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An evaluation of the stormwater quality performance of catch basin filter/inserts

C. Russell Wagner

To the Graduate Council:

I am submitting herewith a thesis written by C. Russell Wagner entitled "An evaluation of the stormwater quality performance of catch basin filter/inserts." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Environmental Engineering.

Bruce A. Tschantz, Major Professor

We have read this thesis and recommend its acceptance:

James L. Smoot, William A. Miller

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a thesis written by Chad R. Wagner entitled, "*An Evaluation of the Stormwater Quality Performance of Catch Basin Filter/Inserts*." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment for the degree of Master of Science with a major in Environmental Engineering.

Dr. Bruce A. Tschantz, P.E. Major Professor

We have read this thesis
and recommend its acceptance:

Dr. James L. Smoot, P.E.

Dr. William A. Miller, P.E.

Accepted for the Council:

Associate Vice Chancellor and
Dean of The Graduate School

AN EVALUATION OF THE STORMWATER QUALITY PERFORMANCE OF CATCH BASIN FILTER/INSERTS

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Chad R. Wagner
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ABSTRACT

With the impending implementation of EPA's National Pollutant Discharge Elimination System (NPDES) Phase II regulations, the demand for innovative and effective means of dealing with point and non-point source pollution is and will continue growing. Catch basin filters have been recently introduced as an alternative type of stormwater quality Best Management Practice (BMP) . With Phase II requirements on the horizon, numerous companies have begun manufacturing and selling unique designs of catch basin insert/filters. This thesis will present a performance analysis of these innovative water quality BMPs to determine if all filter models are practical for all hydrologic and hydraulic conditions. The study will summarize what the filters are and what they do, what filters are being manufactured and by whom, and what level of performance has been observed by selected municipalities who are using the inserts. Also summarized is a field study on the AquaShield™ catch basin filter that was conducted to determine the expected pollutant removal efficiency and overall performance in a highly urban setting. The primary purpose of this thesis is to evaluate the overall performance of catch basin insert/filters and develop recommendations and guidelines for municipalities to use when considering the installation of a this type of water quality BMP.

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Chapter 1 - Introduction

1.1 Background:

Research conducted in the past 20 years has shown that urbanization in watersheds can have adverse effects on the streams, lakes and all other receiving waters. Increased flooding, streambank erosion and extreme water quality degradation are all consequences of urbanization. In the past, management efforts have focused primarily on drainage and flood control through the use of dry detention basins which temporarily store runoff in order to attenuate peak flows so that downstream receiving waters do not experience an increase in peak flows. While Stormwater Quantity Best Management Practices (BMP's) such as detention ponds have done a good job at curtailing flooding problems, they have little or no effect on urbanization's impact on stream habitat and water quality. Recognition, or the need to address stormwater quality, had its modest beginning in the late 1970's, but did not become a major objective of municipalities until the advent of the Clean Water Act (CWA) of 1987. The CWA established two programs which were intended to assist municipalities in improving their stormwater quality: Section 39 Non-point Source Control and (402) Stormwater Permitting.

EPA's stormwater quality permitting requirements, the National Pollution Discharge Elimination System (NPDES), were developed as a result of the preceding CWA programs. The NPDES is the primary permitting program under the CWA, which regulates all stormwater discharges to surface water. Current regulations (Phase I) of the NPDES program requires stormwater permits for the following categories:

- Stormwater discharges associated with industrial activity
- Stormwater discharges from construction sites disturbing five acres or greater
- Discharges from municipal separated storm sewers from cities with populations greater than 100,000.

NPDES Phase II regulations are currently being issued and focus on smaller municipalities with populations less than 100,000 but greater than 50,000 as well as construction activity less than five acres. With these new water quality regulations, the demand for innovative and effective means of dealing with point and non-point source pollution is great and will continue to grow.

To achieve the NPDES requirements, there are numerous structural stormwater quality BMP's used in practice. The following is a short list of common structural BMP's utilized today:

1. Retention Ponds
2. Detention Ponds
3. Extended Detention Ponds
4. Infiltration Trenches/Basins
5. Swales
6. Constructed Wetlands
7. Absorption/Filtration Systems
8. Vegetative Practices
9. Catch Basin Filters

Recently, catch basin filters have been introduced as an alternative type of stormwater quality BMP. With Phase II requirements on the horizon, numerous companies have begun manufacturing and distributing unique designs of catch basin filters. Catch basin inserts are a relatively new type of technology in the realm of stormwater quality best management practices (BMP's). They can be an effective means of reducing nonpoint source pollution. The inserts are not typically designed to provide any temporary storage, thus play no active roll in reducing the post development peak discharge. Catch basin inserts are typically designed to serve parking lots under one acre in size or urban roadways that are expected to receive intense hydrocarbon loadings. Sediment removal is also a benefit of the inserts, yet routine maintenance is required to assure that the system operates according to manufacturer's performance promises and does not become clogged with suspended material or debris.

There are several models or designs of catch basin inserts on the market, which can meet site specific conditions. The following is an abbreviated list of catch basin insert applications:

- Retrofitting existing or a new surface opening without additional construction.
- Capturing debris and pollutants entering curb grates or combination inlets along roadways.
- In-line treatment systems designed for heavier stormwater flow conditions.
- Flow from secondary containment dikes.
- Limited emergency response conditions (hazardous materials spills, pipeline bursts, etc.)

- Treatment of water from remote washdown areas.

Catch basin filters/inserts are usually applied or retrofitted in highly urbanized areas, where space is not available for more effective BMPs.

1.2 Objective:

These catch basin filters will be analyzed to determine if all filters are practical for all hydrologic and hydraulic conditions. The study will summarize what the filters are and what they do, what filters are being manufactured and by whom and which municipalities are using these BMP's. A survey will be conducted to evaluate the various filters' performance as well as compare their effectiveness, costs and maintenance requirements. Once the analysis is complete, a collection of guidelines on using, selecting, and designing the catch basin filter systems for controlling non-point source pollution will be developed.

1.3 Scope of Study:

In order to determine if all filters are practical for all hydrologic conditions, the following will be conducted:

- Identify all available catch basin filter manufacturers in the United States.
- Determine what municipalities across the nation are using catch basin filters.
- Compare manufacturers' claimed performance of various catch basin filters.
- Selected municipalities across the nation using the catch basin filters will be surveyed in order to obtain actual, in-situ performance and maintenance data.
- The survey information will be used to build a performance comparison between the

various catch basin filters used. A comparison between the actual and claimed performance will also be developed from the survey feedback.

- A field study on Remedial Solutions' (Chattanooga, TN) AquaShield catch basin filter, to estimate the expected pollutant removal efficiency and overall performance in a highly urban setting (UT campus and City of Knoxville transfer station).
- Develop guidelines for municipalities to use when considering the purchase and installation of the catch basin filter BMP.

Chapter 2 - Literature Review

As the landscape of our urban areas becomes more dominated by buildings and pavement, finding space for the installation of water quality best management practices (BMPs) for complying with EPA's NPDES Phase I and II storm water standards has become a great concern. In order to address this problem, a new realm of retrofit BMP technologies have emerged in the past decade. Catch basin inserts utilize the space of an existing drainage structure and do not require additional land allocation. This innovative stormwater quality technology can be separated into the following three classifications:

1. In-line Storm Sewer Filtration Systems
2. Oil/Water Separators
3. Catch Basin Inserts.

In-line storm sewer filtration systems consist of a pre-cast underground vault type structure, which houses filter cartridges or consists of baffles and settling tanks. These systems are installed in-line with the storm drains and function by passing stormwater through either media-filled cartridges (trapping particulates and adsorbing materials such as metals and hydrocarbons) or causing the runoff to flow through a series of baffles and storage tanks (skimming off oil and grease and allowing suspended solids to settle out). The following manufacturers currently produce the in-line storm sewer filtration systems:

- Stormwater Management (StormFilter™)
- BaySaver, Inc. (BaySaver™)
- CSR HydroConduit (Stormceptor™)
- HIL Technologies, Inc. (Downstream Defender ™)

- Environment XXI (V2B1 Stormwater Treatment System)
- Vortechnics, Inc. (Vortechs™ Stormwater Treatment System)

Figure 2-1 is a schematic of Stormwater Management's StormFilter™, and Figure 2-2 shows the design of a typical Stormceptor™ device.

Oil/Water separators are defined by EPA's NPDES program as "A device installed usually at the entrance to a drain, which removes oil and grease from water flows entering the drain." This broad definition does not specify how the oil and grease has to be separated from the water, and prior to the introduction of catch basin inserts containing a filter media, the leading technology was the basic media-less baffle systems, which skimmed the oil and grease off the water surface. The following is a short list of manufacturers who produced these basic media-less baffle systems:

- Best Management Products – *SNOUT Oil & Debris Stop*
- Environment XXI - *Ecosep Oil/Water Separators*

Oil absorbent pillows that float on and skim oil and grease off the surface of water in catch basins is a technology that has recently been introduced. Figure 2-3 provides an example of these types of oil skimmers. The following is a short list of manufacturers who produced these oil absorbent skimmers:

- Foss Environmental - *StreamGuard Passive Skimmer*
- AbTech - *OARS® Passive Skimmer*

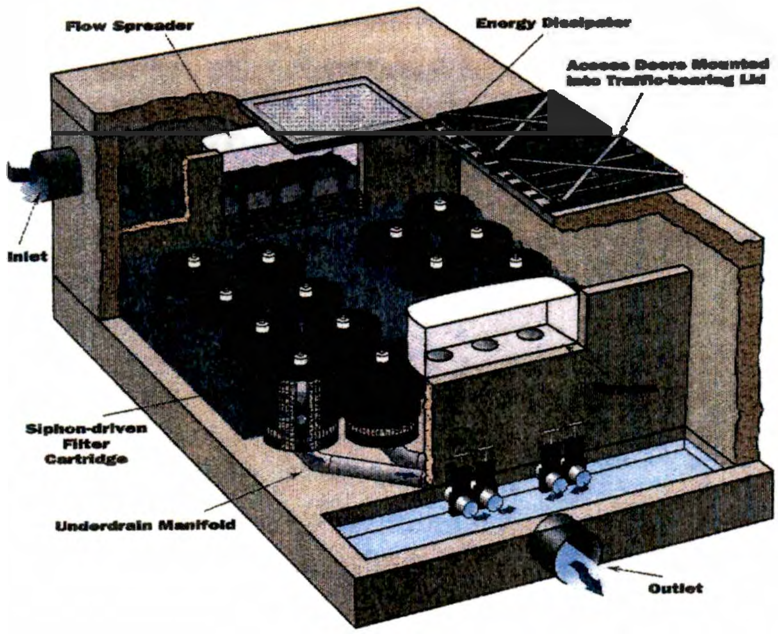


Figure 2-1.
StormFilter™ Schematic

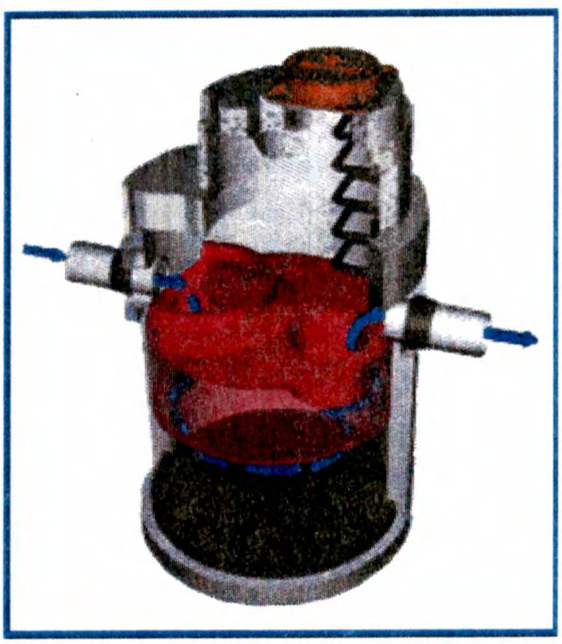


Figure 2-2.
Stormceptor™ Schematic

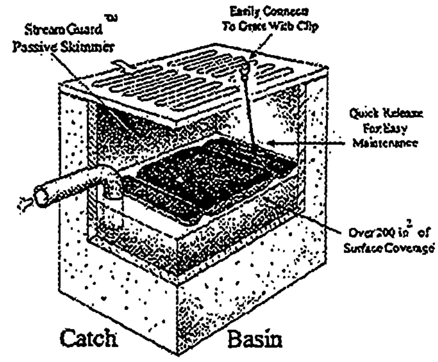


Figure 2-3.
Foss Environmental's StreamGuard Passive Skimmer

The final classification is the focus of this thesis, catch basin insert filters. This technology involves the placement of devices that contain a filtering media (a sorbent) just under a storm drain's inlet. The runoff flows into the inlet, through the filter where the targeted contaminants are removed. The following is a list of current manufacturers of catch basin inserts and the name of their respective product:

- AbTech Industries (Ultra-Urban Filter™)
- ACF Environmental (SiltSack™)
- Aqua Treatment Systems (Gullywasher™)
- Best Management Technologies (BMT Storm Clenz Filter™)
- Builders Environmental Marketing (Storm Watch™)
- Enviro-Drain (Enviro-Drain™)
- EP International (Hydro-Cartridge™)
- Foss Environmental Services (StreamGuard™)
- KriStar Enterprises, Inc. (Fossil Filter™)

- Remedial Solutions, Inc. (AquaShield™)
- Revel Environmental Marketing (Sift Filter™)

Information concerning the products of each of these manufacturers can be obtained by writing or faxing a request or by visiting their web page, if available. A list of each company's mailing address and web page URL (if applicable) is included in Appendix A.

On May 25, 1999, a BMP trade show was held in Providence, Rhode Island which featured innovative technologies for the treatment of urban stormwater runoff. The trade show was organized by EPA and the USDA/Natural Resources Conservation Service in order to educate local planners, engineers, political leaders and anyone involved in stormwater management as to what new stormwater quality practices are available. Among the technologies being displayed were a number of catch basin insert manufacturers. The following is a list of the manufacturers and their respective product's name:

- Remedial Solutions, Inc. – *Aquashield™ Filtration System*
- BaySaver – *BaySaver*
- HIL Technology, Inc. – *Downstream Defender™*
- AbTech Industries – *OARS Ultra-Urban Filter & Passive Skimmer*
- CSR HydroConduit – *Stormceptor*
- Foss Environmental Services – *StreamGuard™ Insert*
- KriStar Enterprises, Inc. – *Fossil Filter™*

A manual of vendor information was compiled from the trade show, which describes the various stormwater quality practices that were displayed. Information concerning each of the catch basin insert products (aside from those manufactured by KriStar Enterprises, Inc.) is presented in the following standard format:

1. Product Schematic
2. Narrative Description
3. Site Constraints/Installation Requirements
4. Specifications
5. Applications
6. Pretreatment Required?
7. Performance
8. Maintenance
9. Longevity
10. Secondary Beneficial or Negative Impacts
11. Costs
12. Delivery Time
13. Additional Information
14. Manufacturer and Supplier Address/Contact

Although the actual design and scale of each type of inserts displayed at the workshop varies, the product guide's template format allows for performance comparisons as well as a general range of costs. Of the products present at the Providence workshop, the capital costs range varied considerably. The various types of the Streamguard catch basin insert had the lowest capital cost ($64), while Stormceptor's STC 7200 Model, capable of treating 1110 gpm with a total holding capacity of 7415 gallons, had the highest capital cost ($33,560).

All of the catch basin inserts are applicable to new developments as well as to retrofit or redevelopment sites and potential spill areas. Each of the inserts presented at the trade show are capable of capturing amounts of oil and grease associated runoff from areas such as convenience stores/gas stations, truck stops, truck maintenance facilities, high traffic parking lots, Interstate highways, residential roadways, fast food restaurants, and potential spill hotspots. Although all of the devices claim to be capable of handling sediment loads, only the AquaShield, BaySaver, Downstream Defender, and Stormceptor have reservoirs that are dedicated for the accumulation of the captured sediment thus allowing the manufacturers to claim a much wider range of applications.

The major drawback to all of the catch basin inserts is that they are extremely maintenance intensive. The manufacturers suggest that a routine maintenance program must be implemented to assure that the inserts function as they were designed. Routine maintenance procedures, typically suggested about every three months, consist of vacuuming the sediment out of the sediment reservoirs (see above for applicable inserts), removing accumulated trash and debris, replacing spent filter or adsorption/absorption media, and removing of accumulated oil and grease (Stormceptor, BaySaver, and Downstream Defender only). Depending upon the surrounding land use and intensity and frequency of rain events, additional inspections and maintenance are usually recommended to prevent resuspension of pollutants and localized flooding due to the system being inundated or clogged with debris and/or sediment.

All of the represented catch basin filters have been or are in the process of having field and/or laboratory tests conducted (in-house or by an independent group) to determine the level of performance capable under ideal operating conditions. The following table (2-1) summarizes the independent and manufacturers' assessments of the performance of the catch basin filters displayed at the Stormwater Technologies Tradeshow:

Table 2-1.
Pollutant Removal Efficiencies

	Removal Efficiencies	
Product Name	**Total Suspended Soilds**	**Oil & Grease**
AquaShield	82% - 89%	96% - 100%
BaySaver	No Report	No Report
Downstream Defender	< 90%	No Report
Ultra-Urban Filter	No Report	< 80%
Stormceptor	77% - 99%	No Report
StreamGuard	88% - 94%	80%
Vortechs	80%	No Report

Although most of the insert manufacturers provided a performance evaluation in the form of pollutant removal efficiencies, none voluntarily provided information on the testing methods or locations. Only Foss Environmental Services (manufacturers of the StreamGuard product) provided any description of their testing, which proved to be independent field sampling in catch basins at a park-and-ride lot as well as at SeaTac International Airport's passenger pick-up area, both in King County, Washington. Proceedings from the trade show presented information on various innovative stormwater treatment designs that were presented at the Providence exhibition.

Other types of technologies were presented besides catch basin inserts; these included such products as underground leaching and infiltration chambers, channel reinforcement linings, constructed wetland systems, automated stormwater samplers, alternative detention structures, and passive, flow-through filtration systems housed in concrete vaults. While more detailed performance information than what is described in the proceedings should be obtained before deciding to implement any of the systems, the document provided a starting point for local planners, designers, engineers, and decision-makers interested in evaluating new and innovative stormwater best management practices.

A field evaluation of the water quality benefits of two types of in-line catch basin inserts was conducted in Wisconsin over a one-year period from 1996 to 1997. The study appraised the Stormceptor and the Multi-Chambered Treatment Train (MCTT) catch basin insert designs. The installation and subsequent assessment was sponsored and administered by the EPA, United States Geological Survey, Cities of Milwaukee and Madison, (Wisconsin), Stormceptor Corporation, University of Alabama-Birmingham, and Wisconsin Department of Natural Resources. The study sites had nearly identical land uses, (public works maintenance yards used for fueling, storage, and maintenance of heavy trucks and other city vehicles), to insure that an accurate comparison of the two designs could be made. The Stormceptor was installed in Madison in a catch basin that collected water from the entire 4.3 acre facility, while the MCTT was implemented in Milwaukee and received water from approximately 0.2 acres of paved area (Greb, 1998).

Each site utilized the same sampling strategies, which consisted of the collection and analysis of the influent and effluent stormwater runoff for various storm events. For larger storms, the water that bypassed the treatment chambers was also collected for investigation. Automated sampling equipment collected event-mean concentration data for the influent and effluent. From April 29, 1996 to September 8, 1996, fifteen consecutive storms were monitored for 68 pollutants at the MCTT site in Milwaukee. In

Madison, the Stormceptor site was monitored for 45 storms from August 6, 1996 to May 1, 1997. Of the 45 storms that were monitored, 15 storms were analyzed for 37 pollutants while the other 30 storms were only analyzed for total suspended solids (TSS), total dissolved solids (TDS), and total phosphorus (TP). Due to a relatively high percentage of the storms resulting in runoff bypassing the treatment chambers, two removal efficiencies were calculated; tank efficiency based on pollutant removal in the runoff passing only through the treatment chambers, and overall removal efficiency which accounts for the load that bypasses any treatment. Below is table 2-2., a summary of the tank loadings, tank removal efficiencies and overall removal efficiencies (Greb, 1998):

Table 2-2.
Treatment Chamber Mass Loads and Efficiencies (Greb, 1998).

Constituent	*MCTT*			*Stormceptor*		
	Load-in	Load-out	% Efficiency	Load-in	Load-out	% Efficiency
TSS	18.3 kg	.30 kg	98	1420 kg	1040 kg	28
TDS	84.3 kg	73.3 kg	13	37500 kg	44700 kg	-19
Total P	19.3 g	2.4 g	88	1.6 kg	1.29 kg	20
Total Zn	11.7 g	1.0 g	91	660 g	520 g	21
Total PAH	.64 g	.039 g	94	67 g	42 g	36

Total Suspended Solids (TSS)
Total Dissolved Solids (TDS)
Phosphorus (P)
Zinc (Zn)
Polycyclic Aromatic Hydrocarbons (PAH)

An interesting observation was made for the MCTT site in regard to the particulate matter. Most (88%) of the suspended solids was comprised of the silt-sized fraction in both the influent and effluent flows. Because a decrease in the overall particle size was expected (due to more rapid settling of larger particles), it was surprising to discover that there was a reduction in the grain size distributions between the influent and effluent stormwater. The fact that the mean grain size increased slightly in the effluent suggests that either the unit is not selective in the size of particles it removes or perhaps some of the fine filter media had escaped through the filter fabric. Although the grain size distribution was not affected by the MCTT, it is important to stress that there was still a considerable reduction in the particulate loading for all the sampled storm events (Greb, 1998).

Even though the costs associated with implementing the studied BMPs were not a major part of the investigation, a crude cost analysis was conducted by the USGS and USDA. The reported capital costs for the MCTT were $72,000 ($360,000/acre), but this figure is a bit skewed due to contractors having to build a new, unfamiliar device, additional reinforcement for heavy truck loads, and retrofitting around an existing sewer. A comparable device was installed in Minocqua, Minnesota for $95,000, but more importantly, only $38,000/acre (Greb, 1998). With the help of some unspecified assumptions, the following estimate for the cost per pound of suspended solids removed and capital cost (MCTT cost based on the Minocua site) was presented:

Overall, the study evaluated the magnitude of the water quality enhancement provided by two innovative Best Management Practices for storm sewer inlets. The MCTT system

Table 2-3. (Greb, 1998)
Stormceptor/MCTT Cost Estimates

Device	Capital Cost	Cost per lb removed
Stormceptor	$60,000	$2.18
MCTT	$95,000	$1.52

was designed for higher pollutant removal efficiencies and the investigation confirms that, quite conclusively. Although the MCTT provided better removal efficiencies, the Stormceptor produced very similar costs per pound of TSS removed (Greb, 1998).

In the fall of 1998, a consortium of municipal agencies and one engineering firm in the area of Southern California draining to Santa Monica Bay conducted a Municipal Stormwater/Urban Runoff Pilot Project to improve the quality of water draining to the bay. The purpose of the pilot project was to provide public works agencies guidance and information on the following:

- Provide a better understanding of how existing municipal catch basins function under a variety of wet and dry conditions.
- Aid in the decision-making regarding the practicality and value of retrofitting catch basins with filter systems to control potential pollutants.
- Provide information to government officials involved in making rational and technically sound decisions regarding how catch basin filters will be used as a part of their local stormwater control programs.

This project focused on storm drainage systems of areas contributing to Santa Monica Bay, but in a way that will allow for transferability of the observations to most areas of coastal Southern California. Existing catch basins that receive runoff from city and county roadways were focused on, rather than new catch basins or those receiving freeway or parking lot runoff. The project was subdivided into five main tasks with many subtasks. The following is a list of the tasks in the order of which they were conducted:

1. Select Target Pollutants and Describe Catch Basin Types and Performance
2. Characterize Local Runoff

3. Develop Approach for Evaluating Catch Basin Performance

4. Test Catch Basin Retrofits

5. Assess the Feasibility of Broad Intercity Application.

The selection of relevant target pollutants was necessary due to the wide spectrum of potential pollutants found in urban runoff and some may not be present in local runoff in high concentrations. In addition, not all pollutants are capable of being controlled by catch basin filters and the cost of collecting and analyzing samples increases with the number and types of pollutants to be studied. The Consortium decided that the project should focus on pollutants that meet all three of the following criteria:

- Pollutants known to be discharged via municipal storm sewer systems in high concentrations, either short term or over long periods of time
- Pollutants known to be in local receiving waters in concentrations that cause harmful water quality problems that could threaten the uses of the receiving waters.
- Pollutants whose concentrations and/or loading rates are capable of being positively affected by the implementation of a catch basin insert/filter.

After reviewing available information regarding the local water chemistry, catch basin retrofits' performance, and water quality data on street runoff and storm drain discharges, the consortium members decided to direct the project to target the following contaminants:

- Total Suspended Solids (TSS)
- Oil and Grease
- Debris.

Once the pollutants were defined, the Consortium members had to be informed on the engineering characteristics of the retrofits' pollutant trapping mechanisms. Woodward-Clyde engineering firm provided a presentation to the Consortium to explain the terminology associated with the catch basin systems and their corresponding pollutant removal mechanisms (i.e. coarse screening, fine screening, filtration, sedimentation, floatation, adsorption, absorption, volatilization, oxidation, and biodegradation).

The final subtask in task 1 was to qualitatively describe the performance of various available catch basin designs based upon available information regarding conventional storm drain inlets, catch basins and retrofit devices (Woodward-Clyde, 1998). The following broad types of design were considered:

- Sump-type catch basins (built to have sumps for collection of settleable solids)
- Sumpless catch basins (known as simply "catch basins")
- Catch basin retrofit devices.

Sump-type catch basins have been found to operate well hydraulically when properly maintained. Because the sump is designed to trap settleable solids (rocks, sand, gravel, particulates, etc.), they tend to accumulate urban litter and debris and can become clogged if not properly maintained. This type of design is typically only effective during relatively low flow conditions, where the retention time in the system is adequate to allow sedimentation to occur (Woodward-Clyde, 1998).

Sumpless catch basins hydraulically preform very well, even under high flow conditions and are much less susceptible to clogging, however they provide almost no pollutant trapping ability. These types of catch basins are common throughout the nation and have proven to be effective at conveying stormwater from above grade gutters and/or swales to underground storm sewer conduit systems(Woodward-Clyde, 1998).

Available information was reviewed for the commercially available catch basin retrofit devices and media listed below:

- Stormceptor™ in-line treatment system
- Xsorb™ petroleum absorbing media
- BioT Products™ biodegradable industrial cleaner/degreaser
- StreamGuard™ catch basin insert
- Fossil Filter™ catch basin insert
- Stormwater Management's CSF© Stormwater Treatment System™ in-line treatment system
- Electrox™ wastewater treatment system
- AbTech's Ultra Urban Filter™ (Oars media) catch basin insert
- LifeEnviscon™ petroleum, diesel, and heavy metal absorbing media
- CDS Technologies™ in-line solid/liquid separating system

Several of these reviewed systems or devices, especially the Stormceptor, CSF Stormwater Treatment System, Electrox, and CDS units, are designed to be stand-alone in-line treatment devices and are not intended for retrofit installations.

The purpose of task 2, characterizing local runoff, was to collect and analyze the runoff to determine the concentrations and types of pollutants that will typically enter the catch basins. This study was to only analyze what is entering the catch basins rather than the discharge from the municipal storm drains which can carry additional pollutants from illegal dumping, illicit discharges, and/or infiltration. Although the many water quality parameters were tested, only the oil and grease and TSS results will be reported, since they were the only two constituents that were targeted by the pilot project.

Table 2-4. summarizes the pollutant concentrations in the runoff from four different sampling sites.

Table 2-4. (Woodward-Clyde, 1998)
Runoff Pollutant Concentrations for Various Sampling Sites

	Site 1 Vehicular Activity		Site 2 Light Commercial		Site 3 Mixed Resiential		Site 4 Mixed Residential	
Parameter	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Oil & Grease (mg/L)	8.2	11	5.9	6.1	5.8	5.6	6.4	8.6
TSS (mg/L)	62	78.9	42	34	35.5	35.5	38.3	42.2

It should be noted that the oil and grease concentrations do not include the oil that adsorbed to the surface of the suspended particles, only the portion that is in a free state.

The third task was to use various information sources (i.e. past studies, knowledge of hydrology and hydraulics, and the application of various models) to develop an approach to evaluate the performance of catch basin filtration systems. With the help of physical, mathematical and conceptual models, the following recommended test program was developed.

1. Field studies were designed to be carried out during both dry- and wet- weather in order to determine how well settleable solids and urban debris are controlled by the following types of catch basins:

    - Conventional catch basins (no modifications or retrofits)
    - Catch basins with vertical board mounted across inlet (to prevent acceptance of urban debris)
    - Catch basins with screened inlets

- Catch basins with debris baskets
- Catch basins with a absorbent/adsorbent filter media.

2. Full-scale lab tests to evaluate the solids removal efficiency were designed utilizing a replication of a typical gutter, curb inlet, catch basin, and retrofit system. Pre-determined concentrations of settleable solids, urban litter, and/or oil and grease would be mixed into the flow and the performance would be measured on the basis of how much of the solids were removed by the retrofit device.
3. Full-scale lab tests to assess the performance of various filter cartridges/media for removing non-emulsified oil and grease were designed. The cartridges or media are to be placed in a mock catch basin and tested with various induced flow rates containing pre-determined concentrations of oil and grease.
4. To assess the performance of various sorption media for removing oil and grease from the stormwater, bench-scale lab tests were designed in which the media was placed in 2-in diameter plastic columns through which contaminated water was passed.

The testing of the catch basin retrofits was broken down into two parts: field studies and laboratory testing. The field program was conducted only on dry-weather screening devices, a simple wet-weather insert, and a non-retrofitted catch basin that was used as a control. The laboratory tests were reserved for the more complex wet-weather inserts, since field sampling would be difficult and controlled repeatable experiments would be almost impossible (Woodward-Clyde, 1998).

Prior to the dry-weather testing the catch basins were cleaned and fitted with screen panels, boardovers, and/or a sorbent media. A boardover consists of a long wooden board that is mounted parallel against the opening of a curb inlet such that only a small opening is available for drainage. These are used in California during the dry-season to prevent litter, trash, vegetative debris, etc. from entering the storm drain and removed during the wet-season. After approximately six weeks of service, the following observations were reported:

- Material had accumulated in front of the boardover at both boardover sites, and the plywood had become slightly warped. The inside of the catch basin chamber was relatively clean, aside for some small organic matter. Stains on the concrete above the inlet was seen as result of contaminants in the runoff.

- At one of the screened sites some light corrosion was observed on the inlet screen panel and minimal debris was found in the catch basin chamber. The other two screened sites were found to have catch basin chambers essentially free of debris but experienced deformations from the impact of car tires. There was much debris clogging all screened sites although the water in front of the inlet never rose to more than two inches in depth.

- The retrofit sites utilized a debris basket designed by AbTech™ and the catch basins were found to be just as clean as those equipped with the boardovers and screens. Leaves and soil were beginning to accumulate in the baskets.

- The first control catch basin had a mound of debris trapped in front of the inlet on the surface and approximately 40% of the chamber bottom could be seen. The remainder of the catch basin's floor was covered with leaves and debris (i.e. candy wrappers, plastic bags, paper advertisements, cigarette butts, sediment, etc.). The second control site revealed several inches of standing water and numerous cockroaches. There were cans, bottles, and newspaper in the chamber and a putrid odor.

- A mechanical street sweeper was observed as it passed each of the test sites. The sweeper's broom was effective in picking up approximately 95% of the accumulated debris at the inlets. It was noticed that the boardovers experienced some damage and significant wear. City of Santa Monica workers seemed to prefer the inlet screen panels with 1-inch mesh because of their relative durability. They also liked the AbTech™ filter basket and cited its ease of maintenance.

Wet-weather observations were made following the dry-weather testing at the screened and retrofitted sites. Approximately 5% of the screens' surface area was found to be covered with debris during one rain event and 50% during a later event. Standing water was also observed (~ 1 inch) at one site, yet other catch basins without screens were observed to have greater depths. A proto-type debris basket was installed as a wet-weather device and its performance was monitored. The device did not impede flow and was found to be full of leaves and debris after one month of service. Its elevation in the catch basin could be adjusted and it was capable of holding a sorbent media (Woodward-Clyde, 1998).

The laboratory tests were conducted as previously explained for oil and grease and total suspended solids. The results from the bench-scale column tests on various filter media are summarized in Table 2-5. (Woodward-Clyde, 1998). The tests were done with oil and grease in both an emulsified and free state to build a comparison.

Table 2-5. (Woodward-Clyde, 1998).
Bench Scale Oil and Grease Removal Efficiencies

Media Type	Oil and Grease State	Removal Efficiency (%)
OARS Ploymer(AbTech)	Emulsified	3
Activated Carbon	Emulsified	11
Aluminum Silicate (Xsorb, Fossil Filter)	Emulsified	0
Straw	Emulsified	0
Compost	Emulsified	0
OARS Ploymer(AbTech)	Free	88, 91
Polyproplyene Matt (type 1)	Free	86, 92
Polyproplyene Matt (type 2)	Free	78, 85
Xsorb (Aluminum Silicate)	Free	94, 89
Aluminum Silicate	Free	89, 86
Compost	Free	28, 49

In the full-scale study, only the StormFilter™ cartridge and the AbTech™ device were tested in the fabricated catch basin laboratory setup. Both units were tested for 90 minutes at a flow rate of 15 gallons per minute (gpm) with an oil and grease concentration of 25mg/L. The results of the full-scale tests can be found in table 2-6. (Woodward-Clyde, 1998).

Table 2-6.
Full-Scale Oil and Grease Removal Efficiencies

Media Type	Oil and Grease State	Removal Efficiency (%)
AbTech (OARS Polymer)	Free	83, 74
AbTech (Xsorb)	Free	91
StormFilter (Perlite)	Free	69
StormFilter (Compost)	Free	74
(Sorbent Type)		

A full-scale laboratory test was conducted on a vertical plate to determine how well it could remove suspended solids. The baffle plate was inserted into a fabricated catch basin dividing the chamber into two parts, one being a sedimentation area. The test was conducted with water containing sediment of known size distribution. The removal efficiencies appeared to be relatively high since the retention time of the device was less than one minute. The results show that the baffle would be effective on larger particles sizes, greater than 100 μm (Woodward-Clyde, 1998).

The final task of the pilot project was to evaluate the feasibility of broad intercity application in and around the Los Angeles area. The following is an outline of potential implementation scenarios that could be employed for retrofit of catch basins:

1) City Wide Implementation - This would involve applying retrofit devices to numerous catch basins which meet a set minimum criteria including, size of catch

basin relative to drainage area and imperviousness, amount of construction activity in adjacent area, pollutant loading, etc.. A city-wide implementation scheme could be broken down into a comprehensive approach (widespread catch basins), or high opportunity approach (fewer catch basins, but those that would have greater impacts per retrofit).

2) Land Use Specific Implementation - This approach would call for the implementation of catch basin inserts to be focused on areas of highest pollutant loading. Commercial and industrial areas (including busy streets) are prime targets because they generally contribute more pollutants than residential areas. Since industries are typically responsible for their own management of stormwater discharges, this approach also could be applied to commercial areas only (including busy streets) because industrial runoff should not contain much contaminants.

3) Sensitive/Targeted Receiving Waters - This scenario would require the identification of sensitive or targeted receiving waters and apply the catch basin inserts in the tributary areas in a comprehensive or high opportunity practice.

4) No Implementation - The municipality could also choose to not retrofit any catch basin because of concerns regarding flooding, high maintenance requirements, benefit/cost economics, etc..

As a part of Task 3, the Consortium was surveyed to determine what some of the potential constraints were that could hinder or prevent the implementation of the catch basin retrofits. The following is a list of the most common potential constraints indicated by the interviewed members of the Consortium:

- Potential Flooding (hydraulic capacity)
- Maintenance Procedures
- Costs (capital and maintenance).

Table 2-7. is an evaluation of each type of catch basin retrofit studied regarding each of the potential constraints.

Catch basin retrofits may also serve as a pre-treatment device for other BMP's such as detention ponds, constructed wetlands, infiltration trenches, etc.. This type of multi-implementation scenario would typically benefit a watershed the most. Potential benefit-cost implications of the installation of catch basin retrofits is also an important part of the retrofit selection criteria. For example, a municipality with 150 potential catch basin retrofit candidates should evaluate the benefit-cost relationship associated with widespread retrofitting of these catch basins. At an average of $500 per retrofit, capital costs alone could be as much as $75,000, excluding operational and maintenance costs. It may be most cost effective to consider a more regional control practice such as a central retention facility, thus as in other selection processes, various implementation scenarios need to be evaluated before the decision to retrofit catch basins is made (Woodward-Clyde, 1998).

Table 2-7.
Evaluation of Potential Constraints (Woodward-Clyde, 1998)

	Comparitive Pollutant Removal Effectiveness									
Retrofit Device	TSS	Oil & Grease	Debris	Hydraulic Capacity	Pollutant Re Release	Maintenance Requirements	Nuisance Potential	Installation Costs	Operational Costs	Land Use Applicability
AbTech	none	low	high	high	low	cleaning 2-4x/yr	low	moderate	moderate to high	all
Boardover	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Debris Basket	none	none	high	high	none	cleaning 2-4x/yr	low	moderate	moderate	all
Inlet Screen Panel	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Sedimentation Baffle	moderate	low	moderate to high	moderate loss	moderate	cleaning 2-4x/yr	moderate	high	moderate to high	all

Note: "NR" indicates the device is not recommended for wet-weather application

In April of 1999, URS Greiner Woodward Clyde submitted a report to the Alameda County Urban Runoff Clean Water Program that reviewed literature on stormwater inlet insert devices. All of the known catch basin insert manufacturers were contacted and asked for information concerning the costs and performance of their respective devices. The various devices' construction and target pollutants, manufacturers claimed product performance, scientific studies, and estimated costs were all summarized in the report.

The general design or construction of the various filters were divided in the following categories:

- Bag filter inserts
- Basket filter inserts
- Tray filter inserts
- Cartridge inserts

Bag filter inserts are defined as consisting of a geotextile bag that absorbs oil and retains sediment which is subsequently collected in the bottom of the insert. Units that consist of some basket configuration that is filled with filter media is defined as a basket filter insert. A tray filter insert is one which is available in a variety of configurations and can have a series of filters stacked on top of one another. They typically have a trough type structure. In the cartridge insert design, stormwater flows into holding areas/sediment traps and is forced up the sides of these traps before spilling over into some type of media contained in cartridges usually located in the middle of the device (URS Greiner Woodward Clyde, 1999).

The manufacturers' claimed performance for their products were analyzed and it was discovered that specific claims can range from vague descriptions such as "will trap sediment and remove some oil and water", to more explicit descriptions, for example "can effectively eliminate 99.4% of contamination by oil and all other petroleum-based products" (URS Greiner Woodward Clyde, 1999). It was discovered that with most of the devices, the performance claims were not sufficiently documented by readily available material or data. Table 2-8. summarizes the manufacturers claims and what material was supplied to support the claims.

Four studies conducted between 1995 and 1998 are summarized by URS Greiner Woodward Clyde in the report. The first was conducted by a Interagency Catch Basin Committee to evaluate the performance of commercially-available catch basin inserts of the treatment of stormwater runoff from developed sites. New Gullywasher™, StreamGuard™, and Enviro-Drain™ inserts were installed in the field and subjected to actual conditions for an extended period before being removed from the field and bench tested.

In 1996, Woodward Clyde consultants developed a parking lot monitoring report for which Enviro-Drain™, Gullywasher™, and Fossil Filter™ inserts were installed in storm drains which received water from .34 to 2.5 acres. Stormwater inflow and outflow samples were collected for each of the in-situ inserts as well as the water that bypassed the filters to determine removal efficiencies. Larry Walker Associates consulting firm completed a study in 1998 on the Fossil Filter™ as a part of the NDMP Inlet/In-Line Control Measure Study Report. A Fossil Filter™ was installed in a storm drain that collected drainage from a 1 acre parking lot.

Table 2-8.
Summary of Manufactures' Pollutant Removal Claims
(URS Greiner Woodward Clyde, 1999).

Insert Type	Manufacturer Claim	Supporting Material
BMT Storm Clenz Filter	Capable of absorbing 5x weight in hydrocarbons	No available information
Enviro-Drain	Pollution Removal Rate: up to 97%	Lab report w/o quality control and study description not available
Fossil Filter	Removes oil and grease from water flow entering drain	Lab report indicating 55% and 53.6% removal @ low and high concentraions resp.
Gullywasher	No specific claim	
Hydro-Cartridge	Over 90% pollution control based on letter from an engineering firm	Lab report used to make claim, not available
SIFT Filter	Can effectively eliminate 99.4% of hydrocarbons, based on lab report	Lab report w/ quality control obtained, no study decription
Storm Watch	Will trap sediment and remove some oil from water	Statement appears to be based on lab data from StreamGuard unit, which has similar construction
StreamGuard	Test summaries indicate efficiencies of 68% to 82.5 for oil & grease and 99.6% for total solids	Test part of pilot study, original lab reports not available
Ultra-Urban Filter	Absorbs and locks up hydrocarbons floating on the water surface based on studies using free product: O & G removal ranged 78% to 87%, avg. 83%	Removal of free product from water was observed in demo. Technical notes on four studies were provided, original lab reports not available

Inflow and outflow samples were taken onsite to determine pollutant removal efficiencies. The final study summarized was the Santa Monica Bay Area Municipal Stormwater/Urban Runoff Pilot Project which evaluated potential catch basin retrofits and is discussed in detail in the preceding pages on this chapter. A summary of the results of these four studies can be found in Table 2-9.

The final topic discussed in the literature review of stormwater inlet insert devices concerns the capital costs and media replacement costs associated with catch basin insert/filters. Table 2-10. summarizes the capital cost and replacement media cost estimations.

<u>Conclusion and Recommendations:</u>

Little independently conducted research has been done in the realm of catch basin insert/filters, perhaps because the technology is relatively new or because of a common perception that the potential negative impacts and maintenance burden of installation out-weight the positive impacts. From the information gathered from the limited research that is summarized in this chapter, the catch basin insert type of BMP can provide a limited amount of pollutant reduction for contaminants such as oil& grease, TSS, and debris if properly inspected and maintained in the field. It should also be noted that municipalities considering this type of water quality BMP should be cautious when interpreting a manufacturers pollutant removal efficiency. The Wisconsin study as well as the four studies summarized in URS Greiner Woodward Clyde's "Stormwater Inlet Insert Devices Literature Review" revealed that the catch basin inserts operated at a much lower removal efficiency than what was claimed by the manufacturers.

Table 2-9.
Summary of Studies (Woodward-Clyde, 1998)

Type of Insert	Sediment Findings	Hydrocarbons Findings	Metals Findings	Maintenance
Evaluation of Commercially-Available Inserts for the Treatment of Stormwater Runoff from Developed Sites				
Enviro-Drain	Reductions from -25% to 28%	Some O & G removal when new but unable to reduce conc. < 10mg/L	No significant removal of copper, lead, or zinc	Maintenance cycle limited by clogging of filter
Gullywasher	Reductions from -41% to 15%	Reduction of ~ 35%	No significant removal of copper, lead, or zinc	Maintenance cycle limited by clogging of filter
StreamGuard	Reductions from -15% to 25%	When new, reduction to < 10 mg/L	No significant removal of copper, lead, or zinc	Maintenance cycle limited by clogging of filter
Parking Lot Monitoring Report				
Enviro-Drain	No significant TSS reduction	Total Petroleum Hydrocarbon reduction, 9.1 mg/L to .6 mg/L	No significant removal of copper, lead, or zinc	Top tray easily clogged by leaves and pine neddles
Gullywasher	No significant TSS reduction	Total Petroleum Hydrocarbon reduction, 1.2 mg/L to .82 mg/L	No significant removal of copper, lead, or zinc	Outer filter caused clogging
StreamGuard	No significant TSS reduction	Total Petroleum Hydrocarbon reduction, 4.8 mg/L to .73 mg/L	No significant removal of copper, lead, or zinc	Bottom of filter bag broke during strom
NDMP Inlet/In-Line Control Measure Study Report				
Fossil Filter	Reductions of 40% for conc. between 25 and 47 mg/L	Total Petroleum Hydrocarbons-Diesel reductions of 50% for conc < 1 mg/L	Avg. Reductions: 28% fo Cu; 33% for Pb; 13% for diss Zn	Media had to be replaced before each rain due to debris buildup
Santa Monica Area Municipal Stormwater/Urbna Runoff Pilot Project				
OARS polymer (Ultra-Urban media)	Not studied	O & G removal eff. of 83% and 74%; full scale simulations	Not Studied	No field tests conducted
Alumina silicate (SIFT & Fossil Filter)	Not studied	O & G removal eff. of 91%; full scale simulation	Not Studied	No field tests conducted

Table 2-10.
Summary of the Inserts' Capital and Filter Media Costs
(URS Greiner Woodward Clyde, 1999).

Device	Type of Unit	Capital Costs	Media Costs
Gullywasher	Basket w/ filter media	$275-360 per unit	Maint. Costs $150 /yr
Storm Watch	Geotextile bag	$63-$125 per unit	Single use
StreamGuard	Geotextile bag	$53-$100 per unit	Single use
Ultra-Urban Filter	Basket w/ filter media	$250 per unit	$99 per unit
Fossil Filter	Trough structure w/ filter media	~ $450 per unit	$180 per year
SIFT Filter	Basket w/ filter media	$350-$700 per unit	$60-$150 per unit
Envrio-Drain	Multi-tray w/ filter media	$4,500 for set of 3 trays	$20-$50 per unit
BMT Storm Clenz Filter	Plastic cartridge w/ filter media	$350-$800 per unit	$20-$55 per unit
Hydro-Cartridge	Bi-directional unit w/ sorbent	$680-$1160 per unit	$25 to replace oil absorbing pads

Installations in the field sometimes present different conditions than those experienced in the laboratory setting where most of the manufacturers' claimed performance data is determined. It is obvious from the amount of literature available on the performance (especially long term) of catch basin insert/filters, that more independent research should be conducted in order to provide municipalities better guidance when deciding upon the adoption of this BMP and provide manufacturers feedback such that manipulations can be made to the various designs in order to increase the overall level of performance.

Chapter 3 - Overview of Selected Catch Basin Insert/Filters

3.1 Introduction to Catch Basin Filtration Systems

Catch basin filtration involves the placement of devices that contain a filtering media or sorbent under the grate of the stormwater inlet (curb, drop, or combination). The runoff enters the inlet and depending upon the technology, may experience some detention or storage before eventually flowing through the filter media where the targeted contaminants are removed. The filter runoff then flows through the drainage system before it enters a receiving body of water. The catch basin inserts must be capable of effectively filtering the first flush of a rain event (usually the first ½" to 1" of runoff, depending on how the particular municipality defines it) and provide an overflow capability sufficient to allow design flows to pass through the system without backing water up on the adjacent roads and/or parking lots. The sorbent filter media itself must be an inert blend of minerals that contain non-hazardous materials, as defined by the EPA, OSHA, and World Health Organization (WHO). According to these same organizations, the media needs to also be non-toxic, non-carcinogenic, non-biodegradable, non-flammable, non-harmful to cement, asphalt, carpet, tile, soil, or plant life (KriStar Enterprises, 1999).

The primary target contaminants of catch basin inserts are petroleum hydrocarbons, heavy metals (i.e. lead, zinc, cadmium, copper), nutrients (i.e. phosphorus, nitrogen) and suspended solids. The majority of the pollutants entering catch basins are generated by motor vehicles powered by fossil fuels or lubricated with any of the by products of fossil fuels. Runoff from parks, golf courses, and lawns posses high amounts of nutrients and construction sites contribute large volumes of suspended solids which typically have other pollutants (i.e. heavy metals) that have become attached to the individual particles.

Catch basin filter systems should be constructed such that the first flush is directed through the filter media and have a fit such that leakage around the filter is prevented. To prevent corrosion and the release of oxidized metals into the filter system, the housing for the filter media should be constructed of high-density polyethylene (HDPE), petroleum resistant fiberglass, or stainless steel; galvanized steel should not be allowed. Perhaps most importantly, the insert should not be the limiting regulator of flow (i.e., should not have high head loss during operation), thus the overflow structure must be able to pass at least as much water as the catch basin system was designed to convey. This will greatly reduce the risk of having the catch basin filter system inundated by runoff which could result in localized flooding. Various catch basin insert filtration technologies have been developed and are currently being manufactured across the nation. The following sections provide a detailed description of some selected examples of catch basin insert/filters that are representative of the various types of designs (listed in Chapter 2) that are currently on the market. The information used to describe the inserts came from corresponding manufacturer-supplied technical manuals, the proceedings from the Providence, RI Stormwater Technologies Trade show, and a vendor survey that was sent to each manufacturer. The vendor survey responses can be found in Appendix B. Each of the selected products will be summarized in the following template format:

- General Description

- Applicability
- Capital Costs and Installation
- Maintenance Requirements and Costs
- Results of Performance Testing

3.2 AquaShield™ (Remedial Solutions, Inc.)

General Description:

Remedial Solutions, Inc. offers a variety of stormwater filtration systems that are designed to meet the water quality needs of typical catch basin inlets to areas with large converging volumes of stormwater runoff and waste water discharges. The AquaShield™ designed to treat runoff entering a typical catch basin is shown in Figure 3-1.

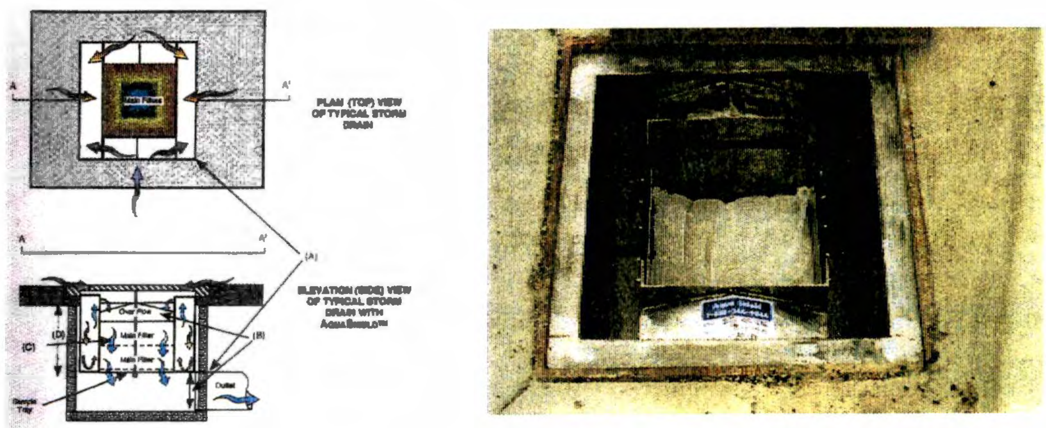


Figure 3-1.
Typical AquaShield Design

As stormwater enters the inlet, it is captured by the sediment traps on either side of the filter media. In the sediment traps, the water accumulates, allowing for settling of suspended solids. Once the runoff has filled the sediment traps, it spills over into the filter media chamber where a series of filters (one under the other) removes pollutants such as oil & grease, heavy metals, and nutrients. The number of filters varies upon the depth of the catch basin and degree of pollutant loading that is typically experienced by the targeted catch basin. The municipal personnel in charge of the insert installation should inform the manufacturer of the adjacent land uses and the depth of the catch basin such that the manufacturer can fabricate the system with a practical number of filters. The AquaShield™ insert has an overflow device that allows for high flows to bypass the filter media to prevent local surface flooding. The area of overflow structure opening is designed by the manufacturer to be equal or greater than the measured area of the catch basin's outlet structure.

The AquaShield™ is constructed of stainless steel that contains 20% to 30% pre-consumer recycled material. The absorbing filter media is a patent pending material that is a conglomeration of wood fiber, coal ash, aluminum compounds, and other proprietary compounds, all of which are 100% reclaimed materials.

Applicability:

The AquaShield™ insert can be used in most stormwater catch basins of new and existing industrial, commercial, governmental, institutional and multi-family developments. The following is a list of potential AquaShield™ applications:

- convenience stores and truck stops
- military and postal facilities
- office and industrial complexes

- government garages and truck maintenance areas
- heavy construction equipment maintenance yards
- fossil fuel plants
- fast food restaurants
- greenways and parks.

Although the primary purpose of the AquaShield™ is not petroleum spill containment, it can be included in a Spill Prevention, Control, and Countermeasure Plan as a first line of defense. The AquaShield™ inserts are not intended to take the place of conventional BMP's such as detention and retention ponds, or constructed wetlands, but can compliment the water quality enhancement of these practices (Remedial Solutions, Inc., 1998).

Installation and Capital Costs:

The installation of a typical AquaShield™ catch basin insert involves removing the grate and lowering the frame into the catch basin. The frame rests upon the ledges that support the inlet's grate. Once the frame is in place, the filter media is placed into the stainless steel containers and then installed into the frame. Finally, the storm grate is replaced.

The capital costs associated with the AquaShield™ insert vary depending upon the characteristics of the catch basin and contributing watershed. There are eleven different models of the AquaShield™ insert that are designed for standard catch basins and the cost of these various models range from $997 for the smallest unit to $3250 for the larger series. Remedial Solutions, Inc. will install the inserts for a minimal charge and bulk purchases are subject to discounts (Stormwater Tech Trade Show, 1999).

<u>Maintenance Requirements and Costs:</u>

Remedial Solutions, Inc. recommends that a routine maintenance program be established based the surface characteristics of the adjacent watershed, volume of contaminant load, and frequency of contaminant releases. The AquaShield™ should be inspected after each rainfall event that produces at least .5 inches in 24 hours. The insert should also be inspected and serviced, by municipal officials, property owners or Remedial Solutions staff, before the start of the rainy season. The manufacturer also suggests that an overall inspection of the system should be made once the insert has treated approximately ten times the design flow capacity. The following is an inspection check list developed by Remedial Solutions, Inc.:

- Position protective barrier, for traffic, around work area
- Open inlet grate
- Observe quantity of sediment and color change in filter media (light grey, very dark grey, black)
- Remove any large debris and trash
- Note any structural damage to the unit and contact Remedial Solutions to determine method to fix the damage (Remedial Solutions, Inc., 1998).

A typical AquaShield™ insert is serviced by removing the inlet grate and vacuuming the accumulated sediment out with a heavy duty wet/dry shop-vac or equivalent device. The spent filters are then extracted from their housing and placed in appropriate containers. New filter media is then installed into the AquaShield™ frame and the inlet grate is replaced. The disposal of the removed sediment and filter media should be in compliance with local, state and federal regulations. Depending upon the types of contaminants that the filters have been exposed to, the final use of the spent media can include fuel blending (b.t.u. value due to captured petroleum products) or biodegradation through land farming (Remedial Solutions, Inc., 1998).

Remedial Solutions, Inc. recommends that under normal operaticonditions, the AquaShield™ should be serviced once every 3 months assuming low to moderate pollutant exposure (i.e., employee parking lot). In the case of chemical and/or petroleum spills, immediate service is required to maintain optimal performance and be prepared for future spills (Remedial Solutions, Inc., 1998).

Results of Performance Testing:

To determine the pollutant removal efficiency of the AquaShield™ filter media, Analytical Industrial Research Laboratories, Inc. of Chattanooga, Tennessee conducted a series of three field tests. The testing location was an industrial lot in Jasper, Tennessee. The first test was controlled and conducted in an area of 540 square feet, which was washed down using a water hose with a flow rate of 7 gallons per minute. The area was washed down for 10 minutes and 30 seconds. Flow entering the catch basin and exiting the AquaShield™ insert was sampled to determined the pollutant concentrations in each. Table 3-1 shows the results of the first test.

Pollutant	Incoming (mg/L)	Outgoing (mg/L)	% Reduction
BOD	47	7	85.11
COD	213	168	21.13
TSS	220	54	75.45
Oil & Grease	2490	45.7	98.16
Lead	0.853	0.126	85.23
Total Nitrogen	5.46	1.03	81.14

Table 3-1
AquaShield Field Test #1 Results

Pollutant	Incoming (mg/L)	Outgoing (mg/L)	% Reduction
BOD	644	274	57.45
COD	1260	474	62.38
TSS	290	243	16.21
Oil & Grease	2280	46.4	97.96
Lead	0.042	0.042	0.00
Total Nitrogen	5.3	1.01	80.94

Table 3-2
AquaShield Field Test #2 Results

The second test was not controlled and utilized natural rainfall as the source of runoff. As in the first test, inflow and outflow samples were collected and analyzed for pollutant concentrations. Table 3-2 reveals the removal efficiencies displayed by the AquaShield™. The third test was controlled and had the same surface and flow parameters as the first test. The only difference between the first and third test is that during the time that the AquaShield™ was installed on the site, two spills occurred which totaled over 20 gallons of diesel fuel. Samples were collected in the manner similar to that of the first and second tests. Table 3-3 shows the results of this third performance test.

Pollutant	Incoming (mg/L)	Outgoing (mg/L)	% Reduction
BOD	211	91	56.87
COD	490	179	63.47
TSS	200	48	76.00
Oil & Grease	13.8	7	49.28
Lead	0.088	0.049	44.32
Total Nitrogen	4.92	0.98	80.08

Table 3-3.
AquaShield Field Test #3 Results

3.3 Fossil Filter™ (KriStar Enterprises)

General Description:

Prior to the introduction of catch basin filters, the leading technology for removing pollutants such as oil and grease from stormwater runoff was large underground precast concrete oil/water separators. This former technology was expensive to purchase and install and could only be used on new construction projects. Routine maintenance and inspections were also difficult and expensive because the units were underground and thus out of sight. Of the various catch basin filtration systems on the market that target the removal of hydrocarbons, the Fossil Filter™ product is considered one of the more prominent. In comparison to the concrete oil/water separators, the Fossil Filter™ costs are much less, and installation can take minutes rather than days (KriStar Enterprises, 1999). Fossil Filter™ can be used on new construction projects as well as be retrofitted to existing drainage systems, and simple visual inspection is feasible.

The Fossil Filter™, shown in Figure 3.1, is a trough structure that is installed just under the grate of stormwater inlets. The structure contains an EPA approved sorbent,

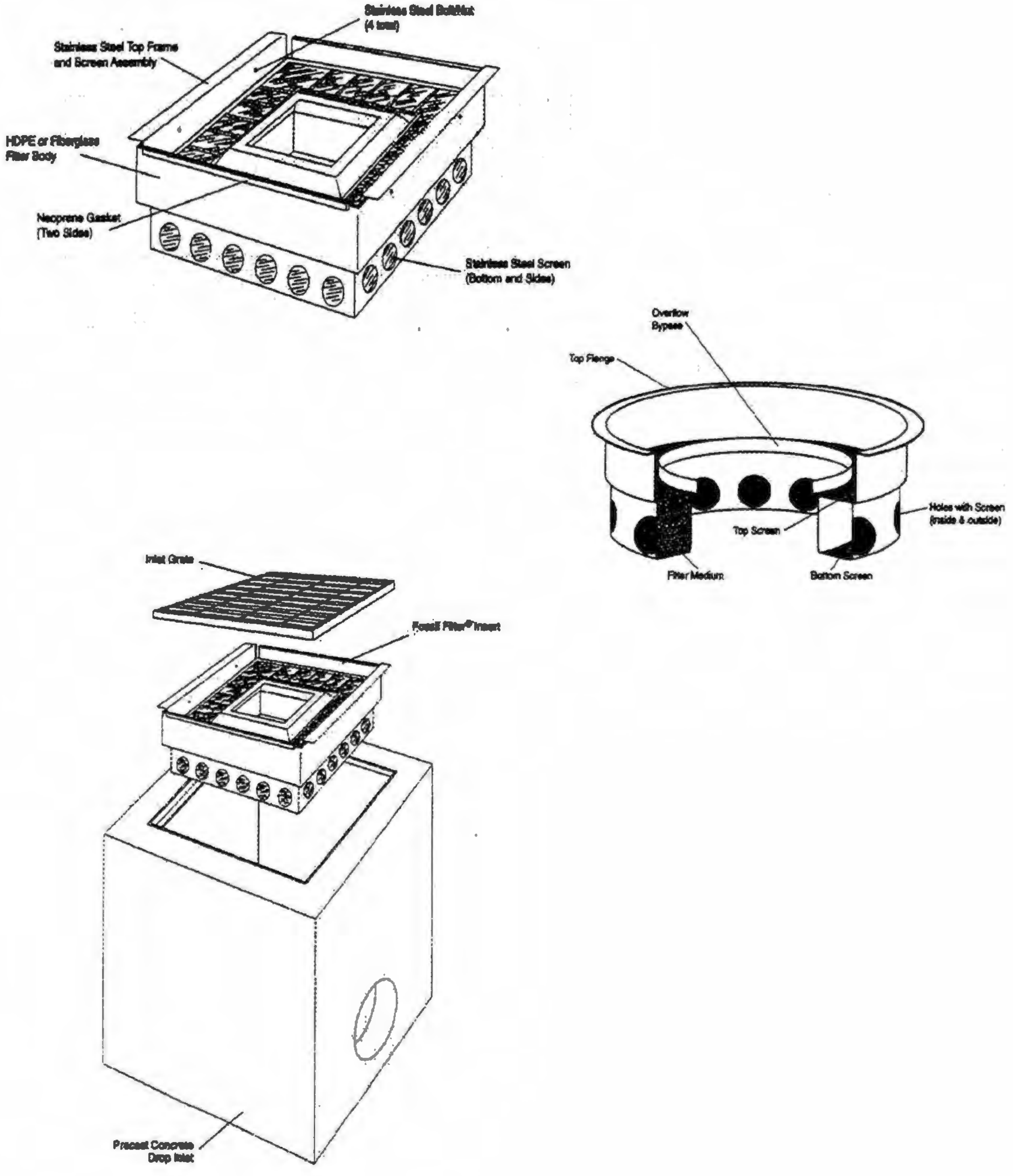


Figure 3-2.
Fossil Filter Schematics

hydrophobic filter media (Fossil Rock), which is intended to remove petroleum hydrocarbons and other pollutants through adsorption (acting like a magnet) while allowing the unhindered conveyance of the stormwater runoff.

The Fossil Rock is a natural petroleum hydrocarbon-attracting material known as Amorphous Alumina Silicate and is approved by the EPA, OSHA, and World Health Organization. According to KriStar's Fossil Rock supplier, laboratory testing has shown that the filter media will initially adsorb, then absorb approximately 1.92 gallons of liquid contaminant per cubic foot before the media will no longer remove oil & grease. A typical 24" x 24" filter contains approximately .56 cubic feet of Fossil Rock media, and thus could adsorb around 1.08 gallons of liquid contaminant (KriStar Enterprises, 1999). KriStar Enterprises, Inc., the product's manufacturer claims the following removal percentages for these urban pollutants:

Oil & Grease - up to 90% (98% waste motor oil)

Total Suspended Solids - none

Heavy Metals - incidental

Total Nitrogen - none

Total Phosphorus - none

Applicability:

Because the Fossil Filter™ was designed to remove petroleum hydrocarbons from stormwater runoff, the most logical application would be anywhere that motor vehicles move, park, are refueled or serviced. The following is a short list of potential prospects for the installation of Fossil Filter:

- customer and employee parking lots
- corporation yards
- service stations
- airport ramps and refueling areas
- some marinas
- tollgates.

The Fossil Filter™ can be used as a water quality BMP on new construction sites as well as be retrofit to an existing drainage system.

Capital Costs and Installation:

Unit capital costs for the installation of Fossil Filter will, of course, vary with size, number of units on a particular site, and other land use and watershed factors. An estimated capital cost for a typical 2' x 2' filter installed on site with the Fossil Rock in place, is around $400. Because the Fossil Filter fits right under the inlet grate, the installation costs and time are minimal. The company will actually come out to the site and install the units for as little as $25 per unit depending upon the type of unit and the number of filters on site.

To install a Fossil Filter in a four-sided (square or rectangular) drainage inlet, the grate is removed and the unit's perimeter flanges rest on the ledge where the grate rests, and then the grate is replaced. If the inlet does not have a grate ledge, the filter will not have a perimeter flange and the unit will be secured to the catch basin wall with anchor bolts. For a curb inlet situation, sections are either cut or assembled to fit the length of the curb opening, and then the two ends are capped. The filter cartridges are assembled, filled with Fossil Rock media, and installed in the straight-rail-trough housing structure. The assembly is then attached to the basin walls, just below the surface, with anchor bolts. Special orders for odd sizes and shapes can be made by contacting the manufacturer and providing the inlet dimensions and characteristics.

<u>**Maintenance Requirements and Costs**</u>:

An installed Fossil Filter requires periodic inspection and subsequent removal of all debris (i.e., leaves, cups, bottles, cigarette butts, paper, etc.) that has collected in the device. To prevent the build-up of trash and debris, the area (i.e., street, parking lot, etc.) surrounding the catch basin inlet should be swept or cleaned on a regular basis. The Fossil Rock adsorbent should be replaced when more than 50% of the granules are coated with contaminants or the unit has become clogged with sediment. This specification is difficult for the ordinary maintenance person to understand and determine, so more discrete filter replacement stipulations should be specified. The manufacturer suggests that the intended useful life of a typical filter is around 6 months. Areas that experience high traffic volumes and/or sediment loading could require more frequent filter replacements, thus routine inspection is critical. To ensure that the insert operates in an efficient manner, the units should be inspected (at minimum) at least 3 times per year; once before and twice during the main wet season. One bag of the Fossil Rock media contains 1.3 cubic feet of sorbent and costs $30. A typical 24"x24" filter contains .56 cubic feet of media, making the cost of a filter replacement around $15 (KriStar Enterprises, 1999).

Because some cities (especially in California) are now requiring proof of a follow-up maintenance program before they issue a final clearance to a installation of a BMP, the KriStar company has developed a team of certified maintenance personnel along with various maintenance plans. KriStar has developed the following three yearly maintenance plans dependent upon the level or type of exposure to silt, sediment, debris, and petroleum hydrocarbons:

Service Plan A - (minimum) Three cleanings and one change of filter sorbent.

Service Plan B - Three cleanings and two changes of filter sorbent.

Service Plan C - (For heavy debris and pollutant loading) More than three cleanings and as many filter changes as necessary.

Each of these services include the following tasks: removal of debris and broom cleaning around the inlet, filter structure be inspected for damage, filter sorbent inspected for remaining useful life, and if media needs replacement, the contaminated sorbent will be properly disposed of as a hazardous waste. The cost of each of the various service plans varies upon the number of filters on site, adjacent land use, etc., but an approximate value for Service Plan A is about $200 (KriStar Enterprises, 1999).

Federal, state, and local Clean Water Act regulations require that all stormwater filtration systems be maintained and serviced on a regular basis. It should be understood that once the filter is installed on a particular site it is the property owner's responsibility to ensure that it is maintained and continues to function effectively. The property owner is also considered a generator of hazardous waste, and is responsible for the proper disposal of the contaminated media.

Results of Performance Testing:

Hydraulic capacity and pollutant removal efficiency tests were conducted on the Fossil Filter™ insert to determine the overall operating characteristics of this Best Management Practice. In May of 1995, Sandine and Associates engineering firm of Santa Rosa, CA preformed hydraulic tests on two types of Fossil Filter™ inserts: a 27 inch x 27 inch flat grated drop inlet, and a typical 48 inches wide and 5 inches high curb inlet. The drop inlet contained a single stage Fossil Filter™ with a total filter length of eight linear feet and a center high-flow bypass of 16 inches x 16 inches. A 450 gallons per minute (1 cfs) flow was applied to the inlet by a fire hose to determine if the hydraulic capacity was diminished by the installed filter. The reported design capacity (the maximum flow before the filters are bypassed) for the Fossil Filter™ system was around .56 cfs, thus the applied flow was almost doubled the design condition. The Fossil Filter™ did not restrict the inlet's hydraulic capacity at a 450 gpm flow rate, and it was apparent that the unit could have handled an even greater flow rate without bypassing the sorbent media. The curb inlet had a dual stage Fossil Filter™ installed and also had a total filter length of 8 linear feet. A water truck was used for the first test and directed a low flow into the inlet and then increased the flow until the upper filter's capacity was met and began to overflow to the lower filter. The upper filter's capacity was reached at a flow rate of around 46 gpm calculated from an 1 ⅛ inch gutter flow depth. The second test began with low flows similar to a first flush scenario and subsequently increased until overflow of the upper and lower filters occurred at a flow rate of 92 gpm. These results suggest that a dual stage Fossil Filter™ has a filtering capacity of 12 gpm per linear foot of filter length. Both of these tests were done on a relatively clean parking lot, so very little debris was entrained in the induced runoff.

A separate set of tests were made in June of 1998 for the City of Sacramento's Stormwater Monitoring program by Eagle Engineering. These tests were conducted in the same manner as those in Santa Rosa in order to determine if the manufacturer's rated filter capacity of 12 gpm per linear foot of filter was valid. The tested filter performed up to their rated capacities and beyond. A 24 inch x 24 inch filter accepted 125% of the design flow and still was well below ultimate capacity, while a circular filter with a 24 inch diameter handled up to a 100 gpm flow rate (208% of rated capacity) before being overwhelmed and allowing water to bypass the filter (KriStar Enterprises, 1999).

These tests confirm that, with proper installation and regular maintenance, the Fossil Filter™ can be an effective way of filtering the first flush of stormwater runoff. Because of the designed bypass areas, the filters are able to pass flows that exceed the design conditions without hindering the hydraulic capacity of the catch basin.

Three independent laboratory tests and two in-situ field tests of the Fossil Rock media have been preformed to determine the removal efficiency of the Fossil Filter™ adsorbent. The first test followed the Toxicity Characteristics Leaching Procedure (TCLP) on the Fossil Rock with two liters of water contaminated with 50 drops of waste oil. The Fossil Rock adsorbed 98% of the waste oil and showed levels of heavy metals far below the EPA detection limits. The laboratory testing results for hydrocarbons and heavy metals from the second and third lab tests are summarized in Table 3-4 (KriStar Enterprises, 1999).

	Oil & Grease	Motor Oil	Diesel	Gasoline	Heavy Metals
Test 2	~ 54%	~ 97%	~ 99%	~ 60.6%	NS
Test 3	~ 54%	~ 97%	~ 99%	~ 60.6%	NS
Note: "NS" - Not Significant					

Table 3-4.
Pollutant Removal Percentages

In July of 1997, Ambient Engineering of Weymouth, MA conducted a field evaluation of Fossil Filters installed on public roadways. Influent and effluent stormwater samples were taken from the Fossil Filter™ unit and analyzed for oil and grease, nitrate, nitrite, nitrogen, phosphorous, and total suspended solids. The study concluded that the oil and grease concentrations were greatly reduced, but there could not be a statistically significant removal of the other pollutants due to a lack of samples. During a rain event in March of 1998, Larry Walker and Associates took samples from a Fossil Filter™ installed in movie theater parking lot. The pollutant removal efficiencies were analyzed for petroleum hydrocarbons, total recoverable metals, dissolved metals, total suspended solids, and diazanon/chlorphyrifos and the removal percentages can be found in Table 3-2 (KriStar Enterprises, 1999).

Pollutant	% Removal
Total Recoverable Lead	33%
Dissolved Lead	11%
Total Recoverable Copper	8%
Dissolved Copper	-7%
Total Recoverable Zinc	17%
Dissolved Zinc	-7%
Total Suspended Solids	60%
Total Petroleum Hydrocarbons	46%

Table 3-5.
Pollutant Removal Percentages for Movie Theater Parking Lot Installation

Further details and information on Fossil Filter™ and their maintenance plans may be obtained from various company sources given in Appendix A.

3.4 Siltsack® (ACF Environmental)

General Description:

The Siltsack®, manufactured by ACF Environmental, Inc., is primarily a catch basin sediment control insert used to prevent silt and sediment from being conveyed to receiving waters through a stormwater drainage system. Sediment is trapped by the Siltsack® while allowing water to pass through freely. The Siltsack® can be installed in a catch basin as a primary or secondary sediment control practice to prevent clogging of a drainage system and pollution of receiving waters. ACF Environmental's catch basin insert is available in both high-flow and regular-flow models with an optional oil absorbent pillow that can be used for spill containment. To prevent erosional sediment from entering curb inlets, the Siltsack® is also available in a curb opening filter design. The Siltsack® is designed of woven polypropylene geotextile fabric and sewn with a double needle machine utilizing high strength nylon thread. This particular catch basin insert is not a pre-fabricated device, but rather is designed according to the dimensions of the catch basin of drop inlet. The manufacturer, ACF Environmental, claims the following potential removal efficiencies for these urban pollutants:

Oil and Grease - 98%

Total Suspended Solids - 98%

Heavy Metals - 98%

Total Nitrogen - 92%

Total Phosphorus - 92%

Due to the removal mechanism of the Siltsack® the removal percentages for heavy metals apparently corresponds to those that are attached to the suspended solids. The oil and grease removal percentages are valid when the oil absorbent pillow is in place.

Applicability:

The primary application for the Siltsack® insert is on construction sites or other land disturbing activities that involve denuded land for extended periods of time. This type of practice does not control erosion, but rather prevents the transported sediment from entering and clogging drainage networks. It can be used as a stand-alone control practice but can be applied more effectively as a secondary sediment control practice in conjunction with silt fencing, for example. A high-flow model allows for application in areas that experience intense stormwater runoff or frequent inflow from equipment wash-downs, irrigation, pond/lake dewatering, etc.. The optional oil absorbent pillow allows for installation in areas with high spill potential or locations with high volumes of truck and heavy equipment traffic.

Installation and Capital Costs:

The installation of Siltsack® requires the inlet grate to be removed and then placement of the insert into the catch basin such that 6 inches (area of the lifting straps) of the sack is outside of the inlet's frame. The grate is then replaced and excess portion of the sack (removal flap packets and emptying straps) should be covered with soil. A properly installed Siltsack® is out of sight on the surface. A typical installation takes two men about 10 minutes thus the installation costs are minimal on an hourly pay basis. According to the manufacturer, the capital costs of the Siltsack® catch basin insert should be included in the bid price for the overall sediment and erosion control plan unless the price is requested. The typical capital cost of a Siltsack® is around $70.

Maintenance Requirements and Costs:

The manufacturer suggests that each Siltsack® should be inspected following every major rain event, and every 2-3 weeks during dry weather periods. This dry-weather inspection frequency, unless wash downs on the site are common, does not seem very practical due to the limited opportunity for material to accumulate in the Siltsack® during these periods. The Siltsack® has a built in means of informing when it should be emptied. A yellow restraint cord, located approximately halfway up the sac, holds the sides away from the walls of the catch basin and acts as a visual means of indicating when the sack should be emptied. When the yellow cord becomes covered with sediment, the device should be emptied, cleaned, and then replaced into the catch basin.

To remove the Siltsack®, two pieces of 1" rebar should be placed through the lifting loops, which are located on either side of the sack, and lifted with a piece of equipment such as a Bobcat, tractor, bulldozer, or forklift. The Siltsack® to be emptied should be moved to where its contents will be collected. Lifting the insert with the piece of equipment by the bottom straps will turn the Siltsack® inside out, thus emptying the accumulated sediment. The sack should then be cleaned, rinsed out, and reinstalled into the catch basin. ACF Environmental claims that once installed, there are no maintenance costs associated with the Siltsack®. It does, however, require some man hours to empty, clean, and replace the insert when necessary. These maintenance hours should be included in the bid price for the sediment and erosion control plan. The Siltsack® is reusable and once construction is complete or permanent ground cover is established, it can be stored out of direct sunlight to be used on future projects.

Results of Performance Testing:

The strength of the Siltsack® has been tested to assure that it can accommodate specified sediment loads. The nylon thread seams were tested according to ASTM standards (ASTM D-4884) and need to have the following strength:

Regular Flow Model - 165 lbs/in

Hi-Flow Model - 114.6 lbs/in.

The woven polypropylene geotextile fabric was also tested according to ASTM standards and has the following properties:

Regular Flow Model

Grab Tensile (ASTM D-4632) - 300 lbs

Grab Elongation (ASTM D-4632) - 20%

Puncture (ASTM D-4833) - 120 lbs

Mullen Burst (ASTM D-3786) - 800 psi

Trapezoid Tear (ASTM D-4533) - 120 lbs

UV Resistance (ASTM D-4355) - 80%

Apparent Opening (ASTM D-4751) - 40 US Sieve

Flow Rate (ASTM D-4491) - 40 gal/min/ft^2

Permittivity (ASTM D-4491) - 1.5 sec^{-1}

Hi-Flow Model

Grab Tensile (ASTM D-4632) - 265 lbs

Grab Elongation (ASTM D-4632) - 20%

Puncture (ASTM D-4833) - 135 lbs

Mullen Burst (ASTM D-3786) - 420 psi

Trapezoid Tear (ASTM D-4533) - 45 lbs

UV Resistence (ASTM D-4355) - 90%

Apparent Opening (ASTM D-4751) - 20 US Sieve

Flow Rate (ASTM D-4491) - 200 gal/min/ft^2

Permittivity (ASTM D-4491) - 1.5 sec^{-1}.

Every Siltsack® should have these minimum properties to operate up to the manufacturer's specifications.

3.4 StreamGuard™ (Foss Environmental)

General Description:

The StreamGuard™ catch basin insert, manufactured by Foss Environmental, has three designs for the removal of the following pollutants: sediment (Figure 3-3), oil & grease (Figure 3-4), and trash & debris (Figure 3-5). The sediment only model, Figure 3-3, is constructed of a geotextile fabric, which allows the passage of flows up to 500 gpm while collecting suspended sediment. The oil & sediment model, Figure 3-3, is constructed of a geotextile fabric and is equipped with a 1-pound granular block of an oil absorbent polymer capable of absorbing two-thirds of a gallon of gasoline, diesel, or other hydrocarbon (Stormwater Tech Trade Show, 1999). As stormwater runoff up to 500 gpm flows into the insert, the fabric absorbs some of the oil and retains the entrained suspended sediment. Floating oil and grease are absorbed by the StreamGuard™ absorbent polymer media contained in a screen bag that is fixed within the unit. Because the StreamGuard™ polymer is a true absorbent, meaning it encapsulates hydrocarbons, the risk of releasing captured petroleum products is reduced and the spent insert can usually be disposed of as a municipal solid waste. Once the geotextile fabric can no longer act as a filter due to the accumulation of contaminants, it then begins to fill with the stormwater runoff and provide detention for gravity settling of sediment before exiting through the bypass. The unit also begins to operate as on oil/water separator once the fabric has become saturated, by continuously absorbing hydrocarbons which float at the surface. This naturally reduces the amount of stormwater that can be successfully treated, stressing the

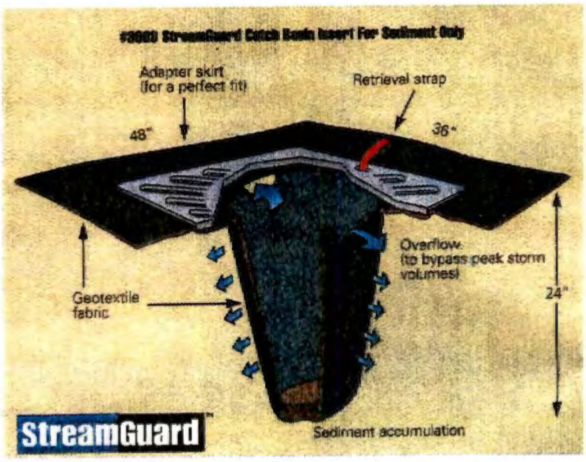


Figure 3-3.
StreamGuard Sediment Model

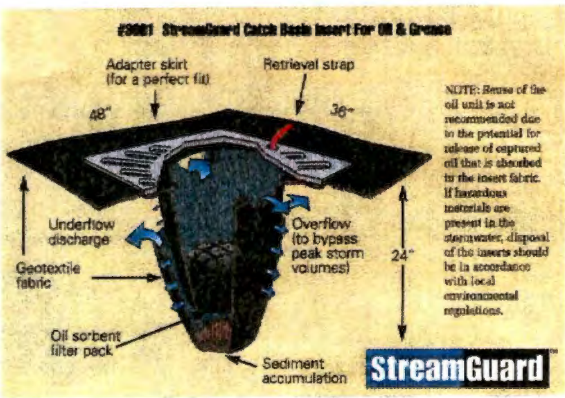


Figure 3-4.
StreamGuard Oil & Grease Model

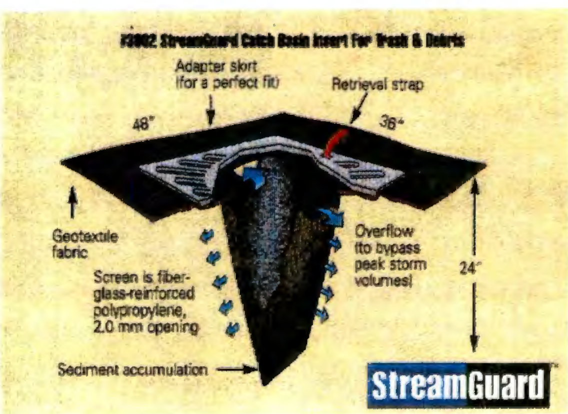


Figure 3-5.
StreamGuard Trash & Debris Model

importance of routine inspections and maintenance (Stormwater Tech Trade Show, 1999).

The StreamGuard™ catch basin insert designed for trash and debris, Figure 3-4, is constructed of a fiberglass-reinforced polypropylene screen, with 2 millimeter openings. As the stormwater enters the StreamGuard™ insert, floatable debris such as cigarette butts, leaves, paper, wrappers, etc. are captured by the mesh bag. All of the StreamGuard™ inserts are available in a curb-style catch basin design up to 36 inches wide. The StreamGuard™ inserts designed for typical drop inlets can fit any size catch basin up to 30 inches x 40 inches (Foss Environmental, 1999).

Applicability:

The three StreamGuard™ models are designed to treat areas with very different pollutant loading characteristics. The insert designed for sediment only is perhaps most practical for construction sites or any application where sediment is likely to be carried into storm drains. The oil and sediment StreamGuard™ model is the most versatile design and can be applied to parking lots, fuel transfer stations, gas stations, vehicle maintenance areas, industrial sites, vehicle washing facilities, marinas, and construction sites. According to Foss Environmental, the insert designed for trash and debris was for use at popular waterfront tourist areas, but can be useful in any application where trash and debris is carried into storm drains such as stadiums, wood products facilities, street fairs and parades, and shopping malls (Foss Environmental, 1999).

<u>Installation and Capital Costs:</u>

The StreamGuard™ catch basin inserts are universally fitting due to a non-rigid fabric skirt construction. Installation requires removal of the inlet grate, cleaning of the inlet supporting ledge, laying the insert over the opening with the bag inside of the catch basin. The inlet grate should then be replaced, pinching the insert fabric in place. The excess filter fabric should be cut off such that there is a 3 to 5 inch wide strip of the fabric outside of the grate.

Capital costs vary upon the type of StreamGuard™ model and the number purchased. Table 3-3 shows a cost breakdown for each StreamGuard™ model.

Model	1-4 units	5-9 units	10-50 units	60-100 units	100+ units
Sediment	$64	$62	$56	$54.50	$53
Oil & Sediment	$89	$87	$79	$76.50	$74
Trash & Debris	$64	$62	$56	$54.50	$53

Table 3-6.
StreamGuard™ Capital Costs per Insert

<u>Maintenance Requirements and Costs:</u>

The maintenance requirements and costs tend to vary upon the type of StreamGuard™ and the amount and type of pollutants present in the contributing watershed. Foss Environmental suggests that if the inserts are being utilized as a BMP, they should be inspected monthly regardless of the model or pollutant loading. The oil and sediment StreamGuard™ design typically requires maintenance (i.e., cleaning accumulated sediment and replacing oil absorbent media) at 3 to 6 month intervals in areas of moderate sediment and hydrocarbon loading and more frequent maintenance in areas of intense pollutant exposure. Replacement oil absorbent filter packs typically cost around $30. The trash and debris model as well as the sediment model require monthly and even weekly maintenance where moderate levels of trash or sediment is encountered. Maintenance consists of completely removing the unit, emptying the accumulated debris or sediment and replacing the insert. The manufacturer suggests that the both insert models be inspected after each significant rainfall event. The trash and debris and sediment control insert are typically replaced annually but wear and tear due to vehicular traffic can reduce the longevity of the StreamGuard™ insert (Stormwater Tech Trade Show, 1999).

Results of Performance Testing:

The hydraulic capacity of all of the StreamGuard™ catch basin insert models have been tested in a laboratory setting with the results summarized in Table 3-4.

	Sediment	Sed. & Oil	Trash & Debris
Total Flow Rate Capacity	500 gpm	500gpm	1000 gpm
Emergency Overflow	250 gpm	250 gpm	250 gpm
Design Treatment Flow	$\leq$ 20 gpm	$\leq$ 20 gpm	$\leq$ 40 gpm

Table 3-7.
Hydraulic Capacity of Each StreamGuard™ Model
(Stormwater Tech Trade Show, 1999)

Of the three StreamGuard™ models, only the Sediment and Oil model has been the subject of field performance testing. An independent study was conducted by the

King County Surface Water Management Division of Washington State to determine the in-situ pollutant removal efficiencies of the StreamGuard™ insert. The study reported an 88% removal of oil and grease at a park-and-ride lot and an 80% TSS and 94% oil and grease removal at a passenger pick-up area in the SeaTac International Airport (Stormwater Tech Trade Show, 1999). The reported airport removal efficiencies are an average for numerous inserts that were installed and tested on-site.

3.6 Ultra-Urban™ Filter (AbTech Industries)

General Description:

The Ultra-Urban™ filter is designed primarily for the removal of oil & grease, sediment and trash that enter stormwater curb inlets. This catch basin insert has a modular design that not only will allow most curb drain designs to accommodated, but also allows for various levels of treatment with the installation of additional modules. Figure 3-6 shows an example of a typical single Ultra-Urban™ filter module. Entrained trash and sediment is captured and accumulated in the internal basket, while oil & grease is removed through the unit's filtration media. AbTech had developed a proprietary polymer filtration media referred to as the Oars® SmartSponge™, which initially adsorbs, then absorbs hydrocarbons thereby reducing the potential for leaching of trapped contamination. The manufacturer claims that the SmartSponge™ media can remove up to 80% of oil & grease in stormwater under typical residential pollutant concentrations to concentrations as high as those associated with direct illegal dumping of motor oil into storm drains. Each of the Ultra-Urban™ modules is packed with 20 pounds of SmartSponge™ filtration media (Stormwater Tech Trade Show, 1999). The curb opening Ultra-Urban™ filter consists of three different modules varying by the location (right, left, or both sides) of the lateral by-pass channel(s). These various models allow for numerous adjacently installed modules to be hydraulically connected, thus allowing for the remediation of higher runoff flow rates. All of the modules have the same outside dimensions (13.75 inch x 14 inch x 23 inch) as depicted in Figure 3-6, and are constructed from galvanized steel. Under high flow conditions, the Ultra-Urban™ filter allows flow to by-pass the module over the top, reducing the risk of local flooding (Stormwater Tech Trade Show, 1999).

Applicability:

Ultra-Urban™ filters are primarily designed for conventional curb drain installation that has an adjacent manhole access into the catch basin. The primary purpose of the Ultra-Urban™ modules is to remove oil & grease from stormwater but also has a secondary sediment and trash removal function. This operational definition suggests that this catch basin insert be targeted for use in areas with high hydrocarbon loadings accompanied by low concentrations of sediment and debris. Each Ultra-Urban™ filter module can treat up to 35 gallons per minute, thus the runoff potential of each catch basin's contributing watershed should be assessed such that a sufficient number of modules are installed.

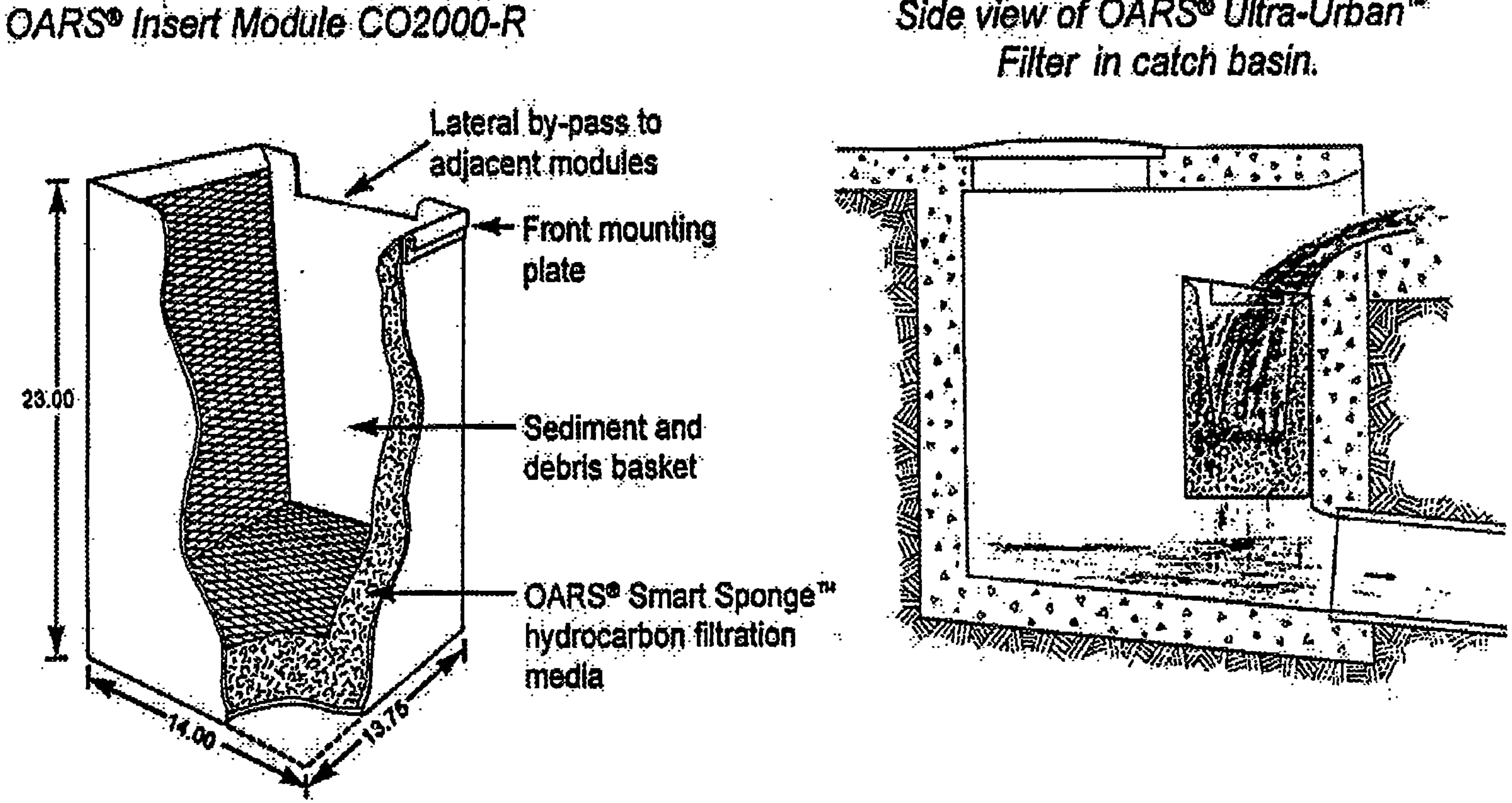


Figure 3-6.
Ultra-Urban Filter Schematic (Stormwater Tech Trade Show, 1999)

Installation and Capital Costs:

The installation of an Ultra-Urban™ filter module requires access into the catch basin via a manhole with a diameter of at least 24 inches. The filter rests upon a single mounting bracket that has to be attached to a vertical surface in the catch basin capable of supporting at least 250 pounds. A single mounting bracket can be used to support up to three modules and a typical curb inlet will require three to five Ultra-Urban™ modules. AbTech Industries claims that the complete installation of one module can be accomplished in about a one hour time frame.

There are some minimal installation costs associated with the necessary minor modifications to the existing catch basin and the purchase of fastening materials (i.e., bolts, drills, etc.). The manufacturer approximates that costs associated with the installation of a single module is around $100 in the southern states and $25 in the northern areas of the country. Capital costs for the Ultra-Urban™ Filter can range from $250 to $3000 depending upon the site conditions.

Maintenance Requirements and Costs:

AbTech recommends that depending upon adjacent land uses, the Ultra-Urban™ filters should be serviced every 3 months to remove accumulated sediment and debris. According to AbTech, the catch basin inserts can be serviced by conventional maintenance equipment such as the city's street cleaner, or a heavy duty shop-vac in 15 minutes or less for a typical curb inlet with 3 to 5 modules. The manufacturer also suggests that the SmartSponge™ filtration media be replaced annually to assure peak performance, but it can last up to 2 to 3 years. The costs associated with the filter media replacement is around $99 per module.

Results of Performance Testing:

Independent testing was performed on the Ultra-Urban™ filter at the University of California, Los Angeles to determine its ability to remove oil & grease. Under low flow conditions, the filter was able to absorb up to 80% of the oil & grease concentration and the pollutant became permanently bonded within the polymer media. AbTech also conducted in-house laboratory studies to determine the hydrocarbon removal effectiveness. The first of two studies was conducted in a laboratory that consisted of a simulated curb and gutter draining into a scaled-down model of a catch basin which contained a representative Ultra-Urban™ filter system. A mixture of used motor oil and diesel fuel was added to a 12 gpm flow, with and without sediment and debris. Six sets of samples were taken, the first three contained 1.4 kg of debris (leaves, small rocks, twigs, etc.) and .3 kg of sediment while the last three were conducted in the absence of sediment and debris. The influent oil & grease concentration was 28 mg/L for each sample and the removal results are summarized in Table 3-8.

	Average Concentration (mg/L)	Average % Removal
Set 1	3.65	87
Set 2	4.82	83
Set 3	3.9	86
Set 4	5.47	80
Set 5	6.03	78
Set 6	4.37	84

Table 3-8.
New Filter Hydrocarbon Removal Results, (AbTech Industries, 1999).

The second in-house laboratory test was conducted in the same laboratory set-up previously described, but utilized an Ultra-Urban™ filter from a residential installation discussed in the Santa Monica Bay Municipal Stormwater/Urban Runoff Pilot Project description found in Chapter 2. The used filter was exposed to flows containing mixtures of used motor oil and diesel fuel with rates ranging between 12 and 15 gpm for 13 minutes. This procedure was conducted six times and the results are summarized in Table 3-9.

Sample No.	Influent Concentration (mg/L)	Effluent Concentration (mg/L)	Percent Removal
Sample 1	28	2.1	92.5
Sample 2	30	2.1	93
Sample 3	32	6.9	78.4
Sample 4	28	1.2	95.7
Sample 5	30	1.3	95.7
Sample 6	32	2.8	91.3
	Average		**91.1**

Table 3-9.
Used Filter Hydrocarbon Removal Results, (AbTech Industries, 1999).

Another study, discussed in Chapter 2, was conducted by a consortium of municipalities in the Santa Monica Bay area and Woodward-Clyde engineering firm to determine the overall sediment and debris removal capabilities under wet and dry weather conditions. AbTech's catch basin insert performed very well under both conditions. A more detailed description of this study and the results can be found in Chapter 2.

Summary:

Figure 3-7 reveals the manufacturer's claimed removal efficiencies for three common urban pollutants, oil & grease, heavy metals, and total suspended solids (TSS). The high oil & grease removal efficiencies for the Siltcack® insert is representative of the model equipped with the oil absorbent pillow, and high heavy metal removal efficiency can be attributed to data that focuses on the metals in suspension (attached to sediment particles).

Figure 3-8 shows a comparison of oil & grease removal results from performance testing of the various catch basin inserts discussed in this chapter. The captions below the insert names describe the state of the filter and whether the efficiencies representative of a study conducted in a laboratory setting or a field installation. The state of the filter (new/used) indicates whether the testing was conducted directly after installation (new) or after an extended period of time in which the filter was exposed to stormwater and its various contaminants (used).

Figure 3-9 reveals the range of common non point source pollutant concentrations experienced during the field performance tests conducted by the various catch basin filter/insert manufacturers as well as the independent AquaShield™ study described in Chapter 4.

Figure 3-10 is a characteristic matrix for all of the catch basin insert/filters listed in Chapter 2 and Appendix A.

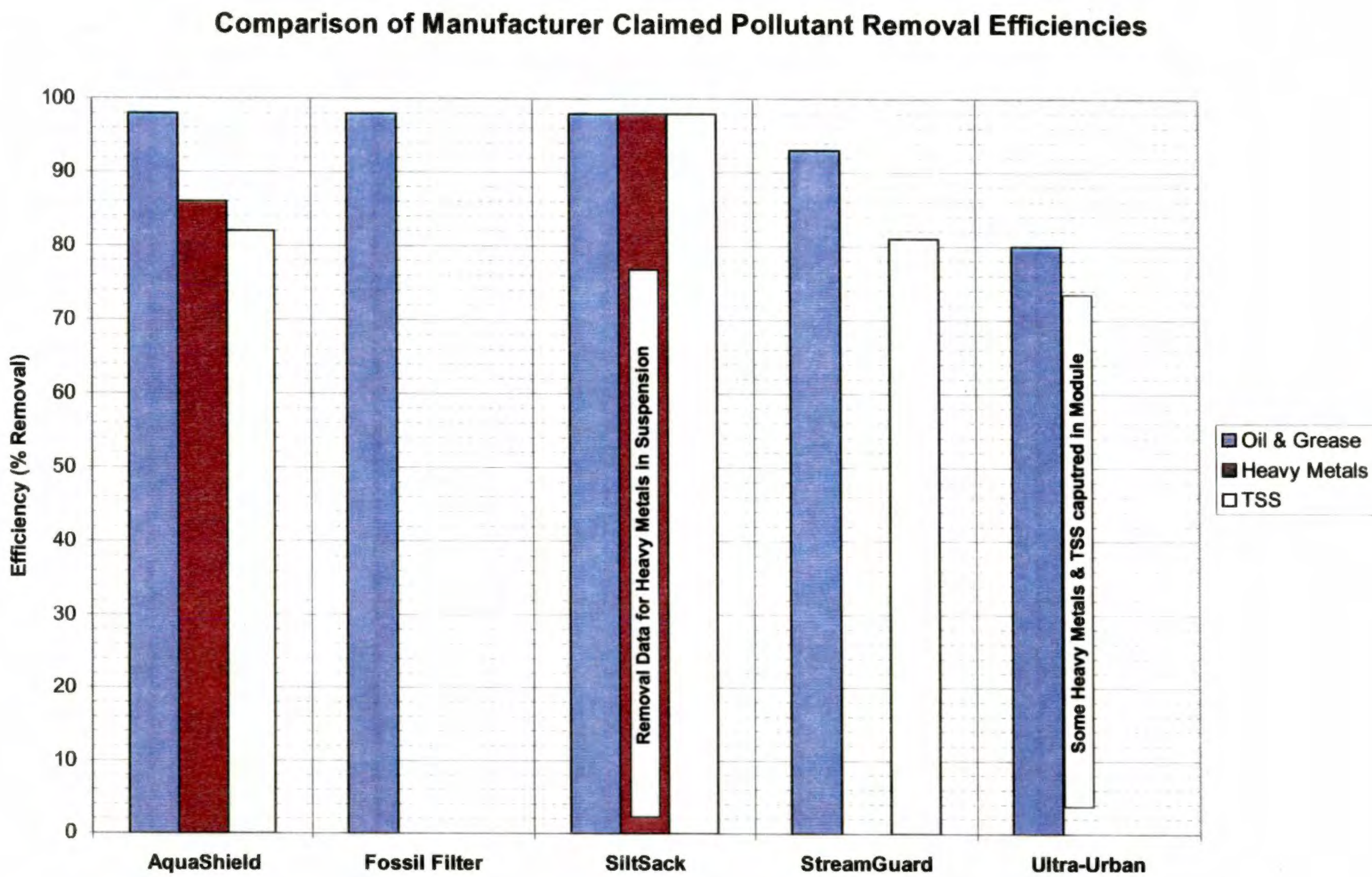


Figure 3-7.
Manufacturer Claimed Pollutant Removal Efficiencies

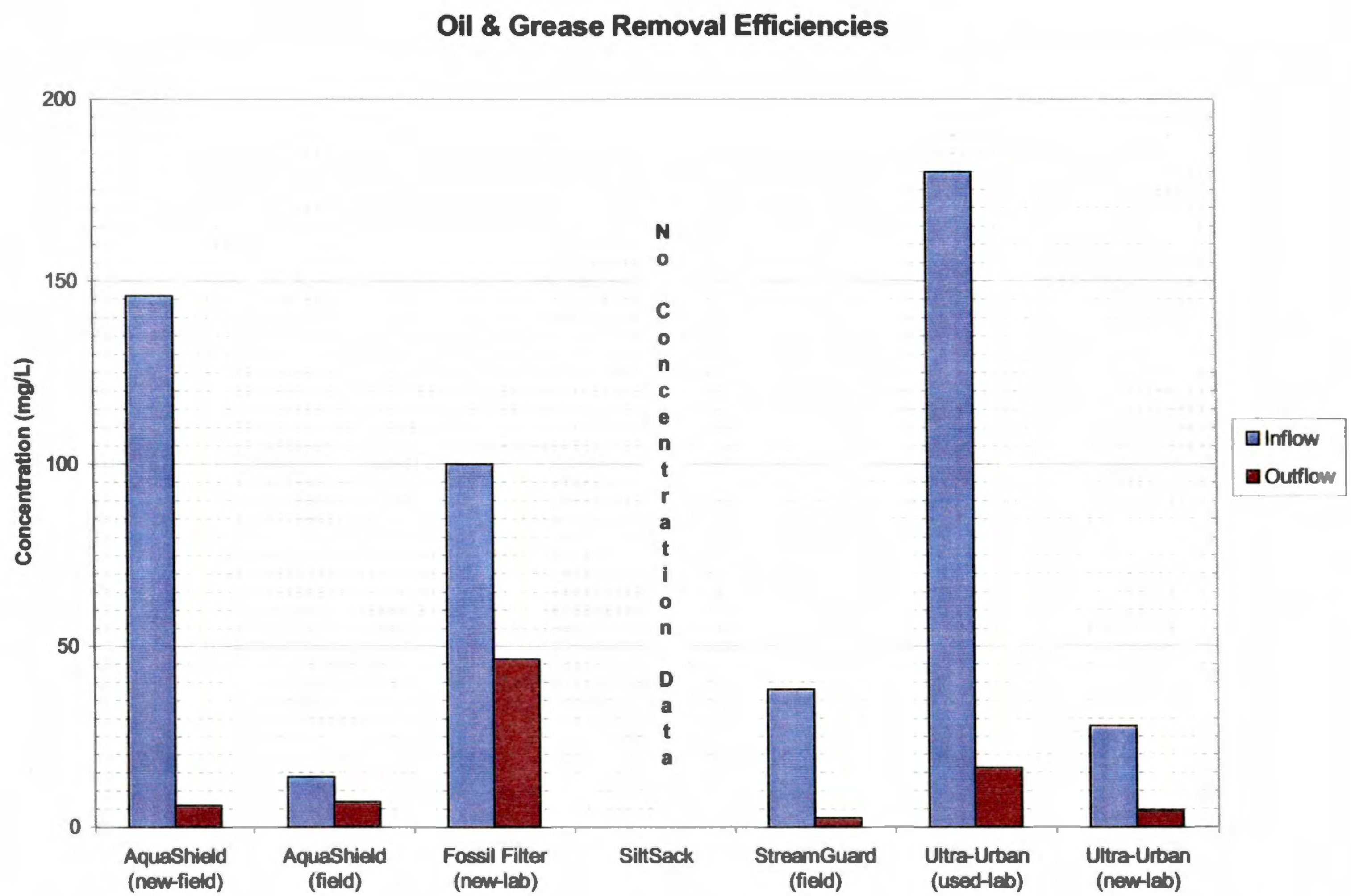
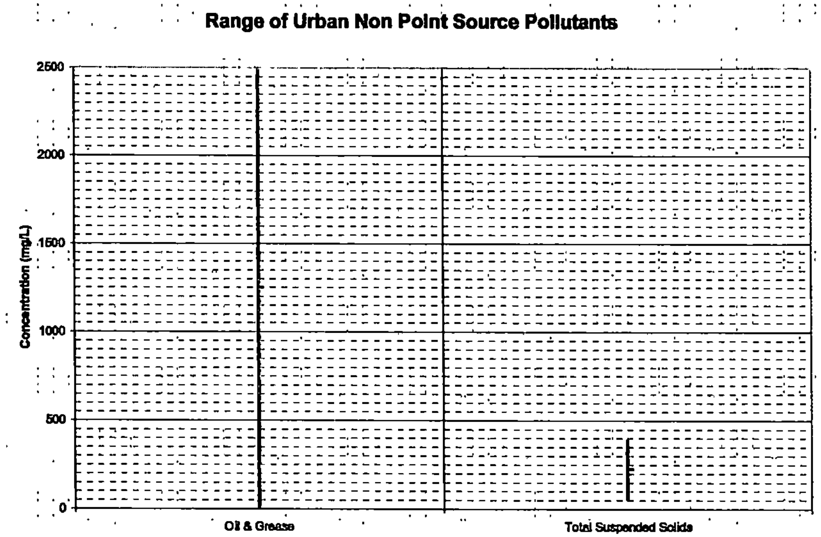


Figure 3-8.
Comparison of Oil & Grease Removal Efficiencies



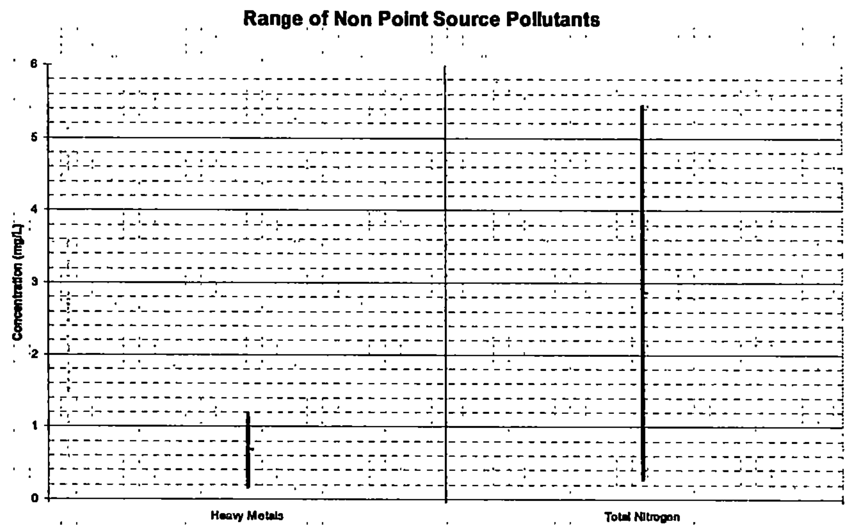


Figure 3–9.
Typical Ranges of Common Pollutant Concentrations in Storm water

Type of Insert	Applications	Target Pollutants	Capital Costs	Maintenance Frequency	Filter Longevity	Max. Claimed Removal Efficiencies: Oil and Grease	Heavy Metals	TSS
AquaShield	New and existing industrial, commercial, governmental, institutional, & multi-family developments	Oil & Grease, TSS, Nutrients, Heavy Metals, BOD	$997 to $3250	After rainfall >.5" in 24hrs; Prior to rainy season; After treating 10x design flow capacity	~ 3 months	98%	86%	82%
BMT Storm Clenz Filter	Areas of high hydrocarbon loading, accompanied by low sediment volumes	Sediment, and petroleum hydrocarbons	$350-$800	3x per year; prior, during, end of wet season	3 to 4 months	Absorbs 5x its weight	None Claimed	No efficiency stated
Enviro-Drain	Parking lots, downtown areas, residential/commercial/ idustrial areas	Hydrocarbons, organics, sediment, heavy metals, nutrients, debris	$4,500	From after every major rain event to after >5 inches of rain	≤ 3 months	97%	97%	97%
Fossil Filter	Anywhere motor vehicles move, park, refuel, or are serviced	Oil & Grease, Gasoline, Diesel Fuel	$400	At least 3x / yr; Once prior to main wet season and twice during	~ 6 months	98%	None Claimed	None Claimed
Gullywasher	Parking lots, residential and downtown streets, commercial areas,	Petroleum hydrocarbons, sediment, debris	$450-$700	From after every major rain event to after >5 inches of rain	≤ 3 months	No Specific Claims		
Hydro-Cartridge	Parking lots, roadways	Sediment, and petroleum hydrocarbons	$680-$1160	2 weeks to 1 month	6 to 8 months	> 90%	None Claimed	> 90%
SIFT Filter	Areas of high hydrocarbon loading	Petroleum Hydrocarbons	$350-$700	6 months to 1 year	6 months to 1 year	99.4%	None Claimed	None Claimed
SiltSack	Construction sites and other land disturbing activities	Suspended Sediment	$70	After every major rain event	Highly Variable	98%	98%	98%
Storm Watch	Areas of high hydrocarbon loading, Construction sites	Sediment, and petroleum hydrocarbons	$63-$125	After every major rain event	3 months to 1 year	Removal data based on StreamGuard testing b/c has bascially same design		
StreamGuard	Construction sites, Areas of high vehicle volume or exposure, Stadiums, Shopping malls, Downtown streets, Waterfront tourist areas	Oil & Grease, TSS, Trash & Debris	$53 to $89	*Trash/Debris Model* and *Sediment Model* - weekly to monthly; *Oil & Grease Model* - monthly	3 months to 1 year	93%	None Claimed	81%
Ultra-Urban	Areas of high hydrocarbon loading, accompanied by low levels of sediment and debris	Oil & Grease, Sediment, Debris	$250 to $3000	Every 3 months	~ 1 year	80%	None Claimed	None Claimed

Figure 3-10.
Catch Basin Insert/Filter Characteristic Comparison Matrix

Chapter 4 - Municipality Performance Evaluations

4.1 Introduction

Although the manufacturers of the various catch basin inserts provide information on the performance of their respective product, most of the supporting data has been laboratory derived or collected in the field over a short time scale. Actual long term exposure of the catch basin inserts to urban conditions can lead to problems unforseen in the laboratory setting or short term field testing. The magnitude of these problems associated with long term urban exposure can be the determining factor in a municipality's decision to include the catch basin filters as a part of their stormwater management plan to comply with EPA's NPDES Phase II regulations. In order to document and compare the actual performance of the various catch basin inserts , a survey questionnaire was sent to various municipalities across the nation who have implemented one or more of the various inserts discussed in Chapter 3. Of the 14 cities and municipalities surveyed, 6 responded to the questionnaire. Table 4-1 shows which city/municipality was surveyed, which filter(s) is installed there, and if they responded to the questionnaire.

The specific objectives of this survey are as follows:

1. Determine the location and types of land use most common for the application of these BMP's.

2. Determine what urban pollutants are the major concern leading to the adoption of catch basin filters.

3. Determine the actual maintenance requirements and problems that long term urban exposure produces.

Table 4-1.
Municipalities Surveyed

City/Municipality Queryed	Type of Insert	Responded to Survey?	
Los Angeles, CA	AquaShield	Yes	
Chattanooga, TN	AquaShield	Yes	
Greendale, IN	AquaShield		No
Wasilla, AK	AquaShield		No
Hayward, CA	Fossil Filter	Yes	
Los Angeles, CA	Fossil Filter	Yes	
Petaluma, CA	Fossil Filter	Yes	
Pleasanton, CA	Fossil Filter		No
Richmond, VA	SiltSack		No
Chesterfield County, VA	SiltSack		No
Austin, TX	StreamGuard		No
Issaquah, WA	StreamGuard		No
Mansfield, CT	StreamGuard	Yes	
Miami Springs, FL	StreamGuard		No
Santa Monica, CA	Ultra-Urban Filter	Yes	
Los Angeles, CA	Ultra-Urban Filter	Yes	

4. Determine an overall performance rating.

5. Develop recommendations from the cities who are using the inserts for those municipalities interested in adopting this type of BMP.

To accomplish these objectives, each of the surveyed municipalities were asked the following questions:

1. **Describe the location and watershed of the installed catch basin filter/insert.**

2. **Was there one pollutant in particular that you were the most concerned about and that lead to the implementation of the catch basin filter? If so, please indicate the pollutant, if not, please indicate which pollutants were of major concern.**

3. **Do you have a routine maintenance program in place? If so, please discuss it briefly.**

4. **On average, how often does the filter media need to be changed and/or how often does the sediment need to be removed?**

5. **Would you consider litter and debris to a major concern to the proper operation of the catch basin filter/insert?**

6. **Have there been any field studies to observe the actual removal efficiency of the catch basin filter system? If so, what were the removal efficiencies for the following urban pollutant:**

    i. **Oil and Grease**

    ii. **Total Suspended Solids**

iii. Heavy Metals

iv. Total Nitrogen

v. Total Phosphorus

7. **Please rate for overall performance of the catch basin insert on the following scale:**

   1 (very poor), 2 (poor), 3 (fair), 4 (good), 5 (excellent)

8. **General Comments/Major Drawbacks.**

Table 4-2 provides a summary of all city/municipality responses to the preceding questions. The actual responses are provided in Appendix D.

4.2 Results

Question 1 - Location of Catch Basin Filter/Insert

A majority of the municipality responses indicated that the inserts were utilized in downtown commercial parking lots. The cities of **Petaluma, CA, and Los Angeles, CA** have inserts installed in curbside catch basins along downtown and residential roadways. **Los Angeles, CA,** has installations at the city's maintenance facility. The Town of **Mansfield, CT** has an installation in a vehicle wash-down area catch basin.

Question 2 - Pollutants of Concern

All of the responses cited oil and grease (and other hydrocarbons) as a pollutant that was of major concern and led to the implementation of the catch basin filter/inserts.

Table 4-2.
Summary of Municipality Survey Responses

City/Municipality	Type of Insert	Location of Insert	Pollutant(s) of Concern	Maintenance Program	Filter Longevity	Litter & Debris Concern	Pollutant Removal %	Overall Rating (1-5)	Comments
Chattanooga, TN	*AquaShield*	Fast Food Parking Lot	Oil & grease, antifreeze	Yes (comments)	3 months	No (comment)	No Data	Still Evaluating	Yes
Los Angeles, CA	*AquaShield*	Downtown Street	O&G, Heavy Metals, TSS, Nutrients, Fecal Coliform, BOD	Pilot Study (comments)	1, 3, or 6 months	Yes (comment)	No Data	Still Evaluating	No
Greendale, IN	*AquaShield*	**Returning Survey Results**							
Hayward, CA	*Fossil Filter*	Parking Lots	Hydrocarbons	Owner Responsibility	Site Dependent	No (comment)	Data Provided	4 (good)	Yes
Los Angeles, CA	*Fossil Filter*	Downtown Street	O&G, Heavy Metals, TSS	Pilot Study (comments)	1, 3, or 6 months	Yes (comment)	No Data	Still Evaluating	No
Petaluma, CA	*Fossil Filter*	Parking Lots & Urban Streets	Oil & Grease	Owner Responsibility	4 months	Yes	No Data	4 (good)	Yes
Mansfield, CT	*StreamGuard*	Vehicle Washdown Area	Oil & Grease, Road Salt	Yes (comments)	6 months	No (comment)	No Data	4 (good)	No
Austin, TX	*StreamGuard*	**Returning Survey Results**							
Los Angeles, CA	*Ultra-Urban*	Downtown Street	O&G, Heavy Metals, TSS	Pilot Study (comments)	1, 3, or 6 months	Yes (comment)	No Data	Still Evaluating	No
Santa Monica, CA	*Ultra-Urban*	Parking Lots & Urban Streets	Trash, TSS	Yes (comments)	Unknown (comment)	Yes	No Data	4 (good)	Yes
Richmond, VA	*SiltSack*	**Returning Survey Results**							
Chesterfield Co., VA	*SiltSack*	**Returning Survey Results**							

The city of **Chattanooga, TN** also mentioned antifreeze as a significant pollutant. **Los Angeles, CA** was also troubled with contamination of receiving waters by heavy metals. Suspended sediment was a pollutant of concern for **Petaluma, CA**, **Los Angeles, CA**, and **Santa Monica, CA**. The city of **Petaluma, CA** was interested in preventing litter and debris contamination. The town of **Mansfield, CT** did not cite one particular pollutant that lead to the implementation of the catch basin insert, but did indicate that oil & grease, and road salt were pollutants of concern.

Question 3 - Description of Maintenance Program

The cities of **Hayward, CA**, and **Chattanooga, TN**, state that maintenance of the catch basin filter is the responsibility of the owner or managing operator of the property or facility where the insert is installed. **Chattanooga, TN** has implemented a Facility Pollution Prevention Program that governs the maintenance of drainage structures, which includes catch basin filter/inserts, and calls for the periodic inspection of these structures by city officials. Some of the facilities in Chattanooga are contracting the maintenance out to the manufacturer, which in this case is Remedial Solutions, Inc., makers of the AquaShield™ insert. In **Los Angeles, CA** the city is conducting a pilot study on various types of catch basin inserts, and the manufacturers are conducting the maintenance on their own product during the study. The city **Petaluma, CA** conducts their own maintenance program that consists of sweeping the adjacent surface area, cleaning the bottom of the catch basin, cleaning the filter insert, and replacing the media if it is at least 50% saturated. **Mansfield, CT** replaces the filter media every 6 months and performs a monthly visual inspection. **Santa Monica, CA** vacuums the catch basin inserts out once a month.

Question 4 - Filter Media Longevity and/or Service Frequency

The city of **Petaluma, CA** replaced the filter media two times during the 8 month rainy season (October through April). Sediment and debris were removed once prior to and three times during the 8 month rainy season. **Mansfield, CT** replaces the filter media and removes accumulated sediment in early spring (April) and late fall (December). **Chattanooga, TN** replied with an 3 month average for the removal of sediment and replacement of the filter media.

Question 5 - Concern of Litter and Debris Effects on Operation

Most of the municipalities who responded feel that litter and debris can limit the hydraulic operation (i.e., clogging) of the inserts if not regularly inspected and serviced. Although **Chattanooga, TN** admits the potential problems litter and debris can create, their concern is minimal because the areas adjacent to the inserts are generally kept clean for aesthetic purposes. **Hayward, CA** does not cite litter and debris to be a major concern to the proper operation of the catch basin filters. The city feels that with the proper surface grate, the litter and debris will never interact with the filter media, and if some litter and/or debris enters through the grate, water easily bypasses the material to be treated by the filter media. The town of **Mansfield, CT** does not consider litter and debris to be a major operational problem in their particular application.

Question 6 - Actual Pollutant Removal Efficiencies

Many of the responses indicated that the city/municipality had not conducted any research or independent studies to determine the actual pollutant removal efficiencies experienced in the field. The city of **Hayward, CA**, provided the following removal efficiencies for the Fossil Filter™ insert: oil & grease (40%), total suspended solids (25 - 47%), heavy metals (28 - 33%), and total nitrogen and phosphorus (unknown). **Hayward, CA** also has other types of the inserts in place and provided the following overall removal efficiency data, which was determined by URS Greiner Woodward Clyde for the Alameda Countywide Clean Water Program: oil & grease(30 to 90%), total suspended solids(-40 to +40%), heavy metals(-9 to 30%), and total nitrogen and phosphorus (unknown).

Question 7 - Overall Performance Rating

A majority of the city/municipalities who responded were able to confidently assess the performance of the various catch basin filter/inserts on a scale of 1 to 5 (1- very poor, 5 - excellent). **Chattanooga, TN**, and **Los Angeles, CA**, are still evaluating this BMP's performance and were not able to confidently provide a rating.

Question 8 - General Comments/Major Drawbacks

The city of **Chattanooga, TN** cites the costs and maintenance requirements of the catch basin filter/inserts as major drawbacks. **Petaluma, CA** feels that the Fossil Filter™ is simple to install and maintain and though routine inspections are important, no major drawbacks have been experienced. **Santa Monica, CA** specified a concern regarding the capital costs of the AbTech design. The city of **Hayward, CA** typically requires catch basin or drain inserts on all new construction sites and the general contractor usually sub-contracts the installation and the cost is absorbed into the budget of the entire project. The city cites a major drawback to be clogging and captured pollutant re-entrainment due to lack of maintenance. This maintenance deficiency is attributed to the fact that when an owner or facility manager occupies new property, they are seldom aware of the installed insert or that the maintenance of these devices is their responsibility.

Chapter 5 - AquaShield™ Field Analysis Results

5.1 Installation Description:

To further develop the evaluation on the actual observed performance of catch basin filter/inserts in the field, a small scale study was conducted with assistance from the City of Knoxville, TN. Remedial Solutions, Inc. donated and installed two AquaShield™ catch basin inserts in the city of Knoxville for the purpose of the study. The first insert was installed on September 27, 1999 at the Knoxville Solid Waste Transfer Station, and the second filter was installed August 3, 1999 on the University of Tennessee campus. The objective of the study was to observe the overall performance, (maintenance requirements, what pollutants are removed, what are the corresponding pollutant removal efficiencies during the "first flush") of the inserts in both a worst case (transfer station) and more typical (UT campus) urban setting.

The installation at the Knoxville Solid Waste Transfer Station was in a rectangular drop inlet catch basin (#1) located under the main access road near the entrance gate of the property (Figure 5-1). This particular inlet receives stormwater runoff from a pollutant rich 1 acre drainage area, which includes a large dumping area of brush, debris, and appliances. Runoff and wash-down water from the main transfer/dumping facility also is captured by the catch basin targeted in the study. In addition, the access road to the facility experiences increased pollutant loads from approximately 180 vehicles and solid waste transfer trucks per day,

Placement of Stainless Steel Housing

Housing in Place, No Filter Media

Installation of Filter Media

Installation Complete

Figure 5-1.
Typical AquaShield™ Installation (Catch Basin #1)

and heavy equipment (i.e., bulldozers, back-hoes). Figure 5-2 shows a picture of the area contributing runoff and pollutants to catch basin #1.

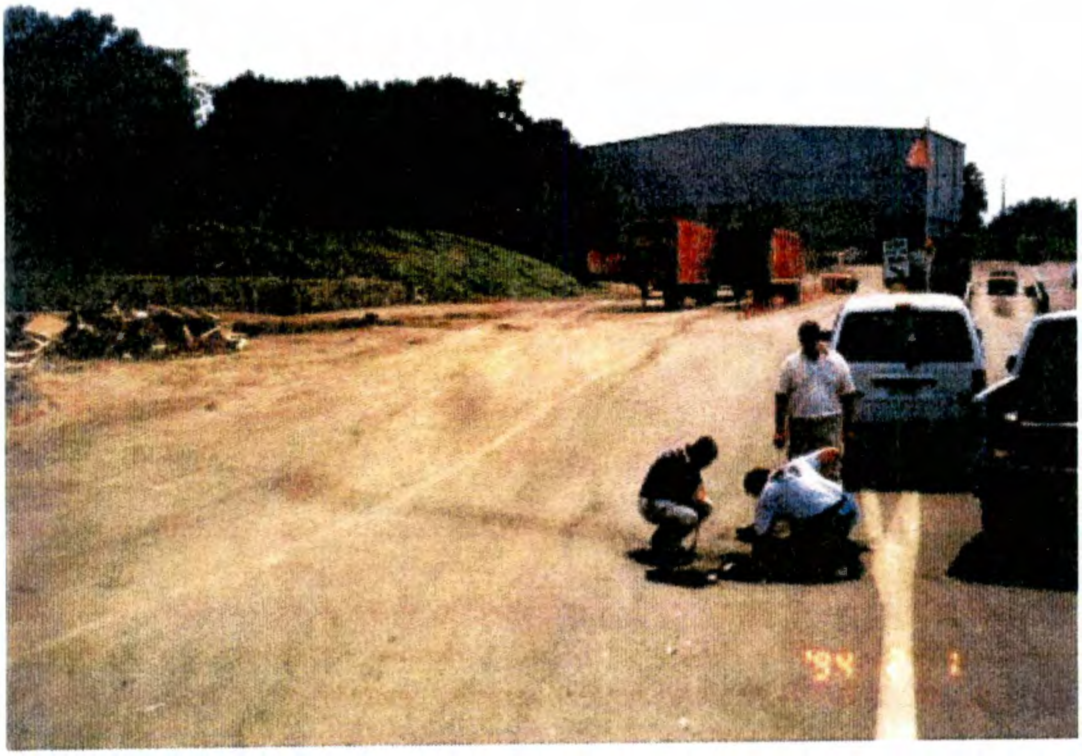


Figure 5-2.
Catch Basin #1 Contributing Drainage Area

The AquaShield™ installation on the University of Tennessee campus (Figure 5-3) is located in a combination drop/curb inlet 2) along Philip Fulmer Way across from Gate 23 of Neyland Stadium. Under normal annual rainfall events, this particular catch basin only excepts drainage from an area of .17 acres due to a adjacent inlets, and a 6 inch curb that surrounds the perimeter of the staff parking lot located directly above the storm drain. There are 8 metered parking spaces along Philip Fulmer Way that drain directly to catch basin #2. In addition to the average daily traffic volume of approximately 2000 vehicles per day, the catch basin is also exposed to large amounts of litter and debris that is generated during UT home football games. Figure 5-4 shows a picture of the area contributing runoff to catch basin #2.

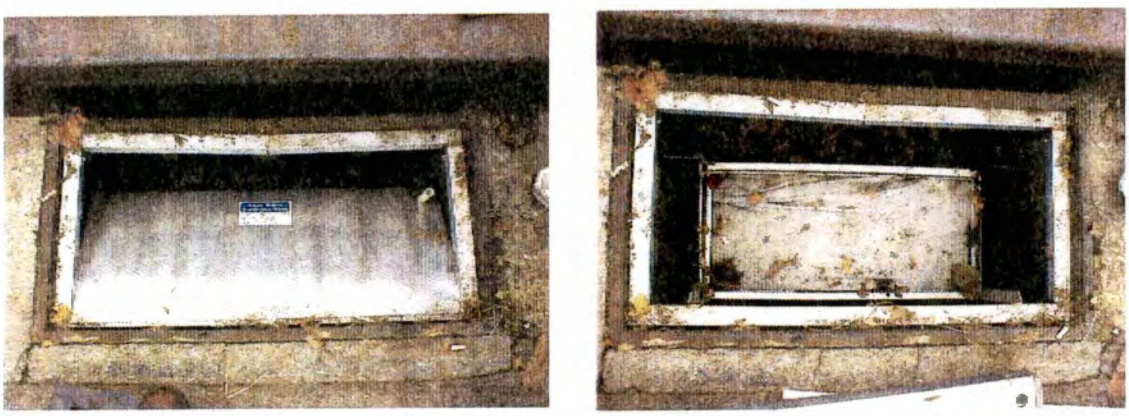


Figure 5-3.
Philip Fulmer Way Installation (#2)
(with diversion plate and without to reveal media)

Figure 5-4.
Catch Basin #2 Contributing Drainage Area

5.2 Testing Procedures:

In order to determine the maintenance requirements, routine weekly inspections of each AquaShield™ insert was made in addition to inspections during and directly following rain events. These purpose of each inspection was to observe the structural integrity of the insert, check for accumulation of litter and debris in the insert and around the inlet, monitor for standing water in the catch basin or an apparent decrease in the hydraulic capacity, check the amount of accumulated sediment, and observe the degree to which the filter media was saturated by contaminants.

In order to determine what pollutants the AquaShield™ is removing and to what degree, stormwater samples were gathered manually and analyzed by the Knoxville Utilities Board's (KUB) laboratory. The objective of this part of the study was to sample the "first flush", which for Knoxville is the first ½ inch of runoff, because this initial runoff typically contains that highest pollutant concentrations. The reason for sampling the "first flush" is to determine the AquaShield's™ performance during the conditions that contribute a considerable amount of non-point source pollution to receiving waters.

Influent runoff grab samples were taken by intercepting the stormwater into 1 liter plastic bottles as it fell into the catch basin as shown in Figure 5-5. The effluent water was sampled with the assistance of a sampling tray, located under the AquaShield™, that captures the water after it passes through the filter media and before it enters the storm drain network. A 7/8-inch PVC tube extended from the surface of the insert down into the sampling tray, allowing the filtered water to be pumped to the surface and sampled in 1 liter plastic bottles (see Figure 5-6).

Figure 5-5.
Influent Grab Sampling

Figure 5-6.
Effluent Pump Sampling

For the first sampled storm, an ISCO® peristaltic pump was used to sample the effluent stormwater. A hand held petroleum siphon pump (shown in Figure 5-6) was utilized for all other effluent sampling. To assure that none of the oil & grease remaining in the effluent adhered to the walls of the sampling tubing, 1/2-inch Teflon™ lined Tygon tubing was used. In order to collect a representative inflow/outflow sample of the "first flush", a grab sample of the initial runoff was taken and the initial water to enter the sampling tray was pumped and collected on the surface.

The influent and effluent samples were analyzed by the KUB laboratory for the following contaminants:

- Oil & grease (EPA 1664)
- Total Suspended Solids (TSS) (EPA 160.2)
- Biochemical oxygen demand (BOD) (Standard Methods 5210B)
- Chemical oxygen demand (COD) (EPA 410.4)
- Total Dissolved Solids (TDS)
- Nitrate + nitrite nitrogen (EPA 353.2)
- Total ammonia nitrogen (N) (EPA 350.3)
- Total Nitrogen (EPA 351.2)
- Total Phenols (EPA 4020.2)
- Total recoverable lead (Pb) (Various EPA Methods)
- Total recoverable zinc (Zn) (Various EPA Methods)
- Dissolved phosphorus (EPA 365.4)
- Total Phosphorus (EPA 365.4)

The KUB laboratory used the standard testing methods fouin parentheses to determine the presence and concentrations of the constituents listed above.

5.3 Inspection Results/Observed Maintenance Requirements:

The Knoxville area experienced an extended dry weather period for the first three weeks after the installation of the AquaShield™ inserts. On August 24,1999, the day following the first rainfall in over three weeks, the transfer station and UT campus inserts were inspected. The transfer station insert had one of the two sediment traps full of standing water due to a clogged weep hole, and a layer of mud and small debris was observed on the surface of the top filter. All three filters at the transfer station site were found to be saturated with pollutants (mainly oil & grease) by observing a black coloration of the media and needed to be replaced. Figure 5-7 reveals the condition of the insert during this inspection.

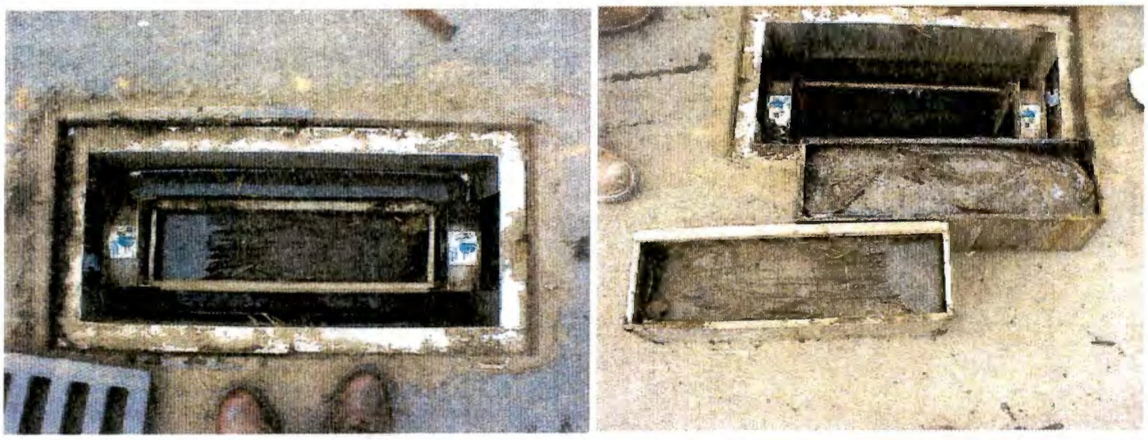


Figure 5-7.
Transfer Station Inspection Photos

The insert located on Philip Fulmer Way also had standing water in the sediment bay due to a weep hole clogged mostly by leaves and some small debris. After unclogging the weep hole, the sediment bay was noticed to be be almost totally void of any sediment accumulation; only a collection of leaves was present. The filter media was still relatively clean and replacement was not necessary. Figure 5-8 shows the condition of the AquaShield™ during this inspection.

Figure 5-8.
Philip Fulmer Way Inspection Photo

On August 27, 1999, after one month and only one rainfall of approximately .9 inches, the filters of the transfer station insert were removed, placed in doubled plastic garbage bags, and delivered to the hazardous waste disposal facility located on-site. The filter media was black and had a smell of petroleum products and other foul odors. After a discussion with the supervisor of the facility, it was discovered that the waste bays and trucks are washed down 2 to 3 times per week. A majority of this highly contaminated wash-down water drains to the inlet of the AquaShield™ equipped catch basin. This is the predominant reason for the rapid pollutant saturation of the filter media during an extremely dry period.

The replacement filters provided by Remedial Solutions were too big to fit into the filter cartridges so no media was replaced. Remedial Solutions was contacted and gave instructions to cut open the filter media bag, take out enough media to allow to filter to be placed back into the cartridge, and then close the bag with staples. These instructions were followed but it was decided that the media would not be replaced until just prior to a rain event due to the rapid pollutant saturation of the media at the household waste facility during dry weather periods.

Weekly inspections continued throughout the drought-stricken month of September and revealed standing water and considerable amounts of debris (i.e., paper, plastic cups, leaves, wood) in the sediment bays of both inserts. September 21, 1999 provided a rainfall of .34 inches (storm #1), the first precipitation in one month. First flush stormwater samples were collected from the AquaShield™ at the Philip Fulmer Way location. During the sampling, litter on the inlet grate and debris (i.e., cups, bottles, piece of clay piping) in the sediment trap was observed (see Figure 5-9). The filter media at the household waste station was not installed, so samples were not collected due to the entire system being clogged with mud and debris causing the media-less insert to be inundated with visibly contaminated water.

A little over a week later, on September 29, 1999 Knoxville received a rainfall of

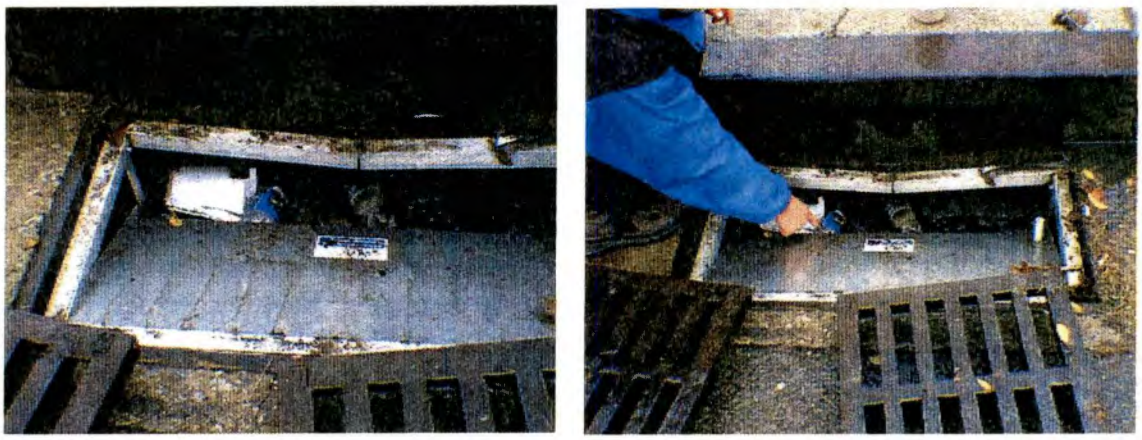


Figure 5-9.
Accumulated Debris at Site #2

.26 inches (storm #2). Inflow and outflow first flush samples were collected at the Phil Fulmer Drive AquaShield™ site under low flow conditions. Some of the low energy runoff was noticed to be dripping though the bypass structure, which did not allow for filtering to take place (see Figure 5-10).

Figure 5-10.
Low Flow Dripping Through Bypass (Site #2)

Upon inspection of the stormwater samples, no visible difference between the inflow and outflow samples was observed. The media was checked and still appeared to be relatively clean (no black coloration observed). The installation of the filter media into the AquaShield™ at the household waste transfer station was again impossible due the system once again being inundated with visibly contaminated runoff (see Figure 5-11).

On Saturday, October 9, 1999, storm #3, a light soaking rain (.66 inches) produced a runoff with a very low flow rate, but enough to collect stormwater samples from the Philip Fulmer site. The filter stages or cartridges were removed after the sampling and it was discovered that the sediment trap weep hole was positioned below the bottom filter. Under low runoff conditions (< .01 cfs), water would not exceed the capacity of the large (~ 7.5 ft^3) sediment bay and spill over into the filters, but would rather exit through the ½ inch weep hole and not experience any remediation. This discovery could explain why there was little or no visible difference in the inflow and outflow samples taken during the current and previous light rainfalls. Aside from some sedimentation experienced in the sediment bay, the chemical composition of the influent and effluent stormwater should be fairly consistent.

5.4 Performance/Pollutant Removal Results:

Precipitation amounts for the three monitored storms ranged from .26 to .66 inches. Both storm 2 and 3 were low intensity events and produced runoff with very low flow rates. Due to the location of the sediment bay weep hole in the UT campus AquaShield™, pollutant removal was minimal because the water never reached the level

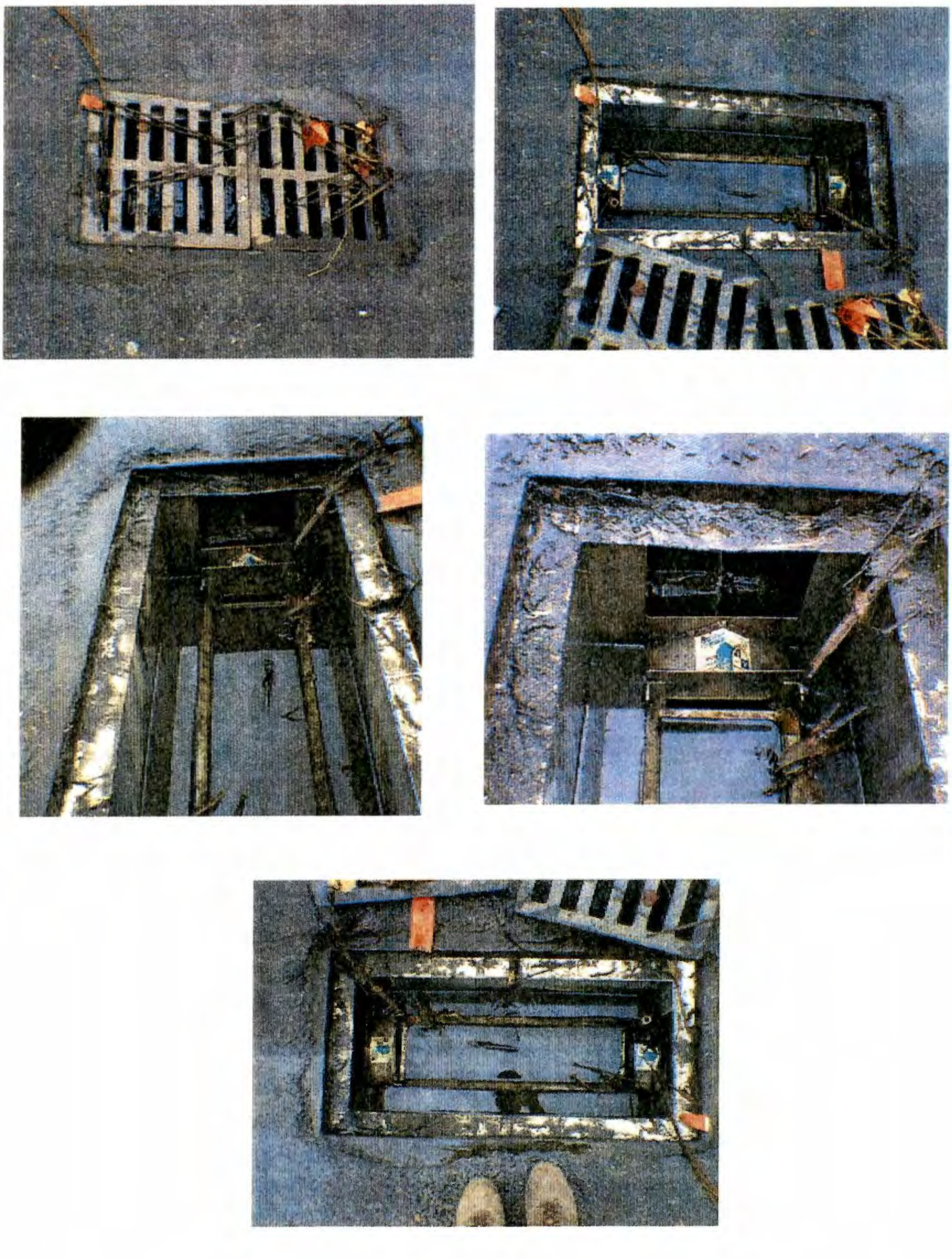


Figure 5-11.
September 11, 1999 Transfer Station Inspection Photos

necessary to spill over into the filters. All of the runoff exited the sediment trap and entered the sampling tray without coming in contact with either of the filters.

The influent oil and grease, total suspended solids (TSS), nitrogen, phosphorus and heavy metals event-mean concentration for the three storms are summarized in Table 5-1.

Table 5-1.
Influent Stormwater Event-Mean Concentrations

Pollutant	Event-Mean Concentration
Oil & Grease	23.3 mg/L
Lead & Zinc	.254 mg/L
TSS	90.7 mg/L
Total Nitrogen	1.33 mg/L
Total Phosphorus	.232 mg/L

Because of the hydraulic residence time and partial clogging of the sediment bay weep hole, effluent water can be a mixture of influent waters from previous storms. Therefore, caution must be used in interpreting individual storm pollutant removal efficiencies.

The laboratory analysis of the influent and effluent stormwater samples for all three storms is summarized in Table 5-2. The AquaShield appeared to perform reasonably well, although not up to the manufacturer's claimed efficiencies, during the first storm of .34 inches. As mentioned previously, this storm produced a relatively high flow rate which was sufficient to fill the sediment trap and spill over through the filter media stages, thus thus functioning as intended.

Figure 5-12, provides a performance comparison between the Remedial Solutions, Inc. claims and what was actually experienced at the Philip Fulmer Way installation site.

The second and third storms did not produce flow rates intense enough to overflow the sediment trap in the filters and thus revealed very poor pollutant removal efficiencies for all the analyzed contaminants except oil & grease. The oil & grease removal efficiencies can be attributed to the petroleum products floating to the surface of the water accumulated in the sediment trap and not present in the sampling tray when the samples were taken. The numerous negative removal efficiencies can perhaps be attributed to effluent sampling of water that was a mixture of collected water from the pervious storm that remained in the sediment trap due to a clogged weep hole. The water that was trapped between storms had an opportunity to be exposed to interim pollutants from atmospheric deposition, and accumulated dry-weather pollutants (i.e., leaves, plastic cups, paper, aluminum cans, etc.). For example, phosphorus begins to be emitted from decomposing leaves within two days, thus captured debris in the sediment trap is a potential reasons for the negative removal efficiencies provided by the AquaShield™ during storms 2 and 3.

5.5 Conclusions and Recommendations

Although the AquaShield™ at the Knoxville household/solid waste transfer station was not able to properly function for more approximately one month, much of the

Table 5-2.
AquaShield Pollutant Removal Laboratory Results for Philip Fulmer Way Site (#2)

	Storm1			Storm2			Storm3		
Pollutants	Influent Concentration (mg/L)	Effluent Concentration (mg/L)	Percent Reduction (%)	Influent Concentration (mg/L)	Effluent Concentration (mg/L)	Percent Reduction (%)	Influent Concentration (mg/L)	Effluent Concentration (mg/L)	Percent Reduction (%)
Oil & Grease	15	2	86.7	25	13	48.0	30	5	83.3
BOD	18	14	22.2	17	13	23.5	9	13	-44.4
COD	161	38.9	75.8	158	25.5	83.9	66.7	61.8	7.3
TSS	128	84	34.4	90	120	-33.3	54	54	0.0
TDS	197	68	65.5	142	269	-89.4	77	153	-98.7
Lead	0.028	0.014	50.0	0.015	0.006	60.0	0.012	0.02	-66.7
Zinc	0.372	0.21	43.5	0.18	0.208	-15.6	0.156	0.148	5.1
Nitrate + nitrite nitrogen	1.1	0.8	27.3	0.5	0.4	20.0	0.4	0.4	0.0
Total ammonia nitrogen	1	0.5	50.0	<.2	<.2	N/A	<.2	<.2	N/A
Total Nitrogen	1.9	2.3	-21.1	0.8	2.1	-162.5	1.3	0.2	84.6
Total Phenols	<.01	<.01	N/A	<.01	0.013	N/A	<.01	<.01	N/A
Dissolved Phosphorus	0.172	0.069	59.9	0.262	0.374	-42.7	0.144	0.114	20.8
Total Phosphorus	0.249	0.118	52.6	0.343	0.613	-78.7	0.103	0.123	-19.4

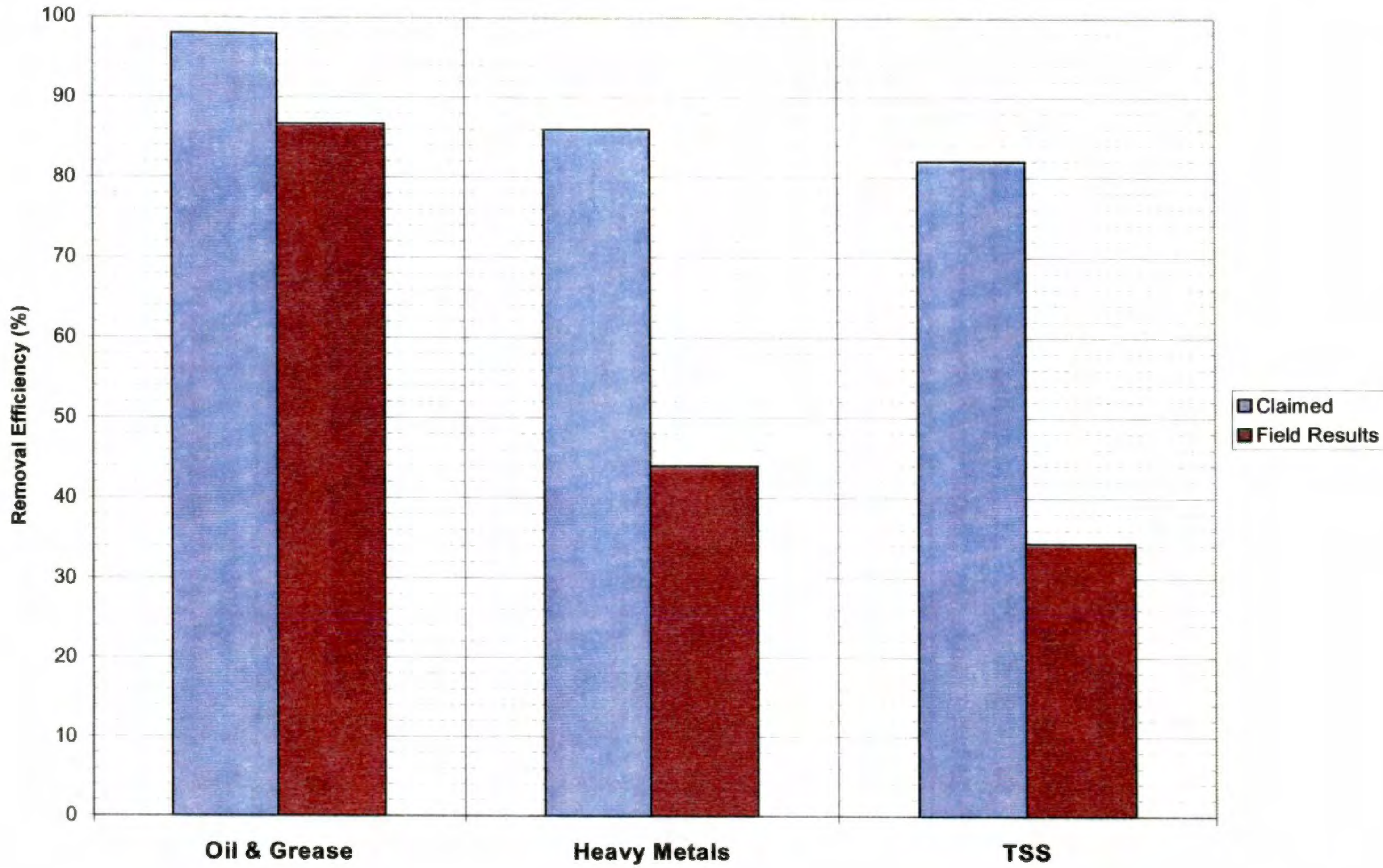


Figure 5-12.
AquaShield Performance Comparison for Storm #1

responsibility for the failure should rest upon the maintenance practices of the transfer station staff. Daily wash-downs of the trucks, equipment, and pavement produced an overwhelming amount of chemical contaminates, not to mention large quantities of trash and debris. Non-structural BMPs such as the use of the city's street cleaners/vacuum trucks rather than washing down the entire station, and the elimination of the large piles of dumped trash and debris in the areas adjacent to the catch basin need to be implemented and enforced by city officials. Improved management practices at the transfer station along with a commitment to routine maintenance could potentially render the AquaShield™ useful in reducing stormwater pollution from the site.

Despite the design configuration of having the sediment trap weep hole drain below the filters, the AquaShield™ installed on the UT campus showed positive pollutant removal capabilities when the device operated as intended (during storm #1). By moving the bottom filter cartridge below the weep hole, all of the first flush could be remediated prior to entering the storm drain network and ultimately the Tennessee River. Another system should be designed other than the standard weep hole to drain the water from the sediment trap. A flexible tube attached to a buoyant device would allow for drainage from the water surface as the level in the trap subsided. The potential for clogging may be reduced if the sediment trap is drained form the water surface.

Both of the AquaShield™ inserts should be left installed and long term evaluation should continue once the recommended changes are implemented.

Chapter 6 - Conclusions and Recommendations

From the information found in the preceding chapters, it is clear that catch basin insert/filters are not practical water quality BMP's for all hydrologic and hydraulic conditions and applications. Areas characterized by high sediment and litter/debris concentration are generally not locations where these catch basin filters will operate optimally. In fact, inserts that are installed in areas of high sediment or litter/debris concentrations will many times become inundated or clogged with suspended material and be rendered non-functional in a very short time (i.e., Knoxville household/solid waste transfer station, AquaShield™ test site #1). Catch basin inserts are typically designed for and perform best when they serve parking lots under one acre in size or urban roadways that are expected to receive intense hydrocarbon loadings and low concentrations of suspended or entrained material (i.e., sediment, litter, debris, etc.). To maximize the potential benefits of catch basin inserts they should not be used as (nor are they designed to be) a stand-alone BMP, but rather be used as a first flush treatment practice prior to a storm drain network, detention facility, infiltration practice, or some other form of water quantity control measure. They should be applied or retrofitted in highly urbanized areas, where space is not available for more effective water quality BMPs.

Assuming that the catch basin inserts are installed in areas conducive to their optimal operation, they still require a rigorous routine maintenance plan or program in order for the device to continue providing beneficial treatment of stormwater. The maintenance of the inserts can be costly and is usually not a priority of a municipality.

Depending upon the municipality, the maintenance responsibility can fall upon the property owner (as shown by the municipality survey responses) who many times is not aware of the filter or is not concerned with the maintenance due to an absence of regulations or regulation enforcement.

In order for municipal managers to make educated decisions regarding the use of catch basin inserts/filters in their existing storm drain network, they must have engineers, public works managers, and/or other technical staff members who understand how these inserts function and to what degree they can reduce pollution under various land use conditions. The following steps can provide guidance to municipal managers in making rational and technically sound decisions about whether and how to utilized catch basin inserts as a water quality BMP:

1. Identify catch basins to potentially be controlled
2. Identify target pollutants
3. Determine whether the goal is to control pollutants in wet or dry-weather discharges, or both.
4. Select the device that is best suited for specific watershed conditions and is economically feasible.

Figure 6-1 provides a decision tree for municipal managers to follow when evaluating potential catch basin remediation.

Municipalities must first decide on an implementation scheme, whether it be widespread across the city or concentrated in areas that have historically contributed the highest pollutant loads or have sensitive receiving waters. It is important to keep in mind that the areas of highest pollutant concentration may not be a location that is conducive for the optimal and long-term function of a catch basin insert. The selection of target pollutants is very important and should not be based upon common assumptions. Target pollutants should have all of, but not be limited to, the following characteristics:

- Pollutants whose concentrations or loads can be greatly affected by the removal mechanisms of catch basin inserts.
- Pollutants that are entrained and discharged via the storm drain network in either high concentrations, high annual loads, first flush, etc.
- Pollutants that through aquatic chemical analysis have been proven to be present in local receiving waters in high concentrations and are subsequently causing problems (Woodward-Clyde, 1998).

After deciding what pollutants should be targeted, the municipality should decide whether they want to control the pollutant(s) during wet and/or dry-weather discharges. Pollutants during dry-weather periods would consists mainly of litter and debris, whereas wet-weather pollutants would be all suspended and dissolved pollutants along with litter and debris. The final step in evaluating potential catch basin inserts is the actual selection of a particular device. Figure 6-2 provides guidance on the aspects that should be considered when selecting the device that is optimal for a specific condition (Woodward-Clyde, 1998).

Due to the precast nature of this BMP, the engineer or planner who is responsible for the installation and operation of the catch basin insert needs to mostly be concerned with determining the site-specific characteristics. The volume of water that is to be

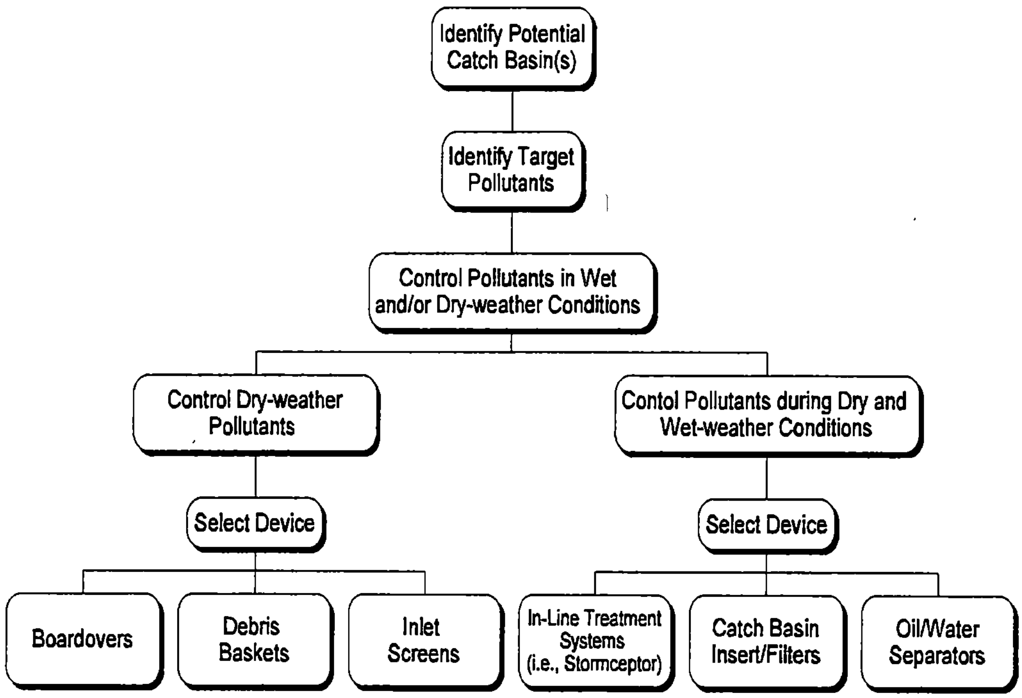


Figure 6-1.
Selection Protocol for Evaluating Potential Catch Basin Inserts

treated must be determined (i.e., first flush, entire 2-yr storm, etc.). Once the way to determine the volume is decided upon, a hydrologic analysis must be done to determine the actual volume of runoff that the insert will need to be sized to treat.

The dimensions of the catch basin that will be collecting the runoff must also be determined in order for the manufacturer to correctly fabricate the BMP and assure that the insert will not be the limiting factor when it comes to passing the design flow. The final step in evaluating potential catch basin inserts is the actual selection of a particular device. Figure 6-2 provides guidance on the aspects that should be considered when selecting the device that is optimal for a specific site (Woodward-Clyde, 1998).

It should also be noted that municipalities considering this type of water quality BMP should be cautious when interpreting a manufacturers pollutant removal efficiency. Installations in the field present very different conditions than those experienced in the laboratory setting where most of the manufacturers' claimed performance data is determined. A limited number of the manufacturer's claimed performance levels were substantiated by field tests, and of those that were, few had adequate and thorough available documentation.

Due to the performance rating response of 4 (1-Poor, 5-Excellent) from all of the surveyed municipalities who were able to confidently rate the inserts' overall performance, it is apparent that under the right site conditions and with a commitment to adequate and routine maintenance, this type of BMP can have success in removing common stormwater pollutants. Although considering catch basin insert/filters as a potential water quality element of a stormwater management plan is valid, it is vitally important to recognize the

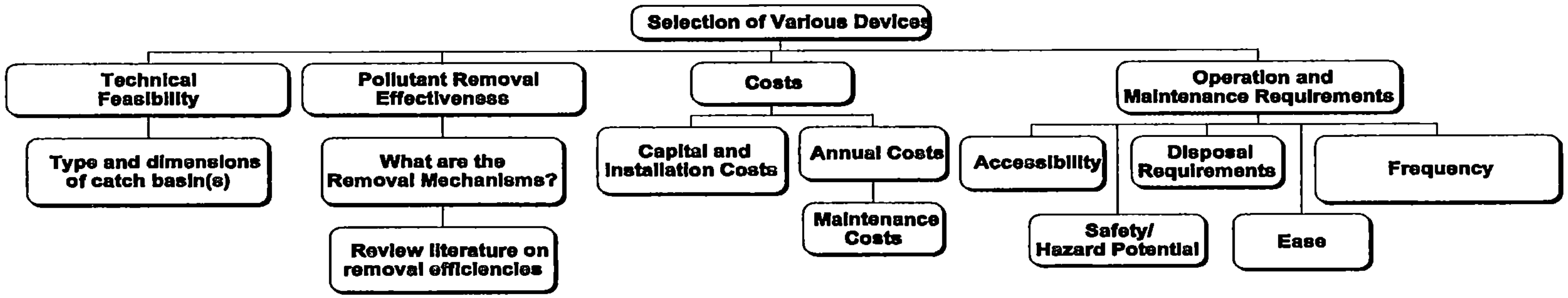


Figure 6-2.
Protocol for Selection of an Optimal Catch Basin Insert

following practical limits on:

- which pollutants can be controlled
- what degree of remediation is realistic, and
- what is actually practicable given the fact that the primary function of catch basins is to collect convey stormwater from streets and parking lots to receiving waters for the purpose of flood prevention.

The overall advantages and limitations of catch basin insert/filters that have been discussed throughout the document are summarized below.

Advantages:

- Marked reduction of hydrocarbon loadings from areas with high traffic/parking volumes
- Some reduction of nutrients, heavy metals, and suspended solids in highly urbanized areas
- Underground placement is not generally noticeable and therefore does not make this BMP aesthetically unpleasant nor take up valuable space
- Routine maintenance procedures, although frequent, are not overly time consuming relative to BMPs such as retention/detention ponds, infiltration trenches, constructed wetlands.

Limitations:

- Difficult to dispose of the spent filter media containing hazardous pollutants and the accumulated toxic sediment in methods that are environmentally sound and cost-effective.
- Possibility of pulse loadings due to resuspension of pollutants from dirty filters during large storms.
- Relatively expensive, considering the limited pollutant removal capabilities under typical field conditions.
- Operational and structural problems due to freezing in northern climates.

- Very high inspection/maintenance frequency and burden required for beneficial performance.

More independent research, especially on long-term performance, should be conducted in order to provide municipalities more scientifically defensible information and better guidance when deciding upon the adoption of this BMP and provide manufacturers feedback such that manipulations can be made to the various designs in order to increase the overall level of performance.

List of References

List of References

Cited References

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5. Greb, S.R., Evaluation of Stormceptor™ and Multi-Chamber Treatment Train as Urban Retrofit Strategies, Wisconsin Department of Natural Resources, Madison, WI, 1998.

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2. Stormceptor Corporation, Stormceptor™ Product Brochure, Rockville, MD, 1999.

3. Stormwater Management, Inc., StormFilter™ Product Brochure, Portland, OR, 1999.

4. Urbonas, Ben, "Assessment of Stormwater BMPs and their Technology," Water Science Technology, Vol. 29, No. 1-2, 1994, pp. 347-353.

Appendices

Appendix A

Manufacturer Contact Information

1. **AquaShield™**
Remedial Solutions, Inc.
2733 Kanisita Drive, Suite A
Chattanooga, TN 37343
Phone: (888) 870-8888
Fax: (423) 870-1005
E-mail: remsol@cdc.net
www.remdialsolutions.com
Contact: Kelly Williamson

2. **Enviro-Drain™**
Enviro-Drain, Inc.
PO Box 1930
Snohomish, WA 98291
Phone: (800) 820-1953
Fax: (425) 820-8364
E-mail: nvirodrain@aol.com
www.enviro-drain.com
Contact: Jim Hutter

3. **Fossil Filter™**
KriStar Enterprises, Inc.
8364 Industrial Ave.
Cotati, CA 94931-4595
Phone: (800) 579-8819
Fax: (707) 792-4669
www.Kristar.com
Contact: James Ford or Rebecca Eccles

4. **Gullywasher™**
Aqua Treatment Systems
Phone: (253) 835-9163
Fax: (253) 835-9444
www.gullywasher.com
Contact: Paul Geisert

5. **Hydro-Cartridge™**
EP International
1576 NE 131 Road
North Miami, FL 33161
Phone: (305) 892-0325
Fax: (305) 892-0325
E-mail: epi.i@usa.net
Contact: Udo Jaehrling

6. **Sift™ Filter**
Revel Environmental Marketing
Phone: (415) 984-0600
Contact: Kevin

7. **Siltsack®**
ACF Environmental
1801 A - Willis Road
Richmond, VA 23237
Phone: (800) 448-3636

8. **Storm Clenz Filter™**
Best Management Technologies
Phone: (888) 237-8648
Fax: (510) 787-1413
Contact: Rod Butler

9. **Storm Watch™ Filter**
Builders Environmental Marketing
Phone: (510) 532-8554

10. **StreamGuard™**
Foss Environmental
PO Box 80327
Seattle, WA 98108
Phone: (800) 909-3677
www.fossenv.com
Contact: Mike Balsam (206) 768-1451

11. **Ultra-Urban™ Filter**
AbTech Industries, Inc.
4110 N. Scottsdale Road
Suite 235
Scottsdale, AZ 85251
Phone: (800) 545-8999
Fax: (480) 970-1665
www.oars97.com
Contact: Robert Liguori

Appendix B

Vendor Survey Responses

Catch Basin Filter Product and Performance Survey

Name: Jim Ford
Title: Consultant, Publications
Organization: KriStar Enterprises, Inc.

1. **Description of the catch basin filter for the following products and performance survey?**

The Federal EPA's NPDES program, designed to control the discharge of pollutants to waters of the United States, cites a definition of oil/water separator as "*A device installed usually at the entrance of a drain which removes oil and grease from water flows entering the drain.*" That definition accurately describes Fossil Filter™.

Fossil Filter™ is a patented trough structure that is installed just under the grates of drainage inlets. The structure contained EPA-approved sorbents which collect petroleum hydrocarbons and other contaminants while permitting the undisturbed passage of water. The structure is available in HDPE (plastic), fiberglass and, in some cases, stainless steel.

The Fossil Filter™ concept is essentially as follows: As the surface water flows into the inlet, it passes through the filter where the installed adsorbent material, removes petroleum-based contaminants while the water flows on into the drainage system.

The petroleum hydrocarbons are collected through a process called adsorption (acts like a magnet) rather than absorption (acts like a sponge). Once collected, the hydrocarbons are non-leaching.

2. **What is the expected removal efficiency of your filter system for the following urban pollutants?**

The ability of any system to remove pollutants is based on such things as the age of the adsorbent, the influence of outside influences (litter, leaves, and debris), the water flow velocity and a host of other things. Laboratory tests of new Fossil Rock exposed to waste oil resulted in a finding that the Fossil Rock retained 98% of the waste oil. Other tests have shown results of more than 50% removal of oil and grease, 99.2% of motor oil, 99.4% of diesel oil and 65% gasoline. Testing data is included in the binder under technical information. To answer your specific question:

• Oil and Grease	Up to 90% efficiency
• Total Suspended Solids	None
• Heavy Metals	Incidental
• Total Nitrogen	None
• Total Phosphorous	None

3. a) **What efficiency or procedures were used in testing the filter's removal efficiency and performance?**

Various procedures were used, depending on the laboratory. See the testing data included in the engineering binder under technical information.

b)What are the routine and long-term maintenance requirements and how often does the filter media need to be replaced?
As the manufacturer, our company recommends that, as a minimum, the Fossil Filter™ systems be serviced a minimum of three times per year with the adsorbent being replaced during two of those visits. The Fossil Rock supplier advises that, absent outside interference from leaves, debris, silt, etc. the material should perform efficiently for about six months.

Routine maintenance includes removal of debris and broom cleaning around the inlet. The inlet grate removed and the filter structure inspected for damage and the installed adsorbent inspected for remaining useful life and changed, if necessary. The area will be broom cleaned once more and the grate replaced.

A key factor in the maintenance procedure is disposal of the contaminated adsorbent. It must be placed in a DOT approved container and disposed of in accordance with local regulatory agency specifications to insure compliance with all local and state environmental legislation. When appropriate, an EPA number will be assigned verifying proper disposal.

See General Specifications for Maintenance of Catch Basin Filtration Systems under Installation and Maintenance in the binder.

4. What is the capital cost of installing the catch basin filter?
What sets the Fossil Filter™ apart from most of its competition is the fact that, because it fits right under the inlet grate, installation costs are minimal. Our company will install them for as little as $25 per unit depending on the number of units at the site and the type of inlet.

5. What are the maintenance costs associated with keeping the filter performing properly?
Our company provides a series of service plans that have set the standard for maintenance plans. They are:
Service Plan A: Three cleanings with one change of filter adsorbent.
Service Plan B: Three cleanings with two changes of filter adsorbent.
Service Plan C: (Special plan for heavy debris and pollutant loading): More than three cleanings and as many adsorbent changes as necessary.
Cost for our company to perform Service Plan A, to include the three visits, one adsorbent change and disposal of the exposed media averages about $200 per year. That number will vary depending on the distance to the site and the number of filters at the site.

6. Comments/additional Information: None

Catch Basin Filter Product and Performance Survey

Name: JEFF BALL
Title: INside Sales
Organization: ACF ENVironmental. Subject - Siltsack.

1. **Description of the catch basin filter for the following product and performance survey:** Siltsack is a sediment control device used to prevent sediment from entering your drainage system.

2. **What is the expected removal efficiency of your filter system for the following urban pollutants:**

   - ✓ Oil and Grease 98%
   - ✓ Total Suspended Solids 98%
   - ✓ Heavy Metals 98%
   - ✓ Total Nitrogen 92%
   - ✓ Total Phosphorus 92%

3. **a) What protocol or procedures were used in testing the filter's removal efficiency and performance?** Grab tensile testing and Trapezoid tear testing were performed.

b) What are the routine and long-term maintenance requirements and how often does the filter media need to be replaced? The time time frame varies on different application – General rule of thumb is when the restraint cord is no longer visible – meaning the sack is full with debris.

4. What is the capital cost of installing the catch basin filter?

2 Guys about 10 minutes to install - very small installation cost.

5. What are the maintenance costs associated with keeping the filter performing properly? Once installed zero maintenance costs.

6. Comments/Additional Information:

This is a very popular item – we can't manufacture them fast enough.

Catch Basin Filter Product and Performance Survey

Name: Robert Liguori
Title: Director – Recycling operations.
Organization: AbTech Industries, Inc.

1. Description of the catch basin filter for the following product and performance survey:

The ULTRA-URBAN™ FILTER IS A S. WATER BMP capable of absorbing petroleum hydrocarbons w/OARS which, is packed with OARS. The OARS structure creates a filter Smart Sponge™. The OARS structure creates a filter media similar to what you see with "popcorn". Water flows through a basket in a stormdrain or catch basin which, is packed with OARS. The oil is absorbed and sediment trash + debris is captured.

2. What is the expected removal efficiency of your filter system for the following urban pollutants:

- ✓ Oil and Grease IN EXCESS OF 80% OF PET. HYDROCARBONS TYPICAL ... (25 to 50 ppm) to street runoff
- ✓ Total Suspended Solids ________
- ✓ Heavy Metals ________
- ✓ Total Nitrogen ________
- ✓ Total Phosphorus ________

(Captured in OARS structure.)

3. a) What protocol or procedures were used in testing the filter's removal efficiency and performance?

- UCLA
- UNIVERSITY OF LOUISIANA
- AbTech LAB'S
- KING COUNTY, WA (DEPT OF ECOLOGY)

b) What are the routine and long-term maintenance requirements and how often does the filter media need to be replaced?

– Vacuum service w/conventional maintenance equipt. (2-6x/year)

– Change OARS media 2-3 years.

4. What is the capital cost of installing the catch basin filter?

Approx $100 per module (South)
" $25 " " (North)
(Multiple modules could exist in certain stormdrains in the South West + South East. Northern applications typically use one module)

5. What are the maintenance costs associated with keeping the filter performing properly?

– Modules are capable of capturing between .045 – .12 cubic yards of sediment, debris + trash.

– Vacuuming takes seconds per module.

6. Comments/Additional Information:

OARS is unique to this emerging market because the polymer is engineered to ABSORB the hydrocarbons and lock them in the product. Waste is therefore handled as a solid waste ... which can be part of a "closed-loop" recycling program + annual recycling reports issued.

Appendix C

Municipality Survey Responses

Catch Basin Filter/Insert Field Performance Survey

Name: Joe Mendoza, 510-881-7968

Organization: City of Hayward, Water Pollution Source Control

Name of Filter/Insert: Mostly, Fossil Filter others include Gullywasher basket, Stream Guard, and Enviro-Drain

1. **Describe the location and watershed of the installed catch basin filter/insert.**

   Southeast San Francisco Bay, City of Hayward, CA 94541, 94542, 94544, 94545
   61 sq. mi. total area (developed, undeveloped, and off-shore)
   28-30 sq. mi. (developed) with population 126,452 as of 1/1/98.

2. **Was there one pollutant in particular that you were the most concerned about and that led to the implementation of the catch basin filter? If so, please indicate the pollutant, if not, please indicate which pollutants were of major concern.**

   Oil and grease from motor oil in parking lots.

3. **Do you have a routine maintenance program in place, and if so, please discuss briefly.**

   Maintenance is required of the owner or operator of the property or facility.

4. **On average, how often does the filter media need to be changed and/or how often does trapped sediment need to be removed?**

   This is dependent on the site conditions and best management practices at the facility.

5. **Would you consider litter and debris to be a major concern to the proper operation of the catch basin filter/insert?**

   No, with the proper surface grate, litter and debris will never interact with the media of the catch basin filter or insert. If some litter or debris enters the catch basin through the grate waste water easily bypasses the litter to be treated by the insert media.

6. **Have there been any field studies to observe the actual removal efficiency of the catch basin filter system? If so, what were the removal efficiencies for the following urban pollutants:**

		Fossil Filter
✓ **Oil and Grease**	*30% to *90%	40%
✓ **Total Suspended Solids**	*40% to *40%	25% to 47%
✓ **Heavy Metals**	*9% to *30%	28% and 33%
✓ **Total Nitrogen**	unknown	unknown
✓ **Total Phosphorus**	unknown	unknown

*"Stormwater Inlet Insert Devices Literature Review" by URS Greiner Woodward Clyde 500 12th St., Ste. 200 Oakland, CA 94607

Prepared for Alameda Countywide Clean Water Program

7. **Please rate the overall performance of the catch basin insert(s) on the following scale:**

   1 (very poor), 2 (poor), (3) (fair), 4 (good), 5(excellent)

8. **General Comments/Major Drawbacks:**

   Typically the City on all new construction requires drain inserts. The General Contractor usually sub-contracts the installation and the cost is absorbed into the entire project. When the owner or facility operator occupies the property very rarely do they know that the inserts are installed or that the inserts need to be maintained. Therefore, the inserts are not maintained, the inserts plug-up and pollutants spill into the overflow.

Catch Basin Filter/Insert Field Performance Survey

Name:

Organization: City of Chattanooga Stormwater Man

Name of Filter/Insert:

1. Describe the location and watershed of the installed catch basin filter/insert. FILTER/INSERT STRUCTURES HAVE BEEN INSTALLED 2 AQUASHIELDS IN PARKING LOT (1 NEAR DRIVE THRU WINDOW) OF NEW CVS PHARMACY. DRAINAGE FROM CVS FLOWS INTO UNNAMED TRIBUTARY ("STATE WATERS") LOCATED APPROX. 100' FROM AQUSHIELD STRUCTURES. UNNAMED TRIBUTARY FLOWS DIRECTLY INTO RYALL SPRINGS BRANCH ("STATE WATERS") — OTHER AQUASHIELD STRUCTURES HAVE BEEN INSTALLED IN SIMILAR LOCATIONS.

2. Was there one pollutant in particular that you were the most concerned about and that led to the implementation of the catch basin filter? If so, please indicate the pollutant, if not, please indicate which pollutants were of major concern. POLLUTANTS THAT ~~WERE~~ ARE MAJOR CONCERN ~~WERE~~ ARE AUTOMOTIVE FLUIDS (OIL, ANTIFREEZE, ETC.)

3. Do you have a routine maintenance program in place, and if so, please discuss briefly. — MAINTENANCE OF FILTER/INSERT STRUCTURE IS THE RESPONSIBILITY OF THE FACILITY MANAGER/OPERATOR. — CITY OF CHATT. STORMWATER MGT. HAS IMPLEMENTED A FACILITY POLLUTION PREVENTION PROGRAM (ORD. # 9942) WHICH GOVERNS MAINTENANCE OF POLLUTION CONTROL STRUCTURES — SOME FACILITIES CONTRACT THE MAINTENANCE OF FILTER/INSERT STRUCTURES OUT TO REMEDIAL SOLUTIONS, INC WHICH IS A LOCAL COMPANY THAT MANUFACTURES THE FILTER/INSERT STRUCTURES. THE FACILITY IS RESPONSIBLE - STORMWATER MANAGEMENT ONLY DOES PERIODIC INSPECTIONS.

4. On average, how often does the filter media need to be changed and/or how often does trapped sediment need to be removed? 3 MONTHS AVERAGE (SURFACE DRAINAGE) FOR ~~AND~~ FILTER CHANGE AND SEDIMENT REMOVAL

5. Would you consider litter and debris to be a major concern to the proper operation of the catch basin filter/insert? - LITTER + DEBRIS COULD BE A CONCERN BUT MOST STRUCTURES ARE INSTALLED ON PARKING LOTS & FACILITIES AND ARE NORMALLY KEPT CLEAN FOR AESTHETIC PURPOSES

6. Have there been any field studies to observe the actual removal efficiency of the catch basin filter system? If so, what were the removal efficiencies for the following urban pollutants:

- ✓ Oil and Grease ________
- ✓ Total Suspended Solids ________
- ✓ Heavy Metals ________
- ✓ Total Nitrogen ________
- ✓ Total Phosphorus ________

7. Please rate the overall performance of the catch basin insert(s) on the following scale:

   1 (very poor), 2 (poor), 3 (fair), 4 (good), 5(excellent)

   Still Evaluating

8. General Comments/Major Drawbacks:

   COST
   MAINTENANCE REQUIREMENTS

Catch Basin Filter/Insert Field Performance Survey

Name: Ruta Skirius
Organization: City of Santa Monica
Name of Filter/Insert: United Pumping Drain Pac & AbTech ...

1. Describe the location and watershed of the installed catch basin filter/insert. City of Santa Monica – 400 catch basins. Ballona Creek Watershed.

2. Was there one pollutant in particular that you were the most concerned about and that led to the implementation of the catch basin filter? If so, please indicate the pollutant, if not, please indicate which pollutants were of major concern. trash, suspended solids

3. Do you have a routine maintenance program in place, and if so, please discuss briefly. Yes, catch basins are "vacuumed" out once a month.

4. On average, how often does the filter media need to be changed and/or how often does trapped sediment need to be removed? After a storm event at least. We've went 3 storms once – the baskets were full. Haven't ... the ... -lined basket yet.

5. Would you consider litter and debris to be a major concern to the proper operation of the catch basin filter/insert? Yes

6. Have there been any field studies to observe the actual removal efficiency of the catch basin filter system? If so, what were the removal efficiencies for the following urban pollutants:

See report sent to you under separate cover.

- ✓ Oil and Grease ________
- ✓ Total Suspended Solids ________
- ✓ Heavy Metals ________
- ✓ Total Nitrogen ________
- ✓ Total Phosphorus ________

7. Please rate the overall performance of the catch basin insert(s) on the following scale: AbTech / United Pumping

1 (very poor), 2 (poor), 3 (fair), 4 (good), 5(excellent)

8. General Comments/Major Drawbacks:

The AbTech design is still a little costly – $1000 per catch basin

Catch Basin Filter/Insert Field Performance Survey

Name: James D. Lopez

Organization: City of Petaluma, Department of Engineering and Public Works

Name of Filter/Insert: Kristar Inc."s Fossil Filter

1. Describe the location and watershed of the installed catch basin filter/insert.

   The City has 27 filters installed, 20 in parking lots and 7 in curbside catch basins.

   The parking lot location watershed is contained to the parking lot. The street location has watershed from street, sidewalk and down spouts from nearby buildings.

2. Was there one pollutant in particular that you were the most concerned about and that led to the implementation of the catch basin filter? If so, please indicate the pollutant, if not, please indicate which pollutants were of major concern.

   The City is concerned about hydrocarbons, silt, and debris entering the Petaluma River, which is located in the historic downtown.

3. Do you have a routine maintenance program in place, and if so, please discuss briefly.

   Yes, we do have a maintenance program which includes: sweeping the immediate surface area, cleaning the bottom of catch basin or inlet, cleaning the filter insert, inspect filter absorbent and replace if 50% saturated. Also make minor repairs to filter system if necessary.

4. On average, how often does the filter media need to be changed and/or how often does trapped sediment need to be removed?

   We have the filter media changed two times in an 8 month period.

   We remove sediment and debris once before rainy season, and three times in an 8 month period. (Rainy season is October through April).

5. Would you consider litter and debris to be a major concern to the proper operation of the catch basin filter/insert?

Yes, litter and debris is monitored to ensure maximum performance of filter system.

6. Have there been any field studies to observe the actual removal efficiency of the catch basin filter system? If so, what were the removal efficiencies for the following urban pollutants:

- ✓ Oil and Grease ________
- ✓ Total Suspended Solids ________
- ✓ Heavy Metals ________
- ✓ Total Nitrogen ________
- ✓ Total Phosphorus ________

The City uses information provided by Entech Analytical Labs, Inc. (see attachment)

7. Please rate the overall performance of the catch basin insert(s) on the following scale:

1 (very poor), 2 (poor), 3 (fair), 4 (good), 5(excellent)

8. General Comments/Major Drawbacks:

Fossil Filter, seems to be simple to install and maintain.
It is important to inspect the filters routinely.
No major drawbacks have been experienced.

Catch Basin Filter/Insert Field Performance Survey

Name: Jerry Maillhiot
Organization: Town of Mansfield CT
Name of Filter/Insert: Foss / 3001 StreamGuard Catch Basin Insert
3017 StreamGuard Passive Skimmer

1. Describe the location and watershed of the installed catch basin filter/insert. The basin is located in a vehicle wash down area.

2. Was there one pollutant in particular that you were the most concerned about and that led to the implementation of the catch basin filter? If so, please indicate the pollutant, if not, please indicate which pollutants were of major concern. Yes. oils, greases and salt

3. Do you have a routine maintenance program in place, and if so, please discuss briefly. Replace every 6 month and a visual monthy.

4. On average, how often does the filter media need to be changed and/or how often does trapped sediment need to be removed? Early spring (Apr) and late fall (Dec)

5. Would you consider litter and debris to be a major concern to the proper operation of the catch basin filter/insert? No.
Not in this application.

6. Have there been any field studies to observe the actual removal efficiency of the catch basin filter system? If so, what were the removal efficiencies for the following urban pollutants:

- ✓ Oil and Grease ________.
- ✓ Total Suspended Solids ________
- ✓ Heavy Metals ________
- ✓ Total Nitrogen ________
- ✓ Total Phosphorus ________

7. Please rate the overall performance of the catch basin insert(s) on the following scale: 4 Good

1 (very poor), 2 (poor), 3 (fair), 4 (good), 5(excellent)

8. General Comments/Major Drawbacks:

From: Ammar Eltawil
To: internet: cwagner3@utk.edu
Date: 10/5/99 11:16AM
Subject: Catch Basin Filter/ Insert Field Performance Survey

Chad Wagner

The City is currently conducting a pilot study on various types of catch basin inserts. I'll answer most of the questions on your survey, based on the available information, as follows:

1. Four Vendors installed five catch Basin inserts around the downtown are. The vendors with their respective CB sites are:

   A. AbTech Industries at the south east corner of 6th St. and Bixel St
   Ballona Creek watershed

   B. Fossil Filter at the north west corner of Union Ave. and 11th St.
   Ballona Creek watershed

   C. Remedial Solutions, Inc. at the north east corner of 20th St. and Maple
   Ballona Creek watershed;
   and a second system at a City maintenance Yard. L.A. river watershed

   D. United Pumping Service, Inc. at the north side of Wilshire Blvd. across from
   Little St. Ballona Creek watershed

2. The Pollutants in concern are: Oil & Grease, Total Suspended Solids, and Heavy Metals. Note that Remedial Solution is interested in determining the removal efficiency for TKN, phosphates, BOD, and fecal choliform.

3 & 4. The vendors will conduct their own maintenance program during the study period. Depending on the location of the CB insert, and the amount of rapped pollutant, some system will require more frequent maintenance than others. Maintenance could be once a month, quarterly, or twice a year. Weekly inspection of the system is being done by some vendors.

5. Litter and Debris are a concern if they clog out the system. It is a plus if they are trapped in the inserts to prevent them from entering the storm drain system. Cleaning the CB inserts before the beginning of the rain season will help in reducing the chance of clogging.

6,7,&8 This year, or this rain season will be our first attempt to evaluate all of the above CB inserts. This information will be available by the end of next year. If you have any information from other agencies on any CB insert, and would like to share it, please mail me a copy to:

Stormwater Management Division
650 S. Spring Street # 700
Los Angeles, CA 90014

If you have any question, please call me at (213) 847-5228

Appendix D

AquaShield™ Laboratory Analysis Sheets

KNOXVILLE UTILITY BOARD

2015 NEYLAND DRIVE P.O.BOX 59017 KNOXVILLE, TN 37916 (423) 594-7491

ROUTINE MONITORING LABORATORY WORK SHEET

NPDES WET WEATHER MONITORING PROGRAM

KNOXVILLE STORMWATER SAMPLE ID NUMBER Influent 9/21/99

Parameters for Routine Monitoring	Analysis Results	Technician's Signature	Analysis date
(BOD) biochemical oxygen demand	18 mg/l	BJK	9-27
(COD) chemical oxygen demand	161 mg/l	BJK	9-30
(TSS) total suspended solids	128 mg/l	SS	9-22
(TDS) total dissolved solids	197 mg/l	SS	9-22
Nitrate + nitrite nitrogen	1.1 mg/l	MB	9/27
(N) total ammonia nitrogen	1.0 mg/l	SS	9-30
Organic nitrogen + total ammonia	1.68 mg/l	SS	~~[illegible]~~ 10-17
TOTAL NITROGEN	1.9 mg/l	MB	9/27
Total phenols	<.01 mg/l	SS	~~[illegible]~~ 10-19
(Pb) total recoverable lead	.028 mg/l	SS	9-30
(Zn) total recoverable zinc	.372 mg/l	SS	9-30
(P) dissolved phosphorus	0.172 mg/l	MB	9/27
(P) total phosphorus	0.249 mg/l	MB	9/27
Oil + Grease	15 mg/l	BJK	10-1

NOTES FROM LAB TO KNOXVILLE STORMWATER: __________

WHEN LAB ANALYSIS IS COMPLETE PLEASE RETURN THIS FORM TO:

CITY OF KNOXVILLE
DEPT OF ENGINEERING
STORMWATER SECTION
P.O.BOX 1631 Suite 480
KNOXVILLE, TN 37901-1631
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ROUTINE MONITORING LABORATORY WORK SHEET

NPDES WET WEATHER MONITORING PROGRAM
KNOXVILLE STORMWATER SAMPLE ID NUMBER Effluent 9/21/99

Parameters for Routine Monitoring	Analysis Results	Technician's Signature	Analysis date
(BOD) biochemical oxygen demand	14 mg/l	BL	9-27
(COD) chemical oxygen demand	38.9 mg/l	BL	9-30
(TSS) total suspended solids	84 mg/l	[illegible]	9-23
(TDS) total dissolved solids	[illegible]68 mg/l	[illegible]	9-2[illegible]
Nitrate + nitrite nitrogen	0.8 mg/l	NB	9/27
(N) total ammonia nitrogen	0.5 mg/l	[illegible]	9-30
Organic nitrogen + total ammonia	1.60 mg/l	[illegible]	9-30
TOTAL NITROGEN	2.3 mg/l	NB	9/27
Total phenols	<.01 mg/l	[illegible]	10-19
(Pb) total recoverable lead	.014 mg/l	[illegible]	9-30
(Zn) total recoverable zinc	.210 mg/l	[illegible]	9-30
(P) dissolved phosphorus	0.069 mg/l	NB	9/27
(P) total phosphorus	0.118 mg/l	NB	9/27
Oil + Grease	2 mg/l	BJL	10-1

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ROUTINE MONITORING LABORATORY WORK SHEET

NPDES WET WEATHER MONITORING PROGRAM

KNOXVILLE STORMWATER SAMPLE ID NUMBER Influent 9/29/99

Parameters for Routine Monitoring	Analysis Results	Technician's Signature	Analysis date
(BOD) biochemical oxygen demand	17 mg/l	R.P.Y.	9-30
(COD) chemical oxygen demand	158 mg/l	BJS.	10-1
(TSS) total suspended solids	90 mg/l	BJS	9-30
(TDS) total dissolved solids	142 mg/l	BJS	9-30
Nitrate + nitrite nitrogen	6.5 mg/l	MB	10/18
(N) total ammonia nitrogen	<.2 mg/l	[illegible]	10-14
Organic nitrogen + total ammonia	1.9 mg/l	[illegible]	10-14
TOTAL NITROGEN	0.8 mg/l	MB	10/18
Total phenols	<.01 mg/l	[illegible]	10-14
(Pb) total recoverable lead	.015 mg/l	[illegible]	10-26
(Zn) total recoverable zinc	.180 mg/l	[illegible]	10-28
(P) dissolved phosphorus	0.262 mg/l	MB	10/18
(P) total phosphorus	0.343 mg/l	MB	10/18
Oil + Grease	25 mg/l	BJS	10-1

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ROUTINE MONITORING LABORATORY WORK SHEET

NPDES WET WEATHER MONITORING PROGRAM

KNOXVILLE STORMWATER SAMPLE ID NUMBER Effluent 9/29/99

Parameters for Routine Monitoring	Analysis Results	Technician's Signature	Analysis date
(BOD) biochemical oxygen demand	13 mg/l	[illegible]	9-30
(COD) chemical oxygen demand	25.5 mg/l	BJL	10-1
(TSS) total suspended solids	120 mg/l	BJL	9-30
(TDS) total dissolved solids	269 mg/l	BJL	9-30
Nitrate + nitrite nitrogen	0.4 mg/l	MB	10/18
(N) total ammonia nitrogen	<.2 mg/l	KF	10-14
Organic nitrogen + total ammonia	3.92 mg/l	KF	10-14
TOTAL NITROGEN	2.1 mg/l	MB	10/18
Total phenols	.013 mg/l	[illegible]	10/14
(Pb) total recoverable lead	.006 mg/l	[illegible]	10/26
(Zn) total recoverable zinc	.208 mg/l	[illegible]	10/26
(P) dissolved phosphorus	0.374 mg/l	MB	10/18
(P) total phosphorus	0.613 mg/l	MB	10/18
Oil + Grease	2 mg/l	BJL	10-1

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ROUTINE MONITORING LABORATORY WORK SHEET

NPDES WET WEATHER MONITORING PROGRAM

KNOXVILLE STORMWATER SAMPLE ID NUMBER Influent 10-9-99

Parameters for Routine Monitoring	Analysis Results	Technician's Signature	Analysis date
(BOD) biochemical oxygen demand	9 mg/l	[illegible]	10-11
(COD) chemical oxygen demand	66.7 mg/l	[illegible]	10-15
(TSS) total suspended solids	54 mg/l	[illegible]	10-13
(TDS) total dissolved solids	77 mg/l	[illegible]	10-13
Nitrate + nitrite nitrogen	0.4 mg/l	MB	10/18
(N) total ammonia nitrogen	<.2 mg/l	[illegible]	10-14
Organic nitrogen + total ammonia	1.96 mg/l	[illegible]	10-14
TOTAL NITROGEN	1.3 mg/l	MB	10/18
Total phenols	<.01 mg/l	[illegible]	10-19
(Pb) total recoverable lead	.012 mg/l	[illegible]	10-20
(Zn) total recoverable zinc	.156 mg/l	[illegible]	10-26
(P) dissolved phosphorus	0.144 mg/l	MB	10/18
(P) total phosphorus	0.103 mg/l	MB	10/18
Oil + Grease	30 mg/l	[illegible]	10-14

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ROUTINE MONITORING LABORATORY WORK SHEET

NPDES WET WEATHER MONITORING PROGRAM

KNOXVILLE STORMWATER SAMPLE ID NUMBER Effluent 10/9/99

Parameters for Routine Monitoring	Analysis Results	Technician's Signature	Analysis date
(BOD) biochemical oxygen demand	13.0 mg/l	R.W.	10-11
(COD) chemical oxygen demand	61.8 mg/l	BJR	10-15
(TSS) total suspended solids	54 mg/l	BJR	10-13
(TDS) total dissolved solids	153 mg/l	BJR	10-13
Nitrate + nitrite nitrogen	0.4 mg/l	MB	10/18
(N) total ammonia nitrogen	<.2 mg/l	KS	10-14
Organic nitrogen + total ammonia	0 mg/l	KS	10-14
TOTAL NITROGEN	0.2 mg/l	MB	10/18
Total phenols	<.01 mg/l	KF	10-14
(Pb) total recoverable lead	.020 mg/l	KS	10-20
(Zn) total recoverable zinc	.148 mg/l	KS	10-20
(P) dissolved phosphorus	0.114 mg/l	MB	10/18
(P) total phosphorus	0.123 mg/l	MB	10/18
Oil+Grease	5 mg/l	BJR	10-14

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VITA

Chad Raymond Wagner was born in St. Petersburg, Florida on February 8, 1976. He graduated from Dixie M. Hollins High School in St. Petersburg in June of 1994. In the fall of 1994, he entered the University of Tennessee, Knoxville and received his Bachelor of Science degree in Civil Engineering in May of 1998. He then entered the Environmental Engineering graduate program at the University of Tennessee, Knoxville in the field of water resources in the summer of 1998. He has worked as a hydraulics (CE 390) lab instructor, computer lab monitor, and graduate research assistant at the University of Tennessee, Knoxville while pursuing his graduate degree.