**REPORT**

# SANTA MONICA BAY AREA MUNICIPAL STORM WATER/ URBAN RUNOFF PILOT PROJECT — EVALUATION OF POTENTIAL CATCHBASIN RETROFITS

*Prepared for*
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UCLA
Psomas & Associates

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For this study, the sampling program was designed to collect samples from stormwater before it enters a catchbasin. Most of the previous work performed by other monitoring studies has addressed stormwater that is either in the catchbasin or in a storm drain that is downstream of the catchbasin. Catchbasins may remove material primarily by sedimentation during periods of low flow. For this reason, samples of stormwater in the catchbasin or downstream of the catchbasin may not be representative of the stormwater that enters the catchbasin.

Water quality samples were collected and analyzed for the target contaminants identified in Task 1, and also for a variety of other water quality parameters, as described in Sections 2.1.2 and 2.1.3. This was possible in part because of ongoing programs at UCLA that facilitate stormwater monitoring and analysis. The collected data will be used by students in their research and class projects. Sampling for debris was not performed in this pilot project, due to the difficulty of obtaining enough samples to be confident that the extremely diverse and variable spectrum of litter components was properly characterized.. We believe a much longer period would be required to obtain representative debris samples. Some limited observation of debris in stormwater and collection of debris in catchbasins was performed in Task 4, (reported in Section 4 of this report), as a part of field studies of candidate retrofits.

## 2.1 METHODS

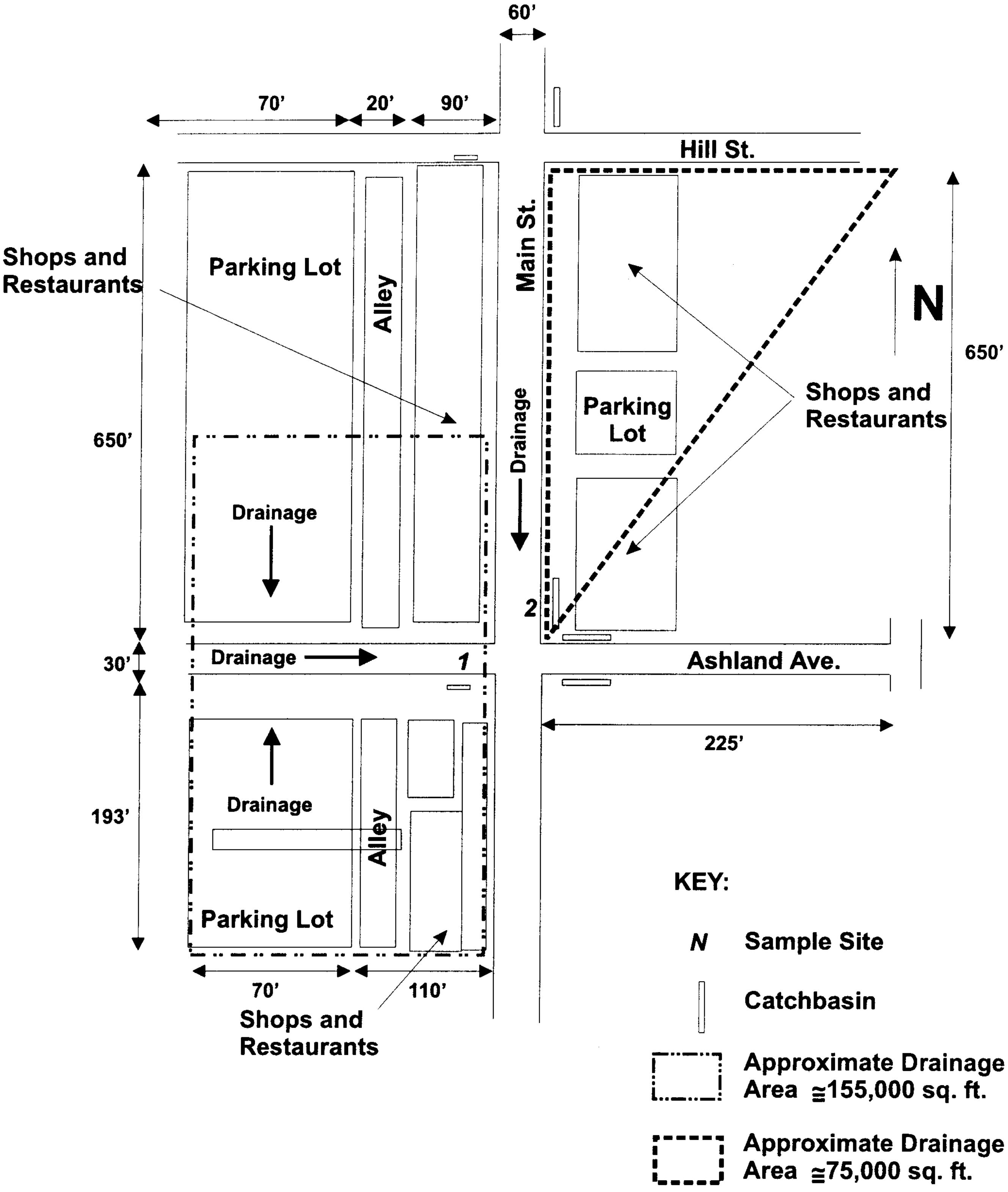
### 2.1.1 Sample Location and Collection

Stormwater samples were collected at the inlets to four catchbasins during storm events occurring from September to December 1997. The locations of these sampling sites are shown in Figures 2-1 to 2-3. All of the sites were in the City of Santa Monica and were selected based on the following criteria:

- Land use and activities in the area draining into the catchbasin;
- Safety of the personnel, including the ability to avoid street traffic as well as potential crime areas.
- Feasibility of sample collection, including proximity of the sites to each other and to UCLA;

Figure 2-1 shows the locations of Sites 1 and 2, which were catchbasins draining commercial and high traffic volume roadway areas. Site 1 is a 4-foot wide catchbasin on Ashland Avenue that receives runoff from the parking lots, alleys, and streets shown on the figure. Approximately 50% of the runoff from the lot between Hill and Ashland Streets enters Location 1. Virtually all of the flow from the lot south of Ashland Avenue enters Site 1. Runoff from the two alleys enters the site in approximately equal proportions. Roof runoff from the shops also flows to Site 1. Restaurants use trash dumpsters along the alley, which at times were observed to be quite full. None of the dumpsters were observed to be leaking. Overall, Site 1 receives runoff that is primarily associated with vehicular activity. The drainage area is approximately 155,000 sq. ft.

Site 2 is an 18-foot wide catchbasin that receives runoff from Main Street (between Hill and Ashland) and a small parking lot. Parking is permitted along Main Street. Runoff flows down Ashland Avenue towards Main Street from the east, but is intercepted by other catchbasins. Roof

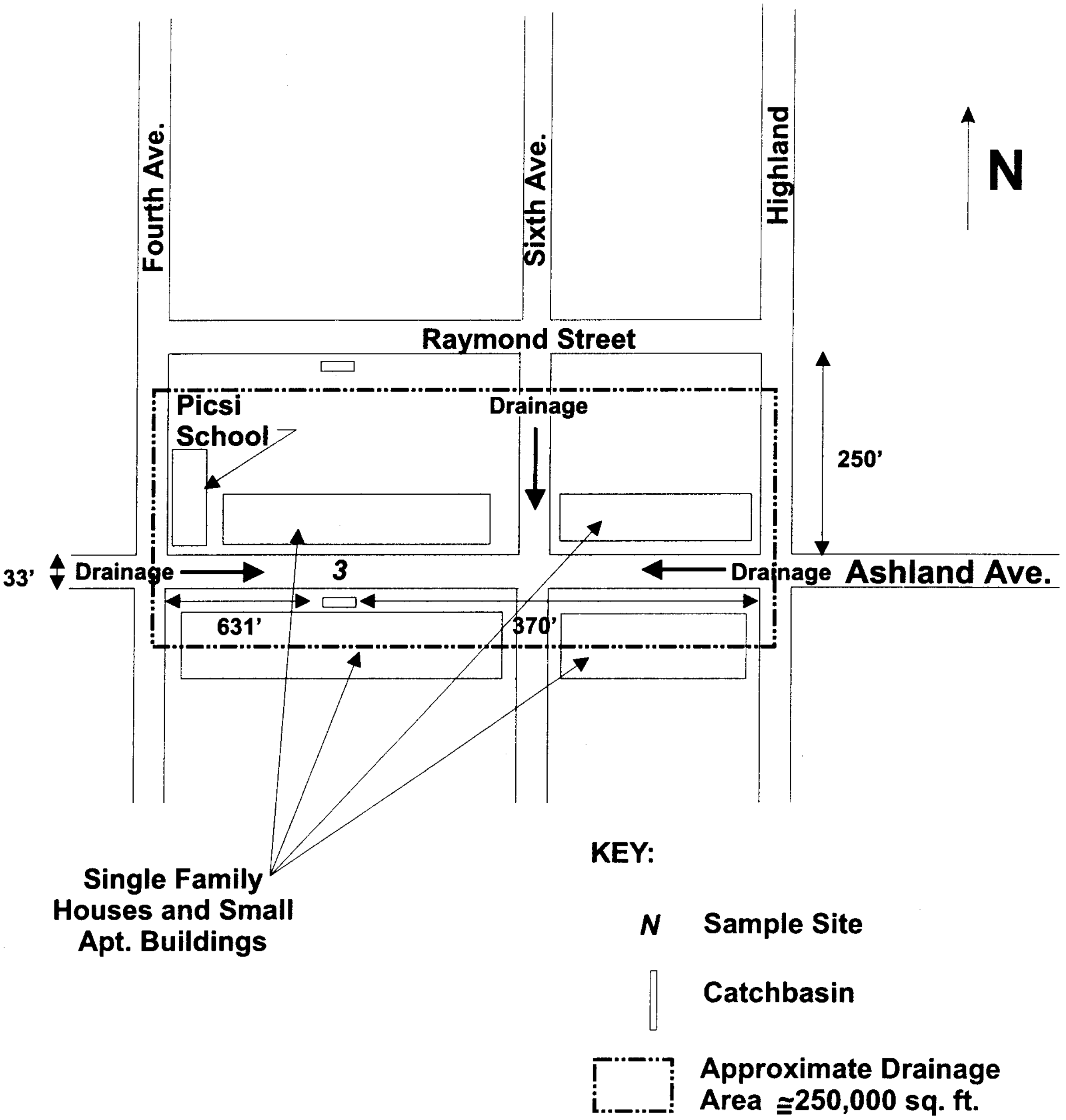


Not to Scale

**SAMPLE SITES 1 and 2**

| | | | | |
|---|---|---|---|---|
| DRAWN BY: cm | CHECKED BY: | PROJECT NO: 9653001F-5000 | DATE: 9-22-98 | FIGURE NO: 2-1 |

Woodward-Clyde



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**SAMPLE SITE 3**

| | | | | |
|---|---|---|---|---|
| DRAWN BY: cm | CHECKED BY: | PROJECT NO: 9653001F-5000 | DATE: 9-22-98 | FIGURE NO: 2-2 |

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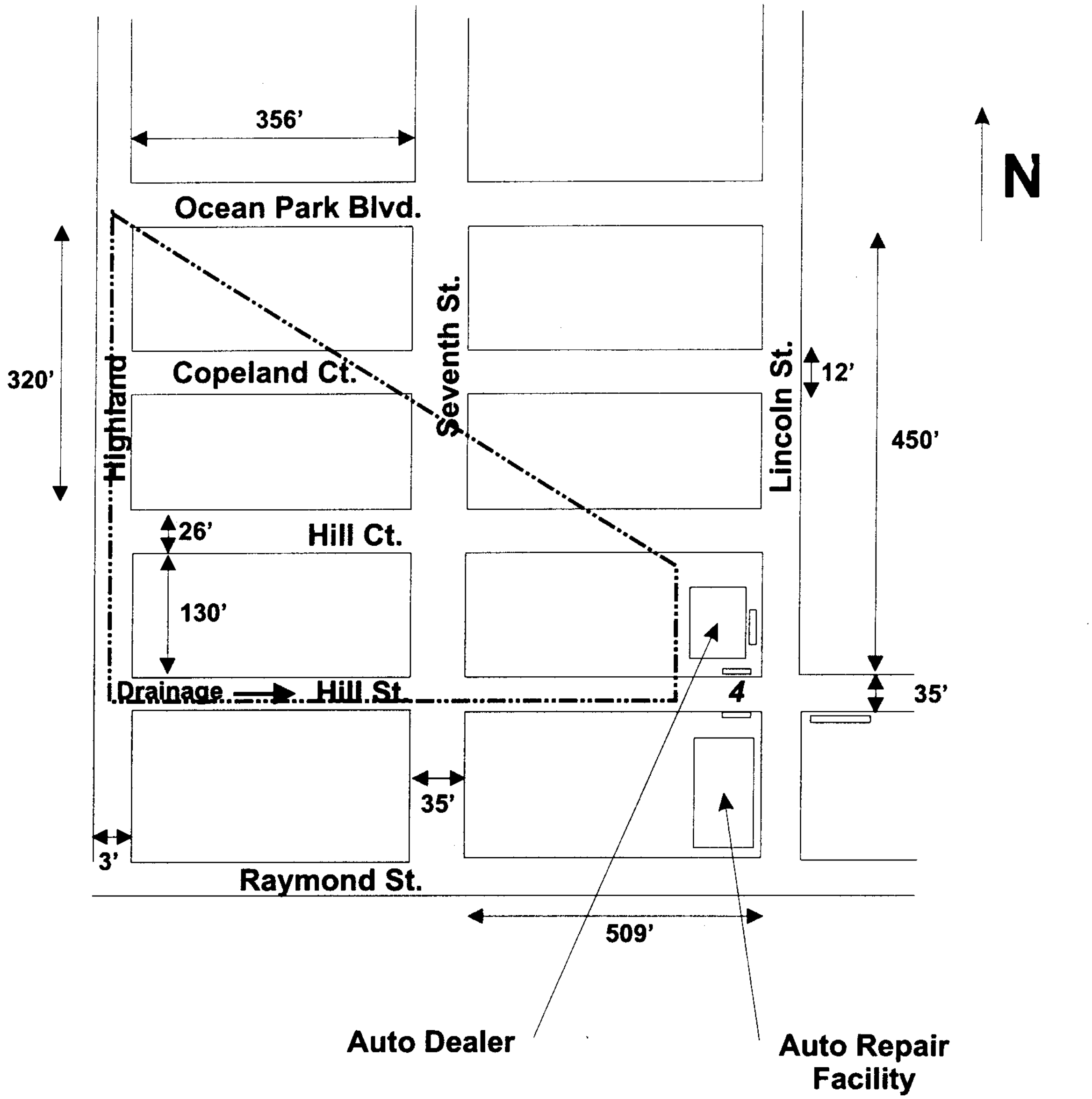

**KEY:**

*N* Sample Site

▯ Catchbasin

⬚ Approximate Drainage Area ≅190,000 sq. ft.

Not to Scale

**SAMPLE SITE 4**

| | | | | |
|---|---|---|---|---|
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runoff is discharged along Main Street and flows to Site 2. No trash dumpsters were noted in the drainage area. Runoff entering this catchbasin is confined to the runoff from the street, sidewalk, parking lot, and roofs from the businesses between and Hill and Ashland Streets. Overall, this site receives runoff that is primarily associated with light commercial activities. The drainage area is approximately 75,000 sq. ft.

Figure 2-2 shows Site 3. This site is located approximately ½ mile from Sites 1 and 2. Highland and Fourth Streets form "ridges" and water flows downhill to Site 3, which is an 8-foot wide catchbasin. The entire area, except for the school, is composed of single family residences and small apartment buildings. Parking is generally permitted along all of the streets shown. Catchbasins also exist on other cross streets (parallel to Ashland) and intercept stormwater. The overall runoff to site is from mixed residential land uses. The drainage area is approximately 250,000 sq. ft.

Figure 2-3 shows Site 4, which is also a mixed residential site. It is located approximately one-half mile from Site 3. Stormwater flows downhill from Highland Street to Site 4, which is a 4-foot wide catchbasin.. No catchbasins exist along Hill Street except at Site 4. Stormwater from Lincoln Street and the south side of Hill Street are intercepted by other catchbasins. No runoff was observed entering this catchbasin from the nearby auto dealer or repair shop during the sampling. Hill Street is lined with single family residences and small apartment buildings. From a cursory observation, the land use draining to this site may appear to be mostly commercial, but in fact is virtually 100% mixed residential. The drainage area is approximately 190,000 sq. ft.

At the curb-face inlet opening of each catchbasin, grab samples of storm runoff were collected from the street surface using a polypropylene scoop, and then transferred to 1-L and 4-L amber glass bottles. The bottles were transported to the UCLA laboratory immediately after collection and were refrigerated until analyzed. The scoop was pressed against the pavement during sampling to capture suspended solids. For selected storms, multiple grab samples were collected.

A summary of the sampling dates, times, and sample types is presented in Table 2-1. The rainfall amounts are also shown in Table 2-1. The rain gauge at UCLA was the closest recording gauge to the field sites. The total amount of rainfall for each sampled storm event is reported, rather than the daily amount. The first sampled storm was also the first storm of the year, representing the first flush of the season. Additionally, when it was possible, the first sample for each event was taken during the first-flush period of the storm. This is noted in the "comments" column.

### 2.1.2 Conventional Water Quality Analyses

Table 2-2 lists the conventional water quality parameters that were analyzed for the stormwater runoff samples. Procedures described in *Standard Methods* (1992) were used except for oil and grease analyses. The dissolved oil and grease content of stormwater runoff was analyzed using a modified C18 solid-phase extraction method described in Lau and Stenstrom (1997). Oil and grease on, that may have been attached to, the suspended solids would not be measured by this method. Usually there is more oil and grease associated with the solids than in the dissolved phase in stormwater. Oil and grease measured by this method is the maximum that could be removed by oil sorbents. Oil and grease adsorbed to solids, which is not measured by this analysis, must be removed by sedimentation or filtration.

## Table 2-1
## SUMMARY OF STORMWATER SAMPLING AND TESTING

| Storm Event No. | Date | Location | Time | Grab Sample No.[a] | Comments[b] |
|---|---|---|---|---|---|
| 1 | 9/25/97 | Site 1 | 12:45 | 1 | Low flow (Rainfall = 0.28 in) |
| | | Site 2 | 13:00 | 1 | Low flow |
| | | Site 3 | 13:15 | 1 | Low flow (liquid phase metals) |
| | | Site 4 | 13.30 | 1 | Low flow (liquid phase metals) |
| 2 | 11/10/97 | Site 1 | 11:00 | 1 | Very low flow (Rainfall = 0.67 in) (liquid phase metals) |
| | | Site 2 | 11:00 | 1 | Very low flow (liquid phase metals) |
| | | Site 3 | 11:10 | 1 | Low flow (liquid phase metals) |
| | | Site 4 | 11:15 | 1 | Moderate flow(liquid phase metals) |
| 3 | 11/13/97 | Site 1 | 08:40 | 1 | Moderate flow (Rainfall = 0.48 in) (all metals) |
| | | | 15:15 | 2 | Low flow |
| | | Site 2 | 08:45 | 1 | Moderate flow |
| | | | 15:15 | 2 | Low flow (all metals) |
| | | Site 3 | 09:00 | 1 | Moderate flow |
| | | | 15:30 | 2 | Low flow (all metals) |
| | | Site 4 | 09:15 | 1 | Moderate flow (all metals) |
| | | | 15:45 | 2 | Low flow |
| 4 | 11/26/97 | Site 1 | 08:50 | 1 | High flow (Rainfall = 0.72 in) (all metals) |
| | | Site 2 | 08:55 | 1 | High flow |
| | | Site 3 | 09:00 | 1 | High flow (all metals) |
| | | Site 4 | 09:05 | 1 | High flow(all metals) |
| 5 | 11/30/97 | Site 1 | 11:40 | 1 | Moderate flow (Rainfall = 1.12 in) (particulate phase metals) |
| | | Site 2 | 11:50 | 1 | Moderate flow(all metals) |
| | | Site 3 | 11:55 | 1 | High flow(all metals) |
| | | Site 4 | 12:00 | 1 | High flow(all metals) |
| 6 | 12/05/97 | Site 1 | 12:10 | 1 | First flush; moderate flow (Rainfall = 3.36) |
| | | | 17:45 | 2 | High flow |
| | 12/06/97 | | 03:00 | 3 | High flow |
| | 12/05/97 | Site 2 | 12:15 | 1 | First flush; moderate flow |
| | | | 17:50 | 2 | Peak flow |
| | 12/06/97 | | 03:05 | 3 | Peak flow |
| | 12/05/97 | Site 3 | 12:20 | 1 | First flush; high flow |
| | | | 17:55 | 2 | Peak flow |
| | 12/06/97 | | 03:10 | 3 | Peak flow |

## Table 2-1 (Continued)
## SUMMARY OF STORMWATER SAMPLING AND TESTING

| Storm Event No. | Date | Site | Time | Grab Sample No.[a] | Comments[b] |
|---|---|---|---|---|---|
| 6 (cont) | 12/05/97 | Site 4 | 12:25 | 1 | First flush; high flow |
| | | | 18:00 | 2 | Peak flow |
| | 12/06/97 | | 03:15 | 3 | Peak flow |
| 7 | 12/18/97 | Site 1 | 12:45 | 1 | Peak flow (Rainfall =0.95 in) |
| | | | 16:35 | 2 | Low flow |
| | | Site 2 | 12:50 | 1 | Peak flow |
| | | | 16:40 | 2 | Low flow |
| | | Site 3 | 12:55 | 1 | Peak flow |
| | | | 16:45 | 2 | Low flow |
| | | Site 4 | 13:00 | 1 | Peak flow |
| | | | 16:50 | 2 | Low flow |

[a] All samples were tested individually except where noted.

[b] Relative flow was based on visual observations. Rainfall data are from the UCLA gauge and are for the total storm.

## Table 2-2
## CONVENTIONAL WATER QUALITY ANALYSIS OF STORMWATER RUNOFF

| Parameter | Method/Instrument | Holding Time and Preservation |
|---|---|---|
| Total suspended solids (TSS), mg/L | 2540.D | 7 days; refrigerated at 4°C |
| Volatile suspended solids (VSS), mg/L | 2540.D | 7 days; refrigerated at 4°C |
| pH | — | Analyzed immediately |
| Turbidity | 2130.B; Hach Turbidimeter | 48 hours; refrigerated at 4°C |
| Conductivity | 2510.B; Fisherbrand™ Conductivity Meter | 28 days; refrigerated at 4°C |
| Alkalinity, mg/L as $CaCO_3$ | 2320.B | 14 days; refrigerated at 4°C |
| Hardness, mg/L as $CaCO_3$ | 2340.C | 6 months; acidified with $HNO_3$ to pH < 2 |
| Chemical oxygen demand (COD), mg/L | 5220.B | Analyzed as soon as possible |
| Dissolved organic carbon (DOC), mg/L | 5310 | 7 days; acidified with $H_3PO_4$ to pH < 2 and refrigerated at 4°C |
| Oil and Grease, mg/L | Lau and Stenstrom (1997) | 28 days; acidified with HCl to pH < 2 and refrigerated at 4°C |
| Ammonia, mg/L as $NH_3$-N | 4500-$NH_3$.F (Orion Model 9512) | Analyzed as soon as possible |
| Anions | Ion Chromatograph | 48 hours; refrigerated at 4°C |
| Nitrite, mg/L as $NO_2$-N | 4500 $NO_2$.B | 28 days; acidified with $H_2S0_4$ to pH<2 and refrigerated at 4°C |
| Chloride, mg/L | 4500 Cl.B | 28 days; refrigerated at 4°C |
| Nitrate, mg/L as $NO_3$-N | Dionex Series 4000 Ion | 28 days; acidified with $H_2S0_4$ to pH <2 and refrigerated at 4°C |
| Orthophosphate, mg/L as P | Chromatograph | 48 hours; refrigerated at 4°C |
| Sulfate, mg/L | 4500-$SO_4$ | 28 days; refrigerated at 4°C |

Anions (fluoride, nitrate, orthophosphate, and sulfate) were analyzed using a Dionex Series 4000 Ion Chromatograph. The ion chromatographic test apparatus included a gradient pump, a conductivity detector, and peak integrator. A 4 x 250 mm I.D. Dionex IonPac AS4 column was used. The eluent used was 1.7 mM sodium bicarbonate and 1.8 mM sodium carbonate solution, and was pumped isocratically through the column at a flow rate of 1.5 mL/min. The regenerant solution used was 0.025 N sulfuric acid. The eluted anions were detected at a suppressed mode at 13†µS.

### 2.1.3 Sample Filtration for Metals and Organic Analysis

All samples collected for organic analysis were stored at 4°C until filtered. Samples were filtered as soon as possible to minimize any alteration or redistribution of contaminants between the dissolved and aqueous phases. Whole water samples were filtered through 142 mm diameter, 0.7 µm pure glass (no binder) TCLP filters (MSI, Inc.). These filters are manufactured specifically to be extremely low in metal contaminants. In addition, they produce the lowest background concentration of organic impurities when used with subsequent supercritical fluid extraction (SCFE). Justification for the use of these filters, and the filter preparation and cleaning procedure are described in Capangapangan *et al.* (1996). The filters used for organic analyses were pre-cleaned by baking at 175° to 200°C overnight, then cooled to room temperature in a desiccator. The filters were then weighed to the nearest 0.1 mg, and placed in order into a glass Petri dish for storage. The filters for metals analyses were used directly from the box.

A stainless steel, Teflon-lined Millipore 142 mm diameter Hazardous Waste Filtration System with an integral 1.5-liter reservoir was used for filtration. The system was pressurized up to 100 psi by zero grade nitrogen. Between 2 and 4 liters of whole water sample were passed through each filter depending upon the suspended solids load. Samples were filtered in one-liter increments until the filter became clogged. A new filter was then used, and filtration resumed until each sample was consumed.

After each sample run was completed, the filtration apparatus was disassembled, and the filter was carefully removed, folded in half, then in quarter to enclose the solids, and placed into a pre-cleaned 125- or 250-ml glass jar with a Teflon-lined closure. The samples for metals analysis were stored at 4°C until digested. Filter blanks were prepared by filtering equal volumes of Milli-Q water through filters, and were then treated as actual samples in all subsequent procedures.

### 2.1.4 Sample Pretreatment

The acid digestion procedures used for filtered samples and suspended solids of wet-weather samples were based on EPA Methods 3120B and 3150B, respectively. Digested samples were then analyzed for trace metals using an inductively coupled plasma atomic emission (ICP-AE).

## 2.2 RESULTS AND DISCUSSION

### 2.2.1 Conventional Water Quality Analyses

Table 2-3 presents the water quality data for each storm water runoff sample (by storm event). Large differences in pollutant concentrations were noted among sites and among samples at a given site. Table 2-4 shows the average and standard deviations of water quality data by site. Site 1, which has the greatest vehicular activity, had the greatest concentrations of organic containing pollutants (e.g., COD, SPE oil and grease, and DOC). This finding is consistent with previous work by the authors for similar land uses. Exhaust emissions and crankcase drippings have been associated with higher concentrations of oil and grease in stormwater.

The magnitude of the parameters shown in Table 2-3 in some instances is comparable with other types of wastewaters. The COD values are generally greater than values commonly observed for treated sanitary wastewaters. The suspended solids level associated with Site 1 is greater than allowable for secondary treated wastewater. Other parameters such as conductivity, chlorides, nitrite, hardness and alkalinity are either not considered pollutants in wastewater or are much less than associated with most wastewaters.

In making comparisons to wastewaters and assessing the potential impacts of stormwater on the environment, additional considerations are important. For example, the composition of the oil and grease from Site 1 is probably quite different than from Sites 3 and 4. Site 1 would most likely contain anthropogenic (synthetic) materials such as refined and cracked petroleum products. Sites 3 and 4 probably contain more biogenic material. Although not always true, the anthropogenic material is usually more harmful to the environment than the biogenic material. Other parameters also vary by land use. For example, the suspended solids in the samples from Sites 3 and 4, which are mixed residential sites, were composed of more leaf and plant debris than the solids at Site 1, which is a vehicular activity site.

To facilitate the evaluation of suspended solids removal during the laboratory phase of testing of retrofits, additional sampling was performed after January 1, 1998, to evaluate the types and size fractions of solids in stormwater. Site 1 was selected because it had the greatest concentration of TSS and the composition of the solids represented constituents which are more desirable to remove than the more biogenic material at Sites 3 and 4. Screens (sieves) were used to filter samples before TSS and volatile suspended solids (VSS) analysis. The TSS and VSS were captured on 100 (0.150 mm), 200 (0.075 mm) and 325 mesh (0.045 mm) ASTM standard screens. Table 2-5 presents the results.

Table 2-5 shows the average size of the material that entered the Site 1 catchbasin. For example, on the average 9.8 mg/L of TSS that is greater than 325 mesh enters the Site 1 catchbasin. This compares to the entire TSS of 62 mg/L (Table 2-5). This suggests that an insert that could remove all suspended solids greater than 325 mesh or 0.045 mm (45 microns) might remove only one-sixth, or 16% of the entire TSS. Later work performed in this study quantified the efficiency for removing various size solids, as described in Section 4.

## Table 2-3
## WATER QUALITY RESULTS OF WET WEATHER RUNOFF FROM SEPTEMBER THROUGH DECEMBER 1997

| **Storm Event No.** | 1 | | | | 2 | | | | 3 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date** | **September 25, 1997** | | | | **November 10, 1997** | | | | **November 13, 1997** | | | | **November 13, 1997** | | | |
| **Time** | **12:45** | **13:00** | **13:20** | **13:35** | **11:00** | **11:00** | **11:10** | **11:15** | **8:45** | **13:00** | **13:20** | **13:35** | **11:00** | **11:00** | **11:10** | **11:15** |
| **Site** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** |
| TSS (mg/L) | 61.4 | 32.1 | 111 | 78 | 277 | 31.5 | 47.6 | 77.2 | 10.7 | 28 | 12.2 | 16.9 | 13.6 | 40.4 | 11.0 | 9.6 |
| VSS (mg/L) | 43.9 | 27.5 | 67.9 | 52 | 240 | 23.4 | 29.1 | 33.8 | 9.23 | 17.4 | 9.06 | 8.93 | 9.9 | 16.3 | 8.5 | 5 |
| Turbidity (NTU) | 74.5 | 22 | 29.4 | 35.5 | 19.2 | 31.3 | 19.1 | 30.9 | 23.5 | 26.6 | 14.2 | 17 | 9.8 | 3.9 | 6.3 | 7.2 |
| Conductivity (mmho/cm) | 314 | 519 | 374 | 453 | 728 | 387 | 502 | 460 | 137 | 116 | 257 | 157 | 94.6 | 88.9 | 233 | 144 |
| pH | 7.1 | 7.45 | 7.6 | 7.7 | 6.45 | 6.6 | 6.9 | 6.9 | 6.85 | 7.1 | 7.15 | 7 | 6.7 | 6.8 | 7.1 | 6.95 |
| Alkalinity (mg/L as $CaCO_3$) | 36 | 47 | 62 | 53 | 54 | 44 | 58 | 60 | 30 | 28 | 36 | 36 | 18 | 20 | 32 | 28 |
| Hardness (mg/L as $CaCO_3$) | 72 | 108 | 98 | 148 | 152 | 72 | 104 | 120 | 28 | 28 | 52 | 48 | 32 | 28 | 44 | 40 |
| COD (mg/L) | 354 | 387 | 387 | 323 | 512 | 69.8 | 186 | 395 | 144 | 91.7 | 128 | 114 | 53.5 | 65.1 | 74.4 | 74.4 |
| SPE Oil and Grease (mg/L) | 24.8 | 17.2 | 13.0 | 15.0 | 33.2 | 16.1 | 17.9 | 29.2 | 6.8 | 5.7 | 4.6 | 4.8 | 2.1 | 2.6 | 2.6 | 3.3 |
| Ammonia (mg/L as $NH_3$-N) | 1.88 | 2.30 | 1.89 | 2.30 | 3.16 | 2.15 | 4.64 | 2.61 | 1.78 | 1.21 | 2.61 | 1 | 1.47 | 0.68 | 3.16 | 1 |
| Chloride (mg/L) | 46.1 | 91.6 | 47.6 | 58.6 | 136 | 66.0 | 67.0 | 64.0 | 16..0 | 18.0 | 51.0 | 23 | 20.5 | 17.5 | 43 | 25 |
| DOC (mg/L) | 81.2 | 151 | 85.8 | 84.5 | 185 | 77.4 | 90.7 | 93.8 | 29.2 | 21.3 | 31.4 | 31.6 | 14.8 | 15.1 | 25 | 26 |
| Nitrite (mg/L as $NO_2$-N) | 0.277 | 0.249 | 0.373 | 0.332 | 0.332 | 0.396 | 1.451 | 0.46 | 0.428 | 0.396 | 0.588 | 0.473 | 0.236 | 0.205 | 0.396 | 0.256 |

## Table 2-3 (Continued)
## WATER QUALITY RESULTS OF WET WEATHER RUNOFF FROM SEPTEMBER THROUGH DECEMBER 1997

| Storm Event No. | 4 | | | | 5 | | | | 6 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | November 26, 1997 | | | | November 30, 1997 | | | | December 5, 1997 | | | | December 5, 1997 | | | |
| Time | 08:50 | 08:55 | 09:00 | 09:05 | 11:40 | 11:50 | 11:55 | 12:00 | 12:10 | 12:15 | 12:20 | 12:25 | 17:45 | 17:50 | 17:55 | 18:00 |
| Site | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| TSS (mg/L) | 39.1 | 96.5 | 33.8 | 10.9 | 22.1 | 22.7 | 21.5 | 23.5 | 128 | 118 | 99.7 | 139 | 33.2 | 33.2 | 27.0 | 10.4 |
| VSS (mg/L) | 20.6 | 39.8 | 16.1 | 9.22 | 15.6 | 14.8 | 16.9 | 16.3 | 63.8 | 55.2 | 46.3 | 58.1 | 16.4 | 21.6 | 9.00 | 4.85 |
| Turbidity (NTU) | 5.9 | 13.5 | 14.5 | 8.8 | 5.9 | 10.9 | 8.5 | 12.8 | 74.8 | 33.3 | 24.3 | 13.1 | 8.2 | 9.2 | 5.6 | 4.7 |
| Conductivity (mmho/cm) | 105 | 97.5 | 147 | 144 | 30 | 102 | 195 | 112 | 392 | 437 | 273 | 207 | 58.4 | 57.6 | 51.3 | 47.4 |
| pH | 6.6 | 6.95 | 7.2 | 6.95 | 6.7 | 6.95 | 7.25 | 7.3 | 5.5 | 6.6 | 6.25 | 6.4 | 6.1 | 6.65 | 6.2 | 6.4 |
| Alkalinity (mg/L as CaCO$_3$) | 14 | 17 | 22 | 24 | 10 | 18 | 28 | 28 | 26 | 40 | 40 | 30 | 12 | 14 | 11 | 12 |
| Hardness (mg/L as CaCO$_3$) | 32 | 30 | 30 | 38 | 16 | 28 | 45 | 19 | 106 | 110 | 76 | 70 | 18 | 22 | 14 | 16 |
| COD (mg/L) | 50.5 | 40 | 46.3 | 37.9 | 46.2 | 37.4 | 57.1 | 48.4 | 682 | 366 | 220 | 195 | 28.6 | 28.6 | 26.5 | 32.7 |
| SPE Oil and Grease (mg/L) | 1.8 | 1.6 | 7.3 | 2.2 | 0.73 | 1.4 | 2.9 | 1.9 | 13.3 | 11.7 | 9.0 | 7.2 | 2.1 | 2.3 | 0.73 | 1.2 |
| Ammonia (mg/L as NH$_3$-N) | 0.96 | 0.41 | 0.57 | 0.52 | 0.41 | 0.48 | 1.9 | 0.50 | 3.78 | 3.443 | 2.574 | 1.487 | 1.396 | 1.145 | 0.902 | 0.633 |
| Chloride (mg/L) | 23 | 21 | 21.5 | 23.5 | 5.5 | 15.5 | 21.5 | 10 | 64.0 | 72.0 | 40.0 | 30 | 8 | 8 | 6.75 | 5.5 |
| DOC (mg/L) | 12.8 | 9.01 | 13.4 | 18.6 | 4.63 | 10 | 19.1 | 13.7 | 141 | 98.5 | 50.4 | 41.1 | 6.93 | 7.03 | 5.63 | 6.53 |
| Nitrite (mg/L as NO$_2$-N) | 0.045 | 0.026 | 0.048 | 0.037 | 0.027 | 0.067 | 0.144 | 0.102 | 0.426 | 0.387 | 0.506 | 0.182 | 0.072 | 0.06 | 0.048 | 0.048 |

## Table 2-3 (Continued)
## WATER QUALITY RESULTS OF WET WEATHER RUNOFF FROM SEPTEMBER THROUGH DECEMBER 1997

| Storm Event No. | 6 | | | | 7 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | December 6, 1997 | | | | December 18, 1997 | | | | December 18, 1997 | | | |
| Time | 03:00 | 03:05 | 03:10 | 03:15 | 12:45 | 12:50 | 12:55 | 13:00 | 16:35 | 16:40 | 16:45 | 16:50 |
| Site | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| TSS (mg/L) | 6.7 | 3.5 | 5.7 | 3.7 | 52.9 | 24.2 | 29.6 | 32.1 | 37.7 | 31.8 | 16.9 | 20.5 |
| VSS (mg/L) | 4.2 | 2.07 | 2.7 | 1.34 | 31.4 | 13.0 | 15.4 | 14.8 | 32.3 | 22.1 | 9.9 | 15.1 |
| Turbidity (NTU) | 2.9 | 3.4 | 3.2 | 3.4 | 7.4 | 4.8 | 7.5 | 4.2 | 34.8 | 26.8 | 12 | 17.9 |
| Conductivity (mmho/cm) | 21.9 | 31 | 47.7 | 45 | 22.1 | 28.8 | 30 | 27.5 | 48.1 | 113 | 91.2 | 79.6 |
| pH | 6.15 | 6.15 | 6.65 | 6.5 | 6.5 | 6.65 | 6.75 | 6.6 | 6.7 | 6.9 | 7.1 | 7.1 |
| Alkalinity (mg/L as $CaCO_3$) | 8 | 9 | 12 | 12 | 10 | 9 | 10 | 10 | 15 | 28 | 26 | 26 |
| Hardness (mg/L as $CaCO_3$) | 7 | 14 | 16 | 18 | 11 | 12 | 13 | 14 | 17 | 34 | 28 | 35 |
| COD (mg/L) | 18.4 | 18.4 | 14.3 | 10.2 | 95.6 | 55.6 | 55.6 | 64.4 | 68.9 | 82.2 | 44.4 | 62.2 |
| SPE Oil and Grease (mg/L) | 2.0 | 2.1 | 1.2 | 1.5 | 1.8 | 1.1 | 0.55 | 0.52 | 2.0 | 3.7 | 3.8 | 4.1 |
| Ammonia (mg/L as $NH_3$-N) | 0.523 | 0.344 | 0.585 | 0.347 | 0.413 | 0.225 | 0.238 | 0.234 | 0.386 | 0.256 | 0.793 | 0.236 |
| Chloride (mg/L) | 4 | 4.25 | 6.25 | 5 | 6 | 4.5 | 4.5 | 4.5 | 5.5 | 11 | 7.5 | 7 |
| DOC (mg/L) | 3.93 | 3.02 | 4.72 | 3.95 | 6.33 | 3.93 | 3.65 | 5.26 | 11.6 | 15.1 | 11 | 14 |
| Nitrite (mg/L as $NO_2$-N) | 0.009 | 0.019 | 0.024 | 0.029 | 0.026 | 0.026 | 0.024 | 0.02 | 0.093 | 0.1 | 0.136 | 0.109 |

### Table 2-4
### WATER QUALITY PARAMETER MEANS AND STANDARD DEVIATIONS OF ALL DATA BY SITE

| | Site 1 | | Site 2 | | Site 3 | | Site 4 | |
|---|---|---|---|---|---|---|---|---|
| | Vehicular Activity | | Light Commercial | | Mixed Residential | | Mixed Residential | |
| **Water Quality Parameter** | **Mean** | **Standard Dev** | **Mean** | **Standard Dev** | **Mean** | **Standard Dev** | **Mean** | **Standard Dev** |
| TSS (mg/L) | 62.0 | 78.9 | 42.0 | 34.0 | 37.8 | 35.5 | 38.3 | 42.2 |
| VSS (mg/L) | 44.3 | 67.2 | 23.0 | 14.2 | 21.0 | 19.7 | 19.9 | 19.4 |
| Turbidity (NTU) | 24.3 | 26.6 | 16.9 | 11.4 | 13.1 | 8.3 | 14.1 | 10.7 |
| Conductivity (mmho/cm) | 178 | 220 | 180 | 177 | 200 | 148 | 171 | 152 |
| pH | 6.5 | 0.4 | 6.8 | 0.3 | 6.9 | 0.4 | 6.9 | 0.4 |
| Alkalinity (mg/L as $CaCO_3$) | 21.2 | 14.2 | 24.9 | 13.6 | 30.6 | 17.6 | 29.0 | 16.0 |
| Hardness (mg/L as $CaCO_3$) | 44.6 | 46.3 | 44.2 | 35.6 | 47.3 | 32.5 | 51.5 | 44.5 |
| COD (mg/L) | 187 | 227 | 113 | 132 | 113 | 112 | 123 | 127 |
| SPE Oil and Grease (mg/L) | 8.2 | 11.0 | 5.9 | 6.1 | 5.8 | 5.6 | 6.4 | 8.6 |
| Ammonia (mg/L as $NH_3$-N) | 1.5 | 1.1 | 1.2 | 1.1 | 1.8 | 1.4 | 1.0 | 0.8 |
| Chloride (mg/L) | 30.4 | 39.9 | 30.1 | 31.2 | 28.8 | 21.9 | 23.3 | 21.0 |
| Nitrate (mg/L as $NO_2$-N) | 0.18 | 0.16 | 0.18 | 0.16 | 0.34 | 0.42 | 0.19 | 0.17 |
| DOC (mg/L) | 45.2 | 63.0 | 37.4 | 49.3 | 31.0 | 31.5 | 30.8 | 31.1 |

### Table 2-5
### SIEVE ANALYSIS OF SUSPENDED SOLIDS FROM SITE 1

| Sampling Date | Rainfall (in.) | TSS (mg/L) | | | | | VSS (mg/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Particle Diameter | | | | | Mesh Size | | | |
| | | >150µm | 150-74µm | 75-45µm | <45µm | Total | >100 | 100/200 | 200/325 | >325 |
| 1/4/98 | 0.42 | 6.41 | 3 | 2.87 | 12.3 | 24.58 | 3.88 | 0.76 | 1.01 | 5.7 |
| 1/19/98 | 0.25 | 3.71 | 2.47 | 2.16 | 8.3 | 16.64 | 2.02 | 1.08 | 0.58 | 3.7 |
| 2/14/98 | 2.53 | 5.26 | 1.92 | 1.62 | 8.8 | 17.6 | 1.73 | 0.55 | 0.64 | 2.9 |
| AVERAGE" | | 5.13 | 2.46 | 2.22 | 9.8 | 19.61 | 2.54 | 0.80 | 0.74 | 4.1 |

## 2.2.2 Metals Analysis

Table 2-6 shows the average and standard deviations of the metals concentration data. Figure A-1 (Appendix A) shows the average, total metals concentration by site. The soluble metal concentration is reported and noted in the table headings. Concentration data for particulate-phase metals (i.e., metals adsorbed to particles) can be reported in two ways. The first is a total liquid concentration (units of mg/L); this is calculated as the total mass of metals recovered, divided by the total volume of water filtered. The second method is a solid-phase concentration, which is reported as the mass of recovered metals divided by the TSS mass. Table 2-6 shows the soluble and particle-phase concentrations. The total concentrations (i.e., the sum of the two concentrations based upon liquid volume) are reported along with the percent that are adsorbed to particles. The tables in Appendix A show all the metals results by storm and site. Metals concentrations as mg of metal per unit particle mass (mg/Kg) are also reported in this table. For some samples, the column is blank. This results because the TSS was too low to quantify even though the ICP can detect metals desorbed form the particles' surfaces. The ICP is much more sensitive that the balance used to weight the filtrate. In some cases, very soluble metals were found in the particulate phase (e.g., sodium). This probably results because of precipitated metals, as opposed to adsorption to the surface of particulates.

Table 2-6 also shows the percent of the total metals that are adsorbed to particles (TTS). This calculation was performed by averaging all soluble phase and particle phase concentrations measured during the study, then determining the percentage. Alternate methods for calculation are also possible, such as restricting the averaging samples from each storm. All data are present in Appendix A, which can be used for alternate calculation procedures, if desired. The blanks in Table 2-6 indicate that samples were not collected, or that too few data were collected to obtain standard deviation. When the concentration was below detection limits, the value was indicated as "<DL" or less than the detection limit.

## 2.3 CONCLUSIONS

The goal of the sampling program was to characterize the pollutants in stormwater runoff entering catchbasins in the study area and the potential for inserts to remove them. This section describes the average concentrations of key constituents such as TSS and oil and grease, that are found in the runoff entering four catchbasins in the study area.

The results lead to the following conclusions:

1. Water quality from the vehicular land use site was generally poorer (i.e., had higher pollutant concentrations) than water quality from the residential land use sites. This is consistent with previous studies that evaluated runoff from various land uses.
2. The average soluble and free oil and grease concentrations ranged from 5 to 8 mg/L for the four sites. These concentrations do not include the oil adsorbed to the surface of suspended solids. In previous studies, the soluble and free oil and grease have been found to average only 10 to 30% of the total oil and grease. Free oil and grease is the form of oil and grease that is most easily removed by devices of interest in this study, such as separators or sorbers. It is important for the reader to understand that many of the sorbers (i.e., adsorption media, absorption media, and various devices that employ such media) that are promoted commercially advertise their effectiveness using tests based on oil and grease concentrations

## Table 2-6
## AVERAGE AND TOTAL METALS CONCENTRATION

| | Site 1 | | | | | | Site 2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soluble Phase | | Particulate Phase | | | % | Soluble Phase | | Particulate Phase | | | % |
| Metal | Avg | SD | Avg | SD | Total | Particulate | Avg | SD | Avg | SD | Total | Particulate |
| Aluminum | 89.04 | 86.73 | 2145.61 | 2300.82 | 2234.65 | 96.02 | 99.08 | 61.05 | 1042.04 | | 1141.13 | 91.32 |
| Antimony | 10.00 | 0.00 | 2.80 | 2.46 | 12.80 | 21.88 | 10.00 | 0.00 | 0.55 | | 10.55 | 5.19 |
| Arsenic | 2.97 | 1.12 | 2.00 | 0.87 | 4.97 | 40.26 | 1.57 | 1.42 | 1.50 | | 3.07 | 48.86 |
| Barium | 294.84 | 483.95 | | | 294.84 | 0.00 | 178.88 | 158.03 | | | 178.88 | 0.00 |
| Beryllium | 1.00 | 0.00 | 1.00 | 0.43 | 2.00 | 50.00 | 1.00 | 0.00 | 0.75 | | 1.75 | 42.86 |
| Boron | 193.90 | 314.94 | 1187.02 | 409.00 | 1380.92 | 85.96 | 134.14 | 111.79 | 1272.95 | | 1407.10 | 90.47 |
| Cadmium | 0.78 | 0.87 | 2.12 | 3.31 | 2.90 | 73.07 | 1.23 | 1.45 | 0.29 | | 1.51 | 18.84 |
| Calcium | 12.52 | 15.08 | 3540.00 | 2391.12 | 3552.52 | 99.65 | 8.48 | 7.25 | 570.00 | | 578.48 | 98.53 |
| Chromium | 2.10 | 1.25 | 7.81 | 8.26 | 9.91 | 78.77 | 1.29 | 0.49 | 2.12 | | 3.41 | 62.21 |
| Cobalt | 3.07 | 3.60 | 0.91 | 1.55 | 3.98 | 22.87 | 1.36 | 1.18 | 0.02 | | 1.38 | 1.09 |
| Copper | 47.69 | 42.15 | 54.82 | 88.12 | 102.50 | 53.48 | 39.67 | 39.33 | 2.48 | | 42.14 | 5.87 |
| Iron | 536.92 | 856.49 | 21.17 | 32.62 | 558.08 | 3.79 | 154.79 | 121.56 | 1.53 | | 156.32 | 0.98 |
| Lanthanum | 5.00 | 0.00 | 0.86 | 0.98 | 5.86 | 14.60 | 5.00 | 0.00 | 0.34 | | 5.34 | 6.32 |
| Lead | 3.24 | 2.99 | 41.67 | 68.62 | 44.90 | 92.79 | 2.65 | 1.19 | 1.31 | | 3.96 | 33.11 |
| Magnesium | 5.19 | 5.61 | 735.00 | 1044.43 | 740.19 | 99.30 | 2.66 | 2.64 | 68.25 | | 70.91 | 96.25 |
| Manganese | 123.14 | 159.15 | 47.88 | 77.49 | 171.02 | 28.00 | 55.80 | 75.97 | 2.56 | | 58.35 | 4.38 |
| Molybdenum | 1.53 | 0.63 | 2.81 | 2.71 | 4.34 | 64.78 | 1.03 | 0.07 | 1.04 | | 2.08 | 50.24 |
| Nickel | 12.60 | 14.19 | 62.45 | 103.49 | 75.05 | 83.21 | 9.32 | 8.41 | 14.36 | | 23.68 | 60.63 |
| Phosphorous | 1308.80 | 1227.87 | 181.53 | 286.34 | 1490.33 | 12.18 | 467.38 | 322.70 | 9.87 | | 477.25 | 2.07 |
| Potassium | 8.66 | 8.74 | 1310.00 | 832.25 | 1318.66 | 99.34 | 4.10 | 2.74 | 941.25 | | 945.35 | 99.57 |
| Selenium | 10.00 | 0.00 | 2.20 | 2.11 | 12.20 | 18.03 | 10.00 | 0.00 | 0.89 | | 10.89 | 8.13 |
| Silicon | 1.10 | 0.33 | | | 1.10 | 0.00 | 0.94 | 0.30 | | | 0.94 | 0.00 |
| Sodium | 34.66 | 39.10 | 2430.00 | 745.94 | 2464.66 | 98.59 | 19.66 | 18.80 | 2692.50 | | 2712.16 | 99.28 |
| Tin | | | 2.38 | 1.81 | 2.38 | 100.00 | | | 1.24 | | 1.24 | 100.00 |
| Vanadium | 4.05 | 3.34 | 1.00 | 0.43 | 5.05 | 19.81 | 3.48 | 3.01 | 0.75 | | 4.23 | 17.73 |
| Zinc | 783.31 | 963.50 | 1817.53 | 1261.60 | 2600.83 | 69.88 | 761.12 | 866.67 | 1300.47 | | 2061.59 | 63.08 |

* all concentrations are in ug/L

SD: Standard deviation

## Table 2-6 (Continued)
## AVERAGE AND TOTAL METALS CONCENTRATION

| | Site 3 | | | | | | Site 4 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soluble Phase | | Particulate Phase | | | % | Soluble Phase | | Particulate Phase | | | % |
| Metal | Avg | SD | Avg | SD | Total | Particulate | Avg | SD | Avg | SD | Total | Particulate |
| Aluminum | 123.69 | 57.57 | 1211.21 | 621.03 | 1334.90 | 90.73 | 165.03 | 74.03 | 513.05 | 65.45 | 678.07 | 75.66 |
| Antimony | 10.00 | 0.00 | 1.49 | 1.75 | 11.49 | 12.97 | 10.00 | 0.00 | 1.03 | 0.15 | 11.03 | 9.30 |
| Arsenic | 3.31 | 1.38 | 2.00 | 0.87 | 5.31 | 37.68 | 2.33 | 1.42 | 1.50 | 0.00 | 3.83 | 39.16 |
| Barium | 353.74 | 398.72 | | | 353.74 | 0.00 | 251.29 | 210.11 | | | 251.29 | 0.00 |
| Beryllium | 1.00 | 0.00 | 1.00 | 0.43 | 2.00 | 50.00 | 1.00 | 0.00 | 0.75 | 0.00 | 1.75 | 42.86 |
| Boron | 375.08 | 342.86 | 1645.21 | 657.96 | 2020.29 | 81.43 | 242.34 | 244.13 | 710.19 | 180.73 | 952.53 | 74.56 |
| Cadmium | 0.52 | 0.20 | 0.29 | 0.20 | 0.81 | 35.92 | 1.15 | 1.48 | 0.35 | 0.20 | 1.50 | 23.31 |
| Calcium | 15.66 | 8.81 | 1030.00 | 617.98 | 1045.66 | 98.50 | 19.56 | 14.67 | 915.00 | 833.55 | 934.56 | 97.91 |
| Chromium | 1.59 | 0.46 | 6.40 | 7.10 | 7.98 | 80.11 | 2.47 | 0.84 | 4.37 | 1.47 | 6.84 | 63.84 |
| Cobalt | 1.58 | 1.29 | 0.02 | 0.01 | 1.60 | 1.25 | 4.87 | 3.70 | 0.02 | 0.00 | 4.89 | 0.31 |
| Copper | 47.38 | 33.84 | 4.19 | 2.74 | 51.57 | 8.12 | 35.20 | 20.91 | 4.46 | 3.81 | 39.66 | 11.24 |
| Iron | 243.01 | 186.92 | 3.54 | 3.18 | 246.54 | 1.43 | 197.91 | 86.30 | 2.95 | 0.81 | 200.86 | 1.47 |
| Lanthanum | 5.00 | 0.00 | 0.34 | 0.16 | 5.34 | 6.28 | 5.00 | 0.00 | 0.22 | 0.10 | 5.22 | 4.21 |
| Lead | 3.88 | 2.64 | 3.33 | 2.97 | 7.20 | 46.17 | 9.14 | 3.63 | 1.92 | 0.85 | 11.05 | 17.32 |
| Magnesium | 5.49 | 3.27 | 99.00 | 49.93 | 104.49 | 94.74 | 4.74 | 3.70 | 78.00 | 17.30 | 82.74 | 94.27 |
| Manganese | 74.18 | 80.93 | 4.68 | 3.46 | 78.86 | 5.93 | 220.03 | 374.83 | 8.02 | 6.84 | 228.05 | 3.52 |
| Molybdenum | 1.15 | 0.36 | 1.99 | 1.91 | 3.13 | 63.35 | 1.00 | 0.00 | 1.89 | 0.51 | 2.89 | 65.40 |
| Nickel | 16.76 | 12.35 | 21.21 | 32.67 | 37.96 | 55.86 | 11.55 | 9.78 | 27.72 | 39.97 | 39.27 | 70.59 |
| Phosphorous | 1571.96 | 956.26 | 17.78 | 11.97 | 1589.74 | 1.12 | 897.69 | 566.16 | 16.45 | 3.89 | 914.14 | 1.80 |
| Potassium | 12.64 | 7.93 | 1170.50 | 464.83 | 1183.14 | 98.93 | 6.45 | 3.05 | 678.00 | 193.57 | 684.45 | 99.06 |
| Selenium | 10.00 | 0.00 | 1.54 | 1.19 | 11.54 | 13.31 | 10.00 | 0.00 | 1.23 | 0.41 | 11.23 | 10.91 |
| Silicon | 1.89 | 1.00 | | | 1.89 | 0.00 | 2.59 | 1.17 | | | 2.59 | 0.00 |
| Sodium | 28.53 | 14.67 | 3425.00 | 1232.04 | 3453.53 | 99.17 | 24.45 | 19.41 | 1495.00 | 606.40 | 1519.45 | 98.39 |
| Tin | | | 1.61 | 0.89 | 1.61 | 100.00 | | | 1.23 | 0.23 | 1.23 | 100.00 |
| Vanadium | 5.62 | 3.99 | 1.00 | 0.43 | 6.62 | 15.11 | 4.66 | 2.46 | 0.75 | 0.00 | 5.41 | 13.87 |
| Zinc | 625.58 | 426.62 | 1751.65 | 680.26 | 2377.22 | 73.68 | 391.83 | 237.64 | 928.71 | 176.27 | 1320.54 | 70.33 |

* all concentrations are in ug/L

SD: Standard deviation

in the thousands (0.1%) or ten thousands (1%) mg/L. It should be clear that results using these very high concentrations are not applicable to average stormwater runoff from the land uses evaluated in this study. To evaluate sorbers for use in the study area, the sorber media and/or devices should be tested at concentrations in the 10 to 35 mg/L range. Although this range is higher than that typically observed in urban runoff from residential areas, concentrations of oil in runoff from commercial and industrial areas may be higher.

3. The storms evaluated early in this study (and earlier in the wet-weather season) were found to have higher concentrations of organic materials (i.e., COD, TOC and oil and grease) than did the later storms. This suggests a potential seasonal first flush effect.
4. Suspended solids from the highest source land use were typically smaller than 325 mesh (0.045 mm or 45 microns). The concentrations of suspended solids that were retained on screens averaged 9 mg/L. The concentrations of suspended solids collected in the earlier testing program that were retained on a 1 micron filter averaged 62 mg/L.

The actual testing program consisted of two parts: field studies and lab testing, as planned in Task 3 and described in Section 3. The field study program was conducted to observe the performance of the dry-weather retrofit devices, the simplest wet-weather retrofit devices, and plain (i.e., not retrofitted) catchbasins (used as experimental controls). The laboratory program was developed to test the more complex wet-weather devices. Field studies were not performed on the complex wet-weather devices because controlled, repeatable experiments could not be performed in the field. It would be particularly difficult to sample the effluent from an existing catchbasin in the field, because it would be necessary to collect samples from below the concrete bottom of the catchbasin chambers or at some location downstream of the catchbasin. Also the installation of some of the wet-weather retrofit devices would have required a budget well beyond the scope of this pilot project.

## 4.1 FIELD STUDIES

### 4.1.1 Selection of the Field Study Sites

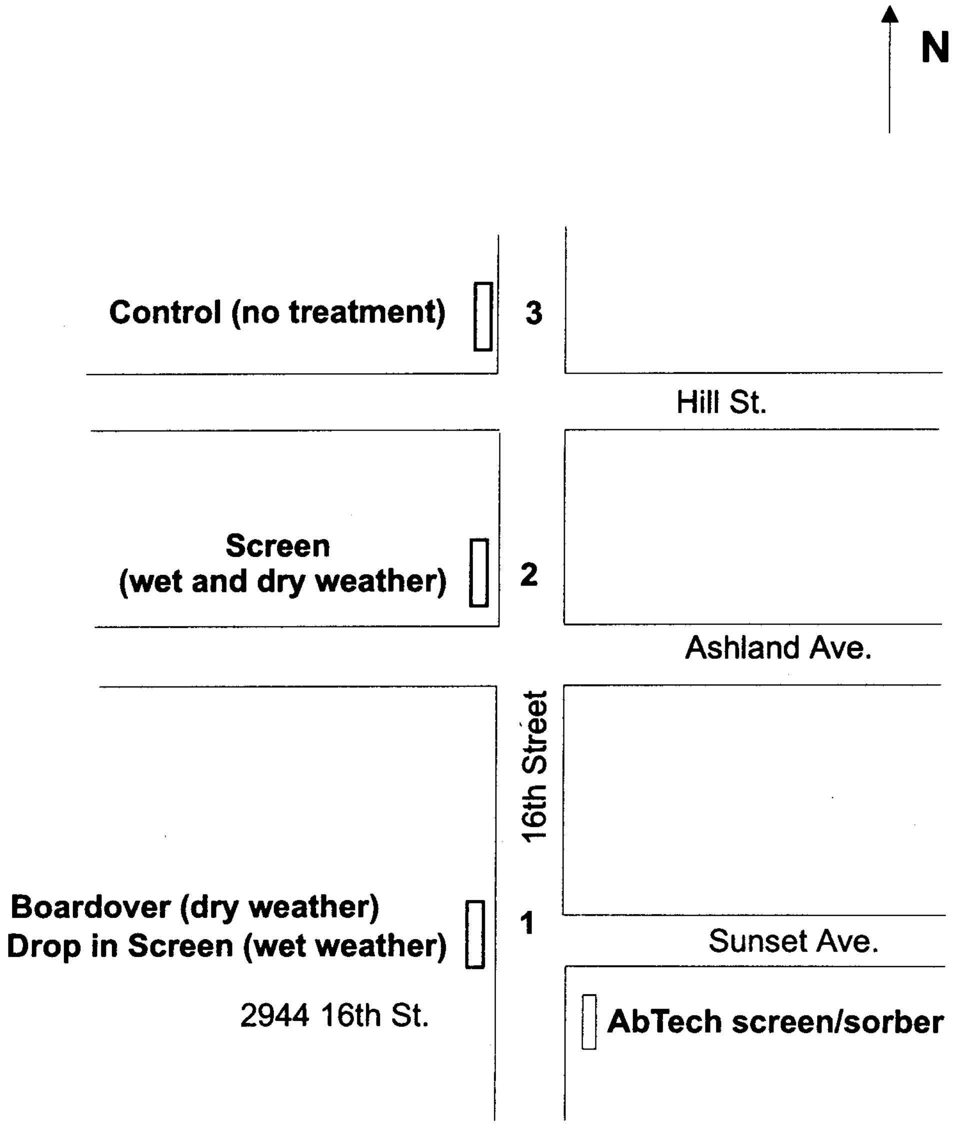
Sites were selected for conducting the dry- and wet-weather field studies. The original intention was to use the same sites that had been used for collecting urban runoff samples (i.e., Sites 1 through 4, described in Section 2), but it was found that the time required to obtain permits to install the retrofits would have been prohibitive. Therefore, existing representative catchbasins owned by the City of Santa Monica were selected as the sites for studying retrofits and controls.

Two general areas within Santa Monica were identified: Sunset Park and the Third Street Promenade. The Sunset Park area was chosen as a representative area for residential land use. This area has almost exclusively single-family residences. The area is also hilly and afforded an opportunity to observe the retrofits in flowing conditions. Figure 4-1 shows three selected Sunset Park catchbasin sites. Drainage is generally from north to south (i.e., from top to bottom on the figure).

The Third Street Promenade is a highly commercialized area that contains many restaurants, theaters, and stores. Pedestrian traffic (both tourists and locals) here is among the greatest in any part of the Los Angeles area. On weekends there are street vendors and performers, and it is sometimes difficult to walk through the area because of the congestion. Also, many homeless people live in this area. The area is known to have unusually high litter generation areas. Figure 4-2 shows four selected catchbasin sites.

Also shown on Figures 4-1 and 4-2 are the sites where the AbTech screen/sorbers were studied. The manufacturer provided these devices at no expense to the pilot project. The prototypes studied in the field comprised of a front screen and a wire mesh basket that hung down inside the catchbasin chamber. In dry weather, the baskets would function as debris traps. In wet weather, the hanging baskets could be filled with an oil sorbent.

A vertical screen panel was placed over the curb inlet opening of the catchbasin at Site 4. The inlet screen panel was identical to the one used in the Sunset Park area, except that it was shorter in order to fit the smaller inlet opening. The catchbasin at Site 5 was used without any



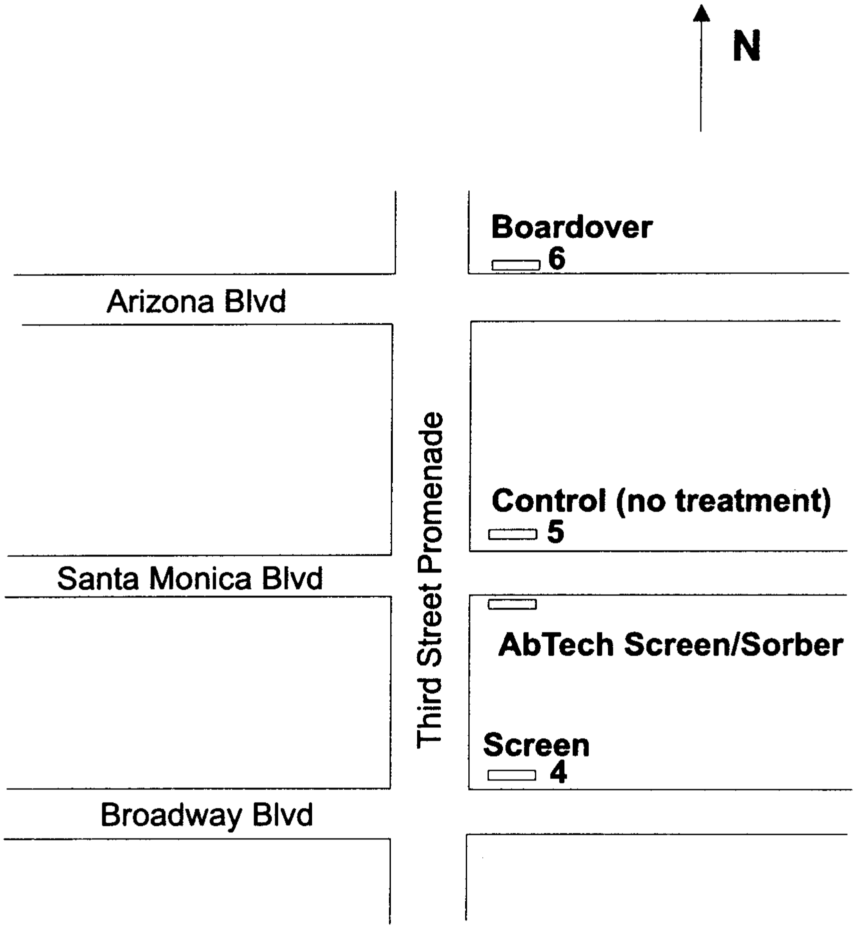
1 Test catchbasin location

NOT TO SCALE

**SUNSET PARK TEST CATCHBASIN LOCATIONS**

| | | | | |
|---|---|---|---|---|
| DRAWN BY: CM | CHECKED BY: | PROJECT NO: 9653001F-5000 | DATE: 7-22-98 | FIGURE NO: 4-1 |

**Woodward-Clyde**



1 Test catchbasin location

NOT TO SCALE

**THIRD STREET PROMENADE TEST CATCHBASIN LOCATIONS**

| | | | | |
|---|---|---|---|---|
| DRAWN BY: CM | CHECKED BY: | PROJECT NO: 9653001F-5000 | DATE: 7-22-98 | FIGURE NO: 4-2 |

Woodward-Clyde

modifications or retrofits, as an experimental control. It was necessary to remove the boardover that the City of Santa Monica routinely installs to cover these and other catchbasins during the summer months. The boardover at Site 6 was retained.

The experimental designs for the Sunset Park and Third Street Promenade study sites were parallel, in that both areas had controls, boardovers, and inlet screen panels. The devices were observed from October to December 1997. The experimental design and specifics of the retrofits were reviewed with City of Santa Monica personnel on September 2, 1997. The inlet screen panels and boardovers were delivered to the City of Santa Monica personnel one week later and were installed at the selected locations between September 15 and 18, 1997.

### 4.1.2 Dry-Weather Field Studies

The object of the dry-weather field studies was to evaluate different devices that could be used to reduce the amount of debris that would otherwise enter the catchbasins during the dry season (approximately April to October for Southern California). During this period, very large amounts of trash and debris can enter catchbasins and create a nuisance or other problems. In some areas, the amounts that enter during dry weather greatly exceed the amounts that are carried in during storm events. Therefore, dry-weather controls can be as important as storm water controls.

Cities and other agencies need to have cleaning programs to address the accumulation of material during dry-weather. The accumulated dry-weather material can create odor or public health problems under certain conditions. For example, if dry-weather flow (e.g., water from landscape irrigation, car washing, sidewalk washing) enters the catchbasin, the accumulated material, can get wet and then biodegrade and create odor, vector, and/or bacterial problems.

In developing the field study program, interviews were conducted with personnel from the City of Santa Monica. In these interviews, workers described cleaning problems and the value of using boardovers to cover catchbasins during the dry season. They noted that in some areas they receive complaints from landowners near the catchbasins about odors and pests (e.g.,flies).

To avoid these problems, the City of Santa Monica implemented a program of placing wooden boards (e.g., "boardovers") over the inlets of catchbasins in sensitive locations. Boards are cut to fit each specific inlet opening and anchored to the front of the catchbasins with bolts set into the concrete curb. The City removes the boards prior to the rainy season, and they have an emergency response plan in the event of an unexpected early rain.

For these field studies, boardovers were prepared and installed at Site 1 in the Sunset Park area (see Figure 4-1) and at Site 6 in the Third Street Promenade area. The Sunset Park boardover was constructed by the consultant team, installed by the City of Santa Monica personnel, and removed by the team after the first light rains occurred. A ¾-inch thick plywood panel was trimmed to physically block the curb inlet opening of the catchbasin. A small clearance (averaging ½-inch) was left below the panel to allow nuisance water to flow into the catchbasin during dry weather. The boardover was secured at each end by bolting to the curb (concrete anchors were fastened into the curb face to accept 3/8 inch-diameter bolts).

The boardover used in the Third Street Promenade area was a part of the City of Santa Monica's normal program. It was installed by the City prior to the field study and was removed when the STET other boardovers were removed.

As an alternative to plywood boards, vertical screen panels were evaluated. When installed over a catchbasin's curb inlet opening, a screen panel can provide a compromise between a solid boardover, which will block virtually all flow, and a completely open catchbasin. The concept of the vertical screen panel is the same as the boardover (i.e., they both function by keeping large particles of litter and debris from entering the catchbasin), except that a vertical screen panel will allow greater flows to enter in the event of an unexpected rain. Some cities and agencies which are unwilling to take the risk of occasional flooding associated with solid boardovers may be willing to use vertical screen panels.

The vertical screen panels were observed in wet-weather and were left in place during the entire rainy season. This was done not because the team recommends using vertical screen panels in wet-weather, but to assess the vertical screen panel's potential for creating flooding problems. At various times during project meetings, Consortium members commented that the vertical screen panels could not be tolerated in wet-weather. It is important to note that our observation of vertical screen panels during wet-weather is not a proposal to use them in wet-weather, but only to assess their potential impact if they were to be accidentally left in place during a storm event.

The vertical screen panel installed at Site 2 in the Sunset Park area (see Figure 4-1) was made from 1-inch square mesh with $^1/_8$-inch diameter wires. A 1-inch angle iron was used to stiffen the bottom. The horizontal part of the angle was turned inward, toward the catchbasin, and trimmed on the ends to avoid striking the curb. The top of the screen was secured by a strip of 1-inch wide sheet metal. The screen was welded to the sheet metal and the angle iron to keep the wires from spreading. The ends were secured with sheet metal and bolted to the curbface in a fashion similar to the boardover. A gap (averaging ½-inch) was left along the bottom to allow nuisance water to enter the catchbasin. A similar vertical screen panel was installed at Site 4 in the Third Street Promenade area (see Figure 4-2).

The catchbasins were cleaned prior to the installation of the boardovers. The boardovers and vertical screen panels were observed on a weekly basis. No quantitative measurements were made until the end of the dry-weather field study period. Experimental controls, which consisted of catchbasins that had been pre-cleaned, but had no boardovers, screen panels or other treatment, were located near the experimental catchbasins. The sites are shown on Figures 4-1 and 4-2. They were compared to the catchbasins that were fitted with boardovers or vertical screen panels. On October 25, after approximately 6 weeks of service, the following observations were made.

### *Boardover, Sunset Park Area (Site 1)*

Material had accumulated in front of the boardover, as shown in Figure 4-3. The boardover, which had been constructed of interior-grade plywood was slightly warped. The inside of the catchbasin chamber was relatively clean, as shown in Figure 4-4, except for light organic material that had apparently been carried in by nuisance water (under the edge of the boardover).

FIGURE 4-3.
BOARDOVER AT CATCHBASIN IN RESIDENTIAL AREA (SUNSET PARK AREA, SITE 1).

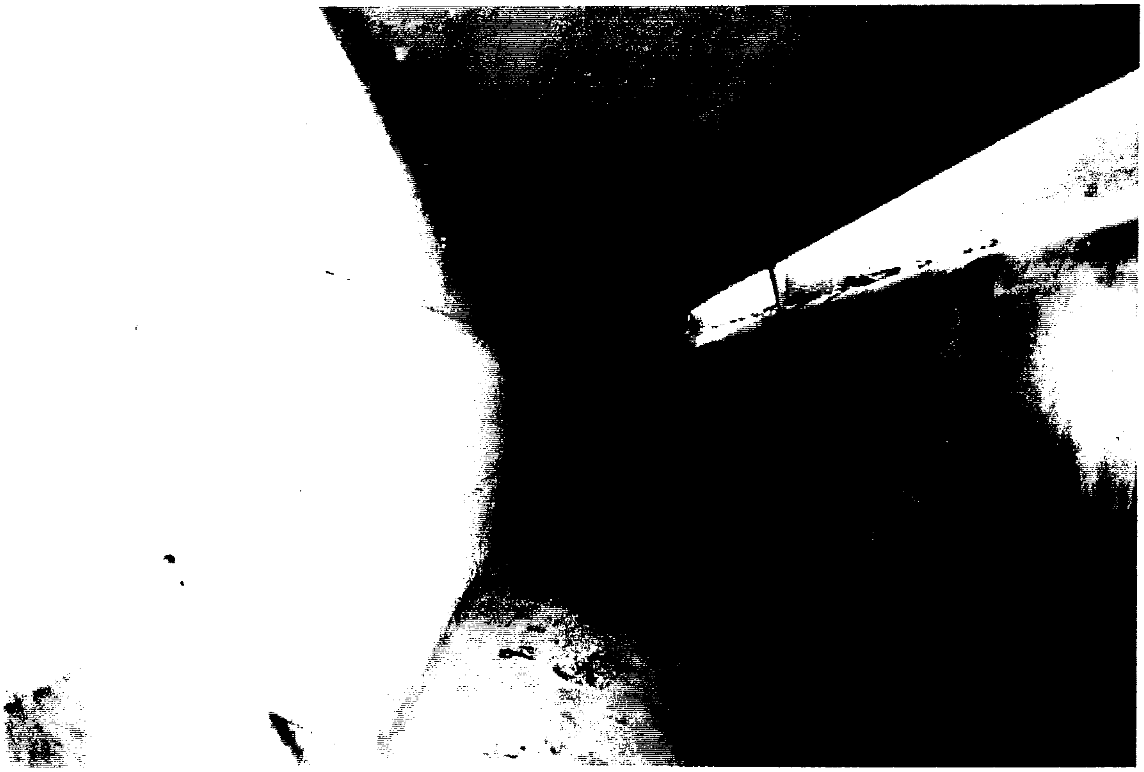


FIGURE 4-4.
INSIDE VIEW OF CATCHBASIN THAT HAD BOARDOVER (SUNSET PARK AREA, SITE 1).

No odors or other problems were noted. No quantitative assessment was made regarding the amount of material inside the chamber.

### *Inlet Screen Panel, Sunset Park Area (Site 2)*

Figure 4-5 shows a close-up of the front of the inlet screen panel. The anchor bolt is visible on the right. Light corrosion is also visible (in a permanent installation, a coating should be applied to protect the screen). Figure 4-6 shows the inside of the catchbasin chamber. This picture was taken through the manhole opening with a special camera lens (called a "fisheye" lens) that photographs a full 180° hemisphere; therefore the entire bottom of the chamber and the walls are visible.

A single Styrofoam "popcorn" pellet, one AA battery, and a few small pieces of leaves were all that were observed in the chamber. There were many spider webs in this, and in other catchbasins. The outlet from the catchbasin chamber (i.e., the piped connection that discharges to the down-gradient storm drain system) can be seen on the right, which is the lower end of the chamber. The red color resulted from spray painting the outside of the panel (residents in the area had asked the City to paint the board and screen to make them less obvious). No quantitative analysis of the debris was performed because of the negligible amount present.

This screen-panel retrofit was also observed during wet-weather. Figure 4-7 shows the screen during active rainfall. Note that a significant volume of water was running down the gutter and bypassing the catchbasin inlet.

### *Control Catchbasin, Sunset Park Area (Site 3)*

Site 3 at Sunset Park was a catchbasin that had not been equipped with either a boardover or a vertical screen panel, so it could function as an experimental control (i.e., was left open to debris accumulation during the period of observation). The effect of nuisance water was visible. There was a mound of trapped debris (e.g., organic material, leaves) in front of the catchbasin. Figure 4-8 shows the accumulated material. Approximately 40% of the chamber bottom can be seen in the photograph. The remainder of the chamber bottom was covered with leaves and debris. Specific items included: small leaves and parts of leaves, candy wrappers, a potato chip bag, a plastic food wrapping, door knob advertisements (someone had tossed about 20 into the basin), a restaurant menu, one cigarette butt, some sediment and dust (some of which could have been from before testing began, since even a thorough cleaning does not remove all dust and sediment), and numerous spider webs.

The material was removed on November 5, 1997, with the assistance of personnel from the City of Santa Monica. Approximately 3 $ft^3$ of leaves and light material (fluff) were collected. The smaller material was screened and weighed at UCLA. Table 4-1 shows the results. Only 3.2% of the material was found to be small enough to pass through a 325 mesh sieve.

Special sieves were used to determine the particle size distribution of the material collected from the catchbasin chamber. It should be noted that the dimensions of the sieve openings used here are not exactly the same as those on ASTM standard (Tyler) screens. The special sieves were

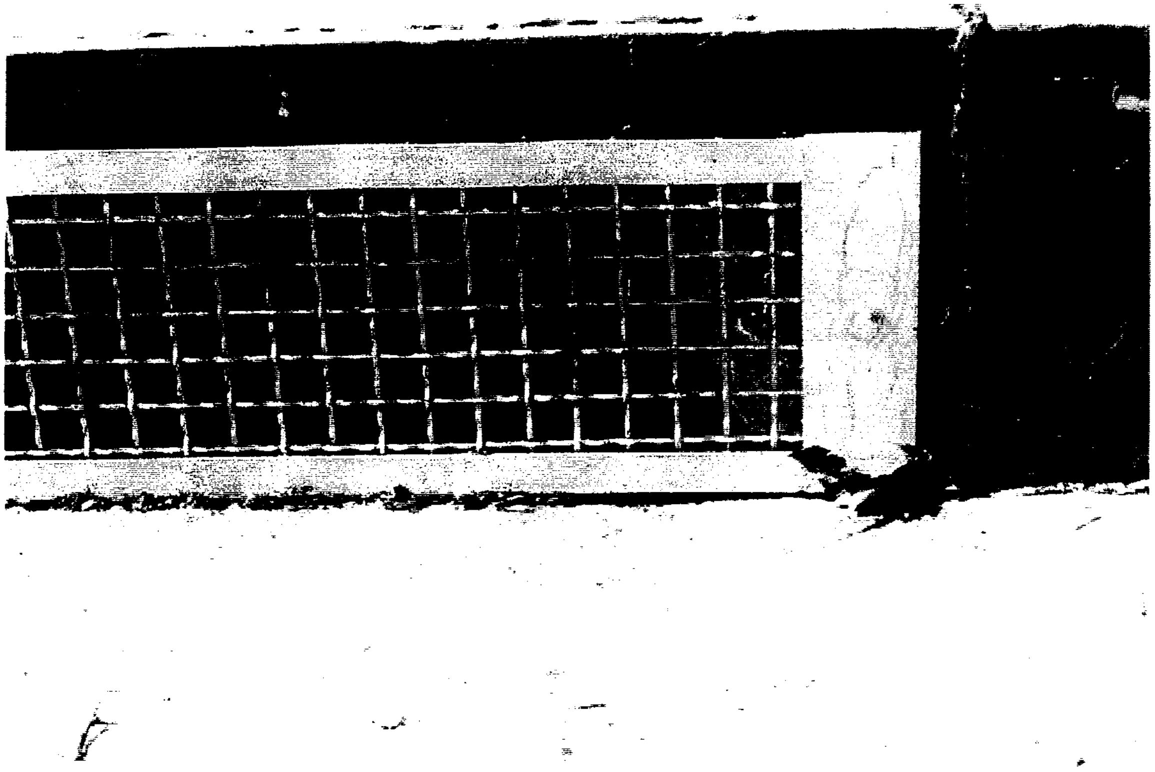


FIGURE 4-5.
CLOSE-UP OF INLET SCREEN PANEL (SUNSET PARK AREA, SITE 2).

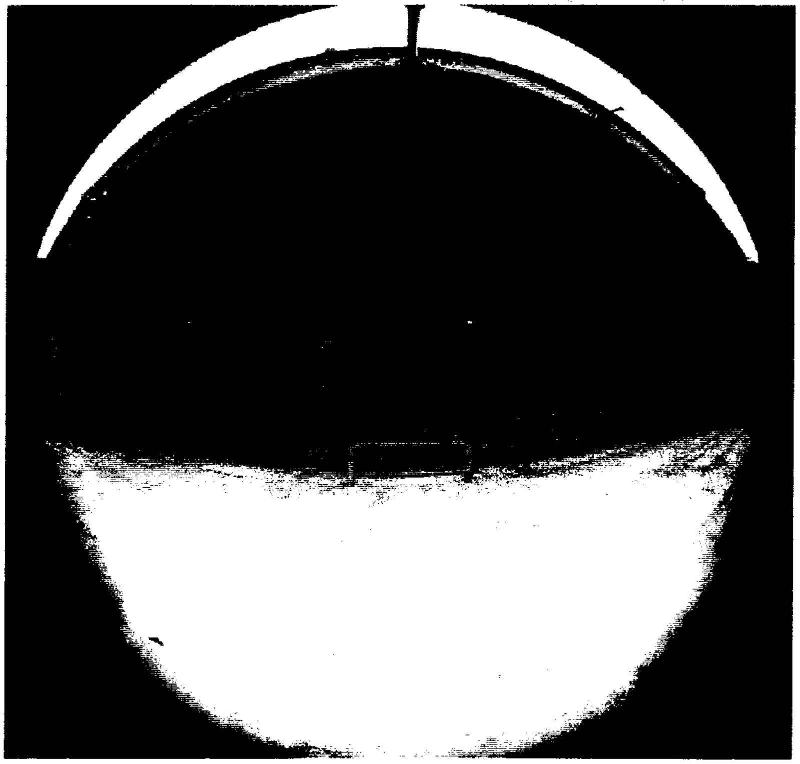


FIGURE 4-6.
"FISH-EYE" LENS VIEW INSIDE OF CATCHBASIN THAT HAD BEEN FITTED WITH INLET SCREEN PANEL (SUNSET PARK AREA, SITE 2).

FIGURE 4-7.
INLET SCREEN PANEL DURING ACTIVE RAINFALL.

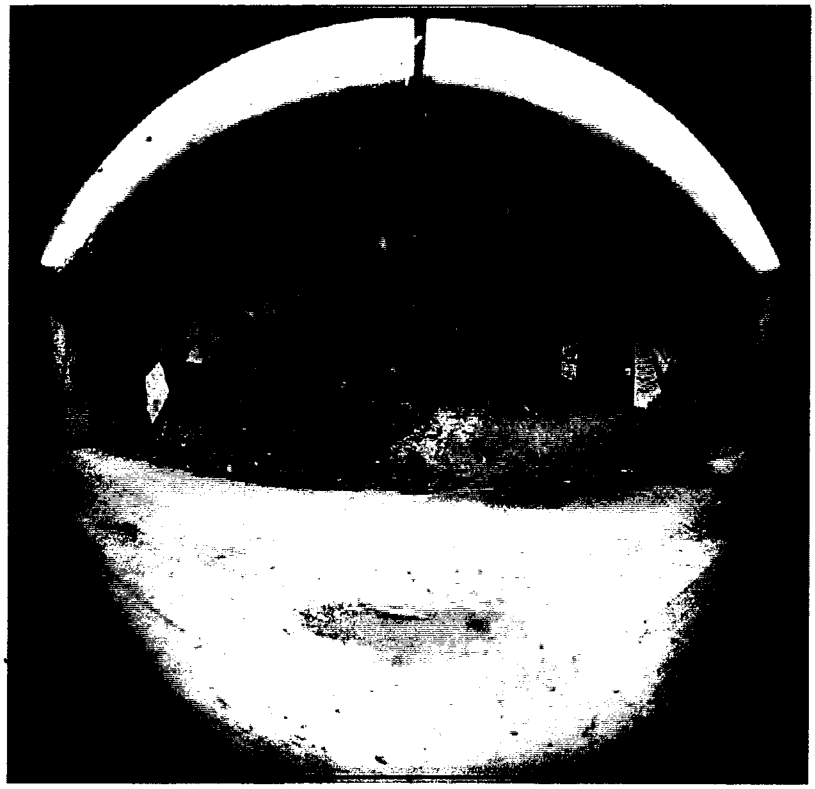


FIGURE 4-8.
ACCUMULATED MATERIAL INSIDE CATCHBASIN AT SUNSET PARK AREA, SITE 3 (CONTROL).

### Table 4-1
### SIEVE ANALYSIS OF ACCUMULATED MATERIAL FROM THE SUNSET PARK CONTROL CATCHBASIN

| Sieve size (mm) | Weight of Sieved Material (g) | Percent of Total (%) |
|---|---|---|
| 20-60 (0.8382 to 0.2489) | 622.3 | 54.3 |
| 60-200 (0.2489 to 0.0737) | 416.2 | 36.3 |
| 200-325 (0.0737 to 0.0508) | 69.6 | 6.1 |
| < 325 (<0.0508) | 37.2 | 3.2 |
| Total | 1145.3 | 99.9 |

made of materials that would not contaminate the samples to be sure the samples could be preserved for future analysis. Combinations of plastic and metal sieve materials were used. The plastic sieves were used to prepare the material for heavy metals analysis, and the metal sieves were used to prepare the material for organic analysis.

### *AbTech Retrofit, Sunset Park Area*

The inside of the catchbasin chamber equipped with the prototype retrofit provided by AbTech was found to be essentially clean, similar to the catchbasins that had been equipped with inlet screen panels and boardovers. A few items of debris were caught in the basket that hangs inside the chamber; leaves were also beginning to accumulate. Figure 4-9 shows the front of the catchbasin. The screen had prevented leaves from entering the catchbasin chamber. Figure 4-10 shows the inside of the catchbasin, photographed from the manhole. In this picture the front screen had been removed, and the internal baskets are clearly visible.

In December, the baskets were cleaned. Several hundred pounds of material (wet weight) were removed from the baskets. This material was composed mostly of vegetative debris (e.g., leaves, branches) and soil. The recovered material was not examined by a sieve analysis because the wetness would have interfered with the particle size measurements.

### *Inlet Screen Panel, Third Street Promenade Area (Site 4)*

The catchbasin chamber was found to be essentially free of debris at the end of the dry-weather study period. Some stains were observed on the interior concrete. Figure 4-11 shows the inlet screen panel. Note that the wire mesh screen fabric had been dented and deformed from the impact of automobile tires. Figure 4-12 shows a close-up view of the inlet screen panel immediately following a rainstorm; much debris was clogging the screen. The debris extended to nearly the top of the screen, although the depth of water directly in front of the screen never increased to more than two inches.

FIGURE 4-9.
VIEW OF FRONT OF AB TECH SCREENED CATCHBASIN (SUNSET PARK AREA).

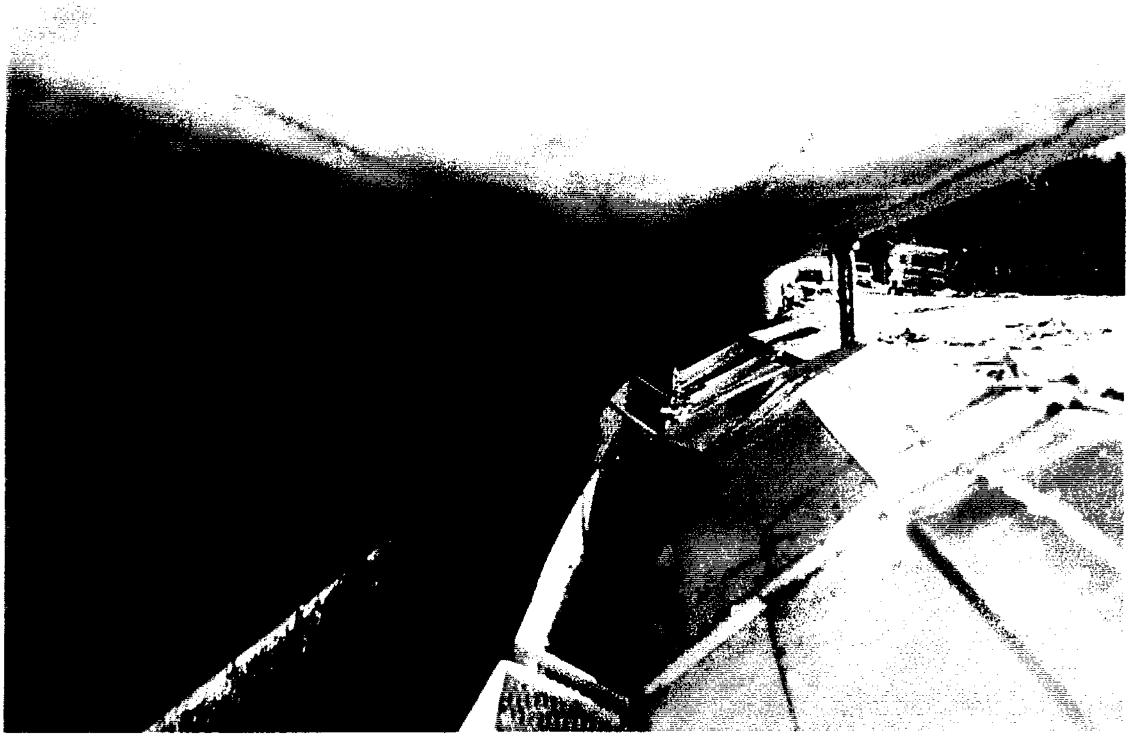


FIGURE 4-10.
VIEW OF INSIDE OF AB TECH SCREENED CATCHBASIN (SUNSET PARK AREA).
(FRONT SCREEN REMOVED AT THE TIME OF THE PHOTOGRAPH).

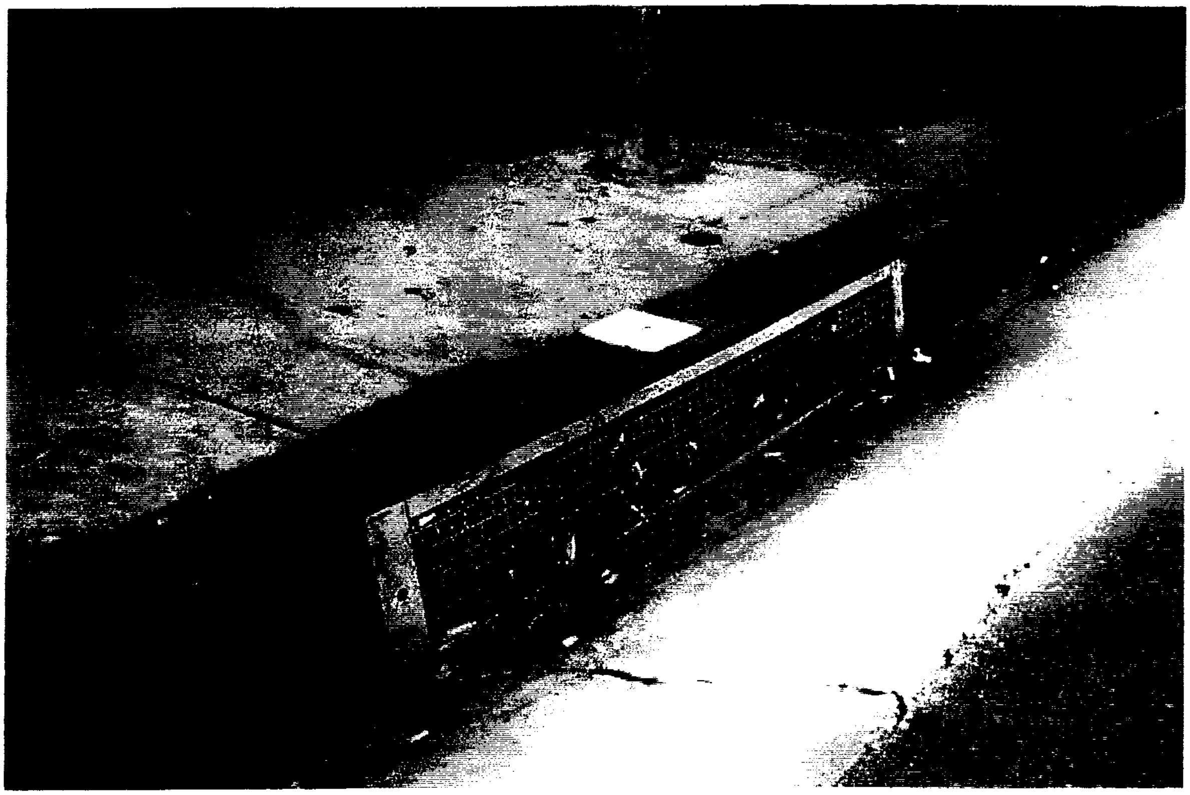


FIGURE 4-11.
VIEW OF SCREENED CATCHBASIN WITH INLET SCREEN PANEL (THIRD PROMENADE AREA).

FIGURE 4-12.
CLOSE-UP VIEW OF INLET SCREEN PANEL IN THIRD PROMENADE AREA IMMEDIATELY FOLLOWING A RAIN STORM.

### *Control Catchbasin, Third Street Promenade Area (Site 5)*

This catchbasin has a square manhole which allowed the chamber to be inspected carefully. Figure 4-13 shows inside of the catchbasin chamber, which was retaining several inches of standing water. Cockroaches were seen to scurry away when the cover was opened. There were some cans, bottles, and what appeared to be decomposing newspaper in the catchbasin. There was a noticeable putrid odor. City of Santa Monica maintenance workers noted earlier that frequent complaints of odors from catchbasins had been a motivation for initiating the city's boardover program.

### *Boardover, Third Street Promenade Area (Site 6)*

The catchbasin chamber was found to be essentially free of debris at the end of the dry-weather study period. There were stains on the concrete from previous contaminants.

### *AbTech Retrofit, Third Street Promenade Area*

The condition of the catchbasin was comparable to what was observed at Site 4 (i.e., the catchbasin that had been retrofitted with the inlet screen panel). Some debris was retained in the baskets that hang down inside the chamber.

### *Observations of Street Sweeper Drive-By and Control Catchbasin Cleaning*

On November 5, 1997, the control catchbasin in the Sunset Park area (Site 3) was cleaned, and a street sweeper was observed as it drove by the inlet screen panels and the boardover. This activity was arranged with the City of Santa Monica, whose personnel performed the cleaning and the street sweeping.

The mechanical street sweeper was a newer design "MOBIL" unit that had two angled gutter brooms and a back roll broom (i.e., the unit was not a vacuum-type sweeper).. The gutter brooms are designed to move debris to the center of the sweeper, and the transverse rear broom picks it up.

The driver stated that in his experience, mechanical broom sweepers are better for small material, whereas vacuum-type street sweepers tend to be better for large material, such as leaves. He noted that in the Sunset Park area, in the fall, the City prefers vacuum-type sweepers to mechanical broom sweepers. The driver also noted that the mechanical sweepers tend to push bottles and cans into the storm drains and that the boardovers prevent the material from entering the catchbasins, which is preferable.

The street sweeper was driven past two inlet screen panel sites and one boardover site during this field observation. All three locations had accumulations of debris in front of the covered inlet opening (such as leaves and nuisance water). The sweeper's gutter broom was seen to be effective in tossing most (~95%) of the material out into the street, to be picked up by the rear broom. The sweeper did not appear to suffer any damage because of the screens. It was noted that the action of the gutter broom abraded the edges of the boardover and screen panels. In the

FIGURE 4-13.
CONTROL CATCHBASIN (THIRD STREET PROMENADE AREA).

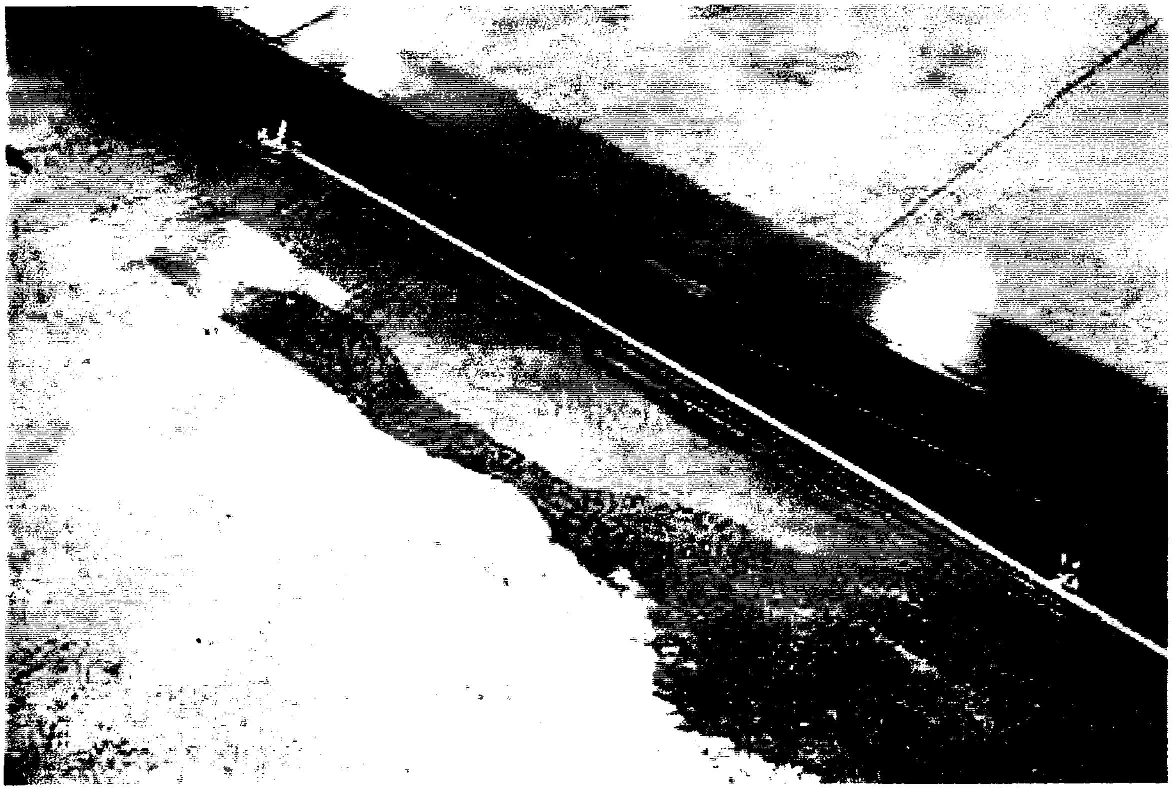


FIGURE 4-14.
WET-WEATHER SCREEN INSTALLED IN CATCHBASIN.

Third Street Promenade area, where boardovers have been used for many seasons, the boards' edges were found to be rounded from sweepers and cars. In some cases, the boards were cracked, and many showed significant wear.

The City workers said that they preferred the inlet screen panels with the 1-inch mesh. They were able to vacuum the AbTech filter boxes from the street opening of the residential catchbasin in about 12 minutes. They proposed a modification to their vector unit's hoses (an elbow attachment for the end) that would allow an even more efficient vacuum operation. They noted that the plywood board used for the boardover site was warping due to water damage and suggested that marine plywood was needed.

### 4.1.3 Wet-Weather Field Studies

On November 29, 1997, the study sites were inspected again. Two rainfall events had occurred before this inspection. The boardovers had been removed prior to the storms, but the inlet screen panels had been left in place at study Sites 2 and 4.

Approximately 5% of the surface area of the screen panels were found to be covered with debris. The insides of the catchbasin that had been provided with inlet screen panels were found to be free of debris. The un-retrofitted catchbasins that were studied as experimental controls had some debris in the chambers, but not nearly as much as had been observed in the previous visit. No standing water was present. The catchbasin that had been retrofitted with the AbTech screen baskets was in a similar condition, and the internal baskets were beginning to fill with debris.

The inlet screen panels were left in place until December 31. They were observed during the same runoff sampling events that were described in Section 2. In some instances, the inlet screen panels appeared to have as much as 50% of their front area blocked. Some standing water (generally about 1-inch) was created at the study sites in the Third Street Promenade area, although other catchbasins without screens were observed to have more standing water.

On December 18, 1997, a new prototype box-shaped debris basket was installed as a wet-weather device in the catchbasin in the Sunset Park area that had been previously boarded over. This prototype debris basket was fabricated from expanded metal screen formed into a box, and strengthened with reinforcing steel. The device was installed by inserting it through the curb inlet opening in front of the catchbasin. The basket was held by chains to a bar placed flat along the street (as an alternative, the unit could also be mounted with plumber's tape to two bolts on the outside). The basket hung down inside the catchbasin's below-grade chamber, about 6 inches below the street surface elevation.

This prototype debris basket was observed during several storms. It did not impede flow, although it was observed that the mounting technique could create a minor interference to flow. After approximately 1 month of service, the basket was found to be full of leaves, litter, and other debris.

Figure 4-14 shows the prototype debris basket after installation. A length of 0.5-inch diameter rebar was placed in front of the curb inlet opening to retain the basket. Attaching the chains to bolts would be an alternative and better mounting technique. Figure 4-15 shows the debris

FIGURE 4-15.
VIEW INSIDE OF CATCHBASIN SHOWING BASKET INSTALLATION.

FIGURE 4-16.
VIEW OF WET-WEATHER BASKET DURING A RAIN STORM.

basket hanging down inside the catchbasin chamber. The debris basket could be mounted at any particular elevation by lengthening or shortening the chains. Figure 4-16 shows the front of the basket during a rainstorm. Note that the mounting bar did not prevent water from entering the basin. Also note that the basket is used only on the upstream part of the catchbasin inlet opening. The downstream part of the catchbasin opening and chamber are. untouched. Figure 4-17 shows the inside of the basket during a rainstorm; the basket was nearly full of debris, and water was beginning to bypass.

This prototype hanging debris basket design was judged to have promise for a variety of wet- and dry-weather applications. If the volume of the catchbasin is sufficiently large, such a debris basket can be installed. The debris basket can be installed from the front without requiring any modifications or entry to the catchbasin. It can be hung low enough to avoid or minimize flooding problems. It could be used to hold sorbents (such as in the AbTech design). Small and inexpensive modifications to the vactor system used by the City of Santa Monica and others (for cleaning catchbasin chambers) would allow the debris basket to be cleaned out without requiring its removal. Alternatively, the baskets could be pulled from the chamber and the debris dumped into a collection truck.

## 4.2 LABORATORY TESTING

### 4.2.1 Lab Test Methodology

Three types of laboratory testing were performed at UCLA:

- Shake tests
- Bench-scale column tests
- Full-scale simulation in a fabricated, above-ground catchbasin.

Used motor oil was used to simulate oil and grease for all experiments. Emulsified oil and grease was created by blending known quantities of motor oil with tap water, at high speed in a blender similar to those used in home kitchens. Free oil and grease mixtures were created by combining the metered streams of motor oil and tap water at know flow rates in a simple mixer, such as a "tee," or in a turbulent stream such as a flume.

The shake tests performed in the UCLA lab were designed to be equilibrium studies, and the specific procedure has been described previously (Stenstrom and Lau, 1995). In these tests, known quantities of sorbent and used motor oil were placed in a small bottle, usually about 500 ml volume. A series of such bottles (generally 8 to 12) are then placed on a mechanical shaker. After a prescribed period of vigorous but uniform shaking to thoroughly mix the oil with the sorbent (usually 12 to 24 hours) the bottles were opened, and the sorbent was removed. The remaining oil and grease was analyzed. Results are reported in graphical form, with the mass of oil and grease adsorbed per unit mass of sorbent plotted as a function of oil and grease concentration. In this way the absolute amount of oil and grease adsorption can be measured. In this type of test, no filtration occurs, and the oil becomes emulsified as the test proceeds. The results of this test provide a comparison of sorption efficiency of various materials but can not be directly extrapolated to column studies.

FIGURE 4-17.
VIEW OF BASKET INSIDE CATCHBASIN DURING A RAIN STORM.

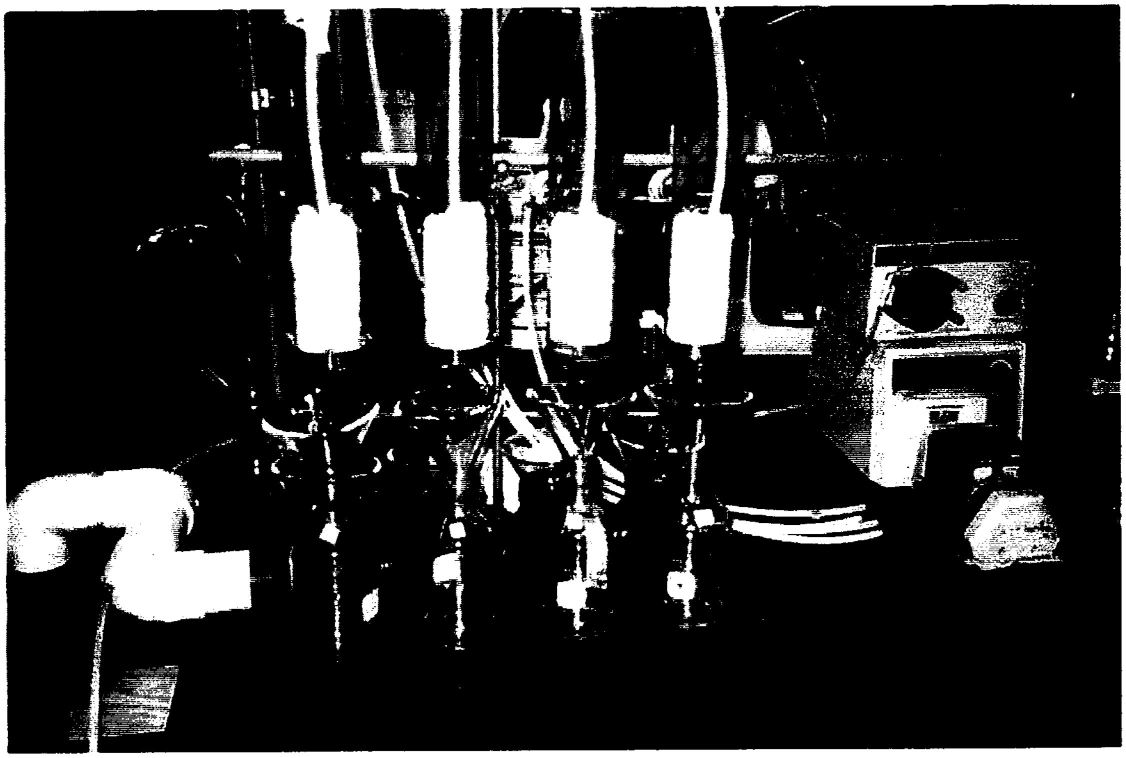


FIGURE 4-18.
BENCH - SCALE COLUMN TESTS OF SORBERS.

Bench-scale column tests were performed to measure both sorption efficiency as well as filtration efficiency. Figure 4-18 is a picture of the 2-inch diameter sorber columns that were used in these tests. Tube-type metering pumps (on the right in the background of the photo) were used to pump used motor oil and water into the sorber columns. The picture shows sample bottles, which were used to measure oil and grease concentration. The typical duration of the bench-scale column tests was 8 hours. Samples of the effluent that drained out of each column were collected every hour and analyzed for oil and grease using the SPE method (described in Section 3). Figure 4-19 shows a schematic diagram of the bench-scale columns. Both the large and small metering pumps had 4 channels, so that the flow of water and oil to each column could be regulated. When testing for emulsified oil and grease, motor oil and water were mixed together (in a high-speed blender) to make a feed stock containing oil in the range of 20 to 50 mg/L.

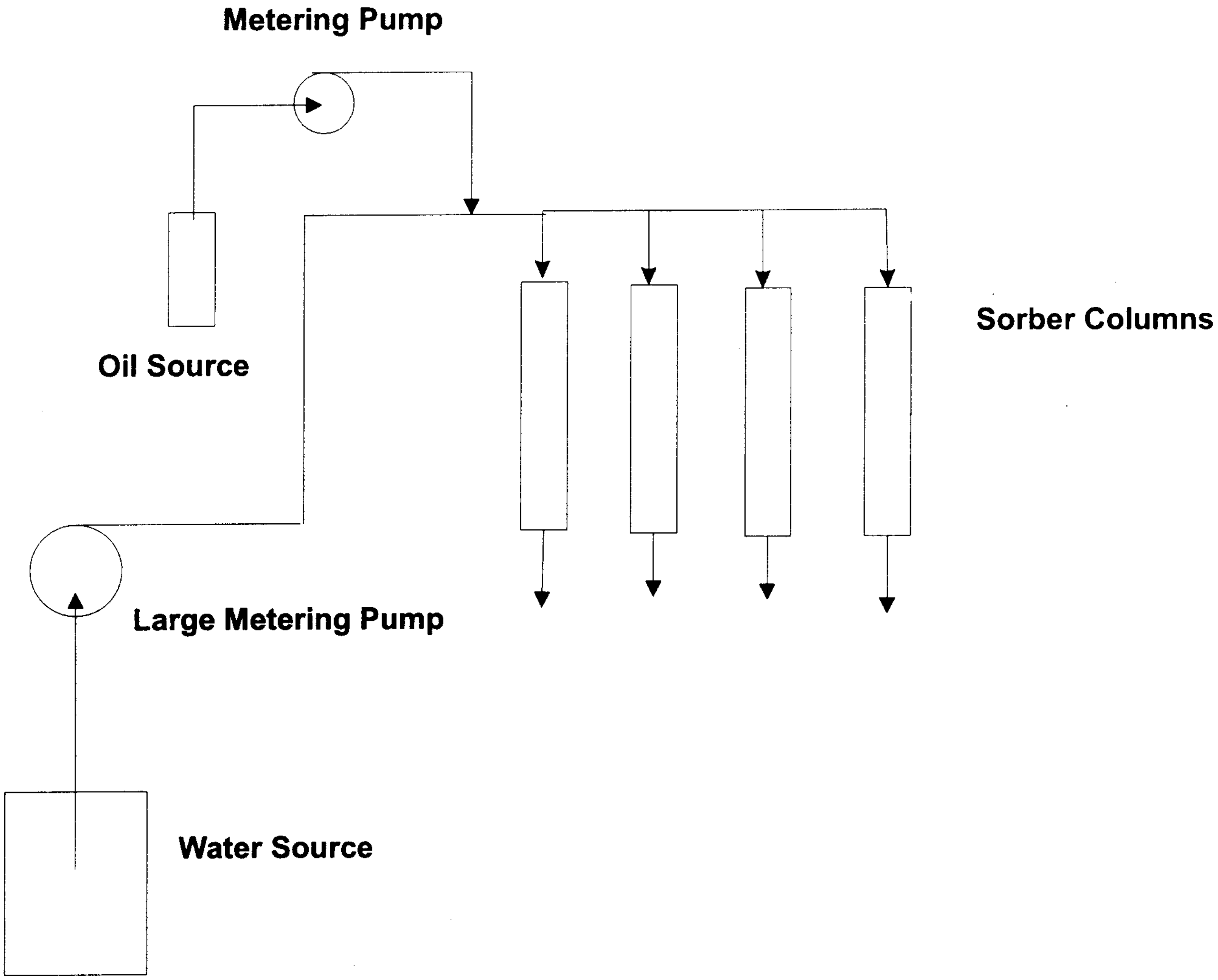
The final method of testing used an aboveground test assembly at the UCLA lab that consisted of a fabricated stilling basin, a fabricated length of curb and gutter, and a fabricated full-scale representation of the smallest catchbasin in the Los Angeles area that fully conforms to the Department of Public Works' specifications.

Figure 4-20 is a schematic of the assembly. The opening of the catchbasin's "curb inlet" is 36 inches wide. The flume that simulates a length of curb and gutter, measures 22 inches in width. Water was introduced to the stilling basin from the City water supply, and flow rates were controlled with a gate valve. An ultrasonic meter was used to measure flow velocity. Small amounts of air were introduced upstream of the meter in order to provide a surface from which to reflect ultrasonic waves to determine the flow velocity. Figures 4-21 and 4-22 are pictures of the assembly in the UCLA lab.

The small bottles shown in Figure 4-21 contain sand, which was released into the flow in controlled amounts. Pre-weighed amounts of sieved sand particles were placed into each bottle and then were sprinkled into the water as it flowed down the flume. Free oil and grease (i.e., used motor oil) was introduced in a similar fashion, except that a small tube-type metering pump was used to add the oil to the inflow.

The types of candidate retrofits to be evaluated were placed into the chamber of the catchbasin. The following candidates were evaluated:

- A vertical baffle plate to create a settling zone within a portion of the catchbasin chamber. The baffle (in the form of a box with an open top) was inserted into the catchbasin chamber and was oriented such that the plane of the vertical baffle plate was perpendicular to the street direction.
- A prototype insert device that used a proprietary StormFilter cartridge from Stormwater Management. This device was tested by creating a false floor in the catchbasin chamber such that stormwater would flow through the cartridge before exiting the chamber.



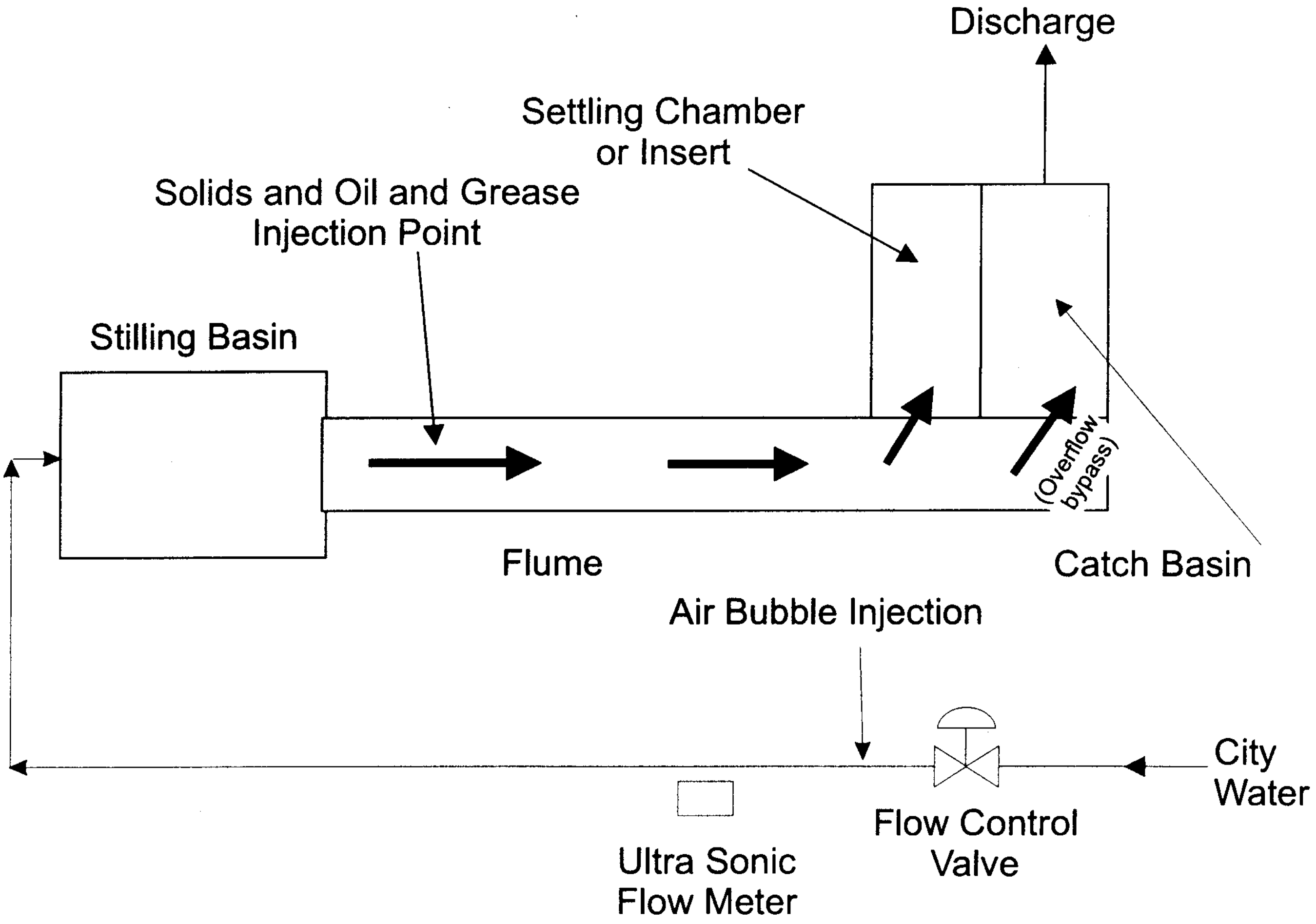
NOT TO SCALE

**SCHEMATIC OF BENCH-SCALE SORBER (COLUMN TEST APPARATUS)**

| | | | | |
|---|---|---|---|---|
| DRAWN BY: CM | CHECKED BY: | PROJECT NO: 9653001F-5000 | DATE: 7-22-98 | FIGURE NO: 4-19 |

**Woodward-Clyde**

Laboratory Catch Basin
Plan View



NOT TO SCALE

**SCHEMATIC OF FULL-SCALE SIMULATED CATCHBASIN TEST APPARATUS**

| | | | | |
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**Woodward-Clyde**

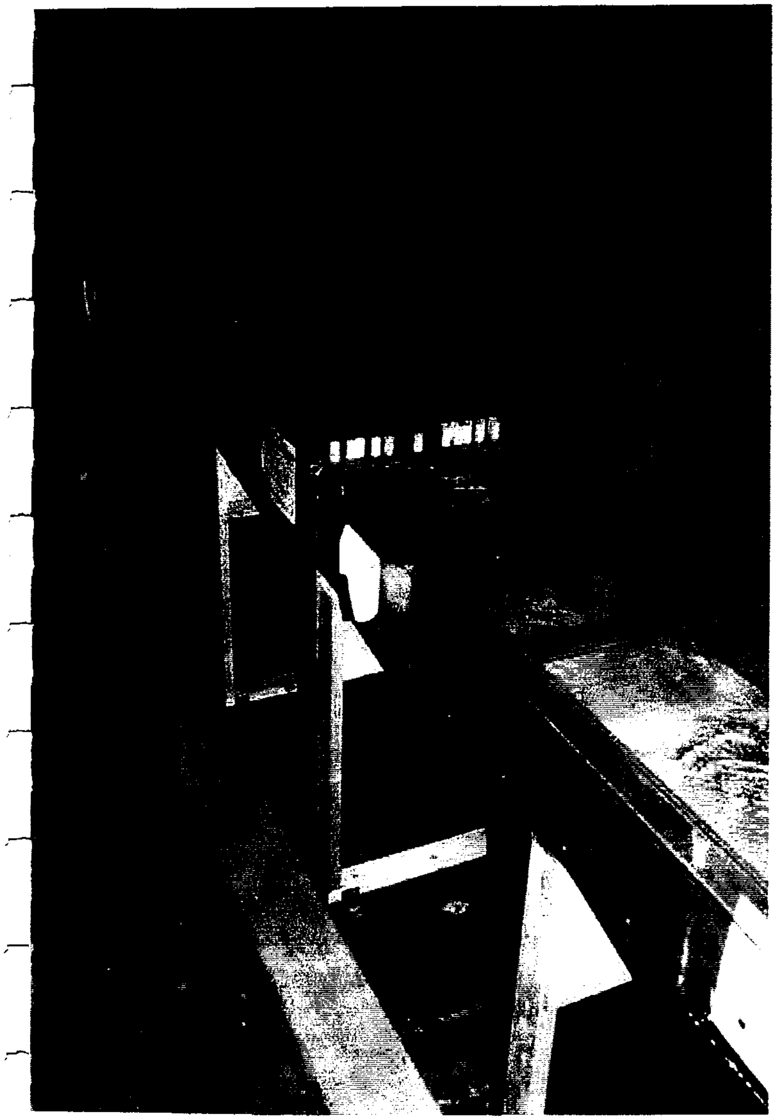

FIGURE 4-21.
GENERAL VIEW OF FULL-SCALE TEST CATCHBASIN AT UCLA LABORATORY.

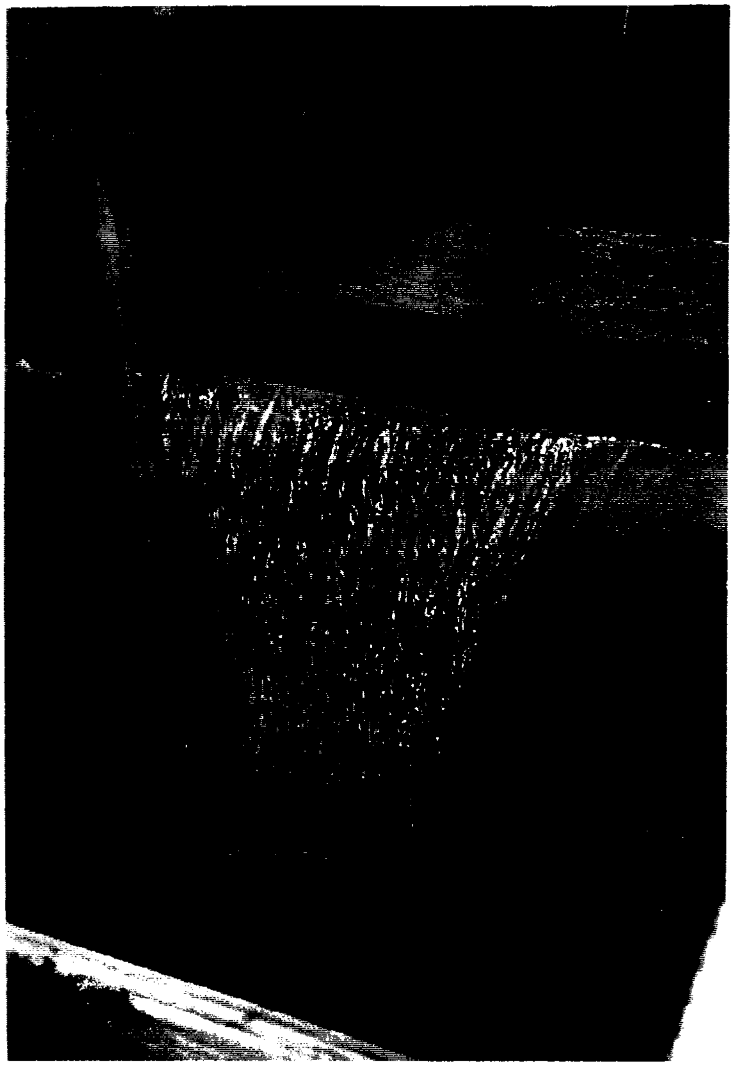

FIGURE 4-22.
CLOSE-UP VIEW OF FULL-SCALE TEST CATCHBASIN AT UCLA LABORATORY.

- An AbTech sorber device that was hung on the edge of the catchbasin (at the curb inlet). This prototype device was provided by AbTech and was similar to the earlier prototype that had been observed in the field studies.
- Columns hanging to the catchbasin wall, using different sorber media.

### 4.2.2 Lab Test Results — Oil and Grease

In the shake tests, twelve different sorption materials were shake tested with emulsified oil and grease (i.e., used motor oil) at an influent concentration of 20 mg/L. These included OARS Polymer media (AbTech), activated carbon, aluminum silicate (the mineral used in Xsorb, Fossil Filter, Perlite, and other sorbents), straw, and polypropylene (the material used in 3M oil socks and pads). None of these sorbent media were able to remove more than 10% to 12% of the oil and grease during the bench-scale shake tests. The mass of adsorbed oil and grease per unit mass of adsorbent ranged in the 0 to 5 mg/g range. These tests indicated that sorbers are not effective for removal of low concentrations of highly emulsified oil and grease.

It should be noted that these test results are in stark contrast to some of the advertised claims made by some manufacturers. It would appear that one must be very careful in interpreting advertised data. For example, the consultants encountered an advertisement that reported tests conducted with very high oil and grease concentrations (4,100 mg/L, which would be approximately 200 to 300 times higher than oil and grease concentrations usually found in stormwater) to demonstrate the efficiency of an adsorbent. This type of result is not applicable to stormwater treatment. Also results from sorber tests conducted at gross oil spills (e.g., tanker spills, or pipe line accidents) are not applicable to stormwater treatment.

In the next series of bench-scale column tests, 2-inch sorber columns were used to measure the sorbers' ability to remove emulsified oil and grease and free oil and grease. I should be noted that free oil and grease behaves differently than emulsified oil and grease. For example, free oil and grease will float on the water surface if left in a quiescent container for a brief period, whereas emulsified oil and grease tends to stay in the water. Table 4-2 shows the results. A number of tests were performed using emulsified oil and grease, but the removal efficiencies were always poor, and only the average results are reported. Replicate tests were generally performed.

The efficiencies were calculated using the early part of the test results. Results after break through (after the sorbent is exhausted) are not reported. The results shown are indicative of the maximum removals possible for the various sorbents in the various contacting methods. If greater retention time were to be used to allow for longer contact, efficiencies would likely increase (and vice-versa.)

As the sorbents are exhausted, the removal efficiency will gradually decrease to zero. The time to exhaustion or breakthrough depends upon several factors, including the mass of oil applied to the sorbent (flow and concentration), the mass of sorbent, and the packing density.

## Table 4-2
## FREE OIL REMOVAL EFFICIENCIES

| Media Type | Oil and Grease Type | Removal Efficiency(1) (%) |
|---|---|---|
| OARS Polymer (AbTech) | Emusified | 3 |
| Activated Carbon | Emusified | 11 |
| Aluminum Silicate (Perlite, Xsorb) | Emusified | ~0 |
| Straw | Emusified | ~0 |
| Compost | Emusified | ~0 |
| OARS Polymer (AbTech) | Free | 88, 91 |
| Perlite (Aluminum-Silicate) | Free | 89, 86 |
| Compost | Free | 28, 49 |
| Polyproplyene Matt (type 1) | Free | 86, 92 |
| Polyproplyene Matt (type 2) | Free | 78, 85 |
| Xsorb (Aluminum-Silicate) | Free | 94,89 |

It was noted in these studies and especially in the 2-inch diameter column studies, that packing density is important. As the sorbents become coated with oil and grease, flow tends to channel through the column. This means that portions of the column may be relatively free of oil and grease while a path through the column of saturated sorbent exists in another location.

Two devices (the StormFilter cartridge and the AbTech prototype) were tested in the UCLA lab at full scale, by installing them in the fabricated catchbasin assembly. Due to differences in the sizes of the units and volumes of pollutant removal media, the units were tested over different lengths of time. The StormFilter cartridge (manufactured by Stormwater Management) was lab-tested with Perlite media and with a proprietary compost media. The AbTech unit was lab-tested with OARS Polymer media. Both units were tested for 90 minutes at 15 gpm with influent oil and grease concentrations of 25 mg/L.

The StormFilter cartridge was mounted in the catchbasin by creating a false floor above the bottom of the catchbasin chamber. The cartridge requires approximately 30 inches head loss to operate, and each cartridge of the type tested is rated as being capable of treating 15 gpm. It should be noted that StormFilter cartridges are typically used as elements in an engineered off-line treatment system. Typically, many cartridges are operated in parallel to obtain the desired treatment capacity. Stormwater Management's technical manuals and advertising literature can be consulted to obtain pictures and dimensions of the devices.

The AbTech unit was attached to the side of the catchbasin and is designed to operate using much less hydraulic head than the StormFilter cartridge. The AbTech prototype shown in Figure 4-23 is the same as the one observed in the field studies. The AbTech prototype shown in

Figure 4-24 has much greater surface area for flow and should be less prone to clogging. Both AbTech devices were found to have similar removal efficiencies for oil and grease.

Table 4-3 shows the results for the devices tested. Again, removal efficiency was calculated for the period prior to the occurrence of breakthrough.

### 4.2.3 Lab Test Results — Suspended Solids

The vertical baffle plate tested in the full-scale catchbasin was found to function well in removing settleable solids (i.e., sand of various particle sizes). As noted earlier, an open-topped box assembly was placed inside the fabricated catchbasin to divide the catchbasin chamber into two parts, one of which acted as a sedimentation zone. A tracer study was performed to determine mixing characteristics. At an inlet flow rate of 50 GPM, short-circuiting began to occur. At higher flow rates (100 and 150 GPM), the zone created by the baffle was completely mixed.

The prototype baffle device was tested using known amounts of screened sand having known particle sizes. Sand was added to the influent flume at a rate that was equivalent to 50 mg/L concentration. The device was operated for 30 minutes during each test run. After each test run, the water was pumped from the box (i.e., the sedimentation zone), and the captured sand was removed. The sand was dried, sieved, weighed, and the data were compared to the starting masses of sand to estimate the removal efficiency.

Table 4-4 shows the removal efficiency for various flow rates and particle sizes. The removal efficiencies appear to be relatively high for a device with a retention time of less than 1 minute.

If by-pass systems were utilized, increased sedimentation times could be expected to result in increased removals for treated flows. The results show that the retrofit baffles would be highly effective on larger particle sizes (greater than 100 µm). Additional testing of smaller size fractions and bypass configurations would be required to assess overall effectiveness on TSS. The field sampling at particle size fractions (Table 2-6) indicates that about 30 percent of the TSS was associated with size fractions analyzed here in this test. The implication is that for about 30 percent of the TSS, between 60 and 70 percent removal would occur at the 50 gpm rate.

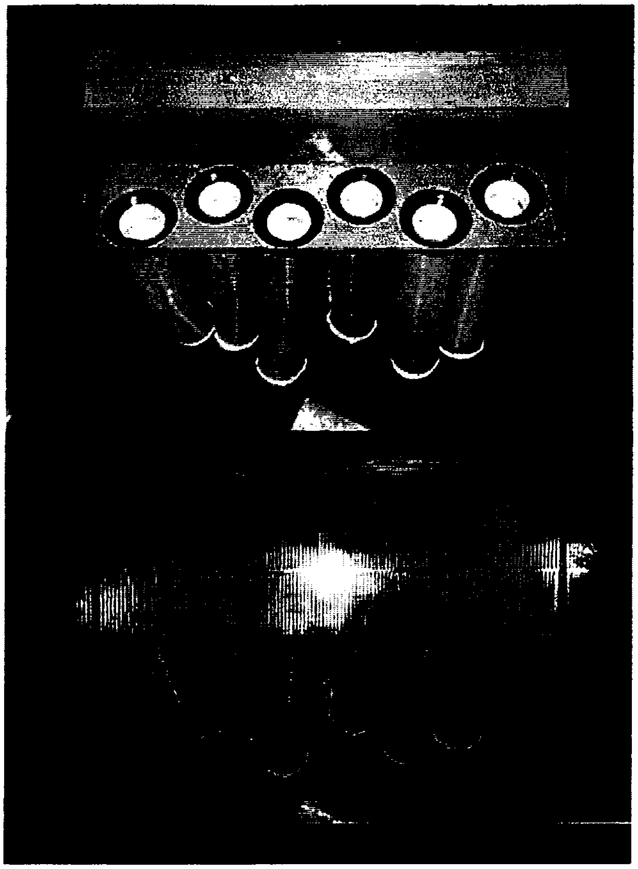

FIGURE 4-23.
TWO VIEWS OF AB TECH CATCHBASIN RETROFIT DEVICE (FIRST PROTOTYPE, TOP WITH DEBRIS SCREEN REMOVED, BOTTOM WITH DEBRIS SCREEN INSTALLED).

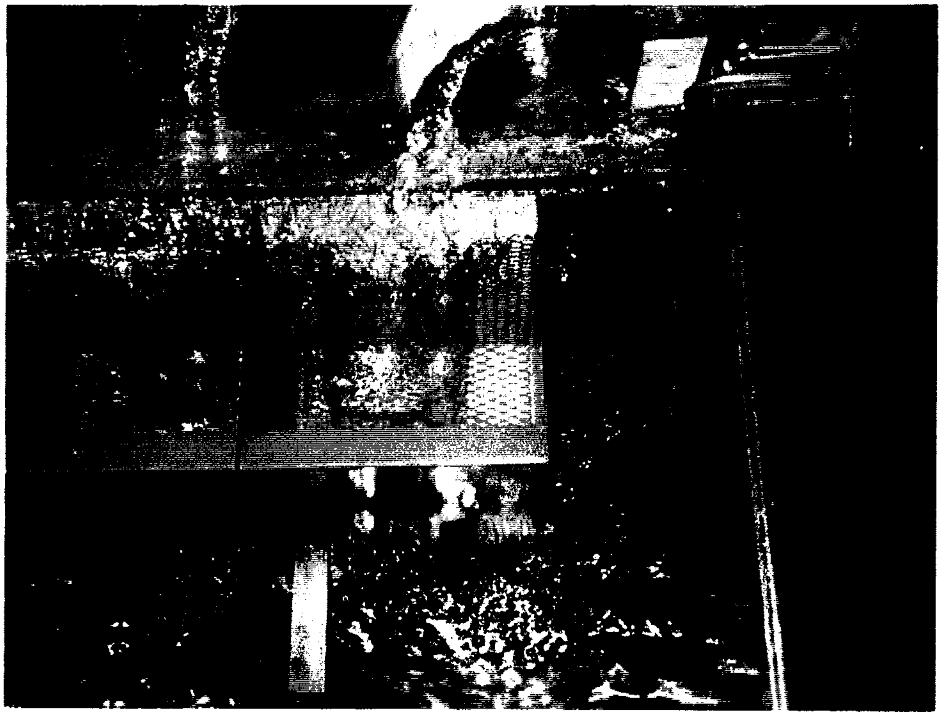

FIGURE 4-24.
AB TECH CATCHBASIN RETROFIT DEVICE (SECOND PROTOTYPE).

## Table 4-3
## OIL AND GREASE REMOVAL EFFICIENCIES IN FULL SCALE SIMULATOR, USING VARIOUS SORBENTS

| Media Type | Oil and Grease Type | Removal Efficiency (1) (%) |
|---|---|---|
| OARS Polymer | Free | 83, 74 |
| Stormwater Management (Perlite) | Free | 69 |
| Stormwater Management (Compost) | Free | 74 |
| Xsorb(Aluminum-Silicate) | Free | 91 |

## Table 4-4
## SAND REMOVAL EFFICIENCIES OF THE PROTOTYPE BAFFLE

| Sand Removal Efficiencies (percent) | | | | |
|---|---|---|---|---|
| | | Test 1 (50 gpm) | Test 2 (100 gpm) | Test 2 (150 gpm) |
| Sand Size Ranges (mesh) | Particle Sizes (microns) | 1.6 min hrt<br>19,060 gal/ft$^2$ day | 0.8 min hrt<br>38,120 gal/ft$^2$ day | 0.53 min hrt<br>57,180 gal/ft$^2$ day |
| 30 to 60 | 295-590 | 73 | 72 | 59 |
| 60 to 100 | 150-295 | 63 | 45 | 42 |
| 100 to 140 | 104-150 | 60 | 37 | 30 |

hrt = Hydraulic retention time

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