NJCAT TECHNOLOGY VERIFICATION

STORMWATER MANAGEMENT STORMFILTER®

CONTECH STORMWATER SOLUTIONS Inc.

January 2007

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1. Introduction

1.1 New Jersey Corporation for Advance technology (NJCAT) Program

NJCAT is a not-for-profit corporation to promote in New Jersey the retention and growth of technology-based businesses in emerging fields such as environmental and energy technologies. NJCAT provides innovators with the regulatory, commercial, technological and financial assistance required to bring their ideas to market successfully. Specifically, NJCAT functions to:

- Advance policy strategies and regulatory mechanisms to promote technology commercialization;
- Identify, evaluate, and recommend specific technologies for which the regulatory and commercialization process should be facilitated;
- Facilitate funding and commercial relationships/alliances to bring new technologies to market and new business to the state; and
- Assist in the identification of markets and applications for commercialized technologies.

The technology verification program specifically encourages collaboration between vendors and users of technology. Through this program, teams of academic and business professionals are formed to implement a comprehensive evaluation of vendor specific performance claims. Thus, suppliers have the competitive edge of an independent third party confirmation of claims.

Pursuant to N.J.S.A. 13:1D-134 et seq. (Energy and Environmental Technology Verification Program) the New Jersey Department of Environmental Protection (NJDEP) and NJCAT have established a Performance Partnership Agreement (PPA) whereby NJCAT performs the technology verification review and NJDEP certifies that the technology meets the regulatory intent and that there is a net beneficial environmental effect of the technology. In addition, NJDEP/NJCAT work in conjunction to develop expedited or more efficient timeframes for review and decision-making of permits or approvals associated with the verified/certified technology.

The PPA also requires that:

- The NJDEP shall enter into reciprocal environmental technology agreements concerning the evaluation and verification protocols with the United States Environmental Protection Agency, other local required or national environmental agencies, entities or groups in other states and New Jersey for the purpose of encouraging and permitting the reciprocal acceptance of technology data and information concerning the evaluation and verification of energy and environmental technologies; and

- The NJDEP shall work closely with the State Treasurer to include in State bid specifications, as deemed appropriate by the State Treasurer, any technology verified under the Energy and Environment Technology Verification Program.

1.2 Interim Certification

The Stormwater Management StormFilter® (StormFilter) is a Best Management Practice (BMP) designed to meet federal, state, and local requirements for treating stormwater runoff in compliance with the Clean Water Act. The StormFilter is typically comprised of a vault that houses rechargeable, media-filled, filter cartridges. Stormwater from storm drains is percolated through these media-filled cartridges, which trap particulates and remove pollutants such as suspended solids, metals, and nutrients. Once filtered through the media, the treated stormwater is directed to a collection pipe or discharged to an open channel drainage way. (See Section 2 for additional description of the technology.)

Originally developed in 1995, the StormFilter technology has been subject to continuous improvement, with three patents covering the siphonic design used today by the over 2,000 cartridges installed in New Jersey (as of June 2006). CONTECH® Stormwater Solutions, Inc. (CONTECH) began the process of obtaining product approval in the State of New Jersey in 2001 by seeking verification by the New Jersey Corporation for Advanced Technology (NJCAT). The initial application did not contain a performance claim, prompting extensive laboratory evaluation of an individual StormFilter cartridge configured with perlite media and operating at a design cartridge filtration rate of 15 gal/min (57 L/min). This testing yielded substantive performance claims for a material with a sandy loam texture (CONTECH, 2001), identified by the New Jersey Department of Environmental Protection (NJDEP) as the benchmark for stormwater suspended solids within their jurisdiction (NJDEP, 2006). This laboratory evaluation (21 runoff simulations at influent concentrations ranging from non-detect to 300 mg/L) was verified by NJCAT in June, 2002 and used to support a Conditional Interim Certification issued on September 20, 2002 by NJDEP (NJDEP 2002). The performance claim verified was as follows:

> "The StormFilter cartridge at 15 gallons per minute (gpm) using a coarse perlite media has been shown to have a TSS removal efficiency of 79% with 95% confidence limits of 78% and 80%, respectively for a sandy loam comprised of 55% sand, 40% silt, 5% clay (USDA) in laboratory studies using simulated storm water (Claim 1)."

A major condition of Conditional Interim Certification by the NJDEP is the execution of a field trial conducted in accordance with TARP (2003) and NJDEP (2006) to verify performance relative to the certified claims. Accordingly, a Project Plan for field verification testing was completed in accordance with the applicable protocols and accepted in June 2004, resulting in the commencement of monitoring activities. In December 2004, Conditional Interim Certification was extended based upon demonstrable project progress.

1.3 Applicant Profile

CONTECH offers a range of stormwater treatment products including filtration, hydrodynamic separation, volumetric separation, detention/retention, screening, oil/water separation, and flow control technologies. A knowledgeable team of 200 professionals across the U.S. provide the engineering and customer service support to determine a project's most appropriate stormwater treatment system that meets the requirements of the relevant permitting jurisdiction.

At CONTECH's state-of-the-art laboratories, engineers and scientists conduct ongoing research to further the understanding of non-point source pollution and develop practical product solutions. CONTECH helps its customers achieve their water quality goals by providing treatment technologies that remove a variety of pollutants from stormwater runoff. These stormwater treatment products are specifically designed to meet federal, state, and local regulations.

Former CONTECH subsidiaries Vortechnics (2004) and Stormwater Management, Inc. (2005) combined to form Stormwater360 (2006), and later became CONTECH Stormwater Solutions, Inc. a division of CONTECH Construction Products Inc. In December 2006, CDS Technologies, Inc. was added into CONTECH Stormwater Solutions product offerings.

CONTECH Stormwater Solutions has four primary regional offices that service their customers.

Ohio (Headquarters)
9025 Centre Pointe Drive, Suite 400
West Chester, OH 45069
800-395-0608

Maryland
521 Progress Drive, Suite H
Lithicum, MD 21090
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Maine
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Scarborough, ME 04074
877-907-8676

Oregon
12021-B NE Airport Way
Portland, OR 97220
800-548-4667

California
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Morgan Hill, CA 95037
800-469-7162

The managers of CONTECH Stormwater Solutions, Inc. are Rick Stepien – President, James Lenhart – Chief Technical Officer, and Tom Slabe – Vice President of Marketing.

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2. The Stormwater Management StormFilter®

In 1990 Congress established deadlines and priorities for EPA to require permits for discharges of storm water that is not mixed or contaminated with household or industrial wastewater. Phase I regulations established that a NPDES (National Pollutant Discharge Elimination System) permit is required for storm water discharge from municipalities with a separate storm sewer system that serves a population greater than 100,000 and certain defined industrial activities. To receive a NPDES permit, the municipality or specific industry has to develop a storm water management plan and identify BMPs for storm water treatment and discharge. Best Management Practices are measures, systems, processes or controls that reduce pollutants at the source to prevent the pollution of storm water runoff discharge from the site. Phase II storm water discharges include all discharges composed entirely of storm water, except those specifically classified as Phase I discharge. Phase II regulations are currently in draft form for review.

CONTECH has developed an innovative storm water treatment system, the StormFilter to meet the requirements of the NPDES. The StormFilter is a passive, flow through, storm water filtration system, improving the quality of storm water runoff by removing non point source pollutants, including total suspended solids (TSS), oil and grease, soluble metals, nutrients, organics, and trash and debris. It has been installed to treat storm water runoff from a wide variety of sites including retail and commercial developments, residential streets, urban roadways, freeways and industrial sites such as shipyards, foundries, etc.

The StormFilter is typically comprised of a vault that houses rechargeable, media-filled filter cartridges. A typical StormFilter configuration is shown in Figure 1. Storm water from storm drains is percolated through media-filled cartridges, which removes particulates and adsorbs materials such as dissolved metals and hydrocarbons. Surface scum, floating oil and grease are also removed. After passing through the filter media, the storm water flows into a collection pipe or discharges to an open channel drainage way. Inherent in the design of the StormFilter is the ability to control the individual cartridge flow rate with an orifice disk placed at the base of the cartridge. The maximum flow rate through each cartridge can be adjusted to between 5 and 15 gpm.

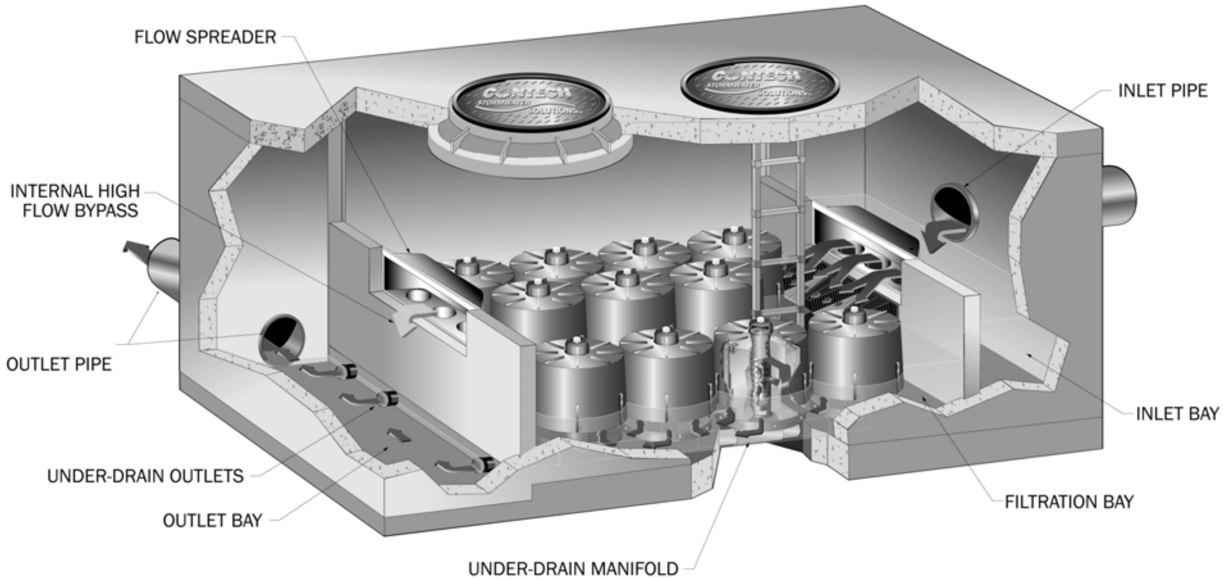

Figure 1 The Precast StormFilter

The StormFilter is sized to treat the peak flow of a design storm as it passes through the system. The peak flow is determined by calculations based on the contributing watershed hydrology and using a design storm magnitude. The design storm is usually based on the requirements set by the local regulatory agency. The particular size of a StormFilter is determined by the number of filter cartridges required to treat the peak water flow.

The StormFilter is offered in multiple configurations: precast, high flow, catch basin, curb inlet, linear, volume, and corrugated metal pipe form. All configurations use pre-manufactured units to ease the design and installation process.

(1) Precast System

Vaults and manholes are used to treat end-of-pipe flow from small and medium sized sites. These units typically arrive on site fully assembled. The contractor places the unit, lid and risers, and then connects the inlet and outlet. Cartridges arrive installed inside the unit. Until construction is completed, stormwater is diverted around the filtration bay through the construction bypass lines. When the site is stabilized plugs are placed in the construction bypass lines and the filtration unit is "on-line".

(2) High Flow

Structures consist of large precast components which are designed for easy assembly on site and treat end of pipe flow from large sites. For very large sites this configuration can be cast-in-place. Similar to the Precast System, cartridges are installed when the vault is completed and construction by-pass is used during construction. If the system is too big to accommodate construction by-pass the cartridges are not installed until the site is stabilized.

(3) Catch Basin – Provides a low cost, low drop, point-of-entry configuration that treats sheet flow from small sites or drainages. This configuration uses the drop from the inlet grate to the conveyance pipe to drive the StormFilter cartridges. Cartridges arrive installed and the unit is put "on-line" by removing a 4" drain plug when construction is completed.

(4) Curb-Inlet – Provides a low drop, point of entry configuration that allows curb inlet openings three to ten feet long. Uses the drop from the curb inlet to the conveyance pipe to drive the StormFilter cartridges. The cartridges arrive installed and the transfer opening from the inlet to the filtration bay is blocked. When construction is complete the transfer opening is un-blocked and the system is "on-line".

(5) Volume – Meets volume-based stormwater treatment regulations by capturing and treating site-specific Water Quality Volume (WQ_v). StormFilter cartridges provide treatment of the WQ_v and the structure can be sized to capture all, or a portion, of the WQ_v. Installation of the Volume StormFilter is similar to the Precast and High Flow systems, depending on the size.

(6) DryWell – Manhole based drywells (also called injection wells and underground injection control - UICs) contain StormFilter cartridges to treat stormwater in the upper portion before it is released into the perforated lower section for infiltration. This configuration can be employed for new construction or to retrofit existing drywells. For new construction, a solid concrete manhole unit containing pre-installed cartridges is placed on perforated rise sections. The retrofit unit is comprised of aluminum decking that can fit through a 24" man-way and assembled in an existing drywell. The cartridges are installed on top of the deck. Any perforations above the deck are filled with grout.

In addition to the most common configurations, the StormFilter can be provided in Linear, DownSpout, and Corrugated Metal Pipe (CMP) configurations.

The typical precast StormFilter unit is composed of three bays: the inlet bay, the filtration bay, and the outlet bay. Storm water first enters the inlet bay of the StormFilter vault. Storm water is then directed through the flow spreader, which traps floatables, oils, and surface scum, and over the energy dissipater into the filtration bay. Once in the filtration bay, the storm water begins to pond and percolates horizontally through the media contained in the cartridges. After passing through the media, the treated water in each cartridge collects in the cartridge's center tube from where it is directed into the outlet bay by an under-drain manifold. The treated water in the outlet bay is then discharged through the single outlet pipe to a collection pipe or an open channel drainage way.

Depending on site characteristics, some systems are equipped with high and/or low flow bypasses. High flow bypasses are installed when the calculated peak storm event generates a flow that overcomes the overflow capacity or design capacity of the system. Base flow bypasses are sometimes installed to prevent continuous inflows caused by groundwater seepage, which usually does not require treatment.

The StormFilter cartridge is the central treatment device within the system. The cartridges are filled with various media depending on the site's runoff. Removal associated with the cartridge is promoted through four mechanisms: physical straining, ion exchange, adsorption, and precipitation.

Physical straining through the media promotes solids removal by trapping solids within interstitial spaces throughout the filtration media. Depending on the media used, dissolved pollutant removal is either associated with ion exchange, adsorption or precipitation reactions.

Ion exchange involves the displacement of ions within the filtration media by ions in the influent stream. The process used by the StormFilter is cation exchange where calcium, magnesium and sodium ions within the filtration media are displaced by ions such as copper, zinc and lead.

Adsorption is a surface reaction where a pollutant is fixed to the filtration media as the pollutant crosses the media's surface. These reactions are usually promoted by polar interactions between the media and the pollutant. In other words, the media may be slightly negative where the pollutant is slightly positive. The interaction is similar to a magnet and occurs primarily at the media's surface.

Precipitation reactions also occur within the filtration media's structure. This involves the exchange, or sharing, of electrons between atoms and molecules to form a solid on the media's surface. In a sense, salts are formed on the media due to the electron interaction.

3. Technology System Evaluation: Project Plan

3.1 Introduction

As part of a performance assessment of the Stormwater Management StormFilter® (StormFilter) in the State of New Jersey, a system using perlite media, installed at Greenville Yards, Jersey City, NJ, was evaluated. This StormFilter system treats stormwater runoff draining from a parking lot and commercial loading dock area. For research purposes, the removal characteristics of the system with respect to solids, metals, and nutrients was simultaneously assessed.

This project was managed by CONTECH Stormwater Solutions Inc. (CONTECH) in cooperation with the site owner and the New Jersey Department of Environmental Protection (NJDEP). Independent oversight of all aspects of the project was provided by Dr. Qizhong Guo of Rutgers University. Sample handling services were provided by Sovereign Consulting Inc. of Parsippany, NJ, and analytical work was conducted by Chemtech of Mountainside, NJ, and North Creek Analytical of Beaverton, OR.

3.2 Site and System Description

Drainage Area

Greenville Yards is a commercial warehouse complex consisting of warehouse space and associated offices, roadways, and cargo docks located at 19 Colony Rd., Jersey City, NJ (Lat: 40.6825532, Long: -74.087318). The entire complex covers a 50-ac brownfield redevelopment site in Jersey City, NJ adjacent to NY harbor. An aerial photo of the portion of the complex used for the study is shown in Figure 2. Stormwater from this complex is generated by over 10-ac of pavement (roof runoff remains untreated) and ultimately drains to the New York harbor. As a regional boat, rail, and truck shipping hub, this complex sees constant activity and receives constant traffic.

The StormFilter System

Stormwater treatment for Greenville Yards is provided by 10 Vault and Catch Basin StormFilters installed during redevelopment. These installations were allowed by NJDEP under the Conditional Interim Certification of the StormFilter due to the need to install a system for local performance evaluation. Each system is designed in an off-line configuration with respect to the stormwater conveyance system. Each StormFilter system operates independently, and the StormFilter used for monitoring will be referred to as StormFilter #6 (SF#6)

SF#6 is installed along the SW edge of the property as indicated in Figure 2. The vault was set below grade and was integrated into the landscaping along the property boundary as shown in Figure 3. SF#6 consists of an 8-ft x 18-ft precast StormFilter vault designed for 27 perlite-media cartridges and configured for a per-cartridge filtration rate of 15 gal/min (57 L/min). The system is designed with a StormGate high flow bypass located upstream of the StormFilter to divert flows larger than the design flow and prevent internal bypass of the StormFilter. As configured, this system is designed to treat a water quality flow rate (treatment flow rate) of 0.90 cfs based upon the 2001 NJDEP 1.25-in/2-hr design storm (the then existing regulation) and 2.00 acres of impermeable surfaces with a composite runoff coefficient of 0.72.

Figure 2. Aerial view of the portion of Greenville Yards being studied. Drainage area is outlined.

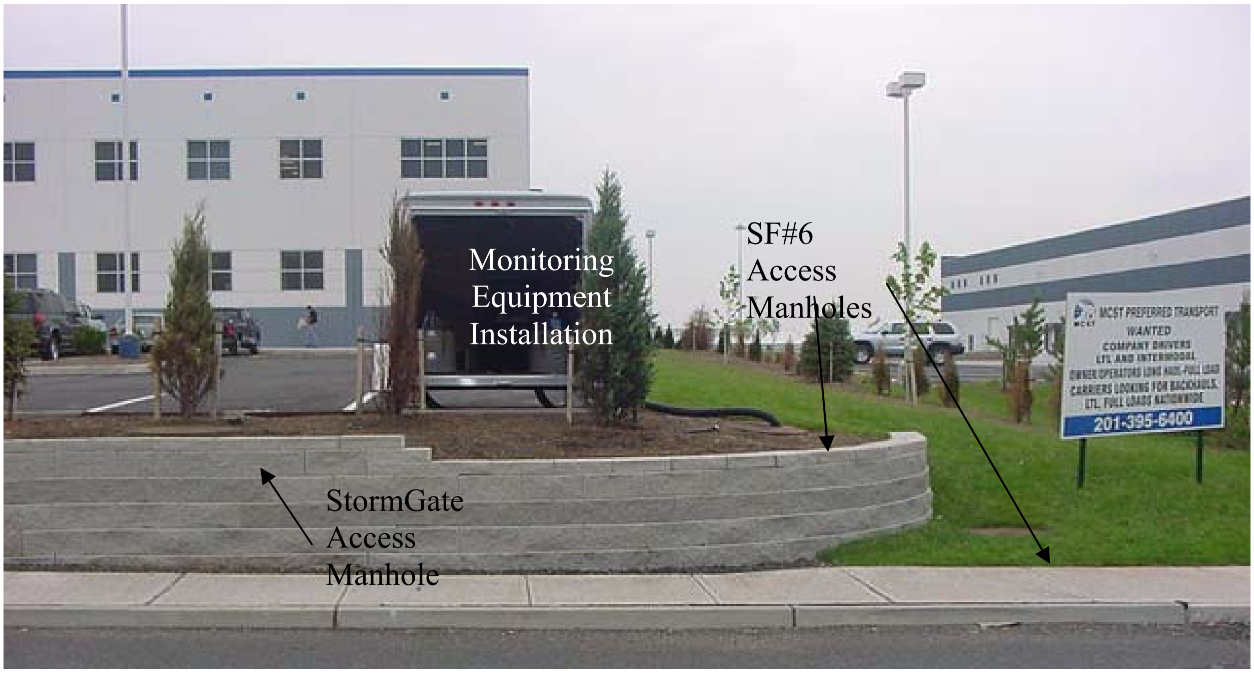

Figure 3. Greenville Yards StormFilter #6 (SF#6).

3.3 Sampling Methods

The equipment and sampling techniques used for this study are in accordance with a Project Plan (CONTECH, 2004a) developed by CONTECH in consultation with NJDEP and NJCAT under the TARP Tier II Stormwater Protocol and the New Jersey Tier II requirements (TARP, 2003; NJDEP, 2006). CONTECH personnel were responsible for the installation, operation, and maintenance of the sampling equipment. Sovereign Consulting, Inc. was utilized for sample retrieval, system reset, and sample submittal activities. Water sample processing and analysis was performed by Chemtech and solids sample analysis was performed by North Creek Analytical. A general overview of the methodology is provided.

Sampling Equipment Specifications and Installation

A mobile monitoring unit (MMU) was provided, installed, maintained, and operated by CONTECH for sampling purposes. The MMU is a towable, fully enclosed, self-contained stormwater monitoring system specially designed and built by CONTECH for remote, extended-deployment stormwater monitoring. The design allows for remote control of sampling equipment, eliminates confined space entry requirements, and streamlines the sample pickup and data collection process. The MMU is shown in Figure 3 as it was installed on-site for the entirety of the study.

Influent and effluent samples were collected using individual ISCO 6712 Portable Automated Samplers configured for standard, individual, round, wide-mouth sample bottles with HDPE bottles in the 1 through 10 position for discrete sample collection and amber glass bottles in the 11 and 12 positions for field composite sample collection. The samplers were connected to individual 12V DC, deep cycle power supplies recharged by a solar panel. Each sampler had individual ISCO 750 Area Velocity Flow Modules with Low Profile Area Velocity Flow Sensors for the purpose of sample pacing and flow analysis. Each sampler also had an ISCO SPA 1489 Digital Cell Phone Modem System to allow for remote communication and data access.

The sample intake from each automated sampler pump was connected to a stainless steel sample strainer (9/16" diameter, 6" length, with multiple ¼" openings) via a length of 3/8" ID Acutech Duality FEP/LDPE tubing. Sample strainers and flow probes were mounted to the invert of the influent/effluent pipes using low profile stainless steel spring rings. Sampling lines between the MMU and the sample points were armored and carefully installed to minimize the risk of sample line contamination through the avoidance of dips and to maximize suction line velocity (>2 ft/s) by avoiding extraneous line length, excessive bends, and kinks.

Bypass hydraulics were analyzed at 1 to 5-min intervals using both an ISCO 4110 Ultrasonic Level Logger and the flow depth measurement provided by the influent flow module. Internal overflow conditions were monitored using an Overflow Detection System (ODS) consisting of a float switch oriented to "CLOSE" at the crest of the downstream weir wall and state logger. Rainfall was analyzed with a 0.01-in resolution with a Texas Electronics TR-4 tipping bucket-type rain gauge.

Sampling Equipment Operation

Flow, level, and precipitation measurement equipment collected continuous data. Samplers were programmed to enable the sampling program after a minimum flow rate condition of >5 gpm was met. Once enabled, the equipment collected samples on a volume-paced basis allowing the specified pacing volume to pass before taking a sample.

Sample Collection Program

The sample collection program input into each automated sampler was a two-part program developed to: 1) maximize the number of discrete samples (aliquots); 2) maximize the coverage of the precipitation event while at the same time maximizing aliquot volume; and 3) allow the collection of field composite samples for hydrocarbon analysis. Influent and effluent sample collection programs were configured to capture a composite sample consisting of 450-mL aliquots spread between up to 10, 1-L HDPE bottles (discrete composite), and two individual, 1-L composite samples consisting of 50-mL aliquots collected within amber glass bottles (in-situ composite).

Due to the variability among precipitation events and stormwater conveyance systems, the sample pacing and sample initiation specifications were variable on a continuous basis and determined in consultation with the most up-to-date precipitation forecasts.

Sample Retrieval and Analysis

Upon collection of samples following a precipitation event, CONTECH personnel remotely communicated with the automated sampling equipment to confirm sample collection and dispatch personnel from Sovereign to retrieve the samples and reset the automated sampling equipment. Samples were delivered to the Analytical Laboratory by Sovereign using cold transport and accompanied by chain-of-custody documentation.

At the direction of CONTECH personnel, discrete composite sample bottles were combined by the Analytical Laboratory to create bulk influent and effluent composite samples through identification of those bottles best representing the precipitation event based upon the hydrograph. Subsamples of the bulk influent and effluent composite samples to be used for analysis were created using an 8-L or 14-L (depending on number of samples), polyethylene Scienceware Churn Sample Splitter (churn splitter). Analytical methods used for this study are provided in Table 1.

Table 1. Analytical methods for analytical parameters of interest.

Parameter	Analytical Method	Water	Solids
Total Solids	EPA 160.3 (modified)		X
Susp. Sediment Conc. (SSC)	ASTM D3977	X	
Tot. Susp. Solids (TSS)	EPA 160.2	X	
Tot. Vol. Susp. Solids (TVSS)	SM2540E	X	
SSC <500-um	500-um Filtration + ASTM D3977	X	
TVSS <500-um	500-um Filtration + SM2540E	X	
Total Cadmium	EPA 200.8	X	X
Total Copper	EPA 200.8	X	X
Total Zinc	EPA 200.8	X	X
Total Lead	EPA 200.8	X	X
Total Phosphorus	EPA 365.1	X	X
Nitrate/Nitrite-N	EPA 353.2	X	
Total Kjeldahl-N	EPA 351.2	X	X
Hardness	SM 2340B	X	
Oil and Grease	EPA 413.1	X	X
TPH (with cleanup)	EPA 8015/3630	X	
Particle Size Distribution	CONTECH PE-SP18		X
Percent Solids	NCA SOP		X

Quality Control

As per the Project Plan, the following quality control samples were used to assess the quality of both field sampling and analytical activities: equipment rinsate blanks, equipment field blanks, method blank, and duplicate analysis. Sample processing blank samples were not taken. Except for solids analyses that employ the use of whole sample volume (SSC), all method blanks and duplicate analyses were handled by the analytical laboratory as per New Jersey certification requirements. Since solids analyses that employ the use of whole sample volume (SSC) consume the entire sample volume, dedicated duplicate samples were prepared (replicates) and analyzed to allow the assessment of analytical accuracy. Analytical duplicate analysis results (Dup. RPD) for all results are provided alongside the presentation of raw data in Appendix A. The results of equipment rinsate blanks, equipment blanks, and sample processing blanks are shown in Table 2 accompanied by associated decisions and action items for instances of detection.

Table 2. Instances of contaminant detection in equipment rinsate blank and equipment field blank samples. Shaded Blank Types indicate the use of distilled water of a known quality as opposed to deionized water.

Date	Blank Type	Detections	Level (mg/L)	Action	% of Sample Pairs Affected
5/4/04	Rinsate	Total Cd	0.00458	None since subsequent stormwater samples returned ND at a lower level	0
3/22/05	Field	Total Cu	0.0040	Disqualify Total Cu results ≤0.02 mg/L for events since last QC Blank	17
4/29/05	Rinsate	Total Zn	0.0075	Disqualify Total Zn results ≤ 0.0375 mg/L for events up to next QC Blank	0
10/17/05	Field	Total Cd Total Zn	0.00058 0.0148	Disqualify Total Zn results ≤0.0740 mg/L for events since last QC Blank; no action for Total Cd since subsequent stormwater samples returned ND at a lower level	0 (Cd) 0 (Zn)
2/28/06	Field	Total Pb Total Zn	0.0035 0.0247	Disqualify Total Zn results ≤0.1235 mg/L for events since last QC Blank; Disqualify Total Pb results ≤0.0175 mg/L for events since last QC Blank	50 (Pb) 38 (Zn)

3.4 Particle Size Distribution and Residual Solids Assessment Methods

The quantity and quality of the solids captured by the system were assessed in preparation for the two system maintenances that occurred during the project as well as at the end of the monitoring phase of the project (Shown in Appendix D). This procedure involved the following activities: 1) the removal of the StormFilter cartridges and selection of a cartridge for solids content and media analysis (filtered material); 2) the careful estimation of the residual solids found inside of the system and outside of the cartridges (settled material); and 3) the methodical collection of a large (20-L to 30-L), composite sample of the residual solids for analysis.

The StormFilter cartridge selected for the assessment was analyzed using direct methods as much as possible. The cartridge was first allowed to drip-dry, and the media was then emptied into shallow, tared trays for compositing and drying. Upon the stabilization of the moisture content of the media, the trays were weighed and representative samples were collected for analysis according to Table 1. This data was then used to represent the dry mass of contaminants contained within all of the cartridges. A measurement of dry bulk-density of the used media was also collected and compared to the typical dry bulk density of unused media to determine the dry mass of solids retained by the filters.

The composite sample of the residual solids was homogenized by hand and representatively sampled for analysis. Samples were submitted for the analytes shown in Table 1. Data for this material was used in conjunction with the volume of residual solids removed from the system in order to determine the dry mass of contaminants contained within the residual solids.

Calculations

Most of the data collected during the study were based upon direct measurement. Some reported values, such as event coverage and the percentage of runoff treated are based upon calculated values. Coverage was calculated by multiplying the number of sample aliquots representing the influent or effluent of a storm event by the volume used to pace the sample collection program and expressing this value as a percentage of the total influent or effluent volume recorded by the flow meter. Percentage of runoff treated was calculated by solving the weir-flow equation for the StormGate using the bypass flow depth measurements and expressing the treated volume (StormFilter influent volume) as a percentage of the total volume (treated and bypassed).

3.5 Data Verification and Validation

Data corresponding to the 16 storm events (a total of 17.13 inches of rainfall) covered by this report were captured over an eighteen-month monitoring period between July of 2004 and December of 2005. Of these 16 storm events, data verification and validation did not lead to the outright disqualification of any events due to obvious monitoring, handling, or analytical errors, or the substantial exceedance of the design operating parameters. Thus all 16 storm events were deemed acceptable for qualification through reconciliation with the data quality objectives (DQOs) of the project. However, some instances were encountered that suggested the disqualification or separation of select analytical results from the data set.

Some monitoring error was encountered in the form of equipment contamination as discussed in the Quality Control section. This suggests the disqualification of a portion of the total metals data according to Table 2. Disqualification of either an influent or effluent result resulted in the elimination of the paired data from the final data set.

Some data were also deemed to be very unusual and thus atypical with respect to the majority of the data. This was observed for Total Phosphorus results. Event GYS071204 demonstrated influent and effluent Total Phosphorus EMCs that were almost an order of magnitude larger than those of other events, and thus also atypical of the majority of the data. The Total Phosphorus data in question from this event is deemed to be an outlier and thus separated from the data set used for performance summarization.

The DQOs presented in the Project Plan and used throughout the project were based directly upon NJDEP (2006) and the NJDEP interpretation of TARP (2003), and are provided in Table 3. All but two of the events qualified according to strict interpretation of all of the DQOs. Considering the very small margin separating these two events from full qualification, they were deemed qualified based upon the best professional judgment of the project team.

4. Technology System Performance

4.1 Performance Measured Relative to Interim Certified Performance Claim

Since many methods for summarizing performance exist, and since performance summarization is a critical part of this study, a detailed discussion of the methods employed to summarize system performance for this study is warranted.

Analytes with a statistically significant relationship between influent and effluent event mean concentrations (EMCs) ($\alpha<0.05$: >95% probability of true relationship) were determined according to the parametric Regression of EMC method; analytes that did not yield a statistically significant ($\alpha<0.05$) relationship between influent and effluent EMCs were determined as "aggregate pollutant loading reduction" (WADOE, 2002 method #2), using the influent flow data to determine runoff volume, and accompanied by a nonparametric test of significance.

Table 3. Results of reconciliation of the storm events observed as part of the Greenville Yards StormFilter Field Evaluation Project

Event ID	Data Quality Objectives (DQOs)					Other Event Characteristics							
	Event Depth (in) [minimum 0.10]	Antecedent Dry Period (hr) [minimum 6-hrs <0.04-in]	Number of Aliquots [minimum of 6 (Inf:Eff)]	Avg. SF Vol. Coverage (nearest 10%) [minimum of 60 (Inf:Eff)]	Qualification based upon Best Professional Judgement	SF Influent Volume (gal)	Percent Treated (nearest 10%) [versus total]	Peak Operating Rate (%) [% of effluent design Q]	Average Intensity (in/hr)	Influent SSC EMC (mg/L)	Effluent SSC EMC (mg/L)	Influent TSS EMC (mg/L)	Effluent TSS EMC (mg/L)
GYS071204	0.13	144	9:12	>90	✓	3678	100	49	0.17	182	19	150	21
GYS071404	0.98	48	7:5	90	✓	13382	40	65	0.49	58	13	70	10
GYS081104	0.46	240	18:20	90	✓	11566	80	31	0.14	280	26	240	28
GYS081404	0.72	24	18:16	60	✓	25208	100	41	0.14	82	9	85	15
GYS083104	0.19	264	5:6	70	✓	7186	100	37	0.10	462	91	420	100
GYS090804	0.39	24	16:13	>90	✓	11692	80	33	0.20	19	9	19	14
GYS091704	2.40	48	9:12	90	✓	12295	20	50	0.80	96	13	100	18
GYS120904	0.72	24	6:8	60	✓	18848	>90	10	0.10	23	5	23	4
GYS043005	0.79	72	12:6	>90	✓	25546	100	44	0.10	11	5	8	4
GYS060605	0.62	72	8:17	>90	✓	9965	90	40	0.23	77	27	62	21
GYS102205	1.73	207	20:10	80	✓	31270	80	100	0.27	54	7	58	14
GYS102405	2.44	24	14:22	>90	✓	44620	100	53	0.17	12	5	12	4
GYS110905	0.68	336	12:11	80	✓	14244	>90	60	0.23	96	23	93	22
GYS112905	2.06	120	20:7	90	✓	52334	60	88	0.34	42	5	31	4
GYS121505	1.83	96	20:18	60	✓	72585	80	44	0.17	29	13	28	14
GYS122505	0.99	222	16:13	>90	✓	37137	>90	56	0.12	20	5	19	4
Sum	17.13	---	---	---	16	391556	---	---	---	---	---	---	---
Median	0.76	84	13:12	90	---	16546	>90	47	0.17	56	11	60	14

shading = DQO met
inversion = analytical MRL substituted for ND value

Appendix A details system performance on an individual storm basis (discrete removal efficiency) using the Washington State Department of Ecology "individual storm reduction in pollutant concentration" method (WADOE, 2002 method #1)—the performance of the system over the course of a single storm event based upon EMC. It is important to note that it is generally accepted that discrete removal efficiencies should not be used for performance summarization by arithmetic averaging, as these efficiencies have been shown to be both sensitive to analytical error and susceptible to negative bias (USEPA, 2002). Hydrograph and rainfall data from the events are also shown in Appendix A.

Both parametric (Regression of EMC) and non-parametric (Aggregate Load Reduction) performance statistics for the performance of the Greenville Yards StormFilter are provided in Table 4. Results of parametric testing shown in Appendix B and Table 4 indicate significant ($\alpha<0.05$) removal of SSC, TVSS, SSC<500-um, TVSS<500-um, and TSS.

Table 4. Summarized performance for Greenville Yards StormFilter. Refer to Table 1 for acronym definitions

				Regression of EMC				Aggregate Load Reduction	
Analyte	*n*	Range of Influent EMCs (mg/L)	Median Influent EMC (mg/L)	Mean Removal Efficiency Estimate (%)	95% Confidence Interval for the Mean Removal Efficiency Estimate (%)	Median Effluent EMC Estimate (mg/L)	95% Confidence Interval for the Median Effluent EMC Estimate (mg/L)	Mean Removal Efficiency Estimate (%)	One-Tailed Sign Test* (H0=H1=0.5)
SSC	16	11.0 to 462	56.0	84***	80 to 88	10.7	5.60 to 15.9	80	R
TVSS	10	10.0 to 420	31.0	93**	89 to 96	9.20	4.19 to 14.2	78	R
SSC<500-um	13	6.00 to 170	26.0	89***	84 to 94	9.55	6.76 to 12.3	68	R
TVSS<500-um	7	12.0 to 130	29.0	---	--- to ---	---	--- to ---	76	R
TSS	16	8.00 to 420	60.0	80***	76 to 84	12.8	8.05 to 17.6	77	R

*** = P < 0.001
** = 0.01 > P > 0.001
* = 0.05 > P > 0.01
bold = equivalent to non-detect
--- = undeterminable due to insufficient data quantity
R = removal is significant at the 5% level or less
~ = no significant difference
A = addition is significant at the 5% level or less

In order to summarize the performance of the system with regard to effluent water quality, median influent EMC values for analytes with statistically significant (P<0.05) Regression of EMC analyses were used with their respective regression equations to estimate median effluent water quality. Results are shown in Table 4. This approach is similar to the Effluent Probability Method recommended by EPA (2002) in that it focuses on median water quality as a measure of performance. The use of the median is most appropriate for stormwater quality data since it is largely influence by climactic events that occur with unequal frequency (not normally distributed). Estimated rather than empirical median values were used in order to provide the statistics necessary for confidence intervals.

Influent Suspended Solids Characteristics

Since suspended solids is the most popular analyte for stormwater BMP performance evaluation and comparison, the influent suspended solids data was analyzed in order to characterize the suspended solids associated with the study. As shown in Figure 4, regression analysis of different influent suspended solids analytes revealed consistent relationships. Comparison of total to volatile suspended solids concentrations reveals that approximately 45% of influent solids are composed of combustible materials that are assumed to be organic in nature. Comparison of influent SSC and SSC<500-um indicates that roughly 80% of the solids captured within the influent samples are less than 500-um in size by mass.

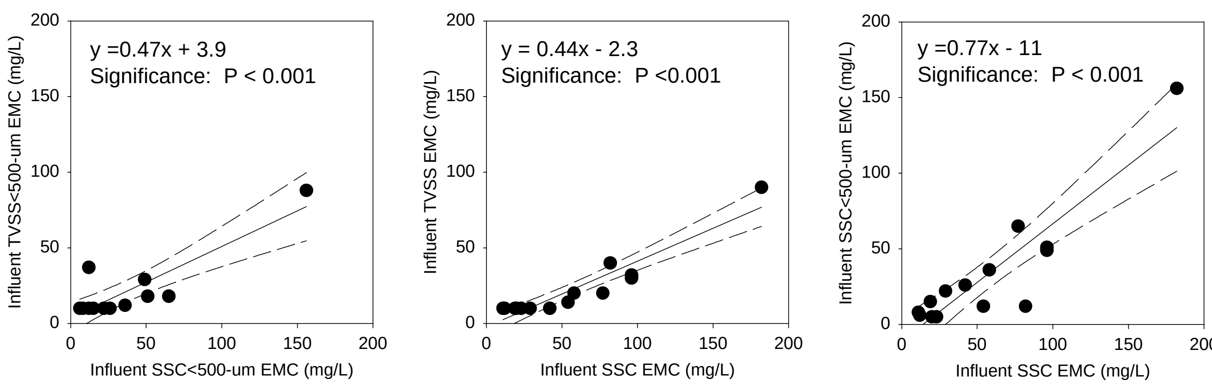

Figure 4. Significant influent relationships between solid analytes for Greenville Yards site. Refer to Table 1 for acronym definitions. Grouped solid and dashed lines illustrate linear regression and 95% confidence intervals.

These analyses do not include solids data for events GYS081104 and GYS083104. These events demonstrated the two highest influent solids EMCs, of which >80% was volatile compared to the 45% volatile content reflected by the majority of the data. Due to both the extreme solids concentrations and the extreme volatile content demonstrated by these two samples, they were deemed to be outliers and thus separated from the data set used to characterize influent solids characteristics.

Assessment of the mass of materials captured by the StormFilter as a whole over the course of the monitoring period revealed a net capture and retention of 2750 lbs (1248 kg) of material. 11% of this material was found inside of the cartridges and 89% was found outside of the cartridges in the inlet bay and on the floor of the cartridge bay.

4.2 Suspended Solids Representativeness

Two methods were employed to satisfy the amended site selection requirements of the TARP Tier II Protocol and the New Jersey Tier II requirements: 1) The Reconstructed Influent PSD Analysis Method (RIPSD); and 2) The Coulter Counter PSD Analysis Method. The following is a brief overview of each of the methods.

Reconstructed Influent PSD Analysis Method

The RIPSD represents the average influent PSD over the course of an operating cycle (CONTECH, 2005). The average influent PSD is determined by a mass weighted PSD based on material that settled in the inlet and cartridge bays, material that was captured by the filter cartridge and the system SSC removal performance as observed through intensive monitoring.

The RIPSD approach to determining the average influent PSD incorporates mass balance theory and PSDs associated with the different components of the mass balance. Influent solids are distributed among settled solids in the vault, solids retained by the filter cartridges, and solids leaving the system via effluent. The characteristics of the solids retained by the filter cartridges, the settled solids mass and the PSD corresponding to the settled solids are discerned from the analysis of a used filter cartridge and samples of material that settled in the inlet and cartridge bays which were collected during system maintenance. The dry solids mass of the used cartridge media was compared to the dry mass of a fresh cartridge media to estimate the mass of solids captured by each filter cartridge. The settled dry solids mass was determined using measurements of settled material bulk density and moisture content, depth of settled material in the system, and area available for settling. The PSDs of the settled material were determined using the hydrometer and sieve wet method particle size analysis. Based on laboratory testing observations, the PSD of solids captured by the perlite filter cartridge were estimated to be within the silt range and the PSD of solids contained in the effluent were estimated to span the clay and lower silt ranges (CONTECH, 2004b). The mass associated with the effluent solids was calculated through application of the observed removal efficiency, as determined by the sum of settled solids and solids retained by the cartridges.

Coulter Counter PSD Analysis Method

The Coulter Counter PSD analysis method consists of using a device called a coulter counter which is considered a true particle counter. A solution containing an electrolyte is passed through an aperture which is bridged by an electrical current. As the particle travels through the aperture, a voltage spike occurs which is proportional to the particle volume.

Influent and effluent composite samples from storm events occurring on 10/22/2005, 10/24/2005, 12/15/2005, and 12/25/2005 were submitted for analysis to Robert Pitt, P.E. DEE, Ph.D at The University of Alabama College of Engineering. The samples were shipped from Chemtech, the certified Analytical Lab who prepared and analyzed the entire captured storm event samples associated with the Greenville Yards Industrial Park Stormwater Management StormFilter Field Evaluation, to the University of Alabama to be analyzed using the Coulter Counter Method. The samples were analyzed for particle size distributions over the overall range from about 0.45 µm to >1500 µm. The different size range subcategories for particulates that were examined were >1500 µm, 0.6 µm to 240 µm and about 240 µm to 1500 µm. The smallest particulate solids range was analyzed using the Coulter Counter, Multi-Sizer III using three different aperture tubes (30 µm aperture tube for particles between 0.6 µm and 18 µm; 100 µm aperture tube for particles between 2 and 60 µm; and 400 µm tube for particles between 8 and 240 µm). Each of the aperture tubes used in the Coulter Counter examined several hundred discrete particle size ranges. The results from each tube were integrated using Coulter software to produce an overall particle size distribution between about 0.6 and 240 µm. This Coulter Counter information was then integrated with the data from the other subcategories to produce the overall particle size distribution.

The samples were split into two equal portions using a USGS/Dekaport cone splitter. Before splitting the samples, the samples were screened using a 1,500 µm mesh screen to remove any large debris that could clog the splitter and would not be well split in the device. The material captured on the screen was washed off, dried and weighed to determine the weight fraction of this largest material. One of the split samples was used for the Coulter Counter analyses and for particulate solids. The other split sample was used to determine the particulate solids captured on a 250 µm sieve. The amount of material captured on the sieves and filters was determined by drying and weighing the sieves and filters before and after filtering, and determining the weight gain. The actual amount of sample used for these measurements was determined after filtering by measuring the filtrate water volume with a graduated cylinder. The volumes were not measured before the filtering to preserve sample integrity.

Results

The results of the RIPSD analysis for three operating cycles (Samples were taken 1/26/05, 7/26/05, and 2/28/06) revealed an average d_{50} of 97 µm. The average particle size distribution was comprised of 59% sand, 34% silt, and 7% clay. This is very close to the 55%, 40% and 5% distribution corresponding to the performance claim and the NJDEP benchmark. The PSD of all three samples provided an indication of a fairly consistent distribution. As per the USDA textural triangle, all three samples analyzed along with the target PSD specified by NJDEP are classified as a sandy loam.

The results of the Coulter Counter influent PSD analysis revealed an average d_{50} of 13 µm. The average particle size distribution was comprised of 15% sand, 68% silt, and 18% clay. The PSD of all four samples provided an indication of a fairly inconsistent distribution. As per the USDA textural triangle three of the samples analyzed were classified as a silt loam and one as clay loam.

The results of the Coulter Counter effluent PSD analysis revealed an average d_{50} of 24 µm. The average particle size distribution was comprised of 22% sand, 67% silt, and 11% clay. The PSD of all four samples provided an indication of a fairly inconsistent distribution. As per the USDA textural triangle three of the samples analyzed were classified as a silt loam and one as a loam.

Discussion

The RIPSD analysis method is considered a less precise method that yields conservative results skewed more towards a coarser particle size distribution. Samples taken represent an entire operating cycle as opposed to an individual storm event. The Coulter Counter analysis method is considered a more precise method that yields results skewed more towards a finer particle size distribution. The samples taken represent an individual storm event and are less representative of an entire operating cycle, unless samples are from a statistically significant number of storm events during an operating cycle.

The more permanent feature of soil texture is the most suitable qualitative reference which must be relied upon to reach a conclusion. The specified target PSD (NJDEP) is classified as a sandy loam. The more conservative of the two approaches taken, the RIPSD, achieved a result that was also classified as a sandy loam. Both the influent and effluent samples analyzed using the Coulter Counter PSD Analysis Method produced results classifying the samples collected as a silt loam, a much finer texture than the specified target PSD. By employing both PSD analysis methods, a range in which the influent PSD would most likely be located can be defined as seen in Figure 5. With a lack of statistically significant data and standard methodology, the most robust and fundamental descriptor, texture, should be employed. The dynamic characteristics of soil such as organic matter content, soil structure, and water and nutrient holding capacity are known to have strong relationships to texture (USDA-NRCS, 2005). That being said, texture demonstrates that the amended site selection requirements as noted by NJDEP (2006) have been satisfied on the most fundamental level as seen in Figure 5.

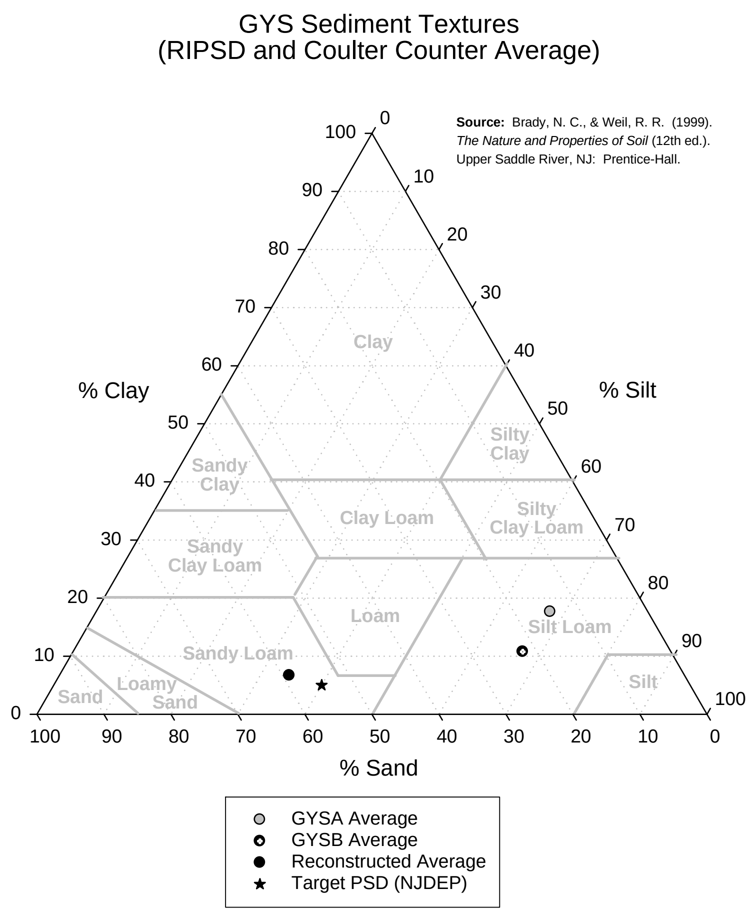

Figure 5. Average and Target PSD analyses within USDA Textural Triangle.

4.3 System Hydraulics

The StormFilter was designed to treat a water quality flow rate of 405 gpm. The peak water quality flow rates of 12 of 16 storm events were at or below the design flow rate. Table 5 shows significant bypass occurred during four intense storm events. Field flow measurements contain a margin of error of +/- 20% per flow probe. The StormFilter system was able meet a treated discharge of 75% or greater for three of the four intense storm events. This demonstrates that the StormFilter system can match influent flow conditions for lower-than-design storm events and can meet design flow conditions for intense storm events. Appendix A contains additional information on each individual storm event.

Table 5. Measured flow rate* vs. design for bypass events

Storm ID	Measured Peak Influent (gpm)	Measured Peak Effluent Treated (gpm)	Design (gpm)	Treated vs. Design (%)	Peak Bypass (gpm)
GYS 071404	681	264	405	65%	2800
GYS 091704	176	302	405	75%	3000
GYS 102205	377	406	405	100%	545
GYS 112905	362	357	405	88%	1477

* Field flow measurements contain a +/- 20% margin of error

4.4 Laboratory Mass Loading of Cartridge

Cartridge scale tests were conducted in the laboratory (CONTECH, 1999) evaluating the StormFilter system using a cartridge operating at 14 gpm with perlite media. Loading was evaluated using a palatine silt loam (37% sand, 60% silt, 3% clay) and demonstrated that approximately 22 pounds (10 kg) per cartridge was removed before a significant decrease in the flow rate occurred. CONTECH uses 22 pounds per cartridge as a design guideline in their Product Design Manual (version 4.2) even though subsequent field studies have shown a higher sediment loading per cartridge.

4.5 Field Mass Loading of Cartridge and Maintenance

Maintenance was performed three times on the StormFilter during the 18-month monitoring period (January 26, 2005, July 26, 2005, and February 28, 2006). An on-site rain gauge measured a total of approximately 103 inches of rainfall during this period (Appendix D). The StormFilter system design predicted the capacity to retain approximately 594 lbs (269 kg) of sediment per maintenance interval for an annual average precipitation year of 40 inches. The evaluation period occurred during a time period where the measured cumulative precipitation was 172% of the historical annual precipitation.

The mass of materials captured by the StormFilter over the course of the monitoring period revealed a net capture and retention of 2751 lbs (1248 kg) of material. Table 6 shows the mass of materials captured and the cumulative measured precipitation per maintenance event. Eleven percent (11%) of this material was retained inside of the cartridges and 89% was found outside of the cartridges in the inlet bay and on the floor of the cartridge bay. Thus the StormFilter system with 27 perlite-filled media cartridges operating at 15 gpm per cartridge was able to remove an average of 34 lbs/cartridge (sandy loam texture) per maintenance cycle.

Table 6. System loading per maintenance event

Maintenance Event	Settled (lbs)	Filtered (lbs)	Measured Total (lbs)	Design (lbs)	Measured vs. Design (%)	Cumulative Measured Rainfall (in)
1/26/2005	794	115	908	594	153%	50
7/26/2005	1027	77	1105	594	186%	18[a]
2/28/2006	626	115	739	594	124%	35
Total	2447	306	2751	1782		103
Average	816	102	917	594	154%	34
						42.5[b]
Per cartridge	30	4	34	22		

[a] 57 day rain gauge data gap

[b] Average (n=2) without using 7/26/2005 cumulative measured rainfall

5. Performance Claim Verification

In accordance with the NJCAT certification process, the performance of SF#6 is intended to be measured relative to a certified performance claim, specifically "Claim 1" of the "Conditional Interim Certification Findings" issued by NJDEP on September 20, 2002 (NJDEP, 2002). This claim is based upon an empirical study of StormFilter performance and utilizes Regression of EMC analysis to summarize performance.

To compensate for the difference in error between laboratory and field testing conditions, the standard error associated with Claim 1 was adjusted during the project planning phase to reflect the lower precision associated with field performance evaluations. The resulting performance claim (presented in the Project Plan as the Field Claim) for the determination of NJCAT certification was 79% efficiency with a standard error[*] of 6% (α=0.05) for the removal of sandy loam suspended solids comprised of 55% sand, 40% silt, and 5% clay (USDA).

For direct comparison with the performance claim, the data was analyzed and subject to Regression of EMC analysis as shown in Figures 6 and 7. As per NJDEP (2006) both TSS and SSC data were analyzed. Both analyses demonstrate a linear relationship between influent and effluent suspended solids EMCs that is significant at the >99.9% confidence level, indicating that the regression statistics can be used for the direct comparison of the field test observations to the performance claim.

[*] The standard error of a statistic (such as the mean) can also be referred to as the standard deviation.

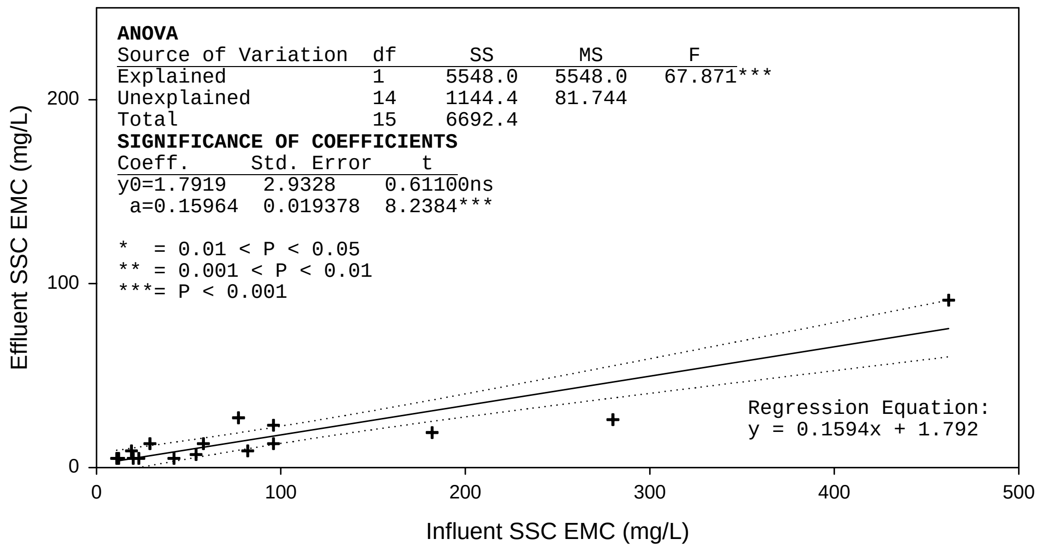

Figure 6. Regression analysis of the observed SSC data.

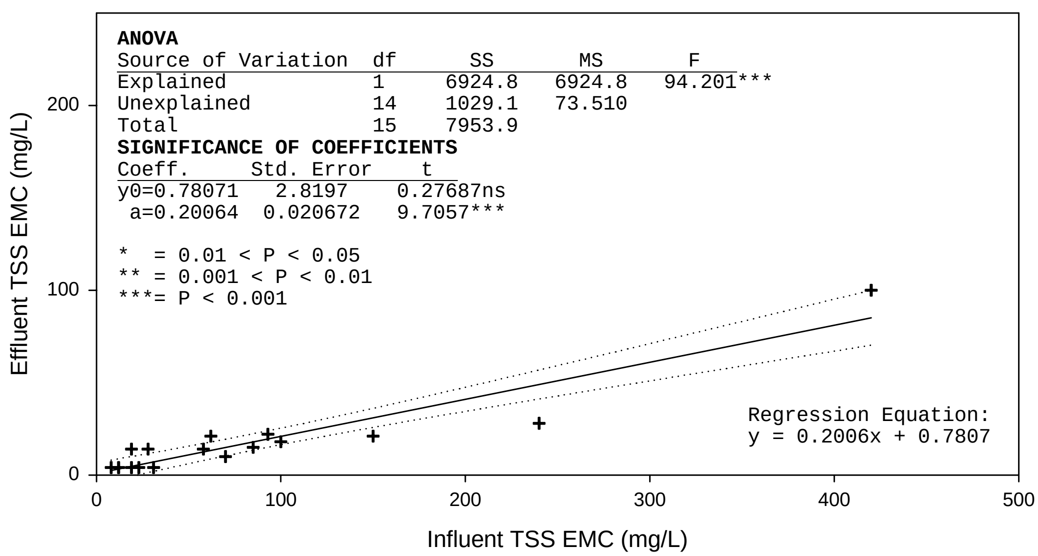

Figure 7. Regression analysis of the observed TSS data.

The regression statistics suggest a mean TSS removal efficiency of 80% with a standard error of 2.1%, and a mean SSC removal efficiency of 84% with a standard error of 1.9%. As discussed in the Project Plan, two-tailed hypothesis testing should be used to compare the observations to the Field Claim. Presented in Figure 8 are normal distributions calculated using the regression statistics corresponding to the observations and the performance claim. Based upon the observation that the mean performance of SF#6 is still within the 95% confidence limits of the mean removal efficiency of the performance claim, there is no significant difference between the performance of SF#6 and that corresponding to the performance claim.

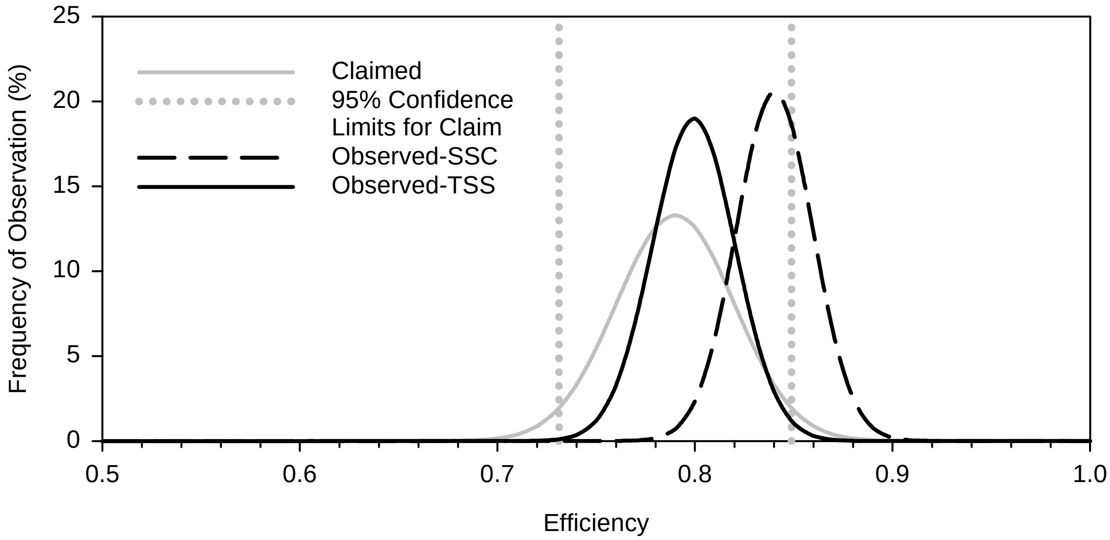

Figure 8. Statistics for the claim and the observations presented as normal probability density functions.

Conclusion

The Greenville Yards StormFilter system field test has demonstrated that: **The Stormwater Management StormFilter® system operating at a specific flow rate of 2.05 gpm/ft^2 per cartridge (15 gpm, 57 l/m) using perlite media has demonstrated a TSS (EPA Method 160.2) removal efficiency of 80% with 95% confidence limits of 76% and 84% for a sandy loam texture sediment (or finer) in the field using the NJDEP TARP/Tier II Protocol.**

6. Net Environmental Benefit

The StormFilter requires no input of raw material, has no moving parts other than a float within the cartridge that moves up and down to engage the siphon, and therefore uses no water or energy other than that provided by stormwater runoff. During the 18-month monitoring period the mass of materials captured and retained by the StormFilter was 2750 lbs. This material would otherwise have been released to the environment during stormwater runoff.

Chemical analysis of the residual solids and used media confirmed the removal and retention of chemical contaminants such as metals and hydrocarbons as suggested by removal performance calculations (Appendix B). Though not observed in interpretation of the water quality data, residual solids analysis suggested some degree of nutrient removal as well. As shown in Figure 9, generally 80% of the contaminant load removed by the system was found outside of the cartridges. Particle size distributions and analytical results for the residuals removed from the StormFilter at the end of the monitoring period are provided in Appendix C.

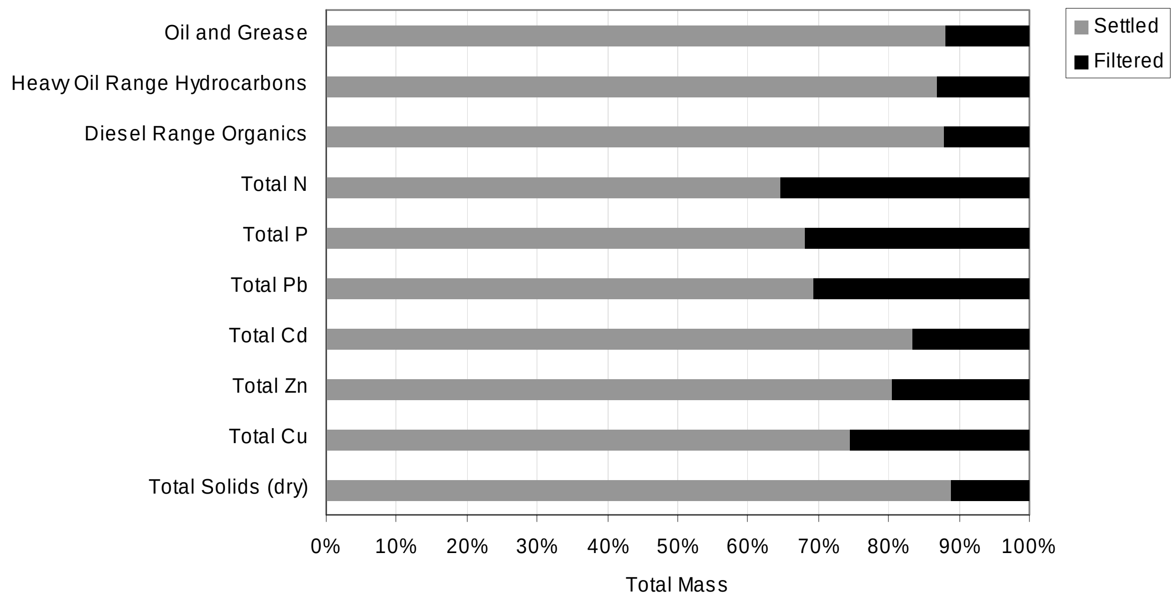

Figure 9. Distribution of the total mass of contaminants found within Greenville Yards StormFilter over the course of the study. These percentages do not directly indicate overall performance afforded by either the settling or filtering aspect of the StormFilter.

7. References

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APPENDICES

APPENDIX A: INDIVIDUAL STORM REPORTS

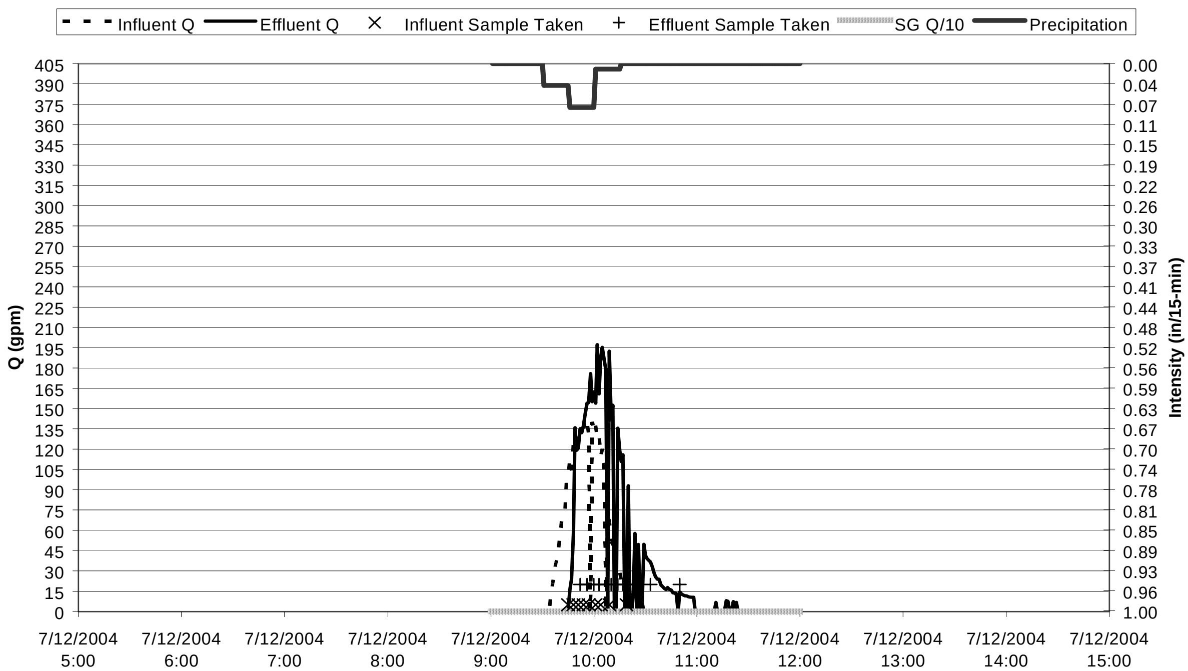
General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	07/12/04
Date of Last Maintenance:	06/16/04
Antecedent Conditions:	6 days since last rain event

Hydrology

Total Precipitation (in):	0.13
Peak Flow, (gpm):	143 SF Influent, 197 SF Effluent, 0 SG Bypass
Total Runoff Volume (gal):	3678 SF Influent, 4910 SF Effluent, 0 SG Bypass
SF Vol. Coverage (nearest 10%):	>90 Influent, >90 Effluent

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	RDL	Dup. RPD	Discrete Removal Efficiency
IN:9	SSC	182	19.0	5	0.01%	90%
EFF:12	TVSS	90	ND	10	20%	89%
	SSC (<500µm)	156	21.0	5	0.01%	87%
	TVSS (<500µm)	88	ND	10	20%	89%
	TSS	150	21	4.00	9.1%	86%
	Hardness	87	75	1.00	20%	undeterminable
	Total P	1.590	1.490	0.01	1.77%	6%
	TKN	2.540	2.430	1.00	41.3%	undeterminable
	NO3-NO2	1.710	2.510	0.55	0%	release
	Total Cd	ND	ND	0.00057	1.0%	undeterminable
	Total Cr	0.0161	0.0038	0.00052	13.5%	76%
	Total Cu	0.0721	0.0366	0.00097	80.8%	undeterminable
	Total Pb	0.0490	0.0134	0.0025	0.2%	73%
	Total Zn	0.747	0.484	0.0016	15.7%	35%

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Reviewed and accepted by NJCAT.

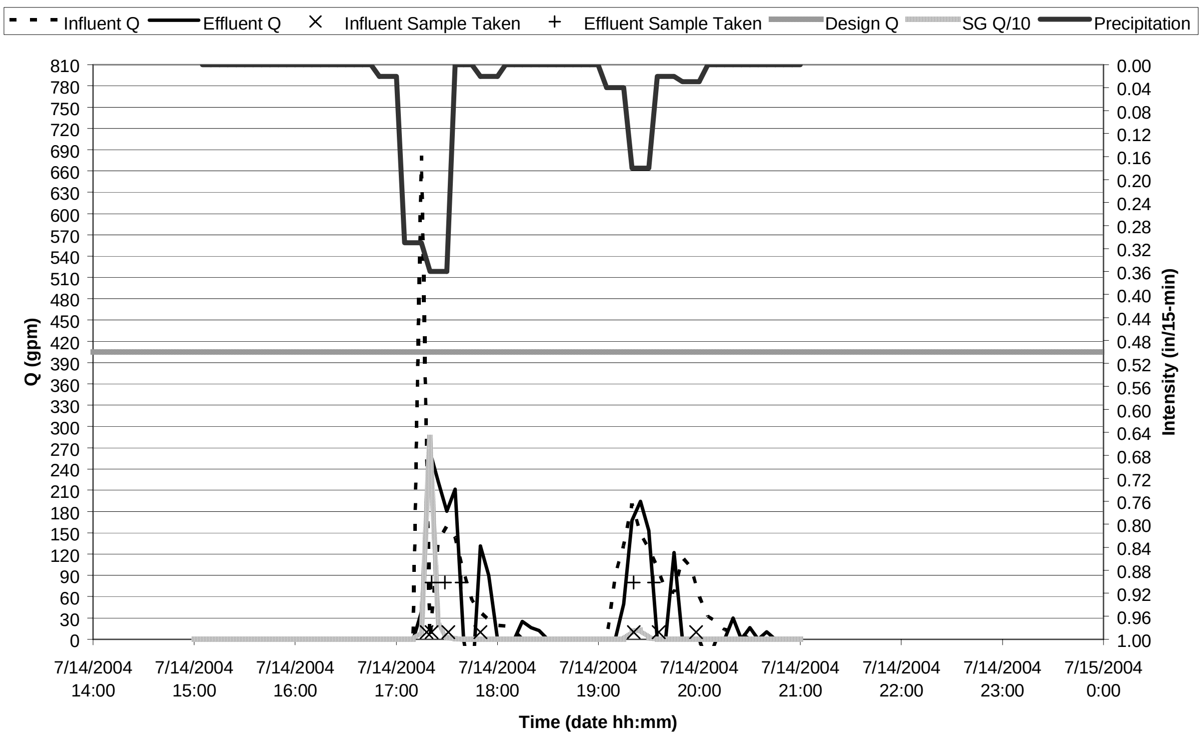
General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	07/14/04
Date of Last Maintenance:	06/16/04
Antecedent Conditions:	2 days since last rain event

Hydrology

Total Precipitation (in):	0.98
Peak Flow, (gpm):	681 SF Influent, 264 SF Effluent, 2800 SG Bypass
Total Runoff Volume (gal):	13382 SF Influent, 9164 SF Effluent, 17000 SG Bypass
SF Vol. Coverage (nearest 10%):	90 Influent, 90 Effluent

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	RDL	Dup. RPD	Discrete Removal Efficiency
IN: 7	SSC	58.0	13.0	5	0.02%	78%
EFF: 5	TVSS	20	ND	10	20%	50%
	SSC (<500µm)	36.0	7.0	5	0.02%	81%
	TVSS (<500µm)	12	ND	10	20%	undeterminable
	TSS	71	10	4.00	20%	86%
	O&G	8.000	10	5.00	1.6%	release
	TPH	ND	ND	1.00	20%	undeterminable

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. No overflow detected within system during entire event. Only enough sample volume collected to perform solids analysis. SSC Dup. RPD based upon replicate influent sample for SSC. Reviewed and accepted by NJCAT.

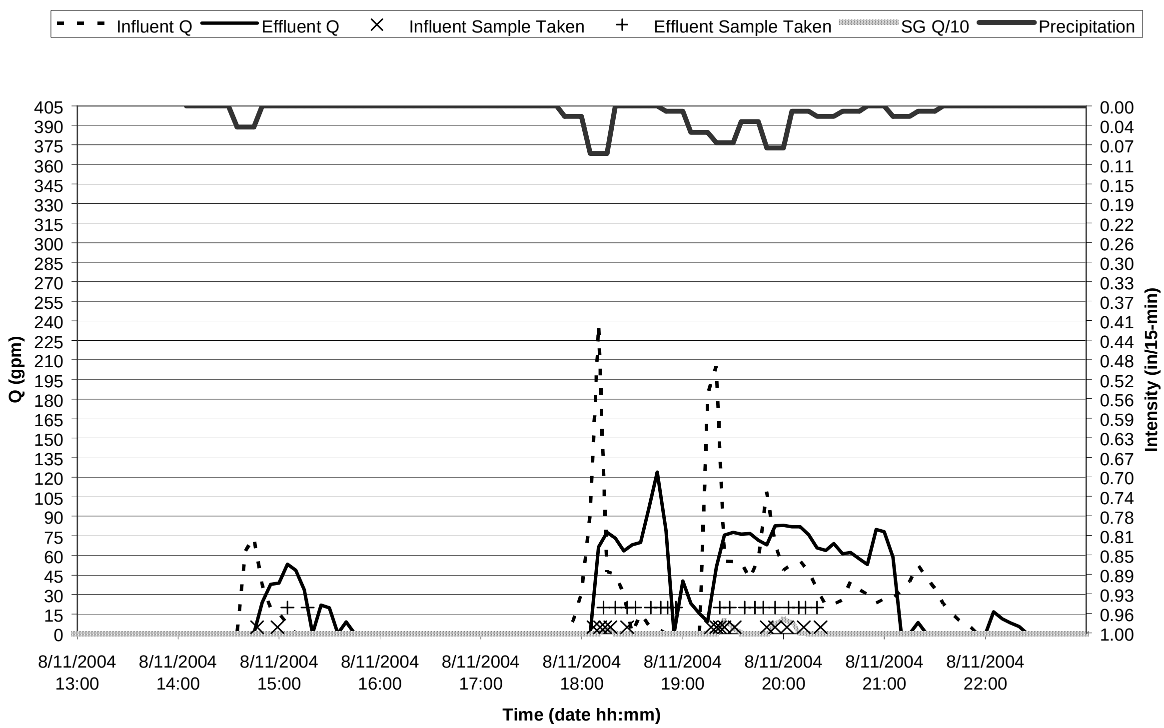
General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	08/11/04
Date of Last Maintenance:	06/16/04
Antecedent Conditions:	10 days since last rain event

Hydrology

Total Precipitation (in):	0.46
Peak Flow, (gpm):	237 SF Influent, 124 SF Effluent, 110 SG Bypass
Total Runoff Volume (gal):	11566 SF Influent, 13477 SF Effluent, 2200 SG Bypass
SF Vol. Coverage (nearest 10%):	90 Influent, 90 Effluent

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	RDL	Dup. RPD	Discrete Removal Efficiency
IN: 18	SSC	280	26.0	5	15%	91%
EFF: 20	TVSS	240	10	10	20%	96%
	SSC (<500µm)	170	23.0	5	15%	86%
	TVSS (<500µm)	130	ND	10	20%	92%
	TSS	240	28	4.00	6.9%	88%
	Hardness	56	48	1.00	20%	undeterminable
	Total P	0.150	0.200	0.01	0%	release
	TKN	1.470	1.550	1.00	4.8%	release
	NO3-NO2	ND	ND	0.55	20%	undeterminable
	Total Cd	ND	ND	0.00057	20%	undeterminable
	Total Cr	0.0138	0.0032	0.00052	5.5%	77%
	Total Cu	0.0764	0.0313	0.00097	2.0%	59%
	Total Pb	0.0595	0.0192	0.0025	200.0%	undeterminable
	Total Zn	0.712	0.463	0.0016	3.4%	35%

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Reviewed and accepted by NJCAT.

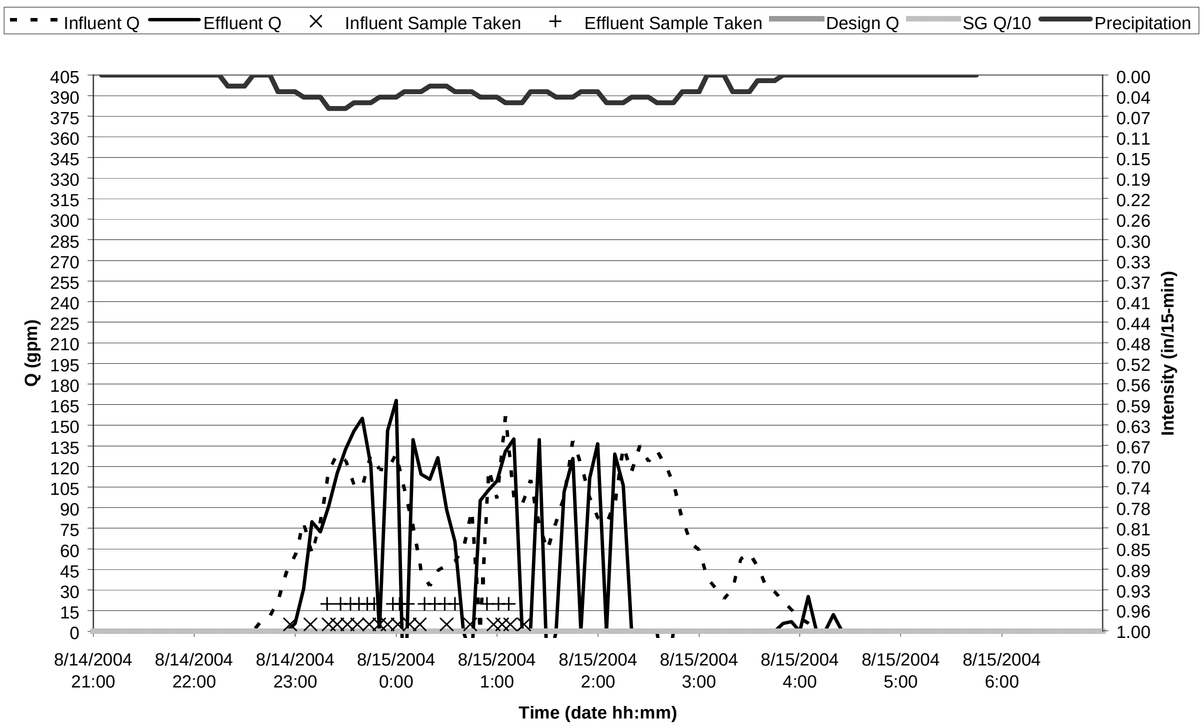
General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	08/14/04
Date of Last Maintenance:	06/16/04
Antecedent Conditions:	1 day since last rain event

Hydrology

Total Precipitation (in):	0.72
Peak Flow, (gpm):	157 SF Influent, 168 SF Effluent, 0 SG Bypass
Total Runoff Volume (gal):	25208 SF Influent, 16146 SF Effluent, 0 SG Bypass
SF Vol. Coverage (nearest 10%):	50 Influent, 70 Effluent

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	RDL	Dup. RPD	Discrete Removal Efficiency
IN: 18	SSC	82.0	9.0	5.00	7.6%	89%
EFF: 16	TVSS	40	ND	10.0	20%	75%
	SSC (<500µm)	12	5.0	5.00	7.6%	58%
	TVSS (<500µm)	37.0	ND	10.0	20%	73%
	TSS	85	15	4.00	2.4%	82%
	Hardness	28	28	1.00	20%	undeterminable
	Total P	0.180	0.270	0.01	5.4%	release
	TKN	1.760	1.290	1.00	4.8%	27%
	NO3-NO2	ND	ND	0.55	20%	undeterminable
	Total Cd	0.001	0.00089	0.00057	1.4%	11%
	Total Cr	0.0056	0.0018	0.00052	16.9%	68%
	Total Cu	0.0366	0.0206	0.00097	0.9%	44%
	Total Pb	0.0219	0.0077	0.0025	1.8%	65%
	Total Zn	0.544	0.285	0.0016	2.5%	48%

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Reviewed and accepted by NJCAT.

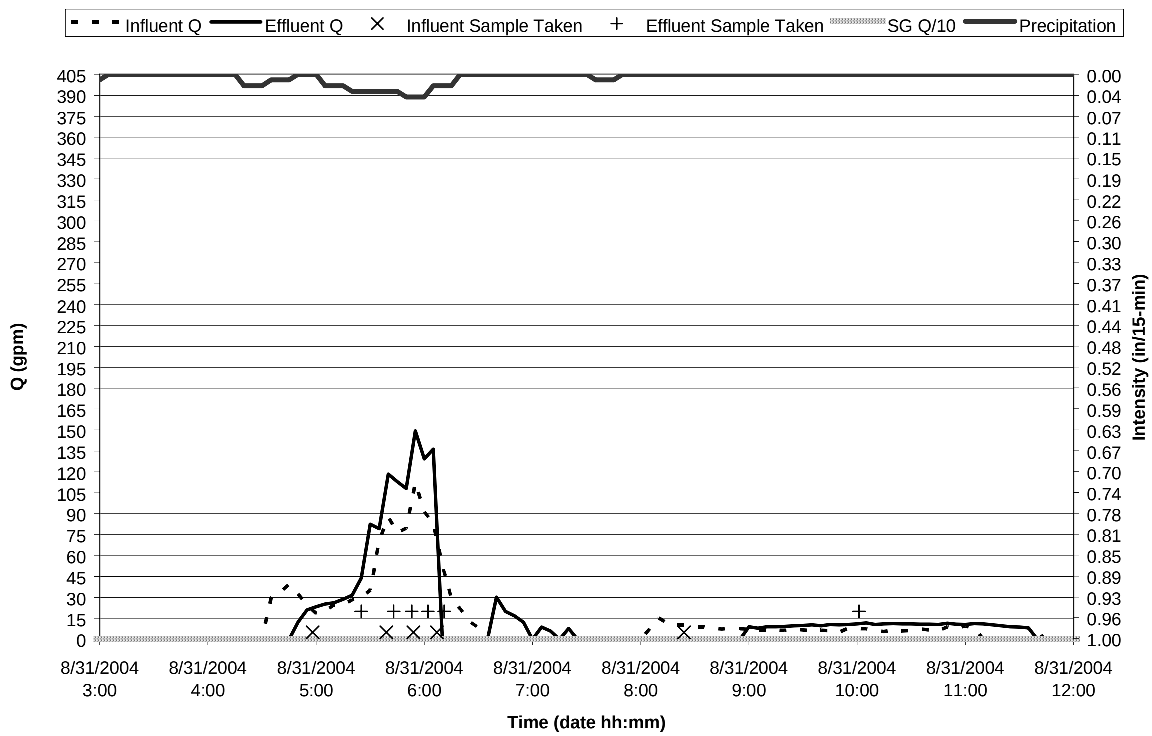
General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	08/31/04
Date of Last Maintenance:	06/16/04
Antecedent Conditions:	11 days since last rain event, 0.71"

Hydrology

Total Precipitation (in):	0.19
Peak Flow, (gpm):	112 SF Influent, 149 SF Effluent, 0 SG Bypass
Total Runoff Volume (gal):	7186 SF Influent, 8265 SF Effluent, 0 SG Bypass
SF Vol. Coverage (nearest 10%):	70 Influent, 70 Effluent

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	RDL	Dup. RPD	Discrete Removal Efficiency
IN: 5	SSC	462	91.0	5	11.9%	80%
EFF: 6	TVSS	420	46	10	20%	89%
	TSS	420	100	4.00	1.9%	76%
	Oil and Grease	25	17	5.00	1.05%	32%
	TPH	2.240	ND	1.00	1.70%	55%

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Reviewed and accepted by NJCAT.

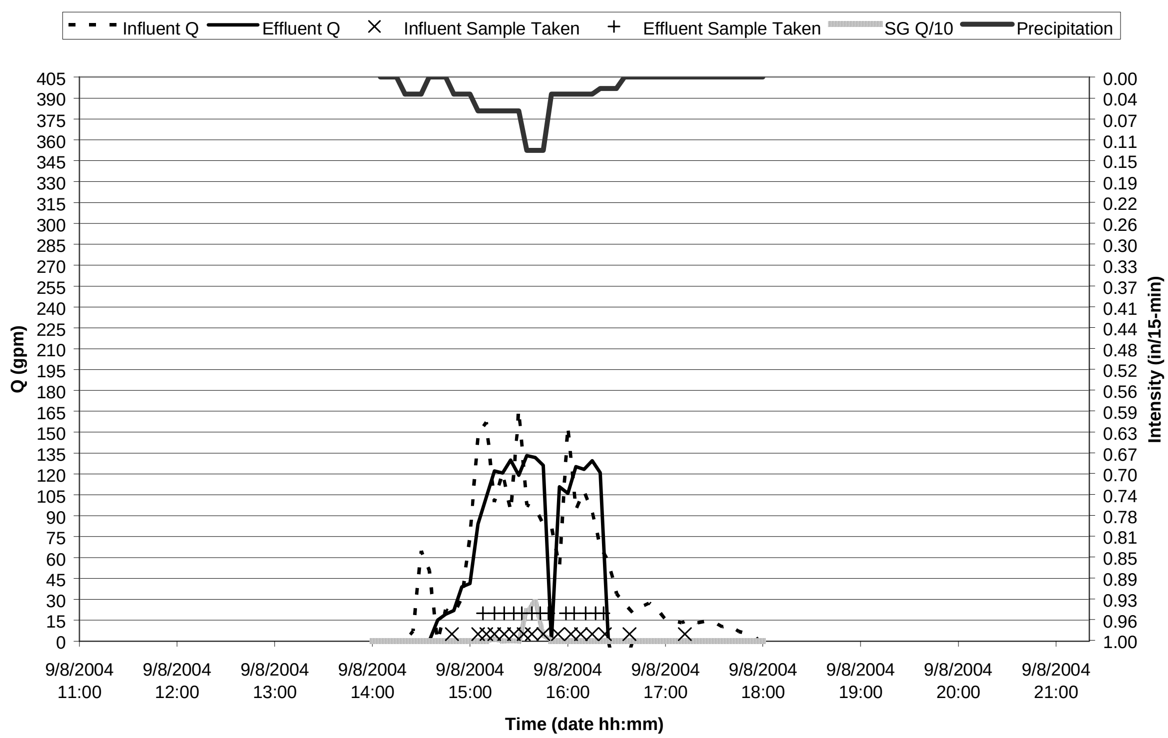
General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	09/08/04
Date of Last Maintenance:	06/16/04
Antecedent Conditions:	1 days since last rain event, 0.12”

Hydrology

Total Precipitation (in):	0.39
Peak Flow, (gpm):	166 SF Influent, 133 SF Effluent, 280 SG Bypass
Total Runoff Volume (gal):	11692 SF Influent, 9388 SF Effluent, 2900 SG Bypass
SF Vol. Coverage (nearest 10%):	>90 Influent, >90 Effluent

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	RDL	Dup. RPD	Discrete Removal Efficiency
IN: 16	SSC	19.0	9.0	5	27%	53%
EFF: 13	TVSS	ND	ND	10	20%	undeterminable
	SSC (<500µm)	15.0	8.0	5	27%	47%
	TVSS (<500µm)	ND	ND	10	20%	undeterminable
	TSS	19	14	4.00	5.1%	26%
	Hardness	19	20	1.00	20%	undeterminable
	Total P	ND	ND	0.01	0.0%	undeterminable
	TKN	2.040	2.640	1.00	20%	release
	NO3-NO2	ND	ND	0.55	20%	undeterminable
	Total Cd	ND	ND	0.00057	0.1%	undeterminable
	Total Cu	0.012	0.0061	0.00097	0.4%	49%
	Total Pb	0.0093	0.0049	0.0025	0.6%	47%
	Total Zn	0.163	0.124	0.0016	2.0%	24%

Notes

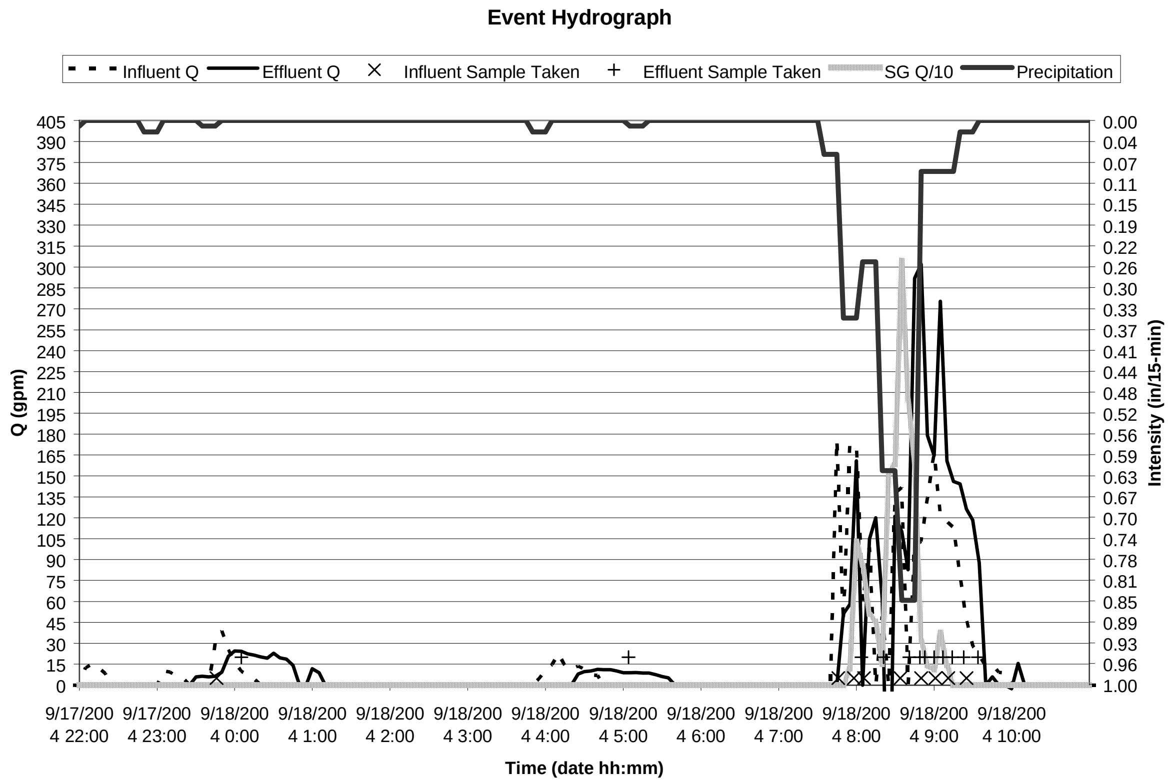
Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Reviewed and accepted by NJCAT.

General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	09/17/04
Date of Last Maintenance:	06/16/04
Antecedent Conditions:	2 days since last rain event, 0.47”

Hydrology

Total Precipitation (in):	2.40
Peak Flow, (gpm):	176 SF Influent, SF 302 Effluent, 3000 SG Bypass
Total Runoff Volume (gal):	12295 SF Influent, 15802 SF Effluent, 70000 SG Bypass
SF Vol. Coverage (nearest 10%):	90 Influent, 90 Effluent



Analytical

Number of Aliquots:	Parameter	Influent EMC	Effluent EMC	RDL	Dup. RPD	Discrete Removal Efficiency
		Concentrations (mg/L)				
IN: 9	SSC	96.0	13.0	5.0	8.70%	86%
EFF: 12	TVSS	32	ND	10	20%	69%
	SSC (<500µm)	51.0	13.0	5.0	8.70%	75%
	TVSS (<500µm)	18	ND	10	20%	44%
	TSS	100	18	4.00	20%	82%
	Hardness	34	38	1.00	20%	undeterminable
	Total Cd	ND	ND	0.00057	0.20%	undeterminable
	Total Cu	0.0272	0.009	0.00097	0.00%	67%
	Total Pb	0.0211	ND	0.0025	0.30%	88%
	Total Zn	0.546	0.180	0.0016	0.30%	67%
	Oil and Grease	12	10	5.00	3.77%	17%
	TPH	ND	ND	1.00	1.83%	undeterminable

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Reviewed and accepted by NJCAT.

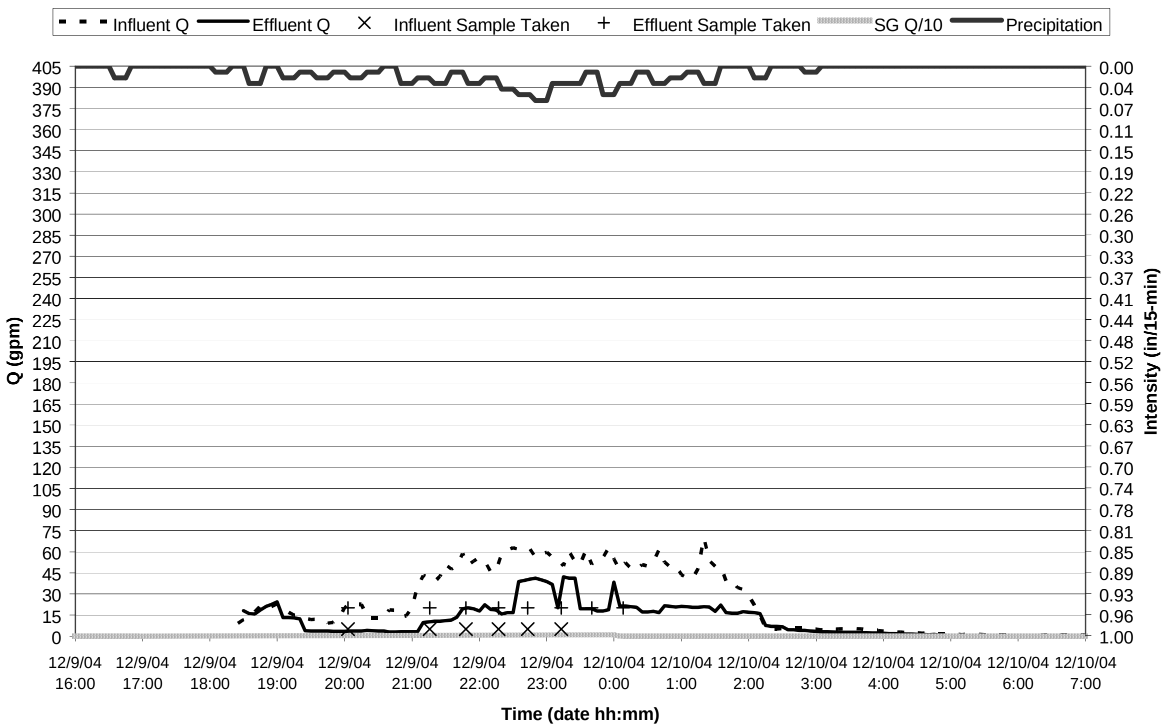
General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	12/09/04
Date of Last Maintenance:	06/16/04
Antecedent Conditions:	1 days since last rain event, 0.18”

Hydrology

Total Precipitation (in):	0.72
Peak Flow, (gpm):	70 SF Influent, 42 SF Effluent, 30 SG Bypass
Total Runoff Volume (gal):	18848 SF Influent, 8564 SF Effluent, 740 SG Bypass
SF Vol. Coverage (nearest 10%):	50 Influent, 70 Effluent

Event Hydrograph



Analytical

Number of Aliquots:
IN: 6
EFF: 8

Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	RDL	Dup. RPD	Discrete Removal Efficiency
SSC	23.0	ND	5.0	20%	78%
TVSS	ND	ND	10	20%	undeterminable
SSC (<500µm)	ND	ND	5.0	20%	undeterminable
TVSS (<500µm)	ND	ND	10	20%	undeterminable
TSS	23	ND	4.000	20%	83%
Oil and Grease	18	10	5.0	4.7%	44%
TPH	7.900	6.600	5.0	6.0%	16%

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. Pacing rate doubled to allow for coverage based on previous IN and EFF Q relationships.

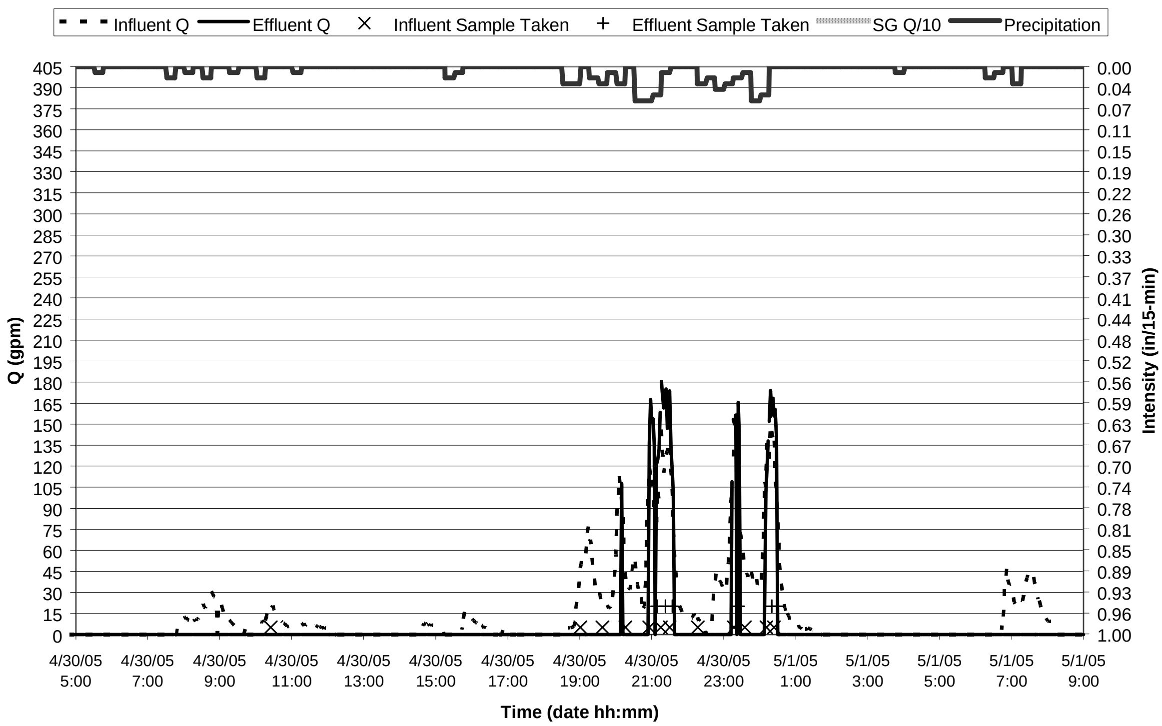
General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	04/30/2005
Date of Last Maintenance:	01/27/2005
Antecedent Conditions:	3 days since last rain event, 0.51?

Hydrology

Total Precipitation (in):	0.79
Peak Flow, (gpm):	157 SF Influent, 180 SF Effluent, 0 SG Bypass
Total Runoff Volume (gal):	25546 SF Influent, 10880 SF Effluent, 0 SG Bypass
Coverage (nearest 10%):	80 Influent, >90 Effluent

Event Hydrograph



Analytical

Number of Aliquots:
IN: 12
EFF: 6

Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	RDL	Dup. RPD	Discrete Removal Efficiency
SSC	11.0	5.0	5.0	20%	55%
TVSS	ND	ND	10	20%	undeterminable
SSC (<500µm)	8.0	7.0	5.0	20%	undeterminable
TVSS (<500µm)	ND	ND	10	20%	undeterminable
TSS	8.000	ND	4.000	13.3%	50%
Hardness	16	14	1.000	20%	undeterminable
Total P	0.110	0.100	0.010	0%	9%
TKN	ND	ND	0.500	20%	undeterminable
NO3-NO2	0.632	ND	0.550	0.4%	13%
Total Cd	ND	ND	0.00052	1.9%	undeterminable
Total Cu	0.0074	0.0048	0.0013	0.6%	35%
Total Pb	ND	ND	0.0016	1.9%	undeterminable
Total Zn	0.126	0.0784	0.00048	8%	38%

Notes

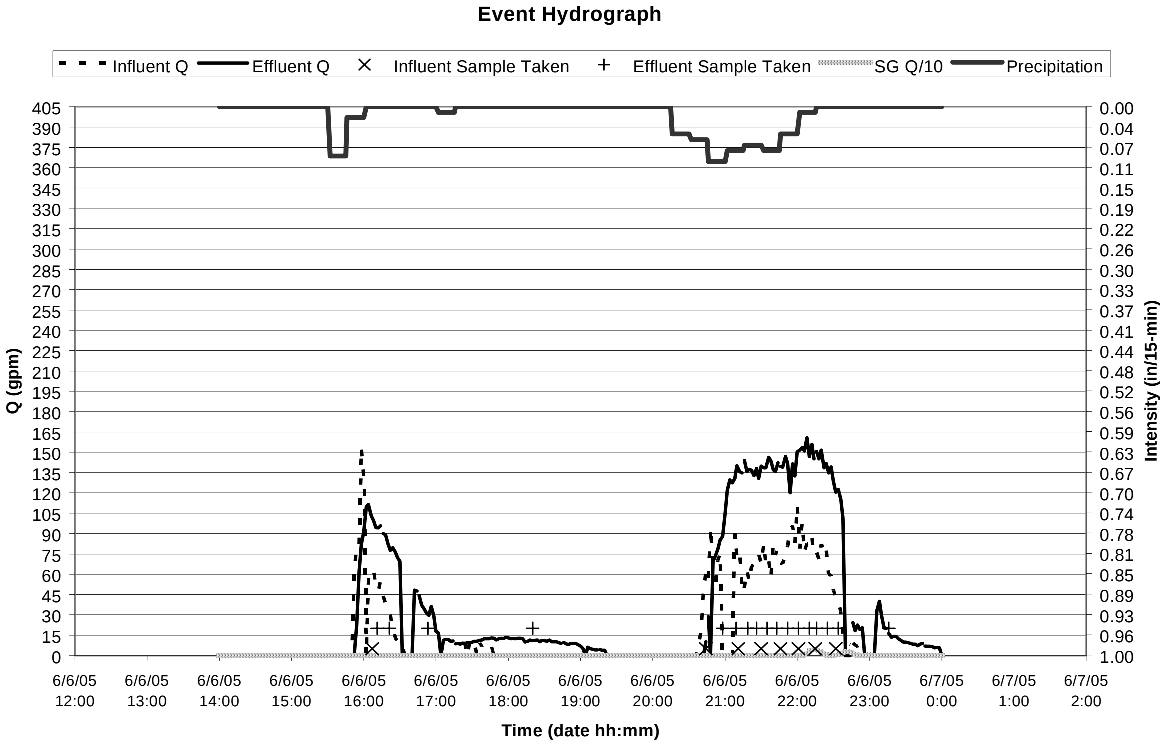
Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC.

General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	06/06/2005
Date of Last Maintenance:	01/27/2005
Antecedent Conditions:	3 days since last rain event, 0.69”

Hydrology

Total Precipitation (in):	0.62
Peak Flow, (gpm):	154 SF Influent, 161 SF Effluent , 48 SG Bypass
Total Runoff Volume (gal):	9965 SF Influent, 20800 SF Effluent , 910 SG Bypass
Coverage (nearest 10%):	>90 Influent, >90 Effluent



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	RDL	Dup. RPD	Discrete Removal Efficiency
IN: 8	SSC	77.0	27.0	5.0	8.7%	65%
EFF: 17	TVSS	20	ND	10	20%	50%
	SSC (<500µm)	65.0	22.0	5.0	8.7%	66%
	TVSS (<500µm)	18	ND	10	20%	44%
	TSS	62	21	4.000	20%	66%
	Hardness	23	28	1.000	20%	undeterminable
	Total P	0.120	0.220	0.010	0%	release
	TKN	0.853	1.010	0.500	5.3%	release
	NO3-NO2	ND	0.672	0.550	20%	undeterminable
	Total Cd	ND	ND	0.00052	0.6%	undeterminable
	Total Cu	0.019	0.017	0.0013	13.3%	undeterminable
	Total Pb	0.0070	0.0050	0.0016	0.0%	29%
	Total Zn	0.186	0.182	0.00048	1.0%	2%
	Oil and Grease	11	6.000	5.00	1.7%	45%
	TPH	6.100	ND	5.00	4.5%	18%

Notes

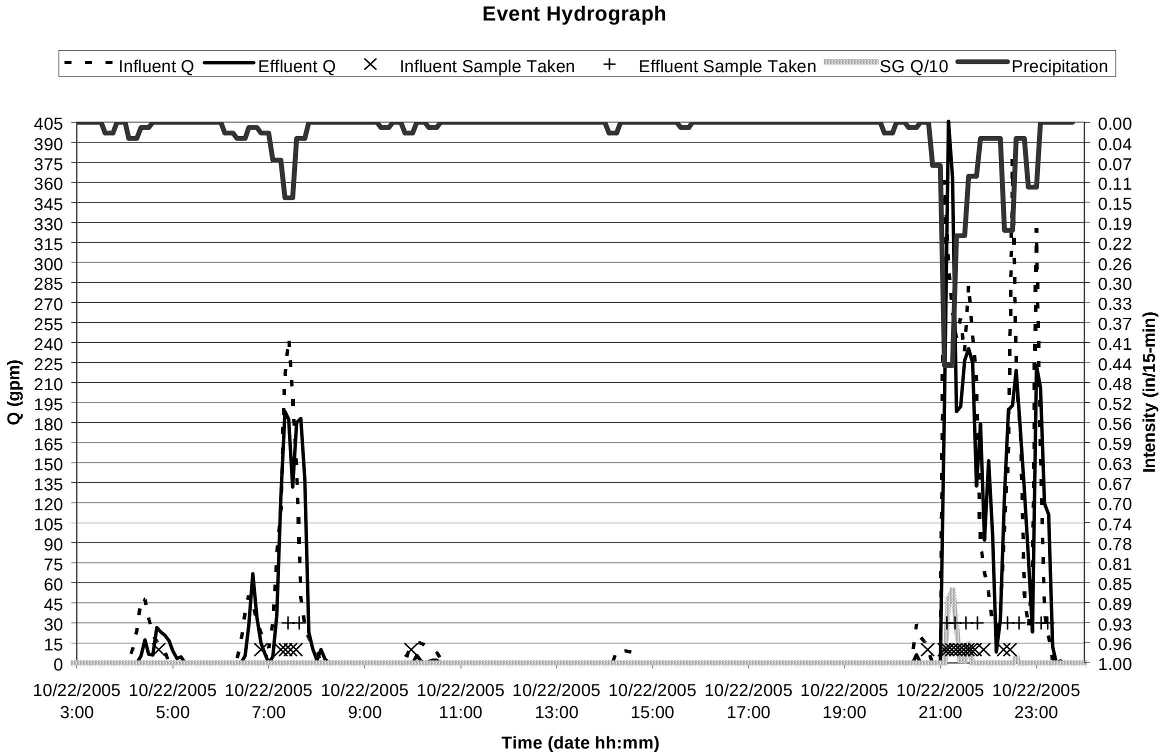
Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC. Suspected time sync issue between SG and influent/effluent hydrographs.

General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	10/22/05
Date of Last Maintenance:	7/26/05
Antecedent Conditions:	8.6 days since last rain event, 5.83”

Hydrology

Total Precipitation (in):	1.73
Peak Flow, (gpm):	377 SF Influent, 406 SF Effluent, 545 SG Bypass
Total Runoff Volume (gal):	31270 SF Influent, SF 30305 Effluent, 7504 SG Bypass
SF Vol. Coverage (nearest 10%):	>90 Influent, 70 Effluent



Analytical

Number of Aliquots:	Parameter	Influent EMC (mg/L)	Effluent EMC (mg/L)	RDL (mg/L)	Dup. RPD	Discrete Removal Efficiency
IN: 20	SSC	54.00	7.00	5.00	12%	87%
EFF: 10	TVSS	14.00	ND	10.00	20%	29%
	SSC (<500µm)	12.00	9.00	5.00	12%	25%
	TVSS (<500µm)	ND	ND	10.00	20%	undeterminable
	TSS	58.00	14.00	4.00	6.9%	76%
	Total P	ND	ND	0.010	0%	undeterminable
	TKN	ND	ND	5.00	20%	undeterminable
	NO3-NO2	ND	ND	0.550	20%	undeterminable
	Hardness	16.59	15.07	0.06	20%	undeterminable
	Total Cd	ND	ND	0.00052	0.8%	undeterminable
	Total Cu	0.0191	0.0172	0.0013	2.0%	10%
	Total Pb	0.0034	0.0040	0.0016	2.7%	release
	Total Zn	0.105	0.0856	0.00047	1.1%	18%
	Oil and Grease	8.600	5.100	5.00	3.7%	41%
	TPH	6	ND	5.00	4.7%	17%

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC.

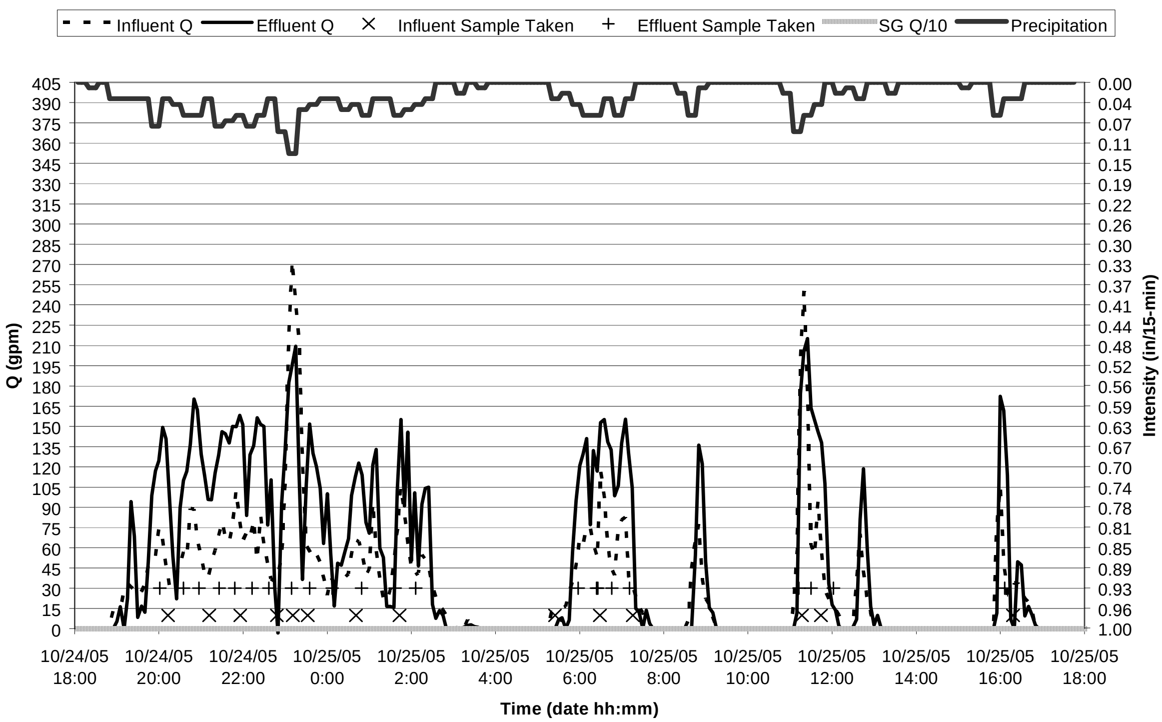
General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	10/24/05
Date of Last Maintenance:	7/26/05
Antecedent Conditions:	2 days since last rain event, 1.73”

Hydrology

Total Precipitation (in):	2.44
Peak Flow, (gpm):	273 SF Influent, 215 SF Effluent, 0 SG Bypass
Total Runoff Volume (gal):	44620 SF Influent, 68180 SF Effluent, 0 SG Bypass
SF Vol. Coverage (nearest 10%):	90 Influent, >90 Effluent

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	RDL	Dup. RPD	Discrete Removal Efficiency
IN: 14	SSC	12.00	ND	5.00	29%	58%
EFF: 22	TVSS	ND	ND	10.00	20%	undeterminable
	SSC (<500µm)	6.00	ND	5.00	29%	undeterminable
	TVSS (<500µm)	ND	ND	10.00	20%	undeterminable
	TSS	12.00	ND	4.000	20%	67%
	Total P	ND	ND	0.010	0%	undeterminable
	TKN	ND	ND	2.000	20%	undeterminable
	NO3-NO2	ND	ND	0.550	20%	undeterminable
	Hardness	11.40	11.96	0.06	20%	undeterminable
	Total Cd	ND	ND	0.00052	0.1%	undeterminable
	Total Cu	0.0134	0.0114	0.0013	0.4%	15%
	Total Pb	0.0072	0.0044	0.0016	0.7%	39%
	Total Zn	0.0672	0.0474	0.00047	0.6%	29%
	Oil and Grease	9.200	5.000	5.00	10.2%	46%
	TPH	NT	ND	5.00	5.7%	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC.

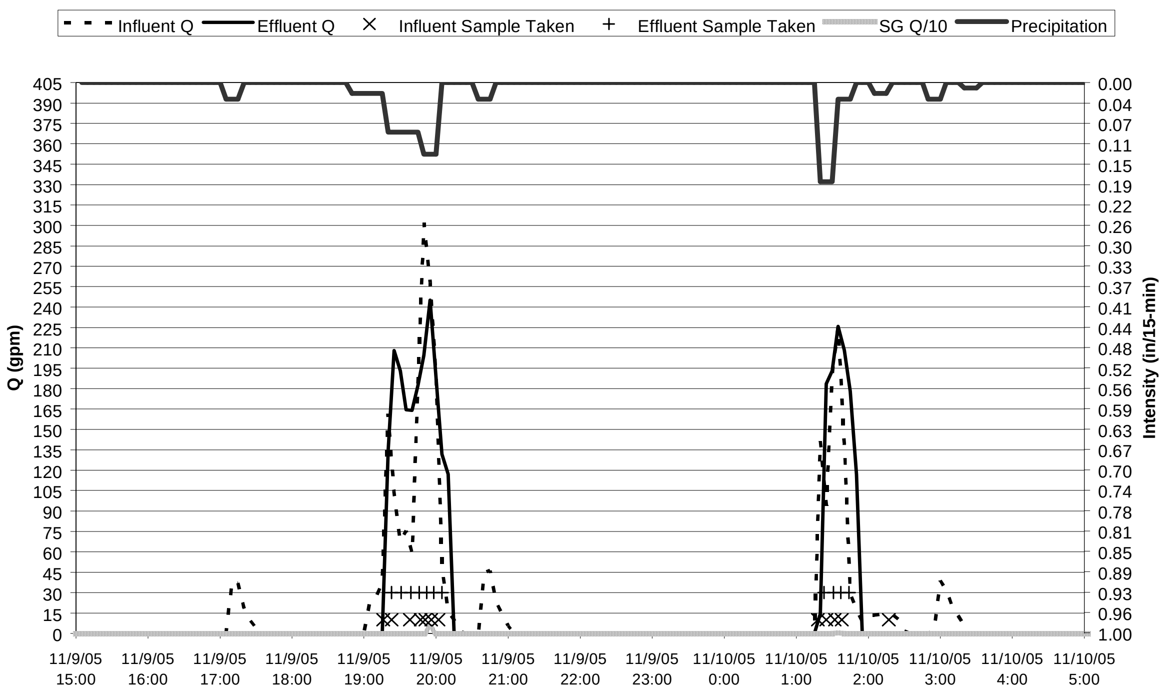
General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	11/09/05
Date of Last Maintenance:	7/26/05
Antecedent Conditions:	14 days since last rain event, 0.05”

Hydrology

Total Precipitation (in):	0.68
Peak Flow, (gpm):	302 SF Influent, 245 SF Effluent, 48 SG Bypass
Total Runoff Volume (gal):	14244 SF Influent, 15263 SF Effluent, 262 SG Bypass
SF Vol. Coverage (nearest 10%):	80 Influent, 70 Effluent

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	RDL	Dup. RPD	Discrete Removal Efficiency
IN: 12	SSC	96.00	23.00	5.00	2%	76%
EFF: 11	TVSS	30.00	ND	10.00	20%	67%
	SSC (<500µm)	49.0	20.00	5.00	2%	59%
	TVSS (<500µm)	29.00	ND	10.00	20%	66%
	TSS	93.00	22.00	4.000	0%	76%
	Total P	0.070	ND	0.010	0%	86%
	TKN	ND	ND	0.500	0%	undeterminable
	NO3-NO2	0.633	0.735	0.550	3.1%	release
	Hardness	19.49	16.71	0.07	20%	undeterminable
	Total Cd	ND	ND	0.00052	0.8%	undeterminable
	Total Cu	0.0111	0.0083	0.0013	0.0%	25%
	Total Pb	0.0046	0.0020	0.0016	1.2%	57%
	Total Zn	0.171	0.122	0.00047	0.3%	29%
	Oil and Grease	13.00	14.00	5.00	9.9%	undeterminable
	TPH	7.500	8.400	5.00	5.1%	release

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC.

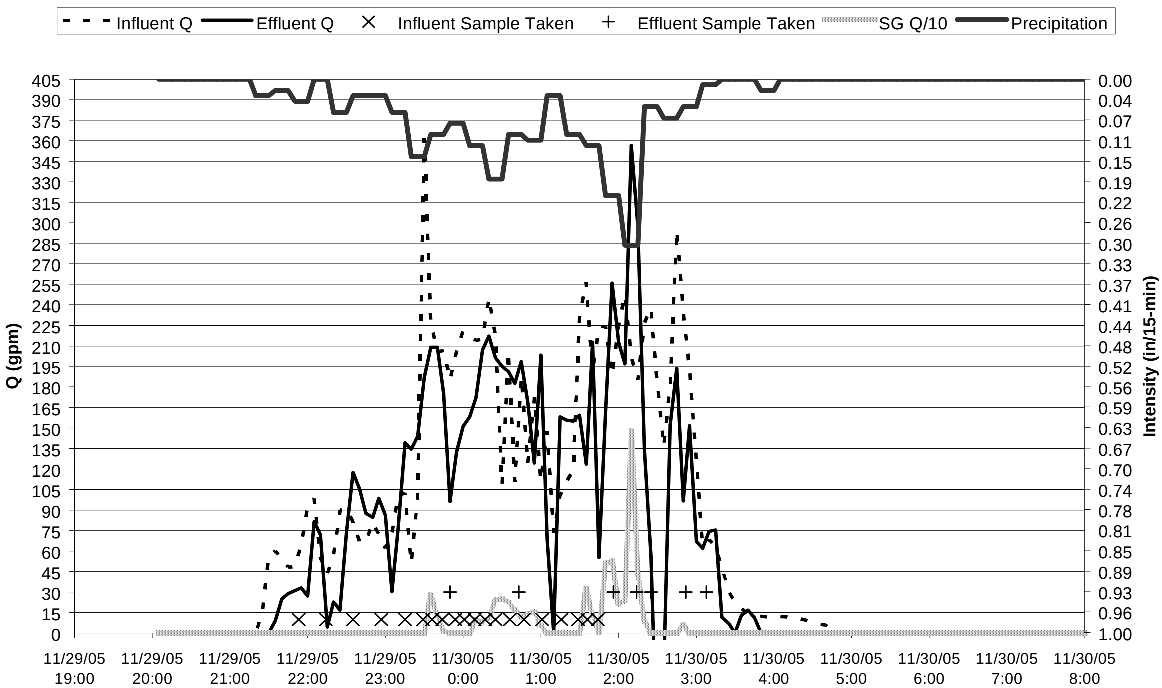
General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	11/29/05
Date of Last Maintenance:	7/26/05
Antecedent Conditions:	5 days since last rain event, 0.03”

Hydrology

Total Precipitation (in):	2.06”
Peak Flow, (gpm):	362 SF Influent, 357 SF Effluent, 1477 SG Bypass
Total Runoff Volume (gal):	52334 SF Influent, 42415 SF Effluent, 30355 SG Bypass
SF Vol. Coverage (nearest 10%):	80 Influent, > 90 Effluent

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	RDL	Dup. RPD	Discrete Removal Efficiency
IN: 20	SSC	42.00	ND	5.00	19%	88%
EFF: 7	TVSS	10.00	ND	10.00	20%	undeterminable
	SSC (<500µm)	26.00	ND	5.00	19%	81%
	TVSS (<500µm)	ND	ND	10.00	20%	undeterminable
	TSS	31.00	ND	4.000	20%	87%
	Total P	0.060	0.050	0.010	0%	17%
	TKN	ND	ND	0.500	20%	undeterminable
	NO3-NO2	ND	ND	0.550	20%	undeterminable
	Hardness	14.36	9.36	0.07	20%	35%
	Total Cd	ND	ND	0.000327	13.0%	undeterminable
	Total Cu	ND	ND	0.003640	0.4%	undeterminable
	Total Pb	0.005760	ND	0.002180	0.2%	62%
	Total Zn	0.143	0.0474	0.000611	4.8%	67%
	Oil and Grease	NT	NT	---	---	---
	TPH	NT	NT	---	---	---

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC.

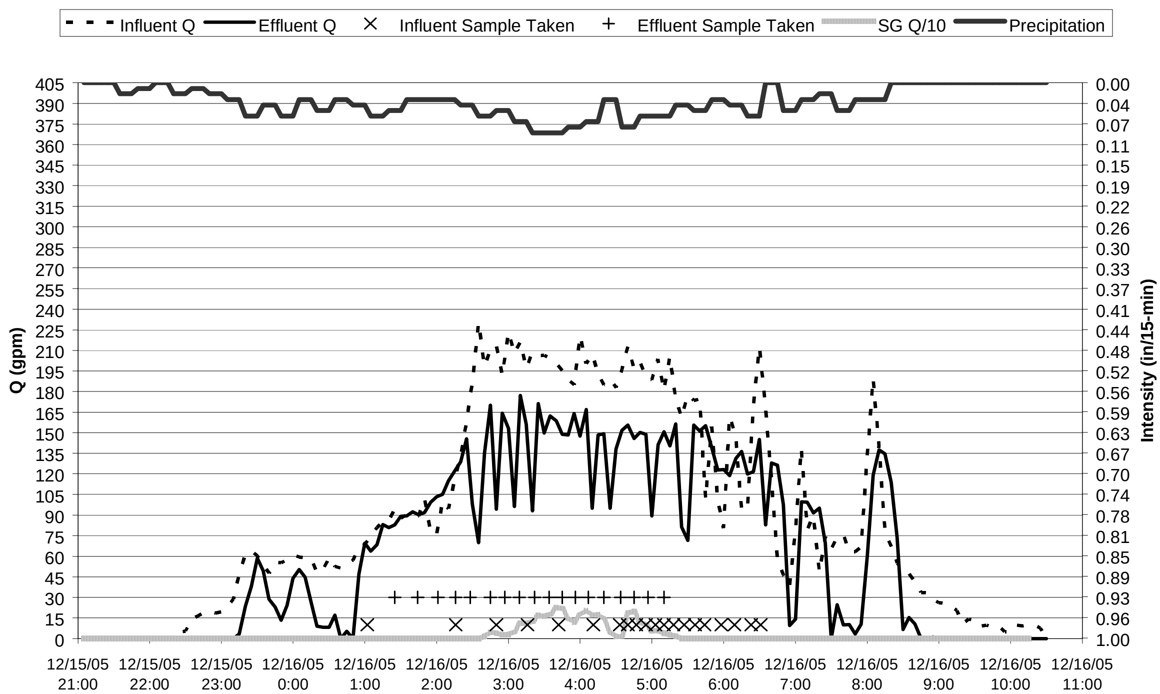
General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	12/15/05
Date of Last Maintenance:	07/26/05
Antecedent Conditions:	4 days since last rain event, 0.05"

Hydrology

Total Precipitation (in):	1.83"
Peak Flow, (gpm):	230 SF Influent, 177 SF Effluent, 225 SG Bypass
Total Runoff Volume (gal):	72585 SF Influent, 52696 SF Effluent, 17631 SG Bypass
SF Vol. Coverage (nearest 10%):	60 Influent, 70 Effluent

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L) Influent EMC	Effluent EMC	RDL	Dup. RPD	Discrete Removal Efficiency
IN: 20	SSC	29.00	13.00	5.00	3.5%	55%
EFF: 18	TVSS	ND	ND	10.00	20%	undeterminable
	SSC (<500µm)	22.00	10.00	5.00	3.5%	55%
	TVSS (<500µm)	ND	ND	10.00	20%	undeterminable
	TSS	28.00	14.00	4.00	15.4%	50%
	Total P	ND	ND	0.01	20%	undeterminable
	TKN	ND	ND	0.50	20%	undeterminable
	NO3-NO2	ND	ND	0.55	20%	undeterminable
	Hardness	12.81	15.70	0.07	20%	release
	Total Cd	ND	ND	0.000327	0.7%	undeterminable
	Total Cu	0.004210	0.004880	0.003640	0.7%	release
	Total Pb	0.002650	0.002920	0.002180	0.7%	release
	Total Zn	0.0936	0.108	0.000611	0.5%	release
	Oil and Grease	12.00	ND	5.00	11.0%	58%
	TPH	ND	ND	5.00	5.2%	undeterminable

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. Pacing rate doubled to allow for coverage based on previous IN and EFF Q relationships.

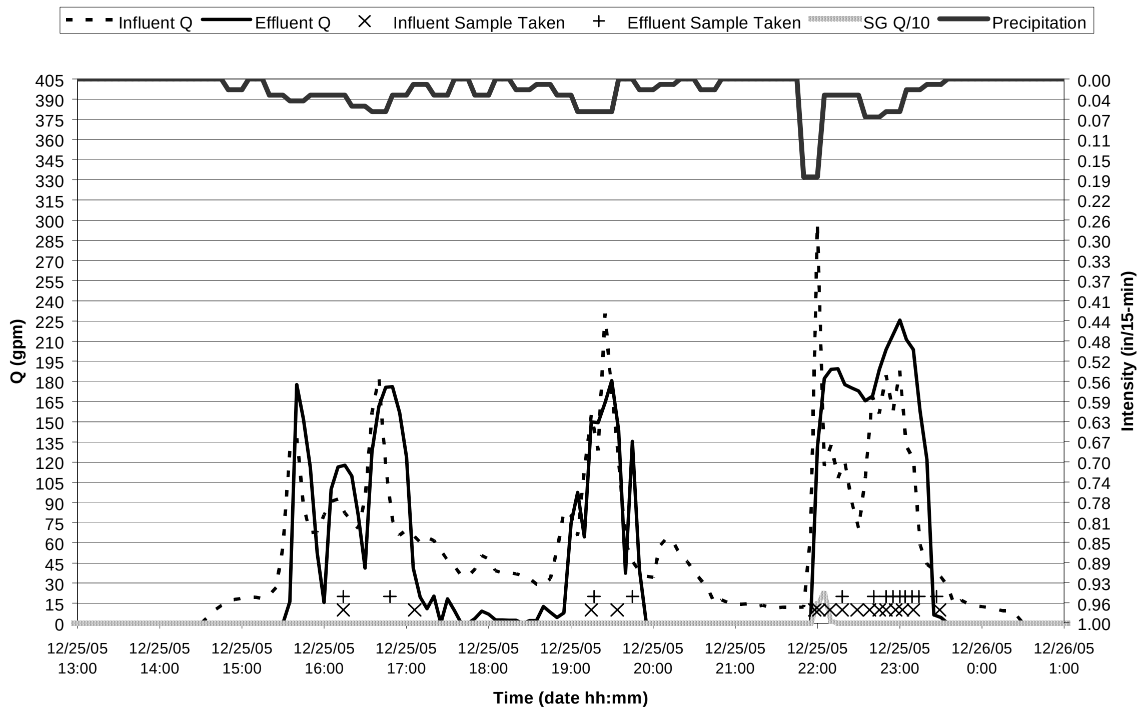
General Information

Site:	Greenville Yards, (3683), Jersey City, NJ
System Description:	8 x 18, Fine Perlite, 27 cartridges, 15 gpm
Event Date:	12/25/05
Date of Last Maintenance:	7/26/05
Antecedent Conditions:	9 days since last rain event, 1.83”

Hydrology

Total Precipitation (in):	0.99”
Peak Flow, (gpm):	298 SF Influent, 226 SF Effluent, 223 SG Bypass
Total Runoff Volume (gal):	37137 SF Influent, 32668 SF Effluent, 1950 SG Bypass
SF Vol. Coverage (nearest 10%):	>90 Influent, >90 Effluent

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Influent EMC (mg/L)	Effluent EMC (mg/L)	RDL (mg/L)	Dup. RPD	Discrete Removal Efficiency
IN: 16	SSC	20.00	ND	5.00	16%	75%
EFF: 13	TVSS	ND	ND	10.00	20%	undeterminable
	SSC (<500µm)	ND	ND	5.00	16%	undeterminable
	TVSS (<500µm)	ND	ND	10.00	20%	undeterminable
	TSS	19.00	ND	4.00	5.1%	79%
	Total P	ND	ND	0.010	0%	undeterminable
	TKN	ND	ND	0.500	20%	undeterminable
	NO3-NO2	ND	ND	0.550	20%	undeterminable
	Hardness	10.87	10.26	0.07	20%	undeterminable
	Total Cd	ND	ND	0.000327	0.2%	undeterminable
	Total Cu	0.0118	0.005150	0.003640	0.1%	56%
	Total Pb	0.004970	0.003250	0.002180	0.3%	35%
	Total Zn	0.121	0.0812	0.000611	0.6%	33%
	Oil and Grease	6.000	ND	5.00	7.7%	17%
	TPH	ND	ND	5.00	5.8%	undeterminable

Notes

Shaded RPD values defaulted to 20% standard due to QC complications. SSC Dup. RPD based upon replicate influent sample for SSC.

APPENDIX B: REGRESSION OF EMC ANALYSIS

Results of parametric testing shown in Figures A-D and Table A indicate significant ($\alpha<0.05$) removal of SSC, TVSS, SSC<500-um, TVSS<500-um, TSS, Hardness, Total Cu, Total Pb, Total Zn, and Oil and Grease; marginal performance for Total Phosphorus; and significant ($\alpha<0.05$) release of NO2/NO3. Performance with regard to TKN and Total Cd could not be confidently assessed due to insufficient data quantity/quality or insufficient quantity of detectable concentrations.

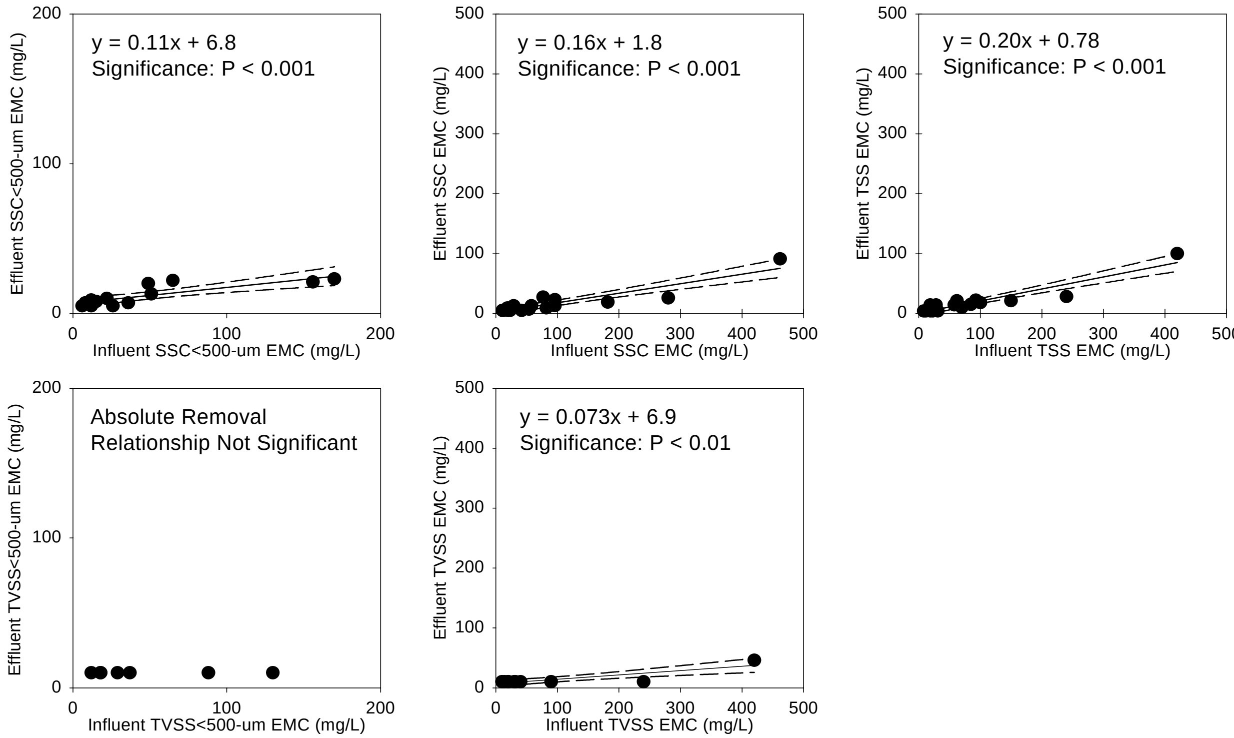


Figure A. Regression analysis of the influent and effluent relationships between solid analytes for the Greenville Yards StormFilter Evaluation. Refer to Table 1 for acronym definitions. Grouped solid and dashed lines illustrate linear regression and 95% confidence intervals.

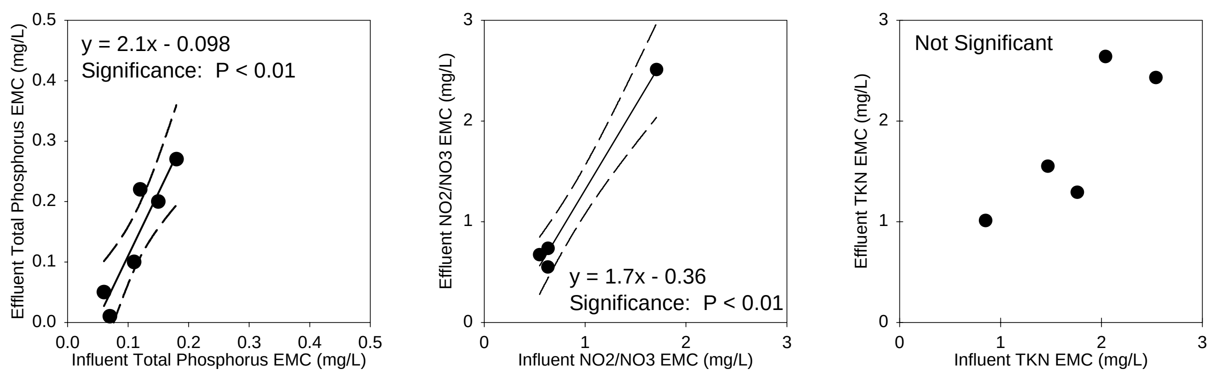


Figure B. Regression analysis of the influent and effluent relationships between nutrient analytes for the Greenville Yards StormFilter Evaluation. Refer to Table 1 for acronym definitions. Grouped solid and dashed lines illustrate linear regression and 95% confidence intervals.

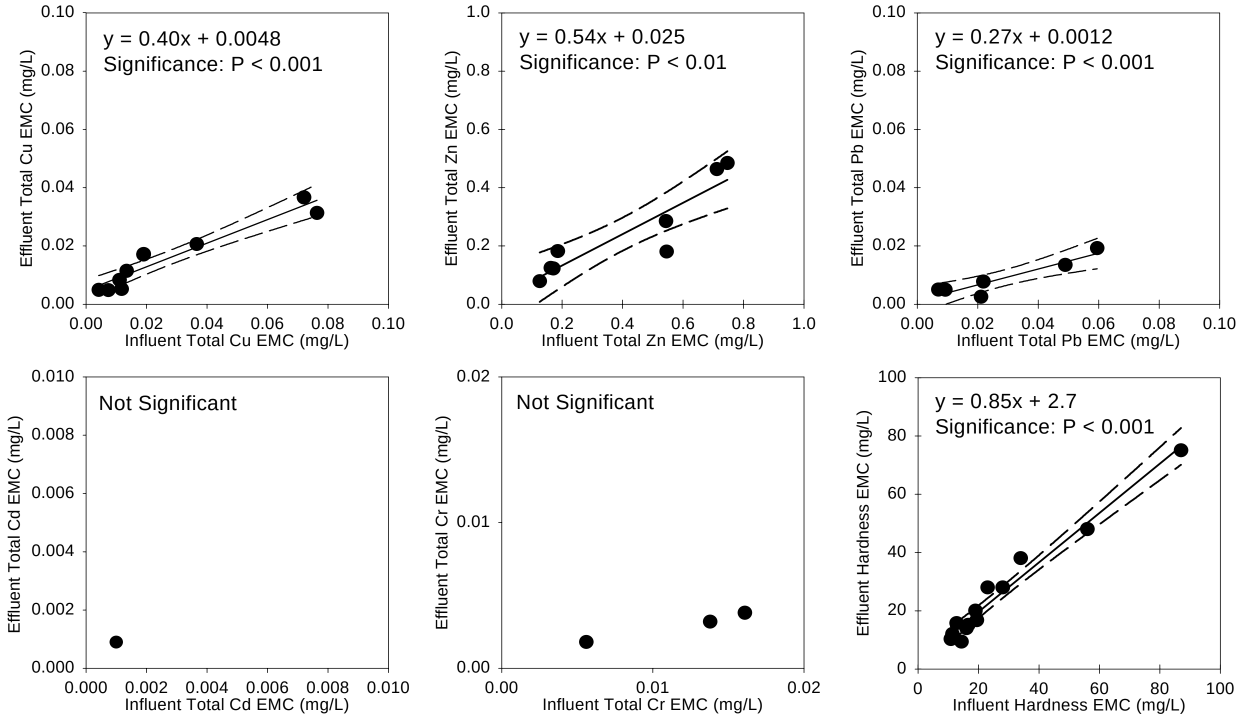


Figure C. Regression analysis of the influent and effluent relationships between metal analytes for the Greenville Yards StormFilter Evaluation. Refer to Table 1 for acronym definitions. Grouped solid and dashed lines illustrate linear regression and 95% confidence intervals.

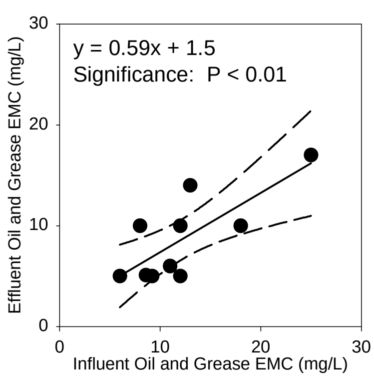


Figure D. Regression analysis of the influent and effluent relationships between hydrocarbon analytes for the Greenville Yards StormFilter Evaluation. Refer to Table 1 for acronym definitions. Grouped solid and dashed lines illustrate linear regression and 95% confidence intervals.

Table A. Summarized performance for Greenville Yards StormFilter. Refer to Table 1 for acronym definitions

				Regression of EMC				Aggregate Load Reduction	
Analyte	*n*	Range of Influent EMCs (mg/L)	Median Influent EMC (mg/L)	Mean Removal Efficiency Estimate (%)	95% Confidence Interval for the Mean Removal Efficiency Estimate (%)	Median Effluent EMC Estimate (mg/L)	95% Confidence Interval for the Median Effluent EMC Estimate (mg/L)	Mean Removal Efficiency Estimate (%)	One-Tailed Sign Test* (H0=H1=0.5)
SSC	16	11.0 to 462	56.0	84***	80 to 88	10.7	5.60 to 15.9	80	R
TVSS	10	10.0 to 420	31.0	93**	89 to 96	9.20	4.19 to 14.2	78	R
SSC<500-um	13	6.00 to 170	26.0	89***	84 to 94	9.55	6.76 to 12.3	68	R
TVSS<500-um	7	12.0 to 130	29.0	---	--- to ---	---	--- to ---	76	R
TSS	16	8.00 to 420	60.0	80***	76 to 84	12.8	8.05 to 17.6	77	R
Hardness	13	10.87 to 87.00	19.00	15***	5 to 26	18.77	16.46 to 21.08	---	~
Total P	6	0.060 to 0.18	0.115	-108**	-228 to 11	0.142	0.092 to 0.192	---	~
TKN	5	0.853 to 2.54	1.76	---	--- to ---	---	--- to ---	---	~
NO2/NO3	4	**0.550** to 1.71	0.633	-67**	-127 to -7	0.701	0.378 to 1.02	---	---
Total Cd	1	0.00100 to 0.00100	---	---	--- to ---	---	--- to ---	---	---
Total Cu	10	0.00421 to 0.0764	0.0162	60***	49 to 70	0.0113	0.00845 to 0.0142	34	R
Total Pb	6	0.00700 to 0.0595	0.0215	73**	57 to 89	0.00703	0.00378 to 0.0103	68	R
Total Zn	8	0.126 to 0.747	0.365	46**	21 to 71	0.221	0.159 to 0.283	42	R
Oil and Grease	10	6.0 to 25	12	41**	1 to 81	8.3	6.1 to 10	---	~

*** = P < 0.001
** = 0.01 > P > 0.001
* = 0.05 > P > 0.01
bold = equivalent to non-detect
--- = undeterminable due to insufficient data quantity
R = removal is significant at the 5% level or less
~ = no significant difference

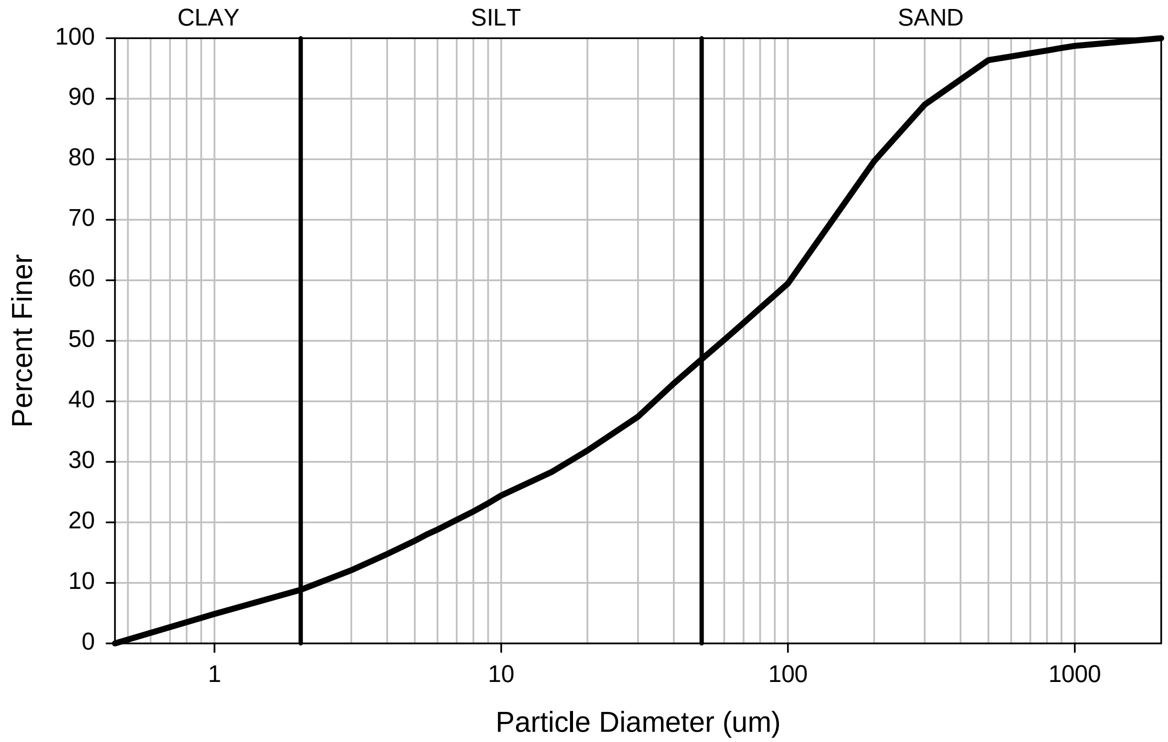
APPENDIX C: RESIDUALS ANALYSIS

General Information

Site:	Greenville Yards (3683), Jersey City, NJ
System Description:	8’x18’, Fine Perlite media, 27 cartridges @ 15 gpm per cartridge
Date of Maintenance:	1/26/05
Date of Previous Maintenance:	6/15/04

Reconstructed Influent Particle Size Distribution

Total Solids:	Sandy Loam (53% Sand, 38% Silt, 9% Clay)



Retained Material Analytical Results

Parameter	units	Mass Retained by StormFilter System		
		Settled	Filtered	Total
Total Solids (dry)	kg	360	51.7	412
Total Cu	g	69.6	32.1	102
Total Zn	g	1200	191	1390
Total Cd	g	1.03	0.143	1.17
Total Pb	g	51.6	30.2	81.8
Total P	g	305	302	608
Total N	kg	1.75	0.917	2.66
Diesel Range Organics	kg	11.6	1.87	13.5
Heavy Oil Range Hydrocarbons	kg	14.8	1.69	16.5
Oil & Grease	kg	24.7	2.86	27.6

Notes

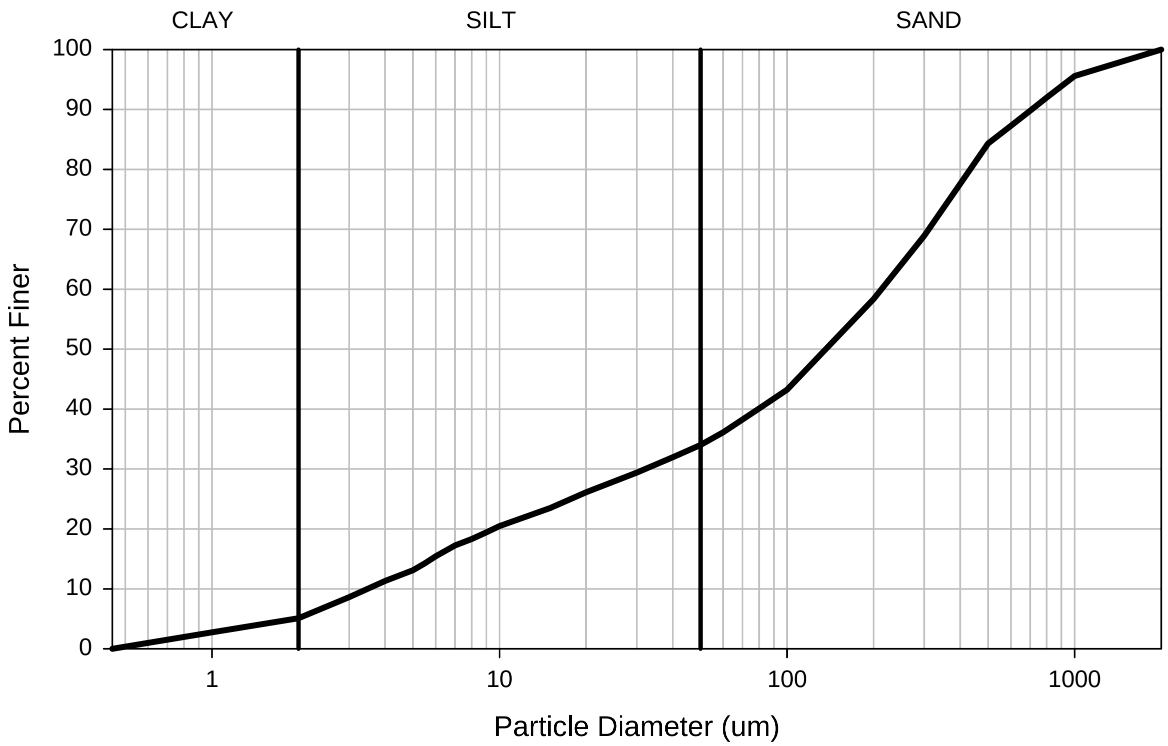
Refer to PE-SP18 for method information.

General Information

Site:	Greenville Yards (3683), Jersey City, NJ
System Description:	8'x18', Fine Perlite media, 27 cartridges @ 15 gpm per cartridge
Date of Maintenance:	7/26/05
Date of Previous Maintenance:	1/26/05

Reconstructed Influent Particle Size Distribution

Total Solids:	Sandy Loam (66% Sand, 29% Silt, 5% Clay)



Retained Material Analytical Results

Parameter	units	Mass Retained by StormFilter System		
		Settled	Filtered	Total
Total Solids (dry)	kg	466	35.1	501
Total Cu	g	113	29.9	143
Total Zn	g	760	266	1030
Total Cd	g	1.86	0.558	2.42
Total Pb	g	85.5	32.5	118.0
Total P	g	995	335	1330
Total N	kg	1.20	0.568	1.77
Diesel Range Organics	kg	9.31	0.850	10.2
Heavy Oil Range Hydrocarbons	kg	11.8	1.58	13.4
Oil & Grease	kg	17.1	2.08	19.2

Notes

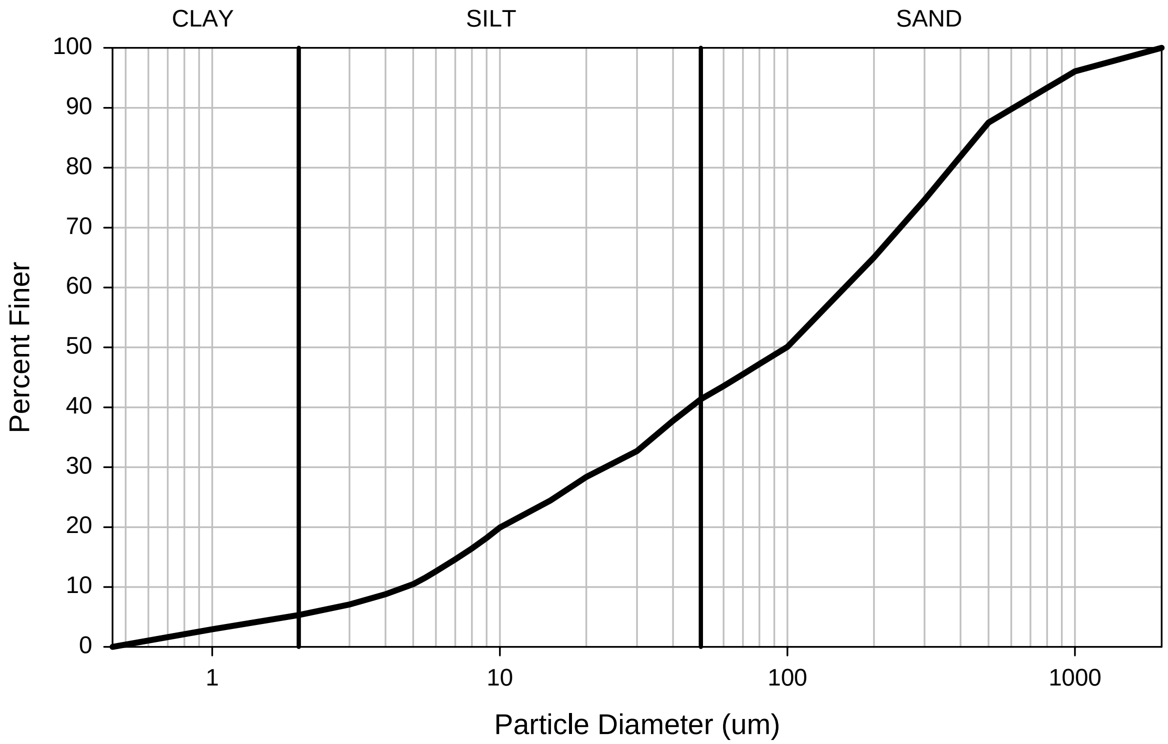
Refer to PE-SP18 for method information.

General Information

Site:	Greenville Yards (3683), Jersey City, NJ
System Description:	8’x18’, Fine Perlite media, 27 cartridges @ 15 gpm per cartridge
Date of Maintenance:	2/28/06
Date of Previous Maintenance:	7/26/05

Reconstructed Influent Particle Size Distribution

Total Solids:	Sandy Loam (59% Sand, 36% Silt, 5% Clay)



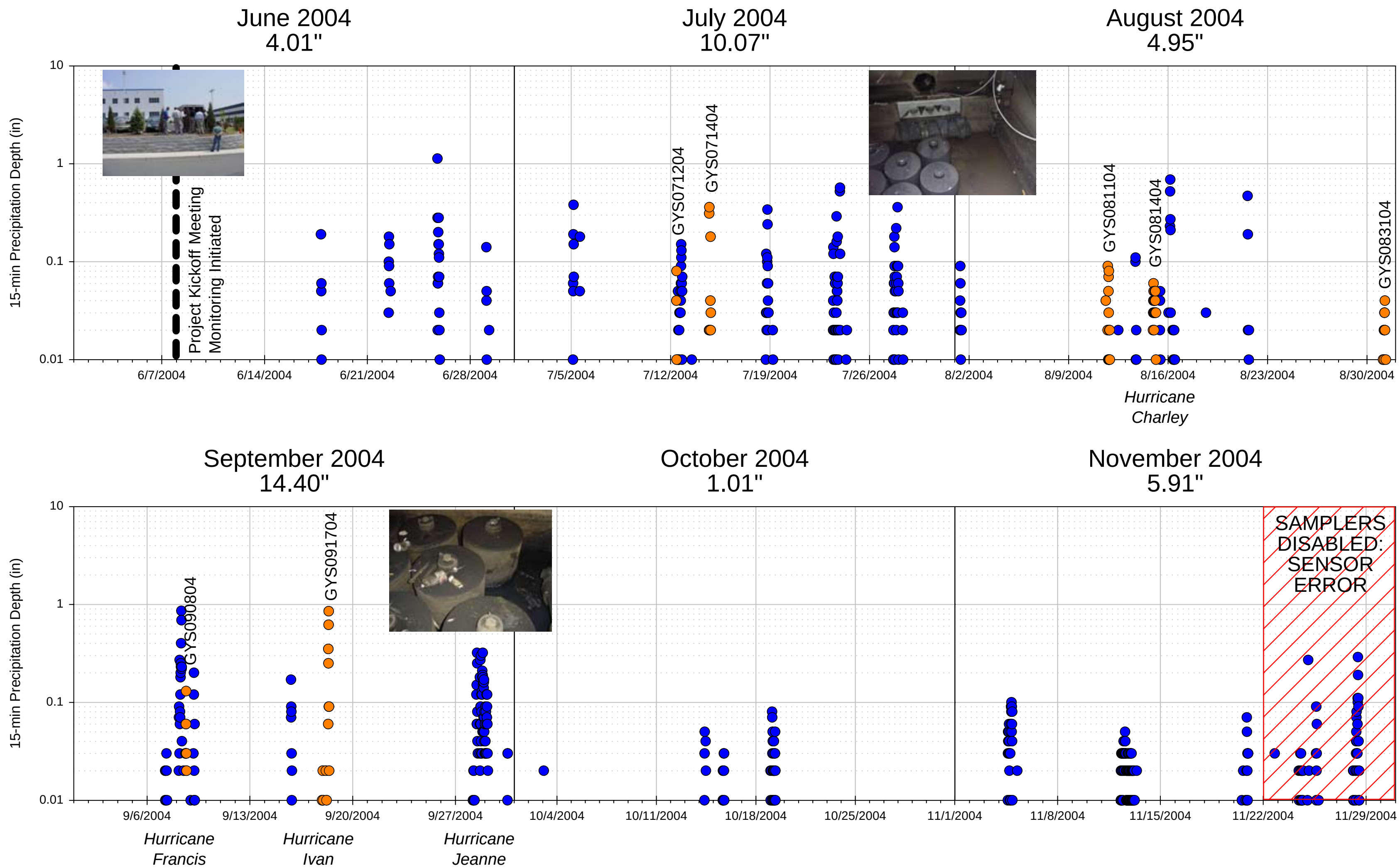
Retained Material Analytical Results

Parameter	units	Mass Retained by StormFilter System: Settled	Filtered	Total
Total Solids (dry)	kg	284	51.3	335
Total Cu	g	79.5	27.3	107
Total Zn	g	1040	269	1310
Total Cd	g	1.04	0.0837	1.12
Total Pb	g	58.5	24.0	83
Total P	g	440	180	620
Total N	kg	0.801	0.565	1.37
Diesel Range Organics	kg	5.08	0.845	5.9
Heavy Oil Range Hydrocarbons	kg	11.2	2.49	13.7
Oil & Grease	kg	12.2	2.33	14.5

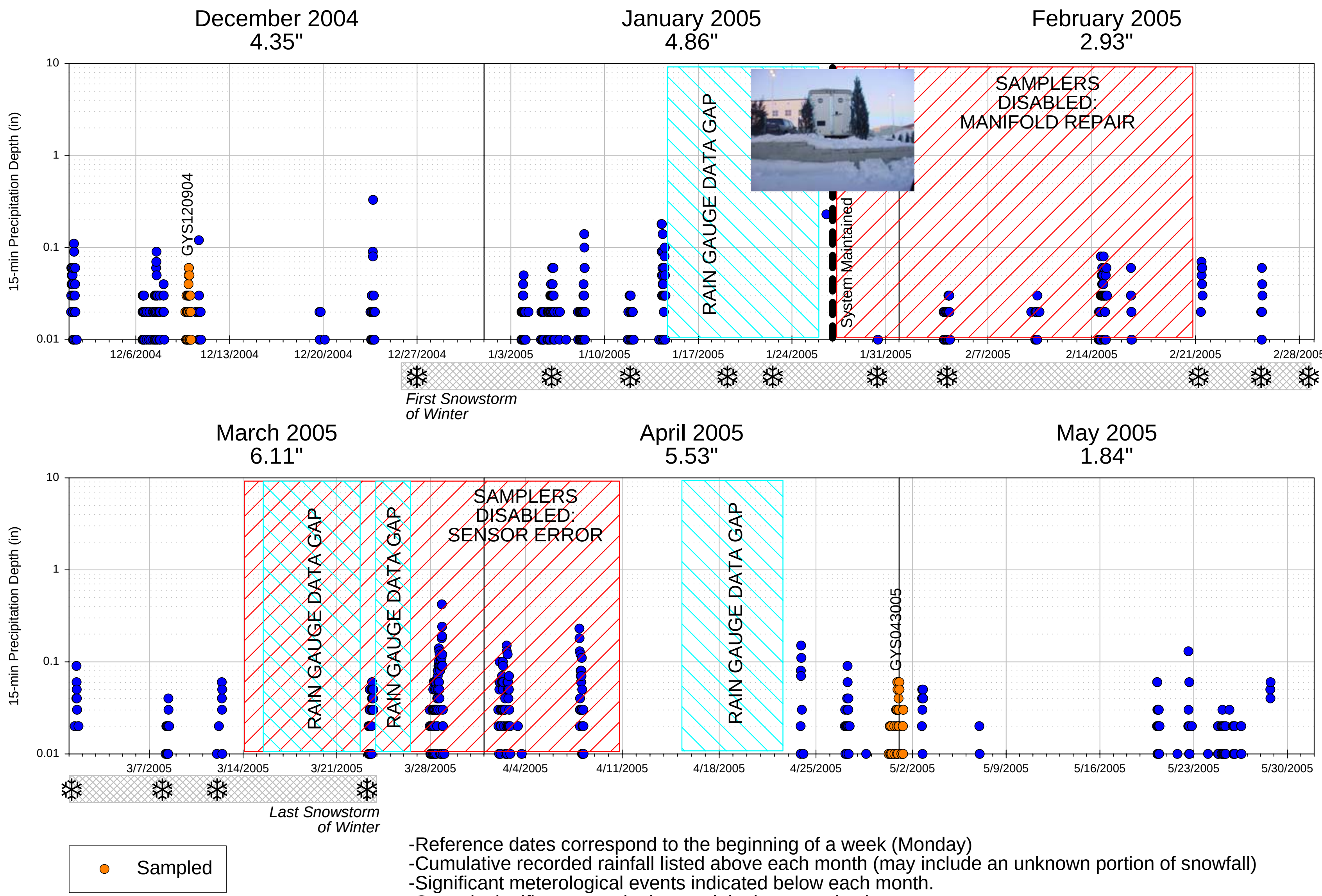
Notes

Refer to PE-SP18 for method information. Of the settled solids, 5% by mass is greater than 2 mm.

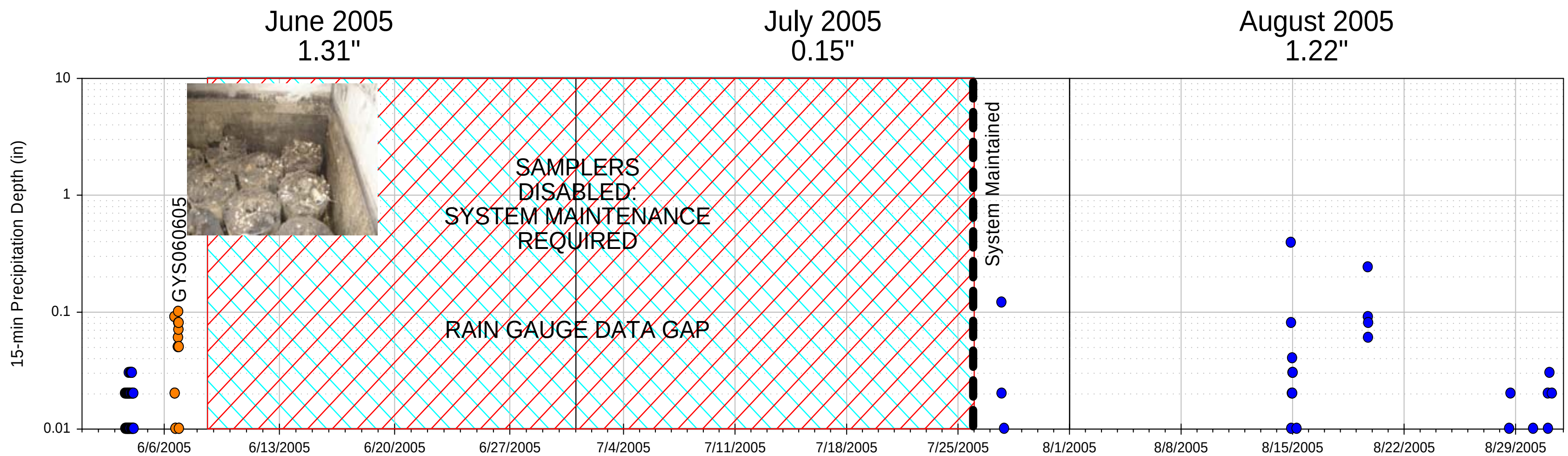
APPENDIX D: MONTHLY RAINFALL DATA

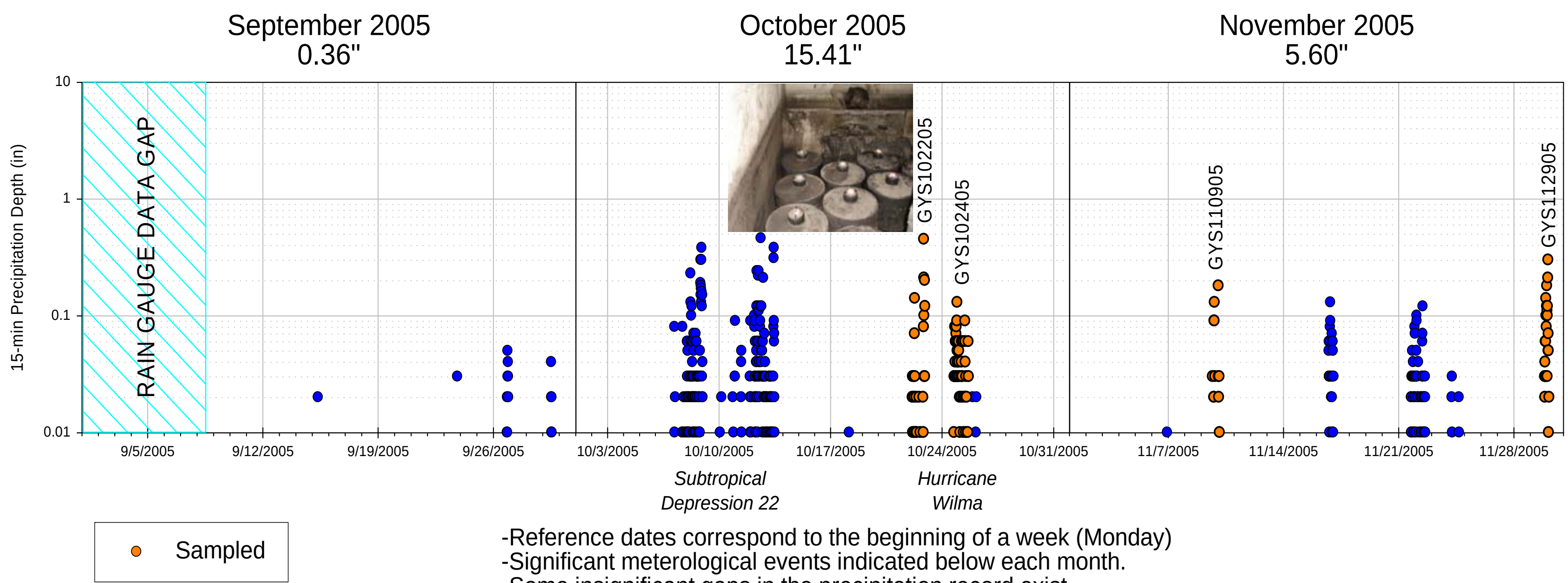


-Reference dates correspond to the beginning of a week (Monday).
-Cumulative recorded rainfall listed above each month.
-Significant meterological events indicated below each month.

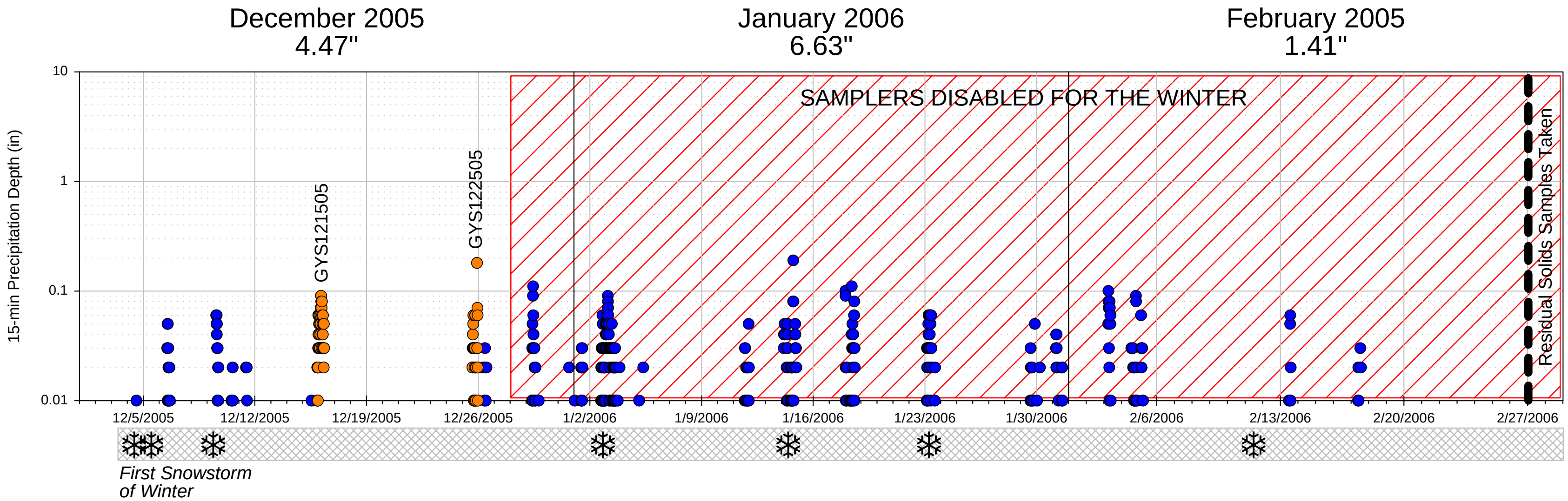


-Reference dates correspond to the beginning of a week (Monday)
-Cumulative recorded rainfall listed above each month (may include an unknown portion of snowfall)
-Significant meterological events indicated below each month.
-Some insignificant gaps in the precipitation record exist.
- ❄ denotes Snowstorm (http://climate.rutgers.edu/stateclim/?section=menu& target=wint0405snowtotals)





-Reference dates correspond to the beginning of a week (Monday)
-Significant meterological events indicated below each month.
-Some insignificant gaps in the precipitation record exist.



-Reference dates correspond to the beginning of a week (Monday)
-Cumulative recorded rainfall listed above each month (may include an unknown portion of snowfall)
-Significant meterological events indicated below each month.
-Some insignificant gaps in the precipitation record exist.
- ❄ denotes Snowstorm (http://climate.rutgers.edu/stateclim/?section=menu&%20target=wint0506snowtotals#12-9-05)