Environmental Technology Verification Report

of the

Low-Cost Stormwater BMP Study

UNIVERSITY of ARKANSAS 1871

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Abstract

This Technology Verification report describes the nature and scope of an environmental evaluation of catchbasin inserts manufactured by AbTech Industries, AquaSheild, Inc., GeoMarine, Inc., and PacTec, Inc. The information contained in this report represents data that were collected in a laboratory study. The study was limited in scope and therefore the information contained within this report should be combined with other evaluations to understand the total capabilities of the inserts. The data as summarized within this Evaluation Report are being made available and distributed to federal, state, and local governmental regulators and to the stormwater treatment community. The goal of this report is to provide users and purchasers of the inserts with information they need to make more informed decisions about catchbasin inserts and their stormwater discharge.

Acknowledgements

The Civil Engineering Research Foundation (CERF) and the University of Arkansas would like to thank those persons who participated in the preparation, review, and approval of this protocol. Due to their efforts, the overall usefulness of this project has been greatly improved.

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We also express appreciation to those companies that assisted by providing equipment for completion of the research. Those companies include: Instrument and Supply Inc. of Hot Springs, AR, Geotechnical Marine Corp, Key West, FL, AbTech Industries, Scottsdale, AZ, AquaShield, Inc. Chattanooga, TN and PacTec, Inc. Clinton, LA.

Finally, the project would not have been possible with out the support of the funding agencies. Funding for this project came from the Mack-Blackwell Transportation Center at the University of Arkansas at Fayetteville, the Arkansas Department of Highways and Transportation (AHTD), and the Federal Highway Administration (FHWA) under the Storm Water Evaluation Component of the FHWA’s Pooled Fund Project (DTFH61-02-X-00010).

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Disclaimer

The information in this document has been funded in part by the Federal Highway Administration (FHWA) under the Storm Water Evaluation Component of the FHWA's Pooled Fund Project (DTFH61-02-X-00010) with the Civil Engineering Research Foundation's (CERF) Environmental Technology Evaluation Center (EvTEC). This verification effort has been subjected to CERF's peer and administrative review. CERF and FHWA make no expressed or implied warranties as to the performance of the inserts evaluated. Mention of corporation names, trade names, or commercial products does not constitute endorsement or recommendation for use of specific products.

Verification Statement

Civil Engineering Research Foundation's Verification Statement for the Low-Cost Stormwater BMP Study

Technology Type:	Stormwater Treatment Technology
Application:	Catchbasin Insert Stormwater Treatment
Technology Name:	Catchbasin Insert BMPs

Company:	AbTech, Industries
Address:	4110 N. Scottsdale Rd. Suite 235 Scottsdale, AZ 85251
Phone:	800-545-8999
URL:	http://www.abtechindustries.com/

Company:	PacTec, Inc.
Address:	PO Box 8069 Clinton, LA 70722
Phone:	800-272-2832
URL:	http://www.drainpac.com/

Company:	GeoTechnical Marine Corp. Advanced Aquatic Products International, Inc.
Address:	1107 Key Plaza #201 Key West, FL 33040
Phone:	305-292-3070
URL:	http://www.Hydro-Cartridge.com

Company:	AquaShield, Inc.
Address:	2733 Kanasita Dr. Chattanooga, TN 37343
Phone:	423-870-8888
URL:	http://aquashieldinc.com/

Program Operation

The CERF Evaluation Program, in partnership with a panel of experts, objectively and systematically documents the performance of commercial-ready technologies. Together, with the full participation of the technology developer, they develop plans, conduct tests, collect and analyze data, and report findings. Verifications are conducted according to a rigorous workplan and established protocols for quality assurance. CERF's Evaluation Program acts as an objective third-party evaluation service.

Technology Description

The technology treatment processes used in catchbasin inserts include: screening, sedimentation, absorption, and floatation depending on the manufacturer. Trash and debris are removed by screening, sediment is removed by sedimentation, whereas, oils, organic chemicals, and hydrocarbons are removed by floatation and absorption.

Evaluation Description

The primary objective of the evaluation of catchbasin inserts was to perform well-defined laboratory tests to provide performance data on each manufacturer's equipment. The data is summarized with this Evaluation Report are being made available for distribution to federal, state, local environmental regulators and to the stormwater treatment community. The goal of this report is to provide potential users and purchasers of catchbasin inserts with this information so that they can make informed decision about using catchbasin inserts in their communities.

Availability of Verification Statement and Report

Copies of the public Verification Statement and Verification Report for the Low-Cost Stormwater BMP Study are available from the following:

Civil Engineering Research Foundation
Suite 600
1015 15th Street, NW
Washington, DC 20005
Web site: http://www.cerf.org/evtec/EVAL/Unofark.htm

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Acronyms and Abbreviations

ASCE	American Society of Civil Engineers
CERF	Civil Engineering Research Foundation
FHWA	Federal Highway Administration
EvTEC	Environmental Technology Evaluation Center
QA/QC	Quality Assurance/Quality Check
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
UofA	University of Arkansas
USEPA	United States Environmental Protection Agency
WAC	Walton Arts Center

cm	centimeter
ft	foot
gpm	gallons per minute
ha	hectare
in	inch
kg	kilogram
lb	pound
m^3/s	cubic meter per second
mm	millimeter
mg/L	milligram per liter

Technical Evaluation Panel Key Contacts

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Project Manager

EvTec assemble the Technical Evaluation Panel Composed of representatives from the user community, academia, and the private sector. The panel oversaw the development and execution of the EvTEC Evaluation Plan and the preparation of this Verification Report. The Technical Evaluation Panel, with the cooperation and assistance of the applicants, identified specific project goals pertaining to the technology

1.0 Introduction

This verification report describes the nature and scope of an environmental evaluation of catchbasin inserts manufactured by four different companies: AbTech Industries, GeoTechnical Marine Corp., AquaShield, Inc., PacTec, Inc. The inserts are manufactured to be retrofitted into existing catchbasins in order to remove sediment, hydrocarbons, metals, nutrients, and debris from stormwater runoff.

The evaluation process and the creation of this report was overseen and coordinated by the Environmental Technology Evaluation Center (EvTEC), a service center of the Civil Engineering Research Foundation (CERF), the research and technology transfer arm of the American Society of Civil Engineers (ASCE). EvTEC is operated through a cooperative agreement with the U.S. Environmental Protection Agency (USEPA). The research was conducted as partial fulfillment of the requirements for a Master's Degree in Civil Engineering and the thesis, with more indepth analysis, is available at the University of Arkansas (Morgan, 2003).

The inserts were evaluated using a prototype catchbasin and in existing parking lot catchbasins. In the prototype catchbasin, a synthetic stormwater was passed through the inserts and the pollutant removal effectiveness was determined at a high flowrate. Operational requirements of the inserts were monitored for six months in catchbasin located in parking lots in Fayetteville, Arkansas.

The goal of this report is to provide users and purchasers of catchbasin inserts with information needed to make informed decisions about the inserts.

1.1 Technical Background

Stormwater characteristics vary from area to area; but, EPA (2001) listed the target pollutants for treatment with catchbasin inserts as litter and debris, solids (both coarse and suspended), and oil and grease (EPA, 2001). Other pollutants are of concern in stormwater are metals (zinc, copper, lead), nutrients (nitrogen, phosphorus), and pathogens. The pollutant removal mechanisms of catchbasin inserts are: screening, sedimentation, flotation, and absorption. Debris and large particles are removed by screening; smaller particles and sediment along with associated hydrocarbons, metals, nutrients, and pathogens are removed by settling; and hydrocarbons that are not associated with sediment are removed by absorption.

1.2 Project Goals

The goal of this project was to evaluate the pollutant removal efficiency of catchbasin inserts treating a flowrate that would be experienced due to a 30-minute SCS Type II storm with pollutant concentrations that are typical for parking lots. In addition, the inserts were evaluated for operational problems. The pollutants that were of concern were: suspended solids, total petroleum hydrocarbons (TPH) and a representative metal (zinc).

1.3 Summary/Overview of Test Program

The Department of Civil/Environmental Engineering at the University of Arkansas was contracted to evaluate inserts. University of Arkansas personnel conducted pilot scale simulations to determine the pollutant removal effectiveness and field tests to observe the inserts under actual working conditions to determine if there were any unexpected operational, maintenance, safety, nuisance, or other issues associated with the inserts. University of Arkansas personnel collected all samples and recorded all observations. Manufacturers representatives were not present during the evaluations

Suspended solids analytical tests were conducted by University of Arkansas researchers. Total petroleum hydrocarbon analytical tests were conducted by an EPA Certified Laboratory, Environmental Services Company, Inc. of Springdale, Arkansas. Zinc analytical tests were conducted by an EPA Certified Laboratory, the USDA Poultry Waste and Water Quality Laboratory on the University of Arkansas campus. The data are presented in Appendix A.

2.0 Methods and Materials

The four inserts were evaluated under field conditions and in pilot scale tests. The field observations were conducted in two parking lots in Fayetteville, Arkansas. The manufacturers provided inserts to hang from the frames of the existing catchbasins in the two parking lots and for pilot scale testing.

2.1 Field Observation

There were two field observation sites, the first site is the Walton Arts Center (WAC) Parking Lot , which provides parking for special events, parking for small businesses (restaurants, bars, and shops), and overflow parking for the University of Arkansas. The second site is the University of Arkansas Physical Plant Vehicle Maintenance Yard (UofA Maintenance Yard)), which provides parking for construction equipment and maintenance vehicles.

The WAC Parking Lot is paved with asphaltic concrete, has no significant run-on, and has area drop inlets to direct runoff to the stormwater collection system. The contributing area to each inlet was approximately 0.2 hectares (0.5 acres) with about 90 percent pavement and 10 percent green space. Grate and frames for the drop inlets are Neenah model R-3573 (Neenah Foundry Company, Neenah, WI). The inserts were placed in the lot and observed for four wettest months of the year (mid-March to mid-July).

The UofA Maintenance Yard is paved with asphaltic concrete, has no run-on, and has area drop inlets to direct runoff to the stormwater collection system. The contributing area to each inlet was approximately 0.14 hectares (0.35 acres) with about 60 percent pavement and 40 percent roof top. Grate and frames for the drop inlets are constructed of steel pipe and angles. The inserts were placed in the lot and observed for seven months (mid-March through October).

2.2 Pilot Scale Testing

The purpose of conducting the simulator study was to test the inserts under controlled conditions. So a simulator was constructed that would:

- provide a known volume and flow rate of water,
- provide known pollutant concentrations,
- allow collection of samples from different tests under near identical conditions, thus allowing for comparison between tests, and allow collection of samples in accordance with a set schedule.

The flow rate selected for the testing was 0.013 to 0.014 m^3/s (200 to 215 gpm). This flow rate was selected because it would be comparable to the average flow rate for a 30 minute storm on the 0.1 ha (0.25 acre) lot as computed by the SCS method. Ten test runs were made on each of the four inserts.

Pollutant concentrations of 225 mg/l TSS and 31 mg/l TPH were selected as typical for stormwater from parking lots based on studies by Novotny and Olem (1994), the ICBIC (1995), and Woodward-Clyde (1998). City of Fayetteville water was spiked with sediment and diesel fuel to obtain these concentrations. The sediment was minus-30 sieve (0.6 mm) street sweepings from the City of Fayetteville. Other than any zinc associated with the street sweepings, zinc was not added to the synthetic stormwater.

A schematic of the pilot scale set up is shown in Figure 1 and a picture of the pilot scale setup is shown in Figure 2. The simulated catch basin consisted of a wooden frame 122 cm square (48 in) and 122 cm (48 in) high. Into this frame, a 76.2 cm x 71.1 cm (30 in x 28 in) hole was cut representing the catch basin frame. The platform was coated with fiberglass to prevent sorption of oil and grease by the wooden frame.

The water was distributed around the periphery of the catch basin in a 5.08-cm (2-in) manifold with 1.3 cm (0.5 in) orifices at 2.54 cm (1.0 in) centers (see Figure 3). The water ran a short distance over a platform on the simulator, then fell over the edge of the catch basin into the insert. This distribution system allowed the system to simulate weir flow into the insert and also allowed for maximum use of the insert material for treatment of the waste.

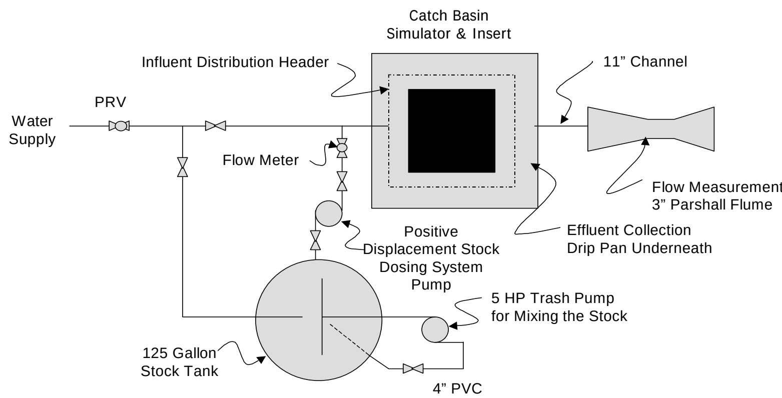

Figure 1. Schematic of pilot scale setup.

Figure 2. Side view of pilot scale set up.

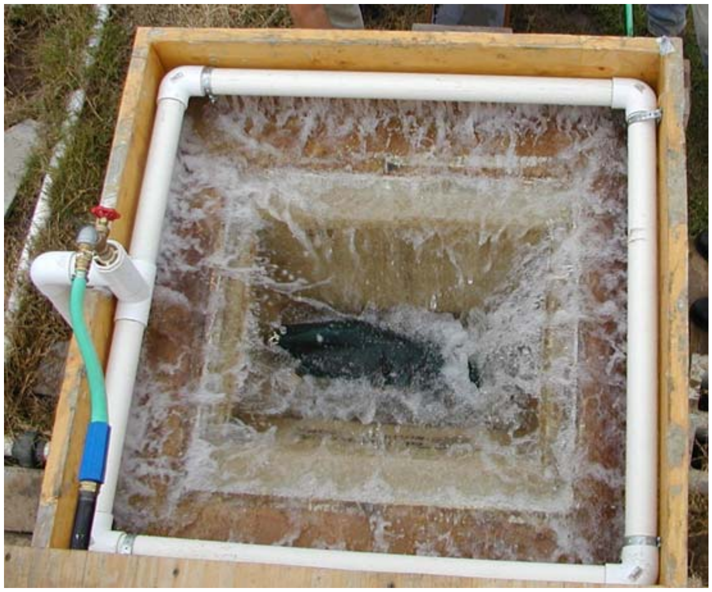

Figure 3. Top view of simulated catchbasin.

2.3 AbTech Industries

The AbTech insert is constructed from high strength corrugated plastic. There are two parts to the AbTech insert, a plastic flange that rested on the catchbasin frame, and the insert that hangs about four inches below the flange (Figure 4). Inside the insert, a plastic mesh covers the sides and bottom. An absorbent material is contained between the wire mesh and the sides or bottom of the insert. After falling through the grate, the water flows directly through the insert and then is discharged from the bottom of the insert. Water ponds in the insert to a point where the available head in the insert is enough to push water through the absorbent material to discharge out the bottom. When flow is higher than the insert could treat, then water bypasses the insert by overflowing between the top of the insert and the plastic flange.

Treatment processes used in the AbTech insert are screening, sedimentation, and absorption. The plastic mesh on the inside of the insert provides screening. Between this mesh and the sides, and between the mesh and the bottom of the insert is an absorbent material that provides for oil and grease absorption. The insert used in the test was 63.5 cm (25 in) deep and the water surface area at the top of the insert unit was 2090 cm^2 (2.25 ft^2).

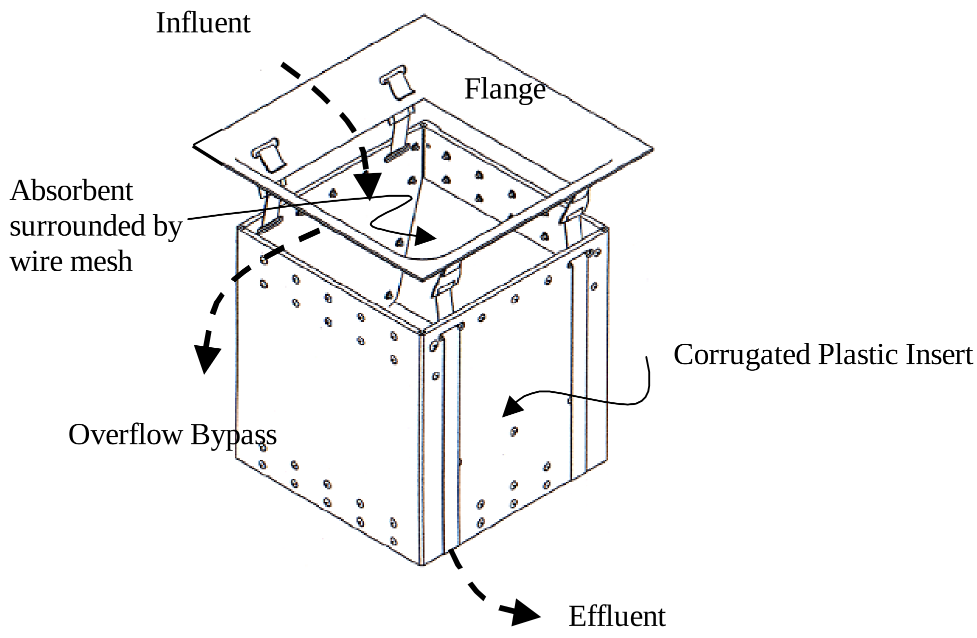

Figure 4. AbTech Industries catchbasin insert.

2.4 AquaShield, Inc.

The AquaShield insert is constructed from stainless steel and high-density polyethylene (HDPE). Stainless steel forms the flange used for hanging the insert from the catch basin frame and supports the insert that is hung below the flange (Figure 5). In the insert, there is an upper compartment that provides for settling. A slotted plug divides the upper and lower compartments and provides straining of stormwater as it flows through the insert. The lower compartment contains an absorbent pillow for oil and grease absorption.

Water enters through the catch basin grate and into the top of the insert then flows through the slotted plug, into the upper compartment of the insert. Water ponds in the upper compartment to a point that the available head is enough to push the water through the slotted plug and the absorbent pillow to discharge out the bottom. When the flowrate is higher than the unit could treat, water bypasses the lower compartment by flowing out of ports around the periphery of the insert. A metal collar inside of the upper compartment prevents bypass of water from the entrance directly to the overflow ports. This collar forms a baffle that forces water downward first, then back up to the overflow.

Treatment processes used in the AquaShield insert are straining, sedimentation, and absorption. The slotted plug that separates the upper compartment from the lower compartment provides straining. Settling occurs in the upper compartment. Absorption of oil and grease was accomplished by the absorbent pillow, which is filled with a patented cellulose material. The AquaShield insert was 46 cm (18.1 in) deep and the surface area at the top of the insert was 1642 cm^2 (1.77 ft^2)

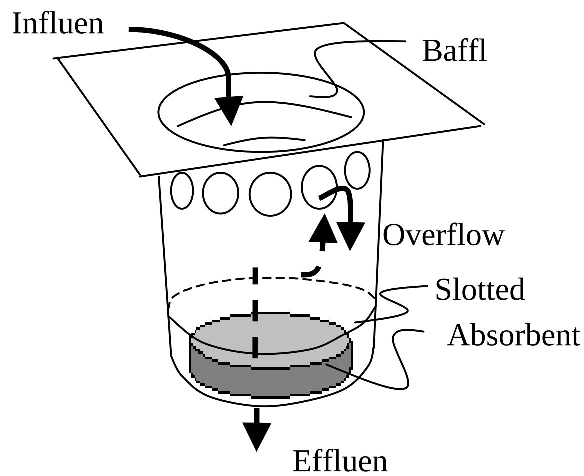

Figure 5. AquaShield catchbasin insert.

2.5 DrainPac

The DrainPac insert is constructed of metal frame to which a plastic mesh is suspended. The metal collar can be constructed to set on the catchbasin frame or to be attached to the catchbasin walls. Set inside of the plastic mesh, a bag filter is placed provide both straining and absorption (Figure 6). Water flows into the insert through the catch basin grate and into the top of the insert. Water flows through the bag filter and then is discharged out of the bottom of the insert. Water ponds in the insert to a point where the available head was enough to push the water through the filter bag. When the flowrate was higher than could be forced through the filter bag then water bypasses the insert by flowing out of four overflow tubes.

Treatment processes used in the DrainPac insert are straining, sedimentation, and absorption. The bag filter provides straining and absorption. Settling occurs within the filter bag volume. The DrainPac insert tested was 50.8 cm (20 in) deep and the water surface area at the throat of the insert was 3,123 cm^2 (3.36 ft^2)

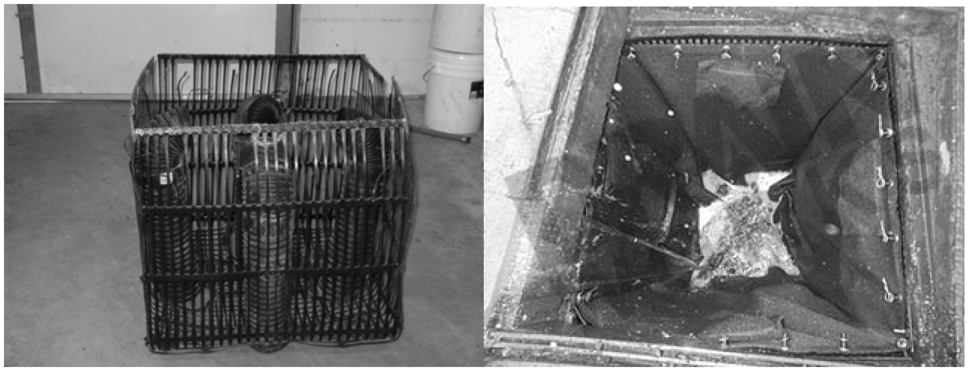

Figure 6. DrainPac catchbasin insert.

2.6 HydroCartridge

The HydroCartridge insert is a single unit constructed from fiberglass that is hung from the catchbasin frame on flanges molded into the insert (Figure 7). Water flows through the catch basin grate and into the top of the insert. From there, all water was forced to flow to the bottom of the insert, then backed up in annular space on two sides where it discharged from the insert over horizontal weirs on each side of the insert. The discharge over the weirs caused water to stand in the insert at all times; but, the company can provide for the insert to drain between storms.

Treatment processes used in the HydroCartridge insert were sedimentation, flotation, and absorption. Sediment and coarse particles with settling velocities greater than the upward velocity in the annular space will settle out. An absorbent sock suspended in the throat of the insert absorbed oil and grease. HydroCartridge's absorbent is a patented material labeled "Rubberizer™." The insert tested was 96.5 cm (38 in) deep and the surface area at the throat of the insert of 3690 cm^2 (3.98 ft^2).

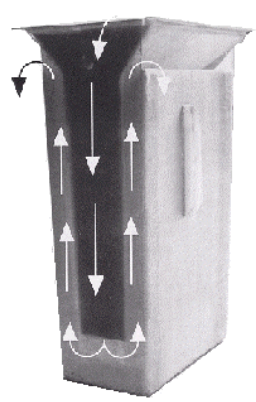

Figure 7. HydroCartridge catchbasin insert.

2.7 Analytical Methods

Analysis for total suspended solids (TSS) was conducted in accordance with Standard Methods 2554 D (APHA, 1998). For total petroleum hydrocarbons (TPH) EPA Method 0418.1 (EPA, 1983b) was used in the analysis. Dissolved zinc samples were analyzed with a SPECTRO Model D ICP Atomic Emission Spectrometer (Kleve, Germany) according to APHA Method 3030E (APHA, 1998).

2.8 Sampling Location and Frequency

Influent grab samples were collected at the top of the pilot scale simulator where water entered the insert. Effluent grab samples were collected below the insert and above the effluent collection pan. The heaviest stream of effluent flow was used as the sampling point. Influent samples were taken at 2, 15, 17, and 30-minutes during each test. The results of the influent tests were averaged for a single influent value. Effluent samples were taken at 5, 10, 20, and 25-minute. The results of the effluent samples were also averaged for a single effluent value.

3.0 Evaluation Project Results

3.1 Field Observations

Installation of the inserts was a simple process and involved lifting the grate, cleaning the frame, setting the insert into the frame, and replacing the grate. At the WAC Parking Lot, the grates were heavy enough to require utilization of a backhoe to lift the grate and to replace it after the insert was installed. Therefore, heavy grates would add to the insert maintenance cost because of the need to have a piece of equipment and an operator each time an insert was cleaned. At the UofA Maintenance Yard, the grates were light enough to lift by hand.

The total rainfall in Fayetteville during the period of study was very close to normal rainfall for the period. The measured rainfall by the National Weather Service at the Drake Field, Arkansas weather station for March 1 through Oct. 31, 2003 was 83.3 cm (32.8 in) versus the 30-year average of 85.2 cm (33.5 in) for the same period (NWS, 2003).

Very little material accumulated in the inserts during the observation period. The lack of accumulation of material was likely due to the almost totally impervious nature of the drainage areas. There was essentially no run-on onto the site; therefore, the only sediment available to the inserts was that which fell off of vehicles in the parking lot. It was noted that the water flowing into the catchbasins WAC Parking Lot was clear. Stormwater runoff was not observed at the maintenance yard.

The material captured by the inserts at the Walton Arts Center, ranged from 40 cm^3 to 190 cm^3 (2.4 in^3 to 11.6 in^3) per insert (Table 1). Removal of accumulated sediment, debris, and other material was not required for any of the inserts during the test period. A sieve analysis was not conducted on the material from the HydroCartridge insert because there was not enough material to analyze.

Table 1. Accumulated solids analysis from the WAC Parking Lot inserts.

Insert	Sediment Volume, cm^3	Sieve Size (mm) % Retained				
		4.75	2.36	1.19	0.60	<0.60
AquaShield	100	17.6	22.7	14.5	13.7	31.5
AbTech	150	38.9	20.2	16.5	12.4	11.9
HydroCartridge	40	-	-	-	-	-
DrainPac	190	8.5	9.3	12.9	15.8	53.5

The results from the field test show 67.7% of particles captured were larger than 0.6 mm diameter. Using Stoke's equation, and an idealized catch basin insert with a throat water surface area of 3000 cm^2 (1.27 ft^2) and a flow rate of 0.013 m^3/s (200 gpm) it was calculated that particles larger than 0.3 mm and some fraction of smaller particles should be removed. This calculation compared favorably with the results given above. The turbulence in the working inserts made them less than idealized settling basins; therefore, causing smaller particles to not be captured. The material captured during the five-month testing period at the Walton Arts Center was mostly coarse sediment, leaves, debris, and litter. In the AbTech insert, enough sediment was captured to support the growth of small vegetation. The AquaShield insert collected material below the filter tray in the second compartment.

Maintenance problems encountered in with the inserts included:

- The AquaShield insert filter tray was unseated during most storms and had to be reset by manipulating it with a metal rod through the grate.
- The HydroCartridge insert was quickly filled with sand from equipment washing at the UofA Maintenance Yard and had to be removed because of flooding problems reported by the maintenance staff. The insert was not reinstalled.
- The DrainPac insert unintentionally had a frontend loader bucket load of dirt dumped into it at the UofA Maintenance Yard; but, only partially filled it, so the insert was left in place, but the material captured was not considered representative of stormwater pollutants.
- The AbTech insert at the WAC Parking Lot had a lot of leafy debris from one storm but the debris had washed out a week later after another storm.

Some of these problems should not be construed as related to these particular inserts; because, each installation or incident was not similarly tested on all inserts. These problems did indicate:

- Public works staff should be educated on the water quality issues related to operation of stormwater BMPs.
- The inserts did captured material from accidental spills and therefore indicates that inserts were effective in preventing accidental spills of sediment.
- Debris (leaves, paper, etc.) might dry out between storms and may wash out of inserts during subsequent storms.
- Inserts must be cleaned according to specific site conditions.

3.2 Pilot Scale Tests

Hydraulic capacity testing of the inserts with clean water indicated that DrainPac, HydroCartridge, and AbTech all had initial capacities in excess of 0.015 m^3/s (240 gpm). The initial hydraulic capacity of the AquaShield insert was 0.00038 m^3/s (6 gpm) without bypassing flow. During pollutant removal efficiency testing, the hydraulic capacity of the DrainPac and AbTech inserts decreased from a capacity greater than 0.015 m^3/s (240 gpm) to less than 0.013 m^3/s (200 gpm).

Total suspended solids percent removal for the inserts varied significantly as shown in Figure 8, where the box plots show the 25th and 75th percentile value. The whiskers are at the 5th and 95 percentile.

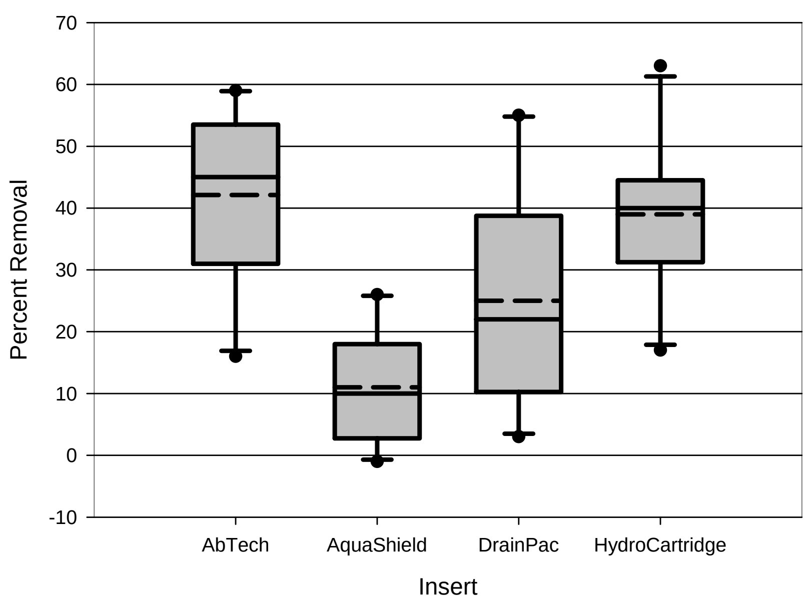

Figure 8. TSS removal efficiency.

Regression analysis of TSS removal efficiency as a function of surface area did show a trend of increasing efficiency with increased surface area. For the available surface area, the AbTech insert performed better than the other inserts; due probably to the fact unlike the other inserts, water flows downward through the AbTech insert and out the bottom.

Another approach to evaluating the effectiveness of the inserts for TSS removal was to look at the trend in removal efficiency with respect to the amount of water filtered. If there was a significant trend, then the slope of that trend would indicate how long the insert could perform before it had to be replaced. During the ten test runs, the TSS removal efficiency of the AquaShield insert decreased from 20 percent to 3 percent, the TSS removal efficiency of the DrainPac insert decreased from 54 percent to 4 percent; whereas, the TSS removal efficiency for the AbTech and HydroCartridge inserts did not change.

The TPH removal efficiency for the inserts was somewhat more consistent than the TSS removal efficiency as shown in Figure 9, where the box plots show the 25th and 75th percentile value. The whiskers are at the 5th and 95 percentile.

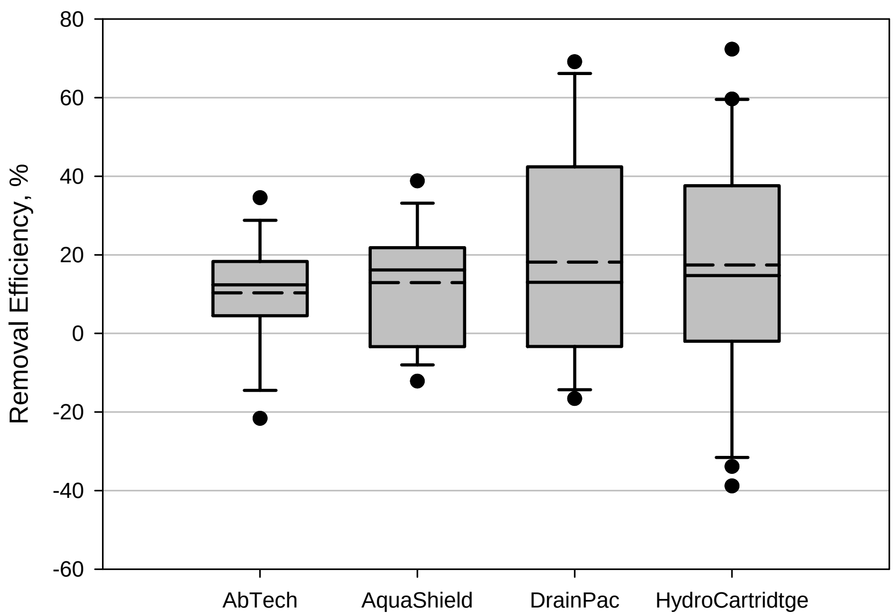

Figure 9. TPH removal efficiency.

After removal of five outliers from the TPH data set, 14 of the 76 tests exhibited negative removal efficiency. This could have been caused from adsorption of diesel onto sediment particles and clumping of these particles. Any one sample could have a higher or lower concentration of these clumps which could be cause the influent concentration to be higher than the average influent concentration and/or the effluent concentration to be lower than the average effluent concentration.

None of the inserts tested exhibited any trend in TPH removal with respect to the volume filtered.

Because the synthetic stormwater was not spiked with zinc, the average concentration of dissolved zinc in the influent samples was only 0.03 mg/l. The results of the zinc tests are presented here (Table 2), but because of the very low concentrations, those results are not considered indicative of the performance of the inserts. None of the inserts exhibited any trends in removal efficiency related to the amount of water filtered. Fourteen of the 80 tests resulted in negative removal efficiencies for dissolved zinc. The most likely causes of negative removal are the same as for the TPH sampling.

Table 2. Zinc removal efficiency.

Insert	Mean Percent Removal
AbTech	39.9
AquaShield	0.0
DrainPac	-6.4
HydroCartridge	47.8

The pH of the simulated stormwater was in the range of 6 to 8 and any change in pH between influent and effluent was insignificant.

3.3 Laboratory QA/QC Summary

The QA/QC for this project included the following:

- Methodology summary
- Method detection limits
- Chain of custody forms
- Field QC checks by duplicating every 10^{th} sample.
- Laboratory QC checks on every 20^{th} sample
- Conformance/Non-conformance summary.

There were no instances that analytical results were outside method QC acceptance criteria.

4.0 Summary

The pollutant removal efficiency of four commercially available catch basin inserts was tested for TSS, TPH, and dissolved zinc. The inserts tested included AbTech Industries Ultra Urban Filter, AquaShield Incorporated's AquaShield insert, PacTec Incorporated's DrainPac, and Geotechnical Marine Corporation's HydroCartridge. Field observations and pilot scale tests were conducted. Pilot scale tests were conducted at flow rates of 0.013 to 0.014 m^3/s (200 to 215 gpm) and concentrations of 225 mg/l for TSS and 31 mg/l for TPH.

4.1 Maintenance and Cost

Two general operational problems of catchbasin inserts were discovered during the testing: 1) the potential for plugging if the inserts are overloaded with sediment, and 2) the potential for debris to dry between storms and flush out in a subsequent storm. Little can be done affordably to solve the second problem; but, the first problem could be solved by appropriate training and maintenance.

Maintenance of inserts is fairly simple provided the inlet grate can be lifted by manpower and power equipment is available for vacuuming the accumulated sediment and debris from the insert. A city or other entity considering catch basin inserts as a component of its stormwater management system should consider the maintenance requirements as well as the initial costs.

Education of citizens and city employees regarding illegal dumping of pollutants into storm drains would decrease maintenance requirements and help avoid plugging and the subsequent flooding that may follow. In addition, a regular schedule of inspection and cleaning could result in more effective removal of debris.

Two operational problems that were particular to the current design of two inserts were discovered during testing: 1) due to an large accidental spill of sediment, the HydrCartridge insert plugged and caused localized flooding, and 2) the slotted center plug of the AquaShield insert could become dislodged and flip if the catchbasin becomes flooded or surcharged.

The quoted cost as of January 2003, without shipping, of each of the four inserts are shown in Table 3.

Table 3. Quoted cost of inserts.

Insert	Quoted Price
AbTech Ultra	\$590
AquaShield™	\$1,200
DrainPac™	\$500
HydroCartridge™	\$1000

4.2 Pollutant Removal

Under the controlled pilot test conditions, the inserts were able to achieve average total suspended solids and total petroleum hydrocarbon removal as shown in Table 4.

Table 4. Average pollutant removal percentages.

Insert	Average TSS Removal (%)	Average TPH Removal (%)
AbTech Ultra	45	11
AquaShield™	10	16
DrainPac™	22	10
HydroCartridge™	40	15

4.3 Summary

For the pollutants (gradation and concentration) and the relatively high flowrates tested in this evaluation, the pollutant removal efficiencies determined in this study were moderate to low and were lower than determined in some previous evaluations (ICBIC, 1995; Woodward-Clyde, 1998; EPA, 1999; CEPA, 2000; Creech Engineers, 2001). Maintenance problems were encountered with some of the inserts and some of the observation locations, which could cause flooding, release of captured debris, decrease in pollutant capture, and mosquito breeding. In addition, due to this work and other findings, some of the manufacturers have made modification in their inserts to improve operation and pollutant removal capabilities. Selection of inserts should take into account many factors; such as, flowrate, pollutants, pollutant concentration, sediment gradation, maintenance requirement, and the current design of the inserts.

REFERENCES

APHA. (1998). *Standard Methods for the Examination of Water And Wastewater, 20th. Edition*. American Public Health Association, Washington, DC.

Creech Engineers. (2001). "Pollutant Removal Testing for a Suntree Technologies Grate Inlet Skimmer Box." Melbourne, FL.

CEPA (2000). "Evaluation of the AquaShield Filtration System (Model SD-100, Series 576)." Environmental Technology Certification Program. California Environmental Protection Agency available at http://www.calepa.ca.gov/CalCert/. Accessed February 28, 2003.

EPA. (1983a). "Results of the Nationwide Urban Runoff Program. Vol. 1. Final Report." U. S. Environmental Protection Agency, Water Planning Division, Washington DC.

EPA. (1983b). "Methods for Chemical Analysis of Water and Wastes." *Document EPA 600/4-79-020*, U. S. Environmental Protection Agency. Available at http://www.epa.gov/clariton/. Accessed in January 2003.

EPA. (1999). "Preliminary Data Summary of Urban Stormwater BMPs." *Document EPA-821-12-99-012*, U. S. Environmental Protection Agency Office of Water, Washington, D.C.

EPA. (2001). "Catch Basins/Catch Basin Inserts, Post-construction Stormwater Management in New Development and Redevelopment." U. S. Environmental Protection Agency, Office of Water, Office of Wastewater Management, Washington, D.C.

ICBIC. (1995). "Evaluation of Commercially-Available Catch Basin Inserts for the Treatment of Stormwater Runoff from Developed Sites." Interagency Catch Basin Insert Committee for King County, Washington, King County, WA.

Morgan, Robert. A. (2003). *An Evaluation of the Urban Stormwater Pollutant Removal Efficiency of Catch Basin Inserts*. Master's Thesis, Department of Civil Engineering, University of Arkansas at Fayetteville.

NWS. (2003). "Local Climatological Data." National Weather Service Forecast Office, Tulsa, OK. Available at http://www.srh.noaa.gov/tulsa/climo.htm. Accessed in January 2003.

Novotny, V. and Olem, H. (1994). *Water Quality, Prevention, Identification and Management of Diffuse Pollution*. Van Nostrand Reinhold, NY.

Woodward-Clyde (1998). *Santa Monica Bay Area Municipal Stormwater/Urban Runoff Pilot Project – Evaluation of Catchbasin Retrofits*. Santa Monica Cities Consortium, Santa Monica, CA.

Appendices

Appendix 1: AbTech Data

Sample #		TSS (mg/l)	Turbidity (NTU)	TPH (mg/l)	Zinc (mg/l)
I	100	176.6	45.2	8.13	0.0282
E	105	90.2	31.7	5.47	0.0104
E	110	84.7	34.1	6.11	0.0073
I	115	280.3	32.5	9.32	0.0177
E	120	125.0	29.9	6.98	0.012
E	125	105.9	37.4	10.37	0.0141
I	200	275.3	35.5	10.71	0.0402
E	205	99.7	40	13.19	0.0192
E	210	232.6	43.7	19.26	0.0145
I	215	297.7	39.9	13.98	0.0274
E	220	111.7	33.9	12.34	0.01
E	225	115.7	41.8	5.97	0.0123
E	226	91.5		7.43	0.0223
I	300	253.2	43.65	11	0.0166
E	305	177.3	42.2	9.31	0.0205
E	310	175.5		11.7	0.0185
I	315	288.4	43.2	10.37	0.0233
E	320	190.9	37.3	9.77	0.0123
E	325	96.5	39	12.98	0.0095
I	400	285.5	53.05	17.53	0.0334
E	405	175.8	40.4	13.83	0.0178
E	410	77.2	46.1	15.43	0.0225
I	415	295.6	45.95	19	0.0421
E	420	230.3	41.7	15	0.0297
E	425	167.4	42.8	16.04	0.0109
E	426	145.1		14.07	0.0229
I	500	247.0	48.15	17.63	0.0296
E	505	177.9	38.8	15	0.0051
E	510	193.6	47.1	13.94	0.0125
I	515	271.3	42.95	17.14	0.0268
E	520	166.8	41.4	14.65	0.01
E	525	157.1	37.4	11.95	0.0068
I	600	196.4	45.15	16.39	0.0314
E	605	187.6	43.5	11.98	0.0208
E	610	162.3	38.1	13.76	0.0134
I	615	214.2	40.4	14.26	0.0214
E	620	184.9	34.8	11.87	0.0159
E	625	156.8	38.4	13.4	0.0191
E	626	169.7		14.36	0.0129
I	700	291.1	37.5	12	0.0216
E	705	132.3	39.8	14.15	0.0094
E	710	136.0	33.7	13.33	0.0136
I	715	272.0	42.3	19	0.0207

E	720	162.5	37.6	15.21	0.0232
E	725	163.9	42.4	17.87	0.0156
I	800	300.6	39.3	18.67	0.0254
E	805	168.0	35.4	17.34	0.0179
E	810	163.4	43.7	16.17	0.0198
I	815	344.4	45.6	20.67	0.0211
E	820	205.9	34.7	17.14	0.0248
E	825	163.6	43.6	17.85	0.0082
E	826	191.6		16.12	0.0111
I	900	277.6	31.5	9.24	0.0033
E	905	193.1	29.3	8.44	0.0119
E	910	102.2	35.3	7.76	0.0124
I	915	344.7	30.4	6.78	0.0334
E	920	159.6	22.5	17.87	0.0102
E	925	148.7	30	5.22	0.0138
I	1000	320.7	33.15	9.77	0.0158
E	1005	143.9	25.1	12.07	0.0103
E	1010	75.4	28.9	11.7	0.0162
I	1015	321.4	20.8	14.55	0.0202
E	1020	133.6	25.9	14.79	0.0171
E	1025	160.1	25.2	12.06	0.0109
E	1026	158.2		15.5	0.0118

Numbering scheme for samples
I = influent sample
E = effluent sample

XXYY = XXth. test run, YYth. minute after start of run. For instance, E 1210 is an effluent sample taken from the 12th. test run, 10 minutes after initiation of the sampling run.

Appendix 2: AquaShield Data

	Sample #	TSS (mg/l)	Turbidity (NTU)	TPH (mg/l)	Zinc (mg/l)
I	100	389.3	33.15	5.7	0.0372
E	105	204.3	24.5	7.14	0.014
E	110	197.8	28.3	5.65	0.0304
I	115	328.7	28.55	12.16	0.0236
E	120	166.4	24.8	9.19	0.0159
E	125	161.3	29.2	8.68	0.0172
I	200	448.0	31.3	10.9	0.0204
E	205	485.1	28.3	8.48	0.1388
E	210	146.7	28.5	8.59	0.0222
I	215	400.9	29.35	13.87	0.0272
E	220	282.3	27.5	10.62	0.0417
E	225	194.4	20.5	12.88	0.0318
E	226	155.6		11.33	0.0463
I	300	410.4	23.8	9.56	0.0322
E	305	184.7	25.9	13.94	0.0372
E	310	241.0	29	13.29	0.0553
I	315	421.9	29.2	13.3	0.0476
E	320	175.0	30.2	11.5	0.0368
E	325	158.4	26	10.81	0.0055
I	400	377.5	27.95	11.56	0.0397
E	405	133.9	28	12.02	0.0162
E	410	150.9	27.7	12.95	0.013
I	415	339.1	28.6	12.84	0.0241
E	420	178.4	26.6	11.93	0.015
E	425	195.4	25.8	14.23	0.0233
E	426	256.1			0.0265
I	500	447.5	28.65	15.09	0.0493
E	505	84.6	20	15.39	0.0086
E	510	147.9	29.9	16.72	0
I	515	512.8	27.8	17.56	0.0305
E	520	214.3	25.9		0.0253
E	525	174.8	24	13.73	0.0102
I	600	408.6	26.3	14.71	0.0134
E	605	214.1	24.6	12.03	0.0518
E	610	184.1	32.1	11.56	0.0186
I	615	514.1	32.3	18.73	0.0245
E	620	232.8	25.9	11.38	0
E	625	216.7	33.7	11.56	0.023
E	626	197.2		14.22	0.0178
I	700	376.3	28.55	13.04	0.0174
E	705	190.8	27.5	12.32	0.012
E	710	206.5	24.2	11.46	0.0054
I	715	344.6	32.55	13.84	0.0117

E	720	264.5	29.7	6.56	0.0111
E	725	193.4	27.3	12.1	0.0022
I	800	290.1	32.1	13.2	0
E	805	172.1	28.5	12.86	0.0044
E	810	211.4	30.4	15.35	0.0509
I	815	394.0	31.45	18.77	0.0167
E	820	180.6	26.5	14.25	0.009
E	825	176.9	26	16.9	0.0136
E	826	162.4		14.64	0.0182
I	900	348.0	29.7	12.51	0.0186
E	905	225.3	23.4	13.03	0.0186
E	910	183.2	31.1	12.84	0.0124
I	915	318.7	30.5	14.1	0.0269
E	920	234.3	28.8	11.58	0.0205
E	925	184.6	29.4	12.77	0.008
I	1000	471.0	28.05	16.48	0.0178
E	1005	168.2	28	13.9	0.0253
E	1010	184.9	29.6	13.01	0.0103
I	1015	349.6	31.15	19.66	0.0209
E	1020	180.9	25.6	10.25	0.0084
E	1025	226.3	34	16.04	0.0122
E	1026	187.7		13.98	0.0053

Numbering scheme for samples
I = influent sample
E = effluent sample

XXYY = XXth. test run, YYth. minute after start of run. For instance, E 1210 is an effluent sample taken from the 12th. test run, 10 minutes after initiation of the sampling run.

Appendix 3: DrainPac Data

Sample #		TSS (mg/l)	Turbidity (NTU)	TPH (mg/l)	Zinc (mg/l)
I	600	81.5	22.1	3.39	0.005
E	602	123.4	11.9	4.35	0.0342
E	605	92.5	16.9	1	0.0499
E	610	66.3	17.6	5.29	0.0186
I	615	324.3	54.3	1.14	0.0252
E	620	231.9	53.6		0.0394
E	630	29.3	29.3	5.39	0.0481
E	631	75.1	29.3	3.23	0
I	700	354.2	57.7	10.71	0.0346
E	702	189.2	44.9	6.67	0.0194
E	705	213.8	46.6	11.74	0.0134
E	710	131.0	63.7	13.98	0.0083
I	715	325.1	69.7	10.84	0.019
E	717	185.3	52.5	9.62	0.0025
E	730	77.3	56.1	15.66	0.0184
I	800	211.7	50.2	6.79	0.0089
E	802	107.3	37.6	6.32	0.0037
E	805	97.6	31.9	4.84	0.0018
E	810	97.4	32.2	4.9	0
I	815	309.1	52.8	9.26	0.0205
E	817	179.6	41	6.89	0.0186
E	830	99.9	46.7	12.57	0.0915
I	900	130.6		1	0.0531
E	905	96.0		3.84	0.024
E	910	39.9		1	0.0168
I	915	355.3	40.4	16.67	0.0685
E	920	225.3	38.1	8.08	0.043
E	925	209.0	32.2	8.88	0.0421
I	1000	298.6	35	5.02	0.0649
E	1005	153.9		3.04	0.0423
E	1010	141.6	39.4	3.83	0.0527
I	1015	247.7	44.5	28.4	0.0543
E	1020	140.1	42.8	7.89	0.0448
E	1025	171.6	41.3	11.54	0.0607
I	1100	253.5	52.45	6	0.0278
E	1105	213.2	49.6	5.45	0.0372
E	1110	179.8	46.5	4.72	0.0335
I	1115	241.8	46.65	11.24	0.0485
E	1120	192.8	44.7	11.36	0.0388
E	1125	208.2	46	11.78	0.0437
E	1126	204.5	46		0.0372
I	1200	219.8	52.5	6.98	0.0224
E	1205	199.7	45.9	4.55	0.033

E	1210	161.0	46	6.67	0.0381
I	1215	208.4	54.95	5.5	0.0192
E	1220	195.7	45.2		0.0178
E	1225	165.2	49		
I	1300	231.6	44.1	3.78	0.0539
E	1305	212.9	39.6	3.26	0.0177
E	1310	197.8	39.3	3.49	0.0298
I	1315	191.5	45.4	6.03	0.028
E	1320	206.8	33.2	5.73	0.0251
E	1325	148.4	44.5	6.34	0.0081
E	1326	191.8	44.5		0.0138
I	1400	239.0	50.05	2.66	0.0164
E	1405	221.1	34.2	3.7	0.0128
E	1410	157.4	39.3	2.37	0.005
I	1415	296.5	49.8	17.16	0
E	1420	198.8	56.1	7.91	0.0145
E	1425	265.5	45.2	10	0.0057
I	1500	188.1	42.5		0.0057
E	1505	178.4	34.7	7.23	0.015
E	1510	129.4	38.1	1.85	0.0221
I	1515	315.1	63.9	2.62	0.0235
E	1520	223.9	48.7	16.78	0.0114
E	1525	183.0769	45.8	7.1	
E	1526	249.8925	45.8	12.84	

Numbering scheme for samples
I = influent sample
E = effluent sample

XXYY = XXth. test run, YYth. minute after start of run. For instance, E 1210 is an effluent sample taken from the 12th. test run, 10 minutes after initiation of the sampling run.

Appendix 4: HydroCartridge Data

	Sample #	TSS (mg/l)	Turbidity (NTU)	TPH (mg/l)	Zinc (mg/l)
I	100	139.7	37.3	6	0.0154
E	105	140.5	22.4	5.45	0.0056
E	110	107.2	23.5	4.72	0.0012
I	115	216.9	51.5	11.24	0.0167
E	120	154.4	42.4	11.36	0.0226
E	125	108.1	47.5	11.78	0.0218
I	200	263.9	41.7	6.98	0.0261
E	205	175.7	27	4.55	0.0103
E	210	132.2	27.8	6.67	0.0157
I	215	214.4	29.5	5.5	0
E	220	143.5	29.1	7.22	0.0008
E	225	85.3	25.1	7.51	0.0026
E	226	46.9		5.85	0
I	300	218.4	34.8	9.78	0
E	305	114.6	32.8	4.05	0
E	310	27.6	24.7	1.37	0
I	315	355.6	42.65	13.74	0
E	320	174.9	39.6	6.45	0.008
E	325	166.6	36.5	4.65	0.0106
I	400	192.8	46.4	7.74	0.0096
E	405	190.6	37.1	6.88	0.011
E	410	151.8	40.5	6.59	0.018
I	415	264.2	36.35	8.51	0.0125
E	420	201.4	33.5	2.84	0.0036
E	425	188.9	39.3	5.29	0.0036
E	426	69.6		6.29	0.0094
I	500	253.7	41.2	5.11	
E	505	126.7	40.3	5.47	0
E	510	167.5	40.5	8.72	0
I	515	210.6	58.3	8.15	0.0058
E	520	90.2	27.8	5.11	0
E	525	194.3		4.97	0
I	600	280.1	49.85	13.86	0.0464
E	605	115.8	40.8	8.14	0.0351
E	610	31.9	29.9	3.26	0.0102
I	615	273.3	47.5	14.56	0.0425
E	620	159.4	45.6	13.07	0.0257
E	625	168.3	43.4	15.78	0.0247
E	626	173.6		13.71	0.0091
I	700	298.2	48.05	13.45	0.0297
E	705	157.3	41.8	9.33	0.0074
E	710	101.0	40.9	12.23	0.0143
I	715	389.5	40.55	9.76	

E	720	131.6	30.6	9.66	0
E	725	131.7	36.2	10.64	0.0063
I	800	316.9	43.6	16.93	0.0319
E	805	188.2	37.8	13.41	0.0295
E	810	171.9	40.9	17.11	0.0209
I	815	299.3	45.25	15.77	0.023
E	820	186.9	40.6	11.5	0.0035
E	825	150.5	38.3	15.57	0.0168
E	826	206.4		17.38	0.0278
I	900	331.4	42	15.66	0.0198
E	905	151.3	40.1	12.98	0.0086
E	910	271.8	43.1	12.66	0.0002
I	915	357.2	44.85	11.66	0.0165
E	920	159.6	40.1	13.45	0.0065
E	925	168.9	42.9	12.33	0.012
I	1000	364.7	46.1	18.16	0.0192
E	1005	184.1	44	14.49	0.025
E	1010	220.6	45.7	18.31	0.0162
I	1015	309.4	53.35	28.06	0.0306
E	1020	209.8	44.1	13.59	0.0197
E	1025	189.3	44.1	22.38	0.0196
E	1026	174.3		20.25	0.0221

Numbering scheme for samples
I = influent sample
E = effluent sample

XXYY = XXth. test run, YYth. minute after start of run. For instance, E 1210 is an effluent sample taken from the 12th. test run, 10 minutes after initiation of the sampling run.