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Spatial and Temporal Trends in Contaminant Levels Associated with Settling Particulate Matter in Sitcum Waterway (Commencement Bay) July 1990 to June 1991

by

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ABSTRACT

To evaluate the effectiveness of source control efforts in reducing the input of problem chemicals to Sitcum Waterway, samples of settling particulate matter (SPM) and in-place bottom sediments were collected between July 1990 and June 1991. All SPM samples were collected with the use of moored sediment traps. Chemical analyses focused on arsenic, copper, lead, zinc, polynuclear aromatic hydrocarbons (PAH), and dibenzofuran which were identified as problem chemicals in the waterway during the Commencement Bay Nearshore/Tideflats (CBNT) Remedial Investigation (Tetra Tech, 1985).

The spatial distribution of contaminants in this study indicates that the major sources of problem chemicals to Sitcum Waterway are Terminal 7, in the vicinity of Berth B, and the North Corner Drain. The highest concentrations of problem metals (arsenic, copper, lead, and zinc) and organics (PAHs, and dibenzofuran) associated with SPM were measured at these two locations. This finding agrees with previous investigations in the waterway. In addition, concentrations (averaged over the study period) of zinc, and high molecular weight PAHs (HPAH) near the North Corner Drain; low molecular weight PAHs (LPAH) and dibenzofuran along Terminal 7, Berth B exceeded cleanup objectives for the CBNT and/or Ecology's Sediment Management Standards. These sediments could therefore be expected to adversely affect marine benthic communities.

In most instances, little difference is evident between present (SPM) and historical (bottom sediment) concentrations of problem metals and organics in Sitcum Waterway. Noteworthy exceptions are lead and zinc levels at Terminal 7, Berth B which appear to be decreasing over-time. Decreases in lead and zinc concentrations near Terminal 7 are probably the result of source control actions taken by Ecology, which resulted in the cessation of black ore (*i.e.*, lead and zinc) handling at Terminal 7, as of July 1991. Arsenic and zinc at the head, and zinc at the mouth of the waterway are the only metals which showed any indications of increasing levels. The observed trends in Sitcum Waterway contaminant levels should viewed with caution, since they are based on a limited amount of data and a portion of the SPM collected by the sediment traps is probably resuspended bottom sediments.

Sedimentation rates for Sitcum Waterway calculated from sediment trap data ranged from 2.1-5.7 $g/cm^2/yr$ with a mean of 3.5 $g/cm^2/yr$. Estimated resuspension rates for bottom sediments ranged from 2.2 to 2.9 $g/cm^2/yr$. Current velocities are generally low in the waterway even during periods of high tidal exchange. Velocities ≤ 4 cm/sec occur approximately 90% of the time at head and 50% of the time at the mouth. However, ship traffic and associated tugboat activity could have a substantial short-term impact on currents in a localized area. Vertical profiles of temperature, salinity, and light transmittance indicate that a fairly thick (approximately 5 ft.) layer of turbid freshwater, most likely from the Puyallup River, is present to some extent throughout the year in Sitcum Waterway.

INTRODUCTION

Sitcum Waterway, shown in Figure 1, is one of seven waterways, which along with the Puyallup River mouth make up the tideflats portion of the Commencement Bay Nearshore/Tideflats (CBNT) Superfund Site. Contamination of Sitcum Waterway sediments with a variety of chemicals was documented during the CBNT Remedial Investigation (CMBRI), (Tetra Tech, 1985). Problem chemicals for Sitcum Waterway were identified during the CBNTRI, they include: arsenic, copper, lead, zinc, low and high molecular weight polynuclear aromatic hydrocarbons (LPAH and HPAH), and dibenzofuran. As a result of this investigation, source control programs aimed at reducing contaminant loadings to the waterway have been implemented by the Department of Ecology, City of Tacoma and the Tacoma-Pierce County Health Department. However, the extent to which these programs are actually reducing inputs of problem chemicals to Sitcum Waterway has not been adequately evaluated. In addition, the rate of bottom sediment accumulation after source control was started, has not been measured.

Ecology's Commencement Bay Urban Bay Action Team therefore requested that the Toxics, Compliance and Ground Water Investigations Section conduct a sediment monitoring study in Sitcum Waterway with the following objectives:

- Determine the concentrations of problem chemicals associated with settling particulate matter (SPM) that is currently being deposited in Sitcum Waterway;

- Estimate present sedimentation rates in the waterway;

The results of this investigation will be used, along with other studies in Commencement Bay to evaluate the effectiveness of source control efforts in reducing the input of problem chemicals to Sitcum Waterway, determine when source control has been achieved, and aid in selecting remediation options for sediments. This paper reports data from the first year of SPM monitoring (July 1990 - June 1991). Results from monitoring conducted after June 1991 will be reported in subsequent updates. Similar monitoring efforts are also being conducted by Ecology concurrently in Thea Foss (formally City) and Hylebos Waterways. Results from these studies will be presented in separate reports.

METHODS

Sample Collection

To characterize present conditions in Sitcum Waterway, water samples, current measurements, SPM, and bottom sediments were collected between July 17, 1990, and June 20, 1991. Sampling locations, shown in Figure 1, were selected to provide a broad spacial coverage of the waterway, and to the extent possible, correspond to major contaminant sources {North Corner

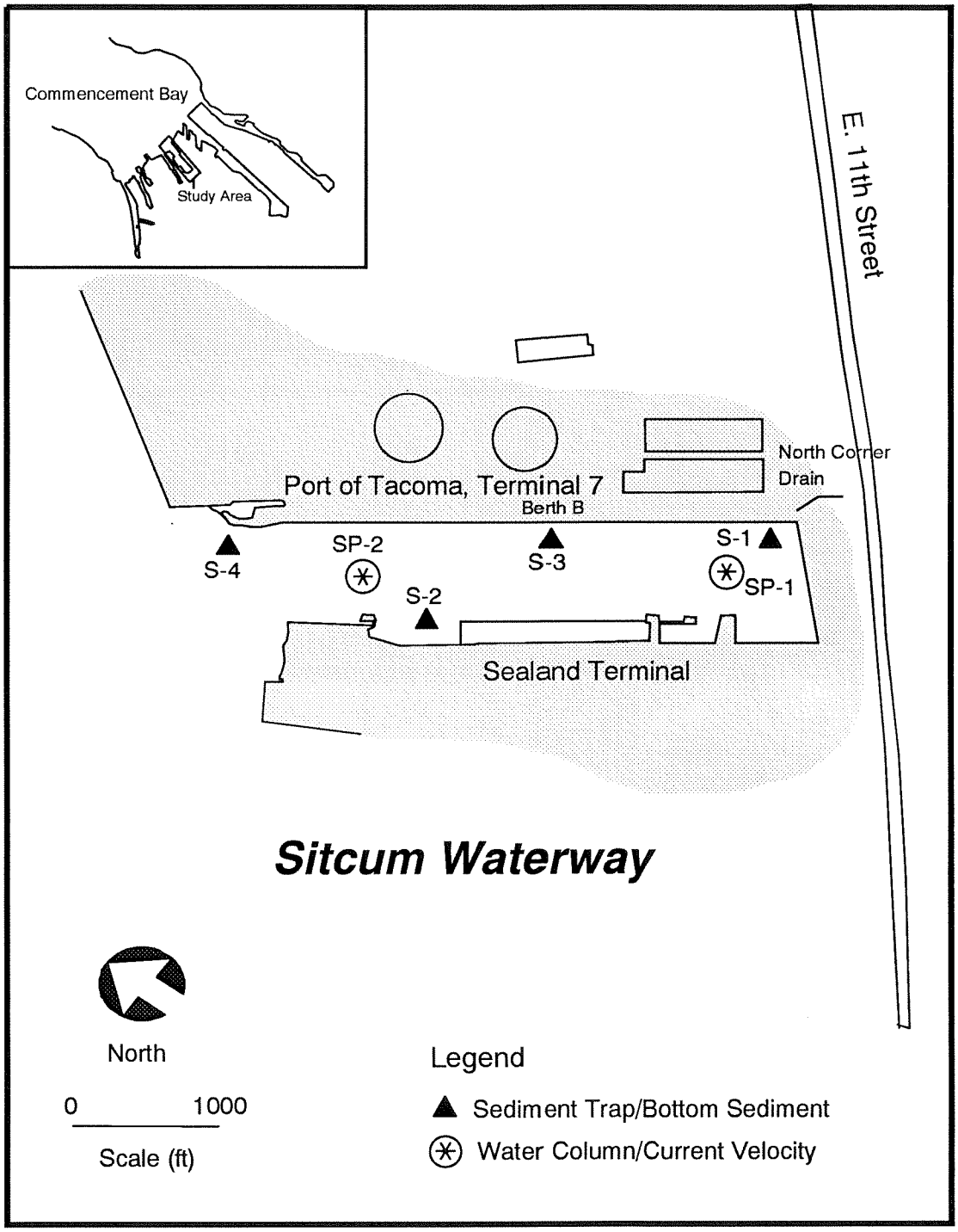


Figure 1: Station Locations for Sitcum Waterway Sediment Trap Monitoring Project.

Drain (SI-172) and ore handling facilities at Terminal 7} identified during the CMBRI. Detailed descriptions of each sampling location are also provided in Appendix A-Table A1. Station positions were located using a Magellan® Model 11001 Nav 1000 Plus GPS receiver, in conjunction with depth readings.

Water Sampling

To help interpret the distribution of particulates in the waterway, vertical profiles of temperature, salinity, light transmission and total suspended solids (TSS) were collected at two mid-channel stations during deployment and retrieval of the sediment traps. Temperature, salinity and light transmission were measured with a Seabird Electronics SEACAT® Model SBE-19 Profiler equipped with a Sea Tech, Inc. 25cm Beam Transmissometer. Samples for TSS determinations were obtained concurrently with a Van Dorn bottle.

Current Velocity Measurements

To characterize current velocities in Sitcum Waterway, two Aanderra® Current Meters Model RCM-4 were deployed for approximately one month (December 27, 1990, - February 5, 1991) at the locations shown in Figure 1. Deployment of the meters coincided with a period of maximum tidal exchange during the study.

SPM Sampling

SPM was collected at four locations in the waterway with the use of moored sediment traps, positioned 3 ft. above the bottom. The traps were deployed on July 17, 1990, and sampled every three months thereafter. The traps are straight-sided glass cylinders with a collection area of 78.5 cm^2 and a height-to-width ratio of five. Previous studies have shown that cylindrical sediment traps with these characteristics would provide unbiased samples of the vertical particle flux in current velocities expected to occur in Sitcum Waterway (Butman, 1986; Butman *et al.*, 1986; Baker, *et al.*, 1988; Larsson, *et al.*, 1986). In addition, these traps were used by Ecology between 1988-1989 to monitor contaminant levels in Thea Foss Waterway with excellent results (Norton, 1990). A schematic of the construction details of the traps and their moorings is presented in Appendix A-Figure A1. At deployment, the traps were filled with two liters of high salinity water (4% NaCl) which contained sodium azide (2%) as a preservative to reduce microbial degradation of the samples. Prior to deployment, the collection cylinders were cleaned with sequential washes of hot tap water/Liquinox® detergent, 10 percent nitric acid, distilled/deionized water, and pesticide grade acetone, then air-dried and wrapped in aluminum foil until used in the field.

Upon retrieval of the traps, overlying water in the collection cylinders was removed with a peristaltic pump. The remaining contents were then transferred to half gallon priority pollutant-cleaned glass jars with teflon-lined lids (supplied by I-Chem, Hayward, CA) and stored at 4°C for transport to the laboratory, where they were frozen within 12 hours of collection pending

processing. Processing consisted of first thawing the samples and then centrifuging to isolate the particulate fraction. All nekton > 2 cm in size were removed from the samples. In order to obtain sufficient volume for semivolatile organics analyses, SPM samples from two consecutive collection periods (*i.e.*, semi-annually) were composited. All other analyses were conducted on a quarterly basis. Manipulation of all SPM samples in the laboratory was accomplished with stainless steel spoonulas cleaned as previously described for the collection cylinders.

Bottom Sediment Sampling

Sampling procedures followed Puget Sound Protocols where applicable (Tetra Tech, 1986). Surface sediments were collected at each of the sediment trap locations on January 23, 1991, using a 0.1 m^2 stainless steel van Veen grab. To assess field variability, replicate samples (*i.e.*, two separate samples from the same location) were collected at station S-3 along Terminal 7 (Berth B). Blind field duplicates (*i.e.*, two samples split from the same homogenate) were also prepared for this location to assess overall variability (sampling collection + laboratory).

After retrieving the grab, the top 2 cm. layer not in contact with the sidewalls of the sampler, was transferred to a stainless steel beaker and homogenized by stirring with a stainless steel spoon. Aliquots for individual analyses were taken from this homogenate and placed in priority-pollutant cleaned glass jars with teflon-lined lids supplied by I-Chem Hayward, CA, wrapped in polyethylene bags, and stored at 4°C for transport to the laboratory. Spoons and beakers were pre-cleaned before use as previously described for the sediment trap collection cylinders.

Analysis and Quality Assurance

The chemical analyses, analytical methods, and laboratories used in this study are listed in Table 1. The quality of the data was assessed by analysis of method blanks, internal standards, surrogate spikes, duplicate matrix spikes, blind field duplicates and standard reference materials (SRM-metals only).

Results of metals analysis of marine SRMs are shown in Table 2. Excellent accuracy was obtained for copper, lead, and zinc ($\pm$10% of the certified range). Slightly lower accuracy was achieved for arsenic ($\pm$16% of the certified range).

Estimates of overall precision (sampling collection + laboratory) calculated as relative percent difference (RPD: range as a percent of the mean) using detected compounds in blind field duplicates were as follows: total suspended solids ($\leq$29%); other conventionals ($\leq$10%): bottom sediment; metals (arsenic 23%, copper 3%, lead 8%, and zinc 4%); semivolatile organics (LPAH 64%, HPAH 7%, and phthalates 10%): SPM; metals (arsenic $\leq$32%, copper $\leq$2%, lead $\leq$3%, and zinc $\leq$20%); semivolatile organics (LPAH $\leq$79%, HPAH $\leq$79%, and phthalates $\leq$170%). Results of blind field duplicate analyses for metals and semivolatile

Table 1: Summary of analytical methods for Sitcum Waterway sediment trap monitoring study.

Analysis	Method	Reference	Laboratory
		Sediment	
Percent Solids	Dry @ 104°C	Tetra Tech, 1986	Ecology/EPA-Manchester, Wa.
Total Organic Carbon	Combustion/CO2 Measurement	" "	AMTEST-Redmond, Wa.
			Sound Analytical Services, Inc.-Tacoma, Wa.
Grain Size	Seive and Pipet	Holme and McIntrye, 1971	Soil Technology, Inc.-Winslow, Wa.
Metals			
Arsenic,Copper,			
Lead,Zinc	X-Ray Fluoresence	Nielson and Sanders, 1983	Battelle Northwest-Sequim, Wa.
Semivolatiles	GC/MS #8270	EPA, 1986	Analytical Resources, Inc.-Seattle, Wa.
			Ecology/EPA-Manchester, Wa.
		Water	
Total Suspended Solids	Gravimetric #205C	APHA, 1985	Ecology/EPA-Manchester, Wa.
Temperature/Salinity	Seacat SBE19-CTD	Seabird Electronics	Field
Current Velocity	Aanderaa Current Meter	Aanderaa Instruments	Field
	Model RCM-4		

Table 2: Results of analysis of certified reference materials for sediment (mg/kg,dry).

Material	PACS-1				NIST-1646			
	Certified	Battelle Result			Certified	Battelle Result		
Collection Period	Range	6-12/90	1/91	1-6/91*	Range	6-12/90+	1/91	1-6/91*
Arsenic	200-222	-	168	172	10.3-12.9	10.2	9.2	11.7
Copper	436-468	-	441	405	15-21	15.8	20.9	20.8
Lead	384-424	-	438	403	26.4-30.0	29.1	30.7	29.0
Zinc	802-846	-	774	804	132-144	128	138	140

PACS-1=Marine Sediment Reference Material for Trace Metals (National Research Council of Canada)
NIST-1646=Estuarine Sediment (National Institute of Standards and Technology)
+=Mean of duplicate analysis
*=Mean of triplicate analysis
-=Not analyzed

organics are summarized in Appendix B-Table B1. These data indicate that sample handlingprocedures and laboratory analyses were not major contributors to data variability for most analytes. The greatest variability was associated with LPAH in bottom sediments, and LPAH, HPAH and dibenzofuran in SPM, which varied within a factor of two for all compounds, except for phthalates in SPM samples for the January to June 1991 collection period. Phthalates results for this collection period could vary by a factor of five.

Quality assurance review of the semivolatile organics data was performed by Dickey Huntamer of the Ecology/EPA Manchester Laboratory. The data were reviewed for qualitative and quantitative accuracy, validity, and usefulness. No major analytical problems were encountered with the analysis of these samples, except for higher quantitation limits on the January to June SPM sample set which is discussed below. Consequently, the data set is considered acceptable for use, with the accompanying qualifiers noted where appropriate.

SPM samples from the January to June, 1991 collection period were pre-screened by Gas Chromatography/Flame Ionization Detector (GC/FID) prior to analysis. Samples which had a high hydrocarbon/lipid background were diluted, which resulted in higher quantitation limits for these samples. Case narratives and data reviews for the semivolatile organics analyses are included in Appendix B-Part 2.

The chemicals in this report are expressed on a dry weight basis in units of mg/kg (parts per million) for metals, and μg/kg (parts per billion) for organics.

RESULTS

Water Column

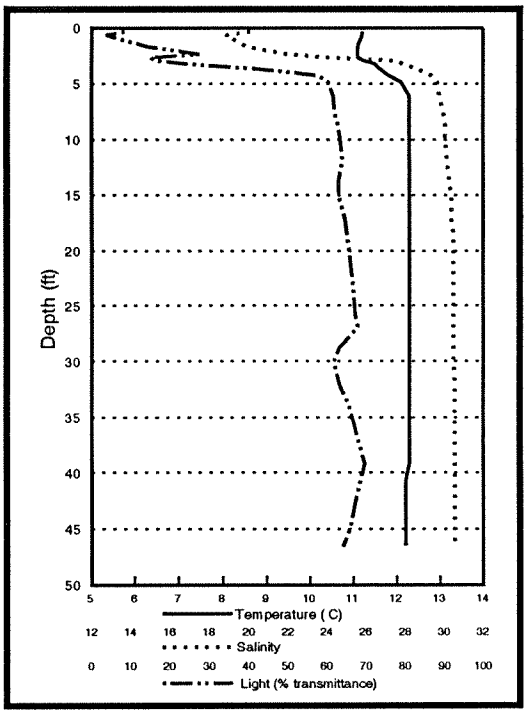
Vertical profiles of temperature, salinity and light transmittance collected during deployment and retrieval of the sediment traps at the head and mouth of Sitcum Waterway are shown in Figure 2. In general, a sharp discontinuity was observed at a depth of approximately five feet at both sites for all parameters. This pattern was not present at the head of the waterway during the January collection. These data indicate that a fairly thick layer of turbid freshwater, most likely from the Puyallup River, is present to some extent throughout most of the year in Sitcum Waterway. TSS concentrations, shown in Appendix C-Table C1 were low and similar throughout the waterway ranging from 2-14 mg/L.

Current Velocity

Near bottom (3 feet) current velocity distributions for two locations in Sitcum Waterway are presented in Figure 3. Bottom currents in the waterway were generally low, even during periods of high tidal exchange. Current velocities ranged from 2-150 cm/sec. The minimum value represents the lower limit of detection for the instrument. Slightly lower current velocities were measured at the head of the waterway compared to the mouth. Velocities $\leq$4 cm/sec occur

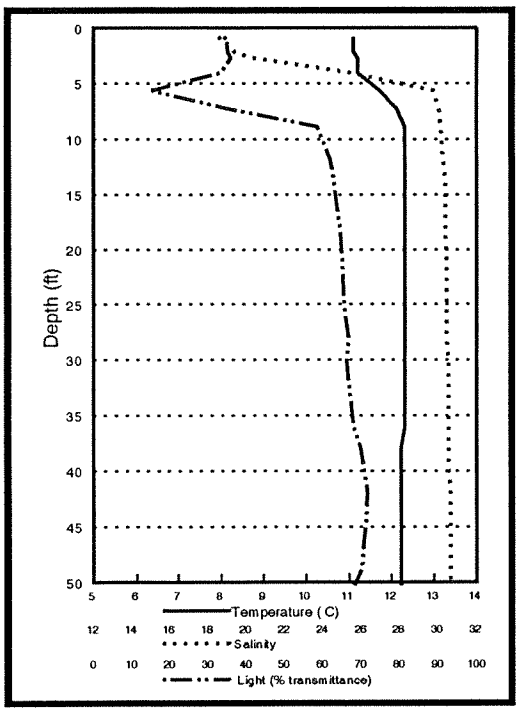
Sitcum Waterway

Head of Waterway

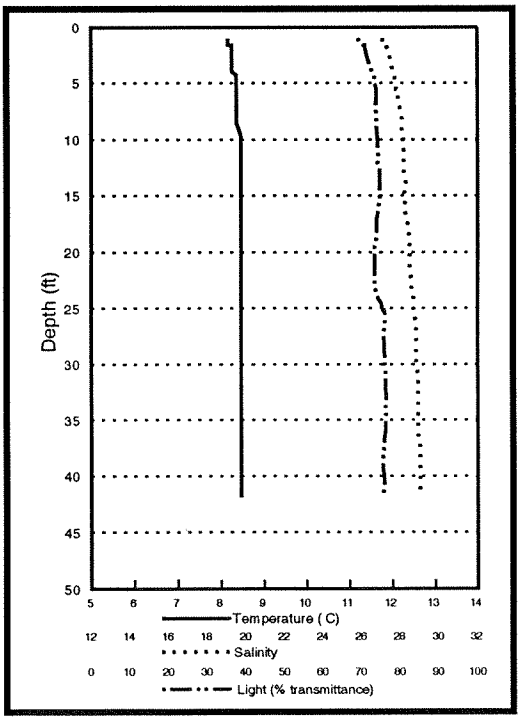


SP-1 (October, 1990)

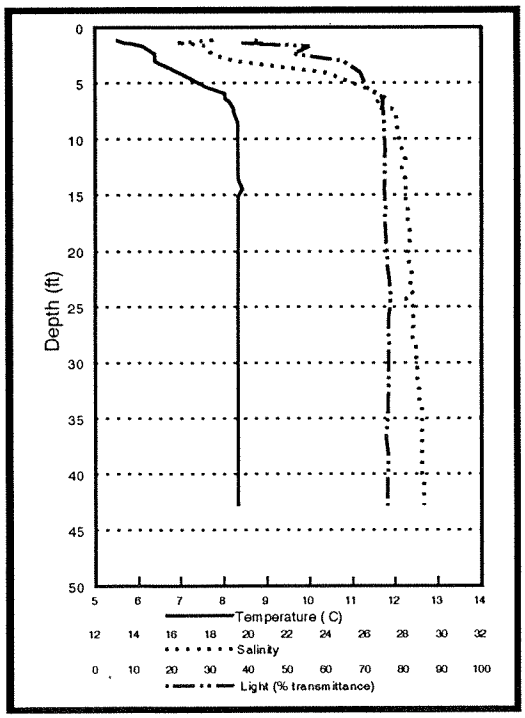
Mouth of Waterway



SP-2 (October, 1990)



SP-1 (January, 1991)

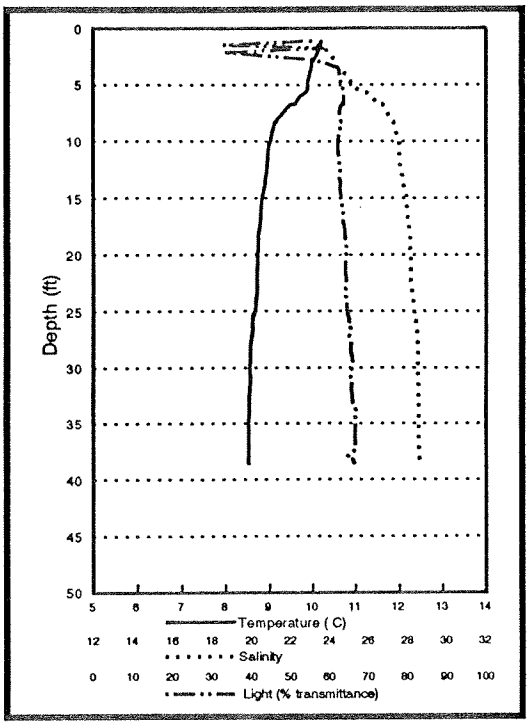


SP-2 (January, 1991)

Figure 2: Temperature, salinity and light transmittance profiles for Sitcum Waterway October, 1990 and January, 1991.

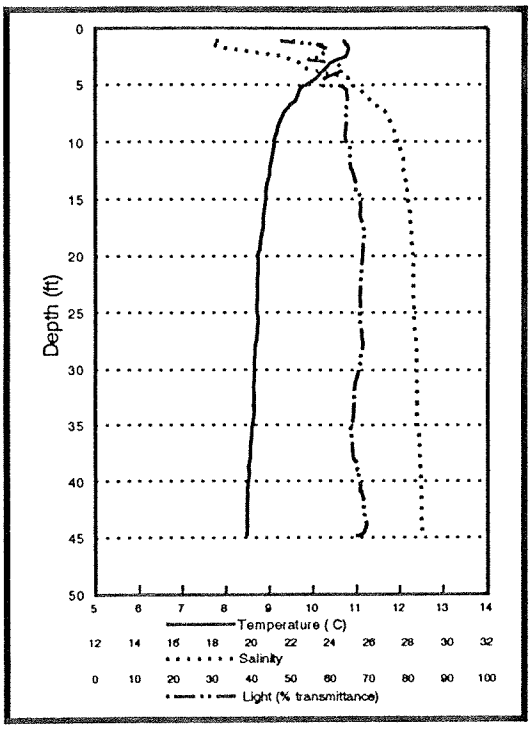
Sitcum Waterway

Head of Waterway

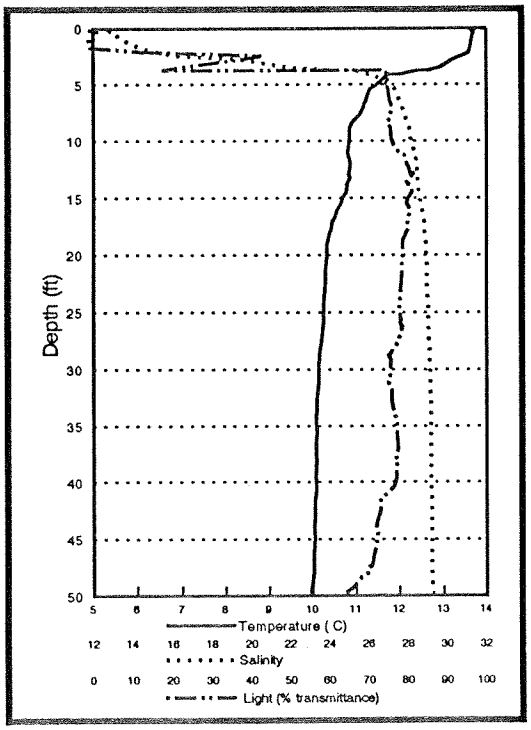


SP-1 (May, 1991)

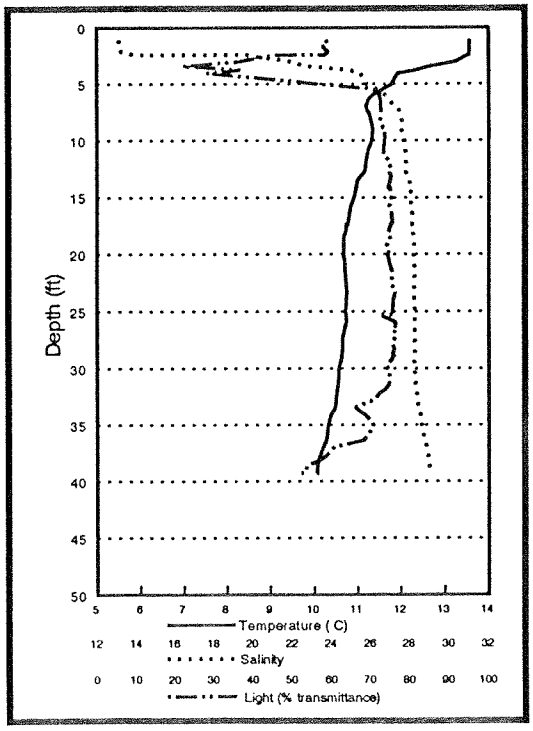
Mouth of Waterway



SP-2 (May, 1991)



SP-1 (June, 1991)



SP-2 (June, 1991)

Figure 2 cont.: Temperature, salinity and light transmittance profiles for Sitcum Waterway May and June, 1991.

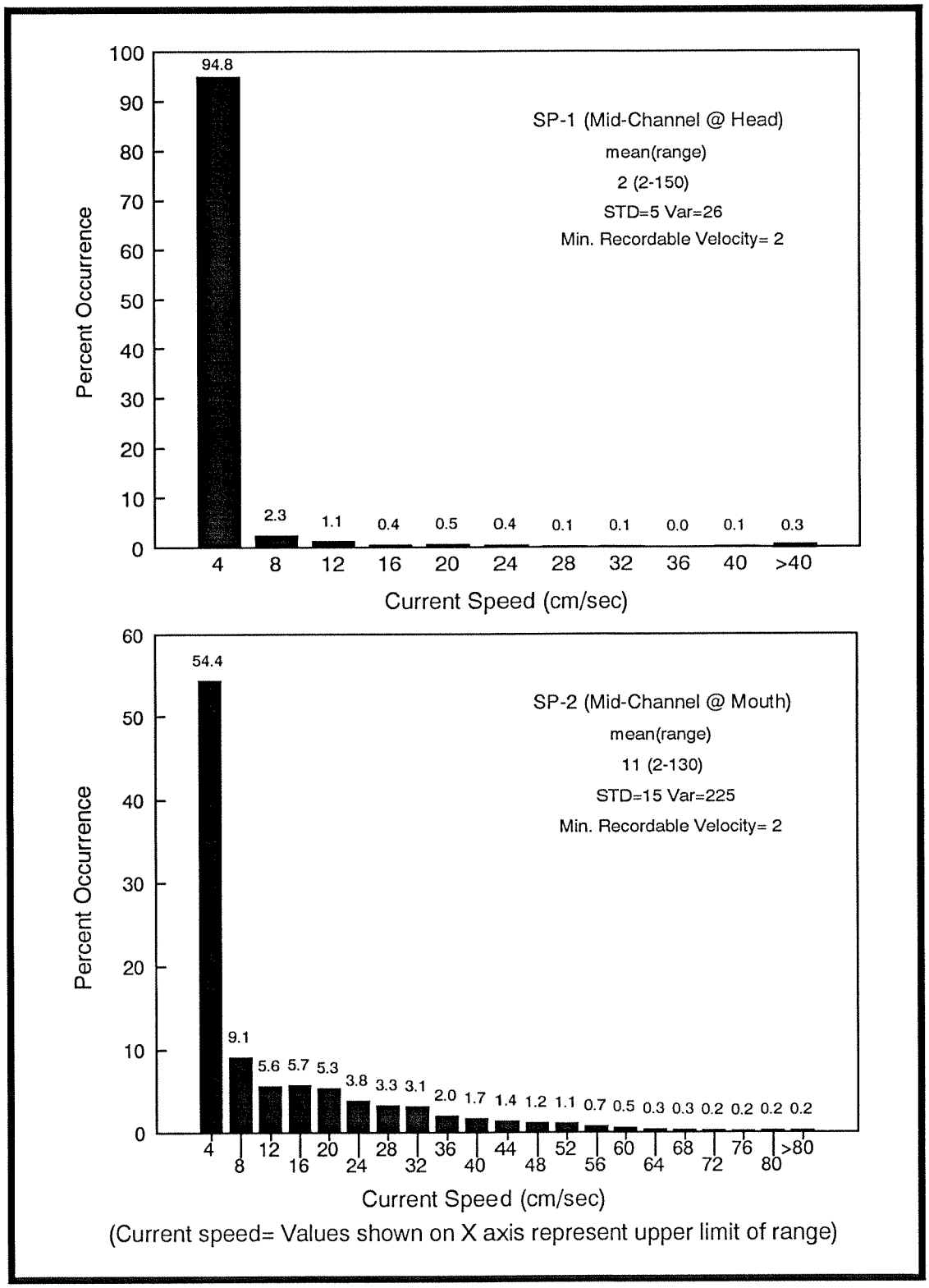


Figure 3: Current Distribution for Sitcum Waterway.
(December 27, 1990 - Febuary 5, 1991)

approximately 90% of the time at the head and 50% of the time at the mouth. Currents at the mouth (SD=15) of the waterway are more variable then those at the head (SD=5). In addition, large, short-term, current velocity increases were measured at both stations. This was especially true at the mouth of the waterway. Ship traffic and associated tugboat activities in the waterway (Sealand Terminal and Port of Tacoma, Terminal 7) probably explains the short-term velocity increases observed.

SPM

It should be noted, that out of the 16 sediment traps deployed in Sitcum Waterway during the first year of monitoring, ten were successfully recovered. The majority of the losses can in all probability be attributed to vessel activity in Sitcum Waterway.

The results of total solids (TS), total organic carbon (TOC) and metals analysis of SPM samples from Sitcum Waterway collected between July 1990 and June 1991 are presented in Table 3. TS concentrations ranged from 51.4 - 65.4% (post-centrifugation). TOC values ranged from 1.4 - 3.7%, with the highest concentration occurring at the head of the waterway near the North Corner Drain. TOC levels tended to decrease throughout the study period.

Metals concentrations in SPM (Table 3) were as follows; arsenic 6-57 mg/kg, copper 66-190 mg/kg, lead 52-370 mg/kg, and zinc 100-580 mg/kg. The highest metals concentrations were typically present at the head of the waterway near the North Corner Drain, and secondarily at Berth B, along Terminal 7. Temporal trends for problem metals in Sitcum SPM are shown in Figure 4. Peak concentrations for all metals occurred at the head of the waterway during the second quarter of monitoring (October 1990 - January 1991). An exception was arsenic, which was highest during the third quarter of monitoring (January - April 1991). This coincides with a period of maximum storm water input to the waterway from the North Corner Drain. Cumulative rainfall during the second quarter of monitoring (20.7 inches) accounted for >48% of the total rainfall measured on the Tacoma Tideflats (43.2 inches) during the study period (City of Tacoma, 1992). The lowest concentrations for all metals occurred at the mouth of the waterway. Intra-station metals concentrations were fairly consistent throughout the study period. Exceptions were arsenic and zinc at the head of the waterway and zinc at Berth B, Terminal 7. Previous sampling in Sitcum Waterway during the CBNTRI identified discharge from the North Corner Drain and ore spillage from Terminal 7 as the major metals sources to the waterway (Norton and Johnson, 1985). Results of metals analysis of SPM samples from the present study are consistent with this previous finding.

The results of semivolatile organics analysis of SPM samples from Sitcum Waterway are summarized in Table 4. Twenty-eight semivolatile organic compounds, primarily PAHs and phthalate esters were detected. Concentrations of problem chemicals were as follows; LPAH (320-8600 μg/kg), HPAH (880-21000 μg/kg), and dibenzofuran (30-1000 μg/kg). Three additional compounds, not identified as problem chemicals, but present at levels >1000 μg/kg included; bis (2-ethyl hexyl) phthalate, di-n-octyl phthalate and benzoic acid. The remaining

Table 3: Results of conventionals and metals analysis of settling particulate matter from Sitcum Waterway July, 1990 to January, 1991.

Location/ Station No.	Head @ North Corner Drain S-1				Sealand Terminal S-2			
Sample No.	8230/31*	8281	8370/71*	8383	-	-	8374	-
Collection Date	7-10/90	10/90-1/91	1-4/91	4-6/91	7-10/90	10/90-1/91	1-4/91	4-6/91
Quarter	1	2	3	4	1	2	3	4
Depth @ MLLW (ft)	22	-	-	-	44	-	-	-
Total Solids (%)	63.4	59.0	56.6	51.4	-	-	55.2	-
Total Organic Carbon (%)	3.7	2.9	1.8	1.8	-	-	1.4	-
Metals (mg/kg, dry)								
Arsenic	20	33	57	39	-	-	17	-
Copper	170	190	170	150	-	-	78	-
Lead	300	370	310	300	-	-	81	-
Zinc	320	580	450	360	-	-	150	-
Location/ Station No.	Terminal 7, Berth B S-3				Mouth @ Terminal 7 S-4			
Sample No.	8234/99*	-	8377/96*	8371/88*	8236/ 37/74**	-	8380	-
Collection Date	7-10/90	10/90-1/91	1-4/91	4-6/91	7-10/90	10/90-1/91	1-4/91	4-6/91
Quarter	1	2	3	4	1	2	3	4
Depth @ MLLW (ft)	47	-	-	-	47	-	-	-
Total Solids (%)	65.4	-	61.3	56.3	64.0	-	58.4	-
Total Organic Carbon (%)	3.3	-	1.6	1.6	2.1	-	1.5	-
Metals (mg/kg, dry)								
Arsenic	23	-	28	29	6	-	13	-
Copper	140	-	120	110	67	-	66	-
Lead	250	-	290	250	52	-	77	-
Zinc	300	-	410	280	100	-	200	-

*=Reported as mean of two samples

**=Reported as mean of three samples

-=No sample (Sediment Trap was not recovered)

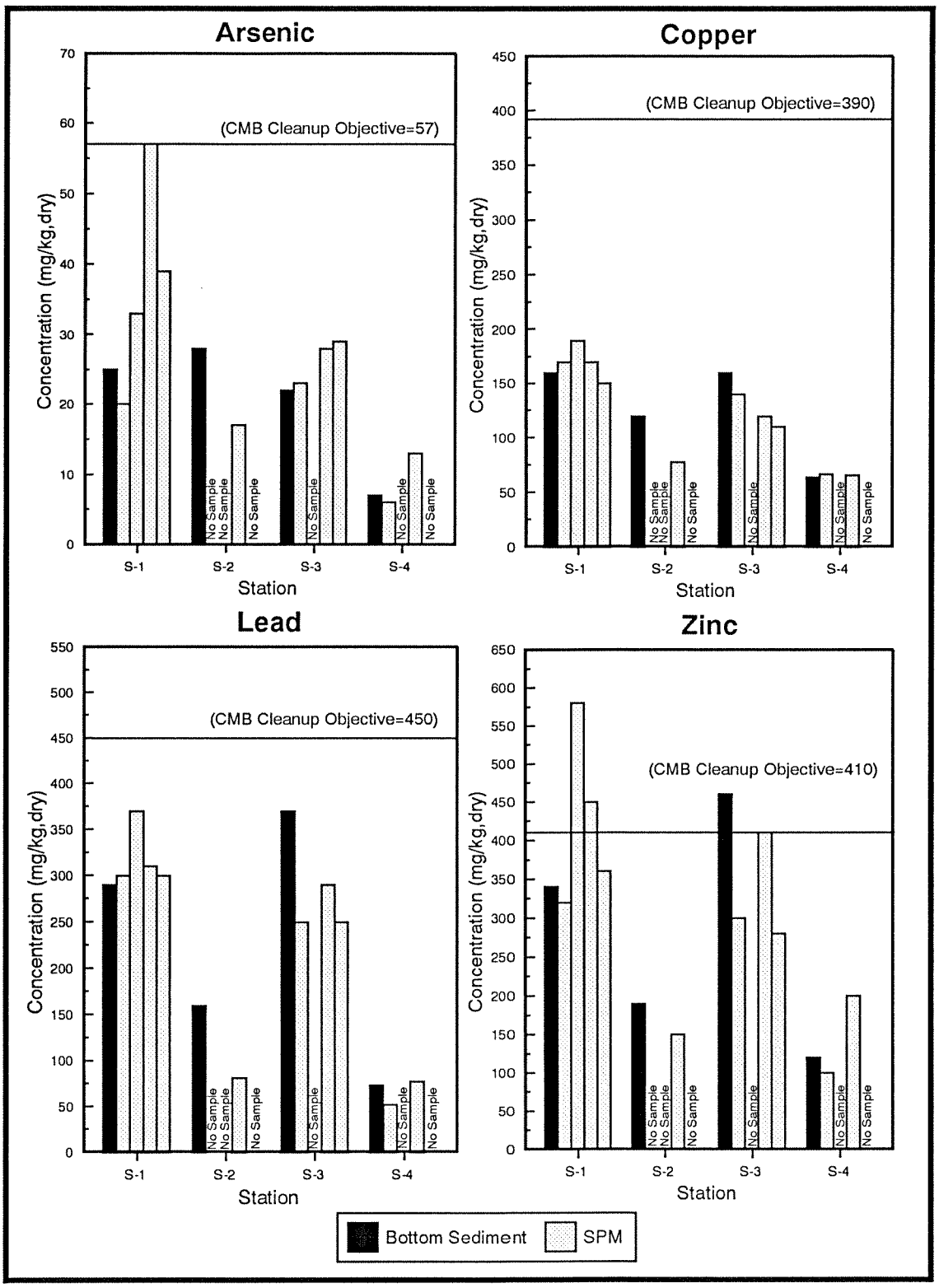


Figure 4: Comparison of problem metals in settling particulate matter (SPM) and bottom sediments from Sitcum Waterway (July, 1990 to June, 1991).

Table 4: Summary of semivolatile organics detected in settling particulate matter from Sitcum Waterway July, 1990 to June, 1991 (ug/kg,dry).

Location	Head @ North Corner Drain		Sealand Terminal		Terminal 7, Berth B		Mouth @ Terminal 7	
Station No.	S-1		S-2		S-3		S-4	
Sample No.	8293/8307*	8392/98*	-	8374	8295	8394	8296/74*	8380
Collection Date	7/90-1/91	1-6/91	7/90-1/91	1-4/91	7-10/90	1-6/91	7-10/90	1-4/91
Quarter	1-2	3-4	1-2	3	1	3-4	1	3
Depth @ MLLW (ft)	22	-	44	-	47	-	47	-
Naphthalene	210	440 j	-	300 j	57	1100	27	99 j
Acenaphthene	320	520 j	-	170 j	140	1000	35	180 j
Acenaphthylene	36	1300 u	-	890 u	15 j	59 j	25 u	590 u
Fluorene	290	670 j	-	180 j	260	1100	34	200 j
Anthracene	390	980 j	-	190 j	660	560 j	40	590 u
Phenanthrene	1800	3900	-	1000	1100	4800	180	1000
Sum LPAH	3000	6500 j	-	1800 j	2200 j	8600 j	320	1500 j
Fluoranthene	3200	5700	-	1000	1500	3000	290	2400
Benzo(a)anthracene	1200	2200	-	320 j	570	850	86	790
Chrysene	1700	2600	-	460 j	860	1100	130	700
Pyrene	1500	5000 j	-	930	750	2900	130	2200
Benzofluoranthenes	2400	2400 j	-	320 j	750	570 j	160	390 j
Benzo(a)pyrene	770	1200 j	-	210 j	220	350 j	41	210 j
Dibenzo(a,h)anthracene	180 j	2800 u	-	2300 u	42	1600 u	11	1500 u
Indeno(1,2,3-cd)pyrene	560	800 j	-	890 u	120	270 j	27	130 j
Benzo(g,h,i)perylene	78 j	760 j	-	890 u	14	220 j	20 u	120 j
Sum HPAH	12000 j	21000 j	-	3200 j	4800	9300 j	880	6900 j
Total PAH	15000 j	27000 j	-	5000 j	7000 j	18000 j	1200	8400
Phenol	50 j	1100 u	-	890 u	35 u	630 u	39	590 u
4-Methylphenol	100 j	1100 u	-	890 u	25 j	100 j	230	590 u
1-Methylnaphthalene	NA	320 j	-	130 j	NA	670	NA	120 j
2-Methylnaphthalene	150 j	300 j	-	120 j	62 j	630 j	30	91 j
Benzoic Acid	470 u	3100 j	-	420 j	170 u	1500 j	680	1500 j
Retene	NA	970 u	-	700 j	NA	630 u	NA	590 u
Isophorone	47 u	1100 u	-	890 u	17 u	27 j	20 u	590 u
Dibenzofuran	280	480 j	-	890 u	140	1000	30	110 j
Dimethylphthalate	850	830 j	-	890 u	23 j	630 u	20 u	590 u
Butylbenzylphthalate	68 j	1600 u	-	2300 u	17 u	1600 u	20 u	1500 u
Di-n-butylphthalate	40	1000 u	-	890 u	17 u	1000	20 u	590 u
Di-n-octylphthalate	76 j	1100 uj	-	890 uj	17 u	2100 j	20 u	590 u
Bis(2-ethylhexyl)phthalate	1600	3900 j	-	1000 u	820	14000 uj	220	810 j

*=Reported as mean of two samples

-=No sample (Sediment Trap was not recovered)

u=Not detected at detection limit shown

j=Estimated concentration

NA=Not analyzed

= Problem chemical-identified during the Commencement Bay Nearshore/Tideflats Remedial Investigation.

nine compounds were all present at levels ≤ 1000 μg/kg. Peak concentrations of HPAH and benzoic acid occurred at the head of the waterway, while LPAH, dibenzofuran, bis (2-ethyl hexyl) phthalate, and di-n-octyl phthalate were highest along Terminal 7, at Berth B. Intra-station concentrations of problem organics (Figure 5) were somewhat variable between monitoring quarters. However, in all instances, peak concentrations were measured during the third and fourth quarter composite samples (January - June, 1991).

In addition to the target organics, twenty semivolatile organic compounds were also tentatively identified in SPM samples. Tentatively identified organics are found during mass spectral searches of sample extracts; they represent some of the most prevalent peaks in sample chromatograms that were not among the original target compounds (PSEP, 1988). These compounds, listed in Appendix D-Table D1 were dominated by fatty acids. Fatty acids occur commonly in many organisms and are routinely reported in recent estuarine sediments (PSEP, 1988). Typical anthropogenic sources of these compounds in the marine environment include municple sewage treatment plant and pulp mill effluents (Verschueren, 1983; Merck, 1983; and PSEP, 1988). Both of the aforementioned anthropogenic sources are present within half-a-mile of Sitcum Waterway.

Sediment accumulation rates for Sitcum Waterway determined from sediment trap data are shown in Table 5. Two types of accumulation rates have been calculated. Mass accumulation ($g/cm^2/yr$) which is the measured sediment flux into the traps, and accumulation rate (cm/yr) which is calculated to represent the actual thickness of new sediments once the particulates have consolidated on the bottom. Both these values should be viewed as estimates of gross sedimentation (ie. net sedimentation + resuspension) in the waterway. Consequently, the values reported here overestimate net sedimentation in the waterway. Sedimentation rate calculations are shown at the bottom of Table 5.

Mass accumulation rates for Sitcum Waterway on a dry weight basis ranged from 2.1-5.7 $g/cm^2/yr$, with a mean of 3.5 $g/cm^2/yr$. Due to sediment trap losses, the only period where a complete data set (all stations) was obtained is the third quarter of monitoring (January-April, 1991). Based on these concurrent data the highest sedimentation rate was measured at Berth B along Terminal 7, with the lowest occurring at the northern end of the Sealand Terminal. The only location where four consecutive quarters of data are available was at the head of the waterway. These data suggest that sedimentation in Sitcum Waterway was highest during the fourth quarter of monitoring (May - June, 1991), and lowest during the second quarter (October - January, 1991). Analysis of loading data for the Puyallup River (@ Meridian Street) collected between 1977 and 1992 indicates, peak TSS loadings typically occur in June (Ecology, 1992). Accumulation rates for the waterway ranged from 2.3 - 5.7 cm/yr, with a mean of 3.7 cm/yr.

Bottom Sediment

The results of conventionals and metals analyses of bottom sediments collected January 23, 1991, from Ecology's sediment trap stations in Sitcum Waterway are shown in Table 6. TOC

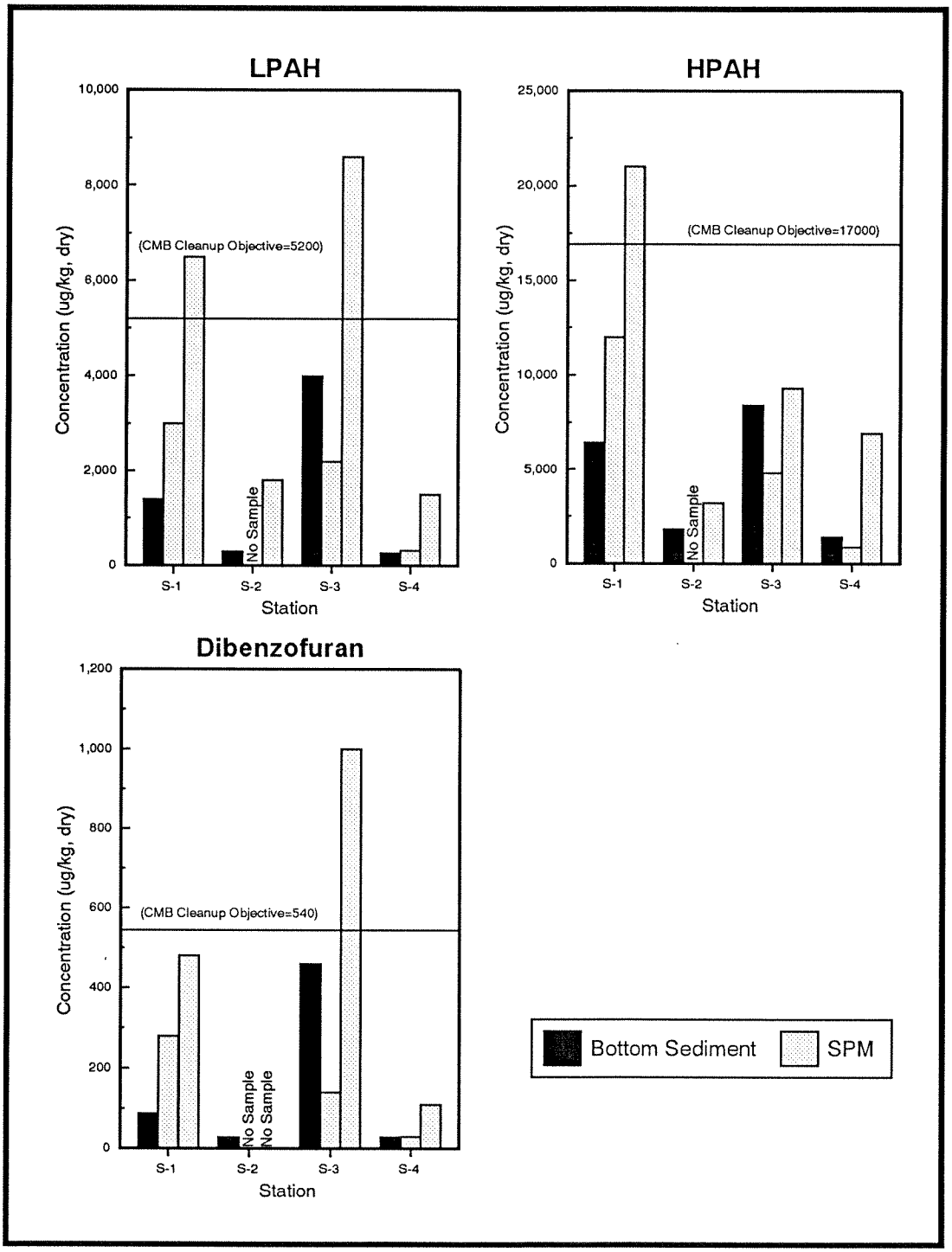


Figure 5: Comparison of problem organics in settling particulate matter (SPM) and bottom sediments from Sitcum Waterway (July, 1990 to June, 1991).

Table 5: Summary of sedimentation rates for Sitcum Waterway from available sediment trap data July, 1990 to June, 1991.

Location	Station	Deployment Period	Number Days Deployed	Sedimentation: Mass Accumulation (g/cm2/year)	Sedimentation: Accumulation Rate (cm/year)
Head @	S-1	7/17-10/16/90	91	3.7	4.1
North	"	10/16/90-1/21/91	97	2.1	2.3
Corner	"	1/21-4/29/91	98	2.9	3.3
Drain	"	4/29-6/19/91	51	4.6	5.2
Sealand Terminal	S-2	2/21-4/29/91	67	2.6	2.6
Terminal 7,	S-3	1/23-4/29/91	94	3.7	3.6
Berth B		4/29-6/19/91	51	5.7	5.7
Mouth @ Terminal 7	S-4	1/24-4/29/91	95	2.9	3.1
		Waterway mean(range)		3.5 (2.1-5.7)	3.7 (2.3-5.7)

Sedimentation Rate Calculations

- Mass Accumulation (g/cm2/yr)= [(P/A)/D] x Y

  P= Amount of material collected (dry grams)
  A= Collection area of sediment trap cylinders (cm2)
  D= No. of days sediment trap was deployed
  Y= No. of days in a year

- Accumulation Rate (cm/yr)= [Mass Accumulation (g/cm2/yr)/dry density (g/cm3)

  Wet Density= Estimated from Puget Sound Density Model (Crecelius, 1989) using % solids data from in-situ bottom sediments.
  Dry Density= [Wet Density x (Bottom Sediment % solids/100)]

Table 6: Results of conventionals and metals analysis of bottom sediments samples from Sitcum Waterway January, 1991.

Location	Head @ North Corner Drain	Sealand Terminal	Terminal 7, Berth B		Mouth @ Terminal 7
Station No.	S-1	S-2	S-3		S-4
Sample No.	8217	8218	8219/20*	8221	8222
Collection Date	1/91	1/91	1/91	Rep	1/91
Depth @ MLLW (ft)	22	44	47	-	47
Total Solids (%)	57.1	61.9	61.7	60.9	60
Total Organic Carbon (%)	1.5	1.5	1.3	2.0	1.9
Grain Size (%)					
Gravel (>2mm)	8	1	1	0	0
Sand (2mm-62um)	22	18	39	41	14
Silt (62um-4um)	50	61	43	42	67
Clay (<4um)	20	20	18	17	19
Metals (mg/kg, dry)					
Arsenic	25	28	20	24	6.9
Copper	160	120	150	160	64
Lead	290	160	370	370	73
Zinc	340	190	450	470	120

*=Reported as mean of two samples

concentrations were fairly consistent throughout the waterway ranging from 1.3 - 2.0%. Grain size analysis indicated that the sediments consisted primarily of silt size material, with the exception of sediments from Berth B, which also had a fairly high percentage of sand.

Metals concentrations in Sitcum bottom sediments were as follows; arsenic 6.9 - 28 mg/kg, copper 64 - 160 mg/kg, lead 73 - 170 mg/kg, and zinc 120 - 470 mg/kg. Arsenic and copper concentrations were fairly consistent between all stations except at the mouth of the waterway. Sediments at the mouth of the waterway, from the northern end of Terminal 7, had the lowest concentrations of all metals. In contrast, zinc and lead levels were somewhat variable throughout the waterway. The highest lead and zinc levels were measured in sediments from Berth B, along Terminal 7. The second highest lead and zinc concentrations were present near the North Corner Drain. Again, spillage of metal ores from Terminal 7 and discharge from the North Corner Drain were both identified as major sources of metals during the CBNTRI (Norton and Johnson, 1985).

Semivolatile organics analysis of the bottom sediments are summarized in Table 7. Twenty-three semivolatile compounds, primarily PAHs, were detected in bottom sediments. Concentrations of LPAH, HPAH and, dibenzofuran ranged from 260 - 5500 μg/kg, 1400 - 10000 μg/kg and, 28-690 μg/kg respectively. Peak concentrations of these problem chemicals occurred at Berth B, along Terminal 7. All remaining non-priority compounds were present at levels < 1000 μg/kg.

In addition to the target organics, eleven semivolatile organics were tentatively identified in bottom sediments. These compounds, listed in Appendix D-Table D2, consisted primarily of substituted PAHs and fatty acids.

Table 8 compares bottom sediment concentrations of metals and organics from the present study with historical data on Sitcum Waterway sediments from the CBNTRI. TOC levels from the present study were similar to those measured during the CBNTRI. Metals (arsenic, copper, lead, and zinc) concentrations from the present study were in good agreement with data collected by Tetra Tech during the CBNTRI. Tetra Tech's samples were all obtained from a longitudinal transect down the center of the waterway. Metals concentrations measured during Ecology's 1984 (Norton and Johnson, 1985) sediment survey in the waterway were all higher by approximately a factor of two compared to these other data sets. Ecology's 1984 samples were obtained from the waterway margins.

The apparent differences between Ecology's 1984 study and the other two investigations most likely reflects spatial variability in sediment metal levels. Results from the most recent and comprehensive sediment investigation in the waterway, conducted by the Port of Tacoma during the summer of 1991, support this statement. Concentrations of arsenic, copper, lead, and zinc in the Port's study ranged over three to four orders of magnitude throughout the waterway (Port of Tacoma, 1991). In addition, these data are consistent with results of previous investigations in the waterway, that identified areas near the North Corner Drain and ore handling facilities at Terminal 7 as the major metals "Hot Spots" in the waterway.

Table 7: Summary of semivolatile organics detected in bottom sediments from Sitcum Waterway January, 1991 (ug/kg,dry).

Location	Head @ North Corner Drain		Sealand Terminal		Terminal 7, Berth B				Mouth @ Terminal 7	
Station No.	S-1		S-2		S-3				S-4	
Sample No.	8217		8218		8219/20*		8221		8222	
Collection Date	1/91		1/91		1/91		Rep		1/91	
Depth @ MLLW (ft)	22		44		47		-		47	
Naphthalene	54		48	j	64	j	280		36	j
Acenaphthene	56		21	j	250		540		17	j
Acenaphthylene	24	j	11	j	20	j	28	j	31	u
Fluorene	170		27	j	290		580		22	j
Anthracene	280		66		440		620		50	
Phenanthrene	820		120		1300		3500		130	
Sum LPAH	1400	j	300	j	2400	j	5500	j	260	j
Fluoranthene	1400		290		2000		3600		300	
Benzo(a)anthracene	660		150		770		1100		120	
Chrysene	950		300		950		1300		190	
Pyrene	1100		290		1300		2300		280	
Benzofluoranthenes	1400		330		1000		1200		230	
Benzo(a)pyrene	360		130		300		350		89	
Dibenzo(a,h)anthracene	120		82		110		78		56	j
Indeno(1,2,3-cd)pyrene	360		150		260		250		93	
Benzo(g,h,i)perylene	32	j	67	j	47	j	30	j	58	j
Sum HPAH	6400	j	1800	j	6700	j	10000	j	1400	j
Total PAH	7800	j	2100	j	9100	j	16000	j	1700	j
Phenol	34	j	94	j	100	u	71	j	240	
2-Methylnaphthalene	48		25	j	87		310		37	
Benzoic Acid	160	j	320	u	300	u	86	j	81	j
Dibenzofuran	88		28	j	230		690		28	j
Dimethylphthalate	320		21	j	33		38		12	
Butylbenzylphthalate	32	u	32	u	30	j	30	u	30	u
Di-n-butylphthalate	32	u	32	u	31	u	30	u	30	j
Bis(2-ethyl hexyl)phthalate	730		180		290		300		160	

*=Reported as mean of two samples

u=Not detected at detection limit shown

j=Estimated concentration

=Problem chemical-identified during the Commencement Nearshore/Tideflats Remedial Inv.

Table 8: Comparison of problem chemicals* detected in bottom sediments from Sitcum Waterway during the present study with historical data from the Commencement Bay Nearshore/Tideflats Remedial Investigation.

Source	Present Study	Ecology, 1984	Tetra Tech, 1985
No. of Samples	6	4	5
TOC (%)	1.5 (1.3–2.0)	2.0 (1.8–2.8)	1.8 (1.6–2.5)
Metals (mg/kg,dry)			
Arsenic	24 (6.9–28)	87 (53–210)	28 (10–93)
Copper	15 (64–160)	320 (230–420)	160 (74–290)
Lead	290 (73–370)	860 (460–1900)	310 (130–660)
Zinc	340 (120–470)	740 (390–980)	250 (110–490)
Organics (ug/kg,dry)			
LPAH	1400j (260j–5500j)	–	1800 (1200–5000)
HPAH	6400j (1400j–10000j)	–	5400 (3000j–7700j)
Dibenzofuran	88 (28j–690)	–	190 (110–610)

Median(range)

*=Problem chemicals–identified during the Commencement Bay Nearshore/Tideflats Remedial Investigation.

–=No data

u=Not detected at detection limit shown

j=Estimated concentration

Sources of Data

Ecology, 1984–Sources of Sediment Contamination in Sitcum Waterway, with Emphasis on Ores Unloaded at Terminal 7 (Norton and Johnson, 1985).

Tetra Tech, 1985– Main sediment quality survey.

Concentrations of semivolatile organics in bottom sediments during the present study were in good agreement with previous sediment investigations, with the exception of bis (2-ethyl hexyl) phthalate. Concentrations of bis (2-ethyl hexyl) phthalate during the present study ranged from 160 - 730 μg/kg with a median of 290 μg/kg. Bis (2-ethyl hexyl) phthalate was not detected in Sitcum Waterway sediments during the CBNTRI.

DISCUSSION

Contaminant Trends

Table 9 compares present (reflected by SPM) and historical (bottom sediments) levels of problem chemicals in Sitcum Waterway (Figures 4 and 5) in an attempt to ascertain if source control efforts are succeeding in reducing inputs of problem chemicals to the waterway. Summarized at the bottom of Table 9 are subjective criteria developed to evaluate differences in chemical concentrations between SPM and bottom sediments. These criteria are based on consideration of measures of precision (see Quality Assurance) available from the present study. Since these comparisons are based on a limited amount of data (particularly for the organics) and the fact that resuspension can be fairly high (see section on comparison of sedimentation rates) these conclusions must be regarded as tentative.

Examination of Table 9 suggests, that for most sites, little change is evident between present and historical levels of the problem metals. Noteworthy exceptions are lead and zinc at Berth B which seem to be decreasing. This finding is consistent with the fact that as of July 22, 1991, off-loading and handling of black ore (lead and zinc) ceased at Terminal 7 (Godbout, 1991). Arsenic and zinc at the head, and zinc at the mouth of the waterway were the only metals which appear to have increased.

In general, as was the case for most problem metals, present levels of problem organics were indistinguishable from historical levels. Based on limited data, LPAH concentrations associated with present inputs to the waterway are higher than bottom sediment concentrations during certain periods of the year. This result is not unexpected, since weathering processes such as evaporation, photochemical oxidation, dissolution, and microbial degradation can preferentially remove PAHs with molecular weights less than that of fluoranthene (*i.e.* LPAH), (Merill and Wade, 1985). Additional data being collected as part of Ecology's ongoing monitoring in the waterway will be critical to further assessing the apparent trends in contaminant levels.

Comparison to Sediment Quality Values

Problem chemical and selected non-priority chemical concentrations in SPM are compared to applicable marine sediment quality values in Table 10. These values are estimates of contaminant concentrations above which deleterious effects would always be observed in marine benthic communities. Two sets of sediment quality values are shown. The first are "Sediment Cleanup Objectives" (SCO) for the CBNT site and the second are Ecology's "Sediment Management

Table 9: Comparison of problem(1) chemicals in settling particulate matter (SPM) and bottom sediments (BS) from Sitcum Waterway, matrix of change indicators.

I. Metals

Station	S-1				S-2				S-3				S-4			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Arsenic	?	+	+	+	*	*	–	*	?	*	?	+	?	*	+	*
Copper	?	?	?	?	*	*	–	*	?	*	?	–	?	*	?	*
Lead	?	?	?	?	*	*	–	*	–	*	?	–	?	*	?	*
Zinc	?	+	+	?	*	*	?	*	–	*	?	–	?	*	+	*

II. Organics

Station	S-1		S-2		S-3		S-4	
Quarter	1-2	2-4	1-2	2-4	1	2-4	1	2-4
LPAH(2)	+	+	*	+	?	+	?	+
HPAH	?	?	*	?	?	?	?	+
Dibenzofuran	?	+	*	ND	?	+	?	+

(1)=Problem chemicals-identified during the Commencement Bay Nearshore/Tideflats Remedial Inv.
(2)=See Text for discussion of cavaets
*=No data (Sediment Trap was not retrieved)
ND=Compound was not detected in SPM

SPM vs Bottom Sediment Calculation

Change (%)= [(SPM-BS)/BS] X 100

Legend of Change Indicators (BS vs SPM)

Metals	Semivolatile Organics
+/-= >30% Likely Change	+/-= >80% Likely Change
? = <30% Uncertain	? = <80% Uncertain

+=Increase in SPM contaminant level
-=Decrease in SPM contaminant level

Table 10: Comparison of problem* chemicals and selected additional organics detected in settling particulate matter from Sitcum Waterway with applicable sediment quality values.

Location	North Corner Drain					Sealand Terminal					Terminal 7, Berth B					Mouth @ Terminal 7					CMB	Ecology
Station	S-1					S-2					S-3					S-4						
Quarter Collected	1	2	3	4	Mean	1	2	3	4	Mean	1	2	3	4	Mean	1	2	3	4	Mean	Cleanup	Sediment
TOC (%)	-	3.4	-	1.8	2.6	-	-	-	1.4	1.4	-	3.3	-	1.6	2.5	-	3.2	-	1.5	2.4	-	-
PROBLEM CHEMICALS																						
Metals (mg/kg,dry)																						
Arsenic	20	33	57	39	37	-	-	17	-	17	23	-	28	29	27	6	-	13	-	9.5	57	57
Copper	170	190	170	150	170	-	-	78	-	78	140	-	120	110	120	67	-	66	-	67	390	390
Lead	300	370	310	300	320	-	-	81	-	81	250	-	290	250	260	52	-	77	-	65	450	450
Zinc	320	580	450	360	430	-	-	150	-	150	300	-	410	280	330	100	-	200	-	150	410	410
Organics (mg/kg)																						
LPAH																						
dry wt	NA	3.0	NA	6.5 j	4.8 j	NA	-	NA	1.8 j	1.8 j	NA	2.2 j	NA	8.6 j	5.4 j	NA	0.3 j	NA	1.5 j	0.9 j	5.2	-
TOC norm	NA	88	NA	360	220	NA	-	NA	130 j	130 j	NA	67 j	NA	540 j	300 j	NA	9.4 j	NA	100 j	55 j	-	370
HPAH																						
dry wt	NA	12 j	NA	21 j	17 j	NA	-	NA	3.2 j	3.2 j	NA	4.8 j	NA	9.3 j	7.1 j	NA	0.9 j	NA	6.9 j	3.9 j	17	-
TOC norm	NA	350	NA	1200	780	NA	-	NA	230 j	230 j	NA	150 j	NA	580 j	370 j	NA	28 j	NA	460 j	240 j	-	960
Dibenzofuran																						
dry wt	NA	0.3	NA	0.5 j	0.4 j	NA	-	NA	0.9 u	0.9 u	NA	0.1	NA	1.0	0.6	NA	0.03	NA	0.1 j	0.07 j	0.54	-
TOC norm	NA	0.8	NA	28	14	NA	-	NA	-	-	NA	3.0	NA	63	33	NA	0.9	NA	6.6 j	3.8 j	-	15
NON-PRIORITY CHEMICALS																						
Diemethylphthalate																						
dry wt	NA	0.9	NA	0.8 j	0.9 j	NA	-	NA	0.9 u	0.9 u	NA	0.02 j	NA	1.0	0.5 j	NA	0.02 u	NA	0.6 u	0.3 u	0.16	-
TOC norm	NA	26	NA	44	35	NA	-	NA	-	-	NA	0.6 j	NA	63	32 j	NA	-	NA	-	-	-	53
Bis(2-ethyl hexyl)phthalate																						
dry wt	NA	1.6	NA	3.9 j	2.8 j	NA	-	NA	1.0 u	1.0 u	NA	0.8	NA	14 uj	7.4 uj	NA	0.2	NA	0.8 j	0.5 j	1.3	-
TOC norm	NA	47	NA	220	130	NA	-	NA	-	-	NA	24	NA	-	24	NA	6.3	NA	53 j	30 j	-	47
Benzoic acid																						
dry wt	NA	0.5 u	NA	3.1 j	1.8 uj	NA	-	NA	0.4 j	0.4 j	NA	0.2 u	NA	1.5 j	0.9 uj	NA	0.7	NA	1.5 j	1.1 j	0.65	0.65

-=No sample (Sediment Trap was not recovered)

NA=Not analyzed

j=Estimated concentration

*=Problem chemicals-identified during the Commencement Bay Remedial Investigation

CMB Cleanup Objectives-based on environmental risks (EPA, 1989)

Ecology Sediment Management Standards-Marine Sediment Quality Standards (Ecology, 1991a)

[ ]=Exceeds sediment quality value

Standards" (SMS). The two sets differ in that non-polar organic compounds are evaluated on a dry weight basis for the SCO and on a TOC normalized basis for Ecology's SMS. Chemicals exceeding sediment quality values are highlighted in Table 10.

Table 11 summarizes problem chemical concentrations in SPM, averaged over the first year of monitoring, which exceeded sediment quality values. Mean concentrations were selected for comparison, to be more representative of overall conditions in the waterway during the study. Two locations in Sitcum Waterway, at the head near the North Corner Drain (zinc and HPAH), and Berth B along Terminal 7 (LPAH and Dibenzofuran) had mean concentrations of problem chemicals which exceeded marine sediment quality values.

In addition to the problem chemicals, three non-priority chemicals (dimethylphthalate, bis(2-ethyl hexyl) phthalate, and benzoic acid) were detected at levels above the marine sediment quality values shown in Table 10.

Problem Chemicals in Sitcum SPM vs other Areas of Commencement Bay and Puget Sound

Shown in Table 12, is a comparison of problem chemicals in Sitcum SPM with contaminant levels in SPM from Thea Foss and Hylebos Waterways, and the Puyallup River. For perspective, also included are data on contaminant levels associated with muddy sediments from depositional areas in the central basin of Puget Sound (Tetra Tech, 1989, and PTI, 1991). Sediments from the central basin were included to reflect problem chemical concentrations associated with fine grained material removed from urban bays.

TOC levels in Sitcum SPM are on the lower end of concentrations measured in Thea Foss and Hylebos Waterways. Based on medians, arsenic levels in Sitcum Waterway are lower then those reported in Hylebos Waterway. Copper concentrations were similar to those measured in Thea Foss and Hylebos Waterways, and the Puyallup River. In contrast, Sitcum Waterway had higher concentrations of lead and zinc than Thea Foss and Hylebos Waterways, and the Puyallup River. LPAH and HPAH levels in Sitcum Waterway were lower than those measured in Thea Foss and similar to those observed in Hylebos Waterway. Dibenzofuran concentrations were similar between waterways.

Compared to muddy sediments from the Central Basin of Puget Sound, arsenic and copper were two to three times higher, while zinc was elevated by a factor of five in Sitcum Waterway SPM. Lead was an order of magnitude higher in the waterway. Concentrations of all problem organics (LPAH, HPAH, and dibenzofuran) in SPM were elevated by an order of magnitude.

Sitcum Sedimentation Rates Compared to other Areas in Commencement Bay and Puget Sound

To place sedimentation rates for Sitcum Waterway into perspective, Table 13 summarizes rates reported for other parts of Commencement Bay and Puget Sound. Mean sedimentation rates for Sitcum, Thea Foss, and Hylebos Waterways determined from sediment trap monitoring (gross sedimentation) agreed within a factor of 2.

Table 11: Summary of metals and semivolatile organics exceeding marine sediment quality values in Sitcum Waterway settling particulate matter (SPM).

I. Problem Chemicals(1) Exceeding Marine Sediment Quality Values.

Station	Location	Chemical	Value Exceeded
S-1	Head @ North Corner Drain	Zinc	SCO/SMS
		HPAH	SCO
S-2	Sealand Terminal	None	-
S-3	Terminal 7, Berth B	LPAH	SCO
		Dibenzofuran	SCO/SMS
S-4	Terminal 7, @ Mouth	None	-

II. Non-Priority Chemicals Exceeding Marine Sediment Quality Values.

Station	Location	Chemical	Value Exceeded
S-1	Head @ North Corner Drain	Dimethylphthalate	SCO
		Bis(2-ethyl hexyl) phthalate	SCO/SMS
S-2	Sealand Terminal	None	-
S-3	Terminal 7, Berth B	Dimethylphthalate	SCO
S-4	Terminal 7, @ Mouth	Benzoic Acid	SMS

SCO= CMB Sediment Cleanup Objectives (EPA, 1989)
SMS= Sediment Management Standards (Ecology, 1991a)

Table 12: Comparison of problem* chemicals detected in settling particulate matter (SPM) from Sitcum Waterway during the present study with other data on contaminant levels associated with SPM from Thea Foss and Hylebos Waterways, the Puyallup River, and bottom sediments from the Central Puget Sound Basin.

Location	Sitcum	Thea Foss	Hylebos	Puyallup R.	Central Basin+
Sample Type	SPM	SPM	SPM	SPM	BS
Collection Period	7/90-6/91	6/89-6/91	7/90-6/91	7/79	3/89-3/90
Number of Samples	10-17	12-22	10-16	2	11
TOC (%)	1.8 (1.4-3.7)	5.8 (2.1-9.5)	2.3 (1.8-4.7)	-	1.8 (1.6-2.5)
Metals (mg/kg,dry)					
Arsenic	26 (6-57)	-	43 (9-100)	22u	10 (6.7-15)
Copper	130 (66-190)	170 (120-340)	140 (110-410)	160	38 (34-53)
Lead	270 (52-370)	240 (120-400)	99 (48-240)	150	22j (18j-40)
Zinc	510 (100-580)	310 (170-460)	200 (140-370)	360	99 (89-110j)
Organics (ug/kg,dry)					
LPAH	2200j (320-8600j)	5500j (2500j-32000j)	2000j (370j-6400)	-	130j (110j-180j)
HPAH	6900j (880-21000j)	18000 (13000j-120000j)	10000j (6300j-21000j)	-	380j (240j-850j)
Dibenzofuran	280 (30-1000)	330j (120j-8200u)	660uj (100-1600u)	-	22 (3j-25)

Median (range)
SPM=Settled Particulate Matter
BS=Bottom Sediment
-=No data
*=Problem chemicals-Identified during the Commencement Bay Remedial Investigation
u=Not detected at detection limit shown
j=Estimated concentration
+=Central basin muddy sediments (>67% fines) from deep areas (>150m), includes stations 24, 29 and 38.

Sources of Data

Sitcum-Present Study
Thea Foss- (Ecology, 1991b) from sediment trap monitoring
Hylebos- (Ecology, 1991b) from sediment trap monitoring
Puyallup River-Riley et al, 1980
Puget Sound-PSAMP (Puget Sound Ambient Monitoring Program) Tetra Tech, 1989 and PTI, 1991.

Table 13: Comparison of sediment accumulation rates for Sitcum Waterway obtained from sediment traps with values reported for other parts of Commencement Bay and Puget Sound.

Source	Location	Method	Sedimentation Rate(1) (g/cm2/yr)	(cm/yr)
Present Study	Sitcum WW	Sediment Trap	3.5 (2.1–5.7)	3.7 (2.3–5.7)
Ecology, 1991b	Thea Foss WW	Sediment Trap	1.6 (0.2–3.9)	2.4 (0.3–6.5)
	Hylebos WW	" "	2.0 (0.6–3.7)	2.8 (0.9–5.8)
Port of Tacoma, 1992	Sitcum WW	Pb–210 cores	0.6 (0.36–0.89)	–
Tetra Tech, 1987 (3)	Sitcum WW	Dredging Horizons (4)	1.3	1.7
	CMB Waterways(2)	Pb–210 cores (4)	0.74 (0.12–1.4)	1.0 (0.27–1.8)
Carpenter et al., 1985	Near Browns Pt.	Pb–210 cores	0.24 (0.2–0.28)	0.42 (0.25–0.58)
	Puget Sound	" "	0.43 (0.046–1.2)	0.68 (0.04–2.4)
Lavelle et al., 1986	Puget Sound	Pb–210 cores	0.72 (0.26–1.2)	1.4 (0.53–2.48)
Bloom and Crecelius, 1987	Puget Sound	Pb–210 cores	0.64 (0.27–1.4)	–

(1)=Mean(range)
(2)=Includes– Thea Foss, Middle, St. Paul, Milwaukee, and Hylebos Waterways.
(3)= Original data from Tetra Tech, 1987– Re–calculated by Jacobs, 1992.
(4)=Estimated values
–=No data

Net sedimentation in Sitcum Waterway was estimated to be 0.6 $g/cm^2/yr$ based on two Pb-210 dated cores collected in 1991 during the Sitcum Waterway Remedial Investigation (Port of Tacoma, 1992). A net sedimentation rate of 1.3 $g/cm^2/yr$ has also been estimated for Sitcum Waterway by examination of dredging horizons in sediment cores (Jacobs, 1992).

Poorer agreement (factor of 5) was seen between mean sedimentation rates for Sitcum Waterway (3.5 $g/cm^2/yr$) and the mean rate (0.74 $g/cm^2/yr$) reported for other Commencement Bay Waterways from Pb-210 dated cores collected during the CMBRI. Compared to other parts of Puget Sound, mean sedimentation rates for Sitcum Waterway are also higher by approximately a factor of 5-6. The higher rates observed in sediment traps versus cores is probably the result of the traps collecting resuspended bottom sediment.

Comparison of sedimentation rates from sediment traps (gross sedimentation) and rates from Pb-210 dated cores (net sedimentation) has been used in other investigations to estimate bottom sediment resuspension rates (Baker, *et al.*, 1991). Assuming that net sedimentation ranges between 0.6 and 1.3 $g/cm^2/yr$, and an estimate of gross sedimentation is 3.5 $g/cm^2/yr$, estimated resuspension rates in Sitcum Waterway range from 2.2 to 2.9 $g/cm^2/yr$. These values are similar to resuspension rates reported by Patmont and Crecelius (1991) for other urban embayments such as Eagle Harbor (1.9 $g/cm^2/yr$) and Bellingham Bay (3.6 $g/cm^2/yr$).

SUMMARY

Overall, the spatial distribution of contaminants observed during the present study are in good agreement with the results of previous investigations in Sitcum Waterway. Previous investigations and the present study identified Terminal 7, and the North Corner Drain as the major sources of problem chemicals to the waterway. The highest concentrations of problem metals (arsenic, copper, lead, and zinc) and organics (LPAH, HPAH, and dibenzofuran) associated with SPM were measured at these two locations. In addition, mean concentrations of zinc, and HPAH near the North Corner Drain; and LPAH and dibenzofuran along Terminal 7, at Berth B were high enough to adversely affect marine benthic communities based on comparisons with marine sediment quality values.

In most instances, little change is evident between present (SPM) and historical (bottom sediment) concentrations of problem metals and organics in Sitcum Waterway. Noteworthy exceptions are lead and zinc concentrations at Terminal 7 (Berth B), which appear to be decreasing. This finding is consistent with the fact that as of July 22, 1991, offloading of black ore (i.e., lead and zinc) ceased at Terminal 7. Arsenic and zinc at the head, and zinc at the mouth of the waterway were the only metals which appeared to have increased. Since these comparisons are based on a limited amount of data and bottom sediment resuspension rates could be fairly high in the waterway, these conclusions should be regarded as tentative.

Summarized below are the major findings of the present study.

- In most instances, little change is evident between present (SPM) and historical (bottom sediment) levels of problem chemicals in Sitcum Waterway. Noteworthy exceptions are lead and zinc at Berth B which seem to be decreasing. Arsenic and zinc at the head, and

zinc at the mouth of the waterway are the only metals which showed any indications of increasing levels. These trends in contaminant levels should be viewed with caution. They are based on a limited amount of data, and bottom sediment resuspension rates could be fairly high in the waterway.

- The highest metals concentrations in Sitcum SPM were measured at the head of the waterway near the North Corner Drain and along Terminal 7, at Berth B.

- The highest SPM concentrations of problem organics (LPAH, HPAH, and dibenzofuran) were also present at the head of the waterway near the North Corner Drain (HPAH=21000 μg/kg) and along Terminal 7 at Berth B (LPAH= 8600 μg/kg; dibenzofuran= 1000 μg/kg).

- Mean concentrations of zinc and HPAH in SPM from the head of the waterway, and LPAH and dibenzofuran along Terminal 7 (Berth B) were high enough to adversely affect marine benthic communities based on comparisons with marine sediment quality values.

- At several locations in the waterway, SPM concentrations of three non-priority organic chemicals (dimethylphthalate, bis(2-ethyl hexyl) phthalate, and benzoic acid), exceeded marine sediment quality values.

- Concentrations of lead and zinc in Sitcum SPM are higher then those measured in SPM from Thea Foss and Hylebos Waterways, and the Puyallup River.

- Sedimentation rates from the present study ranged from 2.1-5.7 g/cm^2/yr with a mean of 3.5 g/cm^2/yr. Based on a comparison of gross (sediment traps) and net (Pb-210 cores) sedimentation rates in Sitcum Waterway, estimated bottom sediment resuspension rates ranged from 2.2 to 2.9 g/cm^2/yr.

- Current velocities are generally low in the waterway, even during periods of high tidal exchange. Velocities $\leq$ 4 cm/sec occur approximately 90% of the time at the head and 50% of the time at the mouth. However, ship traffic and associated tugboat activity could have a substantial short-term impact on currents in a localized area.

RECOMMENDATIONS

Based on the data presented here the following recommendations are made.

- Re-evaluate predicted bottom sediment recovery rates for the waterway based on the data presented here. This information should be incorporated into the remedial design for Sitcum Waterway.

- Continue to monitor and evaluate trends in problem chemical levels in the North Corner Drain (arsenic, zinc, LPAH, HPAH and dibenzofuran) and vicinity of Terminal 7, Berth B (zinc, LPAH, dibenzofuran).

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Appendix A: Station Locations

Table A1: Station locations for Sitcum Waterway Sediment Trap Monitoring Study.

Station No.	Latitude (deg/min/sec)			Longitude (deg/min/sec)			Description	Water Depth (ft @ MLLW)	Sample Type
S-1	47	15	59	122	24	39	Head @ North corner Drain (SI-172)	31	SPM,BS
S-2	47	16	11	122	25	4	North end of Sealand Terminal	42	SPM,BS
S-3	47	16	7	122	24	50	Terminal 7, Berth B	54	SPM,BS
S-4	47	16	20	122	25	8	Mouth @ North end of Terminal 7	45	SPM,BS
SP-1	47	15	59	122	24	43	Mid-Channel @ Head	32	WC,CM
SP-2	47	16	14	122	25	4	Mid-Channel @ Mouth	43	WC,CM

SPM= Settling Particulate Matter
BS= Bottom Sediment
WC= Water Column Profile
CM=Current Meter

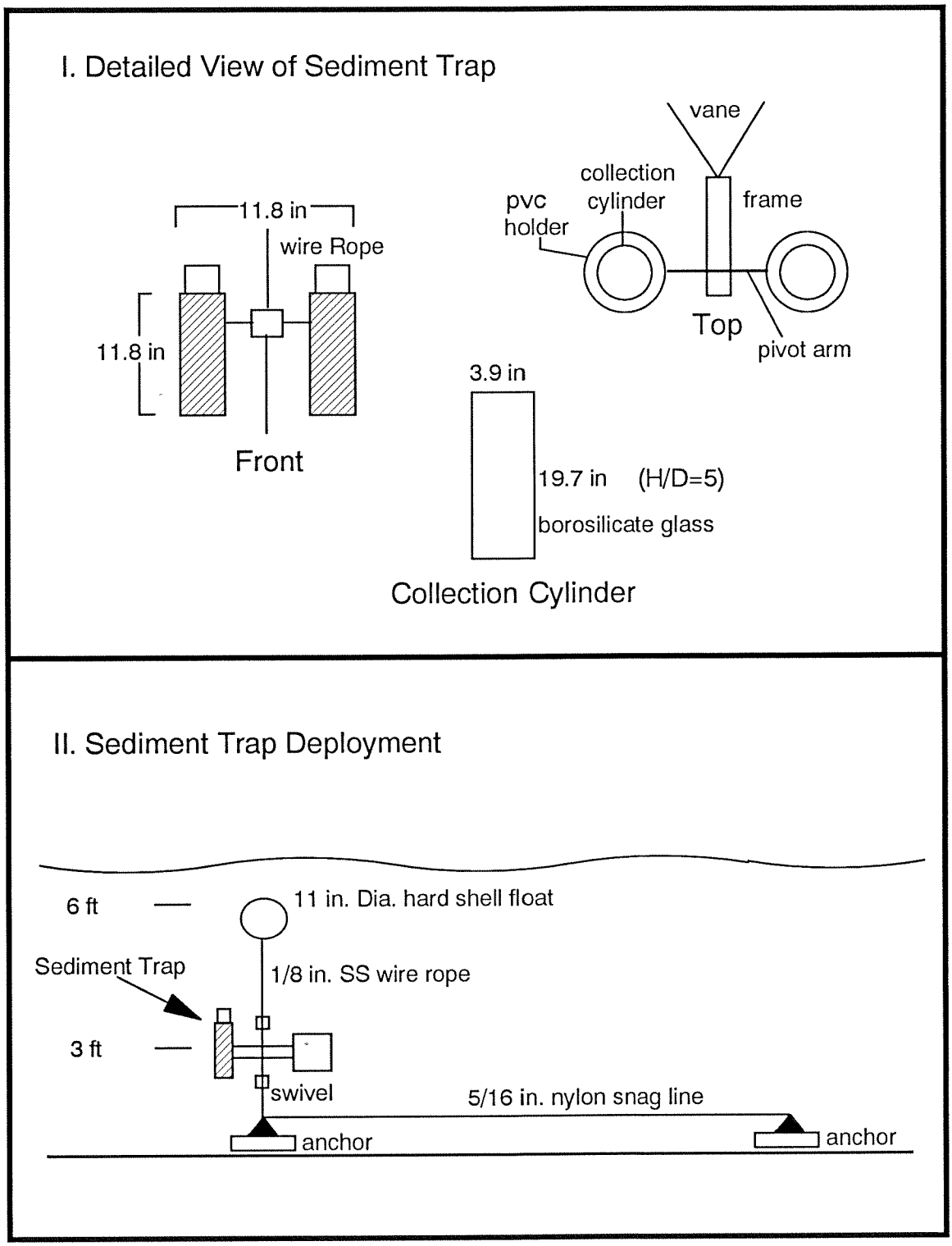

Figure A1: Diagram of Sitcum Waterway Sediment Traps.

Appendix B: Quality Assurance Data

Table B1: Summary of blind field duplicate results for problem chemicals(1) detected in bottom sediments (BS) and settling particulate matter (SPM) samples.

Sample No. (metals)	48219	48220		88234	88299		268377	268396	
Sample No. (organics)	48219	48220		88293	88307		268392	268398	
Collection Date	1/91	-		7/90-1/91	-		1-6/91	-	
Sample Type	BS	BS	RPD	SPM	SPM	RPD	SPM	SPM	RPD
Metals (mg/kg, dry)									
Laboratory		Battelle			Battelle			Battelle	
Arsenic	17.6	22.1	23	27.1	19.6	32	27	29	7
Copper	150	155	3	135	135	0	122	125	2
Lead	387	356	8	250	257	3	286	292	2
Zinc	441	460	4	308	284	8	449	367	20
Semivolatiles (ug/kg, dry)									
Laboratory		ARI			ARI			Man.	
Sum LPAH	1600	3100	64	2800	3300	16	3700	8500	79
Sum HPAH	6500	7000	7	11000	12000	9	13000	30000	79
Sum Phthalates	300	330	10	2200	2600	17	500	6500	170

RPD=Relative percent difference= [(x-y)/((x+y)/2)*100]

Laboratories

Battelle=Battelle Northwest-Sequim, Wa.

ARI=Analytical Resources Inc.-Seattle, Wa.

Man.=Ecology/EPA-Manchester, Wa.

Appendix B, Part 2: Quality Assurance Data Reviews

STATE OF WASHINGTON DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E., Port Orchard, WA 98366

DATA REVIEW
May 1, 1991

Project: City Waterway Phase III

Samples: 91 - 048205, 048206, 048207, 048208, 048209, 048212, 048213, 048214, 048216, 048217, 91 - 048218, 048219, 0482220, 048221 and 048222.

Laboratory: Analytical Resources, Inc.

By: Dickey D. Huntamer
Through: Stuart Magoon

CASE SUMMARY

These analyses were reviewed for qualitative and quantitative accuracy, validity and usefulness. Sample analysis for both matrices used SW846 procedures. Extraction and cleanup methods were consistent with SW 846 Methods for soil samples. Specific methods used and problems incurred during the analysis of these samples are detailed in the case narrative and will not be addressed here. Analytical problems associated with QA/QC will be noted and referenced to the case narrative where appropriate.

There is no need to assimilate the "dilution factor" or "sample wt/vol" into the final values reported; these calculations have already been figured into the reported values. The results are calculated on a dry weight basis.

BNA FRACTION

Method: SW 846 8270

Matrix: Sediment

Holding times

All samples were extracted and analyzed within the recommended holding times.

Surrogates:

All surrogate recoveries for the samples were within acceptable QC limits.

Matrix Spike and Matrix Spike Duplicate (MS/MSD):

Sample 048216 was used for the matrix spike. The spike consisted of the normal CLP spike compounds and recoveries ranged from 63% to 95%. The Relative Percent Difference (RPD), ranged from 0.4% to 9%. All percent recoveries and RPD's were within QC limits. Only the limited set of CLP spike compounds was analyzed for the MS/MSD, however most of the target analytes

detected in 048216 were also detected in the spikes and consequently this data can be used as a triplicate analysis for compounds not added as matrix spike analytes.

Sample Data:

An organic tin compound was tentatively identified in sample, 048221, (stannane, chlorotris(2-methylpropyl)-), but was not detected any other sample.

Additional "J" qualifiers were added to those compounds which exceeded the Continuing Calibration % deviation (%D) limit of 25% for the low level standards. The "M" qualifier was also added to some compounds due to poor spectral match with the target compound library. The data is acceptable for use with the additional qualifiers.

DATA QUALIFIER DEFINITIONS

U - The analyte was analyzed for, but was not detected at or above the reported value.

J - The analyte was analyzed for, and positively identified. The associated numerical value is an estimate.

UJ - The analyte was analyzed for, but not detected at or above the reported estimated value.

D - Signifies that the associated value was derived from a secondary dilution.

E - This qualifier is used when the concentration of the associated value exceeds the known calibration range. (ARI uses a "k")

R - The data are unusable for all purposes. The analyte was analyzed for, but the presence of the analyte has not been verified.

M - Indicates poor mass spectral match.

Note: If this data is entered into some other format an "N" flag should be added to the compounds reported as tentatively identified compounds. The "N" flag indicates that there is presumptive evidence that the analyte is present in this sample.

STATE OF WASHINGTON DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E., Port Orchard, WA 98366

DATA REVIEW
May 1, 1991

Project: Commencement Bay

Samples: 91 - 088274, 088288, 088289, 088290, 088291, 088293, 088295, 088296,0882304, 91 - 0882307.

Laboratory: Analytical Resources, Inc.

By: Dickey D. Huntamer
Through: Stuart Magoon

CASE SUMMARY

These analyses were reviewed for qualitative and quantitative accuracy, validity and usefulness. Sample analysis for both matrices used SW846 procedures. Extraction and cleanup methods were consistent with SW 846 Methods for soil samples. Specific methods used and problems incurred during the analysis of these samples are detailed in the case narrative and will not be addressed here. Analytical problems associated with QA/QC will be noted and referenced to the case narrative where appropriate.

There is no need to assimilate the "dilution factor" or "sample wt/vol" into the final values reported; these calculations have already been figured into the reported values. The results are calculated on a dry weight basis for samples 0882304, 088291, 088290, 088289, and 088288. The remaining samples are reported on a wet weight basis, because insufficient sample was available for dry weight determination.

BNA FRACTION

Method: SW 846 8270

Matrix: Sediment

Holding times

All samples were extracted and analyzed within the recommended holding times.

Surrogates:

All surrogate recoveries for the samples were within acceptable QC limits.

Matrix Spike and Matrix Spike Duplicate (MS/MSD):

Sample 088296 was used for the matrix spike. The spike consisted of the normal CLP spike compounds and recoveries ranged from 43% to 84%. The Relative Percent Difference (RPD), ranged from 0% to 22%. All percent recoveries and RPD's were within QC limits. Only the limited set of CLP spike compounds was analyzed for the MS/MSD, however most of the target analytes detected in 088296 were also detected in the spikes and consequently this data can be used as a triplicate analysis for compounds not added as matrix spike analytes.

Sample Data:

One Tentatively Identified Compound (TIC), sterol isomer was deleted from the TIC list for sample 088307. The spectral match was not close enough and it was changed to, Unknown. An organic tin compound was tentatively identified in sample, 088295, (stannane, chlorotris(2-methylpropyl)-), but was not detected in any other sample.

Additional "J" qualifiers were added to those compounds which exceeded the Continuing Calibration (%D) limit of 25% for the low level standards. The "M" qualifier was also added to some compounds due to poor spectral match with the target compound library. The data is acceptable for use with the additional qualifiers.

DATA QUALIFIER DEFINITIONS

U - The analyte was analyzed for, but was not detected at or above the reported value.

J - The analyte was analyzed for, and positively identified. The associated numerical value is an estimate.

UJ - The analyte was analyzed for, but not detected at or above the reported estimated value.

D - Signifies that the associated value was derived from a secondary dilution.

E - This qualifier is used when the concentration of the associated value exceeds the known calibration range. (ARI uses a "K")

R - The data are unusable for all purposes. The analyte was analyzed for, but the presence of the analyte has not been verified.

M - Indicates poor mass spectral match.

Note: If this data is entered into some other format an "N" flag should be added to the compounds reported as tentatively identified compounds. The "N" flag indicates that there is presumptive evidence that the analyte is present in this sample.

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive SE , Port Orchard Washington 98366

CASE NARRATIVE

September 20, 1991

Subject: Commencement Bay

Samples: 91 - 268313, 268320, 268322, 268327, 268342, 268345, 268351, 268361, 268364, 268365, 268368, 268374, 268380, 268392, 268394 and 268398

Case No. DOE-020P

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis Unit

SEMIVOLATILE ORGANICS

ANALYTICAL METHODS:

The semivolatile soil sample was Soxhlet 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. Normal QA/QC procedures were performed with the analyses. All data is reported on a wet weight basis except for samples, 268313, 268342, 268345, 268351, 268374, 268380 and 268394. Percent solids for the samples, were 33.8%, 38.4%, 42.7%, 42.8%, 55.5%, 65.1% and 58.5% respectively.

HOLDING TIMES:

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

BLANKS:

Low levels of fluoranthene, pyrene and some phthalates were detected in some of the 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. Any target compound failing this criteria is given a "UJ" data qualifier.

SURROGATES:

The normal CLP surrogates were added to the sample prior to extraction. Most surrogate spike recoveries were within acceptable QC limits, however eight samples exceeded the recommended limits for 2-Fluorobiphenyl, three exceeded limits for Phenol-d5 and one exceeded limits for 2-Fluorophenol. No data qualifiers were added because of the high surrogate recoveries. The majority of the target compounds detected were Polynuclear Aromatic Hydrocarbons (PAH) and both the Pyrene-d10 and Terphenyl-d14 surrogates which represent this class of compounds were all within acceptable recovery limits. One laboratory blank, WBS1213B, had low surrogate recoveries for all but, Pyrene-d10 and

Terphenyl-d14 indicating that it was concentrated down too low. Consequently all of the that blank data was given the "R" or "REJ" data qualifier. This blank only applied to sample 268394 for re-extraction.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spike recoveries and Relative Percent Differences (RPD) were within acceptable QC limits for most of the compounds in the samples. No additional qualifiers were added to the data based on matrix spike recoveries.

SPECIAL ANALYTICAL PROBLEMS:

Almost all of the samples were prescreened by Gas Chromatography/Flame Ionization Detector, GC/FID, prior to analysis to optimize the analytical conditions. Those samples which had a high hydrocarbon/lipid background were diluted and this is reflected in the higher quantitation limits reported for those samples. Insufficient sample precluded percent solid determinations on all of the samples. Where practical, percent solids were taken from the metals and general chemistry aliquots when they corresponded to the organic samples.

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 estimate.
UJ	-	The analyte was not detected at or above the reported estimated result.
REJ	-	The data are unusable for all purposes. (Also R)
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 3×10^6.
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.
*	-	The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

Appendix C: Water Column Data

Table C1: Results of analysis of water column samples collected from Sitcum Waterway October, 1990 – June, 1991.

Location	Head			Mouth		
Station No.	SP–1			SP–2		
Level	Surface	Mid	Bottom	Surface	Mid	Bottom
			October 17, 1990			
Sample No. 42–	8242	8243	8244	8245	8246	8247/48*
Depth (ft)	0	25	46	0	27	53
Temp (°C)	11.2	12.4	12.3	11.8	12.4	12.3
Salinity (o/oo)	18.5	30.6	30.6	19.4	30.6	30.6
TSS (mg/l)	6	4	3	5	4	4
			January 22, 1991			
Sample No. 4–	8239	8240	8241	8242/43*	8244	8245
Depth (ft)	0	21	40	0	22	44
Temp (°C)	8.3	8.5	8.6	6.9	8.5	8.5
Salinity (o/oo)	27.1	28.7	28.7	12.7	28.5	28.5
TSS (mg/l)	10	14	6	7	2	13
			May 1, 1991			
Sample No. 18–	8215/16*	8217	8218	8219	8220	8221
Depth (ft)	0	21	40	0	23	45
Temp (°C)	10.4	9.2	8.8	10.3	9.1	8.7
Salinity (o/oo)	22.1	27.6	28.3	18.2	28	28.5
TSS (mg/l)	4	6	5	3	6	5
			June 19, 1991			
Sample No. 26–	8290/91*	8292	8293	8287	8288	8289
Depth (ft)	0	20	39	0	25	50
Temp (°C)	13.6	11.0	10.3	13.8	10.7	10.2
TSS (mg/l)	3	3	5	3	3	3

*=Reported as mean of two samples

Appendix D: Tentatively Identified Organics

Table D1: Summary of tentatively identified semivolatile organics in settling particulate matter samples from Sitcum Waterway July, 1990 to June, 1991 (ug/kg, dry).

Location	Head @ North Corner Drain		Sealand Terminal		Terminal 7, Berth B		Mouth @ Terminal 7	
Station No.	S-1		S-2		S-3		S-4	
Sample No.	8293/8307*	8392/98*	-	8374	8295	8394	8296/74*	8380
Collection Date	7/90-1/91	1-6/91	7/90-1/91	1-4/91	7-10/90	1-6/91	7-10/90	1-4/91
Quarter	1-2	3-4	1-2	3	1	3-4	1	3
Depth @ MLLW (ft)	22	-	44	-	47	-	47	-
Tetradecanoic acid	-	6900 j	NS	2000 j	-	4800 j	2500 j	-
Pentadecanoic acid	-	970 j	NS	-	-	-	550 j	-
Hexadecanoic acid	1500 nj	26000 j	NS	19000 j	-	5300 j	1900 j	26000 j
Octadecanoic acid	-	2500 j	NS	3400 j	-	1400 j	-	9400 j
Phenylacetic acid	-	3100 j	NS	-	-	4100 j	-	-
2-Methylhexanoic acid	-	-	NS	-	-	7200 j	-	-
Decanoic acid, methyl ester	-	1600 j	NS	-	-	-	-	2000 j
1,2 Benzenedicarboxylic acid	-	-	NS	-	-	16000 j	-	-
Decahydro-1,4-methanoazulene	-	180 j	NS	270 j	-	150 j	-	230 j
2,6,10.14 tetrapentadecane	-	2600 j	NS	-	-	-	-	-
Bicyclohexanone	-	390 j	NS	-	-	-	-	-
2-Phenyl-naphthalene	-	-	NS	-	-	-	-	-
1,4 Diemethylnaphthalene	-	-	NS	120 j	-	-	-	-
2,3 dimethylnaphthalene	-	-	NS	-	-	220 j	-	-
Chlorotris(2-methylpropyl)-stannane	-	-	NS	-	820 j	-	-	-
Cholesterol	2400 j	-	NS	-	1500 j	-	5200 j	-
Sterol Isomers (bp m/e 43-69)	2700 j	-	NS	-	570 j	-	13000 j	-
Co-eluting HC/Unknown	410 j	-	NS	-	-	-	-	-
Unk Hydrocarbon (bp me 57)	2600 j	-	NS	-	1300 j	-	1400 j	-
Unk (bp m/e 41-272)	13000 j	-	NS	-	10000 j	-	21000 j	-

*=Reported as mean of two samples
-=Not detected at unspecified detection limit
j=Estimated concentration
NS=No sample (Sediment Trap was not recovered)

Table D2: Summary of tentatively identified semivolatile organics in bottom sediments from Sitcum Waterway January, 1991 (ug/kg, dry).

Location	Head @ SI-172		Sealand Terminal		Port of Tacoma Dock Berth B				Mouth @ Port Dock	
Station No.	S-1		S-2		S-3				S-4	
Sample No.	8217		8218		8219/20*		8221		8222	
Collection Date	1/91		1/91		1/91		Rep		1/91	
Depth @ MLLW (ft)	22		44		47		-		47	
Hexadecanoic acid	600	j	330	j	510	j	-		1000	j
2-Phenylnaphthalene	-		-		510	j	-		-	
Dibenzothiophene	-		-		-		420	j	-	
7-ethenyl phenanthrene	460	j	-		-		-		-	
Chlorotris(2-methylpropyl)-stannane	-		-		-		1300	j	-	
Cholesterol	-		3100	j	-		-		-	
Sterol Isomers (bp m/e 43-69)	2700	j	1800	j	-		-		3800	j
Co-eluting HC/Unknown	420	j	-		-		-		-	
C14-17 H10-12 PNA Isomer	-		-		460	j	2900	j	-	
Long Chain HC or FA	1800	j	920	j	-		490	j	1600	j
Unk Hydrocarbon (bp me 57)	-		-		390	j	-		-	
Unk (bp m/e 41-272)	8900	j	12000	j	16000	j	12000	j	14000	j

*=Reported as mean of two samples

-=Not detected at unspecified detection limit

j=Estimated concentration