead to insurmountable sampling difficulties. A hydrologic change that affects the ability to measure influent or effluent flow from the unit may be a cause for site abandonment.

4.0 Organization and Schedule

The specific responsibilities of the individuals involved in this project are summarized in Table 2. Preliminary monitoring at the Lolo Pass Road was started in January 2012. A total of 16 runoff events were sampled. Duplicate samples were sent in for two of these events and screening parameter testing were performed for three of the events. Contech will continue to monitor at the site until the 2011 TAPE criteria are satisfied and Ecology can make a confident decision regarding satisfaction of the basic and/or phosphorus treatment goals. Contech will seek Ecology's input on the preliminary data and data collected under an approved QAPP to determine if the completion objectives have been satisfied prior to a Technical Evaluation Report (TER) preparation.

Table 2. Summary of roles and responsibilities.

Role	Title	Phone number	Responsibility
Regulatory authority	Douglas C. Howie, P.E. Washington Department of Ecology (WADOE)	360.407.6444	Approval of QAPP, feedback, verification
Site owner	Gretchen Tellessen Contech Engineered Solutions (CONTECH)	503.240.3393	Ensures compliance with utility placement permit issued by Clackamas County and maintains dialog between parties
Project manager	Gretchen Tellessen Contech Engineered Solutions (CONTECH)	503.240.3393	Reporting and Installation and maintenance of monitoring equipment
Project QA manager	Sean Darcy Contech Engineered Solutions (CONTECH)	503.240.3393	Report submittal; maintains dialog between parties
Field personnel	Gretchen Tellessen/ John Pedrick Contech Engineered Solutions (CONTECH)	503.240.3393	Sample retrieval and data collection
Principal in charge	Michael Hunter Contech Engineered Solutions (CONTECH)	503.240.3393	General oversite; funding
Analytical laboratory project manager	Melissa Armstrong Test America	503.906.9200	Analytical services (March 2011-December 2012)
Analytical laboratory project manager	Brian Cone APEX Laboratories	503.718.2323	Analytical services (January 2013- End of Project)
Analytical laboratory	Alexin Analytical Laboratories, Inc.	Contracted through Test America	Analytical for OrthoPhos (November 2012-December 2012)
Analytical laboratory project manager	Greg Conrad Environmental Technical Services	707.778.9605	Analytical for PSD (October 2013-End of Project)
Technical Advisor	Scott A. Wells, PhD, P.E. Portland State University	503.725.5950	Third party certification that QAPP is being followed and that the final data set meets QAPP requirements

5.0 Quality Objectives

The primary goal of this QAPP is to ensure that data collected during this evaluation are scientifically and legally defensible. To meet this goal, the data will be evaluated using the following data quality indicators:

Precision: A measure of the variability in the results of replicate measurements due to random error.

Bias: The constant or systematic distortion of a measurement process, different from random error, which manifests itself as a persistent positive or negative deviation from the known or true value.

Representativeness: The degree to which the data accurately describe the condition being evaluated, based on the selected sampling locations, sampling frequency and duration, and sampling methods.

Completeness: The amount of valid data obtained from the measurement system.

Comparability: A qualitative term that expresses the measure of confidence that one dataset can be compared to another and can be combined or contrasted for the decision(s) to be made.

The Measurement Quality Objectives (MQOs) are performance or acceptance criteria established for the data. The specific MQOs to be used for this study are described below in separate subsections for hydrologic and water quality data below.

6.0 Measurement Quality Objectives for Hydrologic Data

Hydrologic monitoring will involve the measurements of water level and precipitation depth. Potential sources of error associated with flow measurements are the primary and secondary measurement devices. Potential sources of error for precipitation error are associated with the rain gauge. MQOs for these measurements are expressed in terms of precision, bias, representativeness, completeness, and comparability. The associated MQOs for hydrologic data are defined in the subsections below.

6.1 Precision

The precision of the secondary measurement devices will be assessed by submerging the device in a graduated cylinder covered. The gauge reading will be recorded on a 5 minute time step for 4 hours at a temperature of approximately 25 degrees Celsius. The coefficient of variation will be calculated for the data collected using the following equation:

$$C_v = \frac{\sigma}{\mu} * 100\%$$

where:

C_v = Coefficient of variation
σ = Standard deviation
μ = The average gauge reading

The C_v will be calculated for the data collected at 25 degrees Celsius. The MQO will be a C_v of no more than 5 percent.

The rain gauge precision will be estimated by repeatedly releasing a known volume of water into the tipping mechanism and recording the volume required to tip the tipping mechanism. This process will be repeated 10 times and the result C_v will be calculated using the above equation. The MQO for the rain gauge precision will be 5 percent.

6.2 Bias

Bias will be assessed based on a comparison of monitoring equipment readings to reference readings made manually. To assess bias associated with the secondary measurement devices, the devices will be submerged in a graduated cylinder. The measurements obtained in the graduated cylinder using the secondary measurement devices will be compared to the manual reference readings. This process will be repeated three times. The MQO for the level measurements will be a difference of no more than 10 percent between the instrument reading and the reference reading.

Bias in the precipitation depth data collected will be assessed based on a comparison of the rain gauge's actual readings to the rain gauge's theoretical accuracy as specified by the manufacturer. The rain gauge's actual readings will be determined by measuring the volume of water required to initiate one tip of the tipping mechanism by adding incremental drops of water with a pipette. The value obtained will then be compared to the manufactures specifications for this volume. The MQO for precipitation depth will be a difference of no more than 5 percent between the rain gauge's actual reading and the volume specified by the manufacturer.

Bias associated with the primary measurement device structures will be estimated by measuring the dimensions of the device. The MQO for these measurements is a difference of no greater than 5 percent between manual measurements and the dimensions specified by the manufacturer.

6.3 Representativeness

The representativeness of the hydrologic data will be ensured by the proper installation of the monitoring equipment, including primary and secondary measurement devices.

6.4 Completeness

Completeness for flow monitoring will be assessed based on the occurrence of gaps in the data record. Gaps include data that are known to be inaccurate and cannot be corrected using available calibration data. The associated MQO is less than 5 percent of the total data record missing due to equipment malfunctions or other operational problems. Completeness will be ensured through routine maintenance of all equipment and the immediate implementation of corrective actions if problems arise.

6.5 Comparability

There is no numeric MQO for this data quality indicator; however, standard sampling procedures, analytical methods, units of measurement, and reporting limits applied during the evaluation will be used to address the goal of data comparability.

7.0 Measurement Quality Objectives for Water Quality Data

Quality assurance objectives for analytical data are expressed in terms of precession, bias, representativeness, completeness, and comparability. The specific MQOs identified for this project are described below and can be seen Table 3.

Table 3. Measurement quality objectives for water quality monitoring.

Parameter	Laboratory Control Sample (LCS) Recovery (%)	Laboratory Duplicate RPD (%)	Matrix Spike Recovery (%)	Matrix Spike Duplicate (MSD) RPD (%)	Field Duplicate RPD Max. (%)
Susp. Sediment Conc. (SSC)	NA	≤20	N/A	N/A	≤20
Tot. Susp. Solids (TSS)	80-120	≤20	N/A	N/A	≤20
Tot. Vol. Susp. Solids (TVSS)	80-120	≤20	N/A	N/A	≤20
Total Phosphorus	80-120	≤20	75-125	≤20	≤20
Dissolved Phosphorus	80-120	≤20	75-125	≤20	≤20
Orthophosphate	80-120	≤20	75-125	≤20	≤20
Nitrate/Nitrite-N	80-120	≤20	75-125	≤20	≤20
Total Kjeldahl-N	80-120	≤20	75-125	≤20	≤20
Ammonia	80-120	≤20	75-125	≤20	≤20
Total Copper	70-130	≤20	75-125	≤20	≤20
Total Zinc	70-130	≤20	75-125	≤20	≤20
Total Lead	70-130	≤20	75-125	≤20	≤20
Aluminum	70-130	≤20	75-125	≤20	≤20
Hardness	70-130	≤20	75-125	≤20	≤20
pH	NA	NA	NA	NA	≤10
Particle Size Distribution	NA	≤20	NA	NA	≤20

7.1 Precision

For this field evaluation overall project data quality objectives will be based on total and analytical precision. Total precision will be estimated using independent field duplicate samples and laboratory split samples. Analytical precision will be assessed by laboratory sample splits, matrix spikes, and laboratory control samples. These will be assessed using Relative Percent Difference (RPD) which can be seen in Equation 2.

For paired values, in cases that both data are greater than five times the reporting limit, the pooled relative standard deviation (RSD_p) of laboratory and field duplicates will be ≤ 15% for all solids analysis and ≤ 10% for all other analytical parameters. In cases where one or both of the values are less than or equal to five times the reporting limit they will not be included in the RSD_p calculation. The RSD_p of duplicate field samples will be calculated using Equation 1.

Equation 1: Equation to be used to calculate the RSD_p of duplicate field samples.

$$S_p = \sqrt{\frac{\sum(Ci_1 - Cj_2)^2}{2m}} \text{ and } RSD_p = \frac{S_p}{x} \times 100\%$$

where:

S_p = pooled standard deviation
RSD_p = pooled relative standard deviation
Ci_1 and Cj_2 = concentration values
M = number of pairs

Equation 2: Equation to be used to calculate relative percent difference.

$$RPD = \left(\frac{|C_1 - C_2|}{\frac{C_1 + C_2}{2}} \right) \times 100\%$$

where:

RPD = relative percent difference
C_1 and C_2 = concentration values

If sample spilt concentrations are both within five times the reporting limit the RPD goal for all associated parameters will be less than two times the reporting limit. If either of the split samples is at or below the reporting limit the MQO cannot be calculated. RPD values exceeding those described in Table 3 will trigger further assessment as to whether there are any problems with the Analytical Laboratory methodology.

7.2 Bias

Bias will be assessed based on the analysis of method blanks, equipment rinsate blanks, matrix spikes, and laboratory control samples.

Field Sample Bias

Equipment rinsate blank results greater than two times the laboratory reporting limit (RL) will be flagged as default detection limit (U), and associated project samples within five times the default reporting limit will be labeled with a '*J*'. For additional details on steps to be taken if contamination from field equipment is detected see the Quality Control section.

Laboratory Bias

The values for method blanks are not to exceed the reporting limit. The percent recovery of matrix spikes will be between 75 and 125 percent for all applicable parameters. Percent recovery for matrix spikes will be calculated using Equation 3. The percent recovery of laboratory control samples shall be between 80 and 120 percent for all applicable parameters. Percent recovery of laboratory control samples will be calculated using Equation 4.

Equation 3: Equation to be used to calculate percent recovery for matrix spikes.

$$\%R = \frac{(S - U)}{C_{sa}} \times 100\%$$

where:

%R = percent recovery
S = measured concentration in spike sample
U = measured concentration in unspiked sample (If the analyte is not detected in the unspiked sample, then the value of zero will be used in the equation)
C_{sa} = actual concentration if spike added

Equation 4: Equation to be used to calculate percent recovery for laboratory control samples.

$$\%R = \frac{M}{T} \times 100\%$$

where:

%R = percent recovery
M = measured value
T = true value

7.3 Representativeness

The sampling design outlined for this project will provide samples that represent a wide range of water quality conditions during a runoff event. Sample representativeness will be ensured by adequate sample size collected over a sufficient time span of the runoff event, and by employing consistent and standard sampling procedures. Storm event guidelines and sample collection requirements can be seen in Table 4. Storm event guidelines in Table 4 may be less restrictive than the storm event criteria in the TAPE to increase the data pool. Purpose of the storm event criteria is to determine which samples are sent to the analytical laboratory.

7.4 Completeness

Completeness of this field evaluation will be calculated dividing the number of valid values by the total number of values. Valid sample data consists of unflagged data and estimated data that has been assigned a '*J*' qualifier. A qualitative assessment will be made as to which '*J*' flagged data may need to be excluded from this calculation prior to the production of the TER. If less than 95 percent of the samples submitted to the Analytical Laboratory are judged to be valid then additional samples will be collected until at least 95 percent are judged to be valid.

7.5 Comparability

Standard sampling procedures, analytical methods, units of measurement, and reporting limits will be applied to this study to meet the goal of comparability. The results will be tabulated in standard spreadsheets to facilitate analysis and comparison with water quality threshold limits where appropriate.

Table 4. Storm event guidelines and sample collection requirements to be used during this field evaluation.

Parameter	Definition	Guideline (G) /Requirement (R)	
Minimum Influent/Effluent Aliquots	The number of equal-volume samples collected during a storm event. These samples will be combined to create a composite sample.	R	10 aliquots[a]
Minimum Storm Event Coverage	The percentage of the total storm volume that the collected aliquots represent; based on the storm event hydrograph	R	≥75% coverage[b]
Minimum Storm Depth	Total rainfall amount during the storm event	G	0.15-inches
Antecedent Dry-Period (Storm Start)	Minimum time interval without significant rainfall preceeding the beginning of a storm event	G	6 hours w/ rainfall <0.04-inches
Post Storm Dry Period (Storm End)	Minimum time interval without significant rainfall following a storm event	G	6 hours w/ rainfall <0.04-inches
Minimum Storm Duration	Minimum rainfall duration	G	1 hour
Maximum Sampling Duration	Time between the collectin of the first and last aliquots	R	36 hours[c]
Average Storm Intensity	Total rainfall amount divided by total rainfall duration (inches per hour)	G	Range of intensities[d]
Minimum Number of Events Sampled	Number of qualified storm events (events with sucessfully collected flow-weighted composite samples that meet the influent concentration ranges and storm event guideline)	R	12 events[e]

[a] Ecology may accept as few as 7 aliquots; an explaination of why less than 10 were used must be provided in the TER report

[b] Minimum coverage based on the volume associated with the first 24 hours

[c] Samples will be submited to laboratory for storm events with a runoff duration up to 48 hours. Storm events that exceed 36 hours of runoff duration will be evaluated by the Technical Advisor and Ecology for inclusion.

[d] To assess performance on an annual average basis and performance at the system's peak design rate samples should be collected over a range of rainfall intensities

[e] Paired influent and effluent data from more then one site can be combined/pooled to meet the minimum number of events

8.0 Experimental Design

The performance evaluation of the StormFilter with PhosphoSorb media at a specific flow rate of 1.67 gpm/ft^2 in ZigZag, OR will involve continuous flow and precipitation monitoring, the collection of water quality samples during discrete storm events, and accumulated sediment sampling. This section provides detailed information on the experimental design elements associated with the StormFilter performance evaluation.

8.1 Monitoring Site

The Lolo Pass Road site is located in Zigzag, Oregon and is situated at the west protruding end of Zigzag Mountain in the foothills of Mt. Hood and sits approximately 1400 feet above sea level. The site, located on Lolo Pass Road at Bear Creek Bridge, is a 100% impervious medium use road managed by the Clackamas County Department of Transportation and Development. Drainage area of the site is 0.063 acres (2800 square feet) of bridge deck and is located near the intersection of Lolo Pass Road and US Highway 26 (Lat: 45.34420862, Lon: -121.94275218). An aerial view of the site from 2005 is shown in Figure 3. The time of concentration (Tc) on the site is estimated to be 1.4 minutes. A view of the treatment area for the Lolo Pass site can be seen in Figure 4. The site plan is located in Appendix A.

The site is swept periodically, however significant amounts of sediment and organic debris are typically present on site. Sanding (using quarter/ten sanding material) and deicing (magnesium chloride) occurs on US Highway 26 as necessary during the winter months to assist with tire traction and control of ice accumulation. The intersection of US 26 and Lolo Pass Road is approximately a quarter mile from the monitoring site. The site does not receive direct runoff from US 26. Contech will work with the local branch of ODOT (Jim McNamee) to obtain records of when sanding and deicing activities occur on US 26.

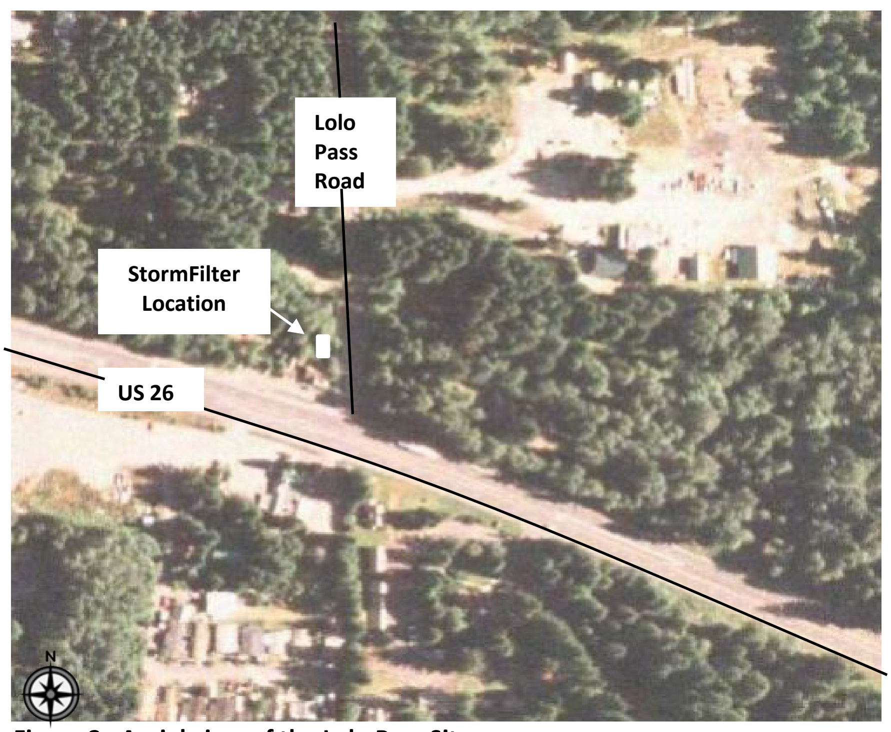

Figure 3. Aerial view of the Lolo Pass Site.

Figure 4. View of the drainage area of the Lolo Pass Site looking south towards US 26.

8.2 Treatment System Sizing

The stormwater treatment system for the site is provided by a StormFilter containing one 18-inch StormFilter cartridge with PhosphoSorb media operating at a specific flow rate 1.67 gpm/ft^2 or 12.5 gpm per cartridge (for an 18-inch cartridge). Previous investigations associated with the Media Filtration System with Perlite used a water quality design flow rate of 23 gpm. The TAPE (2011) has placed additional emphasis on analyzing the pollutant removal as a function of flow rate. This water quality design flow rate was modified by Contech to evaluate hydraulic flow rate and the loading rate of a single cartridge operating at 12.5 gpm.

8.2.1 Hydraulic Flow Rate Evaluation

The TAPE 2011 has placed emphasis on analyzing the pollutant removal as a function of flow rate. As such, a decision was made to add precision to the hydraulic operation characteristics of the system by reducing the number of cartridges to a single cartridge. This would increase the number of events that the system would be at the design operation rate (12.5 gpm) and the ability to analyze the pollutant removal as a function of flow rate. Sizing the system with minimal number of cartridges is likely to increase the frequency of maintenance and may increase the occurrence of external bypass. External bypass will be measured.

8.2.2 Mass Loading Considerations

As the site has been previously evaluated for alternative BMP evaluations, there is additional design information available related to influent solids loading. Previous investigations have resulted in a mean TSS influent concentration of 330 mg/L and a median TSS influent concentration of 199 mg/L for 94 observations. If the system was sized to address a mass loading design (~29 lbs per cartridge), approximately 4-6 StormFilter cartridges would be needed to satisfy the estimated annual mass load (94 to 159 lbs). If sizing for the median TSS influent concentration approximately 4 cartridges would be needed to achieve annual maintenance or 4 maintenance events. If sizing with the mean TSS influent concentration, approximately 6 cartridges would be needed to achieve annual maintenance or 6 maintenance events. Sizing for the estimated annual mass load, however would substantially decrease the number of observations at the cartridge hydraulic design flow rate of 12.5 gpm per cartridge.

8.3 Precipitation Monitoring

Precipitation at the monitoring site will be analyzed with a 0.01-inch resolution Texas Electronics tipping bucket rain gage. The location of the rain gage at the monitoring site can be seen in Figure 6. In the event of the loss of precipitation data, data from the following third-party, public weather station will be substituted:

[Wind Tree Loop, Rhododendron, Oregon Lat = N 45° 21’ 18” Lon = W 121° 58’ 3”]

The above listed weather station is located approximately 1.5-miles northwest of the monitoring site. Hourly precipitation data for the Wind Tree Loop weather station can be found using the Weather Underground website (http://www.weatherunderground.com/) and at the Ambient Weather site (http://mysite.verizon.net/jackpbass/wx.htm).

8.4 Flow Monitoring

Influent and effluent flows will be measured using Large 60°V Trapezoidal Flumes (primary measurement device) in conjunction with individual ISCO 730 Bubbler Flow Modules (secondary measurement devices). Each flow module will be connected to an individual ISCO 6712 Portable Automated Sampler.

Influent and effluent flow will be monitored continuously throughout the evaluation period on a 5-minute time step data interval. Figure 7 shows the flow measurement locations, flow path within the system, and sample locations.

8.5 Water Sampling

The sampling of influent and effluent flows from the Lolo Pass StormFilter will involve the collection of volume-paced samples by the automated sampling equipment over the course of a precipitation event. Individual influent and effluent samples will be combined according to the event hydrograph to create influent and effluent composite samples that represent the mean influent and effluent water quality. EMC subsamples will be taken from the composite samples using the specified subsampling equipment for submittal to the Analytical Laboratory for subsequent analysis.

8.6 Monitoring location and equipment

The StormFilter system is located within a larger vault. A photo of the exterior of the StormFilter system at Lolo Pass Road can be seen in Figure 6.

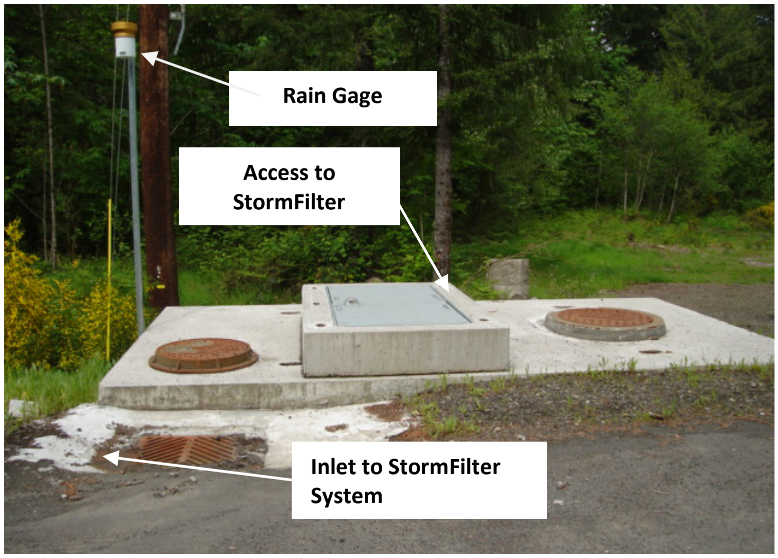

Figure 6. External view of the StormFilter system at Lolo Pass Road.

Influent and effluent samples will be collected using individual ISCO 6712 Portable Automated Samplers configured for standard, individual, round, wide-mouth 1-L HDPE bottles sample bottles. The samplers will be connected to individual 12VDC deep cycle batteries that will be replaced periodically throughout the project. Each sampler will be equipped with an individual ISCO 730 Bubbler Flow Module for the purpose of sample pacing and flow analysis. Each sampler will also have an ISCO SPA 1489 Digital Cell Phone Modem System to allow for remote communication and data access. Sample tubing, 3/8" ID Acutech Duality FEP/LDPE tubing, will be routed from each automated sampler to influent and effluent sample locations. Sample intakes will be located at the invert of both the influent and effluent sample locations. Sampling locations can be seen in Figure 7.

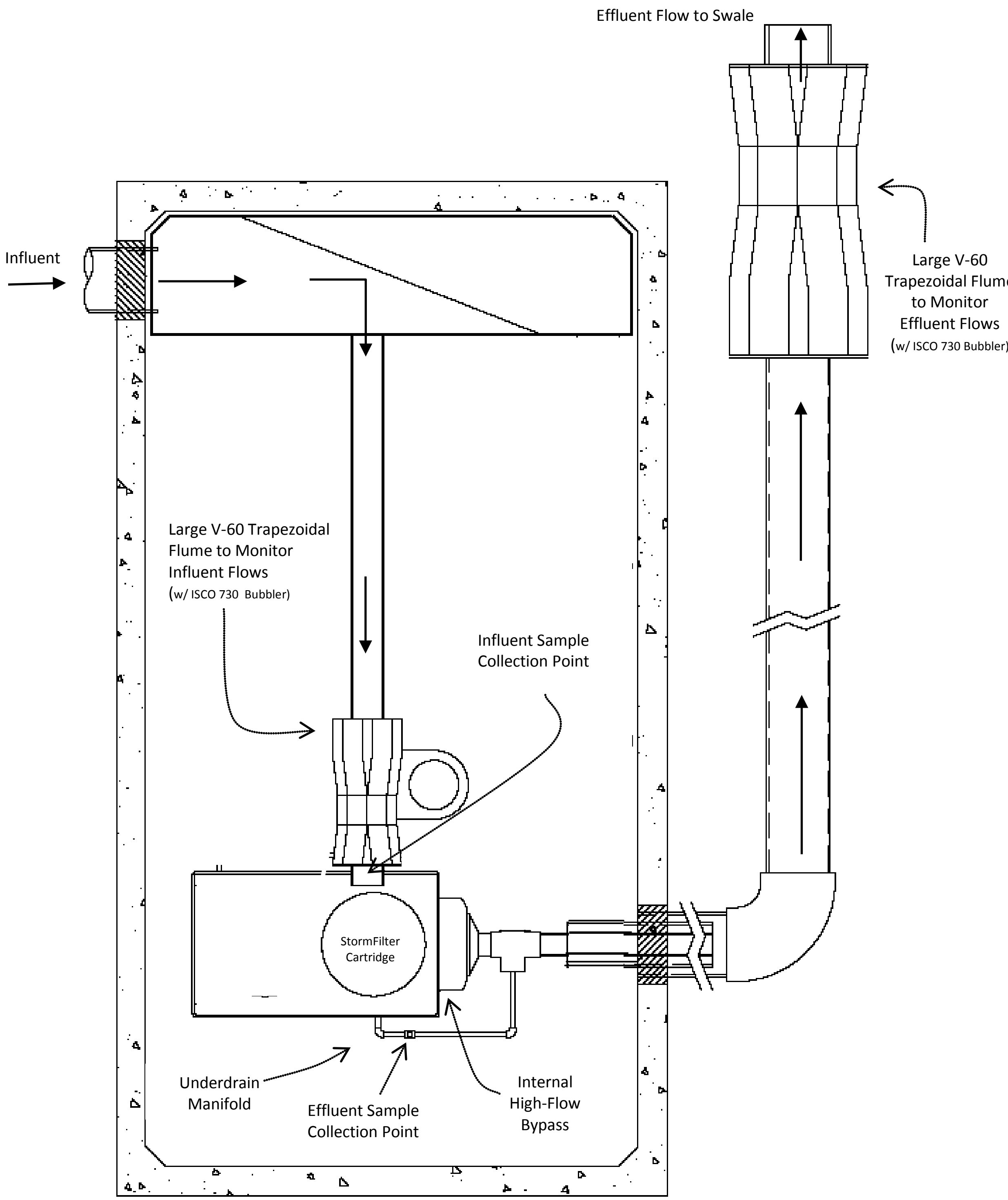

Figure 7. Plan view of StormFilter system at Lolo Pass Road.

8.7 Sampling Methodology

Sampling methodology #2, Discrete Flow Sampling, as described in the 2011 TAPE will be used for this evaluation. A multiple-bottle rack will be used to collected flow paced aliquots.

The sample collection program input into each automated sampler will be a one-part program. Once the program is run, it will be active for a period of 36 hours to ensure capture of a single event. Influent and Effluent sample collection programs will be configured as follows:

Sample Aliquot Volume (mL):	250
Discrete Samples:	Sequential aliquots in bottles 1 through 12; 4 aliquots per bottle

Due to the variability among precipitation events, the sample pacing will vary. Settings and changes will be determined by the Project Manager after the review of the most up to date precipitation forecasts.

8.8 Monitoring Parameters

Water quality parameters, and associated analytical methods, to be tested for each qualified runoff event are listed in Table 3. In addition, screening parameters will be tested a minimum of three times throughout the evaluation period. Influent and effluent samples will be collected during a qualified storm event for the purpose of testing screening parameters in an effort to determine if the unit has the potential to export contaminants including phosphorus and metals. The screening parameters for this project are based on both the basic and phosphorus treatment goals of this project and can be seen in Table 5.

Table 5. Required screening parameters for TAPE monitoring for this field evaluation.

Performance Goal	Required Screening Parameters
Basic	PSD, pH [a], TP, orthophosphate, hardness, total and dissolved copper and zinc
Phosphorus	PSD, pH [a], hardness, total and dissolved copper and zinc

[a] in situ sample only. If a substantial change in pH is measured (>1 standard unit difference between influent and effluent) or an abnormal pH value is measured (<4 or >9 standard units) additional storm events will be monitored.

8.9 Monitoring Duration

As indicated in Table 4, a minimum of 12 flow weighted composite samples will be collected to ensure representative concentrations are available for assessing system performance across a variety of storm event conditions. However, sampling will continue until enough samples have been collected to demonstrate performance of the system at the required level of statistical confidence for obtaining a GULD. In all cases, samples must fall within the influent concentration ranges specified in Table 1 and meet the sample collection requirements specified in Table 4. The storm event guidelines identified in Table 4 will also be evaluated to assess the validity of collected samples.

8.10 Cumulative Load Estimation

Cumulative mass load retained by the system will be estimated on a continuous basis using summation of load calculations. When approximately 30 pounds of sediment per cartridge are estimated to be retained by the system and/or internal bypass is observed in the system when influent flow rates are observed to be ≤ design flow rates the system will be maintained. In addition to the estimated mass of material calculated using water quality results, the mass of material retained by the system will be assessed during the system maintenance as described in Section 8.11 Sediment Sampling, for comparison purposes.

8.11 Sediment Sampling

Maintenance of the system will be performed at the beginning of the project to allow for a baseline for measuring and analyzing solids retained by the system. The wet weight of the StormFilter cartridge will be taken and recorded prior to installation.

The quantity and quality of residual solids captured by the system during each maintenance cycle will be assessed. Prior to system maintenance the StormFilter cartridge will be carefully removed and all settled material within the vault of the unit will be collected. The cartridge will be allowed to drain before being weighed. This wet weight will be directly compared to the cartridge wet weight taken prior to installation to estimate the volume of solids filtered and retained within the media throughout the maintenance cycle.

All residual solids material collected from the vault will be weighted and tested for percent solids to calculate volume of settled material within the vault during the maintenance cycle. A composite sample of the residual solids will be homogenized by hand and a representative sample will be collected and sent to the Analytical Laboratory for analysis. Samples submitted for analysis will be tested for the parameters listed in Table 8. Data from this these analysis will be used in conjunction with the volume of residual solids measured within the system to determine the estimated dry mass of contaminants captured.

9.0 Sampling Procedures

All inspection and calibration activities will be performed by the Project Manager. Maintenance records will be noted by the Project Manager.

9.1 Equipment Installation and Calibration

All measurement equipment will be installed and calibrated according to the manufacturer's instructions. Equipment inspection and calibration specifics can be seen in Table 6. Manufacturer's equipment manuals have been included as references in Section 17.0; these manuals are available upon request.

Table 6. Instrument and equipment testing, inspection, and calibration details.

Equipment	Inspection Items	Procedure	Frequency (minimum)
ISCO 6712 Portable Automated Sampler	Desiccant	Check color- change when pink	Eveny site visit
	Sample dispensing arm	Run diagnostics	Every site visit
	Sample strainer	Check for Occlusion	Every site visit
	Sample and pump tubing	Check integrity	At installation and monthly
	Calibration	Calibrate according to manufacture's instructions	At installation and monthly
ISCO 730 Bubbler Flow Module	Desiccant	Check color- change when pink	Every site visit
	Calibration	Calibrate according to manufacture's instructions	At installation and twice annualy
Large 60°V Trapezoidal Flume	Flow channel	Check for debris and sediment accumulation	Every site visit
Power sources	12VDC Batteries	Check charge	Every site visit
Texas Electronics Tipping Bucket Rain Gauge	Funnel and screen	Check for debris	Every site visit
	Calibration	Calibrate according to manufacture's instructions	At installation and once annualy

9.2 Water Sampling

The StormFilter will be monitored for performance during a qualified storm event. Automated samplers will be used to collect influent and effluent samples during the storm event that will eventually be analyzed for the parameters listed in Tables 3 and 7. Automated samplers will be programmed to initiate sampling after specified hydraulic conditions have been detected. Following initiation, sampling will proceed based upon a volume-paced program. Unless manually disabled or malfunctioning, automated samplers will collect samples during each qualifying storm event (event forecast to be of enough significance to satisfy sampler initiation requirements).

Before the storm event the Project Manager will evaluate the ambient air temperature, if the ambient air temperature is or is forecasted to be $\geq$ 6 degrees Celsius (43 degrees Fahrenheit) the automated samplers shall be filled with ice.

After a storm event the Project Manager will remotely communicate with the automated sampling equipment to confirm sample collection. After sample collection confirmation, the Project Manager will retrieve all samples, replace the sample bottles and reset the automated sampling equipment. Samples will be transported from the sampling location to the Contech lab in Portland, Oregon in coolers containing ice or gel-based ice packs. The site code for the Lolo Pass field evaluation will be LPR. This site code will be used for sample naming purposes both in the Contech lab and for all samples sent to the specified Analytical Laboratory.

The Project Manager will combine collected samples to create influent and effluent composite samples through identification of those bottles best representing the storm event based upon the hydrograph. The selected samples will be thoroughly shaken and emptied into a cone splitter. The cone splitter will then be used to generate the EMC subsamples that will be submitted for analysis. All compositing will be completed at the Contech lab in Portland, Oregon. Table 7 lists the subsamples that will be submitted to the Analytical Laboratory for analysis. The table shows the required analytical container, minimum required sample volume, any handing of the sample that will take place in addition to cooling the sample to ≤6°C, all sample preservation requirements, and pre- and post-preservation holding time limits. The holding time limits will be based upon the collection time of the last sample used to make the composite at each sampling location. All samples will be sent to the analytical laboratory and that data not meeting the hold time will be flagged.

Analytes listed in Table 7 are ranked by priority. Parameters 1 thru 7 (target analytes), the 2011 TAPE PSD method, and the screening parameters (SP 1 thru 7) are to be analyzed as the priority for each qualified event. The goal is to get enough sample volume to analyze the entire list of parameters listed in Table 7.

Subsamples will be transported to the Analytical Laboratory in cooler containing gel-based ice packs. Subsamples will be handled by the Analytical Laboratory using clean technique and processed according to analytical requirements shown in Table 3. Standard chain-of-custody documentation will accompany the submittal and transfer of all samples to the Analytical Laboratory. Blank chain-of-custody forms are included in Appendix C.

Table 7. Sample handling requirements for water quality samples parameters. Labels beginning with SP indicate screening parameters.

Labeling Designation (Bottle Number)	Parameter	Minimum Volume (mL)	Handling in Addition to Cold Storage	Sample Container	Pre-Filtration Holding Time	Total Holding Time
1	TSS pH	250	None	HDPE	NA	7 days
2	SSC TVSS	250	None	HDPE	NA	7 days
3	TSS Duplicate	250	None	HDPE	NA	7 days
4	SSC Duplicate	250	None	HDPE	NA	7 days
5	Total Phosphorus	250	H_2SO_4 to pH<2	HDPE	NA	28 days
6	Dissolved Phosphorus Orthophosphate	250	None	HDPE	12 hours [a]	48 hours
7	TAPE PSD	1000	None	HDPE	NA	7 days
SP1	SSC pH	250	None	HDPE	NA	7 days
SP2	SSC	250	250-um filtration	HDPE	NA	7 days
SP3	SSC	250	62.5-um filtration	HDPE	NA	7 days
SP4	Orthophosphate	250	None	HDPE	12 hours [a]	7 days
SP5	Total Copper Total Zinc Hardness	250	HNO3 to pH<2	HDPE	NA	6 months
SP6	Dissolved Copper Dissolved Zinc	250	0.45-um filtration	HDPE	12 hours [a]	6 months
SP7	Total Phosphorus	250	H_2SO_4 to pH<2	HDPE	NA	28 days
8	Aluminum Total Copper Total Zinc Total Lead Hardness	250	HNO_3 to pH<2	HDPE	NA	6 months
9	SSC<2000-µm TVSS<2000-µm	250	2000-um filtration	HDPE	NA	7 days
10	SSC<500-µm TVSS<500-µm	250	500-um filtration	HDPE	NA	7 days
11	SSC<250-µm TVSS <250-µm	250	100-um filtration	HDPE	NA	7 days
12	SSC<62.5-µm TVSS <62.5-µm	250	100-um filtration	HDPE	NA	7 days
13	SSC<100-µm TVSS <100-µm	250	100-um filtration	HDPE	NA	7 days
14	SSC<50-µm TVSS <50-µm	250	50-um filtration	HDPE	NA	7 days
15	TKN Nitrate/Nitrite-N Ammonia	250	H_2SO_4 to pH<2	HDPE	NA	28 days

[a] Pre-filtration holding times of 15 minutes for dissolved metals and orthophosphate are recommended in US EPA (1983) and required in 40 CFR 136.3, Table 2; however these holding times cannot realistically be met with flow weighted automated sampling techniques. Ecology will accept data qualified as an estimate (J qualifer) in filtration occured between 15 minutes and 12 hours after the last aliquot was collected.

9.3 Sediment Sampling

Prior to system maintenance the quantity and quality of residual solids captured by the system during each maintenance cycle will be assessed. Prior to system maintenance the StormFilter cartridge will be carefully removed and all settled material within the vault of the unit will be collected in clean HDPE buckets and brought back to the Contech lab in Portland, Oregon. The cartridge will be allowed to drain before being weighed. This wet weight will be directly compared to the cartridge wet weight taken prior to installation to estimate the volume of solids filtered and retained within the media throughout the maintenance cycle.

All residual solids material collected from the vault will be weighted and tested for percent solids to calculate volume of settled material within the vault during the maintenance cycle. A composite sample of the residual solids will be homogenized by hand and a representative sample will be collected and sent to the Analytical Laboratory for analysis. Sediment samples will be kept at or below ≤6°C during transport and storage prior to analysis.

9.4 Equipment Decontamination

All water sampling equipment and sediment sampling equipment will be decontaminated between sampling events using deionized water. Suction tubing will be replaced to prevent contamination at least once during the monitoring period and more frequently if equipment rinsate blanks indicate contamination due to highly contaminated runoff.

9.5 Recordkeeping

A field recordkeeping form, as well as field notes will be collected and saved in the project folder. The field recordkeeping form as well as field note information guidelines are included in Appendix D.

10.0 Measurement Procedures

This section focuses on laboratory procedures to be used for water quality and sediment analysis during this field evaluation. The Analytical Laboratory being used for this project is listed in Table 2. Specific contact information for the Analytical Laboratories used throughout this project can be found in the Distribution List. All Analytical Laboratories selected for this evaluation are Ecology-accredited.

10.1 Water Sampling

All EMC sample analysis will be handled by the Analytical Laboratory. Analytical methods that will be specified for sample analysis are shown in Table 3. Reporting limits and analytical methods for water quality and sediment parameters are shown in Table 8. Additional details on the execution of these analyses can be obtained from the Analytical Laboratory.

Table 8. Reporting limits and analytical methods for water quality and sediment parameters.

Parameter	Matrix	Method	Reporting limt target [a]
Susp. Sediment Conc. (SSC)	Water	ASTM D3977	1.0 mg/l
Tot. Susp. Solids (TSS)	Water	SM 2540 D	1.0 mg/l
Tot. Vol. Susp. Solids (TVSS)	Water	SM 2540 G	1.0 mg/l
Total Phosphorus	Water	SM 4500 P F	0.01 mg/l
Dissolved Phosphorus	Water	EPA 200.7	0.01 mg/l
Orthophosphate	Water	EPA 365.2	0.01 mg/l
Nitrate/Nitrite-N	Water	EPA 353.2	0.03 mg/l
Total Kjeldahl-N	Water	EPA 351.2	0.50 mg/l
Ammonia	Water	EPA 350.1	0.05 mg/l
Total Copper	Water	EPA 200.8	0.002 mg/l
Total Zinc	Water	EPA 200.8	0.01 mg/l
Total Lead	Water	EPA 200.8	0.001 mg/l
Aluminum	Water	EPA 200.7	0.1 mg/l
Dissolved Copper	Water	EPA 200.8	0.002 mg/l
Dissolved Zinc	Water	EPA 200.8	0.01 mg/l
Hardness	Water	SM 2340B	0.662 mg/l
pH	Water	EPA 150.1	0.2 units
Particle Size Distribution	Water	TAPE SOP	NA
Percent Solids	Sediment	SM 2540G	NA
Percent Volatile Solids	Sediment	SM 2540G	1%
Grain Size	Sediment	ASTM D422	NA
Total Phosphorus	Sediment	EPA Method 200.7	0.01 mg/kg
Total Recoverable Zinc	Sediment	EPA Method 200.8	5.0 mg/kg
Total Recoverable Copper	Sediment	EPA Method 200.8	0.1 mg/kg
Total Recoverable Lead	Sediment	EPA Method 200.8	0.1 mg/kg

[a] To the extent possible, reporting limits for the analytical laboratory selected should be the same or below those listed here. All results below reporting limits should be reported and identified as such.

Analytical data will be received from the Analytical Laboratory in the form of reports that are submitted in electronic form. These reports will include all analytical results as well as the sampling date, date of preservation (if required), date of filtration (if required), date of extraction, and date of analysis. The analytical report will also contain all laboratory QC samples and information associated with those samples. Electronic analytical reports will be submitted directly to the Project Manager via email attachment and will be transferred to the appropriate subfolder on the Contech Project Drive.

10.2 Particle Size Distribution Procedures

Two particle size distribution methods are being used for this project. The first method is a variation of the serial filtration process and is employed every time a runoff event is sampled. This method is a direct measurement of particle size by mass whereas indirect methods such as Laser Diffraction and the electrical sensing zone method (Coulter Principal) convert counted data points into mass by way of assumptions regarding particle shape and density. For each event samples are split and submitted for analysis. SSC results are obtained for SSC, SSC (<2000-µm), SSC (<500-µm), SSC (<100-µm) and SSC (<50-µm). Samples will be split by the Project Manager and SSC analysis will be performed by the Analytical Laboratory.

A second particle size distribution method will be performed a minimum of three times during the evaluation and will follow the procedure described in the 2011 TAPE. For this particle size distribution 1-L composite influent and effluent samples will be collected during a qualified storm event. Each sample will first be filter through a 250-µm (#60) sieve followed by filtration through a 62.5-µm (#230) sieve and finally though1.5-µm glass fiber filter. These size fractions will be used to determine the percent of medium sand and larger (>250-µm), very fine to fine sand (62.5-250-µm) and silt and clay (<62.5-um). This particle size distribution will be performed by the Analytical Laboratory.

10.3 Sediment Sampling

Sediment samples will be submitted to the Analytical Laboratory for analysis. Table 8 lists the sediment parameters to be analyzed during this evaluation, the analytical method to be used for each parameter and the target reporting limit for the analysis.

The Analytical Laboratory will return reports to the Project Manager that are submitted in electronic form and will include all analytical results as well as the sampling date, date of preservation (if required), date of filtration (if required), date of extraction, date of analysis and if the sample is a QC sample.

11.0 Quality Control

This section of the QAPP includes information on field quality assurance, quality control and laboratory quality control.

11.1 Field Quality Assurance and Quality Control

Quality control samples will be used to assess the quality of both field sampling and analytical activities. Quality control samples will be analyzed for the analytes listed in Table 9. The following quality control samples will be used: equipment rinsate blanks, field duplicates, laboratory control samples, method blank, duplicate analysis (laboratory) and MS/MSDs. Equipment rinsate blanks and field duplicated will be collected by the Project Manager and analyzed by the Analytical Laboratory. All other quality control samples will be the responsibility of the Analytical Laboratory. Parameters to be tested and frequency are detailed in Table 9.

Table 9. Quality control parameters to be evaluated and frequency of sample collection.

Water Quality Parameter	Field QC		Laboratory QC			
	Equipment Rinsate Blank (number)	Field Duplicate	Laboratory Control Sample	Method Blank	Laboratory Duplicate	MS/MSDs
TSS	3	10% of Samples	1 per batch	1 per batch	1 per batch	---
pH	---	10% of Samples	---	---	---	---
Total Phos	3	10% of Samples	1 per batch	1 per batch	1 per batch	1 per batch
Ortho-Phos	3	10% of Samples	1 per batch	1 per batch	1 per batch	1 per batch
Total Copper	3	10% of Samples	1 per batch	1 per batch	1 per batch	1 per batch
Dissolved Copper	3	10% of Samples	1 per batch	1 per batch	1 per batch	1 per batch
Total Zinc	3	10% of Samples	1 per batch	1 per batch	1 per batch	1 per batch
Dissolved Zinc	3	10% of Samples	1 per batch	1 per batch	1 per batch	1 per batch
Hardness	3	10% of Samples	1 per batch	1 per batch	1 per batch	1 per batch

Equipment rinsate blanks will be collected for the purpose of verifying that the sampling equipment is not a source of sample contamination. Equipment rinsate blanks will be collected a minimum of three times throughout the evaluation period.

- After decontamination of the equipment.
- After the first or second qualified storm event.
- At the end of the evaluation period.

If any parameters are detected with concentrations greater than the reporting limit the Project Manager will be responsible for finding the source of contamination and correcting the issue prior the next sampling event.

A field duplicate sample is a second independent sample collected at the same time and location as the original sample. Analyzing field duplicate samples will be used as a way to assess possible errors associated with the sample collection and processing procedure as well as analytical activities. The total number of field duplicate samples to be collected is dependent on the total number of samples collected throughout the evaluation period. Samples are defined as the total number of influent and effluent samples collected for qualified storm events. Duplicates will be collected and analyzed for a minimum of 10% of total samples.

Additional field duplicate QC samples will be collected for solids analyses that employ the use of whole sample volume (i.e. suspended solids concentration). Since the use of the entire sample eliminates the possibility of extracting a duplicate sample from the same sample container, separate duplicate samples must be prepared to accommodate duplicate analysis.

11.2 Equipment Maintenance and Calibration

In addition to the collection of equipment rinsate blanks and field duplicate samples all field equipment will be inspected and maintained throughout the evaluation period. A schedule of inspection and maintenance activities for the monitoring equipment installed at the monitoring site can be seen in Table 6.

11.3 Laboratory Quality Control

The Analytical Laboratory will be responsible for its own assessment and response according to its own QA program. Quality control sample analysis to be provided by the Analytical Laboratory include laboratory control samples, method blank, duplicate analysis, and MS/MSDs. Parameters to be tested for QC purposes and the frequency is shown in Table 9. The QA/QC manual for the Analytical Laboratory is included in Appendix C.

The Project Manager will be responsible for checking analytical reports for completeness following the delivery of analytical reports and communicating any issues to QA personnel from the analytical laboratory for corrective action.

12.0 Data Management Procedures

The following types of field data will be collected as part of this project: 1) hydrographs (influent and effluent); 2) sample collection time stamp (influent and effluent); and 3) cumulative rainfall data. This data will be collected by the instruments and equipment installed in the field and logged by the ISCO 6712 Portable Automated Samplers. Data will be retrieved from the ISCO 6712 Portable Automated Samplers by the Project Manager following a successful sampling event or as needed. Data will be stored in project folder on the Contech Project Drive.

Analytical data are received from the Analytical Laboratory in the form of reports that are submitted in electronic form. These reports will include all analytical results as well as the sampling date, date of preservation (if required), date of filtration (if required), date of extraction, date of analysis, and if the samples are QC samples. All analytical reports received from the laboratory will be stored in the project folder on the Contech Project Drive.

The Project Manager will be responsible for all data management activities. All electronic data will be backed up on a daily basis as per Contech network management protocol. All electronic data will be stored by Contech for a minimum of 5 years following project completion.

Review of analytical, flow, and precipitation data to determine qualification requirements have been met will be performed on a quarterly basis by committee and will involve the Project Manager, Project

QA Manager, and Technical Advisor. All data that meets the qualification requirements will be accepted. Data that do not meet the qualification requirements will be flagged. A decision to reject or accept the flagged data for final analysis will be made based upon best professional judgment. Flagged data and associated acceptance/rejection decisions will be discussed in the Data Summary Report.

13.0 Audits and Reports

The documents and records that will be associated with this QAPP are the following: 1) official analytical reports including both results and analytical QC results; 2) chain-of-custody records; 3) field QC results; 4) equipment testing, inspection, maintenance, and calibration data; and 5) field recordkeeping forms. Hard copies of all documents will be archived in the Contech project binder by the Project Manager and kept for a minimum of 5 years following project completion.

There are two types of interim reports that will accompany this project: the Individual Storm Report (ISR) that documents each individual storm capture and a Data Summary Report. The ISR will be the responsibility of the Project Manager and will be created immediately upon receipt of all data pertaining to an individual storm capture event. The ISR assembles all important data pertaining to an individual storm capture event. The Data Summary report is the responsibility of the Project Manager and will consist of a narrative describing project status, an interim performance summary, any QA issues, and will be accompanied by all qualifying ISRs collected thus far in the project. The Data Summary Report will be distributed to all signatories of the QAPP.

Upon the conclusion of all sampling activities a TER will be written and submitted to Ecology for review and approval. The TER report will follow the guidelines specified in the 2011 TAPE and will include a technology description, sampling procedures, data summary and analysis, operation and maintenance information, and relevant discussions and conclusions.

14.0 Data Verification and Validation

ISRs and analytical reports will be reviewed by the Project Manager on a continual basis. Validation and verification will be conducted by the Project Manager, Project QA Manager, and Technical Advisor upon creation of the Data Summary Report and prior to submittal of the TER.

Data will be validated and verified on a quarterly basis and will involve the Project Manager, Project QA Manager, and Technical Advisor. All quantitative data will be checked to ensure the absence of transcription errors. Transcription errors will be fixed immediately and will not be reported. Reviewers will also check for nonsensical data and outliers using best professional judgment. Any resulting invalidation will be reported in the Data Summary Report.

Quality control documentation associated with each ISR will also be reviewed for accuracy and completeness. The decision to invalidate data due to incomplete QC information will be based upon best professional judgment and will also be reported in the Data Summary Report.

15.0 Data Quality Assessment

The QA manager will review the water quality QC data from each sampling event in accordance with the MQOs shown in Table 3. The results of the review will be presented in a data quality assessment report that will be prepared for inclusion in the data summary report. The report will summarize quality control results, identify when data quality objectives were not met, and discuss resulting limitations, if any, on the use or interpretation of the data. The information to be included in the data quality assessment report will include the following:

- Changes to and deviations from the QAPP
- Results of performance and audits
- Data quality assessment results in terms of representativeness, completeness, and comparability
- Discussion of whether the QA objectives were met and the resulting impact on decision-making
- Limitations on the use of the measurement data

To assess the quality of the flow data a QA report will also be included in the TER. The QA report will summarize quality control results, identify when quality objectives were not met, and discuss the resulting limitations, if any, on the use or interpretation of the data.

16.0 Data Analysis

The data analysis that will be performed to evaluate the water quality treatment performance of the system will follow the procedures outlined in the 2011 TAPE. The specific procedures that will be used in these analyses are as follows.

- Statistical comparisons of influent and effluent pollutant concentrations
- Pollutant removal efficiency calculations
- Statistical evaluation of performance goals

More detailed information on these procedures is provided in the following subsections.

16.1 Statistical comparisons of influent and effluent pollutant concentrations

Statistical analyses will be performed to determine whether there are significant differences in pollutant concentrations between the influent and effluent stations across individual storm events. The specific null hypothesis (Ho) and alternative hypothesis (Ha) for these analyses are as follows:

H_o: Effluent pollutant concentrations are equal to or greater than influent concentrations.

H_a: Effluent concentrations are less than influent concentrations.

To evaluate these hypotheses, a 1-tailed Wilcoxon signed-rank test will be used to compare the influent and effluent performance data. Statistical significance will be assessed based on an alpha (α) level of 0.05.

16.2 Pollutant removal efficiency calculations

Removal efficiencies will be calculated for each measured pollutant using the methods presented below. The calculated pollutant removal efficiency estimates will be presented with the applicable performance goal in a table.

Method #1: Individual storm reduction in pollutant concentration

The reduction in pollutant concentration during each individual storm is calculated as:

$$\frac{100(A-B)}{A}$$

Where:

A = flow-proportional influent concentration
B = flow-proportional effluent concentration

This method is typically applied when there are no water losses in the treatment system between the inlet and outlet (i.e., influent flow volume equals effluent flow volume).

16.3 Statistical evaluation of performance goals

Statistical analyses will be performed to determine whether the collected data demonstrate that the system met applicable performance goal(s) specified in Table 1. To evaluate the performance goals for basic and phosphorus treatment, bootstrapping will be used to compute confidence intervals around the mean effluent concentration or pollutant removal efficiency.

For basic and phosphorus treatment with goals that are expressed as a minimum removal efficiency (i.e., 80 percent TSS removal and 50 percent TP removal), bootstrapping will be used to compute the 95 percent confidence interval around the mean removal efficiency for the treatment system being evaluated. (Individual removal efficiency values will be computed using Method #1 as described above.)

The lower one-sided 95 percent confidence limit will then be compared to the applicable performance goal. If this limit is higher than the treatment goal, it can be concluded that the system met the performance goal with the required 95 percent confidence.

16.4 Pollutant removal as a function of flow rate

A regression analysis will be performed in order to evaluate pollutant removal performance as a function of flow rate. The goal of this analysis will be to determine if the applicable performance goal for a given parameter is being met at the design hydraulic loading rate for the treatment system.

To perform this analysis, an aliquot-weighted influent flow rate will be determined for each composite sample. A regression analysis will then be performed to determine whether the treatment performance increases, decreases, or remains unchanged as function of influent flow rate. More detailed information on these steps is provided in the following subsections.

16.4.1 Flow rate determination

For flow-proportional composite sampling, an aliquot-weighted flow rate will be calculated based on the time that each aliquot was collected. Specifically, the influent flow rate at the time each aliquot was collected will be determined for each storm event based on the continuous flow measurements from the influent monitoring station; these values will then be averaged to obtain an aliquot-weighted flow rate for the sampled storm event.

16.4.2 Regression analysis

Linear regression models will be developed using the influent flow rates described in the previous subsection as the independent variable and pollutant removal performance data (from the composite samples) as the dependent variable. The suitability of the regression equation will be evaluated using the following diagnostics (described in more detail in Helsel and Hirsch [2002]):

- Data coverage – to develop a usable linear regression model, an adequate number of data must have been collected across the influent flow range of interest (i.e., 50 to 125 percent of the design hydraulic loading rate or velocity).
- Outliers – extreme outliers will be evaluated and removed if they impart undue influence on the regression relationship.
- Linearity – scatter plots will be used to determine if a linear regression model provides a good fit to the data; as necessary, data transformations will be performed to improve the linear fit.
- Constant variance – to obtain a valid linear regression model, the variance of the dependent variable should remain relatively constant across the range of values for the independent variable; as necessary, data transformations will be performed to remove or reduce this problem.
- Other explanatory variables – other explanatory variables correlated with the independent variable can influence the dependent variable. For example, influent concentrations of —source limited parameters can decrease as the influent flow rate increases; this can lead to an overall decrease in system performance. To evaluate this and other potential confounding factors, residuals from the linear regression model will be plotted against other likely explanatory variables. Advanced methods for performing linear regression analyses with multiple explanatory variables are described in Helsel and Hirsch (2002).

After performing these diagnostics to obtain the best linear regression model for the data, the p-value of the associated regression line will be evaluated to determine the statistical significance of the associated slope coefficient. If the p-value is greater than 0.05, the slope coefficient can be deemed insignificant (i.e., not significantly different from zero). In these instances it can be assumed that there is no relationship between flow and pollutant removal performance over the range of flow rates measured. If the p-value is less than or equal to 0.05, the slope coefficient can be deemed significant. In these instances, the linear regression model can be used to estimate mean system performance at the design hydraulic loading rate.

Given that the treatment goal is based on the mean individual removal efficiency values computed using Method #1 as described above, data below the lower reporting limit or detection limit, i.e. censored data, will be substituted using the detection limit.

The overall adequacy of the sampling design will be determined based on the satisfaction of the quality objectives outlined in this QAPP, the demonstration of a statistically significant difference between influent and effluent pollutant concentrations, and the satisfaction of minimum removal efficiency requirements (i.e., 80 percent TSS removal and 50 percent TP removal) using bootstrapping so it can be concluded that the system met the performance goal with the required 95 percent confidence.

17.0 References

Washington State Department of Ecology (WADOE). 2011. Guidance for Evaluating Emerging Stormwater Treatment Technologies: Technology Assessment Protocol—Ecology (TAPE). Olympia, WA.

Helsel, D.R. and R.M. Hirsch. 2002 . Statistical Methods in Water Resources. Elsevier Publications, Amsterdam.

Teledyne ISCO. 2012. ISCO 6712 Portable Samplers Installation and Operation Guide. Part #69-9003-588 of Assembly #60-9004-334. Lincoln, NE.

Teledyne ISCO. 2011. 730 Bubbler Module Installation and Operation Guide Part #60-9003-063. Lincoln, NE.

Texas Electronics, Inc. Date Unavailable. Series 525 Rainfall Sensors User's Manual. Dallas, TX. Available on 8/6/2012 at www.texaselectronics.com/pdf/manuals/TR-525.pdf.

APPENDIX C – Field Forms

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event ID
LPR021012

Field Recordkeeping Form

Date and Time of site visit: 2/13/12 9:00am
Reason for Site Visit: Sample collection, equipment re-set
Staff on Site: G. Tellessen
Current weather conditions: Sunny w/ broken clouds, cool

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 10/3
Influent pacing: 75
Number of effluent aliquots/bottles collected: 7/3
Effluent pacing: 75
Sample collection date and time (to be used for COC): 2/10/12 14:42
Runoff event qualified and samples sent to lab: **No Yes** Event #1

Field QC samples collected while on site: No Yes
Type of QC samples collected: ________
Sample collection time (to be used for COC): ________

Condition of sampling equipment: good working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics- passed

Site and System Observations
Major changes to site condition since last visit: no change
Additional activities occurring on site: none

CatchBasin/ Influent obstructions: **No Yes**
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes**
Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor: none/minimal
Sediment present on cartridge hood: **No Yes** Depth: ________
Condition of media: NT

Additional Notes: Samples represent first event. Time/date for event is first influent aliquot collected. Last was collected. 2/10/12 22:53.

Event ID
LPR021412

Field Recordkeeping Form

Date and Time of site visit: 2/15/12 10:00am
Reason for Site Visit: Sample collection, equipment reset
Staff on Site: G. Tellessen
Current weather conditions: Sunny, broken clouds

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 7/2
Influent pacing: 50
Number of effluent aliquots/bottles collected: 7/3
Effluent pacing: 50
Sample collection date and time (to be used for COC): 2/14/12 10:40
Runoff event qualified and samples sent to lab: **No** Yes Event #2

Field QC samples collected while on site: No Yes
Type of QC samples collected: ____
Sample collection time (to be used for COC): ____

Condition of sampling equipment: good working order
Bottles replaced: **No** **Yes**
Batteries replaced: **No** **Yes**
Desiccant replaced: **No** **Yes**
Equipment calibration procedures performed on site: diagnostics- passed

Site and System Observations
Major changes to site condition since last visit: no change
Additional activities occurring on site: none

CatchBasin/ Influent obstructions: **No** **Yes** ____
Influent flume obstructions: **No** **Yes** ____
Effluent and effluent flume obstructions: **No** **Yes** ____

Rain gage in working order: **No** **Yes** ____
Obstructions to rain gage: **No** **Yes** minimal organic matter removed from screen

Average depth of sediment on vault floor: minimal
Sediment present on cartridge hood: **No** **Yes** Depth: ____
Condition of media: NT

Additional Notes: Samples represent Event #2. COC time/date listed is for the first influent aliquot collected. last one was collected 2/14/12 at 19:05.

Event ID
LPR021712

Field Recordkeeping Form

Date and Time of site visit: 2/19/12 9:00 am
Reason for Site Visit: Sample collection, equipment reset.
Staff on Site: G. Tellessen
Current weather conditions: light rain

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 40/10
Influent pacing: 50
Number of effluent aliquots/bottles collected: 32/9
Effluent pacing: 50
Sample collection date and time (to be used for COC): 2/17/12 14:52
Runoff event qualified and samples sent to lab: **No Yes** Event #3

Field QC samples collected while on site: No Yes
Type of QC samples collected: ____
Sample collection time (to be used for COC): ____

Condition of sampling equipment: Pump tubing replaced in both samplers.
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed.

Site and System Observations
Major changes to site condition since last visit: no change
Additional activities occurring on site: traffic heavier then normal due to bridge work further up the road

CatchBasin/ Influent obstructions: **No Yes** ____
Influent flume obstructions: **No Yes** ____
Effluent and effluent flume obstructions: **No Yes** ____

Rain gage in working order: **No Yes** ____
Obstructions to rain gage: **No Yes** ____

Average depth of sediment on vault floor: minimal
Sediment present on cartridge hood: **No Yes** Depth: ____
Condition of media: NT

Additional Notes: COC time/date listed here is first influent aliquot collected. The last was collected 2/18/12 19:45.

Event ID
LPR022012

Field Recordkeeping Form

Date and Time of site visit: 2/21/12 9:00am
Reason for Site Visit: Sample collection, equipment reset
Staff on Site: G. Tellessen
Current weather conditions: light rain (cold!)

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 48/12
Influent pacing: 50
Number of effluent aliquots/bottles collected: 45/12
Effluent pacing: 50
Sample collection date and time (to be used for COC): 2/20/12 06:46 first influent aliquot.
Runoff event qualified and samples sent to lab: **No Yes** Event 4

Field QC samples collected while on site: No Yes
Type of QC samples collected: __________
Sample collection time (to be used for COC): __________

Condition of sampling equipment: working
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations
Major changes to site condition since last visit: no change
Additional activities occurring on site: possible sanding on bridge deck

CatchBasin/ Influent obstructions: **No Yes**
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes**
Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No Yes** Depth: NT
Condition of media: NT

Additional Notes: Samples represent Event #4

Event DQ'ed

Event ID
LPR022412

Field Recordkeeping Form

Date and Time of site visit: 2/27/12 11:00am
Reason for Site Visit: Sample collection, equipment reset
Staff on Site: G. Tellessen
Current weather conditions: Overcast, snow on ground (< 1/2 inch)

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 23/6
Influent pacing: 50
Number of effluent aliquots/bottles collected: 17/5
Effluent pacing: 50
Sample collection date and time (to be used for COC): 2/24/12 18:18 (first aliquot)
Runoff event qualified and samples sent to lab: No Yes event #15

Field QC samples collected while on site: No Yes
Type of QC samples collected: ___
Sample collection time (to be used for COC): ___

Condition of sampling equipment: working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations
Major changes to site condition since last visit: no
Additional activities occurring on site: possible graveling on bridge deck due to weekend storm event.
CatchBasin/ Influent obstructions: **No Yes** ___
Influent flume obstructions: **No Yes** ___
Effluent and effluent flume obstructions: **No Yes** ___

Rain gage in working order: **No Yes** ___
Obstructions to rain gage: **No Yes** ___

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No Yes** Depth: ___
Condition of media: NT

Additional Notes: time/date origionally recorded was for the first influent aliquot collected. The last was collected on 2/25/12 at 4:37.

Event ID
LPR 031012

Field Recordkeeping Form

Date and Time of site visit: 3/12/12 9:00am
Reason for Site Visit: Sample collection, equipment reset
Staff on Site: G. Tellessen
Current weather conditions: wet, overcast

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 20/6
Influent pacing: 50
Number of effluent aliquots/bottles collected: 8/3
Effluent pacing: 50
Sample collection date and time (to be used for COC): 3/10/12 15:46 (first aliquot)
Runoff event qualified and samples sent to lab: **No Yes** event #6

Field QC samples collected while on site: No Yes
Type of QC samples collected: ______
Sample collection time (to be used for COC): ______

Condition of sampling equipment: working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations
Major changes to site condition since last visit: no change
Additional activities occurring on site: high sediment levels seen on bridge deck.

CatchBasin/ Influent obstructions: **No Yes** ______
Influent flume obstructions: **No Yes** ______
Effluent and effluent flume obstructions: **No Yes** ______

Rain gage in working order: **No Yes** ______
Obstructions to rain gage: **No Yes** ______

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No Yes** Depth: ______
Condition of media: NT

Additional Notes: time/date originally recorded was for the first influent aliquot collected. The last was collected 3/11/12 @ 13:07.

[Event DQ'ed]

Event ID
LPR031212

Field Recordkeeping Form

Date and Time of site visit: 3/15/2012 9:00am
Reason for Site Visit: Sample collection, equipment reset
Staff on Site: G. Tellessen
Current weather conditions: wet, overcast, not currently raining

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 14/4
Influent pacing: 50
Number of effluent aliquots/bottles collected: 12/4
Effluent pacing: 50
Sample collection date and time (to be used for COC): 3/12/2012 20:24 (first aliquot)
Runoff event qualified and samples sent to lab: **No Yes** event #7

Field QC samples collected while on site: No Yes
Type of QC samples collected:
Sample collection time (to be used for COC):

Condition of sampling equipment: good working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations
Major changes to site condition since last visit: no change
Additional activities occurring on site: –

CatchBasin/ Influent obstructions: **No Yes**
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes**
Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No Yes** Depth:
Condition of media: NT

Additional Notes: maintenance of system reccmended; samples collected represent Event #7.

time/date recorded here is for the first influent aliquot collected. The last was collected 3/13/12 at 0:19

Event ID
LPR032912

Field Recordkeeping Form

Date and Time of site visit: 4/5/2012 9:30am
Reason for Site Visit: Sample collection, bottle replacement
Staff on Site: G. Tellessen
Current weather conditions: Rain, rain, rain

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 48/12
Influent pacing: 100
Number of effluent aliquots/bottles collected: 45/12
Effluent pacing: 100
Sample collection date and time (to be used for COC): 3/29/2012 13:19 (first aliquot)
Runoff event qualified and samples sent to lab: **No Yes** Event #8

Field QC samples collected while on site: No Yes
Type of QC samples collected: ____
Sample collection time (to be used for COC): ____

Condition of sampling equipment: good, working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics- passed

Site and System Observations
Major changes to site condition since last visit: no change
Additional activities occurring on site: bridge deck appears to have been swept recently
CatchBasin/ Influent obstructions: **No Yes** ____
Influent flume obstructions: **No Yes** ____
Effluent and effluent flume obstructions: **No Yes** ____

Rain gage in working order: **No Yes** ____
Obstructions to rain gage: **No Yes** ____

Average depth of sediment on vault floor: minimal
Sediment present on cartridge hood: **No Yes** Depth: ____
Condition of media: NT

Additional Notes: Samples represent Event #8
time/date recorded here is for first influent sample. last was collected 3/30/12 8:49
[Event DQ'ed]

Event ID
LPR052412

Field Recordkeeping Form

Date and Time of site visit: 5/24/12 4:15pm
Reason for Site Visit: Sample collection, bottle replacement, equipment reset
Staff on Site: G. Tellessen, J. Pedrick
Current weather conditions: wet, but not raining

Water quality samples collected while on site: **No** **Yes**
Number of influent aliquots/bottles collected: 13/4
Influent pacing: 40
Number of effluent aliquots/bottles collected: 15/4
Effluent pacing: 40
Sample collection date and time (to be used for COC): 5/24/12 08:43
Runoff event qualified and samples sent to lab: **No** **Yes** event #9

Field QC samples collected while on site: **No** **Yes**
Type of QC samples collected: ____
Sample collection time (to be used for COC): ____

Condition of sampling equipment: good working order
Bottles replaced: **No** **Yes**
Batteries replaced: **No** **Yes**
Desiccant replaced: **No** **Yes**
Equipment calibration procedures performed on site: diagnostics - passed
ODS unit - working properly

Site and System Observations
Major changes to site condition since last visit: no change
Additional activities occurring on site: no

CatchBasin/ Influent obstructions: **No** **Yes** ____
Influent flume obstructions: **No** **Yes** ____
Effluent and effluent flume obstructions: **No** **Yes** ____

Rain gage in working order: **No** **Yes** ____
Obstructions to rain gage: **No** **Yes** ____

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No** **Yes** Depth: ____
Condition of media: NT

Additional Notes: Samples represent Event #9. Time/date recorded is for first influent aliquot collected. last influent aliquot was collected 5/24/12 11:21 am.

Event ID

LPRO60112

Field Recordkeeping Form

Date and Time of site visit: 6/4/2012 9:45
Reason for Site Visit: Sample collection, bottle replacement, equipment reset.
Staff on Site: G. Tellessen GMT
Current weather conditions: wet + rainy

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 32/8
Influent pacing: 50
Number of effluent aliquots/bottles collected: 37/10
Effluent pacing: 50
Sample collection date and time (to be used for COC): 6/1/2012 19:36 (First aliquot)
Runoff event qualified and samples sent to lab: **No** Yes (Event 10)

Field QC samples collected while on site: ~~No~~ Yes
Type of QC samples collected: Screening parameters
Sample collection time (to be used for COC): 6/1/12 19:36

Condition of sampling equipment: working order
Bottles replaced: **No** Yes
Batteries replaced: **No** Yes
Desiccant replaced: **No** Yes
Equipment calibration procedures performed on site: diagnostics - passed

__Site and System Observations__
Major changes to site condition since last visit: no change
Additional activities occurring on site: no

CatchBasin/ Influent obstructions: No Yes
Influent flume obstructions: No Yes
Effluent and effluent flume obstructions: No Yes

Rain gage in working order: **No** Yes
Obstructions to rain gage: No Yes

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: No Yes Depth:
Condition of media: NT

__Additional Notes__: Samples represent Event #10

Time/date listed on form is for the first influent aliquot collected. The last was collected 6/2/12 at 2:47.

Event ID

LPR 060412

Field Recordkeeping Form

Date and Time of site visit: 6/5/2012 3:30pm
Reason for Site Visit: Sample collection, site visit
Staff on Site: G. Tellessen
Current weather conditions: rain/hail/wind

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 24/6
Influent pacing: 50
Number of effluent aliquots/bottles collected: 25/7
Effluent pacing: 50
Sample collection date and time (to be used for COC): 6/4/2012 17:37
Runoff event qualified and samples sent to lab: **No Yes**

Field QC samples collected while on site: No Yes
Type of QC samples collected:
Sample collection time (to be used for COC):

Condition of sampling equipment: working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed
ODS unit - working properly

Site and System Observations
Major changes to site condition since last visit: no change
Additional activities occurring on site: no

CatchBasin/ Influent obstructions: **No Yes**
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes**
Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No Yes** Depth:
Condition of media: NT

Additional Notes: Represent Event #11

Time/Date listed on form is for the first aliquot collected (influent). last was collected 6/5/14 4:14 am

Event ID
LPRO60712

Field Recordkeeping Form – LRR

Date and Time of site visit: 6/8/12 9:30 am
Reason for Site Visit: Sample collection, bottle replacement
Staff on Site: G. Tellessen
Current weather conditions: wet but not currently raining

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 24/6
Influent pacing: 50
Number of effluent aliquots/bottles collected: 25/7
Effluent pacing: 50
Sample collection date and time (to be used for COC): 6/7/2012 06:21
Runoff event qualified and samples sent to lab: **No Yes**

Field QC samples collected while on site: No Yes
Type of QC samples collected:
Sample collection time (to be used for COC):

Condition of sampling equipment: working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics – passed

Site and System Observations
Major changes to site condition since last visit: no change
Additional activities occurring on site: no

CatchBasin/ Influent obstructions: **No Yes**
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes**
Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No Yes** Depth:
Condition of media: NT

Additional Notes: Represents Event #12. Time / Date listed is for the first influent aliquot collected. Last was collected on 6/7/12 at 18:04.

Event ID

LPR110612

Field Recordkeeping Form

Date and Time of site visit: 11/7/12 1:00pm
Reason for Site Visit: sample collection; equipment reset
Staff on Site: G. Tellessen
Current weather conditions: wet, but not raining, broken clouds.

Water quality samples collected while on site: No Yes

Number of influent aliquots/bottles collected: 13/4

Influent pacing: 75

Number of effluent aliquots/bottles collected: 16/5

Effluent pacing: 75

Sample collection date and time (to be used for COC): 11/6/2012 21:51 first influent aliquot

Runoff event qualified and samples sent to lab: **No Yes**

Field QC samples collected while on site: No Yes

Type of QC samples collected:

Sample collection time (to be used for COC):

Condition of sampling equipment: good working order

Bottles replaced: **No Yes**

Batteries replaced: **No Yes**

Desiccant replaced: **No Yes**

Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations

Major changes to site condition since last visit: no

Additional activities occurring on site: no

CatchBasin/ Influent obstructions: **No Yes**

Influent flume obstructions: **No Yes**

Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes**

Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor: NT

Sediment present on cartridge hood: **No Yes** Depth: NT

Condition of media: NT

Additional Notes: COC time listed is for the first influent aliquot collected. last was collected 11/7/12 @ 4:27 am.

Event ID
LPR111112

Field Recordkeeping Form

Date and Time of site visit: 11/12/12 9:30am
Reason for Site Visit: Sample collection, equipment reset
Staff on Site: G. Tellessen
Current weather conditions: cool, light rain

Water quality samples collected while on site: **No** **Yes**

Number of influent aliquots/bottles collected: 32/8
Influent pacing: 75
Number of effluent aliquots/bottles collected: 31/8
Effluent pacing: 75
Sample collection date and time (to be used for COC): 11/11/12 16:11 first influent aliquot.
Runoff event qualified and samples sent to lab: **No** **Yes**

Field QC samples collected while on site: **No** **Yes**

Type of QC samples collected: Duplicates
Sample collection time (to be used for COC): 11/11/12 16:11

Condition of sampling equipment:

Bottles replaced: **No** **Yes**
Batteries replaced: **No** **Yes**
Desiccant replaced: **No** **Yes**

Equipment calibration procedures performed on site: diagnostics - passed.

Site and System Observations

Major changes to site condition since last visit: no
Additional activities occurring on site: none

CatchBasin/ Influent obstructions: **No** **Yes**
Influent flume obstructions: **No** **Yes**
Effluent and effluent flume obstructions: **No** **Yes**

Rain gage in working order: **No** **Yes**
Obstructions to rain gage: **No** **Yes**

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No** **Yes** Depth:
Condition of media: NT

Additional Notes: COC time/date listed is based on the first influent aliquot collected. The last was collected 11/12/12 at 4:06 am.

[Event DQ'ed]

Event ID
LPR 112312

Field Recordkeeping Form

Date and Time of site visit: 11/26/12 9:00am
Reason for Site Visit: Sample collection, RG fix, equipment reset
Staff on Site: G. Tellessen
Current weather conditions: Cold, dry, Clear, windy

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 48/12 bottles
Influent pacing: 100
Number of effluent aliquots/bottles collected: 41 / 11 bottles
Effluent pacing: 100
Sample collection date and time (to be used for COC): 11/23/12 15:26
Runoff event qualified and samples sent to lab: **No Yes**

Field QC samples collected while on site: ~~No~~ Yes
Type of QC samples collected: screening parameters
Sample collection time (to be used for COC): 11/23/12 15:26

Condition of sampling equipment: good, working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations
Major changes to site condition since last visit: no
Additional activities occurring on site: no

CatchBasin/ Influent obstructions: **No Yes**
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes** obstructions removed, rain gage working again.
Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor:
Sediment present on cartridge hood: **No Yes** Depth:
Condition of media:

Additional Notes: Screening parameters submitted for this event. No rain data for this event; backup data from the Fort Deposit site will be used as a substitute.

[event DQ'ed]

Event ID
LPR113012

Field Recordkeeping Form

Date and Time of site visit: 12/3/12 9:00am
Reason for Site Visit: Sample collection, equipment reset
Staff on Site: G. Tellessen
Current weather conditions: wet and cloudy but not raining

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 27 / 7 bottles
Influent pacing: 100
Number of effluent aliquots/bottles collected: 15/4 bottles
Effluent pacing: 100
Sample collection date and time (to be used for COC): 11/30/12 22:28
Runoff event qualified and samples sent to lab: No Yes sent in w/ duplicates

Field QC samples collected while on site: ~~No~~ Yes
Type of QC samples collected: Duplicates
Sample collection time (to be used for COC): 11/30/12 22:28

Condition of sampling equipment: Good, working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations
Major changes to site condition since last visit: no
Additional activities occurring on site: no

CatchBasin/ Influent obstructions: **No Yes**
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes**
Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No Yes** Depth: NT
Condition of media: NT

Additional Notes: CoC time/date recorded is for the first influent aliquot collected. The last was collected on 12/1/12 at 7:43.

Event ID
LPR051713

Field Recordkeeping Form

Date and Time of site visit: 5/20/13 8:30am arrival
Reason for Site Visit: Sample collection, equipment reset
Staff on Site: G. Tellessen
Current weather conditions: Rainy & wet

Water quality samples collected while on site: No **Yes**
Number of influent aliquots/bottles collected: 4 bottles (16 aliquots)
Influent pacing: 50
Number of effluent aliquots/bottles collected: 4 bottles (13 aliquots)
Effluent pacing: 50
Sample collection date and time (to be used for COC): 5/17/13 20:33 } first influent sample.
Runoff event qualified and samples sent to lab: No **Yes**

Field QC samples collected while on site: **No** Yes
Type of QC samples collected: ____
Sample collection time (to be used for COC): ____

Condition of sampling equipment: Good working order (minus Rain gage)
Bottles replaced: No **Yes**
Batteries replaced: **No** Yes
Desiccant replaced: No **Yes**
Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations

Major changes to site condition since last visit: no
Additional activities occurring on site: none

CatchBasin/ Influent obstructions: **No** Yes ____
Influent flume obstructions: **No** Yes ____
Effluent and effluent flume obstructions: **No** Yes ____

Rain gage in working order: **No** Yes Rain gage not working properly
Obstructions to rain gage: **No** Yes will need to use backup for event ISR.

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No** Yes Depth: ____
Condition of media: NT

Additional Notes: COC time/Date corresponds to the first influent aliquot collected. The last was collected 5/18/13 5:05am.

Event ID
LPR052113

Field Recordkeeping Form

Date and Time of site visit: 5/22/13
Reason for Site Visit: Sample collection, equipment reset
Staff on Site: G. Tellessen
Current weather conditions: light rain

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 9/35 aliquots (4 aliquots per bottle)
Influent pacing: 75
Number of effluent aliquots/bottles collected: 7/28 aliquots
Effluent pacing: 75
Sample collection date and time (to be used for COC): 5/21/13 15:37
Runoff event qualified and samples sent to lab: **No Yes**

Field QC samples collected while on site: No Yes
Type of QC samples collected: ____
Sample collection time (to be used for COC): ____

Condition of sampling equipment: good, working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations
Major changes to site condition since last visit: no
Additional activities occurring on site: none

CatchBasin/ Influent obstructions: **No Yes**
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes**
Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No Yes** Depth: NT
Condition of media: NT

Additional Notes: COC time/date correlates with first influent aliquot collected. Last was collected 5/21/13 at 21:45.

Event ID

LPR062513

Field Recordkeeping Form

Date and Time of site visit: 6/26/13

Reason for Site Visit: Sample collection, equipment reset.

Staff on Site: G. Tellessen.

Current weather conditions:

Water quality samples collected while on site: No **Yes**

Number of influent aliquots/bottles collected: 26/7

Influent pacing: 100

Number of effluent aliquots/bottles collected: 24/6

Effluent pacing: 100

Sample collection date and time (to be used for COC): 6/25/13 15:36 > first influent aliquot

Runoff event qualified and samples sent to lab: No **Yes**

Field QC samples collected while on site: **No** Yes

Type of QC samples collected:

Sample collection time (to be used for COC):

Condition of sampling equipment: working order

Bottles replaced: No **Yes**

Batteries replaced: No **Yes**

Desiccant replaced: No **Yes**

Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations

Major changes to site condition since last visit: NO

Additional activities occurring on site: none

CatchBasin/ Influent obstructions: **No** Yes

Influent flume obstructions: **No** Yes

Effluent and effluent flume obstructions: **No** Yes

Rain gage in working order: No **Yes**

Obstructions to rain gage: **No** Yes ~~minimal~~ debris removed from screen.

Average depth of sediment on vault floor: NT

Sediment present on cartridge hood: **No** Yes Depth: none

Condition of media: NT

Additional Notes: time/date for coc correlates to first influent aliquot collected. Last influent aliquot was collected 6/25/13 at 19:09.

Event ID LPR013014

Field Recordkeeping Form

Date and Time of site visit: 1/30/14 15:00
Reason for Site Visit: Sample collection
Staff on Site: G. Tellessen
Current weather conditions: wet, not currently raining

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 36 - single bottle
Influent pacing: 50
Number of effluent aliquots/bottles collected: 41 - single bottle
Effluent pacing: 50
Sample collection date and time (to be used for COC): 1/30/14 12:58
Runoff event qualified and samples sent to lab: No Yes
last influent aliquot collected.

Field QC samples collected while on site: ~~No~~ Yes
Type of QC samples collected: Screening parameters
Sample collection time (to be used for COC): 1/30/14 12:58

Condition of sampling equipment: Good, working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed.

Site and System Observations
Major changes to site condition since last visit: no
Additional activities occurring on site: no

CatchBasin/ Influent obstructions: **No Yes**
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes**
Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No Yes** Depth: NT
Condition of media: NT

Additional Notes:

Event ID
LPR 030314

Field Recordkeeping Form

Date and Time of site visit: 3/4/14
Reason for Site Visit: Sample collection
Staff on Site: J. Pedricks
Current weather conditions: overcast

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: Single composite, 31
Influent pacing: -
Number of effluent aliquots/bottles collected: Single composite, 43
Effluent pacing: -
Sample collection date and time (to be used for COC): 3/3/14 12:00
Runoff event qualified and samples sent to lab: **No Yes**

Field QC samples collected while on site: No Yes
Type of QC samples collected: Screening parameters.
Sample collection time (to be used for COC): 3/3/14 12:00

Condition of sampling equipment: good, working order.
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: Diagnostics passed

Site and System Observations
Major changes to site condition since last visit: no
Additional activities occurring on site: none

CatchBasin/ Influent obstructions: **No Yes**
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes**
Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No Yes** Depth: NT
Condition of media: NT

Additional Notes:

Event ID
LPR030814

Field Recordkeeping Form

Date and Time of site visit: 3/10/14 10am
Reason for Site Visit: Sample collection, equipment reset
Staff on Site: J. Pedrick
Current weather conditions: overcast, dry

Water quality samples collected while on site: No Yes

Number of influent aliquots/bottles collected: 47/1
Influent pacing: 50
Number of effluent aliquots/bottles collected: 48/1
Effluent pacing: 50
Sample collection date and time (to be used for COC): 3/8/14 15:00
Runoff event qualified and samples sent to lab: **No Yes**

first influent aliquot

Field QC samples collected while on site: No Yes

Type of QC samples collected: Screening parameters
Sample collection time (to be used for COC): 3/8/14 15:00

Condition of sampling equipment: working

Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**

Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations

Major changes to site condition since last visit: no
Additional activities occurring on site: none

CatchBasin/ Influent obstructions: **No Yes**
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes**
Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No Yes** Depth: NT
Condition of media: NT

Additional Notes: COC time/date reflects first influent aliquot collected. Last was 3/9/14 at 4:50am.

[Event DQ'ed]

Event ID
LPR042214

Field Recordkeeping Form

Date and Time of site visit: 4/24/14 4pm
Reason for Site Visit: Sample collection, equipment reset
Staff on Site: J. Pedrick
Current weather conditions: clear, dry

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 50/1
Influent pacing: 40
Number of effluent aliquots/bottles collected: 50/1
Effluent pacing: 40
Sample collection date and time (to be used for COC): 4/23/14 13:30 last aliquot collected
Runoff event qualified and samples sent to lab: **No Yes**

Field QC samples collected while on site: No Yes
Type of QC samples collected: Screening parameters, duplicates.
Sample collection time (to be used for COC): 4/23/14 13:30

Condition of sampling equipment: working
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics – passed

Site and System Observations
Major changes to site condition since last visit: no
Additional activities occurring on site: none

CatchBasin/ Influent obstructions: **No Yes**
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes**
Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No Yes** Depth: NT
Condition of media: NT

Additional Notes: ID after first aliquot (influent) collected 4/22/14 at 14:33

[event DQ'ed]

Event ID
LPR011815

Field Recordkeeping Form

Date and Time of site visit: 1/19/15 9am
Reason for Site Visit: Sample collection, equipment reset
Staff on Site: G. Tellessen
Current weather conditions: light rain.

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 35/1
Influent pacing: ________
Number of effluent aliquots/bottles collected: 38/1
Effluent pacing: ________
Sample collection date and time (to be used for COC): 1/18/15 ~~[illegible]~~ 1:48 last influent aliquot collected
Runoff event qualified and samples sent to lab: No Yes

Field QC samples collected while on site: No Yes
Type of QC samples collected: Screening parameters
Sample collection time (to be used for COC): 1/18/15 ~~[illegible]~~ 1:48

Condition of sampling equipment: good, working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations
Major changes to site condition since last visit: NO
Additional activities occurring on site: None

CatchBasin/ Influent obstructions: **No Yes**
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes**
Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No Yes** Depth: NT
Condition of media: NT

Additional Notes: ________

Event ID

LPR020215

Field Recordkeeping Form

Date and Time of site visit: 2/3/15 10am
Reason for Site Visit: Sample collection, equipment reset
Staff on Site: G. Tellessen
Current weather conditions: overcast, dry

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: 16/1
Influent pacing: 50
Number of effluent aliquots/bottles collected: 14/1
Effluent pacing: 50
Sample collection date and time (to be used for COC): 2/2/15 10:51
Runoff event qualified and samples sent to lab: **No Yes**

Field QC samples collected while on site: No Yes
Type of QC samples collected: __________
Sample collection time (to be used for COC): __________

Condition of sampling equipment: Good
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations
Major changes to site condition since last visit: NO
Additional activities occurring on site: None

CatchBasin/ Influent obstructions: **No Yes**
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes**
Obstructions to rain gage: **No Yes**

Average depth of sediment on vault floor: NT
Sediment present on cartridge hood: **No Yes** Depth: NT
Condition of media: NT

Additional Notes:

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APPENDIX D – Individual Storm Reports

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Individual Storm Report

LPR021412

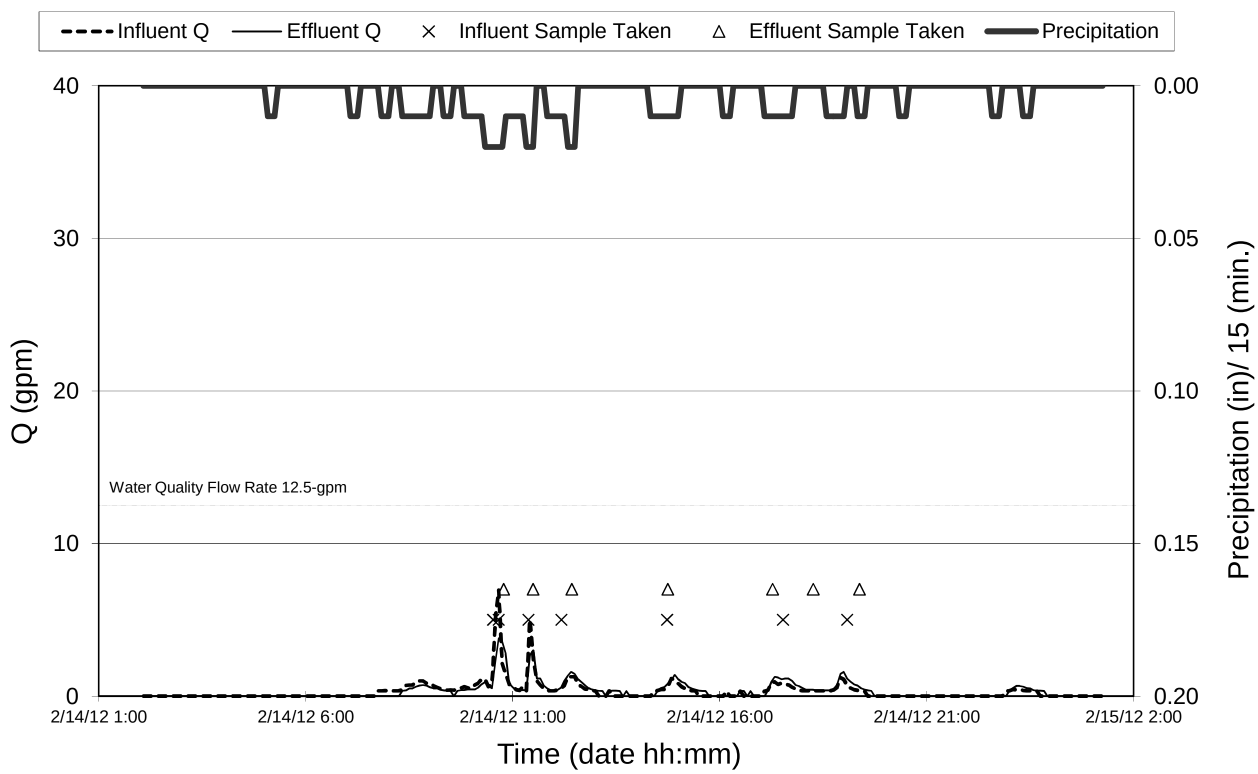
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	2/2/2012
Event Date:	2/14/2012
Antecedent Conditions (hr):	Pre-Event: 21 Post-Event: 36

Hydrology

Total Precipitation (in):	0.34		
Precipitation Duration (hrs):	18		
Rainfall Intensity (in/hr):	Max: 0.12	Average: 0.01	
Total Runoff Volume (gal):	Influent: 442	Effluent: 459	Bypass: 0.00
Peak Flow, (gpm):	Influent: 7.0	Effluent: 3.8	
Average Flow (gpm):	Influent: 0.3	Effluent: 0.3	
Storm Coverage (%):	Influent: 81	Effluent: 78	
Sampling Duration (hrs):	Influent: 8	Effluent: 8	

Event Hydrograph



Storm Name: LPR021412 Reviewed and Verified:

Individual Storm Report

LPR021412

Analytical

	Parameter	Concentrations (mg/L)				Discrete Removal
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
	TSS (SM)	539	32.0	10.00	20%	94%
Number of Aliquots:	SSC	404	35.0	3.85	20%	91%
IN: 7	TVSS	197	10.4	3.85	20%	95%
EFF: 7	SSC (<2000 µm)	NT	NT	NT	---	---
	TVSS (<2000 µm)	NT	NT	NT	---	---
	SSC (<500 µm)	NT	NT	NT	---	---
	TVSS (<500 µm)	NT	NT	NT	---	---
	SSC (<250 µm)	NT	NT	NT	---	---
	TVSS (<250µm)	NT	NT	NT	---	---
	SSC (<100 µm)	NT	NT	NT	---	---
	TVSS (<100 µm)	NT	NT	NT	---	---
	SSC (<62.5 µm)	NT	NT	NT	---	---
	TVSS (<62.5 µm)	NT	NT	NT	---	---
	SSC (<50 µm)	163	30.0	3.70	20%	82%
	TVSS (<50 µm)	29.5	9.26	3.70	20%	69%
	Total Phosphorus	0.22	0.0620	0.0200	0.486%	72%
	Dissolved Phosphorus	ND	ND	0.500	20%	undeterminable
	SRP (Ortho-phosphorus)	ND	ND	0.0100	20%	undeterminable
	TKN	1.14	0.516	0.500	12.9%	55%
	Nitrate/Nitrite-N	0.0641	ND	0.0300	0.72%	53%
	Ammonia	ND	ND	0.0500	20%	undeterminable
	Total Lead	NT	NT	NT	---	---
	Total Copper	NT	NT	NT	---	---
	Total Zinc	NT	NT	NT	---	---
	Aluminum	NT	NT	NT	---	---
	Dissolved Copper	NT	NT	NT	---	---
	Diccolved Zinc	NT	NT	NT	---	---
	Hardness	NT	NT	NT	---	---
	pH	NT	NT	NT	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. ND= non-detect value. NT = parameter was not tested. Parameters listed in bold text did not meet standard hold times.

Storm Name: LPR021412 Reviewed and Verified:

Individual Storm Report

LPR021712

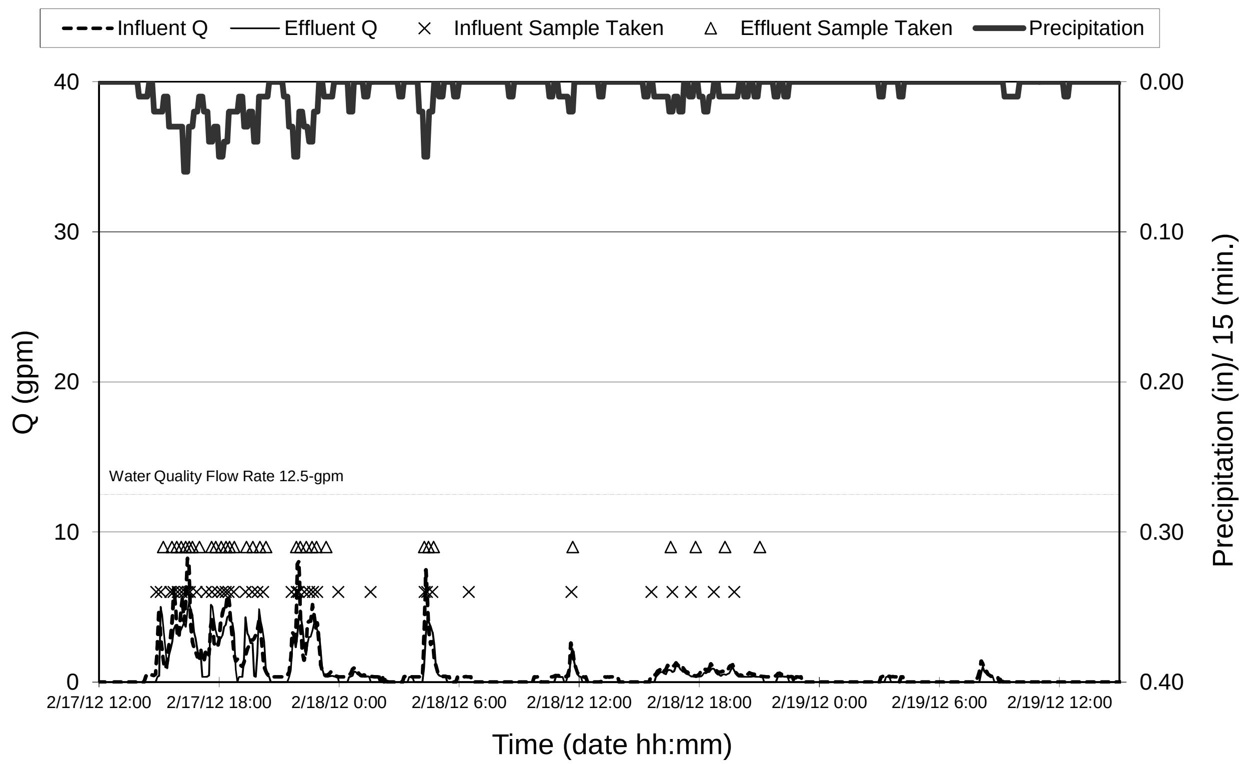
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	2/2/2012
Event Date:	2/17/2012
Antecedent Conditions (hrs):	Pre-Event: 18 Post-Event: 14

Hydrology

Total Precipitation (in):	1.34		
Precipitation Duration (hrs):	46		
Rainfall Intensity (in/hr):	Max: 0.36	Average: 0.02	
Total Runoff Volume (gal):	Influent: 2127	Effluent: 1651	Bypass: 0.00
Peak Flow, (gpm):	Influent: 8.3	Effluent: 5.3	
Average Flow (gpm):	Influent: 0.6	Effluent: 0.5	
Storm Coverage (%):	Influent: 94	Effluent: 97	
Sampling Duration (hrs):	Influent: 28	Effluent: 29	

Event Hydrograph



 Reviewed and Verified:

Individual Storm Report

LPR021712

Analytical

	Parameter	Influent EMC (Concentrations (mg/L))	Effluent EMC	MRL	Dup. RPD	Discrete Removal Efficiency
	TSS (SM)	387	48.0	10.0	20%	88%
Number of Aliquots:	SSC	414	53.5	6.67	2.94%	87%
IN: 40	TVSS	185	15.2	6.67	20%	92%
EFF: 32	SSC (<2000 µm)	397	52.8	6.67	2.94%	87%
	TVSS (<2000 µm)	167	15.2	6.67	20%	91%
	SSC (<500 µm)	270	51.9	5.00	2.94%	81%
	TVSS (<500 µm)	81.5	14.8	5.00	20%	82%
	SSC (<250 µm)	NT	NT	NT	---	---
	TVSS (<250 µm)	NT	NT	NT	---	---
	SSC (<100 µm)	239	48.1	5.00	2.94%	80%
	TVSS (<100 µm)	60.0	14.1	5.00	20%	77%
	SSC (<62.5 µm)	NT	NT	NT	---	---
	TVSS (<62.5 µm)	NT	NT	NT	---	---
	SSC (<50 µm)	208	43.6	5.00	2.94%	79%
	TVSS (<50 µm)	50.0	12.3	5.00	20%	75%
	Total Phosphorus	0.310	0.0674	0.0200	0.486%	78%
	Dissolved Phosphorus	ND	ND	0.500	20%	undeterminable
	SRP (Ortho-phosphorus)	ND	ND	0.0100	0.00%	undeterminable
	TKN	1.52	0.623	0.500	12.9%	59%
	Nitrate/Nitrite-N	0.0564	ND	0.0300	0.724%	47%
	Ammonia	ND	ND	0.0500	20%	undeterminable
	Total Lead	0.0128	0.00337	0.00500	2.8%	74%
	Total Copper	0.0320	0.00599	0.01000	2.39%	81%
	Total Zinc	0.151	0.0335	0.05000	1.94%	78%
	Aluminum	9.15	1.86	0.100	20%	80%
	Dissolved Copper	NT	NT	NT	---	---
	Dissolved Zinc	NT	NT	NT	---	---
	Hardness	60.4	18.7	0.66200	20%	69%
	pH	NT	NT	NT	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Individual Storm Report

LPR022412

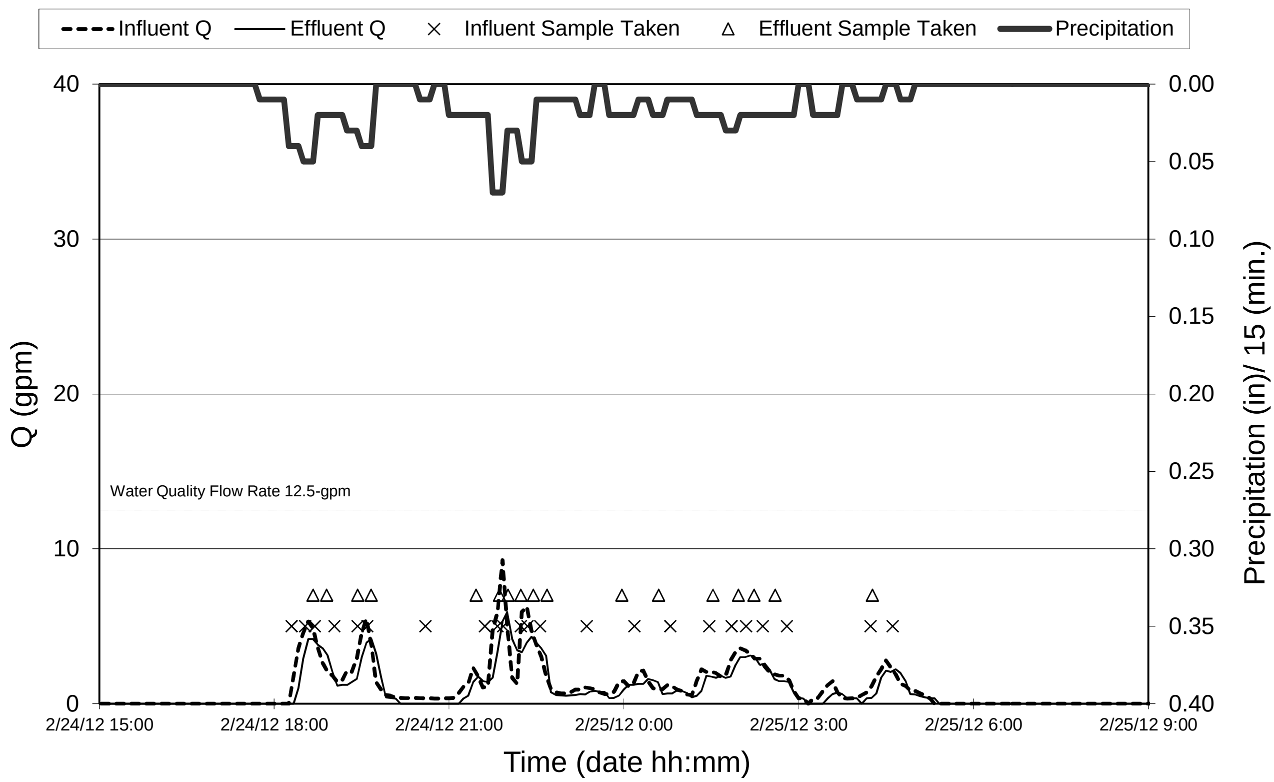
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	2/2/2012
Event Date:	2/24/2012
Antecedent Conditions (hr):	Pre-Event: 31 Post-Event: 11

Hydrology

Total Precipitation (in):	0.80		
Precipitation Duration (hrs):	11		
Rainfall Intensity (in/hr):	Max: 0.48	Average: 0.04	
Total Runoff Volume (gal):	Influent: 1149	Effluent: 993	Bypass: 0.00
Peak Flow, (gpm):	Influent: 9.27	Effluent: 5.94	
Average Flow (gpm):	Influent: 1.0	Effluent: 0.8	
Storm Coverage (%):	Influent: 100	Effluent: 91	
Sampling Duration (hrs):	Influent: 10	Effluent: 9	

Event Hydrograph



Storm Name: LPR022412

Reviewed and Verified:

Individual Storm Report

LPR022412

Analytical

	Parameter	Concentrations (mg/L)				Discrete Removal
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
	TSS (SM)	512	43.0	10.0	20%	92%
Number of Aliquots:	SSC	507	52.7	2.72	17.8%	90%
IN: 23	TVSS	235	14.0	2.72	20%	94%
EFF: 17	SSC (<2000 µm)	589	52.4	7.30	17.8%	91%
	TVSS (<2000 µm)	245	13.5	7.30	20%	94%
	SSC (<500 µm)	309	51.8	2.94	17.8%	83%
	TVSS (<500 µm)	90.9	12.8	2.94	20%	86%
	SSC (<250 µm)	NT	NT	NT	---	---
	TVSS (<250 µm)	NT	NT	NT	---	---
	SSC (<100 µm)	225	53.7	2.98	17.8%	76%
	TVSS (<100 µm)	43.2	13.2	2.98	20%	69%
	SSC (<62.5 µm)	NT	NT	NT	---	---
	TVSS (<62.5 µm)	NT	NT	NT	---	---
	SSC (<50 µm)	148	46.4	3.98	17.8%	69%
	TVSS (<50 µm)	29.1	11.6	3.98	20%	60%
	Total Phosphorus	0.424	0.0701	0.0200	9.41%	83%
	Dissolved Phosphorus	ND	ND	0.500	20%	undeterminable
	SRP (Ortho-phosphorus)	ND	ND	0.0100	0.00%	undeterminable
	TKN	1.09	ND	0.500	20%	54%
	Nitrate/Nitrite-N	ND	ND	0.0300	9.05%	undeterminable
	Ammonia	ND	ND	0.0500	20%	undeterminable
	Total Lead	0.0146	0.00331	0.00500	20%	77%
	Total Copper	0.0316	0.00472	0.01000	0.20%	85%
	Total Zinc	0.191	0.0306	0.05000	20%	84%
	Aluminum	9.65	1.99	0.100	20%	79%
	Dissolved Copper	NT	NT	NT	---	---
	Dissolved Zinc	NT	NT	NT	---	---
	Hardness	80.1	23.4	0.662	20%	71%
	pH	NT	NT	NT	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Storm Name: LPR022412 Reviewed and Verified:

Individual Storm Report

LPR031212

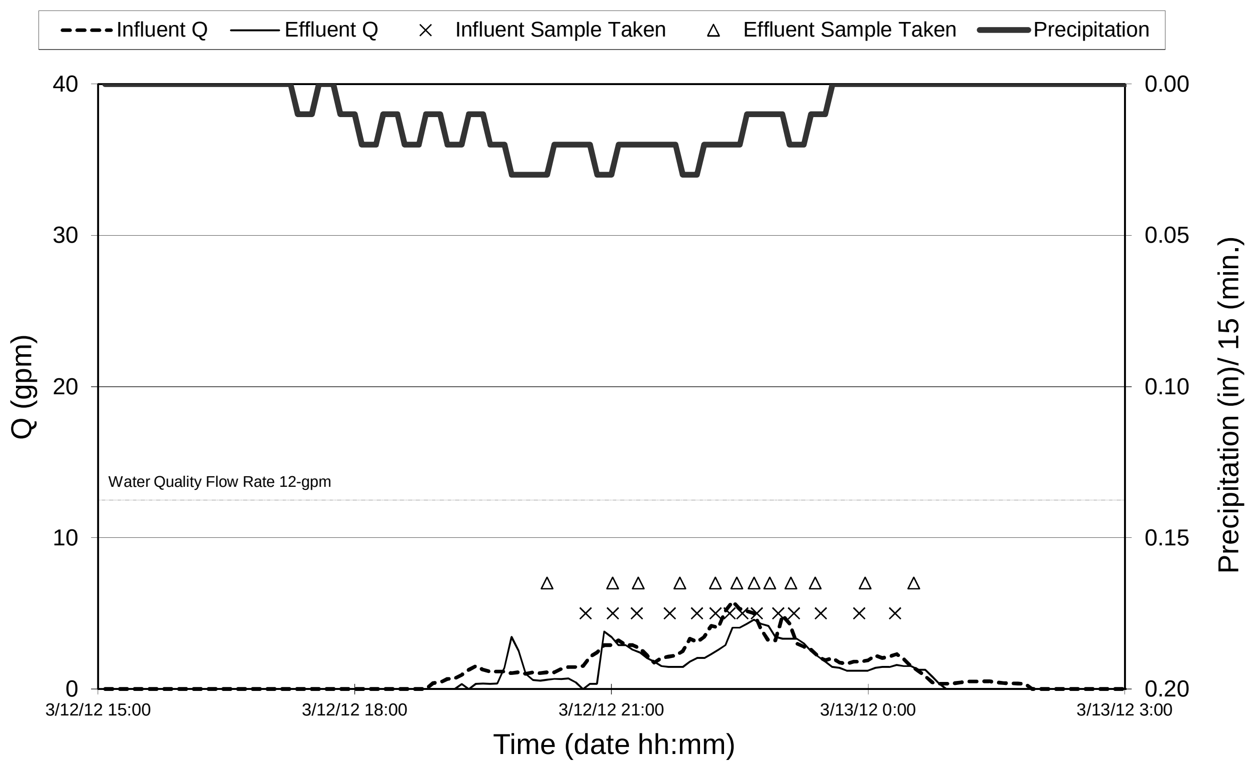
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	2/2/2012
Event Date:	3/12/2012
Antecedent Conditions (hr):	Pre-Event: 28 Post-Event: 16

Hydrology

Total Precipitation (in):	0.44		
Precipitation Duration (hrs):	6		
Rainfall Intensities (in/hr):	Max: 0.12	Average: 0.03	
Total Runoff Volume (gal):	Influent: 836	Effluent: 629	Bypass: 0.00
Peak Flow, (gpm):	Influent: 5.8	Effluent: 4.6	
Average Flow (gpm):	Influent: 1.1	Effluent: 0.8	
Storm Coverage (%):	Influent: 83	Effluent: 95	
Sampling Duration (hrs):	Influent: 3	Effluent: 4	

Event Hydrograph



Storm Name: LPR031212

Reviewed and Verified:

Individual Storm Report

LPR031212

Analytical

	Parameter	Concentrations (mg/L)				Discrete Removal
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
	TSS (SM)	150	18	10	20%	88%
Number of Aliquots:	SSC	220	ND	34	25.6%	85%
IN: 14	TVSS	110	ND	34	20%	69%
EFF: 12	SSC (<2000 µm)	120	ND	27	25.6%	78%
	TVSS (<2000 µm)	34	ND	27	20%	21%
	SSC (<500 µm)	190	ND	27	25.6%	86%
	TVSS (<500 µm)	88	ND	27	20%	69%
	SSC (<250 µm)	NT	NT	NT	---	---
	TVSS (<250 µm)	NT	NT	NT	---	---
	SSC (<100 µm)	95	ND	19	25.6%	80%
	TVSS (<100 µm)	21.0	ND	19	20%	undeterminable
	SSC (<62.5 µm)	NT	NT	NT	---	---
	TVSS (<62.5 µm)	NT	NT	NT	---	---
	SSC (<50 µm)	88	ND	20	25.6%	77%
	TVSS (<50 µm)	ND	ND	20	20%	undeterminable
	Total Phosphorus	0.150	0.037	0.020	20%	75%
	Dissolved Phosphorus	ND	ND	0.50	20%	undeterminable
	SRP (Ortho-phosphorus)	ND	ND	0.010	20%	undeterminable
	TKN	0.61	ND	0.50	20%	undeterminable
	Nitrate/Nitrite-N	ND	ND	0.30	20%	undeterminable
	Ammonia	ND	ND	0.50	20%	undeterminable
	Total Lead	0.0057	0.0016	0.0050	20%	72%
	Total Copper	0.012	0.00260	0.010	20%	78%
	Total Zinc	0.068	0.017	0.0500	20%	75%
	Aluminum	4.3	0.81	0.10	20%	81%
	Dissolved Copper	NT	NT	NT	---	---
	Dissolved Zinc	NT	NT	NT	---	---
	Hardness	28	10	0.20	20%	64%
	pH	NT	NT	NT	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Individual Storm Report

LPR052412

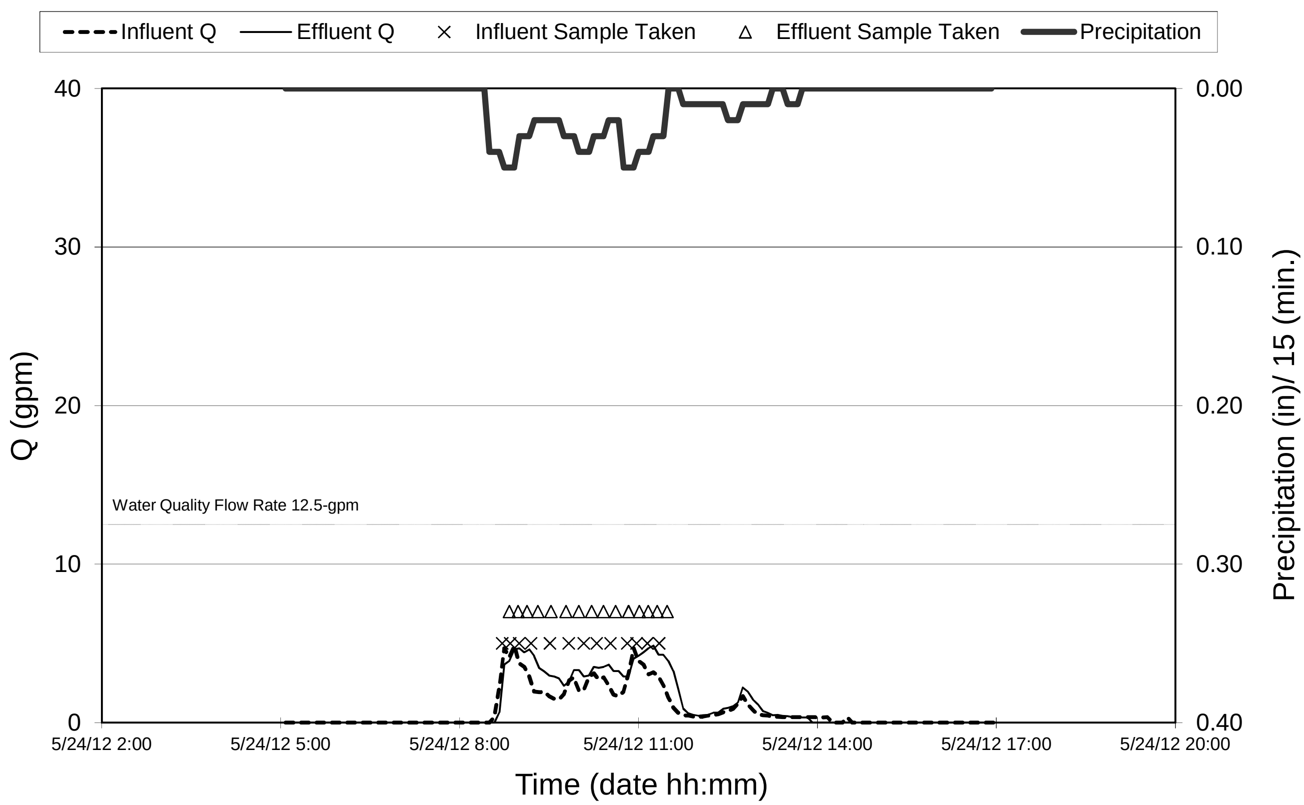
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon	
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres	
Date of Last Maintenance:	3/27/2012	
Event Date:	5/24/2012	
Antecedent Conditions (hr):	Pre-Event: 4	Post-Event: 48

Hydrology

Total Precipitation (in):	0.48		
Precipitation Duration (hrs):	5		
Rainfall Intensity (in/hr):	Max: 0.24	Average: 0.04	
Total Runoff Volume (gal):	Influent: 573	Effluent: 753	Bypass: 0.00
Peak Flow (gpm):	Influent: 4.9	Effluent: 4.9	
Average Flow (gpm):	Influent: 0.9	Effluent: 1.1	
Storm Coverage (%):	Influent: 85	Effluent: 80	
Sampling Duration (hrs):	Influent: 2	Effluent: 2	

Event Hydrograph



Storm Name: LPR052412 Reviewed and Verified:

Individual Storm Report

LPR052412

Analytical

	Parameter	Concentrations (mg/L)				Discrete Removal
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
	TSS (SM)	510	43	10	20%	92%
Number of Aliquots:	SSC	830	47	22	2.38%	94%
IN: 13	TVSS	360	ND	22	20%	94%
EFF: 15	SSC (<2000 µm)	850	46	22	2.38%	95%
	TVSS (<2000 µm)	370	ND	22	20%	94%
	SSC (<500 µm)	400	47	22	2.38%	88%
	TVSS (<500 µm)	100	ND	22	20%	78%
	SSC (<250 µm)	NT	NT	NT	---	---
	TVSS (<250 µm)	NT	NT	NT	---	---
	SSC (<100 µm)	230	45	22	2.38%	80%
	TVSS (<100 µm)	42.0	ND	22	20%	48%
	SSC (<62.5 µm)	NT	NT	NT	---	---
	TVSS (<62.5 µm)	NT	NT	NT	---	---
	SSC (<50 µm)	200	41	37	2.38%	80%
	TVSS (<50 µm)	ND	ND	37	20%	undeterminable
	Total Phosphorus	0.17	0.070	0.020	1%	59%
	Dissolved Phosphorus	ND	ND	0.50	20%	undeterminable
	SRP (Ortho-phosphorus)	ND	ND	0.010	20%	undeterminable
	TKN	1.7	ND	0.50	20%	71%
	Nitrate/Nitrite-N	ND	ND	0.30	20%	undeterminable
	Ammonia	ND	ND	0.050	20%	undeterminable
	Total Lead	ND	ND	0.050	20%	undeterminable
	Total Copper	ND	ND	0.10	20%	undeterminable
	Total Zinc	ND	ND	0.50	20%	undeterminable
	Aluminum	9.7	1.3	1.0	0%	87%
	Dissolved Copper	NT	NT	NT	---	---
	Dissolved Zinc	NT	NT	NT	---	---
	Hardness	38	6.8	0.20	20%	82%
	pH	NT	NT	NT	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Individual Storm Report

LPR060112

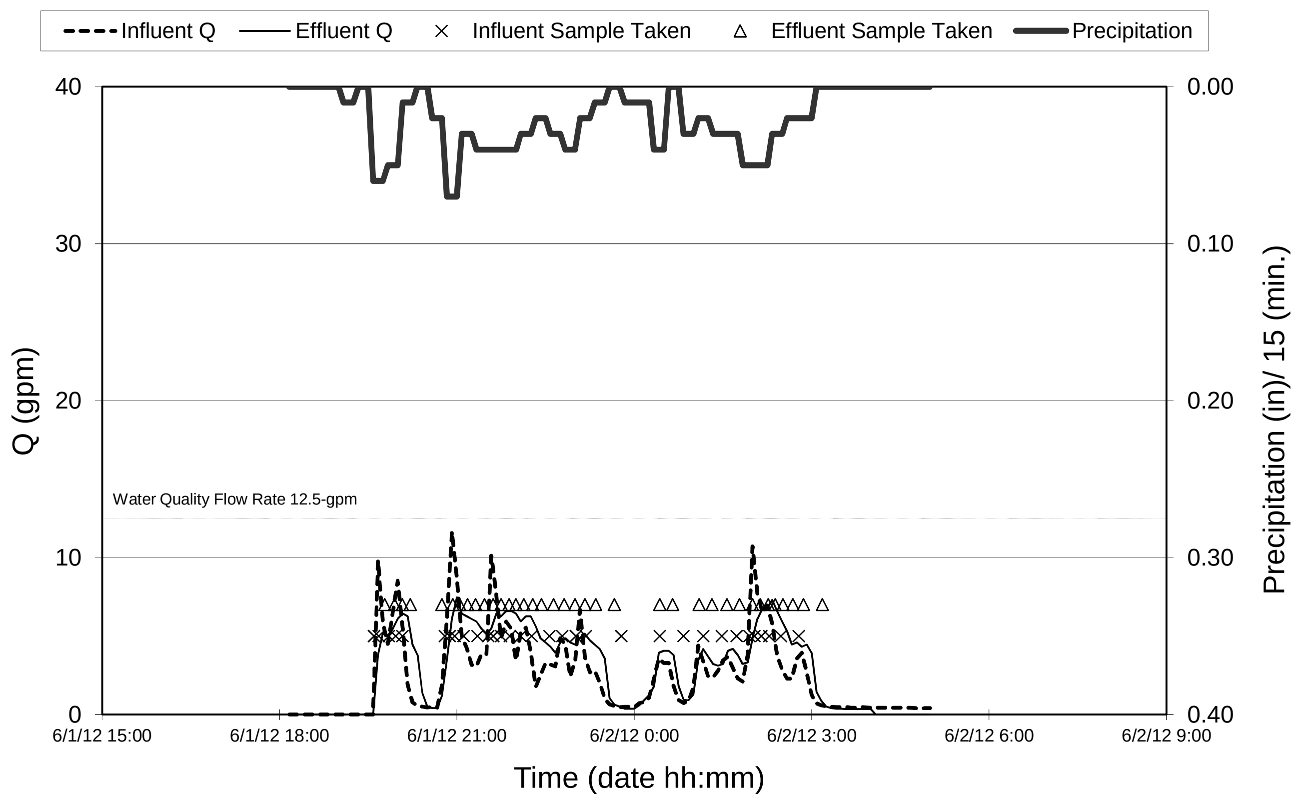
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	3/27/2012
Event Date:	6/1/2012
Antecedent Conditions (hr):	Pre-Event: 104 Post-Event: 10

Hydrology

Total Precipitation (in):	0.86		
Precipitation Duration (hrs):	5		
Rainfall Intensity (in/hr):	Max: 0.48	Average: 0.08	
Total Runoff Volume (gal):	Influent: 1637	Effluent: 1870	Bypass: 0.00
Peak Flow, (gpm):	Influent: 11.7	Effluent: 7.5	
Average Flow (gpm):	Influent: 2.5	Effluent: 2.8	
Storm Coverage (%):	Influent: 97	Effluent: 99	
Sampling Duration (hrs):	Influent: 7	Effluent: 7	

Event Hydrograph



Storm Name: LPR060112 Reviewed and Verified:

Individual Storm Report

LPR060112

Analytical

Number of Aliquots:
IN: 32
EFF: 37

Parameter	Concentrations (mg/L)			Dup. RPD	Discrete Removal Efficiency
	Influent EMC	Effluent EMC	MRL		
TSS (SM)	780	16	10	20%	98%
SSC	960	ND	40	22%	96%
TVSS	320	ND	40	20%	88%
SSC (<2000 µm)	930	ND	48	22%	95%
TVSS (<2000 µm)	300	ND	48	20%	84%
SSC (<500 µm)	540	ND	41	22%	92%
TVSS (<500 µm)	110	ND	41	20%	63%
SSC (<250 µm)	NT	NT	NT	---	---
TVSS (<250 µm)	NT	NT	NT	---	---
SSC (<100 µm)	340	ND	42	22%	88%
TVSS (<100 µm)	45.0	ND	42	20%	undeterminable
SSC (<62.5 µm)	NT	NT	NT	---	---
TVSS (<62.5 µm)	NT	NT	NT	---	---
SSC (<50 µm)	220	ND	40	22%	82%
TVSS (<50 µm)	ND	ND	40	20%	undeterminable
Total Phosphorus	0.20	0.035	0.020	0.6%	83%
Dissolved Phosphorus	ND	ND	0.50	20%	undeterminable
SRP (Ortho-phosphorus)	NT	NT	---	---	---
TKN	2.1	0.79	0.50	0.8%	62%
Nitrate/Nitrite-N	ND	0.082	0.30	20%	release
Ammonia	ND	ND	0.050	20%	undeterminable
Total Lead	0.016	ND	0.010	20%	38%
Total Copper	0.040	0.0026	0.020	20%	94%
Total Zinc	0.23	0.012	0.10	20%	95%
Aluminum	11	0.37	0.20	3%	97%
Dissolved Copper	NT	NT	NT	---	---
Dissolved Zinc	NT	NT	NT	---	---
Hardness	48	5.8	0.20	20%	88%
pH	6.54	6.64	0.100	0.50%	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested. Screening parameters (as per the 2011 WADOE TAPE) were collected during this event and submitted for analysis.

Individual Storm Report

LPR060412

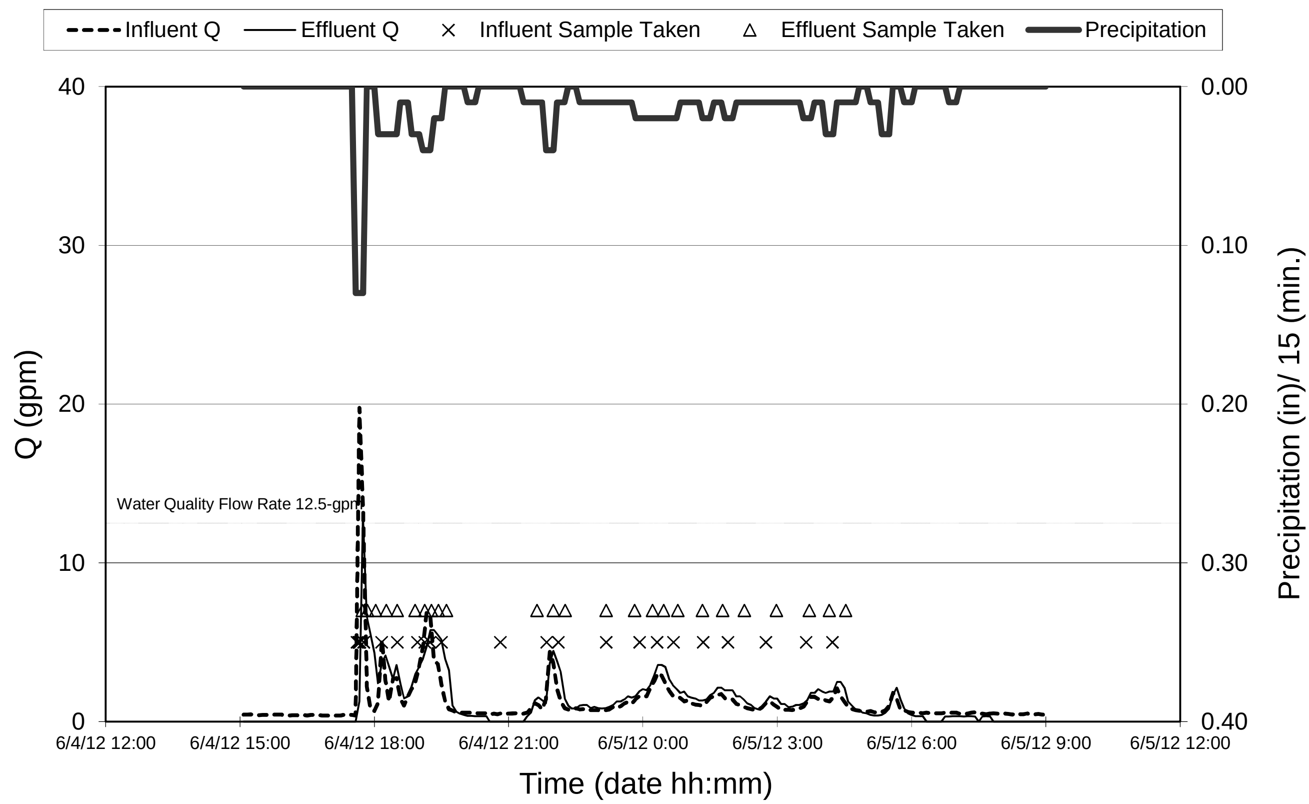
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	3/27/2012
Event Date:	6/4/2012
Antecedent Conditions (hr):	Pre-Event: 5 Post-Event: 5

Hydrology

Total Precipitation (in):	0.77		
Precipitation Duration (hrs):	13		
Rainfall Intensity (in/hr):	Max: 1.44	Average: 0.04	
Total Runoff Volume (gal):	Influent: 1319	Effluent: 1352	Bypass: 95
Peak Flow (gpm):	Influent: 19.8	Effluent: 13.0	
Average Flow (gpm):	Influent: 1.2	Effluent: 1.2	
Storm Coverage (%):	Influent: 84	Effluent: 96	
Sampling Duration (hrs):	Influent: 10	Effluent: 10	

Event Hydrograph



Individual Storm Report

LPR060412

Analytical

	Parameter	Influent EMC (mg/L)	Effluent EMC (mg/L)	MRL (mg/L)	Dup. RPD	Discrete Removal Efficiency
	TSS (SM)	580	32	10	20%	94%
Number of Aliquots:	SSC	1000	30	21	18.2%	97%
IN: 24	TVSS	150	ND	21	20%	86%
EFF: 25	SSC (<2000 µm)	890	30	22	18.2%	97%
	TVSS (<2000 µm)	130	ND	22	20%	83%
	SSC (<500 µm)	670	28	22	18.2%	96%
	TVSS (<500 µm)	72	ND	22	20%	69%
	SSC (<250 µm)	NT	NT	NT	---	---
	TVSS (<250 µm)	NT	NT	NT	---	---
	SSC (<100 µm)	410	28	24	18.2%	93%
	TVSS (<100 µm)	36	ND	24	20%	33%
	SSC (<62.5 µm)	NT	NT	NT	---	---
	TVSS (<62.5 µm)	NT	NT	NT	---	---
	SSC (<50 µm)	230	23	22	18.2%	90%
	TVSS (<50 µm)	25	ND	22	20%	undeterminable
	Total Phosphorus	0.21	0.043	0.020	0.6%	80%
	Dissolved Phosphorus	ND	ND	0.50	20%	undeterminable
	SRP (Ortho-phosphorus)	ND	ND	0.010	20%	undeterminable
	TKN	0.96	ND	0.50	0.8%	48%
	Nitrate/Nitrite-N	0.097	0.077	0.30	20%	21%
	Ammonia	ND	ND	0.050	20%	undeterminable
	Total Lead	0.013	0.0012	0.010	20%	91%
	Total Copper	0.021	0.0026	0.020	3%	88%
	Total Zinc	0.13	0.015	0.10	20%	88%
	Aluminum	12	1.0	0.20	0.3%	92%
	Dissolved Copper	NT	NT	NT	---	---
	Dissolved Zinc	NT	NT	NT	---	---
	Hardness	45	6.1	0.20	20%	86%
	pH	6.57	6.70	0.100	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Individual Storm Report

LPR060712

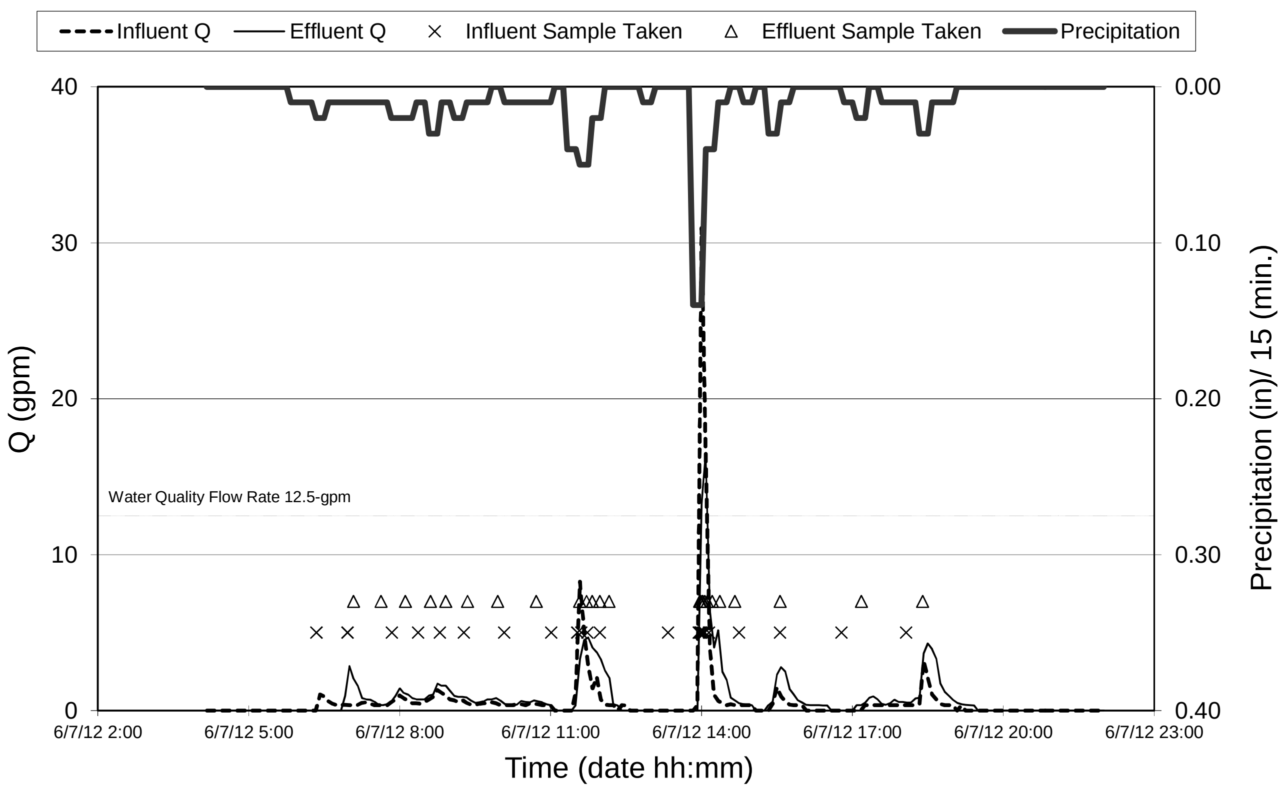
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon	
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres	
Date of Last Maintenance:	3/27/2012	
Event Date:	6/7/2012	
Antecedent Conditions (hr):	Pre-Event: 36	Post-Event: 8

Hydrology

Total Precipitation (in):	0.73		
Precipitation Duration (hrs):	12		
Rainfall Intensity (in/hr):	Max: 0.96	Average: 0.04	
Total Runoff Volume (gal):	Influent: 645	Effluent: 853	Bypass: 89
Peak Flow (gpm):	Influent: 31.0	Effluent: 16.5	
Average Flow (gpm):	Influent: 0.6	Effluent: 0.8	
Storm Coverage (%):	Influent: 96	Effluent: 87	
Sampling Duration (hrs):	Influent: 11	Effluent: 11	

Event Hydrograph



Storm Name: LPR060712

Reviewed and Verified:

Individual Storm Report

LPR060712

Analytical

	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	MRL	Dup. RPD	Discrete Removal Efficiency
	TSS (SM)	570	120	10	20%	79%
Number of Aliquots:	SSC	780	120	45	8%	85%
IN: 24	TVSS	180	ND	45	20%	75%
EFF: 25	SSC (<2000 µm)	750	120	37	8%	84%
	TVSS (<2000 µm)	180	ND	37	20%	79%
	SSC (<500 µm)	470	120	42	8%	74%
	TVSS (<500 µm)	70	ND	42	20%	40%
	SSC (<250 µm)	NT	NT	NT	---	---
	TVSS (<250 µm)	NT	NT	NT	---	---
	SSC (<100 µm)	300	120	41	8%	60%
	TVSS (<100 µm)	ND	ND	41	20%	undeterminable
	SSC (<62.5 µm)	NT	NT	NT	---	---
	TVSS (<62.5 µm)	NT	NT	NT	---	---
	SSC (<50 µm)	240	110	47	8%	54%
	TVSS (<50 µm)	ND	ND	47	20%	undeterminable
	Total Phosphorus	0.17	0.14	0.020	0.6%	18%
	Dissolved Phosphorus	ND	ND	0.50	20%	undeterminable
	SRP (Ortho-phosphorus)	ND	ND	0.010	20%	undeterminable
	TKN	ND	ND	0.50	20%	undeterminable
	Nitrate/Nitrite-N	0.079	0.055	0.30	20%	30%
	Ammonia	ND	ND	0.050	20%	undeterminable
	Total Lead	0.013	0.0049	0.010	4%	62%
	Total Copper	0.028	0.0096	0.020	4%	66%
	Total Zinc	0.17	0.048	0.10	4%	72%
	Aluminum	9.6	4.1	0.20	5%	57%
	Dissolved Copper	NT	NT	NT	---	---
	Dissolved Zinc	NT	NT	NT	---	---
	Hardness	45	14	0.20	20%	69%
	pH	6.89	6.64	0.100	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested. Screening parameters (as per the 2011 WADOE TAPE) were collected for this event and submitted for analysis.

Individual Storm Report

LPR110612

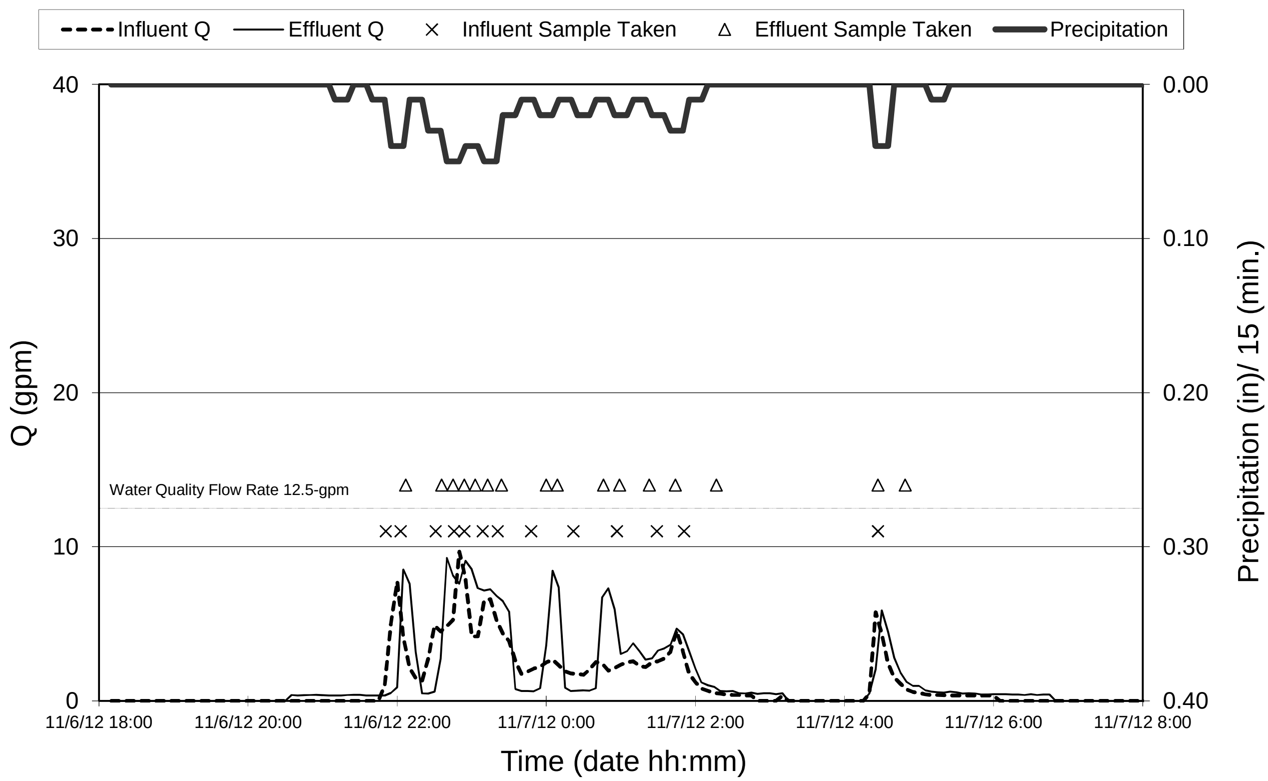
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	3/27/2012
Event Date:	11/6/2012
Antecedent Conditions (hr):	Pre-Event: 117 Post-Event: 55

Hydrology

Total Precipitation (in):	0.47		
Precipitation Duration (hrs):	7		
Rainfall Intensity (in/hr):	Max: 0.36	Average: 0.03	
Total Runoff Volume (gal):	Influent: 971	Effluent: 1223	Bypass: 0.00
Peak Flow (gpm):	Influent: 9.7	Effluent: 9.3	
Average Flow (gpm):	Influent: 1.1	Effluent: 1.4	
Storm Coverage (%):	Influent: 99	Effluent: 94	
Sampling Duration (hrs):	Influent: 6	Effluent: 6	

Event Hydrograph



Storm Name: LPR110612 Reviewed and Verified:

Individual Storm Report

LPR110612

Analytical

	Parameter	Concentrations (mg/L)			Dup. RPD	Discrete Removal Efficiency
		Influent EMC	Effluent EMC	MRL		
	TSS (SM)	40	10	10	20%	75%
Number of Aliquots:	SSC	46	9.0	2.7	28%	80%
IN: 13	TVSS	12	3.3	2.7	20%	73%
EFF: 16	SSC (<2000 µm)	43	9.7	2.7	28%	77%
	TVSS (<2000 µm)	10	4.0	2.7	20%	60%
	SSC (<500 µm)	41	9.3	3.0	28%	77%
	TVSS (<500 µm)	9.2	3.9	3.0	20%	58%
	SSC (<250 µm)	NT	NT	NT	---	---
	TVSS (<250 µm)	NT	NT	NT	---	---
	SSC (<100 µm)	34	7.9	3.0	28%	77%
	TVSS (<100 µm)	6.6	3.3	3.0	20%	50%
	SSC (<62.5 µm)	NT	NT	NT	---	---
	TVSS (<62.5 µm)	NT	NT	NT	---	---
	SSC (<50 µm)	19	6.6	3.0	28%	65%
	TVSS (<50 µm)	4.0	3.9	3.0	20%	undeterminable
	Total Phosphorus	0.068	ND	0.050	20%	26%
	Dissolved Phosphorus	ND	ND	0.50	20%	undeterminable
	SRP (Ortho-phosphorus)	0.0930	ND	0.0500	20%	46%
	TKN	ND	ND	1.00	20%	undeterminable
	Nitrate/Nitrite-N	0.069	0.055	0.030	1%	20%
	Ammonia	0.066	ND	0.050	20%	24%
	Total Lead	0.0010	ND	0.0010	20%	undeterminable
	Total Copper	0.0059	0.0025	0.0020	0.3%	58%
	Total Zinc	0.022	0.014	0.010	20%	36%
	Aluminum	1.3	0.30	0.10	17%	77%
	Dissolved Copper	NT	NT	NT	---	---
	Dissolved Zinc	NT	NT	NT	---	---
	Hardness	11	7.8	0.20	20%	29%
	pH	6.92	6.58	0.100	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Storm Name: LPR110612

Reviewed and Verified:

Individual Storm Report

LPR113012

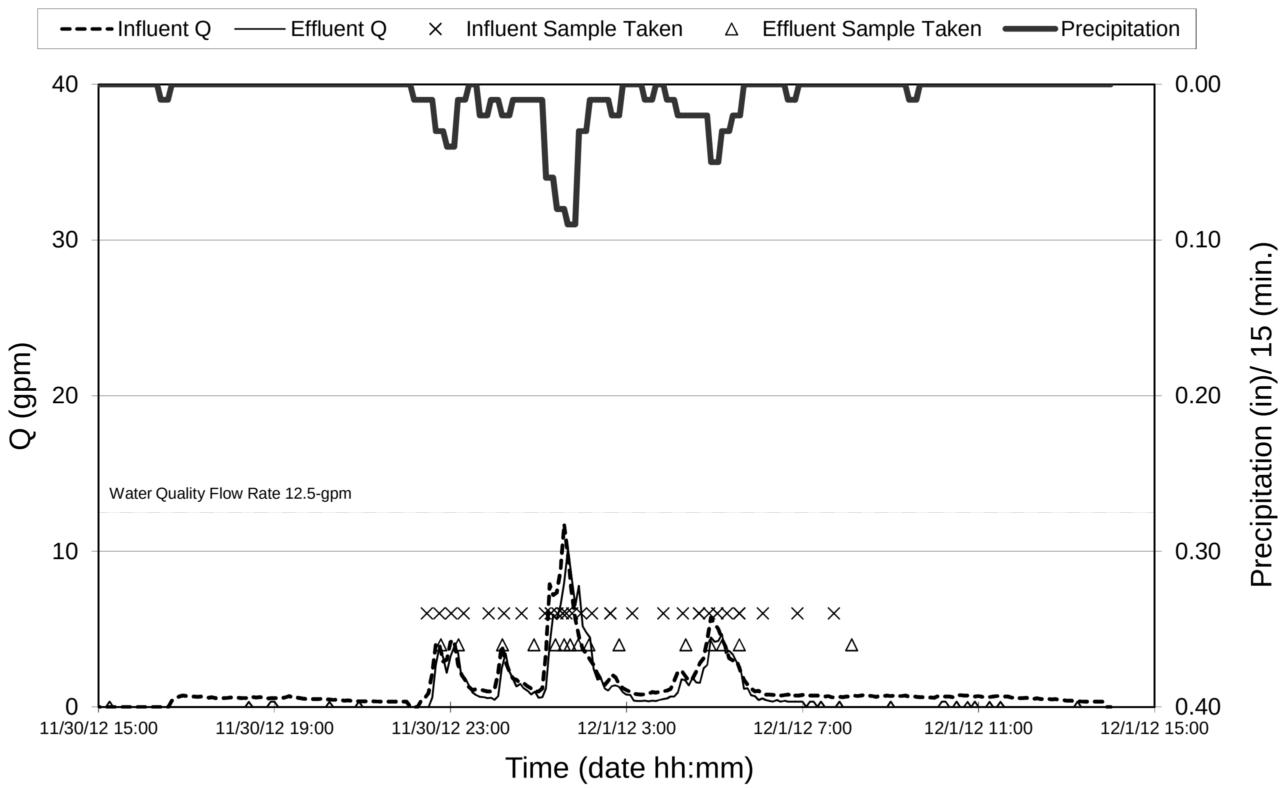
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	3/27/2012
Event Date:	11/30/2012
Antecedent Conditions (hrs):	Pre-Event: 7 Post-Event: 9

Hydrology

Total Precipitation (in):	0.69		
Precipitation Duration (hrs):	16		
Rainfall Intensity (in/hr):	Max: 0.60	Average: 0.03	
Total Runoff Volume (gal):	Influent: 1695	Effluent: 1086	Bypass: 0.00
Peak Flow (gpm):	Influent: 11.8	Effluent: 10.2	
Average Flow (gpm):	Influent: 1.0	Effluent: 0.7	
Storm Coverage (%):	Influent: 79	Effluent: 100	
Sampling Duration (hrs):	Influent: 9	Effluent: 9	

Event Hydrograph



Storm Name: LPR113012 Reviewed and Verified:

Individual Storm Report

LPR113012

Analytical

	Parameter	Concentrations (mg/L)				Discrete Removal
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
	TSS (SM)	230	17	10	5%	93%
Number of Aliquots:	SSC	230	15	2.6	9.09%	93%
IN: 27	TVSS	140	7.8	2.6	20%	94%
EFF: 15	SSC (<2000 µm)	220	16	2.8	9.09%	93%
	TVSS (<2000 µm)	130	7.6	2.8	20%	94%
	SSC (<500 µm)	150	15	3.0	9.09%	90%
	TVSS (<500 µm)	69	7.0	3.0	20%	90%
	SSC (<250 µm)	NT	NT	NT	---	---
	TVSS (<250 µm)	NT	NT	NT	---	---
	SSC (<100 µm)	75	13	2.8	9.09%	83%
	TVSS (<100 µm)	26	6.6	2.8	20%	75%
	SSC (<62.5 µm)	NT	NT	NT	---	---
	TVSS (<62.5 µm)	NT	NT	NT	---	---
	SSC (<50 µm)	49	9.5	2.9	9.09%	81%
	TVSS (<50 µm)	17	4.6	2.9	20%	73%
	Total Phosphorus	0.17	ND	0.050	20%	71%
	Dissolved Phosphorus	ND	ND	0.50	20%	undeterminable
	SRP (Ortho-phosphorus)	0.0990	ND	0.0500	20%	49%
	TKN	1.2	ND	1.0	20%	undeterminable
	Nitrate/Nitrite-N	ND	ND	0.030	20%	undeterminable
	Ammonia	ND	ND	0.050	20%	undeterminable
	Total Lead	0.0050	ND	0.0010	20%	80%
	Total Copper	0.016	0.0023	0.0020	2%	86%
	Total Zinc	0.11	0.016	0.010	0.2%	85%
	Aluminum	3.0	0.44	0.10	20%	85%
	Dissolved Copper	NT	NT	NT	---	---
	Dissolved Zinc	NT	NT	NT	---	---
	Hardness	52	5.4	0.20	20%	90%
	pH	6.64	6.67	0.100	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Individual Storm Report

LPR051713

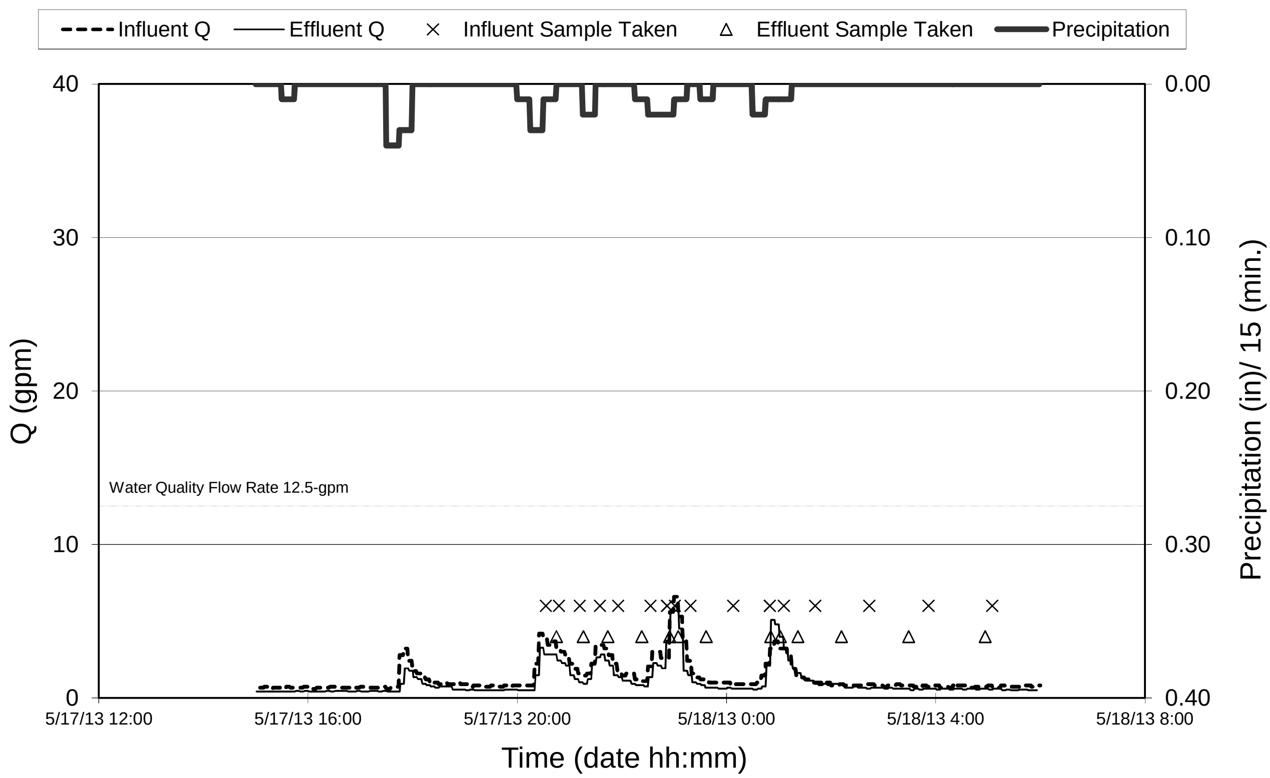
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	3/28/2013
Event Date:	5/17/2013
Antecedent Conditions (hrs):	Pre-Event: 13 Post-Event: 9

Hydrology

Total Precipitation (in):	0.26		
Precipitation Duration (hrs):	9		
Rainfall Intensity (in/hr):	Max: 0.24	Average: 0.02	
Total Runoff Volume (gal):	Influent: 1208	Effluent: 939	Bypass: 0.00
Peak Flow (gpm):	Influent: 6.6	Effluent: 5.7	
Average Flow (gpm):	Influent: 1.3	Effluent: 1.0	
Storm Coverage (%):	Influent: 74	Effluent: 77	
Sampling Duration (hrs):	Influent: 8	Effluent: 8	

Event Hydrograph



Storm Name: LPR051713

Reviewed and Verified:

Individual Storm Report

LPR051713

Analytical

	Parameter	Concentrations (mg/L)			Dup. RPD	Discrete Removal Efficiency
		Influent EMC	Effluent EMC	MRL		
	TSS (SM)	94.0	6.00	5.00		94%
Number of Aliquots:	SSC	211	7.59	4.24	31.2%	96%
IN: 16	TVSS	115	3.15	2.12	20%	97%
EFF: 13	SSC (<2000 µm)	195	4.81	4.81	31.2%	98%
	TVSS (<2000 µm)	117	2.40	2.40	20%	98%
	SSC (<500 µm)	94.3	4.41	4.07	31.2%	95%
	TVSS (<500 µm)	36.6	2.03	3.02	20%	94%
	SSC (<250 µm)	78.5	4.94	2.47	31.2%	94%
	TVSS (<250 µm)	27.4	3.46	1.23	20%	87%
	SSC (<100 µm)	53.4	ND	5.00	31.2%	91%
	TVSS (<100 µm)	15.5	ND	2.50	20%	84%
	SSC (<62.5 µm)	49.4	5.00	5.00	31.2%	90%
	TVSS (<62.5 µm)	15.2	4.50	2.50	20%	70%
	SSC (<50 µm)	63.6	4.42	2.60	31.2%	93%
	TVSS (<50 µm)	20.9	2.86	1.30	20%	86%
	Total Phosphorus	0.282	0.03	0.0100	9%	90%
	Dissolved Phosphorus	0.0260	0.0110	0.0100	20%	58%
	SRP (Ortho-phosphorus)	ND	ND	0.010	20%	undeterminable
	TKN	1.3	0.17	0.050	20%	87%
	Nitrate/Nitrite-N	0.0722	0.0799	0.00500	0.2%	release
	Ammonia	0.0790	0.038	0.0200	20%	52%
	Total Lead	0.00397	ND	0.00100	20%	75%
	Total Copper	0.0160	0.00287	0.00200	20%	82%
	Total Zinc	0.0681	0.0101	0.00400	20%	85%
	Aluminum	1.44	0.134	0.050	20%	91%
	Dissolved Copper	0.00567	0.00218	0.00200	3%	62%
	Dissolved Zinc	0.0192	0.00827	0.00400	1%	57%
	Hardness	24.6	10.5	0.46	20%	57%
	pH	6.98	7.02	---	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Storm Name: LPR051713

Reviewed and Verified:

Individual Storm Report

LPR052113

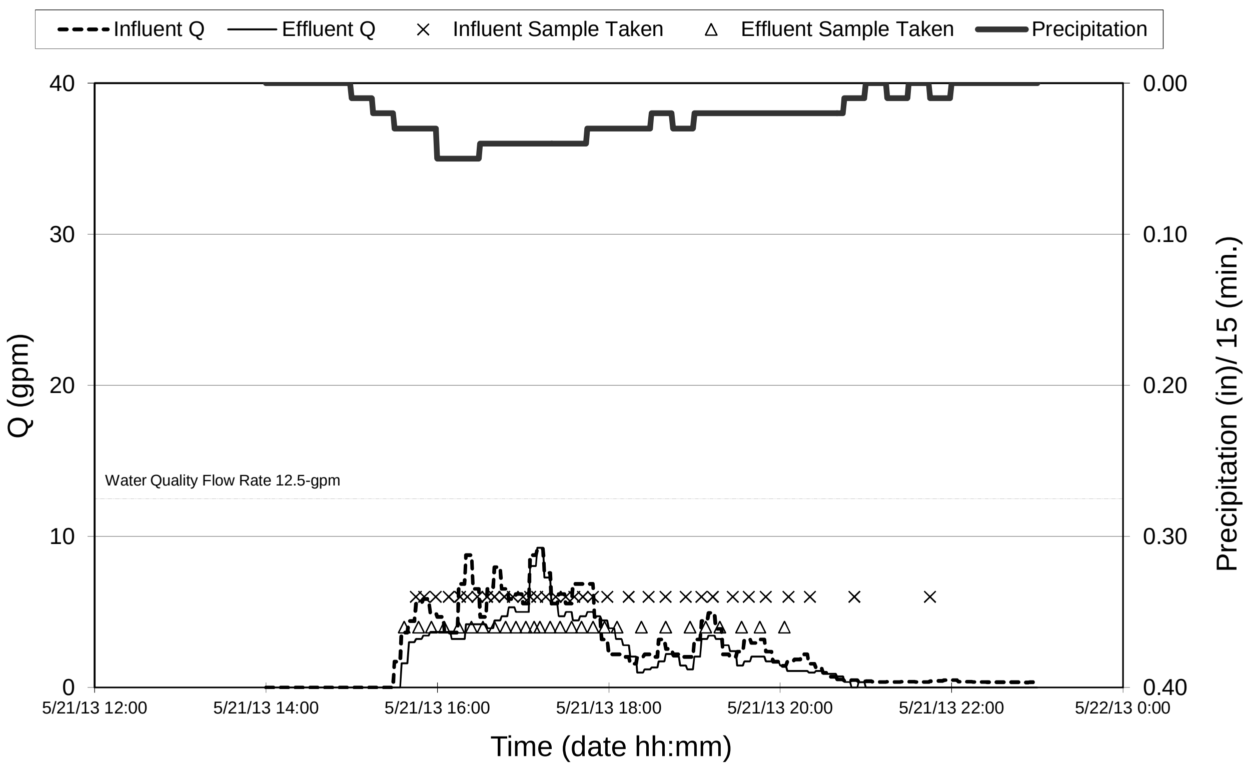
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	3/28/2013
Event Date:	5/21/2013
Antecedent Conditions (hrs):	Pre-Event: 9 Post-Event: 7

Hydrology

Total Precipitation (in):	0.70		
Precipitation Duration (hrs):	6		
Rainfall Intensity (in/hr):	Max: 0.24	Average: 0.08	
Total Runoff Volume (gal):	Influent: 1300	Effluent: 976	Bypass: 0.00
Peak Flow (gpm):	Influent: 9.2	Effluent: 9.3	
Average Flow (gpm):	Influent: 2.4	Effluent: 1.8	
Storm Coverage (%):	Influent: 99	Effluent: 98	
Sampling Duration(hrs):	Influent: 6	Effluent: 4	

Event Hydrograph



Storm Name: LPR052113 Reviewed and Verified:

Individual Storm Report

LPR052113

Analytical

	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	MRL	Dup. RPD	Discrete Removal Efficiency
	TSS (SM)	389	24.0	5.00	20%	94%
Number of Aliquots:	SSC	484	21.4	3.51	0.2%	96%
IN: 35	TVSS	227	6.19	1.75	20%	97%
EFF: 28	SSC (<2000 µm)	498	21.6	3.23	0.2%	96%
	TVSS (<2000 µm)	235	5.75	1.61	20%	98%
	SSC (<500 µm)	243	21.7	3.39	0.2%	91%
	TVSS (<500 µm)	73.9	6.83	1.69	20%	91%
	SSC (<250 µm)	231	25.4	4.76	0.2%	89%
	TVSS (<250 µm)	54.8	10.1	2.38	20%	82%
	SSC (<100 µm)	158	20.2	3.57	0.2%	87%
	TVSS (<100 µm)	28.9	5.95	1.79	20%	79%
	SSC (<62.5 µm)	121	19.5	3.39	0.2%	84%
	TVSS (<62.5 µm)	21.4	5.19	1.69	20%	76%
	SSC (<50 µm)	136	12.7	3.57	0.2%	91%
	TVSS (<50 µm)	21.8	4.55	1.79	20%	79%
	Total Phosphorus	0.558	0.0498	0.0100	14%	91%
	Dissolved Phosphorus	0.0190	0.0118	0.0100	20%	38%
	SRP (Ortho-phosphorus)	ND	ND	0.010	20%	undeterminable
	TKN	0.49	0.18	0.050	20%	63%
	Nitrate/Nitrite-N	0.0409	0.0675	0.00500	0.8%	release
	Ammonia	0.0770	0.0450	0.0200	20%	42%
	Total Lead	0.00892	0.000889	0.00100	20%	90%
	Total Copper	0.0272	0.00598	0.00200	20%	78%
	Total Zinc	0.126	0.0208	0.00400	20%	83%
	Aluminum	3.24	0.358	0.050	20%	89%
	Dissolved Copper	0.00498	0.00438	0.00200	5%	12%
	Dissolved Zinc	0.0149	0.01210	0.00400	4%	19%
	Hardness	27.1	9.49	0.456	20%	65%
	pH	6.82	6.90	---	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Individual Storm Report

LPR062513

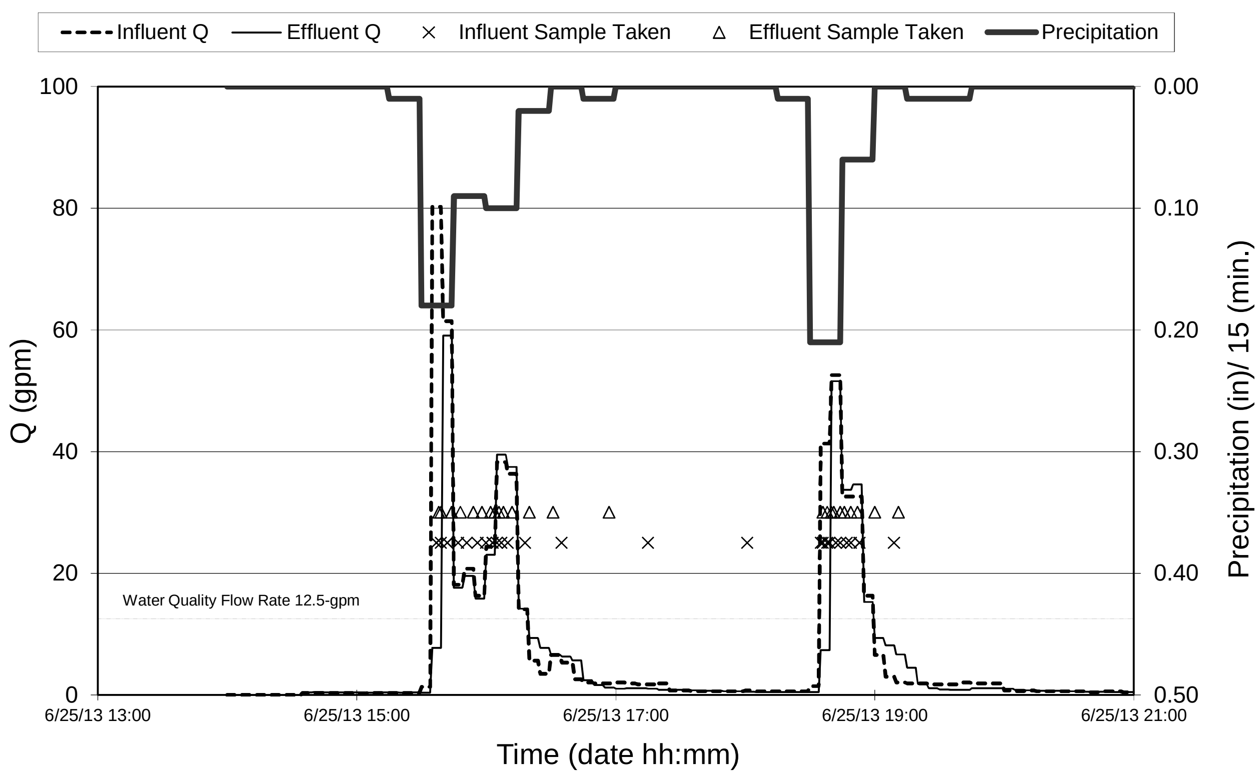
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon		
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres		
Date of Last Maintenance:	3/28/2013		
Event Date:	6/25/2013		
Antecedent Conditions (hrs):	Pre-Event: 2	Post-Event: 2	

Hydrology

Total Precipitation (in):	0.71		
Precipitation Duration (hrs):	4		
Rainfall Intensity (in/hr):	Max: 1.44	Average: 0.10	
Total Runoff Volume (gal):	Influent: 2876	Effluent: 2410	Bypass: 891
Peak Flow (gpm):	Influent: 80	Effluent: 59	
Average Flow (gpm):	Influent: 6.8	Effluent: 5.7	
Storm Coverage (%):	Influent: 93	Effluent: 96	
Sampling Duration (hrs):	Influent: 3	Effluent: 3	

Event Hydrograph



Storm Name: LPR062513

Reviewed and Verified:

Individual Storm Report

LPR062513

Analytical

	Parameter	Concentrations (mg/L)				Discrete Removal
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
	TSS (SM)	308	21.0	10.0	10%	93%
Number of Aliquots:	SSC	710	19.0	2.67	8.2%	97%
IN: 26	TVSS	175	6.17	1.33	20%	96%
EFF: 24	SSC (<2000 µm)	688	35.6	2.74	8.2%	95%
	TVSS (<2000 µm)	161	7.67	1.37	20%	95%
	SSC (<500 µm)	421	32.0	3.33	8.2%	92%
	TVSS (<500 µm)	59.4	5.67	1.67	20%	90%
	SSC (<250 µm)	281	25.0	2.94	8.2%	91%
	TVSS (<250 µm)	41.9	9.1	1.47	20%	78%
	SSC (<100 µm)	306	19.7	3.64	8.2%	94%
	TVSS (<100 µm)	30.2	66.11	1.82	20%	release
	SSC (<62.5 µm)	172	14.9	4.65	8.2%	91%
	TVSS (<62.5 µm)	21.4	6.98	2.33	20%	67%
	SSC (<50 µm)	194	11.5	3.08	8.2%	94%
	TVSS (<50 µm)	24.6	3.64	1.54	20%	85%
	Total Phosphorus	0.583	0.0452	0.0100	2%	92%
	Dissolved Phosphorus	ND	ND	0.0100	20%	undeterminable
	SRP (Ortho-phosphorus)	ND	ND	0.010	20%	undeterminable
	TKN	0.59	0.17	0.10	20%	71%
	Nitrate/Nitrite-N	0.0285	0.0826	0.00500	1%	release
	Ammonia	ND	ND	0.10	20%	undeterminable
	Total Lead	0.00858	0.00150	0.00100	20%	83%
	Total Copper	0.0287	0.00541	0.00200	20%	81%
	Total Zinc	0.120	0.0174	0.00400	20%	86%
	Aluminum	3.94	0.466	0.0500	20%	88%
	Dissolved Copper	0.00301	0.00233	0.00200	5%	23%
	Dissolved Zinc	0.0122	0.0100	0.00400	6%	18%
	Hardness	40.5	5.65	0.456	20%	86%
	pH	7.12	7.02	---	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Individual Storm Report

LPR013014

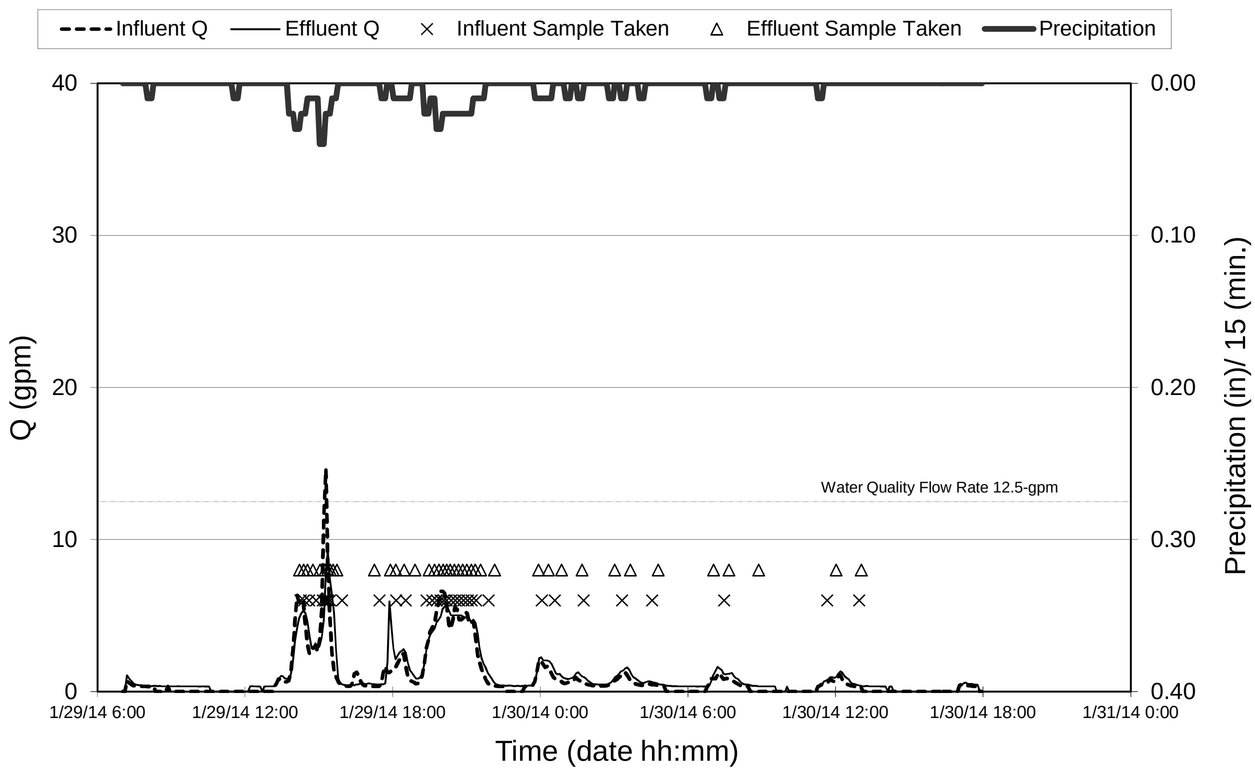
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	1/14/2014
Event Date:	1/30/2014
Antecedent Conditions (hrs):	Pre-Event: 5 Post-Event: 8

Hydrology

Total Precipitation (in):	0.51		
Precipitation Duration (hrs):	27		
Rainfall Intensity (in/hr):	Max: 0.24	Average: 0.01	
Total Runoff Volume (gal):	Influent: 1829	Effluent: 2143	Bypass: 0.00
Peak Flow (gpm):	Influent: 14.6	Effluent: 9.4	
Average Flow (gpm):	Influent: 0.9	Effluent: 1.0	
Storm Coverage (%):	Influent: 96	Effluent: 94	
Sampling Duration (hrs):	Influent: 22	Effluent: 22	

Event Hydrograph



Storm Name: LPR013014 Reviewed and Verified:

Individual Storm Report

LPR013014

Analytical

	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	MRL	Dup. RPD	Discrete Removal Efficiency
	TSS (SM)	170	17.0	5.00	20%	90%
Number of Aliquots:	SSC	175	19.4	10.0	4.47%	89%
IN: 36	TVSS	70.0	4.79	5.00	20%	93%
EFF: 41	SSC (<2000 µm)	184	14.1	10.0	4.47%	92%
	TVSS (<2000 µm)	70.0	2.16	5.00	20%	97%
	SSC (<500 µm)	131	16.9	3.23	4.47%	87%
	TVSS (<500 µm)	41.6	5.38	1.61	20%	87%
	SSC (<250 µm)	155	15.1	3.64	4.47%	90%
	TVSS (<250 µm)	43.6	6.0	1.82	20%	86%
	SSC (<100 µm)	130	14.8	3.77	4.47%	89%
	TVSS (<100 µm)	28.7	4.66	1.89	20%	84%
	SSC (<62.5 µm)	115	10.7	3.64	4.47%	91%
	TVSS (<62.5 µm)	28.0	3.38	1.82	20%	88%
	SSC (<50 µm)	99.6	18.2	3.57	4.47%	82%
	TVSS (<50 µm)	21.1	6.58	1.79	20%	69%
	Total Phosphorus	0.317	0.0530	0.0100	2%	83%
	Dissolved Phosphorus	0.0122	0.0168	0.0100	20%	release
	SRP (Ortho-phosphorus)	ND	0.012	0.010	20%	undeterminable
	TKN	0.19	0.16	0.10	20%	undeterminable
	Nitrate/Nitrite-N	0.0503	0.0520	0.00500	11%	undeterminable
	Ammonia	0.0660	0.0690	0.0200	20%	undeterminable
	Total Lead	0.00606	0.00118	0.00100	20%	81%
	Total Copper	0.0207	0.00374	0.00200	20%	82%
	Total Zinc	0.108	0.0258	0.00400	20%	76%
	Aluminum	3.45	0.796	0.0500	20%	77%
	Dissolved Copper	0.00224	0.00191	0.00100	20%	undeterminable
	Dissolved Zinc	0.0154	0.0131	0.0040	20%	undeterminable
	Hardness	44.1	39.3	2.28	20%	undeterminable
	pH	6.76	6.88	---	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Storm Name: LPR013014

Reviewed and Verified:

Individual Storm Report

LPR030314

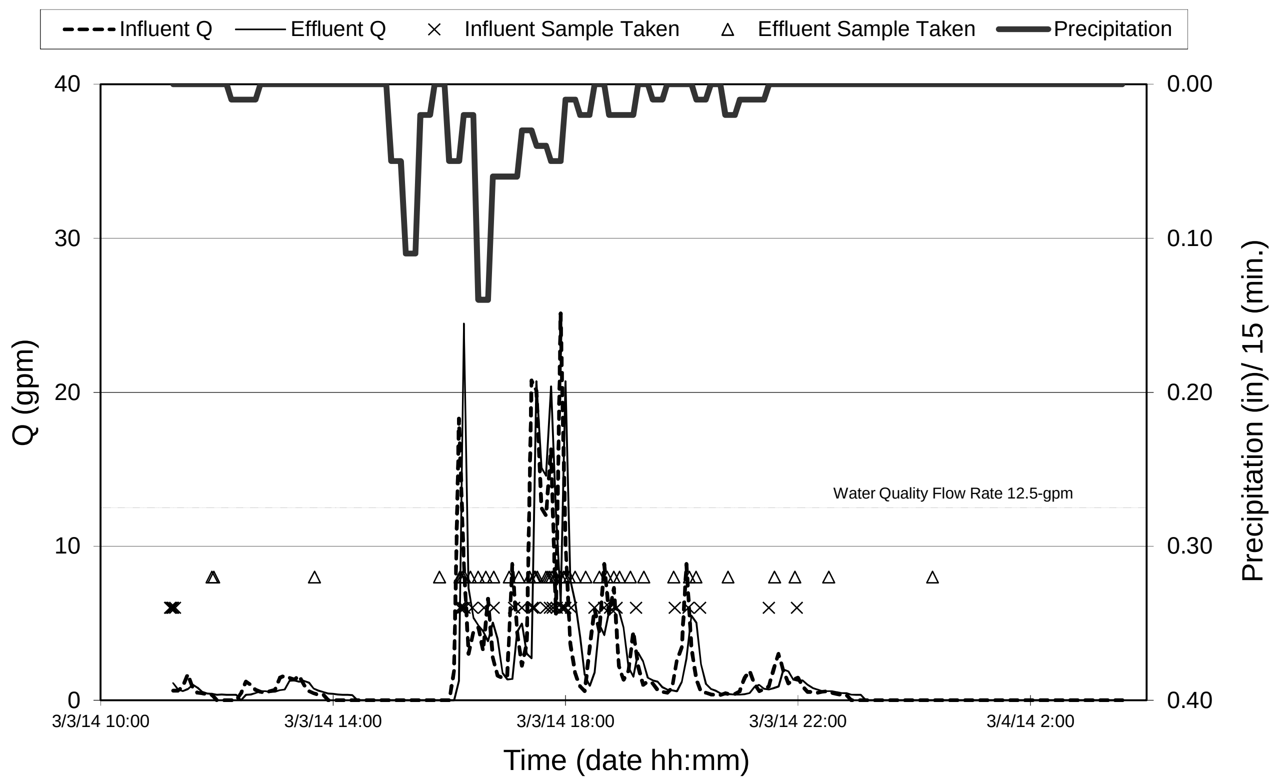
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon	
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres	
Date of Last Maintenance:	1/14/2014	
Event Date:	3/03/2014	
Antecedent Conditions (hrs):	Pre-Event: 6	Post-Event: 9

Hydrology

Total Precipitation (in):	0.76		
Precipitation Duration (hrs):	9		
Rainfall Intensity (in/hr):	Max: 1.08	Average: 0.05	
Total Runoff Volume (gal):	Influent: 1648	Effluent: 1630	Bypass: 359
Peak Flow (gpm):	Influent: 25.1	Effluent: 24.5	
Average Flow (gpm):	Influent: 1.7	Effluent: 1.7	
Storm Coverage (%):	Influent: 100	Effluent: 100	
Sampling Duration (hrs):	Influent: 10	Effluent: 12	

Event Hydrograph



Individual Storm Report

LPR030314

Analytical

	Parameter	Concentrations (mg/L)				Discrete Removal
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
	TSS (SM)	280	95.0	5.00	20%	66%
Number of Aliquots:	SSC	480	90.9	2.06	7.0%	81%
IN: 31	TVSS	177	16.90	1.03	20%	90%
EFF: 43	SSC (<2000 µm)	NT	NT	---	---	---
	TVSS (<2000 µm)	NT	NT	---	---	---
	SSC (<500 µm)	NT	NT	---	---	---
	TVSS (<500 µm)	NT	NT	---	---	---
	SSC (<250 µm)	NT	NT	---	---	---
	TVSS (<250 µm)	NT	NT	---	---	---
	SSC (<100 µm)	NT	NT	---	---	---
	TVSS (<100 µm)	NT	NT	---	---	---
	SSC (<62.5 µm)	NT	NT	---	---	---
	TVSS (<62.5 µm)	NT	NT	---	---	---
	SSC (<50 µm)	NT	NT	---	---	---
	TVSS (<50 µm)	NT	NT	---	---	---
	Total Phosphorus	0.417	0.133	0.0100	20%	68%
	Dissolved Phosphorus	ND	ND	0.0100	20%	undeterminable
	SRP (Ortho-phosphorus)	ND	ND	0.005	20%	undeterminable
	TKN	0.48	0.18	0.10	20%	63%
	Nitrate/Nitrite-N	0.0500	0.0500	0.02000	20%	undeterminable
	Ammonia	0.0800	0.0750	0.0200	6%	6%
	Total Lead	0.00668	0.00253	0.000200	20%	62%
	Total Copper	0.0187	0.00566	0.00100	20%	70%
	Total Zinc	0.0954	0.0288	0.00400	20%	70%
	Aluminum	2.64	1.130	0.0500	20%	57%
	Dissolved Copper	NT	NT	---	---	---
	Dissolved Zinc	NT	NT	---	---	---
	Hardness	17.2	7.37	0.250	20%	57%
	pH	6.75	6.65	---	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Individual Storm Report

LPR011815

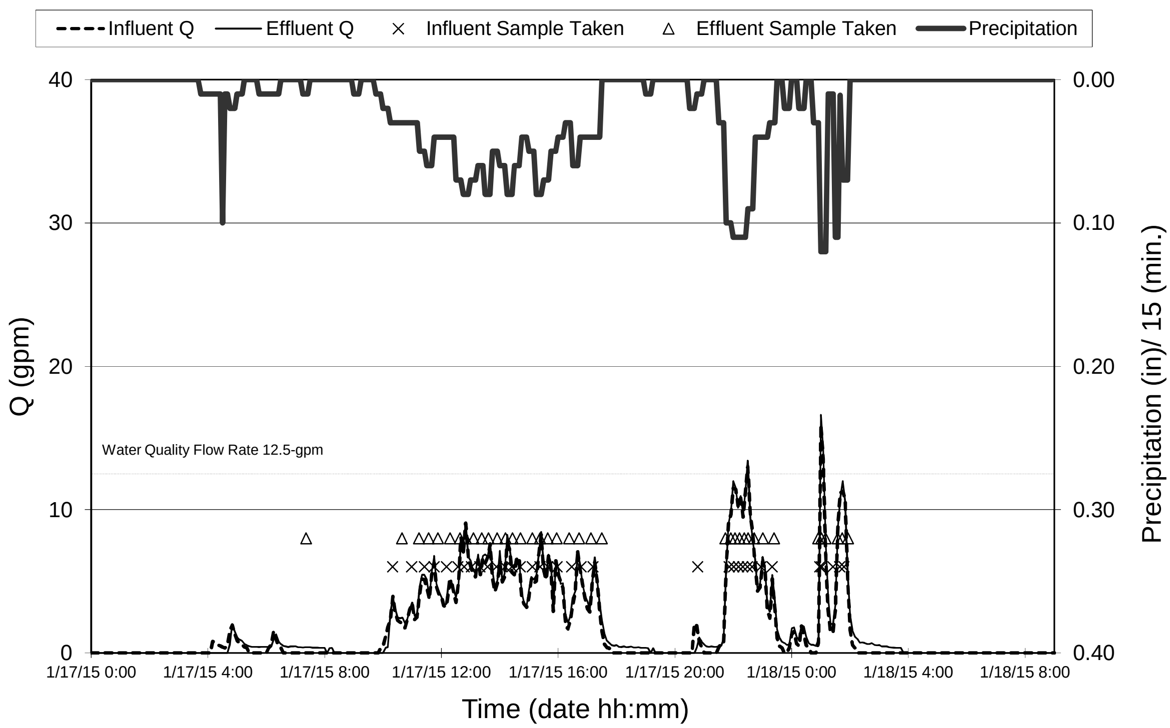
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon	
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres	
Date of Last Maintenance:	10/10/2014	
Event Date:	1/18/2015	
Antecedent Conditions (hr):	Pre-Event: 18	Post-Event: 8

Hydrology

Total Precipitation (in):	2.62		
Precipitation Duration (hr):	26		
Rainfall Intensity (in/hr):	Max: 0.96	Average: 0.08	
Total Runoff Volume (gal):	Influent: 3565	Effluent: 3890	Bypass: 19.2
Peak Flow (gpm):	Influent: 15.9	Effluent: 16.6	
Average Flow (gpm):	Influent: 1.8	Effluent: 2.0	
Storm Coverage (%):	Influent: 97	Effluent: 98	
Sampling Duration (hrs):	Influent: 15	Effluent: 18	

Event Hydrograph



Storm Name: LPR011815

Reviewed and Verified:

Individual Storm Report

LPR011815

Analytical

	Parameter	Concentrations (mg/L)				Discrete Removal
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
	TSS (SM)	529	72.8	5.00	7%	86%
Number of Aliquots:	SSC	611	70.9	3.57	4.69%	88%
IN: 35	TVSS	176	17.2	1.79	20%	90%
EFF: 38	SSC (<2000 µm)	632	71.1	5.26	4.69%	89%
	TVSS (<2000 µm)	181	17.9	2.63	20%	90%
	SSC (<500 µm)	536	71.6	3.70	4.69%	87%
	TVSS (<500 µm)	127	16.7	1.85	20%	87%
	SSC (<250 µm)	489	68.6	3.45	4.69%	86%
	TVSS (<250 µm)	96.9	16.9	1.72	20%	83%
	SSC (<100 µm)	557	69.3	5.13	4.69%	88%
	TVSS (<100 µm)	75.9	14.5	2.56	20%	81%
	SSC (<62.5 µm)	399	62.6	10.1	4.69%	84%
	TVSS (<62.5 µm)	51.0	12.1	5.05	20%	76%
	SSC (<50 µm)	384	60.8	4.08	4.69%	84%
	TVSS (<50 µm)	46.4	11.8	2.04	20%	75%
	Total Phosphorus	0.649	0.1240	0.0100	20%	81%
	Dissolved Phosphorus	ND	0.0116	0.0100	20%	undeterminable
	SRP (Ortho-phosphorus)	ND	ND	0.010	4%	undeterminable
	TKN	0.15	ND	0.10	20%	33%
	Nitrate/Nitrite-N	0.0300	0.0600	0.0200	0%	release
	Ammonia	0.0330	0.0280	0.0200	20%	undeterminable
	Total Lead	0.01460	0.002710	0.000200	20%	81%
	Total Copper	0.0547	0.01010	0.001000	20%	82%
	Total Zinc	0.1510	0.0386	0.00400	20%	74%
	Aluminum	5.32	1.170	0.0500	20%	78%
	Dissolved Copper	0.00313	0.00252	0.00100	20%	19%
	Dissolved Zinc	0.0117	0.0120	0.00400	20%	undeterminable
	Hardness	28.4	11.00	0.250	20%	61%
	pH	6.84	6.70	---	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. Screening Parameters collected for this event. ND= parameter was returned as a non-detect result. NT= parameter not tested.

Individual Storm Report

LPR020215

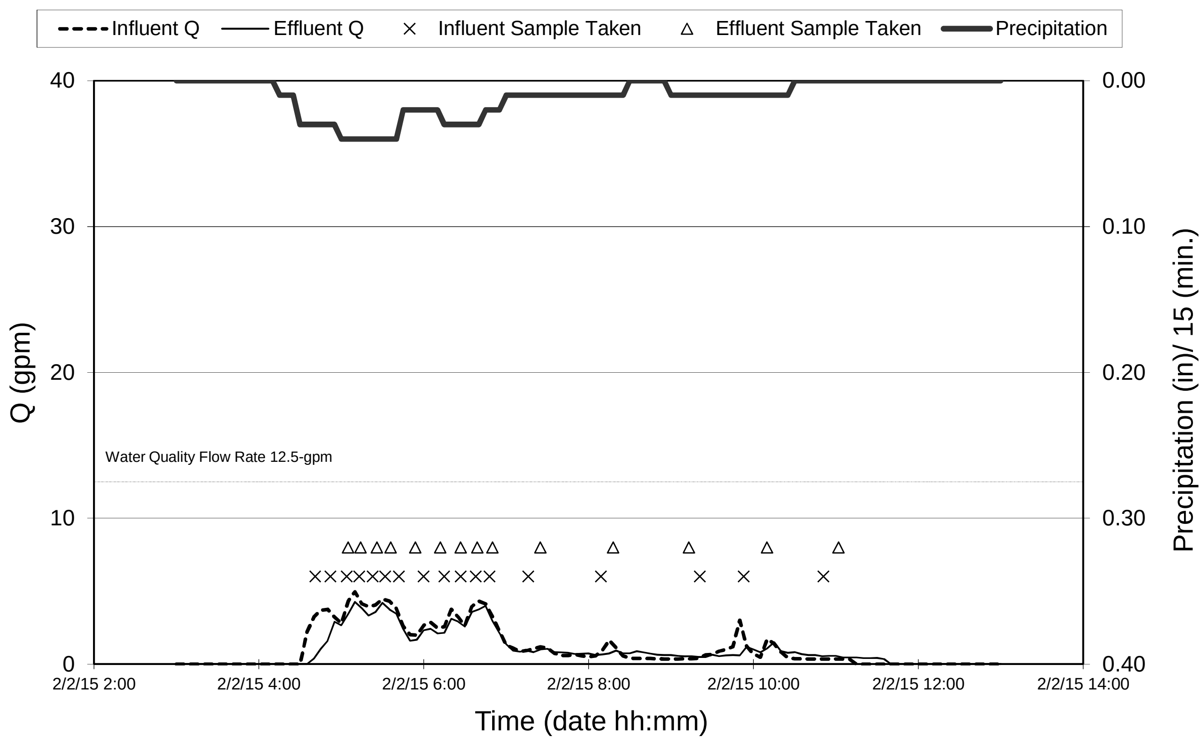
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	10/10/2014
Event Date:	2/2/2015
Antecedent Conditions (hr):	Pre-Event: 13 Post-Event: 21

Hydrology

Total Precipitation (in):	0.43		
Precipitation Duration (hr):	5		
Rainfall Intensity (in/hr):	Max: 0.24	Average: 0.04	
Total Runoff Volume (gal):	Influent: 701	Effluent: 623	Bypass: 0.0
Peak Flow (gpm):	Influent: 5.0	Effluent: 4.3	
Average Flow (gpm):	Influent: 1.2	Effluent: 1.0	
Storm Coverage (%):	Influent: 91	Effluent: 90	
Sampling Duration (hrs):	Influent: 5.0	Effluent: 5.0	

Event Hydrograph



Individual Storm Report

LPR020215

Analytical

	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	MRL	Dup. RPD	Discrete Removal Efficiency
	TSS (SM)	397	67.0	5.00	7%	83%
Number of Aliquots:	SSC	804	53.6	3.77	9.14%	93%
IN: 16	TVSS	446	16.2	1.89	20%	96%
EFF: 14	SSC (<2000 µm)	---	---	---	---	---
	TVSS (<2000 µm)	---	---	---	---	---
	SSC (<500 µm)	405	52.5	4.59	9.14%	87%
	TVSS (<500 µm)	152	17.7	2.29	20%	88%
	SSC (<250 µm)	285	45.6	4.35	9.14%	84%
	TVSS (<250 µm)	82.2	15.7	2.17	20%	81%
	SSC (<100 µm)	---	---	---	---	---
	TVSS (<100 µm)	---	---	---	---	---
	SSC (<62.5 µm)	33.3	14.0	0.567	9.14%	58%
	TVSS (<62.5 µm)	185	43.7	1.13	20%	76%
	SSC (<50 µm)	---	---	---	---	---
	TVSS (<50 µm)	---	---	---	---	---
	Total Phosphorus	0.693	0.100	0.0500	2%	86%
	Dissolved Phosphorus	0.0156	ND	0.0100	20%	36%
	SRP (Ortho-phosphorus)	0.026	0.035	0.010	20%	release
	TKN	2.3	0.33	0.10	20%	86%
	Nitrate/Nitrite-N	0.0200	0.0400	0.0200	0%	release
	Ammonia	0.0320	0.0390	0.0200	3%	release
	Total Lead	0.0112	0.00213	0.000200	20%	81%
	Total Copper	0.0438	0.00748	0.00200	20%	83%
	Total Zinc	0.1920	0.0381	0.00400	20%	80%
	Aluminum	3.85	1.200	0.0500	20%	69%
	Dissolved Copper	---	---	---	---	---
	Dissolved Zinc	---	---	---	---	---
	Hardness	38.8	16.7	0.250	20%	57%
	pH	6.84	6.81	---	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= parameter was returned as a non-detect result. NT= parameter not tested.

Disqualified Events

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Individual Storm Report

LPR021012

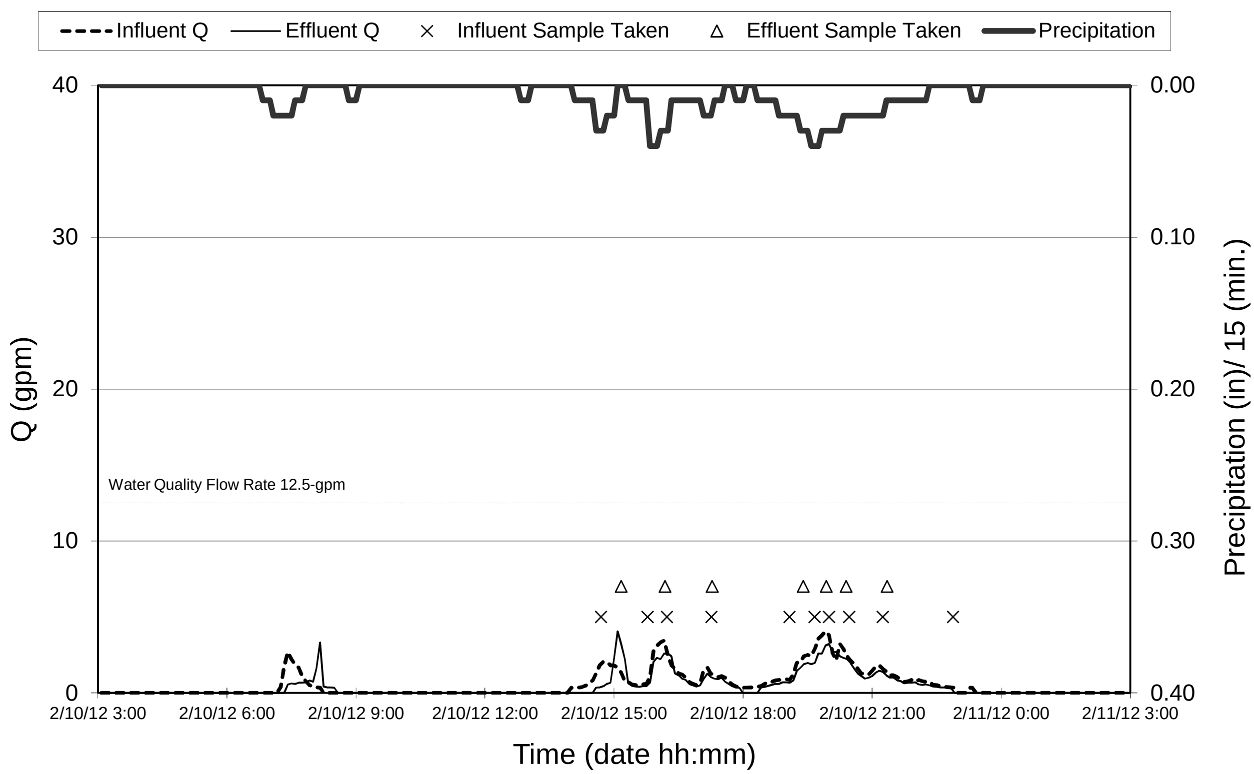
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	2/2/2012
Event Date:	2/10/2012
Antecedent Conditions (hr):	Pre-Event: 21 Post-Event: 49

Hydrology

Total Precipitation (in):	0.63		
Precipitation Duration (hrs):	16		
Rainfall Intensity (in/hr)	Max: 0.24	Average: 0.03	
Total Runoff Volume (gal):	Influent: 784	Effluent: 622	Bypass: 0.00
Peak Flow, (gpm):	Influent: 4.1	Effluent: 4.1	
Average Flow (gpm):	Influent: 0.5	Effluent: 0.4	
Storm Coverage (%):	Influent: 96	Effluent: 84	
Sampling Duration (hrs):	Influent: 8	Effluent: 6	

Event Hydrograph



Storm Name: LPR021012 Reviewed and Verified:

Individual Storm Report

LPR021012

Analytical

	Parameter	Concentrations (mg/L)				Discrete Removal
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
	TSS (SM)	182	63.0	10.00	20%	65%
Number of Aliquots:	SSC	180	68.2	4.57	20%	62%
IN: 10	TVSS	72.1	23.3	4.57	20%	68%
EFF: 7	SSC (<2000 µm)	183	68.4	4.50	20%	63%
	TVSS (<2000 µm)	71.6	22.6	4.50	20%	68%
	SSC (<500 µm)	161	64	4.50	20%	60%
	TVSS (<500 µm)	59.0	22.5	4.50	20%	62%
	SSC (<250 µm)	NT	NT	---	---	---
	TVSS (<250 µm)	NT	NT	---	---	---
	SSC (<100 µm)	NT	NT	---	---	---
	TVSS (<100 µm)	NT	NT	---	---	---
	SSC (<62.5 µm)	NT	NT	---	---	---
	TVSS (<62.5 µm)	NT	NT	---	---	---
	SSC (<50 µm)	106	60.5	4.50	20%	43%
	TVSS (<50 µm)	30.2	19.8	4.50	20%	34%
	Total Phosphorus	0.141	0.104	0.0200	0.710%	26%
	Dissolved Phosphorus	ND	ND	0.500	20%	undeterminable
	SRP (Ortho-phosphorus)	0.0100	0.0100	0.0100	20%	undeterminable
	TKN	1.03	ND	0.500	2.5%	51%
	Nitrate/Nitrite-N	0.0322	ND	0.0300	14.9%	undeterminable
	Ammonia	ND	ND	0.0500	20%	undeterminable
	Total Lead	NT	NT	---	---	---
	Total Copper	NT	NT	---	---	---
	Total Zinc	NT	NT	---	---	---
	Aluminum	NT	NT	---	---	---
	Dissolved Copper	NT	NT	---	---	---
	Dissolved Zinc	NT	NT	---	---	---
	Hardness	NT	NT	---	---	---
	pH	NT	NT	---	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. ND= non-detect value. NT= parameter not tested. Parameters listed in bold text did not meet standard hold times.

Storm Name: LPR021012 Reviewed and Verified:

Individual Storm Report

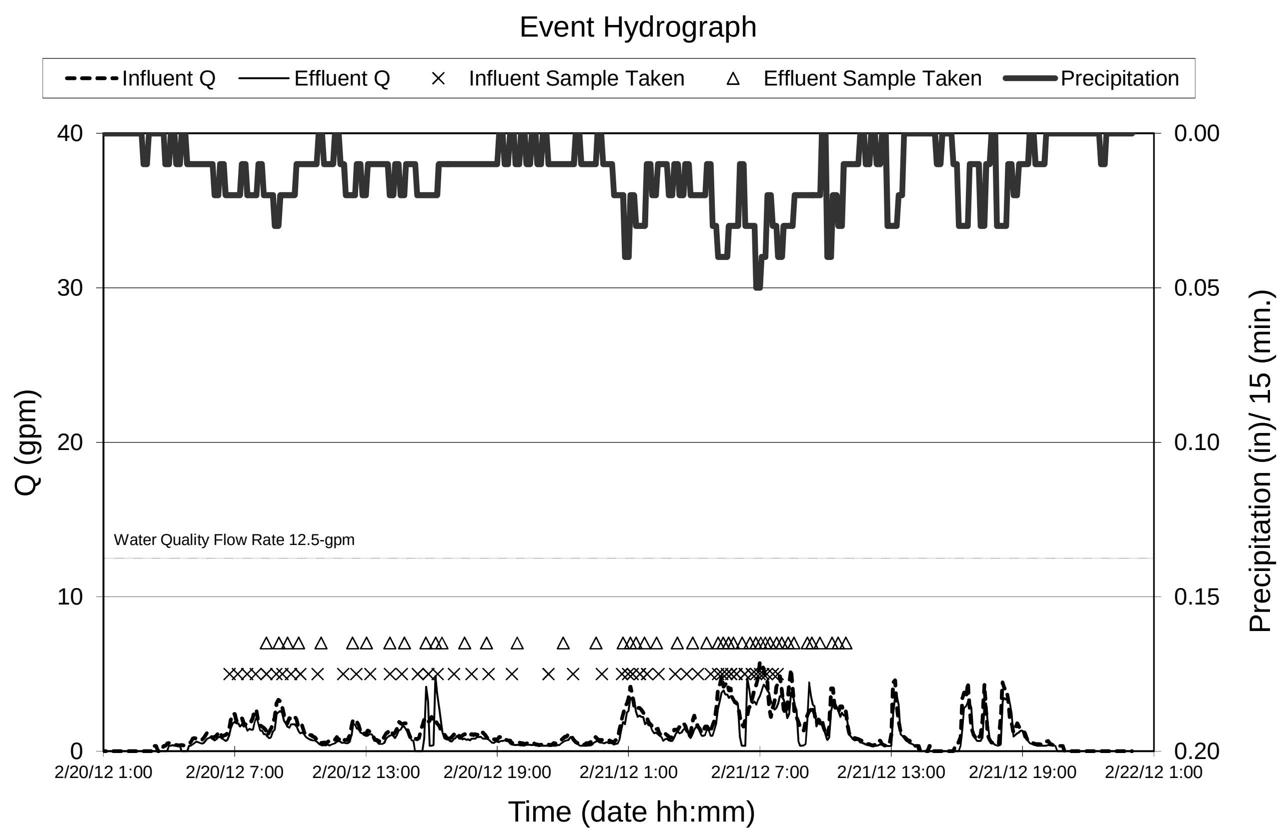
LPR022012

General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	2/2/2012
Event Date:	2/20/2012
Antecedent Conditions (hrs):	Pre-Event: 14 Post-Event: 16

Hydrology

Total Precipitation (in):	2.36		
Precipitation Duration (hrs):	43		
Rainfall Intensity (in/hr):	Max: 0.24	Average: 0.05	
Total Runoff Volume (gal):	Influent: 3583	Effluent: 2943	Bypass: 0.00
Peak Flow (gpm):	Influent: 5.8	Effluent: 4.9	
Average Flow (gpm):	Influent: 1.2	Effluent: 1.0	
Storm Coverage (%):	Influent: 66	Effluent: 76	
Sampling Duration (hrs):	Influent: 25	Effluent: 26	



Storm Name: LPR022012 Reviewed and Verified:

Individual Storm Report

LPR022012

Analytical

	Parameter	Concentrations (mg/L)				Discrete Removal
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
	TSS (SM)	246	ND	10.0	20%	96%
Number of Aliquots:	SSC	258	12.1	4.00	1.17%	95%
IN: 48	TVSS	170	4.1	4.00	20%	98%
EFF: 45	SSC (<2000 µm)	287	13.1	4.00	1.17%	95%
	TVSS (<2000 µm)	189	4.88	4.00	20%	97%
	SSC (<500 µm)	91.7	12.7	3.33	1.17%	86%
	TVSS (<500 µm)	36.7	4.61	3.33	20%	87%
	SSC (<250 µm)	NT	NT	NT	---	---
	TVSS (<250 µm)	NT	NT	NT	---	---
	SSC (<100 µm)	62.6	11.4	2.86	1.17%	82%
	TVSS (<100 µm)	17.1	3.97	2.86	20%	77%
	SSC (<62.5 µm)	NT	NT	NT	---	---
	TVSS (<62.5 µm)	NT	NT	NT	---	---
	SSC (<50 µm)	50.9	10.2	2.86	1.17%	80%
	TVSS (<50 µm)	12.3	3.83	2.86	20%	69%
	Total Phosphorus	0.163	0.0259	0.0200	6.17%	84%
	Dissolved Phosphorus	ND	ND	0.500	20%	undeterminable
	SRP (Ortho-phosphorus)	ND	ND	0.0100	20%	undeterminable
	TKN	0.660	ND	0.500	8.30%	24%
	Nitrate/Nitrite-N	0.0358	ND	0.0300	9.05%	16%
	Ammonia	ND	ND	0.0500	20%	undeterminable
	Total Lead	0.00490	ND	0.00100	20%	80%
	Total Copper	0.0136	ND	0.00200	3.49%	85%
	Total Zinc	0.0761	0.0108	0.0100	1.45%	86%
	Aluminum	2.62	0.319	0.100	6.58%	88%
	Dissolved Copper	NT	NT	NT	---	---
	Dissolved Zinc	NT	NT	NT	---	---
	Hardness	19.5	6.66	0.662	20%	66%
	pH	NT	NT	NT	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Individual Storm Report

LPR031012

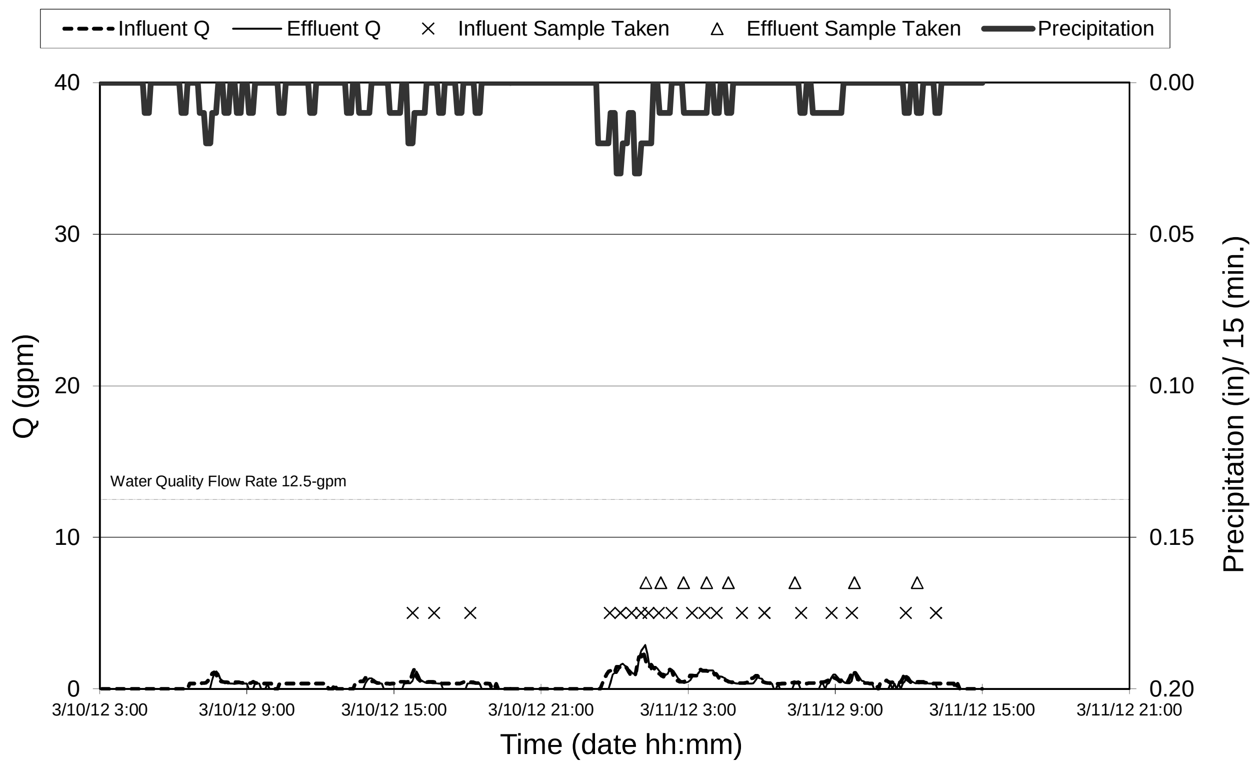
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	2/2/2012
Event Date:	3/10/2012
Antecedent Conditions (hr):	Pre-Event: 89 Post-Event: 28

Hydrology

Total Precipitation (in):	0.58		
Precipitation Duration (hrs):	32		
Rainfall Intensity (in/hr):	Max: 0.24	Average: 0.02	
Total Runoff Volume (gal):	Influent: 890	Effluent: 646	Bypass: 0.00
Peak Flow (gpm):	Influent: 2.5	Effluent: 2.9	
Average Flow (gpm):	Influent: 0.4	Effluent: 0.3	
Storm Coverage (%)	Influent: 79	Effluent: 63	
Sampling Duration (hrs):	Influent: 21	Effluent: 11	

Event Hydrograph



Storm Name: LPR031012   Reviewed and Verified:

Individual Storm Report

LPR031012

Analytical

	Parameter	Concentrations (mg/L)			Dup. RPD	Discrete Removal Efficiency
		Influent EMC	Effluent EMC	MRL		
	TSS (SM)	360	27	10	20%	93%
Number of Aliquots:	SSC	430	ND	22	20%	95%
IN: 20	TVSS	200	ND	22	20%	89%
EFF: 8	SSC (<2000 µm)	NT	NT	---	---	---
	TVSS (<2000 µm)	NT	NT	---	---	---
	SSC (<500 µm)	250	ND	22	20%	91%
	TVSS (<500 µm)	84	ND	22	20%	74%
	SSC (<250µm)	NT	NT	NT	---	---
	TVSS (<250 µm)	NT	NT	NT	---	---
	SSC (<100 µm)	160	ND	23	20%	86%
	TVSS (<100 µm)	36	ND	23	20%	36%
	SSC (<62.5µm)	NT	NT	NT	---	---
	TVSS (<62.5 µm)	NT	NT	NT	---	---
	SSC (<50 µm)	130	ND	24	20%	82%
	TVSS (<50 µm)	27	ND	24	20%	undeterminable
	Total Phosphorus	0.14	0.049	0.020	20%	65%
	Dissolved Phosphorus	ND	ND	0.500	20%	undeterminable
	SRP (Ortho-phosphorus)	ND	---	0.0100	---	---
	TKN	1.7	ND	0.50	20%	71%
	Nitrate/Nitrite-N	ND	ND	0.030	20%	undeterminable
	Ammonia	ND	ND	0.050	20%	undeterminable
	Total Lead	0.0093	0.0020	0.0010	20%	78%
	Total Copper	0.019	0.0034	0.0020	20%	82%
	Total Zinc	0.12	0.022	0.010	20%	82%
	Aluminum	6.2	1.1	0.10	20%	82%
	Dissolved Copper	NT	NT	NT	---	---
	Dissolved Zinc	NT	NT	NT	---	---
	Hardness	55	19	0.20	20%	65%
	pH	NT	NT	NT	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. NT indicates parameter was not tested for this event. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Individual Storm Report

LPR032912

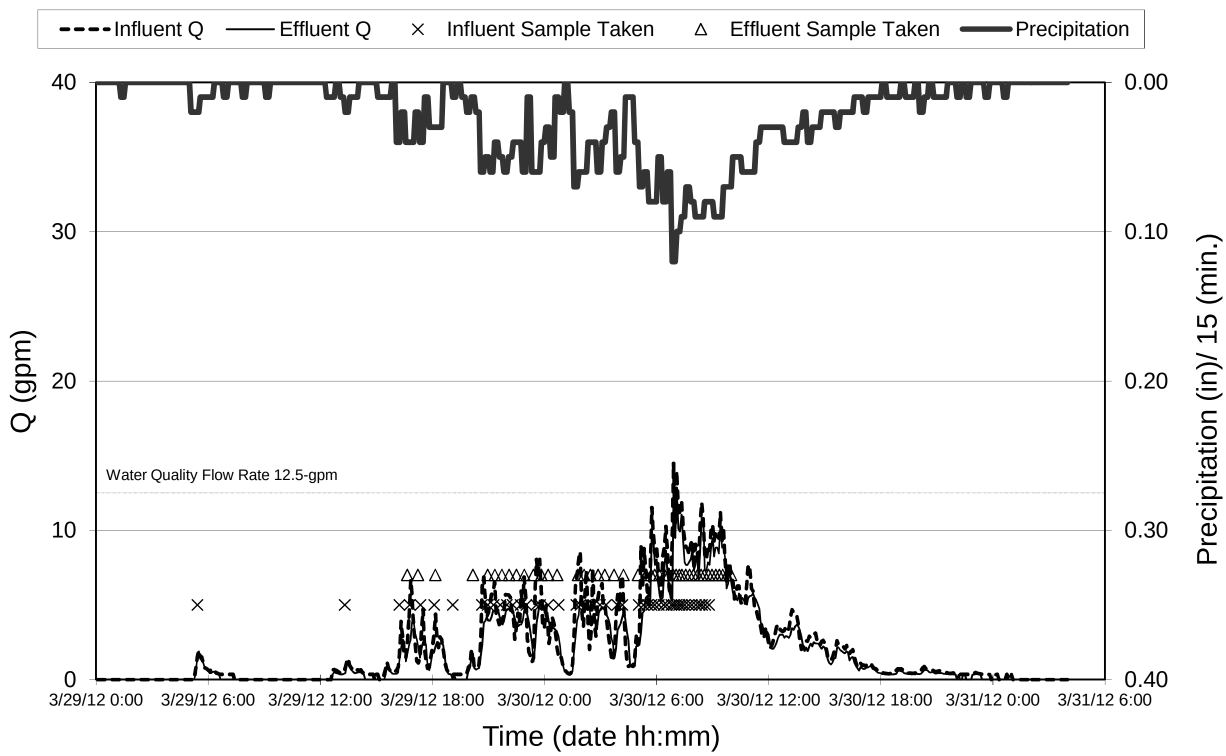
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon	
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres	
Date of Last Maintenance:	3/27/2012	
Event Date:	3/29/2012	
Antecedent Conditions (hr):	Pre-Event: 26	Post-Event: 34

Hydrology

Total Precipitation (in):	4.69		
Precipitation Duration (hrs):	47*		
Rainfall Intensity (in/hr):	Max: 0.60	Average: 0.09	
Total Runoff Volume (gal):	Influent: 6945	Effluent: 6011	Bypass: 10.0
Peak Flow (gpm):	Influent: 14.5	Effluent: 12.8	
Average Flow (gpm):	Influent: 2.2	Effluent: 1.9	
Storm Coverage (%)	Influent: 69	Effluent: 75	
Sampling Duration (hrs):	Influent: 27	Effluent: 17	

Event Hydrograph



Notes

* As per the QAPP event duration was stopped after 48 hours of precipitation. Precipitation continued until 4/2/2012 1:15. Post event dry period is calculated form the end of the precipitation.

Storm Name: LPR032912 Reviewed and Verified:

Individual Storm Report

LPR032912

Analytical

	Parameter	Concentrations (mg/L)				Discrete Removal
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
	TSS (SM)	370	47	10	20%	87%
Number of Aliquots:	SSC	390	58	33	2.6%	85%
IN: 48	TVSS	170	ND	33	20%	81%
EFF: 45	SSC (<2000 µm)	400	57	33	2.6%	86%
	TVSS (<2000 µm)	180	ND	33	20%	82%
	SSC (<500 µm)	230	55	33	2.6%	76%
	TVSS (<500 µm)	75	ND	33	20%	56%
	SSC (<250 µm)	NT	NT	NT	---	---
	TVSS (<250 µm)	NT	NT	NT	---	---
	SSC (<100 µm)	200	54	33	2.6%	73%
	TVSS (<100 µm)	ND	ND	33	20%	undeterminable
	SSC (<62.5 µm)	NT	NT	NT	---	---
	TVSS (<62.5 µm)	NT	NT	NT	---	---
	SSC (<50 µm)	160	53	33	2.6%	67%
	TVSS (<50 µm)	ND	ND	33	20%	undeterminable
	Total Phosphorus	0.28	0.081	0.020	3%	71%
	Dissolved Phosphorus	ND	ND	0.50	20%	undeterminable
	SRP (Ortho-phosphorus)	ND	ND	0.010	20%	undeterminable
	TKN	1.2	ND	0.50	20%	58%
	Nitrate/Nitrite-N	0.030	ND	0.030	20%	undeterminable
	Ammonia	ND	ND	0.050	20%	undeterminable
	Total Lead	0.012	0.0030	0.0010	20%	75%
	Total Copper	0.023	0.0041	0.0020	20%	82%
	Total Zinc	0.16	0.029	0.010	20%	82%
	Aluminum	6.4	1.7	0.20	2%	73%
	Dissolved Copper	NT	NT	NT	---	---
	Dissolved Zinc	NT	NT	NT	---	---
	Hardness	34	7.9	0.20	20%	77%
	pH	NT	NT	NT	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Storm Name: LPR032912 Reviewed and Verified:

Individual Storm Report

LPR111112

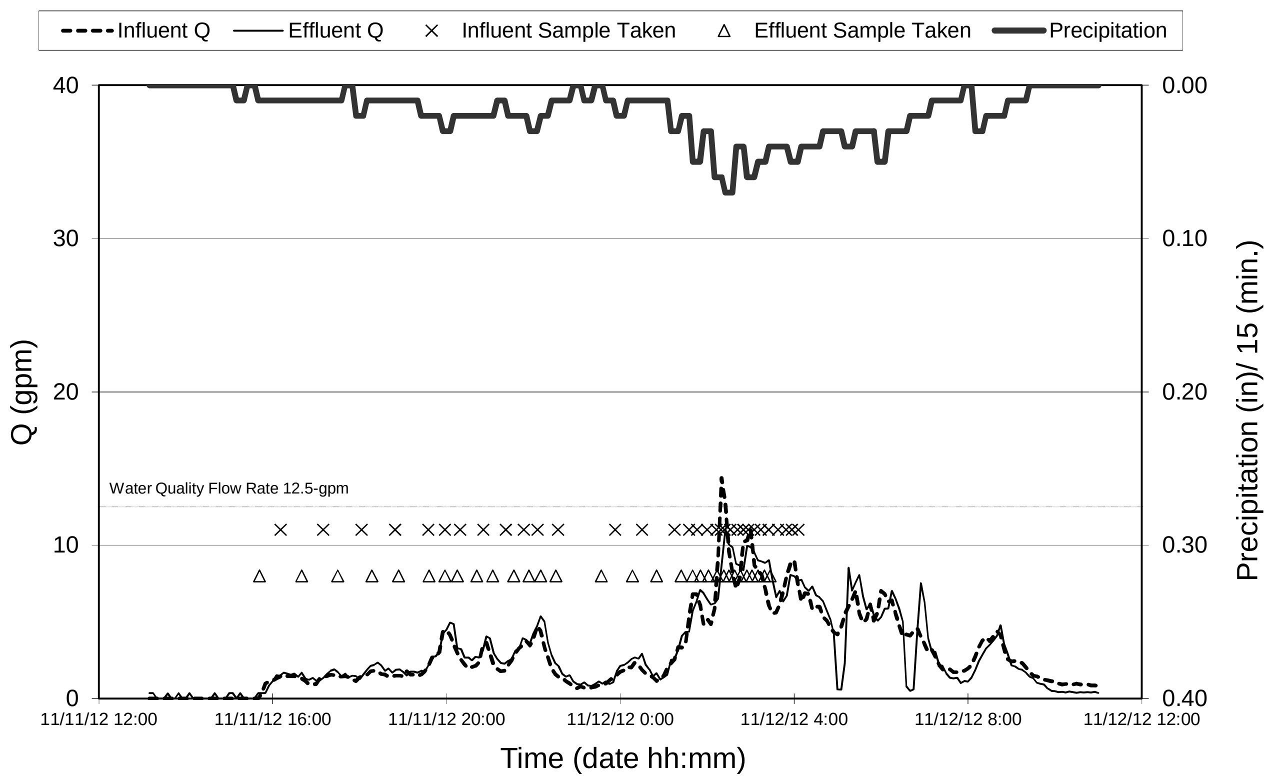
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	3/27/2012
Event Date:	11/11/2012
Antecedent Conditions (hrs):	Pre-Event: 47 Post-Event: 2

Hydrology

Total Precipitation (in):	1.56		
Precipitation Duration (hrs):	17		
Rainfall Intensity (in/hr):	Max: 0.36	Average: 0.07	
Total Runoff Volume (gal):	Influent: 3847	Effluent: 3993	Bypass: 0.00
Peak Flow (gpm):	Influent: 14.4	Effluent: 11.0	
Average Flow (gpm):	Influent: 2.9	Effluent: 3.0	
Storm Coverage (%):	Influent: 64	Effluent: 61	
Sampling Duration (hrs):	Influent: 11	Effluent: 11	

Event Hydrograph



Individual Storm Report

LPR111112

Analytical

	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	MRL	Dup. RPD	Discrete Removal Efficiency
	TSS (SM)	100	14	10	5%	86%
Number of Aliquots:	SSC	92	16	3.6	16.2%	83%
IN: 32	TVSS	61	7.5	3.6	20%	88%
EFF: 31	SSC (<2000 µm)	77	18	3.5	16.2%	77%
	TVSS (<2000 µm)	48	8.7	3.5	20%	82%
	SSC (<500 µm)	47	16	3.4	16.2%	66%
	TVSS (<500 µm)	24	6.1	3.4	20%	75%
	SSC (<250 µm)	NT	NT	NT	---	---
	TVSS (<250 µm)	NT	NT	NT	---	---
	SSC (<100 µm)	31	14	3.5	16.2%	55%
	TVSS (<100 µm)	14.0	5.9	3.5	20%	58%
	SSC (<62.5 µm)	NT	NT	NT	---	---
	TVSS (<62.5 µm)	NT	NT	NT	---	---
	SSC (<50 µm)	24	10	3.5	16.2%	58%
	TVSS (<50 µm)	9.1	5.2	3.5	20%	43%
	Total Phosphorus	0.076	ND	0.050	20%	34%
	Dissolved Phosphorus	ND	ND	0.50	20%	undeterminable
	SRP (Ortho-phosphorus)	0.0590	ND	0.0500	20%	undeterminable
	TKN	ND	ND	1.0	20%	undeterminable
	Nitrate/Nitrite-N	0.084	ND	0.030	1%	64%
	Ammonia	0.063	ND	0.050	20%	21%
	Total Lead	0.0016	ND	0.0010	0.7%	38%
	Total Copper	0.0066	0.0037	0.0020	0.01%	44%
	Total Zinc	0.041	0.028	0.010	1%	32%
	Aluminum	1.2	0.65	0.10	18%	46%
	Dissolved Copper	NT	NT	NT	---	---
	Dissolved Zinc	NT	NT	NT	---	---
	Hardness	20	22	0.20	20%	undeterminable
	pH	6.48	6.58	0.100	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Individual Storm Report

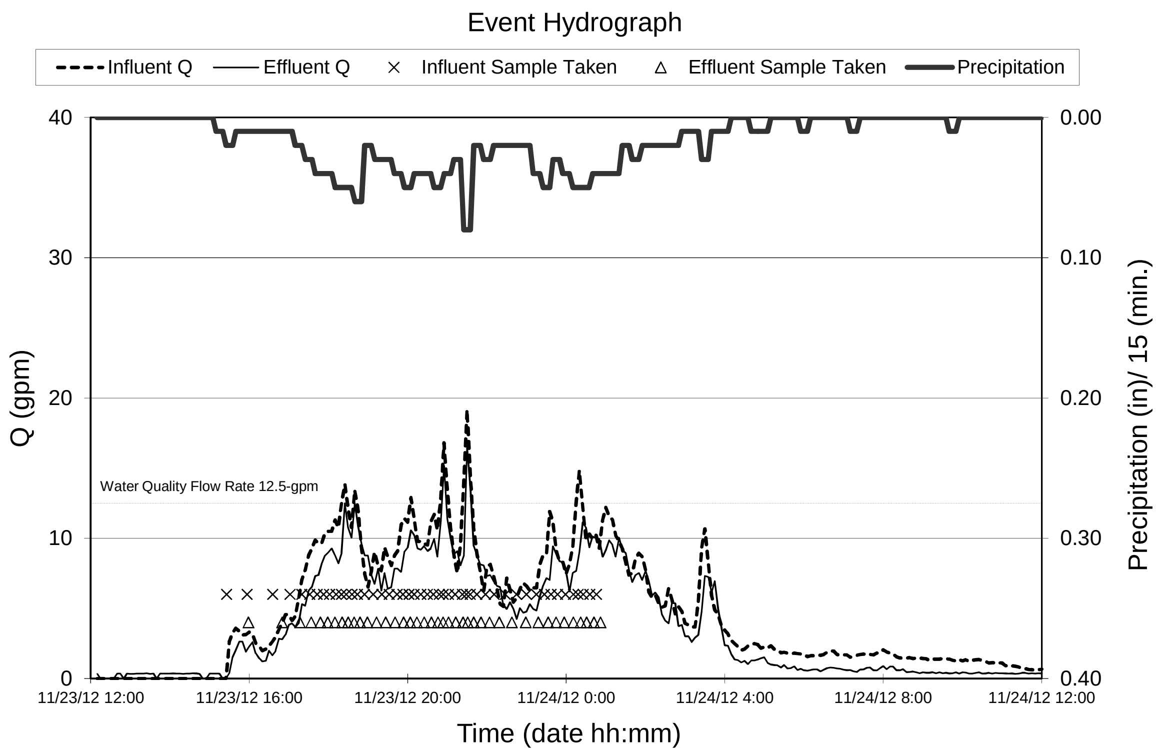
LPR112312

General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	3/27/2012
Event Date:	11/23/2012
Antecedent Conditions (hrs):	Pre-Event: 230 Post-Event: 48

Hydrology

Total Precipitation (in):	1.59		
Precipitation Duration (hrs):	18		
Rainfall Intensity (in/hr):	Max: 0.36	Average: 0.07	
Total Runoff Volume (gal):	Influent: 6819	Effluent: 5572	Bypass: 100.3
Peak Flow (gpm):	Influent: 19.2	Effluent: 16.6	
Average Flow (gpm):	Influent: 4.7	Effluent: 3.9	
Storm Coverage (%):	Influent: 70	Effluent: 73	
Sampling Duration (hrs):	Influent: 9	Effluent: 8	



Individual Storm Report

LPR112312

Analytical

Number of Aliquots:
IN: 48
EFF: 41

Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	MRL	Dup. RPD	Discrete Removal Efficiency
TSS (SM)	110	ND	10	5%	91%
SSC	120	7.6	2.2	0.0%	94%
TVSS	76	3.7	2.2	20%	95%
SSC (<2000 µm)	110	7.5	2.2	0.0%	93%
TVSS (<2000 µm)	73	3.2	2.2	20%	96%
SSC (<500 µm)	67	7.8	2.1	0.0%	88%
TVSS (<500 µm)	31	3.4	2.1	20%	89%
SSC (<250 µm)	NT	NT	NT	---	---
TVSS (<250µm)	NT	NT	NT	---	---
SSC (<100 µm)	40	6.5	2.2	0.0%	84%
TVSS (<100 µm)	13	3.1	2.2	20%	76%
SSC (<62.5 µm)	NT	NT	NT	---	---
TVSS (<62.5µm)	NT	NT	NT	---	---
SSC (<50 µm)	24	5.6	2.2	0.0%	77%
TVSS (<50 µm)	7.6	2.9	2.2	20%	62%
Total Phosphorus	0.082	ND	0.050	20%	39%
Dissolved Phosphorus	ND	ND	0.50	20%	undeterminable
SRP (Ortho-phosphorus)	ND	ND	0.0500	20%	undeterminable
TKN	ND	ND	1.0	20%	undeterminable
Nitrate/Nitrite-N	ND	ND	0.030	20%	undeterminable
Ammonia	ND	ND	0.050	20%	undeterminable
Total Lead	0.0020	ND	0.0010	22%	50%
Total Copper	0.0061	ND	0.0020	20%	67%
Total Zinc	0.049	0.010	0.010	3%	80%
Aluminum	1.2	0.19	0.10	5%	84%
Dissolved Copper	NT	NT	NT	---	---
Dissolved Zinc	NT	NT	NT	---	---
Hardness	17	3.5	0.20	20%	79%
pH	6.66	6.66	0.100	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. ND= non-detect value. NT= parameter not tested.

Individual Storm Report

LPR030814

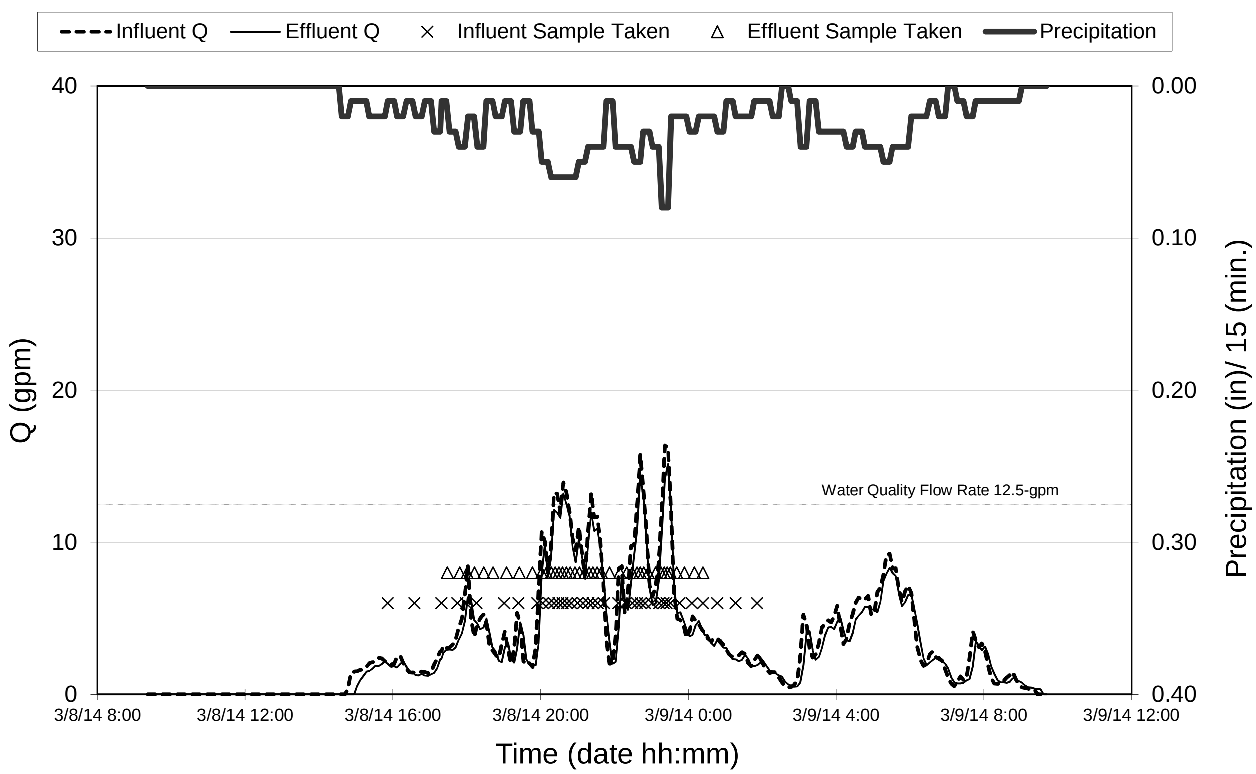
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon	
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres	
Date of Last Maintenance:	1/14/2014	
Event Date:	3/08/2014	
Antecedent Conditions (hrs):	Pre-Event: 27	Post-Event: 11

Hydrology

Total Precipitation (in):	1.89		
Precipitation Duration (hrs):	18		
Rainfall Intensity (in/hr):	Max: 0.36	Average: 0.08	
Total Runoff Volume (gal):	Influent: 4981	Effluent: 4593	Bypass: 70.0
Peak Flow (gpm):	Influent: 16.4	Effluent: 15.2	
Average Flow (gpm):	Influent: 3.4	Effluent: 3.1	
Storm Coverage (%):	Influent: 83	Effluent: 70	
Sampling Duration (hrs):	Influent: 13	Effluent: 9	

Event Hydrograph



Notes

*Back-up rain data from the Fort Deposit monitoring site was used for this event due to issues with the on-site rain gage.

Storm Name: LPR030814 Reviewed and Verified:

Individual Storm Report

LPR030814

Analytical

	Parameter	Concentrations (mg/L)				Discrete Removal
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
	TSS (SM)	173	26.0	5.00	20%	85%
Number of Aliquots:	SSC	408	22.0	3.57	11.1%	95%
IN: 47	TVSS	230	3.37	1.79	20%	99%
EFF: 48	SSC (<2000 µm)	NT	NT	---	---	---
	TVSS (<2000 µm)	NT	NT	---	---	---
	SSC (<500 µm)	NT	NT	---	---	---
	TVSS (<500 µm)	NT	NT	---	---	---
	SSC (<250 µm)	144	20.0	3.57	11.1%	86%
	TVSS (<250 µm)	NT	NT	---	---	---
	SSC (<100 µm)	NT	NT	---	---	---
	TVSS (<100 µm)	NT	NT	---	---	---
	SSC (<62.5 µm)	92	18.8	4.55	11.1%	80%
	TVSS (<62.5 µm)	NT	NT	---	---	---
	SSC (<50 µm)	NT	NT	---	---	---
	TVSS (<50 µm)	NT	NT	---	---	---
	Total Phosphorus	0.261	0.0514	0.0100	20%	80%
	Dissolved Phosphorus	0.0114	ND	0.0100	20%	undeterminable
	SRP (Ortho-phosphorus)	ND	ND	0.005	20%	undeterminable
	TKN	0.41	ND	0.10	20%	76%
	Nitrate/Nitrite-N	0.0200	0.0300	0.02000	20%	release
	Ammonia	0.0370	0.0240	0.0200	20%	35%
	Total Lead	0.00460	0.00131	0.000200	20%	72%
	Total Copper	0.0175	0.00219	0.00100	20%	87%
	Total Zinc	0.0876	0.0133	0.00400	20%	85%
	Aluminum	1.67	0.342	0.0500	20%	80%
	Dissolved Copper	0.00293	ND	0.00100	20%	66%
	Dissolved Zinc	0.00661	ND	0.00400	20%	39%
	Hardness	15.8	3.70	0.250	20%	77%
	pH	6.95	6.73	---	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. Screening Parameters collected for this event. ND= non-detect value. NT= parameter not tested.

Individual Storm Report

LPR042214

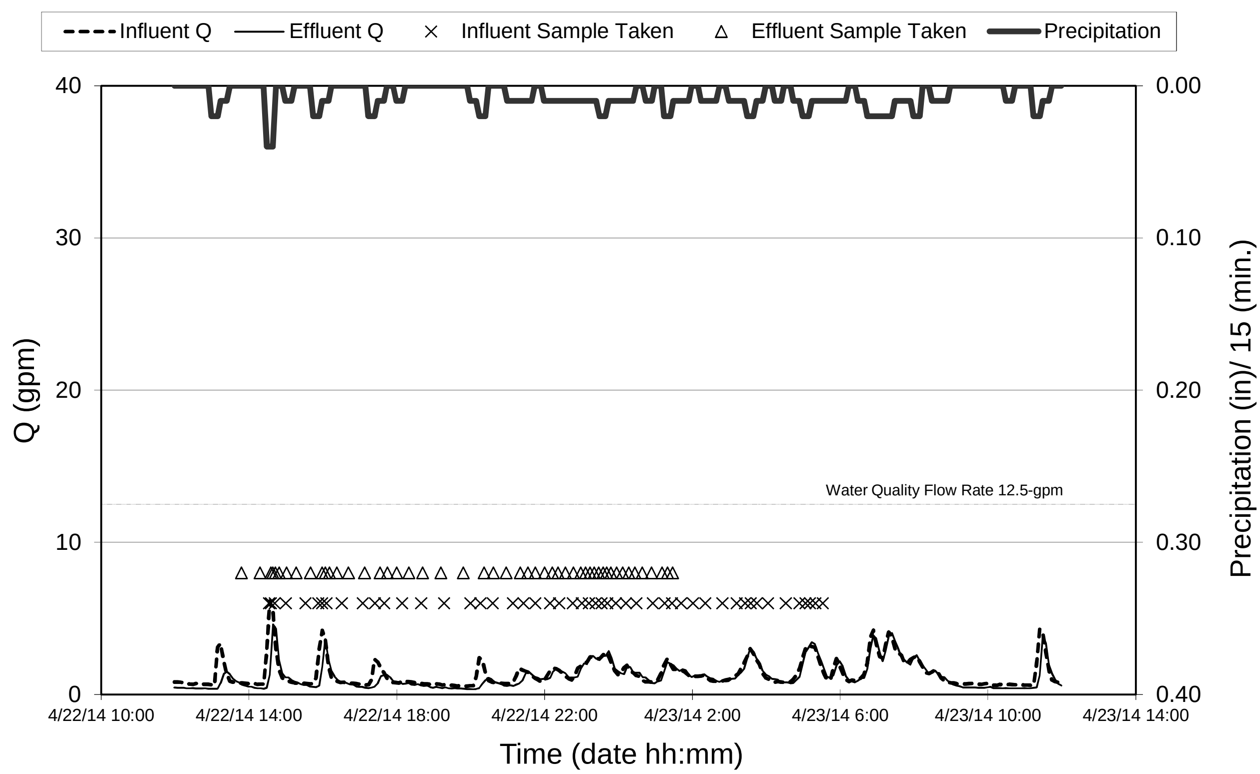
General Information

Site:	Lolo Pass Road (26607), Zigzag, Oregon
System Description:	StormFilter, PhosphoSorb Cart. (12.5-gpm); 0.063-acres
Date of Last Maintenance:	1/14/2014
Event Date:	4/22/2014
Antecedent Conditions (hr):	Pre-Event: 6 Post-Event: 3

Hydrology

Total Precipitation (in):	0.69		
Precipitation Duration (hr):	22		
Rainfall Intensity (in/hr):	Max: 0.06	Average: 0.03	
Total Runoff Volume (gal):	Influent: 1992	Effluent: 1757	Bypass: 0.0
Peak Flow (gpm):	Influent: 6.2	Effluent: 4.6	
Average Flow (gpm):	Influent: 1.4	Effluent: 1.2	
Storm Coverage (%):	Influent: 64	Effluent: 44	
Sampling Duration (hrs):	Influent: 14	Effluent: 11	

Event Hydrograph



Storm Name: LPR042214 Reviewed and Verified:

Individual Storm Report

LPR042214

Analytical

	Parameter	Influent EMC	Effluent EMC	MRL	Dup. RPD	Discrete Removal Efficiency
		Concentrations (mg/L)				
	TSS (SM)	159	18.0	5.00	21%	89%
Number of Aliquots:	SSC	212	23.3	3.85	20%	89%
IN: 50	TVSS	90.8	27.0	5.00	20%	70%
EFF: 50	SSC (<2000 µm)	NT	NT	NT	---	---
	TVSS (<2000 µm)	NT	NT	NT	---	---
	SSC (<500 µm)	NT	NT	NT	---	---
	TVSS (<500 µm)	NT	NT	NT	---	---
	SSC (<250 µm)	371	16.6	5.7	20%	96%
	TVSS (<250 µm)	NT	NT	NT	---	---
	SSC (<100 µm)	NT	NT	NT	---	---
	TVSS (<100 µm)	NT	NT	NT	---	---
	SSC (<62.5 µm)	268	18.5	2.2	20%	93%
	TVSS (<62.5 µm)	NT	NT	NT	---	---
	SSC (<50 µm)	NT	NT	NT	---	---
	TVSS (<50 µm)	NT	NT	NT	---	---
	Total Phosphorus	0.234	0.0368	0.0100	5%	84%
	Dissolved Phosphorus	ND	0.0260	0.0100	20%	release
	SRP (Ortho-phosphorus)	ND	ND	0.005	20%	undeterminable
	TKN	0.37	0.13	0.10	20%	65%
	Nitrate/Nitrite-N	0.0400	0.0600	0.0200	20%	release
	Ammonia	0.0360	0.0290	0.0100	7%	19%
	Total Lead	0.00324	0.000889	0.000200	4%	73%
	Total Copper	0.0103	0.00333	0.00100	2%	68%
	Total Zinc	0.0521	0.0162	0.00400	0.9%	69%
	Aluminum	1.56	0.403	0.0500	18%	74%
	Dissolved Copper	0.00102	0.00142	0.00100	60%	undeterminable
	Dissolved Zinc	0.00851	0.0077	0.00400	1%	10%
	Hardness	12.2	7.75	0.250	20%	36%
	pH	6.39	6.36	---	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Parameters listed in bold text did not meet standard hold times. Screening Parameters collected for this event. ND= parameter was returned as a non-detect result. NT= parameter not tested.

Storm Name: LPR042214 Reviewed and Verified:

APPENDIX E – Quality Assurance Quality Control

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Memorandum

Date: 5/18/2015

Project: Stormwater Management StormFilter PhosphoSorb

From: John Pedrick, Contech Engineered Solutions

Subject: Water Quality Data Quality Assurance Review

This memorandum presents a review of data quality for 25 composite (including 4 field duplicate samples) influent and effluent stormwater samples collected from the Stormwater Management StormFilter® (StormFilter) with PhosphoSorb media in Zigzag, Oregon between February 2012 and February 2015.

From February 2012 to June 2012, Test America in Beaverton, Oregon analyzed the composite samples for the parameters listed in Table 1. From November 2012 to February 2015, APEX in Tigard, Oregon analyzed the composite samples for the parameters listed in Table 1.

Table 1. Parameters and Methods

Parameter	Method
Susp. Sediment Conc. (SSC)	ASTM D3977
Tot. Susp. Solids (TSS)	SM 2540 D
Tot. Vol. Susp. Solids (TVSS)	SM 2540 G
Total Phosphorus	SM 4500 P F
Dissolved Phosphorus	EPA 200.7
Orthophosphate	EPA 365.2
Nitrate/Nitrite-N	EPA 353.2
Total Kjeldahl-N	EPA 351.2
Ammonia	EPA 350.1
Total Copper	EPA 200.8
Total Zinc	EPA 200.8
Total Lead	EPA 200.8
Total Aluminum	EPA 200.7
Dissolved Copper	EPA 200.8
Dissolved Zinc	EPA 200.8
Hardness	SM 2340B
pH	EPA 150.1

Each laboratory's performance was reviewed in accordance with quality control (QC) criteria outlined in the Quality Assurance Project Plan (Contech, 2013).

Quality control data summaries submitted by the laboratories were reviewed. Data quality spreadsheets summarizing the quality assurance and quality control (QA/QC) review were completed for each sampling event and are included with in Attachment A. Data qualifiers were added to the sample results in the laboratory reports. Data validation results are summarized below followed by definitions of data qualifiers.

Custody, Preservation, Holding Times, and Completeness—Acceptable with Qualification

The samples were properly preserved and sample custody was maintained from sample collection to receipt at the laboratories. With the exceptions noted in Table 3, all samples were analyzed within the required holding times shown in Table 2. The laboratory reports were complete and contained results for all samples and tests requested on the chain-of-custody (COC) forms.

Table 2. Collection requirements and reporting limits

Parameter	Method	Handling in Addition to Cold Storage	Pre-Filtration Holding Time	Total Holding Time	Reporting limit target [a]
Susp. Sediment Conc. (SSC)	ASTM D3977	None	NA	7 days	1.0 mg/l
Tot. Susp. Solids (TSS)	SM 2540 D	None	NA	8 days	1.0 mg/l
Tot. Vol. Susp. Solids (TVSS)	SM 2540 G	None	NA	9 days	1.0 mg/l
Total Phosphorus	SM 4500 P F	H2SO4 to pH<2	NA	28 days	0.01 mg/l
Dissolved Phosphorus	EPA 200.7	None	12 hours [b]	48 hours	0.01 mg/l
Orthophosphate	EPA 365.2	None	12 hours [b]	48 hours	0.01 mg/l
Nitrate/Nitrite-N	EPA 353.2	H2SO4 to pH<2	NA	28 days	0.03 mg/l
Total Kjeldahl-N	EPA 351.2	H2SO4 to pH<2	NA	28 days	0.50 mg/l
Ammonia	EPA 350.1	H2SO4 to pH<2	NA	28 days	0.05 mg/l
Total Copper	EPA 200.8	H2SO4 to pH<2	NA	6 months	0.002 mg/l
Total Zinc	EPA 200.8	H2SO4 to pH<2	NA	6 months	0.01 mg/l
Total Lead	EPA 200.8	H2SO4 to pH<2	NA	6 months	0.001 mg/l
Total Aluminum	EPA 200.7	H2SO4 to pH<2	NA	6 months	0.1 mg/l
Dissolved Copper	EPA 200.8	0.45-um filtration	NA	6 months	0.002 mg/l
Dissolved Zinc	EPA 200.8	0.45-um filtration	12 hours a	6 months	0.01 mg/l
Hardness	SM 2340B	HNO3 to pH<5	12 hours a	6 months	0.662 mg/l
pH	EPA 150.1	None	NA	7 days	0.2 units

[a] To the extent possible, reporting limits for the analytical laboratory selected should be the same or below those listed here. All results below reporting limits should be reported and identified as such.

[b] Pre-filtration holding times of 15 minutes for dissolved metals and orthophosphate are recommended in US EPA (1983) and required in 40 CFR 136.3, Table 2; however these holding times cannot realistically be met with flow weighted automated sampling techniques. Ecology will accept data qualified as an estimate (J qualifier) in filtration occurred between 15 minutes and 12 hours after the last aliquot was collected.

Table 3. Summary of sample results qualified due to hold time criteria exceedance

Event ID	Parameter	Qualifier
LPR020215	Dissolved Phosphorus	J
LPR021012	Orthophosphate	J
LPR021412	Orthophosphate	J
LPR021712	Orthophosphate	J
LPR022012	Orthophosphate	J
LPR022412	Orthophosphate	J
LPR031012	Orthophosphate	J
LPR031212	Orthophosphate	J
LPR060412	Orthophosphate	J
LPR051713	Orthophosphate	J
LPR052113	Orthophosphate	J
LPR030314	Orthophosphate	J
LPR030814	Orthophosphate	J
LPR042314	Orthophosphate	J
LPR011815	Orthophosphate	J
LPR062513	Orthophosphate	J
LPR052113	Susp. Sediment Conc. (SSC)	J
LPR111112	Tot. Susp. Solids (TSS)	J
LPR052113	Tot. Susp. Solids (TSS)	J
LPR052113	Tot. Vol. Susp. Solids (TVSS)	J

Laboratory Reporting Limits—Acceptable with Qualification

The QAPP specified reporting limits are provided in Table 2. With the exceptions noted below in Table 4, the laboratory reporting limits met the QAPP specified reporting limits for all analyses. Data were qualified based on laboratory reporting limits. Qualified sample pairs are shown in Table 4.

Table 4. Summary of sample results qualified due to target reporting limit exceedance

Event ID	Parameter	Qualifier	Event ID	Parameter	Qualifier	Event ID	Parameter	Qualifier
LPR032912	Total Aluminum	J	LPR060712	Susp. Sediment Conc. (SSC)	J	LPR032912	Total Zinc	J
LPR052412	Total Aluminum	J	LPR110612	Susp. Sediment Conc. (SSC)	J	LPR052412	Total Zinc	J
LPR060112	Total Aluminum	J	LPR111112*	Susp. Sediment Conc. (SSC)	J	LPR060112	Total Zinc	J
LPR060412	Total Aluminum	J	LPR112312	Susp. Sediment Conc. (SSC)	J	LPR060712	Total Zinc	J
LPR013014	Total Aluminum	J	LPR113012	Susp. Sediment Conc. (SSC)	J	LPR021012	Tot. Susp. Solids (TSS)	J
LPR021012	Ammonia	J	LPR051713	Susp. Sediment Conc. (SSC)	J	LPR021412	Tot. Susp. Solids (TSS)	J
LPR021412	Ammonia	J	LPR052113	Susp. Sediment Conc. (SSC)	J	LPR021712*	Tot. Susp. Solids (TSS)	J
LPR022412	Ammonia	J	LPR062513	Susp. Sediment Conc. (SSC)	J	LPR022012*	Tot. Susp. Solids (TSS)	J
LPR031012	Ammonia	J	LPR013014	Susp. Sediment Conc. (SSC)	J	LPR022412	Tot. Susp. Solids (TSS)	J
LPR031212	Ammonia	J	LPR030314	Susp. Sediment Conc. (SSC)	J	LPR031012	Tot. Susp. Solids (TSS)	J
LPR111112	Ammonia	J	LPR030814	Susp. Sediment Conc. (SSC)	J	LPR031212	Tot. Susp. Solids (TSS)	J
LPR112312	Ammonia	J	LPR042314	Susp. Sediment Conc. (SSC)	J	LPR032912	Tot. Susp. Solids (TSS)	J
LPR062513	Ammonia	J	LPR011815	Susp. Sediment Conc. (SSC)	J	LPR052412	Tot. Susp. Solids (TSS)	J
LPR021012	Dissolved Phosphorus	J	LPR020215	Susp. Sediment Conc. (SSC)	J	LPR060112	Tot. Susp. Solids (TSS)	J
LPR021412	Dissolved Phosphorus	J	LPR060712	Total Kjeldahl-N	J	LPR060412	Tot. Susp. Solids (TSS)	J
LPR021712	Dissolved Phosphorus	J	LPR110612	Total Kjeldahl-N	J	LPR060712	Tot. Susp. Solids (TSS)	J
LPR022012	Dissolved Phosphorus	J	LPR111112	Total Kjeldahl-N	J	LPR110612	Tot. Susp. Solids (TSS)	J
LPR022412	Dissolved Phosphorus	J	LPR112312	Total Kjeldahl-N	J	LPR111112	Tot. Susp. Solids (TSS)	J
LPR031012	Dissolved Phosphorus	J	LPR113012	Total Kjeldahl-N	J	LPR112312	Tot. Susp. Solids (TSS)	J
LPR031212	Dissolved Phosphorus	J	LPR021712	Total Copper	J	LPR113012	Tot. Susp. Solids (TSS)	J
LPR032912	Dissolved Phosphorus	J	LPR022412	Total Copper	J	LPR051713	Tot. Susp. Solids (TSS)	J
LPR052412	Dissolved Phosphorus	J	LPR031212	Total Copper	J	LPR052113	Tot. Susp. Solids (TSS)	J
LPR060112	Dissolved Phosphorus	J	LPR032912	Total Copper	J	LPR062513	Tot. Susp. Solids (TSS)	J
LPR060412	Dissolved Phosphorus	J	LPR052412	Total Copper	J	LPR013014	Tot. Susp. Solids (TSS)	J
LPR060712	Dissolved Phosphorus	J	LPR060112	Total Copper	J	LPR030314	Tot. Susp. Solids (TSS)	J
LPR110612	Dissolved Phosphorus	J	LPR060712	Total Copper	J	LPR030814	Tot. Susp. Solids (TSS)	J
LPR111112	Dissolved Phosphorus	J	LPR021712	Total Lead	J	LPR042314	Tot. Susp. Solids (TSS)	J
LPR112312	Dissolved Phosphorus	J	LPR022412	Total Lead	J	LPR011815	Tot. Susp. Solids (TSS)	J
LPR113012	Dissolved Phosphorus	J	LPR031212	Total Lead	J	LPR020215	Tot. Susp. Solids (TSS)	J
LPR013014	Hardness	J	LPR032912	Total Lead	J	LPR021012	Tot. Vol. Susp. Solids (TVSS)	J
LPR011815	Hardness (calcium)	J	LPR052412	Total Lead	J	LPR021412	Tot. Vol. Susp. Solids (TVSS)	J
LPR020215	Hardness (calcium)	J	LPR060112	Total Lead	J	LPR021712*	Tot. Vol. Susp. Solids (TVSS)	J
LPR011815	Hardness (magnesium)	J	LPR060712	Total Lead	J	LPR022012*	Tot. Vol. Susp. Solids (TVSS)	J
LPR020215	Hardness (magnesium)	J	LPR021012	Total Phosphorus	J	LPR022412	Tot. Vol. Susp. Solids (TVSS)	J
LPR021012	Nitrate/Nitrite-N	J	LPR021412	Total Phosphorus	J	LPR031012	Tot. Vol. Susp. Solids (TVSS)	J
LPR031212	Nitrate/Nitrite-N	J	LPR021712	Total Phosphorus	J	LPR031212	Tot. Vol. Susp. Solids (TVSS)	J
LPR052412	Nitrate/Nitrite-N	J	LPR022012	Total Phosphorus	J	LPR032912	Tot. Vol. Susp. Solids (TVSS)	J
LPR060112	Nitrate/Nitrite-N	J	LPR022412	Total Phosphorus	J	LPR052412	Tot. Vol. Susp. Solids (TVSS)	J
LPR111112	Nitrate/Nitrite-N	J	LPR031012	Total Phosphorus	J	LPR060112	Tot. Vol. Susp. Solids (TVSS)	J
LPR110612	Orthophosphate	J	LPR031212	Total Phosphorus	J	LPR060412	Tot. Vol. Susp. Solids (TVSS)	J
LPR111112	Orthophosphate	J	LPR032912	Total Phosphorus	J	LPR060712	Tot. Vol. Susp. Solids (TVSS)	J
LPR112312	Orthophosphate	J	LPR052412	Total Phosphorus	J	LPR110612	Tot. Vol. Susp. Solids (TVSS)	J
LPR113012	Orthophosphate	J	LPR060112	Total Phosphorus	J	LPR111112*	Tot. Vol. Susp. Solids (TVSS)	J
LPR021012	Susp. Sediment Conc. (SSC)	J	LPR060412	Total Phosphorus	J	LPR112312	Tot. Vol. Susp. Solids (TVSS)	J
LPR021412	Susp. Sediment Conc. (SSC)	J	LPR060712	Total Phosphorus	J	LPR113012	Tot. Vol. Susp. Solids (TVSS)	J
LPR021712*	Susp. Sediment Conc. (SSC)	J	LPR110612	Total Phosphorus	J	LPR051713	Tot. Vol. Susp. Solids (TVSS)	J
LPR022012*	Susp. Sediment Conc. (SSC)	J	LPR111112	Total Phosphorus	J	LPR052113	Tot. Vol. Susp. Solids (TVSS)	J
LPR022412	Susp. Sediment Conc. (SSC)	J	LPR112312	Total Phosphorus	J	LPR062513	Tot. Vol. Susp. Solids (TVSS)	J
LPR031012	Susp. Sediment Conc. (SSC)	J	LPR113012	Total Phosphorus	J	LPR013014	Tot. Vol. Susp. Solids (TVSS)	J
LPR031212	Susp. Sediment Conc. (SSC)	J	LPR011815	Total Phosphorus	J	LPR030314	Tot. Vol. Susp. Solids (TVSS)	J
LPR032912	Susp. Sediment Conc. (SSC)	J	LPR020215	Total Phosphorus	J	LPR030814	Tot. Vol. Susp. Solids (TVSS)	J
LPR052412	Susp. Sediment Conc. (SSC)	J	LPR021712	Total Zinc	J	LPR042314	Tot. Vol. Susp. Solids (TVSS)	J
LPR060112	Susp. Sediment Conc. (SSC)	J	LPR022412	Total Zinc	J	LPR011815	Tot. Vol. Susp. Solids (TVSS)	J
LPR060412	Susp. Sediment Conc. (SSC)	J	LPR031212	Total Zinc	J	LPR020215	Tot. Vol. Susp. Solids (TVSS)	J

Blank Analysis—Acceptable with Qualification

Method Blanks—Acceptable with Qualification

Method blanks were generally analyzed at the required frequency. No reported method blanks had levels of target analytes above the method detection limits.

Rinsate Blanks—Acceptable with Qualification

Two rinsate blank samples from both the inlet and effluent were collected as per the QAPP. Rinsate blank samples were analyzed for total and dissolved metals, total phosphorus, and Orthophosphate. With the exceptions noted in Table 5, no target analytes were detected prior during monitoring activities.

Table 5. Summary of sample results qualified due to detection of target pollutants in rinsate blank samples

Event ID	Parameter	Qualifier
LPR021012	Dissolved Zinc	J
LPR021412	Dissolved Zinc	J
LPR021712	Dissolved Zinc	J
LPR022012	Dissolved Zinc	J
LPR022412	Dissolved Zinc	J
LPR031012	Dissolved Zinc	J
LPR031212	Dissolved Zinc	J
LPR032912	Dissolved Zinc	J
LPR052412	Dissolved Zinc	J
LPR060112	Dissolved Zinc	J
LPR060412	Dissolved Zinc	J
LPR060712	Dissolved Zinc	J
LPR110612	Dissolved Zinc	J
LPR111112	Dissolved Zinc	J
LPR112312	Dissolved Zinc	J
LPR113012	Dissolved Zinc	J
LPR051713	Dissolved Zinc	J
LPR052113	Dissolved Zinc	J
LPR062513	Dissolved Zinc	J
LPR013014	Dissolved Zinc	J
LPR030314	Dissolved Zinc	J
LPR030814	Dissolved Zinc	J
LPR042314	Dissolved Zinc	J
LPR011815	Dissolved Zinc	J
LPR020215	Dissolved Zinc	J

Laboratory Control Sample Analysis—Acceptable with Qualification

Laboratory control samples were generally analyzed at the required frequency. With the exceptions noted below in Table 6, the percent recovery values for all sampling events met the laboratory criteria. Qualified sample pairs are shown in Table 6.

Table 6. Summary of sample results qualified due to Laboratory control percent recovery limit criteria exceedance

Event ID	Parameter	Qualifier
LPR111112	Total Kjeldahl-N	J

Matrix Spike Analysis—Acceptable with Qualification

Matrix spike (MS) samples were generally analyzed at the required frequency. Several MS or MSD recoveries were outside of control limits. Data were not qualified if the exceedances occurred with a batch QC sample, and all other QC criteria were met. Qualified sample pairs are shown in Table 7.

Table 7. Summary of sample results qualified due to matrix spike recovery criteria exceedance

Event ID	**Parameter**	**Qualifier**
LPR032912	Total Aluminum	J
LPR060112	Total Aluminum	J
LPR022412	Ammonia	J
LPR111112	Ammonia	J
LPR011815	Nitrate/Nitrite-N	J

Laboratory Duplicate Analysis— Acceptable with Qualification

Laboratory duplicates or laboratory control sample duplicates were generally analyzed at the required frequency. The relative percent difference (RPD) was calculated for each analyte where both duplicate values were greater than five times the reporting limit (RL). The difference between duplicate values was calculated if the detected compound concentration was less than five times the RL in either the sample or the field duplicate. A control limit of two times the RL was used to evaluate difference values. Several batch sample duplicate RPDs or differences exceeded the established control limits. However, no data were qualified because of batch sample exceedances, and all other QC criteria were met. Qualified sample pairs are shown in Table 8.

Table 8. Summary of sample results qualified due to laboratory control sample criteria exceedance

Event ID	Parameter	Qualifier
LPR011815	Nitrate/Nitrite-N	J
LPR013014	Susp. Sediment Conc. (SSC)	J
LPR042314	Susp. Sediment Conc. (SSC)	J
LPR042314	Tot. Susp. Solids (TSS)	J
LPR013014	Tot. Vol. Susp. Solids (TVSS)	J

Field Duplicates—Acceptable with Qualification

Field duplicates were analyzed for all analyses. The QAPP specified that a field duplicate sample be collected at a frequency of 10 percent. As shown in Table 9, field duplicates were generally collected at the required frequency. No data were qualified due to field duplicate collection frequency.

Table 9. Frequency of field duplicate sample collection

Number of samples	Number of duplicates collected	Percentage of samples
25	4	16%

With the exceptions noted below in Table 10, field duplicate precision met the QAPP specified criteria. Table 10 summarizes the samples that were qualified as estimated (J) for field duplicate RPD exceedance. No other data associated with the sample batch were qualified due to field duplicate criteria exceedance because other quality control criteria were met.

Table 10. Summary of field duplicate criteria exceedance

Event ID	Parameter	Qualifier
LPR042314	SSC	J
LPR042314	TSS-SM	J

Data Quality Assessment Summary

In general, the data quality for all parameters were found to be acceptable based on holding time, reporting limit, method blank analysis, rinsate blank analysis, laboratory control sample analysis, matrix spike analysis, laboratory duplicate sample analysis, and field duplicate analysis. 20 sample pairs were qualified as estimated (J) due to holding time exceedance. 162 sample pairs were qualified as estimated (J) due to reporting limit exceedance. No sample pairs qualified due to a method blank detection limit exceedance. Twenty-five sample pairs were qualified as estimated (J) due to detection of target pollutants in rinsate blank samples. One sample pair was qualified as estimated (J) due to laboratory control sample recovery limit exceedance. Five sample pairs were qualified as estimated (J) due to matrix spike recovery limit exceedance. Five sample pairs were qualified as estimated (J) due to laboratory duplicate sample RPD limit exceedance. Two sample pairs were qualified as estimated (J) due to field duplicate criteria exceedance. Usability of the data are based on the guidance documents previously noted. Upon consideration of the information presented here, the data are acceptable as qualified.

Definition of Data Qualifiers

The following data qualifier definitions are taken from USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (USEPA 2002).

U- The material was analyzed for, but was not detected above the level of the Associated value. The associated value is either the sample quantitation limit or the sample detection limit.

J-The associated value is an estimated quantity.

UJ- The material was analyzed for, but was not detected. The associated value is an estimate and may be inaccurate or imprecise.

R -The data are unusable. (Note: analyte may or may not be present.)

References

Contech 2013. Quality Assurance Project Plan The Stormwater Management StormFilter® PhosphoSorb® at a Specific Flow Rate 1.67 gpm/ft2 Performance Evaluation. Prepared by Contech Engineered Solutions., Portland, OR. September 2013.

USEPA. 2002. Contract laboratory program national functional guidelines for inorganic data review. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C. (EPA-540/R-01/008).

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APPENDIX F – Raw Data

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Event ID	Total Precipitation Depth (in)	Max Precipitation Intensity (in/hour)	Avg Precipitation Intensity (in/hr)	Precipitation Duration (hours)	Influent Sampling Duration (hours)	Effluent Sampling Duration (hours)	Influent Coverage	Effluent Coverage	Antecedent Dry period (hours)	Post Event Dry Period (hours)
LPR021012	0.63	0.24	0.03	16	8	6	96%	84%	21	49
LPR021412	0.34	0.12	0.01	18	8	8	81%	78%	21	36
LPR021712	1.34	0.36	0.02	46	28	29	94%	97%	18	14
LPR022012	2.36	0.24	0.05	43	25	26	66%	76%	14	16
LPR022412	0.80	0.48	0.04	11	10	9	100%	91%	31	11
LPR031012	0.58	0.24	0.02	32	21	11	79%	63%	89	28
LPR131212	0.44	0.12	0.03	6	3	4	83%	95%	28	16
LPR032912a	4.69	0.60	0.09	47	27	17	69%	75%	26	34
LPR052412	0.48	0.24	0.04	5	2	2	85%	80%	4	48
LPR060112	0.86	0.48	0.08	7	7	7	97%	99%	104	10
LPR060412	0.77	1.44	0.04	13	10	10	84%	96%	5	5
LPR060712	0.73	0.96	0.04	12	11	11	96%	87%	36	8
LPR110612	0.47	0.36	0.03	7	6	6	99%	94%	117	55
LPR111112	1.56	0.36	0.07	17	11	11	64%	61%	47	2
LPR112312	1.59	0.36	0.07	18	9	8	70%	73%	230	48
LPR113012	0.69	0.60	0.03	16	9	9	79%	100%	7	9
LPR051713	0.26	0.24	0.02	9	8	8	74%	77%	13	9.0
LPR052113	0.70	0.24	0.08	6	6	4	99%	98%	9	7
LPR062513	0.71	1.44	0.10	4	3	3	93%	96%	2	2
LPR013014	0.51	0.24	0.01	27	22	22	96%	94%	5	8
LPR030314	0.76	1.08	0.05	9	10	12	100%	100%	6	9
LPR030814a	1.89	0.36	0.08	18	13	9	83%	70%	27	11
LPR042214	0.69	0.24	0.03	22	10	11	45%	45%	6	3
LPR011815	2.62	0.96	0.08	26	15	18	97%	98%	18	8
LPR020215	0.43	0.24	0.04	5	5	5	91%	90%	13	21
Min	0.26	0.12	0.01	4.00	2.00	2.00	45%	45%	2.00	2.00
Max	4.69	1.44	0.10	47.00	28.00	29.00	100%	100%	230.00	55.00
Mean	1.07	0.48	0.05	18.07	11.63	10.89	84%	84%	34.02	18.89

[a] as per the QAPP, event duration was stopped after 48 hours of precipitation

Event ID	Number of aliquots (Influent)	Number of aliquots (Effluent)	Total Influent Volume (gal)	Total Effluent Volume (gal)	Peak Influent Flow (gpm)	Peak Effluent Flow (gpm)	Average Influent Flow (gpm)	Average Effluent Flow (gpm)	Bypass Volume (gal)	Avg. IN Q at time of sample collection (gpm)	Avg. EFF Q at time of sample collection (gpm)
LPR021012	10	7	784.3	622.4	4.1	4.1	0.5	0.4	0.0	2.1	2.16
LPR021412	7	7	441.8	459.4	7.0	3.8	0.3	0.3	0.0	2.2	1.6
LPR021712	40	32	2126.9	1650.9	8.3	5.3	0.6	0.5	0.0	3.2	2.9
LPR022012	48	45	3582.8	2942.9	5.8	4.9	1.2	1.0	0.0	2.3	2.3
LPR022412	23	17	1148.7	932.9	9.3	5.9	1.0	0.8	0.0	3.2	2.3
LPR031012	20	8	890.3	646.3	2.5	2.9	0.4	0.3	0.0	1.0	1.0
LPR031212	14	12	835.8	629.2	5.8	4.6	1.1	0.8	0.0	3.4	2.7
LPR032912b	48	45	6944.9	6011.2	14.5	12.8	2.2	1.9	0.0	6.3	5.8
LPR052412	13	15	572.5	753.2	4.9	4.9	0.9	1.1	0.0	3.1	3.8
LPR060112	32	37	1637.0	1869.6	11.7	7.5	2.5	2.8	0.0	5.0	5.0
LPR060412	24	25	1319.3	1352.5	19.8	13.0	1.2	1.2	94.5	5.1	2.9
LPR060712	24	25	645.1	853.1	31.0	16.5	0.6	0.8	89.3	6.6	2.9
LPR110612	13	16	970.8	1223.3	9.7	9.3	1.1	1.4	0.0	4.6	5.3
LPR111112	32	31	3847.0	3993.3	14.4	11.0	2.9	3.0	0.0	5.4	5.2
LPR112312	48	41	6818.7	5572.5	19.2	16.6	4.7	3.9	25.0	9.3	8.3
LPR113012	27	15	1694.7	1086.0	11.8	10.2	1.0	0.7	0.0	3.9	4.0
LPR051713	16	13	1207.9	938.6	6.6	5.7	1.3	1.0	0.0	2.4	2.2
LPR052113	35	28	1300.2	976.3	9.2	9.3	2.4	1.8	0.0	4.9	3.9
LPR062513	26	24	2876.1	2410.4	80.2	59.1	6.8	5.7	891.1	36.8	24.8
LPR013014	36	41	1828.9	2142.5	14.6	9.4	0.9	1.0	0.0	4.3	3.3
LPR030314	31	43	1648.5	1629.8	25.1	24.5	1.7	1.7	358.7	9.6	6.1
LPR030814	47	48	4981.4	4593.1	16.4	15.2	3.4	3.1	34.7	7.6	7.2
LPR042214	35	50	1992.3	1757.4	6.2	4.6	1.4	1.2	0.0	1.9	1.5
LPR011815	35	38	3565.0	3890.3	15.9	16.6	1.8	2.0	19.2	6.6	6.3
LPR020215	16	14	701.2	622.8	5.0	4.3	1.2	1.0	0.0	3.1	2.3
Min	7.00	7.00	441.80	459.35	2.50	2.91	0.32	0.30	0.00	0.99	1.02
Max	48.00	50.00	6944.90	6011.20	80.24	59.06	6.83	5.73	891.09	36.76	24.79
Mean	28.44	27.89	2183.62	2002.30	14.07	11.12	1.69	1.55	56.02	5.62	4.53

Parameter	TSS-SM				SSC				TVSS				SSC (<2000-um)				TVSS (<2000-um)			
Units	(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)	
Location	Influent	Effluent			Influent	Effluent			Influent	Effluent			Influent	Effluent			Influent	Effluent		
Event ID	Result	Result	MRL	Flags	Result	Result	MRL	Flags	Result	Result	MRL	Flags	Result	Result	MRL	Flags	Result	Result	MRL	Flags
LPR021012	182.00	63.00	10.00		180.00	68.20	4.57		72.10	23.3	4.57		183.00	68.40	4.5		71.60	22.6	4.5	
LPR021412	539.00	32.00	10.00		404.00	35.00	3.85		197.00	10.4	3.85		NT	NT	---		NT	NT	---	
LPR021712*	387.00	48.00	10.00		414.00	53.50	6.67	A-01	185.00	15.2	6.67	A-01a	397.00	52.80	6.67	A-01	167.00	15.2	6.67	A-01a
LPR022012*	246.00	ND	10.00	ND (eff)	258.00	12.10	4.00	A-01	170.00	4.14	4.00	A-01a	287.00	13.10	4.0	A-01	189.00	4.88	4.0	A-01a
LPR022412	512.00	43.00	10.00		507.00	52.70	2.72		235.00	14	2.72		589.00	52.40	7.3		245.00	13.5	7.3	
LPR031012	360.00	27.00	10.00		430.00	ND	22	ND (eff)	200.00	ND	22	ND (eff)	NT	NT	---		NT	NT	---	
LPR031212	150.00	18.00	10.00		220.00	ND	34	ND (eff)	110.00	ND	34	ND (eff)	120.00	ND	27	ND (eff)	34.00	ND	27	
LPR032912	370.00	47.00	10.00		390.00	58.00	33		170.00	ND	33	ND (eff)	400.00	57.00	33		180.00	ND	33	
LPR052412	510.00	43.00	10.00		830.00	47.00	22		360.00	ND	22	ND (eff)	850.00	46.00	22		370.00	ND	22	
LPR060112	780.00	16.00	10.00		960.00	ND	40	ND (eff)	320.00	ND	40	ND (eff)	930.00	ND	48	ND (eff)	300.00	ND	48	ND (eff)
LPR060412	580.00	32.00	10.00		1000.00	30.00	21		150.00	ND	21	ND (eff)	890.00	30.00	22		130.00	ND	22	
LPR060712	570.00	120.00	10.00		780.00	120.00	45		180.00	ND	45	ND (inf)	750.00	120.00	37		180.00	ND	37	
LPR110612	40.00	10.00	10.00		46.00	9.00	2.70		12.00	3.3	2.70		43.00	9.70	2.7		10.00	4	2.7	
LPR111112*	100.00	14.00	10.00	H (inf)	92.00	16.00	3.60		61.00	7.5	3.60		77.00	18.00	3.5		48.00	8.7	3.5	
LPR112312	110.00	ND	10.00	ND (eff)	120.00	7.60	2.20		76.00	3.7	2.20		110.00	7.50	2.2		73.00	3.2	2.2	
LPR113012	230.00	17.00	10.00		230.00	15.00	2.60		140.00	7.8	2.60		220.00	16.00	2.8		130.00	7.6	2.8	
LPR051713	94.00	6.00	5.00		211.00	7.59	4.24		115.00	3.45	2.12		195.00	4.81	4.81		117.00	2.4	2.4	
LPR052113	389.00	24.00	10.00	H-06	484.00	21.40	3.51	H-01	227.00	6.19	1.75	H-01	498.00	21.60	3.23		235.00	5.75	1.61	
LPR062513	308.00	21.00	10.00		710.00	19.00	2.67		175.00	6.17	1.33		688.00	35.60	2.74		161.00	7.67	1.37	
LPR013014	170.00	17.00	5.00		175.00	19.40	10.00		70.00	4.79	5.00		184.00	14.10	10		70.00	2.16	5	
LPR030314	280.00	95.00	5.00		480.00	90.90	2.06		177.00	16.9	1.03		NT	NT	---		NT	NT	---	
LPR030814	173.00	26.00	5.00		408.00	22.00	3.57		230.00	3.37	1.79		NT	NT	---		NT	NT	---	
LPR042214	159.00	18.00	5.00		212.00	23.30	3.85		90.80	27	5.00		NT	NT	---		NT	NT	---	
LPR011815	529.00	72.80	5.00		611.00	70.90	3.57		176.00	17.2	1.79		632.00	71.10	5.26		181.000	17.900	2.63	
LPR020215	397.00	67.00	5.00		804.00	53.60	3.77		446.00	16.2	1.89		NT	NT	---		NT	NT	---	

ND under the flag column indicates one or both of the results is non-detect MRL used as substitution value
H= Sample was prepped or analyzed beyond the specified hold time
A-01=Due to the nature of samples, less volume was used instead of the nominal amount (1000ml)
A-01a= Due to the natures of the samples, less volume was used instead the the nominal volume (1000mL)
H-06= This sample was received, or the analysis requested, outside the recommended hold time
H-01= This sample was analyzed outside the recommended hold time
NT = Not Tested
SP = Screening parameter result used

Parameter	SSC (<500-um)				TVSS (<500-um)				SSC (<250-um)				TVSS (<250-um)			
Units	(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)	
Location	Influent	Effluent			Influent	Effluent			Influent	Effluent			Influent	Effluent		
	Result	Result	MRL	Flags	Result	Result	MRL	Flags	Result	Result	MRL	Flags	Result	Result	MRL	Flags
Event ID																
LPR021012	161.00	64.00	4.5		59.00	22.50	4.5		NT	NT	---		NT	NT	---	
LPR021412	NT	NT	---		NT	NT	---		NT	NT	---		NT	NT	---	
LPR021712*	270.00	51.90	5.0	A-01	81.50	14.80	5.0	A-01a	NT	NT	---		NT	NT	---	
LPR022012*	91.70	12.70	3.33	A-01	36.70	4.61	3.33	A-01a	NT	NT	---		NT	NT	---	
LPR022412	309.00	51.80	2.94		90.90	12.80	2.94		NT	NT	---		NT	NT	---	
LPR031012	250.00	ND	22	ND (eff)	84.00	ND	22	ND (eff)	NT	NT	---		NT	NT	---	
LPR031212	190.00	ND	27	ND (eff)	88.00	ND	27	ND (eff)	NT	NT	---		NT	NT	---	
LPR032912	230.00	55.00	33		75.00	ND	33	ND (eff)	NT	NT	---		NT	NT	---	
LPR052412	400.00	47.00	22		100.00	ND	22	ND (eff)	NT	NT	---		NT	NT	---	
LPR060112	540.00	ND	41	ND (eff)	110.00	ND	41	ND (eff)	NT	NT	---		NT	NT	---	
LPR060412	670.00	28.00	22		72.00	ND	22	ND (eff)	NT	NT	---		NT	NT	---	
LPR060712	470.00	120.00	42		70.00	ND	42	ND (eff)	NT	NT	---		NT	NT	---	
LPR110612	41.00	9.30	3.0		9.20	3.90	3.0		NT	NT	---		NT	NT	---	
LPR111112*	47.00	16.00	3.4		24.00	6.10	3.4		NT	NT	---		NT	NT	---	
LPR112312	67.00	7.80	2.1		31.00	3.40	2.1		35.00	6.00	2.20	SP	NT	NT	---	
LPR113012	150.00	15.00	3.0		69.00	7.00	3.0		NT	NT	---		NT	NT	---	
LPR051713	94.30	4.41	4.07		36.60	2.03	2.03		78.50	4.94	2.47		27.40	3.46	1.23	
LPR052113	243.00	21.70	3.39		79	6.83	1.69		231.00	25.40	4.76		54.80	10.10	2.38	
LPR062513	421.00	32.00	3.33		59.40	5.67	1.67		281.00	25.00	2.94		41.90	9.10	1.47	
LPR013014	131.00	16.90	3.23		41.60	5.38	1.61		155.00	15.10	3.67		43.60	6.00	1.82	
LPR030314	NT	NT	---		NT	NT	---		NT	NT	---		NT	NT	---	
LPR030814	NT	NT	---		NT	NT	---		144	20.00	3.57		NT	NT	---	
LPR042214	NT	NT	---		NT	NT	---		371	16.60	5.71		NT	NT	---	
LPR011815	536.00	71.60	3.70		127.00	16.70	1.85		489	68.60	3.45		96.90	16.90	1.72	
LPR020215	405.00	52.50	4.59		152.00	17.70	2.29		285	45.60	4.35		82.20	15.70	2.17	

ND under the flag column indicates one or both of the results is non-detect MRL used as substitution value
H= Sample was prepped or analyzed beyond the specified hold time
A-01=Due to the nature of samples, less volume was used instead of the nominal amount (1000ml)
A-01a= Due to the natures of the samples, less volume was used instead the the nominal volume (1000mL)
H-06= This sample was received, or the analysis requested, outside the recommended hold time
H-01= This sample was analyzed outside the recommended hold time
NT = Not Tested
SP = Screening parameter result used

Parameter	SSC (<100-um)				TVSS (<100-um)				SSC (<62.5-um)				TVSS (<62.5-um)			
Units	(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)	
Location	Influent	Effluent			Influent	Effluent			Influent	Effluent			Influent	Effluent		
	Result	Result	MRL	Flags	Result	Result	MRL	Flags	Result	Result	MRL	Flags	Result	Result	MRL	Flags
Event ID																
LPR021012	NT	NT	---		NT	NT	---		NT	NT	---		NT	NT	---	
LPR021412	NT	NT	---		NT	NT	---		NT	NT	---		NT	NT	---	
LPR021712*	239.00	48.10	5.0	A-01	60.00	14.10	5.0	A-01a	NT	NT	---		NT	NT	---	
LPR022012*	62.60	11.40	2.86	A-01	17.10	3.97	2.86	A-01a	NT	NT	---		NT	NT	---	
LPR022412	225.00	53.70	2.98		43.20	13.20	2.98		NT	NT	---		NT	NT	---	
LPR031012	160.00	ND	23	ND (eff)	36.00	ND	23	ND (eff)	NT	NT	---		NT	NT	---	
LPR031212	95.00	ND	19	ND (eff)	21.00	ND	19	ND (eff)	NT	NT	---		NT	NT	---	
LPR032912	200.00	54.00	33	ND (eff)	ND	ND	33	ND	NT	NT	---		NT	NT	---	
LPR052412	230.00	45.00	22		42.00	ND	22	ND (eff)	NT	NT	---		NT	NT	---	
LPR060112	340.00	ND	42	ND (eff)	45.00	ND	42	ND (eff)	NT	NT	---		NT	NT	---	
LPR060412	410.00	28.00	24		36.00	ND	24	ND (eff)	NT	NT	---		NT	NT	---	
LPR060712	300.00	120.00	41		ND	ND	41	ND	NT	NT	---		NT	NT	---	
LPR110612	34.00	7.90	3.0		6.60	3.30	3.0		NT	NT	---		NT	NT	---	
LPR111112*	31.00	14.00	3.5		14.00	5.90	3.5		NT	NT	---		NT	NT	---	
LPR112312	40.00	6.50	2.2		13.00	3.10	2.2		66.00	4.00	2.20	SP	NT	NT	---	
LPR113012	75.00	13.00	2.8		26.00	6.60	2.8		NT	NT	---		NT	NT	---	
LPR051713	53.40	ND	5.0	ND (eff)	15.50	ND	2.5	ND (eff)	49.40	5.00	5		15.20	4.50	2.50	
LPR052113	158.00	20.20	3.57		28.90	5.95	1.79		121.00	19.50	3.39		21.40	5.19	1.69	
LPR062513	306.00	19.70	3.64		30.20	6.11	1.82		172.00	14.90	4.65		21.40	6.98	2.33	
LPR013014	130.00	14.80	3.77		28.70	4.66	1.89		115.00	10.70	3.64		28.00	3.38	1.82	
LPR030314	NT	NT	---		NT	NT	---		NT	NT	---		NT	NT	---	
LPR030814	NT	NT	---		NT	NT	---		92.00	18.80	4.55		NT	NT	---	
LPR042214	NT	NT	---		NT	NT	---		268.00	18.50	2.2		NT	NT	---	
LPR011815	557.00	69.30	5.13		75.90	14.50	2.56		399.00	62.60	10.1		51.00	12.10	5.05	
LPR020215	NT	NT	---		NT	NT	---		33.30	14.00	0.567		185.00	43.70	1.13	

ND under the flag column indicates one or both of the results is non-detect MRL used as substitution value
H= Sample was prepped or analyzed beyond the specified hold time
A-01=Due to the nature of samples, less volume was used instead of the nominal amount (1000ml)
A-01a= Due to the natures of the samples, less volume was used instead the the nominal volume (1000mL)
H-06= This sample was received, or the analysis requested, outside the recommended hold time
H-01= This sample was analyzed outside the recommended hold time
NT = Not Tested
SP = Screening parameter result used

Parameter	SSC (<50-um)				TVSS (<50-um)			
Units	(mg/L)		(mg/L)		(mg/L)		(mg/L)	
Location	Influent	Effluent			Influent	Effluent		
	Result	Result	MRL	Flags	Result	Result	MRL	Flags
Event ID								
LPR021012	106.00	60.50	4.5		30.20	19.80	4.5	
LPR021412	163.00	30.00	3.7		29.50	9.26	3.7	
LPR021712*	208.00	43.60	5.0	A-01	50.00	12.30	5.0	A-01a
LPR022012*	50.90	10.20	2.86	A-01	12.30	3.83	2.86	A-01a
LPR022412	148.00	46.40	3.98		29.10	11.60	3.98	
LPR031012	130.00	ND	24	ND (eff)	27.00	ND	24	ND (eff)
LPR031212	88.00	ND	20	ND (eff)	ND	ND	20	ND
LPR032912	160.00	53.00	33		ND	ND	33	ND
LPR052412	200.00	41.00	37		ND	ND	37	ND
LPR060112	220.00	ND	40	ND (eff)	ND	ND	40	ND
LPR060412	230.00	23.00	22		25.00	22.00	22	
LPR060712	240.00	110.00	47		ND	ND	47	ND
LPR110612	19.00	6.60	3.0		4.00	3.90	3.0	
LPR111112*	24.00	10.00	3.5		9.10	5.20	3.5	
LPR112312	24.00	5.60	2.2		7.60	2.90	2.2	
LPR113012	49.00	9.50	2.9		17.00	4.60	2.9	
LPR051713	63.60	4.42	2.6		20.90	2.86	1.3	
LPR052113	136.00	12.70	3.57		21.80	4.55	1.79	
LPR062513	194.00	11.50	3.08		24.60	3.64	1.54	
LPR013014	99.60	18.20	3.57		21.10	6.58	1.79	
LPR030314	NT	NT	---		NT	NT	---	
LPR030814	NT	NT	---		NT	NT	---	
LPR042214	NT	NT	---		NT	NT	---	
LPR011815	384.00	60.80	4.08		46.40	11.80	2.04	
LPR020215	NT	NT	---		NT	NT	---	

ND under the flag column indicates one or both of the results is non-detect MRL used as substitution value
H= Sample was prepped or analyzed beyond the specified hold time
A-01=Due to the nature of samples, less volume was used instead of the nominal amount (1000ml)
A-01a= Due to the natures of the samples, less volume was used instead the the nominal volume (1000mL)
H-06= This sample was received, or the analysis requested, outside the recommended hold time
H-01= This sample was analyzed outside the recommended hold time
NT = Not Tested
SP = Screening parameter result used

Parameter	Total Copper				Total Zinc				Total Lead				Aluminum			
Units	(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)	
Location	Influent	Effluent			Influent	Effluent			Influent	Effluent			Influent	Effluent		
	Result	Result	MRL	Flags	Result	Result	MRL	Flags	Result	Result	MRL	Flags	Result	Result	MRL	Flags
Event ID																
LPR021012	NT	NT	---		NT	NT	---		NT	NT	---		NT	NT	---	
LPR021412	NT	NT	---		NT	NT	---		NT	NT	---		NT	NT	---	
LPR021712	0.032	0.00599	0.010		0.151	0.0335	0.050		0.0128	0.00337	0.005		9.15	1.86	0.1	
LPR022012	0.0136	ND	0.002	ND (eff)	0.0761	0.0108	0.010		0.0049	ND	0.001	ND (eff)	2.62	0.319	0.1	
LPR022412	0.0316	0.00472	0.010		0.191	0.0306	0.050		0.0146	0.00331	0.005		9.65	1.99	0.1	
LPR031012	0.019	0.0034	0.002		0.12	0.022	0.010		0.0093	0.002	0.001		6.20	1.10	0.1	
LPR031212	0.012	0.0026	0.010		0.068	0.017	0.050		0.0057	0.0016	0.005		4.30	0.810	0.1	
LPR032912	0.023	0.0041	0.002		0.16	0.029	0.010		0.012	0.003	0.001		6.40	1.70	0.2	
LPR052412	ND	ND	0.100	ND	ND	ND	0.500	ND	ND	ND	0.050	ND	9.70	1.30	1.0	
LPR060112	0.04	0.0026	0.020		0.23	0.012	0.100		0.016	ND	0.010	ND (eff)	11.0	0.370	0.2	
LPR060412	0.021	0.0026	0.002		0.13	0.015	0.010		0.013	0.0012	0.001		12.0	1.00	0.2	
LPR060712	0.028	0.0096	0.020		0.17	0.048	0.050		0.013	0.0049	0.010		9.60	4.10	0.1	
LPR110612	0.0059	0.0025	0.002		0.022	0.014	0.010		0.001	ND	0.001	ND (eff)	1.30	0.300	0.1	
LPR111112	0.0066	0.0037	0.002		0.041	0.028	0.010		0.0016	ND	0.001	ND (eff)	1.20	0.650	0.1	
LPR112312	0.0061	ND	0.002	ND (eff)	0.049	0.010	0.010		0.002	ND	0.001	ND (eff)	1.20	0.190	0.1	
LPR113012	0.016	0.0023	0.002		0.110	0.016	0.010		0.005	ND	0.001	ND (eff)	3.00	0.440	0.1	
LPR051713	0.016	0.00287	0.002		0.0681	0.0101	0.004		0.00397	ND	0.001	ND (eff)	1.44	0.134	0.05	
LPR052113	0.0272	0.00598	0.002		0.126	0.0208	0.004		0.00892	0.00889	0.001	J (inf)	3.24	0.358	0.05	
LPR062513	0.0287	0.00541	0.002		0.120	0.0174	0.004		0.00858	0.00150	0.001	FILT1	3.94	0.466	0.05	
LPR013014	0.0207	0.00374	0.001		0.108	0.0258	0.004		0.00606	0.00118	0.00020		3.45	0.796	0.05	
LPR030314	0.0187	0.00566	0.001		0.095	0.0288	0.004		0.00668	0.00253	0.00020		2.64	1.130	0.05	
LPR030814	0.0175	0.00219	0.001		0.088	0.0133	0.004		0.0046	0.00131	0.00020		1.67	0.342	0.05	
LPR042314	0.0103	0.00333	0.001	FILT1	0.052	0.0162	0.004	FILT1	0.00324	0.00089	0.00020		1.56	0.403	0.05	
LPR011815	0.0547	0.0101	0.001		0.151	0.0386	0.004		0.0146	0.00271	0.00020		5.32	1.170	0.05	
LPR020215	0.0438	0.00748	0.002		0.192	0.0381	0.004		0.0112	0.00213	0.00020		3.85	1.200	0.05	

NT = Not Tested

J= Estimated result. Result detected below the lowest point of the calibration curve, but above the specified MDL.

FILT1= Sample was lab filteres and acid preserved prior to analysis

SP = Screening parameter result used

B-02 = Analyte detected in an associated blank at a level betweeen one-half the MRL and the MRL.

A-01a = Sample not perserved within according to method

Parameter	Dissolved Copper				Dissolved Zinc				Hardness			
Units	(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)	
Location	Influent	Effluent			Influent	Effluent			Influent	Effluent		
Event ID	Result	Result	MRL	Flags	Result	Result	MRL	Flags	Result	Result	MRL	Flags
LPR021012	NT	NT			NT	NT			NT	NT		
LPR021412	NT	NT			NT	NT			NT	NT		
LPR021712	NT	NT			NT	NT			60	19	0.662	
LPR022012	NT	NT			NT	NT			19.5	6.7	0.662	
LPR022412	NT	NT			NT	NT			80	23	0.662	
LPR031012	NT	NT			NT	NT			55	19	0.20	
LPR031212	NT	NT			NT	NT			28	10	0.20	
LPR032912	NT	NT			NT	NT			34	7.9	0.20	
LPR052412	NT	NT			NT	NT			38	6.8	0.20	
LPR060112	ND	ND	0.002	SP	ND	ND	0.01	SP	48	5.8	0.20	
LPR060412	ND	ND	0.002		ND	ND	0.01		45	6.1	0.20	
LPR060712	0.0045	0.0025	0.002	SP	ND	ND	0.01	SP	45	14	0.20	
LPR110612	NT	NT			NT	NT			11	7.8	0.20	
LPR111112	ND	0.002	0.002	ND (eff)	0.013	0.017	0.01		20	22	0.20	
LPR112312	ND	ND	0.002	ND (eff)	0.014	ND	0.01	ND (eff)	17	3.5	0.20	
LPR113012	0.0031	ND	0.002	ND (eff)	0.034	ND	0.01	ND (eff)	52	5.4	0.20	
LPR051713	0.00567	0.00218	0.002		0.0192	0.00827	0.004		24.6	10.5	0.456	
LPR052113	0.00498	0.00438	0.002		0.0149	0.0121	0.004		27.1	9.49	0.456	
LPR062513	0.00301	0.00233	0.002		0.0122	0.01	0.004		40.5	5.65	0.456	
LPR013014	0.00224	0.0019	0.0018	SP	0.0154	0.0131	0.0072	SP	44.1	39.3	2.28	
LPR030314	ND	ND	0.001	SP	0.0079	0.00648	0.004	SP	17.2	7.37	0.250	
LPR030814	0.00293	ND	0.001	SP, ND (eff)	0.00661	ND	0.004	SP, ND (eff)	15.8	3.7	0.250	
LPR042314	0.00102	0.00142	0.001	SP	0.00868	0.00766	0.004	SP	12.2	7.75	0.250	
LPR011815	0.00313	0.00252	0.001	B-02	0.0117	0.012	0.004	B-02	28.4	11	0.250	
LPR020215	NT	NT			NT	NT			38.8	16.7	0.250	

NT = Not Tested
J= Estimated result. Result detected below the lowest point of the calibration curve, but above the specified MDL.
FILT1= Sample was lab filteres and acid preserved prior to analysis
SP = Screening parameter result used
B-02 = Analyte detected in an associated blank at a level betweeen one-half the MRL and the MRL.
A-01a = Sample not perserved within according to method

Parameter	Total P				Ortho-P				Diss Phos				PP	
Units	(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)	(mg/L)
Location	Influent	Effluent			Influent	Effluent			Influent	Effluent				
	Result	Result	MRL	Flags	Result	Result	MRL	Flags	Result	Result	MRL	Flags	Result	Result
Event ID														
LPR021012	0.141	0.104	0.020		0.01	0.01	0.010	H3	ND	ND	0.500	ND	0.14	0.10
LPR021412	0.220	0.062	0.020	P7	ND	ND	0.010	H3,ND	ND	ND	0.500	ND	0.22	0.06
LPR021712	0.310	0.0674	0.100	P7	ND	ND	0.010	H3,ND	ND	ND	0.500	ND	0.31	0.07
LPR022012	0.163	0.0259	0.020	P7	ND	ND	0.010	H3,ND	ND	ND	0.500	ND	0.16	0.03
LPR022412	0.424	0.0701	0.020	P7	ND	ND	0.010	H3,ND	ND	ND	0.500	ND	0.42	0.07
LPR031012	0.140	0.049	0.020		ND	ND	0.010	H,ND	ND	ND	0.500	ND	0.14	0.05
LPR031212	0.150	0.037	0.020		ND	ND	0.010	H,ND	ND	ND	0.500	ND	0.15	0.04
LPR032912	0.280	0.081	0.020		ND	ND	0.010	ND	ND	ND	0.500	ND	0.28	0.08
LPR052412	0.170	0.070	0.020		ND	ND	0.010	ND	ND	ND	0.500	ND	0.17	0.07
LPR060112	0.200	0.035	0.020		ND	ND	0.010	SP	ND	ND	0.500	ND	0.20	0.04
LPR060412	0.210	0.043	0.020		ND	ND	0.010	H,ND	ND	ND	0.500	ND	0.21	0.04
LPR060712	0.170	0.140	0.020		ND	ND	0.010	ND	ND	ND	0.500	ND	0.17	0.14
LPR110612	0.068	ND	0.050	ND (eff)	0.0930	ND	0.050	ND (eff)	ND	ND	0.500	ND	0.07	0.05
LPR111112	0.076	ND	0.050	ND (eff)	0.0590	ND	0.050	ND (eff)	ND	ND	0.500	ND	0.08	0.05
LPR112312	0.082	ND	0.050	ND (eff)	ND	ND	0.050	R,ND	ND	ND	0.500	ND	0.08	0.05
LPR113012	0.170	ND	0.050	ND (eff)	0.099	ND	0.050	R,ND	ND	ND	0.500	ND	0.17	0.05
LPR051713	0.282	0.0286	0.010		ND	ND	0.010	H-06,ND	0.0260	0.0110	0.010		0.26	0.02
LPR052113	0.558	0.0498	0.01		ND	ND	0.01	H-06,ND	0.0190	0.0118	0.01		0.54	0.04
LPR062512	0.583	0.0452	0.010		ND	ND	0.010	H-06,ND	ND	ND	0.010	ND	0.57	0.04
LPR013014	0.317	0.053	0.010		ND	0.012	0.010	ND (inf)	0.0122	0.0168	0.010		0.30	0.04
LPR030314	0.417	0.133	0.010		ND	ND	0.010	H-06,ND	ND	ND	0.010	ND	0.41	0.12
LPR030814	0.261	0.0514	0.010		ND	ND	0.010	H-06,ND	0.0114	ND	0.010	ND (eff)	0.25	0.04
LPR042314	0.234	0.0368	0.010		ND	ND	0.010	H-06,ND	ND	0.0260	0.010	A-01, B,ND	0.22	0.01
LPR011815	0.649	0.124	0.010		ND	ND	0.010	H-06,ND	ND	0.0116	0.010	ND (inf)	0.64	0.11
LPR020215	0.693	0.100	0.050		0.026	0.035	0.010	H-06	0.0156	ND	0.010	ND (eff)	0.68	0.09

ND under the flag column indicates one or both of the results is non-detect MRL used as substitution value

H3= Sample was received and analyzed past hold time

H= Sample was prepped or analyzed beyond the specified hold time

R= Sample exceeded hold time and was analyzed per customer request

H-06= This sample was received, or the analysis requested, outside the recommended hold time

P7= Sample filtered in lab

RL1= Reporting limit raised due to sample matrix effects

A-01= Sample stored at 3 degrees above recommended temperature; or Sample not preserved according to method

B= Analyte detected in an associated blank at a level above the MRL

NT = Not Tested

SP = Screening parameter result used

A-01a = Sample not perserved within according to method

Parameter	TKN				Nitrate/Nitrite-N				Ammonia				TN		ON	
Units	(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)	(mg/L)	(mg/L)	(mg/L)
Location	Influent	Effluent			Influent	Effluent			Influent	Effluent			Influent	Effluent	Influent	Effluent
	Result	Result	MRL	Flags	Result	Result	MRL	Flags	Result	Result	MRL	Flags	Result	Result	Result	Result
Event ID																
LPR021012	1.03	ND	0.500	ND (eff)	0.0322	ND	0.030	ND (eff)	ND	ND	0.05	ND	1.06	0.53	0.98	0.45
LPR021412	1.14	0.516	0.500	P7	0.0641	ND	0.030	ND (eff)	ND	ND	0.1	RL1,ND	1.20	0.55	1.04	0.42
LPR021712	1.52	0.623	0.500	P7	0.0564	ND	0.030	ND (eff)	ND	ND	0.05	ND	1.58	0.65	1.47	0.57
LPR022012	0.66	ND	0.500	ND (eff)	0.0358	ND	0.030	ND (eff)	ND	ND	0.05	ND	0.70	0.53	0.61	0.45
LPR022412	1.09	ND	0.500	P7,ND (eff)	ND	ND	0.030	ND	ND	ND	0.5	RL1,ND	1.12	0.53	0.59	0.00
LPR031012	1.70	ND	0.500	ND (eff)	ND	ND	0.030	ND	ND	ND	0.05	ND	1.73	0.53	1.65	0.45
LPR031212	0.61	ND	0.500	ND (eff)	ND	ND	0.300	ND	ND	ND	0.5	ND	0.91	0.80	0.11	0.00
LPR032912	1.20	ND	0.500	ND (eff)	0.03	ND	0.030	ND (eff)	ND	ND	0.05	ND	1.23	0.53	1.15	0.45
LPR052412	1.70	ND	0.500	ND (eff)	ND	ND	0.300	ND	ND	ND	0.05	ND	2.00	0.80	1.65	0.45
LPR060112	2.10	0.79	0.500		0.3	0.082	0.300		ND	ND	0.05	ND	2.40	0.87	2.05	0.74
LPR060412	0.96	ND	0.500	ND (eff)	0.097	0.077	0.030		ND	ND	0.05	ND	1.06	0.58	0.91	0.45
LPR060712	ND	ND	1.000	ND	0.079	0.055	0.030		ND	ND	0.05	ND	1.08	1.06	0.95	0.95
LPR110612	ND	ND	1.000	ND	0.069	0.055	0.030		0.066	ND	0.05	ND (eff)	1.07	1.06	0.93	0.95
LPR111112	ND	ND	1.000	ND	0.084	ND	0.300	ND (inf)	0.063	ND	0.5	ND (eff)	1.08	1.30	0.94	0.50
LPR112312	ND	ND	1.000	ND	ND	ND	0.030	ND	ND	ND	0.1	ND	1.03	1.03	0.90	0.90
LPR113012	1.20	ND	1.000	ND (eff)	ND	ND	0.030	ND	ND	ND	0.05	ND	1.23	1.03	1.15	0.95
LPR051713	1.30	0.17	0.050	ND (eff)	0.0722	0.0799	0.005		0.079	0.038	0.02		1.37	0.25	1.22	0.13
LPR052113	0.49	0.18	0.050		0.0409	0.0675	0.005		0.077	0.045	0.02		0.53	0.25	0.41	0.14
LPR062512	0.59	0.17	0.100		0.0285	0.0826	0.005		ND	ND	0.1	ND	0.62	0.25	0.49	0.07
LPR013014	0.19	0.16	0.100		0.0503	0.052	0.005		0.066	0.069	0.02		0.24	0.21	0.12	0.09
LPR030314	0.48	0.18	0.100		0.0500	0.0500	0.020		0.08	0.075	0.02		0.53	0.23	0.40	0.11
LPR030814	0.41	ND	0.100	ND (eff)	0.0220	0.0300	0.020		0.037	0.024	0.02		0.43	0.13	0.37	0.08
LPR042314	0.37	0.13	0.100		0.0400	0.0600	0.020		0.036	0.029	0.02		0.41	0.19	0.33	0.10
LPR011815	0.15	ND	0.100		0.0300	0.0600	0.020		0.03	0.028	0.02		0.18	0.16	0.12	0.07
LPR020215	2.30	0.33	0.100		0.0200	0.0400	0.020		0.032	0.039	0.02		2.32	0.37	2.27	0.29

ND under the flag column indicates one or both of the results is non-detect MRL used as substitution value

H3= Sample was received and analyzed past hold time

H= Sample was prepped or analyzed beyond the specified hold time

R= Sample exceeded hold time and was analyzed per customer request

H-06= This sample was received, or the analysis requested, outside the recommended hold time

P7= Sample filtered in lab

RL1= Reporting limit raised due to sample matrix effects

A-01= Sample stored at 3 degrees above recommended temperature; or Sample not preserved according to method

B= Analyte detected in an associated blank at a level above the MRL

NT = Not Tested

SP = Screening parameter result used

A-01a = Sample not perserved within according to method

APPENDIX G – Analytical Lab Reports

(Provided as a Separate Document)

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APPENDIX H – Wilcoxon

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Wilcoxon Signed Rank Test Wednesday, October 07, 2015, 2:31:39 PM

Data source: Data 1 in Notebook 1

Normality Test: Passed (P = 0.586)

Group	N	Missing	Median	25%	75%
IN_TSS	17	0	389.000	215.000	531.500
EFF_TSS	17	0	32.000	17.000	52.750

W= -153.000 T+ = 0.000 T-= -153.000
Z-Statistic (based on positive ranks) = -3.621
P(est.)= <0.001 P(exact)= <0.001

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

Wilcoxon Signed Rank Test Wednesday, October 07, 2015, 2:32:09 PM

Data source: Data 1 in Notebook 1

Normality Test: Passed (P = 0.264)

Group	N	Missing	Median	25%	75%
IN_TP	17	0	0.282	0.170	0.458
EFF_TP	17	2	0.0620	0.0435	0.0925

W= -120.000 T+ = 0.000 T-= -120.000
Z-Statistic (based on positive ranks) = -3.408
P(est.)= <0.001 P(exact)= <0.001

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

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APPENDIX I – Bootstrap Results

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Bootstrapping LCL95 results for TSS (n=15)

1. Clear any previous effluent and remove data by clicking on the **Clear Data** button

2. Enter effluent concentration and remove efficiency data in columns K and L

3. Select which confidence limit to calculate

   - Upper 95% confidence limit for effluent concentration
   - Lower 95% confidence limit for removal efficiency

4. Click on the calculate button **Calculate**

Lower 95% for removal efficiency (%) **0.852**

Effluent Concentration	Removal Efficiency (%)
32	0.940630798
48	0.875968992
43	0.916015625
18	0.88
43	0.915686275
16	0.979487179
32	0.944827586
120	0.789473684
17	0.926086957
24	0.938303342
21	0.931818182
17	0.9
95	0.660714286
72.8	0.862381853
67	0.831234257

Bootstrapping LCL95 results for SSC<500 µm (n=14)

1. Clear any previous effluent and remove data by clicking on the **Clear Data** button

2. Enter effluent concentration and remove efficiency data in columns K and L

3. Select which confidence limit to calculate

   - Upper 95% confidence limit for effluent concentration
   - Lower 95% confidence limit for removal efficiency

4. Click on the calculate button **Calculate**

Lower 95% for removal efficiency (%) **0.853**

Effluent Concentration	Removal Efficiency (%)
51.9	0.807777778
51.8	0.83236246
27	0.86
47	0.8825
50	0.91
28	0.958208955
120	0.744680851
15	0.9
4.4	0.953191489
21.7	0.910699588
32	0.923990499
16.9	0.870992366
71.6	0.86641791
52.5	0.87037037

Bootstrapping LCL95 results for Silt and Clay (n=16)

1. Clear any previous effluent and remove data by clicking on the **Clear Data** button
2. Enter effluent concentration and remove efficiency data in columns K and L
3. Select which confidence limit to calculate

   ◻ Upper 95% confidence limit for effluent concentration

   ◉ Lower 95% confidence limit for removal efficiency

4. Click on the calculate button **Calculate**

Lower 95% for removal efficiency (%) **0.732**

Effluent Concentration	Removal Efficiency (%)
30	0.81595092
43.6	0.790384615
46.4	0.686486486
27	0.693181818
41	0.795
45	0.795454545
23	0.9
110	0.541666667
6.6	0.652631579
9.5	0.806122449
5	0.898785425
19.5	0.838842975
14.9	0.913372093
10.7	0.906956522
62.6	0.843107769
14	0.57957958

Bootstrapping LCL95 results for Silt and Clay > 100 mg/L (n=11)

1. Clear any previous effluent and remove data by clicking on the **Clear Data** button
2. Enter effluent concentration and remove efficiency data in columns K and L
3. Select which confidence limit to calculate

   ◻ Upper 95% confidence limit for effluent concentration

   ◉ Lower 95% confidence limit for removal efficiency

4. Click on the calculate button **Calculate**

Lower 95% for removal efficiency (%) **0.750**

Effluent Concentration	Removal Efficiency (%)
30	0.81595092
43.6	0.790384615
46.4	0.686486486
41	0.795
45	0.795454545
23	0.9
110	0.541666667
19.5	0.838842975
14.9	0.913372093
10.7	0.906956522
62.6	0.843107769

Bootstrapping LCL95 results for Total Phosphorus (n=16)

1. Clear any previous effluent and remove data by clicking on the **Clear Data** button

2. Enter effluent concentration and remove efficiency data in columns K and L

3. Select which confidence limit to calculate

   ○ Upper 95% confidence limit for effluent concentration

   ◉ Lower 95% confidence limit for removal efficiency

4. Click on the calculate button **Calculate**

Lower 95% for removal efficiency (%) **0.672**

Effluent Concentration	Removal Efficiency (%)
0.062	0.718181818
0.0674	0.782580645
0.0701	0.834669811
0.037	0.753333333
0.07	0.588235294
0.035	0.825
0.043	0.795238095
0.14	0.176470588
0.05	0.705882353
0.0286	0.89858156
0.0498	0.9004
0.0452	0.9096
0.053	0.832807571
0.133	0.681055156
0.124	0.752
0.1	0.8

Bootstrapping UCL95 effluent results for Total Phosphorus (n=16)

1. Clear any previous effluent and remove data by clicking on the **Clear Data** button

2. Enter effluent concentration and remove efficiency data in columns K and L

3. Select which confidence limit to calculate

   ◉ Upper 95% confidence limit for effluent concentration

   ○ Lower 95% confidence limit for removal efficiency

4. Click on the calculate button **Calculate**

Upper 95% for effluent concentration **0.084**

Effluent Concentration	Removal Efficiency (%)
0.062	0.718181818
0.0674	0.782580645
0.0701	0.834669811
0.037	0.753333333
0.07	0.588235294
0.035	0.825
0.043	0.795238095
0.14	0.176470588
0.05	0.705882353
0.0286	0.89858156
0.0498	0.9004
0.0452	0.9096
0.053	0.832807571
0.133	0.681055156
0.124	0.752
0.1	0.8

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APPENDIX J – Regression Statistics

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	1-EVENT_ID	2-MAX_Q	3-AVG_Q	4-TSS_RE	5-TP_RE
1	LPR021412	6.9500	2.1975	0.9406	0.7182
2	LPR021712	8.2500	3.2207	0.8760	0.7826
3	LPR022412	9.2700	3.1921	0.9160	0.8347
4	LPR031212	5.7800	3.4187	0.8800	0.7533
5	LPR052412	4.8700	3.0629	0.9157	0.5882
6	LPR060112	11.6600	5.0258	0.9795	0.8250
7	LPR060412	19.7700	2.8584	0.9448	0.7952
8	LPR060712	30.9600	2.8584	0.7895	0.1765
9	LPR110612	9.6900	4.6436	0.7500	0.2647
10	LPR113012	11.7500	3.8636	0.9261	0.7059
11	LPR051713	6.6010	2.3944	0.9362	0.8986
12	LPR052113	9.1680	4.9331	0.9383	0.9108
13	LPR062513	80.2380	24.7932	0.9318	0.9225
14	LPR013014	14.6070	4.2951	0.9000	0.8328
15	LPR030314	25.1240	6.1030	0.6607	0.6811
16	LPR011815	15.9110	6.3234	0.8624	0.8089
17	LPR020215	4.9600	3.1394	0.8312	0.8557

	11-Residuals 1	12-Parameters 2	13-Predicted 2	14-Residuals 2	15-Parameters 3
1	-9.2290	1.4877	5.3204	-3.1229	0.6029
2	-8.1574	4.0745	5.0569	-1.8362	6.1575
3	-7.3221		5.2201	-2.0280	
4	-10.5237		5.0733	-1.6547	
5	-10.8482		5.2187	-2.1559	
6	-4.8978		5.4787	-0.4529	
7	3.3177		5.3375	-2.4791	
8	16.7020		4.7045	-1.8461	
9	-4.8809		4.5436	0.0999	
10	-4.3854		5.2611	-1.3975	
11	-10.2177		5.3022	-2.9078	
12	-7.6939		5.3109	-0.3777	
13	63.3345		5.2845	19.5087	
14	-1.9785		5.1548	-0.8597	
15	9.0767		4.1798	1.9232	
16	-0.5898		5.0015	1.3219	
17	-11.7067		4.8746	-1.7353	

Linear Regression Thursday, October 08, 2015, 2:35:39 PM

Data source: Data 1 in Notebook1

TSS_RE = 0.885 - (0.000224 * MAX_Q)

N = 17

R = 0.0492 Rsqr = 0.00242 Adj Rsqr = 0.000

Standard Error of Estimate = 0.085

	Coefficient	**Std. Error**	**t**	**P**
Constant	0.885	0.0280	31.570	<0.001
MAX_Q	-0.000224	0.00118	-0.191	0.851

Analysis of Variance:

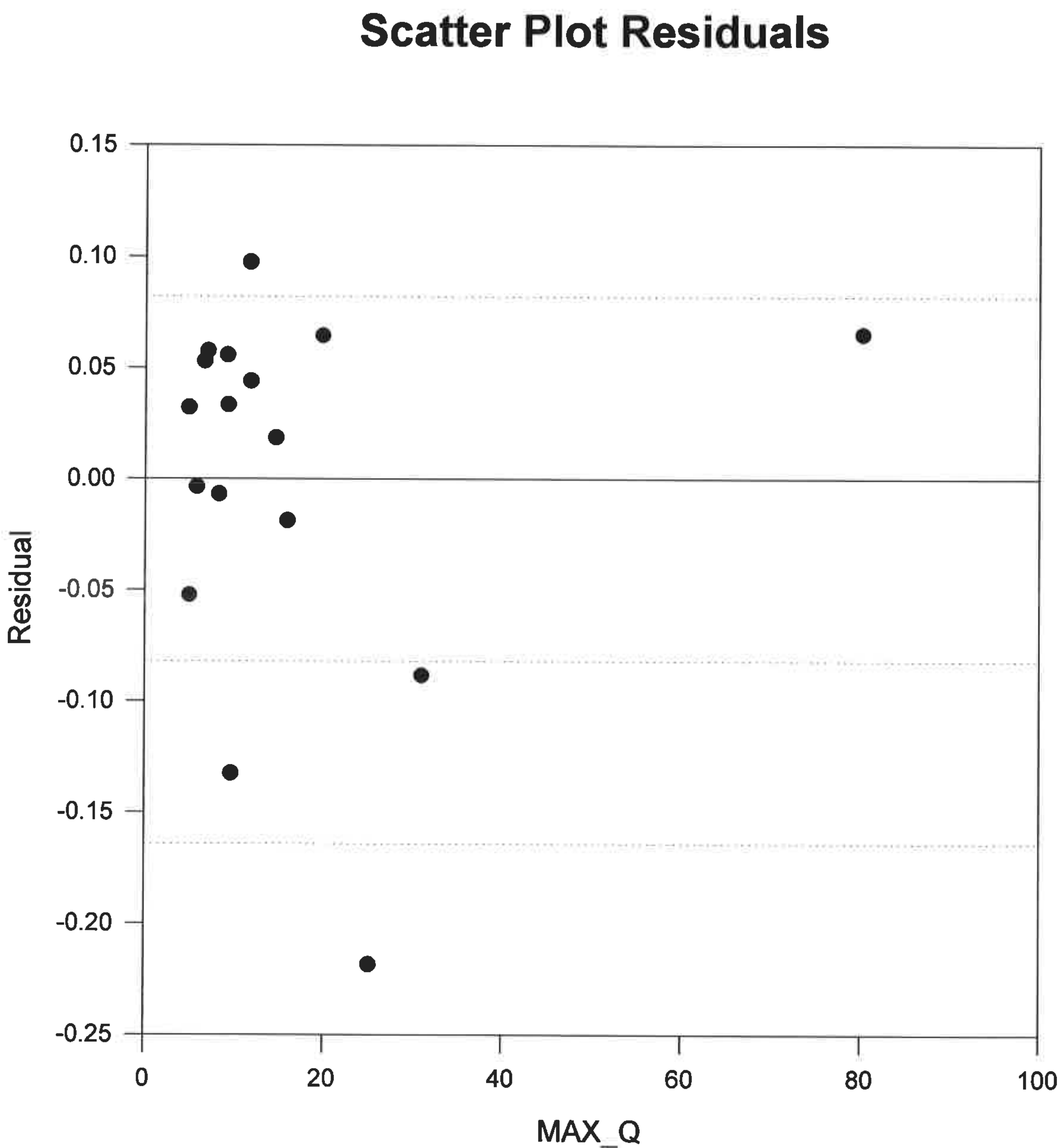
	DF	**SS**	**MS**	**F**	**P**
Regression	1	0.000261	0.000261	0.0363	0.851
Residual	15	0.108	0.00718		
Total	16	0.108	0.00675		

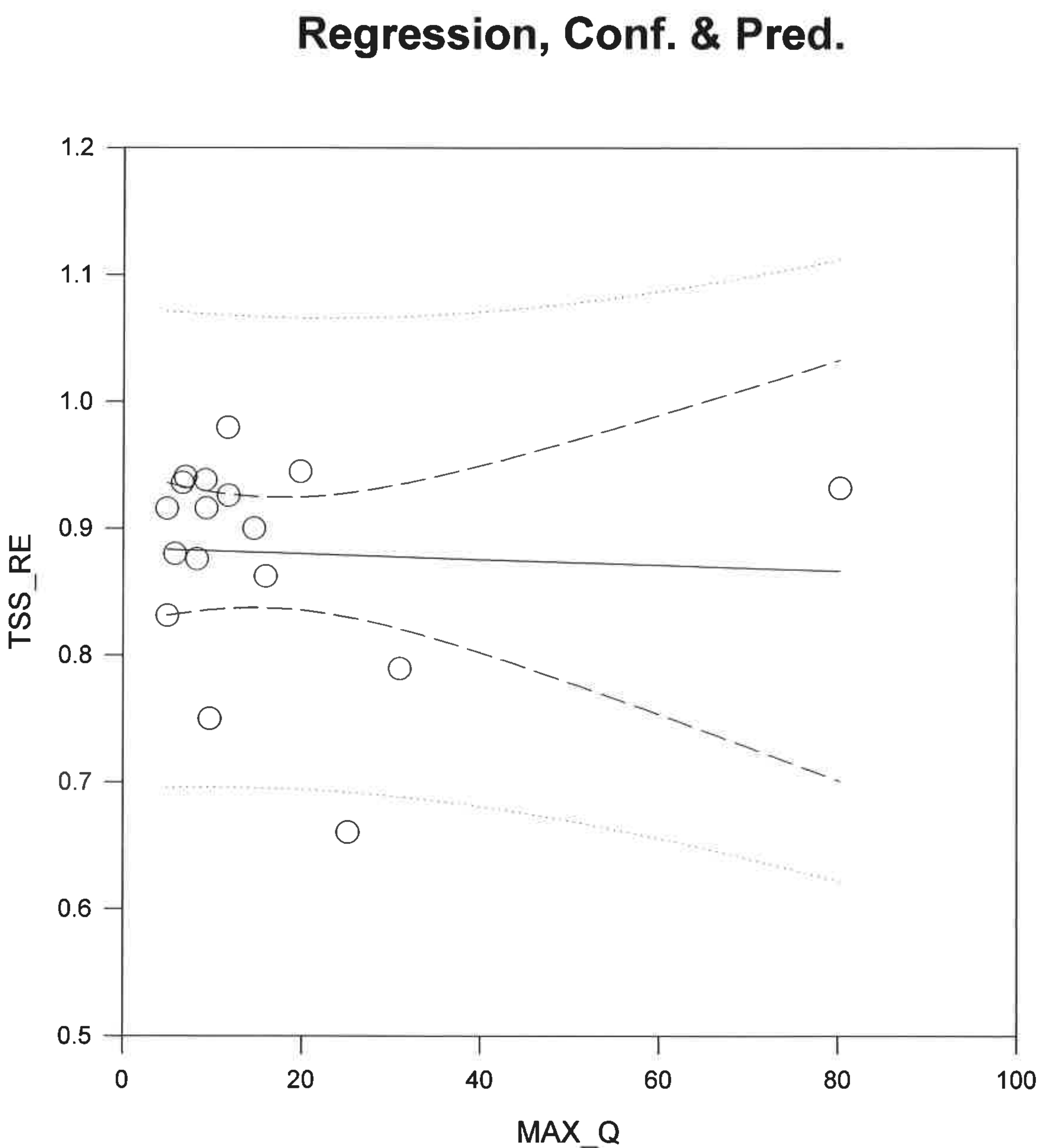
Normality Test: Passed (P = 0.166)

Constant Variance Test: Passed (P = 0.051)

Power of performed test with alpha = 0.050: 0.038

The power of the performed test (0.038) is below the desired power of 0.800.
Less than desired power indicates you are less likely to detect a difference when one actually exists.
Negative results should be interpreted cautiously.


Scatter Plot Residuals
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
Residual
0
20
40
60
80
100
MAX_Q


Regression, Conf. & Pred.
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
TSS_RE
0
20
40
60
80
100
MAX_Q

Nonlinear Regression

Data Source: Data 1 in Notebook1
Equation: Polynomial, Linear
f=y0+a*x

R	Rsqr	Adj Rsqr	Standard Error of Estimate
0.0492	0.0024	0.0000	18.5932

	Coefficient	Std. Error	t	P	VIF
y0	25.7115	50.0598	0.5136	0.6150	123.2303<
a	-10.7844	56.5838	-0.1906	0.8514	123.2303<

Analysis of Variance:

Uncorrected for the mean of the observations:

	DF	SS	MS
Regression	2	4479.1910	2239.5955
Residual	15	5185.6243	345.7083
Total	17	9664.8153	568.5185

Corrected for the mean of the observations:

	DF	SS	MS	F	P
Regression	1	12.5579	12.5579	0.0363	0.8514
Residual	15	5185.6243	345.7083		
Total	16	5198.1822	324.8864		

Statistical Tests:

PRESS 6335.6547

Durbin-Watson Statistic 2.0009 Passed

Normality Test Passed (P = 0.1249)

K-S Statistic = 0.2758 Significance Level = 0.1249

Constant Variance Test Passed (P = 0.4314)

Power of performed test with alpha = 0.0500: 0.0379

The power of the performed test (0.0379) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Regression Diagnostics:

Row	Std. Res.	Stud. Res.	Stud. Del. Res.
1	-0.4635	-0.4863	-0.4735
2	-0.4311	-0.4444	-0.4322
3	-0.3530	-0.3660	-0.3552
4	-0.5616	-0.5788	-0.5656
5	-0.5898	-0.6116	-0.5983
6	-0.1876	-0.2033	-0.1967

```
reciprocal_y = 1/abs(y)
reciprocal_ysquare = 1/y^2
'Automatic Initial Parameter Estimate Functions
F(q)=ape(x,y,1,0,1)
[Parameters]
y0 = F(0)[1] "Auto {{previous: 25.7115}}
a = F(0)[2] "Auto {{previous: -10.7844}}
[Equation]
f=y0+a*x
fit f to y
"fit f to y with weight reciprocal_ysquare
"fit f to y with weight reciprocal_y
[Constraints]
[Options]
tolerance=1e-10
stepsize=1
iterations=200
```

Number of Iterations Performed = 1

Linear Regression Thursday, October 08, 2015, 2:40:22 PM

Data source: Data 1 in Notebook1

TP_RE = 0.719 + (0.000480 * MAX_Q)

N = 17

R = 0.0413 Rsqr = 0.00170 Adj Rsqr = 0.000

Standard Error of Estimate = 0.216

	Coefficient	**Std. Error**	**t**	**P**
Constant	0.719	0.0716	10.042	<0.001
MAX_Q	0.000480	0.00300	0.160	0.875

Analysis of Variance:

	DF	**SS**	**MS**	**F**	**P**
Regression	1	0.00120	0.00120	0.0256	0.875
Residual	15	0.703	0.0469		
Total	16	0.704	0.0440		

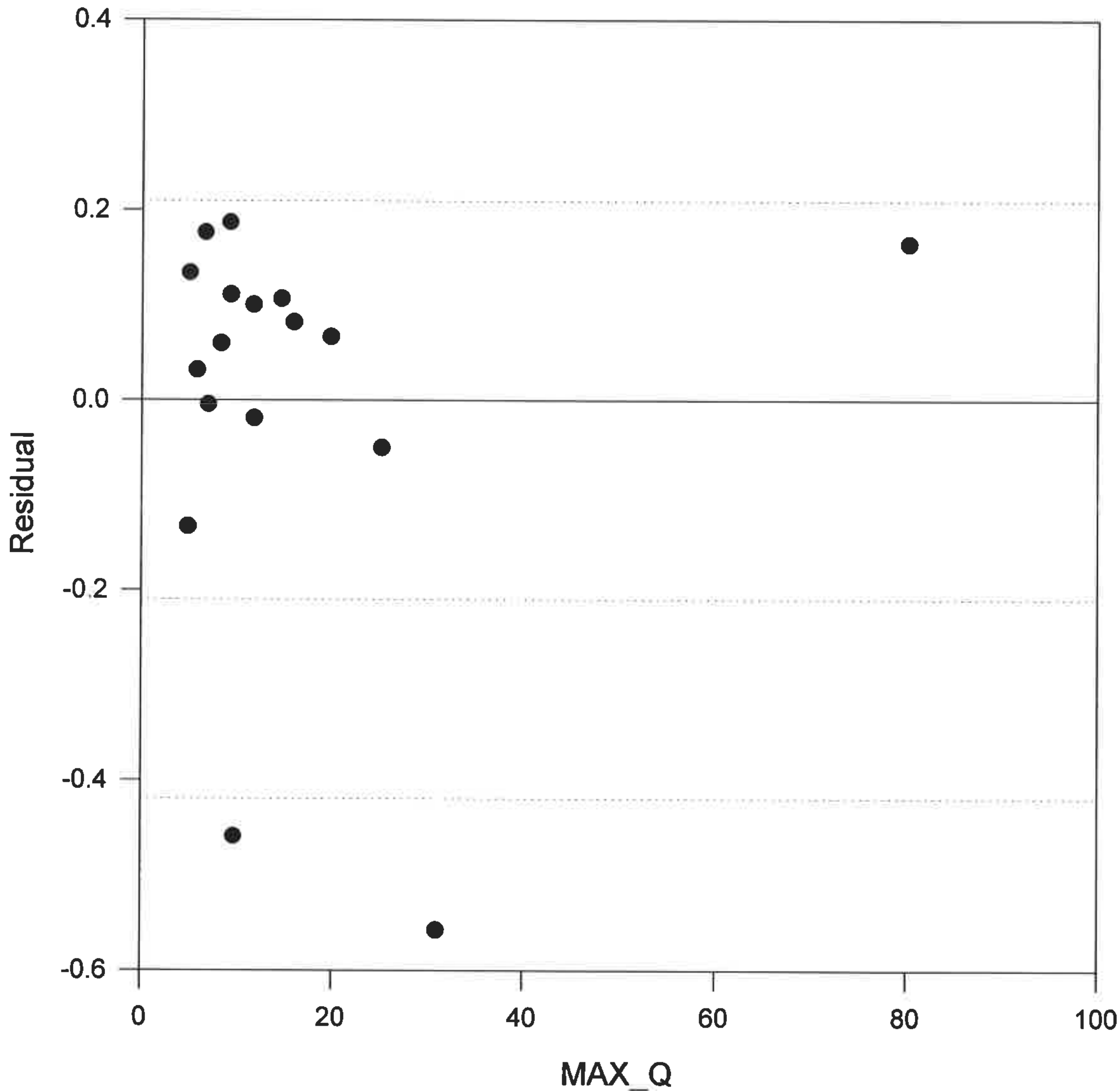
Normality Test: Failed (P = 0.015)

Constant Variance Test: Passed (P = 0.809)

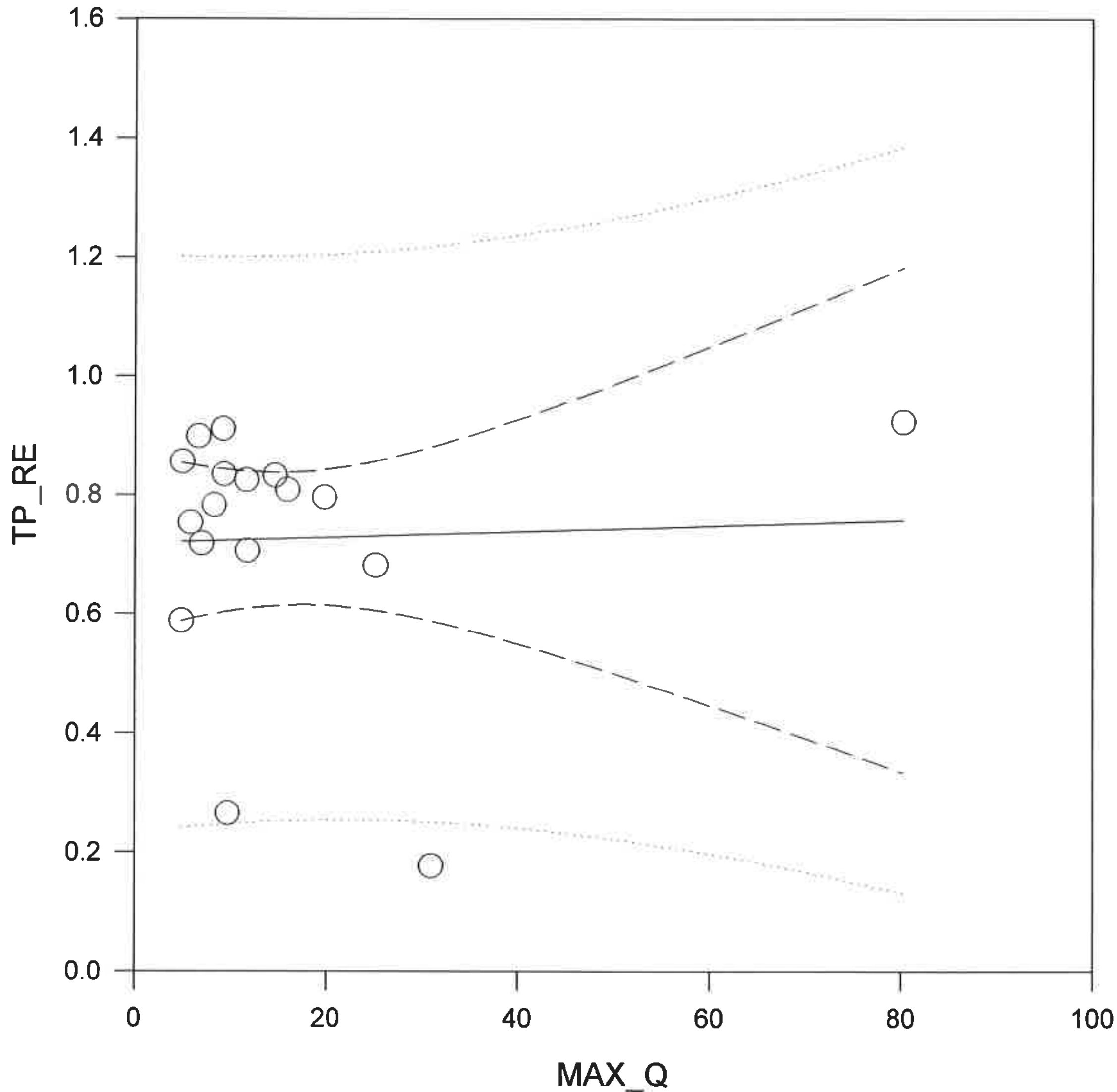
Power of performed test with alpha = 0.050: 0.036

The power of the performed test (0.036) is below the desired power of 0.800.
Less than desired power indicates you are less likely to detect a difference when one actually exists.
Negative results should be interpreted cautiously.

Scatter Plot Residuals



Regression, Conf. & Pred.



Nonlinear Regression

Data Source: Data 1 in Notebook1
Equation: Polynomial, Linear
f=y0+a*x

R	Rsqr	Adj Rsqr	Standard Error of Estimate
0.0413	0.0017	0.0000	18.5999

	Coefficient	Std. Error	t	P	VIF
y0	13.6321	16.7277	0.8149	0.4279	13.7499<
a	3.5462	22.1645	0.1600	0.8750	13.7499<

Analysis of Variance:

Uncorrected for the mean of the observations:

	DF	SS	MS
Regression	2	4475.4891	2237.7446
Residual	15	5189.3262	345.9551
Total	17	9664.8153	568.5185

Corrected for the mean of the observations:

	DF	SS	MS	F	P
Regression	1	8.8561	8.8561	0.0256	0.8750
Residual	15	5189.3262	345.9551		
Total	16	5198.1822	324.8864		

Statistical Tests:

PRESS 7254.8039

Durbin-Watson Statistic 2.0139 Passed

Normality Test Passed (P = 0.1200)

K-S Statistic = 0.2778 Significance Level = 0.1200

Constant Variance Test Passed (P = 0.9585)

Power of performed test with alpha = 0.0500: 0.0355

The power of the performed test (0.0355) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Regression Diagnostics:

Row	Std. Res.	Stud. Res.	Stud. Del. Res.
1	-0.4962	-0.5115	-0.4985
2	-0.4386	-0.4531	-0.4408
3	-0.3937	-0.4094	-0.3977
4	-0.5658	-0.5835	-0.5702
5	-0.5832	-0.6101	-0.5968
6	-0.2633	-0.2734	-0.2648

```
reciprocal_y = 1/abs(y)
reciprocal_ysquare = 1/y^2
'Automatic Initial Parameter Estimate Functions
F(q)=ape(x,y,1,0,1)
[Parameters]
y0 = F(0)[1] "Auto {{previous: 13.6321}}
a = F(0)[2] "Auto {{previous: 3.54625}}
[Equation]
f=y0+a*x
fit f to y
"fit f to y with weight reciprocal_ysquare
"fit f to y with weight reciprocal_y
[Constraints]
[Options]
tolerance=1e-10
stepsize=1
iterations=200
```

Number of Iterations Performed = 1

Linear Regression Thursday, October 08, 2015, 2:42:06 PM

Data source: Data 1 in Notebook1

TSS_RE = 0.876 + (0.00101 * AVG_Q)

N = 17

R = 0.0641 Rsqr = 0.00411 Adj Rsqr = 0.000

Standard Error of Estimate = 0.085

	Coefficient	**Std. Error**	**t**	**P**
Constant	0.876	0.0291	30.132	<0.001
AVG_Q	0.00101	0.00405	0.249	0.807

Analysis of Variance:

	DF	**SS**	**MS**	**F**	**P**
Regression	1	0.000443	0.000443	0.0619	0.807
Residual	15	0.108	0.00717		
Total	16	0.108	0.00675		

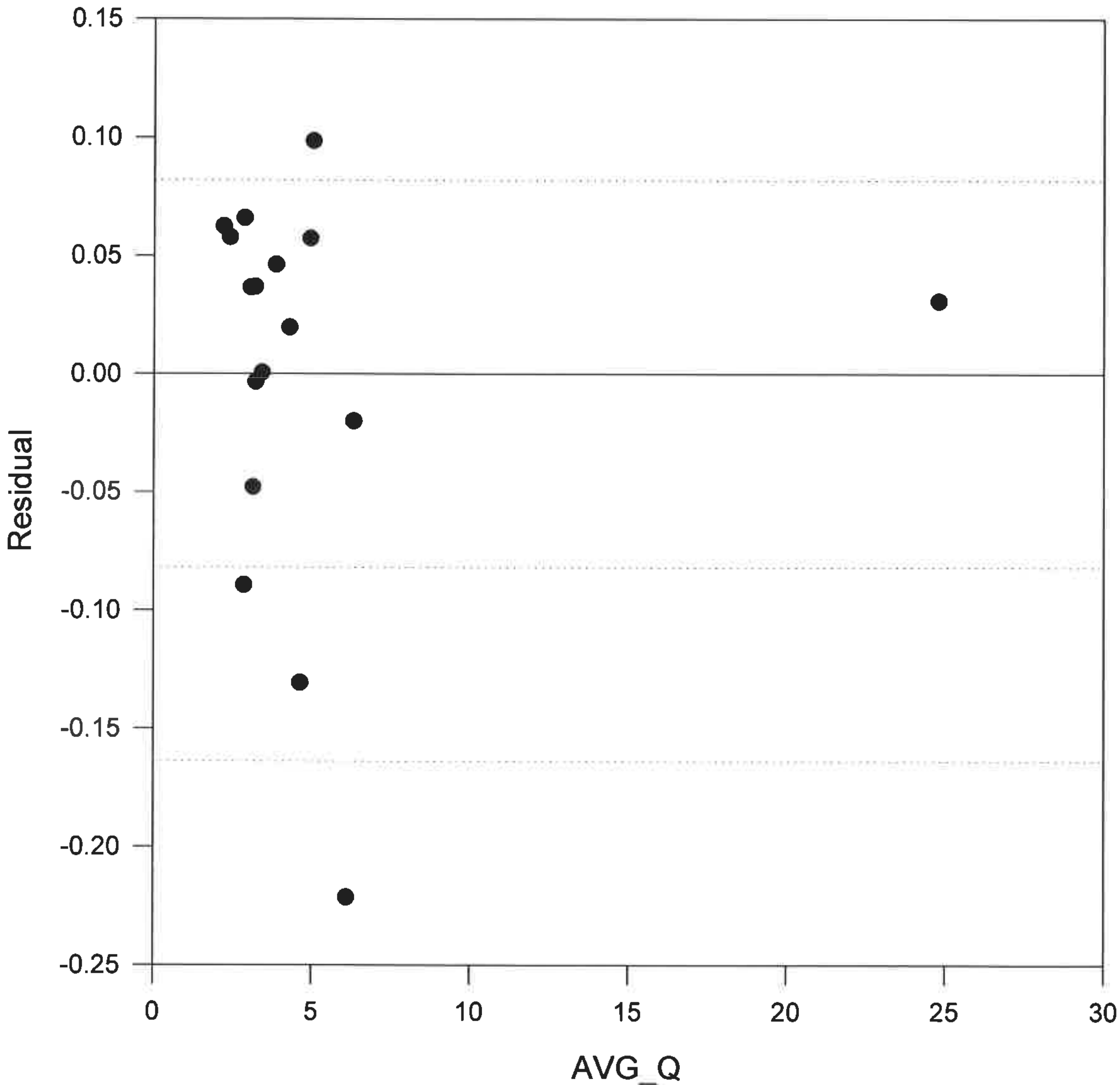
Normality Test: Passed (P = 0.100)

Constant Variance Test: Passed (P = 0.694)

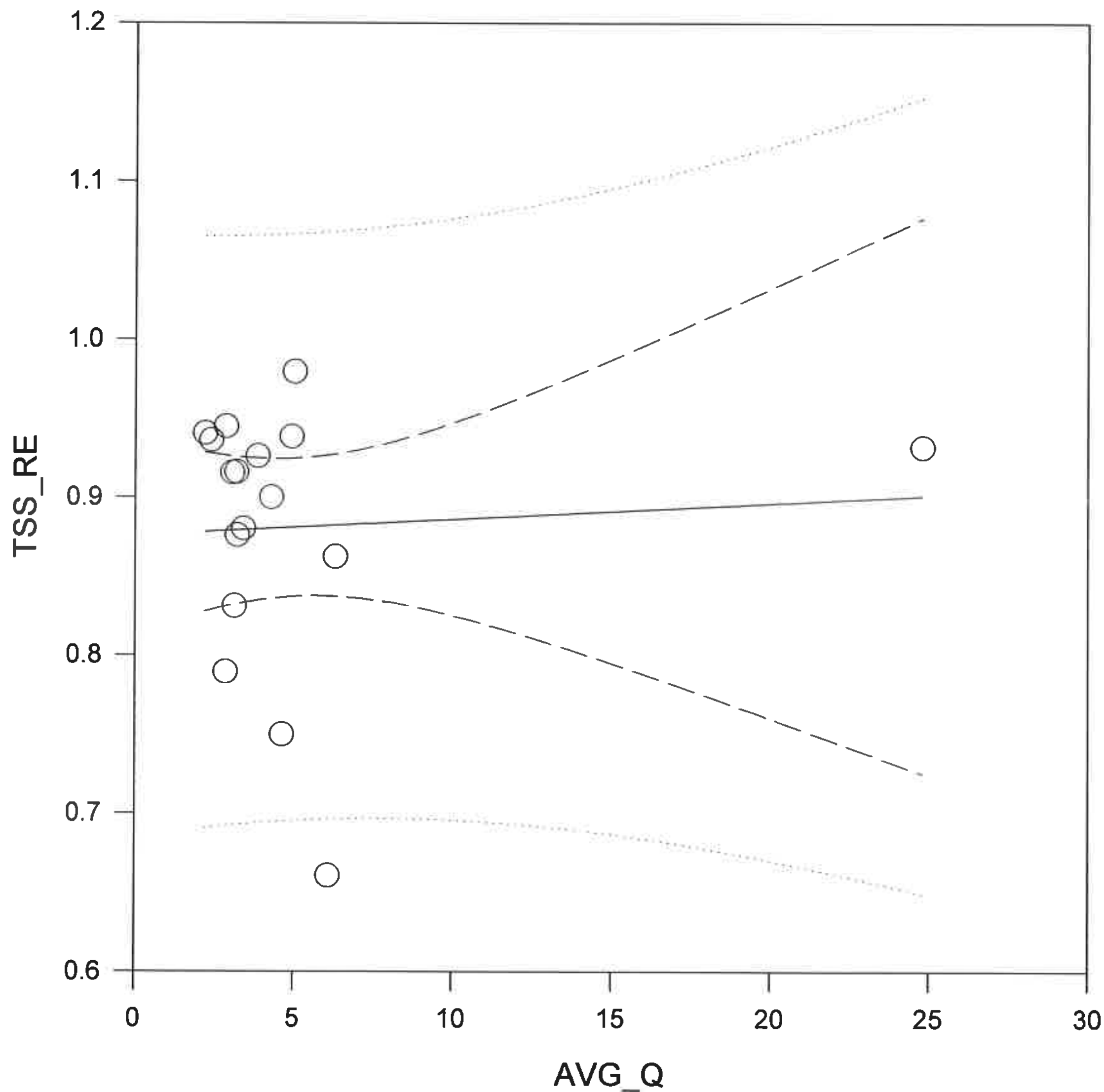
Power of performed test with alpha = 0.050: 0.043

The power of the performed test (0.043) is below the desired power of 0.800.
Less than desired power indicates you are less likely to detect a difference when one actually exists.
Negative results should be interpreted cautiously.

Scatter Plot Residuals



Regression, Conf. & Pred.



Nonlinear Regression

Data Source: Data 1 in Notebook1
Equation: Polynomial, Linear
f=y0+a*x

R	Rsqr	Adj Rsqr	Standard Error of Estimate
0.0641	0.0041	0.0000	5.3835

	Coefficient	Std. Error	t	P	VIF
y0	1.4877	14.4943	0.1026	0.9196	123.2303<
a	4.0745	16.3832	0.2487	0.8070	123.2303<

Analysis of Variance:

Uncorrected for the mean of the observations:

	DF	SS	MS
Regression	2	440.1267	220.0633
Residual	15	434.7278	28.9819
Total	17	874.8545	51.4620

Corrected for the mean of the observations:

	DF	SS	MS	F	P
Regression	1	1.7926	1.7926	0.0619	0.8070
Residual	15	434.7278	28.9819		
Total	16	436.5204	27.2825		

Statistical Tests:

PRESS 527.8233

Durbin-Watson Statistic 1.9598 Passed

Normality Test Passed (P = 0.0526)

K-S Statistic = 0.3159 Significance Level = 0.0526

Constant Variance Test Passed (P = 0.3211)

Power of performed test with alpha = 0.0500: 0.0427

The power of the performed test (0.0427) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Regression Diagnostics:

Row	Std. Res.	Stud. Res.	Stud. Del. Res.
1	-0.5801	-0.6086	-0.5954
2	-0.3411	-0.3516	-0.3411
3	-0.3767	-0.3906	-0.3793
4	-0.3074	-0.3168	-0.3071
5	-0.4005	-0.4152	-0.4035
6	-0.0841	-0.0912	-0.0881

```
reciprocal_y = 1/abs(y)
reciprocal_ysquare = 1/y^2
'Automatic Initial Parameter Estimate Functions
F(q)=ape(x,y,1,0,1)
[Parameters]
y0 = F(0)[1] "Auto {{previous: 1.48773}}
a = F(0)[2] "Auto {{previous: 4.07454}}
[Equation]
f=y0+a*x
fit f to y
"fit f to y with weight reciprocal_ysquare
"fit f to y with weight reciprocal_y
[Constraints]
[Options]
tolerance=1e-10
stepsize=1
iterations=200
```

Number of Iterations Performed = 1

Linear Regression Thursday, October 08, 2015, 2:43:41 PM

Data source: Data 1 in Notebook1

TP_RE = 0.676 + (0.00993 * AVG_Q)

N = 17

R = 0.247 Rsqr = 0.0612 Adj Rsqr = 0.000

Standard Error of Estimate = 0.210

	Coefficient	**Std. Error**	**t**	**P**
Constant	0.676	0.0721	9.382	<0.001
AVG_Q	0.00993	0.0100	0.989	0.339

Analysis of Variance:

	DF	**SS**	**MS**	**F**	**P**
Regression	1	0.0431	0.0431	0.977	0.339
Residual	15	0.661	0.0441		
Total	16	0.704	0.0440		

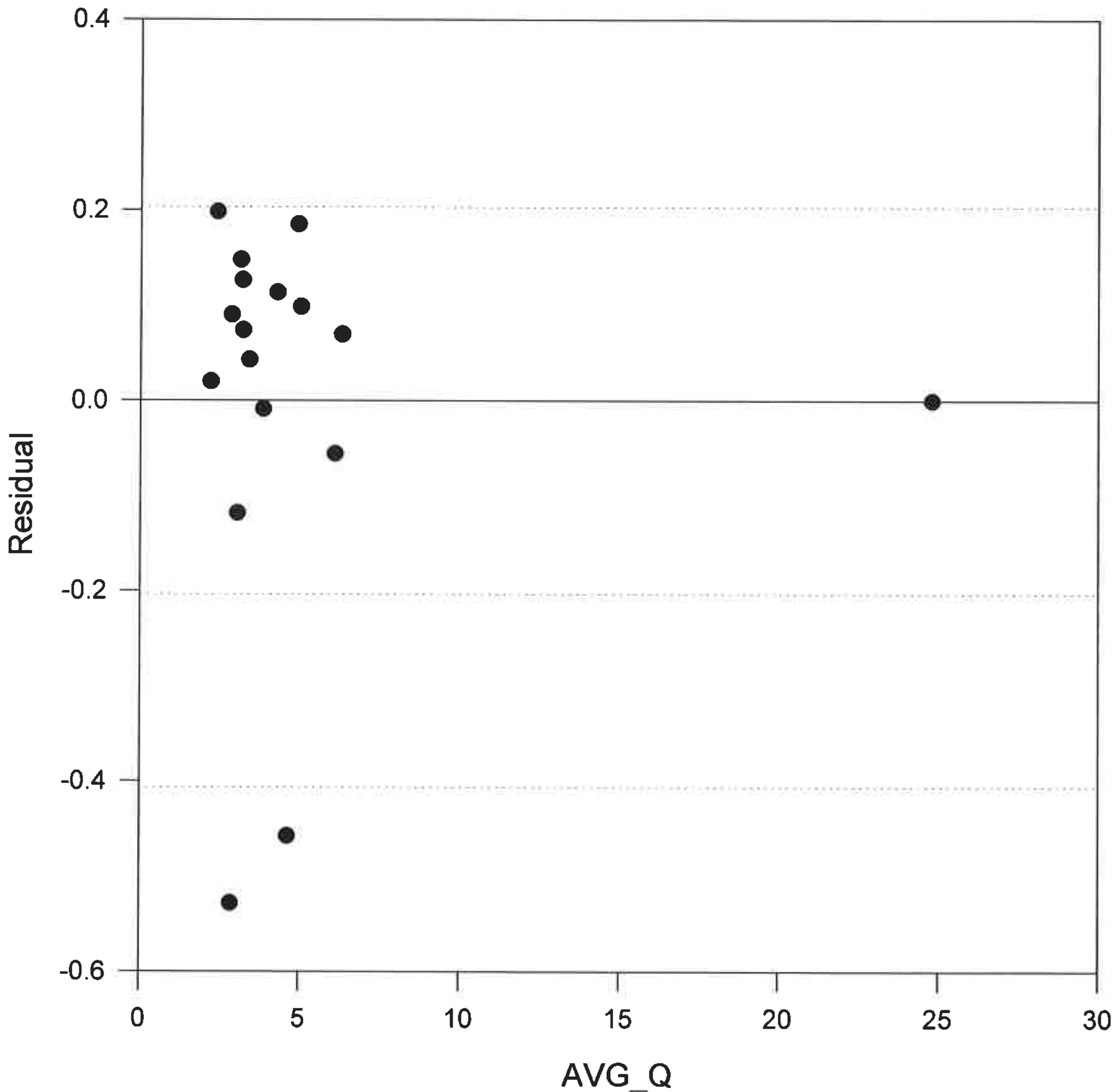
Normality Test: Failed (P = 0.007)

Constant Variance Test: Passed (P = 0.211)

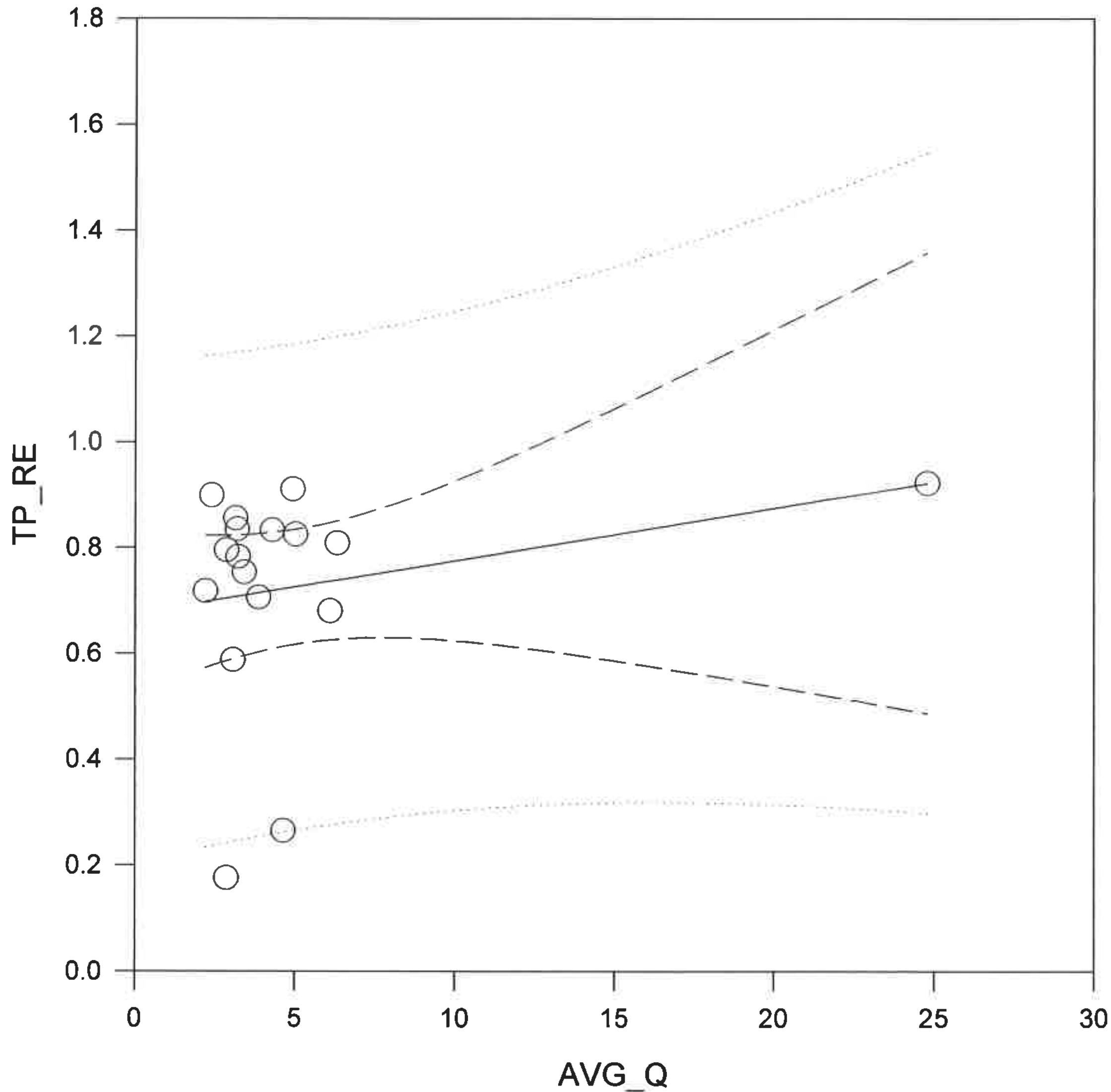
Power of performed test with alpha = 0.050: 0.155

The power of the performed test (0.155) is below the desired power of 0.800.
Less than desired power indicates you are less likely to detect a difference when one actually exists.
Negative results should be interpreted cautiously.

Scatter Plot Residuals



Regression, Conf. & Pred.



Nonlinear Regression

Data Source: Data 1 in Notebook1
Equation: Polynomial, Linear
f=y0+a*x

R	**Rsqr**	**Adj Rsqr**	**Standard Error of Estimate**
0.2473	0.0612	0.0000	5.2270

	Coefficient	**Std. Error**	**t**	**P**	**VIF**
y0	0.6029	4.7008	0.1283	0.8996	13.7499<
a	6.1575	6.2287	0.9886	0.3386	13.7499<

Analysis of Variance:

Uncorrected for the mean of the observations:

	DF	**SS**	**MS**
Regression	2	465.0340	232.5170
Residual	15	409.8205	27.3214
Total	17	874.8545	51.4620

Corrected for the mean of the observations:

	DF	**SS**	**MS**	**F**	**P**
Regression	1	26.6999	26.6999	0.9773	0.3386
Residual	15	409.8205	27.3214		
Total	16	436.5204	27.2825		

Statistical Tests:

PRESS 525.7684

Durbin-Watson Statistic 2.0896 Passed

Normality Test Passed (P = 0.1135)

K-S Statistic = 0.2805 Significance Level = 0.1135

Constant Variance Test Passed (P = 0.1185)

Power of performed test with alpha = 0.0500: 0.1551

The power of the performed test (0.1551) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Regression Diagnostics:

Row	**Std. Res.**	**Stud. Res.**	**Stud. Del. Res.**
1	-0.5410	-0.5576	-0.5444
2	-0.4211	-0.4351	-0.4230
3	-0.4879	-0.5074	-0.4945
4	-0.3487	-0.3597	-0.3490
5	-0.2223	-0.2326	-0.2251
6	-0.1257	-0.1305	-0.1262

```
reciprocal_y = 1/abs(y)
reciprocal_ysquare = 1/y^2
'Automatic Initial Parameter Estimate Functions
F(q)=ape(x,y,1,0,1)
[Parameters]
y0 = F(0)[1] "Auto {{previous: 0.602926}}
a = F(0)[2] "Auto {{previous: 6.15749}}
[Equation]
f=y0+a*x
fit f to y
"fit f to y with weight reciprocal_ysquare
"fit f to y with weight reciprocal_y
[Constraints]
[Options]
tolerance=1e-10
stepsize=1
iterations=200
```

Number of Iterations Performed = 1

APPENDIX K – Particle Size Distribution

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Portland, OR 97220
Phone: (800) 548-4667
www.ContechES.com

Project: Stormwater Management StormFilter PhosphoSorb Field Evaluation

Author: Contech Engineered Solutions, LLC

Date: April 17, 2015

Topic: Serial Filtration Particle Size Distribution Results

The Lolo Pass Road site, which is the subject of the current StormFilter with PhosphoSorb media monitoring project, was previously monitored in 2006 (Contech, 2007). At that time, the average particle size distribution (PSD) had a mean particle diameter (d_{50}) of 29 microns and was characterized as a silt loam. PSD results during the StormFilter monitoring period varied widely and were comparatively coarse, with a d_{50} of 200 microns, and are best characterized as a sandy loam (Figure 1). The current gradation was influenced by the amount of coarse sediment greater than 500 microns transported to the influent sampling point. The percentage of the suspended solids concentration (SSC) comprised of particles greater than 500 microns ranged from 11% to 64% with a mean of 38%. The mean concentration of SSC greater than 500 microns was 205 mg/L with a standard deviation of 184 mg/L. Several possible reasons for this shift in PSD have been postulated but have not been quantitatively explored. For example, aging and abrasion of the pavement surface, changes in traffic patterns and in traction sand application frequency may have all had an impact.

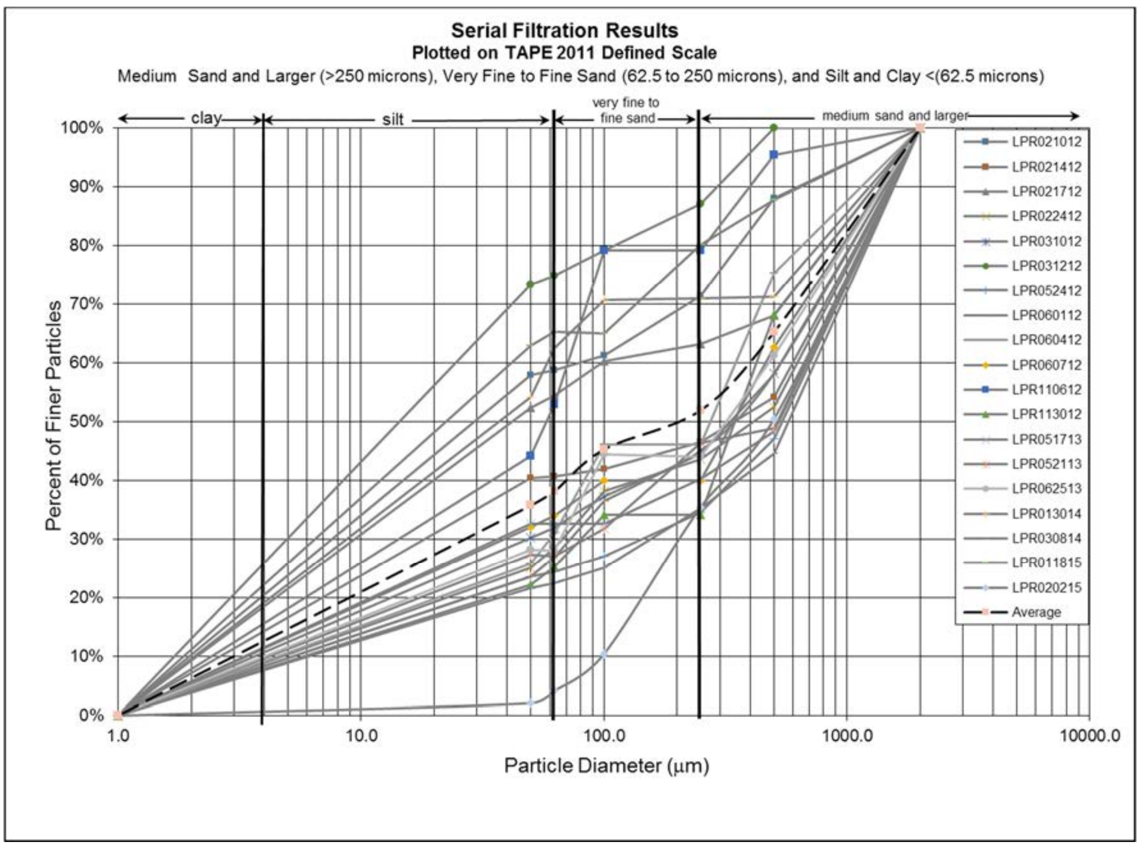

Figure 1. Individual Serial Filtration PSD data for qualified events (n=19).

In consideration of Basic Treatment performance, Ecology has previously expressed interest only in the portion of the TSS load comprised of particles finer than 500 microns, considering larger particles "similarly to debris and other coarse solids, all of which should be pretreated and removed upstream of basic treatment devices."(2004 TAPE). While this language does not appear in the current TAPE, it is the basis for including a 500 micron sieve in the serial filtration method and suggests that a closer look at the PSD and removal efficiency for particles finer than 500 microns may be warranted.

Throughout the project, a Serial Filtration method (Contech, 2013) was used to evaluate the full range of particle size fractions (50, 62.5, 100, 250, 500, and 2000 microns). The resulting PSD information can be combined with influent and effluent concentrations for various solids size fractions to evaluate the performance of the StormFilter with PhosphoSorb on narrower PSD ranges.

Serial Filtration results for the solids fraction less than 500 microns (SSC <500µm) are presented in Figure 2 for 17 events. These events meet all storm event criteria and represent the entire evaluation period. The d_{50} is 50 microns, suggesting that if pretreatment had been used on site, the StormFilter influent particle size distribution would have been best characterized as a silt loam. The 500 micron data set was analyzed using the bootstrap method which resulted in a lower 95% confidence limit of 80% removal (n=17).

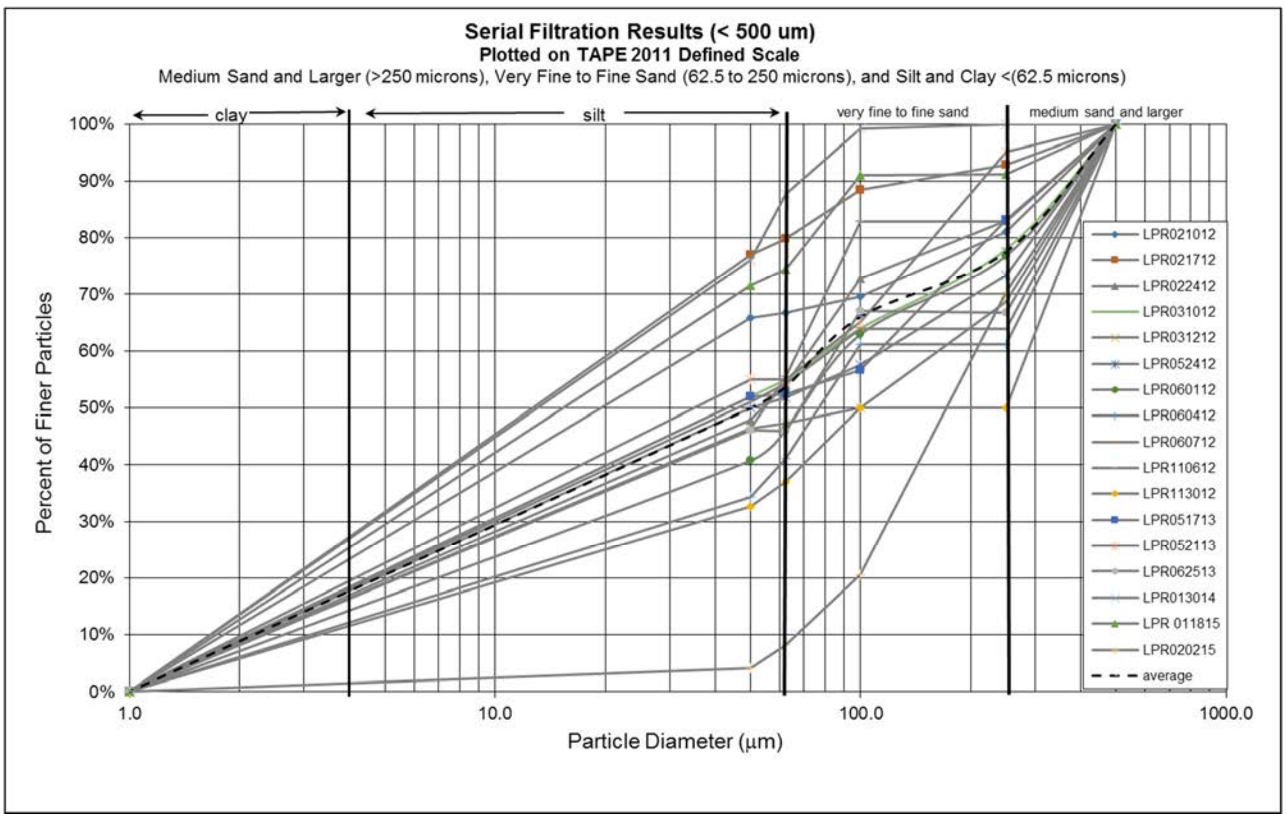

Figure 2. Serial Filtration results for the solids fraction less than 500 microns (n=17).

The overall particle size distribution observed during the study period on this site was coarser than expected based on historic information. However, the Serial Filtration method results allow narrower ranges of the total solids load to be segregated for analysis. This site and monitoring configuration were designed to eliminate any opportunity for sediment to settle out in the conveyance system between the grate inlet and the influent sampling point. This was a deliberate decision, made to reduce influent concentration variability associated with settling and resuspension of solids in the inlet pipe and upstream structures. Had a conventional sumped catch basin been employed upstream, it is likely that the PSD observed at the StormFilter influent sampling point would have more closely resembled the PSD of solids finer than 500 microns and would be classified as a silt loam. StormFilter performance for this finer fraction of the influent solids load meets the basic treatment goal.

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APPENDIX L – Deicing Activities

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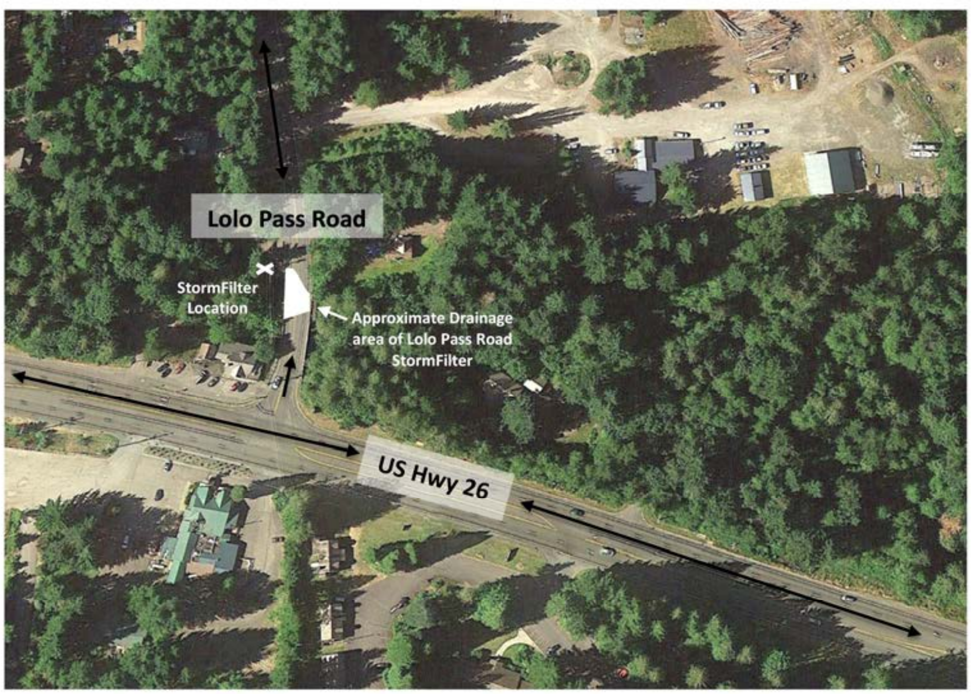
Contech Engineered Solutions LLC

Memorandum (DRAFT)

To: Lolo Pass Road Project
From: Gretchen Tellessen, Contech Engineered Solutions LLC
Date: 4/7/2015
Subject: De-icing Activities Occurring on US Highway 26, a Drainage Area Adjacent to the Lolo Pass Road Monitoring Site Drainage Area

The Lolo Pass Road evaluation site is located in Zigzag, Oregon in the foothills of Mt. Hood, which is part of the Cascade Mountain Range. The drainage area is located on Lolo Pass Road at Bear Creek Bridge, near the intersection of Lolo Pass Road and US Highway 26. Sanding, graveling, and de-icing activities occur on the site as necessary during winter to control ice accumulation and assist with tire traction. These activities are overseen by the Oregon Department of Transportation (ODOT) but are outsourced locally and are not tracked or recorded by ODOT personnel. This memorandum discusses de-icing activities that occur on US Highway 26, the closest drainage area to the Lolo Pass Road drainage area of which we have access to records of de-icing activities.



As can be seen in Figure 1, the drainage area of the Lolo Pass Road evaluation site is adjacent to US Highway 26. Even though de-icing and sanding activities that occur on US Highway 26 do not directly impact water quality of the runoff being treated by the Lolo Pass Road StormFilter, the information can be used as an indicator of possible deicer and sand applications within the Lolo Pass Road drainage area, outlined in Figure 1.

In response to Ecology's request for deicer application records in the area of the evaluation site, Contech worked with James McNamee, ODOT Maintenance Manager at the Government Camp/Parkdale station. As stated earlier, ODOT outsources de-icing and sanding activities occurring on Lolo Pass Road and does not keep record of these activities. However, ODOT crews do control all de-icing and sanding activities along US Highway 26, including near the intersection of US Highway 26 and Lolo Pass Road. The deicer used by ODOT is magnesium chloride and is applied as needed to control ice accumulation. Table 1 shows the date, time of day, and amount of deicer applied to US Highway 26 near Zigzag, Oregon for the 2013/2014 and 2014/2015 winter seasons, as provided by ODOT. This information was not recoded by ODOT personnel for the 2012/2013 winter season and thus was not provided.

Table 1. Deicer (magnesium chloride) applications on US Highway 26 near Zigzag, Oregon. Information provided by ODOT.

2013 / 2014 Season			2013 / 2014 Season Cont.			2014 / 2015 Season		
Date	Time of Day	GPLM Applied	Date	Time of Day	GPLM Applied	Date	Time of Day	GPLM Applied
11/20/2013	4:00 PM	30	1/17/2014	5:30 AM	30	11/13/2014	6:30 PM	30
11/22/2013	7:30 AM	30	1/19/2014	5:00 AM	30	11/14/2014	5:00 PM	30
12/3/2013	6:00 AM	30	1/20/2014	4:30 AM	30	11/15/2014	4:00 PM	30
12/3/2013	3:00 PM	30	1/21/2014	4:30 AM	30	11/16/2014	4:00 PM	30
12/5/2013	12:30 PM	30	1/22/2014	5:30 PM	30	11/17/2014	5:00 PM	30
12/9/2013	4:00 PM	30	1/23/2014	5:00 AM	30	11/29/2014	5:30 PM	30
12/10/2013	4:00 PM	30	1/24/2014	4:30 AM	30	11/30/2014	5:00 AM	20
12/11/2013	5:00 PM	30	1/25/2014	4:00 AM	30	11/30/2014	3:30 PM	30
12/12/2013	9:30 PM	20	2/1/2014	7:00 PM	30	12/1/2014	5:00 AM	30
12/13/2013	10:00 PM	30	2/2/2014	5:00 AM	30	12/1/2014	7:00 PM	30
12/14/2013	5:30 PM	30	2/3/2014	6:30 PM	30	12/2/2014	4:00 PM	30
12/17/2013	4:30 AM	30	2/4/2014	7:30 AM	30	12/3/2014	3:30 PM	30
12/24/2013	7:30 AM	30	2/4/2014	4:00 PM	30	12/4/2014	6:00 PM	30
12/25/2013	4:30 AM	30	2/10/2014	5:00 PM	30	12/13/2014	4:30 PM	30
12/26/2013	8:30 AM	30	2/18/2014	5:30 AM	30	12/27/2014	12:00 AM	30
12/27/2013	4:30 AM	30	2/28/2014	4:30 AM	30	12/29/2014	4:00 PM	30
12/28/2013	9:00 PM	30	3/18/2014	7:00 AM	30	1/1/2015	4:30 PM	30
1/1/2014	5:30 AM	20	3/31/2014	2:00 AM	30	1/2/2015	5:00 AM	30
1/2/2014	5:00 AM	20				1/2/2015	4:00 PM	30
1/3/2014	9:00 PM	30				1/8/2015	2:30 AM	30
1/4/2014	4:30 AM	30				1/9/2015	5:00 AM	30
1/5/2014	5:00 AM	30				1/16/2015	5:00 PM	30
1/6/2014	6:00 AM	30				1/21/2015	4:00 AM	30
1/16/2014	5:00 AM	20						

Of the 25 events sampled (both qualified and disqualified) at the Lolo Pass Road evaluation site, 11 events (10 qualified) occurred during the time frame in which deicer application records were provided. Of this, only two sampled events occurred within a week of a deicer application on US Highway 26; LPR013014 which was sampled 5 days after an application and LPR011815 which was sampled 2 days after an application. Considering that the minimum length of time between a recorded deicer application on US Highway 26 and a sampled event at the Lolo Pass Road evaluation site is 2 days, it can be assumed that deicer applications, either on US Highway 26 or Lolo Pass Road, had a negligible effect on the water quality of runoff entering the StormFilter.

APPENDIX M – Maintenance Recordkeeping Field Forms

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Field Recordkeeping Form

Date and Time of site visit: 2/2/2012
Reason for Site Visit: System maintenance, equipment prep/QC sample collection
Staff on Site: J. Pedrick, G. Tellessen
Current weather conditions: sunny, dry

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: ____________
Influent pacing: ________
Number of effluent aliquots/bottles collected: ____________
Effluent pacing: ________
Sample collection date and time (to be used for COC): ____________________
Runoff event qualified and samples sent to lab: **No Yes** ____________________

Field QC samples collected while on site: No Yes
Type of QC samples collected: Field rinsate blanks
Sample collection time (to be used for COC): 2/2/12 15:30

Condition of sampling equipment: good! Set up and ready to sample
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed
ODS - in working order

Site and System Observations
Major changes to site condition since last visit: no change
Additional activities occurring on site: none

CatchBasin/ Influent obstructions: **No Yes** ________ all fully cleaned
Influent flume obstructions: **No Yes** ________ during system
Effluent and effluent flume obstructions: **No Yes** ________ maintenance

Rain gage in working order: **No Yes** ____________
Obstructions to rain gage: **No Yes** ____________

post-maintenance
Average depth of sediment on vault floor: none
Sediment present on cartridge hood: **No Yes** Depth: ______________
Condition of media: new - unused

Additional Notes: full system maintenance performed; new cartridge installed; site and equipment prep for sample collection; project officially restarted - next sampled event will be Event #1.

3/27/2012

Field Recordkeeping Form

Date and Time of site visit: 3/27/2012 10:00am
Reason for Site Visit: Full system maintenance and cartridge replacement.
Staff on Site: J. Pedrick, G. Tellessen
Current weather conditions: dry, partly cloudy

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: ____
Influent pacing: ____
Number of effluent aliquots/bottles collected: ____
Effluent pacing: ____
Sample collection date and time (to be used for COC): ____
Runoff event qualified and samples sent to lab: **No Yes** ____

Field QC samples collected while on site: No Yes
Type of QC samples collected: ____
Sample collection time (to be used for COC): ____

Condition of sampling equipment: good, working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed.

Site and System Observations
Major changes to site condition since last visit: no change
Additional activities occurring on site: –

CatchBasin/ Influent obstructions: **No Yes** All cleaned during maintenance
Influent flume obstructions: **No Yes**
Effluent and effluent flume obstructions: **No Yes**

Rain gage in working order: **No Yes** ____
Obstructions to rain gage: **No Yes** ____

post-maint.
Average depth of sediment on vault floor: none
Sediment present on cartridge hood: **No Yes** Depth: ____
Condition of media: new and unused

Additional Notes: Sediment collected from vault prior to maintenance and brought back to PDX lab for evaluation; spent cartridge brought back to PDX lab for evaluation; full system maintenance performed; new cartridge installed; new ODS installed.

Field Recordkeeping Form

Date and Time of site visit: 3/28/13 10 am
Reason for Site Visit: System maint, Cartridge replacement
Staff on Site: G. Tellessen, G. Kowalsky
Current weather conditions: Dry, partly sunny

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: ___
Influent pacing: ___
Number of effluent aliquots/bottles collected: ___
Effluent pacing: ___
Sample collection date and time (to be used for COC): ___
Runoff event qualified and samples sent to lab: **No Yes** ___

Field QC samples collected while on site: No Yes
Type of QC samples collected: ___
Sample collection time (to be used for COC): ___

Condition of sampling equipment: Good working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations
Major changes to site condition since last visit: no
Additional activities occurring on site: none

CatchBasin/ Influent obstructions: **No Yes** all flumes and piped
Influent flume obstructions: **No Yes** cleaned thoroughly
Effluent and effluent flume obstructions: **No Yes** during system maintenance

Rain gage in working order: **No Yes** ___
Obstructions to rain gage: **No Yes** ___

Average depth of sediment on vault floor: 9-in (pre.maint.)
Sediment present on cartridge hood: **No Yes** Depth: ~ 1in (pre maint.)
Condition of media: new cartridge installed at time of maintenance.

Additional Notes: full system maintenance, all flumes cleared, catch basin emptied and cleaned, new PSorb cartridge installed! New batteries installed, system left online and ready for sampling at next qualified event.

1/13/14

Field Recordkeeping Form

Date and Time of site visit: 1/13/14 All Day
Reason for Site Visit: equipment re-install, system maint.
Staff on Site: Pedrick, Darcy
Current weather conditions: dry

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: ____________
Influent pacing: ________
Number of effluent aliquots/bottles collected: ____________
Effluent pacing: ________
Sample collection date and time (to be used for COC): ________________
Runoff event qualified and samples sent to lab: **No Yes** ________________

Field QC samples collected while on site: No Yes
Type of QC samples collected: ________________
Sample collection time (to be used for COC): ________

Condition of sampling equipment: all equipment re-installed, new batteries
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics - passed

Site and System Observations
Major changes to site condition since last visit: no
Additional activities occurring on site: none

CatchBasin/ Influent obstructions: No Yes ________
Influent flume obstructions: No Yes ________ full system maint.
Effluent and effluent flume obstructions: No Yes ________

Rain gage in working order: **No Yes** ________
Obstructions to rain gage: **No Yes** ________

Average depth of sediment on vault floor: ________
Sediment present on cartridge hood: **No Yes** Depth: ________ full system maint.
Condition of media: new cartridge

Additional Notes: full system maintenance performed, new cartridge installed, all monitoring equipment re installed (minus modems & ODS)

10/10/14

Field Recordkeeping Form

Date and Time of site visit: 10/10/14 All day
Reason for Site Visit: full system maint., reinitialize sampling at site
Staff on Site: Tellessen / Pedrick
Current weather conditions: dry, clear skies

Water quality samples collected while on site: No Yes
Number of influent aliquots/bottles collected: ___
Influent pacing: ___
Number of effluent aliquots/bottles collected: ___
Effluent pacing: ___
Sample collection date and time (to be used for COC): ___
Runoff event qualified and samples sent to lab: **No Yes** ___

Field QC samples collected while on site: No Yes
Type of QC samples collected: equipment blanks
Sample collection time (to be used for COC): ___

Condition of sampling equipment: good, working order
Bottles replaced: **No Yes**
Batteries replaced: **No Yes**
Desiccant replaced: **No Yes**
Equipment calibration procedures performed on site: diagnostics- passed.

Site and System Observations
Major changes to site condition since last visit: no
Additional activities occurring on site: no

CatchBasin/ Influent obstructions: **No Yes** influent conveyence cleaned during maint.
Influent flume obstructions: **No Yes** ___
Effluent and effluent flume obstructions: **No Yes** ___

Rain gage in working order: **No Yes** ___
Obstructions to rain gage: **No Yes** ___

Average depth of sediment on vault floor: ___ new cartridge / clean vault
Sediment present on cartridge hood: **No Yes** Depth: ___
Condition of media: ___

Additional Notes: full system maintenance, new SF cartridge installed

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APPENDIX N – Operations and Maintenance

StormFilter Inspection and Maintenance Procedures

The Stormwater Management StormFilter®

Maintenance Guidelines

The primary purpose of the Stormwater Management StormFilter® is to filter out and prevent pollutants from entering our waterways. Like any effective filtration system, periodically these pollutants must be removed to restore the StormFilter to its full efficiency and effectiveness.

Maintenance requirements and frequency are dependent on the pollutant load characteristics of each site. Maintenance activities may be required in the event of a chemical spill or due to excessive sediment loading from site erosion or extreme storms. It is a good practice to inspect the system after major storm events.

Maintenance Procedures

Although there are likely many effective maintenance options, we believe the following procedure is efficient and can be implemented using common equipment and existing maintenance protocols. A two step procedure is recommended as follows:

1. Inspection

Inspection of the vault interior to determine the need for maintenance.

2. Maintenance

Cartridge replacement

Sediment removal

Inspection and Maintenance Timing

At least one scheduled inspection should take place per year with maintenance following as warranted.

First, an inspection should be done before the winter season. During the inspection the need for maintenance should be determined and, if disposal during maintenance will be required, samples of the accumulated sediments and media should be obtained.

Second, if warranted, a maintenance (replacement of the filter cartridges and removal of accumulated sediments) should be performed during periods of dry weather.

In addition to these two activities, it is important to check the condition of the StormFilter unit after major storms for potential damage caused by high flows and for high sediment accumulation that may be caused by localized erosion in the drainage area. It may be necessary to adjust the inspection/maintenance schedule depending on the actual operating conditions encountered by the system. In general, inspection activities can be conducted at any time, and maintenance should occur, if warranted, in late summer to early fall when flows into the system are not likely to be present.

Maintenance Frequency

The primary factor controlling timing of maintenance of the StormFilter is sediment loading.

A properly functioning system will remove solids from water by trapping particulates in the porous structure of the filter media inside the cartridges. The flow through the system will naturally decrease as more and more particulates are trapped. Eventually the flow through the cartridges will be low enough to require replacement. It may be possible to extend the usable span of the cartridges by removing sediment from upstream trapping devices on a routine as-needed basis in order to prevent material from being re-suspended and discharged to the StormFilter treatment system.

Site conditions greatly influence maintenance requirements. StormFilter units located in areas with erosion or active construction may need to be inspected and maintained more often than those with fully stabilized surface conditions.

The maintenance frequency may be adjusted as additional monitoring information becomes available during the inspection program. Areas that develop known problems should be inspected more frequently than areas that demonstrate no problems, particularly after major storms. Ultimately, inspection and maintenance activities should be scheduled based on the historic records and characteristics of an individual StormFilter system or site. It is recommended that the site owner develop a database to properly manage StormFilter inspection and maintenance programs.

Prior to the development of the maintenance database, the following maintenance frequencies should be followed:

Inspection

One time per year

After major storms

Maintenance

As needed, based on results of inspection (The average maintenance lifecycle is approximately 1-3 years)

Per Regulatory requirement

In the event of a chemical spill

Frequencies should be updated as required. The recommended initial frequency for inspection is one time per year. StormFilter units should be inspected after major storms.

Sediment removal and cartridge replacement on an as needed basis is recommended unless site conditions warrant.

Once an understanding of site characteristics has been established, maintenance may not be needed for one to three years, but inspection is warranted and recommended annually.

Inspection Procedures

The primary goal of an inspection is to assess the condition of the cartridges relative to the level of visual sediment loading as it relates to decreased treatment capacity. It may be desirable to conduct this inspection during a storm to observe the relative flow through the filter cartridges. If the submerged cartridges are severely plugged, then typically large amounts of sediments will be present and very little flow will be discharged from the drainage pipes. If this is the case, then maintenance is warranted and the cartridges need to be replaced.

Warning: In the case of a spill, the worker should abort inspection activities until the proper guidance is obtained. Notify the local hazard control agency and CONTECH Construction Products immediately.

To conduct an inspection:

Important: Inspection should be performed by a person who is familiar with the operation and configuration of the StormFilter treatment unit.

1. If applicable, set up safety equipment to protect and notify surrounding vehicle and pedestrian traffic.
2. Visually inspect the external condition of the unit and take notes concerning defects/problems.

3. Open the access portals to the vault and allow the system vent.
4. Without entering the vault, visually inspect the inside of the unit, and note accumulations of liquids and solids.
5. Be sure to record the level of sediment build-up on the floor of the vault, in the forebay, and on top of the cartridges. If flow is occurring, note the flow of water per drainage pipe. Record all observations. Digital pictures are valuable for historical documentation.
6. Close and fasten the access portals.
7. Remove safety equipment.
8. If appropriate, make notes about the local drainage area relative to ongoing construction, erosion problems, or high loading of other materials to the system.
9. Discuss conditions that suggest maintenance and make decision as to weather or not maintenance is needed.

Maintenance Decision Tree

The need for maintenance is typically based on results of the inspection. The following Maintenance Decision Tree should be used as a general guide. (Other factors, such as Regulatory Requirements, may need to be considered)

1. Sediment loading on the vault floor.
   a. If >4" of accumulated sediment, maintenance is required.
2. Sediment loading on top of the cartridge.
   a. If >1/4" of accumulation, maintenance is required.
3. Submerged cartridges.
   a. If >4" of static water in the cartridge bay for more that 24 hours after end of rain event, maintenance is required.
4. Plugged media.
   a. If pore space between media granules is absent, maintenance is required.
5. Bypass condition.
   a. If inspection is conducted during an average rain fall event and StormFilter remains in bypass condition (water over the internal outlet baffle wall or submerged cartridges), maintenance is required.
6. Hazardous material release.
   a. If hazardous material release (automotive fluids or other) is reported, maintenance is required.
7. Pronounced scum line.
   a. If pronounced scum line (say ≥ 1/4" thick) is present above top cap, maintenance is required.
8. Calendar Lifecycle.
   a. If system has not been maintained for 3 years maintenance is required.

Assumptions

- No rainfall for 24 hours or more
- No upstream detention (at least not draining into StormFilter)
- Structure is online
- Outlet pipe is clear of obstruction
- Construction bypass is plugged

Maintenance

Depending on the configuration of the particular system, maintenance personnel will be required to enter the vault to perform the maintenance.

Important: If vault entry is required, OSHA rules for confined space entry must be followed.

Filter cartridge replacement should occur during dry weather. It may be necessary to plug the filter inlet pipe if base flows is occurring.

Replacement cartridges can be delivered to the site or customers facility. Information concerning how to obtain the replacement cartridges is available from CONTECH Construction Products.

Warning: In the case of a spill, the maintenance personnel should abort maintenance activities until the proper guidance is obtained. Notify the local hazard control agency and CONTECH Construction Products immediately.

To conduct cartridge replacement and sediment removal maintenance:

1. If applicable, set up safety equipment to protect maintenance personnel and pedestrians from site hazards.
2. Visually inspect the external condition of the unit and take notes concerning defects/problems.
3. Open the doors (access portals) to the vault and allow the system to vent.
4. Without entering the vault, give the inside of the unit, including components, a general condition inspection.
5. Make notes about the external and internal condition of the vault. Give particular attention to recording the level of sediment build-up on the floor of the vault, in the forebay, and on top of the internal components.
6. Using appropriate equipment offload the replacement cartridges (up to 150 lbs. each) and set aside.
7. Remove used cartridges from the vault using one of the following methods:

Method 1:

A. This activity will require that maintenance personnel enter the vault to remove the cartridges from the under drain manifold and place them under the vault opening for lifting (removal). Unscrew (counterclockwise rotations) each filter cartridge from the underdrain connector. Roll the loose cartridge, on edge, to a convenient spot beneath the vault access.

Using appropriate hoisting equipment, attach a cable from the boom, crane, or tripod to the loose cartridge. Contact CONTECH Construction Products for suggested attachment devices.

Important: Note that cartridges containing leaf media (CSF) do not require unscrewing from their connectors. Take care not to damage the manifold connectors. This connector should remain installed in the manifold and could be capped during the maintenance activity to prevent sediments from entering the underdrain manifold.

B. Remove the used cartridges (up to 250 lbs. each) from the vault.

Important: Care must be used to avoid damaging the cartridges during removal and installation. The cost of repairing components damaged during maintenance will be the responsibility of the owner unless CONTECH Construction Products performs the maintenance activities and damage is not related to discharges to the system.

C. Set the used cartridge aside or load onto the hauling truck.

D. Continue steps a through c until all cartridges have been removed.

Method 2:

A. Enter the vault using appropriate confined space protocols.

B. Unscrew the cartridge cap.

C. Remove the cartridge hood screws (3) hood and float.

D. At location under structure access, tip the cartridge on its side.

Important: Note that cartridges containing media other than the leaf media require unscrewing from their threaded connectors. Take care not to damage the manifold connectors. This connector should remain installed in the manifold and capped if necessary.

D. Empty the cartridge onto the vault floor. Reassemble the empty cartridge.

E. Set the empty, used cartridge aside or load onto the hauling truck.

F. Continue steps a through e until all cartridges have been removed.

8. Remove accumulated sediment from the floor of the vault and from the forebay. This can most effectively be accomplished by use of a vacuum truck.
9. Once the sediments are removed, assess the condition of the vault and the condition of the connectors. The connectors are short sections of 2-inch schedule 40 PVC, or threaded schedule 80 PVC that should protrude about 1” above the floor of the vault. Lightly wash down the vault interior.
   a. Replace any damaged connectors.
10. Using the vacuum truck boom, crane, or tripod, lower and install the new cartridges. Once again, take care not to damage connections.
11. Close and fasten the door.
12. Remove safety equipment.
13. Finally, dispose of the accumulated materials in accordance with applicable regulations. Make arrangements to return the used empty cartridges to CONTECH Construction Products.

Related Maintenance Activities -

Performed on an as-needed basis

StormFilter units are often just one of many structures in a more comprehensive stormwater drainage and treatment system.

In order for maintenance of the StormFilter to be successful, it is imperative that all other components be properly maintained. The maintenance/repair of upstream facilities should be carried out prior to StormFilter maintenance activities.

In addition to considering upstream facilities, it is also important to correct any problems identified in the drainage area. Drainage area concerns may include: erosion problems, heavy oil loading, and discharges of inappropriate materials.

Material Disposal

The accumulated sediment found in stormwater treatment and conveyance systems must be handled and disposed of in accordance with regulatory protocols. It is possible for sediments to contain measurable concentrations of heavy metals and organic chemicals (such as pesticides and petroleum products). Areas with the greatest potential for high pollutant loading include industrial areas and heavily traveled roads.

Sediments and water must be disposed of in accordance with all applicable waste disposal regulations. When scheduling maintenance, consideration must be made for the disposal of solid and liquid wastes. This typically requires coordination with a local landfill for solid waste disposal. For liquid waste disposal a number of options are available including a municipal vacuum truck decant facility, local waste water treatment plant or on-site treatment and discharge.

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www.contech-cpi.com

Support

- Drawings and specifications are available at contechstormwater.com.
- Site-specific design support is available from our engineers.

CONTECH Construction Products Inc. provides site solutions for the civil engineering industry. CONTECH's portfolio includes bridges, drainage, sanitary sewer, stormwater and earth stabilization products. For information on other CONTECH division offerings, visit contech-cpi.com or call 800.338.1122

Inspection Report

Date: ______________________ Personnel: ______________________

Location: ______________________ System Size: ______________________

System Type: Vault ☐ Cast-In-Place ☐ Linear Catch Basin ☐ Manhole ☐ Other ☐

Sediment Thickness in Forebay: ______________________ Date: ______________

Sediment Depth on Vault Floor: ______________________

Structural Damage: ______________________

Estimated Flow from Drainage Pipes (if available): ______________________

Cartridges Submerged: Yes ☐ No ☐ Depth of Standing Water: ______________________

StormFilter Maintenance Activities (check off if done and give description)

☐ Trash and Debris Removal: ______________________

☐ Minor Structural Repairs: ______________________

☐ Drainage Area Report ______________________

Excessive Oil Loading: Yes ☐ No ☐ Source: ______________________

Sediment Accumulation on Pavement: Yes ☐ No ☐ Source: ______________________

Erosion of Landscaped Areas: Yes ☐ No ☐ Source: ______________________

Items Needing Further Work: ______________________

Owners should contact the local public works department and inquire about how the department disposes of their street waste residuals.

Other Comments:

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Review the condition reports from the previous inspection visits.

StormFilter Maintenance Report

Date: ______________________ Personnel: ______________________

Location: ______________________ System Size: ______________________

System Type: Vault ☐ Cast-In-Place ☐ Linear Catch Basin ☐ Manhole ☐ Other ☐

List Safety Procedures and Equipment Used: ______________________

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System Observations

Months in Service:

Oil in Forebay: Yes ☐ No ☐

Sediment Depth in Forebay: ______________________

Sediment Depth on Vault Floor: ______________________

Structural Damage: ______________________

Drainage Area Report

Excessive Oil Loading: Yes ☐ No ☐ Source: ______________________

Sediment Accumulation on Pavement: Yes ☐ No ☐ Source: ______________________

Erosion of Landscaped Areas: Yes ☐ No ☐ Source: ______________________

StormFilter Cartridge Replacement Maintenance Activities

Remove Trash and Debris: Yes ☐ No ☐ Details: ______________________

Replace Cartridges: Yes ☐ No ☐ Details: ______________________

Sediment Removed: Yes ☐ No ☐ Details: ______________________

Quantity of Sediment Removed (estimate?):

Minor Structural Repairs: Yes ☐ No ☐ Details: ______________________

Residuals (debris, sediment) Disposal Methods: ______________________

Notes:

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