2 LITERATURE REVIEW

The following subsections provide a brief background of the issues regarding oil and grease in stormwater runoff in urban areas in general, and the Los Angeles area in particular (Section 2.1); a literature review of studies that have evaluated the performance of catch basin inserts at removing oil and grease (Section 2.2); expected ranges of stormwater runoff concentrations, as well as the expected level of treatment of catch basin inserts for oil and grease and total petroleum hydrocarbons (TPH) (Section 2.3).

2.1 BACKGROUND AND IDENTIFICATION OF RESEARCH NEEDS

Oil, grease, and hydrocarbons in urban stormwater runoff originate primarily from leaking vehicles, car maintenance activities, illegal dumping of oil, auto accidents, and spills. Heavy metals in urban stormwater originate primarily from roadway construction materials, deteriorating building surfaces, burning of fossil fuels, and engine wear and leaks and brake pad and tire wear. These pollutants are of environmental concern because nature cannot rapidly degrade or assimilate them. So, even if runoff contains low concentrations of the pollutants, they can accumulate in the environment and have acute and chronic toxic effects on aquatic organisms.[1]

A study conducted by the Pelegrin Research Group in 1997 found that 15% of the residents in Los Angeles County who change their own oil (~20% of the residents) participate in improper disposal, with 1% (of the 20%) disposing of it by dumping directly onto the street, gutter, or storm drain.[2] With an L.A. County population close to 10 million people and assuming 4 gallons of used oil per year are disposed of by people who engage in illegal storm drain disposal, these people are may be contributing about 80,000 gallons of oil per year, directly to the Los Angeles County storm drain system. Leaks from automobiles are likely contributing much more than this, as it was estimated that approximately 64 million gallons of the oil sold in California in the 2000/2001 fiscal year either leaked out of, or was burned in engines.[3] With nearly 30% of the State's population living in Los Angeles, approximately 19 million gallons of this leaked or burned oil likely occurred in L.A. County.

Motor oil that leaks from automobiles is dispersed; resulting in generally low stormwater concentrations, and therefore, the acute environmental impacts of leaked oil is likely less than environmental impacts of illegal dumping activities. For instance, stormwater monitoring by the County of Los Angeles has shown that the land uses associated with the highest average concentrations of oil and grease are commercial (3.3 mg/L) and transportation (3.1 mg/L).[4] In another stormwater characterization study in the City of Santa Monica, average oil and grease

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[1] Bosworth, N. 1999. Tertiary Treatment of Urban Stormwater. University of Newcastle. http://www.stormwater-resources.com/library.htm

[2] Pelegrin Research Group (1997). "Los Angeles County Stormwater Segmentation Study-Resident Population." Prepared for the Los Angeles County of Public Works.

[3] California Integrated Waste Management Board (2002). "California's Used Oil Recycling Program." Publication Number 332-97-015.

[4] Los Angeles County Department of Public Works (2002). "Los Angeles County 1994-2000 Integrated Receiving Water Impacts Report" [Online] http://ladpw.org/wmd/npdes/IntTC.cfm.

concentrations were reported as 5.9 mg/L and 8.2 mg/L for commercial and transportation land uses, respectively.[5]

These data represent storm event averages, or more precisely, averages of mean storm event concentrations (multiple grab samples were taken throughout the duration of individual storms, but they were not necessarily flow- or time-weighted composites). However, these data mask the "first flush" phenomenon that can occur during the beginning of storms and/or any illegal oil dumping activities. For many pollutants, approximately 30% of the mass is released during the first 20% of the storm.[6] Therefore, oil and grease concentrations at the beginning of a storm could potentially be much higher than the average storm event concentrations. These data represent storm event averages, or more precisely, averages of mean storm event concentrations

Oil, grease, and hydrocarbons interfere with plant photosynthesis and with reproduction, respiration, and growth and development of aquatic organisms. These chemicals can accumulate in sediments and tissues of fish and other aquatic organisms, potentially causing cancer, mutations, and even death. Furthermore dissolved oxygen levels may become depleted through the degradation of hydrocarbons.[7]

Dissolved metals, that can be associated with motor oils can cause short and long-term toxic effects on aquatic organisms. They can bioaccumulate in animal tissue and affect reproduction rates and life spans of aquatic organisms. Metals deposit in sediments where they negatively impact benthic organisms and their predators.

Oil and grease in stormwater runoff can be free-floating, suspended, or emulsified or can sorb to trash, debris, and particles. Between 83-98% of total hydrocarbons in stormwater runoff are bound to particulate matter, and most of these particles are settleable. Most stormwater studies only report free-floating oil concentrations, which typically range from 2-35 mg/L. Free-floating oil and grease can be removed by sorbent materials, such as those found in catch basin inserts.[8]

In highly urbanized environments, such as the City of Los Angeles, where available space for many traditional Best Management Practices (BMPs) is limited (for example retention ponds, constructed wetlands, or infiltration basins), proprietary devices, such as catch basin filters are often used to capture oil and grease. The manufacturer usually provides some quantitative and/or qualitative measure of the effectiveness of these types of devices at removing pollutants. Inconsistent testing and reporting protocols and the absence of self-imposed testing quality control have generated concerns over the reliability of available performance data. These

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[5] Woodward-Clyde (1998). "Santa Monica Bay Area Municipal Stormwater/Urban Runoff Pilot Project – Evaluation of Potential Catchbasin Retrofits." *Prepared for Santa Monica Cities Consortium c/o City of Santa Monica.*
[6] Ma, S., S. Khan, Y. Li, L. Kim, S. Ha, S. Lau, M. Kayhanian, and M. Stenstrom (2002). "First Flush Phenomena for Highways: How it can be meaningfully defined." *Proc. Ninth Inter. Conf. on Urban Drainage*, E. Strecker and W. Huber, eds., Lloyd Center, Doubletree Hotel, Portland, Oregon, Sept. 8-13, 2002.
[7] Bosworth, N. 1999. Tertiary Treatment of Urban Stormwater. University of Newcastle. http://www.stormwater-resources.com/library.htm
[8] Environmental Protection Agency (EPA). 2002. Storm Water Technology Fact Sheet. Publication # 832-F-02-020. September.

concerns have prompted some agencies to prepare protocols for the verification of proprietary stormwater treatment devices.[9,10,11]

Adoption of these protocols is increasing; however, currently there are few data available on the wide variety of devices currently employed throughout California. (Currently the only stormwater treatment technology certified by the CalCert Program is the AquaShield™ Filtration System, Model SD-100 and the performance claim states the product "removes 92% of oil and diesel fuel in water when influent concentrations are between 1,000 to 2,000 mg/l."[12] These influent concentrations are nearly 3 orders of magnitude greater than typical stormwater concentrations of oil and grease). Independent or "third-party" testing of these devices and detailed effluent quality characterization, can improve estimates of the quality of stormwater reaching receiving water bodies from drainages receiving this type of treatment. Also, an improved understanding of the potential water quality and spill (and intentional dumping) mitigation functionality of catch basin filters, the amount of motor oil captured in the storm drain filters can be estimated. This will help improve the understanding of the fate (mass balance) of motor oil sold in California and the effectiveness of catch basin filter treatment technologies.

Typically in practice, catch basin filters have two intended primary functions: (1) to reduce loading resulting from high concentration flows (typically associated with low flow rates) from spills, significant leaks, and improper disposal to storm or surface drains; and (2) to reduce loading from typical urban stormwater discharges (typically relatively lower concentration at much higher flow rates). An initial review of third party stormwater treatment technology evaluations conducted to-date has shown highly variable results in the performance of filter media at removing oil and grease from stormwater and mitigating high concentration, lower flow discharges. This report will review and report on laboratory and field studies conducted on the effectiveness of catch basin inserts in removing oil, grease, hydrocarbons, and heavy metals from urban runoff.

2.2 CATCH BASIN INSERT PERFORMANCE STUDIES

Several catch basin insert studies have been performed by various third-party researchers and insert manufacturers and vendors. Due to the wide variety of insert configurations, insert types, and site-specific conditions, more studies are still needed to adequately assess the ability of this technology to reduce the amount of oil and grease reaching receiving streams. Also, few studies (if any) have specifically evaluated the ability of catch basin inserts to retain used motor oil that has been illegally dumped directly into the storm drain.

The following studies all determined pollutant removal efficiencies by comparing inlet and outlet concentrations.

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[9] Washington Department of Ecology (2002). "Stormwater Treatment Facility Performance Evaluation Guidance Document." *Washington Department of Ecology*

[10] Bachhuber, James, Steven Corsi, and Roger Bannerman (2002). "ETV Verification Protocol Stormwater Source Area Treatment Technologies, Draft 4.1.' *U.S. EPA Environmental Technology Verification Program.*

[11] CalCert (2001). "Stormwater Best Management Practice Demonstration Tier II Protocol for Interstate Reciprocity." *Endorsed by the States of California, Massachusetts, New Jersey, Pennsylvania, and Virginia* [Online Available, April 2002] http://www.calepa.ca.gov/CalCert/documents/Stormwater.pdf

[12] California Environmental Technology Certification Program (2000). "Evaluation of the AquaShield™ Filtration System." [Online] http://www.calepa.ca.gov/CalCert/CertifiedTech

2.2.1 INTERAGENCY CATCH BASIN INSERT COMMITTEE (ICBIC) LAB STUDY

In a catch basin insert study conducted in Seattle, Washington, oil and grease removals were studied to evaluate changes in removal rates over-time.[13] The study consisted of testing four (4) proprietary filter media in a laboratory (before and after being field conditioned), using influent oil and grease concentrations of 20-90 mg/L at a flow rate of 5-10 gpm. Field conditioning included placing each filter in field catch basins that serviced approximately the same drainage areas and land uses (i.e. parking lots), until approximately 0.75" of rainfall occurred. After field conditioning, the filters were taken to the laboratory to be tested again. The field sites included a vehicle maintenance shop yard, an arterial road, a park-and-ride lot, and an industrial storage yard. Drainage areas ranged from 0.11 to 0.34 acres.

Results of the study showed a significant decline in oil and grease removal rates from when the filters were new, to after two (2) field-laboratory test sequences. Negative removal rates during some of the tests indicated release of oil and grease from the filter media, which indicated the filter had exceeded its holding capacity and, in fact, washout/leaching was occurring. Furthermore, few of the filters were able to produce effluent concentrations below 10 mg/L, even when the filters were new, at the influent concentrations tested. Table 2-1 summarizes the results of this study.

New inserts removed 20 to 90% of petroleum hydrocarbons from water containing 34 to 85 mg/L of oil. For most of the devices tested, performance declined rapidly with use. During the first test, the inserts were removed from the field after two-inches of rain. This test showed that new inserts were able to remove oil and grease by 30 to 90%. After two-inches of rain, the removal efficiency dropped to less than 30%. During the second test, the inserts were removed from the field after 0.5 to 0.75-inches of rainfall. New inserts removed 21 to 85% of oil and grease during this second test. The Stormwater Services devices maintained a removal efficiency of approximately 50%, even after three field tests. In contrast, the Enviro-Drain's removal efficiency was 50 to 60% when in new condition. One Aqua-Net device's removal efficiency increased from 21 to 82% with use, while the other device maintained a removal efficiency of around 35%. None of the devices removed copper, lead, or zinc. Inserts captured between 0 to 41-pounds of sediment during a 120-day period.

For all but one insert, field observations indicated that stormwater could enter the catch basin without passing through the insert. Instead, the water flows between the pavement and the outer edge of the grate frame and then beneath the frame of the insert. Maintenance frequencies depended on site conditions such as oil and grease loading rates. Because accumulation of sediment can clog the filter and prevent further absorption, the authors recommended maintenance ranging from after every rainfall event to after every five-inches of cumulative rain. Because wood-fiber can become saturated and decompose, these types of filters would need to be replaced after a month or two.

[13] Interagency Catch Basin Insert Committee (1995). "Evaluation of Commercially-Available Catch Basin Inserts for the Treatment of Stormwater runoff from Developed Sites." Collaborative research team consisting of King County Surface Water Management Division and Department of Metropolitan Services, Snohomish County Surface Water Management Division, Seattle Drainage and Wastewater Utility, and the Port of Seattle.

Table 2-1. Summary of oil and grease removal efficiency of catch basin inserts tested by the Interagency Catch Basin Insert Committee (1995)

Vendor	Device	Media Type	Test Interval	Influent (mg/L)	% Removal New	% Removal Used
All	All		2" rain	35	30-90	<35
Aqua-Net Gullywasher	AN-A	Basket, AbW Wood-fiber	2" rain	35	60	NA
All	All		2" rain	67, 85	21-85	NA
Aqua-Net Gullywasher	AN-AW	Basket, AbW Wood-fiber	0.75" rain	67, 85	21	82
Aqua-Net Gullywasher	AN-AS	Basket, Supersorb Wood-fiber	0.75" rain	67, 85	35	35
Environmental Services Enviro-drain	ED-SAA	Two trays, course screen AbW Wood-fiber	0.75" rain	67, 85	50-60	NA
Stormwater Service	SS-2O SS-3	Sock with polypropylene strips	0.75" rain	67, 85	50	50

NA - not available

2.2.2 Santa Clara Valley Parking Lot Study

Woodward-Clyde (1996)[14] tested the performance of catch basin inserts manufactured by Aqua-Net, Inc.; Enviro-Drain, Inc.; and Stormwater Services during two (2) storm events. The Aqua-Net Gullywasher consisted of two baskets, with Absorbent W (a natural wood fiber cellulose) pillows between the two baskets. A bag filled with PetroLOK (a polymer and activated carbon absorbent) was placed around the outside basket.

The Enviro-Drain device has three stacked trays, with the middle and bottom trays containing Absorbent W. The Stormwater Services Stream Guard Type II consists of a boot filled with polypropylene strips that directs water into a polypropylene bag. Drainage basin areas draining to the inserts ranged from 0.77 to 2.5-acres.

During the first storm, sediment, leaves, and/or pine needles were observed to cause considerable clogging and bypass of the filter inserts, which limited the performance of the filters. The top tray of the Enviro-Drain and the outer filter of the Gullywasher were easily clogged and the bag of the Stream Guard broke during one storm. The inserts were effective at removing total petroleum hydrocarbons (TPH), but no significant reduction in TSS concentrations were observed. The authors suggested that since the post-filter samples were pumped out of the bottom of a funnel, surface oils might not have been captured. The Enviro-Drain and the Stream Guard removed an average of 90% and 85% of hydrocarbons with influent concentrations of 9.1 and 4.8 mg/L, respectively. Gullywasher only removed an average of 30% of hydrocarbons with an average influent concentration of 1.2 mg/L.

The Aqua-Net gullywasher removed an average of 59.58% hydrocarbons. The authors proposed that the Gullywasher would work better without the additional PetroLOK. No discernible removal of chromium, copper, lead, nickel, or zinc was found.

[14] Woodward-Clyde. 1996. Parking Lot Monitoring Report. Prepared for the Santa Clara Valley Non-point Source Pollution Control Program. June 11.

2.2.3 Sacramento Parking Lot Study

Larry Walker Associates (1998)[15] studied the performance of Fossil Filter manufactured by KriStar Enterprises, Inc., in a one-acre parking lot during three (3) separate storm events. The Fossil Filter is a ring-shaped filter filled with alumina silicate. The filter removed 50% of total petroleum hydrocarbons, 28% of copper, 33% of lead, and 13% of zinc (although for two storms, the zinc concentration increased).

Water bypassed the filter for flows exceeding 0.05 in/hr per watershed acre. It was observed that 60% to 70% of the flow bypassed the filter. In addition, when the grading at the inlet was uneven, bypass flow would occur because the water would not flow evenly through the filter. During a storm in January, it rained 0.56" in 1.5 hours. Samples were not collected at this time, but the insert was full and water with lines of oil and grease was observed flowing into the bypass. The filter media had to be replaced before each storm event due to debris accumulation.

2.2.4 Santa Monica Bay Study

A full-scale laboratory study conducted as part of the Santa Monica Bay Municipal Stormwater/Urban Runoff Pilot Project evaluated the oil removal efficiencies of three (3) different types of proprietary catch basin filter media. Using an influent free oil (i.e. well mixed, but not emulsified) concentration of 25 mg/L at a flow rate of 15 gpm, the study showed significant removals (69-91%) for all of the media types (when new), during the 90-minute test period.

The study included both full scale and bench scale tests to evaluate the performance of OARS polymer (Abtech), compost, polypropylene, and alumina silicate (Perlite, X sorb) in removing free oil and grease. Oil and grease removal efficiencies averaged 84% for OARS, 81.33% for Perlite (aluminum silicate), 91.5% for Xsorb (aluminum silicate), 50.33% for compost, and 85.25% for polypropylene. No sorbent was effective at removing emulsified oil and grease. The authors concluded that sorbent breakthrough time depends on the mass of oil applied (concentration and flow) and the mass and packing density of the sorbent.

A laboratory study by Lau et al. (2001)[16] showed that metal boxes containing OARS sorbent removed an average of 34.5% of polycyclic aromatic hydrocarbons from water containing 50 ug/L of hydrocarbons. Polypropylene insert devices (DrainPac by United Stormwater) removed an average of 65% of the polycyclic aromatic hydrocarbons. The OARS device removed an average of 71% of oil and grease. The DrainPac had an average oil and grease removal efficiency of 67%.

Lau et al. (2001) also performed a field study to determine the effectiveness of polypropylene and OARS polymer inserts in commercial (1.24 acres) and residential (2.97 acres) areas. Over a six-hour period the OARS sorbent efficiency declined linearly from 85% to 40%, and the polypropylene sorbent efficiency declined linearly from 85% to 50%. The oil and grease concentrations were 19.02 mg/L for the first two hours, 14.0 mg/L for the next two hours, and 10.91 mg/L for the last two hours. Flow bypassing the inserts gradually increased as the inserts became more clogged.

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[15] Larry Walker Associates. 1998. NDMP Inlet/In-line Control Measure Study Report 1997-98. Prepared for County of Sacramento, City of Sacramento, City of Folsom, and City of Galt. June.
[16] Lau, S.L., E. Khan, and M.K. Stenstrom. 2001. Catch Basin Inserts to Reduce Pollution from Stormwater. Water Science and Technology. 44(7): 23-34.

To prevent debris accumulation in the inserts during the dry season, Lau et al (2001) covered two catch basins with plywood and two with wire screen, leaving a 2.5 cm gap at the bottom to allow runoff to enter the basin. These covers prevented 95% of trash and debris from entering the catch basin. Street sweepers were able to remove the material that accumulated at the bottom of the covers without damaging the covers.

2.2.5 City of Los Angeles Study

During the 1999-2000 and 2000-2001 wet seasons, the City of Los Angeles Stormwater Management Division studied the performance of five (5) different types of catch basin inserts at removing sediments, trash, oil and grease, and metals.[17] Due to a limited number of sampling events (4) and study sites (5), the results of this study were inadequate for a statistically valid assessment of the performance of the inserts studies. However, qualitatively the results of the study found that all of the units were moderately effective at removing oil and grease, suspended solids, and heavy metals. Furthermore, the study indicated that for most insert types, inspection and maintenance should occur before and after each rain event during wet weather and monthly during dry weather to maintain their performance integrity and to minimize leaching of previously captured pollutants.

The study included evaluating the performance of AbTech's Ultra Urban Filter, the Fossil Filter, Remedial Solutions Models CD-300 and SD-100, and United Storm Water's DrainPac Storm Drain Filter. The Ultra Urban Filter is a galvanized steel basket packed with Smart Sponge (synthetic polymers). The Fossil Filter is a fiberglass trough with 4" thick Fossil Rock (an absorbent) between two stainless steel screens. Both Remedial Solution devices are stainless steel with a sediment removal basin and three stacked filtering baskets containing 100% reclaimed material. The DrainPac is a non-woven filter cloth liner filled with polypropylene.

The Fossil Filter was maintained monthly, but was clogged during the first half-hour of light rain. The Remedial Solution devices were maintained weekly during which the filter media were replaced five times during nine months. At a sanitation yard site, the filter collected a total of 16 pounds of plastic, 24 pounds of paper, 7 pounds of grass, and 24 pounds of sediment. At a maintenance yard site, the filter collected a total of 108 pounds of oily sediment and 4 pounds of debris. During three rain events, all the runoff was bypassing the filter due to a gap between the filter and the catch basin opening. No data was collected from the above three filters due to the excessive clogging.

The DrainPac had one cleaning during which 400 pounds of trash, debris, and sediment containing 1,480 mg/kg of oil and grease (the CA limit is 1000 mg/kg for nonhazardous waste disposal) was removed from the device. Due to clogging, data from only one storm event was collected, during which the DrainPac removed 52% of the oil and grease.

During all storm events the AbTech device was filled almost completely with trash and sediment. It captured 302 pounds of sediment and trash. The 8.2% removal of oil and grease was contributed to the large amount of runoff bypassing the filter. Alternatively, the sponge may not have effectively captured pollutants or may have reached its sorption capacity. Oil and grease removal did not increase during the third event, which occurred three days after a cleaning (two maintenances were performed during the study, one occurring after the third rain event).

[17] City of Los Angeles, Stormwater Management Division (2001). "Catch Basin Insert Pilot Study Report and Addendum."

Zinc concentrations increased 45%, which was contributed to leaching by the zinc-coated galvanized steel basket.

2.2.6 CALIFORNIA EPA STUDY

The California EPA (2000)[18] evaluated the AquaShield Filtration System Model SD-100. The AquaShield is a stainless steel structure containing recycled cellulose fibers packed in a nylon mesh bag. The influent concentrations of oil and grease were very high compared to the 2 to 35 mg/L found in stormwater runoff. The concentrations ranged from 1,022 to 2,192 mg/L with an average of 1,477 mg/L. This system removed 92% of the oil and grease.

2.2.7 KING COUNTY STUDY

The Model 3001 StreamGuard™ Insert is designed for oil and grease removal in areas such as parking lots, construction sites, marinas, industrial sites, and vehicle washing facilities. King County Surface Water Management Division of Washington State performed independent testing of this technology and found removal efficiencies of oil and grease at 88% for a StreamGuard installation in a park-and-ride lot. Sea-Tac International Airport installations were also monitored and removal efficiencies were approximately 80% for Total Suspended Solids and 94% for oil and grease.[19]

2.2.8 UNIVERSITY OF CALIFORNIA LOS ANGELES STUDY

Strenstrom et al (2002)[20] performed a series of experiments to evaluate the removal efficiencies of various Kristar (Fossil Filter) catch basin inserts. The target pollutants were oil and grease and suspended solids. The experiments were conducted in a full-scale catch basin located in a laboratory in UCLA. They tested two different types of inserts, namely Flo-Gard™ and Flo-Gard™ High Capacity. Oil and grease influent concentrations were varied from 16 mg/L to 36 mg/L and Total Suspended Solids influent concentrations were varied 65 mg/L to 100 mg/L. Automobile crank case oil and graded fine sand were used to simulate oil and TSS respectively.

They observed oil removal efficiencies of 70% to 80% and sand removal efficiencies of almost 100% for particles 30-mesh (589 to 833 mm) and larger, 20% for particles 60-mesh (250 to 420 mm) and nearly zero for smaller particles.

2.2.9 ROUGE RIVER WATERSHED STUDY

Alsaigh et al (1999)[21] presents the performance of four catch basin insert technologies monitored for a 19 Month period. The devices were installed at two gas station sites in the Cites of Livonia and Westland, Michigan. The devices are the Gullywasher™, the Hydro-Cartridge®, the StreamGuard™ and the Grate Inlet Skimmer Box. Parameters of interest included capital cost,

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[18] California Environmental Protection Agency (EPA). 2000. Evaluation of the AquaShield Filtration System (Model SD-100, Series 576). Environmental Technology Certification Program. January.
[19] New England Environmental Protection Agency(EPA NE) (2003) “Streamguard™ Catch Basin Inserts” http://www.epa.gov/region1/assistance/ceitts/stormwater/techs/streamguardinsert.html
[20] Stenstrom M. K., Lau S. (February, 2002) “Oil and Grease and Particle Removal by KriStar Flo-Gard and Flo-Gard High Capacity Stormdrain Inserts” 12pp http://stormdrainfilters.com/flogard.doc
[21] Alsaigh, R., Boerma, J., Ploof, A. Regenmorter, L. (April 1999) “Evaluation of On-Line Media Filters in the Rouge River Watershed”. Task Product Memorandum Nonpoint Work Plan No. URBSW5, Task No.3. Wayne County, MI: 51pp

operations and maintenance costs, and pollutant removal efficiencies. They rank the devices as follows:

- The Gullywasher™ was found to be the most efficient at removing sediment;
- The Hydro-Cartridge® was most efficient in terms of oil removal 9,700(mg/Kg captured /1,000 gallons filtered);
- The Hydro-Cartridge® and the StreamGuard™ were the easiest to maintain;
- The StreamGuard™ had the lowest initial capital cost; and
- The Hydro-Cartridge® had the cheapest replacement inserts.

Table 2-2 presents a summary of insert performance with respect to sediment and oil and grease removal in addition to capital cost.

Table 2-2. Removal efficiency and capital cost summary.

Device	Average Sediment captured / Gallons Filtered (lbs/1,000 gallons)	Average Oil Captured / Gallons Filtered ((mg/Kg)/1,000 gallons)	COST			
			Structure	Media	Approx. Media Replacement Interval	Est. First Year Capital Cost
Hydro-Cartridge	0.19	9,700	$700 - $800	$9	3 months	$736 - $836
StreamGuard	1.11	5,000	n/a	$40-$80	2 months	$240 - $480
Gullywasher	6.60	2,100	$440	$60	3 months	$680
Grate Inlet Skimmer Box	0.39	700	$475	$25	3 months	$575

The authors concluded that all four (4) filters performed well and that filter performance is heavily dependent on site conditions and project objectives.

2.2.10 AbTech Ultra-Urban Filter - Vendor Studies

Summarized below are summaries of several studies by AbTech that evaluate the performance of their Ultra-Urban Filter. [22]

Tucson, AZ

This study included laboratory experiments to determine the effectiveness of the Ultra-Urban Filter, a galvanized steel basket containing Smart Sponge, in removing motor oil and diesel fuel. A 50-50 mixture of motor oil and diesel fuel with a concentration of 28 mg/L was run through the filter. Studies were run with and without debris (leaves, rocks, and twigs) and sediment. The filter removed an average of 83% of the oil and grease. Performance did not decline with the addition of debris and sediment.

Santa Monica, CA

In this study, an Ultra-Urban Filter that had been installed in a residential area for two months during the Santa Monica Bay Municipal/Urban Runoff Pilot Project was evaluated. A 28 to 32 mg/L mixture of motor oil and diesel fuel was run through the filter. The concentration of oil and grease was reduced by an average of 91%.

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[22] AbTech. 2003. Detailed Technical Field Test Results: The Ultra-Urban Filter with Smart Sponge. http://www.abtechindustries.com/Test%20Results%20Menu.htm

Seattle, WA

Minton (2002)[23] performed laboratory studies to determine the efficiency of AbTech's Ultra-Urban Filter in removing motor and diesel oil. A new unit's removal efficiency averaged 81%, when the influent concentration was between 10 to 30 mg/L. Performance of the device gradually dropped by 10 to 20% during the 120-minute tests. A device that had been in the field removed 78 to 96% of the 30 mg/L oil and grease.

Springfield, MA

Astro Environmental, LLC (2003)[24] performed field studies of AbTech's Ultra-Urban Filter. The influent contained either 250 mg/L of oil, grease, and vegetable oil or 100 mg/L of motor oil and diesel. The filters removed an average of 95.88% of the oil and grease. An average of 94% of total petroleum hydrocarbons were removed during two tests. The filters also removed 99% of 50 mg/L lead, zinc, and copper. This study suggested vacuuming out the filters prior to the winter season, since one filter accumulated greater than 95-pounds of debris during the fall season.

2.3 EXPECTED HYDROCARBON RUNOFF CONCENTRATIONS AND TREATMENT LEVELS

The Los Angeles County Department of Public Works (LACDPW) has monitored and characterized stormwater runoff since 1994 as part of the requirements of their NPDES Municipal Separate Storm Sewer (MS4) Permit[25]. The first two years of monitoring was done under the 1990 permit, while current monitoring efforts fall under the 2001 Municipal Storm Water Permit adopted on December 13, 2001.

The objectives of the County's monitoring program are: (1) to assess compliance with the NPDES Permit; (2) to measure and improve the effectiveness of the stormwater quality management plans (SQMPs); (3) to assess urban runoff water quality impacts to receiving waters; (4) to characterize stormwater discharges; (5) to identify sources of contaminants; and (6) to evaluate the long-term trends in receiving water quality. The monitoring program was expanded under the 1996 permit to include the Mass Emission, Land Use, and Critical Source Monitoring Programs and new pilot studies such as "Wide Channel" and "Low Flow" analyses. The 2001 permit eliminated the Land Use and the Critical Source components to focus on core monitoring, regional monitoring, and three special studies.

The mean and median TSS, oil and grease, TPH, and dissolved and total metals concentrations obtained from the 1994-2000 monitoring efforts are summarized in Table 2-3. Note that transportation and commercial land uses yield the highest concentrations of petroleum hydrocarbons in urban stormwater runoff in the City of Los Angeles and commercial, transportation, and light industrial land uses all yield high copper and zinc concentrations.

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[23] Minton, G.R. 2002. Technical Review of the AbTech Ultra-Urban Filter. Resource Planning Associates.
[24] Astro Environmental, LLC. 2003. Field Test Results of AbTech Industries Ultra-Urban Filter. http://www.abtechindustries.com/Test%20Results%20Menu.htm.
[25] California Regional Water Quality Control Board, Los Angeles Region (2001). "NPDES Permit No. CAS004001 - Waste Discharge Requirements for Municipal Storm Water and Urban Runoff Discharges Within the County of Los Angeles, and the Incorporated Cities Therein, Except the City of Long Beach."
Los Angeles County Department of Public Works (LACDPW). (August, 2002). "Los Angeles County 2001-2002 Storm Water Quality Monitoring Report" 26pp.

However, the range of oil and grease concentrations from each of the land use types are well below the influent concentrations typically used in catch basin insert studies (~10 to 40 mg/l).

Table 2-3. Summary of 1994-2000 land use results for TPH, oil and grease, and metals.

Land Use Type	Constituent	Units	No. of Samples	No. of Non-Detects	Percent Detects	Mean	Median	CV
Commercial	TSS	mg/L	29	0	100	66	53	0.65
	TPH	mg/l	8	2	75	3.1	2.9	0.63
	Oil and Grease	mg/l	8	1	88	3.3	2.9	0.51
	Dissolved Copper	ug/l	24	3	88	14	11	0.84
	Total Copper	ug/l	24	0	100	39	22	1.57
	Dissolved Lead	ug/l	24	20	17	S.I.D.	S.I.D.	S.I.D.
	Total Lead	ug/l	24	15	38	18	2.5	2.80
	Dissolved Zinc	ug/l	40	4	90	152	130	0.66
	Total Zinc	ug/l	40	0	100	241	192	0.71
Light Industrial	TSS	mg/L	41	0	100	240	129	1.36
	TPH	mg/l	5	1	80	1.7	1.4	0.68
	Oil and Grease	mg/l	5	1	80	1.7	1.4	0.68
	Dissolved Copper	ug/l	37	5	86	20	14	1.07
	Total Copper	ug/l	37	0	100	32	21	1.03
	Dissolved Lead	ug/l	37	32	14	S.I.D.	S.I.D.	S.I.D.
	Total Lead	ug/l	37	18	51	17	5.1	1.88
	Dissolved Zinc	ug/l	51	3	94	407	303	1.18
	Total Zinc	ug/l	51	0	100	639	366	1.53
High Density Single Family Residential	TSS	mg/L	30	0	100	95	61	1.16
	TPH	mg/l	3	0	100	1.3	1.2	0.23
	Oil and Grease	mg/l	3	0	100	1.3	1.2	0.23
	Dissolved Copper	ug/l	32	15	53	8.5	6.7	0.95
	Total Copper	ug/l	32	2	94	15	11	0.57
	Dissolved Lead	ug/l	32	28	13	S.I.D.	S.I.D.	S.I.D.
	Total Lead	ug/l	32	14	56	10	5.4	1.03
	Dissolved Zinc	ug/l	38	30	21	44	25	1.42
	Total Zinc	ug/l	38	13	66	79	66	0.75
Transportation	TSS	mg/L	61	0	100	78	50	1.30
	TPH	mg/l	4	0	100	3.1	2.8	0.47
	Oil and Grease	mg/l	4	0	100	3.1	2.8	0.47
	Dissolved Copper	ug/l	54	0	100	33	27	0.63
	Total Copper	ug/l	54	0	100	56	39	1.15
	Dissolved Lead	ug/l	54	48	11	S.I.D.	S.I.D.	S.I.D.
	Total Lead	ug/l	54	29	46	10	2.5	1.57
	Dissolved Zinc	ug/l	65	5	92	192	152	0.74
	Total Zinc	ug/l	65	0	100	291	218	0.99

Note: The detection limit for TSS is 2.0 mg/L, for both TPH and oil and grease is 1 mg/l, for total and dissolved copper and lead is 5 ug/L, and for total and dissolved zinc is 50 ug/L. S.I.D. = Statistically Invalid Data, not enough data above detection limit collected.

A review of the literature pertinent to the evaluation of catch basin insert efficiencies shows that a good number of the available studies use percent removals as a criterion for evaluating insert performance. A major limitation to this approach is that percent removals can be manipulated by increasing or lowering influent concentrations.

Examples of other methods that have been used to assess BMP evaluation studies include: summation of loads, regression of loads, mean concentration, efficiency of individual storm loads, reference watersheds, and before and after studies (GeoSyntec Consultants, 2002)[26].

One of the most useful methods of evaluating BMP performance is the Effluent Probability Method. For this method, the influent and effluent are first checked to see whether they are statistically significantly different. Then side-by-side cumulative distribution functions of influent and effluent quality (or standard parallel probability plots) are generated to evaluate the nature of the difference. Nonparametric approaches are recommended to estimate the magnitude of the difference, if the influent and effluent concentrations appear to arise from different distributions. As more studies adopt this approach to reporting BMP efficiencies, more data will be available to support values that can be used to estimate reasonable expected effluent concentrations from BMPs such as catch basin inserts. Since the reasonable expected removals for BMPs provided in this section are based on a review of previous studies, we are limited to the use of percent removals.

Among the reviewed studies, catch basin insert efficiencies varied significantly. Vendor publications report oil and grease removal efficiencies of 81% to 99% for new inserts. Third party laboratory studies report removal efficiencies of greater than 50% for oil and grease, and greater than 34% for hydrocarbons. Nearly all of the third-party field studies reported clogging and bypass of the filters, which reduces the filter efficiency. In the worst case, excessive clogging resulted in only an 8.2% removal of oil and grease (which was likely not statistically significant). Unfortunately, nearly all of the studies (third-party or otherwise) used influent oil and grease concentrations that were well above the expected concentrations in urban runoff in the Los Angeles area (i.e., greater than 3 standard deviations above the L.A. County data shown in Table 2-3). Furthermore, the achieved effluent oil and grease concentrations for the studies that actually reported them were typically above or near the expected influent levels. Based on these issues, the expected effluent concentrations from catch basin inserts during stormwater runoff events cannot be adequately assessed. However, the studies do suggest that catch basin inserts will not reliably reduce oil and grease concentrations below about 5-10 mg/l.

As discussed above in Section 2.1, the low oil and grease concentrations typically observed in urban runoff caused by primarily dispersed sources, likely represent less of a threat to receiving waters than the illegal dumping of used oil directly into the storm drain system. Therefore, the ability of catch basin inserts to remove oil from stormwater may not be as important as their ability to retain previously captured oil from illegal dumping activities during high-flow conditions. However, since no studies were found that evaluated the mass of used oil retained following an illegal dumping activity, it is not possible to assess the ability of catch basin inserts to effectively hold oil and grease until maintenance is performed.

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[26] GeoSyntec Consultants (April 2002). "A Guidance Manual for Meeting the National Stormwater BMP Database Requirements." ASCE / EPA

3 RESEARCH METHODOLOGY

An integral part of this Catch Basin Insert Performance Study was the selection of catch basin sites and inserts compatible with those sites. This study included the selection of 24 cumulative pollutant capture sites and 12 field-to-laboratory sites. The purpose of the cumulative pollutant capture sites was to assess long-term performance and maintenance requirements, as well as characterize bulk pollutants captured during the study period. The purpose of the field-to-laboratory sites was to numerically evaluate changes in pollutant removals after being exposed to field conditions. The results from both sites were used to qualitatively and quantitatively compare the performance of the four (4) different types of filters tested. The following paragraphs describe the site and catch basin insert selection methodology, the monitoring and testing plan, and the design and construction of the insert testing apparatus.

3.1 STUDY SITE SELECTION

Site selection was an important component of this project because one of the objectives was to evaluate insert performance after being exposed to dry weather conditions and wet weather urban runoff from high oil and grease source areas. These areas have a high potential for receiving significant amounts of motor oil and other petroleum products into drains via illicit dumping and improper vehicle maintenance. The City of Los Angles staff provided an initial map of 52 candidate catch basin sites located in areas believed to be high oil and grease source areas. The suitability of these candidate sites were investigated as part of the second phase of the study. Approximate drainage areas, dominant land uses, catch basin dimensions, and other site constraints were evaluated. Other factors considered for the final site selection included representativeness, personnel safety, ease of access, and security. The following paragraphs describe each of these factors in more detail.

3.1.1 REPRESENTATIVENESS

Sites chosen for catch basin filter performance comparison were selected based on similar sized drainage areas (gross approximation), land use types, and relative proximity to one another. Sites were located in areas that represent highly-developed urban areas of the City of Los Angeles. Drainage areas with known active or planned construction were intentionally avoided.

3.1.2 SAFETY

Site safety is the number one concern for any field investigation. An attempt was made to avoid sites having excessive traffic and high speed limits. For the safety of the monitoring crews who were accessing the sites, only well lit areas with moderate traffic and speed limits below 55 mph were chosen. Areas with excessive pedestrian traffic were also avoided for the general safety of the public and the site crew.

3.1.3 EASE OF ACCESS

This was a low priority; however, whenever possible, sites were chosen that were closer to the UCLA laboratory rather than those that are further away. Also sites that had structures that are easily accessible are favored. For instance, catch basins that were only accessible through a heavy drop inlet grate that required two or more people to lift were avoided.

3.1.4 SECURITY

Vandalism was as issue that was taken into account in the site selection process. Although hard to predict, situations that present opportunities for vandalism were avoided where ever possible.

The catch basin inserts were contained and no equipment was ever left on-site, so the potential for vandalism was low. Nonetheless, well lit open areas were chosen to discourage vandals and criminals alike from interfering with the inserts, the activities of the monitoring crews, or the results of the study. All field monitoring was done in broad daylight.

3.2 CATCH BASIN INSERT SELECTION

The initial list of candidate catch basin inserts consisted of products from nine (9) different vendors with a variety of design configurations and media types. Based on cost, ease of installation and maintenance, number and quality of existing evaluation studies, and the target pollutants, these nine candidate inserts were narrowed down during repeated project team discussions to the following four (4) vendors: Drainworks DrainPac, Suntree Curb Inlet Basket, Kristar FloGard-Plus, and Hydro Compliance Hydro-Kleen. All of these inserts were available in a variety of sizes and configurations, but some designs were more compatible with some individual catch basins than others. The descriptions of the selected catch basin inserts in the manufacturers' words are provided in the next section.

3.2.1 DRAINWORKS INC. – DRAINPAC

The DrainPac™ is a flexible storm drain catchment and filtration liner designed to filter pollutants, debris, and solids prior to discharge into storm drain systems. The DrainPac™ is available in four (4) styles: grate top, curb, and round configurations, as well as new styles designed for outfall, or "end of pipe" applications and drop-in drain applications. Each insert is equipped with a choice of two (2) overflow systems, the hydraulic bypass and the new uninhibited bypass, both of which accommodate heavy rains and potential flooding. A picture of the curb inlet DrainPac™ system is shown in Figure 3-1.

According to the manufacturer, the DrainPac™ can handle flow rates of up to 150 gpm/sq. ft and hold up to 7100 pounds of material. Tests performed at UCLA (not in this study) show removal efficiencies for the DrainPac™ System at 99% for TSS, and 51% to 88% for PAHs. Typical cost for the DrainPac™ System range from about $1000 for a 21-foot wide curb inlet to about $500 for a 4- to 7-foot wide curb inlet. The manufacturer recommends that maintenance be performed at least twice per year (once before the wet season and once after the wet season). Quarterly inspections during dry periods and monthly inspections during wet periods are also recommended. The cost of a yearly maintenance service agreement with the manufacturer is $225 per unit.

Figure 3-1. DrainPac™ catch basin insert.

A full description and a complete list of applications are available at the manufacturer's web site: http://www.drainpac.com/index1.htm.

3.2.2 SUNTREE TECHNOLOGIES INC. – CURB INLET BASKET

The Curb Inlet Basket is a multi-stage, removable filtration basket that was designed to capture everything from hydrocarbons to sediment, grass clippings, and human trash. It is made of durable fiberglass with stainless steel filter screens, backed by heavy-duty aluminum grating. The Curb Inlet Basket telescopes to change size, so that it can fit almost any catch basin. However, custom-shaped units are available from the manufacturer. A picture of the Curb Inlet Basket is show in Figure 3-2.

The cost of the Curb Inlet Basket ranges from $695 to $795. Pricing for custom units can be obtained from the manufacturer[27]. The maintenance of the Curb Inlet Basket can be performed by hand, without the need for heavy equipment. Maintenance entails removing the inlet access cover, lifting out the basket by hand or with a manhole puller and dumping out the contents. The basket is placed back into the catch basin and the sorbent boom is replaced. The manufacturer recommends quarterly maintenance of the basket to remove sediment and debris, along with semi-annual replacement of the sorbent boom. Performance evaluation of the Grate Inlet Skimmer Box System performed by the Reedy Creek Improvement District and Walt Disney Imagineering, reported removal efficiencies of 74% for total suspended solids and 54% for oil and grease.

A full description and a complete list of applications for the Curb Inlet Basket are available at the manufacturer's web site: http://www.suntreetech.com/ .

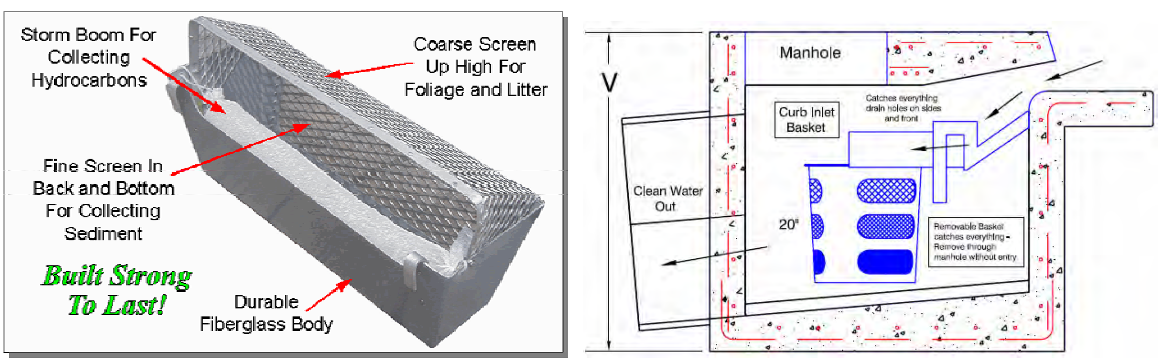


Figure 3-2. Curb Inlet Basket functional details and installed configuration.

3.2.3 KRISTAR ENTERPRISES INC. – FLOGARD+PLUS™

The FLOGARD+PLUS™ is a multipurpose catch basin insert designed to capture sediment, debris, trash, and oils/grease from low (first flush) flows. A high-flow bypass screen allows flows to bypass the device while retaining sediment and larger floatables (debris & trash), and allows sustained maximum design flows under extreme weather conditions. The system is designed for use in areas with low to higher than normal sediment, trash, and debris; and moderately high

[27] August 2003 Catalog. Sun Tree Technologies Inc.

levels of petroleum hydrocarbons such as parking lots, as well as public and private streets.

The cost of the FloGard Plus System ranges from $350 for a 2-foot curb opening installation to about $2,200 for a 15-foot curb opening installation. UCLA conducted tests (not this study) to determine the removal efficiency of the fossil filter FloGard System in October 2000. Oil and grease removal efficiencies were found to range from 70% to 90%. The manufacturer recommends at least three (3) inspections per year, and more in high exposure areas. Maintenance entails removing the device from the inlet and dumping the contents into an approved drum for disposal. Cleaning can also be accomplished with a vacuum truck. Maintenance costs for a curb inlet installation with a 7-foot curb opening ranges from $250 to $375 per annum.

A full description and a complete list of applications for the FloGard Plus System are available at the manufacturer's web site: http://www.kristar.com/fosys.html.

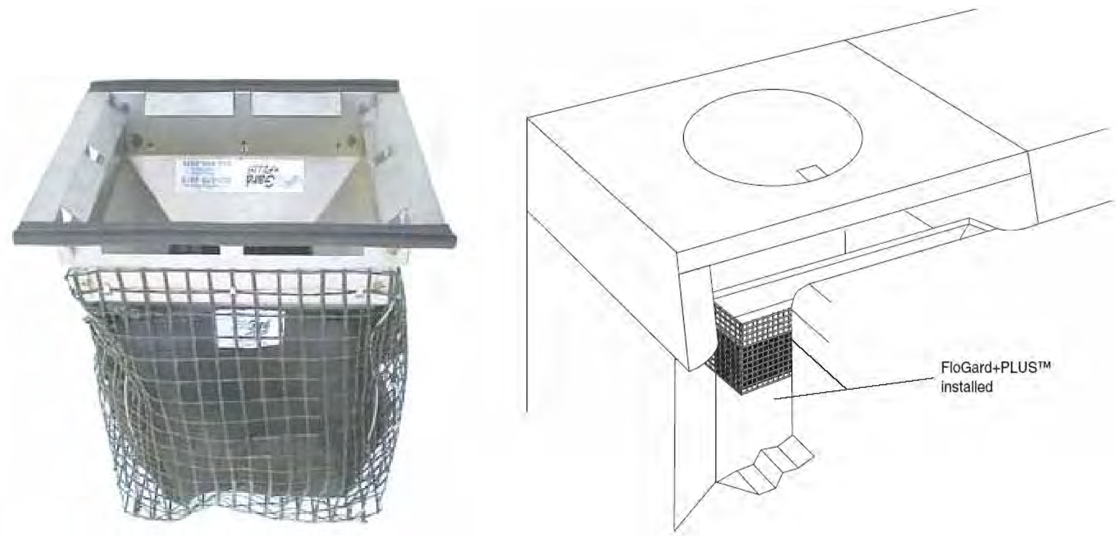


Figure 3-3. FloGard Plus catch basin insert.

3.2.4 HYDRO COMPLIANCE MANAGEMENT INC. – HYDRO-KLEEN

The patented Hydro-Kleen Filtration System is a stormwater compliance technology for use with stormwater catch basins and drains to trap hydrocarbons, metals, sediments, and other contaminants contained in stormwater and other surface runoff. The multi-media filtration system contains design features that effectively filter out hydrocarbons and other contaminants, while alleviating concerns with water flow.

Flows enter the unit and are directed into a pre-settling sedimentation chamber that collects heavy sediments and debris passing through the grate. Water then passes through transition inlets at the top of the sediment chamber into the filtration chamber. The primary media, Sorb-44, traps hydrocarbons through adsorption to a hydrophobic cellulose material. The secondary media is a special blend of activated carbon (AC-10) that removes most remaining hydrocarbons, as well as a variety of other organics, and metals and other contaminants from the runoff. Water then passes through the bottom of the treatment chamber into the catch basin. The system can fit both circular and rectangular catch basin grates. An illustration of the Hydro-Kleen Filtration System is shown in Figure 3-4.

According to the manufacturer, typical cost of a 24-inch square unit is $1150, while a 2-foot by 4-foot unit costs about $2,300. Maintenance costs are typically $300 per year. Maintenance is straightforward and can be accomplished by vacuuming sediment loadings from the sedimentation chamber and replacing the filters. It is recommended that filters be changed every 4 to 6 months, depending on the application. Disposal of the spent media in a typical application may be accomplished through placement into lined landfills, as the filter media is non-leaching. Third part analytical test results obtained from the manufacturer show removal efficiencies of 83% to 95% for BTEX and almost 70% for total suspended solids.

A few examples of current applications of this Hydro-Kleen System include installations by American Airlines, Alcoa, Federal Express, Ford Motor Company, General Motors, Kroger, Seven Eleven, and the US Army. A full description and a complete list of applications are available at the manufacturer's web site: http://www.hydrocompliance.com/.

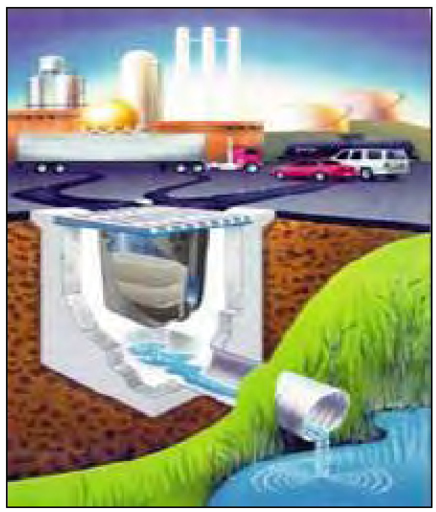


Figure 3-4. Hydro-Kleen Stormwater Filtration System.

3.3 SUMMARY OF THE MONITORING AND TESTING PROCEDURES

As discussed above, four different catch basin insert technologies were selected for this study: DrainPac, Curb Inlet Basket, FloGard-Plus, and Hydro-Kleen. The performance of these inserts was evaluated in two parts: at field-to-laboratory (FL) sites and at cumulative pollutant capture (CPC) sites. The FL sites were used to evaluate the performance of the inserts by performing a series of laboratory tests on them before and after being exposed to field conditions. The CPC sites were used to evaluate the long-term performance of the insert technologies through periodic field inspections during the wet and dry seasons and then collecting the inserts for pollutant capture analyses at the end of the evaluation period or at the end of their useful lives (determined by the inspection team).

A monitoring plan was prepared that outlined the field inspection activities and the laboratory testing procedures. Some elements of the monitoring plan were modified during the course of the study due to circumstances beyond control that caused delays in getting project tasks completed. For instance, the fire disaster that occurred in southern California during the summer of 2003 left a significant amount of ash covering the area and it was decided that the "first flush" event would not likely represent typical conditions so the project team decided to install and begin conditioning the catch basin inserts during the middle rather than at the beginning of the wet season (2003-2004). Also, the catch basin insert testing apparatus at UCLA had to be relocated because of ongoing construction activities. After it was moved, the apparatus needed to be repaired due to leakage, which caused delays in the laboratory testing. Consequently, the study occurred in two phases: cumulative pollutant capture phase (Feb. 2004 - Oct. 2004) and field-to-laboratory phase (Nov. 2004 - May 2005).

During the course of these two phases of the study, one insert at a CPC site and three inserts at FL sites were replaced by the City of Los Angeles with an alternative insert system without the knowledge of the research team. This alternative system is shown in Figure 3-5 and consists of a screen that covers the entire bottom of the catch basin. Notice that this design provides no oil absorption, but has ample capacity for capturing bulk solids. The loss of the inserts was unfortunate and reduced the number of inserts available for the study.

Figure 3-5. Alternative catch basin insert system installed by the City of Los Angeles.

The following subsections briefly summarize the insert monitoring and testing activities.

3.3.1 FIELD INSPECTIONS

Field inspection of the cumulative capture sites were conducted to:

- Ensure that all inserts were functioning properly
- Detect and eliminate unnatural conditions such as excessive clogging or blockage from oversized objects
- Detect and replace missing, damaged, or defective inserts
- Document the condition of inserts through visual observation, photographs, and field notes

Inserts were installed at all sites between October and November 2003. Field inspections began after in February 2004 and continued through October 2004. Sites designated as FL sites were inspected as if they were CPC sites and were generally inspected at the same frequency as the CPC sites. Field inspections occurred on 2/4/04, 2/27/04, 3/23/04, 6/30/04, 10/21-22/04, and 3/24/05.

Field procedures included inspecting both the drainage structure and the installed insert and noting any observations that required correction such as damaged structures, missing or damaged inserts, blocked inlets, etc. Photographs of the inside of the structure were taken to document any debris that had bypassed the insert as well as debris that had been collected inside the insert structure. Photographs of the installed inlets looking through curb openings were also taken.

During the routine inspections, if any of the insert media appeared to have reached their maximum capacity (e.g., standing water in the insert) or was damaged beyond repair, it was noted, photographed and retrieved for laboratory analysis.

3.3.2 Laboratory Testing

The primary objectives of the laboratory tests were to:

- Quantitatively evaluate changes in pollutant removal rates of 4 different types of catch basin filters after being exposed to field conditions.
- Evaluate the quantity of used motor oil captured by catch basin inserts when new and weathered and the potential for captured oil, and associated pollutants, to leach from catch basin inserts.
- Estimate the performance of each proprietary filter tested with respect to the removal and retention of used motor oil and make statistically valid performance comparisons.

Laboratory tests began during the 2004-2005 wet season after new inserts were installed in all of the FL sites. All laboratory testing was performed at UCLA using an apparatus built by Professor Michael Stenstrom (see Section 3.4). Two categories of laboratory tests were conducted including: New Filter Performance Tests and Used Filter Performance Tests.

A large stock of the used motor oil was created for use throughout the study. The total and particulate heavy metals concentrations were measured in the oil stock to determine if the catch basin insert may impact metals removal and if sampling of suspended solids and total metals should be measured in the effluent from the catch basin during the washout experiment.

New Filter Performance Tests. Four unused catch basin insert types from four different manufacturers for controlling gross spills were tested. The tests were conducted by pouring 1 quart of used motor oil directly into each catch basin insert type. The amount that drained through the insert was captured and the volume was measured. The test was continued until the insert ceased to drip measurable amounts of motor oil. Following the drainage period, the catch basin insert was placed in the insert testing flume and exposed to a design flow rate (20 to 25 GPM). Oil and grease washout was monitored over the next 90 minutes taking a total of six grab samples, including at the beginning of flow and then every 18 minutes. Each grab sample was then analyzed for total oil and grease. The extracts of the oil and grease measurements were combined and analyzed for PAHs.

In addition to the spill tests, one example of each insert type was laboratory tested with a sustained flow of introduced pollutants. The test was conducted for 60 minutes at 20 to 25 GPM using tap water dosed with oil and grease and glass beads to simulate sand and clay. Commercially available glass beads (McMaster Carr, Los Angeles, CA) used for “sand blasting” were used for testing. These beads are provided in several sizes. Four grades of beads were mixed to create the fraction shown in Table 3-1. Ten grab samples, one each 6 minutes, were collected for oil and grease analyses. The suspended solids removal was measured by capturing all the particles that passed through the catch basin insert during the 60 minute test, screening into the same size fractions as used initially, dried and weighed. The influent sand concentration was approximately 200 mg/L and the influent oil and grease concentration was approximately 20 mg/L. To understand the potential removal of heavy metals and PAHs contained in the oil and grease that might be removed by adsorption, the concentrations of both were measured in the used oil. These concentrations can be multiplied by the oil and grease concentrations or removals to estimate the impact of the inserts on removals of metals and PAHs.

Table 3-1. Target particle size percentiles by mass for artificial stormwater TSS concentrations.

Percentile by Mass	Diameter Range	Approximate Target Concentration Range
25%	Passing 40 mesh (430 µm) but retained on 60 mesh (250 µm)	~ 50 mg/L
25%	Passing 60 mesh (250 µm) but retained on 120 mesh (125 µm)	~50 mg/L
25%	Passing 100mesh (150 µm) but retained on 170 mesh (90 µm)	~ 50 mg/L
25%	Passing 170 mesh (90 µm) but retained on 325 mesh (45 µm).	~ 50 mg/L

Used Filter Performance Tests. The UCLA Team placed twelve new inserts into designated catch basins prior to the 2004-2005 rainy season (~early October). At the middle of the 2004-2005 wet season, the field-to-laboratory inserts (9 total) were collected and transported by the Team to the UCLA laboratory (3 inserts were inadvertently removed by the City of Los Angeles in their experimental program). Each insert was placed in the flume and a fine solids capture screen was placed below the insert. After removing large debris such as plastic bags, newspapers, and leaves, it was hydraulically tested starting at a flow rate of 5 GPM. If the insert was not clogged by fine sediment, the flow rate was gradually increased to the flume's maximum capacity (60 gpm) or until the insert bypassed. Depth of water in the insert was recorded as a function of flow rate and the flow rate at which bypass occurred was noted. During this hydraulic capacity testing, fine solids that had been captured by the inserts while out in the field that washed out were collected, but no solids removed from the insert while it bypassed flows were collected. These collected solids were characterized by weighing and sieving.

After completing the capacity testing, the continuous flow testing was begun. The flow was set to the maximum possible without bypassing up to 25 gpm maximum. Grab samples were collected through the 60 minutes to create a composite sample for oil and grease analysis. Solids removal was quantified by collecting solids in a 325 mesh (45 µm) screen below the insert. This was the same screen used in the capacity testing, although it was cleaned to avoid mixing the two types of solids. The solids retained by the fine screen, were weighed and sieved into the four size fractions as shown in Table 3-1.

After all tests were completed, spill tests were performed on the used inserts using the same procedure described for the new filter tests to evaluate any changes in retention capacity after the filters had been used.

3.4 DESIGN AND CONSTRUCTION OF TESTING APPARATUS

The design of the UCLA testing apparatus is based on a curb and gutter flume design used for previous catch basin insert studies conducted by Professor Stenstrom, together in some cases with GeoSyntec staff and is intended to simulate the influent hydraulics of a curb inlet catch basin. A plan view schematic of the testing apparatus is shown in Figure 3-6 and a profile view schematic is shown in Figure 3-7.

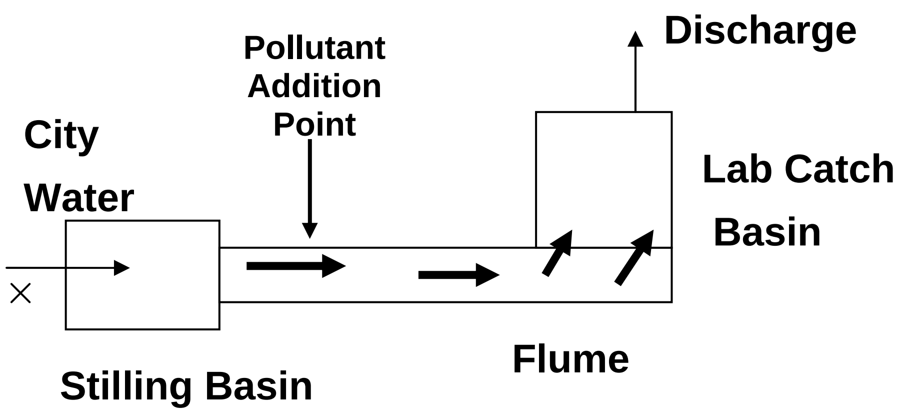


Figure 3-6. Laboratory testing apparatus schematic (plan view).

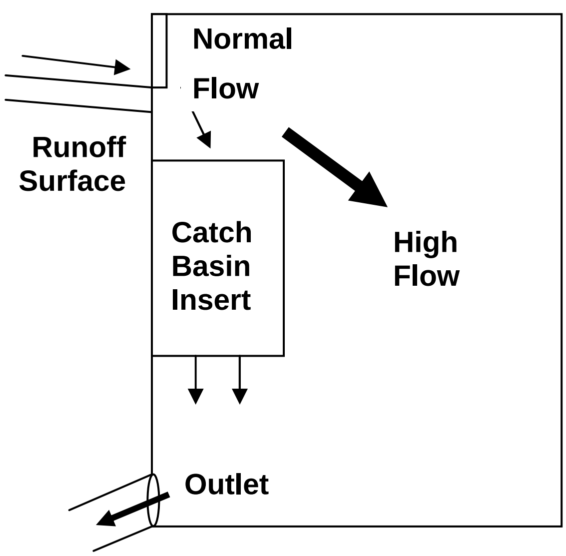


Figure 3-7. Curb inlet schematic (profile view).

As mentioned above, the UCLA testing apparatus was moved from its previous location and needed to be repaired due to leaks and needed to be modified to accommodate the inserts tested in this study. A new stilling basin tank was also installed.

Pictures of the testing apparatus in its new location are shown in below. Figure 3-8 shows a full view of the apparatus prior to and after being upgraded. Figure 3-9 shows the inlet configuration, the new stilling basin, and the catch basin outlet.

Figure 3-8. Testing apparatus prior to upgrade (left) and after upgrade (right).

Figure 3-9. Testing apparatus stilling basin (left) and synthetic catch basin (right).

3.5 PRECIPITATION DURING THE STUDY PERIOD

The sites received runoff from several storm events during both phases of the study, but the amount of rainfall that occurred during the field-to-laboratory phase (2004-2005 wet season) was much greater than during the cumulative capture phase (02/2004 - 10/2004). Figure 3-10 provides daily rainfall totals for 2004 and Figure 3-11 provides daily rainfall totals for 2005 through April for the Downtown Los Angeles USC Campus rain gage. These data are used to qualitatively relate observed conditions to the amount of rainfall between observations.

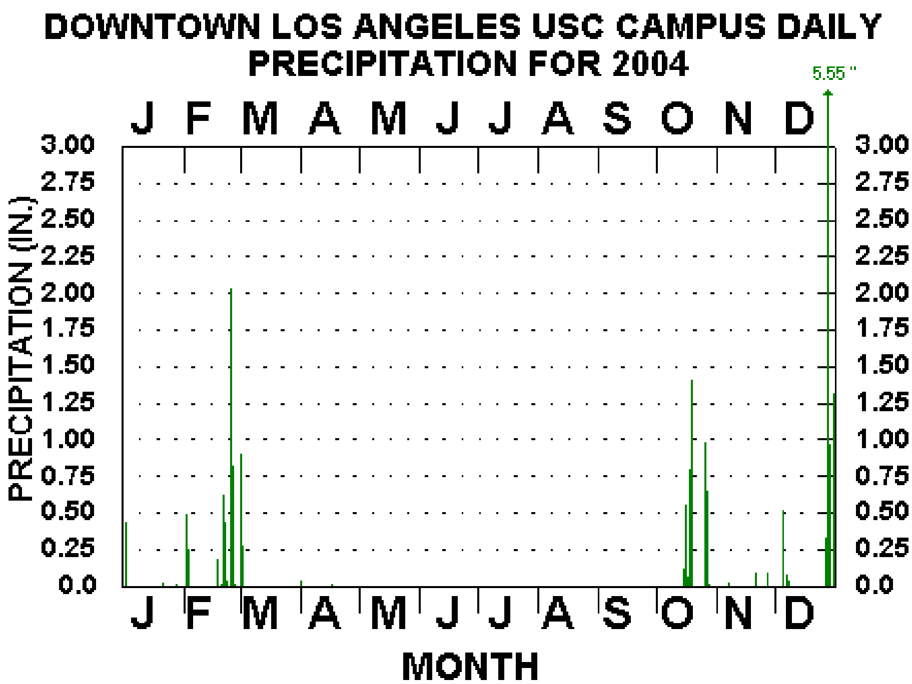


Figure 3-10. 2004 precipitation record for the Downtown USC Campus rain gage. Source: http://home.att.net/~station_climo/

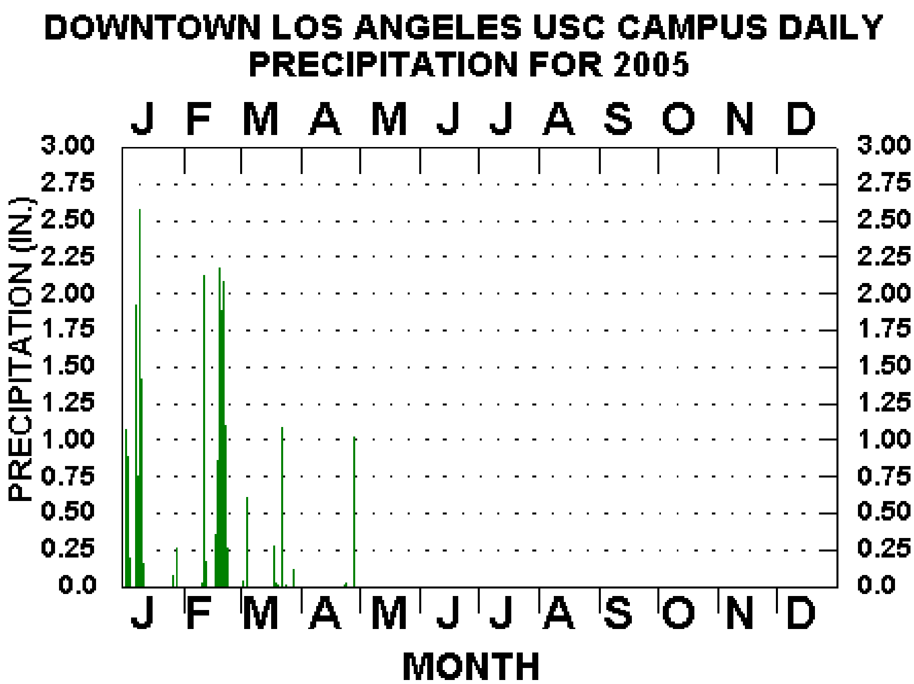


Figure 3-11. 2005 precipitation record for the Downtown USC Campus rain gage. Source: http://home.att.net/~station_climo/

4 RESULTS AND DISCUSSION

The following subsections discuss the results of the field inspections and the laboratory analyses. The cumulative pollutant capture part of the study was based on the field inspections of both the CPC sites and the FL sites.

4.1 FIELD INSPECTIONS

The performance of four catch basin inserts selected for this study was evaluated at twenty-four (24) CPC sites and twelve (12) FL sites during the study period 2003-2005. Location maps of all of sites are provided in Appendix A. Figure A1 includes the locations of all of the CPC sites and Figure A2 includes the locations of all of the FL sites. Figures A3 and A4 are aerial photographs of the FL sites grouped into east and west sites, respectively.

One of the most consistent observations made during field surveys is that almost all inserts installed in the field were quickly overwhelmed with trash and debris, which causes stormwater bypass and resulting in limited contact with the absorptive media. While the capture trash and debris may provide some pollutant retention, without significant stormwater/media contact the ability of these devices to remove oil and grease, as well as other pollutants, is severely limited. No significant attempt was made to maintain the CPC sites; instead the accumulation of trash and debris was simply observed and the inserts were retired shortly after they reached their holding capacity. All field survey photos and observations made during the inspection of CPC and FL sites are provided in Appendix B. As mentioned earlier, the FL sites were treated as CPC sites during the inspections. However some of the FL inserts had not yet been installed by the vendor during the initial field inspections, so there are fewer observations of these sites than the CPC sites provided in Appendix B. Representative photographs and field observations that provide a qualitative indication of the performance of each type of insert selected for this study are provided below. Since these sites have different drainage areas, land use types, and catch basin configurations, the following observations are not meant to be representative of the overall performance of each insert type and should not be construed as a comparative analysis.

The subsections below present some an example site and resulting observations for each of the catch basin insert types. All field notes and photos are provided in Appendix B.

4.1.1 DRAINPAC AT WASHINGTON AND VERMONT

A DrainPac catch basin insert was installed at the southeast corner of Washington Blvd. and Vermont Ave. in January, 2004. This site receives runoff from primarily commercial, multi-family residential, and transportation land uses. Figure 4-1 shows the location of the catch basin in relation to the City of Los Angeles' storm drain system including the direction of surface runoff. Figure 4-2 is an aerial photo of the site showing the surrounding land use activities and Figure 4-3 shows two ground-level photographs taken from the site.

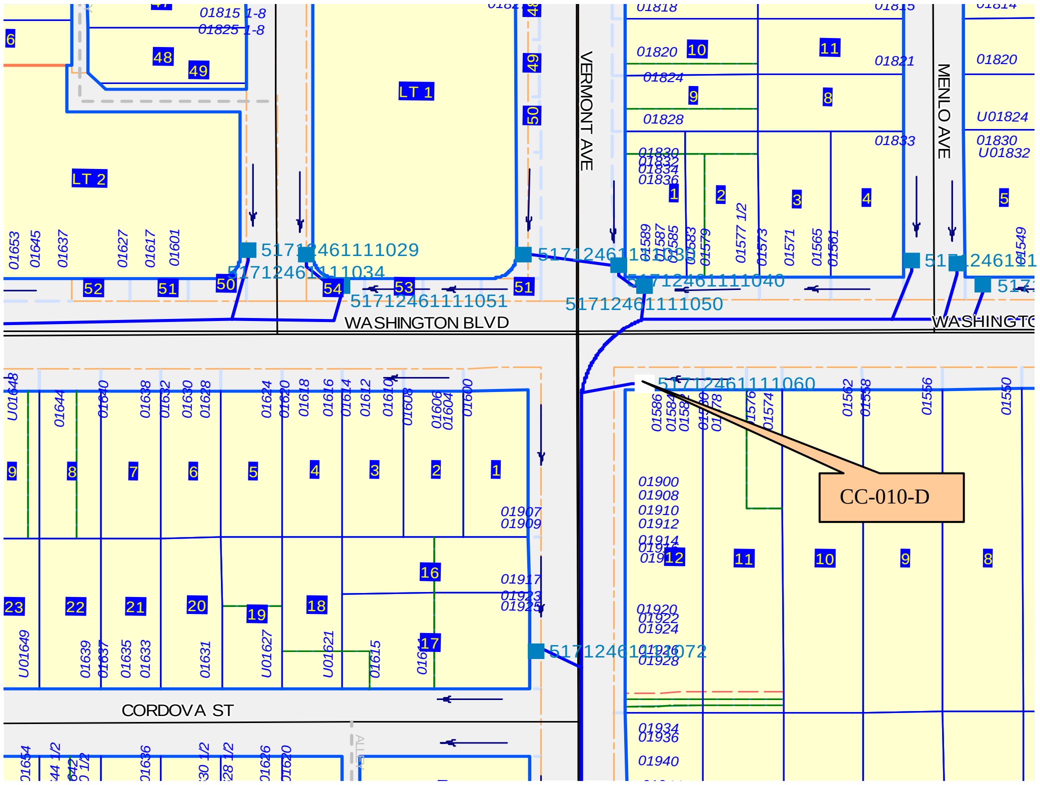


Figure 4-1. Map showing the location of CC-001-D site installed with DrainPac insert.

Figure 4-2. Aerial photo of site CC-010-D.
(Source: http://terraserver.microsoft.com).

Figure 4-3. CC-010-D site photos upstream (left) and to the intersection of Vermont and Washington (right).

The initial site visit (10-24-03) before the installation of the DrainPac indicated that the site was located at a busy intersection with very high trash loading (Figure 4-4a). The first inspection after the installation of the insert was made on 02-04-04 during a small storm event (~0.75"; see Figure 3-10). Although the insert appeared to be operating at full hydraulic capacity, the inflow was still being processed by the insert (Figure 4-4b). The next visit (02-27-04) occurred in less than a month after a relatively large storm event (>2"). The site examination indicated that some flow bypass had occurred with trash and debris settling at the edge of the insert (Figure 4-4c). Also, standing water indicated the insert was beginning to clog. The site was completely overwhelmed with trash during the fourth visit (03-23-04; Figure 4-4d) and since only one storm (>1") occurred since the previous visit, most of the trash was likely due to wind rather than runoff. The next inspection on 06-30-04 the insert appeared to be completely buried with wind-blown trash (Figure 4-4e). During the last inspection of the site (10-21-04) the insert was retired and captured debris were collected for laboratory tests (Figure 4-4f).

Figure 4-4. Field inspection photos of DrainPac catch basin insert at the intersection of Washington Blvd. and Vermont Ave.

4.1.2 CURB-INLET BASKET AT PORTLAND AND 23RD

The study site CC-008-C located at the intersection of 23rd and Portland St. was installed with a Curb-Inlet Basket. This site receives runoff from high density single family residential land uses. Figure 4-5 shows the location of the catch basin in relation to the City of Los Angeles' storm drain system including the direction of surface runoff. Figure 4-6 is an aerial photo of the site showing the surrounding land use activities and Figure 4-7 shows two ground-level photographs taken from the site.

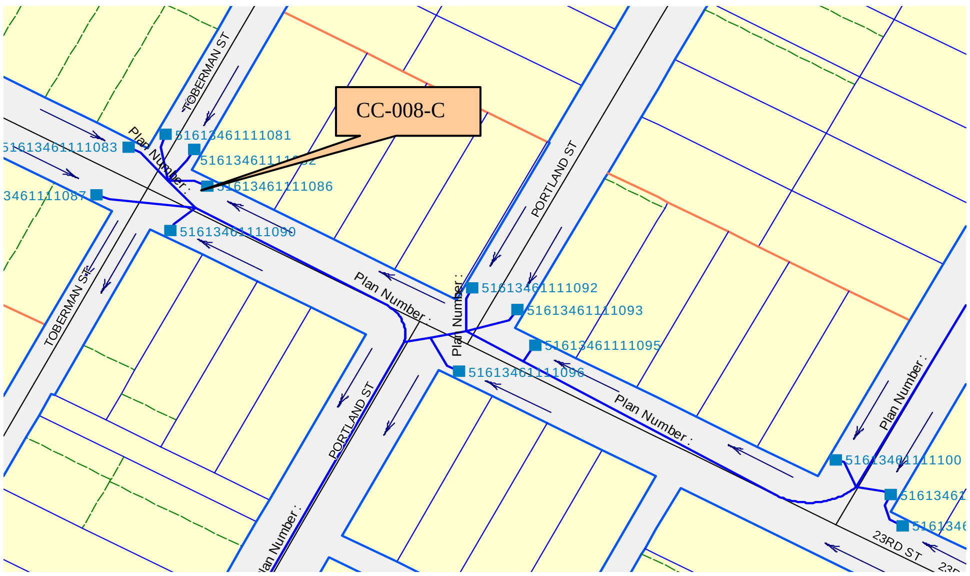


Figure 4-5. Map showing the location of CC-008-C site installed with a Curb-Inlet Basket.

Figure 4-6. Aerial photo of site CC-008-C.
(Source: http://terraserver.microsoft.com).

Figure 4-7. CC-008-C site photos upstream (left) and to the intersection of 23rd and Portland (right).

The initial site survey was completed on 12-10-03 before the installation of the insert. Excessive leafy debris from nearby deciduous trees appears to comprise a significant proportion of the material delivered to this catch basin (Figure 4-8a). The first visit (02-04-04) after insert installation was performed just after one storm event (~0.75"). Some trash and debris along with a notable accumulation of coarse sediment were collected by the insert (Figure 4-8b). However, the insert still had plenty of capacity at this time. During the next visit in less than two months after installation (03-23-04) the insert had accumulated a significant amount of trash, but was still functioning with limited signs of bypass (Figure 4-8c). The site survey conducted on 6-30-04 showed that the insert had reached its full capacity and was overflowing with wind-blown trash and debris (Figure 4-8d). The final site inspection was performed on 10-21-04 after a few inches of rainfall (see Figure 3-10). There was less trash in the insert than the previous visit and the media boom at the lip of the insert was missing its adsorptive material indicating that the insert was cleaned by Los Angeles County maintenance staff prior to the wet season. Since the absorptive media was missing, this insert was retired during this final visit (Figure 4-8e and Figure 4-8f).

Figure 4-8. Field inspection photos showing the condition of Curb-Inlet Basket at the intersection of 23rd St. and Portland (east side).

4.1.3 FLOGARD-PLUS AT 18TH AND FLOWER

The site CC-007-F installed with a FloGard Plus unit is located at the intersection of 18th and Flower Street. This site receives runoff from retail and commercial land uses. However, the close proximity of the I-10 freeway may impact the deposition of airborne debris and particulates. Figure 4-9 shows the location of the catch basin in relation to the City of Los Angeles' storm drain system including the direction of surface runoff. Figure 4-10 is an aerial photo of the site showing the surrounding land use activities and Figure 4-11 shows two ground-level photographs taken from the site.

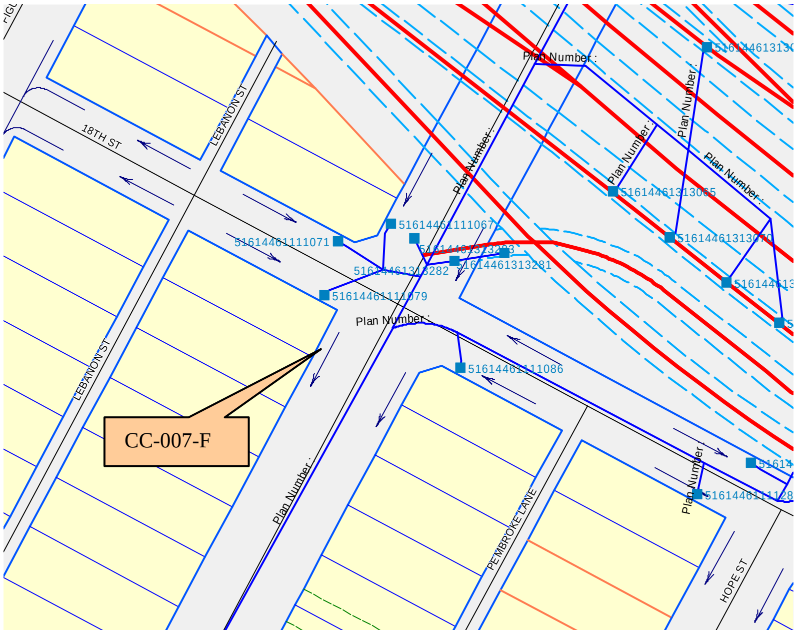


Figure 4-9. Map showing the location of CC-007-F site installed with a FloGard Plus insert.

Figure 4-10. Aerial photo of site CC-007-F.
(Source: http://terraserver.microsoft.com).

Figure 4-11. CC-010-D site photos upstream (left) and to the intersection of 18th and Flower (right).

The initial site visit was conducted on 12-10-03 before the installation of the FloGard Plus. The catch basin appeared to be a shallow unit with relatively low trash loading (Figure 4-12a). However, the first inspection (02-04-04) after installation of the FloGard Plus showed standing water in the unit from the approximately 0.75 inches of rainfall that occurred the night and morning before, indicating the unit may have already begun to clog. The adsorbent boom with amorphous alumina silicate was seen floating in the standing water (Figure 4-12b). The second inspection (02-27-04) of the insert showed slightly more capture of debris and trash and the standing water had drained (Figure 4-12c) even though more rainfall had occurred. During the third inspection, which occurred within a month of installation (03-23-04), the insert was nearly at its volumetric capacity (Figure 4-12d). During the next inspection (06-30-04) the insert showed that the insert reached its capacity and was overflowing with trash. As with the other inserts, the majority of the trash appeared to have been transported by wind rather than runoff (Figure 4-12e). The last inspection was conducted on 10-21-04. Some of the trash appeared to have bypassed after a rain event and some has consolidated in the insert. The insert was retired after this visit and the captured debris was collected for laboratory sieve analysis (Figure 4-12f).

Figure 4-12. Field inspection photos showing the condition of FloGard Plus at the intersection of 18th St. and Flower St. (southwest corner).

4.1.4 HYDRO-KLEEN AT WASHINGTON AND CATALINA

The location of this field survey site, CC-001-H with the Hydro-Kleen insert is near the intersection of Washington and Catalina Streets. This site receives runoff from primarily commercial land uses (auto dealers and repair shops) and transportation (Washington Blvd.). Figure 4-13 shows the location of the catch basin in relation to the City of Los Angeles' storm drain system including the direction of surface runoff. Figure 4-14 is an aerial photo of the site showing the surrounding land use activities and Figure 4-15 shows two ground-level photographs taken from the site.

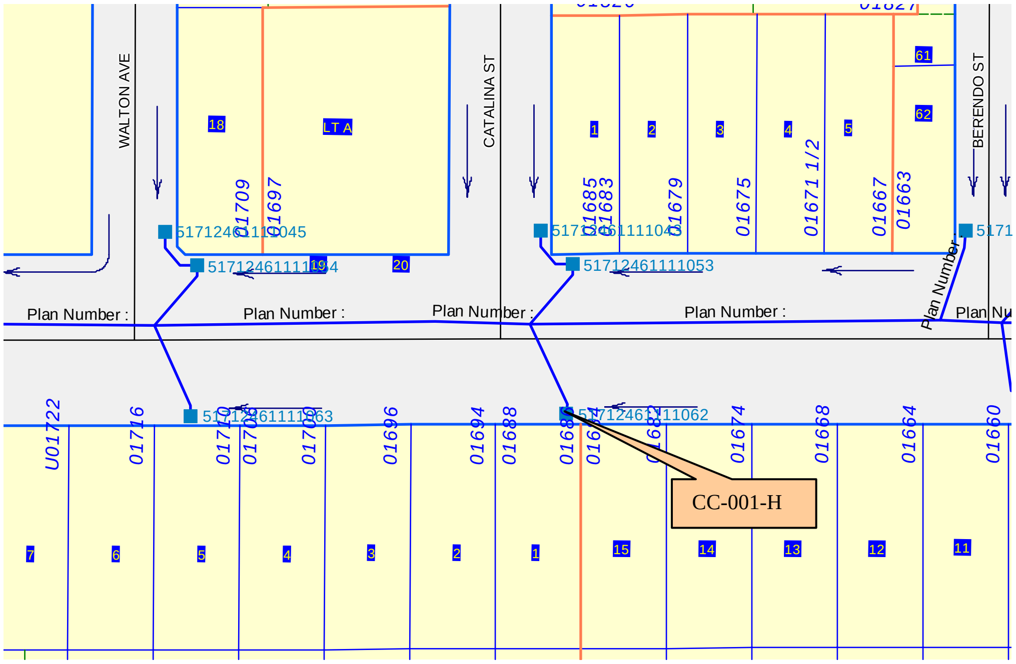


Figure 4-13: Map showing the location of CC-001-H site installed with a Hydro-Kleen insert.

Figure 4-14. Aerial photo of site CC-001-H. (Source: http://terraserver.microsoft.com).

Figure 4-15. CC-001-H Site Photos Upstream (left) and Downstream (right).

The initial site survey before the installation of the Hydro-Kleen insert occurred on 12/11/03. Examination of the site showed evidence of high trash loadings and a missing catch basin lid (Figure 4-16a). The first inspection after installation of the insert occurred on 02-27-04. Although there was evidence of bypass (Figure 4-16b), the insert appeared to be in good working condition even after a few storms, including an event greater than 2 inches. The missing concrete cover had been replaced prior to the installation of the insert. During the second inspection, it was noticed that the insert was capturing significant amounts of trash (Figure 4-16c). The third inspection was completed after another few months (06-30-04) and although the insert has captured more trash than the last visit it still appeared to be in good working condition (Figure 4-16d). The final inspection was conducted approximately three months later (10-22-04) and the insert had reached its volumetric capacity. There was a significant amount of oily sediment and debris on the curb indicating blockage of the insert. The insert was retired and the captured contents were collected for laboratory analysis (Figure 4-16e and Figure 4-16f).

Figure 4-16. Field inspection photos showing the condition of Hydro-Kleen at the intersection of Washington and Walton.

4.1.5 Summary of Field Inspections

The field inspections revealed that nearly all of the inserts were quickly overwhelmed with trash after just a couple months and a few inches of rain (3-4 storms). Observations of material hanging over the edge of the inserts and silt build-up on the outside of several of the inserts indicated that flow bypass was common. While these devices are designed to bypass to ensure the road does not flood during large runoff events, bypass was observed at several of the sites during an average size storm event (~0.75 inches). Bypass occurred due to low flow capacity (presumably due to clogging), as well as improper installation. For example, Figure 4-17 shows a HydroKleen insert bypassing a significant proportion of the inflow during this April 4th, 2004 site visit after only one month in the field. Figure 4-18 shows an improperly installed FloGard that created a lip near the inlet that caused the flow to bypass the insert. In contrast, Figure 4-19 shows two properly installed inserts near capacity, but processing the flow.

Figure 4-17. Relatively low-intensity storm showing bypass (FL-006-H, 2/4/04).

Figure 4-18. Improper installation of insert that caused bypass (CC-003-F, 2/4/04).

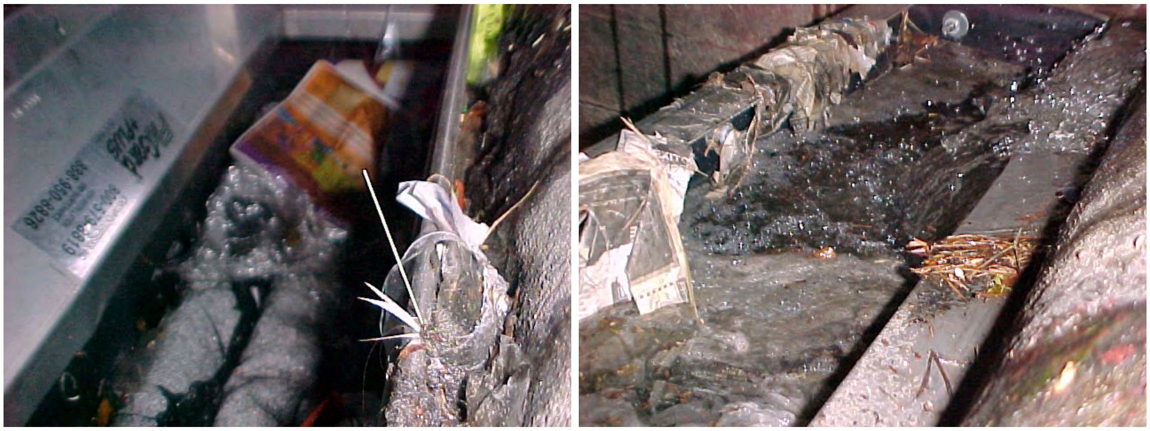


Figure 4-19. Two inserts operating properly during the 2/4/04 event: CC007-F (left) and CC009-D (right).

Two of the sites had screens installed at the curb inlet (FL003-F and CC004-H) as shown in Figure 4-20. These curb inlet screens blocked much of the trash and debris from entering the curb inlet. Consequently, the inserts installed at these locations appeared to show significantly less trash and debris accumulation. While no data yet to support, it is presumed that these simple inlet screens can improve long-term oil retention of any catch basin insert type by reducing the tendency for blinding the absorbent media.

Figure 4-20. Curb inlet screens installed at two sites: FL003-F (left) and CC004-H (right).

In summary, DrainPac appeared to have the largest capacity for trash and debris and was still able to process high flows. HydroKleen, which appears to have the most effective filtration system, has limited trash holding capacity and tends to bypass at relatively low flows (this is investigated further in the laboratory tests in the preceding section). The absorbent materials in both the Curb Inlet and the FloGard inserts were frequently observed to be missing, damaged, or hanging on the outside of the insert. Also, the "sausage" style absorbents in these two devices are such that not all of the flow through the insert will necessarily contact the media, which inevitably affects the absorbent effectiveness of these insert filters.

4.2 LABORATORY TESTS

As mentioned above, the laboratory tests consisted of two categories of tests: new filter tests and used filter tests. The used filter tests occurred after new inserts were conditioned in the field for approximately 4 months after installation in November 2004. The following paragraphs provide details of the testing procedures followed by the results of each test.

4.2.1 TESTING OF NEW FILTERS

Three tests were performed on new filters of each insert type: 1) spill tests, 2) particle capture tests and 3) oil and grease removal tests. All of these tests were conducted using the insert testing apparatus operating at a design flow rate of 20-25 gallons per minute.

4.2.1.1 Spill Tests

This test is designed to assess the ability of a catch basin insert device to capture a gross oil spill. This might occur if a person were to dump oil directly into the catch basin. Evidence of this activity has been observed over the years at many inlet/catch basins and educational activities such as stenciling storm drains have been practiced to teach the public that this is an unacceptable behavior.

In order to simulate a gross dump, 1 liter (~ 1 quart) of used motor oil was poured into each catch basin insert tested. The used motor oil was obtained from two sources and the entire volume was mixed to create a common source of used motor oil for all the tests used in the project.

The inserts were equipped with new media for these tests. Each insert was suspended on two saw horses above an oval shaped, galvanized tub. One liter of used motor oil was poured into the front of the insert and allowed to drip down the front of and then into the insert. The tests were performed at room temperature (18 to 21 ^{o}C) and the pouring was timed and completed over 2 minutes. Figure 4-21 illustrates the laboratory testing procedure for the spill tests.

For all tests on all of the insert types, the oil flowed through the insert and was seen exiting the bottom within 10 seconds of entering the top. The oil was allowed to drip from the insert into the tub. Dripping continued for approximately 10 minutes at which time no new drops formed. The tub was then emptied and the contents were measured. The recovered volume was compared to the original 1 liter and the amount of retained oil was recorded (Table 4-1).

The oil and insert were allowed to dry for two weeks in the laboratory at room temperature. This simulated drying in the field that might occur between an illegal dump and the following rainfall. The inserts were then placed in the catch basin insert flow testing apparatus and tested to determine how much oil would wash out of the inserts during a storm event. The flume was operated at approximately 25 gallon per minute (equivalent to about 0.1 inch/hour storm over a catchment that is about 50 percent impervious) and the entire flow was directed through the insert. Samples were collected for oil and grease analysis by collecting grab samples as the water exited the bottom of the insert.

Six grab samples were collected over 90 minutes. The first grab sample was collected as soon as water exited the bottom of the insert. Samples were analyzed for oil and grease using as solid phase extraction (SPE) procedure (see Appendix C).

Table 4-1. Volume of oil retained within each new insert.

Catch Basin Insert	Volume Retained (ml)
Kristar FloGard	120
Curb Inlet Basket	640
DrainPac	290
HydroKleen	980

Laboratory set up for testing oil spill capture efficiency

1-L of used motor oil

Pouring oil on HydroKleen

Pouring oil on Curb Inlet sorber

Figure 4-21: Laboratory set up for the evaluation of spill control by catch basin inserts.

The ability of each device to retain oil will depend upon the way the oil enters the front. Only the HydroKleen and DrainPac devices ensure that all the oil will be contacted by the oil absorber. However, the DrainPac has sorption surfaces on the bottom but there is too little sorbent to retain a full liter of used motor oil. The FloGard will have variable results depending on the positions of the oil sorber "sausages" and if they touch the oil and grease flow. The Curb Inlet device has good contact with the oil if the sorber is tightly attached to the leading edge. If the sorber is loose, oil could flow underneath it. Many of the Curb Inlet and FloGard inserts were observed to have loose, damaged, or missing sorbers after the first storm in the field.

Figure 4-22 show the oil and grease concentrations versus time from the flume test. The inserts were not effective in retaining the oil. The bulk of the oil flowed out in the first minute of operating. The first grab sample captured higher oil and grease concentration, but was not effective in capturing a representative sample. The oil was seen to flow out as immiscible packets of oil that did not mix with the water. After the test was complete, the sorbers in the inserts were physically examined. Oil could still be observed on the sorbers as dark spots, shinny areas and areas that felt "slick," but the bulk of the previously retained oil had washed away. The HydroKleen device could not be successfully operated at 25 gallons per minute. Flow was reduced to less than 15 gallons per minute to avoid bypassing.

The catch basin inserts, as configured are not effective in trapping at 1 liter oil spill. They initially retained 30 to 85% but released the oil when water was passed through at rates from 15 to 25 gallons per minute.

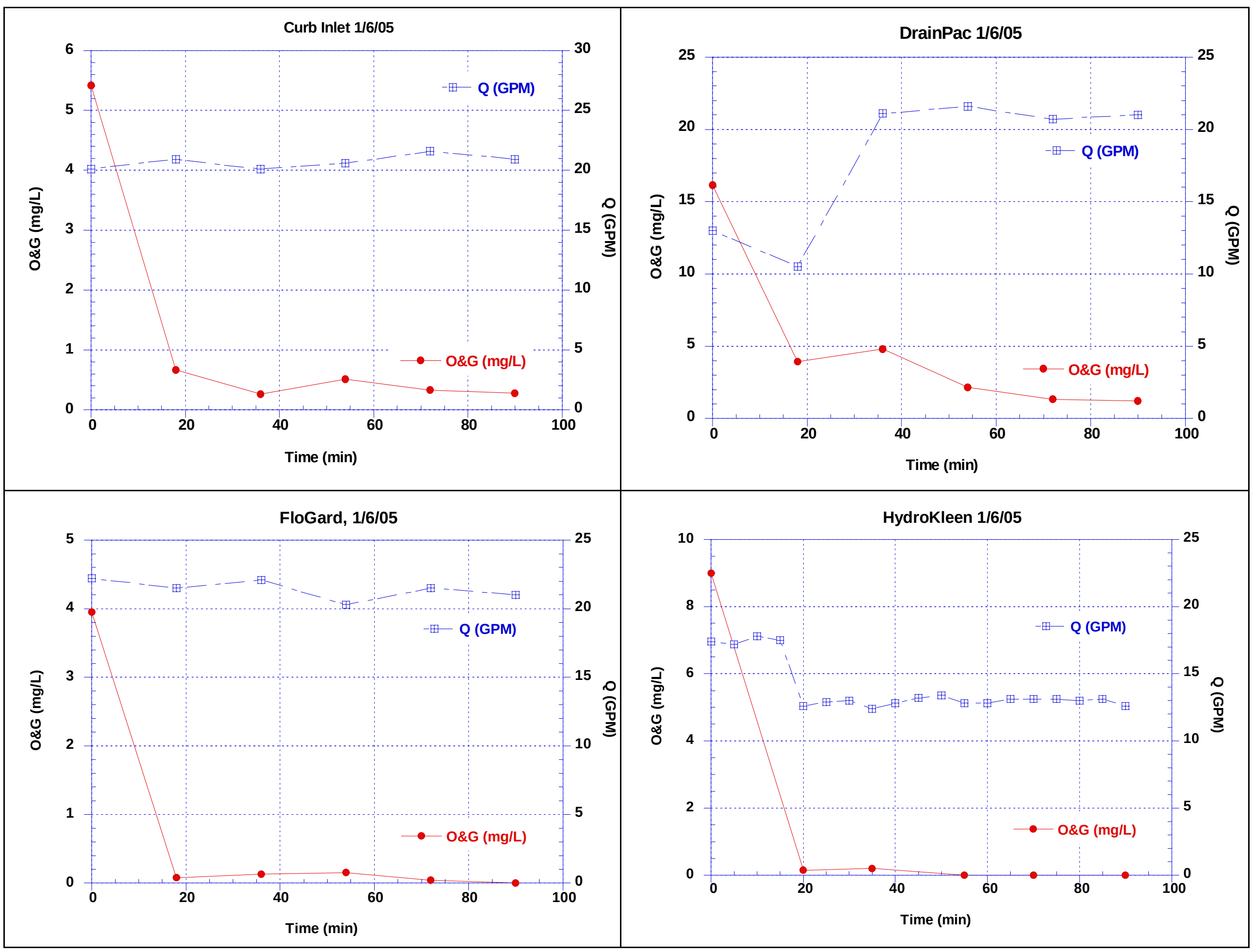


Figure 4-22 Oil & grease wash-out concentration versus time.

4.2.1.2 Particle Capture Tests

The purpose of the particle capture tests was to evaluate the sediment removal performance of the four insert types at removing various particle sizes. Four different particle sizes were used as shown in Table 4-2. To reduce the possibility particle size changing due to abrasion and to minimize oil sediment absorption, glass beads were used to simulate particulate solids. The glass beads were obtained from McMaster Carr in Los Angeles, CA in the four size fractions illustrated in Figure 4-23 and then sieved into the sizes shown in Table 4-2.

Table 4-2. Sieve sizes and corresponding grain sizes used in the particle capture tests.

Sieve Size	Grain Size
> #60	>250µm
> #100	>150µm
> #200	>75µm
Pan	<75µm

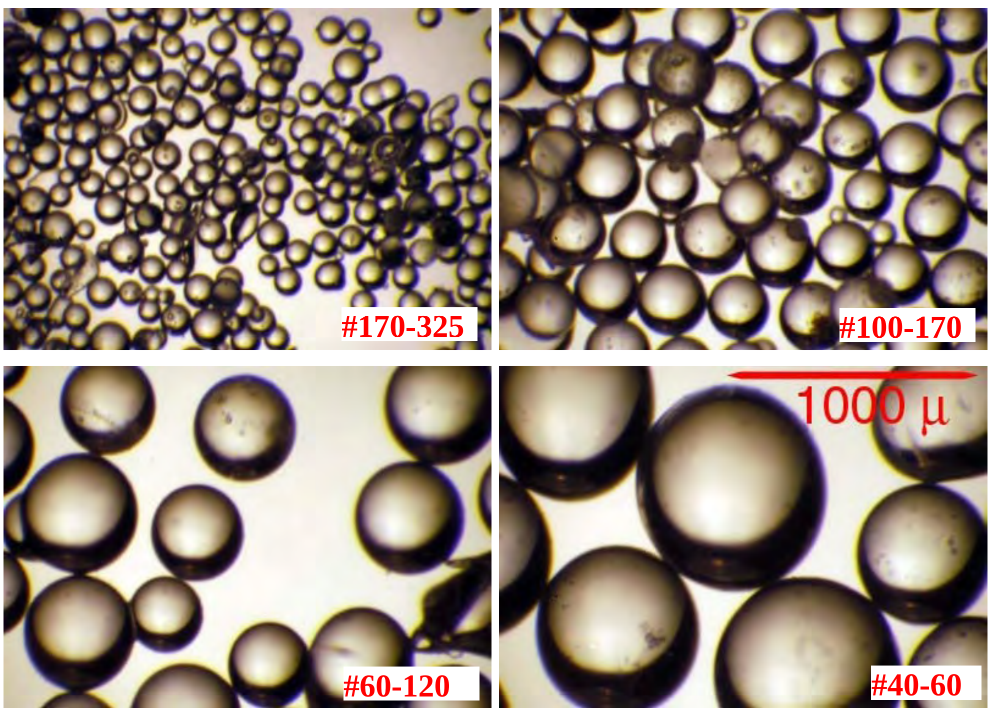


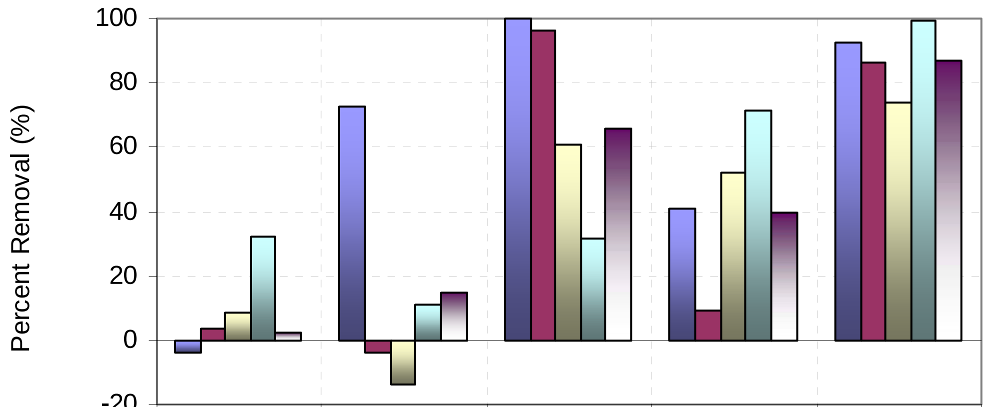
Figure 4-23. Glass blasting beads used for particulate solids removal tests.

Using the catch basin insert testing apparatus at a design flow rate between 20 and 25 gallons per minute, each insert type was tested to determine its particle capture efficiency. A known mass of particles from each size range was delivered to the influent stream. After flowing through the insert, the effluent was passed through a silk screen to capture all unfiltered particles. Table 4-3 shows the influent and effluent mass in each particle size range for each insert tested. A control test was conducted to evaluate the loss of particles in the system with no insert installed. Notice that significant losses were observed for the smallest particle sizes, and these occurred via splashing as the flow tumbles down the edge of the catch basin. They are shown as "removal" for the control. Losses occurred by the control was subtracted out of the device tests to account for splash losses. The precision of the tests is probably in the range of +/- 5 to 10%. The "negative" removals shown by the FloGard are within this precision.

Table 4-3. New filter effluent sediment loading by particle size.

Particle Size	Influent (grams)	Effluent (grams)				
		Control	FloGard	DrainPac	Curb Inlet	HydroKleen
>250 µm	266	276	72	0	151	19
150-250 µm	289	279	300	11	272	42
75 - 150 µm	309	283	352	130	160	88
<75 µm	269	182	240	244	102	2
Total	1134	1020	964	386	684	151

The percent removal for each insert type is shown in Figure 4-24. Notice that HydroKleen had the highest removals for most of the particle sizes. However, this insert could not be operated at the 25 gpm design flow rate without bypassing, so the test was conducted at 10 gpm. DrainPac had the next highest removals and was operated at the 25 gpm design flow rate. Curiously, the Curb Inlet Basket removed the smallest particle sizes better than the larger particles, but this is likely due primarily to losses in the testing apparatus since the control test showed about 32 % removal of particles less than 75 microns. FloGard appears to be moderately effective at removing particles greater than 250 microns, but ineffective at smaller sizes.



	Control	FloGard	Drain Pak	Curb Inlet	HydroKleen
>250µm	-3.7	72.7	100.0	41.2	92.5
150-250µm	3.4	-3.5	96.3	9.0	86.0
75-150µm	8.4	-13.7	61.1	52.4	73.7
<75µm	32.5	10.9	31.6	71.5	99.5
Total	2.4	15.0	66.0	39.7	86.7

Figure 4-24. New filter percent sediment mass removal by particle size.

It is important to understand the mechanism of particle removal. The DrainPac and FloGard devices acted as sieves and retained particles at the bottom of the device, and the entire volume of the device is available for particle retention. The Curb Inlet device retained the fine particles in the oil absorbent sausage. It has a screen in the bottom, but this screen is coarser than most of the particles used during the testing. The mass of particles that can be retained in the sausage is low, compared to the volume for particle retention in the DrainPac or FloGard devices. The particles in the sausage are not tightly retained and can be lost into the effluent if the sausage is flexed or moved about. In this regard, the solids removal test for the Curb Inlet device is not as realistic of a test as it is for the other inserts. The solids retained by the HydroKleen are removed by sedimentation in the first compartment. At high flow rate, the turbulence in this compartment was sufficient to resuspend the fine fraction so that it was discharged in the effluent.

A realistic appraisal of the test results suggests that particles removed by DrainPac and FloGard through sieving will be reliably retained. Particles retained by lodging in the sorbers or removed by sedimentation may be lost or resuspended during high flows and/or if the insert is physically moved or disturbed.

4.2.1.3 Oil & Grease Removal Efficiency

The effectiveness of each new insert at removing oil and grease from stormwater was evaluated by delivering a steady stream of used motor oil into the flume operating at 25 GPM and taking influent and effluent samples every 6 minutes for one hour. The influent samples were composited at the end of the experiment because these concentrations were not expected to vary substantially, but the effluent samples were analyzed independently to capture the variability in effluent quality. Table 4-4 shows the oil and grease influent and effluent concentrations for each insert type. Notice that HydroKleen shows the lowest oil and grease effluent concentrations, followed by DrainPac and Curb Inlet Basket, which were comparable. FloGard showed the highest effluent concentrations, but this device also received the highest influent concentration. To evaluate the performance in terms of percent removals, Figure 4-25 shows side-by-side box and whisker plots of the oil and grease reduction percentages. Notice that the 95% confidence intervals of the median percent removal for several of the inserts overlap indicating that the differences in performance are not statistically significant. FloGard does appear to have a lower performance than Curb Inlet and HydroKleen, but is not statistically different from DrainPac.

Table 4-4. New filter oil and grease effluent concentrations versus time.

	DrainPac	FloGard	Curb Inlet	HydroKleen
Influent (mg/L)	**26.3**	**33.5**	**30.1**	**19.5**
Time (min)	Effluent (mg/L)	Effluent (mg/L)	Effluent (mg/L)	Effluent (mg/L)
6	7.3	13.7	12.2	5.4
12	12.0	23.4	11.4	4.7
18	12.8	22.1	13.5	9.1
24	10.0	19.4	13.9	5.1
30	11.0	23.9	12.7	3.3
36	13.9	15.4	8.8	11.8
42	10.3	16.1	10.1	4.5
48	11.2	19.7	11.1	6.8
54	18.8	16.6	9.9	2.4

60	21.1	17.4	12.9	7.5
Median	**11.6**	**18.4**	**11.8**	**5.3**

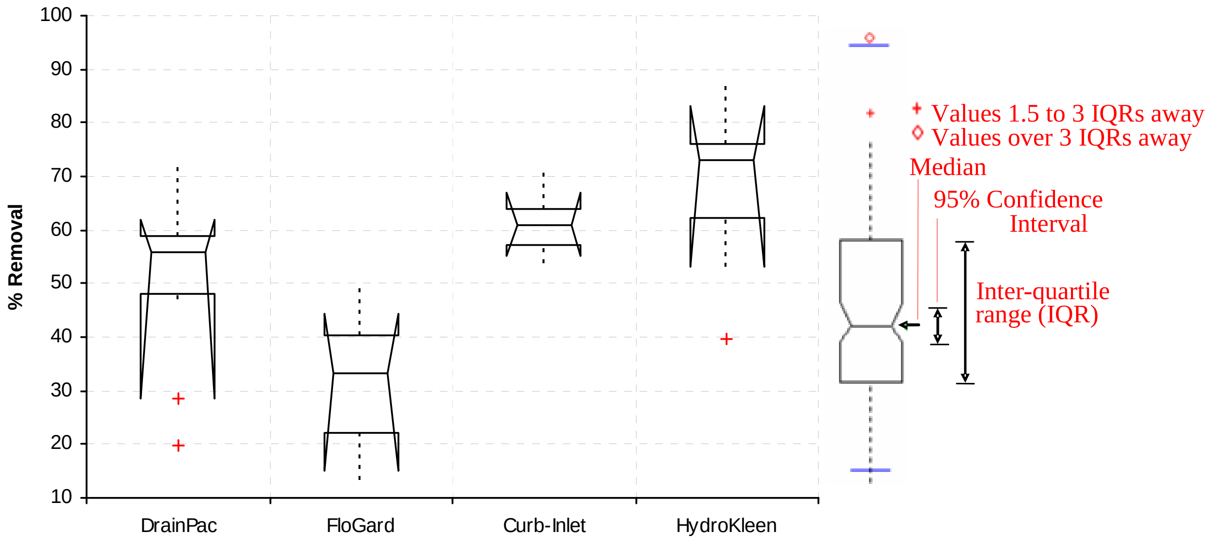


Figure 4-25. Box and whisker plots of oil and grease removal tests with new inserts.

The stock oil solution was analyzed for metals concentration to estimate the potential removals of metals if oil and grease were removed. Table 4-5 provides the metals concentrations in the oil stock solution and the calculated effluent metals concentrations based on the median oil and grease concentrations for each insert. Notice that the effluent metals concentrations are all extremely low; below most analytical method detection limits, with the possible exception of zinc.

Table 4-5. Metals concentrations in oil and the calculated metals removals for each insert type.

Metals	Conc. in Used Motor Oil	Calculated Metals Effluent Concentrations			
		DrainPac	FloGard	Curb Inlet	HydroKleen
	ug/g	ug/L	ug/L	ug/L	ug/L
Cr	0.53	0.006	0.010	0.006	0.003
Ni	1.72	0.020	0.032	0.020	0.009
Cu	21.16	0.245	0.390	0.250	0.112
Zn	501.83	5.821	9.249	5.922	2.645
As	0.03	0.000	0.001	0.000	0.000
Cd	0.04	0.001	0.001	0.001	0.000
Pb	3.36	0.039	0.062	0.040	0.018

4.2.2 TESTING AND ANALYSIS OF USED FILTERS

The used inserts were retrieved from the field and taken to the laboratory for final testing and analysis. The bulk solids captured by the CPC and FL inserts during the cumulative pollutant capture part of the study period was characterized by size and weight. Four tests were performed on the FL inserts after the field-to-laboratory portion of study, including flow rate tests, solids removal tests, oil and grease removal tests, and used oil spill tests. The following subsections describe the results of these tests and analyses.

4.2.2.1 Captured Bulk Solids Analysis

After the cumulative pollutant capture period of the study, material recovered from the inserts was characterized. The materials captured by all four types of inserts (Catch Basin Inlet, DrainPac, FloGard, and HydroKleen) at various sites were returned to the UCLA campus for analysis. Consisting of primarily coarse sediment, leaves, debris, and litter, the material captured by each insert was weighed wet and then a representative volume of the material was sampled, air dried, sieved into two size fractions using a 1-inch screen, and then weighed. Figure 4-26 includes photographs illustrating this solids analysis procedure.

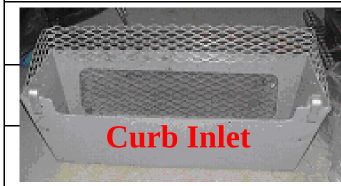
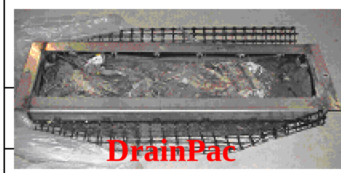
Figure 4-26. Photos of bulk solids screening process.

Table 4-6 summarizes the screening results for the CPC inserts and Table 4-7 summarizes the screening results for the FL inserts. Notice that the majority of the material mass was generally smaller than 1-inch. This result supports visual observations that much of the captured material appeared to consist of coarse sediment, degraded trash, and composted debris. Hence, the duration that material is left in an insert appears to have an affect on the particle size distribution of the captured bulk solids. Lead tire weights, cell phones, batteries and other potentially hazardous materials were also found in the retained material. Given the state of decay of the material, all the interesting spiders, worms and insects, and the fact that potentially hazardous material were accumulating in the inserts, it is concluded that if the inserts are allowed to stay in the field too long, they could likely become a nuisance and a potential public health hazard.

Table 4-6. Accumulated bulk solids screening analysis for CPC inserts.

Catch Basin No.	Total Sample Weight (kg)	Representative Sample Weight (kg)	Representative Sample Volume (L)	Date & Order	After Drying (kg)		Date & Order	% Solids
					1" Sieving	Passed		
CC-008-C	6.2	6.1	8.0	11/15_1	0.9	1.3	11/17_2	35.2
CC-007-C	8.0	7.8	12.0	11/15_2	0.8	3.9	11/17_1	60.3
CC-014-C	28.2	11.3	16.0	11/12_6	0.8	5.3	11/15_2	54.0
CC-014-C2	22.2	8.5	16.0	11/10_4	1.7	4.6	11/12_2	72.9
CC-004-C	17.0	11.8	16.0	11/10_8	1.1	7.8	11/12_4	75.0
CC-002-C	14.3	10.3	16.0	11/10_1	0.9	4.5	11/12_7	51.9
CC-009-D	19.8	13.4	16.0	11/12_5	1.1	7.5	11/15_1	64.2
CC-010-D	37.3	9.7	16.0	11/10_7	4.1	4.0	11/12_1	83.5
CC-009-F	28.4	13.3	16.0	11/12_2	0.3	6.8	11/15_6	53.4
CC-007-F	22.8	4.7	16.0	11/12_4	1.2	1.3	11/15_4	53.2
CC-013-F	29.9	6.2	16.0	11/10_6	1.6	2.9	11/12_3	71.8
CC-003-F	49.5	12.0	16.0	11/10_3	1.8	5.4	11/12_5	59.6
CC-011-F	86.0	30.5	32.0	11/10_2	2.3	23.6	11/12_6	84.6
CC-004-F	55.0	9.9	16.0	11/12_1	0.5	5.3	11/15_7	58.9
CC-003-H	14.8	11.9	16.0	11/8_1	2.3	5.1	11/10_1	62.2
CC-001-H	12.3	9.1	13.0	11/12_3	1.7	3.1	11/15_5	53.0
CC-003-H2	15.4	13.7	16.0	11/10_5	1.2	4.3	11/15_3	40.1

Table 4-7. Accumulated bulk solids screening analysis for FL inserts.

Insert Type	Catch Basin No.	Total Sample Weight (kg)	Total Sample Volume (L)	Date & Order	Sieving (kg)	
					#1 Sieving	Passed
	FL-004-C	0.35	4.0	11/19_1	0.15	0.20
	FL-003-C	0.60	6.0	11/19_2	0.15	0.45
	FL-001-C	2.70	4.0	11/19_3	0.25	2.45
	FL-008-D	0.90	4.0	11/19_5	0.15	0.75
	FL-003-D	1.20	5.0	11/19_6	0.25	0.95
	FL-001-D	1.30	1.5	11/19_7	0.15	1.15
	FL-003-F	3.35	8.0	11/19_8	0.20	3.15
	FL-001-F	5.25	8.0	11/19_9	1.05	4.20
	FL-004-F	0.25	1.0	11/19_10	0.05	0.20
	FL-006-H	1.10	3.0	11/19_4	0.10	1.00
	FL-008-H	0.25	0.5	11/19_11	0.05	0.20
	FL-002-H	0.25	0.2	11/19_12	0.00	0.25

4.2.2.2 Flow Rate Tests

A problem reported with catch basin inserts in the past has been clogging and bypassing. This is to be expected since the fine screens or meshes in some of the devices can be overwhelmed, or "blinded" by debris, as well clogged by sediment. The volume of the insert can also fill with litter and trash so that there is little room for stormwater to accumulate to create sufficient pressure to flow through the screen. During this study, the captured material caused both blinding due to large items, such as plastic bags and newspaper, and clogging due to sediment. The sediment coats the screens at the bottom of the insert and appears as a moist mud layer when the insert is wet. After the insert dries out, the mud layer forms a largely impermeable barrier. Barriers such as this were noted in many of the used inserts. In the case of the HydroKleen, barriers were formed in the top of the second compartment, which prevented stormwater from passing through the sorbent pillows.

In order to evaluate clogging of the used inserts, a flow test was performed. The insert was subjected to low flow at first and the water level in the insert was allowed to stabilize. The depth of water in the insert was then measured. Next the flow was increased and the depth was remeasured. This process was continued until the maximum capacity of the flume was reached (60 GPM), or the insert bypassed. Figure 4-27 shows the results of several tests where the maximum flow rate achieved without bypass shown at the endpoint. (Note as mentioned above three inserts were replaced by the City of L.A. and were not available to test). All but two inserts bypassed at less than 60 GPM flow (equivalent of about 0.2 inches per hour over a catchment with 70% imperviousness). Both of the FloGards (FL001-F, FL003-F) passed more than 50 GPM before bypassing. One DrainPac (FL001-D) did not bypass at 60 GPM and the other (FL008-D) bypassed at 50 GPM. Three Curb Inlet Basket devices were tested. One bypassed at 20 GPM, another (FL003-C) at 50 GPM (FL001-C), and the final device (FL004-C) did not bypass. The oil sorbent sausage was missing from this particular insert; it was somehow lost during operation in the field or perhaps cleaned out by City maintenance personnel not familiar with project. The HydroKleen devices bypassed at 12 GPM (FL008-H) and 40 GPM (FL001-H).

It was noticed during the suspended solids testing (next subsection) that the hydraulic capacity was further reduced by the accumulation of glass beads.

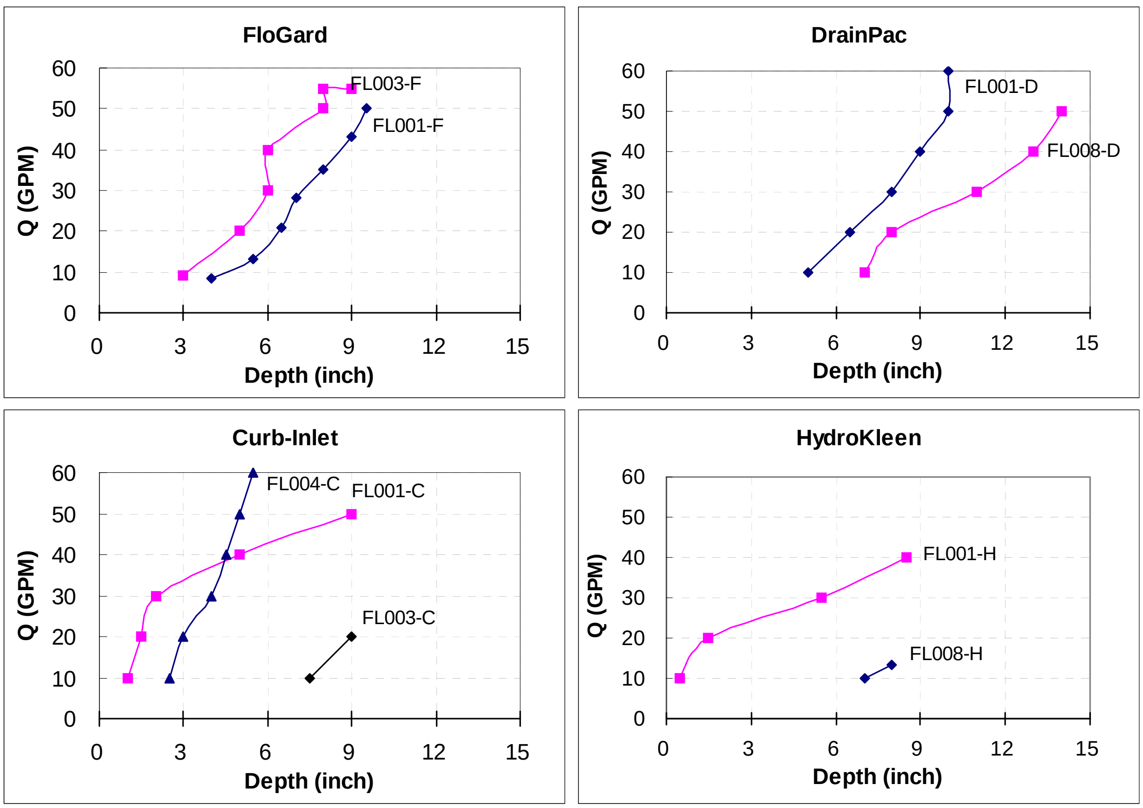


Figure 4-27. Used catch basin insert flow rate tests.

During the flow rate tests sediment particles that washed out of the used inserts were captured and sieved to evaluate the mass of retained particles released during a runoff event. Table 4-8 shows the mass of particles within each size range that were washed out from each insert. Notice that DrainPac and Curb Inlet tended to release the largest amount of particles. However, since the mass particles retained prior to the washout test was not known these results are only useful for a qualitative assessment of the ability of the insert to retain particles.

Table 4-8. Washout of particles from used inserts during the flow rate tests.

Particle Size (microns)	FloGard		DrainPac		Curb Inlet			HydroKleen	
	FL001-F	FL003-F	FL001-D	FL008-D	FL003-C	FL001-C	FL004-C	FL008-H	FL001-H
> 400	9.51 g	3.92 g	5.31 g	44.80 g	10.07 g	5.70 g	8.70 g	8.00 g	0.00 g
250-400	2.10 g	1.83 g	2.43 g	18.70 g	7.98 g	3.59 g	11.03 g	5.67 g	3.50 g
150-25-	2.07 g	1.92 g	1.80 g	18.70 g	6.66 g	2.43 g	12.80 g	4.40 g	0.00 g
75-150	2.58 g	2.55 g	2.76 g	10.32 g	6.40 g	2.62 g	18.20 g	3.42 g	0.00 g
< 75	2.05 g	1.33 g	0.16 g	3.50 g	0.00 g	1.06 g	0.00 g	0.00 g	0.00 g
Total	**18.31 g**	**11.55 g**	**12.46 g**	**96.02 g**	**31.11 g**	**15.40 g**	**50.73 g**	**21.49 g**	**3.50 g**

4.2.2.3 Solids Removal Tests

Suspended solids testing were performed on used inserts in the same manner as the new inserts. Figure 4-28 shows the removal efficiencies of the inserts recovered from the field. The removal rates were better than observed with new inserts likely due to the retained material retained in the filters from the field. This retained material acts as a pre-coat or dynamic membrane and improves removal efficiency at the expense of reduced flow capacity and increased bypass, as noted in the previous section. This improved performance/decreased capacity relationship is shown in Figure 4-28 for the Curb Inlet insert FL003-C and HydroKleen insert FL008-H, where the flow rate was reduced to 5 GPM to avoid bypass. Comparing only the inserts that were successfully tested at 25 GPM, FloGard and DrainPac appear to have the highest removals for the full range of particle sizes. However as mentioned previously for the new filter particulate capture tests, small particles are easily lost in the testing apparatus, so the results for these smaller particles likely over-predict the actual removals.

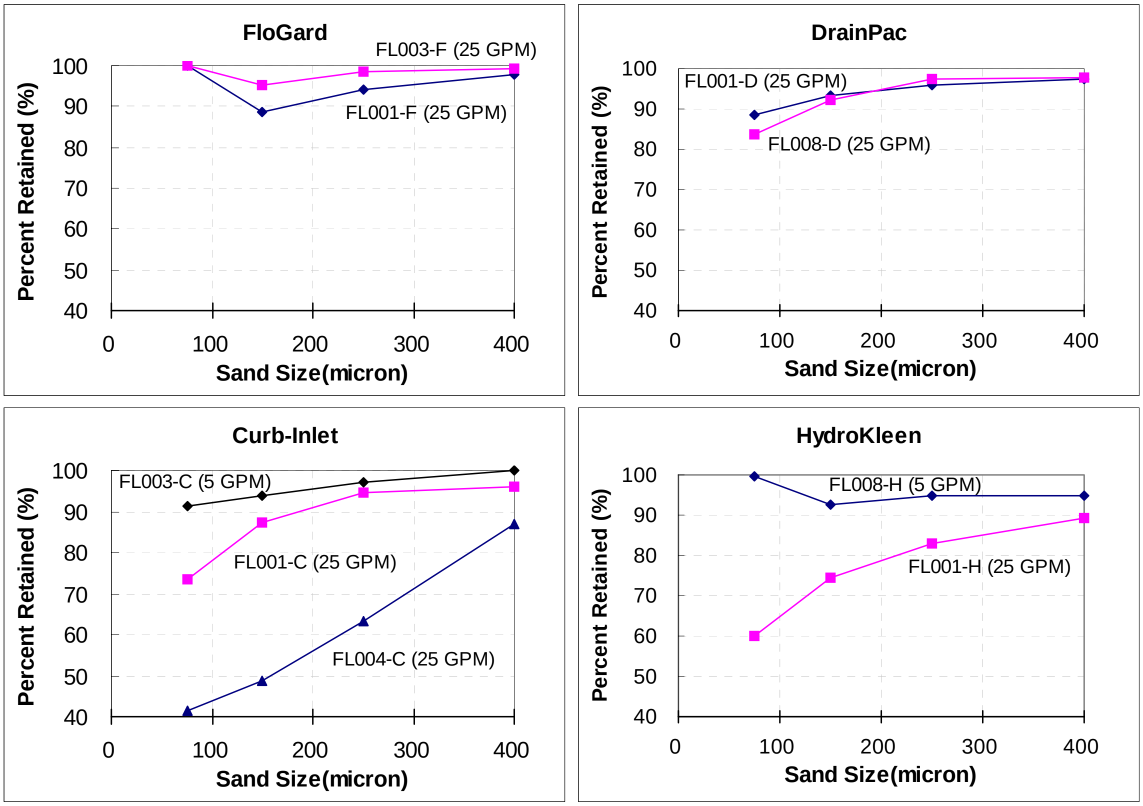


Figure 4-28. Used insert particulate solids removal test.

4.2.2.4 Oil & Grease Removal Tests

The tests were performed in the same way as the tests on the new inserts, except that the maximum flow rate without bypassing was used. Flume testing for oil and grease removal is limited to about 10 GPM minimum due to the oil addition pumps. Below 10 GPM, it is not possible to added motor oil at a low enough flow rate to produce 10 to 25 mg/L concentration range that was desired for the test. Testing at higher oil and grease concentrations would not be representative of the performance at lower concentrations. Consequently, only 6 of the 9 inserts recovered from the FL sites had acceptable flow rates for this test based upon the above testing (see Section 4.2.2.2). (Recall that 3 of the original 12 FL inserts had been removed by the City and were unavailable for the FL tests). Only one of the HydroKleen (FL008-H) units was tested at 10 GPM. The other units (one DrainPac, one Curb Inlet, and one HydroKleen) were not tested because the flow rates were too low.

Table 4-9 shows the oil and grease effluent concentrations for each 6 minute sample collected during the 1-hour test. All inserts were tested at 25 GPM except for HydroKleen, as discussed above, was tested at 10 GPM. As with the test while new, this insert had the lowest overall effluent quality. For the inserts tested at 25 GPM, DrainPac showed the lowest median effluent quality followed by FloGard. Curb Inlet had the highest median effluent quality.

Table 4-9. Used filter oil and grease effluent concentrations versus time.

	DrainPac	FloGard	FloGard	Curb Inlet	Curb Inlet	HydroKleen*
	FL003-D	FL003-F	FL001-F	FL004-C	FL001-C	FL008-H
Influent (mg/L)	**16.33**	**20.72**	**27.65**	**23.91**	**26.43**	**22.25**
Time (min)	Effluent (mg/L)	Effluent (mg/L)	Effluent (mg/L)	Effluent (mg/L)	Effluent (mg/L)	Effluent (mg/L)
6	3.74	5.94	8.7	15.54	23.72	1.02
12	3.12	7.4	9.52	17.36	18.84	1.46
18	4.52	7.72	14.08	14.12	14.84	3.04
24	9.4	7.02	15.86	14.7	25.66	3.68
30	6.66	6.88	10.2	21.66	24.9	6.2
36	8.52	7	6.46	18.36	16.34	5.28
42	7.68	6.6	13.44	15.04	13.94	6.74
48	5.48	8.6	12.78	16.1	19.82	9.38
54	7.02	8.96	9.78	16.92	13.34	7.06
60	4.32	9.92	7.5	12.04	14.3	5.98
Median	**6.1**	**7.2**	**10.0**	**15.8**	**17.6**	**5.6**

* Tested at 10 GPM.

To investigate whether the oil and grease removals are statistically different from one another, Figure 4-29 is a side-by-side box plot of the percent removals of the used inserts. Note that all inserts except for Curb Inlet have overlapping 95% confidence intervals about their median percent removals. The HydroKleen insert slightly outperforms FloGard insert FL003-F, but is not statistically different from FL001-F.

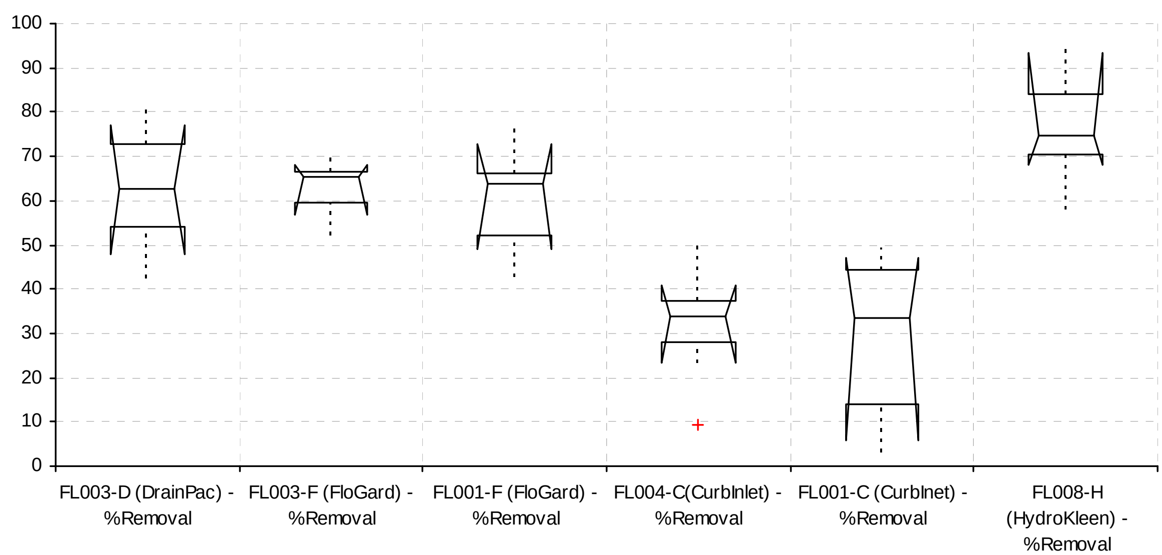


Figure 4-29. Box and whisker plots of oil and grease removal tests with used inserts.

Table 4-10 compares the median oil and grease effluent quality and percent removals for the new and used inserts. Note that the effluent quality is reduced for DrainPac and FloGard, but is slightly increased for Curb Inlet and HydroKleen. However, this difference is not significant due to the variability in the data. In general the removal efficiencies of the used inserts was greater than the new inserts because it is likely that the retained material from the field acts as a sorbent just as the captured material acted as a filter for the particulate solids removal test. However, the percent removals for Curb Inlet decreased. This reduction in performance for the Curb Inlet is likely due to loosely held absorbents after it has been used and is consistent with field observations that indicated the absorbent was easily disturbed causing limited contact with the inflow.

Table 4-10. Comparison of new and used insert oil & grease removal efficiency.

	Median Effluent Quality (mg/L)		Median Percent Removals (%)	
	New	Used	New	Used
DrainPac	11.6	6.1	56.0	62.8
FloGard	18.4	7.2 - 10	33.3	63.9 - 65.2
Curb Inlet	11.8	15.8 - 17.6	60.8	33.8 - 33.5
HydroKleen	5.3	5.6	72.9	74.7

4.2.2.5 Spill Tests on Used Inserts

After the completion of flow, suspended solids removal and oil and grease removal testing, a second series of spill tests was performed to assess how the oil retention capacity of the inserts are affected after they have been field conditioned. One liter of used motor oil was pored through each insert in the same way as performed on the new inserts (see Section 4.2.1.1). The only difference was the condition/age of the insert. In this case the inserts were used and contained removed solids from field testing as well as the glass beads from laboratory testing. The large litter had been removed prior to hydraulic testing. The volume of oil retained for a representative used insert of each type is shown in Table 4-11. For all inserts except the HydroKleen, more oil was retained by the used insert than the clean inserts. This likely is the results of the accumulation of solids and small liter retained in the insert act as sorbents. FloGard, which had the lowest retention capacity of all the inserts while new, showed the largest increase its oil retention capacity after it had been used. DrainPac had the highest retained percentage while used and HydroKleen had the highest retained percentage while new.

Table 4-11. Volume of oil retained within each used insert and the % increase compared to the new insert oil retention.

Catch Basin Insert	Volume Retained (ml)	% Increase from New
FloGard (FL003-F)	630	425%
Curb-Inlet (FL004-C)	460	59%
DrainPac (FL001-D)	730	152%
HydroKleen (FL008-H)	600	-39%

5 RESEARCH SYNOPSIS AND RECOMMENDATIONS

This research was performed to provide an independent performance assessment of storm drain inlet filter devices at removing oil and grease and bulk pollutants from stormwater in the City of Los Angeles. A review of literature found that several researchers have studied the pollutant removal effectiveness of catch basin inserts, but the large variety of devices, the different methods for evaluating performance, and the fact that the technology is continually evolving indicates that there are still data and knowledge gaps in this area of stormwater BMP research.

Four different catch basin insert technologies were selected for testing in this study: DrainPac, Curb Inlet Basket, FloGard, and HydroKleen. The selection was based on the number and quality of existing studies testing these devices, the budgetary and technical feasibility of testing them during the course of this study, and the perceived or advertised ability of these devices to remove and retain oil and grease from stormwater and illicit dumping activities. The performance of the selected inserts was subsequently evaluated in twenty-four CPC (cumulative pollutant capture) sites and twelve FL (field-to-laboratory) sites during the study period of 2003-2005. This was accomplished in two phases. In Phase I, the CPC sites were evaluated for long-term performance of the inserts through periodic field inspections and qualitative and quantitative assessment of accumulated pollutants during the wet and dry seasons. In Phase II, the FL site inserts were evaluated by conducting a series of laboratory tests before and after exposing them to field conditions. Significant conclusions derived from this study are provided below.

5.1 SUMMARY OF RESEARCH CONCLUSIONS

<u>Conclusions Related to Literature Review:</u>

- The limited available data on oil and grease removal indicates that catch basin inserts would provide some removal of oil and grease from stormwater.
- In general, some devices have been tested more thoroughly than others. However due to the variety of configurations and media types among the large number of competing products, it is difficult to comparatively assess their performance.
- Due to the inconsistencies in reporting performance monitoring data and the fact that percent removals (a misleading measure of BMP efficiency) are most often reported, it is not possible to determine the average achievable effluent oil and grease concentrations from catch basin inserts from the existing data.
- It "appears" that oil and grease can only be reduced to about 5-10 mg/L by catch basin inserts. However the available data are too limited to statistically support this assertion. Also, the ability of inserts to retain oil, once it has absorbed to the media has not been thoroughly investigated.

Conclusions Related to Field Inspections:

- In general, catch basin inserts are excellent litter removal devices, although they have limited capacity as compared to the inflow of litter observed.
- In higher litter producing areas in the City of Los Angeles, almost all of the inserts clogged or reached their trash loading capacity very early in the rainy season.
- All manner of litter was collected including paper, plastics, and coarse sediments as well as oil and grease.
- Litter collection interferes with the insert's other desired functions. Excessive accumulation of trash and debris and evidence of clogging at almost all sites would significantly affect oil & grease capture efficiency.
- DrainPac and FloGard have larger capacities and finer screens and therefore retained bulk solids most effectively. Efficient capture of bulk solids consequently helped continued oil capture up until the accumulated debris caused bypass.
- For FloGard, the presence of lip at the curb caused the insert to be bypassed at least on one site.
- Curb-Inlet Basket does not appear to remove sediment except for on the inlet shelf and the insert does not contain a filter fabric. The absorbent boom has low structural integrity because the media was observed to have been washed from the boom.
- HydroKleen, appeared to have the highest potential for removing oil and grease based on the laboratory testing (see below). However, by-passes at low flows and limited capacity for bulk solids (e.g., bulk solids and fine solids caused by-pass to occur quickly) are some of the observed problems for this insert and would limit its actual ability to be effective overall at oil and grease removal. Also, the settling chamber permanently retains water that can breed mosquitoes.

Conclusions Related to Laboratory Tests:

- Retention in the inserts of a gross spill of 1 liter of used motor oil ranged from 10 to 90%. However, most of the captured oil was lost during subsequent flow testing, and in the field, would surely have been lost during the next rain event.
- Apparently, accumulated litter and sediments may help capture of a gross spill of used motor oil up to the point where bypassing occurs.
- Most of the inserts were effectively able to remove particles larger than 250 μm. The DrainPac and FloGard inserts remove solids by sieving. The HydroKleen removes solids by sedimentation in the first compartment and then filtration in the second compartment. Curb Inlet removes small particulates in the absorbent boom and larger particles in mesh screen.
- Smaller particles were sometimes removed by entrapment in sorber "sausages" (Curb Inlet and FloGard) but it is unlikely that this mechanism would be quickly overwhelmed in the field due to the limited capacity for retaining sediments.
- Retention of particles also occurred via settling in the first chamber of the HydroKleen

unit and on the shelf of the Curb Inlet Basket. However, sediments captured by settling appear to be easily lost during high flows.

- Laboratory tests showed that significant "blinding" (e.g., clogging of flow paths) occurred with solids accumulation and resulted in overflow/bypass.
- Trade-offs exist between O&G removal capabilities and capture of litter and solids:
  - Inserts with lots of sorbent for O&G removal have little room for solids and litter and therefore blind more quickly.
  - Inserts with room for litter and solids have less room for sorbents and therefore are less effective for oil and grease removal.
  - Inserts to remove oil and grease in the presence of high loads of litter and solids may not be a good choice.
  - Inserts protected from litter, with devices such as coarse screens installed at the curb, could then be optimized for oil and grease removal by maximizing the volume of sorbents available.

5.2 CHALLENGES, LESSONS LEARNED, AND SUGGESTIONS FOR FUTURE RESEARCH

Some elements of the monitoring plan were modified during the course of the study due to circumstances beyond the research team's control that caused delays in getting project tasks completed. For instance, the catch basin insert testing apparatus at UCLA had to be relocated because of the demolition of a laboratory building, so laboratory testing was delayed. Also, the fire disaster that occurred in southern California during the summer of 2003 left a significant amount of ash covering the area and it was decided that the first events of the season would not likely represent typical conditions. Therefore the project team decided to install and begin conditioning the catch basin inserts during the middle of the wet season rather than at the beginning.

Other significant challenges faced during this study included the initial selection, installation, and tracking of installed inserts. Only approximate drainage areas for the catch basins could be estimated, as it was impossible to determine the rooftop contributing areas. Also, the variety of catch basin configurations (e.g. depth, width, manhole size and shape, etc.) made it difficult to find sites with similar characteristics and in close proximity to one another. Some of these characteristics made installation difficult for some of the inserts, even when detailed field measurements were made. For instance, the plastic lip on the HydroKleen insert had to be trimmed to fit into a couple of the catch basins.

The relative timing of the installations also limited the ability to compare sites. Since the vendors of each insert type installed the inserts, some inserts were installed several weeks after others were installed so the amount of field conditioning differed somewhat between sites. In fact, a couple of the inserts at CPC sites lagged so much that it was decided to switch previously designated FL sites to CPC sites (which were subsequently switched back to FL sites for the field-to-laboratory phase of the study). Choosing new sites or switching sites from CPC to FL was confusing and cumbersome with the original naming convention that was used. It is recommended that if a large number of catch basin sites are to be studied in the future that site is given a unique site number that is never reused as well as a study number that can be reused when a substitution is made.

Another lesson learned during this study is that it is important to ensure communication is established with the department responsible for maintenance of catch basins (Wastewater Collection Systems Division for the City of Los Angeles). It is clearly evident that the City's Watershed Protection Division, who was a participant in this project and was aware of the location of the study catch basin sites, did not notify the Wastewater Collection Systems Division of this study. While the loss of the four study inserts reduced the amount of data that was obtained from this study, it did not seem significantly change the overall conclusions of the study. However, if the City expects to further its goal of improving the quality of runoff from its storm drain system, it is absolutely vital that these two organizations establish more efficient communication channels.

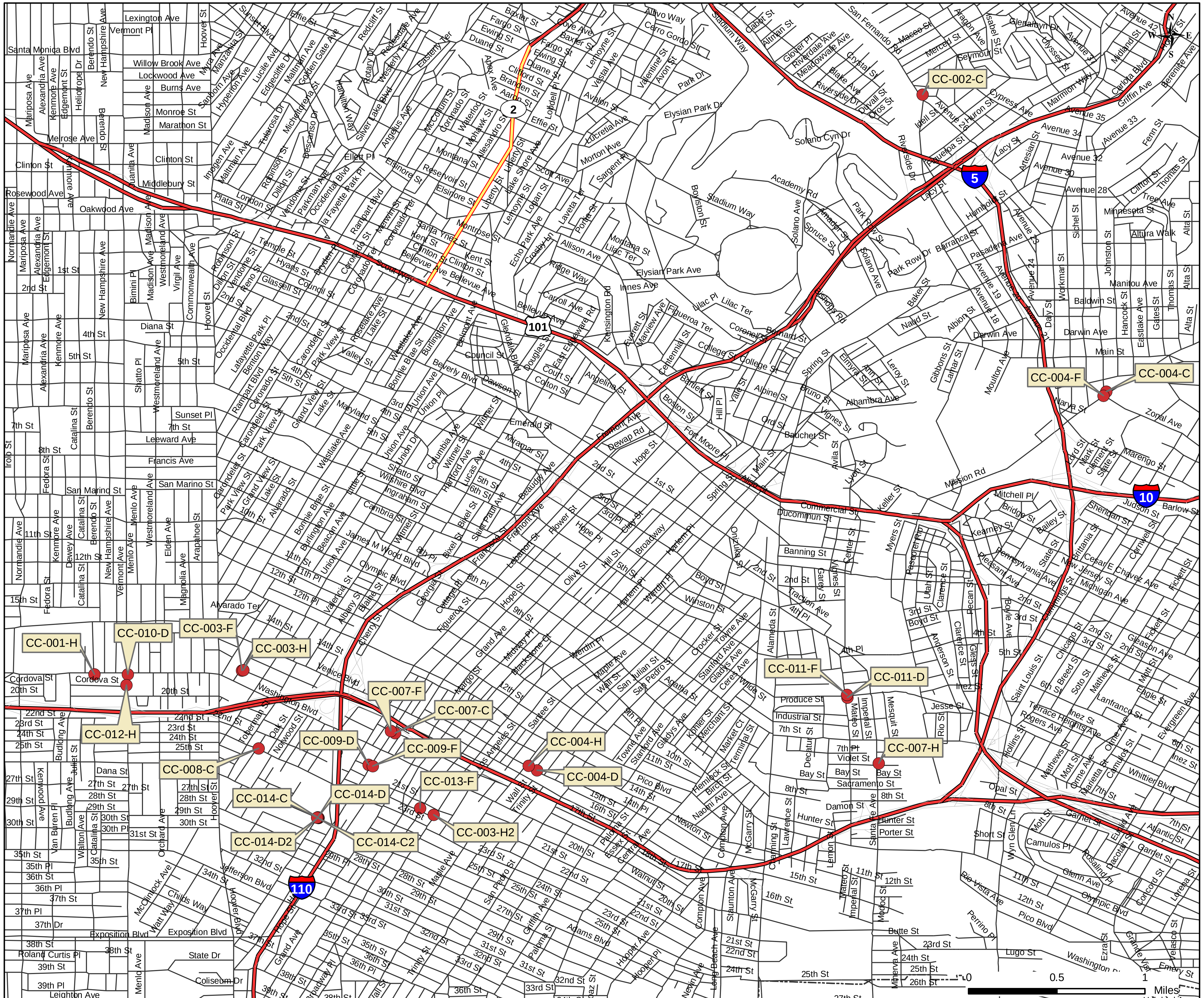
The litter generation rates at the locations of the inserts used in this study were several times and perhaps ten times greater than observed in the previous studies conducted by the investigators.[5,28] While the field observations indicate that oil generation, particularly from illicit dumping of used oil, was also particularly high in the study area, the large amount of litter often blocked the entrance to the catch basin itself. If further work is preformed to use catch basin inserts to trap oil spills (which appears to be needed in the study area), a modified approach should be taken for areas generating such large amounts of litter. Coarse screens, either with square meshes (~1 inch) or expanded metals screens (although expanded metal is more difficult to clean) should be used to protect the catch basin inserts from excessive litter. Street sweeping can be used to pick up the rejected litter and it was demonstrated in the researchers' previous study that the screens are not damaged by street sweepers and vice versa. While the frequency of street sweeping may need to be increased to avoid complete blockage of the inlet, the frequency of catch basin cleaning may be significantly reduced. Also, if the inserts are protected from litter they can be optimized for oil removal and retention. Much greater masses of sorbents, such as is used in the HydroKleen insert, can be used in the insert to provide more oil sorption capacity while reducing the tendency for clogging.

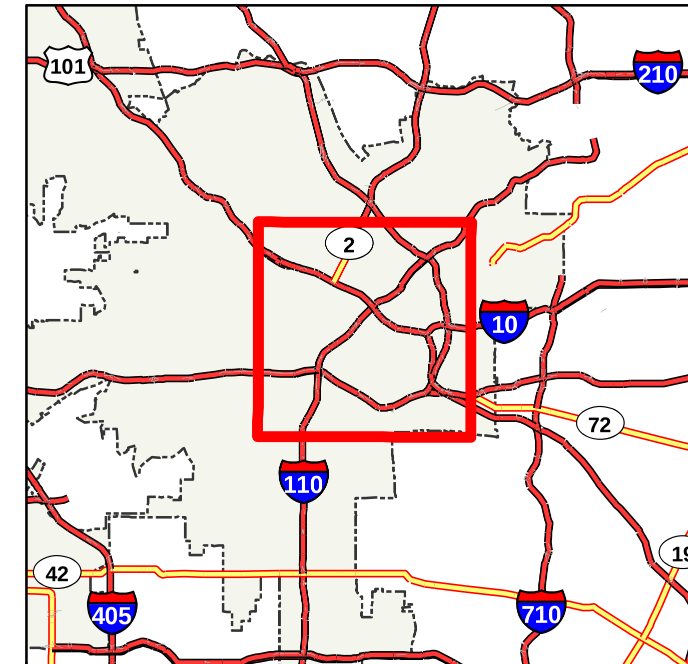
Curb inlet trash screens have been installed by the City of Los Angeles at a few of the field-to-laboratory study locations. These are expected to keep out large objects that obstruct the inserts and prevent the inserts from functioning properly. A recommendation for further research is to compare the performance of the same insert types with and without curb inlet trash screens.

Catch basin insert vendors are beginning to market curb inlet trash screens. For instance, Kristar Enterprises, the manufacturer for FloGard, is currently marketing a curb inlet trash screen to provide pre-treatment to their catch basin insert devices. United Stormwater, the Los Angeles area representative for DrainPac, also markets curb inlet screens.

[28] Lau, S-L and M.K. Stenstrom, "Best Management Practices to Reduce Pollution from Stormwater in Highly Urbanized Areas," WEF Tech, Chicago, IL, September 30-October 3, 2002.

APPENDIX A- SITE LOCATION MAPS





Legend

- Limited Access Higway
- Highway
- Ramps
- Local Roads
- Cumulative Pollutant Capture Sites
- City of Los Angeles Boundary

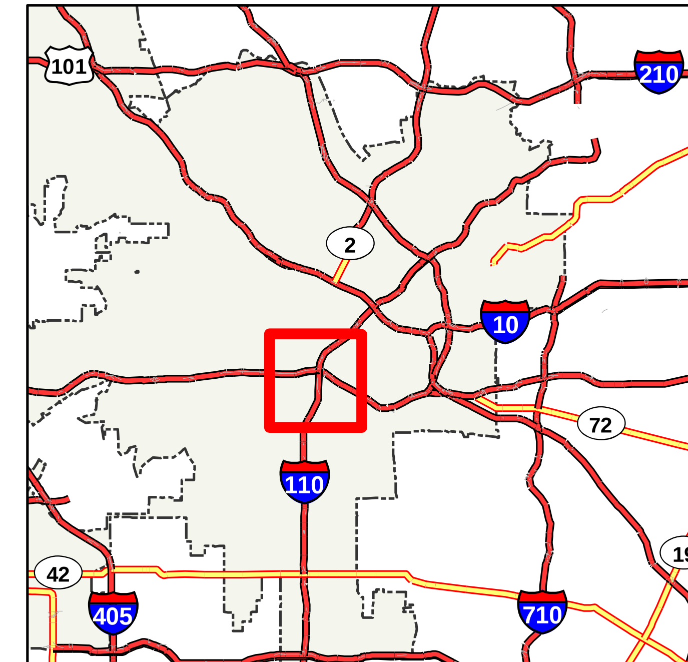
Figure A1

Cumulative Pollutant Capture Catch Basin Insert Sites

May 2005

GeoSyntec Consultants

Preliminary Draft Beach Cities EWMP



Legend

- Limited Access Higway
- Highway
- Ramps
- Local Roads
- Field-to-Laboratory Sites
- City of Los Angeles Boundary

Figure A2

Field-to-Laboratory Catch Basin Insert Sites

May 2005

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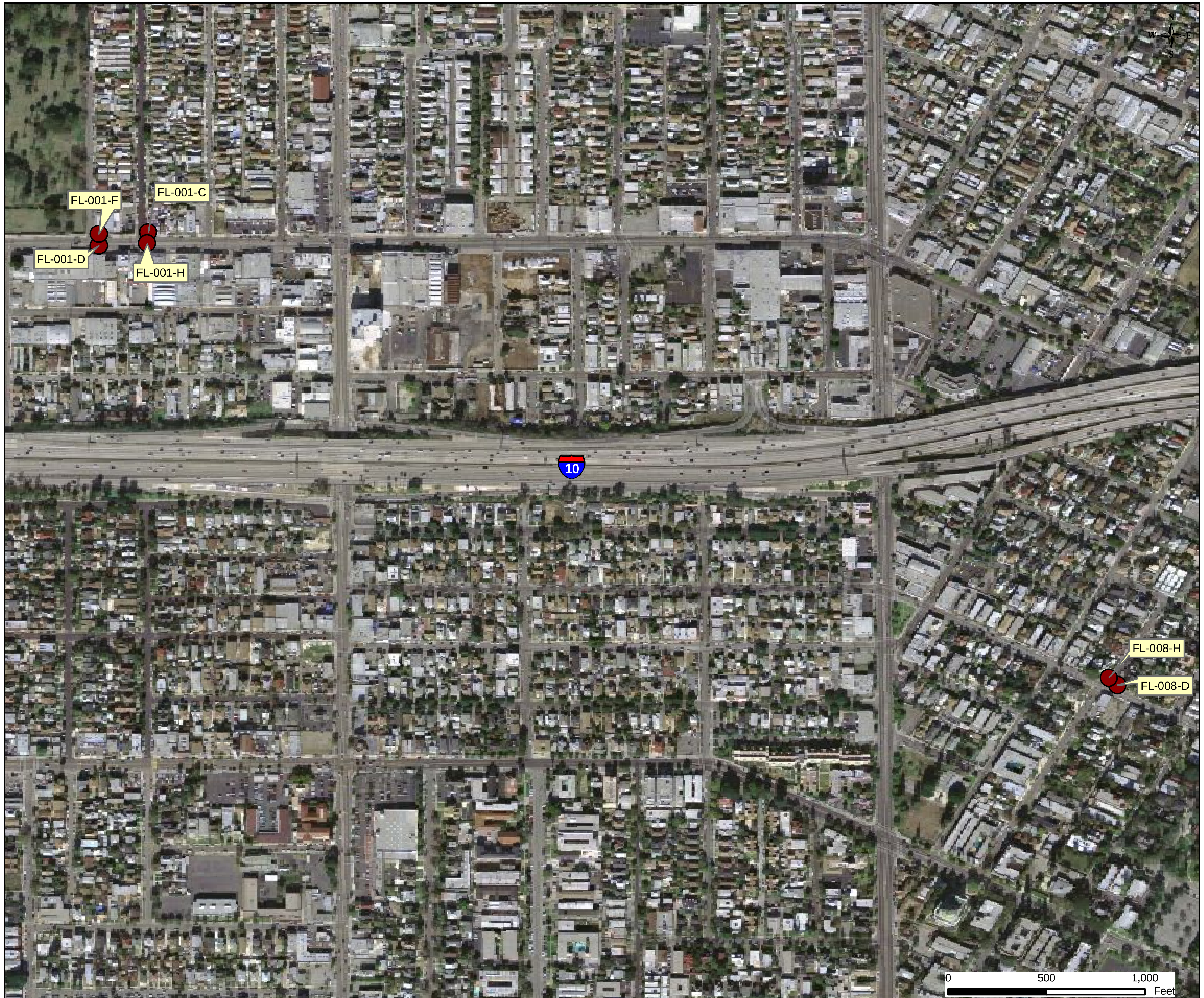

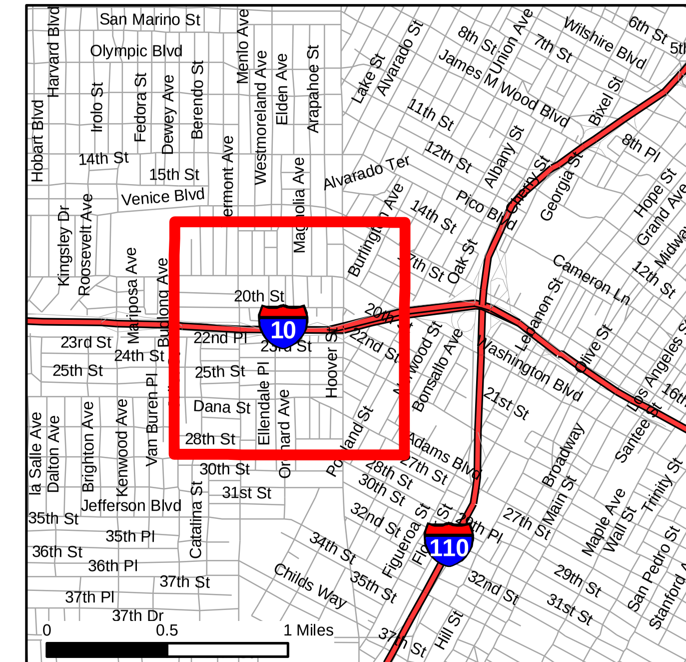

Legend

- Field-to-Laboratory Sites
- Local Roads
- Limited Access Higwhay
- Highway
- Ramps

Figure A3

Aerial Photo of West Field-to-Laboratory Catch Basin Insert Sites

May 2005

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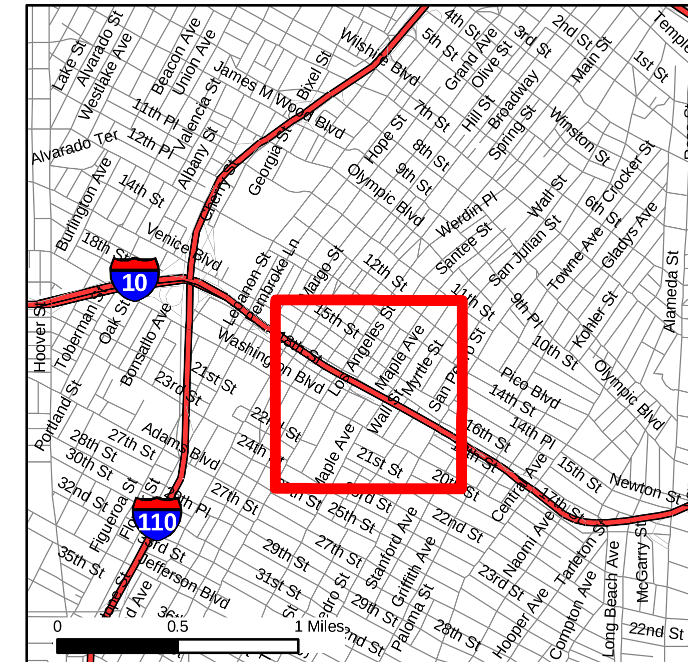

Legend

- Field-to-Laboratory Sites
- Local Roads
- Limited Access Higwhay
- Highway
- Ramps

Figure A4

Aerial View of East Field-to-Laboratory Catch Basin Insert Sites

May 2005

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APPENDIX B - FIELD INSPECTION PHOTOS AND NOTES

Area 1 - Site A

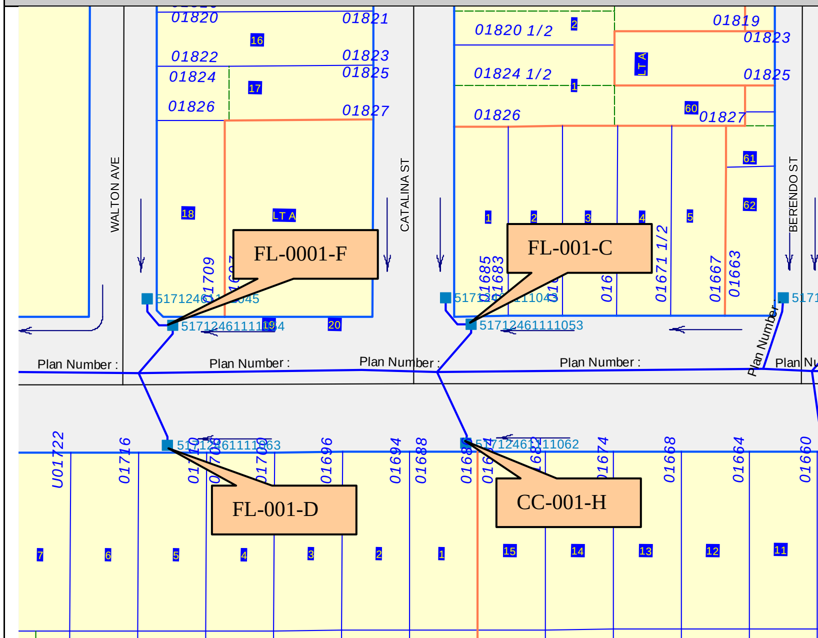
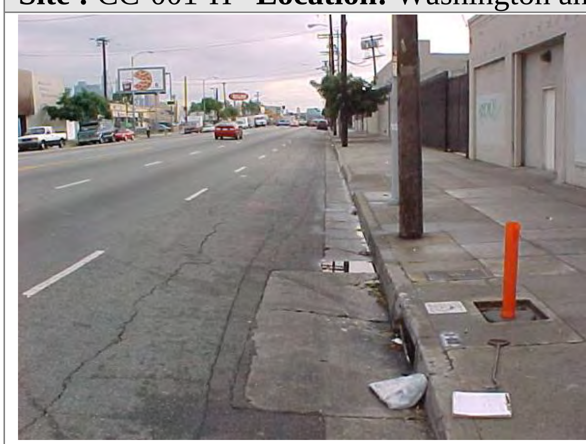


Photo looking east from FL-001-D

Intersection	Washington Blvd. & Walton Ave.
No. of Installations	4

Inlet Number	Technology Type	Easting	Northing	Measurements (see Figure 2)		
				A-Curb Opening	B-Drain inside width	C-Drain inside depth
FL-001-D	DrainPac	380519	3767123	3.5	3.2	3
FL-001-F	Flogard+Plus	380466	3767357	3.5	3.2	3
FL-001-C	Curb Inlet Basket	380532	3767363	3.5	3.2	3.5
CC-001-H	Hydro-Kleen	380530	3767336	3.5	3.2	3.1

Site : CC-001-H **Location:** Washington and Walton (Area 1 - Site A) | HydroKleen

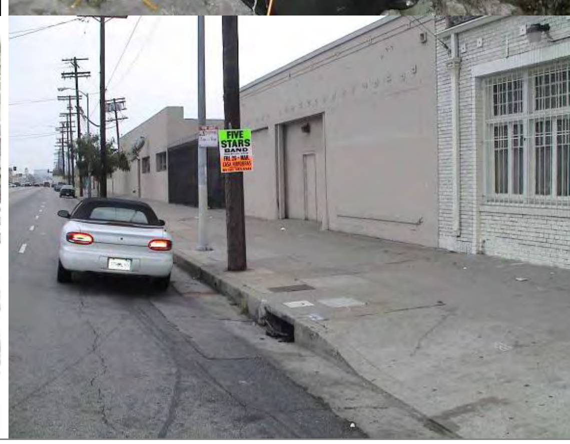


Date inspected:
12/11/03

Comments:
Initial site visit. Notice the missing cover and damaged inlet.

B1

Site : CC-001-H **Location:** Washington and Walton (Area 1 - Site A) | HydroKleen



Date inspected:
2/27/04

Comments: After a few storm events this device appears to be in good working order. Notice the missing concrete cover has been replaced.

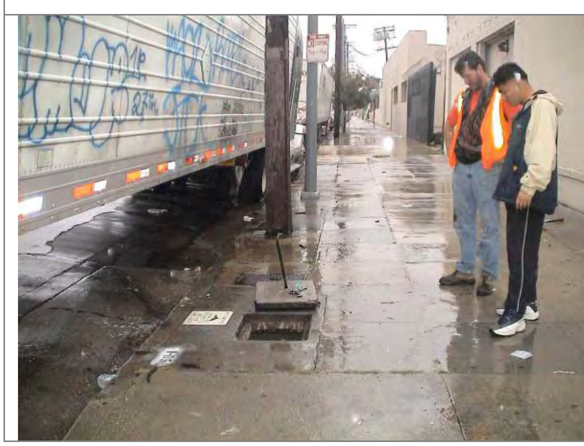
Site : CC-001-H **Location:** Washington and Walton (Area 1 - Site A) | HydroKleen

Date inspected:
3/23/04

Comments: This site had a significant amount of trash inside the catch basin prior to installation. Now the insert is capturing nearly all of the trash. This was previously a field-to-laboratory site that was switched due to installation timing conflicts.

Date inspected:
10/22/04

Comments:
Significant oily sediment and debris present at the curb; evidence of blockage.



Date inspected:
03/22/05

Comments: It was raining during this visit to retrieve this insert. After this visit, this insert was taken to the laboratory for its final tests.

Site : CC-001-H **Location:** Washington and Walton (Area 1 - Site A) | HydroKleen




Site : FL-001-D **Location:** Washington and Walton (Area 1 - Site A)




Date inspected:
2/4/04

Comments: This is the first visit after installation and one storm event. Notice water flowing into catch basin appears to be coming from a roof drain. The bottom of this catch basin shows significant oil and grease on the ponded water surface The insert was removed from the catch basin and subsequently transported to the UCLA laboratory for testing during this site visit.

Site : FL-001-D **Location:** Washington and Walton (Area 1 - Site A)

Date inspected:
2/27/04

Comments: Note this is not one of the inspections sites. These photos were taken just downstream (west) of the FL-001-D catch basin site. Notice the excessive amount of trash, including used motor oil and oil-soaked debris. Also note this basin had been cleaned by LADPW maintenance personnel only 1-2 months prior to this photo as indicated by the painted month and year.

Date inspected:
03/22/05

Comments: After this visit, this insert was taken to the laboratory for its final tests.

Site : FL-001-F **Location:** Washington and Walton (Area 1 - Site A)

Date inspected:
12/11/03

Comments: Initial site visit. Top left photo is looking upstream; top right is downstream. The catch basin was relatively clean with minor dry weather flows. Note that this catch basin is inline with the storm drain system.

Date inspected:
2/4/04

Comments: This was the first site visit after one storm event. This insert was removed from the site and subsequently transported to the UCLA laboratory for testing.

Site : FL-001-F **Location:** Washington and Walton (Area 1 - Site A)




Date inspected:

Comments: This insert showed significant signs of sediment caking. The absorbent was hanging outside the insert. After this visit, this insert was taken to the laboratory for its final tests.


Date inspected: 10/21/04

Comments: During this visit the insert was cleaned and the media was replaced.

Site : FL-001-C **Location:** Washington and Walton (Area 1 - Site A)


Date inspected: 12/11/03

Comments: Initial site visit. Top left photo is looking upstream; top right is downstream. The bottom right photo shows resurfacing activities on Catalina Ave. Note that this catch basin is inline with the storm drain system.

Site : FL-001-C **Location:** Washington and Walton (Area 1 - Site A)

Date inspected:
2/4/04

Comments: This is the first visit after installation and one storm event. An oil pan with automotive fluid was found at the inlet of this catch basin during this visit. No signs of oil inside the insert, but plenty of coarse sediment and some vegetative debris. The insert was removed from the catch basin and subsequently transported to the UCLA laboratory for testing during this site visit.

Date inspected:
03/22/05

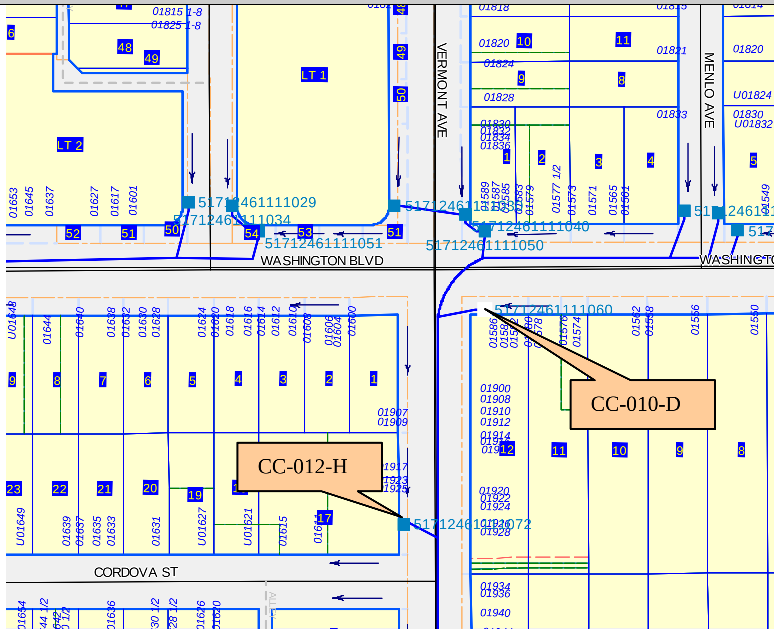
Comments: During this visit, the insert showed significant signs of sediment accumulation and oily sediment. It also appeared to have recently bypassed. After this visit, this insert was taken to the laboratory for its final tests.

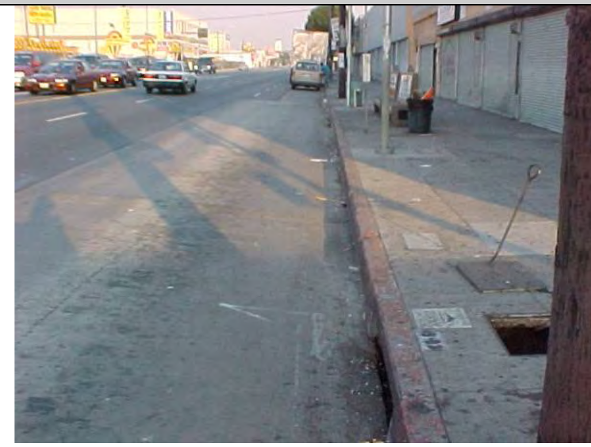
Site : FL-001-C **Location:** Washington and Walton (Area 1 - Site A)

Date inspected:
10/21/04

Comments: These photos were taken immediately after it was installed in preparation for the wet season.

Area 1 - Site B





Looking upstream (east) of CC-010-D

Intersection	Washington Blvd. & Vermont Ave. Vermont & Cordova
No. of Installations	2

Inlet Number	Technology Type	Easting	Northing	Measurements (see Figure 2)		
				A-Curb Opening	B-Drain inside width	C-Drain inside depth
CC-010-D	DrainPac	380866	3767153	3.5	3.2	3.2
CC-012-H	Hydro-Kleen	380849	3767053	3	3.2	5.7

Site : CC-010-D **Location:** Washington and Vermont Ave, SW (Area 1 - Site B) DrainPac

Date inspected:
10/24/03

Comments: Initial site visit. Top left photo is looking upstream; top right is looking downstream into the intersection. As shown in the figures, obviously this site is located in a very busy intersection with high trash loading.

Site : CC-010-D **Location:** Washington and Vernon Ave, SW (Area 1 - Site B) | DrainPac

Date inspected: 2/4/04

Comments: This was the first site visit after installation. It was raining and appeared to be at full hydraulic capacity but still processing the flow.

Date inspected: 2/27/04

Comments: Trash at lip of insert indicates bypass may have previously occurred. Standing water in insert slowly draining indicates the filter media is beginning to clog.

Date inspected: 3/23/04

Comments: This site was completely overwhelmed with trash during this visit. Subsequent events are likely to dislodge larger objects and floatables.

Site : CC-010-D **Location:** Washington and Vermont Ave, SW (Area 1 - Site B)	DrainPac
   	**Date inspected:** 6/30/04 **Comments:** The insert is now completely buried by trash. This device will be retired during the next site visit.
   	**Date inspected:** 10/21/04 **Comments:** Some of the trash that was in the insert has been removed and some bypass, but still lots of trash and debris. The insert was retired during this visit.

Site : CC-012-H **Location:** Vermont, N of Cordova, west side (Area 1 - Site B) | Hydro Kleen

Date inspected:
10/24/03

Comments: Initial site visit. Top left photo is looking upstream; top right is looking downstream. This deep catch basin had a significant amount of trash.

Date inspected:
2/27/04

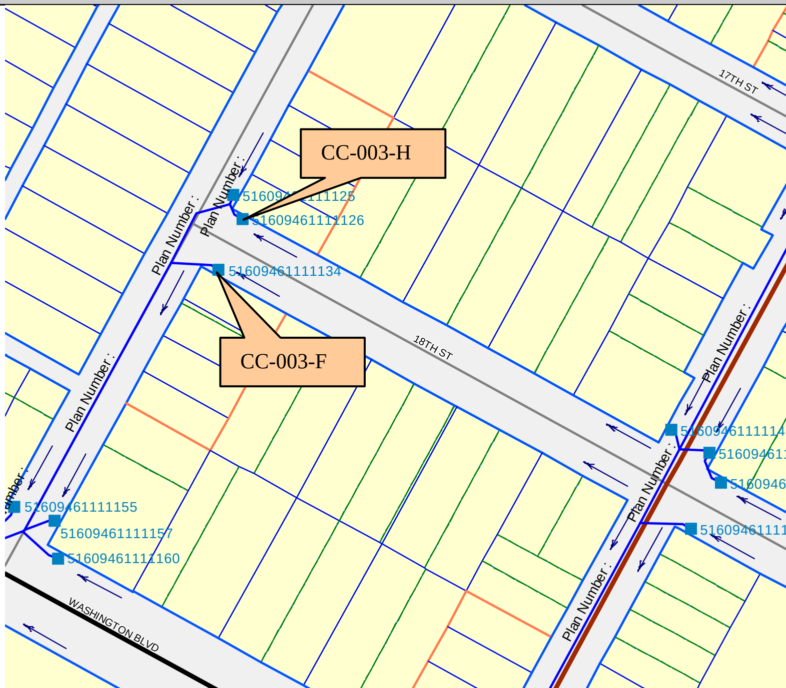
Comments: This insert was installed in the second week of February. After about a week and a half, there is already significant trash and debris with signs of bypass.

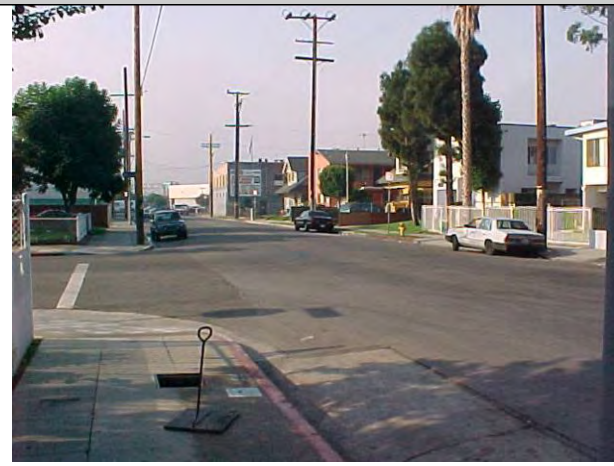
Date inspected:
3/23/04

Comments: After another month in the field this insert has nearly reached its trash loading capacity.

Site : CC-012-H **Location:** Vermont, N of Cordova, west side (Area 1 - Site B)		Hydro Kleen
		
		**Date inspected:** 6/30/04 **Comments:** The insert is now overflowing with trash and should be retired during the next site visit.

Area 1 - Site C





Looking toward intersection from Burlington Ave. (south)

Intersection	18th St. & Burlington Ave.
No. of Installations	2

Inlet Number	Technology Type	Easting	Northing	Measurements (see Figure 2)		
				A-Curb Opening	B-Drain inside width	C-Drain inside depth
CC-003-H	Hydro-Kleen	381658	3767369	3.5	3.2	2.8
CC-003-F	Flogard+Plus	381649	3767368	3.5	3.2	3

Site : CC-003-H **Location:** 18th and Burlington Ave, S corner (Area 1 - Site C) | HydroKleen

Date inspected:
12/11/03

Comments: Initial site visit. Top left photo is looking upstream; top right is looking downstream to the intersection. All residential area. Little trash and debris in catch basin.

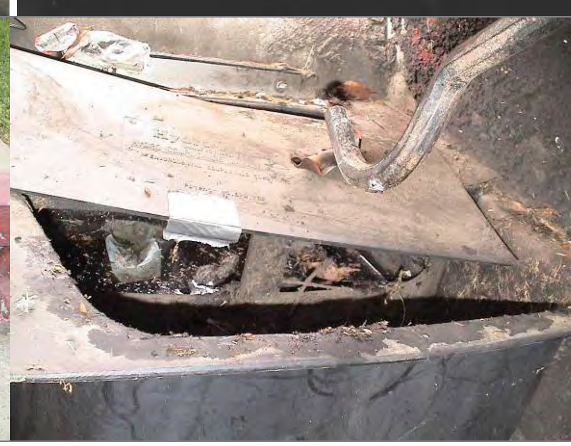
Site : CC-003-H **Location:** 18th and Burlington Ave, S corner (Area 1 - Site C) | HydroKleen





Date inspected:
2/27/04

Comments: As intended by the design, notice the standing water in the sedimentation chamber and the captured trash and debris in the filtration chamber.

Date inspected:
3/23/04

Comments: There was less water during this visit, but there is evidence of recent high flow bypass with the sediment residue on the lid and lip of the insert. The media appears to be beginning to clog.

Site : CC-003-H **Location:** 18th and Burlington Ave, S corner (Area 1 - Site C) | HydroKleen





Date inspected:
6/30/04

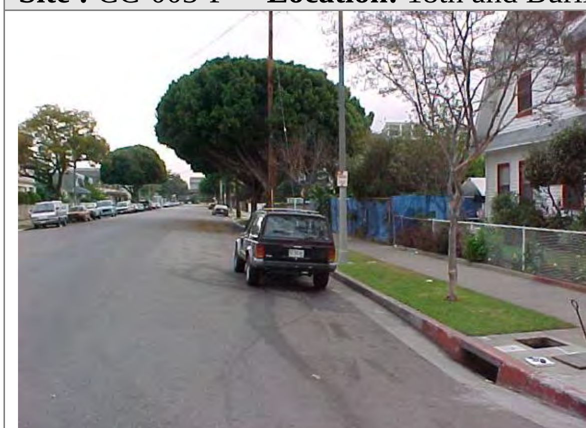
Comments: The insert is completely full and the media is likely clogged. The insert will be retired during the next site visit.

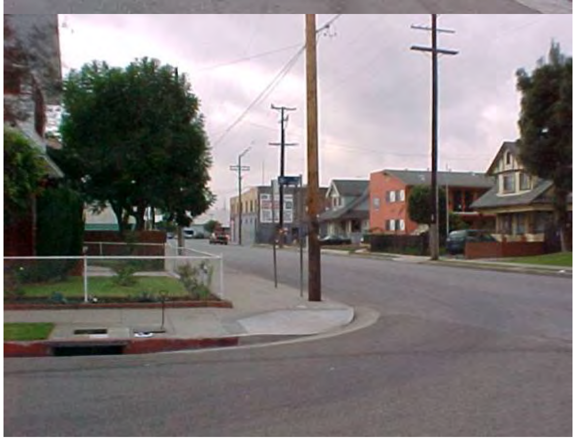

Date inspected:
10/21/04

Comments: As before, this insert was filled with material during this visit. The trash was removed for laboratory analysis. This site was converted to an FL site for the next wet season.

Site : CC-003-H **Location:** 18th and Burlington Ave, S corner (Area 1 - Site C) | HydroKleen

Site : CC-003-F **Location:** 18th and Burlington Ave, N corner (Area 1 - Site C) | Flo-Gard Plus





Date inspected:
12/11/03

Comments: This was the initial site inspection prior to insert installation. Notice the relatively small amount of trash and debris inside the catch basin.

Site : CC-003-F **Location:** 18th and Burlington Ave, N corner (Area 1 – Site C) | Flo-Gard Plus

Date inspected:
2/4/04

Comments: These pictures were taken during an actual storm event. Notice bypass flows along the lip and down the side of the insert. Also notice the absorbent boom floating at the surface of the insert; which is the intention of the design.

Date inspected:
2/27/04

Comments: Notice the significantly greater amount of trash and debris since the last inspection.

Site : CC-003-F **Location:** 18th and Burlington Ave, N corner (Area 1 – Site C) | Flo-Gard Plus

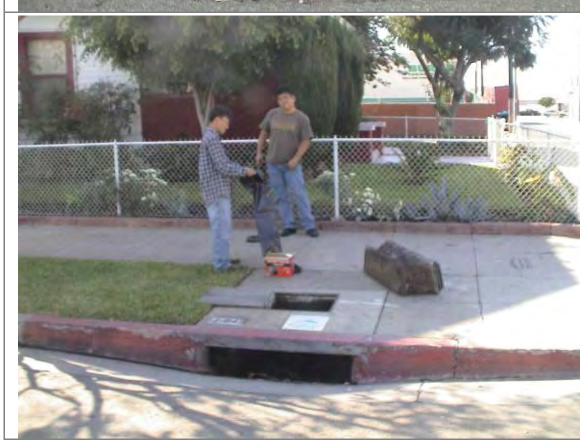


Date inspected:
3/23/04

Comments: The insert is now shown nearly at full capacity.

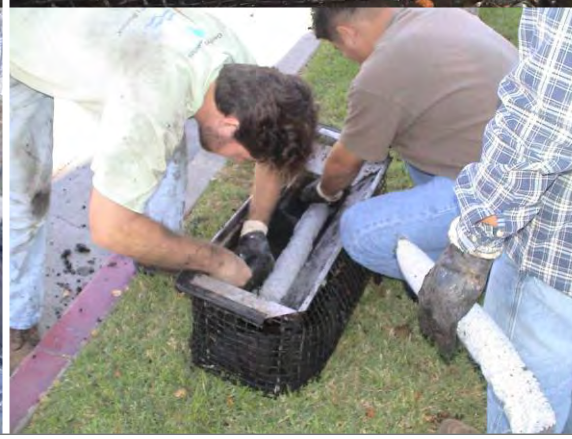

Date inspected:
6/30/04

Comments: The insert cannot hold anymore trash. Any further loadings will bypass.

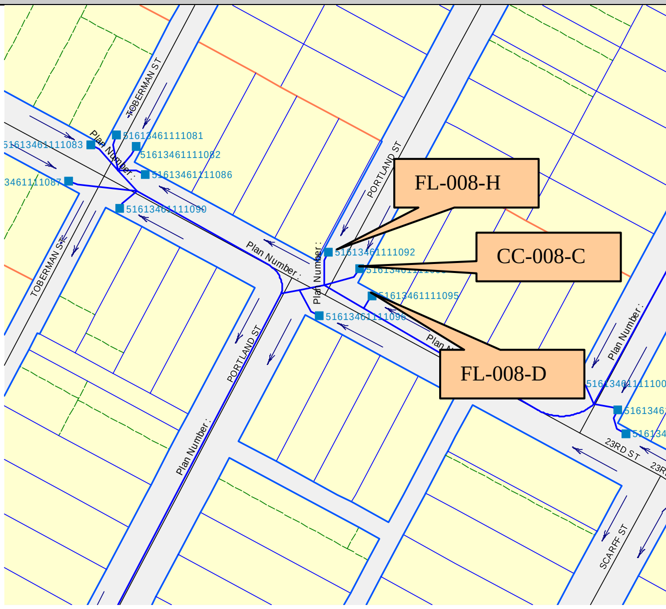



Date inspected:
10/22/04

Comments: The material in this insert was removed during this visit. New media was inserted and it was converted to an FL site.

Site : CC-003-F **Location:** 18th and Burlington Ave, N corner (Area 1 – Site C)	Flo-Gard Plus
   	

Area 1 - Site D

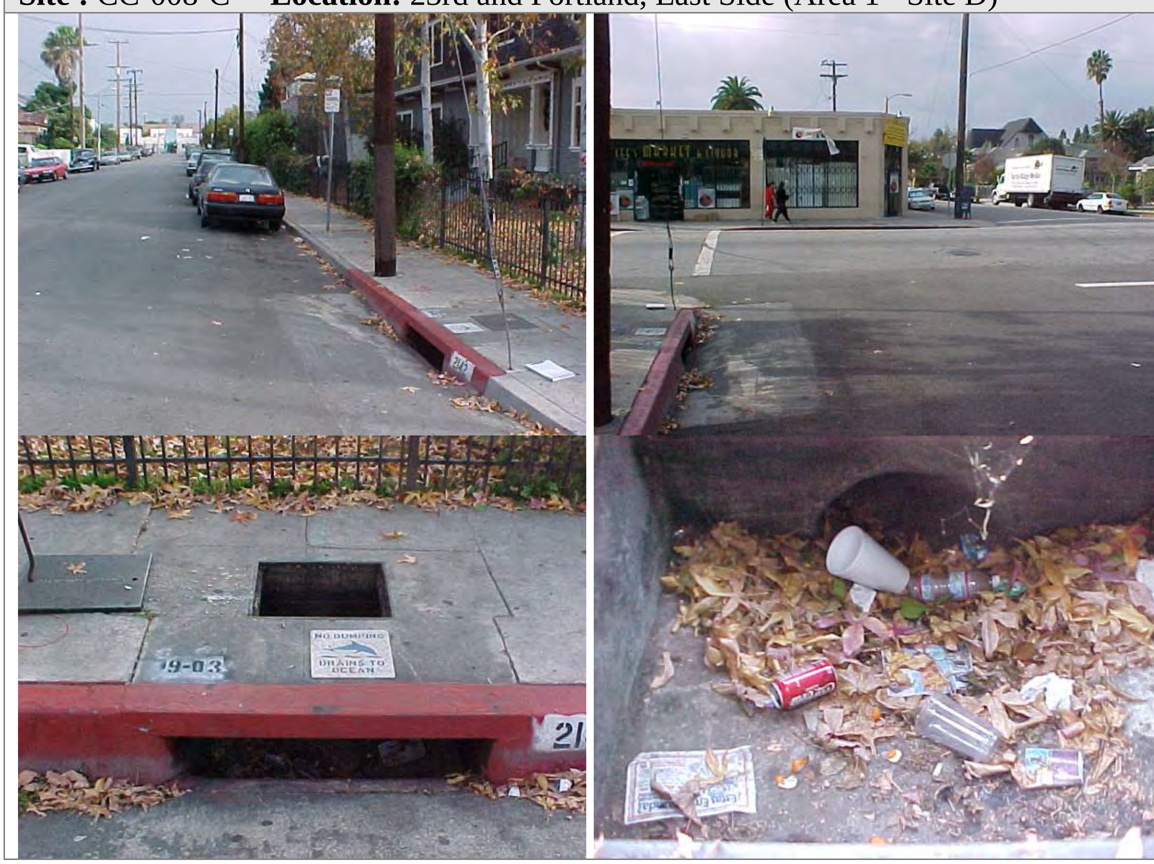


Looking upstream (southeast) of FL-008-D

Intersection	23rd St & Portland St
No. of Installations	3

Inlet Number	Technology Type	Easting	Northing	Measurements (see Figure 2)		
				A-Curb Opening	B-Drain inside width	C-Drain inside depth
CC-008-C	Curb Inlet Basket	381765	3766656	3.5	3.2	2.7
FL-008-D	DrainPac	381851	3766453	3.2	3.5	3.0
FL-008-H	Hydro-Kleen	381758	3766660	3.5	3.2	2.7

Site : CC-008-C **Location:** 23rd and Portland, East Side (Area 1 - Site D) | Curb Inlet Basket



Date inspected:
12/10/03

Comments: Initial site visit. Top left photo is looking upstream; top right is looking downstream. Nearby deciduous trees appear to deliver excessive leafy debris to this catch basin.

Site : CC-008-C **Location:** 23rd and Portland, East Side (Area 1 - Site D) | Curb Inlet Basket

Date inspected:
2/4/04

Comments: First site visit after installation and one storm event. Some trash and debris accumulation, but still plenty of capacity.

Date inspected:
3/23/04

Comments: Compared to the last inspection, the insert has accumulated significant trash and debris. It now appears to be near capacity and probably should be retired.

Date inspected:
6/30/04

Comments: As before, this insert is full and is beginning to overflow with trash.

B23

Site : CC-008-C **Location:** 23rd and Portland, East Side (Area 1 - Site D) | Curb Inlet Basket




Date inspected:
10/21/04

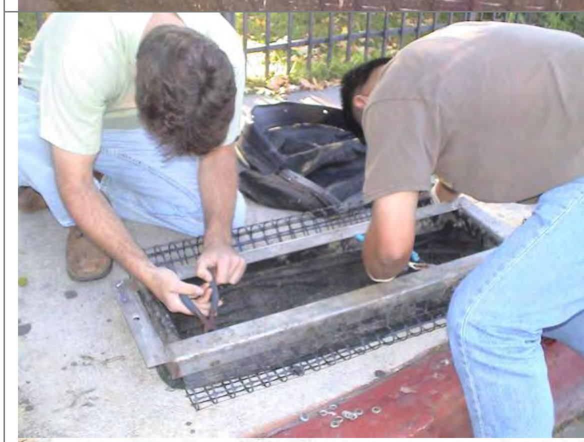
Comments: This insert was retired during this visit.

Site : FL-008-D **Location:** 23rd and Portland, NE on 23rd (Area 1 - Site D) | DrainPac



Date inspected:
12/10/03

Comments: Initial site visit. Top left photo is looking upstream; top right is looking downstream.

Site : FL-008-D **Location:** 23rd and Portland, NE on 23rd (Area 1 - Site D)		DrainPac
 	 	**Date inspected:** 2/4/04 **Comments:** This was the first inspection of this site. Notice the device has accumulated significant trash for only one storm event. This was originally a CC site, but was changed to an FL site due to installation timing conflicts.
 	 	**Date inspected:** 10/22/04 **Comments:** This FL insert was installed during this visit in preparation for the wet season.

B25

Site : FL-008-D **Location:** 23rd and Portland, NE on 23rd (Area 1 - Site D)

DrainPac

Date inspected:
03/22/05

Comments: After this visit, this insert was taken to the laboratory for its final tests.

Site : FL-008-D **Location:** 23rd and Portland, NE on 23rd (Area 1 - Site D) | DrainPac

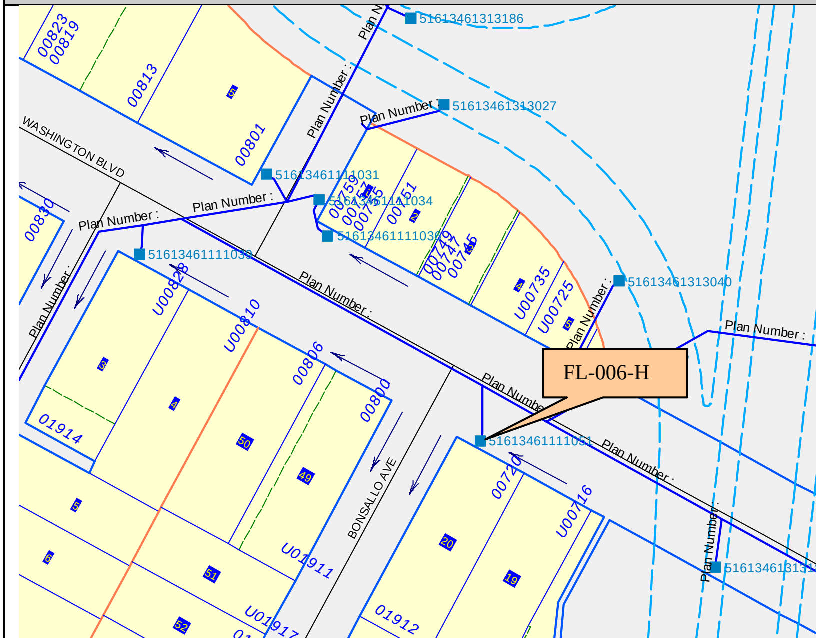
Site : FL-008-H **Location:** 23rd and Portland, NE on 23rd (Area 1 - Site D) | Hydro Kleen

Date inspected:
12/10/03

Comments: Initial site visit. Top left photo is looking upstream; top right is looking downstream. There is evidence of significant trash loading to this catch basin as shown in the photo.

Site : FL-008-H **Location:** 23rd and Portland, NE on 23rd (Area 1 - Site D)	Hydro Kleen
	**Date inspected:** 2/4/04 **Comments**: Notice the standing water. This device is actually designed to have standing water in the first chamber to allow for settling. This was originally a CC site, but was changed to an FL site due to installation timing conflicts. It was removed and subsequently transported to the UCLA laboratory during this visit.
	**Date inspected:** 03/22/05 **Comments:** After a few months in the field this insert did not show significant accumulation. After this visit, this insert was taken to the laboratory for its final tests.

Area 1 - Site E

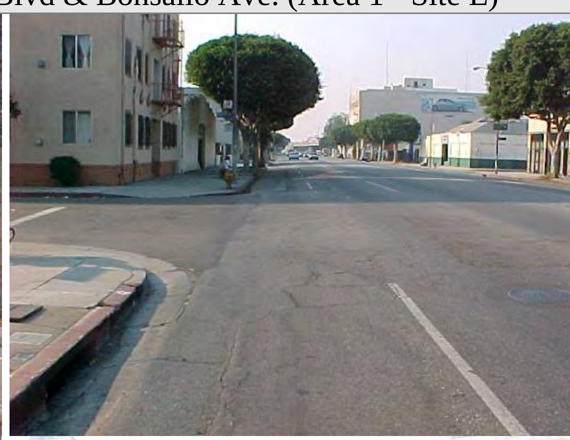


Looking upstream (southeast)

Intersection	Washington Blvd & Bonsallo Ave.
No. of Installations	1

Inlet Number	Technology Type	Easting	Northing	Measurements (see Figure 2)		
				A-Curb Opening	B-Drain inside width	C-Drain inside depth
FL-006-H	Hydro-Kleen	382356	3766644	3.5	3.2	3.0

Site : FL-006-H **Location:** Washington Blvd & Bonsallo Ave. (Area 1 - Site E) | Hydro Kleen



Date inspected:
10/24/03

Comments: Initial site visit. Top left photo is looking upstream; top right is looking downstream. Bottom left picture is looking down Bonsallo Ave. Notice the large amount of trash and debris within the catch basin.

Site : FL-006-H **Location:** Washington Blvd & Bonsallo Ave. (Area 1 - Site E)

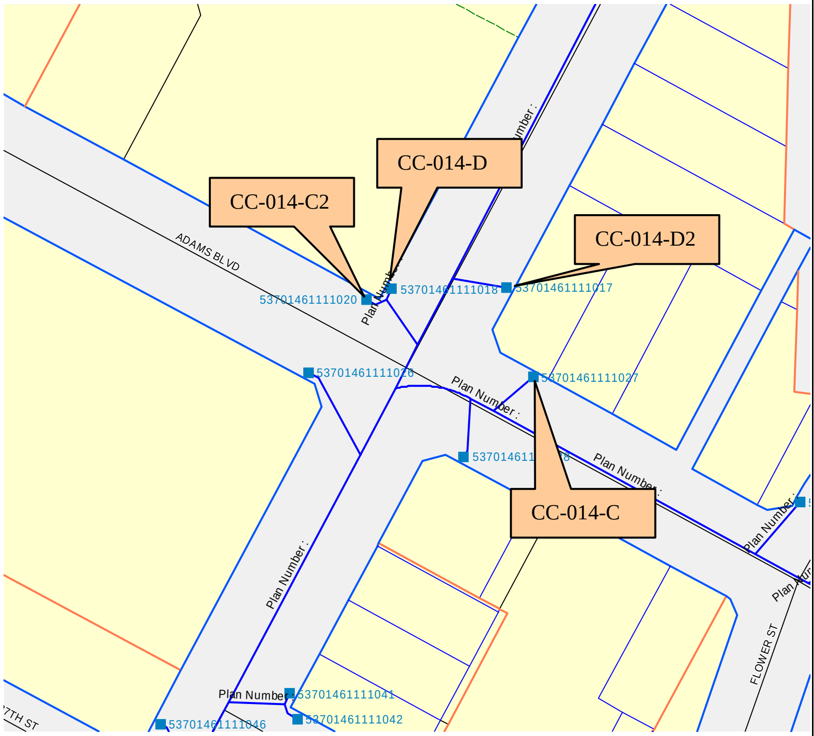
Hydro Kleen

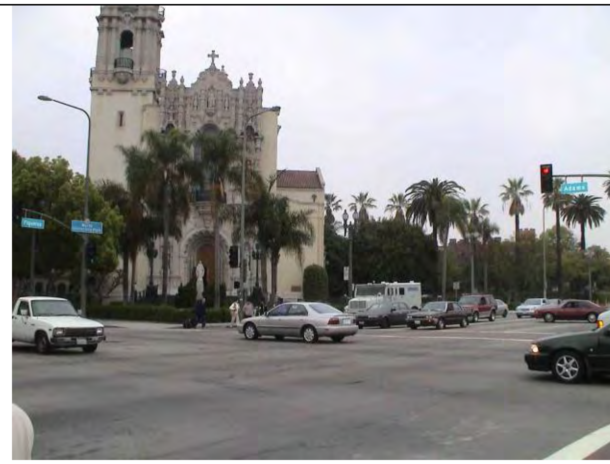




Date inspected:
2/4/04

Comments: This installation utilizes a weir to route flows into the insert because the inlet width is wider than the insert width. Majority of the flows at this site were found to bypass the insert during this storm event. The insert was removed and transported to the laboratory for testing. Note that the lip of the insert had to be trimmed and notched to fit in this catch basin. It was sealed using black caulking. Thus, upon reinstallation the insert should again be caulked to minimize the chance for bypass.



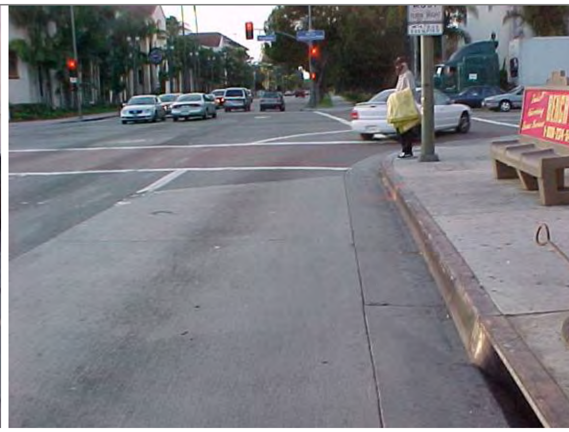
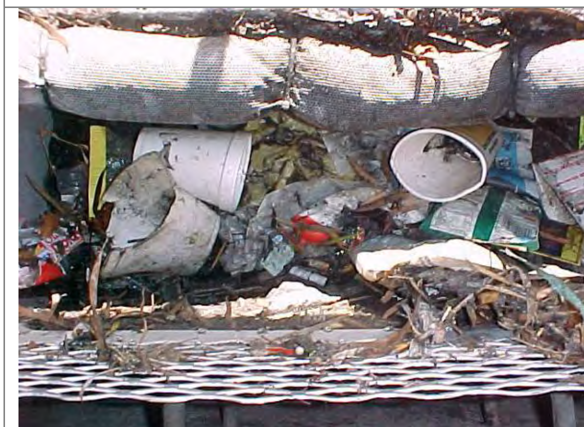


Looking across the intersection from the north east corner.

Looking across intersection from southeast corner.

Intersection	Figueroa St. & Adams Blvd.
No. of Installations	4

Inlet Number	Technology Type	Easting	Northing	Measurements (see Figure 2)		
				A-Curb Opening	B-Drain inside width	C-Drain inside depth
CC-014-C2	Curb Inlet Basket	382170	3766022	3.5	3.2	3.3
CC-014-C	Curb Inlet Basket	382226	3766007	7	3.2	5.9
CC-014-D	DrainPac	382274	3765843	7	3.2	4.6
CC-014-D2	DrainPac	38220	3766028	7	3.1	4

Site : CC-014-C **Location:** Adams and Figueroa St (Area 1 - Site F)		Curb-Inlet Basket
		**Date inspected:** 12/10/03 **Comments:** Initial site visit. Top left photo is looking upstream; top right photo is looking downstream. This catch basin is at a bus stop that gets a lot of vehicular and pedestrian traffic.
 		**Date inspected:** 2/4/04 **Comments:** First site visit since installation indicates significant trash loadings at this site.
		**Date inspected:** 2/27/04 **Comments:** Notice this site exhibits very high sediment loadings and evidence of oil and grease.

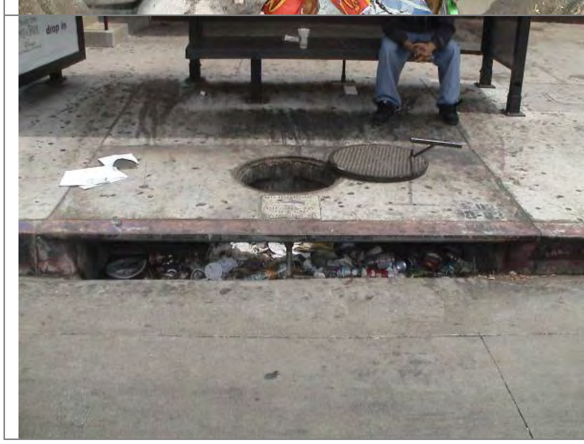
Site : CC-014-C **Location:** Adams and Figueroa St (Area 1 - Site F)

Curb-Inlet Basket




Date inspected: 3/23/04

Comments: After just two months, this insert is completely filled with mostly anthropogenic refuse and sediment.




Date inspected: 6/30/04

Comments: Additional trash has accumulated in the insert and on the sedimentation shelf. This insert should be retired during the next site visit.

Site : CC-014-C **Location:** Adams and Figueroa St (Area 1 - Site F)

Curb-Inlet Basket

Date inspected: 10/21/04

Comments: The insert at this busy intersection has received lots of trash and sediment. The media shown in the lip of the insert appears deflated indicating the absorbent material has been lost during operation. Significant sediment build-up on weir indicates coarse sediment removal is occurring.

Site : CC-014-C **Location:** Adams and Figueroa St (Area 1 - Site F)

Curb-Inlet Basket

Site : CC-014-C2 **Location:** Adams and Figueroa St (Area 1 - Site F)

Curb Inlet Basket

Date inspected:
12/10/03

Comments: Initial site visit. Top left photo is looking upstream; top right photo is looking downstream toward the intersection. Significant trash and debris loads present at site. Notice the catch basin outlet appears to be nearly clogged.

Site : CC-014-C2 **Location:** Adams and Figueroa St (Area 1 - Site F)

Curb Inlet Basket

Date inspected: 2/4/04

Comments: First site visit since installation. As compared to CC-014-C across the street, this site contains more leaf litter and sediment than human-generated trash.

Date inspected: 2/27/04

Comments: More trash and debris has accumulated since last visit and some has bypassed insert, but still appears to be slightly below capacity.

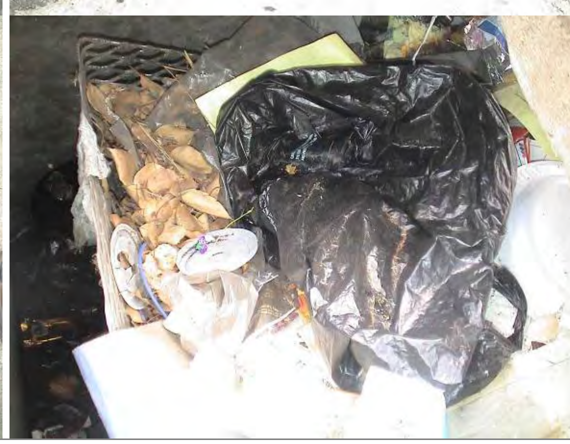
Site : CC-014-C2 **Location:** Adams and Figueroa St (Area 1 - Site F) | Curb Inlet Basket




Date inspected:
3/23/04

Comments: The insert is now at capacity and should be cleaned prior to the next wet season.



Date inspected:
6/30/04

Comments: As before, this insert is full and needs to be cleaned. The last cleaning of this catch basin appears to have been Sept. 2003. Notice the build-up of sediment and growth of weeds at the inlet of this catch basin.

Site : CC-014-C2 **Location:** Adams and Figueroa St (Area 1 - Site F) | Curb Inlet Basket

Date inspected:
10/22/04

Comments: This insert receives mostly sediment, leaves, and pine needles. The media appears to be "deflated" indicating the absorbent material was lost during operation. It was retired after this inspection.

Site : CC-014-D **Location:** Figueroa St and Adams (Area 1 - Site F) | DrainPac

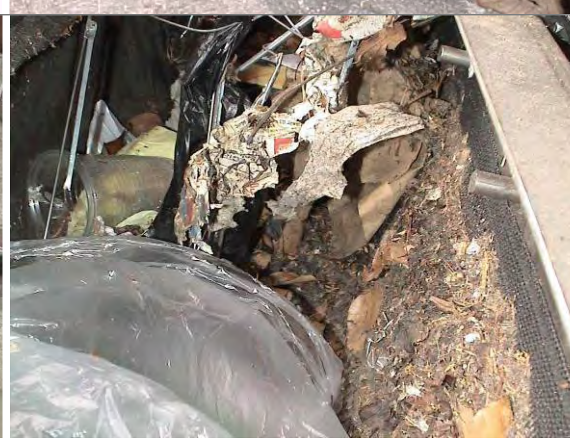
Date inspected:
12/10/03

Comments: Initial site visit. Top left photo is looking upstream; top right photo is looking downstream toward the intersection. This site is located at a bus stop.

Site : CC-014-D **Location:** Figueroa St and Adams (Area 1 - Site F)	DrainPac

Date inspected:
2/4/04

Comments: This was the first site visit after installation. The photo on the top left is a "birds-eye" view of the insert. Notice there is still some water from the previous day's storm event. The photo on the top left shows the relatively clean catch basin bottom due to the high capture rate of the insert.



Date inspected:
3/23/04

Comments: Compared to the last inspection there is significantly more trash and debris, but the insert still has capacity and appears to be functioning properly. Only a small amount of bypass is indicated by the limited amount of debris at the bottom of the catch basin.

Site : CC-014-D **Location:** Figueroa St and Adams (Area 1 - Site F) | DrainPac







Date inspected:
6/30/04

Comments: Since the last visit a lot more trash has accumulated in the insert and is now nearly at capacity.

Site : CC-014-D **Location:** Figueroa St and Adams (Area 1 - Site F)	DrainPac
	

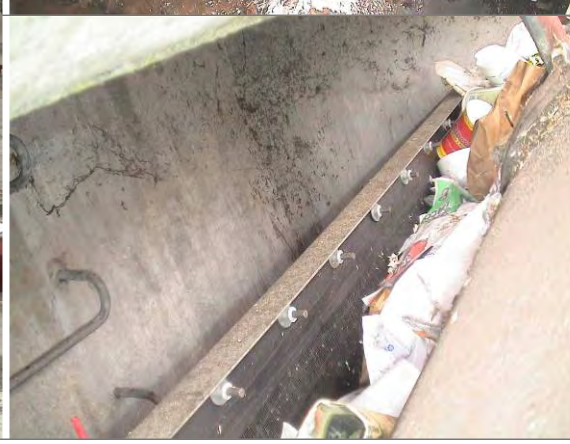
Site : CC-014-D2 **Location:** Figueroa St and Adams (Area 1 - Site F)	DrainPac
	**Date inspected:** 12/10/03 **Comments:** Initial site visit. Top left photo is looking upstream; top right photo is looking downstream toward the intersection. This site is located at a bus stop.
	**Date inspected:** 2/4/04 **Comments:** This is the first inspection after installation and it appears to be functioning well.

Site : CC-014-D2 **Location:** Figueroa St and Adams (Area 1 - Site F)

DrainPac

Date inspected:
3/23/04

Comments: After nearly two months, this insert is still functioning well and has remaining capacity.

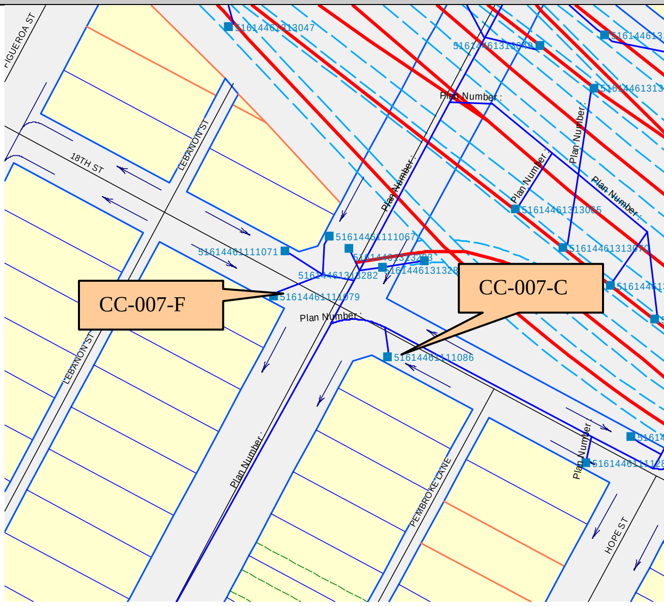


Date inspected:
6/30/04

Comments: More trash and debris have accumulated since the last visit. However, it appears to still have some remaining capacity.

Site : CC-014-D2 **Location:** Figueroa St and Adams (Area 1 - Site F)		DrainPac
		

Area 1 - Site G



Northwest corner of 18th and Flower St.

Intersection	18th St. & Flower St.
No. of Installations	2

Inlet Number	Technology Type	Easting	Northing	Measurements (see Figure 2)		
				A-Curb Opening	B-Drain inside width	C-Drain inside depth
CC-007-C	Curb Inlet Basket	382871	3766585	3.5	3.0	6.5
CC-007-F	Flogard+Plus	382771	3766801	3.5	3.2	3.5

Site : CC-007-C **Location:** 18th and Flower St., South East Corner (Area 1 - Site G) — Curb Inlet Basket

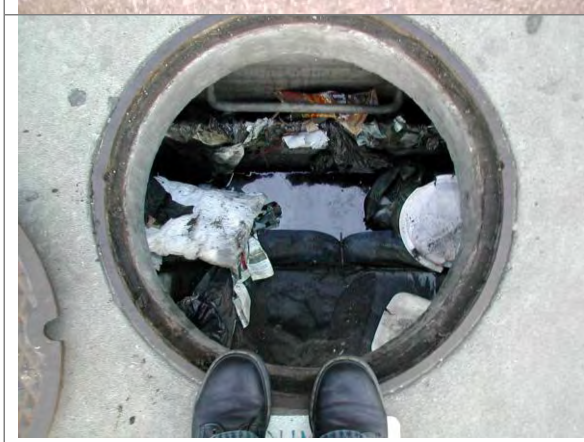
Date inspected:
10/24/03

Comments: Initial site visit. Top left photo is looking upstream; top right is looking downstream.

Site : CC-007-C **Location:** 18th and Flower St., South East Corner (Area 1 - Site G) | Curb Inlet Basket

Date inspected:
2/4/04

Comments: This visit occurred about a week after installation. Notice the oil collecting on the surface of the absorbent boom.



Date inspected:
2/27/04

Comments: As compared to the last inspection, this insert has received a significant amount of oil; probably from a direct illicit discharge of used motor oil. Notice the puddle of oil on the lip of this insert.

Site : CC-007-C **Location:** 18th and Flower St., South East Corner (Area 1 - Site G) | Curb Inlet Basket




Date inspected:
3/23/04

Comments: This insert is no longer visible due to the excessive trash and debris.

Date inspected:
6/30/04

Comments: As before, this insert is completely overwhelmed with trash and needs to be cleaned. It should be retired during the next site visit.