WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Stormwater Sediment Trap Pilot Study

November 1996

Publication No. 96-347

printed on recycled paper

*For additional copies of this publication,
please contact:*

*Department of Ecology
Publications Distributions Office
P. O. Box 47600
Olympia, Washington 98504-7600
(360) 407-7472*

Refer to Publication Number 96-347

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Stormwater Sediment Trap Pilot Study

by
Craig Wilson
and
Dale Norton

Environmental Investigations and Laboratory Services Program
Olympia, Washington 98504-7710

November 1996

Publication No. 96-347
printed on recycled paper

This page is purposely blank for duplex printing

Table of Contents

List of Figures and Tables

Page

Figures

Tables

Abstract

A prototype stormwater sediment trap was constructed and tested under actual field conditions at four sites in the vicinity of the city of Lacey (Washington State) between June 29 and October 4, 1995. Low flow conditions were present during the testing period with rainfall totaling 5.18 inches.

The sediment traps were able to collect sufficient material (8-164 grams, dry) at all sites to perform at least a portion of the planned physical/chemical analysis on the trapped particulates. Results of chemical analysis of the trap samples indicated that, for metals, the data collected were comparable to a particulate sample collected by continuous-flow centrifugation. Concentrations of polynuclear aromatic hydrocarbons in the trap samples most closely resembled bottom sediment concentrations after the data had been normalized to the total organic carbon content of the samples.

Data collected during the pilot study suggest that stormwater sediment traps have the potential to significantly lower monitoring costs for collection of particulate samples from stormwater discharges. Additional data on the performance of the stormwater sediment traps under actual field conditions (especially high flow) are needed before the traps are ready for routine application in a regulatory framework. Recommendations for follow-up work are provided.

Executive Summary

Summary

Particulates transported by point and non-point stormwater discharges are a major source of sediment contamination in some receiving waters. Current sampling techniques for stormwater particulates are typically labor intensive, expensive, and difficult to coordinate with episodic runoff events.

The current study was intended to provide an initial evaluation of a prototype stormwater sediment trap under actual field conditions. The trap was designed to be a passive particulate collector which can be installed in a variety of stormdrain configurations. For comparison, bottom sediments and centrifuged particulate samples were also collected.

Prototype stormwater sediment traps were successfully deployed in a variety of stormwater structures for a period of 98 days (June 29 to October 4, 1995) in the Lacey area. Sufficient material (8-164 grams, dry) was collected at all sites to perform at least a portion of the planned physical/chemical analysis on the trapped particulates. Unfortunately, only one site collected enough material to perform grain size analysis. This sample contained primarily sand size particles. A visual examination of the remaining trap samples indicated they were composed of much finer material. We anticipate the traps would collect a much larger sample volume if they were deployed under higher flow conditions.

Results of chemical analysis of the trap samples indicated that, for metals, the data collected were comparable to particulates samples collected by continuous-flow centrifugation. Concentrations of polynuclear aromatic hydrocarbons (PAHs) in the trap samples most closely resembled bottom sediment concentrations after the data had been normalized to the total organic carbon (TOC) content of the samples.

One important observation during the study was that the traps were able to collect sufficient material for analysis at two sites where no bottom deposits were accumulating.

The data collected during the pilot study suggest that stormwater sediment traps have the potential to significantly lower monitoring costs for collection of particulate samples from stormwater discharges. The traps also have the ability to provide samples which are integrated over several months. This ability to integrate samples over a number of episodic runoff events should produce data that are more representative of long-term stormwater quality. Use of the traps could also increase

the number of available sampling points within a stormdrain system since the traps are able to collect particulates from locations where bottom deposits are not accumulating.

The best application of the stormwater sediment trap at its current stage of development is as a screening tool to prioritize and isolate branches of a system for further characterization. However, additional data are needed on the performance of the stormwater sediment traps under actual field conditions (especially high flow) before they are ready for routine application in a regulatory framework.

Recommendations

Based on the data collected during the Stormwater Sediment Trap Pilot Study the following recommendations are made:

- Performance of the stormwater sediment trap should be evaluated over a range of flow conditions. This is especially true for high flows which are expected to occur during winter storm events. This evaluation should at a minimum include collection of grain size and total organic carbon information.

- TOC normalization is recommended prior to comparing bottom sediment and particulate concentrations for nonionic organic compounds.

- Modify the stormwater sediment trap design to permit recovery and re-deployment of the collecting vessel without having to enter confined spaces. This situation would only apply when direct access to the traps from an overhead opening (e.g., manhole or grate) is possible.

- Where appropriate, stormwater sediment traps should be recommended by Ecology as an alternate tool for collecting particulate samples from stormwater discharges in future monitoring projects.

Acknowledgments

Many individuals have made significant contributions to the Stormwater Sediment Trap Pilot Study. The authors extend special thanks to those listed below:

- Ecology's Sediment Management Unit and Water Quality Program provided funding for the study.
- City of Lacey Environmental Section and Thurston County Environmental Health provided historical data on the study area.
- City of Lacey Sewer and Utility Department provided signage and flaggers for deployment and retrieval of the sediment traps.
- Dave Serdar and Jim Cubbage assisted in setup of the centrifuge trailer.
- Brett Betts, Jim Cubbage, and Larry Goldstein reviewed the report and provided many valuable comments.
- Joan LeTourneau edited and formatted the report.

Introduction

Project Background

In recent years pollution control agencies have increasingly focused on the importance of both point and non-point stormwater discharges to overall contaminant loadings. Particulates transported by stormwater are potentially a major source of bottom sediment contamination in receiving waters due to the affinity of many contaminants (metals and organics) to be associated with small diameter solids. The ability to inexpensively collect quality stormwater particulate samples would provide several benefits to groups charged with controlling, regulating, and monitoring stormwater quality:

- Simultaneously collect data from a number of discharges to prioritize their relative importance as contaminant sources to a receiving water, so source control efforts could be concentrated where the impacts are greatest.

- Isolate sources of contamination within a drainage system. By placing passive samplers at key points in a stormdrain, pollution sources could be isolated.

- Assess the effectiveness of stormwater Best Management Practices (BMPs). Samplers placed above and below water quality control structures would help evaluate how well BMPs are working.

Ecology's Environmental Investigations and Laboratory Services (EILS) program conducted a review of commonly used sampling technologies for stormwater particulates (Barnard and Wilson, 1995). The results of this investigation indicated that sampling techniques currently used are labor intensive, expensive, and difficult to coordinate with runoff conditions. This review indicated that development of a sediment trap with the following characteristics would be desirable:

- Passively collect stormwater particulates from a high-energy stormdrain environment.

- Operate over a relatively long period without maintenance (approximately 3 months).

- Collect material in sufficient volume (approximately 50-100 grams) to perform a variety of analyses.

- Collect a proportionate amount of material in the silt/clay range of <63 um. The silt/clay fines attract contaminants because of their relatively large surface area, and is the material which stays in suspension and is ultimately deposited in the receiving waters.

- Adaptable to a variety of stormdrain designs and be easily installed and retrieved.

- Be relatively inexpensive to manufacture and maintain.

No sediment trap specifically designed for application to stormwater sampling was located during the literature review. However, we found two designs that were under development for marine applications which showed potential under laboratory test conditions (Gardner, 1980). The two designs were the domed bottle trap and the slitted cylinder trap. Of these two designs the domed bottle trap appeared to be the best suited for adaptation to stormwater sampling, due to its ability to efficiently trap particles from any direction. The slitted cylinder was only efficient at trapping particles in a uni-directional flow environment.

Project Description

Based on results of the literature review described above, it was decided to undertake a pilot study to build and test a prototype stormwater sediment trap. Ecology's Sediment Management Unit and Water Quality Program contracted EILS to perform this work. The primary objective of the pilot study was to build and test a stormwater sediment trap under actual field conditions to see if it would collect an adequate and representative sample in a reasonable amount of time to perform a variety of analyses. Secondary objectives of the pilot study are described below.

One intended use for the stormwater trap was to isolate contaminate sources within a stormdrain system. This objective was addressed by mounting traps at two sites within a single system. One set of traps was mounted near the outfall (downstream) and the other on a lateral line to the trunk. Flexibility of the trap design was challenged by selecting a variety of stormdrain configurations (catch basin, junction box, and interceptor line) for installation. Finally, comparability of the data generated from the stormwater sediment trap to existing sampling techniques was evaluated by collecting bottom sediments and centrifuge samples at concurrent locations.

It is anticipated that information generated from the pilot study could be used by groups involved with stormwater control, to aid in designing lower cost monitoring programs.

Methods

Site Selection

To evaluate the performance and adaptability of the stormwater sediment trap we attempted to locate a relatively small area for sampling that had the following features:

- Variety of land use types in the drainage basin (commercial, industrial, residential)
- Access to a variety of stormwater structures (catch basin, manhole, junction box, etc.)
- Availability of small to medium size drainage basins
- Availability of data from previous sampling efforts
- Willingness of the local municipality or owner to allow us to install and test the sampler

The city of Lacey, which is located in Thurston County just east of Olympia on the Interstate-5 corridor was selected as a suitable area for the pilot study. The specific sampling area is shown in Figure 1.

Based on the previously described objectives of the pilot study, four sites within the Lacey stormwater system were selected for installation of the prototype traps. These sites are shown in Figure 1 and described below:

Site 1 - Tanglewilde

This system has a drainage area of approximately 372 acres. Land use is composed primarily of a suburban residential neighborhood (Tanglewilde) with some medium commercial strip development. Discharge from the system enters Woodland Creek on the south side of Martin Way. The sampling site is located approximately 250 yards east of the mouth of the drain. The traps were mounted to the sides of a straight section of corrugated metal pipe. Sediment sampling at this location has been performed during two earlier studies conducted by Thurston County and the city of Lacey (Davis and Coots 1989; Thompson 1991).

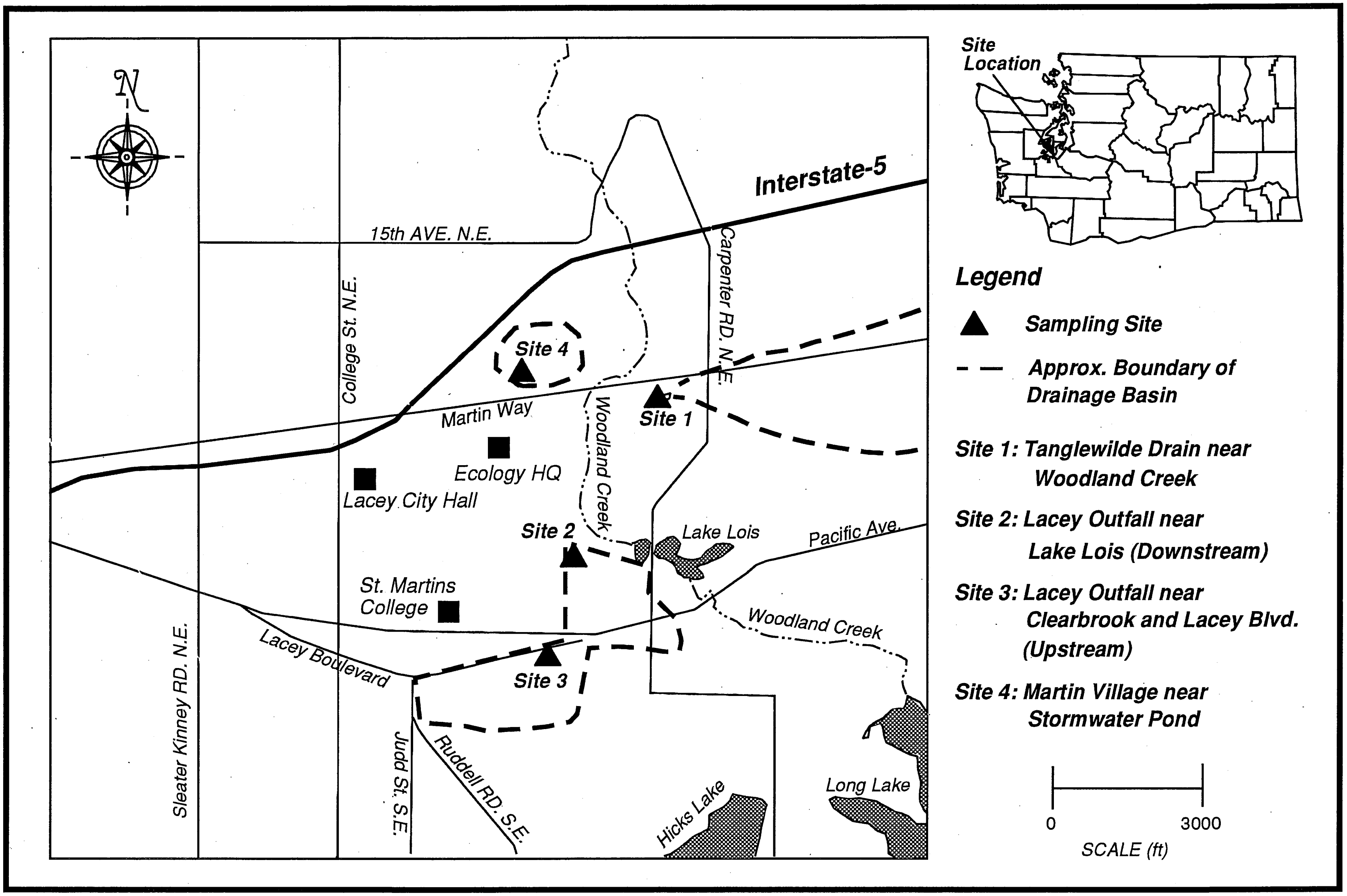

Figure 1: Stormwater Sediment Trap Pilot Study, Sampling Sites.

Site 2 - Lacey Outfall near Lake Lois

The next site is in a 387-acre sub-basin which also discharges into Woodland Creek, approximately 450 feet downstream of the Lake Lois overflow. The system serves primarily Lacey Boulevard from Ruddell Road to Hoffman Drive, the Carpenter Road and Pacific Avenue intersection, and portions of Pacific Avenue. Land use in the drainage is dominated by residential, with one-quarter used by commercial activities. The stormwater traps were installed in a medium size concrete junction box located at the intersection of 7th Avenue and Lacey Street. Previous sampling was conducted in this portion of the drainage in 1989 as part of the Woodland and Woodard Creek Basins, Stormwater Quality Survey (Davis and Coots, 1989)

Site 3 - Lacey Outfall near Lacey Village

Site 3 is located in a small catchbasin at the corner of Clearbrook and Lacey Boulevard. Stormwater entering the catch basin is primarily from street runoff and parking lot drainage from a small retail shopping center, Lacey Village.

Site 4 - Martin Village

The final site is located in the Martin Village commercial/retail development. The drainage basin is bounded by Interstate-5 to the North, Martin Way to the south, a Washington State Department of Transportation "Park and Ride" to the west, and Woodland Creek to the east. The system has a drainage area of approximately 100 acres with almost 100% of the runoff coming from roof drains and paved parking. The stormwater system is relatively new (<5 years old) and is privately owned and maintained by Martin Village. The runoff is conveyed to the northeast corner where it enters two large detention ponds. Effluent from the ponds is discharged via a dispersal pipe to the riparian corridor adjacent to Woodland Creek. The traps were mounted in a large concrete junction box located just before the detention ponds. This site has not been previously sampled but was selected to be an ambient monitoring site by the city of Lacey.

Sampling Procedures

Suspended Particulates

Sediment Traps

Two sediment traps were deployed at each of the four sampling sites between June 29 and October 4, 1995. A diagram of the construction details of the prototype traps is shown in Figure 2. The typical mounting configuration is shown in Figure 3.

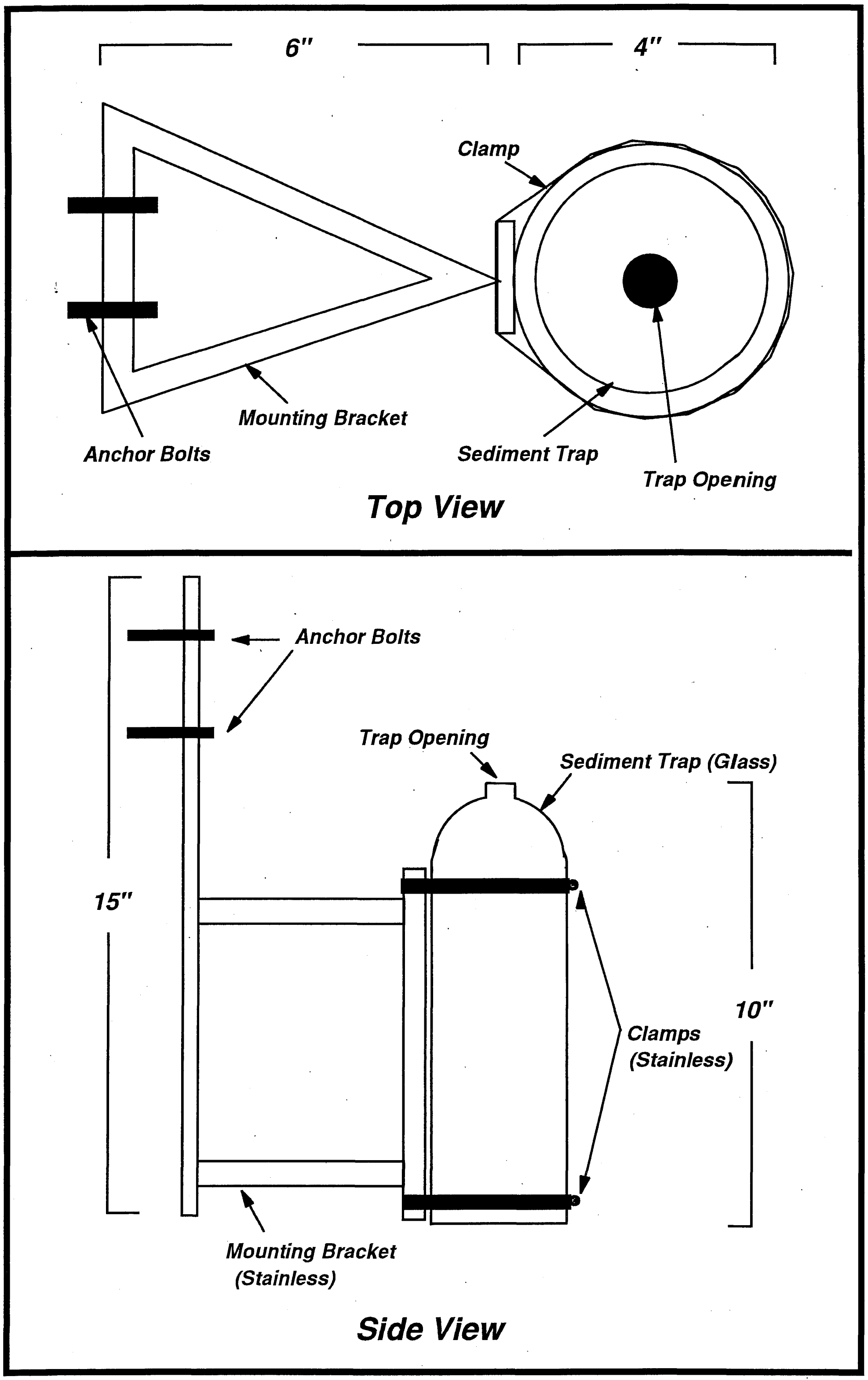

Figure 2: Construction Details of Stormwater Sediment Trap.

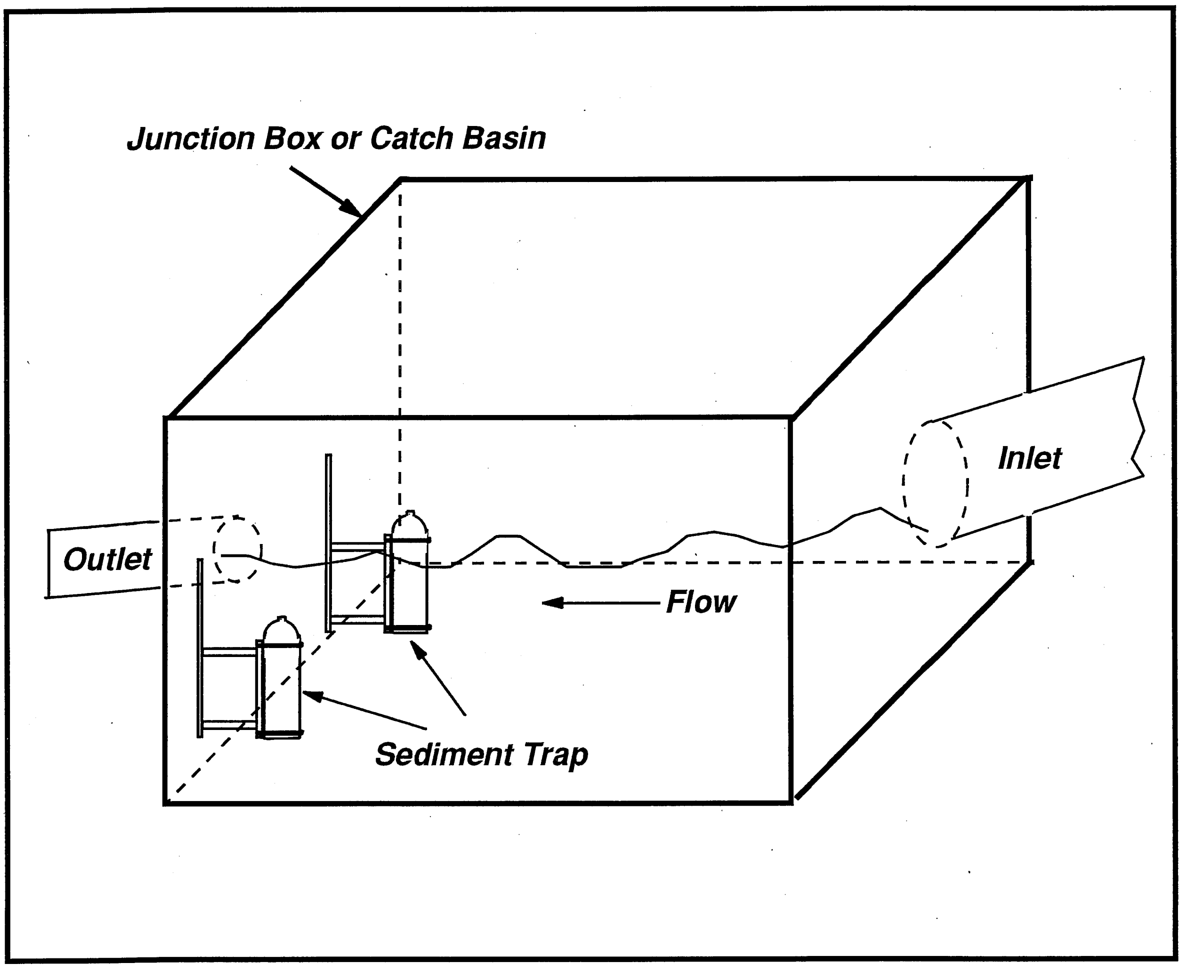

Figure 3: Mounting Location of Stormwater Sediment Trap.

Installation of the traps required entry of personnel into several of the stormdrain structures. A copy of the confined space entry plan for the project is included in Appendix A. The City of Lacey Storm Sewer Utility Department provided flaggers and signage for traffic control to allow entry into the manholes.

After retrieving the traps, personnel capped and labeled the collected bottles then stored them on ice in coolers at 4°C, pending processing. Processing began within 24 hours of retrieval and consisted of first decanting off a portion of the overlying water, then centrifuging the remaining slurry to isolate the particulate fraction. Manipulation of samples in the laboratory was accomplished with stainless steel spoons.

Centrifugation

At the Martin Village Site, suspended particulates were also collected with the use of a trailer-mounted, continuous-flow centrifuge. Fifteen-hundred and fifty gallons of water was centrifuged over a 20-hour period between October 3 and 5. This sample was obtained to allow comparison of particulate data collected by the prototype traps and the more traditional method of continuous-flow centrifugation.

Bottom Sediments

To evaluate the comparability of bottom sediment data to information generated from the stormwater sediment traps, an attempt was made to collect bottom deposits at each of the sampling locations on October 4. Prior to initial deployment of the sediment traps, the city of Lacey removed existing sediment deposits from Sites 2 and 3 with a vactor truck.

At the end of the deployment period, bottom sediment was successfully collected at the same location as the sediment traps at Sites 1 and 2. At Site 3 no material had accumulated during the deployment period, consequently a bottom sample was not obtained at this location. At the Martin Village location no sediment had accumulated at the trap location so sediments were collected from the detention pond immediately downstream.

All bottom sediment samples were collected as grabs using a petite ponar sampler. To obtain sufficient volume for analysis, 3 to 4 grabs from each site were collected and homogenized in a stainless steel beaker.

Quality Assurance

All physical/chemical analysis of samples for this project were conducted using procedures specified in the Puget Sound Protocols as amended and updated (PSEP, 1986). In addition, the type and frequency of laboratory quality assurance (QA) samples at a minimum follow those specified in the Ecology/EPA Manchester Laboratory QA Manual (Ecology, 1988). A summary of analytical methods and laboratories used in the Stormwater Sediment Trap Pilot Study is shown in Table 1.

Quality of the data generated was evaluated with the following sample types: procedural blanks, duplicate matrix spikes, internal standards, surrogate spikes, and field duplicates. Staff at the Manchester Laboratory performed QA reviews of the data. Copies of the individual case narratives are included in Appendix B. The reader is referred to the case narratives for specific details concerning the data quality.

Overall, no major analytical problems were encountered in the analysis of samples for this project with the exception noted below. Consequently, the data generated are considered acceptable for use as qualified in the data tables and noted in the case narratives.

Poor agreement was seen between the bottom sediment field duplicates (a single sample homogenized and split into two separate aliquots) for the polynuclear aromatic hydrocarbon (PAH) analysis. In contrast, excellent precision was seen between the conventionals and metals analysis of the individual duplicates for these samples. This observation suggests that the poor precision seen in the PAH analysis of these samples is the result of an analytical problem rather than a problem with the homogeneity of the duplicates.

Unless otherwise noted, all concentrations in this document are reported on a dry weight basis.

Table 1: Summary of analytical methods used for the Stormwater Sediment Trap Pilot Study.

Analysis	Method	Reference	Laboratory
Percent Solids	Dry @ 104°C	PSEP, 1986	Ecology/EPA- Manchester, WA.
Grain Size	Seive and Pipet	"	Soil Technology, Inc.- Bainbridge Is., WA.
Total Organic Carbon	Combustion/CO2 Measurement	"	Sound Analytical Services- Tacoma, WA.
Total Metals			
Cadmium	ICP	EPA,1986	Ecology/EPA- Manchester, WA.
Chromium	ICP	"	" " "
Copper	ICP	"	" " "
Lead	ICP	"	" " "
Mercury	CVAA	"	" " "
Zinc	ICP	"	" " "

ICP= Inductively Coupled Plasma

CVAA= Cold Vapor Atomic Absorption

Results

Physical/Chemical Analysis

The stormwater sediment traps were deployed for a total of 98 days between June 29 and October 4, 1995. Data on the amount of material collected by each of the traps are summarized below in Table 2. The amount of material collected by the traps was somewhat variable, ranging from 164 grams (dry) at the Tanglewilde Site to 8 grams at Martin Village. The median amount collected was 11 grams.

Table 2: Quantity of Suspended Particulates Collected by Stormwater Sediment Traps.

Location	Station	No. Days Deployed	Percent Solids*	Wet Grams	Dry Grams
Tanglewilde	S-1A	98	53	310	164
	S-!B	98	35	302	106
Lacey Outfall (downstream)	S-2A	98	28	87	24
	S-2B	98	28	34	10
Lacey Outfall (Upstream)	S-3A	98	24	42	10
	S-3B	98	24	37	9
Martin Village	S-4A	98	25	44	11
	S-4B	98	25	33	8

*Post Centrifugation

Rainfall records from the National Weather Service meteorological station located at the Olympia Airport are summarized in Figure 4. Measurable rainfall was recorded on 21 days during the sampling period. Total precipitation for the period was 5.18 inches. Given the time of year that sampling was conducted (summer low-flow) the quantity of particulates collected by the traps probably represents the minimum that could be expected during a three-month deployment at these locations.

The results of conventionals, metals, and organics analysis of the sediment trap samples are listed in Table 3. Total organic carbon (TOC) concentrations were quite variable between sites ranging from 4 to 22 %. The highest values were measured in the Lacey Outfall. Unfortunately, sufficient material was only obtained at the Tanglewilde Site to perform grain size analysis. Results of this analysis indicated that

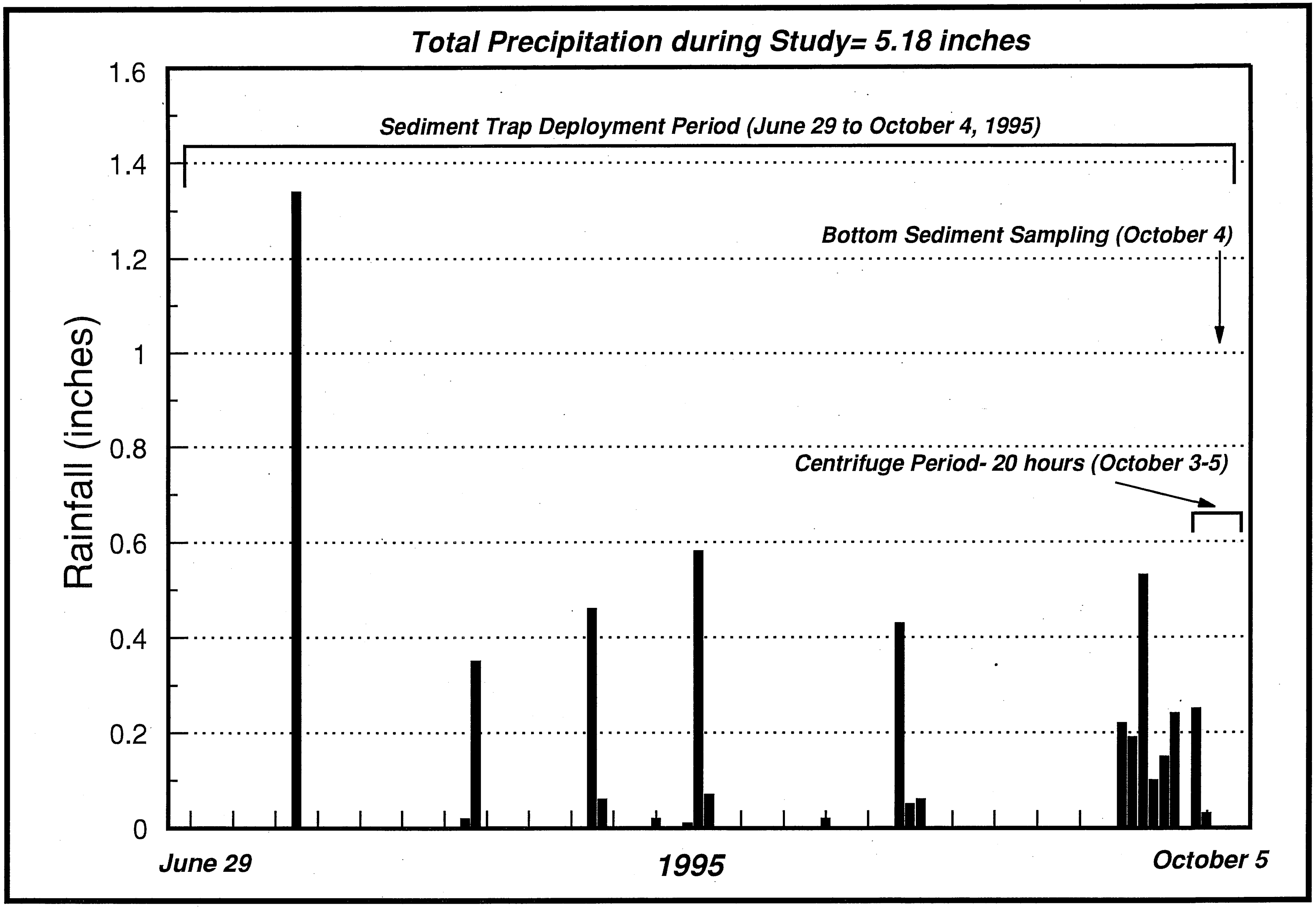

Figure 4: Precipitation recorded at the Olympia Airport during the Stormwater Sediment Trap Pilot Study.

Table 3: Summary of Conventionals, Metals, and Organics Analysis of Suspended Particulates and Bottom Sediments from Lacey Stormdrains.

Location	Tanglewilde Drain near Woodland Creek			Lacey Outfall: Near Lake Lois (Downstream)		Lacey Outfall: Clearbrook and Lacey Blvd (Upstream)	Martin Village near Stormwater Pond			
Station	S1			S2		S3	S4			
Sample Type	SPM	SPM (rep)	BS	SPM	BS	SPM	SPM	BS	BS (dup)	Centrifuge
Sample No. 40-	8130	8131	8132	8134	8136	8138	8141	8143	8145	8144
CONVENTIONALS (%)										
TSS (mg/l)	na	na	na	na	na	na	na	na	na	2
Solids	53	35	83	28	81	24	25	39	37	27
TOC	4	8.8	0.59	15	0.58	22	12	1.3	1.5	22
Grain Size										
Gravel (>2mm)	23	10	53	na	65	na	na	0	0	1
Sand (2mm-62um)	74	81	47	na	35	na	na	9	9	16
Silt (62um-4um)	3	7	0	na	0	na	na	54	55	51
Clay (<4um)	0	2	0	na	0	na	na	37	36	32
METALS (MG/KG, DRY)										
Cadmium	0.38	0.92	0.3 u	2.5	0.3 u	2.2	2.3	0.3	0.3	2.7
Chromium	9.4	18	18	33	13	46	46	45	47	66
Copper	33	44	21	82	17	110	120	37	38	120
Lead	47	80	18	190	20	140	120	13	13	200
Mercury	0.02 j	0.04 j	0.005 u	0.06	0.01 j	0.06	0.03	0.03	0.03	0.07
Zinc	130	210	62	670	94	800	770	90	93	840
POLYNUCLEAR AROMATIC HYDROCARBONS (UG/KG, DRY)										
Acenaphthene	63 u	89 u	48 u	140	47 u	28 j	260 u	86 u	29 j	140 u
Acenaphthylene	63 u	89 u	48 u	45 j	2.1 j	21 j	42 j	86 u	40 j	140 u
Naphthalene	63 u	21 j	48 u	130	9.1 j	72 j	85 j	86 u	93	140 u
Fluorene	63 u	15 j	48 u	270	8.2 j	52 j	90 j	86 u	73 j	140 u
Anthracene	63 u	21 j	2.6 j	400	17 j	91 j	180 j	86 u	130	140 u
Phenanthrene	67 j	150 j	13 j	2800	110	710	970	25 j	870	35 j
Sum LPAH	67 j	210 j	16 j	3800 j	150 j	970 j	1400 j	25 j	1200 j	35 j
Fluoranthene	130	330	31 j	5200	190	1600	2300	54 j	1900	77 j
Benzo(a)anthracene	63 u	120	48 u	1800	69	470	720	86 u	560	140 u
Chrysene	130	280	40 j	3100	140	1100	1500	47 j	1600	140 u
Pyrene	110	260	29 j	4000	170	1300	2000	59 j	2000	79 j
Benzofluoranthenes	130 j	350	28 j	4700	170	1600	1800	46 j	1500	68 j
Benzo(a)pyrene	42 j	120	15 j	1800	77	540	620	19 j	540	28 j
Dibenzo(a,h)anthracene	63 u	89 u	48 u	480	47 u	120 j	130 j	86 u	140 u	140 u
Indeno(1,2,3-cd)pyrene	49 j	130	17 j	1700	62	660	610	86 u	540	140 u
Benzo(g,h,i)perylene	61 j	140	18 j	1500	73	790	760	35 j	890	59 j
Sum HPAH	650 j	1700	180 j	24000	950	8200 j	10000 j	260 j	9500	310 j
Total PAH	720 j	1900 j	200 j	28000 j	1100 j	9200 j	11000 j	290 j	11000 j	350 j
Retene	63 u	68 j	48 u	190	23 j	110 j	130 j	15 j	340	140 u
Carbazole	63 u	22 j	48 u	470	14 j	110 j	120 j	86 u	72 j	140 u
1-methylnaphthalene	63 u	13 j	48 u	75 j	8.4 j	41 j	48 j	86 u	58 j	140 u
2-methylnaphthalene	14 j	26 j	2 j	160	13 j	100 j	120 j	86 u	140	140 u
2-chloronaphthalene	63 u	89 u	48 u	110 u	47 u	210 u	260 u	86 u	84 u	140 u

SPM= Settling Particulate Matter
BS= Bottom Sediment
u= Not detected at detection limit shown
j= Estimated concentration
na= Not analyzed

material collected at the Tanglewilde Site was composed primarily of sand size (2mm-62um) particles. Visual examination of the remaining samples suggested that material collected was much finer than that obtained at the Tanglewilde Site. The TOC results tend to support this observation.

Metals concentrations were generally low in all of the samples tested with the exception of zinc. Relatively high zinc concentrations (670-800 mg/kg) were detected in the Lacey Outfall and Tanglewilde systems.

In all instances concentrations of low molecular weight PAH (LPAH) were less than that of high molecular weight PAH (HPAH). This is a commonly observed distribution of PAHs in sediment samples since weathering processes tend to preferentially remove LPAHs (Merill and Wade, 1985). Concentrations of most organics tended to be highest at the mouth of the Lacey Outfall (Site 2) and lowest at the Tanglewilde Site. Low contaminant levels at the Tanglewilde Site are probably related to the high sand content in these samples.

Some differences in PAH levels were noted between the two locations sampled in the Lacey Outfall. LPAH and HPAH levels at the downstream site were elevated by factors of 4 and 3, respectively, compared to levels at the upstream site.

To evaluate the variability present within a stormdrain structure, replicate samples (two independent samples from the same location) were analyzed at the Tanglewilde Site. For metals, the mean relative percent difference (range of concentrations/mean concentration) between samples was 58%. Based on a comparison of detected concentrations of individual organics, the mean relative percent difference was 98%.

The organics data in Table 3 were TOC normalized to reduce the variability associated with differences in TOC content. Results of this normalization are presented in Table 4. Examination of the data in Table 4 indicates that while the overall pattern of contamination does not change (i.e. highest concentrations at Site 2 and lowest at Site 1) the comparability of replicates is greatly increased. The mean relative percent difference between replicates at the Tanglewilde Site was 15% after TOC normalization.

Comparison of Sampling Methods

Comparability of the stormwater sediment trap data to more traditional sampling methodologies was evaluated by attempting to collect bottom sediment deposits at the same locations as the traps. Sites 1 and 2 were the only locations where simultaneous trap and bottom samples were obtained. In addition to bottom sediments, a particulate sample was obtained from the Martin Village Site with the use of a continuous-flow centrifuge.

Table 4: Summary of Organic Carbon Normalized Concentrations of Semivolatile Organics Detected in Lacey Stormdrains

Location	Tanglewilde Drain near Woodland Cr.			Lacey Outfall			Martin Village Near Stormwater Pond			
				Near Lake Lois (Downstream)		Clearbrook and Lacey Blvd (Upstream)				
Station	S1			S2		S3	S4			
Sample Type	SPM	SPM (rep)	BS	SPM	BS	SPM	SPM	BS	BS (dup)	Centrifuge
Sample No. 40-	8130	8131	8132	8134	8136	8138	8141	8143	8145	8144
TOC	4	8.8	0.59	15	0.58	22	12	1.3	1.5	22
PAH (UG PAH/KG OC)										
Acenaphthene	1600 u	1000 u	8100 u	930	8100 u	130 j	2200 u	6600 u	1900 j	640 u
Acenaphthylene	1600 u	1000 u	8100 u	300 j	360 j	95 j	350 j	6600 u	2700 j	640 u
Naphthalene	1600 u	240 j	8100 u	870	1600 j	330 j	710 j	6600 u	6200	640 u
Fluorene	1600 u	170 j	8100 u	1800	1400 j	240 j	750 j	6600 u	4900 j	640 u
Anthracene	1600 u	240 j	440 j	2700	2900 j	410 j	1500 j	6600 u	8700	640 u
Phenanthrene	1700 j	1700 j	2200 j	19000	19000	3200	8100	1900 j	58000	160 j
Sum LPAH	1700 j	2400 j	2700 j	25000 j	26000 j	4400 j	12000 j	1900 j	80000 j	160 j
Fluoranthene	3300	3800	5300 j	35000	33000	7300	19000	4200 j	130000	350 j
Benzo(a)anthracene	1600 u	1400	8100 u	12000	12000	2100	6000	6700 u	37000	640 u
Chrysene	3300	3200	6800 j	21000	24000	5000	13000	3600 j	110000	640 u
Pyrene	2800	3000	4900 j	27000	29000	5900	17000	4500 j	130000	360 j
Benzofluoranthenes	3300 j	4000	4700 j	31000	29000	7300	15000	3500 j	100000	310 j
Benzo(a)pyrene	1100 j	1400	2500 j	12000	13000	2500	5200	1500 j	36000	130 j
Dibenzo(a,h)anthracene	1600 u	1000 u	8100 u	3200	8100 u	550 j	1100 j	6600 u	9300 u	640 u
Indeno(1,2,3-cd)pyrene	1200 j	1500	2900 j	11000	11000	3000	5100	6600 u	36000	640 u
Benzo(g,h,i)perylene	1500 j	1600	3100 j	10000	13000	3600	6300	2700 j	59000	270 j
Sum HPAH	16000 j	19000	31000 j	160000	160000	37000 j	83000 j	20000 j	630000	1400 j
Total PAH	18000 j	22000 j	34000 j	190000 j	190000 j	42000 j	92000 j	22000 j	730000 j	1600 j
Retene	1600 u	770 j	8100 u	1300	4000 j	500 j	1100 j	1200 j	23000	640 u
Carbazole	1600 u	250 j	8100 u	3100	2400 j	500 j	1000 j	6600 u	4800 j	640 u
1-methylnaphthalene	1600 u	150 j	8100 u	500 j	1400 j	190 j	400 j	6600 u	3900 j	640 u
2-methylnaphthalene	350 j	300 j	340 j	1100	2200 j	450 j	1000 j	6600 u	9300	640 u
2-chloronaphthalene	1600 u	1000 u	8100 u	730 u	8100 u	950 u	2200 u	6600 u	5600 u	640 u

SPM= Settling Particulate Matter
BS= Bottom Sediment
u= Not detected at detection limit shown
j= Estimated concentration
na= Not analyzed

TOC results for each sample type are compared in Figure 5. Compared to bottom sediments, TOC levels in the associated sediment trap samples were typically an order of magnitude higher. In contrast, TOC in the sediment trap sample was approximately one-half that measured in the corresponding centrifuge sample. Despite the fact that centrifuge and bottom sediment samples had similar grain size distributions (primarily silt size particles), TOC levels were much higher in the particulates collected by centrifuge.

Concentrations of copper, lead, and mercury in suspended particulates and bottom sediments are compared in Figure 6. All three metals were typically higher in the sediment trap samples compared to corresponding bottom sediments, with the following exceptions: Copper and lead at the Tanglewilde Site, and lead at the Martin Village Site were similar in trap samples and bottom sediments. Particulate samples collected by the sediment traps and centrifuge were similar, with the exception of lead which was slightly higher in the centrifuge sample.

Data from the Tanglewilde Site indicated that trap and bottom sediment samples were both composed of primarily coarse grain material and possessed similar concentrations of copper, lead, and zinc. At the Martin Village Site, particulates collected by sediment traps and centrifuge also had similar concentrations of these three metals.

Figure 7 compares PAH levels in particulates and bottom sediments on a dry weight and TOC normalized basis. At Sites 1 and 2 where trap and bottom sediment samples were obtained from the same location, LPAH and HPAH concentrations were quite different in particulates and bottom sediments on a dry weight basis. After TOC normalization PAH concentrations were in excellent agreement. Unfortunately the analytical variability present in the bottom sediment duplicate results for PAHs at the Martin Village Site (see Table 3) precludes a comparison of trap and bottom sediment data at this location.

Substantial differences were observed between particulate samples collected with traps and the centrifuge. Trapped particulates consistently had higher PAH levels compared to the centrifuge sample regardless of whether the data were on a dry weight or TOC normalized basis.

Based on a limited amount of data it appears that for metals the stormwater sediment traps collected samples that yield similar results to suspended particulates collected by centrifugation. For PAHs, after the data have been TOC normalized the trap samples most closely resemble bottom sediment concentrations. The reader is cautioned that these conclusions should be viewed as preliminary since they are based on a limited amount of information and the centrifuge sample was collected over a much shorter time period then the trap samples. Additional information on the grain size composition of the trap particulates would be useful in making comparisons between sample types.

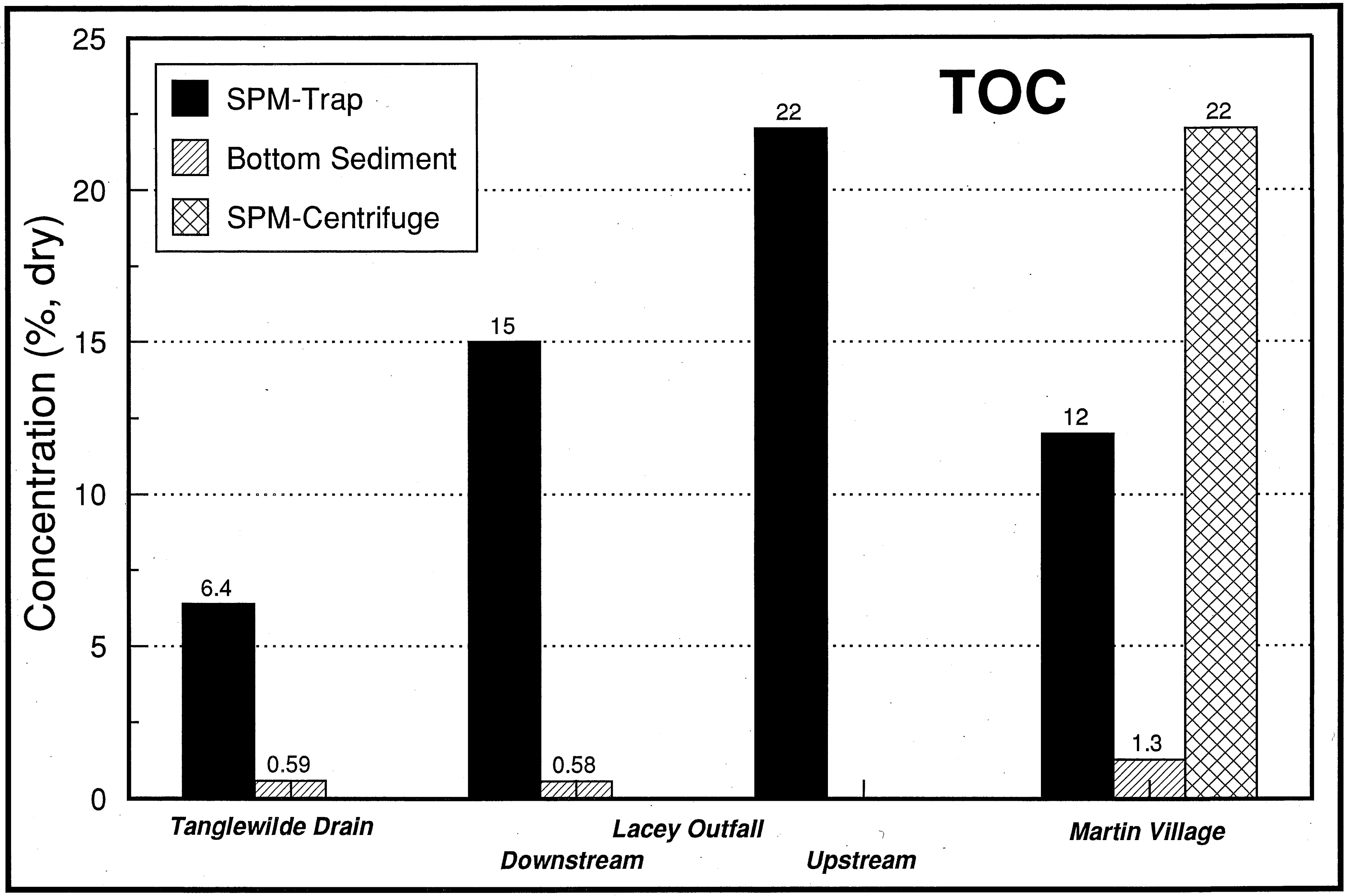

Figure 5: Comparison of Total Organic Carbon Concentrations in Suspended Particulates and Bottom Sediments from Lacey Stormdrains.

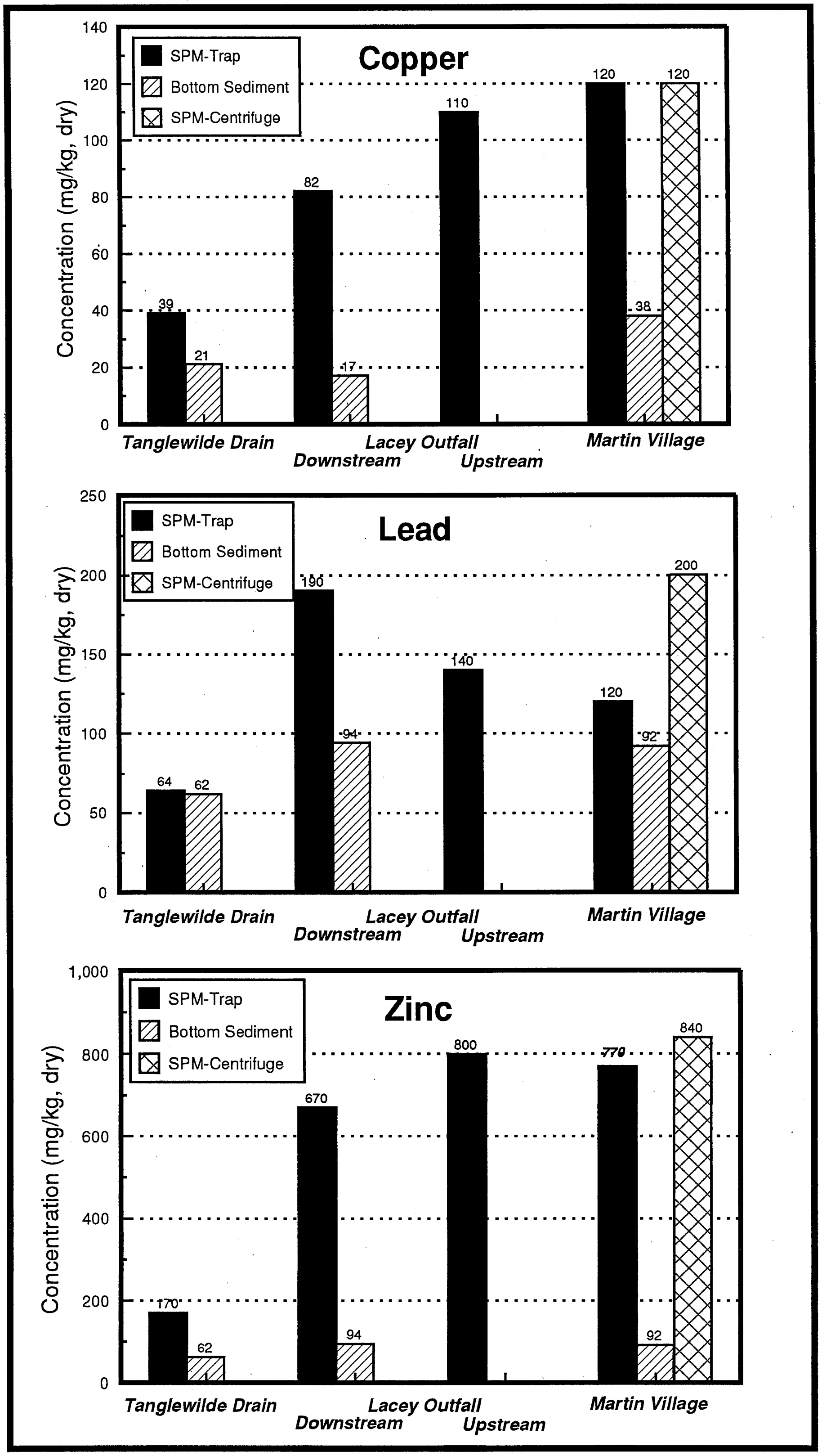

Figure 6: Comparison of Copper, Lead, and Zinc Concentrations in Suspended Particulates and Bottom Sediments from Lacey Stormdrains.

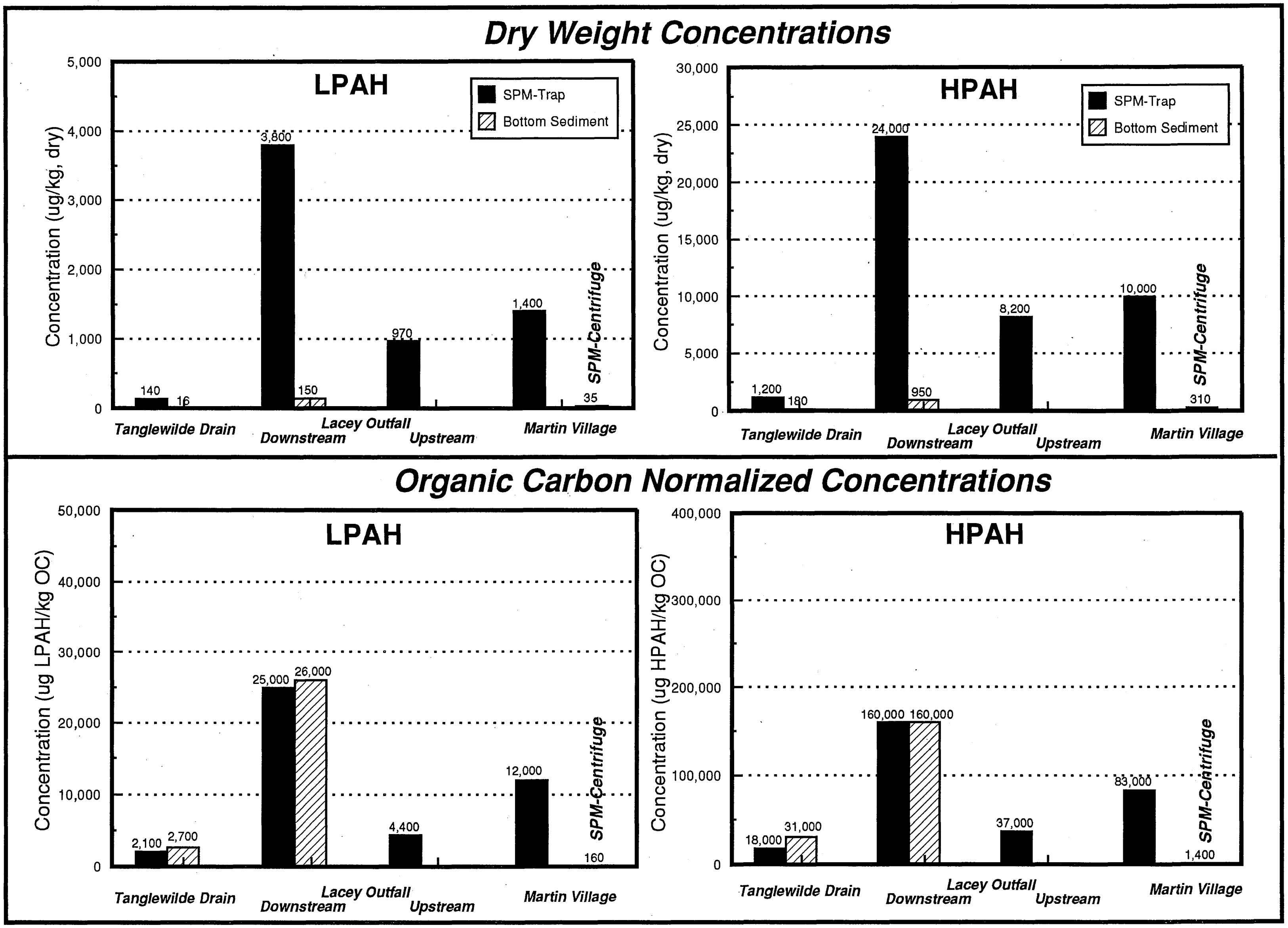

Figure 7: Comparison of Dry Weight and Organic Carbon Normalized LPAH and HPAH Concentrations in Suspended Particulates and Bottom Sediments from Lacey drains.

Comparison to Other Data from Thurston County

Table 5 summarizes data collected during the Pilot Study and compares it to previous data collected by the city of Lacey and Thurston County on typical metals and PAH concentrations in stormdrains from the area. These data are presented to evaluate the comparability of the Pilot Study results to these earlier findings.

Based on median concentration, bottom sediment results from the Pilot Study are in good agreement with previous data from the area, being within a factor of 2 in most instances. In contrast, PAH levels in sediments from the present study are over an order of magnitude less than those measured in these earlier studies.

Suspended particulate results from the sediment traps were within a factor of 2 for chromium, lead, mercury, and LPAH compared to the earlier data. Poorer agreement (factor of 4) was seen for cadmium, copper, and HPAH.

Table 5: Comparison of chemical data on particulates and bottom sediment from Thurston County stormdrains.

Source	Pilot Study			Thurston County Stormdrains[1,2]
Sample Type	Sediment Traps	Bottom Sediment	Centrifuge	Bottom Sediment
No. of Samples	5	4	1	7-23
Conventionals				
TOC (%)	**12** (4-22)	**0.95** (0.58-1.5)	**(22)**	**2.0** (1.2-8.4)
Metals (mg/kg, dry)				
Cadmium	**2.2** (0.38-2.5)	**0.3** (0.3u-0.3)	**(2.7)**	**0.56** (0.15u-2.7)
Chromium	**33** (9.4-46)	**32** (13-47)	**(66)**	**20** (13-45)
Copper	**82** (33-120)	**29** (17-38)	**(120)**	**21** (3.0-140)
Lead	**120** (47-190)	**16** (13-20)	**(200)**	**58** (1.5-510)
Mercury	**0.04j** (0.02j-0.06)	**0.02j** (0.005u-0.03)	**(0.07)**	**0.026** (0.011u-0.094)
Zinc	**670** (130-800)	**92** (62-94)	**(840)**	**110** (28-600)
Organics (ug/kg, dry)				
LPAH	**970j** (67j-3800j)	**89j** (16j-1200j)	**(35j)**	**1500**(420-23000)
HPAH	**8200** (650j-24000)	**610j** (180j-9500)	**(310)**	**35000** (3100-160000)

Values shown are: median(range)

u= Not detected at detection limit shown

j= Estimated concentration

Data Sources

1= Thurston County Stormwater Quality Report- December 1989 (Davis, et.al., 1989)

2= Stormdrain Monitoring Project, City of Lacey- October 1991 (Thompson, N., 1991)

Conclusions

Prototype sediment traps were successfully deployed in a variety of stormwater structures in the Lacey area, under low flow conditions. Sufficient material (8-164 grams, dry) was collected at all sites to perform at least a portion of the planned physical/chemical analysis on the trapped particulates. Unfortunately, only one site collected enough material to perform grain size analysis. This sample contained primarily sand size particles. A visual examination of the remaining samples suggested that they were composed of much finer material. It is anticipated that the traps would collect a much larger sample volume if they were deployed under higher flow conditions.

Results of chemical analysis of the trap samples indicated that, for metals, the data collected were comparable to particulates samples collected by continuous-flow centrifugation. With respect to PAHs, concentrations in the trap samples most closely resembled bottom sediment concentrations after the data had been TOC normalized.

One important observation during the study was that the traps were able to collect sufficient material for analysis at two locations where no bottom deposits were accumulating.

Data collected during the pilot study seem to suggest that the stormwater sediment traps have the potential to significantly lower monitoring costs for collection of particulate samples from stormwater discharges. The traps have the ability to provide samples which are integrated over several months. This ability to collect samples over a number of episodic events should produce data that is more representative of long-term stormwater quality. Use of the traps could also increase the number of available sampling points, since the traps are able to collect particulates from locations where bottom deposits are not accumulating.

The best application of the stormwater sediment trap at its current stage of development would be as a screening tool for prioritizing and isolating drainages for further characterization. Additional data on the performance of the stormwater sediment traps under actual field conditions (especially high flows) are needed before the traps are ready for routine application in a regulatory framework.

References

Barnard, B. and C. Wilson, 1995. Stormwater Sediment Trap Literature Review and Design Evaluation. Publication No. 95-309. Dept. of Ecology, Olympia, WA.

Burbage, J., 1995. Personal communication. City of Lacey, Lacey, WA.

Davis, S., 1995. Personal communication. Thurston County Environmental Health, Olympia, WA.

Davis, S. and R. Coots, 1989. Woodland and Woodard Creek Basins, Stormwater Quality Survey. Thurston County Environmental Health, Olympia, WA.

Ecology, 1988. Manchester Environmental Laboratory Quality Assurance Manual. Dept. of Ecology, Manchester, WA.

Ecology, 1994. Laboratory Users Manual. Dept. of Ecology, Manchester, WA.

Ecology, 1994. Quality Assurance Project Plan Guidance. Dept. of Ecology, Manchester, WA.

EPA, 1986. Test Methods for Evaluating Solid Waste. 3rd ed. Laboratory Manual for Physical/Chemical Methods. Office of Solid Waste and Emergency Response, Washington, D.C.

Gardner, W. D., 1980. Sediment Trap Dynamics and Calibration: A Laboratory Evaluation. J. of Marine Research, 38:1, pp. 17-39.

Merill, E.G. and T.L. Wade, 1985. Carbonized Coal Products as a Source of Aromatic Hydrocarbons in Sediments from a Highly Industrialized Estuary. Environmental Science and Technology, Vol. 19, pp. 597-603.

PSEP, 1986. Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound. Final Report TC-3991-04. Prepared by Tetra Tech, Inc. for the Puget Sound Estuary Program, EPA Region 10, Seattle, WA.

Thompson, N. M., 1991. Report of Results Stormdrain Monitoring Project. City of Lacey, Lacey, WA.

This page is purposely blank for duplex printing

Appendices

This page is purposely blank for duplex printing

Appendix A

Confined Space Entry Plan

This page is purposely blank for duplex printing

DEPARTMENT OF ECOLOGY

June 20, 1995

TO: Janet Hyre, Safety Office

FROM: Dale Norton, Toxics Investigations Section D.N.

SUBJECT: Proposed Safety Plan for Installing Sediment Traps in Stormdrains.

As you are aware we will be conducting a project to evaluate the ability of a piece of equipment we have designed and manufactured to collect stormwater particulates. This project will involve installing four of these stormwater samplers into catch basins and junction boxes in several local stormwater collection systems.

While there is no reason to believe that any of the systems selected for sampling pose a health threat, listed below is our proposed confined space entry plan to make sure that no problems arise. I have reviewed the confined space regulations (WAC 296-62-Part M) you provided and believe our plan meets the requirements of a non-permitted confined space.

Air Monitoring

Prior to entry and continuously during the time personnel are in the confined space the atmosphere where personnel will be working will be tested with the following direct reading instruments;

Meter	Purpose
LEL/O2 Meter	Monitor O2 levels and test for the presence of combustible gases
Drager Tubes	Test for the presence of hydrogen sulfide
Tip meter	Test for the presence of organic vapors

If a dangerous atmosphere is detected (any of these conditions are present: $O_2 < 19.5\%$, $> 10\%$ of the LEL, or presence of H_2S) personnel will not enter the system. I will be the acting supervisor on-site. I have been trained in the use of all this equipment and will brief Craig Wilson (the other person working on the project) on its operation prior to pre-entry testing. A log of all testing results will be maintained on-site.

Physical Hazards

All work will be performed using the buddy system. Only one member of the team will enter the system at any time. The other individual will remain out of the confined space to act as a rescuer should that become necessary. The individual inside the system will wear a harness equipped with a safety line to the surface. This line will be attached to a tripod system that is capable of being operated by one person should it become necessary to hoist the person out of the system. In addition, the safety line will be maintained to prevent the entry individual from falling to the floor of the stormdrain.

We are scheduled to perform this work on June 29. I am requesting that you review our proposed plan prior to that date to see if it is consistent with the regulations governing entry into confined spaces. Please advise me of any problems you see.

Thank you for your assistance in reviewing our plan. It is appreciated.

DN:jl

cc Larry Goldstein
Craig Wilson

Appendix B

Case Narratives for Laboratory Analysis

This page is purposely blank for duplex printing

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366
November 14, 1995

Project: **Stormwater Sediment**

Samples: 408130, 408131, 408132, 408134, 408136, 408138, 408141, 408143, 408144, 408145

Laboratory: Sound Analytical Services, Inc. 52153

By: Karin Feddersen KF

These samples were received at the Manchester Environmental Laboratory (MEL) on October 6, 1995, and were sent to Sound Analytical Services, Inc. on October 16, 1995, for TOC analysis using the following: Puget Sound Estuary Program.

HOLDING TIMES

These samples were analyzed within the specified PSEP TOC holding time for frozen sediments of six (6) months.

METHOD BLANKS

The method blanks associated with these samples have demonstrated that the process is free from contamination.

CHECK STANDARDS

All recoveries were within QC limits of +/- 20% of the expected values.

TRIPLICATE

Sample 408130 was analyzed in triplicate. The Relative Standard Deviation (RSD) was within 20%.

SUMMARY

For consistency with MEL reporting protocol, all non-detect values have been qualified with a "U" (the analyte was not detected at or above the reported result). This data is acceptable for use as amended.

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

October 30, 1995

Project: Stormwater Sediment Traps

Samples: 40-8130-32, 36,43,45, 41-8144

Laboratory: Soil Technology

By: Pam Covey

Case Summary

The Stormwater Sediment Trap samples required seven (7) Grain Size analyses on sediment using Puget Sound Esturary Program protocols.

These samples were received at the Manchester Environmental Laboratory on October 6, 1995 and transported to Soil Technology on October 16, 1995 for Grain Size analyses. These analyses were reviewed for qualitative and quantitative accuracy, validity and usefullness.

The results are acceptable for use as reported.

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (360) 871-8860 • FAX (360) 871-8850

November 6, 1995

To: Dale Norton, Project Officer

From: Myrna McIntosh, Metals Chemist

Subject: Stormwater Sediment Trap

QUALITY ASSURANCE SUMMARY

Data quality for this project is excellent. No significant quality assurance issues are noted with the data.

SAMPLE INFORMATION

The samples from the Stormwater Sediment Trap project were received by the Manchester Laboratory on 10/6/95 in good condition.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples show no analytically significant levels of analytes.

SPIKED SAMPLE ANALYSIS

Spiked and duplicate spiked sample analysis were performed on this data set. All spike recoveries are within the CLP acceptance limits of +/- 25%.

PRECISION DATA

The results of the spiked and duplicate spiked samples are used to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes is within the 20% CLP acceptance window for duplicate analysis.

LABORATORY CONTROL SAMPLE (LCS) ANALYSIS

LCS analysis are within the windows established for each parameter.

Please call Bill Kammin at SCAN 360-871-8801 to further discuss this project.

MMM:mmm

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

December 13, 1995

Subject: Stormwater Sediment Trap

Samples: 95 - 408130 to -408132, -418134, -408136, -408138, -408141, -408143, -408145 and -418144.

Case No. 2232-95

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis ~~Unit~~

POLYNUCLEAR AROMATIC HYDROCARBONS

ANALYTICAL METHODS:

The semivolatile soil samples were extracted with acetone following the Manchester modification of the EPA CLP and SW 846 8270 procedure with capillary GC/MS analysis of the sample extracts. The sample extracts were cleaned up using the EPA silica gel cleanup method 3630. Normal QA/QC procedures were performed with the analyses .

HOLDING TIMES:

All sample and extraction holding times were within the recommended limits.

BLANKS:

Low levels of some target compounds were detected in the laboratory blanks. The EPA five times rule was applied to all target compounds which were found in the blank. Compounds that were found in the sample and in the blank were considered real and not the result of contamination if the levels in the sample are greater than or equal to five times the amount of compounds in the associated method blank.

SURROGATES:

The normal Manchester Laboratory surrogates were added to the sample prior to extraction. Several are removed by the silica gel cleanup and 1,2-dichlorobenzene-d4 is partially removed by the cleanup process. Neither 2-fluorobiphenyl or d-14 terphenyl are Polynuclear Aromatic Hydrocarbon (PAH) compounds but their behavior may mimic the PAH compounds. Only d10-pyrene is a true PAH compound. All surrogate recoveries except for 1,2-dichlorobenzene were within acceptable limits and no data qualifiers were added..

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spike recoveries were in the 35% to 60% range for most of the compounds. Both the high native PAH amounts present in the matrix spike source sample, -408145 and the silica gel cleanup may have contributed to the low recoveries. No recovery limits have been established for use of the silica gel cleanup method and no qualifiers were added to the sample results..

ANALYTICAL COMMENTS:

No special analytical problems were encountered in the semivolatile analyses. The data is acceptable for use as qualified. Sample, -408145, had some PAH concentrations in the part per million range and unfortunately was a poor choice for the matrix spike sample.

DATA QUALIFIER CODES:

U	-	The analyte was not detected at or above the reported value.
J	-	The analyte was positively identified. The associated numerical value is an <u>estimate</u>.
UJ	-	The analyte was not detected at or above the reported estimated result.
REJ	-	The data are <u>unusable</u> for all purposes.
EXP	-	The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3 X 10^6.
NAF	-	Not analyzed for.
N	-	For organic analytes there is evidence the analyte is present in this sample.
NJ	-	There is evidence that the analyte is present. The associated numerical result is an estimate.
E	-	This qualifier is used when the concentration of the associated value exceeds the known calibration range.
bold	-	The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)